Government of **Western Australia**
Department of **Water**

Nutrient management for the Avon River Basin

A toolkit for managing nutrient loss to the environment from a range of land uses

Looking after all our water needs

Front cover photo
The Avon River downstream of York.
Photo by Kate Gole.

Nutrient management for the Avon River Basin:

A toolkit for managing nutrient loss to the environment from a range of land uses

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Limitation statement

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Section 1 Introduction

The toolkit is based upon four key steps:

1. **Assessing the risk.**
2. **Evaluating management options.**
3. **Implementing the chosen management option.**
4. **Monitoring the response.**

To assist in the use of the toolkit these steps have been broken down into 10 actions to systematically guide you through the process of assessing and managing nutrient loss from your property. These actions have been highlighted in each of the chapters of the toolkit.

The toolkit provides practical information on managing nutrient loss for those who live and work in the Avon River Basin. Case studies outline actual examples of nutrient management activities undertaken in the region. The following case studies are included in the toolkit:

- Case study 1 **Shire of Northam Wundowie wastewater reuse** **(page 40)**
- Case study 2 **York Integrated Livestock Industries** **(page 48)**
- Case study 3 **PR Hepple & Sons, Avon Valley Beef Abattoir** **(page 56)**
- Case study 4 **Central Wheatbelt farming system** **(page 70)**
- Case study 5 **Shire of Brookton, Integrated Town Water Management** **(page 86)**

The toolkit also includes Information boxes which provide more detailed information for important management practices that apply to many enterprises:

An extensive list of references has been provided in the toolkit to assist you in accessing additional information to assess and managing nutrient loss from your property.

Small changes made by many individual enterprises will reduce the impacts of excess nutrients. The challenge to those who live and work in the Avon River Basin is to contribute ‘their bit’ towards cleaner water in the Avon and Swan river systems for a healthier and sustainable future.

1.1 How to use the toolkit

The purpose of the toolkit is to encourage a sense of environmental stewardship in those working and living in the Avon region. This requires those who cause excess nutrient loss from the landscapes of the Avon River Basin to recognise their responsibility to take action to minimise these losses.

The toolkit applies to 'point' and 'diffuse' sources of nutrients. This includes wastewater treatment plants, abattoirs, intensive animal industries such as feedlots, landfill sites and other intensive nutrient use or waste generating sites. It also applies to small-scale and broadacre farming enterprises, and rural towns. The toolkit aims to achieve consistency in the management of excess nutrients between the differing enterprises and activities in the region.

Photo 1 *An example of a point source land use, a cattle feedlot (Photo courtesy DAFWA)*

Photo 2 *Broadacre farming – an example of a diffuse source of nutrients (Photo courtesy DAFWA)*

Excess nutrients diminish the environmental and social values of river pools and other water resource assets in the Avon River Basin. Some river pools are central to major rural towns such as Northam, York and Beverley. Fresh water and saline lakes as well as farm water supply dams can be affected by high nutrient levels. The Avon River system is also identified as a major source of excess nutrients into the Swan–Canning estuary, the river feature that is central to the character of the City of Perth.

The intent of the toolkit is to provide land managers with ways to limit nutrient loss from a variety of land uses and to restore the environmental values of waterways in the Avon River Basin. This requires a clear understanding of the sources of excess nutrients and the pathways they travel from sources to waterways.

It is recognised that there is not a single set of practices that is applicable to all individual enterprises due to differences in environmental conditions and social and economic circumstances.

The following user groups will find the toolkit beneficial:

- **farmers and farm managers**
- **farm consultants and advisers**
- **fertiliser industry field advisers**
- **fertiliser suppliers and contractors**
- **managers of intensive animal industries**
- **small landholders**
- **local government asset and infrastructure managers.**

Each user group can use the toolkit to understand the nutrient processes they manage, assess the risk of nutrient loss to the environment and take relevant action.

2 Nutrients in the Avon River Basin

Section 2 Nutrients in the Avon River Basin

The ways we use and dispose of nutrients are increasingly important. Inefficient use of nutrients applied as fertiliser is expensive. Nutrient enrichment of waterways causes algal blooms and other environmental and social problems. Effective management of nutrients is in everyone's interest.

2.1 Why we need to manage nutrients

Nutrients occur naturally and are essential in the environment for plant survival and growth. Nutrient cycles in natural systems are balanced between inputs and outputs with storage in soils and organic matter. While nutrient losses occur from natural systems, they are significantly increased by human activity.

In the Avon River Basin, excess nutrients could potentially affect many water resources, including:

- rivers, tributaries and creeks
- river pools
- fresh and brackish lakes
- farm dams and groundwater supplies (from bores, wells and soaks).

Excess nutrients in surface water can cause algal blooms, fish deaths and offensive odours. Water quality can become unsuitable for domestic or farm water supply. There is further potential for harmful health effects to humans and animals through contact with polluted water.

Water quality monitoring has shown that the Avon River is the largest single contributor of nutrients into the Swan–Canning Estuary. It contributes an estimated 69 per cent of the Total Nitrogen (TN) load and 43 per cent of the Total Phosphorus (TP) load each year. Algal blooms occur in this important community asset every summer due to excess nutrients.

2.2 Purpose and scope of nutrient management

The purpose of nutrient management is to reduce the environmental impacts of nutrient discharge from human activities. The most significant nutrients for management are phosphorus (P) and nitrogen (N). The toolkit focuses on these nutrients.

Nutrient discharge can occur from a wide range of human activities including:

- fertiliser use on crops and pastures on broadacre farms
- fertiliser use on hobby farms
- livestock management
- wastewater treatment plants
- fertiliser use or irrigation of wastewater at parks and recreation reserves
- landfill and other waste disposal sites
- town stormwater drainage
- feedlots and other intensive stock containment
- piggeries
- abattoirs.

The general nutrient management guidance and potential solutions in this toolkit are based on an extensive review of nutrient management practices The recommendations made do not override any statutory obligation or Government policy statement. Alternative practical environmental solutions suited to local conditions may be considered. Regulatory agencies should not use the recommendations in the toolkit without a site-specific assessment of the environmental risk of any project. Any conditions should consider the values of the surrounding environment and the safeguards in place, and take a precautionary approach.

2.3 Integrated nutrient management – the preferred approach

Integrated nutrient management is the preferred approach in the Avon River Basin because of the diversity of nutrient sources. This approach means the adoption of improved management practices by many landowners and land managers, which could lead to significant improvements in water quality on a regional scale.

The nutrient management practices identified in the toolkit are based upon four key principles:

- **Sustainability.** Development should improve the overall quality of life, both now and in the future, and maintain the environmental processes on which life depends.
- **Environmental Stewardship.** The protection and sustainable management of the environment is shared by all those whose actions affect the environment, including individuals, companies, communities and government organisations.
- **Producer Responsibility.** Producers of consumer goods are required to take greater responsibility for managing the environmental impact of their products throughout the entire life cycle of those products.
- **Proportional Contribution.** All those whose actions adversely impact upon the environment will undertake actions proportional to the level of their contribution.

3 Assessing the risk of nutrient loss

Section 3 Assessing the risk of nutrient loss

To assess the risk of nutrient loss and environmental harm at individual locations requires an understanding of the following:

- the sources of nutrients and their transport pathways through the landscape
- the values of the receiving environment
- the manner in which increased nutrient levels may impact upon them.

A plan of your property can be used to identify and summarise the key factors to be considered when assessing the risk of nutrient loss. Detailed soil and landform mapping will assist in identifying and mapping the causes of nutrient loss. A very useful summary of the practical steps in preparing a property plan is outlined in the *Property Planning Manual for Western Australia* (DAFWA, 2007), produced by the Small Landholder Information Service of the Department of Agriculture and Food (see Appendix 1). Topographic maps and aerial photos are a good basis for property plans and are available from local government and state government agencies including Landgate and the Department of Water.

Action 1. Develop a Property Plan.

A property plan should identify 1) existing physical features 2) Land Management Units (LMUs) and 3) current land uses.

Existing physical features include:

- waterways, wetlands and drainage lines
- ridges
- remnant vegetation, particularly along waterways (noting the condition of the vegetation)
- existing infrastructure (in particular, fences, dams and bores)
- existing earthworks (for example, grade banks, contour banks, shallow surface drains and watering points)
- the name of the catchment.

Land Management Units (LMUs) are areas of your property with similar soil types and landforms which will react to management practices in a similar way (LMUs are described in Appendix 1). Current land uses include areas used for cropping, pasture, stock feedlots or containment areas.

3.1 Sources of excess nutrients

The toolkit focuses upon phosphorus (P) and nitrogen (N), two nutrients that are potentially harmful to the environmental values of water resources when present in high concentrations.

Action 2. Identify on your property plan the types of land uses that are potential point sources or diffuse sources of nutrient loss.

There is a wide range of potential sources of nutrients in the Avon River Basin. For example, large volumes of fertiliser are applied for crop and pasture production across the catchment. As this occurs across a wide geographic area, it is referred to as being a diffuse source of nutrients. There are also point sources of P and N, where these nutrients are discharged directly into waterways. Point sources include wastewater treatment plants, intensive animal industries, landfill sites and other municipal or industrial developments. Smaller scale point source discharge may also occur as drainage into a waterway from activities such as stock holding yards.

Approximately 7.4 million ha of land in the Avon River Basin is used for agricultural production (39 per cent of all agricultural land in the south-west of Western Australia). The amount of nutrients lost from agricultural land is relatively small (less than 0.5 kg/ha/year) compared with urban areas (17 kg/ha/year), small landholdings (11–13 kg/ha/year) and feedlots (9 kg/ha/year). However, as nutrients are lost from an extensive area, the total nutrient loads exported from the Avon River Basin from agricultural land is substantial.

Point source nutrient discharge may have a significant environmental impact, especially in close proximity to a valued waterway or wetland (for example, a river pool central to a rural town). The risk of nutrient export from diffuse and point sources varies considerably depending on the type of industry, soil type, gradient, vegetation cover and the distance from waterways.

3.2 Nutrient cycles and pathways

Phosphorus (P) and nitrogen (N) have nutrient cycles and pathways that differ significantly. Understanding these differences is important for management.

Phosphorus pathways

The potential pathways for P loss from the point of application include:

- plant use, grazing by animals or export from the property as plant or animal products
- attached to soils, some of which remains available for plant use and some of which is ‘fixed’ in insoluble forms
- eroded from the landscape in particulate form, especially when high rainfall follows broadcast application of fertiliser on soils with limited vegetative cover
- leached to groundwater and transported by groundwater flow (a limited process in the Avon region).

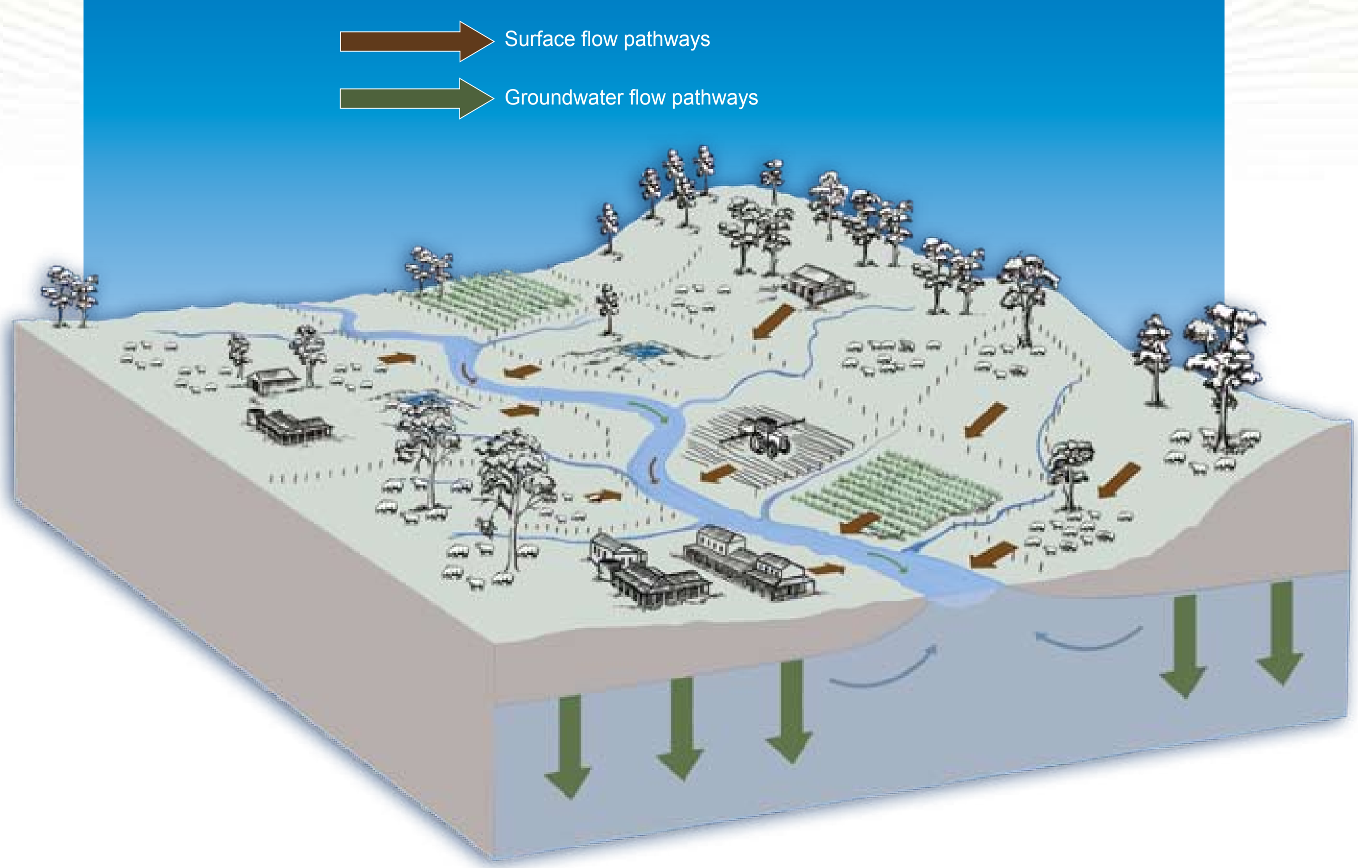
P is strongly adsorbed to soil particles so very little enters into soil solution to be transported by groundwater processes. However, sands with very low clay content (<5 per cent) have low capacity to adsorb P and may readily leach P.

Phosphorus movement through the landscape is influenced by soil and landform, catchment size, drainage density, proximity to drains, rainfall/runoff, climate and distribution of remnant natural vegetation.

Figure 1 represents nutrient pathways from slopes to waterways by surface water and groundwater processes. In the Avon River Basin (ARB), the most significant pathway for P is by soil loss.

Organic P and N derived from waste products, including farm livestock, is more likely to enter waterways directly, particularly following summer rainfall events which generate surface water runoff. Animal manure is easily washed into creeks and rivers to contaminate pools or to be flushed downstream, especially where stock have direct access to waterways.

Figure 1: **Representation of nutrient pathways through the landscape to waterways**



Nitrogen pathways

The pathways for N from the point of application or discharge towards waterways is more complicated. In agricultural areas, organic N may be formed by leguminous plant growth and stored in the plant roots and soil. Over time this is converted to inorganic forms that are available to plants. The inorganic forms of N include nitrate, nitrite and ammonium. Nitrogen fertilisers supply inorganic nitrogen directly to the soil.

Mechanisms for N removal from the landscape include:

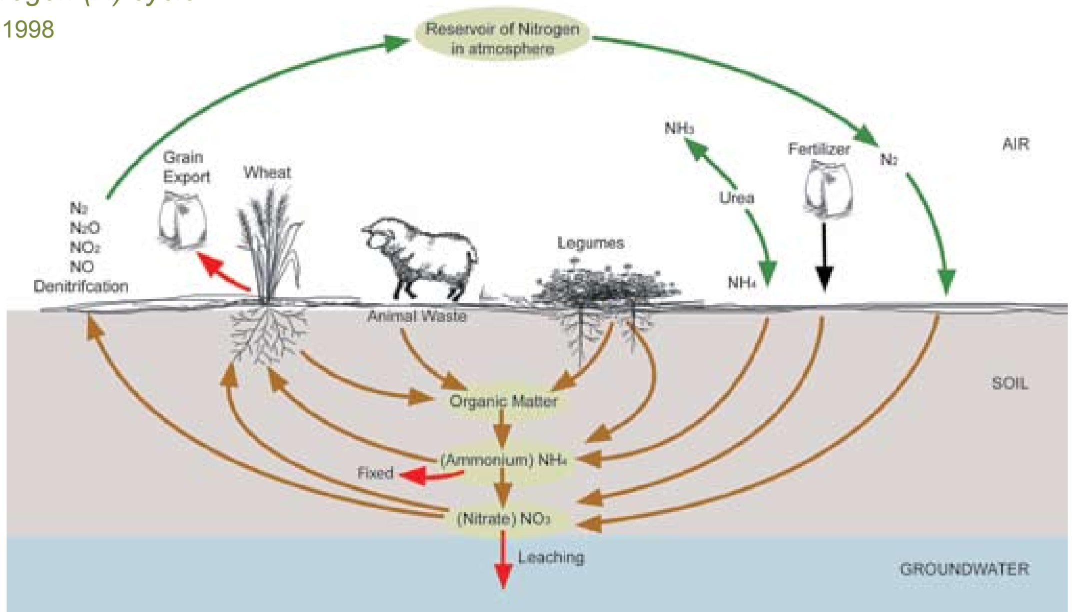
- plants use followed by recycling through plant decomposition, grazing by animals or export from the property as plant or animal products
- denitrification, that is, when nitrate is converted to nitrous oxide gas and is lost to the system (particularly in waterlogged areas)
- leaching as nitrate which is highly water soluble and may be leached from the soil profile
- volatilisation or loss of nitrogen to the atmosphere as ammonia gas (NH_3) from soils or from fertiliser applied to soil surfaces (depending on temperature, pH and soil water content)
- ammonium attached to soils lost by water erosion. Ammonium may be oxidized over time to form nitrate which is then susceptible to leaching.

Figure 2 represents the processes involved in N transport and cycling through the landscape. It shows the sources of N from plants, animals, the atmosphere and fertiliser (for example, urea). Nitrogen is used by plants, fixed to soils, lost to the atmosphere or leached to groundwater.

Sources of N from animal and other waste products can contaminate surface and groundwater bodies directly. The proximity of these sources to waterways and groundwater aquifers is a key factor in determining the level of risk.

Figure 2 *Nitrogen (N) cycle*

Source: Mason 1998



Assessing the risk of nutrient loss

3.3 Assessing soils and landform for nutrient loss risk

Action 3. On your property plan, note which soil types in the LMUs pose a medium or high risk of nutrient loss (see Table 2).

Soils and landforms have been mapped for the Avon River Basin.

The Department of Agriculture and Food Western Australia (DAFWA) has estimated the potential for phosphorus export hazard for Agricultural Sub-regions of the Avon River Basin (Galloway, 2006). This is based on evaluating a set of land qualities, including water erosion hazard, flood hazard and landform. It is estimated that 11per cent (822,000 ha) of agricultural soils in the Avon River Basin have high to extreme P export hazard (Table 1). The areas identified where this is greatest are in the Mortlock, Avon Valley, Dale/Upper Avon and Darling Range Agricultural Subregions. Map 1 shows the location of Agricultural Subregions in the Avon River Basin.

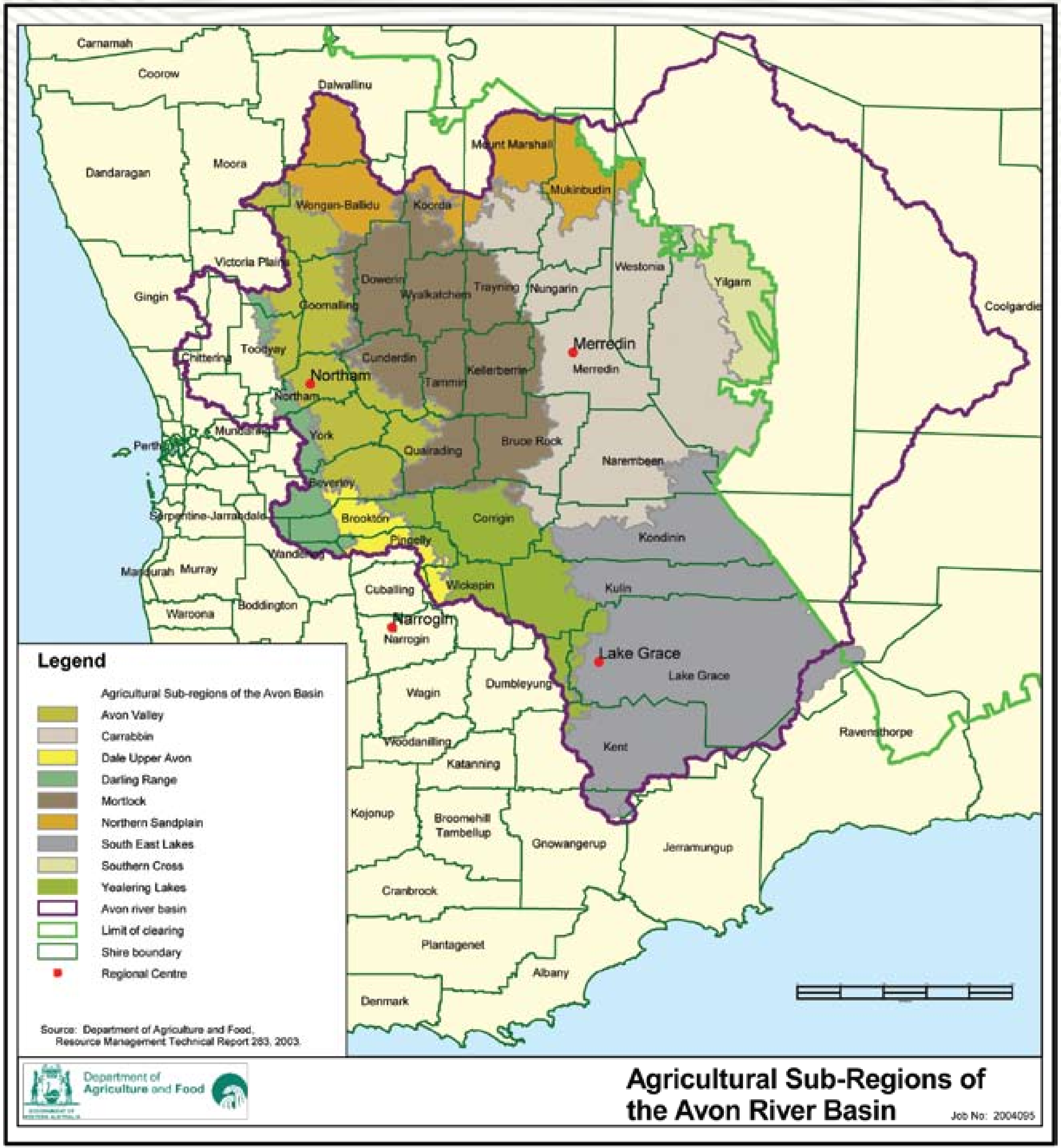
Assessing the risk of nutrient loss

***Table 1** Phosphorous loss potential in Agricultural sub-regions - Avon River Basin*

Agricultural subregion	Land area ('000) ha	Soils with high to extreme P loss potential	
		Area ('000 ha)	%
South-East Lakes	1,604	97	4.9
Darling Range	148	22	15.0
Avon Valley	813	156	19.1
Dale Upper Avon	163	28	17.3
Northern Sandplain	687	39	5.7
Mortlock	1,326	289	21.8
Carrabbin	1,794	164	9.2
Yealering Lakes	661	38	5.8
Southern Cross	189	5	2.8
TOTAL	**7,387**	**822**	**11.1**

Source: adapted from Galloway 2006

Map 1 Agricultural sub-regions in the Avon River Basin



Source: Galloway 2004

Table 2 shows the major soil types and the area over which they occur in the Avon River Basin. A broad assessment of the potential for nutrients to be lost from these soil types is shown. By using Tables 1 and 2 and Map 1, landowners will be able to obtain a preliminary indication of the nutrient loss potential of their property. Additional information about soil types is available from regional DAFWA offices, the Avon Catchment Council (ACC) or local Landcare or Natural Resource Management Officers.

***Table 2** Risk assessment of soil types in the Avon River Basin (ARB)*

		Area in ARB			
Soil types	**Description**	**Area ('000 ha)**	**%**	**P loss risk through erosion**	**N loss risk through leaching**
Deep sandy duplexes	Sandy surface and a texture or permeability contrast at 30–80 cm	977	13	Low	Medium
Shallow loamy duplexes	Loamy surface and a texture contrast at 3–30 cm	964	13	Medium	Low
Sandy earths	Sandy surface, grading to loam by 80 cm. May be clayey at depth	937	13	Medium	Medium
Loamy earths	Loamy surface and either loamy throughout or grading to clay loam or clay by 80 cm	924	13	High	Low
Shallow sandy duplexes	Sandy surface and a texture or permeability contrast at 3–30 cm	870	12	Low	Medium
Ironstone gravels	Ironstone gravels or duricrust dominant in the top 15 cm	792	11	Medium Variable, some with high risk	Low Variable, some with high risk
Deep sands	Sands greater than 80 cm deep	546	7	Low	High

Wet or waterlogged	Seasonally wet within 80 cm of the surface for most of the year	390	5	Medium	High
Shallow sands	Sands less than 80 cm deep over rock, hardpan or other cemented layer	236	3	Medium	High
Rocky or stony	Rock outcrop and shallow soils with more than 50% gravels and stones (>20 mm) throughout the profile	168	2	Medium Variable	Medium Variable
Non-cracking clays	Clay surface at least 30 cm thick that does not crack strongly when dry	163	2	Medium Variable, landscape dependant	Low
Cracking clays	Clay surface at least 30 cm thick that cracks strongly when dry	119	2	Low Variable, landscape dependant	Low
Shallow loams	Loam 80 cm deep, over rock, hardpan or other cemented layer	117	2	High	Low
Deep loamy duplexes	Loamy surface and a texture contrast at 30 to 80 cm	116	2	Medium	Low
Miscellaneous soils	Other minor soils	45	<1		
TOTAL		**7,377**	**100**		

Source: adapted from Galloway 2004 (not including risk assessment)

The next step in the process of assessing the risk of nutrient loss requires an understanding of the environmental values that may be impacted in susceptible areas.

3.4 Values of the receiving environment in the Avon region

Action 4. On your property plan, note the water resources that may be at risk from increased nutrient levels. Water resources such as waterways, wetlands, dams and groundwater are the part of the environment most at risk from increased nutrient levels.

The Avon River provides natural drainage for surface water from the vast Avon River Basin that extends to Dalwallinu in the north, east past Southern Cross, and south beyond Lake Grace. It is an area of over 120 000 square kilometres.

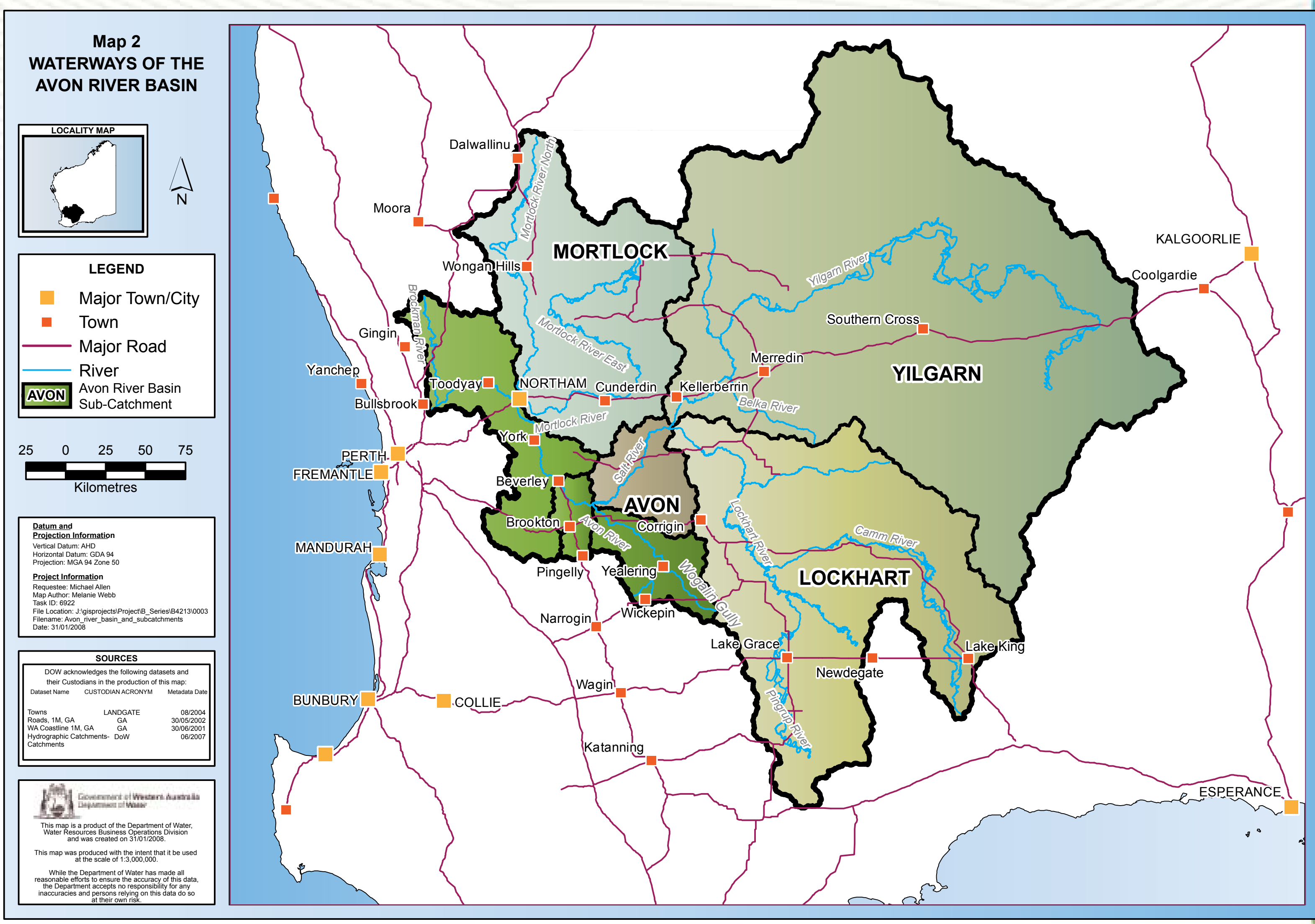
Map 2 shows the major waterways, natural drainage pattern and key features of the Avon River Basin. Stream flow from the Avon discharges to the Swan–Canning Estuary in Perth. The Avon and the Swan are the same river system but are named separately. The Avon is that section of the river inland of the confluence with Wooroloo Brook at Walyunga.

There is estimated to be more than 50 000 km of waterways in the Avon River Basin. Some are quite large, but most are the smaller creeks or brooks that provide natural drainage for the landscape.

Most farms and recreational lifestyle blocks have a waterway or drain running through them.
Some have wetlands or salt lakes. Waterways and wetlands are an essential component of our landscapes. They discharge excess water from the landscape, lessen the intensity of floods and provide habitat for wildlife. They are also highly valued by local communities.

The next step in the process is to understand the manner in which increased nutrient levels may impact upon the water resources you have identified on your property.

Map 2 Major waterways of the Avon River Basin



Assessing the risk of nutrient loss

3.5 Environmental risks from nutrient loss

In the Avon region excess nutrient loss may adversely impact upon natural water resources such as rivers and river pools and inland lakes. The Avon is also a significant contributor of nutrients into the Swan–Canning Estuary. At a local scale there is the potential for nutrient contamination of farm water supplies, especially farm dams polluted by animal manure.

Action 5. Identify on your property plan where water resources appear to have been impacted by nutrient enrichment or eutrophication.

Nutrient enrichment of surface water bodies may cause eutrophication resulting in high algal growth and poor water quality. A eutrophic waterbody has a high level of algal or other macrophyte growth that leads to:

- significant discolouration of the waterbody (usually green or brown, but can be other colours)
- algal scums or mats on the surface of the waterbody
- unpleasant odours from decomposing algae
- low oxygen levels in water (this can cause fish and crustacean death)
- release of toxins formed by blue-green algae (toxic algae may also be present in polluted farm dams)
- release of nutrients from sediments.

Social impacts of a eutrophic waterbody include:

- health risk for people and animals
- closure of waterways to fishing and recreation (affecting tourism and other economic values)
- nitrate toxicity in groundwater supplies
- offensive odours due to algal decomposition
- unsightly scum or mats of algae on the water surface.

At times the water quality in some pools on the Avon (such as Northam Town Pool and Beverley Town Pool) has become significantly degraded due to eutrophic conditions.

***Photo 3** An algal bloom in the Northern Town Pool*
(Photo by Chris Ryan)

The Swan–Canning Estuary is the final 'sink' for excess nutrients discharged from the Avon River Basin. When algal blooms do occur in the estuary, the impacts are significant given its very high recreational, social, cultural and environmental values.

Each catchment in the Avon River Basin contributes to excess nutrients that accumulate in the Swan–Canning Estuary. The potential contribution is substantially greater from high rainfall events and during floods if adequate management is not in place.

In 2009, water quality monitoring data was used to estimate nutrient loads for the Swan–Canning from its tributaries. The model estimates that the Avon discharges an average annual load of 575 tonnes TN and 20 tonnes TP to the Swan–Canning Estuary. This varies considerably with rainfall and other factors. For example, the January 2000 flood event generated an estimated 800 tonnes TN and 35 tonnes TP over just 31 days.

Most groundwater aquifers in the Avon River Basin are saline; however, there are localised fresh groundwater aquifers that are at risk of N pollution due to leaching. This could impact on water quality in natural waterways as well as farm water supplies. For example, farm dams that are maintained by groundwater seepage are likely to experience summer algal blooms due to excess nutrients in groundwater.

Photo 4 *A farm dam affected by an algal bloom*
(Photo by Kate Gole)

While there are few public drinking water source areas in the Avon region, those that do exist need to be protected from nutrient contamination, especially from highly soluble nitrates. All public drinking water source areas are currently protected by statutory controls under the *Country Areas Water Supply Act 1947*. These include groundwater areas at Bolgart, Brookton (Happy Valley), Calingiri and Yerecoin.

Information box 1 Management of the Swan–Canning Estuary

The Swan River Trust has undertaken significant planning and on-ground works to reduce the impact of nutrient enrichment on the Swan–Canning Estuary. The draft *Healthy River Action Plan* (Swan River Trust, 2008) includes:

- identifying the need for better regulation of point source nutrients in contributing coastal catchments
- supporting local government and community initiatives for waterway restoration (*Riverbank* program)
- integrated management in eight priority catchments for nutrient reduction (*Healthy Catchments* program)
- phasing out the use of highly water soluble P fertilisers (all users on the coastal plain)
- removing nutrients from urban drainage systems
- mechanical injection of oxygen to maintain river health in high risk sections of the Swan and Canning rivers (Photo 5)
- trial application of Phoslock® to remove P from the waterbody
- public education programs to reduce fertiliser use (for example, *Great Gardens* program).

Photo 5 *Tanks used by the Swan River Trust for river oxygenation trials*
(Photo by Kirrily King)

3.6 Risk Factor Checklist

Soils and landform are the most significant factors affecting diffuse loss of nutrients from the landscape. The risk factors outlined below are applicable to diffuse and point sources of nutrients. Use the checklist to broadly identify areas of increased risk of nutrient loss.

Action 6. On your property plan, identify areas where the following specific risk of nutrient loss may be present.

A. A high soil erosion hazard is present (high slope, poor soil structure, waterlogged and salt-affected soils with minimal groundcover such as stubble or pastures).

B. Sandy textured soils are present with high permeability increasing the risk of leaching or through flow.

C. Soil loss is occurring in close proximity (<50m) to a creek or drainage line.

D. Agricultural activity (such as grazing, cropping) is occurring in the floodplain where there is a significant risk of the loss of sediment and alluvial soils.

E. Channel and gully erosion are occurring in the riparian zone, resulting in the erosion of alluvial and other recent depositional soils.

F. Wind or water erosion is removing topsoil due to insufficient vegetative cover.

G. Areas are prone to waterlogging or groundwater discharge (including salt-affected land).

H. Fertiliser is being applied at rates higher than required for plant use, or where there are high soil nutrient levels.

I. Stock have uncontrolled access to water supplies, waterways or wetlands.

J. High levels of organic matter have built up where stock are concentrated near drainage lines (for example, stock yards, shearing sheds, watering points, sheep ‘camping areas’).

K. There is insufficient filtering capacity in riparian vegetation (especially due to inadequate groundcover).

L. There are areas of bulk fertiliser storage (paddock storage, roller roof shed, bins and tanks).

M. Fertiliser is being applied across drainage lines or seasonal watercourses.

N. There are general farm management activities that may increase the risk of nutrient loss.

O. A point source of nutrients is present (for example; a piggery, stockyard, feedlot or wastewater treatment system).

Key Points Summary

- The major nutrients to be managed are phosphorus (P) and nitrogen (N).
- Excess nutrients discharged to the environment in the Avon region are from diffuse sources (mostly fertilisers used for agriculture) and point sources (including intensive animal industries and wastewater treatment plants).
- P loss is mostly due to soil erosion.
- N loss is mostly by leaching to groundwater.
- The average annual load of Total Nitrogen (TN) discharged from the Avon is estimated to be 575 tonnes.
- The average annual load of Total Phosphorus (TP) discharged from the Avon is estimated to be 20 tonnes.
- Greatest nutrient loss from the Avon occurs during floods. The January 2000 flood discharged 800 tonnes of TN and 35 tonnes of TP to the Swan–Canning Estuary in just one month.
- High nutrient levels affect farm water supplies, river pools, lakes, groundwater aquifers and the Swan–Canning Estuary.
- The effects of excess nutrients include algal blooms, fish deaths, offensive odours and risks to human or animal health

4 Nutrient management for point sources

Section 4 Nutrient management for point sources

Point sources of nutrient loss are relatively easy to identify and can be efficiently and effectively managed because of their confined locations. Although the Avon River Basin does not contain a large number of intensive point source industries, those that are present have the potential to discharge high levels of nutrients to the environment unless well managed.

A brief overview of the statutory approvals relevant to point source industries is outlined below.

4.1 Licensing and regulation

Point source discharge of nutrients (and other pollutants) is controlled by legislation in Western Australia. The following Acts are relevant to the Avon River Basin.

Environmental Protection Act 1986

The *Environmental Protection Act 1986* is the primary legislation for regulation of activities that may adversely impact upon the environment. There are two mechanisms that are specifically relevant to point source nutrient management:

- Part IV under which the Environmental Protection Authority (EPA) advises the Minister for the Environment of the requirement for environmental assessment if proposals are ' … likely, if implemented, to have a significant effect on the environment'.
- Part V (environmental regulation using licenses, works approval and registrations) which provides pollution control mechanisms for prescribed activities with significant potential for pollution of air, land or water based on the assessment of the Department of Environment and Conservation (DEC). A Works Approval may be required prior to application for a License or Registration.

Metropolitan Water Supply, Sewage and Drainage Act 1909 and Country Area Water Supply Act 1947

Public Drinking Water Source Areas (PDWSA) are catchments that have been identified under the *Metropolitan Water Supply, Sewage and Drainage Act 1909* or the *Country Area Water Supply Act 1947* as water sources for schemes supplying cities and towns. PDWSAs require comprehensive water resource quality and land planning protection measures to ensure the ongoing availability of safe, good quality drinking water.

There are three priority classifications:

1. Priority 1 (P1) classification areas are managed to ensure that there is no degradation of the drinking water source by preventing the development of potentially harmful activities in these areas. Most land uses create some risk to water quality and are therefore defined as 'Incompatible' in P1 areas.
2. Priority 2 (P2) classification areas are managed to ensure that there is no increased risk of water source contamination. Some development is allowed in P2 areas for land uses that are defined as either 'Compatible with conditions' or 'Acceptable'.
3. Priority 3 (P3) classification areas are defined to manage the risk of pollution to the water source from catchment activities. P3 areas are declared over land where water supply sources coexist with other land uses such as residential, commercial and light industrial development.

These Acts are administered by the Department of Water.

Planning and Development Act 2005

The Planning and Development Act 2005 provides for efficient and effective land use planning in the state. It helps to promote sustainability by including the sustainable use and development of land as a fundamental and underlying purpose of the planning legislation. This Act is administered by the Department of Planning.

Soil and Land Conservation Act 1945

The Soil and Land Conservation Act 1945 provides for the conservation of soil and land from the effects of erosion, salinity, flooding and eutrophication. The legislation is administered by the Department of Agriculture and Food.

Local government approval may also be required according to local planning policies and health regulations. In the following section the key management practices recommended for point sources of nutrients are identified for each industry type. These are supported by case studies based on examples from in the Avon River Basin.

Action 7. Review the recommended point source nutrient management options and note any that specifically address nutrient loss from your property.

4.2 Wastewater treatment plants

There are 26 wastewater treatment plants (WWTPs) servicing rural towns in the Avon River Basin. Twenty of these are less than 1 km from a waterway. Six sites discharge treated wastewater to the environment (Northam, Brookton, Merredin, Meckering, Cunderdin and Kulin). Twelve sites reuse water for irrigation of public facilities.

The majority of WWTPs in the Avon are operated by the Water Corporation with a small number managed by local government or education and training institutions (for example, Muresk Institute in the Shire of Northam). All sites are regulated under Part V of the *Environmental Protection Act 1986.*

The annual nutrient load to the Avon River from WWTPs can be significant. For example, in 2001 the annual load from just four WWTPs to the river was estimated to be 12.7 tonnes of nitrogen and 1.2 tonnes of phosphorus. This highlights the need for careful design and management of WWTPs to minimise nutrient loss to the environment. A range of design and management practices are outlined for consideration below.

Photo 6 *Cunderdin Wastewater Treatment Plant*
(Photo by Michael Allen)

Site selection

The key issues to consider in site selection are:

- Site soil type and landform. Ponds should be located in stable sands or loamy soils on gently sloping sites with gradients of less than 1:10. Sites to be avoided include hard rock, seismic fault or drainage lines, peat beds, wetlands, sites with a shallow watertable (groundwater levels less than 1 m to the base of the pond liner) and floodways.
- Significant buffer zones to waterways and wetlands. It is recommended that buffer zones to public places and residences should exceed 250 m.

Pond design

Designing a WWTP system is a complex process which requires a clear understanding of the following:

- the characteristics of the wastewater to be treated (volumes, quality, variability)
- operational factors such as treatment method (anaerobic or aerobic), pond depth, organic loading and treatment retention time
- seasonal pond water temperatures
- pond water balance; including input variability, rainfall, surface evaporation, seepage
- the treatment objective (final water quality) determined by the disposal method (evaporation, re-use, environmental discharge) intended to protect the environmental values of waterways, wetlands and aquifers.

Where practical, pond liners should be constructed of natural soils to achieve very low levels of permeability (less than 10^{-9} m/sec) or incorporate artificial liners (for example geomembrane liners such as HDPE and PVC). A minimum freeboard of 500 mm is recommended to contain incidental rainfall and wave action. To prevent erosion of pond embankments, stormwater runoff should be diverted around ponds.

More detailed descriptions of anaerobic, aerobic, detention and evaporation pond design specifications are outlined in Information box 3.

Pond operation and maintenance

An inspection and maintenance schedule should include observation of pond condition, pond stabilisation performance tests, programmed desludging and sludge disposal.

Contingency planning is recommended for extreme rainfall events, organic overloading, equipment malfunction and poor treatment performance.

Regular monitoring of the pond system should include pond input and output volumes, organic loading, sludge levels and pond performance (analysis of detailed water chemistry at the inlet and outlet).

Existing WWTPs

Many established WWTPs are located close to waterways and some are located in the floodplain of major waterways. Where it is not practical to relocate WWTPs, management actions can reduce the risk of exceeding the capacity of the treatment facility, including:

- Adoption of water use efficiency practices by local government, industry and rural communities to reduce demand on WWTPs.
- Construction of additional capacity in anticipation of population growth.
- Investigation of wastewater re-use, for example, through irrigation of public recreation facilities which reduces the need to discharge effluent to the environment (see Information box 2).

Wastewater re-use can provide social and economic benefits to rural communities (Case Studies 1 and 5), including:

- provision of low cost water and nutrients to irrigate public recreation facilities
- opportunity to irrigate commercial tree plantations
- potential for 'third pipe' plumbing for recycled water in new urban development
- potential to harvest stormwater and combine this with treated wastewater in an integrated irrigation program.

Wastewater treatment methods vary between towns. The settling pond that is located near the river in Brookton discharges liquid effluent with limited organic matter treatment. A nutrient-stripping artificial wetland has been established between the pond and the river by the Department of Water and the Shire of Brookton (with funding from Avon Catchment Council). Recent monitoring has shown that the constructed wetland has significantly reduced the P and N load to the river. This is an interim measure while the Shire of Brookton arranges a system of wastewater re-use in the town to minimise or eliminate discharge to the river (see Case Study 5).

Information box 2 Wastewater Re-use

Irrigation with nutrient-rich water using effluent from wastewater treatment plants or intensive industries can provide an opportunity for increased production from waste disposal. Potential uses for production or public benefits include:

- agricultural crops and pastures
- commercial tree crops
- turf areas.

To minimise environmental harm by wastewater re-use, it is important that the proposed irrigation site has the following attributes:

- zoned as a compatible use in the local government planning scheme
- adequate buffers to sensitive land uses where odours or spray drift may cause local nuisance
- minimum depth to groundwater is greater than 2.0 m
- suitable soils for production
- gradient less than 1:20
- not subject to seasonal flooding
- adequate buffers to identified water resources.

Approval is required from the Department of Water for nutrient-rich water re-use in areas identified as Public Drinking Water Source Areas (PDWSA).

Proposals for wastewater re-use should develop a Nutrient and Irrigation Management Plan (NIMP) as part of an Environmental Management Plan. Sites with an irrigated area greater than 10 ha will require application of a nutrient model to estimate potential off-site impacts. Where the quantity of wastewater to be used exceeds 100 kilolitres per year, a license will be required under Part V of the *Environmental Protection Act 1986.*

There are specific requirements to minimise public health risks, including the potential for transmission of harmful micro-organisms. This may limit the food crops or animal pastures to which treated wastewater can be applied. There may be a requirement for regular monitoring of physical, chemical or microbial impacts of wastewater re-use.

On-site storage is a significant management consideration. Storage may be required to contain wastewater during winter months when crop or pasture water requirements are low. Monthly storage requirements should be calculated to ensure adequate capacity throughout the year.

Use of nutrient-rich wastewater should be based on soil type, crop requirements and existing nutrient status. This will ensure the most efficient use of nutrients and minimise the potential for loss to the environment.

Sites can be assessed for potential to contribute to eutrophication of downstream surface waters (Table 3). The most vulnerable sites (Category A) are on coarse textured soils within 500 m of downstream surface water with significant risk of eutrophication. Recommended maximum rates of application of inorganic nitrogen and reactive phosphorus are shown in Table 4.

Table 3 *Site vulnerability categories for wastewater disposal*

Characteristics of irrigated soils	Vulnerability to eutrophication of downstream surface waters (within 500 m of the site)	Vulnerability category
Coarse textured soils (e.g. sands and gravels)	Significant[a] Low[b]	A B
Fine textured soils (e.g. loams and clay)	Significant[a] Low[b]	C D

Source: adapted from Water Quality Protection Note No. 22 (Department of Water 2006)

Notes

a Significant vulnerability to eutrophication applies to clear inland waters where nutrient levels are elevated (Dissolved Inorganic Nitrogen (DIN) > 1.0 mg/L and Soluble Reactive Phosphorus (SRP) >0.1 mg/L), resulting in occasional algal blooms.

b Low eutrophication vulnerability applies to turbid or coloured waters with rarely observed algal blooms and low nutrient levels (DIN< 0.5 mg/L and SRP< 0.05 mg/L).

Table 4 Maximum application rates for nutrient-rich wastewater

Vulnerability category	Maximum inorganic nitrogen (as N)		Maximum reactive phosphorus (as P)	
	Application rate (Kg/ha/yr)	Equivalent water concentration (mg/L)[1]	Application rate (Kg/ha/yr)	Equivalent water concentration (mg/litre)[1]
A	140	9	10	0.6
B	180	11	20	1.2
C	300	19	50	3.1
D	480	30	120	7.5

Source: adapted from Water Quality Protection Note No. 22 (Department of Water 2006)

Notes

[1] N and P concentrations are based on an average of 50 millimetres (500 kilolitres/ha) of water applied per week for 32 weeks per year with no further nutrient addition to the land (including animal manure). For other irrigation regimes, equivalent water concentration rates should be calculated on a pro-rata basis.

Case study 1 Shire of Northam Wundowie wastewater re-use

Wundowie is a rural town of 800 people south-west of Northam. The town has a sewerage system which discharges to a wastewater treatment plant operated by the Water Corporation, adjacent to Werribee Creek.

Water supply for the town oval was previously sourced from a wetland seepage area located approximately 3 km north-east of the town and piped to a Shire of Northam reservoir. The reservoir did not have adequate storage capacity, it leaked and was at risk to saline groundwater intrusion.

Nutrient loss and impact

Leakage from the storage reservoir posed a significant threat to water quality in Werribee Creek as the treated wastewater stored in the reservoir had very high levels of nitrogen and phosphorus. Ongoing discharge created a significant risk of eutrophication during the late spring and early summer months which could result in algal blooms and very low oxygen levels.

Nutrient management practices

In a co-investment project with the Water Corporation and the Commonwealth government (Community Water Grants Scheme), the Shire of Northam almost doubled the capacity of the reservoir to 37 000 m^3 and lined it with a 1.5 mm plastic liner. Wastewater from the treatment plant is now pumped to the reservoir for storage and subsequent irrigation of the Wundowie oval. Stormwater from the town is directed to the reservoir. A gate valve can be closed to divert excess stormwater inflow.

The re-use of wastewater from the wastewater treatment plant to irrigate the public recreation area reduces nutrient discharge to the environment. The Wundowie plant is a secondary treatment process. It is registered under Schedule 1 of the *Environmental Protection Regulations 1987*. The Water Corporation operates the treatment plant and is responsible for monitoring discharge from the site.

Outcomes

The development of Wundowie's integrated water re-use system provides these advantages:

- reduced discharge of nutrients to the waterway
- reduced impact on a natural wetland now that pumping has ceased
- reliable water supply to irrigate the town oval.

Wundowie now has an improved public recreation facility with an adequate water supply for irrigation. This water re-use project has also provided significant environmental benefits.

Photo 7 *Plastic lined reservoir for wastewater and stormwater storage (Photo by Phil Steven)*

4.3 Intensive animal industries

Cattle and sheep feedlots, piggeries, saleyards and containment areas are sites where feed and water is provided for stock confined to a limited space. These facilities have the potential to generate a high level of nutrient-rich organic waste.

Considering the vast area of the Avon River Basin, there are very few cattle feedlots. There is, however, increasing interest in sheep feedlots or temporary containment. More than 20 properties are known to have established sheep feedlots in the Shires of York and Beverley alone over recent years.

The main types of sheep containment are:

- housed sheep containment in a controlled environment system (see Case Study 2)
- permanent open sheep containment
- temporary open sheep containment.

Small piggeries were a common feature on wheatbelt farms in past times. Wheat ‘seconds’ were fed to pigs run either free range or semi-intensively. Very few piggeries are an integral part of farming systems in the Avon, because of the current high value of grain and higher bio-security standard requirements.

Piggeries in the Avon region are of moderate size, generally being of less than 150 sow capacity. Pigs produce almost 4 kg/head/year of N and approximately 1–3 kg/head/year of P.

Assessing nutrient loss risk

Intensive animal industries pose a risk to the environment through nutrient contamination of waterways or groundwater resources. For example, cattle in feedlots produce an estimated 20–30 kg/head/year N and over 6 kg/head/year of P.

Minimising the risk of environmental harm from intensive animal industries is achieved through well planned site location, design and management.

Department of Environment and Conservation approval may be required to establish and operate an intensive animal industry. This may include a Works Approval, License or Registration under the *Environmental Protection Act 1986*. Approval requirements are summarised in Table 5.

Table 5 Approval requirements relevant to animal industries under Part V of the Environmental Protection Act 1986

Intensive animal industry	Description	Product or design capacity	Approval required
Cattle feedlots	Feedlots with a stocking rate of over 50 cattle/ha located: • less than 100 m from a watercourse • more than 100 m from a watercourse	500 animals or more	• Works approval and Licence • Works approval and Registration
Sheep feedlot	Not a prescribed activity		Not required under Part V of the *Environmental Protection Action 1986*
Intensive piggery	Piggery on which pigs are intensively fed, watered and housed in pens	1000 or more pigs 500–1000 pigs	Works Approval and Licence Works Approval and Registration
Stockyards	Livestock saleyard or holding pens in which live animals are held pending their sale, shipment or slaughter	10 000 or more animals per year	Works Approval and Licence

There are currently no guidelines specifically for the establishment and management of sheep feedlots in the region. However, the guidelines for intensive animal industries are also broadly applicable to sheep feedlots.

Key considerations in the design and management of intensive animal industries are:

- site selection
- stock containment area design
- solid waste management
- liquid waste management
- stormwater management.

Site selection

One of the most significant factors for establishing an intensive animal industry is its location. Key criteria to consider in site selection are:

- separation distances from residential properties, waterways, water supply and other water resource assets (see Information box 4)
- elevation above the 100-year flood level and other flood-prone land
- selecting well drained soils (for example, deep permeable duplex soil) but not deep leaching sands
- groundwater levels more than 2.0 m below the ground surface
- slope of 2–5 per cent to enable efficient surface water management (including constructed drainage for higher slopes)
- sufficient area for safe waste disposal.

Some farmers are considering temporary containment of sheep on salt-affected land. These areas are considered unsuitable because they are near waterways and have erosion-prone soils due to groundwater seepage and low vegetation cover.

Stock containment area design

Design factors to consider in establishing an intensive animal industry:

- Stock containment areas should have a low permeability hardstand floor (for example, compacted clay) or if impractical, a hard surface pad formed by compaction should be encouraged.
- Uncontaminated stormwater should be kept separate from wastewater.
- Pre-treat wastewater to remove solids before entry into treatment ponds (for example by installing a manure screening trap).
- Provide for sediment detention and removal capacity immediately down-slope from the site.
- Establish a fenced vegetative filter strip between the stockyard and waterways.
- Incorporate a system for effluent disposal (irrigation of liquid waste, broadcasting solids or safe off-site disposal).

The pig production industry is well aware of market sensitivity to issues of 'cleaner production', bio-security and animal welfare. Many piggeries now adopt straw-based 'deep litter' bedding. The advantages of this are:

- lower water use
- less effluent being produced
- straw waste suitable for composting
- improved shed conditions for the pigs.

Photo 8 *A piggery using straw based deep litter bedding (Photo courtesy DAFWA)*

Enviro-check, an initiative of Australian Pork Ltd, is a useful reference to help piggery managers assess performance against good practice procedures described in the *National Environmental Management Guidelines for Piggeries* (Australian Pork Ltd, 2006). Using this reference, managers can identify, prioritise and implement actions to improve environmental management in piggeries.

Solid waste management

Solid waste from intensive animal industries can be incorporated into soils if the disposal site is rotated between paddocks. This may suit some smaller industries, provided the recommended separation distances to water resources are met. Maximum application rates for disposal of nutrient-rich waste material are determined by assessment of site vulnerability (based on soil type and risk of eutrophication in surface water). The maximum nutrient application rates are shown in Table 6.

Table 6 *Maximum phosphorus (P) and nitrogen (N) application rate criteria to protect water quality.*

Vulnerability category (as described below)	Site description	Maximum available P loading (kg/ha/yr)	Maximum available N loading (kg/ha/yr)
A	Coarse sandy soils / gravels draining to soils with a moderate to high risk of eutrophication	10	140
B	Coarse sandy soils / gravels draining to soils with a low risk of eutrophication	20	180
C	Loams / clay soil draining to water with a moderate to high risk of eutrophication	50	300
D	Loams / clay soil draining to water with a low risk of eutrophication	120	480

Characteristics of soils	**Vulnerability to eutrophication of downstream surface waters** (within 500 m of the site)	Vulnerability category
Coarse textured soils (e.g. sands and gravels)	Significant[a] Low[b]	A B
Fine textured soils (e.g. loams and clay)	Significant[a] Low[b]	C D

Notes on Vulnerability category

a Significant vulnerability to eutrophication applies to clear inland waters where nutrient levels are elevated (DIN > 1.0 mg/L and SRP >0.1 mg/L), resulting in occasional algal blooms.

b Low eutrophication vulnerability applies to turbid or coloured waters with rarely observed algal blooms and low nutrient levels (DIN< 0.5 mg/L and SRP< 0.05 mg/L).

Source: adapted from *Irrigation with nutrient-rich wastewater, Water Quality Protection note No. 22, Water and Rivers Commission 1998* (Department of Water, 2006)

Larger intensive animal industries will require more comprehensive waste management. Options include:
- removal (for example, by front-end loader) and appropriate storage in stockpiles
- manure storage areas designed with adequate storage capacity so that all manure collected is properly contained. In low rainfall areas, an impervious bunded area with controlled drainage to wastewater ponds may suffice.
- aerobic composting as a commercial by-product
- disposal of solid waste to land by broadcasting
- waste application rates for pastures need to be based on plant nutritional requirements and recommended application rates as shown in Table 6.

Dead animals from intensive animal industries should be buried with a minimum soil cover of 1.0 m (unless commercial rendering plant is available). Burial pits should be located:
- more than 100 m from wells, domestic water bores, streams and surface waterbodies
- in low permeability soils (for example, clays)
- more than 1.5 m above maximum groundwater levels (from the base of the pit)
- at separate locations if more than one pit is required.

Liquid waste disposal

Liquid waste from intensive animal industries should be managed by:

- discharge of wastewater into a well designed wastewater treatment pond system (see Information box 3)
- diverting surface water run-off away from operational and storage areas on-site using diversion drains or bunds
- containment in lined settling ponds (see Information box 3)
- disposal over land (see Information box 2).

Treatment ponds for large, intensive animal industries usually include anaerobic and aerobic processes. However, the relatively low rainfall and high evaporation rates of the Avon River Basin may allow evaporative ponds to be effective, especially if there is primary treatment to remove solid waste from the effluent (see Information box 3).

Case study 2 York Integrated Livestock Industries

Tony, Sally and Scott Boyle have plans for an innovative development on their 'Broadlands' property south-east of York, plans based on their experience with building an intensive under-cover sheep feedlot some years ago. The feedlot has been successful in diversifying the family farm enterprise from a broadacre cropping program. Sheep no longer graze across the property; instead, there are up to 100 000 sheep housed annually in the raised feedlot.

The current feedlot facility is located on land between the Avon and Mackie rivers. Store sheep are trucked to the site, housed and fed for one to two months, then sold to market.

The approved plans are to increase the feedlot capacity by building another two sheds near the original one, and to construct a 'state of the art' abattoir for on-site processing to meet overseas market demand for retail-ready lamb products. The feedlot and abattoir are expected to process more than 500 000 sheep annually when fully operational.

Feed supplies will be mostly produced on-farm although supplementary feed will be purchased.
The site for the existing feedlot and the proposed facilities is located up-slope of and between two major waterways. The activities proposed on-site have the potential to generate very large quantities of solid and liquid waste. The potential for nutrient loss directly to these rivers does exist; however, a high standard of on-site management will minimise this risk.

Nutrient management practices

The existing feedlot housing is raised to enable easy removal of sheep manure, which is valued as an organic fertiliser by horticultural industries.

A substantial earth diversion bank drains surface water runoff away from the site for disposal to the river floodplain. This ensures no water runs onto the site. In addition, there are concrete bunds above and below the feedlot covered area to control run-on and runoff from the site. The proposed new sheep sheds will have a similar standard of nutrient management.

The planned abattoir will be licensed under the *Environmental Protection Regulations 1987*. Wastewater treatment will be through a series of anaerobic and aerobic ponds located more than 500 m from both waterways. Treated wastewater from the pond system will be used to irrigate an extensive area of lucerne that will be ‘cut and carried’ for use as a feed source. Trees will be planted as a buffer between the irrigated area and the riparian zone of the Avon River to ensure minimal transport of nutrients to the waterway.

A future option is for rendering processes to convert tallow waste from the abattoir into a farm fertiliser.

Outcomes

The existing and proposed sheep feedlot and integrated meat processing facilities demonstrate that vertical integration of farm enterprises including intensive animal industries can incorporate management strategies to ensure protection of the environment.

The Boyles have taken a precautionary approach by allowing adequate time and resources to ensure that the planning and approval processes are thorough and complete.

Tony comments that...

"… we have left no stone unturned for environmental management. Our investors and our international clients now expect top-notch environmental care. We want to do the right thing".

Photo 9 *Tony Boyle with sheep in the raised feedlot near York (Photo by Viv Read)*

Information box 3 Detention and organic matter stabilising ponds

The use of well designed ponds for wastewater storage and treatment is an important component of point source nutrient management. Ponds are used for two main purposes:

1. detention of wastewater, for example, storage after wastewater treatment for re-use by irrigation
2. stabilising organic matter by decomposition of complex animal and plant waste using micro-organisms and algae.

Treatment ponds are used in a range of industries including sewage treatment, abattoirs, piggeries, feedlots and stockyards. They provide environmental benefits by allowing controlled decomposition of organic matter. Decomposition in waterways or other surface water bodies reduces dissolved oxygen levels resulting in death of fish and other aquatic fauna.

Selecting sites for ponds

Locating ponds for effective and safe operation requires careful site assessment. The key criteria to consider are:

- stable soils (sand or loam rather than clay)
- avoiding shallow bedrock, porous soils (for example, limestone), drainage lines, seasonal flood-prone areas, wetlands, shallow watertables, seismic fault areas and places identified as having ethnographic or heritage significance
- slope of less than 1:10
- down-slope from proposed processing site (for gravity-fed inflow)
- separation distance from residential or other areas of at least 250 m.

Design criteria

Detailed on-site design is required for all detention and treatment ponds. Guidelines for design criteria are:

- Usually constructed as a sequential ‘treatment train’ of two to four ponds in series.
- Include pre-treatment to remove coarse or incompatible solids.
- Final pond has pumped discharge with capacity for re-use or recycling within the treatment system.
- Pond capacity is calculated based on inputs (wastewater volume, rainfall), required water quality reduction, treatment type (for example, aerobic or anaerobic), retention time, seasonal variation and outputs (desired effluent quality).
- Construction considers potential for seepage from the pond. The use of a low permeability earth, concrete or geomembrane pond liner may be required.
- Pond freeboard provides for a minimum freeboard of 500 mm to minimise the risk of overflow.
- Stormwater running on to the site should be controlled with diversion drainage.

Ponds should be designed with adequate capacity for current use and for projected future increase in volume of effluent to be detained or treated.

There is a range of types of detention and treatment ponds. Some are of relatively simple design and require only low maintenance. Others incorporate complex design criteria and require a high level of ongoing management and monitoring.

Nutrient management for point sources

Detention and evaporation ponds

- used to reduce the volume of wastewater by evaporation as a disposal method, or to allow storage for seasonal irrigation
- require a large surface area for effective evaporation
- best suited to areas with high evaporation rates
- designed to ensure adequate capacity through high and low evaporation periods, and to accommodate all water inputs
- monitoring required for water quality (for example, salinity).

Artificially aerated ponds

- Ponds are two to four metres deep with wastewater detention period of approximately one week.
- Oxygen is supplied to enhance aerobic microbial processes to stabilise organic matter in wastewater.
- Air is pumped to floating aerators or submerged bubblers for even mixing in pond waters.
- A settling period (when pumps are turned off) is required prior to discharge to the environment.
- Design must avoid over-loading ponds and premature discharge of untreated water to the environment.
- Detailed monitoring and analysis of organic loading, micro-organism balance, aeration rates and settling characteristics is required for effective processes.

Aerobic and facultative ponds

- Aerobic ponds are shallow (0.9–1.2 m) and use sunlight, atmospheric oxygen and algae to assist microbes to stabilise wastewater.
- Facultative ponds are deeper (1.2–2.0 m) to enable the waterbody to stratify into a deeper sludge-rich layer and an aerobic surface layer.
- Efficient aerobic processes depend upon maximum air diffusion at the surface (ponds need to be clear of scum, weeds).
- Pond design is based on a Biological Oxygen Demand (BOD) of less than 500 milligrams/litre.
- Routine monitoring is required to manage BOD levels to avoid algal blooms which reduce decomposition efficiency.

Anaerobic ponds

- Pond design is based on high BOD (greater than 500 milligrams/litre) for concentrated organic wastes, such as wastewater treatment plants.
- Anaerobic ponds are commonly used as the first treatment in a series of ponds, with subsequent treatment in aerobic or facultative ponds.
- Anaerobic ponds are deep (2.0–6.0 m) and based on volumetric loading (normally 250–300 g of BOD/ cubic metre/day) to achieve 60–70 per cent BOD reduction.
- They stabilise wastewater with micro-organisms that use combined oxygen rather than free oxygen to produce methane and carbon dioxide gas by-products.
- Stabilised solids settle in the pond as sludge.
- A floating crust is formed to minimise atmospheric oxygen transfer at the surface.
- Desludging is required (normally after about 10 years of use). Two ponds operating in parallel are usually constructed to enable continued operation while desludging occurs.

Case Study 5 provides an example of the use of detention ponds and Case Study 3 provides an example of the use of treatment ponds.

4.4 Abattoirs

Abattoirs are important regional industries that provide value-adding services to rural production and provide employment opportunities in rural communities.The key components of abattoirs are:

- processing facilities
- rendering plant or other value-adding processes
- stock holding yards (some may have feedlot capacity)
- stock transport wash-down facilities
- solid and liquid waste treatment.

Of the five abattoirs in the Avon River Basin; four are within 1 km of a waterway. Another high volume abattoir facility is proposed for the region (see Case Study 2).

Abattoirs are listed as Prescribed Premises and licensed under the *Environmental Protection Regulations 1987*. Large-scale abattoirs are required to be licensed. Small-scale abattoirs (100 to 1000 tonnes of processed animal live weight) are required to be registered under the *Environmental Protection (Abattoirs) Regulations 2001*. Registration does not require annual renewal.

Photo 10 *Primary treatment of abattoir wastewater*
(Photo by Michael Allen)

Site selection, design and management

Abattoirs have the potential to contribute nutrients to waterways and other water resources in the Avon River Basin through the discharge of animal wastes from holding yards and treated wastewater from processing. Site selection for abattoirs is based on the key criteria already identified for intensive animal industries (see section 4.3).

Design criteria specific to the construction of abattoirs includes:

- holding yards constructed with a hardstand surface (permeability of 10^9 m/sec or less) with controlled run-off from the site (including wash-down facilities) discharged to a wastewater treatment system
- all processing facilities on concrete flooring graded to wash-down drains
- holding yards located away from waterlogged areas and natural drainage lines and at least 100 m from waterways and wetlands
- manure stored in a container or area that is protected from rainfall and surface runoff, located on high ground and at least 100 m from waterways, wetlands and natural drainage lines
- screens to separate paunch contents to prevent them entering the wastewater stream
- clean stormwater kept separate from contaminated areas and directed to the stormwater drainage system.

Abattoirs are required to have a Contingency Plan identifying responses to incidents that may lead to environmental harm such as stormwater contamination, process equipment malfunction or an on-site spillage.

Waste storage and disposal

Requirements for waste disposal from abattoirs are similar to that for wastewater treatment plants (see section 4.2) and intensive animal industries.

Specific waste disposal criteria for abattoirs are:

- Gross solid wastes should be removed so they do not enter treatment ponds.
- Solid waste should be stored separately to wastewater streams.
- Solid waste may be stockpiled on-site or off-site for use in commercial composting and other by-products.
- Liquid waste should be treated through a two-stage process. The primary stage is the removal of floating and settling solids through screening. The secondary stage is to stabilise and reduce organic matter in pond systems (see Information box 3).
- Blood greatly increases the organic load into wastewater treatment systems. It should be regarded as a resource and directly recovered to enable separate processing.
- Sludge removed from treatment ponds should be stockpiled on a bunded hardstand surface to dry prior to spreading at recommended application rates (see Table 6).
- Where possible, treated wastewater should be disposed of via irrigation of pasture, woodland or crops (see Information box 2). Other options include re-use within the abattoir for flushing or disposal via evaporation.
- A Nutrient and Irrigation Management Plan (NIMP) is recommended for sites with reticulated waste disposal. NIMPs demonstrate that inputs such as water and nutrients are well matched to the plant growth cycle resulting in minimal nutrient losses into the surrounding environment.

Case Studies 2 and 3 provide examples of proposed and existing abattoirs in the region.

Nutrient management for point sources

Case study 3 PR Hepple and Sons, Avon Valley Beef Abattoir

The Avon Valley Beef abattoir is located on a hill crest 8 km from Northam along the Goomalling Road. It is more than 400 m up-slope from a waterway that is a tributary to the Mortlock River.

The abattoir has been established for many years and previously processed a range of meat products. Current holding and processing arrangements have capacity for up to 55 head/day of beef cattle. There is no animal feedlot associated with this enterprise. Cattle are held for only a short period in yards adjacent to the processing plant. By-products from meat processing include tallow and meat-meal.

Nutrient management practices

A number of activities conducted on-site pose the risk of nutrient discharge, including wash-down facilities within the abattoir, runoff from stock holding yards and disposal of solid waste material (including manure and paunch material). Wastewater is piped to one of two deep anaerobic ponds which discharge to three shallow aerobic ponds. Excess water is pumped to irrigate a 2.45 ha mid-slope pasture site.

The wastewater treatment facilities were designed according to the *Abattoir Wastewater and Odour Management* manual (Meat Research Corporation, 1992). The enterprise is a prescribed premise and is licensed under the *Environmental Protection Act Regulations 1987* which is administered by the Department of Environment and Conservation (DEC).

Water samples are taken at the end of the treatment processes and reported on a 3-monthly basis. Analysis of samples includes Total Nitrogen (TN), Total Phosphorus (TP), Total Soluble Solids (TSS), Biochemical Oxygen Demand (BOD) and pH.

Water levels in the ponds are checked daily. If required, excess water is pumped to the metered sprinkler system for pasture irrigation. The volume used for irrigation ranges up to 300 kilolitres/month.
The site managers have contingency plans for effluent disposal.

One anaerobic pond is now filled with sludge. The fat content is considered to be too high to be suitable for compost or other by-products. It will probably be disposed of by broadcasting onto paddocks with suitable soils and with a significant buffer distance from waterways.

Outcomes

The site is managed as a zero discharge treatment system with the aim that all nutrients are contained on the property. Abattoir Manager Mick Bloomfield advised that the system is relatively low maintenance and that it is important to closely monitor wastewater levels and use the irrigation system when required.

***Photo 11** Anaerobic pond adjacent to the Avon Valley Beef meat processing plant (Photo by Viv Read)*

4.5 Landfill sites

Landfill sites are classified according to the type of waste received. All landfill sites in the Avon River Basin are Class III (for solid, non-hazardous waste, including putrescible material, that is, material that can decompose) or less. There are 33 landfill sites identified in the Avon River Basin; 14 are within 1 km of a waterway.

Landfill sites have potential to discharge nutrients and other pollutants to the environment directly by surface water flow or through leaching to groundwater. The following management recommendations focus upon site selection, design and management strategies that will prevent or minimise nutrient loss.

Photo 12 *A small landfill site in the Wheatbelt (Photo by Michael Allen)*

Site location, design and management

Landfill sites have traditionally been located in sandy soils where excavation was easy or near salt lakes or waterways where metals would rapidly rust. All locations in close proximity to water bodies or in soils with high leaching capacity are now considered unacceptable.

A number of former landfill sites are now closed for use and waste is transferred to a fully managed disposal site. For example, the landfill site for the Shire of York was located in deep yellow sand on the banks of the Avon River. Waste is no longer disposed of at this site which has been converted to a transfer station with capacity for recycling. All waste is now transferred to a regional landfill facility west of Northam.

Selecting a landfill site requires careful consideration of a wide range of social and environmental criteria. These criteria are outlined in detail in *Siting, design, operation and rehabilitation of landfills–draft for Best Practice Environmental Management* (Department of Environment, 2005)

Contamination of groundwater by leachate from landfills is very difficult to remediate. It is therefore very important that landfills are sited in areas where impacts on beneficial uses of groundwater are minimised. In particular, landfills should not be located:

- in areas having potable groundwater, groundwater recharge areas or in an area identified as a public drinking water source area
- below the regional watertable.

A separation distance of 100 m is recommended between a putrescible landfill site and surface water bodies such as waterways and wetlands. Inert waste materials can be located within 100 m of surface water bodies if an assessment can demonstrate that there will be no effect on surface water or groundwater quality. A minimum separation distance of 3 m above the highest known groundwater level at the site is required for registration of rural landfills.

Depending on site environmental conditions, construction of the landfill may require the use of a low permeability liner (for example, clay layer or geomembrane) to prevent leachate discharge from the site and protect groundwater quality. The majority of the rural landfills in the Avon River Basin are small facilities receiving low volumes of waste. For larger landfill facilities a leachate collection and disposal system may also be required.

Specific management criteria for landfill sites are:

- Stormwater is managed on-site with drains and bunds to divert runoff away from waste, or to contain contaminated runoff within a low permeability sump on-site.
- Drainage is designed to contain and control rainfall for a 1-in-20 year storm event for a putrescible landfill or a 1-in-10 year storm event for an inert landfill.
- Proposals involving discharge of wastewater from a landfill site require assessment by the Department of Environment and Conservation. Approval will be considered subject to appropriate treatment prior to discharge which demonstrates that impacts upon the receiving environment will be acceptable.

Where a regional groundwater aquifer exists or there is potential for significant leaching from the site, monitoring of groundwater quality is required. Groundwater monitoring bores should be installed so that background water quality (that is, from bores up-slope of the site) can be compared with water quality monitoring results down-slope of the site. Groundwater recovery, storage and safe disposal may be required where the potential for contamination is identified.

Consideration should be given to the closure of small poorly designed and managed landfill sites that pose a risk to the environment. Waste should be transferred to well designed and managed regional facilities where available.

Key Points Summary

There are a number of industries in the Avon River Basin which have been identified as potential point sources of nutrients. They include wastewater treatment plants, cattle and sheep feedlots, stockyards, piggeries, abattoirs and landfills.

Key factors to consider in assessing and managing the risk of nutrient loss from a point source industry include:

- soil type and landform
- proximity to a waterway, water supply or groundwater resource
- maintenance of vegetated buffers between the activity and waterways and wetlands
- management of stormwater to prevent contamination with solid and liquid wastes in processing, storage and treatment areas
- containment, treatment and safe disposal of liquid and solid waste material from the site
- disposal of treated wastewater or solid waste on-site to ensure nutrient loading rates are sustainable and based upon site vulnerability (primarily soil type and risk of eutrophication in surface water bodies)
- buffer zones maintained between waterways and wetlands and on-site disposal areas for treated wastewater and solid waste
- incorporation of low permeability processing/storage/treatment structures to minimise leaching of nutrient-rich wastewater to groundwater
- contingency planning to prevent unplanned discharge to the environment
- regular monitoring and inspection of processing, treatment and storage areas for efficient functioning
- reuse treated wastewater wherever possible to minimise the need for discharge to the environment.

5 Nutrient management options for diffuse sources

Section 5 Nutrient management options for diffuse sources

Diffuse sources of nutrients in the Avon River Basin include the extensive areas of land used for dryland agriculture, the increasing number of small landholdings, rural towns, roads and other public infrastructure.

Managing diffuse sources of nutrients requires a different approach to point source management. Its focus is on nutrient loss from fertiliser applications rather than the discharge of nutrient-rich wastes. Diffuse source discharges are dispersed over a wide area and difficult to measure. Management involves the incorporation of ‘environmentally responsible practice’ into production and other natural resource management activities.

The priority for nutrient management in the Avon River Basin is to minimise environmental harm from phosphorus (P), the limiting nutrient in freshwater systems. Managing P in the Avon region involves reducing soil loss by implementing sediment control management practices.

Excess levels of N are recorded in some locations in the region due to its leaching to groundwater through transmissive sandy-textured soils. In this low rainfall agricultural landscape, the N pathway is best controlled by applying rates of nitrogenous fertilisers which do not exceed plant requirements.

Action 8. Review the recommended diffuse source nutrient management options and note those which specifically address nutrient loss from your property.

5.1 Managing the fertiliser supply chain

Fertilisers are manufactured in Western Australia or imported for agriculture, municipal or domestic use.

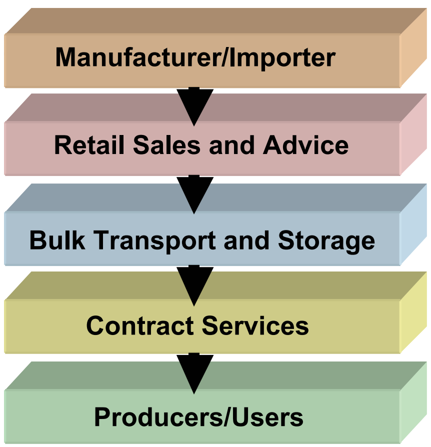


Figure 3 Fertiliser supply chain

Figure 3 represents the supply chain from manufacturer/importer to producers/users.

The Fertilizer Industry Federation of Australia (FIFA) recognises the potential for environmental harm from fertiliser products and promotes industry responsibility for best management practice along the supply chain. FIFA and the Australian Fertiliser Services Association (AFSA) have developed codes of practice, training and accreditation in the *Fertcare* program, for those directly involved in the fertiliser industry.

Agronomists, sales representatives and industry advisers who inform farmers and other users about their fertiliser requirements should also be accredited through FIFA *Fertcare* or a similar program.

FIFA has developed a Nutrient Management Toolbox (FIFA, 2001) as a part of *Fertcare* training for advisers. The training package has information modules for:

- soil testing
- plant tissue testing
- soil buffering capacity (measures)
- nutrient budgeting
- land capability and suitability
- CRAFT (choice, rate, application frequency, timing)
- equipment calibration and maintenance
- paddock records
- precision agriculture
- handling fertiliser
- disposal of packaging
- managing for climate change

Further information on the *Fertcare* program and other useful information on fertiliser management can be found on the FIFA website (www.fifa.asn.au).

The Australian Fertiliser Services Association (www.afsa.com.au) represents industry service operators. Benefits to members include:

- discounted accreditation through the *Fertcare* program
- *Fertcare* Accu-Spread approval for equipment (field testing to verify width control and uniformity of fertiliser spread)
- a draft *Code of Practice* for three key operational areas of product knowledge: spreading, transport and storage, which forms the basis for some of the *Fertcare* training.

Photo 13 *Field testing for Accu-Spread approval (Photo by Nick Drew)*

Farmers and other contract service users should ensure that services are provided by operators with industry accreditation.

5.2 Farm fertiliser management

In the Avon River Basin, farming systems are predominantly crop/pasture rotational systems. Wheat, barley, canola and to a lesser extent oats and lupins are grown in rotation with pastures. Some farming systems are based on total cropping without pasture improvement for livestock. A high proportion of farmers in the Avon region have adopted minimum tillage or no-till cultivation systems to improve soil structure and organic content. These systems are linked with stubble retention and other conservation farm practices that reduce soil loss through water and wind erosion.

Nutrient management is a key component that affects both profitable and sustainable production. Managing nutrients on commercial farms is based on five management strategies, as shown in Figure 4.

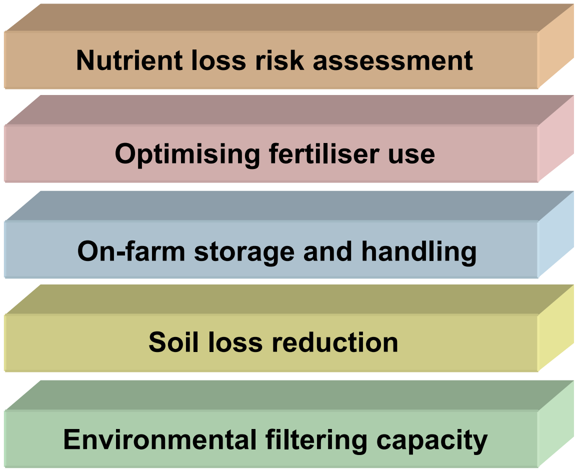


Figure 4 Management strategies for commercial farms

5.2.1 Nutrient loss risk assessment for farming systems

Each farming system has annual nutrient inputs and outputs. Your farm nutrient balance can be calculated (FIFA, 2001). However, for the extensive farming systems of the Avon River Basin, it is more practical and effective to identify areas of nutrient loss risk. This step has been outlined in section 3.3.

5.2.2 Optimising fertiliser use–management options

Commercial farmers are well aware of the rising costs of fertilisers. Using too much or too little can affect the profitability of farm enterprises. It is no longer a wise investment to 'put on a bit extra just to be sure'. Modern farm enterprises have the decision-making skills and suitable machinery to fine-tune fertiliser applications to suit crop and seasonal requirements.

Soil testing

Environmentally responsible fertiliser management is based on soil nutrient status. Routine soil testing is effective for measuring available phosphorus, potassium, nitrogen and soil pH in soils. Up to 20 topsoil (10 cm deep) cores may be combined into one sample and up to four samples are recommended for large paddocks where soil types vary. Most sampling is undertaken in summer months (January–March) when soil is dry. It is recommended that soil samples are taken for crop paddocks each year to ensure up-to-date information for fertiliser decisions.

Plant tissue testing

Plant tissue testing can be used diagnostically for a range of plant nutrients. While P cannot be effectively added to crops post-seeding, tissue testing results can inform supplementary nitrogen fertiliser applications and monitor trace element status.

Planning and record-keeping

It is recommended that detailed records of annual fertiliser applications are recorded for each paddock. These records can be combined with other information, such as crop and pasture rotation history, soil and plant tissue sampling results and crop yield.

Yield monitoring

Recent advances in header technology allows monitoring of crop yields during harvest, as numerical records for each paddock or as spatial soil type maps. Yield monitoring assists future fertiliser use decisions, including reduced application rates in consistently low-yielding areas (for example, some deep leaching sands or frost-prone areas).

Fertiliser Management Systems

Considering the large scale of most cropping programs and the current high cost of fertiliser, there are substantial returns to be gained from decisions based on advice from recognised agronomists/advisers. Fertiliser advisory services often include the use of a credible Fertiliser Management System or other decision support tool, such as the following:

- *Nu-logic* developed by CSBP Ltd. (http://www.csbp.com.au/downloads/fertilisers/1094789913_CSBP_TechProductBro_FINAL.pdf)
- *Nutrient Advantage* developed by Incitec Pivot. http://www.incitecpivot.com.au/nutrient_advantage.cfm)
- *N-P DECIDE* developed by the Department of Agriculture and Food, Western Australia to assist wheatbelt cereal growers to make better fertiliser use decisions. It provides agronomic and economic information by estimating the crop response to combinations of phosphorus and nitrogenous fertilisers and the profit outcome from these decisions.
- *Select Your Nitrogen* (Department of Agriculture, 2003), a weekly time step simulation model that gives the user a quantitative feel for how different components of the farming system impact on available nitrogen, grain yield, grain quality and economic returns.

It is important that these tools use current information relevant to cropping systems in the Avon region. It is estimated that 90–95 per cent of farmers currently do not use an accredited Fertiliser Management System. One option is to ensure that advice is sought from a *Fertcare Accredited Advisor* who has undergone an independent assessment of advisor competence against national competency standards.

Variable fertiliser application rates

Farmers can purchase or modify seeding equipment that delivers variable rates of fertiliser application. The rate may change automatically in response to soil type or composite fertilisers may be placed during seeding. Triple box air-seeders allow the application rate of one nutrient (usually N) to be changed without varying the application rate of the other nutrients.

This new precision agricultural technology reduces the risk of nutrient loss. Estimates suggest that savings could exceed the machinery capital cost within one year for an average cropping program in the Wheatbelt.

Variable time of application

Recent advances in 'continuous feed' systems using liquid nitrogen (urea, ammonium nitrate, aqua ammonia) allow identified areas of crop to receive supplementary fertiliser applications as required.

Legumes in crop rotations

While leguminous crops and pastures are not able to fix nitrogen in soils at levels required by high yielding crops in the following season, they do reduce the need for fertiliser application.

Environmentally sensitive fertiliser use

When broadcasting granular fertiliser or spraying liquid fertiliser, there are options to minimise environmental harm. These include:

- applying at times of low wind and minimal risk of storm events
- avoiding applications across minor waterways prone to soil erosion (small gullies or creeks) even if they do not have stream flow
- ensuring a zero-application buffer from water receiving environments. These areas should include:
    - floodways in the floodplain (good vegetation groundcover will minimise transport of broadcast fertilisers in these areas)
    - areas prone to erosion near waterways (for example, erosion gullies)
    - deep leaching sand lenses located near waterways
    - approximately 15 m either side of small and medium on-farm waterways
    - farm dam roaded catchment areas.

These options should be used by farm staff or contractors during fertiliser application. It is recommended that equipment be calibrated for width and uniformity of spread and that drivers are competent at managing environmental risks in line with the principles above.

Case study 4 Central Wheatbelt farming system

Kit and Eileen Leake farm at 'Nanyanine' approximately 25 km north of Kellerberrin in the central Wheatbelt. They are enjoying the lifestyle in their third decade on the farm and remain optimistic about agriculture. Their property is adjacent to Durokoppin Nature Reserve and is a part of the Wallatin–O'Brien Catchment Demonstration Initiative, a major project linking farm production with salinity management undertaken by Wallatin Wildlife and Landcare Inc. Kit is enthusiastic about soil conservation and has been actively involved in the Western Australian No-Till Farming Association (WANTFA).

The Leakes have recently simplified their farming system by focussing on cropping. They produce short, medium and long season wheat, barley, feed barley, canola, lupins, peas and export oaten hay. There is no fixed crop rotation. Decisions are made annually, determined by soil health factors, weed management and consideration of risk factors, including input and commodity prices. There is no need for pasture production. Kit notes that while he is enthusiastic about farming, he is not exceptional. There are many other Wheatbelt farmers making careful, informed fertiliser management decisions.

Photo 14 *Kit Leake*
(Photo by Viv Read)

Fertiliser program

Fertiliser is applied during the one-pass operation at seeding. A triple-box seeder provides precision and flexibility for fertiliser placement above, below or with the seed. A compound fertiliser (with phosphate, nitrogen and sulfur) and urea are applied through the seeder.

Liquid nitrogen is applied through the boom spray during crop growth when required. This allows repeat applications or limited spot spraying in identified areas. Trace elements shown to be deficient are applied by foliar spray. Potassium is broadcast prior to seeding.

Kit and Eileen are acutely aware of the high cost of fertilisers. They note that poor decisions can be very costly if fertiliser is wasted. They ensure decisions for their annual fertiliser program are based on good information.

Soil and tissue testing

Soil testing has been an annual practice on 'Nanyanine' for over 30 years. Each paddock is tested once in every three years. The sample sites are now located by GPS for consistent sampling. There are four to six sample sites in a 100 ha paddock depending upon soil type variability. Soils have been mapped for the farm and Kit considers that knowledge of soils is important information for a farmer.

Tissue testing has been a farm practice for almost as long. It provides crucial information for final crop nutrition requirements and assists in management decisions for yield and protein content as the season progresses. Any problem sites are also noted for future planning.

Fertiliser program decisions are assisted by the Leake's consultant agronomist and farm adviser using Nu-logic (the CSBP Ltd decision-support software) based on soil and tissue testing information. Kit estimates the yield outcome for each paddock and then determines fertiliser requirements. He aims to optimise crop profitability rather than just maximise yield.

Adopting precision agriculture

Kit has recently fitted auto-steer to his tractor and harvester. He considers the cost to be relatively small compared with the benefits, particularly from fertiliser use efficiency (less over-lapping application).
A yield-monitor is fitted to the harvester. Kit considers that the main advantage of this technology is that it increases information about crop performance during the season. He already knows where the low yield

areas are so does not produce yield maps. Kit says that investing in his knowledge of soils is more important than producing maps. CSIRO's imagery of crop biomass on the property confirms that Kit's knowledge of productivity variation within the paddock is sound.

Local contractors are engaged for broadcast applications. The contractors use a GPS guidance system and their spreader is equipped with 'load-cells' that accurately show the rates at which fertiliser is applied across a paddock. This rate can be varied. The contractor produces accurate 'coverage maps' for each paddock, a guarantee that fertiliser goes on the crop and not into bush or creeks.

On-farm storage

There is a 200 tonne enclosed fertiliser storage shed on the farm which has four bays with front-end loader access. Plastic covering is used if required. Liquid nitrogen is stored in two specific purpose approved tanks. These have 'Tab-lock' taps to ensure there is no accidental leakage. Kit considers that the risk of spillage is very low. Tank manufacturers suggest construction of an earth containment bund as an option.

Outcomes

Kit claims that no soil is lost from the farm these days, since he has adopted soil conservation as a high priority for management. With minimum tillage, stubble retention and no livestock, surface water runoff and wind erosion are minimised.

Kit is emphatic that getting soil pH right is the key factor. He knows that low or high pH causes inefficient use of valuable fertiliser. Lime applications for surface soil acidity is a normal farm practice. Recent testing has shown areas of low pH in subsoils that need to be managed. Kit applies a higher rate of lime in these areas to increase subsoil pH. There is also a lime deep placement trial on the property.

Kit and Eileen say that...

> *… farmers in the central Wheatbelt need to apply fertiliser to grow a crop but they are just not going to waste it – the cost is too high".*

They aim to optimise their cropping program rather than applying fertiliser to maximise yield.
Kit notes that...

> *… understanding soil health and making informed economic decisions about fertiliser use is the key to sustainable agriculture".*

5.2.3 On-farm storage and handling

On-farm fertiliser storage is part of an efficient farming system. Options for storage include:

- fertiliser storage shed
- concrete containment area with a roll-back roof for front-end loader access
- open storage with tarpaulin covers
- metal bulk storage bins (temporary storage for broadcast application)
- tanks (for liquid nitrogenous fertilisers).

Site selection

If liquid fertiliser is stored in on-farm tanks, the following steps are recommended:

- Compacted earth bunding is constructed around storage tanks to contain accidental spillage.
- Physical barriers (for example, heavy chain) are used to prevent farm machinery colliding with the tanks.
- Discharge taps have locking devices to reduce the risk of accidental loss.

Handling fertilisers on-farm inevitably involves some spillage particularly at the point of transfer (for example, front-end loader to truck transfer at seeding). To minimise nutrient loss to the environment, locate fertiliser storage facilities in low risk areas and consider the following factors:

- Avoid storage over deep leaching, transmissive soils or soils prone to erosion.
- Locate away from waterways, including small natural drainage lines with occasional stream flow and subsurface seepage. A minimum distance of 100 m from waterways is recommended.
- Areas prone to flooding, including the floodplain or localised flood areas, should not be used.
- Divert surface water drainage around the storage facilities.

Although it is important for efficient transport to locate fertiliser storage facilities in easily accessible areas, there may be some potential for nutrient loss (for example, compacted soils, or a nearby creek).

Temporary paddock storage before seeding has been a common practice, particularly for urea to be spread within a few days. This poses a potential environmental risk from fertiliser that cannot be retrieved from the stockpile.

The recommended practice for paddock storage is to store fertiliser on a bunded hardstand area constructed of concrete or compacted low permeability soil. Constructed paddock storage areas also minimise fertiliser wastage.

Site maintenance

Simple practices can be adopted to minimise environmental harm when cleaning storage sites and machinery. These include:

- Dry sweep the concrete flooring.
- Clean farm machinery (spreaders, air-seeder bars, bulk bins, liquid spray units) onto concrete flooring (for containment) or on low risk soils well away from waterways.
- Ensure no clean-down occurs in or near waterways.
- Dispose of collected waste fertiliser safely. If waste fertiliser it is not suitable for re-use the recommended disposal method is extensive broadcast onto soils with high nutrient retention capacity and low erosion or leaching risk.

5.2.4 Soil loss reduction

Most P mobilised from paddocks to waterways is attached to soil. Reducing soil loss and transport will minimise environmental harm.

It is recommended that farm plans include surface water management with a focus on controlling surface water run-off, waterlogging and soil erosion. Surface water management options include:

- graded interception drainage
- broad-based banks
- W-drains
- absorption and level banks
- relief drains
- stabilised artificial waterways.

The following management practices are recommended as options to reduce soil loss by water or wind erosion:

- contour cultivation
- minimum or zero tillage
- stubble retention
- soil structure improvement
- pasture improvement.

Photo 15 Minimum tillage
(Photo courtesy DAFWA)

5.2.5 Environmental filtering capacity

Nutrients may be lost to the environment by the transport of sediments, organic matter or seepage water to waterways. However, the environment can effectively filter transported material and assimilate nutrients. An important component of nutrient management on farms is to maximise environmental filtering capacity. The environmental filtering capacity on farms can be increased by maintaining or restoring vegetation in the riparian zone of waterways. The following areas are recommended for riparian revegetation and restoration projects:

- rivers and tributaries such as creeks and drainage lines
- lakes and wetlands
- artificial waterways constructed as a part of integrated surface water management of farms
- land up-slope of farm dams.

The following management practices can be considered to enhance on-farm environmental filtering capacity:

- Fence waterways to control stock access.
- Revegetate with multi-storey species to form shrub and groundcover (grasses, logs, litter). Filtering capacity is best with 10–15 cm vegetation height and 100 per cent groundcover. Trees are not particularly effective; tussock grasses are moderately effective.
- Establish grasses (a range of perennial, native grasses or others) in drainage lines and artificial waterways.
- Where feasible, ensure small tributaries discharge to the floodplain or vegetation areas (rather than directly to major waterways).
- Control run-off from road and farm track crossings to prevent erosion.
- Construct sediment traps up-slope of farm water supplies.

Photo 16 *Poor environmental filtering capacity, due to cleared vegetation and stock access (Photo by Lucy Sands)*

Constructing artificial nutrient-stripping wetlands on farms is also an option (see Information box 5). However, given the diffuse source of nutrients it is recommended that large-scale farms increase waterway filtering capacity extensively on-farm to control sources of nutrient loss.

In the extensive landscapes of the Avon River Basin, soil transport from a paddock is most commonly to an area of lower slope. Sediment and organic matter are not always transported directly to the riparian zone.

While vegetative filter strips can be calculated for average annual rainfall, it is during flood events that most of the nutrient-rich matter is transported. It is therefore recommended that the width of the riparian buffer zone be maximised within the practical limits of agricultural land use. For larger watercourses, a buffer width of 50 m may be appropriate.

Information box 4 Vegetation buffers and separation distances

Vegetation buffers to water courses, wetlands and water supplies provide environmental benefits by filtering nutrient-rich sediments from runoff. Buffers also improve water quality, control channel erosion, reduce the spread of environmental weeds, support aquatic ecosystem functions by shading waterways and reducing temperatures, and provide habitat for fauna.

Naturally occurring vegetation buffers should be retained and protected where they occur (for example, substantial healthy riparian vegetation). Where there is inadequate buffer width, revegetation may be required.

In the Avon River Basin, buffering vegetation on most small and medium waterways and wetlands is minimal. Salinity and other threatening processes such as grazing are reducing the quality of riparian vegetation. Most of the main channel of the Avon River and some sections of the major tributaries have been fenced to control grazing. Fencing of riparian zones has been demonstrated to improve vegetation health and increase regeneration rates. However, there is a need to increase the buffer width in areas identified with nutrient loss risk.

An effective vegetated buffer for sediment detention and nutrient stripping should have:

- understorey vegetation (grasses and sedges)
- overstorey vegetation (shrubs and trees)
- dense and diverse litter cover.

Buffer width should be increased in situations characterised by:

- increasing land slope
- decreasing vegetation density.

Table 7 identifies the suggested width for vegetated buffers to reduce nutrient transport.

Table 7 Recommended buffer widths to reduce nutrient transport

Location	Minimum buffer distance (m)
Flood fringe of the Avon River or its major tributaries	50
Banks of smaller waterways and wetlands	30

The publication, *Managing waterways in the Avon wheatbelt: Field Guide* (Department of Water, 2008) discusses assessment, planning and action for the restoration and management of the waterway vegetation.

Separation distance is the area between the boundary of a point source site, such as an abattoir, and the boundary of a sensitive land use where unacceptable adverse impacts may occur. Sensitive land uses include residential areas and other urban, commercial, industrial and institutional facilities. A guide for separation distances for point sources relevant to the Avon River Basin is provided in Table 8.

Table 8 Recommended separation distances for point sources

Natural resource or social feature	Minimum separation distance (m)
Groundwater table (wet seasonal level)	1.5 (depth)
Banks of intermittent low flow waterway	50
Property boundary	50
Private water supply (bores and dams)	100
Banks of permanent water (streams and rivers)	100

Conservation wetlands	200
Boundary of wetland vegetation around lakes	200
Neighbouring isolated residences or public amenity	1000
Populated townsite (residential areas)	5000

Source: modified from *Environmental management of beef cattle feedlots in Western Australia* (Department of Agriculture and Department of Environment 2004)

5.3 Managing other diffuse nutrient sources

While commercial agriculture is the most extensive form of diffuse source nutrient loss in the Avon River Basin, there are other areas where nutrient management should be applied. These include the increasing number of small landholdings used as hobby farms for small-scale production, and the semi-urban and urban areas of rural towns.

5.3.1 Nutrient loss management for small landholdings

Small landholdings generally range from 1–50 ha. Although not extensive, they can contribute excess nutrients to waterways. Most are located in the Avon Valley where the erodible steeper slopes have soil loss potential. A large number of small-scale properties are adjacent to the Avon River or major tributaries.

It is recommended that a property plan be developed for each small landholding regardless of the size or its existing or proposed activities. Property planning and nutrient management advice for small landholdings is available through:

- Small Landholder Information Service (SLIS) run by the Department of Agriculture and Food, WA, South Perth
- *Heavenly Hectares* training courses through the Department of Agriculture and Food WA or the Swan River Trust.

Guidelines for managing small properties are provided in *The Land is in your Hands – Guide* (DAFWA 2008) prepared by SLIS. This includes a section on managing water quality. Contact details are provided in section 6.4.

Nutrient management options

Use fertiliser carefully

- Test your soil to identify fertiliser requirements and seek agronomic advice.
- Apply fertilisers where and when required (avoid broadcasting granular fertilisers onto bare soils that may wash in a storm).
- Do not apply fertilisers into or near waterways or wetlands.
- Store bagged fertilisers safely (in a shed with a sealed floor is best).
- Choose fertilisers with low phosphorus (P) content or low-water soluble P.
- Do not apply excessive organic fertiliser (for example, chicken or sheep manure, compost). This is easily leached through soils as it decomposes.

Minimise soil erosion

- Maintain vegetation cover (avoid over-grazing by carrying too many stock).
- Construct banks, drains or artificial waterways to control surface water.
- Revegetate high run-off areas (for example, shallow soils near rock outcrops).

Rehabilitate creeks, drainage lines and wetlands to increase nutrient filtering capacity

- Fence to exclude stock.
- Construct stock access points or crossings.
- Revegetate the riparian zone with trees, shrubs and groundcover.
- Establish sedges and rushes as fringing vegetation.
- Control weeds and avoid fire.

Photo 17 *A well vegetated fenced waterway (Photo by Greg Hedley)*

Review stockfeed storage and usage

- Store stockfeed on a hard base (concrete pad or plastic liner) away from waterways or wetlands.
- Avoid over-feeding stock (excess organic matter is leached or washed to groundwater or waterways).

Construct artificial wetlands

- Plan and design a nutrient stripping wetland (see Information box 5).
- Consult with neighbouring owners (options for joint projects).

Protect water sources (dams and soaks)

- Measure water quality (including nutrients) and identify algal blooms that might occur (contact Department of Water).
- Control stock access to the water source.
- Avoid feeding stock up-slope of the water supply.
- Barley straw may be added to water bodies to help inhibit algal growth.

Actions taken by many small landholders to reduce nutrient loss can significantly reduce environmental impacts. The actions should also generate benefits such as reduced costs of excess fertiliser or stock feed, or by adding value to the property through landscape enhancement.

5.3.2 Rural towns

Rural towns in the Avon River Basin are widely dispersed and many are quite small. However, all have the potential to contribute nutrients to waterways or other water resources. Rural towns with river pools (such as Northam, York and Beverley) are particularly susceptible to occasional unsightly algal blooms and offensive odours.

Assessing the nutrient loss risk

Local Shires and community groups should assess the potential for diffuse source nutrient loss from their towns. Potential risk factors to consider include:

- stormwater drainage
- turf nutrient management at recreational facilities
- wastewater re-use (see Information box 2)
- fertiliser use on municipal and domestic gardens
- nurseries and garden centres
- storage and containment facilities in light industrial areas.

A number of rural towns have nutrient management actions underway. Some involve statutory processes relating to planning regulations and development approvals. Deep sewers are being installed to replace older septic systems in some towns. Shires and community groups in many towns are implementing conservation or environmental enhancement activities that will also provide nutrient reduction benefits. Recommended nutrient management options and strategies for local government and town communities are listed below.

- Construct detention basins or nutrient stripping wetlands for management of stormwater (see Information box 5).
- Restore fringing zone vegetation for waterways and wetlands.
- Develop Nutrient and Irrigation Management Plans for large-scale recreational facilities.
- Adopt water sensitive urban design (WSUD) principles and practices for urban development.
- Adopt land use planning decisions which will achieve the following:
    - restriction of development in the floodplain and waterlogged areas
    - recognition of land capability constraints (for example, soil type and landform), the potential for nutrient loss to the environment and appropriate management of this risk.
- Require light industry to develop and implement contingency plans to prevent or manage unplanned off-site discharges.
- Monitor water quality of receiving waters where Shire facilities may be impacting on nutrient levels, to assess the impact of management practices and make changes where necessary.
- Support state government agencies by promoting local community awareness and information about nutrient management and environmental impacts.

Information box 5 Constructed nutrient stripping wetlands

Constructed wetlands are used to strip suspended sediments and dissolved nutrients from stream flow. In recent years, they have been incorporated into water sensitive urban design (WSUD) to improve water quality, especially where there is significant urban or rural stormwater runoff. They are also used for partial treatment of effluent with reduced organic content discharged from some intensive industries or treatment processes. Nutrient stripping wetlands are an ‘end-of-catchment’ treatment and do not diminish the need to manage nutrients at their source. There are other environmental benefits from using constructed wetlands such as the creation of habitat for native fauna.

Nutrient stripping occurs through three largely passive processes which require limited management intervention:

- physical – sedimentation, filtration and aggregation
- chemical – precipitation, adsorption and volatilisation
- biological – direct and in-direct biological uptake (bio-films, algae and emergent macrophytes), microbial decomposition and transformation.

Planning and design criteria

Constructed wetlands are normally one part of a sequential 'treatment train' of two to four ponds in series.

Nutrient-stripping wetlands for stormwater treatment should be designed in a manner that is compatible with the naturally occurring waterway and wetland system. Low flow creeks in a floodplain with separate capacity for high flow events are well suited. A detailed site plan is required, with consideration of soils, surface and groundwater, existing drainage lines and natural vegetation.

The following design criteria should be considered when planning a constructed wetland:

- quality of inflow water, the target nutrients to be removed and the required level of nutrient reduction
- hydro-period (time of water detention)
- area and volume (adequate capacity for targeted nutrient reduction without causing stagnant pool water)
- stream flow velocity with meanders, vegetation, constrictions (such as riffles, logs or other fixed debris)
- a high flow bypass to reduce the risk of remobilising settled sediments
- alternating shallow and deep water zones (to facilitate different nitrogen removal processes)
- diverse in-stream and fringing revegetation patterns
- aquatic vegetation species that are suitable for the site (that is, species that will survive without dominating the aquatic ecosystem)
- seasonally dry areas (to aerate sediments)
- water quality of the receiving environment (for example, downstream river)
- human health and safety issues (including potential for breeding mosquitoes and the drowning risk with deep water)
- the potential to expose acid sulfate soils and intercept shallow groundwater.

An example of simple wetland design used in the region is shown in Figure 5.

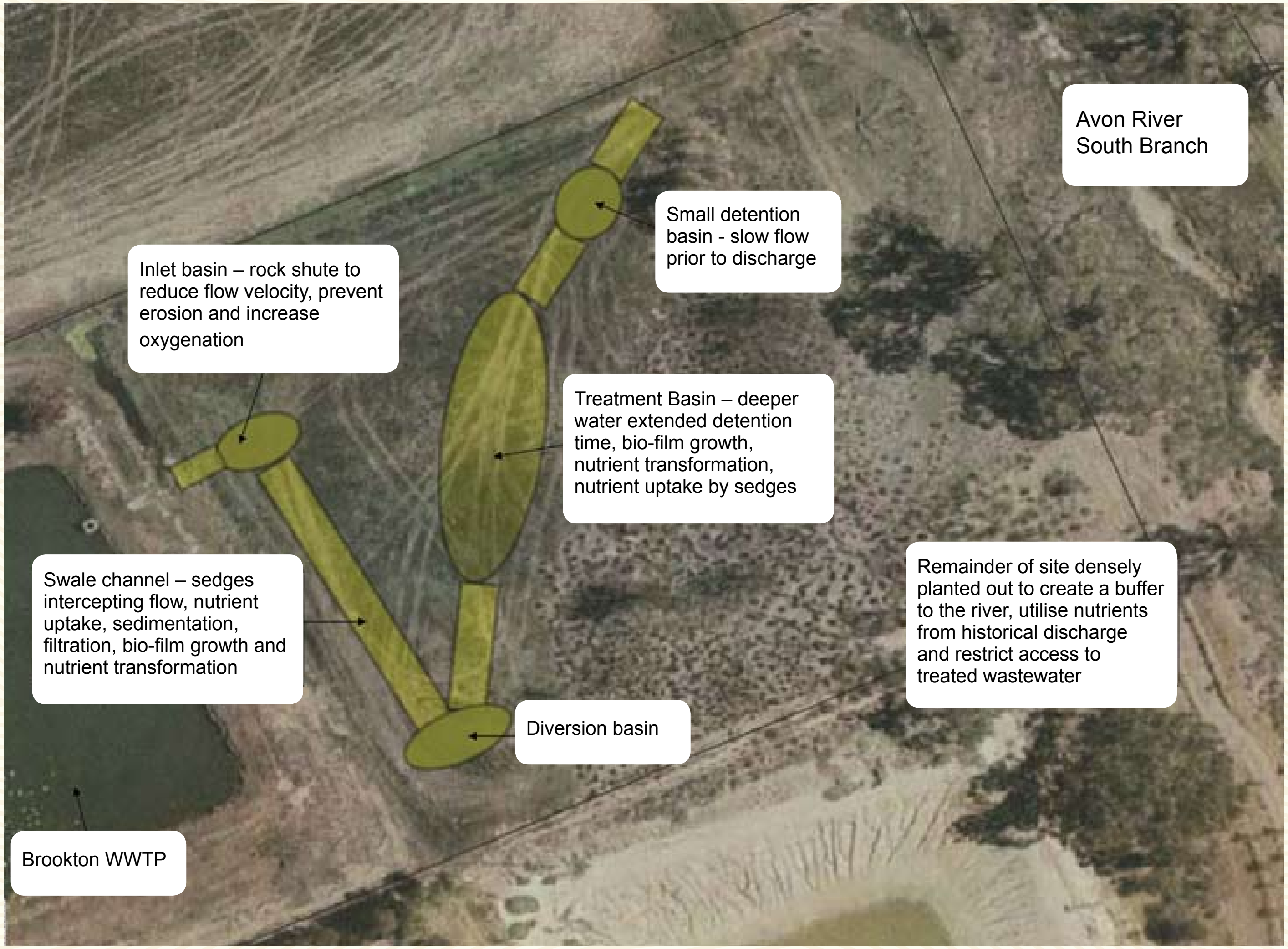


***Figure 5** Brookton constructed wetland design*
Source: Michael Allen, Department of Water, Northam

Advice should be sought from state and local governments on the planning and environmental approvals required for specific constructed wetland projects. It is essential to consult adjacent landowners or managers regarding the project.

Water quality monitoring

Regular monitoring of surface water quality will show the quality of inflow and outflow from the wetland and upstream and downstream of the discharge point in the receiving waterway. This will indicate the nutrient reduction efficiency of the constructed wetland and the quality of water being discharged to the receiving environment.

Monitoring groundwater level and quality will identify the potential for site inundation and any adverse impacts upon groundwater quality.

The effectiveness of constructed wetlands may reduce over time if there is excess sediment deposition or when the rate of revegetated plant growth slows. Regular monitoring will highlight when the capacity of the wetland is reduced and maintenance is required.

Case Study 5 provides an example of a constructed wetland used to reduce nutrients from a wastewater treatment pond.

Case study 5 Shire of Brookton, Integrated Town Water Management

Brookton is a rural town in the central Wheatbelt located on the South Branch of the Avon River. The Shire of Brookton has been aware for many years that treated wastewater discharged to the river had a high level of nutrients. The Shire has also been concerned about the potential risk of impact to buildings and recreation facilities due to salinity. It has sought to tackle both problems through an integrated water management program for the town.

Most houses in the town are serviced by individual septic systems. Wastewater from these units drains to a detention basin adjacent to the Avon River. A chlorination plant had been previously installed to enable the Department of Education to irrigate local recreation grounds.

The Brookton Shire Council had undertaken a series of investigations into managing rising groundwater in the town causing salinity impacts. Some of the investigations were funded through the state government's Liquid Assets Town Salinity program. One identified option is to pump groundwater from under the town to reduce the salinity threat.

There were also water resource opportunities by harvesting stormwater from urban areas for recycled use.

Discharge from the Brookton WWTP posed a significant threat to water quality in the Avon River South Branch and a river pool a short distance downstream (Mile Pool). Treated wastewater discharged from the WWTP had very high levels of nitrogen and phosphorus. Algal blooms and very low oxygen levels in the river downstream from the discharge point indicated the threat of eutrophication in late spring and early summer.

Nutrient management practices

The Shire saw an opportunity to reuse the combined wastewater, stormwater and pumped groundwater as a resource for recreation facilities. These included the oval and park facilities at the WB Eva Pavilion and possibly, the local golf club.

The Shire also sees potential future water efficiency opportunities in using a 'third pipe' system for recycled water when plumbing new urban development. Using nutrient-rich water to irrigate commercial tree plantations was also being considered.

To maximise these benefits, the Shire intends to construct a 50 000 m^3 reservoir close to town for winter storage and summer use of excess wastewater and pumped groundwater.

In a further nutrient loss management action, the Department of Water, Northam, has constructed a nutrient stripping wetland. This project involved:

- excavating an elongated, meandering watercourse between the basin and the river
- installing in-stream ponds for supplementary treatment
- installing small riffles (in-stream rock structures) to reduce stream flow velocity
- establishing a range of native riparian species including sedges, rushes, paperbarks and sheoaks to utilise excess nutrients in stream flow.

Outcomes

Monthly monitoring upstream and downstream of the constructed wetland has shown significant reductions in concentrations of Total Phosphorus and Total Nitrogen in the first nine months following its establishment.

The capacity of the wetland to remove nutrients is greatest when there is rapid vegetative growth. This capacity will reduce when the plants become mature. Removal of plant material from the site is one option although this is labour intensive. The wetland is considered as a short-term measure to reduce nutrient discharge until the longer term option of wastewater re-use in the town is developed.

The Shire of Brookton has combined the management of nutrient loss with solving a salinity problem in the town. These productive options also provide local social benefits through the irrigation of recreational facilities.

Gary Clark, the Chief Executive Officer of the Shire of Brookton comments that...

> *… it has taken some time to get the integrated water re-use system to the stage where we are now testing sites for reservoir construction. The effectiveness of the constructed wetland has taken some of the pressure off the Shire and enables us to plan carefully for the longer term solutions. It is exciting for the Town to recognise the potential to gain benefit from solving these problems”.*

Photo 18 *Brookton constructed wetland 18 months after construction (Photo by Michael Allen)*

Key Points Summary

- Management of all aspects of the fertiliser supply chain is recommended so that responsibility for fertiliser use is extended through all stages from production to use.
- Farmers and other fertiliser users need to ensure that fertiliser management advice is sought from agronomists, sales representatives and industry advisers who have undergone appropriate training and accreditation.
- Nutrient management is a key component that affects both profitability and protection of the environment.
- Soil testing and good decision support systems are now essential for optimising sustainable farm production.
- Technological developments for precision agriculture (for example, yield mapping, and 'on the move' variable rate fertiliser application) provide options for more efficient fertiliser use.
- Environmentally sensitive fertiliser use on farms, including safe paddock storage and 'zero-application' buffer areas, should be adopted.
- Surface water management for soil loss reduction should be a high priority in farm planning processes.
- Environmental filtering capacity on farms can be significantly increased without loss of production.
- Water sensitive urban design and other urban nutrient management initiatives should be adopted for rural towns.

6 Implementing nutrient management options

Section 6 Implementing nutrient manangement options

Nutrient management to reduce potential environment harm in the Avon River Basin and Swan–Canning Estuary is recognised across industry, government and communities as a high priority. Previous actions taken include control of point sources of nutrients through licensing and regulation, wastewater re-use, relocation of landfill and adoption of sustainable farming practices with nutrient management benefits. Most actions have provided multiple benefits, including cost savings through improved efficiency.

The toolkit builds on current effective practices by encouraging voluntary adoption across industry and community interests. Long-term improvements in water quality requires broadscale adoption (that is, everyone ‘doing their bit’ within the limits of their capacity for change) and information to re-enforce the perception that actions are making a difference.

6.1 Integrated approach to nutrient management

The process outlined in the toolkit encourages individuals or groups to take responsibility for their contribution in managing nutrients in the environment.

Many landowners and facility managers are able to undertake these steps, but not everyone can manage nutrients without support. Industry, government, community and a range of other supporting organisations are able to provide assistance in implementing a coordinated approach to nutrient management in the region.

Nutrient management adoption processes which may require support include:

- identifying valued natural, social and economic assets at risk (such as waterways, wetlands and good quality groundwater resources)
- on-site risk assessment requiring a detailed knowledge of soil and landscapes
- understanding nutrient pathways and processes (including research and extension where needed)
- preparing plans such as farm plans for commercial and small landholdings, industry contingency plans and rural town stormwater management plans
- implementing ‘environmentally responsible practice’
- communicating and sharing information
- monitoring and reporting (at site, local, catchment and regional scales).

An overview of supporting organisations is provided in section 6.4.

6.2 Applying recommended actions for reducing nutrient loss

The next step in the process of using the toolkit is to review the recommended management options for the medium and high nutrient risk areas identified on your property plan. The recommended management options for diffuse sources are summarised in Table 9. Nutrient management options for point source activities are summarised in Table 10.

Action 9. Identify on your property plan where diffuse and point source activities are occurring on medium and high risk LMUs. Select recommended management options from those summarised in Table 9 and Table 10.

Table 9 Nutrient management options for diffuse sources

Nutrient risk area	Recommended options for nutrient management	Further information and references
A. A high soil erosion hazard is present (high slope, poor soil structure, waterlogged and salt-affected soils with minimal groundcover such as stubble or pastures).	**Soil conservation earthworks:** Intercept runoff and effectively reduce slope length by constructing contour sills, grade banks, broad-based banks and interceptor drains.	5.2.4
	Reduced tillage: Improve soil stability by converting to minimum or no tillage cropping systems.	5.2.4, Case study 4
	Maintain vegetative cover: Prevent erosion by establishing perennial vegetative cover, maximising productivity of annual crops, retaining stubble and trash in broadacre crops, and using cover crops to maintain adequate vegetative cover.	5.2.5, Information box
	Stock control: Manage grazing pressure so that paddocks are not denuded and soils are not disturbed by livestock when waterlogged or susceptible to erosion.	5.2.5

B. Sandy textured, highly permeable soils with a low capacity to retain phosphorus are present, increasing the risk of leaching or through flow.	**Revegetate with perennials:** Plant perennial species (pastures, trees, shrubs) to access water and nutrients from a greater soil depth over a longer time. Perennials more thoroughly dry out the soil profile and create a buffer to reduce recharge.	5.2.5 Information box 4
	Fertiliser management: Match fertiliser applications to plant requirements by conducting and correctly interpreting tests of soil, tissue and/or sap, as appropriate.	5.2.2
	Apply fertilisers at the correct time and use appropriate application methods to prevent run-off and leaching.	5.2.2
	Soil amendments: Improve nutrient retention of soil by applying amendments (e.g. claying sandy soils, increasing organic carbon levels).	5.2.2
C. Soil loss is occurring in close proximity (<50 m) to a creek or drainage line.	**Maintain vegetative cover:** Prevent erosion by establishing perennial vegetative cover.	5.2.5
	Stock control: Manage grazing pressure so that paddocks are not denuded and soils are not disturbed by livestock when waterlogged or susceptible to erosion.	5.2.5
	Vegetation buffer: Establish a fenced vegetated buffer along the creek or drainage line.	5.2.5 Information box 4
	S**oil conservation earthworks:** Divert run-off by constructing contour sills, grade banks, broad-based banks and interceptor drains.	5.2.4

D. Agricultural activity is occurring in the floodplain where there is a significant risk of the loss of sediment and alluvial soils.	**Fence and revegetate** the floodplain to exclude stock, stabilise soils and filter nutrients from surface water flows.	5.2.5
	Maintain vegetative cover: Prevent erosion by establishing perennial vegetative cover, retaining stubble and trash in broadacre crops, and using cover crops to maintain adequate vegetative cover.	5.2.5
E. Channel and gully erosion are occurring in the riparian zone, resulting in the erosion of alluvial and other recent depositional soils.	**Gully control:** Control and rehabilitate erosion gullies with structures such as rock chutes.	5.2.4
	Fence and revegetate the affected area to exclude stock and stabilise soils.	5.2.5
	Soil conservation earthworks: Intercept run-off by constructing contour banks and shallow diversion drains for safe disposal.	5.2.4
	Contour cultivation, where possible, to slow down and disperse runoff over a wide area.	5.2.4
	Farm layout: Design and maintain farm tracks and culverts so that drainage is evenly dissipated and does not concentrate along any section.	Appendix 1
	Riffle construction (for channel erosion): Reduce stream flow velocity and stabilise sediment by constructing one or more rock riffles in the channel.	5.2.4

F. Wind or water erosion is removing topsoil due to insufficient vegetative cover.	**Maintain vegetative cover:** Prevent erosion by establishing perennial vegetative cover, retaining stubble and trash in broadacre crops, and using cover crops to maintain adequate vegetative cover. **Stock control:** Manage grazing pressure so that paddocks are not denuded and soils are not disturbed by livestock when waterlogged or susceptible to erosion.	5.2.5 5.2.5
G. Areas are prone to waterlogging or groundwater discharge (including salt-affected land).	**Revegetate with perennials:** Plant perennial species (pastures, trees, shrubs) to access water and nutrients from a greater soil depth over a longer time. Perennials more thoroughly dry out the soil profile and create a buffer to reduce recharge.	5.2.5
H. Fertiliser is applied at rates higher than required for plant use, or to areas with high soil nutrient levels.	**Fertiliser management:** Match fertiliser applications to plant requirements by conducting and correctly interpreting tests of soil, tissue and/or sap, as appropriate. Apply fertilisers at the correct time and use appropriate application methods to prevent runoff and leaching.	5.2.1 5.2.2
I. Stock have uncontrolled access to water supplies, waterways or wetlands.	**Fence and revegetate** to exclude stock, stabilise soils and filter nutrients from surface water flows.	5.2.5

J. High levels of organic matter have built up where stock are concentrated near waterways and drainage lines (e.g. stock yards, shearing sheds, watering points, sheep 'camping areas').	**Store nutrient-rich organic matter** on low permeability, bunded areas. **Dispose of nutrient-rich organic matter:** Broadcast on suitable soils at recommended application rates with buffers to watercourses. **Stormwater management:** Use contour banks or diversion banks to minimise/prevent surface water running on to the area. **Farm layout:** If feasible, relocate high risk areas to establish buffers between high nutrient risk areas, waterways and drainage lines.	Information box 3 Table 3 5.2.4 Appendix 1
K. There is insufficient filtering capacity in riparian vegetation (especially due to inadequate groundcover).	**Fence and revegetate** to exclude stock, stabilise soils and filter nutrients from surface water flows. **Protect, manage and enhance remnant vegetation:** Enhancing the quality and area of riparian remnant vegetation will assist in stabilising soil and reduce the transport of nutrients off-site.	5.2.5 5.2.5 Information box 4
L. Areas of bulk fertiliser storage (paddock dump, roller roof shed, bins and tanks).	**Site selection:** Avoid storage over deep leaching, transmissive soils or soils prone to erosion. Areas prone to flooding, including the floodplain or waterlogged areas, should not be used. **Establish buffer:** Locate away from waterways, including small natural drainage lines where there may be occasional stream flow and subsurface seepage. A minimum distance of 100 m from waterways is recommended. **Stormwater management:** Use contour banks or diversion banks to minimise/prevent surface water running on to the area.	5.2.3 Information box 4 5.2.4

M. Fertiliser is being applied across drainage lines or seasonal watercourses.	**Avoid fertiliser applications** across waterways (small gullies or creeks) even if they do not have stream flow as these areas are prone to soil erosion. **Establish a zero-application buffer** from water receiving environments.	5.2.2 5.2.2
N. General farm management activities may increase the risk of nutrient loss.	**Fertiliser management** • soil testing • plant tissue analysis • planning and record keeping • yield monitoring • fertiliser management systems • variable fertiliser application rates • variable time of application • legumes in crop rotations • environmentally sensitive fertiliser use • farm machinery accredited and calibrated for width and uniformity of spread • site maintenance. **On-farm storage of fertiliser** **Liquid fertiliser storage** **Soil loss reduction** **Environmental filtering capacity** **Constructed wetland use** **Vegetated buffers**	5.2.1 5.2.2 Case Study 4 5.2.3 5.2.3 5.2.4 5.2.5 Information box 4 & 5 Information box 4

Table 10 Nutrient management options for point sources

Land use	Key issues for nutrient management	Further information and references
Wastewater treatment plants	Site selection Pond design Pond operation, discharge and maintenance	4.2 Case study 1 Information boxes 2 and 3
Intensive animal industries	Site selection Stock containment area design Solid waste management Liquid waste disposal	4.3 Case Study 2 Information box 3 Table 6
Abattoirs	Site selection, design and management Waste storage and disposal Solid and liquid waste management and discharge	4.4 Case Study 3 Information box 3 Table 6
Landfills	Site selection, design and management	4.5

6.3 Prioritisation of nutrient management options

Action 10. Review the list of management actions and prioritise actions for implementation.

It is recommended that all the nutrient management options that have been identified are listed and then prioritised for implementation using the information that you have summarised on your property plan.

To identify priorities for implementation it is recommended that the following issues are considered:

- The scale of the problem – how many hectares of land are affected?
- Is there evidence of current impacts upon water resources?
- The value of the receiving environment:
    - Is the nutrient loss likely to have a local impact upon an important water source for the property such as a farm dam, a natural waterway or wetland, or a constructed drain?
    - Is the nutrient loss likely to have a more regional impact? (does the waterway or drain discharge into a significant waterway in the Avon River Basin?)
- The type of nutrient loss – is it a point source or a diffuse source?
- The likely effectiveness of the nutrient management option. The DAFWA publication *Natural Resource Management Issues in the Avon River Basin* (Galloway, 2006) provides a good summary of the effectiveness of different management options.
- Does the nutrient management option has multiple benefits? (for example, revegetation to reduce erosion which will also reduce nutrient loss and provide habitat)
- Is funding available for the implementation of the nutrient management option? Funding may be available from the state or federal government or other funding organisations (contact the Avon Catchment Council for more information).

The *Property Planning Manual for Western Australia* (DAFWA, 2007) produced by the Small Landholder Information Service is an excellent guide to planning and implementing a project for your property, regardless of its size.

6.4 Natural Resource Management organisations in the Avon River Basin

Management of natural resources in the Avon River Basin is undertaken by a wide range of organisations.

Avon Catchment Council (ACC) is a partnership organisation that helps to coordinate natural resource management (NRM) in the region. The ACC influences management through preparation of strategies, policies, plans and statements of 'environmentally responsible practice'. This organisation is not empowered with legislation for regulation and control.

Department of Environment and Conservation (DEC) has a range of statutory responsibilities relevant to nutrient management which are described in the *Environmental Protection Act 1986*. This includes licensing of wastewater treatment plants, landfill sites, abattoirs and some intensive animal industries in the Avon River Basin. Most wastewater treatment plants in the Avon region are managed by the Water Corporation (WC).

Department of Water has a lead role in managing the State's water resources. It is responsible for monitoring water resources through a network of gauging stations in the Avon River Basin. All gauging stations measure stream flow and salinity. Many sites have been used for nutrient load measurement.

The department publishes a wide range of guidelines and management advice on protecting water quality. See www.water.gov.au (water quality>publications).

The department in Northam provides leadership for river management through the Avon Rivercare Program. This involves local communities in river recovery planning and actions that improve the condition of the river and its environment. Nutrient and sediment management, water quality monitoring at specific sites and annual 'snapshots' are important components of this program.

Department of Agriculture and Food Western Australia (DAFWA) assists the State's agriculture, food and fibre sectors to be sustainable and profitable. DAFWA's research and advisory services provides direction for fertiliser management in the region and sustainable land use advice relating to issues such as soil conservation. DAFWA administers the *Soil and Land Conservation Act 1945* which can be applied where there is an unacceptable level of soil loss through water erosion.

The fertiliser industry is represented by the **Fertiliser Industry Federation of Australia (FIFA)**. This national organisation recognises that excessive use of fertilisers can cause environmental harm. FIFA's industry training program (*Fertcare*) aims to build the capacity within the industry for nutrient management. This program adopts principles of environmental stewardship.

Local Government has an important role in nutrient management through planning decisions and the administration of municipal facilities, including irrigated recreation areas and waste disposal sites.

Contact details for key agencies and organisations

Organisation	Contact details
Agricultural and environmental consultants	Australian Association of Agricultural Consultants of WA www.aaacwa.com.au Environmental Consultants Association of WA www.eca.org.au
Avon Catchment Council	ph 9690 2250 www.avonnrm.org.au
Catchment and landcare groups	Local area or catchment plans, integrated property planning, group training, combined project initiatives Contact DAFWA about groups operating in your area. Northam ph 08 9690 2000 Merredin ph 08 9081 3111
Community conservation groups	Group skills training for waterway restoration, restoration projects for nutrient loss reduction Contact DEC or Department of Water regarding groups operating in your area. DEC Northam ph 08 9622 8940 Narrogin ph 08 9881 9222 Department of Water Northam ph 08 9690 2600

Department of Agriculture and Food Western Australia	Northam ph 08 9690 2000 Merredin ph 08 9081 3111 Small Landholder Information Service (SLIS) ph 08 9368 3807 www.agric.wa.gov.au
Department of Environment and Conservation	Northam ph 08 9622 8940 Narrogin ph 08 9881 9222 www.dec.wa.gov.au
Department of Water	Northam ph 08 9690 2600 www.water.wa.gov.au
Fertiliser industry Federation of Australia	ph 02 6230 6987 www.fifa.asn.au
Intensive animal industry organisations and support tools	Australian Lot Feeders Association www.feedlots.com.au Meat & Livestock Association Australia www.mla.com.au CSIRO Expert advice for piggery managers – 'Auspig' www.auspig.csiro.au WA Pork Producers Association www.wappa.com.au

Swan River Trust	*Healthy River Action Plan* (Swan River Trust, 2008) sets targets for nutrient load, river and estuary nutrient monitoring, public information and engagement; Heavenly Hectares program. www.dec.wa.gov.au ph 08 9278 0900
Water Corporation	Provides water and wastewater services to households, businesses and farms in towns and communities. Northam ph 9622 4888 www.watercorporation.com.au
Landgate	Provides land and property information Midland ph 9273 7373 www.landgate.wa.gov.au

7 Monitoring outcomes of nutrient management

Section 7 Monitoring outcomes of nutrient management

Action 11. Put in place monitoring strategies to assess the outcomes your nutrient management actions.

Simple monitoring techniques can be used to review the outcomes of your nutrient monitoring actions and to assess the success of your project;

- Establish permanent photo reference points to enable progress to be visually documented (particularly for revegetation and erosion control projects). Each reference point site needs a good visual range and should be marked using two reference points such as two star pickets. The first star picket identifies the camera position; the photo is taken of the second star picket and project area in the background. Photograph the reference sites at least twice a year at the same time of year (end of autumn and end of spring).
- Aerial photography of the property can be obtained from Landgate for a small fee (see section 6.4). Aerial photos of your property taken approximately every five years will provide a good objective means of assessing the benefits of on-ground actions, particularly revegetation and fencing.
- Soil sampling every two to three years will enable you to assess the success of your fertiliser program or grazing program.
- Sampling of water quality for nutrient levels (such as TN and TP) in waterways, dams and groundwater on your property indicates the impacts of your on-ground actions. Water quality sampling should be done regularly over a period of years from fixed sampling points.
- A simple (although more subjective) method to assess the health of water resources on your property is to record your observations every month.
  - water colour
  - water odour
  - water clarity
  - presence of algal blooms
  - whether the water is flowing or stagnant (for waterways).

Glossary

Glossary

Aerobic	With oxygen; usually referring to chemical reactions or organisms.
Anaerobic	Without oxygen; referring to chemical reactions or organisms.
Aquifier	A geological formation or group of formations capable of receiving, storing and transmitting significant quantities of water.
Catchment	The area of land which intercepts rainfall and contributes the collected water to a common point through surface and groundwater movement.
Denitrification	Process of reducing nitrate or nitrite to nitrogen gas, in the absence of freely available oxygen.
Discharge	Volumetric outflow rate of water, typically measured in cubic meters per second. Applies to groundwater and surface water.
Erosion	The removal of soil or rock particles from one location and their deposition in another location.
Eutrophication	A natural process of accumulation of nutrients leading to increased plant growth in waterways. Human activities that generate high levels of nutrients can accelerate this process and lead to algal blooms and deterioration in water quality.
Floodplain	A broad, flat, low-lying area of land in the valley floor that is inundated during a 100-year flood. Includes the flood fringe and floodway.
Flood – 100 year	The 100-year flood has a statistical probability of occurring, on average, once every 100 years. The 100-year flood level is the contour to which this flood will rise.
Flood fringe	The area of the floodplain outside of the floodway that is affected by flooding.
Floodway	The river channel and portion of the floodplain which forms the main flow path for flood waters after the main channel has overflowed.

Foreshore	Area of land next to a waterway.
Groundwater	Water which occupies the pores and crevices of rock or soil.
Leaching	The process by which materials such as organic matter and mineral salts are washed out of a layer of soil when dissolved or suspended in percolating rainwater.
Nitrification	Biological process by which bacteria convert ammonia to nitrate.
Nutrient load	The amount of nutrient (usually nitrogen and/or phosphorus) reaching a waterway from its catchment area over a given time period.
pH	The concentration of hydrogen ions in solution that indicates the acidity or alkalinity in water. A pH value of 7 is neutral, above 7 is alkaline and below 7 is acidic.
Recharge area or zone	An area through which water percolates to replenish (recharge) an aquifer. Unconfined aquifers are recharged through rainfall. Confined aquifers are recharged in specific areas where water leaks from overlying aquifers, or where the aquifer rises to meet the surface.
Remnant vegetation	An area of native vegetation remaining after a major disturbance, such as land clearing.
Riffle	High points in the channel, for example, bedrock bars, accumulations of rock or woody debris.
Riparian vegetation	Vegetation growing in the riparian zone.
Riparian zone	The riparian zone includes the floodplain and adjacent verge. The width of the riparian zone varies greatly, from tens of metres to kilometres, depending on the type of waterway and its catchment.

River basin	The area drained by a waterway and its tributaries (see Catchment).
Runoff	Water that flows over the soil surface when rainfall is greater than the infiltration capacity of the soil. Flow in waterways results from rainfall runoff.
Sediment	Sand, clay, silt, pebbles and organic matter carried and deposited by wind or water.
Sedimentation	The process by which sediment is deposited, for example, in waterways.
Third pipe plumbing	A separate pipe used to supply reclaimed water to residential homes for non-potable use such as garden watering.
Tributary	A waterway that flows into a larger waterway.
Volatilisation	Conversion of a chemical substance from a liquid or solid to a gas.
Water quality	The physical, chemical and biological characteristics of water.
Watertable	Saturated level of unconfined groundwater. Wetlands in low-lying areas may be surface expressions of groundwater.
Waterway	Surface water bodies, including streams, rivers, lakes, wetlands, estuaries, coastal lagoons and inlets. Can be seasonally or permanently inundated.

Appendix 1 Property Planning Guide

Appendix 1 Property Planning Guide

What is Property Planning?

A property plan is a tool to graphically describe the main features of your property and to record the activities you are going to carry out and where you will do them.

Property planning is all about planning for sustainable land management. Good planning takes into account the capability of your land so that appropriate management can halt, reduce and prevent degradation. It also includes personal factors (such as your finances, labour resources and lifestyle) and legal aspects (such as water rights and controls and planning scheme controls).

Property planning involves looking at ways of integrating the natural features of your property (for example, soils, bush, creeks) with any enterprises you want to run (such as cropping or livestock) and working out how to achieve the maximum outcomes for all aspects.

Part of the process is to identify issues and concerns of importance to your property management and environment, and to derive practical solutions.

This is a tool or learning process that works equally well for small or large landholders. It is well supported by the *Property Panning Manual for Western Australia* (DAFWA, 2007).

Before you even start your plan, it is important to have a clear vision of what you want to achieve on your property. Why did you buy it and what do you want to do with it? What values are important to you? Whether your aims are to do with lifestyle or developing a commercial farm, your plan will help you achieve your vision. If you have commercial enterprises the property plan will ideally be a companion to your business plan.

A useful way to produce a final property plan that shows your various actions and management practices is with a series of overlays and an aerial photograph of the farm. On the overlays you are record different types of information about your farm. Then, by combining the overlays and the aerial photo, you will see clearly how the natural and constructed features of the farm fit together. You will notice ways in which the farm's features and your management activities could be better combined to achieve your goals.

Start with an aerial photograph or property map as your base layer and use three clear plastic overlays for the three information layers. Some fine point overhead markers will be also needed.
Begin by attaching the first clear overlay to the photo and identifying the existing physical features that realistically will not or cannot be changed. This should include the following features:

- boundary fences, other infrastructure such as house, yards and sheds
- drainage lines
- ridges
- areas of remnant vegetation to be fenced
- existing tree planting
- existing dams, soaks and springs
- existing drainage earthworks.

On the second overlay you will map the Land Management Units (LMUs), the areas on your property which react in a similar way to various management practices. Or, to put it another way, they are areas of land with similar soils and landforms that should be managed similarly to maximise benefits to you and, at the same time, minimise degradation. When combined with the existing physical features, this layer provides the framework for planning how your property should be managed. To identify LMUs you need to think about the physical characteristics of your property.

Overlay 3 is your final plan or proposed new layout. The final plan should be based on the features that you have mapped on the Existing Physical Features Overlay and the LMUs Overlay. The final plan of your property should focus on preserving one of your most valuable natural resources, the soil.

It should incorporate the following features:

- proposed new fencing and other infrastructure such as house, yards and sheds
- proposed tree planting
- proposed dams
- proposed drainage earthworks.

You should seek professional advice for the location and construction of any dams, earthworks or drains. Other features of the proposed works overlay could include:

- remnant vegetation areas to be protected
- areas that will be used for new enterprises/land uses
- size of existing and proposed paddocks
- length of fencing to be erected.

To develop the third overlay you will need to go through a decision-making process. Some important questions to ask yourself when preparing your property plan include:

- Which parts of the property need fencing into separate paddocks?
- How can fencing be designed to fit in with LMUs and other natural features?
- Where should houses and buildings be positioned (if not already in place)?
- Where are the areas of degradation and what can be done to address them?
- Are any drainage earthworks required to prevent erosion and waterlogging?
- Which parts of the property need better water supplies?
- Is all weather access currently possible over the entire property?
- Is adequate stock shelter available?
- What land use diversification options are feasible, and where can they be run?
- How many paddocks do I need and of what size?

Although there are resources and guides that can 'walk' you through the property planning process, it is highly recommended that landholders attend a Property Planning Workshop rather than try to develop a plan on their own.

The Small Landholder Information Service runs Property Planning Workshops for landholders who want to access experienced land managers and consultants for one-on-one advice and information.
At Property Planning Workshops, participants work on their own aerial photograph and can address any problems or land management issues affecting their property. For more information, visit www.agric.wa.gov.au/small_landholder.

Appendix 2 Current status of nutrients in the Avon

Appendix 2 Current status of nutrients in the Avon

The most commonly used measures of nutrient levels are Total Phosphorus (TP) and Total Nitrogen (TN). These are determined from water samples collected in the field, stored at low temperature and sent to a laboratory for analysis. Sampling results are provided in concentrations of milligrams per litre (mg/L). Where adequate water quality and stream flow monitoring is undertaken, nutrient concentrations may be multiplied by annual stream flow to estimate total nutrient loads (tonnes/annum).

The Swan River Trust (SRT) has monitored nutrients in major tributaries to the Swan–Canning Estuary, including the Avon, since 1987. The Avon River is a major contributor of nutrients to the estuary. Of the total estimated load of nitrogen, 69 per cent came from the Avon catchment, primarily due to large annual flow discharge. About 43 per cent of the phosphorus load to the estuary came from the Avon. This equates to 575 tonnes of TN and 20 tonnes of TP.

The annual loads for the Avon River were calculated by the Swan River Trust (Table 11).

Table 11 *Annual nutrient loads discharged by the Avon River to the Swan–Canning Estuary*

Year	Annual flow (ML)	Annual TN load (Tonnes)	Annual TP load (Tonnes)
1997	184 367	248	7.7
1998	196 248	257	8.0
1999	588 999	1454	41.6
2000	576 296	2403	95.6
2001	90 518	116	3.9
2002	87 750	84	2.5
2003	278 435	428	14.3

2004	118,509	139	4
2005	304,607	458	16.2
2006	113,614	161	5.5
Average	253,934	575	20

Targets for nutrient reduction

The Avon Catchment Council (ACC) target for the Avon River states that the average monthly concentration should not exceed 1 mg/L for TN and 0.1 mg/L for TP (as measured at the Walyunga gauging station). These are consistent with the targets set for the Avon River under the *Swan and Canning Environmental Protection Policy (EPP) 1998*. The Swan–Canning Environmental Protection Policy specifies a target of 6.4 tonnes TP maximum annual discharge to the Swan–Canning estuary from the Avon River.

The annual load and flow weighted concentration for TN and TP is shown in Table 12 for 19 years from 1987 to 2006 measured at the Walyunga gauging station. The Avon River has been under the target for TP for all of the past 10 years. For TN the Avon River has been below target in all but one year in the last 10 (the exception being the summer flood year in 2000).

While the concentrations of TN and TP are low in the Avon River, the high flow volume of river means that it is still contributing a significant amount of nutrients to the Swan–Canning Estuary. It currently has the highest median TN load (calculated from 2002–2006 data, approximately four times higher than the next highest tributary) and the second highest median TP load of all the tributaries being monitored. In addition there is an emerging increasing trend in TN over the last five years and the bio-available proportion of TP has shifted from 15 per cent to 47 per cent of the TP load.

Table 12 *Nutrient concentrations discharged from the Avon River to the Swan–Canning Estuary*

Year	TN FWC (mg/L)	TP FWC (mg/L)
1987	0.8	0.11
1988	1.1	0.05
1989	1.3	0.09
1990	1.1	0.06
1991	1.2	0.03
1992	1.1	0.03
1994	1.5	0.04
1995	1.2	0.03
1996	0.67	0.02
1997	0.77	0.18
1998	0.66	0.016
1999	0.92	0.019
2000	1.2	0.019
2001	0.5	0.013
2002	0.54	0.015
2003	0.735	0.018
2004	0.515	0.016
2005	0.775	0.022
2006	0.79	0.01

Notes: FWC = flow weighted mean concentration
mg/L = milligrams per litre

Source: Donohue, *et al.* (1994) for 1987-1992; Swan River Trust (2008) for 1994–2006

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