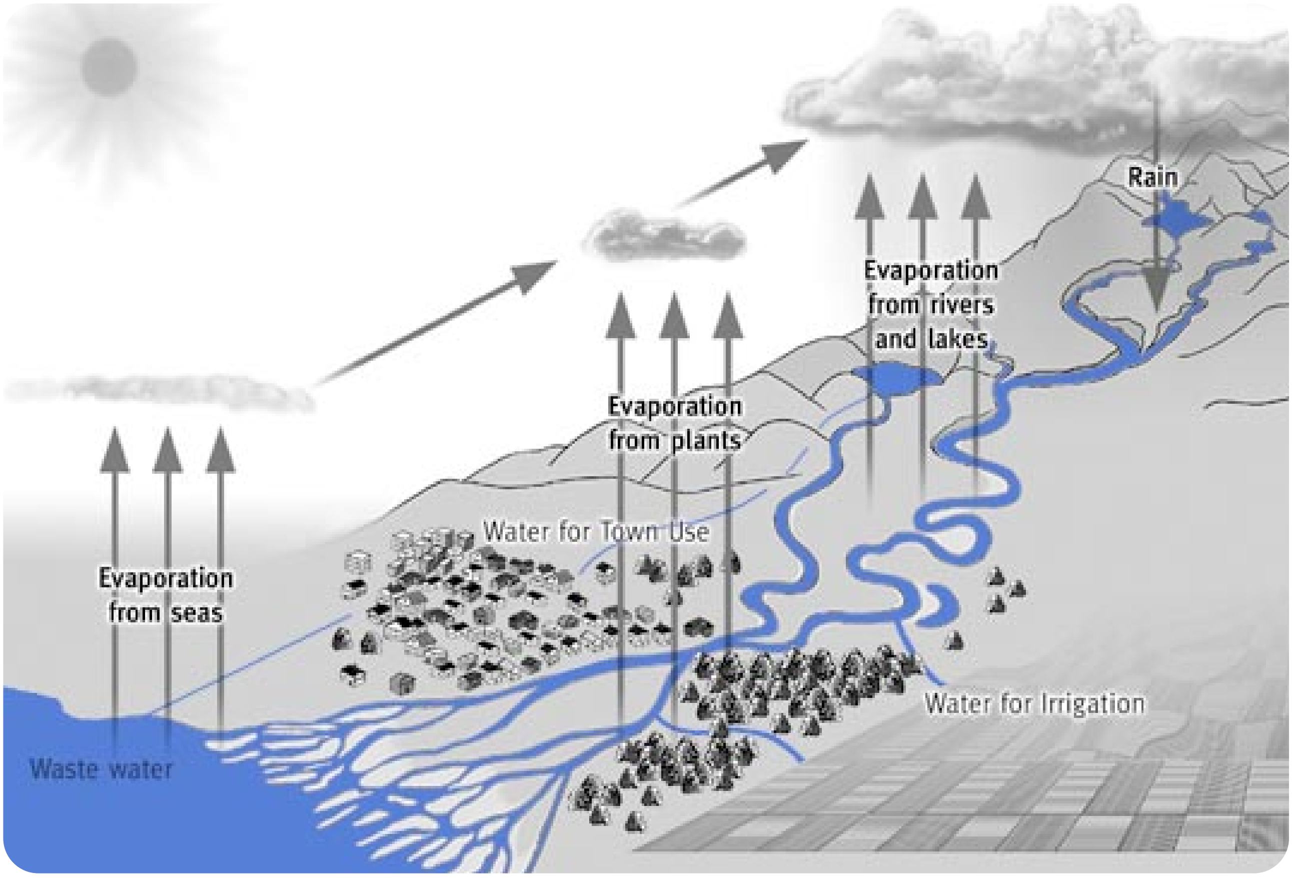
Water Cycle

OUR COASTS, RIVERS AND LAKES

The water cycle is the Earth's driving biogeochemical cycle. Within it is integrated nutrient cycles such as the nitrogen, phosphorus and carbon cycles. The water cycle is responsible for the collection, purification and distribution of our water resources.



The water cycle

The water cycle is powered by solar energy. Heat from the sun causes water to evaporate from the oceans, lakes and seas. This evaporation changes liquid water to gaseous water vapour in our atmospheres. When the water vapour cools, condensation takes place, and water falls back to the Earth's surface as precipitation in the form of rain or snow.

On the land, water infiltrates into the soil. Excess soil water can percolate further into the ground, replenishing groundwater resources. This groundwater can feed streams and rivers or become springs which are valuable water resources in dry times.

Water also dissolves minerals from rocks and soils to be utilised for plant growth. It carves river valleys, shaping the landscape and eroding rocks, transporting them from mountains to the sea. These are all natural processes associated with the water cycle.

Human interferences to the water cycle

Humans impact upon the water cycle in two ways; utilising too much water from rivers, streams and groundwater resources, and changing natural catchments by clearing vegetation for different land uses. The result is less infiltration to groundwater and increasing surface flow, resulting in more flooding and soil erosion.

The direct impact to humans will be reduced water quality.

CASE STUDY
Environmental flows – A river's legal right to water

The Thomson Reservoir was completed in 1983 and was the last major reservoir constructed to supply Melbourne with water. Most of the water stored in the reservoir is allocated to domestic, commercial and industrial use in the city and surrounding urban areas. The diversion of water from the Thomson River to Melbourne represents a significant transfer from one river basin to another.

After the dam was constructed, the annual pattern and volume of flows in the Thomson River were distinctly altered resulting in flows being reduced to about half of their natural capacity. Evidence collected since then indicates that the post-dam flows in the Thomson are inadequate, and are impacting upon the health of the river and ultimately the Gippsland Lakes.

In late 2005 under the Water (Resource Management) Bill, the Victorian Minister for Water granted a bulk entitlement to the Thomson River of 10,000 megalitres, which forms part of the Environmental Water Reserve (EWR) for the river. The Environmental Water Reserve is the share of water set aside to protect and enhance the environmental values of a river and to ensure its future sustainability. This water was able to be allocated due to an increase in water saving practices in Melbourne.

The Environment Bulk Entitlement is held by the Minister and the West Gippsland Catchment Management Authority has been appointed managers of the EWR. As managers of the EWR the WGCMA are required to develop strategies for the effective release of environmental flows.

Release patterns are varied throughout the year to try and replicate natural seasonal flows and achieve ecological objectives such as:

- Improving water quality through flushing of stagnant pools
- Maintaining and enhancing native fish populations through movement of sediment and provision of in-stream habitat
- Rehabilitating native, in-stream and riparian vegetation communities
- Protecting the physical structure of the waterway for flora and fauna habitat.

Reference

Melbourne Water, 'River Revival', The Source, Issue 35, October 2005 pp 4-5.

Melbourne Water Fact Sheet Thomson Reservoir

West Gippsland Catchment Management Authority Environmental Water Resources Officers Frank Donohue & Eleisha Keogh

Groundwater

Groundwater is an integral part of the Hydrological system, and is a vital natural resource. It can occur anywhere where there are permeable soils and rock, such as under deserts, mountain ranges, and parts of the sea, even under the Arctic Ocean.

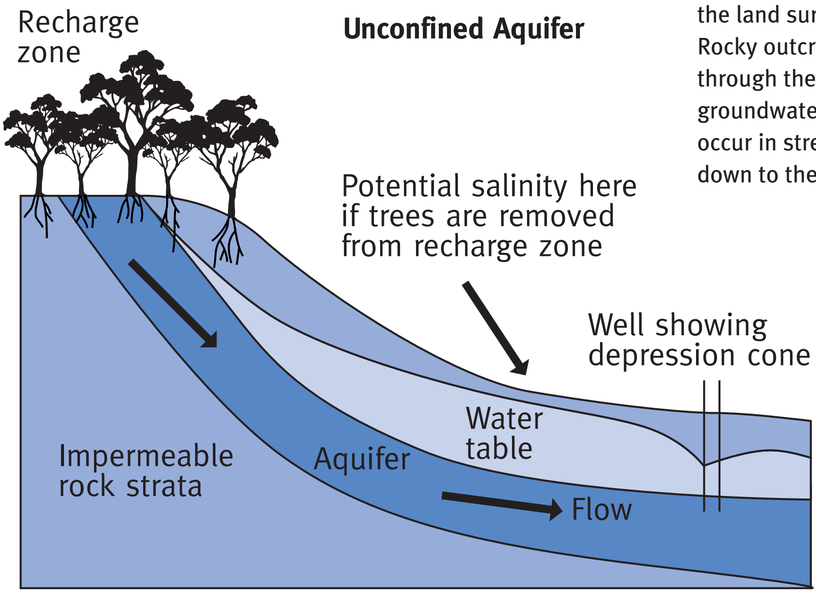
In any catchment, water arriving as precipitation will travel either over the land as overland flow (surface water), collecting into streams and then rivers, or infiltrate into the soil and cracks to form groundwater or artesian water.

Groundwater moves down into the soil and also downhill, travelling through porous, permeable rock or soil material forming an aquifer. The groundwater eventually accumulates in low-lying areas to form underground artesian basins. Water held in an aquifer is usually contained in permeable rock, though sometimes the water may form open underground 'lakes' and rivers; such as those occurring in limestone country.

Often, groundwater contributes to surface water flow, such as where an aquifer is cut by a stream or river, allowing the aquifer water to enter the stream. Usually the stream level also represents the level of the groundwater in the immediate vicinity, and in dry times may be the only source of water for the stream.

Confined and unconfined aquifers

An aquifer is known as a confined aquifer if it is enclosed above and below by impermeable rock layers. An unconfined aquifer has only permeable material above it. In an unconfined aquifer, a rising water table (the upper level of the aquifer) may reach the surface in low-lying areas, forming wetlands and marshes. Similarly, falling groundwater levels will lead to drying out of swampy low lands.



Recharge zones

The headlands above the artesian basin normally form the basin's recharge zone, where the majority of the water entering the aquifer is sourced. This is because the porous rocky material of the aquifer is either exposed or very near to the surface. Water can more readily infiltrate into the aquifer, rather than become overland flow.

The headlands usually take the form of hills of ranges adjacent to, or surrounding the lowland plains. The role of recharge zones is important to understanding dryland salinity.

Pressure head

The water entering an aquifer recharge zone flows towards areas of lower pressure, such as discharge zones (streams, springs, etc.). Since confined aquifers are constrained above and below by impermeable material, water pressure will increase lower down along the aquifer. In lower lying areas this water pressure, known as pressure head, can become substantial, and if a well is dug it may be sufficient for the groundwater to flow up through the well to the surface.

Springs and wells

In an unconfined aquifer, the water table cannot reach the surface, preventing low-lying areas from being inundated by groundwater. Natural springs will form anywhere where the land surface is below the level of the water table. Rocky outcrops, escarpments and cliffs or incisions through the rock strata may expose the aquifer, allowing groundwater to escape as natural springs. Springs also occur in streams, supplying the stream where it has cut down to the water table.

Threats to groundwater resources

Salinity
The soils of much of Gippsland contain high levels of ancient salts, held deep within the soil profile.
Tree clearing for agriculture can reduce the amount of rainfall utilised in a catchment, and cause groundwater levels to rise. When groundwater rises through this profile the salt is dissolved, bringing salt closer to the surface. Initially this affects deeper-rooted plants such as trees, then attacks grasses and crops. Salt-tolerant plants appear, and flourish. Finally saline water reaches the surface, and evaporation leaves salt on the surface, leading to severe salt scalds where nothing but the hardiest salt tolerant plants can grow.

There are two main types of soil salinity, one that is associated with irrigation and the other that is associated with land clearing, known as dryland salinity. Increased rates of shallow groundwater recharge has led to salinisation of pasture and crops, most notably in the Macalister Irrigation District, the Yarram district, areas of south-west Gippsland, and more isolated pockets through central and eastern Gippsland. The introduction of irrigation in some districts has exacerbated the problem.

Increasing saline runoff from affected land is affecting some important streams and rivers, such as the lower Thomson, Macalister and Perry Rivers.

Groundwater Pollution
Groundwater can be affected by septic tank discharges, particularly in unsewered towns on sandy soils such as those in coastal areas. There is also potential for aquifers to be affected by intensive agriculture and urban activities, including contamination by pesticides, heavy metals and leaching of exposed acid sulphate soils. Badly designed landfills and waste storage areas may further contaminate groundwater aquifers.

Resources

National Land and Water Resource Audit
www.nlwra.gov.au

Groundwater Victoria
www.nre.vic.gov.au/dnre/grndwtr/grndwtr.htm

Centre for Groundwater Studies
www.groundwater.com.au

Australian Government Agriculture Portal – Groundwater
www.agriculture.gov.au

CASE STUDY
Coastal subsidence

If many wells or bores are dug in an aquifer, or there is excessive pumping from these wells, there may not be sufficient water recharge of the aquifer to replace the water that is being extracted. This can lead to wetlands and springs fed by that aquifer to dry out and cause major environmental changes to habitats. Excess groundwater extraction can also affect our landscapes, as removal of too much water from below the surface can cause the ground to subside.

In central Gippsland, falling groundwater levels in the Latrobe Valley aquifers show that groundwater extraction is significantly greater than their recharge. These aquifers extend out under Bass Strait, and are affected by offshore oil and gas extraction and land irrigation in the Yarram district and aquifer depressurisation around the Latrobe Valley's open-cut coal mines. This depressurisation is required to prevent the open-cut mines from bulging or filling with water. About 22,763 ML/year at up to 280 L/min is extracted from the surrounding aquifers and, after use in the power stations, is discharged into surrounding streams or piped to the coast via the saline outfall pipe.

Fluid extractions from the Latrobe Aquifer	Volume (megalitres/year)
Sale urban water supply	Small quantities
Ground water for irrigation	5,000–10,000
Coal mine de-watering	25,000–30,000
Bass Strait oil and gas production	100,000

The resulting regional groundwater level decline of approximately 1 m/year suggests there is significant over-allocation of groundwater resources in the Latrobe Valley, however, there is insufficient information to predict possible levels of subsidence over time.

Where to now?
The threat of subsidence to the coastal region is also exacerbated by possible sea level rises associated with climate change. Because of the value of the coal and gas industries to Victoria, it is unlikely that reduction in fluid extractions can be ceased. It is possible, however, to artificially recharge the aquifer using salt water in Bass Strait oil regions and freshwater on land. The Gippsland Coastal Board will undertake studies to determine the costs and benefits of this practice and commence monitoring of ground levels to determine subsidence levels.

References
Gippsland Coastal Board Coastal Subsidence Learn about the Coast Information Sheet

Wetlands & Lakes

Wetlands and lakes can be defined as significant bodies of water, occupying low-lying areas within our landscape. The water is usually still, and may be freshwater, brackish or saline. Wetlands water sources include rivers and streams, surface flow, groundwater and seawater inundation.

Lakes can be broadly categorised into coastal and estuarine lakes, reservoirs and dams, and hinterland lakes. Wetlands often have alternative names including marshes, swamps and morasses, e.g. Heart Morass.

Importance of wetlands and lakes

Historically, marshy wetlands and tidal flats were seen as undesirable. The land was known to be fertile so many wetland landscapes were drained or reclaimed for agricultural purposes. Over time, their value to our biodiversity was recognised. Many wetlands around the world have now been classified as significant or important in their function as: habitats for migrating or resident bird populations, fish breeding grounds, biodiversity, significant wetland plants (e.g. mangroves), their role in filtering excess nutrients and silts, and as food sources for other animals.

Conventions such as the Ramsar convention (see Our Heritage, Culture and Communities) seek to protect these environments for perpetuity, in an effort to stem the loss of these vital wetlands and their important environmental role.

Structure of wetlands and lakes

Generally, wetlands and lakes can be structurally broken down into four main zones. These are the Littoral, Limnetic, Profundal and Benthic zones.

- **Littoral zone:** Includes the shoreline and inner shallows, and is nutrient, plant and organism rich.
- **Limnetic zone:** Open water; to a depth where photosynthesis can still occur. Inhabited by planktons and shallow water fish.
- **Profundal zone:** Deep open water, too dark for photosynthesis. Occupied by deep water fish and organisms.
- **Benthic zone:** Bottom of the lake or wetland, occupied by organisms such as bacteria and molluscs that act as decomposers or feed off detritus.

Eutrophism

Eutrophic lakes or wetlands are typically shallow, with high photosynthetic activity near the surface. They may support large populations of fish, macroinvertebrates and plants, and often provide food for large bird populations. Eutrophism is a natural process that can be accelerated by catchment activities such as agricultural runoff and urban drainage. If nutrient loads are excessive, the wetland or lake may become oxygen-deprived, particularly in its deeper reaches. This can occur quite quickly and impact oxygen-dependant creatures such as fish, causing major fish kills.

Eutrophic conditions also allow some toxic organisms to emerge and flourish, such as blue-green algae, which naturally occurs in the sediments at the bottom of lakes and wetlands. This can have severe impacts on animals and organisms dependant on the wetlands, such as bird colonies and small mammals.

Stratification

Deep lakes such as reservoirs are subject to thermal stratification, where warmer water heated by the sun accumulates near the surface, and colder water sinks to the bottom. Stratification hinders mixing, the water remains sharply stratified, with a relatively thin thermocline layer between the warm and cold water. Stratification is worse in summer, where surface heating is more apparent. In winter, lower temperatures cool the surface, allowing the water to cycle more effectively.

Stratification is a serious problem in reservoirs that release water downstream from the bottom of the dam. This water is cold and devoid of nutrients, causing the receiving river environment to experience sudden changes in both water quality and the habitat of its natural fish and animal population.

Sedimentation

Lakes and wetlands that are downstream from highly erosive areas such as mountainous terrain, or where riverbanks have been cleared by fire, logging, mining, roads or agriculture, may accumulate excessive silt. This also causes an increase in the turbidity of the water.

When sedimentation occurs, a lake becomes progressively shallower, eventually becoming a marshy swamp or completely drying out. In the case of a reservoir, this renders it useless for its intended purpose. High sediment loads can also affect estuaries and river mouths, causing extensive delta formation and silt jetties.

Turbidity

Turbidity is caused by the suspended particles in water, such as fine clays and silts. High levels of turbidity cause cloudiness and opacity, reducing the light penetration for photosynthesis by wetland organisms. This reduces the growth of organisms dependant on light, such as algae, then further up the food chain, reducing numbers of invertebrates, fish and birds.

Wetland plants

Wetland plant species vary depending upon the type of wetland environment i.e. inland or coastal. One way of broadly classifying wetland plants is by the 'niche' they occupy in the wetland ecosystem, e.g. free floating species, submergent plants, emergent edge plants. The change in salinity levels in Lake Wellington through the artificial entrance has resulted in the dieback of the common reed Phragmites australis. This emergent edge plant traditionally protected the banks of the lake from erosion. Increased erosion from its loss has accelerated deposition in the lakes.

Coastal and estuarine lakes and wetlands

Coastal and estuarine lakes often develop when there has been inundation of a river mouth by a rise in the level of the ocean. Coastal lakes do not have an opening to the sea; they are usually fresh water and often incorporate marshy swamps along their perimeter.

Estuarine lakes are open to the sea, and vary from little more than a series of marshes near a rivermouth to large lakes with a small channel accessing the sea. Where strong sea currents prevail, such as along Gippsland's Ninety-Mile Beach, sand spits propagate that can eventually close the channel, especially in drier times when influx into the lake is limited.

Heavy rains or flooding replenishing the lake will often reopen the channel. This process has formed the Barrier Islands of Gippsland. Because of their relative isolation they have been a haven for shore birds and ground dwelling mammals. Fox control programs have been implemented on some of the Barrier Islands to protect migratory birds such as the Little Tern and the Hooded Plover.

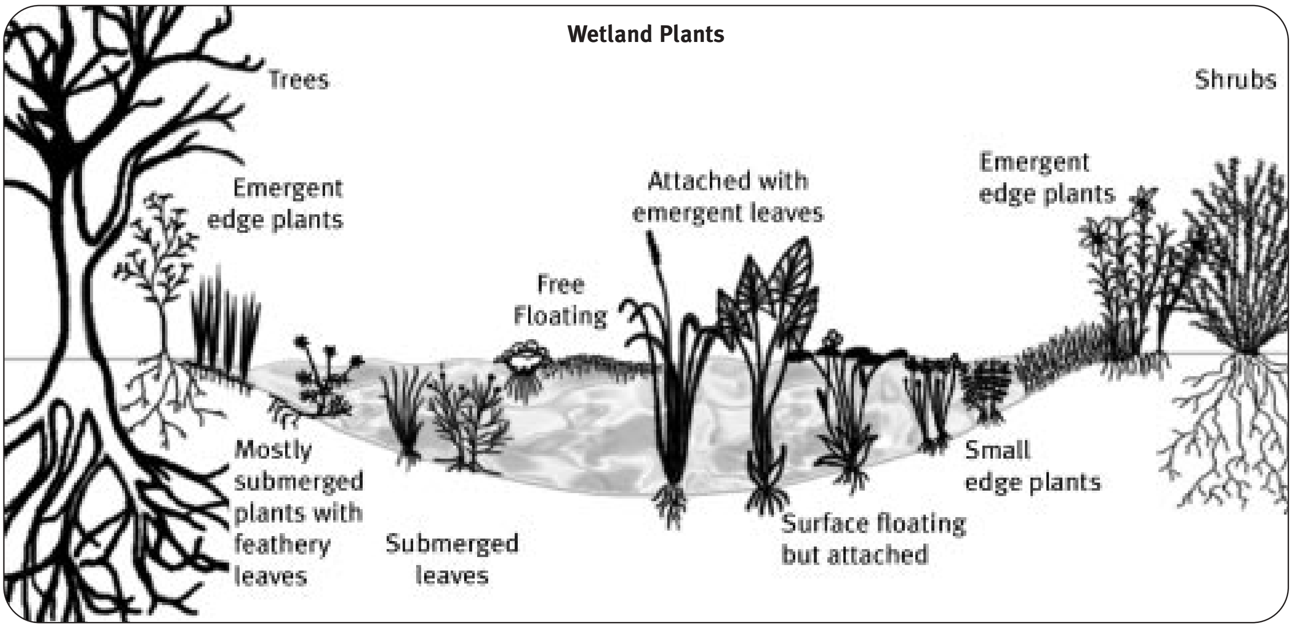
Estuarine and coastal lakes support very high levels of plants and animals. They act as a spawning ground for fish, refuge and breeding grounds for birds and sanctuary for many other animals and plants; many that are currently threatened with extinction.

Resources

Gippsland Coastal Board
www.gcb.vic.gov.au/gippslandlakes/fact.htm

Department of Sustainability and Environment
www.dse.vic.gov.au

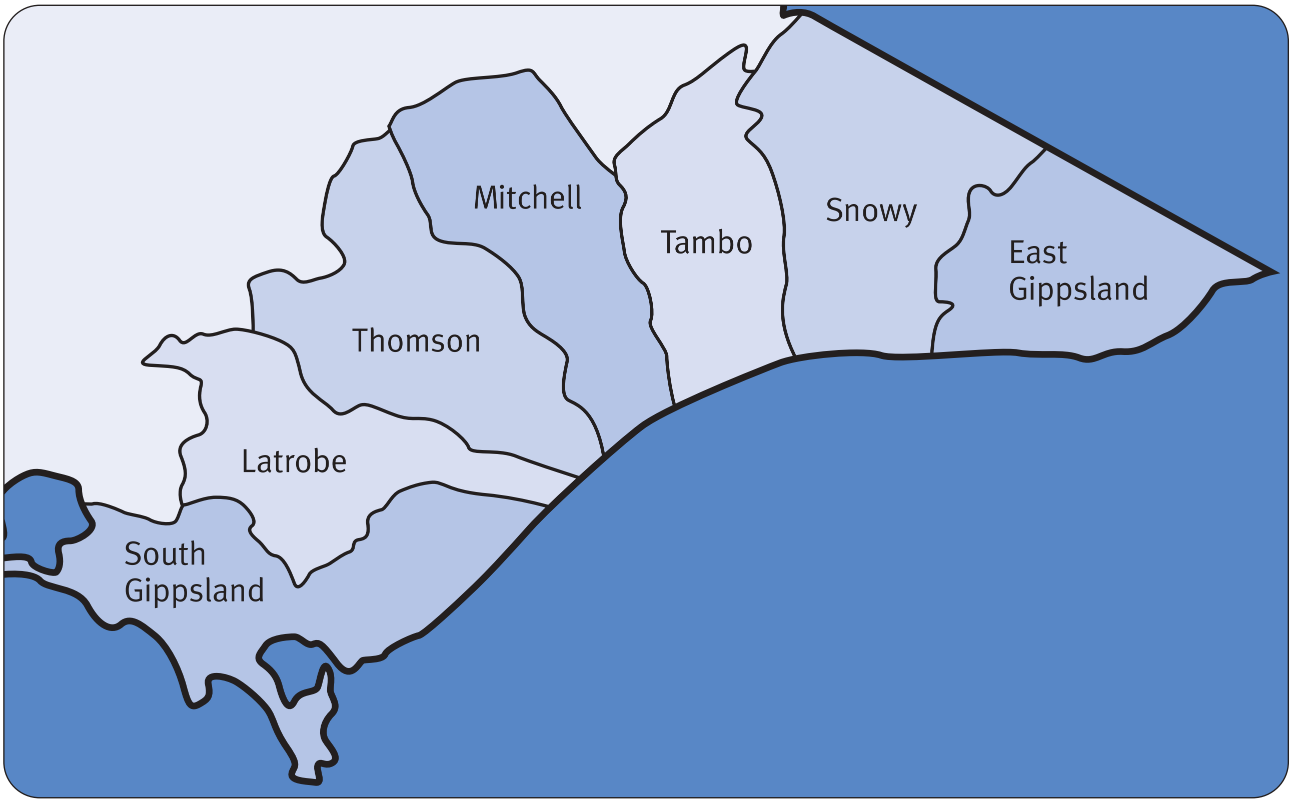
Wetland Plants



Gippsland's River Systems

OUR COASTS, RIVERS AND LAKES

River systems host a range of unique ecosystems that alter as a river grows; from the fast flowing rapids of its upper reaches, down to the slow meandering channels of its floodplain. Understanding these ecosystems requires examination of the entire river system and how it works.



Gippsland's river catchments

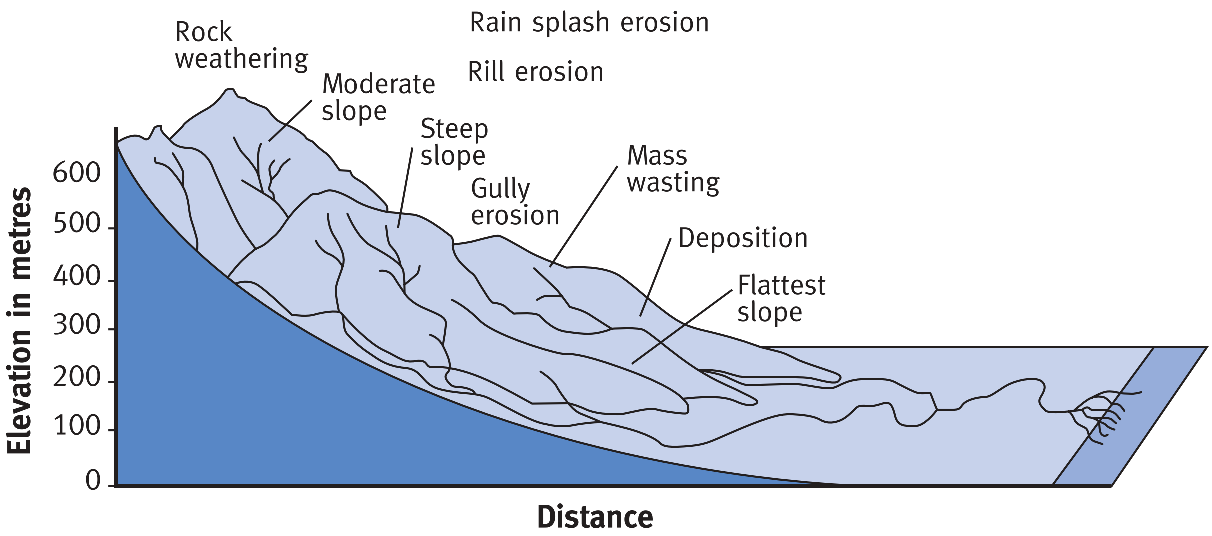
A catchment is the total area of land drained by a particular river system. It contains all land surfaces from which a river or stream sources its water, including the river headwaters, all tributary streams, flood plains and swampy lowlands, down to the river terminus. Each tributary stream has its own individual catchment. These combine to form the complete catchment for the major river. A number of river catchments can be combined to form a basin.

Stages of a river

There are three main geomorphic stages of a river: Erosional, Transportational and Depositional. Each stage has particular characteristics and performs a different function.

These stages equate broadly with the Upper, Middle and Lower catchment areas of a river.

The erosional stage consists of the headwaters and a network of streams high in the upper catchment. Water volume is relatively low but moves rapidly, transporting most sediments. Typically the bottom is rocky or pebbly. It has high erosive power and drops rapidly in altitude, channeling water and eroded material from surrounding highland to the main stream. It is characterised by many tributaries. On a map or viewed from an aerial photograph, it often has a dendritic appearance similar to the branches of a tree.



The transportational stage carries water and sediment to the lower reaches of a river system. Erosive and depositional processes are both active, particularly during flooding. In appearance, this section of the river is often braided, with numerous exposed sand bars and dissecting channels during non-flood periods.

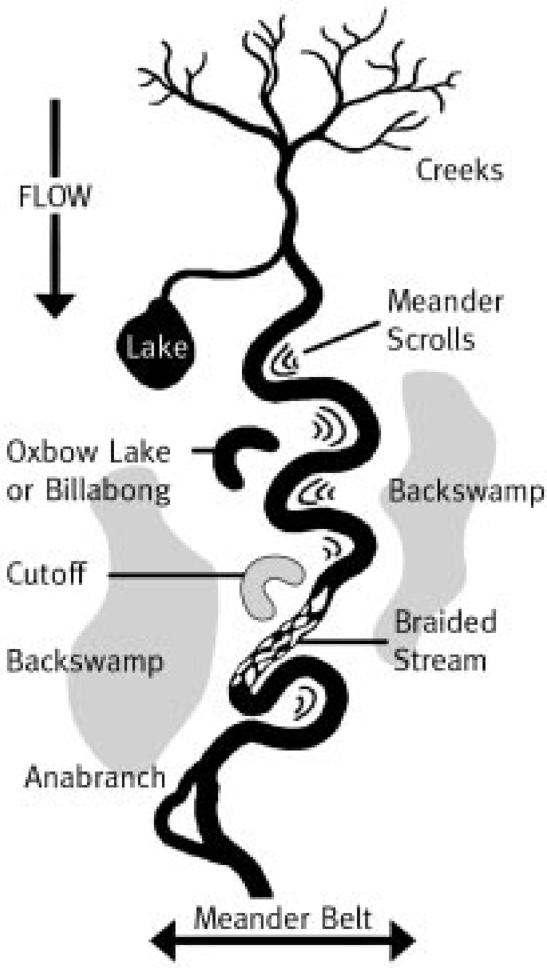
The depositional stage occurs when a river matures, entering its lower reaches. The river becomes meandering with a wide floodplain and broad flat valley, edged with levee banks and many cut-off or ox-bow lakes and swamps. Deltas and silt jetties result from deposition of remaining fine silts at the river terminus.

Changes over time

River systems are dynamic, changing their course, volume, water quality and velocity over seasons and years. In their natural state, a river will gradually widen and age, over time reaching deeper and further into its catchment.

Annual flooding and drying cycles replenish floodplains of soil nutrients, and maintain water quality in wetland marshes and swamps that are sanctuaries and breeding grounds for fish and birds. These natural processes are vital for maintaining river health, and ensuring biodiversity of ecosystems and quality habitats.

Sediment transportation



Human impacts

Human influences can accelerate or retard these dynamic changes; by harnessing the river to provide water for towns, cities, agriculture and stock, for discharging waste water, removing the threat of flooding, and as a source of hydro-electricity.

The most marked human impacts include:

Dams, weirs and reservoirs

- Eliminate or at least control periodic downstream flooding, as well as supplying essential water for irrigation and human consumption and for power generation.
- Alter its natural flood cycles, often eliminating them altogether. Often water discharge into a stream is sourced from the bottom of a dam, where water is at a much cooler temperature than would naturally occur in the stream. This affects natural organisms adapted to warmer temperatures.
- Diversion of water can remove sufficient water to deplete environmental flows necessary for existing habitat survival, such as has occurred in the upper reaches of the Snowy River.

Dredging, straightening and de-snagging

- Accelerates flow velocity without altering water volume. Also gives easier access for boating and river transport. Most importantly, reduces flood incidence by creating a faster channel for floodwaters to escape.
- Leads to scouring of river banks and river bottoms, with the removal of riparian vegetation vital for habitat. Only the most hardy plants and organisms survive.
- Unimpeded high sediment loads flatten and widen the river, further debilitating habitat and smothering the river bottom and bottom-dwellers with sand and silt.

Clearing of riverbanks

- Often done to allow stock access to drinking water, or as a source of feed for grazing animals.
- Leads to rapid erosion of riverbanks, particularly where there are bends with high water velocity. Can be self-perpetuating, eventually leading to significant loss of surrounding farmland due to the widening river. In some instances very difficult to stop.
- Depending on the environment, may also lead to gullying of streams and rapid deepening of the channel.
- Runoff from cleared banks and adjacent fields can greatly increase suspended sediment load, impairing photosynthesis capability of light-dependent organisms.

Wastewater from industries, towns, stormwater, sewage, farm animals, agriculture, roads etc.

- Contributes significant nutrient loads that may cause explosive algal growth, and deprive river water of oxygen necessary for fish and other river organisms.

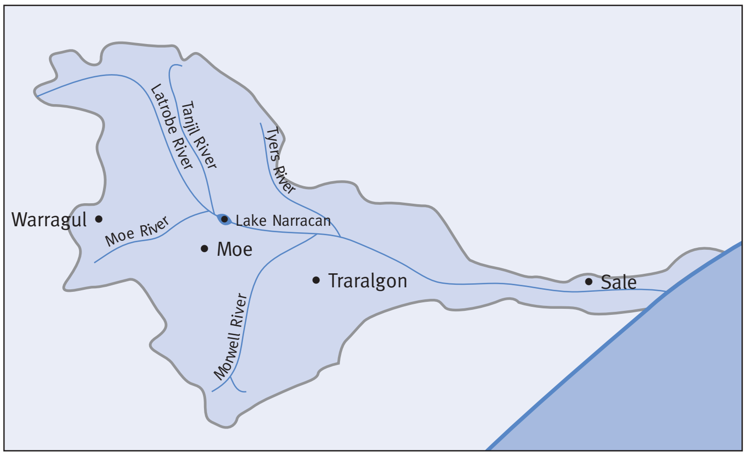
Introduction of pest species of plants and animals

- E.g. carp, willow, woody weeds. Carp are bottom-feeders and notorious for muddying formerly clear streams. Weed species often out-compete native vegetation and become dominant on riparian zones.

Irrigation and land clearing practices

- Can increase salt load in a river, with subsequent decline and loss of freshwater or salt-intolerant species.
- Clearing from forestry practices and agriculture can considerably increase sediment loads.

The Latrobe



Latrobe River catchment

The Latrobe system consists of a series of streams that flow south from the Great Divide and north from the Strzelecki Ranges to the Latrobe River, which rises in the north-west and flows south-easterly to Moe, then easterly across the Gippsland Plains to Lake Wellington.

The major tributaries of the Latrobe River are Toorongo, Tanjil and Tyers Rivers from the northern highlands, the Moe River from the west, and the Morwell River and Traralgon Creek from the Strzelecki Ranges in the south. Major storages in the basin are Blue Rock Lake, Moondarra Reservoir, Yallourn Storage and Hazelwood Pondage.

Water quality is generally poor in the major streams of the basin, particularly in the central zone of the Latrobe River, which is subject to discharge and pollution from urban, mining and industrial activities. The Latrobe River Basin comprises deep and shallow aquifers. An extensive program of groundwater pumping has taken place at Morwell to de-water the mining area. In drought years groundwater has provided a valuable supplement to power station requirements. Groundwater extraction has caused a major decrease in the Latrobe River Basin aquifer levels.

Water quality

Water quality within the Latrobe River varies greatly, and is highly influenced by land use practices and industrial and urban discharges. Turbidity increases from the most upstream monitoring station on the Latrobe River, through to the monitoring station at Rosedale. Nutrient attainment was generally very low in the Latrobe River Basin, with every station within the basin exceeding total phosphorus (TP) objectives and the majority of stations failing to meet total nitrogen (TN) objectives. High nutrient loads have been recorded at Moe River and Moe drain stations. High phosphorus loads have been recorded in the lower reaches of the Latrobe River, particularly at Kilmany South. There is a significant downward trend in TP at the Latrobe River at Rosedale.

Water allocation

The basin water yield, which is defined as the mean annual runoff for the Latrobe, is 887,000 ML/annum. The Sustainable Yield, which is the estimated maximum volume of water that can be diverted after taking into account in stream environmental water requirements,
is 261,000 ML/annum. The Developed Yield, which refers to the annual volume of water that is currently available for diversion at a defined level of reliability, taking into account environmental water requirements,
is 261,600 ML/annum.

Threats and impacts

There is projected future demands on Blue Rock Lake, which is a major storage on the Tanjil River. This demand is for the power industry, where a new base load, brown coal fired, power station is anticipated in the year 2010. Combined growth of all other industries, together with urban demands, is not expected to exceed 1,500 ML/annum by 2020. The water demands of irrigated agriculture are estimated to increase by between 6,500 and 19,000 ML/annum between 2002 and 2020, for the expansion of horticulture, wildflower and dairy enterprises.

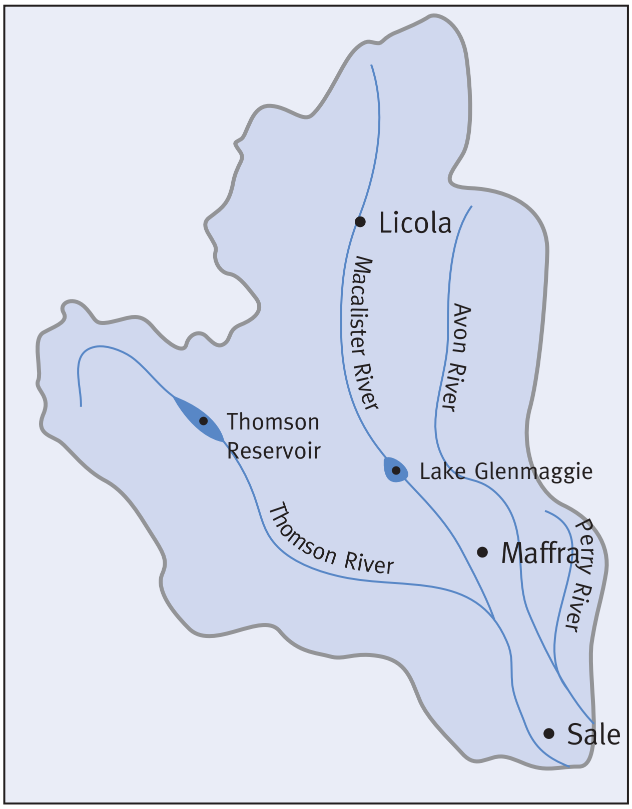
Reference

http://audit.ea.gov.au/anra/atlas_home.cfm

Latrobe Basin Water Quality	Latrobe River at Noojee	Latrobe River at Thoms Bridge	Latrobe River at Rosedale (main stream)
Position in the Catchment	**Upper**	**Middle**	**Lower**
Dissolved oxygen mg/l	10.3	10.1	9.45
Electrical conductivity uS/cm	62	270	340
Nitrates and nitrites mg/l	0.37	0.38	0.38
pH	6.7	7.1	6.9
Turbidity NTU	7.3	13	19
Total phosphorus mg/l	0.048	0.07	0.09

Mean Annual Water Quality Source: Vic Waterdata Warehouse

The Thomson/ Macalister



Thomson/Macalister River catchments

The Thomson, Macalister and Avon are the major rivers in the Thomson Basin, draining to the west, central and eastern zones respectively, as they flow south towards the Latrobe River and Lake Wellington. There are two main storages in the Thomson Basin – Lake Glenmaggie situated on the Macalister River north of Heyfield, and the Thomson Reservoir on the north-west of the basin in the upper reaches of the Thomson River.

The Gippsland Lakes are the terminal lake system for the rivers of the Thomson and Latrobe Basins. The main lakes; Wellington, Victoria and King cover approximately 340 km^2. The Thomson River, and its major tributary the Macalister River, enter the Latrobe River several kilometres before the Latrobe reaches Lake Wellington.

The Thomson River is designated a Heritage River under the Heritage Rivers Act 1992. The Heritage corridor extends 200 m both sides of the river, from the Thomson Dam to Coopers Creek.

Water quality

Throughout the Thomson River Basin, water quality is generally good, although elevated nutrient levels occur in some areas. High turbidity has been recorded occasionally downstream of the Thomson Dam and in the lower reaches of the Macalister River. The aquifer system is shallow within a large proportion of the basin, and provides a relatively small proportion of water for irrigation compared to the volumes extracted from surface water.

In the Thomson Basin, poorer water quality is found in the lower reaches of the Thomson Macalister and Avon Rivers. Nutrient concentrations and loads increase in the lower reaches of the Thomson River, with greater loads being contributed during high flow periods in winter and spring, when 40% of the basins flow occurs.

Water allocation

The basin yield is estimated to be between 1,081,000 and 1,358,000 ML annually. The Developed Yield is allocated by Bulk Water Entitlement to Melbourne Water Corporation (265,000 ML/year) and Southern Rural Water (260,000 ML/year), with a small amount going to rural, private diversions (2,459 ML/year). Although the Bulk Water Entitlement for Melbourne Water is 265,000 ML/year, an estimated 137,000 ML/year is actually diverted to Melbourne users.

Threats and impacts

Bulk Water Entitlements in the Thomson Macalister system are considered to be above what is necessary to maintain the Thompson's environmental health. As the Thomson is integral to the health of the Gippsland Lakes, and also the urban supply of Melbourne, the pressure for sensible management of water from all aspects of society is necessary.

Reference

http://audit.ea.gov.au/anra/atlas_home.cfm

Thomson Basin Water Quality	Thomson River at the narrows	Thomson River at Cooper Creek	Thomson River at u/s of Cowwarr Weir	Thomson River at Wandocka
Position in the Catchment	**Below Dam**	**Upper**	**Middle**	**Lower**
Dissolved oxygen mg/l	10.1	9.35	10	9.8
Electrical conductivity uS/cm	53	75	67	88
Nitrates and nitrites mg/l	0.16	0.051	0.11	0.1
pH	7.2	7	7.5	7
Turbidity NTU	1.7	2.7	1.5	5.4
Total phosphorus mg/l	0.029	0.008	0.0085	0.023

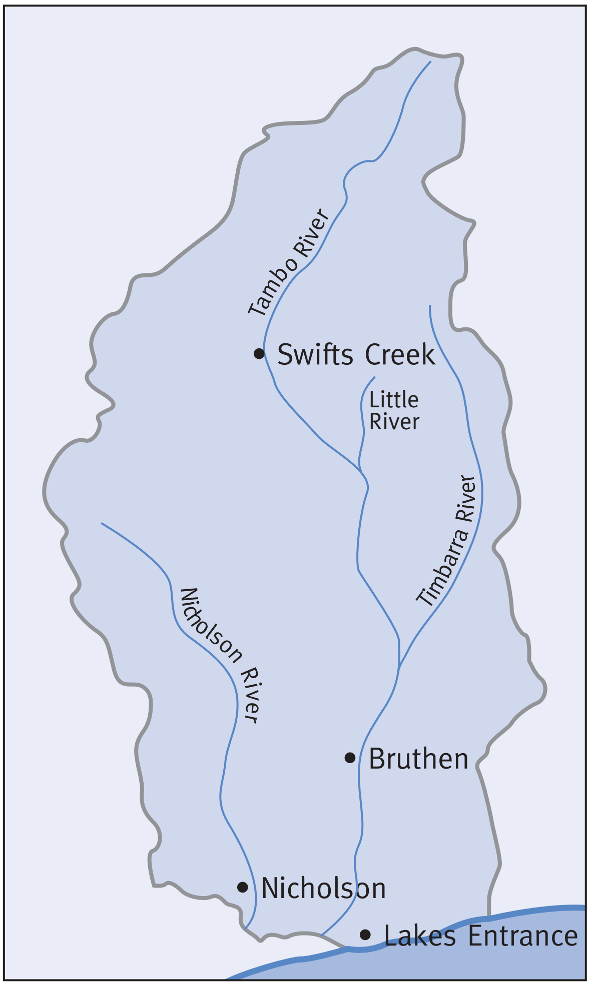
Mean Annual Water Quality Source: Vic Waterdata Warehouse

The Tambo / Nicholson

The Tambo/Nicholson River catchments

The Tambo River Basin includes the Tambo and Nicholson Rivers, and has a total area of 425,000 ha. Its average annual discharge is approximately 325,000 ML. The basin extends north for 120 km, with most of its area in steep forested mountains. There is only a small southern section of flat farmland and an area of farmland in the middle to upper reaches of the Tambo River valley.
The mean annual rainfall in the central Tambo River area is 500–700 mm with 700–1,000 mm in the upper catchment. The upper catchment is well forested, varying from very tall ash and alpine/sub alpine vegetation in the headwater area of the Timbarra River, to mixed species forest in the middle and lower reaches of the rivers. The Timbarra River is a major tributary of the Tambo, and forms the western boundary of the East Gippsland region.

The Tambo and Timbarra Rivers have a reliable flow rarely ceasing to flow. The Nicholson River often ceases to flow during summer. Both the Nicholson and particularly the Tambo Rivers have extensive estuaries, with the predominant fish species being bream. Estuary perch are common in the Tambo River. Access to most rivers is restricted because of the terrain. Unfortunately the most accessible river (the Tambo) is of limited angling value because of the scarcity of angling species.



Water allocation

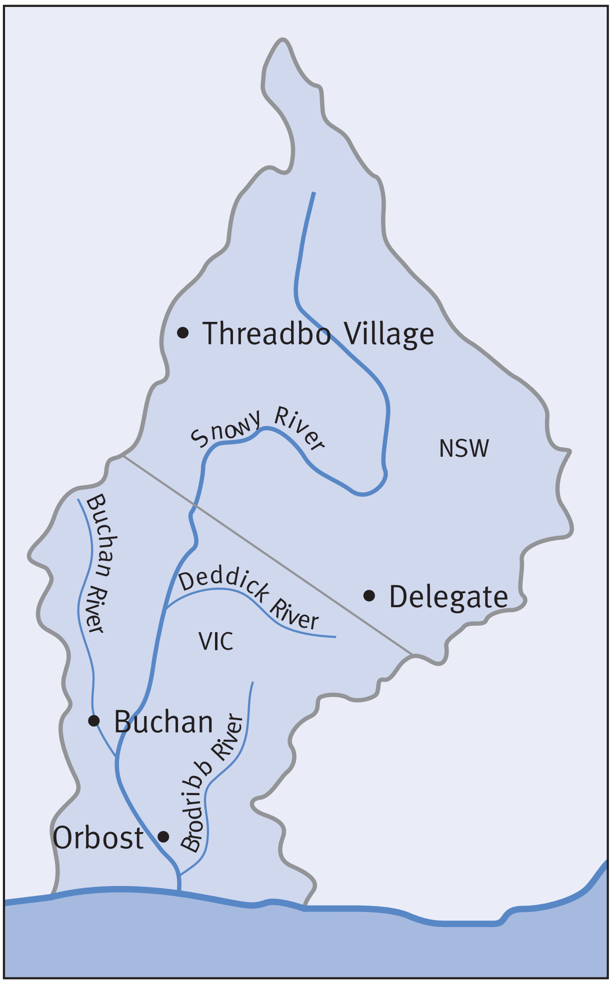
Of the Tambo's 325,000 ML discharge approximately 100,000 ML are divertible and only 5,000 ML have been developed.

Water is pumped from the Tambo River to the towns of Swifts Creek and Bruthen. The Nicholson River supplies to Lakes Entrance directly and via a 637 ML reservoir. There is a 45 ML reservoir at Boggy Creek that also supplies to Nowa Nowa.

Tambo/Nicholson Basin Water Quality	Tambo River at Ramrod Creek		Nicholson River at Deptford		Nicholson River at rivers' mouth (surface/depth)	
Date	14 Sep '98	22 Oct '98	14 Sep '98	22 Oct '98	12 Apr '04	10 May '04
Dissolved oxygen mg/l	10.60	9.80	10.20	9.80	7.2	13.4
Electrical conductivity uS/cm	220	210	95	100	37,520/43,410	27,580/36,800
Temperature °C	14.5	16.5	13.0	16.0	18.5/18.5	13.5/13.5
pH	7.7	7.9	7.6	7.6	8.5/8.5	9/8.5
Turbidity NTU	1.5	0.8	1.5	1.0		
Total phosphorus mg/l	0.011	0.014	0.010	0.015		
Reactive P mg/l	0.003	0.003	0.003	0.003	0.03/0.03	0.0/0.015
Average annual flow ML/day	1131.447		145.076			

Mean Annual Water Quality Source: East Gippsland Waterwatch Data, Vic Waterdata Warehouse

The Snowy



The Snowy River catchment

The Snowy River flows from high tablelands near the New South Wales border, and continues through areas of mountainous ranges to Orbost. The Snowy Basin includes a number of major tributaries including the Suggan Buggan, Little and Buchan Rivers to the west, and the Deddick, Rodger and Brodribb Rivers to the east. The Snowy River Catchment itself has a total area of 1,580,000 ha of which 41% lies in Victoria.

In the lower reaches around Orbost the riparian vegetation is poor. There is considerable deposition of sand occurring. The tributary and minor streams in the forested sections (over 95% of their total length) are in good to excellent condition. The river reaches in cleared farmland and does have some erosion problems. Riparian vegetation is degraded but they are generally in moderate condition.

Water allocation

The area of the Snowy Catchment that occurs in New South Wales generates the greatest proportion of the basin's total annual 3,490,000 ML flow, 1,130,000 ML of which is currently diverted into the Snowy Mountains Hydroelectric Scheme. Average annual water use within the Victorian part of the basin is only 2,230 ML, three-quarters of which is used for irrigation.

Threats and impacts

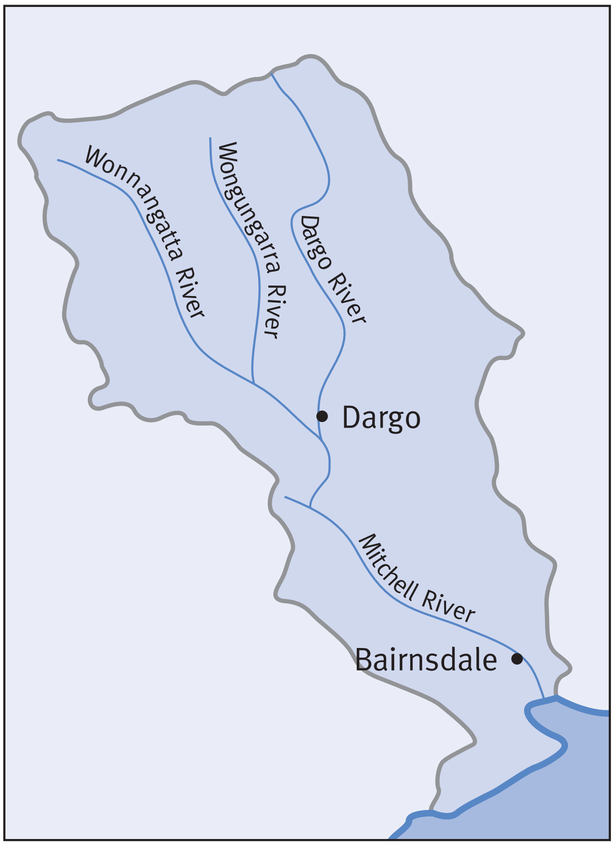
Greater environmental flow releases have recently commenced on the Snowy. The objective is to restore flows to 28% of mean annual flow. There is also a proposal to restore original instream habitat, including deep pools. Much of the Basin is located in National Parks. Access to the Snowy River Valley is difficult. The pristine sections are located in National Parks and are worth a visit.

Because flow in the Snowy River is controlled by water released from NSW, the upper reaches within Victoria have been severely degraded. There has also been severe sedimentation in the estuary from reduced high flows that used to carry sediments out to sea. Increased environmental flow and river health strategies should see the Snowy improve in the future.

Snowy Basin Water Quality	Rodger River at Jacksons Crossing	Snowy River at downside of Basin Creek	Snowy River at Orbost
Position in the Catchment	Upper	Middle	Lower
Dissolved oxygen mg/l	9.8	9.8	9.5
Electrical conductivity uS/cm	81	110	145
Nitrates and nitrites mg/l	0.0645	0.0105	0.26
pH	7.1	7.7	7.3
Turbidity NTU	2.5	1.8	2.5
Total phosphorus mg/l	0.013	0.012	0.016

Mean Annual Water Quality Source: Vic Waterdata Warehouse

The Mitchell



The Mitchell River Catchment

The Mitchell River Catchment extends 120 km in length from the High Plains near Mount Hotham to Lake King, and is 40 km in width. It covers a total area of 544,884 ha, which is 2.5% of the area of Victoria. Its annual flow is 960,000 ML.

Much of the upper Mitchell River Catchment is State Forest and National Park. The Major Rivers that flow into the Mitchell include the Wonnangatta, Wongungarra, Dargo, Wentworth and Tabberabbera River. Once the river emerges onto undulating plains at Glenaladale, intensive vegetable farming and cattle grazing begins. The Mitchell River flows through 8 km of silt jetties, before feeding into Lake King in the Gippsland Lakes. The water of the Gippsland Lakes is a mixture of fresh and salt water (brackish). This system is called an estuary. Brackish water pushes up the Mitchell River when there is low river flow.

Water allocation

The Mitchell River Catchment has not been dammed for domestic water supply, however this has been proposed. Currently, 18,900 ML/year is allocated for use. Irrigators use 75% and most of the remainder is allocated for urban and industrial use. This estimate of water use does not take account of the volume of reclaimed or returned water.

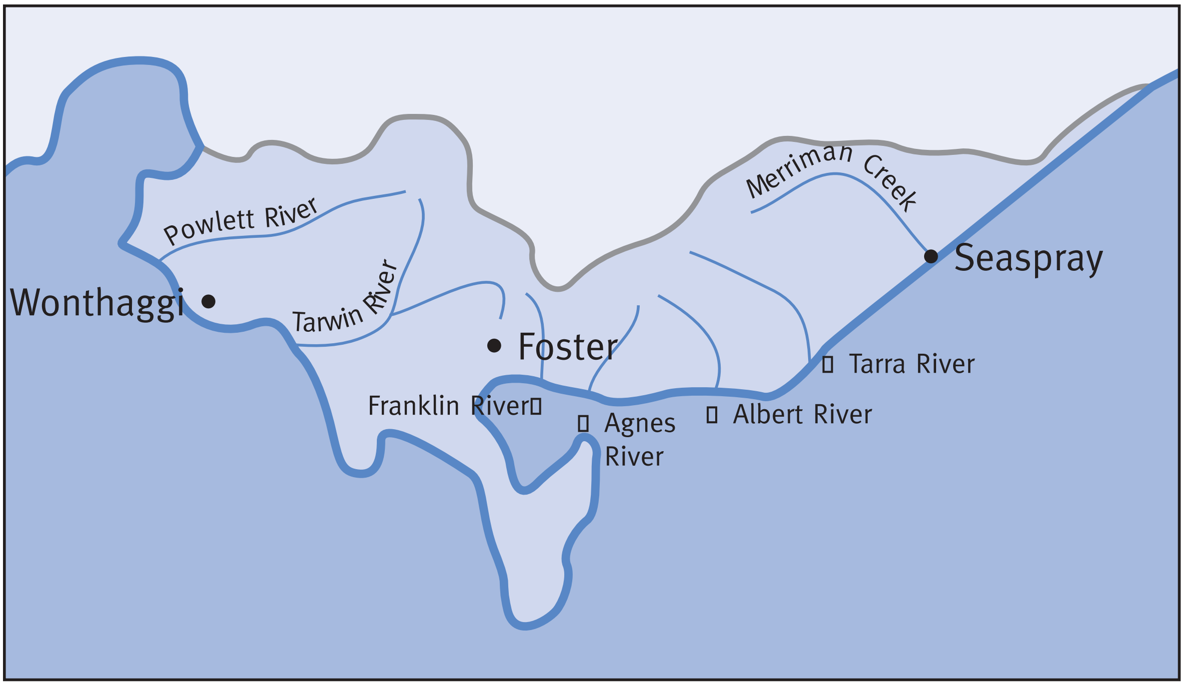
Threats and impacts

The river flows through the Mitchell River National Park, which covers an area of 12,000 ha, and is famous for the Mitchell River Gorge, Den of Nargun and Billy Goat Bend Bluff. White water rafters and hikers take advantage of the flow levels and walking track that follows the Mitchell River. The river does however have weed infestation (blackberries and willows) on its banks. Planned work by the Catchment Management Authority is removing willows, which are being replaced with native riparian species. Deer, goat, wild dog, fox, rabbit and hair are all common throughout the Mitchell River Catchment. Regular feral animal control programs are conducted.

Mitchell Basin Water Quality	Mitchell River at Hillside		Wonnangatta River at Waterford	
Date	8 Dec '03	15 Jan '04	18 Jun '90	30 Jul '90
Dissolved oxygen mg/l			11.80	11.40
Electrical conductivity uS/cm	54	64	58	41
Temperature °C	21.0	24.0		
pH	6.5	6.5	7.0	7.0
Turbidity NTU	90	10	1.7	5.9
Total phosphorus mg/l			7.5	8.0
Reactive P mg/l	0.012	0.0		
Average annual flow ML/day			2438.52	

Mean Annual Water Quality Source: East Gippsland Waterwatch Data, Vic Waterdata Warehouse

South Gippsland



South Gippsland catchments

The catchments of South Gippsland are the most Southern in Victoria. They extend from Westernport Bay in the west to Lake Reeve in the east, and cover 6,789 km (3% of the State). This includes Wilson's Promontory National Park and Phillip Island, The Strzelecki and the Hoddle Ranges. The landscape is hilly in the north western and Wilson's Promontory regions. The western and eastern areas are mainly undulating. There are plains along the eastern coast. The main stream networks are the Bass, Powlett, Tarwin, Franklin, Agnes and Tarra rivers. The average rainfall varies from 755 mm at Yarram to 970 mm at Leongatha. The Strzelecki Ranges receive up to 1,500 mm annually.

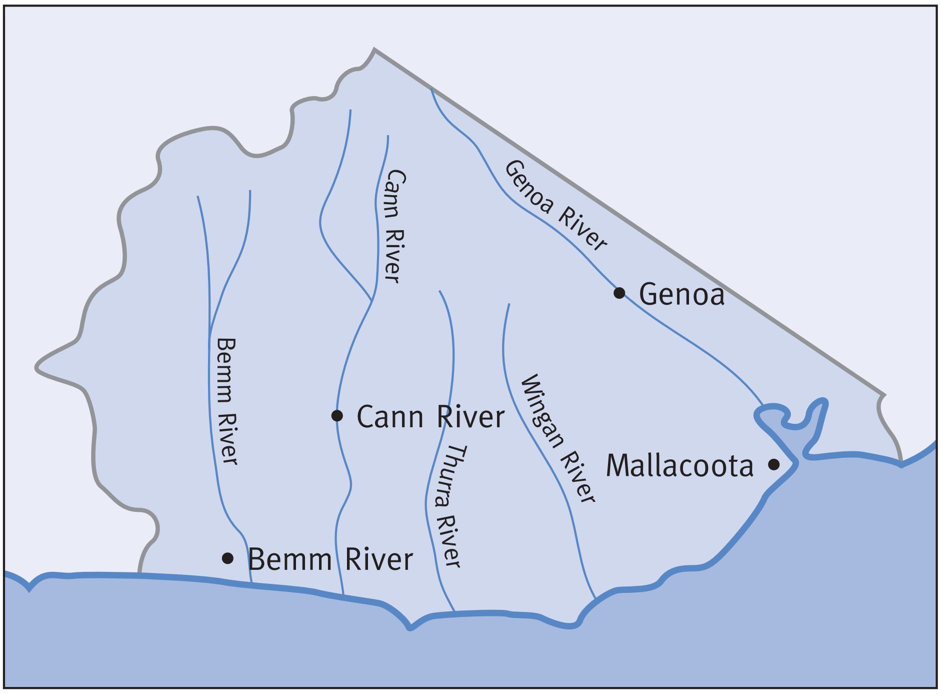
Water allocation and use

The mean annual flow of the basin is 851,000 ML, which represents 4.2% of the total runoff generated in the state. Within the catchments there are two major storages for domestic water supply; Candowie Reservoir is situated on Tennant Creek, a tributary of Bass River, and has a capacity of 2,270 ML. It supplies water to the towns around Western Port Bay and Phillip Island. Lance Creek Reservoir is situated on a tributary of the Powlett River, and has a capacity of 1,900 ML. The reservoir supplies the townships of Wonthaggi and Inverloch.

The main land-uses in the basin include dairy farming, crops, pigs, cattle and sheep for wool. Tourism also plays an important role, with major tourist destinations including Wilson's Promontory and Phillip Island. The average annual water use is 11,860 ML; 52% for urban and industrial use, 35% for irrigation, and the remaining 13% for rural use. Elevated nutrient levels from intensive agricultural activity affect water quality within the South Gippsland Basin. From mid 1994 to mid 1995 a number of algal blooms were recorded.

The South Gippsland Basin comprises shallow and deep aquifers. Water is extracted from both groundwater and surface water sources for irrigation, urban and industrial use. A deep aquifer exists in the east of the basin known as the Latrobe Group aquifer. The quality of the basin's groundwater is generally fresh to marginal, however the areas in the north-west of the basin and just north of Welshpool yield marginal to brackish quality.

Far East Catchments



Far East catchments

The East Gippsland River Catchments, in the far east of Victoria, are characterised by there extensive forest cover. They begin in deeply dissected mountains in the north, moving towards the south. The terrain gradually flattens out to foothills, then broad coastal plains and extensive dune systems. The far east Gippsland Catchments include; Yeerung River, Bemm River, Cann River, Thurra River, Wingan River, Betka River, Genoa River and many remote coastal streams.

The catchments cover a total area of 604,000 ha. Approximately 150,000 ha is in south western New South Wales. The Victorian portion of the catchments amounts to 2 percent of Victoria. The mean annual stream flow of the basin is 770,000 ML or 3.5% of total state discharge. The predominant land uses in the East Gippsland River catchments are State Forest and National Parks, however there is some grazing.

Water allocation and quality

There are no major water storages in far east Gippsland Catchments. The water diversions currently allocated include 1,230 ML/yr for urban and irrigation use. Water quality is excellent due to the largely unmodified basin conditions.

The pristine conditions house several species protected under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 including:

- Australian Grayling (a native fish)
- The green and golden bell frog
- Southern bell frog
- Giant Burrowing frog

Threats and impacts

Because of the low human population in the region, Far East Gippsland river catchments are amongst the least disturbed in the state. Of the 56 river reaches across Victoria that have been defined as ecologically healthy, 16 of these are in Far East Gippslands' River Catchments. The National Land and Water Resources Audit has classified all the estuaries as 'near pristine' or 'largely unmodified'. The rivers between the Bemm and Genoa Rivers flow through Croajingolong National Park and are within the UNESCO Biosphere Reserve. Threats to these rivers include:

- Severe flooding which causes erosion of river banks and siltation of river beds
- Invasion of pest fish species such as carp and trout
- Weed infestations such as Willows, blackberries and Bridal Creeper

The Gippsland Lakes

Estuarine and coastal lakes such as the Gippsland Lakes are very important to the region in many ways. They support very high levels of plants and animals, acting as spawning ground for fish, refuge and breeding grounds for birds and sanctuary for many other animals and plants. They provide a recreational venue for people for boating, skiing, fishing and swimming and an aesthetic landscape to holiday or live. The lakes are protected under the Ramsar Convention.

The Gippsland Lakes system

The Gippsland Lakes are a series of shallow, interconnected estuarine and coastal lagoons stretching almost 70 km long and 15 km wide at the widest point, around 200 km east of Melbourne. The lakes run almost parallel with the Ninety-Mile Beach along Bass Strait, and have a combined surface area of 365 km^2. They drain a catchment area of 20,600 km^2.

The lakes are the outfalls for the Tambo, Mitchell, Thomson and Latrobe basins, which drain a number of river catchments.

These include:

- the Latrobe, Macalister, Thomson, Avon, Mitchell, Nicholson and Tambo River catchments, as well as Perry Creek, Toms Creek, Middle Creek and Slaughterhouse Creek.

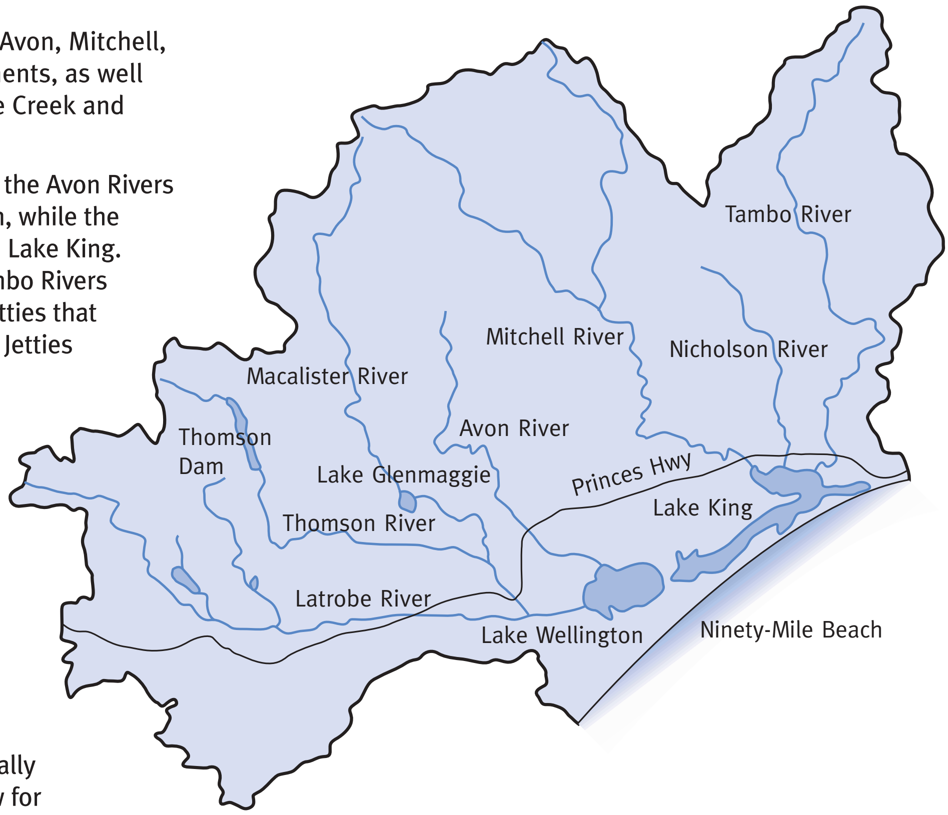
The Latrobe, Thomson, Macalister, and the Avon Rivers drain predominately to Lake Wellington, while the Mitchell, Nicholson and Tambo drain to Lake King. Sediment loads in the Mitchell and Tambo Rivers have led to the formation of long silt jetties that jut out into Lake King. The Mitchell Silt Jetties are considered a geomorphic site of international significance. Smaller silt jetties are located on the Avon and Latrobe river mouths.

The Entrance

In 1869 a channel was dug across the sand dune spit at what is now Lakes Entrance, to provide access for boating to and from Bass Strait. A natural entrance had already existed near the end of Cunninghame Arm that periodically opened to the sea, but was too shallow for navigation. The new channel led to considerable mixing of sea water into the lakes, altering the once freshwater lakes and wetland systems into saline or brackish waters.

As agriculture and towns flourished around the lakes and in the catchments, nutrient loads and silts gradually increased. This contributed significantly to the lakes' current high nutrient loading.

Several serious ecological changes have accompanied this transition, including algal blooms, sedimentation and oxygen deficiency in deeper water areas. These have the potential for major environmental consequences, as well as impacting on human activities.



Environmental issues of the lakes

Eutrophication
In 1991, some 3470 tonnes of nitrates and 347 tonnes of phosphates entered the lakes system. This included nutrient loads in urban and boat sewage, agricultural runoff, stormwater, industrial effluent and animal effluent. Eutrophication leads to toxic algal blooms, oxygen deprivation and eventual loss of biodiversity (see Wetlands & Lakes Information Sheet).

Sedimentation and turbidity
High sediment loads come from roads, agricultural runoff, mine tailings, land clearing, irrigation drains and erosion after fire or logging. Rivers with silty bottoms also contribute to high sediment loads.

High turbidity limits photosynthesis, affecting aquatic plants on which many animals and fish rely. Sedimentation on the bottom of lakes smother organisms such as macroinvertebrates.

Plants and vegetation
Very little original native vegetation remains along the shores of the lakes. Significant alteration of water salinity due to the entrance has contributed to dieback of Melaleuca (paperbark) stands. Land clearing and agricultural practices have led to large declines in native reeds and rushes, such as Ribbon Weed and Common Reed. In their place, introduced weeds such as Cape Ivy and Agapanthus have proliferated.

Native fish stocks
Native fish stocks such as the Black Bream are declining in the lakes. Reduced levels of available oxygen from high nutrient loads, turbidity and loss of seagrasses have reduced spawning opportunities for fish, as have fishing practices. European Carp have invaded the lakes. They are prolific breeders and bottom feeders, increasing the turbidity of the water.

Litter
Human litter typically enters the lakes either by stormwater outfall from urban areas in the catchments, or from tourists and boats using the lakes. Litter is both unsightly and environmentally damaging, and can threaten birds and fish stocks.

CASE STUDY
Gippsland Lakes Future Directions and Action Plan

Studies by the CSIRO have identified increases in sediment and nutrient loads into the Gippsland Lakes as the key issue in their degradation. In order to restore the lakes to a healthy environment the State Government released the Gippsland Lakes Future Directions and Actions Plan in 2002. This plan aims to reduce nutrient levels entering the lakes by 40% by 2022, and will provide $12.8 million in funding. The other objectives include:

1. Balancing freshwater and salt water flows to improve the ecological health of the lakes
2. Maintaining and enhancing wetlands biodiversity
3. Increasing community awareness and participation
4. Continued planning and evaluation of the program's effectiveness

Nutrient abatement projects include reducing phosphorus loads from the Macalister irrigation district and dairy effluent management.

In 2003, an old causeway on the Cunninghame Arm was replaced with a concrete bridge and channel. The causeway prevented fish migration and water passage between Warm Holes; an important fish habitat and breeding ground, and Cunninghame Arm.

References
www.gcb.vic.gov.au/gippslandlakes/fact.htm

Resources

Gippland Coastal Board
– Gippland Lakes Environmental Study Fact Sheets
www.gcb.vic.gov.au/gippslandlakes/fact.htm