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PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Tasmania

Aquatic Ecology of the Montagu River Catchment

A Report Forming Part of the Requirements for State of Rivers Reporting

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The Department of Primary Industries, Water and Environment provides leadership in the sustainable management and development of Tasmania's resources. The Mission of the Department is to advance Tasmania's prosperity through the sustainable development of our natural resources and the conservation of our natural and cultural heritage for the future.

The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

Summary

This report deals with aspects of the aquatic ecology of the Montagu River and associated tributaries. It provides an overview of the aquatic fauna of the catchment and details of the habitat requirements of particular species found in the Montagu River catchment. The report also provides an overview of fauna and flora within the catchment that are of conservational significance, with particular reference to those species that rely on the aquatic or riparian environment. Details of the species status, distribution, habitat requirements, and threatening processes are also included. The main focus of this report details work carried out in the Montagu catchment in February 1999 using AusRivAS (Australian River Assessment System) to assess riverine health using macroinvertebrates as bio-indicators.

The major findings of the study are summarised below:

- A clear pattern of river health deterioration exists for the Montagu River mainstream for reaches sampled in developed/agricultural areas. Of the eleven sites analysed using AusRivAS, 2 sites were classified as unimpaired, 7 sites were classified as significantly impaired and 2 sites as severely impaired. The decline in river health scores was primarily attributable to a dramatic loss of taxa that would be present under unimpacted conditions. At all but one site river health status for the mainstream appears to be determined by poor habitat availability rather than poor water quality.

- The tributaries of the catchment were found to be significantly impaired. Throughout, habitat degradation has been identified as the potential source of impact on condition. Water quality has also been identified as a potential source of impact for tributary reaches within agricultural areas. Water quality has an important influence on 'river health' for areas that have been subject to modification by channelisation and riparian clearing.

Implementation of better riparian management practices, riparian and instream habitat restoration, decreasing agricultural runoff, limiting stock access, minimising sediment and nutrient input and improving water quality have been identified as positive measures essential for improving the health of waterways in the Montagu catchment.

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Glossary of Terms

Anadromous	Fish that hatch in freshwater, then migrate to salt water to grow and mature, and in turn migrate back into fresh water to spawn and reproduce.
Amphidromous	Refers to fishes that regularly migrate between freshwater and the sea (in both directions), but not for the purpose of breeding, as in anadromous and catadromous species.
AusRivAS	Australian River Assessment System - Series of procedures and associated software for the rapid assessment of river conditions or 'health' using macroinvertebrate communities.
Catadromous	Fish that migrate from fresh water to salt water to spawn or reproduce.
Dimorphic	The existence of distinct male and female forms within a species, based on marked differences in shapes, size, colour and morphology.
Demersal	Living and feeding in the water column (i.e. rather than at the surface or on the bottom).
Fish passage	The directed movement of a fish past a given point in a stream. Particularly relates to the engineering and biological aspects of restoring free passage at barriers.
Macrophytes	Large aquatic plant.
Macroinvertebrates	Invertebrate (without a backbone) animals which can be seen with the naked eye.
Pools	Deep, still water , usually within the main river channel.
Riffles	Areas of fast moving, broken water.
Riparian vegetation	Vegetation on the banks of streams and rivers.
Run	Unbroken, moving water.
Substrate	The structural elements of the river bed; boulder, cobble etc.
Taxon (plural: taxa)	The member of any particular taxonomic group eg. a particular species, family etc.
Woody debris	Dead or living tree (branch or root system) that has fallen into or is immersed (totally or partially) in a stream. Generally with diameter greater than 10cm and length exceeding 1metre (large woody debris). Key habitat for many species of in-stream fauna.

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1. Introduction

This report deals with aspects of the aquatic ecology of the Montagu River and associated tributaries. It provides an overview of the aquatic fauna of the catchment and details of the habitat requirements of particular species found in the Montagu River catchment. The report also provides an overview of fauna and flora within the catchment that are of high conservation significance, with particular reference to those species that are found in the aquatic or riparian environment. Details of the species status, distribution, habitat requirements, and threatening processes are also included. This report also highlights the key threats to the aquatic ecology of the Montagu catchment and suggests management measures to maintain or enhance of the current status of aquatic populations in the Montagu catchment.

The main focus of this report details work carried out in the Montagu catchment in February 1999 using AusRivAS (Australian River Assessment System) to assess riverine health using macroinvertebrates as bio-indicators. The models used to assess river health were developed under the Australia Wide Assessment of River Health (AWARH) project (Krasnicki *et al.*, 2001). These models are comprehensive in their development and allow a relatively rapid biological assessment of riverine health at specific sites.

1.1 General description

The Montagu River originates in low hills directly south of the Roger River State Reserve at an altitude of 180 metres above sea level and flows into Robbins Passage near Robbins Island. The Montagu River is approximately 42 km long and has a catchment area of approximately 357 km^2. The headwaters of the river overlie the Trowutta Land System. Parent materials of this land system are comprised of volcanic and sedimentary rocks from the Cambrian. This land system supports an open forest community dominated by stringybark (*Eucalyptus obliqua*), myrtle (*Nothofagus cunninghamii*) and sassafrass (*Atherosperma moschatum*), with an understorey of dogwood (*Pomaderris apetala*), leatherwood (*Eucryphia lucida*) and soft tree fern (*Dicksonia antarctica*). A small outcrop of Precambrian mudstones belonging to the Milshake Hills Land System occurs in the vicinity of the Roger River Road crossing and extends almost to the township of Roger River (Richley, 1978). The Milkshake Land System supports a tall open forest vegetation type, which is dominated by stringybark and Smithton peppermint (*Eucalyptus nitida*). Myrtle, sassafrass, swamp gum (*Eucalyptus ovata*) and celery top pine (*Phyllocladus asplenifolius*) are also a prominent feature of the vegetation of this land system. At Roger River Road the river is at an altitude of 50m above sea level, having descended some 130 metres over the 3 km from its source.

Downstream of Roger River Road the river passes into the Montagu River Land System. The Montagu River Land System extends for around 4 km downstream of the road crossing and is typified by level or slightly undulating plains developed on Quaternary sand deposits (Richley, 1978). This land system typically supports open eucalypt forest dominated by Smithton peppermint and swamp gum with an understorey of leatherwood, manuka (*Leptospermum scoparium*), woolly tea-tree (*Leptospermum lanigerum*) and the variable sallow wattle (*Acacia mucronata dependens*). Along drainage lines the vegetation forms a closed shrub community of leatherwood, manuka, cutting grass (*Gahnia grandis*), myrtle and celery top pine. In the vicinity of Christmas Hills Road the river passes for around 3 km through the Ekberg Creek Land System (Richley, 1978). This land system is typified by gently undulating plains of Precambrian dolomite that supports a tall open Eucalypt forest community. Smithton peppermint, stringybark, swamp gum and myrtle dominate the overstorey whilst variable sallow wattle, woolly tea-tree, lance wood (*Phebalium squameum*) and stinkwood (*Zieria arborescens*) are key elements of the understorey. The Montagu Land

System outcrops again becoming the predominant land system from this point to the vicinity of Rennison Road near Togari.

The Plains Land System (comprised of Quaternary deposits) underlies the river from this point to the outlet at Robbins Passage approximately 20 km downstream. This land system forms extensive areas of flat to gently undulating plains throughout the North West corner of Tasmania. The township of Brittons Swamp also overlies the Plains Land System. The vegetation supported by this land system forms an open heath community, comprising the bottlebrush tea-tree (*Melaleuca squarrosa),* manuka, and other tea-tree species. On better drained areas an open forest of Smithton peppermint, white gum (*Eucalyptus viminalis*) and swamp gum is common. Extensive areas of this land system have been cleared and drained for grazing and restricted cropping. The belts of low hills that demarcate the western (Bond Tier) and eastern extent (Christmas Hills) of the catchment to the north of the Bass Highway are comprised of Cambrian greywacke turbidite sequences belonging to the Fagans Road Land System (Richley, 1978). Fixters and Farnhams Creeks also overly this land system. The Fagans Road Land System is dominated by tall open forests of stringybark, swamp gum, myrtle and blackwood (*Acacia melanoxylon*). The understorey is typically dominated by species such as dogwood, lancewood and cutting grass.

Approximately 45% of the catchment has been developed for agriculture which has resulted in the fragmentation of native vegetation within the catchment (Montagu River Catchment Management Plan - options paper, 1998). Much of the low lying areas have been converted from swamp land to pasture for grazing, including the middle reaches of the mainstream, around Brittons Swamp and near Togari. These low lying areas are naturally poorly drained and historically were extensive areas of swamp habitat. Drainage of these swampy areas has been undertaken through the development of the swale and ridge (hump and hollow) pattern drainage system, which directs flow from waterlogged areas to the river via a system of drains. The Brittons Swamp and Togari Drainage Trusts have been responsible for the development and ongoing management of these drainage systems.

Sections of the Bond Tier and Christmas Hills have been converted to eucalypt and pine plantation although native vegetation is still the dominant vegetation type through these areas (Richley, 1978, TASVEG, 2002). Willow (*Salix fragilis*) and blackberries (*Rubus fruticosus*) occur throughout much of the developed zones of the catchment, though they are less dominant riparian zone species in comparison to the riparian vegetation found in other Tasmanian catchments.

1.2 Montagu Rivercare Plan

The Montagu River Catchment Management Group (MRCMG) has developed a two stage Rivercare plan for the Montagu catchment. The Montagu Rivercare plan was developed to address the natural resource management issues and objectives identified within the Montagu River Catchment Management Plan (MRCMP) completed by the MRCMG in 1997. Works aimed at addressing the key management resource issues and objectives as outlined within the Rivercare Plan 2000 (Stage 1) have been undertaken within the catchment and were completed in January 2002. Proposed works under Stage 2 of the Rivercare plan (Montagu Rivercare Plan, 2002) aim to address issues within the catchment relating to flooding and drainage, vegetation management and fauna issues, weeds, water quality and siltation.

Sediment input is undoubtedly a natural and important ecological process within low gradient rivers (Davies, 1999), though excessive siltation as a result of soil erosion and sediment mobilisation has the potential to affect in-stream ecology (Houshold, 2002). Land clearing and the development of drainage channels have been identified as major contributing factors to the presently elevated levels of sediment mobilisation within the Montagu and Welcome catchments (Houshold and Jerie, 2001). As a result of this sediment influx, many of the low energy reaches of these rivers have become laden with fine sediment (Houshold, 2002). A geomorphological investigation of the Welcome catchment has shown that the Welcome river naturally de-silts over time when sediment input has diminished (Houshold and Jerie, 2001).

Channelisation and desnagging have been proposed as control measures for the current sediment loads within the Montagu catchment (Montagu Rivercare Plan, 2002). Rivers of this geomorphological type however, are likely to be highly susceptible to significant erosional adjustment following such activities (Davies, 1999). As the system has the capacity to naturally desilt overtime, dredging of the mainstream is likely to be unwarranted (Houshold, 2002). The incorporation of sediment retention basins on drainage channels should impede the movement of sediment into the mainstream and thus control a major source of sediment input. Should the source of sediment input to the system be ameliorated, then natural flushing processes by flood events are likely to result in the system de-silting over time and returning to a more natural state.

2. Aquatic Fauna

2.1 Freshwater Crayfish

There are four major genera of native freshwater crayfish (Family Parastacidae) found within the northwest of Tasmania, being *Astacopsis, Parastacoides, Engaeus and Geocharax*. *Astacopsis and Parastacoides* are found only in Tasmania, whilst *Engaeus and Geocharax* are also found on mainland Australia. The genus *Cherax*, has been introduced to Tasmania from mainland Australia. No members of the genus *Parastacoides* have been recorded from the Montagu catchment to date.

Three species of *Astacopsis* occur in Tasmania (Hamr, 1990), with *Astacopsis gouldi* (the Giant freshwater crayfish) being the only member of this genus to occur within the Montagu catchment. *Astacopsis gouldi* is listed as a 'vulnerable' species under the Tasmanian *Threatened Species Protection Order 2001* and will be discussed further in Section 3.

There are 35 species in the genus *Engaeus* (Burrowing crayfish) in Australia. Thirteen of these species are endemic to Tasmania and two have ranges that extend to southeastern Australia. In Tasmania four species of *Engaeus* are currently listed as 'vulnerable' or 'of high conservational significance' (Bryant and Jackson, 1999). These are, the Burnie Burrowing Crayfish (*E. yabbimunna*), the Mt Arthur Burrowing Crayfish (*E. orramakunna*), Scottsdale Burrowing Crayfish (*E. spinicaudatus*), and the Flinders Island Burrowing Crayfish (*E. martigener*). Due to the limited distribution ranges of these species it is unlikely that they will occur within the Montagu catchment.

Four species of *Engaeus* (*E. fossor, E. lengana, E. cunicularius* and *E. cisternarius*) are likely to be found within the Montagu catchment. Throughout the North west of Tasmania, these species are found within swampy areas dominated by *Acacia melanoxylon* and or tea-tree species (Horwitz, 1990). Species of *Engaeus* are characterised by their ability to burrow (Horwitz, 1990). Horwitz and Richardson (1986) classified the burrows of Australian freshwater crayfish based on their relationship to the water-table. Species of *Engaeus* were found to occur in burrows which connect to permanent open water (Type 1b), burrows which connect to the water-table (Type 2) and or burrows independent of the water-table (Type 3) (Horwitz and Richardson, 1986). Tasmanian species of *Engaeus* typically occur in simple vertical shafts that connect the ground surface to the lowest depth of the water table (Type 2 burrows). Surface water run-off from nearby water bodies during periods of high flow typically raise the water level within these burrows to near the ground surface. During such periods, adults tend to become temporary surface dwellers, whilst juveniles are able to disperse from the burrows (Horwitz and Richardson, 1986). As surface flows are required for the dispersal of *Engaeus* species there are ecological implications for the failure to provide for these flows within the Montagu catchment.

The number of species that occur within the Genus *Geocharax* throughout Australia is at present unclear (Horwitz, 1995) however it is believed that *Geocharax gracilis* is the only species that occurs within Tasmania. *G. gracilis* is restricted to the far north west of Tasmania, occurring between Rocky Cape and Temma on the Tasmanian mainland and also on islands of the Hunter group and King Island. *G. gracilis* is commonly found in lowland coastal areas, in freshwater lagoons, along with blackwood and tea-tree swamps. Within such habitats they construct simple burrows that extend to the lowest level of the water table. As a result the burrows are often inundated during periods of high flow and during such times the crayfish emerge from the burrows.

2.2 Freshwater fish

There are 15 species of freshwater fish found within the North West of Tasmania (Fulton, 1990), seven of which have been recorded from the Montagu catchment to date (Table 1).

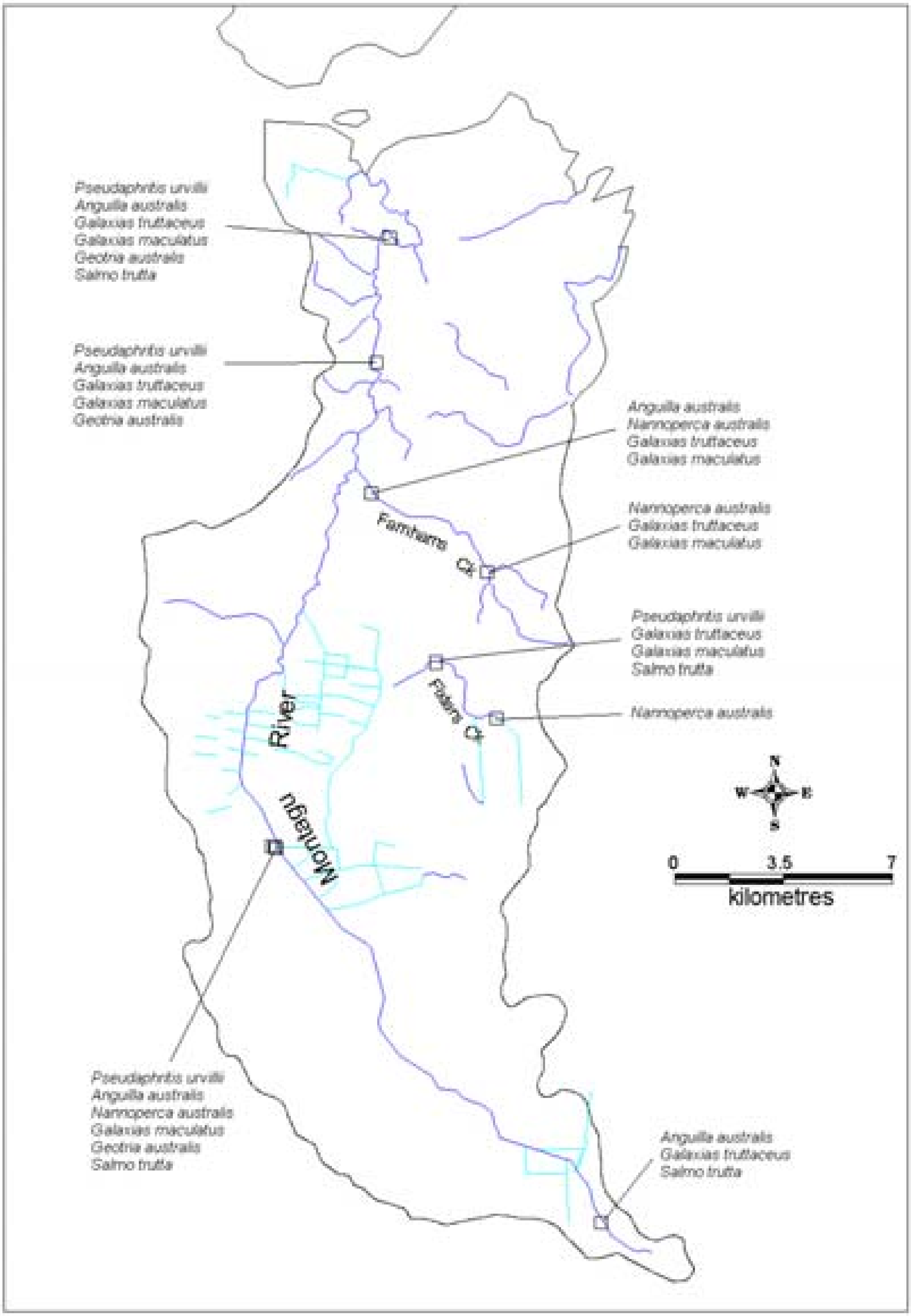
Table 1. Freshwater Fish of the Montagu Catchment.
Life History: M = migrates to and from sea or estuary, F = freshwater only
Habitat: R = rivers, L = lake, W = wetlands

Scientific Name	Common Name	Life History	Habitat
Native Fish			
Geotria australis	Pouched lamprey	M	R
Anguilla australis	Short-finned eel	M	R/L/W
Galaxias maculatus	Jollytail	M	R/L
Galaxias truttaceus	Spotted galaxias	M	R/L
Nannoperca australis	Pygmy perch	F	R/L/W
Pseudaphritis urvillii	Sandy flathead	M	R
Introduced Fish			
Salmo trutta	Brown Trout	M	R/L

In addition to the species listed in Table 1, a further three freshwater fish species are highly likely to occur within the Montagu catchment based on known distribution records and habitat requirements. These are; the dwarf galaxias (*Galaxiella pusilla),* the Australian grayling (*Prototroctes maraena*) and the Tasmanian smelt *(Retropinna tasmanica)*. *Galaxiella pusilla* is listed as 'rare' and *Prototroctes maraena* as 'vulnerable' under the Tasmanian *Threatened Species Protection Order 2001* and further information on these species is provided in the following section.

A survey was carried out at selected sites in the Montagu catchment in February 2002 to characterise the freshwater fish fauna of the Montagu catchment via presence of different species at selected sites. The results of this survey and existing fish distribution records are illustrated in Figure 1. It is evident that at present, fish passage within the catchment is little affected by in-stream barriers. Fish diversity within the main channel is high for most of its length and likewise for the major tributaries. The high diversity and numbers of native fish species surveyed at each site in the catchment and low numbers of introduced species such as brown trout are consistent with the findings of Davies (1999) for the Welcome catchment. It could be argued that fish diversity and distribution within these catchments is representative of near natural conditions and fish passage has been little altered by in-stream developments to date (such as dams, bridges, and culverts). With this in mind, careful consideration should be taken to ensure that future in-stream developments for the mainstream and tributaries do not result in the development of significant barriers to fish passage. This is particularly important, given that eleven of Tasmania’s 25 native fish species are migratory and require free passage between headwaters and the sea in order to maintain population diversity (Walker, 1999). Barriers can therefore have major implications for fish populations with the potential to cause localised extinctions, reduce fish abundance and lower genetic diversity (Thorncraft and Harris, 2000).

Figure 1: Fish distribution map for the Montagu catchment.



2.3 Amphibians

Five different frog species have been recorded from the Montagu catchment and an additional species (*Limnodynastes peroni*) is likely to occur within the catchment based on known distribution and habitat requirements (Table 2). The species noted all are of secure status within the state (Smith, 1990) and well represented within their range.

Table 2. Frog species of the Montagu catchment.

Scientific name	Common name	Status
Crinia signifera	Brown froglet	native
Crinia tasmaniensis	Tasmanian froglet	native/endemic
Geocrinia laevis	Tasmanian smooth frog	native
Limnodynastes dumerili	Banjo frog	native
Limnodynastes peroni	Striped marsh frog	native
Litoria ewingi	Brown tree frog	native

Despite their secure status frog populations with Tasmania have undergone a steady decline over the past few decades (Amphibian Advisory Committee, 1997) in responses to environmental changes, including increased ultraviolet levels, global warming and habitat changes, such as draining of swamp habitats. Key threats for frogs in include the draining of wetland habitats, invasion of weed species, pollution by pesticides, fertilizers and effluent, predation by introduced animals and siltation of waterways by surface runoff (Bryant and Jackson, 1999). At a global level the increased level of ultra-violet light radiation associated with the depletion of the ozone appears to have a negative impact on frog populations (Amphibian Advisory Committee, 1997). Amphibian densities and distributions were not directly studied in the determination of the condition of the aquatic ecology for the catchment.

3. Endangered species

Two plant and six animal species that are either aquatic or obligate riparian taxa, which are listed in the *Tasmanian Threatened Species Act 1995* are known to occur within the Montagu catchment. Details of the status of these species are provided in Table 3 below (Source – PWS GTSPOT Database) with further information on habitat requirements and distribution outlined in the following sections. A species is regarded as endangered when the causal factors relating to its decline continue operating and ultimately reduce the long term survival prospects of that species (Bryant and Jackson, 1999). Alterations to the natural flow conditions have the potential to impact on these species either directly or indirectly.

Table 3. Threatened species list for the Montagu catchment.

NAME	COMMON	CLASS	SCHEDULE
*Galaxiella pusilla**	Dwarf Galaxiid	Fish	rare
*Prototroctes maraena**	Australian grayling	Fish	vulnerable
*Astacopsis gouldi**	Giant freshwater crayfish	Crustacea	vulnerable
*Beddomeia fultoni**	hydrobiid snail	Gastropoda	rare
*Tasmaphena lamproides**	Keeled snail	Gastropoda	rare
*Ooperipatellus cryptus**	Northwest velvet worm	Onychophora	rare
*Hypolepis muelleri**	Harsh ground fern	Filicopsida	rare
*Acacia mucronata dependens**	Variable sallow wattle	Dicotyledonae	rare

Species marked with an asterisk are aquatic or obligate riparian species.

It should be noted that this section aims to identify endangered species currently known to or expected to occur within aquatic and riparian environments of the Montagu catchment. It may be likely that in the future further species will become of conservation significance within the catchment, particularly those species for which threatening processes continue to operate. In the following section detailed information is provided for each species listed in Table 3 above.

3.1 Threatened fauna

3.1.1 *Galaxiella pusilla*

The dwarf galaxiid (*Galaxiella pusilla*) is one of twelve freshwater fish currently listed on Tasmania's Threatened Species Protection Order 2001. The species is listed as 'rare' within Tasmania and as 'vulnerable' on a national level under the *Commonwealth Environment Protection and Biodiversity Protection Act 1999.*

The dwarf galaxiid is a small native fish that occurs solely in freshwater and does not exceed a length of 4 centimetres (McDowall and Fulton, 1996). The species is sexually dimorphic with the females being the larger and less brightly coloured sex (McDowall and Fulton, 1996). The dwarf galaxiid is more or less a transparent with olive-amber colouration dorsally and a silvery white belly. Three black longitudinal stripes run the length of the trunk in both sexes. The males have an additional orange stripe between the middle and lower longitudinal stripes making them distinctive from the females. Spawning occurs between August and October with eggs being deposited on aquatic plants one at a time. Individual females make take as much as two weeks to deposit up to 250 eggs. Within 2 to 3 weeks the larvae hatch. *G. pusilla* is an annual species, with the adults dying following spawning, thus populations are of a single year class (McDowall and Fulton, 1996).

The range of the species within Tasmania is quite disjunct, being restricted to the far northwest and north east (including Flinders Island) of the state (Bryant and Jackson, 1999). The species occurs mainly in lowland waterways that are still or gently flowing with well developed aquatic macrophyte or emergent plant communities. *G.pusilla* have typically been found in swamps and drains, or backwaters of streams, hiding amongst vegetation (Jean Jackson, Native Fish Conservation officer, pers.comm., Inland Fisheries Service, 2001). They may also be found in temporary waters that dry up during periods of low flow (typically the summer months) and are recharged during periods of higher flow (Bryant and Jackson, 1999).

Key threats for the species as identified by Bryant and Jackson (1999), include;

- Loss and degradation of habitat for any reason (e.g. draining of wetlands, trampling by stock, clearance of stream side and other vegetation);
- Water extraction for irrigation and stock;
- Siltation due to erosion and surface runoff.

3.1.2 *Prototroctes maraena*

The Australian grayling (*Prototroctes maraena*) is listed as 'vulnerable' within Tasmania under the *Threatened Species Protection Order 2001* and as 'vulnerable' on a national level under the Commonwealth Environment Protection and Biodiversity Protection Act 1999. *Prototroctes maraena* is an anadromous species that can grow to over 300 mm (McDowall, 1996). *P. maraena* are usually dark greenish to greyish olive dorsally becoming lighter and more silvery laterally and whitish ventrally (Fulton, 1990). A dark mid-lateral streak is usually evident, effectively dividing the pigmentation pattern.

Prototroctes maraena can be found at low altitudes in the middle to lower reaches of coastal rivers and streams that open to the sea. It occurs widely in northern and eastern coastal rivers and streams but less commonly in western rivers. Though knowledge has increased significantly over the past few decades as a result of intensive studies, much of the basic biology, including distribution and migratory behaviour, is relatively unknown (McDowall, 1996; Bryant and Jackson, 1999).

The reproductive period for the Australian grayling (*Prototroctes maraena*) is from late summer to early autumn although Fulton (1990) suggests that spawning in Tasmania may take place from late spring to early summer. Little is known of the characteristics of spawning sites (McDowall, 1996) though it appears that areas of moderately flowing freshwater with a gravelly stream bed are preferred (Bryant and Jackson, 1999). Each female produces about 25,000 to 68,000 demersal eggs that are probably shed and settle to the bottom just downstream of the spawning site (McDowall, 1996). The developmental period for the egg is dependant on water temperature with the period increasing as temperature decreases. At about 16^{o}C the eggs take 12 days to hatch. The newly hatched larvae are positively phototrophic, which means they will actively swim toward the surface of the water. This is believed to be the mechanism by which the larvae are swept down to estuaries and to sea. The larvae are strictly marine and return as juveniles to the freshwater environment after a period of around 6 months (McDowall, 1996). Male fish may reach sexual maturity after one year and females after the second year. The species may live up to five years, with most individuals typically reaching 2 to 3 years of age.

Key threats for the species as identified by Bryant and Jackson (1999), include;

- Habitat loss and disturbance, especially to the lower reaches of rivers.
- Dams and weirs preventing upstream movement and migration.
- Pollution of waterways by agriculture, forestry and urban development.
- Changes in flow patterns caused by dams and water extraction for irrigation.
- Habitat alterations such as wood removal and channel realignment for flood mitigation.

3.1.3 *Astacopsis gouldi*

The giant freshwater crayfish (*Astacopsis gouldi*) is listed as 'vulnerable' within Tasmania under the *Threatened Species Protection Order 2001* and as 'vulnerable' on a national level under the *Commonwealth Environment Protection and Biodiversity Protection Act 1999*.

Horwitz (1994) documented the distribution of *A. gouldi* within Tasmania. According to Horwitz (1994) the species is restricted to the northern flowing catchments of Northern Tasmania and is naturally absent from the Tamar valley system. Hamr (1990) documented the reproductive biology of *A. gouldi*, and he found that females mate and spawn in autumn (April – May) and carry eggs over winter. Females mature after 14 years of age and then breed every two years (Bryant, 1998a). The young hatch in January and remain attached until well into the following summer (Bryant and Jackson, 1999). *A. gouldi* juveniles and adults are most active during summer and early autumn (Bryant, 1998b) when flows are naturally lowest within the Montagu River (see Hydrology report). Further reductions in flow over this period have the potential to further reduce habitat availability for this species. In addition critical periods for key events in the lifecycle of this species occur during the irrigation season (hatching and detachment of juveniles). Differences in habitat utilisation have been noted for varying age classes of this species with adults typically being in pools containing snags and CWD and juveniles in shallow riffles or smaller stream zones. Though both favour habitats within reaches with an intact cover of riparian vegetation. The habitats used by *A. gouldi* are most at risk of becoming unwetted during periods of low flows, which has potential future implications for the amount of water abstraction for the river. It is beyond the scope of this study however to determine the effect of low flows on this species. The species is known to occur within the lower reaches of the mainstream and the major tributaries, though it is likely to occur throughout the catchment, wherever suitable habitat occurs (GtSpot Database).

Key threats for the species as identified by Bryant and Jackson (1999) include:

- Any form of habitat disturbance, including the removal of stream side vegetation, bank erosion, de-snagging, shifting of channels, siltation, organic and chemical pollution;
- Conversion of native forest to plantation (eucalypt tree farm or pine plantation) which results in the loss of canopy cover, increased erosion, sedimentation and changes to stream dynamics;
- Removal of woody debris from streams;
- Water pollution by pesticides, fertilisers and sediment;
- Increased road development leading to greater fishing potential and access to previously unexploited populations;
- Illegal fishing (poaching);
- Fragmentation of populations by barriers to movement, such as poorly constructed or raised culverts.

3.1.4 *Beddomeia fultoni*

The genus *Beddomeia* is one of four genera that comprise the Beddomeia complex of Hydrobiid snails (Family Hydrobiidea). Ponder *et al.* (1993) provides detailed descriptions and information of all members of the Beddomeia complex. The genus *Beddomeia* is comprised of 47 species that represent the bulk of the 67 species that belong to the Beddomeia complex. The genus *Beddomeia* occurs across the northern third of the state and is endemic and restricted to Tasmania (Bryant and Jackson, 1999). Many of the species belonging to the genus have limited geographical ranges with isolated populations in particular catchments and as such are susceptible to disturbance processes. This has provided the impetus required for the current listing of 42 members of the Beddomeia complex as rare under the *Tasmanian Threatened Species Protection Act 1995* including *Beddomeia fultoni*.

Beddomeia fultoni is restricted in geographic distribution to the Montagu catchment, where it has been found in the tributaries of Farnhams and Fixters Creeks (Ponder *et al.*, 1993). Christmas Hills and Brittons Swamp are key sites for the species (Bryant and Jackson, 1999). The species is typically cryptic in habit with a tendency to occur in areas of low hydrological variation within small to large streams. *Beddomeia fultoni* has been found to occur in association with a variety of substrates including, detritus, CWD, root mats and rocky substrates (Ponder *et al.*, 1993). Ponder (1988) suggests that landuse impacts and competition with introduced species such as *Potamopyrgus antipodarium* are having a deleterious effect on native snail populations and these impacts primarily occur in lowland rural and urban streams (Davies, 1995).

Key threats for the species as identified by Bryant and Jackson (1999) include:

- Clearing of stream side vegetation which alters temperature, light and food availability;
- Destruction of small seepages;
- Water pollution by pesticides, fertilisers and increased sediment loads;
- Damming of streams, especially in the headwaters;
- Extraction of rock or gravel or heavy machinery and structures placed in the stream bed.

3.1.5 *Tasmaphena lamproides*

The Keeled snail (*Tasmaphena lamproides)* is listed as 'rare' within Tasmania under the *Threatened Species Protection Order 2001,* though it is not listed at a national level under the *Commonwealth Environment Protection and Biodiversity Protection Act 1999.* The main population of *T. lamproides* occurs within the north west of Tasmania, with smaller populations being present on Three Hummock Island, and on Wilsons Promontory in Victoria (Bonham and Taylor, 1997). The Montagu catchment, particularly the Togari forest block to the north and west of Christmas Hills is a 'hot spot' for the species. Populations of *T. lamproides* appear to be correlated with forest types with deep leaf litter accumulation, typically wet, mixed and old growth forests within riparian zones (Bryant and Jackson, 1999). The species is cryptic and occurs deep within leaf litter, under rocks, and in association with rotting logs (Smith and Kershaw, 1981). Riparian processes govern the availability of the microhabitat preferred by the species and as such changes to riparian processes (eg. limiting of inundation during high flow events) may impact negatively upon the species.

Key threats for the species as identified by Bryant and Jackson (1999) include:
• Loss and fragmentation of native forest habitat due to clearing;
• Conversion of native forest to plantation (eucalypt tree farm and pine);
• Hot and frequent fires which destroy the litter layer and ground elements needed for shelter.

3.1.6 *Ooperipatellus cryptus*

The Northwest velvet worm (*Ooperipatellus cryptus)* is listed as 'rare' within Tasmania under the *Threatened Species Protection Order 2001*. Velvet worms belong to the Phylum Onychophora are a considered a 'missing link' between true worms and insects. Velvet worms are caterpillar like in appearance, with a pair of psuedopodia (non-segmented legs) arising from each of the internal body segments and a single pair of antenna. The presence of minute papillae (skin folds) over the body gives the velvet like appearance by which the phylum is colloquially known. *Ooperipatellus cryptus* is a small cryptic species bearing 14 pairs of psuedopodia and reaching a length of up to 10 centimetres. Velvet worms are particularly prone to water loss and as a result occur in microhabitats which typically have a relatively high water content and that remain constantly moist (Horner, 1995). Such stable environments tend to be patchy in distribution occurring in habitats such as well decomposed logs, under deep woody litter and in some instances even rock scree talus (Bryant and Jackson, 1999). Many of these prime microhabitat types occur at relatively high frequency within riparian zones, and as a result population densities tend to be higher within the riparian zones (Mesibov and Ruhberg, 1991). *Ooperipatellus cryptus* occurs over an area of around 2000 km^2, with the main population centred around the Christmas Hills, Arthur River and Rapid River areas (Forest Practices Board, 1998).

Key threats for the species as identified by Bryant and Jackson (1999) include:

• Conversion of native forest to plantation (eucalypt tree farm or pine) due to the removal of rotting log habitat from the ground;
• Clearing of forest for agriculture, resulting in loss of log and litter layers;
• High frequency or high-intensity fires which can eliminate decaying log habitat. This includes heaping and burning windrows.

3.2 Threatened flora

3.2.1 *Hypolepis muelleri*

The harsh ground fern (*Hypolepis muelleri*) is listed as 'rare' in the *Tasmanian Threatened Species Protection Act 1995*. *H. muelleri* is reserved within the north east of the state in Mt William National Park and in Strezlecki National Park on Flinders Island. The species has a limited distribution with a range of less than 20 10km x 10km National Mapping grid squares (Kirkpatrick *et al.*, 1991). The species occurs within wet eucalypt forest habitat with deep alluvial soils at altitudes below 120 metres above sea level. The species is commonly encountered within the riparian zone along river flats and flood plains and is known to occur within the Farnhams Creek area.

3.2.3 *Acacia mucronata dependens*

The variable sallow wattle (*Acacia mucronata dependens*) is listed as 'rare' in the *Tasmanian Threatened Species Protection Act 1995*. The taxa is not known to occur within any secure reserve within the State and has a range of less than 20 10km x 10km National Mapping grid squares (Kirkpatrick *et al.*, 1991). *Acacia mucronata dependens* is a facultative riparian shrub occurring in the moist zone back from the water edge. This species is reliant on consistent moisture levels and may be adversely effected by changes in stream flow characteristics (Askey-Doran *et al.*, 1999). Water extraction over the summer period is a key threat as it has the potential to alter moisture gradients within the riparian zone. The main threats to riparian vegetation are vegetation clearance, stock access, flow regulation and invasive weeds (Askey-Doran *et al.*, 1999). Riparian vegetation is commonly cleared for cropping and grazing purposes, but may also be cleared for improved drainage, river access, improved recreational amenities and fire hazard reduction (Askey-Doran *et al.*, 1999). The modifications that result from these activities are often compounded by natural processes that reinforce any degradation that has occurred. Maintaining and or restoring indigenous vegetation at such sites is often very difficult as natural processes tend to be over ridden (Askey-Doran *et al.*, 1999).

3.3 Overview of threatening processes

From the above information it is evident that the aquatic and riparian fauna and flora of conservational significance within the Montagu catchment are likely to be at risk from a similar suite of processes. Key threatening processes as identified by Bryant and Jackson (1999) that appears to operate within the Montagu catchment, include:

- Loss of riparian habitat through land clearing;
- Channelisation and modification of stream courses;
- Siltation due to erosion and surface runoff;
- Unrestricted stock access to the riparian zone and stream course;
- Invasion of exotic species of plant and animal;
- Removal of woody debris from streams;
- Water pollution by pesticides, fertilisers and sediment.

Ongoing clearance, degradation and conversion of native vegetation are recognised as major threats to the long term survival of many animal and plant species within Tasmania. Other impacts such as pollution of waterways, commercial and industrial practices, inappropriate recreational activities, and invasion by exotic species collectively threaten rare and common taxa (Bryant and Jackson, 1999). In areas where such processes continue to operate species of conservational significance are further at risk of decline and even local extinction. Species that are currently secure are also at risk of declining numbers and may become of conservational significance if the threatening processes continue to operate. Specific areas where 'threat abatement' measures should be prioritised within the Montagu catchment can be identified by the distribution of threatened species and the identification of areas that are in natural or near natural condition.

At present, throughout Australia and Tasmania, considerable resources are being expended to conserve threatened species and to protect and/or rehabilitate their required habitats (Askey-Doran *et al.*, 1999). The value of protecting areas that contain natural or near natural habitat should be intuitive. By maintaining or promoting natural habitat conditions the future cost associated with their conservation and rehabilitation will be significantly lower.

Though addressing 'threat abatement' may appear to be a challenging task activities may only require simple actions or minor changes in current practices. Appropriate management techniques will not only reduce potential impacts to currently threatened species but also provide for the long term conservation and enhancement of all native fauna and flora within the Montagu catchment. The threat abatement measures identified above are consistent with the vision for the catchment highlighted in elements of the Montagu River Catchment Management Plan (MRCMP, 2000).

4. AUSRIVAS assessment

4.1 Methodology

The National River Health Program was formed in 1993 by the Federal Government to provide a means of assessing the ecological condition of Australia's river systems. The Australian Wide Assessment of River Health (AWARH) project in Tasmania commenced in 1994 and the programs primary objectives were to develop predictive models to allow assessment of river health using macroinvertebrates as biological indicators. Over 250 sites in Tasmania were sampled in order to build the bioassessment models. As part of this sampling, 3 test sites were sampled during autumn and spring of 1997 in the Montagu catchment. No reference sites were sampled within the catchment. Reference sites are defined as sites that are least disturbed and are suitable for use in the construction of predictive models. Test sites are those sites defined to be of importance in assessing the condition of a river known or thought to be experiencing an impact from water quality or habitat degradation. Because the selection of sites in the Montagu catchment was primarily aimed at the development and testing of river health models, the overall coverage of the catchment was not extensive.

A more intensive survey was conducted as part of this State of Rivers study during February 1999. This snapshot survey collected information from 18 sites throughout the catchment, including sites along the entire mainstream channel of the Montagu River as well as multiple sites on Fixters and Farnhams Creeks (see Figure 2). These sites are the primary focus of the next section and where possible comparisons have been made with AWARH sites (BT26, BT27 and BT28) from autumn and spring of 1997. The biological assessment package AusRivAS (Australian River Assessment System) was used to provide a broad scale picture of river health at selected sites in the Montagu catchment.

The sites were sampled using the rapid bioassessment technique outlined in CEPA (1994) and Oldmeadow *et al*. (1998). This involved collecting biological samples from riffle and edgewater habitats where possible. Riffles are defined as areas of shallow, fast-flowing broken water usually stony or rocky substrates. Samples were collected from riffles by disturbing the substrate by the sampler's feet to dislodge animals, which were swept into a net by the current. The edgewater sample was collected by sweeping the net along the lateral margins of the river and in backwaters and pools which have slow currents or no flow. Aquatic plants (macrophytes), which provide additional habitat for aquatic macroinvertebrates, are often found in these edgewater habitats and were included in the sweep sample.

Water quality measurements including temperature, pH, dissolved oxygen, electrical conductivity and turbidity were made at each site. Observations were also made on the vegetation along the river banks (riparian zone), aquatic habitat (substrate, depth, velocity) and surrounding land use. The samples were live-sorted and preserved in the field and transported to the laboratory for further identification. All macroinvertebrates were identified to family level except in the following cases: Chironomidae (midges) were identified to sub-family level Oligochaeta (worms), Hirudinea (leeches), Acarina (mites) and Turbellaria (flatworms) were identified to order and class level.

4.2 AusRivAS modelling

The AusRivAS model essentially predicts the aquatic macroinvertebrate fauna that would be expected to occur at a site in the absence of environmental stress such as pollution or habitat degradation. The first step of the model building process is classifying reference sites into groups that have similar invertebrate composition, based on family level presence/absence data. This is done using the agglomerative clustering technique, flexible unweighted pair-group arithmetic averaging (UPGMA). The reference site groups from the classification are entered into the reference habitat data set and a stepwise multiple discriminant function analysis (MDFA) is used to select the predictor variables used in a model. This procedure selects a subset of habitat variables that best discriminate between the groups of sites formed from the faunal classifications. The subset of habitat variables obtained from the stepwise MDFA is used as predictor variables for the AusRivAS model being constructed. The predictor variables and the reference site invertebrate classification form the foundation of AusRivAS, allowing predictions of which taxa should be found at new sites to be made. A comparison of the invertebrates predicted to occur at the test sites with those actually collected provides a measure of biological impairment at the tested sites (Simpson *et al*., 1996). A more detailed description of AusRivAS modelling is provided by Krasnicki *et al*., 2001).

4.3 O:E Indices

Each site is classified into five categories based on the ratio of macroinvertebrates "Observed" (or sampled) to the macroinvertebrates "Expected". This ratio is known as the observed / expected score or "OE". Table 4 presents the categories used and the OE ratio ranges for each cut off. The OE ratio represents the percentage of taxa sampled at a site. From the table below, a site with less than 15 percent of the taxa expected to be present at the site is considered to be impaired to some degree. The advantage of these river health models is that not only the presence of an impact but also the magnitude can be determined for a specific site.

Another biotic index is incorporated into the model output to provide an insight into the nature of the disturbance or impact at a site. OESIGNAL (Stream Invertebrate Grade Number Average Level) is a ratio of the observed (sampled) SIGNAL score to the expected SIGNAL score (Chessman, 1995). The index is based on the sensitivity of macroinvertebrates to pollution. Each family of macroinvertebrates is assigned a grade according to their tolerance where a grade of 10 represents a high sensitivity to pollution and a grade of 1 represents a high tolerance to pollution. The "observed" SIGNAL score is the sum of the grades divided by the number of taxa collected and the "expected" score is the sum of the grades divided by the number of taxa expected.

OE is sensitive to a wide variety of disturbances provided they result in the loss of families of macroinvertebrates from the habitats sampled at a site. Thus this index should detect not only loss of families due to deteriorated water quality, but also loss because of physical habitat degradation. OE SIGNAL weights the families by their sensitivity to water pollution. Accordingly, OESIGNAL can detect situations where water pollution has resulted in the loss of only a few, but very sensitive, families of macroinvertebrates.

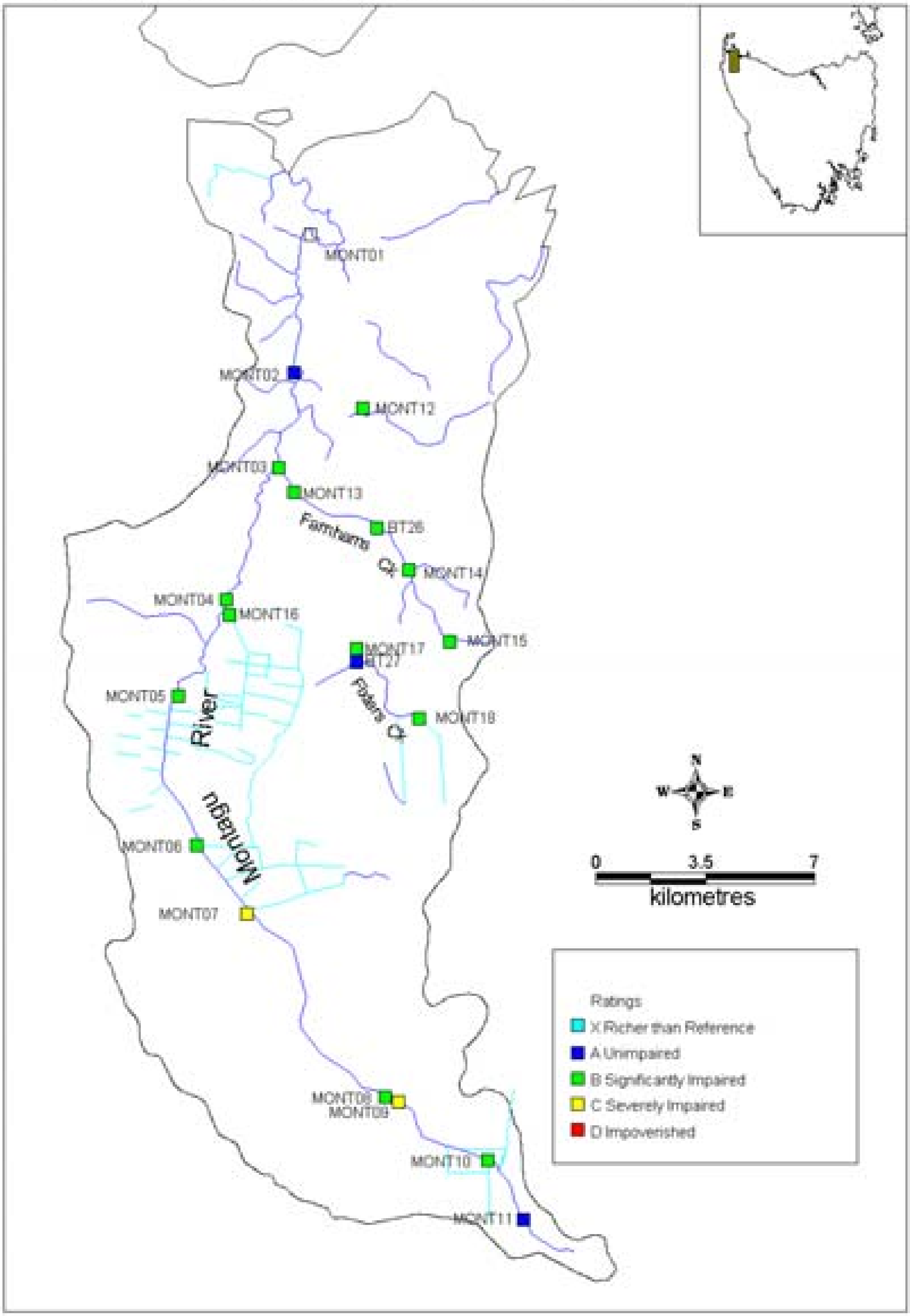
Table 4: River Health categories and associated OE scores.

Band Label	OE Scores	Band Name	Comments
X	>1.15	Richer than Reference	• More families than expected • Potentially biodiverse site • Possible mild organic enrichment
A	0.85-1.14	Unimpaired	• Index value within range of the central 80% of reference sites
B	0.52-0.84	Significantly Impaired	• Fewer families than expected • Potential mild to moderate impact on water quality, habitat or both, resulting in the loss of families
C	0.12-0.54	Severely Impaired	• Considerably fewer families than expected • Loss of families due to moderate to severe impact on water and/or habitat quality
D	<0.12	Impoverished	• Very few families collected • Highly degraded • Very poor water and/or habitat quality

Taxa and habitat data from the edgewater samples has been analysed using autumn edgewater models developed by DPIWE (Krasnicki *et al*., 2001). The predictor variables for the autumn edgewater model are percentage boulder cover, conductivity, depth, latitude and longitude (see Appendix 2).

Riffle habitats are rare in the Montagu catchment and were only sampled at 3 locations under the AWARH project (Farnhams Ck. at Farnhams Creek Rd., Fixters Ck. at Riseborough Rd., and Montagu River at Renison Rd.) and 2 locations under this project (Montagu River at Stuarts Rd. and Montagu River at Roger River Rd.). As a result of the low occurrence of riffle habitat and the prevalence of edgewater habitat, the latter habitat has been favoured for diagnostic interpretation in the AusRivAS analysis as it provides a more detailed view of riverine health for the entire catchment. AusRivAS analysis of taxa and habitat data classes the five sites at which riffle samples were collected as significantly impaired (B band) (Krasnicki *et al*., 2001).

Figure 2: AUSRIVAS river health ratings for the Montagu catchment.



4.4 Results

A total of 59 taxa were identified from the edgewater habitats sampled. Sampled taxa are representative of a low gradient, slow flowing system that drains directly to the coast (Sphaerid bivalves, freshwater crabs, freshwater shrimps, water boatmen and diving beetles). Several of the common taxa are regularly encountered in rivers that are subject to high organic enrichment (freshwater leeches, physid snails, and “blood worms” or chironomid fly larvae (*Chironomus spp*)). Insects were the most dominant fauna, representing around 71% of the total number of taxa collected and accounting for over 67% of the number of individuals collected. The most dominant families in terms of distribution and abundance were Leptoceridae (caddisflies), Chironomidae (midges) Leptophlebiidae (mayflies) and Parameletidae (scuds/amphipods).

The number of invertebrate taxa found in a river reach can give a reasonable representation of the health of a stream, though is a coarse interpretation of the data. The total number of taxa recorded per site ranged from 4 to 16 with a mean of 10 per site. However, the number of taxa found at a site did not always appear to reflect the ecological health of the river at that site. For example, some sites that received a poor river health rating such as, Montagu River at Donalds Rd. (MONT10) could still support a relatively large number of aquatic macroinvertebrate taxa. Conversely, some sites that were rated as good for environmental aquatic habitat such as, Montagu River at Thorpes Plains (MONT03), could only support a relatively low number of families. This shows that it is not only the number of taxa alone that is important but the type of families and whether they are indicative of healthy or degraded rivers. In this respect, the AusRivAS outputs are better indicators of river health since, as biological assessments, they consider factors other than physical habitat condition. These factors include tolerance or intolerance to pollution and a range of physico-chemical, geographical and habitat variables.

The AusRivAS outputs of OE, OESIGNAL and Band allocations for each site are provided in Table 5. AusRivAS outputs for the edgewater samples rated 3 of the 19 sites as unimpaired (A band), 14 sites as significantly impaired (B band) and 2 sites as severely impaired (C band).

Table 5. Number of Families, AusRivAS OE and OESIGNAL scores for autumn edgewater models for sites in the Montagu catchment.

Site Name	Northing	Easting	No. of Taxa	OE50	OESignal	Band
Farnhams Ck/Farnhams Ck Rd.(BT26)	5479400	327700	8	0.67	0.8	B
Fixters Ck @ Riseborough Rd.(BT27)	5469300	326850	12	0.89	0.89	A
Montagu R off Quillams Rd (MONT02)	5478500	322490	15	1.08	0.92	A
Montagu R off Barcoo Rd. (MONT03)	5475500	324300	7	0.72	1.07	B
Montagu R at 14 Mile Plain (MONT04)	5470800	322820	10	0.6	0.95	B
Montagu R at Rennison Rd. (MONT05)	5468200	321100	15	0.71	0.95	B
Montagu R at Bass H'way (MONT06)	5463400	321700	9	0.48	0.69	B
Montagu R off Eldridges Rd. (MONT07)	5461200	323300	6	0.22	0.89	C
Montagu R D/S Christmas Hills Rd. (MONT08)	5455300	327700	16	0.6	0.94	B
Montagu R U/S Christmas Hills Rd. (MONT09)	5455300	327700	10	0.31	0.91	C
Montagu R at Donalds Rd.(MONT10)	5453300	331000	15	0.67	1.1	B
Montagu R at Roger River Rd. (MONT11)	5451400	332150	12	1.05	1.06	A
Un-named Trib at Barcoo Rd. (MONT12)	5477400	327000	4	0.56	0.69	B
Farnhams Ck at Barcoo Rd. (MONT13)	5475700	324800	7	0.44	0.93	B
Farnhams Ck at Fagans Rd. (MONT14)	5472200	328500	10	0.56	0.99	B
Farnhams Ck at Bass H'way (MONT15)	5469900	329800	8	0.62	0.79	B
Canal off Barcoo Rd. (MONT16)	5470800	322850	9	0.48	0.87	B
Fixters Ck at Riseborough Rd. (MONT17)	5469300	326850	7	0.67	0.8	B
Fixters Ck at Bass H'way (MONT18).	5467500	328800	11	0.48	0.76	B

4.4.1 Montagu River Mainstream

Eleven sites were sampled on the Montagu mainstream (Figure 2) during the February 1999 snapshot, with the Montagu River at Stuarts Rd. (MONT01) being the only site at which an edgewater habitat was not sampled. At this site only the riffle habitat was sampled and as a consequence the resultant AusRivAS output is not directly comparable to outputs based on edgewater assessments. As previously stated (Section 4.3) both sites for the mainstream at which riffle samples were collected during the February 1999 snapshot, were found to be significantly impaired (B band).

Generally, the number of edgewater taxa was consistent across all sites within the main channel, and the taxa that were found are generally tolerant to a broad range of environmental conditions. Taxon number was found to be lower in some reaches that were adjacent to or directly downstream of areas developed for dairy farming.

The AusRivAS outputs for the 10 mainstream sites at which edgewater habitats were sampled rated the Montagu River off Quillams Rd. (MONT02) and Montagu River at Roger River Rd. (MONT11) as unimpaired. The Montagu River at Thorpes Plains (MONT03), Montagu River upstream canal off Barcoo Rd. (MONT04), Montagu River at Rennison Rd. (MONT05), Montagu River at Bass Highway (MONT06), Montagu River downstream of Christmas Hills Rd. (MONT08), and Montagu River at Donalds Rd. (MONT10) sites were rated as significantly impaired. Two sites were classed as severely impaired. These were Montagu River off Eldridges Rd. (MONT07) and Montagu River upstream of Christmas Hills Rd. (MONT09).

Interpretations for the possible causes of the lower OE scores are presented in Figure 3, which plots the OE score against the OESIGNAL scores for sites analysed by AusRivAS. This type of plot demonstrates the usefulness of including OESIGNAL for interpretation and diagnosis.

From Figure 3 it is evident that the Montagu River off Quillams Rd. (MONT02) (lower catchment) and Montagu River at Roger River Rd. (MONT11) (upper catchment) sites are unimpaired (A band). OE scores indicate that more taxa than expected were encountered at each of these sites and OESIGNAL scores suggest that the taxa present are relatively sensitive to disturbance. In-stream habitat data shows that both of these sites are subject to limited silt accumulation and provide diverse substrate sizes for habitat. Both sites also have natural riparian zones of over 40 metres in width and display little signs of disturbance.

Of the mainstream sites that were rated as significantly impaired (B band) (see Table 5 and Figure 3), most sites are potentially impacted by factors other than water quality. However, the Montagu River at Bass Highway (MONT06) may also be affected by water quality in addition to habitat based factors. Montagu River at Bass Highway (MONT06) received the lowest OE score (0.48 or 52% of expected taxa absent) for the mainstream sites that rated as slightly impaired (B band). For the remaining sites within this band, OE scores ranged between 0.6 and 0.72 (indicating that 28 to 40% of expected taxa are absent). With the exception of Montagu River at Thorpes Plains (MONT03), the B band sites were subject to moderate to extreme disturbance and had reduced to no riparian cover. The Montagu River at Thorpes Plains (MONT03) though having a near natural riparian cover displayed signs of scouring from flooding and offered little CWD cover. Aquatic macrophyte and algal growth are typically elevated in areas lacking riparian cover as a result of the increased incidence of solar radiation which favours an increase in primary production. Substrate diversity for the B band sites is low with most sites being dominated by fine sediments with minor bedrock elements. It has long been recognised that macroinvertebrate diversity and abundance are influenced by substrate size and substrate heterogeneity (Minshall, 1984). The lack of substrate diversity and the dominance of substrate types (silt, clay and gravel) that provide for limited habitat availability may explain the absence of many of the expected taxa for these sites.

The Montagu River at Bass Highway (MONT06) is the only mainstream site that rated as slightly impaired (B band) which may be influenced by water quality in addition to habitat condition. From Figure 3 it is evident that 42% of the taxa expected to occur at Montagu River at Bass Highway (MONT06) were absent and that those taxa present have a relatively high tolerance to disturbance. River contaminants from the drainage district upstream of the Bass Highway and localised changes in geology are likely to be the key factors influence water quality (refer to Water Quality report) at this site. Such stresses on in-stream fauna are typical of poor condition low land streams within intensive agricultural zones (Wilcock *et al.*, 1995).

The Montagu River off Eldridges Rd. (MONT07) and Montagu River upstream of Christmas Hills Rd. (MONT09) rated as significantly impaired, with both sites being impacted by factors other than water quality (see Figure 3). From Figure 3 it is evident that 78% of the taxa expected to occur at Montagu River off Eldridges Rd. (MONT07) and 69% of the taxa expected at Montagu River upstream of Christmas Hills Rd. (MONT09) were absent. Habitat data however reveals that the former site has the lower overall disturbance rating of the two sites (moderate as opposed to high disturbance) possibly due to a more intact riparian zone.

Examination of in-stream substrate information shows that the Montagu River off Eldridges Rd. (MONT06) is dominated by bedrock (60% of substrate available). Erosion of the bedrock material has produced pebble and gravel material that accounts for around 20% of the substrate cover. The Montagu River upstream of Christmas Hills Rd. (MONT09) is dominated by clay (50%), with gravel being the largest substrate class encountered. A substrate of this composition is more typical of the catchment as a whole. Low silt and detritus cover, may suggest that this site occurs in a relatively high energy reach (Houshold, 2002). Krasnicki *et al*., (2001) found that edgewater habitats within high energy reaches support a less diverse macroinvertebrate fauna than those of low energy reaches.

Since collection of data for interpretation by AusRivAS, Rivercare works have been conducted within several reaches of the main channel. These works are likely to have impacted either directly or indirectly on riverine condition from the Bass Highway to the mouth of the river. It is however, beyond the scope of this study to determine the effect of works conducted post sampling on the aquatic health of the river. Further studies in the catchment are required to determine the efficacy of works conducted in rehabilitating the river and riparian zones.

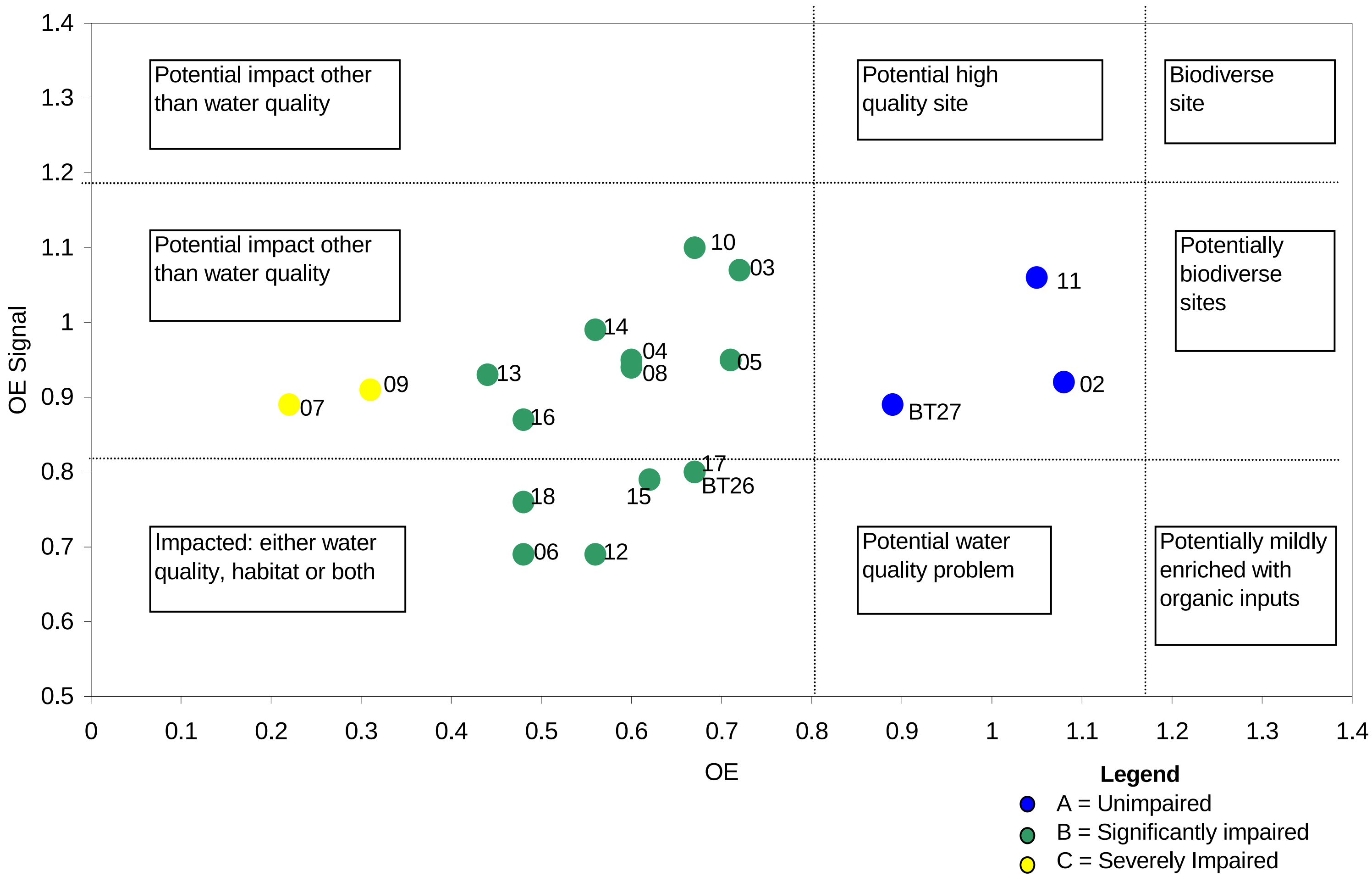


Figure 3. Plot of OE vs OESIGNAL for edgewater habitats at each site sampled under the present study and possible interpretations fo place sites in different bands. The vertical and horizontal lines indicate the upper and lower bounds for unimpaired (A) high quality site

4.4.2 Montagu River Tributaries

Sites on two major tributaries (Farnhams Creek and Fixters Creek) were sampled under the FNARH (First National Assessment of River Health) project in 1997. Additional site information for these tributaries, along with site information on a minor tributary and a canal off Barcoo Rd. were also collected for the purpose of the current study. Site codes MONT17 (this study) and BT27 (sampled in 1997) relate to a single site, Fixters Ck. at Riseborough Rd., which was sampled under both projects. This allows a coarse comparison of river health at different points in time for this site. AusRivAS outputs for the tributary sites rated all sites as significantly impaired (Band B) with the exception of Site BT27 (Fixters Ck. at Riseborough Rd.) which rated as similar to reference (A band). Under the FNARH project riffle samples were collected at Fixters Ck. at Riseborough Rd. (BT27) and Farnhams Ck. at Farnhams Creek Rd. (BT26). AusRivAS outputs indicate that river health status for these habitats is significantly impaired (B band) (Krasnicki *et al.*, 2001).

Farnhams Creek (MONT13, MONT14, MONT15 and BT26)

The fauna present within Farnhams Creek is typical of that which occurs within low gradient, slow flowing rivers of the region (Davies, 1999). All four sites surveyed on this tributary rated as significantly impaired using edgewater AusRivAS models. AusRivAS outputs (Figure 3) indicate that Farnhams Ck. at Barcoo Rd. (MONT13) and Farnhams Ck. at Fagans Rd. (MONT14) are impacted by factors other than water quality, whilst Farnhams Ck. at Bass Highway (MONT15) and Farnhams Ck. at Farnhams Creek Rd. (BT26) are impacted either by water quality, habitat or both.

OE scores for this tributary indicate that 33 to 56% of taxa that were expected to occur were absent from the sites sampled. Analysis of habitat data shows that the riparian zone at each sample point was in natural to near natural condition (refer to IRC report). In-stream habitat data shows that clay and silt are the dominant substrates within Farnhams Creek. Such substrates provide for limited habitat availability for macroinvertebrates (Minshall, 1984) and are a likely to impact on the number of expected taxa occurring at each site (Figure 3). Farnhams Ck. at Bass Highway (MONT15) and Farnhams Ck. at Farnhams Creek Rd. (BT26) are impacted either by water quality, habitat or both. Input of contaminants from the Brittons Swamp drainage district has the potential to impinge on water quality in this tributary, in particular Farnhams Ck. at Bass Highway (MONT15). The potential source of impact on water quality is not as clear for Farnhams Ck. at Farnhams Creek Rd. (BT26). It is likely that there is a downstream effect of inputs from Brittons Swamp as well as potential inputs from forestry practices within the region. Forestry operations have generally been found to increase inorganic sediment loads, increase organic matter input and elevate the loss of nutrient through surface runoff (Taylor, 1991). These factors are likely to alter water quality, which may account for the loss of sensitive macroinvertebrate taxa from Farnhams Ck. at Farnhams Creek Rd. (BT26).

Fixters Creek (MONT17, MONT18 and BT27)

Both sites on this tributary (Fixters Ck. at Riseborough Rd. (MONT17) and Fixters Ck. at Bass Highway (MONT18) sampled during this study were found to be significantly impaired (B band). Interpretation of AusRivAS outputs (Figure 3) suggest that both sites were impacted by water quality, habitat condition or both. The in-stream habitat for both sites is dominated by clay and fine sediments which provide limited habitat for macroinvertebrates. The riparian zone of the Fixters Ck. at Bass Highway (MONT18) has been highly altered, with the zone being depauperate of native flora and subject to minor infestations of blackberry and thistles (See IRC report). In contrast the riparian zone of Fixters Ck. at Riseborough Rd.

(MONT17) has been subject to limited disturbance and is in essentially natural condition. As with Farnhams Creek, water quality is likely to be reduced by runoff of contaminants from the drainage district at Brittons Swamp. These factors may also be responsible for the potential for water quality to impact on OE vs OESIGNAL scores at the Fixters Ck. at Riseborough Rd. site. This site is only three kilometres downstream of the Bass Highway crossing and passes through agriculture land for most of that distance.

Previous sampling of the edgewater habitat of the Fixters Ck. at Riseborough Rd. site (BT27) during autumn of 1997 (Krasnicki *et al*., 2001), rated this site as unimpaired (A band). OE scores indicate that between the two sampling events 22% of the taxa expected to occur at this site have become absent. Taxa information shows that this equates to 4 taxa that were represented by a total of 12 individuals. The absent taxa were; Parameletidae (previously 3 individuals), Tanypodiinae (5 individuals), Oniscigastridae (2 individuals), and Gripopterygidae (2 individuals). OESIGNAL scores also indicate that there has been a reduction in the number of taxa that are sensitive to changes in water quality, such as Gripopterygidae (sensitivity grade of 9) and Oniscigastridae (sensitivity grade of 7). Overall the site has been subject to limited physical disturbance between the two sampling events. The difference in river health ratings is likely to be a reflection of potential deterioration of water quality. This may be attributable to downstream effects from intensive agriculture throughout Brittons Swamp and to a lesser degree forestry in the area of Riseborough Road.

Sites on small tributaries (MONT12 and MONT16)

Both the un-named tributary off Barcoo Rd. (MONT12) and the un-named canal off Barcoo Rd. (MONT16) rated as significantly impaired using AusRivAS models. An OE score of 0.56 for the un-named tributary off Barcoo Rd. (MONT12) indicates that 44% of the taxa expected to occur at the site were absent. An OE score of 0.48 indicates that 52% of expected taxa were absent from the un-named canal off Barcoo Rd. (MONT16). From Figure 3 it is evident that the un-named tributary off Barcoo Rd. (MONT12) is potentially impacted by water quality, habitat or both, whilst the un-named canal off Barcoo Rd. (MONT16) is potentially impacted by factors other than water quality. Habitat data indicates that substrate habitat availability for invertebrate taxa is limited, as the site is dominated by bedrock and fine particulate material (such as sand and clay). From the Water Quality report, it is evident that low Ph values and periodically low oxygen levels occur at this site and these parameters are likely to also impinge on river health status.

Analysis of habitat data for the un-named canal off Barcoo Rd. (MONT16) shows that the riparian zone is highly modified, lacking overstorey and understorey components. In such instances it would be expected that aquatic plant and algae levels within the reach would be elevated by the increased light availability. Analysis of habitat data indicates that algae and aquatic plant growth is prolific at the site. The growth noted may also be enhanced by nutrient inputs from agricultural practices upstream. Under such conditions it would be expected that grazing taxa would be well represented. This is reflected in the taxa identified with grazing snails (Hydrobids and Physids) accounting for around 50% (98 of the 197) of the total number of individuals collected.

4.5 Summary

Overall, the river health of the Montagu catchment is poor with three-quarters of the sites sampled being found to be significantly impacted (B band). River health in edgewater habitats that were sampled varied from unimpaired in areas with natural vegetation cover to severely impaired within agricultural areas. All sites at which riffle habitats were assessed were found to be significantly impaired (B band).

River health for mainstream appears to be primarily determined by poor habitat availability rather than poor water quality. In general, AusRivAS OE and OESIGNAL scores as well as the loss of families expected indicate impacts on river health within mainstream reaches that have been subject to modification by channelisation and riparian clearing. In terms of overall diversity, the number of taxa did not drop significantly along the main channel, though there is a trend of lower numbers of taxa in reaches within agricultural areas.

Throughout the tributaries both habitat degradation and water quality have been identified as a potential source of impact on river health. AusRivAS OE and OESIGNAL scores indicate that poor water quality is an important driver of a more degraded 'river health' status in river habitats that have been subject to modification by channelisation and riparian clearing.

Turbidity is likely to be a key parameter influencing water quality for tributaries within agricultural areas of the Montagu catchment. High turbidity levels and generally poor water quality were found for the tributaries that drain Brittons Swamp and this is likely to be a result of current land use practices. Prolific growth of algae and macrophytes within some reaches indicate that nutrient enrichment may also impinge on river health status.

Edgewater models are thought to be less sensitive than riffle models because edgewaters are likely to harbour a more tolerant fauna. Many taxa that are able to live in depositional environments are ‘pre adapted’ to cope with moderate impacts on rivers such as mild sedimentation and organic enrichment (Oldmeadow *et al*., 1998). The edgewater habitat is closely linked to the riparian zone. Riparian vegetation provides a habitat and food source for many macroinvertebrates by dropping leaves, branches and logs into the stream and protecting bank structure. It also provides an important filtering mechanism, which reduces the level of contaminants entering the stream. Degradation of the riparian zone often leads to deterioration of the edgewater habitat and a decrease in water quality.

Sedimentation is likely to be a key parameter influencing habitat availability for in-stream fauna within the Montagu catchment. Sedimentation is known to reduce habitat availability for bottom dwelling fish and macroinvertebrate species by the filling of spaces between larger substrate particles (Minshall, 1984, Quinn and Stroud, 2001, Richardson and Jowett, 2002). In instances where sediment deposition has been elevated by human activity the amount of suitable habitat available for benthic species has generally been greatly reduced when compared to non-impacted systems (Richardson and Jowett, 2002). Richardson and Jowett (2002) suggest that activities that increase sediment loads in rivers will have a negative impact on fish communities by limiting suitable habitat. This is likely to be a key factor in the low number of *S. trutta* within the Montagu catchment, as gravel beds which are essential for egg deposition and juvenile development are rare.

Channelisation of a waterway eliminates morphological features of natural streams, such as meanders and pool riffle-sequences and decreases hydraulic complexity (Negishi *et al.,* 2002). The subsequent loss of habitat heterogeneity is known to result in marked changes in invertebrate communities (Quinn *et al.,* 1992) and reduced fish diversity and abundance (Richardson and Jowett, 2002). This is due to the loss of habitat that acts as flow refugia, such as CWD, pools and large substrate. These findings are of particular relevance to the Montagu catchment due to the degree of channel modification that has occurred to date.

Implementation of better riparian management practices, decreasing agricultural runoff, minimising sediment inputs and providing adequate environmental flows especially during periods of low flow have been identified as positive measures essential for sustaining the health of water ways within the Montagu catchment. Such measures will greatly benefit not just macroinvertebrate communities but the aquatic ecology of the whole stream ecosystem.

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Appendix 1: Taxa List for sites sampled as part of the State of Rivers survey

	Order	**Platyhelminthes**	**Mollusca**	**Mollusca**	**Mollusca**	**Mollusca**	**Mollusca**	**Hirudinea**	**Oligochaeta**	**Hydracarina**
	Family	Turbellaria	Hydrobiidae	Ancylidae	Planorbidae	Physidae	Sphaeriidae			
	Subfamily									
Code	Name	IF999999	KG029999	KG069999	KG079999	KG089999	KP039999	LH999999	LO999999	MM999999
BT26	Farnhams Ck / Farnhams Ck Rd.		22						1	
BT27	Fixters Ck / Riseborough Rd	1	1						9	
MONT02	Montagu R d/s Trib off Quillams Rd		2		1		7	1	1	1
MONT03	Montagu R off Barcoo Rd @ Thorpes Plains		3							
MONT04	Montagu R u/s canal off Barcoo Rd @ 14 Mile Plain			1						5
MONT05	Montagu R @ Rennison Rd @ Togari					37		3		
MONT06	Montagu R @ Bass H'way @ Togari					3				1
MONT07	Montagu R off Eldridge Rd @ Montagu Swamp									
MONT08	Montagu R @ Christmas Hills Rd d/s bridge			2		3				
MONT09	Montagu R @ Christmas Hills u/s bridge					1	2			
MONT10	Montagu R @ Donalds Rd		54	2		5				
MONT11	Montagu R @ Roger River Rd						3	1		
MONT12	Un-named Trib @ Barcoo Rd						1		8	
MONT13	Farnhams Ck @ Barcoo Rd		20				2			
MONT14	Farnhams Ck @ Fagans Rd		1							
MONT15	Farnhams Ck @ Bass H'way @ Brittons Swamp							1	1	
MONT16	Canal off Barcoo Rd @ 14 Mile Plain		87			11		11	1	1
MONT17	Fixters Ck @ Riseborough Rd		2						2	
MONT18	Fixters Ck @ Bass H'way @ Brittons Swamp					85		7	1	

Order	**Amphipoda**	**Amphipoda**	**Amphipoda**	**Isopoda**	**Isopoda**	**Decapoda**	**Decapoda**	**Decapoda**	**Coleoptera**	**Coleoptera**	**Coleoptera**	**Coleoptera**	**Coleoptera**
Family	Ceinidae	Eusiridae	Parameletidae	Phreatoicidae	Janiridae	Atyidae	Parasacidae	Hymenosomatidae	Noteridae	Dytiscidae	Dytiscidae	Hydrophilidae	Scirtidae
Subfamily										Adults	Larvae		
Code	OP029999	OP039999	OP069999	OR039999	OR189999	OT019999	OV019999	OX010000	QC089999	QC09999A	QC09999L	QC119999	QC209999
BT26			72				1						
BT27			3		1		1						1
MONT02		1	9			3		1		1			
MONT03		17	5					4					
MONT04	2	20								2			
MONT05	19	42	9					1		2		1	
MONT06		20								5			
MONT07		2											
MONT08										2			
MONT09													
MONT10			28									1	
MONT11			10				1	1					4
MONT12			7	1	1								
MONT13			29										
MONT14			24					2					
MONT15			19					4					
MONT16	2	8								1	1		
MONT17			26	1				1					
MONT18									1	28	4	7	1

Order	**Coleoptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Diptera**	**Ephemoptera**
Family	Elmidae	Tipulidae	Dixidae	Culicidae	Ceratapogonidae	Simuliidae	Athericidae	Stratiomyidae	Chironomidae	Chironomidae	Chironomidae	Chironomidae	Oniscigastridae
Subfamily	Adults								Podonominae	Tanypodinae	Orthocladiinae	Chironomiinae	
Code	QC34999A	QD019999	QD069999	QD079999	QD099999	QD109999	QD229999	QD249999	QDAD9999	QDAE9999	QDAF9999	QDAJ9999	QE039999
BT26			6		1					10		21	
BT27			3	1		1				5		30	2
MONT02							1			4		3	2
MONT03												8	
MONT04											4	28	
MONT05						3				1	1	4	
MONT06										2	1	39	
MONT07										1	1		
MONT08					2					2	1	6	1
MONT09									2		3	5	
MONT10			7			11	1			7	9		1
MONT11	1		1							4		1	1
MONT12		1								1		36	
MONT13											1	5	
MONT14		1				1						1	1
MONT15										1	1	7	
MONT16				1		2							
MONT17			16		1					1		1	
MONT18								1				104	

Order	**Ephemoptera**	**Ephemoptera**	**Hemiptera**	**Hemiptera**	**Hemiptera**	**Mecoptera**	**Odonata**	**Odonata**	**Odonata**	**Odonata**	**Odonata**	**Plecoptera**
Family	Leptophlebiidae	Caenidae	Veliidae	Corixidae	Naucoridae	Nannochoristidae	Coenagrionidae	Lestidae	Aeshnidae	Synthemidae	Corduliidae	Gripopterygidae
Subfamily												
Code	QE069999	QE089999	QH569999	QH659999	QH669999	QK019999	QO029999	QO059999	QO129999	QO161800	QO169999	QP039999
BT26	41		23									
BT27			3	1								2
MONT02	15	1				2			1			3
MONT03	40											20
MONT04	8		1	34								3
MONT05	34	4	1	3			2					
MONT06		4		70	1		5					
MONT07				5						1		
MONT08	42		1	7					1		4	1
MONT09	12	2		24							4	
MONT10	25		6	1								
MONT11	12											3
MONT12												
MONT13	3		1									
MONT14	20		1			1						
MONT15			1			8						
MONT16				14				5				
MONT17	55											
MONT18			4				1					

Order	**Plecoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**	**Trichoptera**
Family	Notonemouridae	Hydrobiosidae	Hydroptilidae	Hydropsychidae	Ecnomidae	Conoesucidae	Calocidae	Philorheithridae	Atriplectididae	Leptoceridae
Subfamily										
Code	QP049999	QT019999	QT039999	QT069999	QT089999	QT159999	QT189999	QT219999	QT239999	QT259999
BT26										10
BT27		2								114
MONT02		1					19	1		36
MONT03				2				1	1	40
MONT04					1					34
MONT05	1			2					1	27
MONT06										8
MONT07									1	24
MONT08					2				1	24
MONT09										15
MONT10	23	6	2			4				8
MONT11		2					12	4		19
MONT12										4
MONT13		1		1						23
MONT14		5							1	18
MONT15								1	4	10
MONT16	25								1	26
MONT17										9
MONT18										3

***Appendix 2**: Habitat Variables and Water Quality Measurements*

Code	Name	Boulder Score	Conductivity (μS/cm)	Mean Depth (cm)	Northing	Easting
BT26	Farnhams Ck / Farnhams Ck Rd.	0	261	20	5479400	327700
BT27	Fixters Ck / Riseborough Rd	0	312	25	5469300	326800
MONT02	Montagu R d/s Trib off Quillams Rd	1	649	50	5478500	322490
MONT03	Montagu R off Barcoo Rd @ Thorpes Plains	0	578	30	5475500	324300
MONT04	Montagu R u/s canal off Barcoo Rd @ 14 Mile Plain	0	705	40	5470800	322820
MONT05	Montagu R @ Rennison Rd @ Togari	0	550	30	5468200	321100
MONT06	Montagu R @ Bass H'way @ Togari	0	265	40	5463400	321700
MONT07	Montagu R off Eldridge Rd @ Montagu Swamp	0	237	30	5461200	323300
MONT08	Montagu R @ Christmas Hills Rd d/s bridge	0	181.6	50	5455300	327700
MONT09	Montagu R @ Christmas Hills u/s bridge	0	182.7	20	5455300	327700
MONT10	Montagu R @ Donalds Rd	0	168.5	30	5453300	331000
MONT11	Montagu R @ Roger River Rd	0	170.3	20	5451400	332150
MONT12	Un-named Trib @ Barcoo Rd	0	454	25	5477400	327000
MONT13	Farnhams Ck @ Barcoo Rd	0	280	20	5474700	324800
MONT14	Farnhams Ck @ Fagans Rd	0	261	20	5472200	328500
MONT15	Farnhams Ck @ Bass H'way @ Brittons Swamp	0	263	10	5469900	329800
MONT16	Canal off Barcoo Rd @ 14 Mile Plain	0	430	35	5470800	322850
MONT17	Fixters Ck @ Riseborough Rd	0	292	30	5469300	326850
MONT18	Fixters Ck @ Bass H'way @ Brittons Swamp	0	403	40	5467500	328800

Predictor variables used for the Autumn edgewater model.

Code	Name	Temperature ^0C	Conductivity (μS/cm)	Turbidity NTU	Dissolved O2 mg/l	PH
BT26	Farnhams Ck / Farnhams Ck Rd.	10.5	261	18.2	N/A	8.2
BT27	Fixters Ck / Riseborough Rd	10.1	312	24.4	N/A	8.5
MONT02	Montagu R d/s Trib off Quillams Rd	17.6	649	5.92	7.5	7.26
MONT03	Montagu R off Barcoo Rd @ Thorpes Plains	18	578	11.9	6.2	7.58
MONT04	Montagu R u/s canal off Barcoo Rd @ 14 Mile Plain	20.2	705	5.55	8.4	8.06
MONT05	Montagu R @ Rennison Rd @ Togari	21.1	550	14.6	8.2	7.61
MONT06	Montagu R @ Bass H'way @ Togari	19.9	265	5.84	5.1	6.9
MONT07	Montagu R off Eldridge Rd @ Montagu Swamp	16.5	237	3.53	6.2	7.14
MONT08	Montagu R @ Christmas Hills Rd d/s bridge	21	181.6	4.22	11.1	8.25
MONT09	Montagu R @ Christmas Hills u/s bridge	21	182.7	4.32	9.9	8.62
MONT10	Montagu R @ Donalds Rd	15.1	168.5	8.53	7.24	6.97
MONT11	Montagu R @ Roger River Rd	13.9	170.3	3.27	10.3	7.82
MONT12	Un-named Trib @ Barcoo Rd	15.1	454	8.34	6.2	5.2
MONT13	Farnhams Ck @ Barcoo Rd	16.6	280	20.6	0.2	7.35
MONT14	Farnhams Ck @ Fagans Rd	16.3	261	10.4	7.7	7.16
MONT15	Farnhams Ck @ Bass H'way @ Brittons Swamp	15.8	263	8.69	6.9	6.83
MONT16	Canal off Barcoo Rd @ 14 Mile Plain	19.5	430	6.31	7.8	7.82
MONT17	Fixters Ck @ Riseborough Rd	17.6	292	9.63	7.1	7.5
MONT18	Fixters Ck @ Bass H'way @ Brittons Swamp	19.3	403	15.2	0.9	7

Water Quality measurements for sites sampled under the Index of River Condition and AWARH sampling programs