DEPARTMENT *of*
PRIMARY INDUSTRIES,
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Tasmania

Ecological flow requirements for the Great Forester River

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A Glossary of Terms

base flows	flow in a river composed of water from deep subsurface and groundwater sources with no contribution from precipitation
broadwater	long, broad run with slow water flow
downwarped	
IFIM	Instream Flow Incremental Methodology
macrophytes	large aquatic plant
macroinvertebrates	invertebrate (without a backbone) animals which can be seen with the naked eye
ppt	parts per thousand
riparian vegetation	vegetation on the banks of streams and rivers
sinuosity	degree of "bendiness" of a river (ratio of valley length: river length)
snags	instream woody debris
pools	deep, still water , usually within the main river channel
riffles	areas of fast moving broken water
run	unbroken, moving water
substrate	the structural elements of the river bed; boulder, cobble etc.
T. G. R.	Tasmap Grid Reference
WUA	Weighted Useable Area, or the amount of useable habitat available in the river for a species

Executive Summary

This report details the ecological assessment of flow requirements for the Great Forester River and forms part of the process of developing a water management plan for the catchment. Both community and State technical values were identified as part of the assessment process and the ecological values identified from this process were used to focus the ecological flow assessment.
Ecological values specifically targeted included:

- Maintain habitat for brown trout (*Salmo trutta*), shortfinned eel (*Anguilla australis*), jollytail (*Galaxias maculatus*) and blackfish (*Gadopsis marmoratus*) populations.
- Maintain habitat for macroinvertebrate populations found in the Great Forester River.

A risk analysis was performed to provide: (1) a series of options for future water management planning, and (2) the ecological risk of failure in not achieving these flows for each of these values. This was achieved by determining the flow at which the useable habitat available to a species changes by a certain percentage, relative to a reference flow. The percentage changes in habitat that determined risk categories were taken from Davies and Humphries (1996). This analysis was done for each of the key biota (including both fish and invertebrate species).

Other values identified, and discussed elsewhere in the report include:

- Maintain suitable flows for the protection of the giant freshwater crayfish *Astacopsis gouldi*.
- Maintain enough water for stream habitat for water life.
- Protect whitebait and blackfish fisheries.
- Maintain suitable flow for the protection of the dwarf galaxiid *Galaxiella pusilla* and the Australian grayling (*Prototroctes maraena*).
- Maintain suitable flow for the protection of the giant freshwater crayfish *Astacopsis gouldi*;
- Maintain rearing and/or spawning habitat for lampreys (*Mordacia mordax* and *Geotria australis*), blackfish (*Gadopsis marmoratus*), brown trout (*Salmo trutta*), freshwater flathead (*Pseudaphritis urvillii*), Australian grayling (*Prototroctes maraena*), spotted galaxiid (*Galaxias truttaceus*), common jollytail (*Galaxias maculatus*) and estuarine perch (*Macquaria colonorum*).
- Maintain instream woody debris as habitat for trout and blackfish.
- Protect habitat for Scottsdale burrowing crayfish *Engaeus spinicaudatus* (an obligate riparian dweller).

Two sites were selected to represent distinctive reaches of the river identified by preliminary analysis of river reach characteristics along the river continuum. The ecological flow requirements and associated risk of failure to provide these flows are as follows.

Great Forester River - Prosperity Road Reach

Flows discussed in Table i) relate to the uppermost reaches of the Great Forester River to the point where the river crosses the Tasman Highway.

Table i) Flows for each risk category, Prosperity Road (cumecs)

Risk Category	**I**	**II**	**III**
Month	**No risk**	**Moderate risk**	**High risk**
Dec	≥0.5	0.5 - 0.3	≤0.3
Jan	≥0.3	0.3 - 0.2	≤0.2
Feb	≥0.3	0.3 - 0.2	≤0.2
Mar	≥0.2	0.2 - 0.1	≤0.1
Apr	≥0.4	0.4 - 0.2	≤0.2

Great Forester River - Waterhouse Road Reach

Flows in Table ii) relate to the section of the river downstream from the Tasman Highway to the entry of the river into wetland areas at the bottom.

Table ii) Flows for each risk category, Waterhouse Road

Risk Category	**I**	**II**	**III**
Month	**No risk**	**Moderate risk**	**High risk**
Dec	≥1.5	1.5 - 1.0	≤1.0
Jan	≥1.1	1.1 - 0.7	≤0.7
Feb	≥0.9	0.9 - 0.7	≤0.7
Mar	≥0.8	0.8 - 0.7	≤0.7
Apr	≥1.2	1.2 – 0.9	≤0.9

For both reaches the flow recommendations resulting from the risk analysis are considerably influenced by the water requirements for trout. However, we consider these flows are necessary also to adequately protect the endangered species *Astacopsis gouldi*, and strongly recommend that flows remain in the ‘no risk’ category in both reaches to ensure this value is maintained.

An important caveat to this report is that the flows recommended for each month are only appropriate for that period. Additional work will be required to identify other necessary components of the flow regime should significant developments be proposed in this catchment.

1 Introduction

In accordance with the water reform agenda set out by the Council of Australian Governments, or COAG (ARMCANZ and ANZECC, 1996), Tasmania is currently developing water management plans for many of its major rivers. Intrinsic to this process is the requirement that a supply of water will be provided to the environment as well as to human users to maintain or improve ecosystem quality and health of river systems. For full details about the process of developing a water management plan, refer to Fuller and Read (1997) and Appendix 1. Briefly, the process involves:

- the identification of water values by the community and the State Technical Committee for Environmental Flows (a panel representing the State government's technical and scientific expertise);
- the assessment of the flow necessary to maintain these values, which includes an environmental flow assessment;
- negotiation and tradeoff of these values if required when determining a new flow management regime; and
- monitoring of both compliance and environmental benefit of the new flow regime once this is in place.

This report forms part of the water management planning process for the Great Forester River. It details the assessment of the ecological flow requirements of key aquatic fauna that show distinct preferences to changes in discharge. The values identified by the community and the State Technical Panel play a key role in focussing this assessment. Therefore both sets of values for the Great Forester River have been provided in the report, and addressed where appropriate.

The Great Forester River has been subject to water abstraction for many years, as the abstraction of water for irrigation has occurred since at least 1972 (DPIWE data). The water is diverted throughout the year, but this assessment will concentrate on the low flow period between December to April, as this is when the river is suspected to be most under stress. However, the issue of non-summer flows may need attention in future if abstraction increases or there is further development of the water resource.

An important caveat to this report is that the flows recommended for each month are only appropriate for that period. Additional work will be required to identify other necessary components of the flow regime should significant developments be proposed in this catchment.

2 Great Forester River

2.1 General Catchment Features

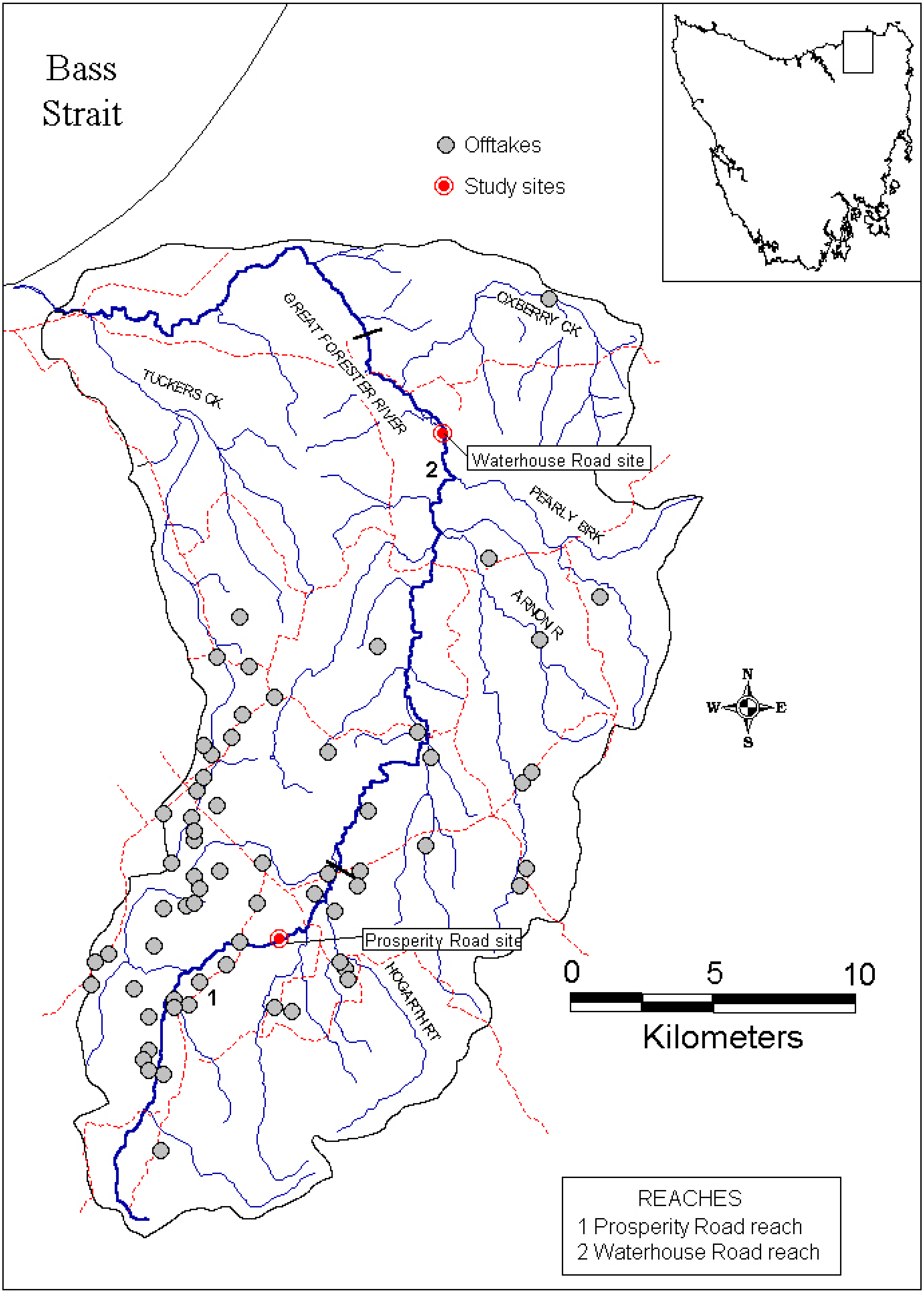
2.1.1 Catchments and Drainage System

The Great Forester River originates on the northwestern slopes of Mt. Maurice (elevation 1121m) and flows north past Mt. Stronach (elevation 497m) towards the coast. At Wonder Valley, the river turns west and meanders across the coastal plains before entering Bass Strait east of Bridport (Figure 2.1). The general topography is hilly inland grading to down flat coastal plains characterised by extensive sand dunes.

The catchment is bounded to the south and west by the St Patricks and Brid catchments respectively, and to the east by the Ringarooma catchment. Major tributaries of the Great Forester are Hogarth Rivulet (which enters upstream of Tonganah), the Arnon River (draining the eastern side of the catchment around Tuldeena) and Pearly Brook (draining land west of Mt Horror). Lower down on the floodplain Oxberry Creek enters from the east and Tuckers Creek joins the river at Adam's Cut with pickup from the area north of Scottsdale.

The Great Forester catchment is relatively free of large scale drainage works. Most of the middle and upper reaches of the river have only had minor works carried out to improve small farm drainage. However, as the lower reaches of the Great Forester are wide floodplain areas, many parts are swampy. As a result, many landowners have constructed drainage works to reclaim some of this land. One of the more notable of these works was carried out in the 1920's, when the Great Forester was diverted from its original outlet to the sea near Bridport by excavating a drain in a more direct line to the coast 4km to the east (Jordan, 1973). This is known as 'Adam's Cut' and reduced the rivers length by more than 7km while increasing the gradient of the river such that 325 ha of land could be reclaimed.

Figure 2.1 Map of the Great Forester River showing CWRs and study reaches. Bars denote representative reaches (refer to text).



2.1.2 Geomorphology and Geology

The Great Forester River lies within the Scottsdale Basin, which is a down-warped area occupied mainly by Tertiary sediments. In the north, the basin merges with the flat coastal plains of the Bridport - Waterhouse area. The high country on the eastern and western sides of the basin are composed of metamorphosed sedimentary rocks of the Mathinna Beds. These have been intruded by the granite and granodiorite of the Devonian aged Scottsdale batholith, which forms the hills of Mt. Stronach and Mt. Kapai.

The lower part of the basin is composed of Tertiary sand, clay and gravel with a maximum thickness in excess of 180m. This forms a good groundwater aquifer beneath the Quaternary sands and clay of the coastal plain at Waterhouse. In this part of the catchment, coastal dunes are the dominant feature. They have developed during the Holocene period, when wind and sea action has built up large deposits of sand all along the coast. Prior to European settlement, these high 'frontal' dunes (as high as 30m) were relatively stable and it is thought that native vegetation would have provided adequate cover (Steane, 1995). With the arrival of European settlers, this cover was diminished and wind erosion initiated degradation of the dunes and increased mobility of sand. Marram grass (an introduced species *Ammophila breviligulata*) is now used to try and stabilise dunes and reduce sand movement all over Tasmania.

2.1.3 Climate and Rainfall

Although the climatic conditions of the northeast region are generally influenced by its proximity to the sea, there is a natural increase in weather extremes with increasing elevation. The distribution of rainfall is very much controlled by topographic changes, with highest rainfall occurring around the Ben Nevis and associated ranges. Nearer the coast, annual average rainfall is about 750 - 800 mm (cf Bridport) increasing to around 1200 mm near the top of the catchment at South Springfield (cf Diddleum). The highest monthly rainfall totals occur in July and August and the lowest in February and March.

2.1.4 Vegetation

Throughout the catchment, vegetation varies according to topography, rainfall and soil type. Rainforest species (*Nothofagus cunninghamii*, *Olearia argophyllum* and *Atherosperma moschatum*) are found in the wet and humid gullies in the upper reaches of the Great Forester catchment. They are generally relict patches in the higher reaches where fire has been unable to reach (Duncan, 1995). These patches are generally surrounded by mixed or wet sclerophyll forests dominated by *Eucalyptus regnans*, *E. viminalis* and *E. obliqua*, as well as remnant stands of blackwood (*Acacia melanoxylon*).

Lower in the catchment, the vegetation is predominantly mixed forest and more open woodland which is characterised by a healthy and varied understorey of shrubs and smaller trees as well as bracken and sword sedge. In relatively undisturbed areas alongside the river, the riparian strip is dominated by dogwood (*Pomaderris apetala*), tea tree (*Leptospermum* spp.), blackwood (*Acacia melanoxylon*) and silver wattle (*A. dealbata*). In areas where removal or modification of the riparian corridor has occurred, introduced willow (*Salix fragilis*) and blackberry (*Rubus fruticosus*) are more abundant.

Coastal areas are largely vegetated by heath and scrub communities which are better adapted to dry conditions. The riparian area is dominated by tea tree and paperbark species as well as other species adapted to swampy conditions. Although these plant communities are well reserved (Harris and Kirkpatrick, 1995), it has been suggested that weeds may pose a serious threat in the future.

The wetlands of the northeast have been shown to have a rich floral community (Cameron, 1995), and the Waterhouse Protected Area (just to the north of the lower catchment) is currently an important reserve as it supports native plant and animal species which are considered rare, or endangered (ANCA, 1994), as well as protecting the relict coastal dunes.

2.1.5 Land Use and Degradation

The agricultural soils found in this part of the State have been described as variable (Pinkard, 1995) as a result of the complex underlying geology of the area. The principal soil types in the Great Forester include low fertility, porous sands in the coastal plains to the north, alluvial soils of the floodplains in the middle of the catchment, and the highly productive krasnozems around Scottsdale.

Cropping in this catchment tends to be restricted to the fertile krasnozem soils, although there are some limits to where crops can be grown due to the steep slopes on which this soil occurs. Some hop growing occurs on the river flats in the Tonganah area. Dairying is widespread on the krasnozem soils as well as on the alluvial floodplains in the mid catchment on improved pasture. Grazing of sheep and beef cattle on improved and unimproved pasture is more widespread in the middle catchment and lower floodplains of the Great Forester. While pig farming is not common, there is a moderate sized piggery located on land adjacent to the Great Forester River at Tonganah, upstream of the junction with Hogarth Rivulet. Hop and potato cultivation are prevalent in the lower catchment.

In the upper catchment, forestry is the other major land use. Pine and *Eucalypt* plantations are common. Radiata pine plantations support two major pine board mills in the Scottsdale area. There is also a trout farm located at South Springfield, at the top of the Great Forester River.

Mining activity has been minimal in the Great Forester. The mining which has occurred has been restricted to a few small tin mines to the northeast of Mt. Stronach, on the tributaries of Great Forester River. As a consequence, there is some siltation, but it appears to be mostly confined to these tributaries (Jordan, 1973).

There is limited industry in the catchment. Aside from the pine board mills, there is the vegetable processing factory at Scottsdale. This operation discharges treated effluent water into the Scottsdale sewage treatment plant, where it is further treated before being discharged into Cox's Rivulet, which flows directly north into Bass Strait between the Great Forester and Brid river catchments.

Present land and soil degradation in the catchment include: wind, sheet and rill erosion; nutrient and structural decline of soils; and waterlogging and salinity. The sandier soils are generally highly erodable due to their light texture and low organic matter, while the krasnozems are prone to water erosion due to their position on moderate to steep slopes (Pinkard, 1995). Significant degradation of the sandy coastal soils has occurred since European settlement (refer to previous section), primarily due to wind erosion of land stripped of vegetation. Salinity in the coastal areas has also become a problem due to poor surface drainage resulting in high water tables. There are also significant problems with stream bank erosion and willow infestation along some stretches of the river and its tributaries.

2.1.6 Hydrology

The Great Forester river exhibits a strongly seasonal flow pattern (Graham, 1999) with flows peaking in the period July through to September. Lowest flows are experienced between January and April. This period also corresponds to the peak irrigation demand in the river. Base flow estimates for the river in winter months are approximately 1.1 cumecs while in summer the base flow is reduced to 0.23 cumecs. This low flow is primarily caused by irrigation extractions in summer. The annual median flow is 1.7 cumecs and summer median flow is 0.8 cumecs. There is an average summer (December to April) water extraction of approximately 1923.7 megalitres which is estimated from the 75 allocated Commissional Water Rights (CWRs) for the catchment.

2.2 Site Selection

The section of the river which requires environmental flow assessment is that affected by water abstraction (or offtakes), as well as any part likely to be affected by offtakes in the future. Abstraction here refers to irrigation offtakes, termed CWRs (Commissional Water Rights). With the exception of the uppermost tributaries, all reaches of the Great Forester River are affected by abstraction and site selection was considered along the entire length of the mainstream.

Study sites for assessing the relationship between habitat availability of key species and water discharge were selected according to the protocol of Bovee (1982). The upper reaches are typified by a cobble-gravel substrate grading to boulder-cobble in the highest reaches, and the lower reaches are dominated by sand. Three representative reaches were identified within the entire river and a representative site was selected on the middle and lower reaches (see Figure 2.1). The uppermost reaches of the inflowing tributaries were not surveyed due to the low intensity of CWRs or other abstractions, although this may be required in future if water development occurs in the upper catchment.

2.2.1 Great Forester River at Prosperity Road

The study site is approximately 193m long and is located approximately 50m downstream of the Prosperity Road Bridge (TASMAP grid reference 5437900 546800). This site was selected as being representative of the upper reaches of the river to its crossing of the Tasman Highway (see Figure 2.1). The river here is dominated by sequences of short cobble riffles interspersed with cobble/sand runs and some deep pools.

2.2.2 Great Forester River at Waterhouse Road

The study site is approximately 307m long and is located just below the Waterhouse Road bridge (TASMAP grid reference 5455900 552400). The site is representative of the middle to lower reaches of the Great Forester from below the Tasman Highway to the entry of the river into McKerrow's Marsh (see Figure 2.1). The substrate in this reach is substantially finer than that at the upper Prosperity Road reach and is typified by long sandy runs with some deep pools. The site has a high standing stock of large and coarse woody debris.

3 Values

3.1 Community Values

The community values for the Great Forester River were identified at a meeting held in Bridport on the 15/12/1997. The values as identified and prioritised by representatives of various interest and stakeholder groups for both catchments are shown in Table 3.1. Values not prioritised were considered to be equally of least importance.

Table 3.1 Community Water Values for the Great Forester River

BROAD WATER VALUE CATEGORIES	SPECIFIC WATER VALUES	PRIORITISED VALUES
1. Ecosystem	Protect *Astacopsis gouldii.*	3a
	Protect riparian zone.*	
	Maintain or improve water quality.	
	Improve quantity of low flows, establish minimum levels.	1
	Maintain enough water for stream habitat for water life.	2
	Maintain an adequate flow regime.	3
	Avoid excessive filamentous algal blooms (blue greens as well).	
	Maintain adequate flows into estuary.	
	Protect whitebait and blackfish fisheries.	3b
2. Consumptive and non-consumptive use	Maintain sufficient water for Scottsdale.	1
	Maintain riparian rights.	2
	Maintain water for fish farm.	
	Maintain sufficient water for industry.	3
	Maintain sufficient water for irrigation.	3
	Establish a water rationing/emergency plan for water use.*	3
	Improve storage of water and timing of take.*	

Table 3.1 cont.

1. Recreational	Maintain sufficient flows for canoeing.	
	Maintain water quality at Scouts cabin for swimming and outdoor recreation for primary contact.	
	Maintain or improve whitebait fishery in lower Great Forester River.	1
	Maintain or improve trout fishery.	1
	Maintain or improve blackfish fishery.	1
	Maintain sufficient flows for platypus watching.	
2. Physical Landscape	Reduce erosion or riverbanks and loss of land.*	1
	Protect “the Cut”.*	
	Reduce catchment scale erosion (land based).*	4
	Protect or improve riparian zones.*	2
		3
3. Aesthetic	Maintain adequate flows over Cuckoo Falls.	
	Reduce unnatural turbidity of water.	1
	Reduce incidence of green slime, algal blooms.	
	Maintain or improve riparian zone.*	2
	Remove unnatural objects in river.*	

* The maintenance or enhancement of those values marked with an asterisk were not considered to be influenced by changes in discharge or water quantity and will not be discussed further in this report.

3.2 State Technical Values

Additional values were identified for the Great Forester River by the State Technical Panel for Environmental Flows. The panel included representatives from DPIWE, all of who provided advice on aquatic ecology, wetlands, geomorphology, riparian vegetation, and estuarine ecology, fisheries biology and ecology, environmental representatives from the Hydro-Electric Corporation and a representative from the University with relevant expertise in environmental flows. The values that the panel thought warranted consideration or further investigation were:

- Maintain suitable flow for the protection of the rare fish species: dwarf galaxiid (*Galaxiella pusilla);* and Australian grayling (*Prototroctes maraena*).
- Maintain suitable flow for the protection of the giant freshwater crayfish *Astacopsis gouldi* which is listed as endangered in the *Tasmanian Threatened Species Act 1995*.
- Maintain rearing and/or spawning habitat for lampreys (*Mordacia mordax* and *Geotria australis*), blackfish (*Gadopsis marmoratus*), brown trout (*Salmo trutta*), freshwater flathead (*Pseudaphritis urvillii*), Australian grayling (*Prototroctes maraena*), spotted galaxiid (*Galaxias truttaceus*), common jollytail (*Galaxias maculatus*) and estuarine perch (*Macquaria colonorum*).
- Maintain instream woody debris as habitat for trout and blackfish.
- Protect habitat for Scottsdale burrowing crayfish *Engaeus spinicaudatus* (an obligate riparian dweller).

For further information on the importance of these values refer to Section 6: Discussion.

3.3 Values Assessed

It should be noted that while water quality was identified as a community value it was not assessed. Davies and Humphries (1996) found that nutrient and turbidity levels in the South Esk river basin were primarily determined by flood flows and were not related to low flows. The same also applied to dissolved oxygen conditions in pools. The water quality risks associated with declining flows during the irrigation season were therefore not considered significant. In addition, a comprehensive assessment of water quality and influencing factors in the catchment is provided by the State of Rivers survey conducted by DPIWE (Bobbi et al., 1999).

3.3.3 Summary of Values Assessed

In summary, the values that were considered by DPIWE during the assessment of ecological requirements for flow in the Great Forester River include:

- Maintain suitable flows for the protection of the giant freshwater crayfish *Astacopsis gouldi*.
- Maintain enough water for stream habitat for water life.
- Protect whitebait and blackfish fisheries.
- Maintain suitable flow for the protection of the dwarf galaxiid *Galaxiella pusilla* and the Australian grayling (*Prototroctes maraena*).
- Maintain suitable flow for the protection of the giant freshwater crayfish *Astacopsis gouldi*.
- Maintain rearing and/or spawning habitat for lampreys (*Mordacia mordax* and *Geotria australis*), blackfish (*Gadopsis marmoratus*), brown trout (*Salmo trutta*), freshwater flathead (*Pseudaphritis urvillii*), Australian grayling (*Prototroctes maraena*), spotted galaxiid (*Galaxias truttaceus*), common jollytail (*Galaxias maculatus*) and estuarine perch (*Macquaria colonorum*);
- Maintain instream woody debris as habitat for trout and blackfish.
- Protect habitat for Scottsdale burrowing crayfish *Engaeus spinicaudatus* (an obligate riparian dweller).

Values that were targeted for detailed and specific assessment include:

- Maintain trout (*Salmo trutta*) populations.
- Maintain shortfinned eel (*Anguilla australis*), jollytail (*Galaxias maculatus*) and blackfish (*Gadopsis marmoratus*).
- Maintain macroinvertebrate populations found in the Great Forester River.

Those values not specifically targeted are discussed in detail in section 6.

4 Methodology

The method used to assess the flow requirements of key species (see Table 5.2) was the Instream Flow Incremental Methodology (IFIM), originally described by Bovee (1982). In this process, the preferences of key species for velocity, depth and substrate parameters are combined with transect-derived hydrologic data at specific discharges. This data is then incorporated into a suitability index which is a function of available depth, velocity and substrate. This suitability function is then summed over the study reach to give the Weighted Usable Area, or WUA (refer to Jowett, 1992).

Hydraulic simulation is used to generate velocity and depth data for each transect at the discharges for which data are not available. The outcome is a plot of WUA against discharge for each species or lifestage (see Figure.5.1). An analysis of the flow levels that will provide varying degrees of risk to the ecosystem is then possible. The software package used for this process was the RHYHABSIM (River HYdraulics and HABitat SIMulation) program developed by Jowett (1992).

4.1 Physical Habitat Data

Transects were established at both sites, according to the protocol detailed by Bovee (1982). Within each study reach, a number of distinctive sub-reaches was identified on the basis of hydraulic characteristics and substrate. Transects were established within each of these sub-reaches, perpendicular to the channel.

At each transect, a semi-permanent datum (or header peg) was established by driving a mild steel star picket deep into the upper section of the bank. All measurements were taken perpendicular to the direction of flow, to a point on the opposite bank at a similar height above water level. Water surface elevation relative to the elevation of the header peg was recorded at each transect.

On the initial visit from the 24th - 25th February 1998, depth, average water velocity and substrate composition were measured and recorded at regular intervals evenly distributed across the channel with a minimum of 10-15 wetted points. In this way each transect was divided into regular 'cells' by collecting all data at the same distances from the header peg. Depth and velocity at 0.6 of the depth from the surface were recorded at each of these points using a pre-calibrated Pygmy current velocity meter and wading rod. Percentage substrate composition was also recorded at each location using the following categories: aquatic vegetation; mud; sand; fine gravel; large gravel; cobble; boulder and bedrock. Substrate particles were characterised by the following modified Wentworth scale:

R = Bedrock	
B = Boulder	≥256 mm
C = Cobble	64 - 256 mm
P = Pebble	8 - 64 mm
G = Gravel	2 - 8 mm
S = Sand	0.06 - 2 mm
M = Silt/Mud	≤0.06mm

Two calibration gaugings were carried out at a suitable location within both study reaches to determine discharge. The height of the water surface from the datum peg was measured at each transect at the same time. The data collected from these sites were entered into an Excel™ spreadsheet in the format required by the RHYHABSIM program.

4.2 Biological Data

4.2.1 Invertebrates

A total of 30 biological samples were taken on the Great Forester River. 13 of these were taken in the reach at Waterhouse Road and 17 were taken at Prosperity Road. The sampling occurred on the 5th March, 1998.

Sampling effort was stratified in order to fully represent the range of depth, velocity and substrate at the sites. Stratification was carried out on the combined habitat data from both sites sampled, using the methodology described by Davies et al. (1997). Sampling for macroinvertebrates was carried out by disturbing the substrate within a $1m^2$ quadrat upstream of a 250µm kick net. The preserved samples were later sub-sampled to 20% and invertebrates were identified to the lowest taxonomic level possible using the most up-to-date taxonomic keys.

The resulting habitat preference information was used for the creation of WUA-Q curves for key fish and macroinvertebrate species. Key species were selected on the basis of:

- not having rare or patchy abundance; and
- exhibiting clear preferences for depth, velocity and substrate

4.2.2 Fish

Habitat preference curves used for brown trout (*Salmo trutta*) early young of the year, or 0+ were developed from data collected in March 1990 - 1993 by Davies and Diggle (unpublished data) and preference curves for brown trout adults were developed by Bovee (1978). Habitat preference information for shortfinned eels (*Anguilla australis*) and jollytail (*Galaxias maculatus*) was collected by Jowett and Richardson (1995), and curves for blackfish (*Gadopsis marmoratus*) were developed by Koehn (1986).

The transfer of habitat preference curves between different catchments is regarded by many ecologists as an acceptable practice for the above species. Examination of curves for brown trout by previous workers has generally found that these curves are similar in their rise and fall between rivers both in Australia and overseas (Dr Peter Davies, Freshwater Systems, pers. comm.). Similarly, the habitat requirements for blackfish are regarded as comparable between rivers (Jackson, 1978, Koehn, 1986, Davies, 1989), and curves for shortfinned eels and jollytails are similar between rivers also (Jowett and Richardson, 1995). Given the agreement among these ecologists in the transfer of these curves, these preference curves have been adopted for use in this assessment.

4.3 Hydraulic Simulation

From the habitat data of both sites combined, and the biological samples collected, values of useable habitat area (called Weighted Useable Area or WUA) were generated in m^2/m of stream channel for each species or lifestage at a range of discharges. The protocol for generating these WUA-Q curves is that described by Jowett (1992), using the RHYHABSIM hydraulic modelling and simulation package. A single Excel™ data set, containing:

- velocity, depth and substrate data at every offset for each transect;
- locations of all water edges ;
- inter-transect distances; and
- stage-discharge relationships for each transects;

This information was used to generate velocities and depths at discharges from 0.055 to 4.05 cumec. The protocol used for the hydraulic simulation is described by Davies and Humphries (1997).

The WUA-Q curve generation is described in detail by Jowett (1992). Habitat preference data were combined with simulated velocity and depth data and the measured substrate data, so as to calculate habitat suitability for each cell. The values for all cells from all transects were combined to generate a species' total habitat area (WUA) in m^2/m or % of stream area for the whole site for each discharge value. This process was used to generate WUA curves for both sites, for all the key species and life stages.

4.4 Risk Analysis

The risk analysis used in this study is a modification of that developed by Davies and Humphries (1996). Risk is based upon changes in habitat (ΔWUA) relative to a reference flow. In this study the reference flows used (Qm) were the median monthly flows at each site for the period 1968-1999 adjusted to account for irrigation takes (ie. the median monthly flows at each site that would have occurred without abstraction).

In this case there are three risk categories (see Table 4.1), and six variables. The variables include:

1. WUA for brown trout adults
2. WUA for brown trout early young of the year
3. WUA for blackfish
4. WUA for shortfinned eels
5. WUA for jollytails
6. WUA for key individual macroinvertebrate taxa (see Table 5.2 for a list of these species)

Table 4.1. Criteria for assigning risk levels to different values of change in habitat (ΔWUA) relative to the reference flow (Q_m) for the key ecological variables in this study. Derived from Davies and Humphries (1995).

Risk Category	**I**	**II**	**III**
Variable	**No Risk**	**Moderate Risk**	**High Risk**
ΔWUA for trout, blackfish, jollytail and eels (variables 1-5)	≥85% WUA cf Q_m	60-85% WUA cf Q_m	30-60% WUA cf Q_m
ΔWUA for individual invertebrate taxa (variable 6)	≤10% taxa with ≤75% WUA cf Q_m	≥10% of taxa with ≤75% WUA cf Q_m	≥25% of taxa with ≤75% WUA & ≥10% of taxa with ≤50%WUA cf Q_m

The risk assessment was conducted as follows for each of the above variables:

- WUA as it varies with Q is normalised so that the maximum (WUA_{m}) is 100%
- Q_n can then be read directly from the relevant percentage of WUA_n on the graph (the appropriate percentage for each risk level is indicated in Table 4.1)

  where

  WUA_n = Weighted Usable (habitat) Area for month of concern

  WU_m = Weighted Usable Area for pre-offtake median flows

  Q_n= Boundary flow for risk level during month of concern (*n)*
  (See Figure 5.1 for worked example)

5 Results

5.1 Physical Habitat Data

Hydrologic and substrate information was collected at both sites for discharges of 0.14 cumec at Prosperity Rd and 0.64 cumec at Waterhouse Rd. Subsequent gauging visits were carried out when the discharge was 0.95 and 2.61 cumec at Prosperity Rd and 2.1 and 3.9 cumec at Waterhouse Rd. Ranges of depth, velocity and substrate at each site are presented in Table 5.1

Table 5.1 Ranges of depth, velocity and substrate at both sites on the Great Forester River

Variable	Range Prosperity Road	Range Waterhouse Road
Depth (m)	0-0.97m	0-0.97m
Velocity (m/s)	0-0.71m/s	0-0.69m/s
Silt (%)	0-100%	0-100%
Sand (%)	0-100%	0-100%
Gravel (%)	0-60%	0-90%
Pebble (%)	0-40%	0-25%
Cobble (%)	0-60%	0-0%
Boulder (%)	0-20%	0-0%
Bedrock (%)	0-80%	0-100%

5.2 Biological Data

30 invertebrate samples were successfully taken across two IFIM reaches, Great Forester River at Prosperity Road and Great Forester River at Waterhouse Road. These curves are provided in Appendix 2.WUA-Q curves were developed for each of the key taxa listed in Table 5.2.

Table 5.2: Selected taxa for which WUA curves were developed

Type	Common name	Taxon	Lifestage (s)
Fish	Blackfish	*Gadopsis marmoratus*	adults
	Brown trout	*Salmo trutta*	adults and late 0+
	Jollytail	*Galaxias maculatus*	adults
	Shortfinned eel	*Anguilla australis*	adults
Invertebrates			
Insects	Mayflies	*Baetidae Genus 2*	larvae
		Austrophlebioides sp.	larvae
		Nousia sp.	larvae
	Caddisflies	*Cheumatopsyche* sp.	larvae
		Notalina sp.	larvae
		Aphilorheithrus sp.	larvae
		Agapetus sp.	larvae
		Tamasia variegata	larvae
	Midges	Chironominae	larvae
		Orthocladinae	larvae
		Tanypodinae	larvae
	Flies	Tipulidae	larvae
		Ceratopogonidae	larvae
	Blackflies	*Austrosimulium furiosum*	larvae
	Beetles	Scirtidae	larvae
		Simsonia sp.	larvae
		Austrolimnius sp.	adults and larvae
	Worms	Oligochaeta	adults
Freshwater Mites	Mites	Hydracarina	adults
Molluscs	Freshwater bivalve	*Pisidium casertanum*	adults

5.3 Risk Analysis

A worked example of the risk assessment process for one variable is shown in Figure 5.1. Detailed risk assessment tables for each month are provided (Tables 5.3 and Tables 5.4), along with curves of the relationship between Weighted Usable Area vs Flow for each species investigated (Appendix 2). Note that risk analysis was not performed on juvenile trout at Waterhouse Rd, due to the ambiguity of the WUA curves for this species in this reach.

Figure 5.1 : Worked example of Risk Analysis.

To determine the flow at which there is no risk to adult trout at North Esk River, Watery Plains reach in December (some values excluded for brevity):

1. RHYHAB gives values for WUA as it varies with Q:

Flow	WUA (m^2/m)
0.05	0.94
0.45	2.95
0.85	3.93
1.25	4.63
1.65	5.31
2.05	5.91
2.45	6.2
2.85	6.37
3.25	6.47
3.65	6.53
3.85	6.55

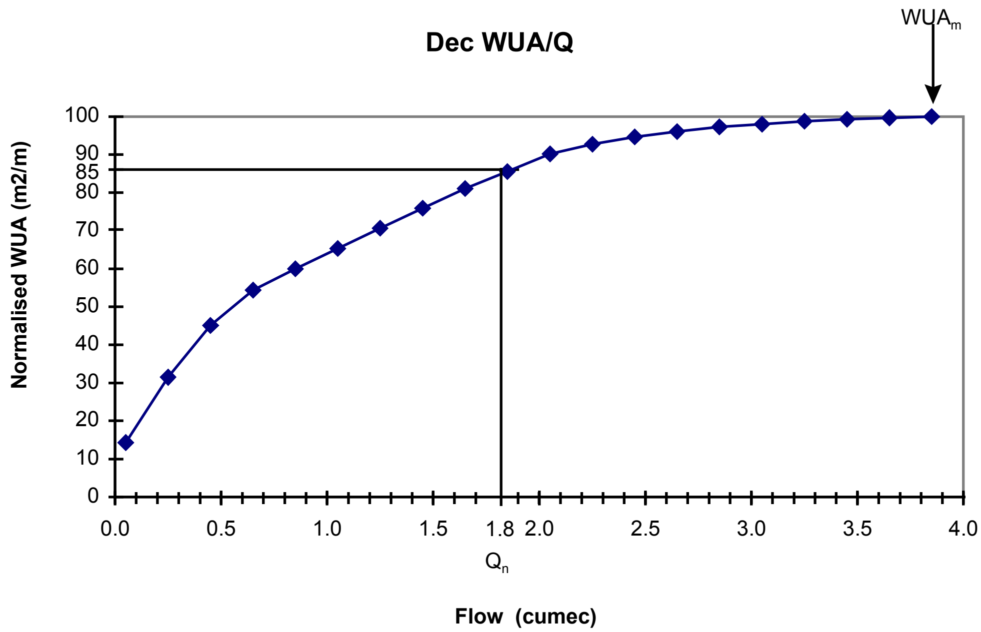
2. This is then normalised so that the maximum, WUA_m, is 100%:

Flow	Normalised WUA
0.05	14.35
0.45	45.04
0.85	60.00
1.25	70.69
1.65	81.07
2.05	90.23
2.45	94.66
2.85	97.25
3.25	98.78
3.65	99.69
3.85	100.00

Figure 5.1 cont:

3. Q_n can then be read directly from the relevant percentage of WUA_n on the graph where:

WUA_d = Weighted Useable (habitat) Area for December
HA_m = Weighted Useable Area for pre-offtake median flows
Q_n= Boundary flow for risk level during month of concern (*n)*



ie. to get the no risk flow, the percentage WUA above 1.8 cumec, there should be no risk to trout adults in the North Esk River, Watery Plains reach in December.

Table 5.3 Flows for each risk category, Prosperity Road (cumecs). Final flows are given to one decimal place for simplicity of application.

December

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.11	0.11 - 0.06	≤0.06
adult trout	≥0.52	0.52 - 0.34	≤0.34
G. maculatus	≥0.10	0.10 - 0.05	≤0.05
0+ trout	≥0.36	0.36 - 0.13	≤0.13
shortfinned eel	≥0.12	0.12 - 0.04	≤0.04
invert. taxa	≥0.30	0.30 - 0.24	≤0.24
flow	≥0.5	0.5 - 0.3	≤0.3

January

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.13	0.13 - 0.07	≤0.07
adult trout	≥0.30	0.30 - 0.15	≤0.15
G. maculatus	≥0.14	0.14 - 0.06	≤0.06
0+ trout	≥0.35	0.35 - 0.13	≤0.13
shortfinned eel	≥0.14	0.14 - 0.04	≤0.04
invert. taxa	≥0.23	0.23 - 0.21	≤0.21
flow	≥0.3	0.3 - 0.2	≤0.2

February

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.13	0.13 - 0.07	≤0.07
adult trout	≥0.30	0.30 - 0.15	≤0.15
G. maculatus	≥0.14	0.14 - 0.06	≤0.06
0+ trout	≥0.35	0.35 - 0.13	≤0.13
shortfinned eel	≥0.14	0.14 - 0.04	≤0.04
invert. taxa	≥0.23	0.23 - 0.21	≤0.21
flow	≥0.3	0.3 - 0.2	≤0.2

March

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.14	0.14 - 0.07	≤0.07
adult trout	≥0.22	0.22 - 0.12	≤0.12
G. maculatus	≥0.16	0.16 - 0.07	≤0.07
0+ trout	≥0.13	0.13 - 0.06	≤0.06
shortfinned eel	≥0.13	0.13 - 0.04	≤0.04
invert. taxa	≥0.19	0.19 - 0.15	≤0.15
flow	≥0.2	0.2 - 0.1	≤0.1

April

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.12	0.12 - 0.07	≤0.07
adult trout	≥0.42	0.42 - 0.24	≤0.24
G. maculatus	≥0.13	0.13 - 0.06	≤0.06
0+ trout	≥0.38	0.38 - 0.14	≤0.14
shortfinned eel	≥0.13	0.13 - 0.04	≤0.04
invert. taxa	≥0.27	0.27 - 0.23	≤0.23
flow	≥0.4	0.4 - 0.2	≤0.2

Table 5.4 Flows for each risk category, Waterhouse Road (cumecs). Final flows are given to one decimal place for simplicity of application.

December

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.35	0.35 – 0.25	≤0.25
adult trout	≥1.45	1.45 - 1.00	≤1.00
G. maculatus	≥0.18	0.18 - 0.12	≤0.12
0+ trout	≥0.26	0.26 – 0.18	≤0.18
shortfinned eel	≥0.15	0.15 - 0.10	≤0.10
invert. taxa	≥1.20	1.20 – 0.90	≤0.90
flow	≥1.5	1.5 - 1.0	≤1.0

January

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.35	0.35 – 0.25	≤0.25
adult trout	≥1.05	1.05 - 0.30	≤0.30
G. maculatus	≥0.30	0.30 - 0.20	≤0.20
0+ trout	≥0.31	0.31 – 0.24	≤0.24
shortfinned eel	≥0.21	0.21- 0.15	≤0.15
invert. taxa	≥0.96	0.96 - 0.71	≤0.71
flow	≥1.1	1.1 - 0.7	≤0.7

February

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.40	0.40 - 0.25	≤0.25
adult trout	≥0.87	0.87 - 0.70	≤0.70
G. maculatus	≥0.34	0.34 - 0.25	≤0.25
0+ trout	≥0.40	0.40 – 0.34	≤0.34
shortfinned eel	≥0.25	0.25 - 0.19	≤0.19
invert. taxa	≥0.77	0.77 - 0.63	≤0.63
flow	≥0.9	0.9 - 0.7	≤0.7

March

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.40	0.40 - 0.25	≤0.25
adult trout	≥0.80	0.80 - 0.68	≤0.68
G. maculatus	≥0.36	0.36- 0.28	≤0.28
0+ trout	≥0.40	0.40 – 0.34	≤0.34
shortfinned eel	≥0.29	0.29 - 0.20	≤0.20
invert. taxa	≥0.68	0.68 - 0.57	≤0.57
flow	≥0.80	0.80 - 0.70	≤0.70

April

Risk Category	No Risk	Moderate Risk	High Risk
Blackfish	≥0.35	0.35 - 0.25	≤0.25
adult trout	≥1.15	1.15 – 0.87	≤0.87
G. maculatus	≥0.24	0.24 - 0.18	≤0.18
0+ trout	≥0.35	0.35 - 0.30	≤0.30
shortfinned eel	≥0.19	0.19 - 0.12	≤0.12
invert. taxa	≥1.1	1.1 – 0.87	≤0.87
flow	≥1.2	1.2- 0.9	≤0.9

6 Discussion

Before discussing the implications of the risk analysis results, it is important to re-iterate the caveat stated at the beginning of the report which is that the flows are only appropriate for the individual months for which they have been recommended. However, the ecological integrity of rivers is dictated by hydrological processes operating throughout the year, and if there is further development of the water resource the issue of non-summer flows will require attention and further assessment by DPIWE.

It should also be stressed that an essential part of setting an environmental flow is the monitoring of compliance and environmental benefit. Further assessment may need to be undertaken in the future if monitoring highlights values that are not being met by the negotiated flow regime.

Any risk assessment must be made relative to some reference period. In this study the reference flows used were the median monthly flows at each site for the period 1972-1999, adjusted to account for irrigation takes. (In other words, the flows used were estimations of the median monthly flows that would have occurred at each site without abstraction). Medians have been used for the risk analysis rather than means due to the effect of high flow events skewing means upward and away from a true measure of the central tendency of the data.

The risk analysis (section 5.3) relates to the values specifically considered, including:

- Maintain trout (*Salmo trutta*) populations.
- Maintain shortfinned eel (*Anguilla australis*), jollytail (*Galaxias maculatus*) and blackfish (*Gadopsis marmoratus*).
- Maintain macroinvertebrate populations found in the Great Forester River.

The risk analysis also indirectly assesses other values nominated by the community, namely:

- Maintain enough water for stream habitat for water life.
- Protect whitebait and blackfish fisheries.

Other values not specifically targeted are discussed in detail below.

6.1 Crayfish

6.1.1 *Astacopsis gouldi*

There is a lack of habitat preference information relating to *Astacopsis gouldi* and it was beyond the scope of this study to collect such information. However, the protection of this species is an important community and technical value. It is listed as vulnerable in the *Tasmanian Threatened Species Protection Act 1995*. It is recommended that flows in the 'no risk' category should remain in the river for its protection. This is to ensure that:

- a range of size of pools are maintained for adults and subadults;
- boulder riffles are maintained for juveniles; and
- base flows are maintained at sufficient levels to keep water temperatures at a level conducive to survival of all age classes (below 18°C Forteath, 1987).

It is conceded that for both reaches the flow recommendations resulting from the risk analysis are considerably influenced by the water requirements for trout. However, we consider these flows are necessary also to adequately protect the endangered species *Astacopsis gouldi*, and strongly recommend that flows remain in the 'no risk' category in both reaches to ensure this value is maintained.

6.1.2 *Engaeus spinicaudatus*

The Scottsdale burrowing crayfish (*Engaeus spinicaudatus*) is listed as vulnerable due to its very restricted distribution and disturbance to its habitat. This species is restricted to a small area in the northeast, in the Surveyors Creek and Great Forester River valley just northeast of Scottsdale. It requires organic, permanently saturated surface soils and is found in buttongrass and heath plains, the floodplains and riparian areas of streams, seepages and wet pastures. The species spends most of its life in a burrow.

The greatest threats to this species include: drainage of swamps; conversion to pasture; erosion causing solids deposition in swamps; siltation of streams and swamps; and pesticide contamination of water (Forest Practices Board, 1998). The mating period occurs in November to December when the crayfish are likely to be at or near the surface.

Forest Practices Board (1998) define a series of management recommendations for the species. In summary these state that all areas in which the crayfish occurs are essential habitat, and these areas and catchment areas immediately affecting them should be left undisturbed. Important areas of State forest relevant to the Great Forester catchment are: Surveyors Creek west of Old Waterhouse Road; around the junction of China Creek, Ruby Creek and Great Forester River; on a tributary of the Great Forester River near the junction of Old Waterhouse and Forester Rds; along the banks of Hang Dog Creek and Parrs Rivulet; and two areas west of the Great Forester River near Jensens Rd.

Little information is available on the effect of fluctuating discharge on *E. spinicaudatus* habitat. The most likely threat to this species' habitat is decreasing saturation of peat burrows under low flows during the irrigation period, although there is no direct evidence of this occurring.

6.2 Fish

6.2.1 *Mordacia mordax* and *Geotria australis*

Requirements for the maintenance of rearing and spawning habitats for lampreys (*Mordacia mordax* and *Geotria australis*) are described in Koehn (1990). *Mordacia mordax* enters fresh water to breed, migrating upstream to headwaters between November and March. Actual spawning occurs between July and September. Newly hatched ammocetes larvae live in soft mud. Downstream migration to the sea usually occurs in spring about three to four years after hatching. *Geotria australis* lives in seas for an undetermined period thought to extend for several years. Breeding occurs in freshwater following upstream migration which may last sixteen months. Spawning takes place in relatively shallow, relatively fast flowing waters on gravel bottoms, probably in small headwater streams and is thought to occur in late spring from October to December (Koehn, 1990). The adults do not feed while in fresh waters and die shortly after spawning. Lamprey larvae live buried in soft bottomed sediments and live in freshwater for about three to four years. The young lampreys then transform to the adult stage and migrate downstream to the sea.

The spawning requirements of both these species are likely to be unaffected by the current water demand in the Great Forester River as these lifestages occur outside of high water demand and as a result were not considered further in this report.

6.2.2 *Gadopsis marmoratus* and *Salmo trutta*

Spawning of the blackfish (*Gadopsis marmoratus*) occurs in spring to early summer. Each female deposits 20-500 eggs depending on size. These are laid in a patch on the bottom surface of a log or rocks. Sufficient resources were not available to include an assessment of the habitat requirements for spawning in this report.

Brown trout (*Salmo trutta*) spawn in late autumn. Eggs are deposited in gravel nests or redds in streams and eggs take at least 28 days to hatch. The spawning of brown trout was not investigated as this occurs outside the irrigation period, between April and August (Davies and McDowell, 1996).

While snags are indeed important as habitat for trout and blackfish, it is beyond the capacity of this assessment to ensure their maintenance. Davies and Humphries (1995) examined the relationship between flow and wetted area of snag and found that only small changes in the amount of snag inundation occur within the flow ranges typical of the irrigation season. Other issues outside the management of water quantity, such as riparian zone management and snag removal, will have greater influence on this value.

6.2.3 *Pseudaphritis urvillii*

Few details of the life history of freshwater flathead (*Pseudaphritis urvillii*) are available, but the adults appear to migrate downstream to spawn in estuaries from late April to August (Andrews, 1996). Their preferred freshwater habitat is usually slow flowing water around log snags, under overhanging banks or among leaf litter. As little is known of the spawning requirements of the freshwater flathead, the assessment of the influence of flow on their spawning was beyond the resources of this study.

6.2.4 *Galaxias truttaceus*

The spotted galaxiid (*Galaxias truttaceus*) is similar to the common jollytail (*Galaxias maculatus*), in that both species have a marine juvenile stage and a diadromous life cycle. Non land-locked populations migrate downstream to estuaries during autumn-spring tides where spawning and hatching occurs. The newly hatched larvae are swept out to sea and the juveniles eventually migrate back to shore and enter freshwater streams during late winter or spring (Fulton, 1990). Both species form a large part of the whitebait runs at this time. Flow requirements have not been assessed for the whitebait run since it occurs outside of the irrigation season. In addition, habitat preference information is not available for any lifestages of *Galaxias truttaceus* and therefore the assessment of their flow requirements is outside the scope of this study.

6.2.5 *Prototroctes maraena*

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. Each female produces about 25,000 to 68,000 eggs that sink to the bottom just downstream of the spawning site (McDowall, 1996). Newly hatched larvae are thought to be swept down to estuaries where they remain for about 6 months before returning to freshwater to complete their lifecycle. As little is known of the spawning requirements of the grayling, the assessment of the influence of flow on their spawning was beyond the resources of this study.

6.2.6 *Macquaria colonorum*

Estuarine perch (*Macquaria colonorum*) are most common in estuaries affected by tides, but also occurs in rivers and lakes in salinities less than 1-2ppt. Spawning occurs in saltwater estuaries when temperatures reach 14.5-16^{o}C, during July or August in NSW but as late as November or early December in Victoria (and most likely Tasmania) (Allen 1989). Adult fish move downstream prior to spawning. This species is unlikely to be affected by water demand in the Great Forester River as much of its lifestages take place outside of freshwater.

6.2.7 *Galaxias pusilla*

The dwarf galaxiid (*Galaxiella pusilla*) is found in lowland areas in the northeast of Tasmania. It lives in slow flowing waters such as swamps and drains or backwaters of streams amongst aquatic vegetation in shallow water. It is sometimes found in temporary waters which dry up in summer although these will always be connected to permanent water. Little information exists on the ecological flow requirements for this species although Forest Practices Board (1998) list a management recommendation of maintaining water quality and flow regime for this species.

6.3 Flow Recommendations

This section offers a summary of flows that will provide certain, defined risks to the maintenance of ecological values in the relevant reaches. As previously discussed, it is conceded that for both reaches the flow recommendations resulting from the risk analysis are considerably influenced by the water requirements for trout. However, we consider these flows are necessary also to adequately protect the endangered species *Astacopsis gouldi*, and strongly recommend that flows remain in the 'no risk' category in both reaches to ensure this value is maintained.

6.3.1 Prosperity Road

Table 6.1 provides a summary of flows that will provide certain, defined risks to the maintenance of ecological values in the Prosperity Road reach. These risks only apply to the upper reach of the Great Forester River to its crossing of the Tasman Highway. Flows in the 'no risk' range should remain in the river for protection of *Astacopsis gouldi.*

Table 6.1 Flows for each risk category, Prosperity Road (cumecs)

Month	No risk	Moderate risk	High risk
Dec	≥0.5	0.5 - 0.3	≤0.3
Jan	≥0.3	0.3 - 0.2	≤0.2
Feb	≥0.3	0.3 - 0.2	≤0.2
Mar	≥0.2	0.2 - 0.1	≤0.1
Apr	≥0.4	0.4 - 0.2	≤0.2

6.3.2 Waterhouse Road

Table 6.2 provides a summary of flows that will provide certain, defined risks to the maintenance of ecological values in the Waterhouse Road reach of the Great Forester River. These risks only apply to this reach from downstream of the Tasman Highway to the entry of the River into Backup Marsh and McKerrows Marsh wetlands. Again, flows in the 'no risk' range should remain in the river for protection of *Astacopsis gouldi.*

Table 6.2 Flows for each risk category, Waterhouse Road (cumecs)

Risk Category	**I**	**II**	**III**
Month	**No risk**	**Moderate risk**	**High risk**
Dec	≥1.5	1.5 - 1.0	≤1.0
Jan	≥1.1	1.1 - 0.7	≤0.7
Feb	≥0.9	0.9 - 0.7	≤0.7
Mar	≥0.8	0.8 - 0.7	≤0.7
Apr	≥1.2	1.2 – 0.9	≤0.9

7 References

Allen, G.R., 1989. Freshwater Fishes of Australia. T.F.H. Publications, Inc., USA.
ANCA,1994. A Directory of Important Wetlands in Australia. Series Editors: Usback, S. and James, R.. Commonwealth of Australia, Canberra, ACT.

Andrews, A.P., 1990. Family Bovichtidae: Congolli. In: McDowall, R.M. (Ed.) Freshwater Fishes of South-Eastern Australia. Reed Books, Hongkong.

Bobbi, C., Nelson, M., Krasnicki, T., Graham, B., 1999. State of Rivers Report for Rivers in the Great Forester Catchment. Department of Primary Industries, Water and Environment, Hobart. WRA 99/05-08.

Bovee, K.D., 1978. Probability -of-use criteria for the family Salmonidae. Instream Flow Information Paper 4. U.S. Fish and Wildlife Service.FWS/OBS-78/07. 80 pp.

Bovee, K.D., 1982. A guide to stream habitat analysis using the instream flow incremental methodology. Instream Flow Information paper No.21, Co-operative Instream Flow Group, US Fish and Wildlife Service, Colorado.

Cameron, M., 1995. The flora of the wetlands of northeast Tasmania. In: Mesibov, R. (Ed.) Biogeography of northeast Tasmania: Records of the Queen Victoria Museum. Launceston, Tasmania.

Davies, P.E., 1989. Relationships between Habitat Characteristics and Population Abundance for Brown Trout, *Salmo trutta* L. and Blackfish, *Gadopsis marmoratus* Rich. in Tasmanian Streams. Australian Journal of Marine and Freshwater Research 40, pp 341-59.

Davies, P.E., and Humphries, P., 1996. Final Report: An Environmental Flow Study of the Meander, Macquarie and South Esk Rivers, Tasmania.

Davies, P.E. and McDowall, R.M., 1996. Family Salmonidae: Salmons, trouts and chars. In: McDowall, R.M. (Ed.) Freshwater Fishes of South-Eastern Australia. Reed Books, Hongkong.

Davies, P.E., McKenny, C. and Cook, L., 1997. Mersey River Environmental Flow Study: Report to the Hydro-Electric Corporation Tasmania for the Mersey River Study Committee.

Duncan, F., 1995. Lowland forests and woodlands in northeast Tasmania. In: Mesibov, R. (Ed.) Biogeography of northeast Tasmania: Records of the Queen Victoria Museum. Launceston, Tasmania.

Forteath, N., 1987. The aquaculture potential of the giant fresh-water crayfish *Astacopsis gouldi*, School of Applied Science, Tasmanian State Institute of Technology, Launceston.

Fuller, D. and Read, M., 1997. Environmental Flows Assessment and Allocation. Department of Primary Industries and Fisheries, Hobart, WRA 97/07.

Fulton, W., 1990. Tasmanian Freshwater Fishes. Fauna of Tasmania handbook 7. University of Tasmania and Inland Fisheries Commission, Hobart, Tasmania.

Graham, B., 1999. The Hydrology of the Great Forester River: A report forming part of the requirements for the State of Rivers Reporting. . Department of Primary Industries and Fisheries WRA 99/08.

Harris, S. and Kirkpatrick, J., 1995. The coastal vegetation of northeast Tasmania. In: Mesibov, R. (Ed.) Biogeography of northeast Tasmania: Records of the Queen Victoria Museum. Launceston, Tasmania.

Jackson, P.D., 1978. Benthic invertebrate fauna and feeding relationships of brown trout, *Salmo trutta* Linnaeus, and river blackfish, *Gadopsis marmoratus* Richardson, in the Aberfeldy River, Victoria. Australian Journal of Marine and Freshwater Research 29, pp 725-42.

Jackson, P.D., Koehn, J.D., Lintermans, M. and Sanger, A.C., 1996. Family Gadopsidae: Freshwater blackfishes. In: McDowall, R.M. (Ed.) Freshwater Fishes of South-Eastern Australia. Reed Books, Hongkong.

Jordan, W.M., 1973. Tasmanian Water Resources Survey - Report No. 14 on the Great Forester and Tomahawk Rivers 1973. Rivers and Water Supply Commission Report No. 14 . Hobart, Tas.

Jowett, I.G., 1992. River hydraulics and instream habitat modelling for river biota. Chapter 14 in 'Waters of New Zealand'. New Zealand Hydrological Society Inc.

Jowett, I.G. and Richardson, J., 1995. Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. New Zealand Journal of Marine and Freshwater Research 29, pp17-23.

Koehn, J., 1986. Approaches to determining flow and habitat requirements for freshwater native fish in Victoria. In: Campbell, I.C. (Ed.) Stream Protection: The Management of Rivers for Instream Users. Pub. By Water Study Centre, Chisholm Institute of Technology, Melbourne.

Koehn, J.D., 1990. Threats to Victorian native freshwater fish. Victorian Naturalist 107, pp 5-12.

McDowall, R.M., 1996. Family Prototroctidae: Southern graylings. In: McDowall, R.M. (Ed.) Freshwater Fishes of South-Eastern Australia. Reed Books, Hongkong.

Forest Practices Board, 1998. Threatened fauna manual for production forests in Tasmania (revised version). Forest Practices Board, Hobart, Tasmania.

Pinkard, G., 1995 Agricultural soils in northeast Tasmania. In: Mesibov, R. (Ed.) Biogeography of northeast Tasmania: Records of the Queen Victoria Museum. Launceston, Tasmania.

Potter, I.C., 1996. Family Mordaciidae: Shortheaded Lampreys. In: McDowall, R.M. (Ed.) Freshwater Fishes of South-Eastern Australia. Reed Books, Hongkong.

Steane, D., 1995. Some man-induced geomorphic changes in the coastal environment of northeast Tasmania since European settlement and some related observations on coastal vegetation. In: Mesibov, R. (Ed.) Biogeography of northeast Tasmania: Records of the Queen Victoria Museum. Launceston, Tasmania.

Threatened Species Act 1995. Government of Tasmania, Hobart.

Appendix 1 The role of environmental flow assessment in water management in Tasmania

Introduction

Australian governments have adopted a set of National Principles for Provision of Water for ecosystems (ARMCANZ and ANZECC, 1996). These principles guide the management of environmental flow regimes across Australia, through the Council of Australian Government's (COAG) water reform agenda (ARMCANZ, 1996). State governments are able to individually adopt a more strategic and accelerated approach to environmental flow assessment and water management.

This section introduces the Tasmanian approach to water management planning. It places the environmental flows program in Tasmania in relation to other stages of developing water management plans. These include:

- the identification of water values by the community and the State government;
- the negotiation and tradeoff of these values that may be required when determining a new flow management regime; and
- an iterative process of monitoring and review of both compliance and environmental benefit of this new flow regime.

The environmental flows program in Tasmania has been structured to allow effective assessment of ecological flow requirements, and constructive negotiation in flow management. Therefore the program has a number of key features, including:

- comprehensive community consultation to identify water values within a catchment;
- comprehensive technical consultation in order to gather information about the river ecosystem and which values need protection;
- the use of the most appropriate environmental flow assessment tool to identify the ecological requirements, given the nature of the stress the river experiences; and
- the provision of a series of options and associated ecological and hydrological risks to assist in any negotiation and tradeoff process that may occur.

The remainder of the section deals with each stage of the water management process that are principally involved in the formulation of a new flow management regime. Other documents such as Fuller and Read (1997), Nelson (1997) and Phillips (1998) have detailed various aspects of the evolving water management process during the current period of water reform in Tasmania, and provide a comprehensive background to the current state of water reform in Tasmania.

The values approach

In Tasmania, environmental flow assessment for each catchment operates within a water value setting framework. This is discussed by Fuller and Read (1997) who suggest a management approach for environmental flow assessment and allocation. Values form a useful basis from which to establish management actions/plans which have broad support. The co-operative approach to the identification of these values by various parties is more likely to achieve the intended outcomes than plans drawn up by any single party (Fuller, 1998).

The Department of Primary Industries, Water and Environment across a number of programs use a common approach in setting catchment values through community consultation. Although the value setting approach for water quantity complements the approach described in the State Policy on Water Quality Management (Government of Tasmania, 1997) on the setting of Protected Environmental Values (PEV's), they are not integrated. Recently, the processes have been brought closer together by carrying out the community consultation process for both water quantity and quality values in tandem for specific regions prioritised for PEV setting. Table 1 illustrates the common themes for values in each of these processes.

Table 1 Comparison of water quality and quantity value setting processes

State Water Quality Policy (PEV's)	**Water Management Planning (Water Values)**
Protection of aquatic ecosystems	Ecosystem values
Recreational water quality and aesthetics	Recreational values Aesthetic landscape values
Raw water for drinking supply Agricultural water uses Industrial water supply	Consumptive/non-consumptive uses
	Physical landscape values

The identification of values is a fundamental step in developing water quality guidelines for specific water bodies and Water Management Plans. Water Management Plans are intended to be a vehicle for the open management of water resources in a catchment and contain:

- environmental flow requirements;
- guidelines on water trading;
- agreed plans for sustainable water development; and
- protocols for the implementation of restrictions during drought periods (Fuller, 1998); and
- details of the methodology that will be used to monitor compliance and environmental benefit.

Preliminary values can identify the information gathering needs of each catchment. Typically, they will encompass specific issues which need to be considered in environmental flow assessment, and, to some extent, guide scientific investigations into the requirements of the river in question. They will also contain a review of water quality and a set of allocation constraints which can be considered during water balance modelling. Prioritisation of values within each category is fundamental, as it provides guidance on the values which could potentially be "traded off" during negotiations and hence guidance for hydrologists in investigating water allocation scenarios.

Identification of preliminary values by community consultation

Within the catchment a water management plan is implemented. A focus or stakeholder group from the community is formed to identify and prioritise specific water values within each of the above water value categories. Meetings to identify community values include representatives from different groups within each the community (eg. recreational fishing, farming, environmental, irrigation, local government etc.). These people are sent a letter prior to the meeting, along with documents explaining the value setting approach and a detailed description of the water value categories. The meetings are run by a facilitator who guides the group to identify specific water values under each water value category. These values are then are collectively prioritised within each category.

Essentially, the final product is a list of prioritised values important to the focus group of the catchment in question in relation to the river. These preliminary values form part of the basis for negotiation later on in the water management planning process if required.

Technical values

The community process is complemented by the identification of values (including non-negotiable values) at the state level. State values include issues such as wetlands protected under legislation/agreements, endangered species and important recreational fisheries, etc.

The identification of state values is achieved through the State Technical Committee on Environmental Flows and consists of representatives from relevant government agencies and some external institutions. These representatives have expertise in various disciplines related to river ecosystems, such as estuarine ecology, riparian vegetation and wetland ecology. Collectively, they can adopt a holistic approach to identifying values from a scientific perspective. These state values are identified in much the same way as community values; that is in a workshop process and on a catchments by catchment basis.

The group operates on the following terms of reference (Fuller, 1998):

- to determine a set of defined catchments for which water management planning will be completed;
- to develop an agreed process(es) for quantitatively defining catchment priorities according to the stresses placed on their waters, or other special management requirements; and
- to identify water values from a technical and scientific perspective including the non-negotiable values which are implicit in various local, national and international agreements and legislation.

It is anticipated that these technical representatives will provide advice to the state in any negotiation process that may occur.

Both sets of values are normally expected to be tabled in focus group meetings after the environmental flow assessment has been made and negotiation has commenced.

Environmental Flow Assessment

The environmental flows assessment process in Tasmania has been outlined by Fuller and Read (1997). Nelson (1997) provides the major objectives of the DPIWE environmental flows program and its implementation in Tasmania. These objectives are:

- to prioritise and rank rivers on the basis of the significance of management issues and the level of demands;
- to undertake preliminary work to identify important instream requirements (eg. critical flow periods, spawning flows for fish, water quality parameters and significant biotic factors);
- to establish management values and objectives by using a consultative process for each catchment;
- to adopt a desktop approach for low priority rivers; and
- to adopt more detailed field techniques for high priority rivers.

Tasmania has adopted a wide range of environmental flow assessment tools in the past. This has largely been due to the need for the most appropriate methodology to address the environmental requirements of a given catchment. As many studies have addressed catchments in low flow periods, the Instream Flow Incremental Methodology (IFIM) has been used. This method provides a direct, measurable relationship between ecological habitat and flow, and allows direct linkage with hydrological studies and risk assessment. IFIM is recognised internationally as one of the most biologically defensible techniques available, and it allows different parties to negotiate on common ground (Jowett, 1996).

Other methods for environmental flow assessment are reviewed by Nelson (1997). This report provides a comprehensive appraisal of methods used in Tasmania to date, and outlines methods that are likely to be used in future. DPIWE has adopted a position of determining the method of environmental flow assessment on a catchment basis. The method selected will depend largely on what part of the flow regime is affected, and on the environmental requirements of the particular river. On rivers that are largely unaffected by water abstraction, desktop methods will usually be used and a criterion set for when a certain level of water use is reached. Desktop methods aim to maintain the general integrity of an ecosystem by safeguarding riverine habitat to support ecosystem function.

In highly stressed rivers or rivers earmarked for future resource development, more reliable and defensible techniques based on field assessment will be used, and this will usually be accompanied by an evaluation of the risk of failure to achieve environmental flows.

Tradeoff of environmental outcomes

Naturally, the allocation of water to meet ecological values is not independent of the need to provide water to meet other values (i.e. consumptive/non consumptive). As a result, models of the resource are required to assess the effects of allocation strategies (Fuller, 1998).

Water is a dynamic resource and clearly there will be circumstances in which there is insufficient water to meet all demands. The final outcomes of environmental flow assessment should include a series of recommendations of different flows and the ecological risks associated with the failure to meet each flow.

In addition, hydrological models can assist water managers to quantify the risk associated with resource allocations. The tradeoff process relies on the adoption of a set of priorities which are attributable to the water values for a given catchment. The aim at this stage is to move from the preliminary values to clear management objectives which are needed to develop a draft water management plan for the catchment.

If it is determined that the river system is not over allocated then ecological recommendations may go directly into the water management process. Only if the system is found to be over allocated will a negotiation process with potential tradeoff need to occur. This will take place between the committee that identified the values and the Water Manager. Once negotiation is finalised, the allocation of water for the environment will be included in the draft water management plan for the river.

It is clear that in some instances there should be a relatively smooth tradeoff process, and in other instances resolution may not be reached. Nevertheless, the resource management agency has the task of developing a balanced water management plan in the interests of all users and is responsible for negotiation between all parties involved.

Public consultation and ratification of the plan

Once the negotiation with the focus group and the tradeoff process has occurred, the draft management plan can be developed. This plan will then be exposed to full public consultation and revision, before formal implementation as a statutory plan. Water management plans will be implemented as part of Tasmania's integrated Resource Management and Planning System (RMPS) and subject to appeal through the Resource Management and Planning Tribunal.

Monitoring

Another component of the plan will identify the level and type of monitoring required in implementation of the plan. This monitoring will then act as a clear indicator of the performance of the Water Manager and as a test of any environmental benefit or detriment to the river ecosystem. Realistically, there will be a tradeoff between what can be achieved and the resolution of monitoring required to understand the complexities of the ecosystem.

Monitoring can be divided into two areas: (i) compliance monitoring; and (ii) monitoring environmental benefit. Compliance monitoring will largely rely on the operation of stream gauging stations and water quality monitoring networks. This type of data can be directly assessed against the flow and water quality requirements of the Water Manager. Monitoring of environmental benefit/status is more difficult and the State is currently developing a combination of approaches for this purpose.

Firstly, the ecological models of river health being developed under the National River Health Program provide a broad range of tools for the assessment of impacts. These tools (based on macroinvertebrate sampling) are useful for identifying changes over time but have some problems in terms of sensitivity. These problems may be overcome to some extent by:

- the creation of catchment specific models rather than the regional models used to date;
- the use of lower levels of taxonomic identification (species);
- the implementation of quantitative rather than qualitative sampling protocols;
- the development of rank abundance models which are more sensitive to hydrological disturbance than the current models adopted by the state.

Secondly, indices of stream/river condition are being adopted in Victoria and Queensland as tools for qualitative assessment of environmental condition (Nelson, 1999). These tools are not designed specifically to monitor or assess hydrological impacts and are aimed at assessing overall catchment condition. However, they may provide another source of information which can be used in a broad management sense. Such indices may be useful in monitoring rivers that are not subject to large amounts of water abstraction.

Thirdly, a performance reach based approach (Sedger, 1997) is being adopted in NSW. This approach provides a more quantitative assessment of ecological condition in gauged reaches, thus establishing a more accurate assessment of ecological health and its variation with flow. A similar but more comprehensive approach is currently being carried out in the Mersey River Catchment. However, these monitoring protocols are labour intensive and very costly. Hence this approach is likely to only be used in situations where a river system is significantly impacted, or where there are special needs.

Finally, if ecological values and objectives can be specified with sufficient clarity, it will be possible to monitor changes in that part of the ecosystem. For example, if protection of an endemic species population is a management priority, then monitoring of population dynamics would provide a direct measure of management actions (assuming all other factors are equal). This type of monitoring may need to be undertaken by other agencies either as part of their normal actions or alternatively at the expense of the water manager.

It is intended that water management plans will have a finite life, of about 5 years, and be subject to review after this period.

Summary of environmental flow setting procedure

DPIWE has attempted to place environmental flow assessment in a series of defined steps that:

- involve consultation with the community within each catchment and the state agencies;

- carry out the most appropriate environmental flow assessment relevant to the particular requirements or stresses currently on the catchment; and
- provide a series of options to the parties involved in any negotiation that may take place, in order to carry out more informed decision making and negotiation.

References

ARMCANZ and ANZECC, 1996. National Principles for the Provision of Water for Ecosystems, Sustainable Land and Water Resources Management Committee, Subcommittee on Water Resources, Occasional Paper SWR No 3.

Fuller, D.A., 1998. Environmental Flows - the Tasmanian Experience. Irrigation Association Conference, Sale.

Fuller, D. and Read, M., 1997. Environmental Flows Assessment and Allocation. Department of Primary Industries and Fisheries, Hobart, Report WRA 97/07

Nelson M., 1997. Environmental Flows Assessment Methods - A Technical Review,
Department of Primary Industry and Fisheries, Tasmania, Report WRA 97/08

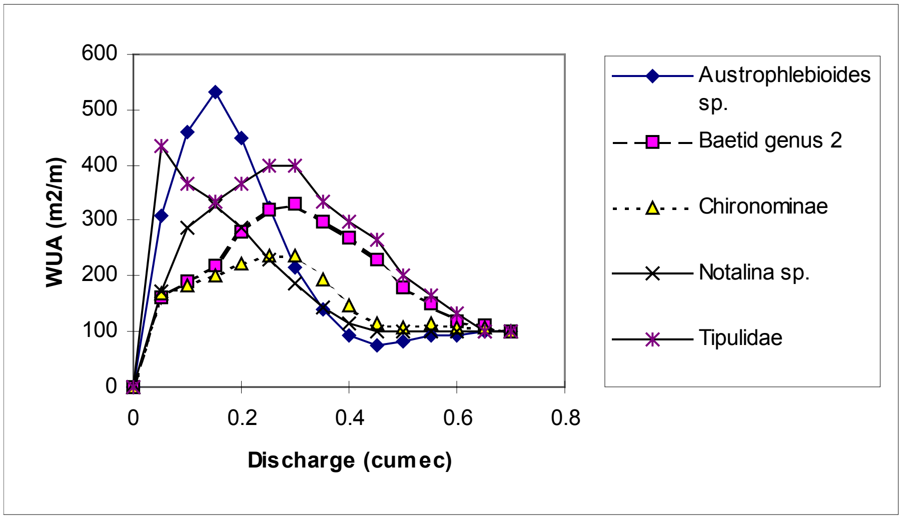
Nelson, M.D., 1999. Index of River Condition for the Ringarooma River, Report WRA 99/04

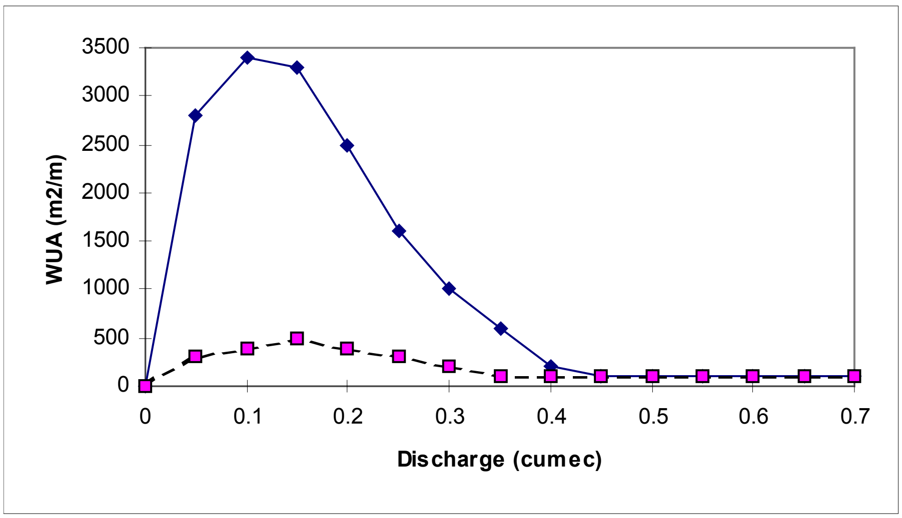
Phillips, R., 1998. Draft Discussion Paper for Water Management Planning. Department of Primary Industry and Fisheries, Tasmania.

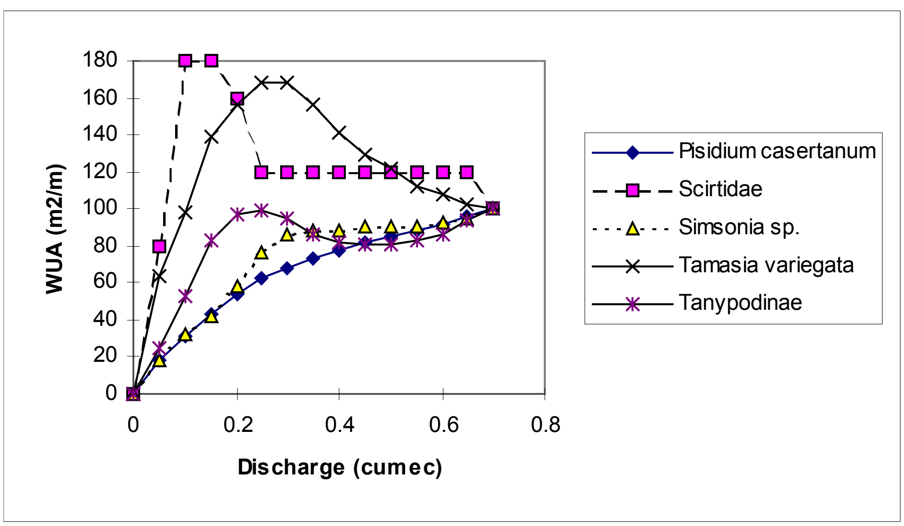
Sedger, A. 1997. Performance Reach Project: Report to External Review Panel. Department of Land and Water Conservation.

Appendix 2 WUA graphs for Great Forester river

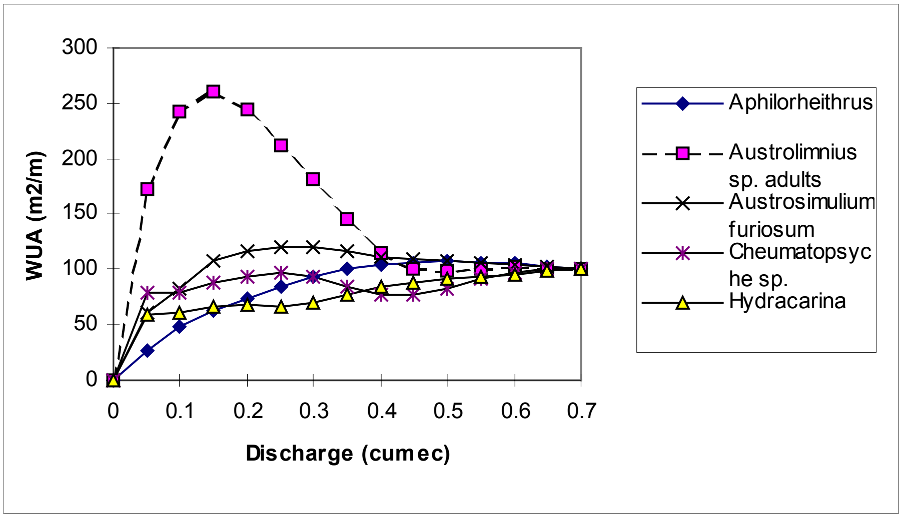
Prosperity Road reach

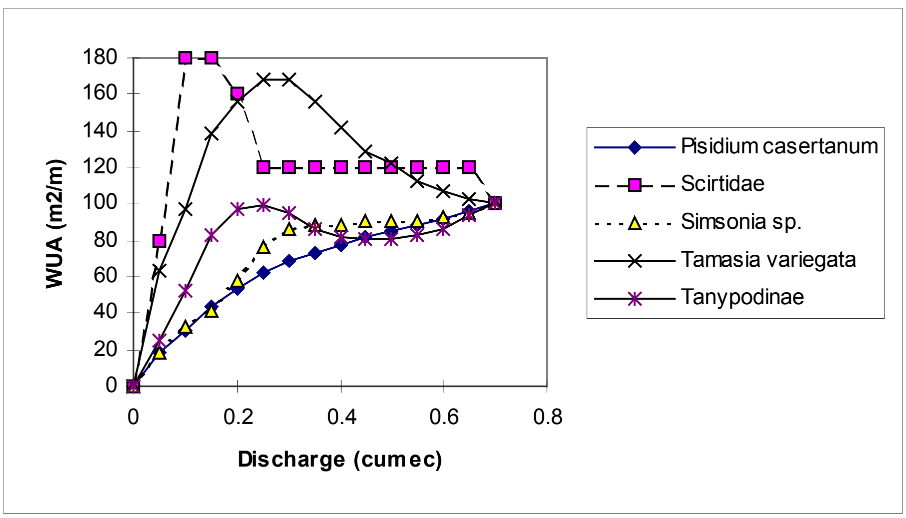






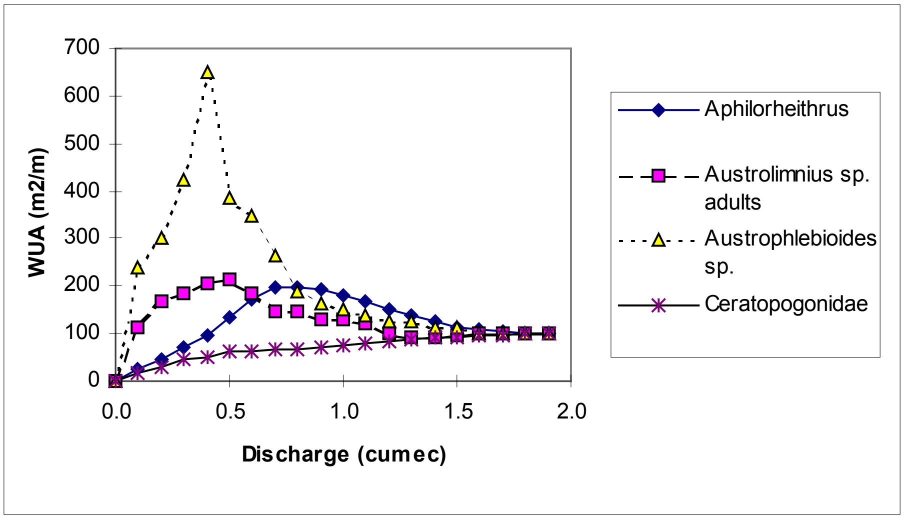
Prosperity Road reach cont.

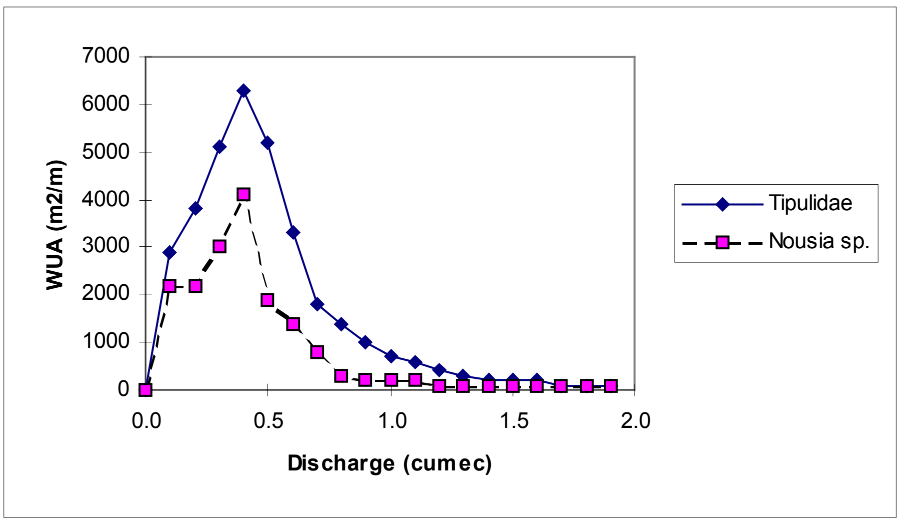


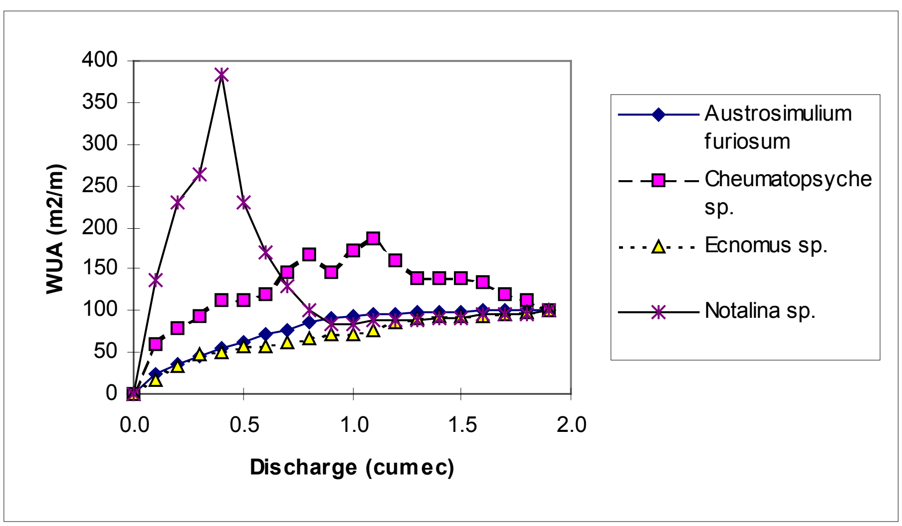


Appendix 2 cont.

Waterhouse Rd reach







Waterhouse Rd reach cont.