Water

Use this section to find out more about water, catchments and rivers in the Central Tablelands. Learn about the streams and riparian areas, groundwater and geology, and what our water is suitable for.

What is in this section?

This section contains general information about water and water resources in the Central Tablelands Land care district. It includes information about the catchments of our streams and rivers, our riparian and wetland areas, and our groundwater and related geology. We look at the qualities and capabilities of our water and how it should be protected.

Water Snapshot – Central Tablelands

Our waterways

- ***The broad range of geology and geography in our district has resulted in a great variation in types of waterways, ranging from fast-running upland streams to wetlands, rivers and dams.***
- ***Environmental services are provided by the water in our streams and rivers, and by the many aquatic animals and plants that live in them.***
- ***Where our waterways are healthy there is an abundance of fauna (invertebrate and vertebrate) and of aquatic flora.***

Human Impacts

- ***Our waterways have been altered significantly by urban and agricultural development.***
- ***Erosion leading to siltation and sedimentation of creeks and rivers, pollution by excess nutrients and toxicants has resulted in a decrease in water quality.***
- ***Physical alteration of rivers and creeks by construction of reservoirs and dams, and the extraction of surface and ground water for human, agricultural, industrial and mining uses, has led to the reduction and modification of river flows and water availability. This affects aquatic habitats and the leads to a loss of aquatic and riparian diversity.***

Management Options

- ***Management options that are necessary for the restoration and enhancement of our waterways and reservoirs include:***
  - ***Rectification of soil erosion***
  - ***Changes in agricultural practices including cropping practices, overstocking and overfertilisation***
  - ***Excluding stock from river banks and lakeshores***
  - ***Revegetating the riparian zone***
  - ***Establishment of deep rooted perennial and native pastures***
  - ***Planting recharge areas where there is evidence of dryland salinity***
  - ***Reforestation and rehabilitation of woodlands***
  - ***Preventing pollution from point sources***

Contents

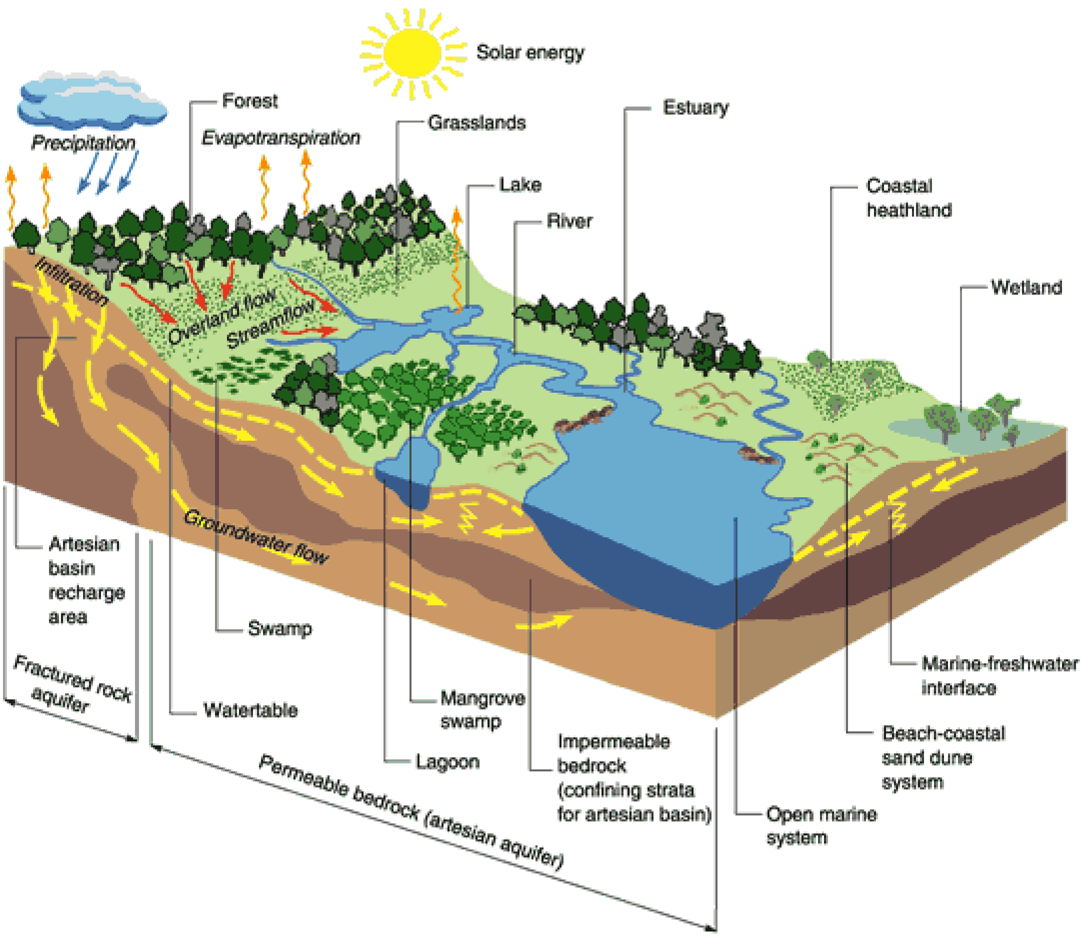
1 Water in the Environment

The hydrologic cycle

The amount of water in the environment at any one time is always constant. It is distributed among clouds, hail, steam, snow and rain. It accumulates in large bodies such as wetlands, ground water, streams, rivers, estuaries, oceans and ice floes. It also exists within living organisms.

Water cycles continuously between the earth's surface and the atmosphere. High in the atmosphere water vapour becomes cold and by **condensation** forms into tiny droplets which cluster together to form clouds. These water droplets eventually fall as precipitation – rain, hail or snow – and the water is returned to the land and ocean. The heat of the sun returns water from the earth's surface to the atmosphere through **evaporation.** This is known as the **water or hydrologic cycle** (Figure 8.1).

Figure 8.1: The Hydrologic Cycle



Source:
Derived from HDLWC 2000

In the natural environment, precipitation either falls directly onto the ground or is intercepted by leaves, branches and trunks of vegetation, eventually moving to the ground. Some of the precipitation that falls directly on land runs into rivers, lakes or oceans. Other water reaching the ground is absorbed by leaf litter or stored in depressions and cracks. Water from precipitation also filters into the upper layer of soil. If there is more precipitation than the soil can absorb, it runs off the surface (overland flow or run-off) or enters the upper soil layers where it moves laterally.

Water normally leaves the upper layers of the soil through **transpiration** by trees and other vegetation or by **percolation** into even deeper ground layers. Water that percolates into **groundwater** reserves may take months, years or even hundreds of years to pass back to the surface. Groundwater reserves play an important role in sustaining flows in streams between surface recharge events (such as rainfall) and are the main source of stream flow during dry periods.

Geological features, such as land and water formations, have a large influence on the hydrologic cycle. For example, when moisture filled air is forced upwards over a mountain range, the vapour cools and usually falls as rain, hail or snow on the windward side of the range.

Global Distribution of Water

The Earth has an abundant supply of water which sets us apart from any other planet in the solar system.

It is estimated that the Earth's surface is covered by 75% of water. As well as surface water such as oceans, lakes and rivers water also is found in the atmosphere in the form of vapour and in groundwater systems. The following diagram indicates the distribution of water on earth.

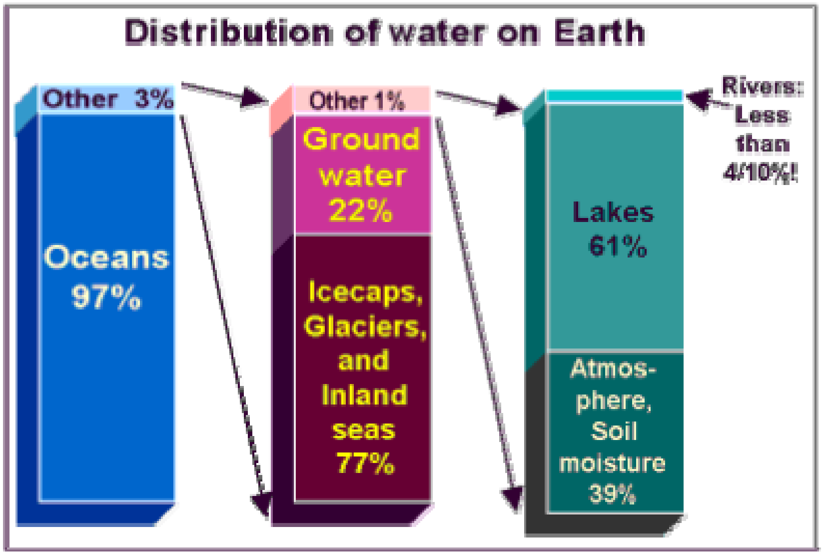


Figure 8.2: Distribution of water on Earth

The above figure indicates where the world's water is located. The first bar is the total amount of water on the Earth's surface, which is made up of 97% ocean water and only three percent of other water. That three percent is represented in the second column. The final 1% of water, in the third column, is the fresh water cycle we depend upon. It makes up our rivers, lakes, soil and atmospheric moisture.

Although river systems contain the least amount of water - approximately 0.0001% of the total on Earth - it is the water supply most relied upon throughout the world. The greatest supply of freshwater on earth is by far icecaps and glaciers.

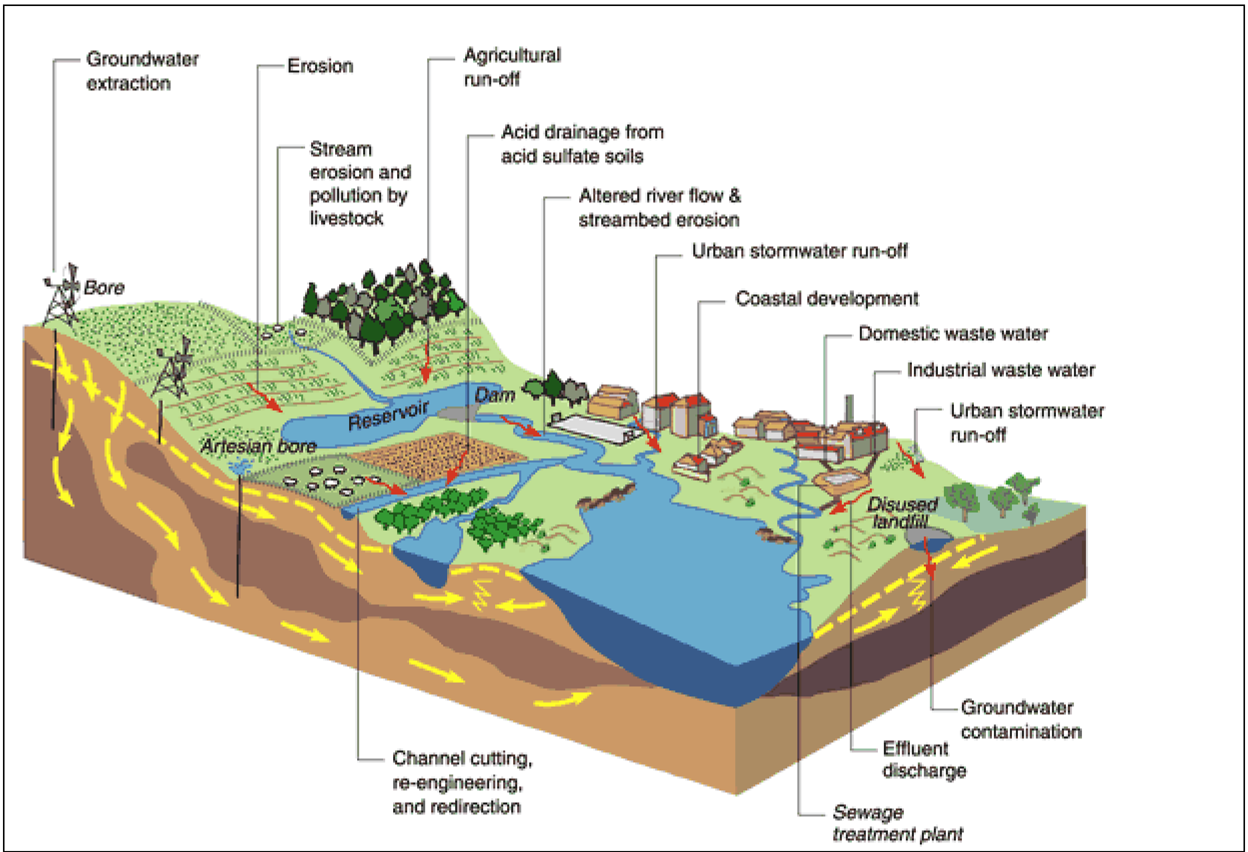
Rainfall distribution is variable throughout the world.

Human Impact on the hydrologic cycle

Human activities can have an important effect on the hydrologic cycle (Figure 8.3). Land use has an impact on evaporation rates, the amount of water infiltrating to ground water, the rate of run-off and erosion, and the quality of water reaching water bodies.

The amount of water absorbed into the ground and the quantity and purity of run-off vary with different soil and vegetation types. Cities and roads contain less open ground to absorb water, so run-off is greater in these areas.

Figure 8.3: General relationships between the natural hydrologic system and human land use.



Water in the Australian Environment

Europeans arriving in Australia two centuries ago found a continent very different from their homeland. The relatively benign European climate contrasted sharply with the Australian one where rainfall and runoff are often variable and erratic. In the north, where tropical and sub-tropical climates demonstrate high temperatures and **evapotranspiration** throughout the year, runoff depends on excess precipitation and, except for the short rainy season, does not occur at all.

In the more temperate southern regions there are **seasonal variations** in precipitation and evapotranspiration associated with variability in river flows, usually with low flows in summer and peak flows in winter and spring. Australia is also distinguished by having significant areas of low rainfall with a third of the continent considered arid and another third semi-arid. In addition, by world standards annual precipitation is extremely variable. The annual average precipitation for Australia is 420 mm and only 12 per cent of this represents run-off. On a world scale Australia has the lowest runoff (1%) of any continent, including Antarctica.

Permanent rivers are few and small by world standards and natural lakes are also poorly represented. The historical response to this paucity of water has been to construct **dams** to store water for human consumption, irrigation, hydroelectricity and, most importantly, as a buffer against the ravages of the periodic droughts that beset Australia.

Agriculture and land clearing have radiated around these dams, affecting **runoff**, and the removal of vegetation has exacerbated problems associated with **land degradation.**

During the twentieth century, fifty per cent of water has been stored in very large structures, while many quite small dams (<5 ML) have proliferated throughout the rural landscape and account for the remaining water storage. The result is that **Australia has the highest per capita water storage in the world**.

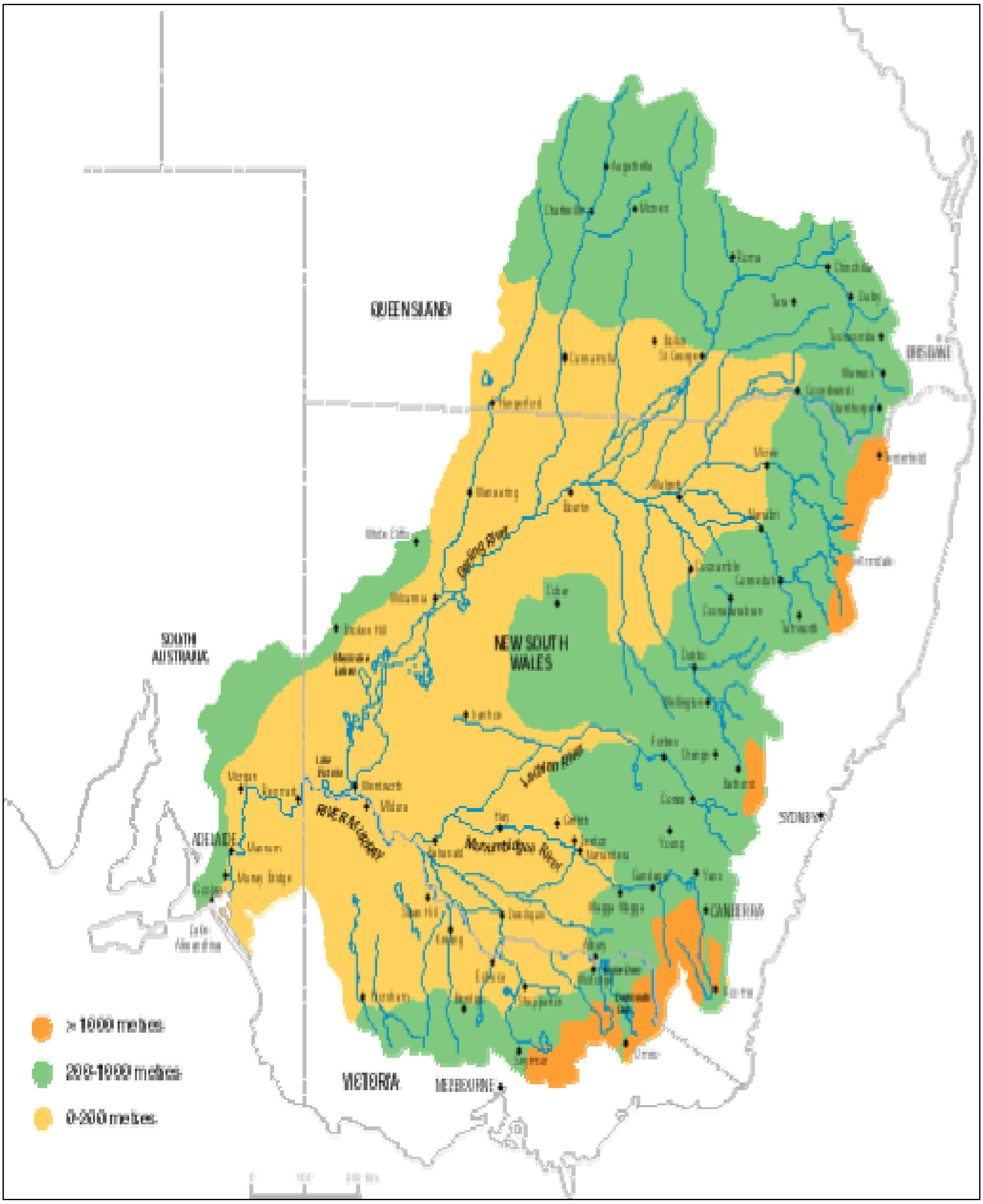
Until the last couple of decades the approach to water storage has been principally one of engineering but, as **water quality problems** have manifested themselves (for example, salinity, excessive nutrients, blue-green algae blooms), the emphasis has shifted to understanding aquatic ecology to interpret the causes of declining water quality.

The Murray-Darling Basin

The two largest river systems in Australia are the **Murray River** and the **Darling River**. The catchment region for these river systems is called the **Murray-Darling Basin** and is the largest surface water supply in eastern Australia.

The Murray Darling Basin starts in Queensland and extends to South Australia and covers an area of 1,061,469 square km, equivalent to 14% of the total area of Australia. The Basin extends 1250 km from its most easterly point near Warwick to its most westerly point north-west of Goolwa. North-south the distance is 1365 km from the source of the Warrego River to the headwaters of the Goulburn River.

Figure 8.4: The Murray-Darling Basin



The Murray-Darling Basin lies west of the Great Dividing Range but, at its limits, includes Australia's highest country, with Mount Kosciusko rising to 2228 metres. Most of the Basin however is extensive plains and low undulating areas, mostly below 200 metres above sea level.

The Darling (2740 kms), the Murray (2530 km) and the Murrumbidgee (1690 km) are Australia's longest rivers. NSW contains just over half of the Basin and, within NSW, it comprises 75% of the state's area. It includes the eight major rivers that flow westward or toward the inland and that meander over wide, flat plains. These lose a large amount of water into the soil (absorption) or the air (evaporation). This usually occurs as a result of floods, when large quantities of water flow over the land, exposing an increased surface area to warmth, dry air and winds. It is estimated that there are more than 30,000 wetlands in the Basin, many of which are now endangered.

The Basin is Australia's most important **agricultural region**, accounting for 41% of the value of agricultural production. Around 70% of all water used for agriculture is used by irrigation in the Basin. In addition manufacturing, mining industries and power stations use considerable quantities of water. The human populations in the townships, villages and rural properties (approximately 2 million people) within the Basin also use water for domestic and stock purposes.

The Murray Darling Basin is made up of 26 different catchments and subcatchments. A **catchment** is a designated area where water drains to a common river or water source. To use an analogy, a catchment can be compared to the roof of a house, where all the water runs into a gutter system and drains directly into a tank. The area of this catchment would be the roof of the house and the common water source would be the tank.

Catchments are very complex structures consisting of topography, rainfall, soil types, hydrology, vegetation, biodiversity, agricultural practices, population, communities and much more. Much of this information is contained in other chapters in this toolkit.

Water in the Central Tablelands

This Toolkit concerns the **Central Tablelands** area of the Murray-Darling Basin. Within the Central Tablelands lie parts of the Central West catchment area and the Lachlan catchment area.

The **Central West catchment** includes the Castlereagh, Bogan and Macquarie River valleys and covers and area of 92,000 square kilometres. It borders with the Barwon catchments to the north and west, the Lachlan River catchment to the couth and the Sydney/Shoalhaven Basin to the east. Major towns within the Catchment include Orange, Bathurst, Dubbo, Mudgee, Nyngan and Wellington. The population of the catchment area is 240,000 people.

Within the Central Tablelands the **Macquarie River** is the major river draining into the Central West catchment. About two thirds of the Central Tablelands area lies within the catchment for the Macquarie River (see Figure 8.5) and comprises catchments of the Bell River, Lewis Ponds Creek, Winburndale Rivulet, Turon River, Fish River, Campbells River and Evans-Charlotte Vale-Eglinton catchments.

Figure 8.5: Subcatchments of the Central Tablelands

The Macquarie River is formed at the confluence of the Campbells and Fish Rivers, which drain a high plateau near Oberon. Here the elevations are high (900 to 1000 meters above sea level) and drop down gradually as the river flows northwards through steep gorge areas in the Hill End area until it is impounded by the Burrendong Dam upstream of Wellington just outside of the Central Tablelands area. The Central Tablelands is characterised by fast to moderately flowing streams with sandy and pebbly beds, steep, densely vegetated ranges to extensively cleared grazing lands.

The remaining one third of the Central Tablelands area lies within the **Lachlan River** catchment. The Lachlan catchment is bordered by the Macquarie and Bogan catchment to the north and Darling to the west, Murrumbidgee to the south and the Sydney-Shoalhaven Basin to the east. It rises near Gunning and ends in the Great Cumbung Swamp near Oxley in the west. The river is 1450 km in length. Major tributaries include the Abercrombie, Boorowa, Belubula and Crookwell Rivers. The Lachlan catchment has an area of approximately 84,700 square kilometres with a population in excess of 100,000 people. Major towns include Crookwell, Boorowa, Cowra, Blayney, Eugowra, Grenfell, Forbes, Condolbolin and Hillston.

Subcatchments within the Central Tablelands which are part of the Lachlan are the Belubula River, the Abercrombie River and Mandagery Creek (Figure 8.5).

2 Our water body systems

The interconnectedness of water bodies

The Central Tablelands has a wide variety of water-body types. Water moves through the environment in lakes (dams and reservoirs), rivers and streams, ground water and wetlands. Ultimately how water bodies link to larger rivers and ultimately empty into the sea via the Murray and Darling Rivers.

The assemblages of animals, plants and other organisms in aquatic ecosystems are dictated by and specifically adapted to water composition, temperature and flow. Water provides the medium for most aquatic animals and plants to maintain gas exchange, obtain food, disperse their larvae or seeds, and remove metabolic wastes. It also provides a transport system for aquatic organisms to disperse and to recolonise disturbed areas.

Rivers

Rivers (including floodplains) can generally be divided into two categories: short, relatively high-gradient coastal streams, and long, low-gradient inland rivers. Rivers in the Central Tablelands fall within the second category.

Flow of rivers in NSW is often unpredictable. Streams and creeks are sometimes systems that flow for a large part of the year and only after heavy rainfall and floods (ephemeral). In the Central Tablelands, as in other areas of southern Australia, generally have higher flows in winter and spring, and lower flows in summer.

Rivers rely on floods to deliver the organic material and nutrients required to keep their systems healthy. The flood-assisted interaction between river channels and floodplains provides this material.

West flowing rivers generally discharge a total of 10.5 million megalitres each year. Many dams and weirs substantially alter the natural flow of these rivers – major government-owned dams control from 45% to 80% of annual average flow, depending on the river. Flow is further altered by large urban water-supply dams and dams for power generation.

Lakes

Inland lakes include still-water bodies of many types. The **billabong** is the most common type of lake in NSW, particularly inland. **Ephemeral lakes and permanent pools** associated with temporary rivers are also common.

Billabongs – pools associated with a river which have become isolated from the main channel, either in the beds of temporary streams or formed at the bend of in a river – tend to be rich in plant nutrients, and because of the rapid turnover of nutrients, can support a diversity of aquatic life.

Billabongs could be considered the **"biological storehouses"** of the river-floodplain system. Dormant microscopic life in the sediment of temporary billabongs is awakened within hours of flooding.

Riparian zone

The riparian zone is the area comprising the bank and edge of water bodies. This zone forms a critical link between land and water environments. This zone plays and important role in the maintenance of productive and stable catchments.

Vegetation growing alongside rivers and creeks is known as riparian vegetation and is the most important component of the riparian zone. It includes emergent aquatic and semi-aquatic plants and over- and understorey vegetation. This vegetation stabilises the river banks, stops erosion and subsequent saltation, and contributes organic matter to the water body. This vegetated strip also partially filters pollutants such as soil, pesticides and fertiliser from run-off, and prevents them being carried to the waterway.

Rivers are dynamic habitats, and changes in the size, shape and characteristics of the channel will occur even under natural conditions. However, these changes are exacerbated by the removal of suitable vegetative cover from the riparian zone. The roots of the trees bind and stabilise the soil, minimise saltation, provide shelter, help to retain the general channel shape, including such critical channel features as pools, riffles and backwaters which provide important habitat for many species.

The zone may reduce peak flows during floods by lowering surface-water flow velocity and increasing infiltration, making the storage capacity of the catchment greater.

Wetlands

A **wetland is any area temporarily or permanently waterlogged or inundated land**, whether natural or artificial. It includes waster that is standing or running, ranging from fresh to saline, which has an influence on the biota and ecological processes occurring at any time.

Natural wetlands perform a number of important biochemical and physical functions for groundwater and surface-water habitats. They serve as:

- flow retention basins, by naturally regulating flow in general, and stabilising peak flows from floods;
- natural flood-mitigation devices, by acting as "sponges";
- "filters" that can improve water quality and increase the productivity of associated aquatic and terrestrial ecosystems by trapping suspended solids resulting from variable flows and natural or human- or livestock-induced erosion;
- nutrients traps, by capturing and converting nitrogen and phosphorus in biochemical reactions in their soils and plants;
- perennial habitats for a variety of micro- and macrofauna, and temporary habitats and important corridors for migratory species of macrofauna;
- sources of groundwater recharge;
- providers of aesthetic qualities consistent with current positive attitudes to environmental issues in the community.

Groundwater

Groundwater is all water that occurs below the land surface in aquifers. **Aquifers** occur in geological formations (sediments and rocks) that are sufficiently permeable to allow water to infiltrate, move through and leave.

Groundwater filters down from the surface, seeps slowly for numerous kilometres and many years and eventually emerges naturally as valley streams or rivers, or as mound springs that force their way to the surface.

In the western two-thirds of NSW there are two groundwater basins: the Great Artesian Basin in the north and the Murray Basin in the south.

All surface water bodies, including lakes, wetlands, swamps, rivers, creeks, drains and canals are connected to geological materials saturated with groundwater. Lakes and wetlands provide “windows” to groundwater.

Recharge of water into groundwater systems in a catchment can be localised (direct recharge from streams and lakes) or diffuse (under crops, pastures and trees). **Discharge** from groundwater systems occurs as subsurface flow (underground water movement) from the catchment and surface seepage (streams, rivers, springs, tree root areas, land evaporation).

If groundwater recharge exceeds discharge, the watertable rises. Recharge and discharge can occur in the same location. Many of the aquifers in NSW have low rates of natural recharge compared with the volumes of groundwater stored and must be carefully managed.

In NSW, much of the groundwater is naturally **saline**. Groundwaters are vulnerable to contamination from land and chemical use, and if an aquifer is polluted it is extremely difficult and expensive to monitor and restore it.

Aquatic sediments

Although **sediments** are obviously not a water body, they are critically important as aquatic habitats because of their large extent, and the fact that they contain a complex of heterogeneous mixture of gaseous, liquid, solid, inorganic, organic and living components.

These components are derived from various sources, and are controlled by numerous physical, chemical and biological variables. Depending on the level of disturbance to sediments, they can be both a source and a sink of nutrients and, if contaminated, have a toxic effect on the overlying and downstream aquatic systems.

Ultimately, all sediments in freshwater environments are derived from erosion of the catchment. This can occur via surface erosion, and by mass movement of sediments by gravity, including landslides, soil creep and slumping. Clearing for agriculture has contributed large amounts of sand to some rivers, altering their channel shape and streambed.

The natural or human-altered variability of Australia’s streams also affects sediment properties, which in turn affect the quality of overlying water when previously dry waterholes or streams refill. Drought or dry periods cause many fundamental changes to sediment properties, in turn altering nutrient dynamics after re-inundation.

Regulation of the natural system

To deal with extremely variable flow and periods of water shortage, the amount and timing of flow in rivers has been modified or regulated. Large dams and weirs have been built to capture water when it is readily available and store it for later use. River flows have been regulated to supply water for irrigation, urban development, industrial uses and hydro-electric power generation.

In NSW water is held in:

- artificial lakes created by dams and weirs built across rivers;
- natural lakes linked to each other or to a nearby river by channels;
- lakes that have been enlarged or reinforced to take greater quantities.

Water bodies are also regulated for non-extractive purposes, such as construction of drains through wetlands for flood mitigation.

There are several thousand dams and weirs on rivers throughout NSW. River flows below these dams have been regulated to supply water mostly for irrigation. These rivers are known as regulated rivers.

Unregulated rivers are those that do no have large government-owned storages that regulate downstream flows. However, there are several thousand dams and weirs operated by water management authorities and private individuals on both regulated and unregulated rivers, that do not regulate downstream flows in a controlled manner.

3 The value of water

Ecosystem health

An adequate flow of good-quality water is fundamental to the support of ecosystem health. Conversely, it is also true that healthy ecosystems generate and maintain adequate flows of good-quality water. Within ecosystems there is an interdependence and an interaction between living organisms and their immediate physical, chemical and biological environments.

Within an aquatic ecosystem the relationship between physical processes (e.g. the quality, quantity and movement of water, sedimentation, processes within sediments and water chemistry) and biological processes (e.g. habitat use, reproduction, competition for resources, grazing and predation) is extraordinarily complex.

Consider some of the main links that can occur within a typical creek or river in the Central Tablelands.

Nutrients enter the system via run-off from catchments. Once nutrients are in the system they can be taken up directly by plants or animals, or attach to particles and settle to the creek bed and become incorporated into the sediments; or they can be borne further downstream where they may be similarly processed.

Nutrients in sediments may be used directly by rooted aquatic plants or they may be processed within the sediments by chemical and biological reactions for release back into the water. Nutrients in the water are lost by direct removal of plants and animals, or by the production of nitrogen gas in sediments (denitrification). A web of interactions between plants and animals acts to maintain populations of phytoplankton, zooplankton and carnivores such as some fish.

Disruption occurs when, for example, excessive inputs of nutrients lead to plant production in excess of grazers' ability to consume it. Disruptions to grazers or carnivores result in a changed community structure or can block key biochemical processes (such as denitrification).

Human Uses

Human uses, or values, of water include drinking, recreation, domestic garden and stock watering, agricultural irrigation and a wide variety of industrial uses.

A secure and safe supply of drinking water is fundamental to the maintenance of public health and guideline criteria for quality are necessarily high. The costs associated with treating poor-quality water to comply with these guidelines can be very expensive.

Drinking water in most areas of NSW (including the Central Tablelands) rely on drinking water extracted from the fresh surface waters of catchments which is either taken directly from a river or captured in water storages such as dams before treatment and distribution. A smaller portion of the population relies on groundwater extraction and a substantial number of people living in the rural areas rely on rain water which is collected into tanks and used on site. Dams used to store drinking water in the Central Tablelands include Chifley Dam (Bathurst), Sumer Dam (Orange), Lake Lyell (Lithgow), Lake Oberon (Oberon) and Lake Rowlands (Blayney, Millthorpe and villages).

As development and increasing urbanisation of the population within the Central Tablelands there will be increasing pressure to provide additional water of suitable quality for drinking. This will inevitably lead to the production of greater amounts of waste water (which require treatment and are a potential source of recycled water). Extensive infrastructure to facilitate the uses of water by an increasing population will also need to be expanded. Most importantly there is an absolute need to protect the catchments and aquifers that provide our water.

Industry and mining use considerable quantities of water for their various activities. Coal fired power stations, for instance, are water intensive. Gold mining, with several large mines in the Central Tablelands, also have a great requirement for water in their operations. Quality requirements vary for different industries, and many premises treat water before or after use (before it leaves the site). EPA (Environmental Protection Authority) requirements for treatment of contaminated water are strict in an attempt to protect the receiving environment from poor-quality water.

In our community great value is placed on the quality of recreational waters and their suitability for activities such as swimming, surfing and fishing. Primary contact recreation includes such activities as swimming whereas secondary contact recreation includes boating and fishing where there is less frequent body contact with water and there is little chance of swallowing water.

When testing water for either drinking or recreation the following parameters are important:

- bacterial water quality using faecal coliform and enterococci bacteria as indicatory organisms;
- the presence of nuisance organisms, such as algae;
- visual clarity and colour;
- acidity or alkalinity (pH);
- a visual assessment of surface films;
- temperature.

Agriculture

Agricultural water supplies (for irrigated crops in particular) are required at certain times of the year, at specific levels of extraction. Much river regulation in western NSW has occurred to accommodate irrigated agriculture.

For livestock to remain productive, water must meet certain guideline criteria. Good-quality water is also essential for irrigating fruit (including grapes) and vegetable crops. Poor-quality water can lead to yield losses and disease, inferior product size and quality, and sprinkler blockages or damage to irrigation equipment.

In the Central Tablelands most of the water for irrigation comes from the Macquarie River and its tributaries and from Carcoar Dam on the Belubula River. Irrigated water is used in the Central Tablelands for vegetable, fruit, wine and berry production, and for the production of pasture and lucerne hay. There are limited dairy and pig industries within the Central Tablelands which also require large quantities of good-quality water. Other livestock industries (sheep, cattle, horses, goats) usually obtain water from rivers, creeks, or farm dams which capture water from run-off.

The principal factors affecting water quality for land-based agricultural uses include:

- toxic elements and compounds such as iron, chemical residues and pesticides;
- salinity;
- acidity or alkalinity (pH);
- excessive algal and bacterial growth;
- turbidity.

Another form of food production requiring good-quality water is aquaculture (the cultivation of aquatic organisms including fish, molluscs and crustaceans for human consumption). Very little aquaculture occurs in the Central Tablelands.

4 Water Quality

What is water quality?

Water pollution occurs when rivers and creeks become contaminated or polluted by a range of material from adjacent land and settlements. Examples of contaminants are soil particles (sediment), nutrients such as phosphorus and nitrogen, salt, litter, chemicals and microbes. In rural Australia, eroding soil and its nutrients, and in some cases salt, are the most important and widespread causes of reduced water quality.

Sediment and some **nutrients** (particularly phosphorus) are carried to streams in the overland flow of water. This flow can range from minute threads, to broad sheets of water and to concentrated flow from dips in the landscape. Nutrients, salt, and other materials (such as dissolved organic carbon) can also move through the soil in underground lateral flow and contaminate water.

The clearing of catchments for agricultural land, soil disturbance during forestry operations or urban development, and bare areas such as gravel roads and stock paths, have led to substantial increases in the amounts of sediment (gravel, sand, silt and clay) entering our creeks and rivers.

This sediment can contaminate human and stock water supplies, smother breeding sites for fish and other in-stream animals, and deprive these animals of the deep pools which are a vital refuge in dry seasons and prolonged droughts. Whatever the specific impact, the end result is likely to be severely decreased water supply.

Water pollution sources fall into two categories: point sources and non-point or diffuse sources.

Point sources include sewage treatment plants, industrial discharge points, dams and intensive agriculture such as piggeries, feed lots and dairies.

Non-point sources include erosion and run-off from grazing and cultivated land after rain, which collects pollutants over a wide areas and, to a lesser extent, contributions of pollutants from the atmosphere by direct deposition or via rainfall. Other sources include tailwater from irrigation areas and increasing riverbank and streambank erosion arising from the removal of vegetation.

Factors which can affect the quality of water in run-off include:

- the steepness of the terrain;
- the texture and erodibility of the soil;
- the amount of disturbance to the soil;
- the infiltration capacity of the soil;
- vegetation cover;
- foreign substances on or in soils, or on the surface of sealed areas (e.g. oil on roads).

The nature and degree of the impact of both sources of pollution on aquatic systems depend on several factors:

- the type of pollutant;
- the volume and load of substances;
- the frequency of input;
- the volume, flow and resilience of the waterway at both the discharge point (for point sources) and downstream.

Nutrients and eutrophication

Nutrients, in small amounts, are necessary for plant growth and are important in the natural food chain. They move through aquatic ecosystems attached to soil particles, dissolved in water, or in gaseous form during high flows.

However, nutrients can become a problem when present in excess. This results in **eutrophication** of waterways, that is, the over-enrichment of a body of water with nutrients leading to excessive growth of organisms and decreased oxygen concentration.

The two nutrients most influential in aquatic systems are **phosphorus** and **nitrogen.** In unpolluted natural ecosystems phosphorus and nitrogen supplies are often less available than other nutrients and thus “limit” growth of organisms. There is therefore a dynamic balance between nutrients and organisms which allows a significant biodiversity of organisms to develop.

When excessive concentrations of phosphorus and nitrogen enter the system they no longer limit growth. These conditions, together with other factors such as adequate light, low turbidity, suitable temperatures, a lack of turbulence and a sufficiently long residence time of water can lead to a rapid increase in certain organisms, such as algae, which come to dominant the system to the detriment of other less competitive organisms. The resultant **algal bloom** uses up the oxygen in the water and the de-oxygenated conditions can also result in the death of other organisms. Some algae, such as blue-green algae, can also release toxins which may be harmful to other animals and to humans.

Turbidity

Turbidity is a measure of **water clarity.** It is an indicator of the presence of suspended solids such as silt and clay, decaying organic matter and, to a lesser extent, phytoplankton and zooplankton.

High turbidity reduces light penetration and visibility, which in turn limits plant growth (including algal blooms), fish movements, and the ability of predatory fish and birds to see their prey. When sediments from turbid water settle, they may smother organisms living on the bottom of waterways and alter aquatic habitats.

Turbidity is affected by **river flows** and **run-off** from land. Particular problems may arise from the erosion of dispersed clays, which are common in NSW. Although some suspended mater in waterways may come from natural sources (e.g. natural soil and riverbank erosion) most turbidity comes from human impacts. Examples include:

- large volumes of water flowing over extensively paved surfaces of urban areas;
- erosion of streambanks caused by poor agricultural practices when ploughing, excessive stock grazing, and unrestricted stock access to streams;
- removal of riparian vegetation, which results in reduced bank stability, decreased run-off filtration, and hence decreased removal of coarse sediment;
- construction of forestry roads and reduced vegetation cover after harvesting and burning;
- the introduced carp (*Cyprinus carpio*), whose characteristic feeding behaviour re-suspends sediments and disturbs aquatic plants.

Salinity

Salt differs from other pollutants in that it is generally derived from sources within the natural environment. Salts are present in rock and soil and are leached out by water to enter streams by either above-ground run-off or subsurface drainage.

River salinity is a collection of various dissolved salts in a given volume of water. These may include sodium, calcium, magnesium, sulphate, chloride, carbonate and bicarbonate. River waters in NSW demonstrate a wide range of concentrations of these different salts because of the significant influence of different geology and soils, geological structures and the extent to which they are influenced by inflows of saline ground water.

Increased river salinity in NSW is due primarily to **dryland salinity**. This has been caused by the replacement of deep-rooted native perennial vegetation with shallow-rooted annual crops and pasture. These shallow-rooted plants make less efficient use of water in the soil, allowing the watertable to rise. Salts that have accumulated in the subsoil over thousands of years are carried by the excess ground water at or near the soil surface where they are concentrated by evaporation or discharged into drainage systems and surface water bodies.

Irrigation salinity, by contrast is caused by over-application of irrigation water to crops and pastures, causing usually only localised rise in watertables and consequent waterlogging and salinisation of the irrigated crops. Of the two dryland salinity poses the greater environmental and economic concern.

Excessive salinity is a major threat to both surface and groundwater resources in NSW. Increasing salt concentrations can be observed in many streams and rivers, particularly in the southern half of the Murray-Darling Basin which is where the Central Tablelands is situated. Rising groundwater in the basin leads to saline discharges to streams and increasing salt availability at the soil surface. These changes have significant impacts on aquatic ecosystems and all extractive users.

It is recognised that salinity problems can take over 100 years to emerge, and it may take 200-300 years or more to reach a new equilibrium. At that time ground water will stop rising and the spread of soil salinity will cease.

Soil salinity poses a threat to the health and productivity of many catchments and threatens rural and urban communities that are affected by it. The impacts of salinity include damage to roads and urban infrastructure, poor water quality, reduced biodiversity and loss of agricultural production. Rising watertables and salinity provide poor growing conditions for native vegetation and this in turns results in loss of habitat for many important animal species.

Waterlogging and salinity can prevent agricultural crops from growing. High levels of salinity in rivers may also limit water use for irrigation, stock watering and domestic water supplies.

The chemistry of water – a Central Tablelands case study

The chemical and physical properties of water in creeks and rivers is greatly influenced by the geology, geography and topography of the catchment, the use and management of the adjacent land, the rainfall and consequent flows of run-off, the degree regulation of the waterway, seasons and temperatures, and may other inter-related factors.

The following table (Table 8.1) is presented to illustrate the amount of variation that can be found in both rivers and reservoirs. This comes from a study that was carried out comparing the chemistry of Carcoar Dam and Lake Rowlands, and their catchments (Watts, 2000). Both reservoirs are situated in the Central Tablelands near Blayney. Carcoar Dam lies on the Belubula River, while Lake Rowlands is a reservoir on Coombing Creek, a tributary of the Belubula River. The catchment of Carcoar Dam, while largely rural, is greatly influenced by urban and industrial pollution from the township of Blayney whereas the catchment of Lake Rowlands is almost exclusively rural. The catchments are in close proximity, but quite separate, and share similar sizes, climate, geology and agricultural practices.

Table 8.1

Characteristic (range of median values)	Carcoar Dam	Carcoar Dam catchment – Belubula River and tributaries *	Lake Rowlands	Lake Rowlands catchment – Coombing Creek and tributaries
pH	8.00 – 8.50	7.35 – 7.93	7.22 – 8.00	6.70 – 7.45
Conductivity µS/cm (!)	395 – 467	224 – 953	180 – 200	50 – 260
Dissolved Oxygen mg/l	7.45 – 10.45	4.60 – 10.60	4.15 – 9.10	-
Turbidity NTU	0.40 – 2.20	0.60 – 120.00	0.35 – 0.70	0.60 – 10.00
Ammonia-Nitrogen mg/l	0.102 – 0.261	0.047 – 0.790	0.060 – 0.263	0.040 – 0.100
Nitrate-Nitrogen mg/l	0.085 – 0.278	0.025 – 2.935	0.120 – 0.269	0.080 – 0.367
Total Nitrogen mg/l	1.033 – 1.500	1.00 – 10.40	0.671 – 1.338	0.430 – 1.200
Soluble phosphorus mg/l	0.016 – 0.086	0.017 – 1.033	0.010 – 0.021	0.013 – 0.034
Total phosphorus mg/l	0.059 – 0.216	0.090 – 2.150	0.057 – 0.095	0.026 – 0.068
Calcium mg/l	11.75 – 16.27	8.13 – 26.02	10.65 – 12.00	1.65 – 13.00
Magnesium mg/l	19.19 – 20.68	8.66 – 49.26	7.03 – 7.69	0.61 – 11.17
Sodium mg/l	35.15 – 40.78	8.52 – 128.66	14.20 – 16.76	3.16 – 25.38
Potassium mg/l	4.21 – 5.24	1.32 – 14.83	1.27 – 1.60	0.38 – 3.07
Sulphate mg/l	12.87 – 21.45	3.54 – 116.16	4.23 – 5.64	0.90 – 12.36
Iron mg/l	bdl	bdl – 0.31 #	bdl	bdl – 1.12
Copper mg/l	bdl – 0.01	bdl – 0.50	0.01 – 0.20	bdl – 0.51
Manganese	bdl – 0.005	0.01 – 0.87	bdl – 0.01	bdl – 0.22
Zinc mg/l	-	bdl – 0.21	-	bdl – 0.37

(!) Conductivity measurements can be taken as an indication of levels of salinity.

* Carcoar Catchment: High values represent those generally found in vicinity of the old abbatoirs at Blayney, while the lowest levels were found at the top end of the catchment.
# bdl = below detectable limits

Toxicants

Toxicants describe chemical contaminants which have the potential to exert toxic effects on biological processes if present in sufficient quantities. Key sources of toxic contaminants in the groundwater and surface waters of the Central Tablelands include agriculture and forestry, mining, urban stormwater, sewage treatment plants, industry, chemical spills, and contaminated sites.

The main toxicants from **agriculture and forestry** include pesticides and pathogens from stock. Herbicides used in forestry operations can find their way into creeks and rivers. Chemical contamination from agriculture and forestry operations can be caused by overspray and spray drift from the application of chemical close to waterways. These chemicals can also be washed into waterways in run-off from significant storm events.

Industrial mining operations may allow **heavy metals** to reach aquatic ecosystems in concentrations that are higher than normal. While the release of heavy metals from ore bodies may occur naturally mining operations often concentrate these metals to higher than usual levels. Mining operations can also cause pollution through the release of waste materials into streams and the contamination of underground drainage water.

Depending on the geological formation involved, mine drainage water can contain considerable quantities of salts of copper, zinc, lead, cadmium and other metals and these can pose a serious problem. In addition, certain mining processes use a range of chemicals, such as cyanide, to extract metals such as gold and these chemicals can also find their way into waterways.

Stormwater can also gather pollutants from a wide variety of sources including those from urban and industrial sites, as well as agricultural lands. These pollutants can include residual pesticides, herbicides, oils, grease and pathogens from animal faeces and sewer overflows and leaks. **Sewage treatment plants** and **industrial operations**, depending on the degree of water treatment, can also be significant sources of toxicants and pollutants.

The impact of toxicants can be immediate (“acute” effects) or can be delayed for months or years (“chronic” effects). Impacts may be minor or short-term (e.g. irritations of fish scale or human skin) or major (e.g. the death of many organisms such as a fish kill or vegetation destruction). Some toxicants have hormonal properties, which have been used to disrupt the endocrine systems of pests such as insects and these can also affect the endocrine systems of non-target species.

Thermal pollution

Water temperature regulates many of the biological processes in the aquatic environment. It controls spawning, hatching of young and growth. Water temperature largely determines which species will be present in any one area and the main cause of temperature variations occur as a result of climatic influences.

In the human-modified environment the construction of dams and the resulting water stored in them have had a significant impact on water in streams and rivers. Between spring and autumn the water stored in large dams stratifies, with a warm surface layer overlying a cold bottom layer. Most dams have valves that are situated at the bottom of the dam wall. The water that is released is therefore from the cold bottom layer and this causes cold-water or **"thermal" pollution**.

Lower temperatures can result in slow fish growth, limited food production and a loss of biodiversity. Additionally bottom layers of standing water bodies accumulate plant detritus, which may cause turbidity and deplete dissolved oxygen levels downstream when water is released from these cold bottom layers.

Biodiversity effects include the survival and predominance of fish that thrive in these temperatures (e.g. trout) but disadvantage many native species which can lead to localised depletion and can reduce the total fish biomass in the system. Significant volumes of water being released from large storage dams can affect the water temperatures up to 400 kilometres downstream.

Thermal pollution can also result from the discharge of cooling water circulated through thermal electricity-generating plants, which generate electricity from heat. The process is very inefficient and large quantities of waste heat are produced. The water used to absorb excess heat may be taken from an aquatic area, used, and then discharged at a higher temperature (up to 10^o hotter).

Some species of freshwater temperate fish are killed by temperatures less than 20^o higher than their normal water temperature. Some species are more tolerant than others, but some will be killed if there is a relatively fast temperature change. In addition, heated water often stratifies the discharge area, further limiting the areas in which certain species can remain.

Water flows and river regulation

Aquatic health and the maintenance of aquatic habitats are essential for the maintenance of a healthy ecosystem. Habitat destruction can occur by human activities such as dredging, land reclamation and, particularly in the Central Tablelands, by draining of wetlands, river regulation and the introduction of exotic or feral species of fauna and flora.

Construction of dams and weirs exert impacts on ecosystems both upstream and downstream. **Upstream** the impacts include pooling and stratification (layering) of water, trapping of sediments, accumulation of nutrients and toxicants, increased likelihood of algal blooms and the blocking of fish passage.

Downstream the impacts result from the reduction of flow, the nature of controlled releases and sediment discharge, which can alter river channels.
Stream-flow regulation can have many effects:

- The volume and speed of water flow influence the type of habitat available and the transport of food, nutrients, eggs and larvae. It can also affect water quality, especially turbidity, which can reduce available light. This is important for the survival of a variety of fauna and flora.
- The rate of water flow can affect the sediment in an area. In turbulent waters only large rocks can remain while the light sediments are moved and deposited in calm locations. This can also influence the habitat for aquatic plants and animals.
- It can alter a running-water environment to a still-water environment, or vice versa, and the section of river affected may be very great ranging from tens to hundreds of kilometres.
- Important terrestrial habitats for particular fish species can be submerged, which directly affects the population numbers.
- There are reduced floods and freshes (flows resulting from localised rainfall that remain within the river banks) so that there are less frequent high flows, which are important because they provide water fro riparian vegetation, riverine habitats, replenish wetlands (triggering many organisms to breed), help maintain river channel and land morphology, recharge groundwater systems and discourage algal growth.
- There are fewer brief floods which are often ecologically important, e.g. many waterbird colonies need several months of flooding to complete breeding cycles.
- There are more rapid rises and falls in water levels that can lead to erosion and bank slumping, which in turn can destroy or damage riparian and in-stream vegetation and habitats and lead to increased levels of turbidity and nutrients.
- Release of colder water from the bottom of reservoirs results in temperature alterations (discussed above).
- There is often increased stream flow during naturally dry periods, which can degrade natural habitats, change aquatic ecosystems and encourage alien species, such as carp.
- Altered seasonal flow, such as happens with many of the rivers within the Murray-Darling Basin for instance, result from dam releases in summer or autumn to suit the irrigated cropping industry. However native plants and animals have adapted to natural seasonal variation, that is, high winter and spring river flows.
- Regulation of rivers creates barriers to fish movement, often have impacts on breeding.
- Degradation of aquatic habitat leads to impoverished fish populations which therefore have reduced resilience to invasion by alien fish species.

While the development of water resources for irrigated agriculture has brought many benefits, the consequent changes present a major challenge for the management of water resources and the maintenance of river health.

Of importance when considering alteration of river flows is the extraction of water from the riverine systems by the construction of a plethora of **small reservoirs and farm dams.** This can account for up to 50% of stored water in some areas. This particularly affects the number and degree of small flooding events and has particular effect on the health of wetlands.

Water quality and sediments

Sediments are extremely important as aquatic habitats (see below) and are a major **storage and recycling medium for nutrients** in aquatic systems. They accumulate large reserves of nutrients during sedimentation and release them to overlying waters when conditions are altered.

Natural processes responsible for the formation of bottom sediments are altered by human activities, particularly by soil erosion which carries excess soil into our waterways and which is accelerated by poor land management. Excess nutrients from agricultural lands and organic and metal compounds from urban and industrial areas usually become associated with particulate matter, which is carried by currents into quite areas in our waterways. The particulate matter settles and becomes part of the sediment. However, under altered conditions. particulate matter can be released back into the water and accumulate in the food chain.
Sediments may also cause shading or smothering, and sediments may alter the flushing characteristics of waterways, thus affecting the ability of the system to deal with pollutant loads.

5 Aquatic fauna and flora

Flora of streams and rivers

Many upland streams drain naturally from forested catchments and are well-shaded. Here light can be limited and therefore effects the abundance of plants able to grow in the water. Coarse, rocky sediments can also limit the establishment of **aquatic plants** although a few species have holdfasts and can cling to smooth rocks in fast flowing water. **Mosses** which require less light are often the only plants attached to boulders or near waterfalls.

Further downstream where there is more light, **algae** and some aquatic plants such as the strap-like water ribbon (*Triglochin* species) and ribbon weed (*Vallisneria* species) root in areas where they can establish a hold. Many of our streams dry up in summer or are greatly reduced in flow. Plants therefore need to be able to survive these conditions and those best adapted often do so by producing seeds which resist drying out and by being able to germinate quickly once the seed bank is re-wetted.

Most aquatic plants are not encountered until water flows slow down further downstream again. Here shading further diminishes and sediments are deeper, finer and more suitable for establishing roots. Many species in these quieter waters are similar to those found in lakes and dams (see below), including water milfoil (*Myriophyllum* species), floating pondweed (*Potamogeton tricarinatus)* and *Vallisneria.*

Streams flowing through farsm and cities are often choked in summer with filamentous green algae (e.g. *Cladophora* species). Sometimes, slippery pads of blue-green algae (Family Oscillatoriaceae) coar rocks, surrounding by disintegrating sheaths of brown diatoms (e.g. *Aulacoseira*). Where land use is less intensive red algae may be found as mucilaginous bushy tufts on rocks in swift-flowing streams. In slower water widespread green algae such as *Spirogyra* develop large floating or attached tangles.

Fauna of streams and rivers

There are three quite distinct microhabitats found in streams: **benthic habitats** (bottom dwelling), **surface habitat**, and the **hyporheic zone** (within sediments). By far the majority of **invertebrates** in upland streams are found in benthic habitats, ranging from sand and gravel to boulders and mats of plants. Insects dominate the surface whereas crustaceans are abundant and diverse in the hyporheic zone. In sheltered backwater and pools, invertebrates typical of dams and lakes also occur, e.g. snails, freshwater mussels, yabbies, crayfish, dragonfly nymphs, backswimmers and water-boatmen, diving and whirligig beetles and case-building caddisflies.

In fast-flowing riffles (streams with rapids or fast and turbulent flows) the upper surfaces of rocks may be covered with black-fly larvae, case-building chironmid midge larvae and caddisflies that spin nets to catch their food. Predatory flatworms (Playhelminths) may be found in the coarse sediments in riffles, along with a wide variety of fly larvae.

Vertebrates in streams and rivers are include **fish** species (native and introduced) which mostly feed on benthic or terrestrial invertebrates. Many native fishes are migratory and can travel great distances (e.g. golden perch, *Macquaria ambigua*). The erection of barriers in many of the inlands rivers and streams has curtailed this migration to a large extent. Exotic fish (introduced for recreational fishing, the aquarium industry and aquaculture) have affected communities of flora and fauna in streams, altered nutrient status and, in some cases, contributed to algal blooms. Exotic species have also been implicated in the decline of endangered, vulnerable, rare and common native fish species. Introduced species of concern in the Central Tablelands are carp (*Cyprinus carpio*), trout (family Salmonidae) and goldfish (*Carassius auratus*).

The **tadpoles** of many species of frog live in a wide array of aquatic habitats from temporary and permanent upland streams to backwaters and margins of larger, slower flowing rivers. Most of these tadpoles graze algae from rocks or feed on faeces and detritus wedged among rocks and litter on the streambed.

In south-eastern Australia, the **reptile**, the Eastern Water Dragon (*Physignathus lesueurii*) is quite common along rivers, basking on rocks and dropping into the water if disturbed.

The **platypus** *(Ornithorhynchus anatinus*) is a distinctive inhabitant of eastern Australian streams. It feed exclusively on live prey including yabbies, shrimps, fishes and worms. It is a nocturnal animal, and secretive in habit, and therefore not commonly seen. Although it is not now actively hunted, the gradual loss of suitable stream habitat is of concern.

The **water-rat** (*Hydomys chrysogaster*) is a mammal which is widely distributed and feeds on crayfish, mussels, frogs and dishes. The animals often have a favourite feeding platform, evidenced by fragments of broken mussel shell.

Flora of dams, lakes and wetlands

There are four major habitats of standing waters – their edges (littoral zone) and bottoms (profundal zone), the open-water, and the water-air interface. The divisions between these zones is often blurred and can have common flora and fauna.

Aquatic plants are divided into emergent, submerged, floating and amphibious (semi-aquatic).

Emergent plants are those plants rooted in the sediments with a major proportion of their photosynthetic parts above water. They include bulrushes, reeds and sedges, and are limited by their life form to water shallower than about 2 metres. These plants play a key role in nutrient cycling, provide habitat for nesting and foraging waterbirds, calling places for breeding frogs, and upright stems for aquatic invertebrates such as dragonfly nymphs to climb when they are ready to emerge. Micro-algae, bacteria, fungi and other tiny organisms may also attach to stems.

Submerged plants (e.g. ribbon weed, *Vallisneria* species, water milfoil, *Myriophyllum* species) photosynthesise under water, and although they are rooted in the sediments, they pollinate at the surface. These plants provide a complex physical habitat for attached biofilms, algae and aquatic invertebrates.

Floating plants have either the whole plant or just leaves at the water surface, and abound in sheltered areas or among emergent plants. They also provide microhabitats for other flora and fauna. Aquatic invertebrates and fishes shelter below the leaves or in the fibrous suspended roots. Examples include duckweed (*Lemna* or *Wolffia*), the liverwort (*Ricciocarpus*) and ferns such as *Azolla*.

Amphibious plants are those that can tolerate or respond to wetting and drying. They are considered semi-aquatic as they live on the margins of wetlands and can be subjected to periodic inundation or drying out. There are diverse examples of amphibious plants including paperbarks (*Melaleuca* species), spike rushes (*Eleocharis* species), swamp wallaby grass (*Amphibromus* species) and sedges (*Carex* species).

Algae can occur in considerable numbers in standing waters. Algae can attach at the sediments, e.g. stoneworts and charophytes. Filamentous algae (usually Chlorophyta) often form mats either attached to plants, in the open-water or at the surface. Blue-green algae (cyanobacteria), although microscopic as individual cells, can form algal booms in the water body.

Fauna of dams, lakes and wetlands

Invertebrates occur in all zones within lakes and wetlands. In the littoral zone can be found aquatic snails, mayfly nymphs, caddisfly larvae and beetles. In the open-water zone zooplankton are very important including rotifers, water fleas and copepods. Water boatmen occur in virtually every shallow standing wetland.

Most familiar invertebrates at the water surface are the bugs and beetles such as water striders and veliids, and whirligig beetles. Other invertebrates may live below the water surface but have to rise to the surface to breathe. These include diving beetles, mosquito larvae, soldier-fly larvae and water scorpions.

Vertebrates include native fishes found in the littoral zone e.g. native minnows, pigmy perch and freshwater smelt. The most common fish now found in littoral zone of many Australian lakes is the introduced mosquito fish (*Gambusia*). Goldfish and carp are also found. Redfin perch (*Perca fluviatilis*) is abundant in lakes and farm dams in our district and has been implicated in the decline of important native fisheries. As large lakes are rare in Australia few species of native fishes are lake-dwellers; most occur in streams and rivers.

Examples of other vertebrates to be found in lakes are turtles (or tortoises), water-rats and platypus although likes fishes these are more typically found in rivers and streams.

Waterbirds are probably the most common vertebrate to be found in lakes and wetlands. They readily move between waterbodies to seek feeding, breeding and nesting sites. Examples of these include the large Australian pelican, kingfishers, Darters, cormorants, ospreys, herons, egrets, numerous ducks species and swans. They have a variety of feeding mechanisms including predation on smaller vertebrates and invertebrates (both in and out of the water), and feeding on aquatic plants, e.g. swans which feed on roots and tubers underwater.

The riparian zone

The riparian zone or land is any land that **adjoins or directly influences a body of water.** It includes:

- The land immediately alongside small creeks and rivers, including the riverbank itself;
- Gullies and dips which sometimes run with surface water;
- Areas surrounding lakes;
- Wetlands on river floodplains which interact with the river in times of flood.

Riparian soils are more moist than adjacent land and therefore support a distinctive flora. Healthy riparian land supports a diverse range of plants and animals. Tree, shrub and grass roots provide stability for the streambank and help in preventing erosion.

Riparian land is often highly productive. As a result, the land has often been heavily cleared and used for intensive cropping (e.g. intensive grazing or irrigated cropping). Riparian land also plays an important role in the lifecycle of many native animals and plants. By its very nature riparian land is fragile and its productivity makes it vulnerable to overuse and to practices which cause it to deteriorate, creating additional problems.

The flora and fauna of the riparian zone is extensively dealt with in Chapter 7 on Biodiversity (Section 7.2).

6 Managing and restoring our waterways

An Overview

Human impacts are among the most potent forces influencing physical, chemical and biological properties of standing and running waters. Effects may be direct (e.g. alteration of flows) or indirect (e.g. changes to water quality), and these effects often interact. Many of the problems exhibited by our waterways show up as **symptoms** but to solve the problems we need to treat and manage the **causes**.

Consequently we now attempt to look at and manage water issues at a catchment or sub-catchment scale (called integrated catchment management, ICM, or total catchment management, TCM). This can be a complex mix of biological, social and economic factors (Fig 8.xx)

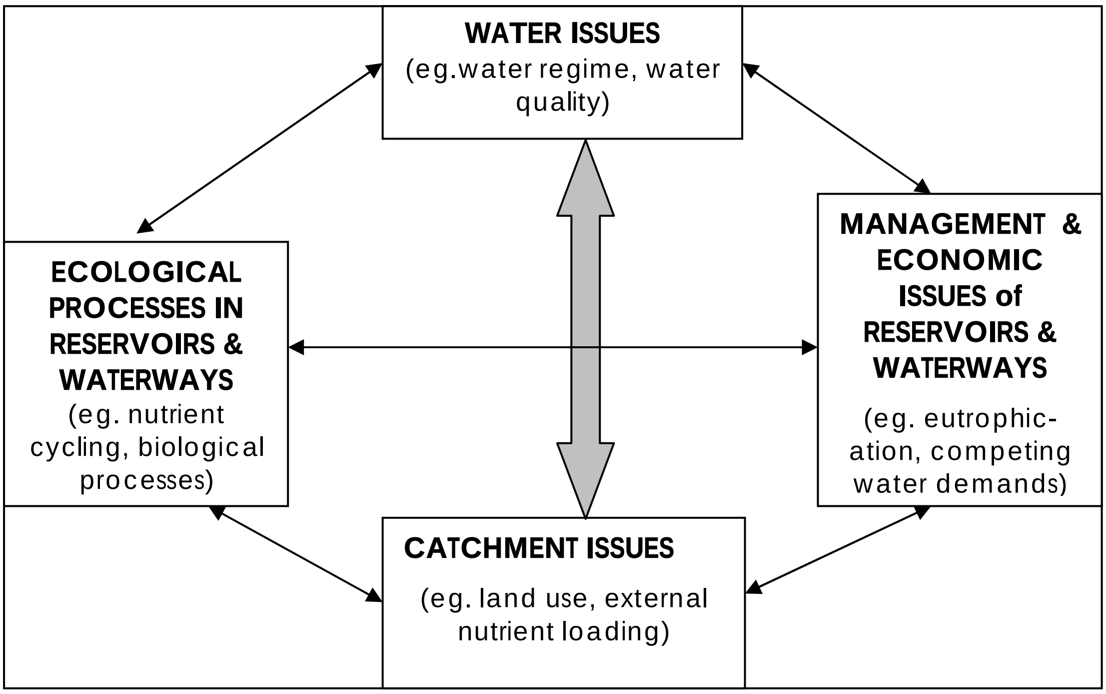


Fig 8.XX: Integrated Catchment Management: The relationship between catchment, water issues and management of water bodies (from Watts, 2000)

The two aspects of water pollution need to be managed differently. **Point source pollution** should be treated where the pollution actually occurs. For instance, sewage treatment plants can treat effluent on site before it is released back to waterways or it can be used for various operations (e.g. for mining or irrigated agriculture). Industries and intensive agriculture (e.g. dairies, piggeries, feedlots) can also treat water before it is released. Urban run-off and stormwater could also be collected before it carries pollutants and excess nutrients into waterways, often by using natural or artificial wetlands.

Non-point (or diffuse) pollution is especially associated with agricultural lands and management needs a different approach. The main aim should be to reduce erosion and consequent sedimentation in and eutrophication of our waterways and reservoirs. This can include:

- Reforestation and rehabilitation of woodland remnants;
- Rectification of soil erosion, mainly channel and gully erosion, which may include earthworks;
- Streambank stability is very important and this can be assisted by slowing down stream flow. Large woody debris or snags create a range of flows which provide a variety of different habitats for aquatic fauna and flora, including fish, and it is important that these be maintained or introduced.
- Changes in agricultural practices including some cropping practices, overstocking and over-fertilisation. Exclusion of livestock from creek banks and dams by fencing should be encouraged.
- Creation, maintenance or enhancement of vegetation buffer strips along the riparian zones of reservoirs, rivers and streams;
- Establishment of deep rooted perennial pastures and re-establishment of native grasses where possible;
- Dryland salinity (both incipient and active) needs to be rigorously monitored and planting o recharge areas made a priority.

Actions you can take

If you are an individual landholder many of the above approaches to management of creeks and waterways that may pass through your property can be instituted. Agricultural practices are very much the personal decision of the landholder and are very important.

However it is important to realise that whatever actions (or inactions) the individual landholder takes impacts on surrounding landscapes, and particularly on water quality and aquatic health downstream.

The best management is therefore **integrated catchment management** which draws together numbers of landholders and other stakeholders to mesh individual actions into a comprehensive and effective whole. It is obviously of little use for an individual landholder to instigate best practice agriculture and land management to have his/her efforts negated by poor management in other parts of the catchment.

Landcare groups, and other community groups, are proving to be an effective way to bring landholders together to take on catchment or sub-catchment projects and land and water reclamation. **Catchment Management Authorities (CMA)** are government authorities which are attempting to integrate land management over the wider scale of big river catchments (in our case, the Lachlan CMA and the Central West CMA). Funding assistance for projects is available through various government programmes (state and federal) and through the CMAs.

For more information about what you can do and how you can manage your land and water read the information in the Chapter on your own **sub-catchment**.

7 Conclusions

Rivers and streams in the Central Tablelands have a distinct natural cycle of heavier flows in the winter and spring, and slower or no flows in summer and autumn. This has been modified extensively by human activities due to construction of dams and reservoirs which impound water and release it during summer and autumn (for human consumption and irrigated agriculture).

This has disrupted aquatic habitats and affected the aquatic biodiversity, both in quality and quantity. River health has also been affected by erosion and sedimentation of streams and rivers, which again has a critical effect on aquatic wildlife.

Future improved management of our catchments and sub-catchments is important to the successful restoration of our waterways. Both point sources and non-point sources of pollution need to be addressed, and within the agricultural community land management is essential and involves good cropping, livestock and pasture management, enhancement of the riparian zone and prevention of erosion.

The best approach to land and water management problems is through Integrated Catchment Management.

8 References and further information

The following sources were used in the writing of the Water section of the Central Tablelands Landcare Natural Resources Toolkit.

Boulton, A.J. and Brock, M.A. (1999). *Australian Freshwater Ecology. Processes and Management.* Gleneagles Publishing, Glen Eagles, South Australia.

Brock, M.A. and Casanova, M.T. (2000). *Are there plants in your wetland? Revegetating wetlands.* LWRRDC, UNE, DLWC and EA, Canberra, ACT.

Central West Catchment Management Authority:
http://www.cw.cma.nsw.gov.au/catchment.html (accessed April 2007)

Lachlan Catchment Management Authority:
http://www.lachlan.cma.nsw.gov.au/catchment.html (accessed April 2007)

Mitrovic, S. (1995). *What scum is that? Algal Blooms and Similar Prolific Plant Growth.* DLWC, Sydney, NSW.

Murray Darling Basin Commission:
http://www.mdbc.gov.au/about/basin_statistics (accessed April 2007)
http://kids.mdbc.gov.au/encyclpedia/waterquality (accessed April 2007)

New South Wales State of the Environment Report. Water Backgrounder. (2000). Environment Protection Authority, NSW, Sydney.

Riparian Management Fact Sheets 1-7 (1996). Produced by Land and Water Resources Research and Development Corporation, Canberra, ACT

Watts, C.J. (2000). *Sinks, Sources and Pathways of Phosphorus in Two New South Wales Reservoirs.* Ph. D. Thesis, University of New England, Armidale, NSW.