Watercourse Management

A Field Guide for the Mount Lofty Ranges

Fourth Edition, 2020

Management strategies and actions for

healthy creeks and rivers

UPPER RIVER TORRENS LANDCARE GROUP

LANDSCAPE SOUTH AUSTRALIA HILLS AND FLEURIEU

Watercourse Management
A Field Guide for the Mount Lofty Ranges

(Fourth Edition)

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FOREWORD

The riparian lands within the Mount Lofty Ranges Watershed form a key role in protecting our waterways and provide a diverse range of habitats for native plants and animals. They buffer the watercourses and form an important link between the aquatic environment and adjacent farming lands. This was highlighted 1993 when the Upper River Torrens Landcare Group, in partnership with the formerly known Catchment Water Management Boards (now Landscape SA Boards), Environment, Protection Agency formerly known as Watershed Protection Office and the former Mount Lofty Ranges Catchment Program, published the first edition of ***Watercourse Management: A Field Guide for the Mount Lofty Ranges***. This provided landholders with comprehensive information addressing some of the issues involved in improving management of watercourses.

The embryonic development of the Upper River Torrens Landcare Group is described by its founding chair, Robert (Bob) Myers who said:

"A landcare group was loosely formed in the Upper River Torrens area in 1989 when a number of landowners began to tackle, in their own way, the problems caused by woody weed removal on sandy and alluvial soil banks of the River Torrens and its tributaries. We soon recognised that a conflict existed between the removal of the so-called stabilising woody weeds and the subsequent soil erosion caused by free-foraging livestock and wet winters. The reduction in bird habitat as a result of plant removal was also a concern. The landowners also needed to take into account the special nature of the upper River Torrens. Water piped from the River Murray was often released into the Torrens just to the west of Mount Pleasant and immediately west of Birdwood at Angas Creek to feed into the reservoir storages that supply metropolitan Adelaide. Savings in pumping costs and oxygenation of the water were the dual benefits of doing this. However, from our Landcare point of view, the healthier the catchment, the healthier the water. Our project committee was formed on 21 February 1990, coinciding with the launch of the Decade of Landcare. We identified a manageable zone of concern, covering approximately 10 kilometres of river and a strip extending a kilometre each side of the river and including parts of the tributary watercourses. We began to actively observe other Landcare projects, establish priorities, research available data and consult with people trained in our fields of concern, both in South Australia and interstate. Our demonstration sites show the implementation of what we learned during this process. The data sheets presented in this manual detail the same information for use by the local and wider community in the management of our watercourses. The data sheets are our attempt to simplify a considerable volume of material into a manageable and, we trust, useful form."

There is no doubt this guide has significantly assisted landholders in protecting and restoring our natural ecosystems within the watershed over the past 25 years. However, it is increasingly recognised that land changes by some agricultural, urban, or recreational activities are continuing to degrade these achievements and that we need ongoing restoration activities to bring the rivers back to life.

Some key features, new and updated in this 2020 edition include information on fire preparedness and post fire sediment control in watercourses, grazing pressure of pest herbivores and over-abundant species, farm dams, response to climate change, recognition of the Aboriginal custodians and update and addition of references, resources and contacts. In addition, all fact sheets have been thoughtfully revised, updated and expanded to reflect current knowledge and management options. This edition will be made available online through the URTLG and its partners.

I would like to express my appreciation to the authors and editors of this guide which will serve you well in your challenge to protect and restore streams, rivers, and catchments within the Mount Lofty Ranges.

I hope that you will find it helpful and welcome your comments to improve future editions.

Robin Harding, May 2020

Chairman

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ACKNOWLEDGEMENTS

The Upper River Torrens Landcare Group (URTLG) wishes to acknowledge the original co-author of the previous editions, Robert (Bob) Myers (OAM, Chairperson Seeding Natives Incorporated), for his significant past and current contribution to this document. In addition, the editor of the 2020 version, Ellen Krahnert, wishes to acknowledge other past contributors, and those for this version, such as Robin Harding (URTLG Chairperson), Kim Thompson (URTLG Secretary), Caroline Dorr (DEW & Green Adelaide), Andrew Fairney (Seeding Natives), Sheree Bowman (TSEC consultant), Steve Walker (FrogWatchSA), Nick Whiterod (Aquasave-NGT), Joel Allan (DEW), Peter Lang (SA Herbarium), Allan Sumner (Kaurna Cultural Bearer), Michael Field (Cultural heritage) and William Hannaford (Landscape SA Officer H&F).

WaterCare, was a South Australian Government initiative which was designed to encourage the public to protect and preserve their local catchment and waterways and recognising their input to these tasks was the primary supporter for this guide. By their contribution to funding the third edition (2003), WaterCare recognised the response from our rural communities. In addition, past funding contributors and supporters of the original version include the Soil Conservation Boards, Mount Lofty Ranges Catchment Program and Natural Heritage Trust.

The URTLG wishes to acknowledge and thank the Landscape SA Hills and Fleurieu Board, formerly known as the Adelaide and Mount Lofty Ranges Natural Resources Management Board (AMLR NRMB), for funding and support of the 2020 edition production. The 2020 edition was produced in partnership with URTLG committee members, Robert (Bob) Myers, and Caroline Dorr from the Water Management Services, DEW. In addition, much of the new information added to the 2020 edition was sourced from the Landscape SA Hills and Fleurieu website, factsheets and various resources.

Lastly, the URTLG wishes to acknowledge volunteers, landholders, and community members for engaging with the various landcare projects within the Mt Lofty Ranges region over many years to improve and restore watercourses on private lands. As volunteers and landholders, we value your commitment to the environment and your stewardship of protecting and caring for our precious waterways.

Aboriginal Custodianship of Country

1. Acknowledgement to Country

The Upper River Torrens Landcare Group (URTLG) acknowledges Peramangk and Kaurna as the First Peoples and Nations of the lands and waters we live and work upon and we pay our respect to their Elders past, present and emerging. We acknowledge and respect the deep spiritual connection and relationship that Aboriginal and Torres Strait Islander people have to Country.

The Peramangk traditional lands occupy the east-central part of the Mount Lofty Ranges while the Kaurna lands begin at Crystal Brook to the Clare Valley and Southwards to Cape Jervis.

This document speaks to an area that is significant to the Traditional Owners, the Kaurna People and Peramangk People where their Country is located.

2. Understanding Aboriginal Connection to Country and Water

The River Torrens, known as "Karrawirra Parri", meaning River of the Red Gum Forest, to the Kaurna Nation starts at the top of Mount Pleasant while the Onkaparinga River, referred to as "Ngangkiparinga", meaning Women's River, begins its journey near Charleston, and is a known as a Women's space to its Aboriginal people. Karrawirra Parri starts in Peramangk Country and ends as an artificial channel on Kaurna Country. These two main river systems are highly significant to both Peramangk and Kaurna Nations. The River Torrens is so important to the Kaurna people which is demonstrated by the fact it was given a different name based on the change of season and in its distinct parts (Clarke 2005).

"One of the most fundamental differences between Aboriginal and non-Aboriginal people is the understanding of the relationship between people and the land". "For thousands of years the Kaurna followed a lifestyle that involved intimate interaction with their environment and with their watercourses". "Rivers were rich areas and of prime importance to Aboriginal people" which provided them with "practical and spiritual knowledge" and were a "source of food, implements and water", and this reliance on the natural water and land resources for survival, meant that it was valued and respected (Clarke 2005).

Connection to Country and water are important because:

- Aboriginal people have an intrinsic relationship with water
- Water is life - it is Country, culture, and spirit
- The celestial connection to Country
- The meaning of rivers is transcending in time, never broken despite the physical change

Through colonisation people were removed from Country but their relationship with these places is still strong.

3. Land Management Pre-Colonisation

Before Colonisation, the land was abundant with water, food, and resources. Pre-colonial Aboriginal Australian Society is described in explorers' journals as "grassy plains, bountiful rivers" (Pascoe 2018). Along with this, settlers witnessed "people fishing with canoes, lines and nets" and the building of weirs and the use of fish traps along river systems to capture and harvest fish (Pascoe 2018). The Peramangk shared with other clans, many trade items and dreaming across common ground, water, sky and the stars (Copley 2015) and they did not need to move far as water, animals and plant life was abundant (ACHM 2015). As highlighted by Pascoe (2018), the relationship between people and the landscape was evident through the presence of seasonal highways and trade routes.

Agriculture and aquaculture land management activities were being practiced in Australia prior to colonisation. "Many explorers and pastoralists saw dams and irrigation trenches being built" and these practices were "an integrated and sustainable system" (Pascoe (2018). Aboriginal people managed the land as an open grassy woodland, and it was managed with fire (A. Fairney, pers. comm. 2020).

4. Cultural Heritage Awareness Today

Watercourses, by their very nature, are inherently rich in cultural heritage and hold unique value to Traditional Owners. Aboriginal spirituality is inextricably linked to these locations. The disturbance of watercourses and cultural sites including Old People (burials) brings intense feelings of pain and loss to the Aboriginal community (Green Adelaide 2020).

In line with best-practice land management outcomes and respect for Kaurna's past, present and ongoing connection to the landscape, a precautionary approach must be adopted when undertaking new work along watercourses, especially earth moving activities. Damaging cultural sites can also bring significant liability and financial cost to the land manager.

Typical watercourse work includes the construction of fencing to exclude livestock, revegetation, and weed and erosion control in and around watercourses. Due to the proximity of these activities to watercourses they may incidentally take place in locations considered culturally significant to Traditional Owners and as a result of this they have the potential to disturb Aboriginal sites, objects and remains and have an impact on broader cultural landscapes.

Aboriginal archaeological significant sites, such as campsites, birthing and ceremony places in the Mount Lofty Ranges are likely found near watercourses, and that watercourses are also considered to be culturally significant (ACHM 2015). In particular, large River Red Gums along and near watercourses can be found with scars by which shields, and canoes have been taken from. These trees are known as Culturally Modified Trees (CMT). These trees, often hollowed out, provided shelter and a dwelling, or were birthing or burial sites.

When working within these areas in the Mount Lofty Ranges look out for these trees or other culturally significant sites. A landholder should seek to minimise the risk of activities disturbing Aboriginal sites, objects and remains and to ensure that the legislative requirements of the Aboriginal Heritage Act 1988 (South Australia) and the Native Title Act 1993 (Commonwealth of Australia) are being met.

"Karrawirra Parri is a beautiful river that belongs to the Karuna People. Our connection to our Country and our water is important for us as Aboriginal People including our animals, reptiles, insects, fish that also live in the river. For thousands of years Aboriginal People have looked after the Country including our wonderful River, Karrawirra Parri" (A. Sumner 2020, River Torrens Recovery Project).

If you would like to learn more about cultural heritage in your area or connect with a Traditional Owner, please contact your local Landscapes SA Officer or the Department for Environment and Water (DEW) for further information.

Hills and Fleurieu Landscape SA Board

1. A Program to Manage the Environment

The Mount Lofty Ranges Catchment Program has developed over the years and is now known as the Hills and Fleurieu (HF) Landscape Board, focusing on a larger region extending to the coast, developing the regional understanding of our natural resources and preparing an investment strategy for the implementation of works programs, monitoring, benchmarking, education and capacity building.

The Mount Lofty Ranges Catchment Program, now HF Landscape SA Board, began in 1993 and was a cooperative approach between the community and the Federal, State and Local governments to improve the management of natural resources throughout the Ranges. The Program sought to carry out natural resource strategies developed during the Mount Lofty Ranges Review and detailed in the Regional Strategy Plan of 1993. Refer to map on page 4 showing the Mt Lofty Ranges Catchment Areas.

Whilst our work in the upper Torrens catchment has always been community driven using the grass roots approach with locals driving environmental change, the URTLG aims to deliver outcomes aligning with the Adelaide and Mount Lofty Ranges Natural Resources Management Board Strategic Plan (2014-15 to 2023-24). The regions NRM Strategic Plan identifies the key pressures on essential natural resources and targets effort that can have the greatest effect.

The Adelaide and Mount Lofty Ranges Natural Resources Management Plan was developed by the Adelaide and Mount Lofty Ranges NRM Board (AMLR NRMB) in partnership with the community and key stakeholders. From the 1 July 2020, the AMLR NRMB became the Hills and Fleurieu Landscape Board (with new members), and Green Adelaide and in addition, the northern portion of the existing AMLR region transferred to the new Northern and Yorke Landscape Board. For more information visit Landscape SA or Green Adelaide.

These strategies will:

- ensure long-term viability of the agricultural and interwoven natural systems we all depend on;
- protect the water resources from pollution and overuse; and protect and enhance the scenic and social amenity of the Ranges.

2. Government and Community Working Together

The URTLG's greatest strengths; engaging community and individual property owners has resulted in many opportunities to receive support from a range of funding bodies, at local, State and Federal level. The URTLG acknowledges the community commitment to enhancing the natural biodiversity of the Upper River Torrens catchment and recognises the past and current landholders who continue to work tirelessly to improving catchment management in our region. With the majority of natural resources in our State owned and managed by private individuals, the URTLG has always focused on building capacity within the community to take enable landholders to take responsibility and have ownership for improvements in management of their land and valuable watercourses.

Over the past 30 years, the URTLG has co-ordinated and facilitated significant number of on ground works on properties including:

- Watercourse fencing
- Revegetation & restoration activities

- Pest plant and animal control
- Remnant vegetation management

Many projects have worked collaboratively with local and/or other environmental groups to achieve these outcomes.

Funds continue to be provided to assist community groups, Local Government and State agencies to work together to deal with issues such as sustainable primary production, erosion control, protection of native vegetation, revegetation, effluent and stormwater management, and protection of watercourses and riparian (next to watercourse) areas. The emphasis is on working together to achieve common goals for integrated natural resource management.

INTRODUCTION

Why Manage Watercourses?

Early European settlers in the Mount Lofty Ranges encountered grassy woodlands situated between a complex system of streams and wetlands and forested hillsides. Known in Aboriginal language as the "River of the Red Gum Forest", the River Torrens (Karrawirra Parri) was a place where these grew, and still is today. "Settlers remarked on the gentleness of the area, the grandeur of the river red gums, the majestic mountains in the background and variety of shrubs and birds" (Clarke 2005).

Adelaide was built where it is today because of the River Torrens. It provided a water source for colonists but since then it has been over worked and overused. It was a water source, a sewer and used to dump rubbish, but later it was recognised for recreational purposes which is why the Torrens Lake was formed. The River Torrens was transformed into an artificial lake in 1881.

Observations on the condition of watercourses and land management in the early years of Colonisation are valuable. As late as 1901 pioneers like Mrs. Helen Mantegani of North Adelaide (daughter of Mr. and Mrs. Robert Thomas) could still recall what the River Torrens looked like over 60 years earlier *(inset below on next page)*.

Seasonal flooding and flows once fed wetlands and floodplains that supported dense vegetation. "The river was prone to flooding, particularly the Reedbeds where the full force of the water spilled onto the plains" (Clarke (2005), as documented by Colonel Light. However, "the Kaurna accepted flooding as a natural course of events". In a short time, the River Torrens showed signs of degradation because of various causes such as higher population density, heavy pollution and damming activities (Clarke 2005).

The introduction of domestic grazing livestock and intensive cultivation has significantly altered the vegetation over the majority of the Mount Lofty Ranges' catchments. It has been estimated that at the time of settlement as much as 90 % of the River Torrens catchment was vegetated, thus lessening the effects of flooding" (Clarke 2005).

Major changes have occurred in the once productive grassy woodlands and to the watercourses and wetlands. These changes continue to affect the stability of watercourses and water quality. During 1847, erosion and tree damage along the River Torrens occurred, as a result of flooding, while in the same period of 1850-51 there was a water shortage and severe flooding known as the "Great Flood" which caused avalanches of soil (Clarke 2005).

Early responses to land degradation included the installation of dams and weirs, not just to pool water but to trap increasing sediment and pollutant loads from development elsewhere in the catchment.

Watercourses provide environmental, economic, social, and Aboriginal cultural value. Managing watercourses provides an opportunity to engage with the broader and local community, which can build peoples respect and value for our precious waterways. Water is essential for life for all species, including us and we have an ethical and statutory obligation to care for it.

Healthy watercourses are essential for sustainable land management and are an important part of our landscape as outlined on the Landscape SA Hills and Fleurieu information page and in the Water Wise No. 1 factsheet – Managing Your Watercourse. In the Hills and Fleurieu region we have many creeks and rivers, mostly in good condition (47%) but 24% being in poor condition (EPA 2017). Within the Adelaide Hills Council region creeks and watercourses on private property "operate under common law and as the resident or land owner you are responsible for the maintenance and upkeep of the watercourse…." (Adelaide Hills Council 2020).

Despite the cessation of broadscale land clearance, biodiversity in our region continues to decline, demonstrated most prominently by the local

decline and disappearance of birds such as diamond firetails, restless flycatchers and tree martins.

It is recognised that supporting landholders who wish to manage specifically for biodiversity outcomes, either through a very low-input system of livestock production or the retirement of agricultural land to reinstate native vegetation, is an essential component of a solution to biodiversity loss.

An understanding of natural processes is fundamental to the implementation of sustainable practices and for the long-term protection of our water supplies, a diminishing resource on a world scale.

Approximately 60 % of the water in the Torrens and Onkaparinga Rivers come from water pumped from the River Murray (C. Dorr, pers. comm., 2020). The natural hydrologic system, plants and ecology have been altered and significant native vegetation has been lost. Of about 240,000 ha of native vegetation in 1945, less than 90,000 ha remained by 1980, a reduction of 60%. Only three significant stands of native vegetation remained (Griffen and McCaskill 1986). This loss of 150,000 ha of habitat has contributed to the now long list of birds on the critically endangered list (Gillam and Urban 2014). The 1945 and 1980 maps in Appendix 2 are a clear illustration of the changes that occurred following the development of fertilisers capable of maintaining pastures and livestock on extremely impoverished soils.

Revegetation of watercourse 'reserves' using local native species is promoted in this manual. Local species are adapted to local conditions and provide habitat for native animals. However, the use of local species in revegetation work will only be successful if weeds are effectively controlled. Project planning is an essential part of any watercourse management program.

The River Torrens (Karrawirra Parri) offers many benefits to the community. People visit the river today for rest and reflection. Water creates a "calmness' when you are near it. Today the River Torrens is managed by many partners (State government agencies, Councils, Aboriginal Custodians, SA Water and Community groups) who have been working together for many decades towards a healthier river. Much has been achieved over the years and now the challenge is to maintain the effort to ensure a healthy future. To look at what the Department for Environment and other key groups are doing to support the River Torrens Recovery Project 2014-2020 visit the Green Adelaide website.

This Field Guide has been compiled as a practical resource for land managers wanting to restore and manage watercourses in their care. It contains management strategies and actions for healthy creek and rivers for the Mount Lofty Ranges region.

We have sought help, advice, and material from a range of sources. Acknowledgements and references are cited throughout the field guide in the relevant sections where appropriate. Please refer to Appendix 3 for cited and additional References, Resources and Contacts.

***The Torrens**: The River Torrens as I first saw it in the winter of 1837 was very pretty and picturesque: high and steep banks either side, closely covered with beautiful shrubs of all sorts; splendid gum trees also were growing on the banks and in the stream, overhanging the water, which was narrow and deep; small fish were plentiful and the strange creature, the platypus, was occasionally seen on its bank. But some stupid people cut away the shrubs and trees that held the banks together.*

Consequently, the soft alluvial soil fell away, and the river became broad and shallow and very ugly. After this the winter floods carried away the banks that remained, making it a most unsightly spot for many years and entailing an enormous expense to restore it to anything like beauty, though it will never be as picturesque as Nature made it.

Source: Proceedings of the Royal Geographical Society of Australasia (SA Branch) Vol. 5 pp. 73-74, 1901-1902

How to Use this Field Guide

The Upper River Torrens Landcare Group (URTLG) developed the 2003 revised Field Guide with the assistance of WaterCare. When using this guide please take into consideration that the AMLR NRM Board became the Hills and Fleurieu Landscape Board and Green Adelaide as of July 2020 and therefore name changes have occurred during this time of the revision and may do so into the future.

The guide offers practical management options, and along the way, the broader issue of sustainability is explored which has been developed for private landholders, land managers, practitioners and community and volunteer members. The previous editions were written for rural creeks and rivers from Nuriootpa to the southern part of the Landscape SA Murraylands and Riverland boundary, formerly the SA Murray-darling Basin region. The main focus is on the River Torrens but other creek and river systems within the Mount Lofty Ranges region, such as the Onkaparinga River, Brownhill Creek, First and Sixth Catchments, to name just a few, also hold relevance and some of the information provided can be applied to these waterways as well.

The writer (George King) for the 2003 edition was aided by the editorial committee (Bob Myers, Edgar Castle, Dr Neil Davis and Gerry Butler), in consultation with Geoffrey Bishop and Associates, Andrew Harris and Melanie Hibbert, and with support from the Steering Committee of Partner Representatives. The 2020 edition was reviewed and edited by Ellen Krahnert with support from Robert (Bob) Myers, Caroline Dorr, Kim Thompson, Robin Harding, Andrew Fairney, Sheree Bowman and other contributors mentioned in Acknowledgements. In addition, Ariel Printing was engaged by the URTLG to edit the 2003 version and to produce the 2020 online format.

The Field Guide is divided into **two main sections.**
Section One explains why watercourses should be managed separately from adjacent, sustainable productive land.

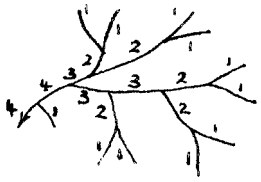
Section Two is a collection of data sheets outlining riparian biodiversity and practical management techniques.

The **Appendices** contain related habitat and management information and list additional resources and sources of information. Note that resources and contacts in this 2020 version may become out of date over time and if so, please contact your nearest landcare group or Landscape SA Board office for the most up-to-date information. However, it is anticipated the 2020 online version will be updated periodically.

The **Additional Resources** section will only be available in hardcopy version which can be used to manage and hold other resources that you may wish to collect.

Riparian environments are found on nearly all properties in the Mount Lofty Ranges, but individual management situations are unique. This Field Guide provides a variety of management techniques for different circumstances. Over three decades of landcare has generated much local practical experience, some of which has been drawn upon by the editors to produce this field guide for land managers. Our aim is to provide a general introduction to contemporary riparian management. Experiences will vary and change over time. The selection of datasheets explores topics such as biodiversity of native aquatic plants, frogs, fish and bats and birds, farm dams, bank stabilisation, watercourse fencing, soil and pasture establishment and management, pest animals, woody weed removal and revegetation. References to other resources are made throughout the Field Guide and are also listed in the Appendices.

Mount Lofty Ranges Catchment Areas



Stream Classification
(The Strahler System or Stream Order)

Unbranching channels originating at a source are known as first order streams. When two streams of the same order join together, a stream of that order plus 1 is formed (for example, two first order streams joining forms a second order stream). When two streams of different orders join together, the channel downstream retains the higher of the orders of the two streams (for example, if a second order and a third order stream join together, the downstream section will be a third order stream). The main channel of a river is only a fraction of stream orders that feed it.

What does stream order mean to you are a landholder? The bigger the stream, the more catchment area therefore, the more chance of high flows and disturbance. This can result in less chance of the landholder being able to control these effects and so managing for slower flows should be the aim.

In the first and second order stream the landscape typically consists of dams and so from here to the fourth order stream the magnitude of water increases. Fast flowing water tends to cause erosion; therefore, creeks can widen, and bank slumping can occur. Eighty percent of second order streams have changed since colonisation (C. Dorr, pers. comm., 2020). Prior to 1990, farm dams were commonly sited on first and second order watercourses. They overflowed in winter and put our increased magnitude of water on third and fourth orders. Slowing this water down within the stream orders is critical and a responsibility of land managers to minimise the potential impacts and to consider the implications if nothing is done – the financial and environmental costs. Our management objective should never be to keep a stream in the exact same form as we first found it but accept a certain amount of change and help to slow it down if these changes are happening very suddenly.

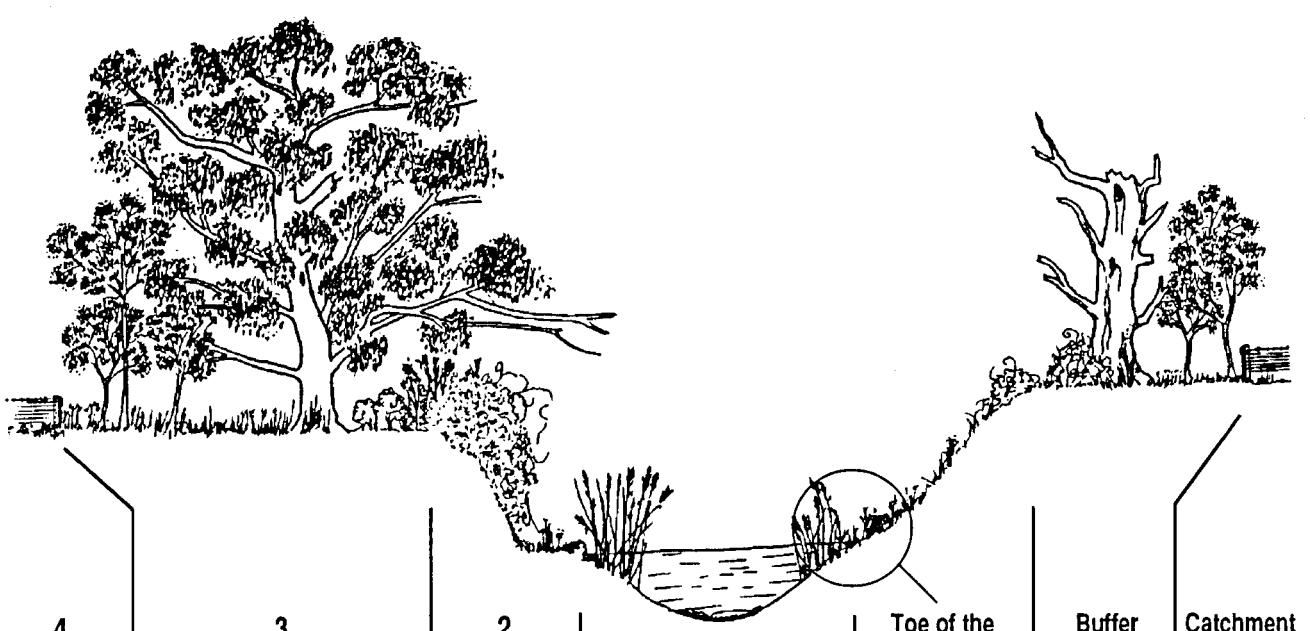
Our understanding of the effects of grazing and specifically overgrazing in these fragile environments, and the direct impacts of water quality are essential in developing management options for property owners. Building capacity and knowledge about stream classification and the importance and relevance of this system, provides the basis upon which individual land managers can effectively manage the collection of water on their property, which can include:

- Promoting a ‘big picture’ perspective for catchment management
- Visiting and increasing demonstration sites
- Accessing of water monitoring tools / methods i.e. How much water is moving through my property?

The Riparian Zone
(The watercourse, banks and alluvial flats)

A watercourse can be viewed as four differently functioning zones as seen in the cutaway profile below. Throughout this Field Guide you will be referred to them. Your focus on each will help your understanding of the total energy system of a watercourse; its discharge volumes and sediment loads; its interacting plants, animals and insects – a view of inputs and outputs. Local observations and an appreciation of the history of 'your' watercourse will then define your actions.

WATERCOURSE ZONES



4 Catchment zone

3 Buffer zone (extends to protective fencing)

Defines the outer edge dimensions of the watercourse.

Influences (+ and -)
Stock access/destabilisation
Sand/gravel extraction
Compaction
Laying back banks

Stabilisers
Grass, shrub and tree cover
Stock exclusion fencing

The filter system

2 Bank batter zone

1 Stream bed zone

Components
- width
- depth
- velocity
- slope
- sinuosity

Its condition is the linchpin of watercourse works.

Influences (+ and -)
Width
Movement of bed load
Degrading of the bed
Headward erosion/ deepening
Gradient / bed slope
Meanders

Control points:
roads, bridge supports, fords, weirs, rock reefs, riffles, snags.

Toe of the batter

The toe of the batter is the security system of the water-course.

Three possible erosion processes:
- loss of soil from the face of the toe
- slumping
- scouring (undercutting)

Stabilisers:
- Sedges, rushes, reeds and grasses.
- Alignment fences / groynes / no stock

Buffer zone

Catchment zone

The filter system – processes sediments of chemicals, manures and soils from run-off.