DEPARTMENT *of*
PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Tasmania

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Water Quality In The Montagu River Catchment

Part 4

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The Department of Primary Industries, Water and Environment

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.

2.5 Diurnal Water Quality Variations

During the study, continuous monitoring equipment was deployed at three sites within the Montagu River. The sites investigated were:

MR1 – Montagu River at Stuarts Rd;

MR6 – Montagu River at Rennison Rd; and

MR8 – Montagu River at Togari

On one occasion, two multi-parameter loggers were deployed simultaneously to compare diurnal patterns of change at Togari (where nutrient input was likely to be highest and there was a total absence of riparian vegetation) with that experienced in lower reaches of the Montagu River (MR1) where there is extensive riparian cover. The following section presents the data collected during these logging events and discusses the time series in relation to the physical and chemical characteristics of the sites.

2.5.1 Montagu River at Stuarts Rd (MR1)

Two logging events were carried out at this site to characterise diurnal patterns of change in water quality; a short deployment in February 1999 and a much longer deployment in March 2001. The latter was undertaken simultaneously with a deployment at MR9 (Togari) and the results of this deployment are presented and discussed in a later section.

The data collected during both deployments at MR1 showed that diurnal variation in water quality at this site is markedly dampened compared to other sites in the catchment that were examined. During the February 1999 deployment, water temperature and dissolved oxygen (Figure 2.36) varied by as little as 1.5 ^{o}C and 4% saturation respectively. There was no noticeable change in either pH (steady at about 7.9) or conductivity (640 $\mu S.cm^{-1}$), so these data have not been presented. The depressed saturation levels of oxygen displayed at this site is to be expected in the lower reaches of a river that has a very low gradient, has a relatively solid cover of native riparian vegetation and is substantially a depositional environment. The sediment and nutrient input upstream is also likely to contribute greatly to the overall lower oxygen levels at this site (see also Section 2).

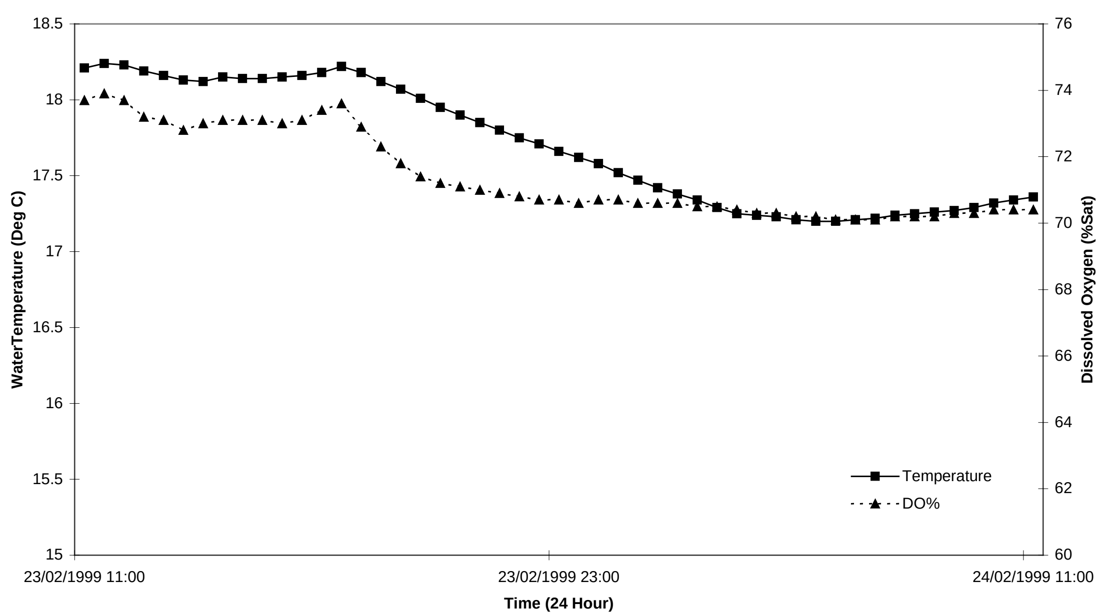

Figure 2.36: Diurnal variation in water temperature and dissolved oxygen in the Montagu River at Stuarts Rd (MR1) recorded in February 1999.

2.5.2 Montagu River at Rennison Rd (MR6)

Two short-term deployments were carried out at the site during the summer of 2000. The results, illustrated in Figures 2.37 - 2.39 below, show that the high level of exposure to sunlight, combined with the relatively high nutrient load, result in large fluctuations in dissolved oxygen and water temperature at this location. Maximum daytime oxygen levels in the river at this site exceeded 108%, with early dawn minima dropping as low as 47% saturation. This very large daily fluctuation is typical of a site that is eutrophic and has very active primary productivity (ie plant growth). The river-bed at this site has extensive coverage of aquatic plant, which are likely to be the main driver for the large daily changes in dissolved oxygen. This scale of daily change in dissolved oxygen is similar to that recorded upstream at MR8, and contrasts greatly with that displayed downstream at site MR1.

Despite the very large daily variations in dissolved oxygen and temperature (Figure 2.38) found at this location, pH levels do not show similarly large changes (Figure 2.39). Large daily changes in pH were expected at this site, as daily variation at Togari upstream were moderately high (see below). The lack of clear daily variation at this site is likely to be due to the influence of dolomite outcropping within the reaches of the Montagu River downstream from Togari, which would provide much greater buffering capacity in the river, reducing the impact of changes in dissolved oxygen on instream pH.

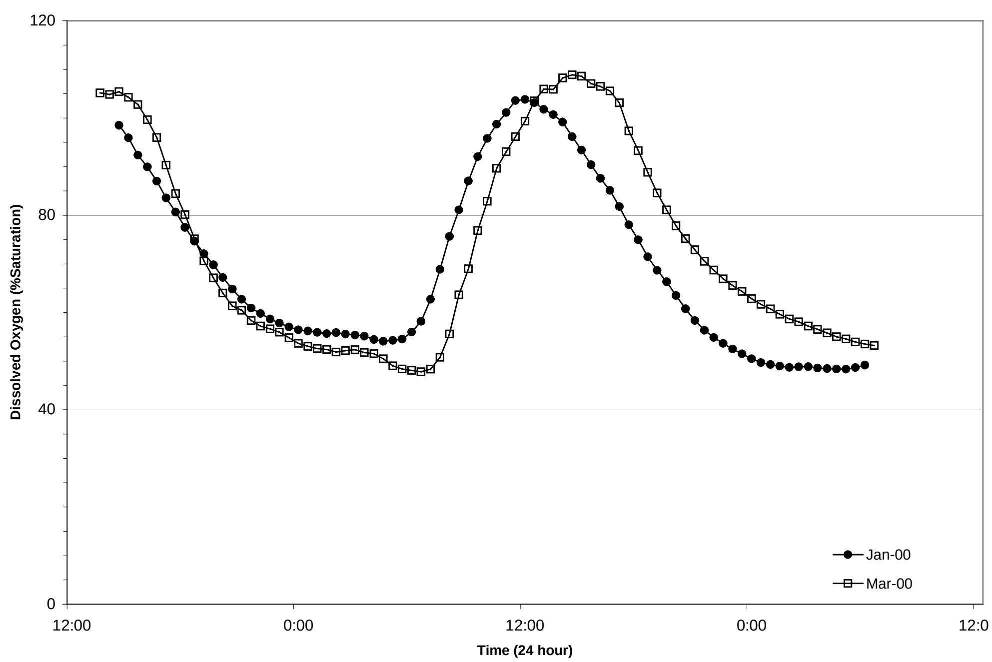

Figure 2.37: Comparison of diurnal variation in saturation levels of dissolved oxygen in the Montagu River at Rennison Rd (MR6) in January and March 2000.

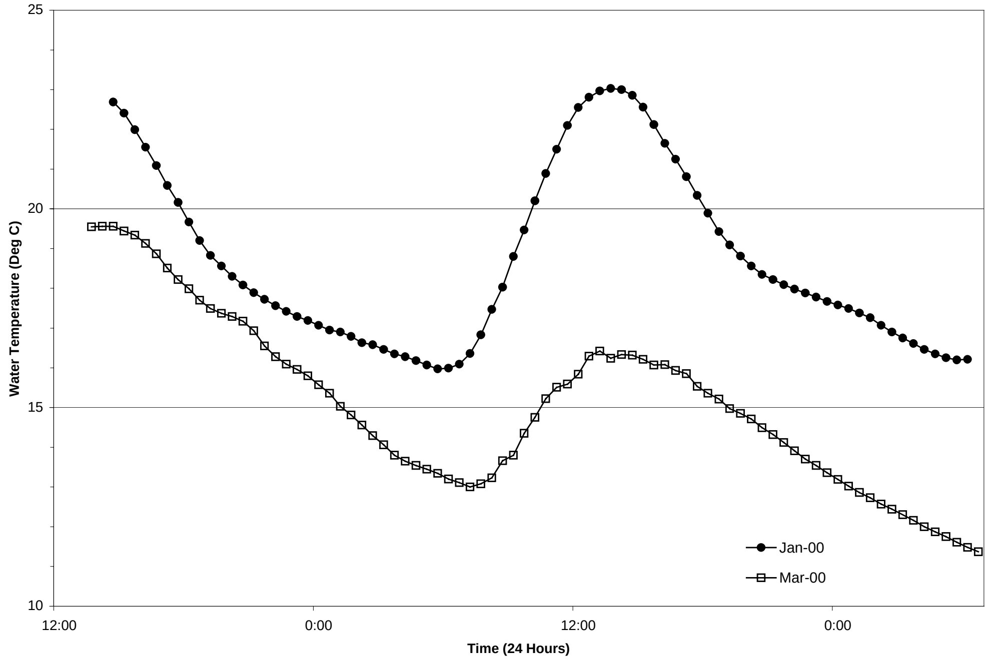

Figure 2.38: Comparison of diurnal variation in water temperature in the Montagu River at Rennison Rd (MR6) in January and March 2000.

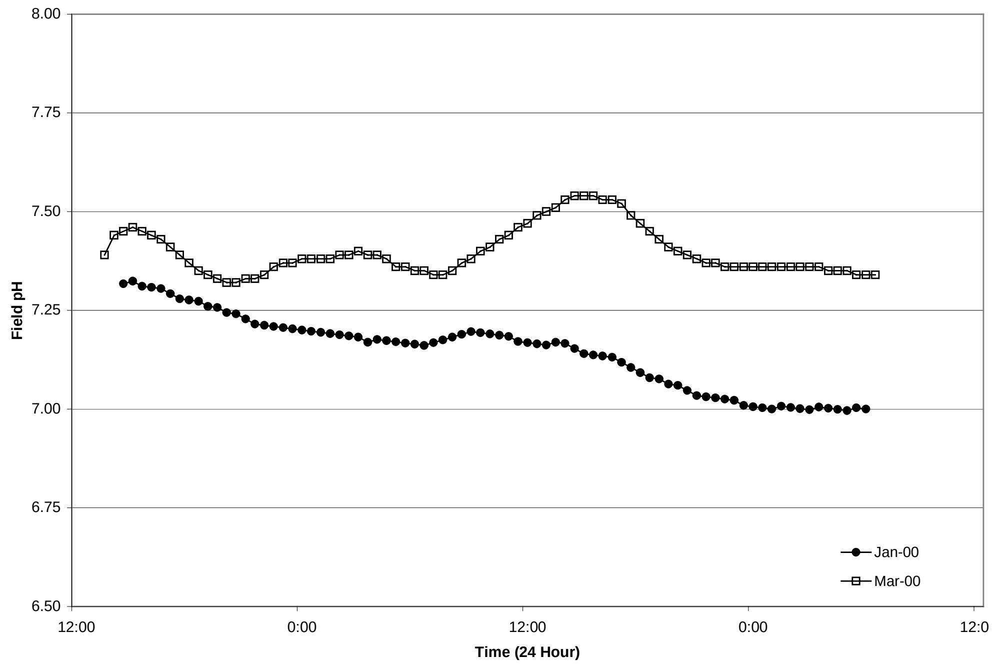

Figure 2.39: Comparison of diurnal variation in pH in the Montagu River at Rennison Rd (MR6) in January and March 2000.

2.5.3 Montagu River at Togari (MR8)

An extended 24-day logging event was carried out at this location (March/April 2001), along with a simultaneous deployment at MR1 at the bottom of the catchment. The plots below (Figure 2.40 – 2.43) allow conditions at these two sites to be compared. For those water quality parameters that typically show some diurnal variation (dissolved oxygen, pH and water temperature) the plots clearly show that conditions at site MR8 induce much greater extremes than at MR1 further downstream. In fact, the magnitude of the changes in dissolved oxygen and water temperature are much more similar to that recorded at MR6 (Rennison Rd), where the Montagu River is heavily impacted by nutrient enrichment and resulting aquatic plant growth.

Both MR8 and MR6 are also very exposed sites, where there is almost a complete lack of riparian shading, which might reduce instream plant productivity and therefore reduce the scale of daily changes in water quality. These very large fluctuations are likely to cause significant stress to aquatic biota, and may be one of the factors causing the lower than expected AusRivAs scores at these sites, particularly at MR8 where only 9 taxa were recorded.

The density of shading at MR1 has obviously dampened daily variations in water temperature, and despite the elevated concentrations of nutrients at MR1 (which are quite similar to those recorded at MR6), DO is much more stable. This stability in oxygen levels can be directly attributed to the degree of shading provided at MR1, and there is no doubt that removal of this cover would result in daily cycles similar to those recorded upstream.

The influence of dolomite outcrops in the lower reaches of the river is clearly evident in the trace for pH and conductivity at MR1, which is noticeably different to that for MR8. The pH at MR1 is alkaline (with a pH of about 8) and shows only very small variations at the daily time-scale compared to MR8, where the river is slightly acidic. The additional buffering provided to the lower reaches of the river by the dolomite (as seen in the elevated calcium, magnesium and alkalinity shown in Section 2) has lifted conductivity more than 3-fold that recorded at MR8.

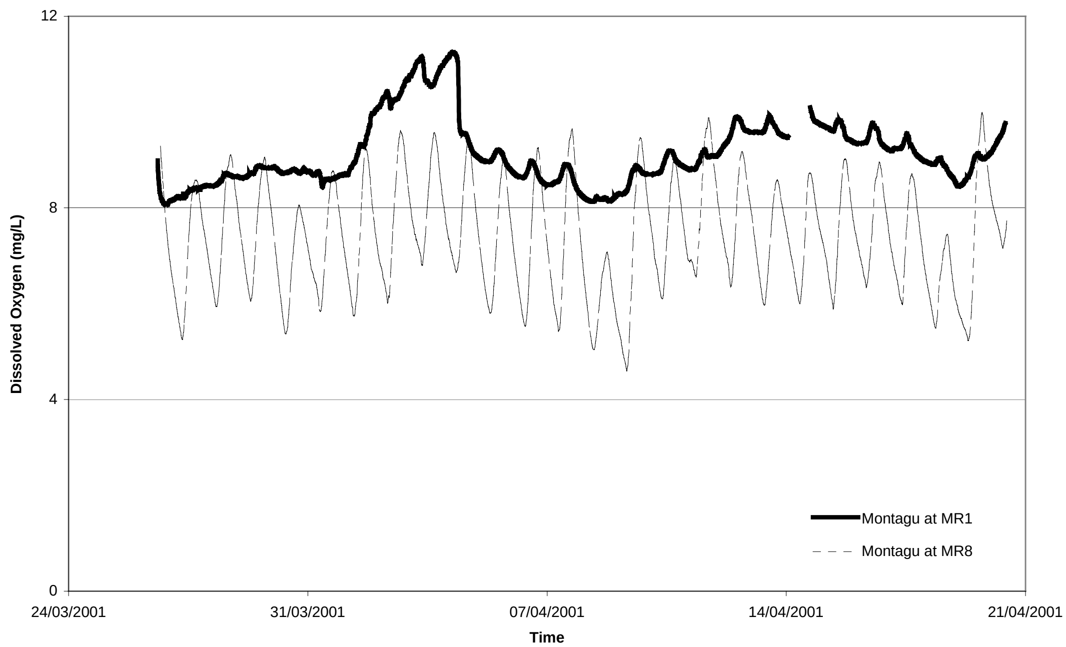

Figure 2.40: Comparison of diurnal variation in dissolved oxygen in the Montagu River at MR1 (Stuarts Rd) and MR8 (Togari) recorded in March 2000.

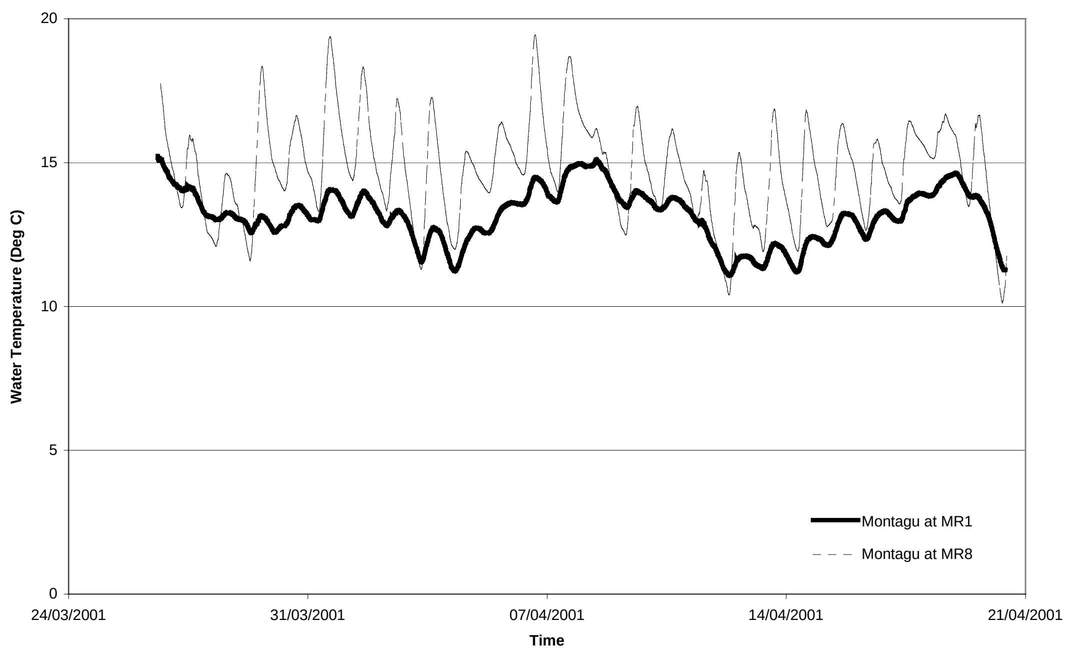

Figure 2.41: Comparison of diurnal variation in water temperature in the Montagu River at MR1 (Stuarts Rd) and MR8 (Togari) recorded in March 2000.

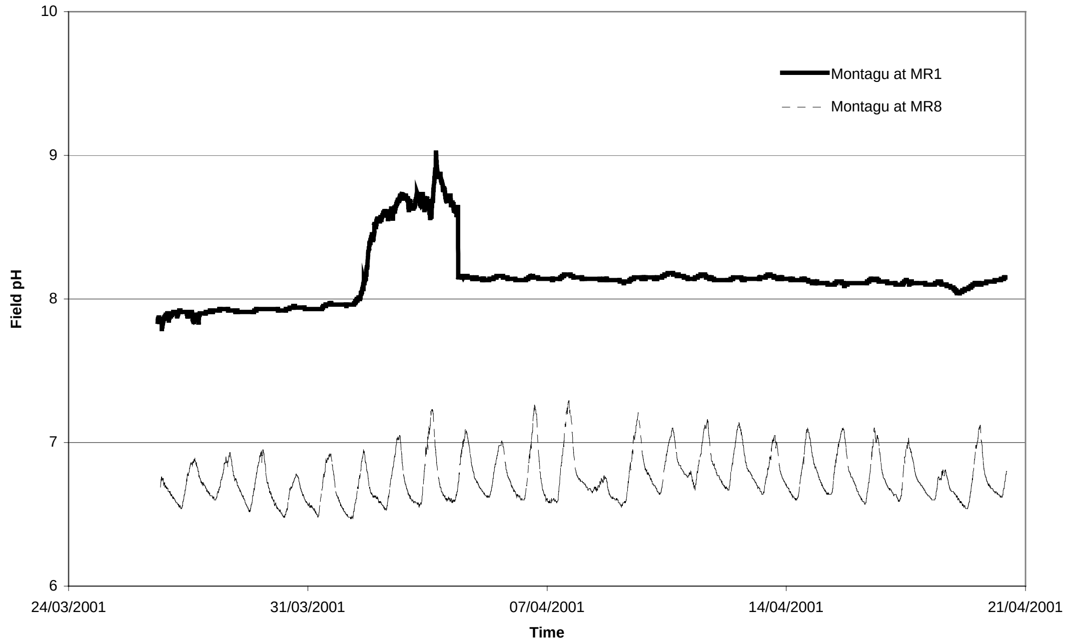

Figure 2.42: Comparison of variation in pH in the Montagu River at MR1 (Stuarts Rd) and MR8 (Togari) recorded in March 2000.

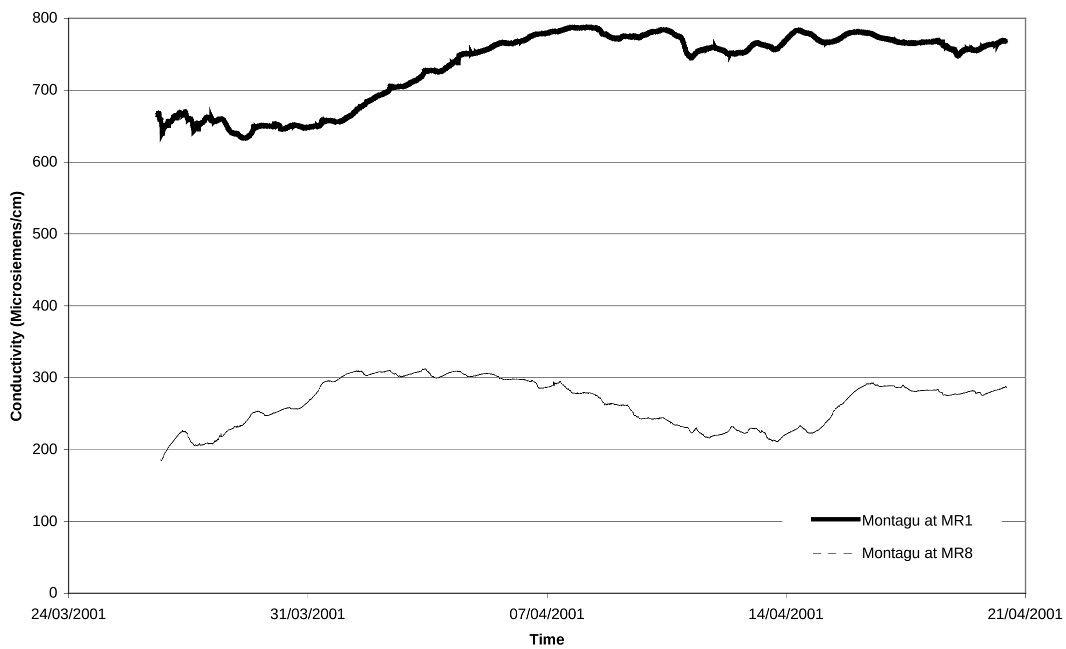

Figure 2.43: Comparison of variation in conductivity in the Montagu River at MR1 (Stuarts Rd) and MR8 (Togari) recorded in March 2000.

3 Nutrient Load Estimates

3.1 Background

Nutrient load estimates for the Montagu River were derived from nutrient and flow data collected at the Stuarts Rd site (MR1), approximately 3km upstream from the river mouth at Robbins Passage. Data for load analysis was collected by two principal methods. A total of 35 monthly nutrient samples were collected from this site between February 1999 and December 2001, and 13 trimonthly general ions samples were also collected and analysed over this period. Automatic flow triggered water sampling equipment was not installed at this site and so a limited number of flood flow nutrient samples were collected manually whenever staff were available to sample events. A permanent river level monitoring station at this site provided a near continuous record of discharge covering the period, the data from which was used in the derivation of load estimates. It must be noted that because of the low gradient of the river and the nature of the site, the rating used to derive river flows (especially at higher flows) is not of good quality, and reduces the accuracy and precision of load estimates. Unfortunately the turbidity record from this site is relatively small as it is composed of values collected during monthly sampling and during manual event sampling, and as such was not suitable for the derivation of load estimates or turbidity/nutrient relationships.

3.2 Monthly sampling

Table 3.1 shows a summary of turbidity and nutrient concentrations collected on a monthly basis from the Montagu River at Stuarts Rd (MR1). Turbidity levels showed moderate variation during monthly sampling over the study period, with values within the expected range for lowland rivers as defined by the ANZECC (2000) guidelines (6-50NTU). While most Tasmanian rivers are classified as upland rivers, the low altitude of the Montagu catchment means that it more appropriate to classify it as a lowland river. Mean, and to a lesser extent, median total phosphorus and dissolved reactive phosphorus levels also exceeded national guidelines for lowland rivers (0.05 mg/L TP and 0.02 mg/L DRP respectively). Mean and median total nitrogen levels exceeded guideline values by over 100%, while mean nitrate and ammonia levels were around 5 times higher than lowland river guideline values.

While comparisons with national guidelines are useful, it is probably more appropriate to compare the nutrient and turbidity statistics from monthly sampling at the Montagu with equivalent Tasmanian rivers. Comparison with data collected during the Mersey River Experimental Study (Bobbi, 1997) indicates that the Montagu River shows relatively high nutrient concentrations in a Tasmanian perspective, with mean nitrate levels in the Montagu exceeding the majority of sites monitored in the Mersey catchment. Mean TN and TP levels exceeded those recorded from all Mersey sites in that study, and were equivalent to the elevated mean TN and TP levels recorded from Coilers Creek (TN 1.33 mg/L) and Redwater Creek (TP 0.235 mg/L) respectively, the latter receiving enriched effluent discharge from the Railton sewage treatment plant. Coilers Creek and Redwater creeks were considered degraded in water quality report for the Mersey River Experimental Study Report (Bobbi, 1997). The elevated nutrient levels detected in monthly sampling of the Montagu River at MR1 reflect the impact of catchment land use practices on base flow water quality in the catchment, primarily intensive dairy agriculture.

Table 3.1: Summary statistics for nutrients and suspended solids collected from the Montagu River at Stuarts Rd (MR1) during **monthly** sampling conducted between February 1999 and December 2001.

	Total suspended solids (mg/L)	Turbidity (NTU)	Total N (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	Total P (mg/L)	DRP (mg/L)
N=	13	35	35	35	35	35	35	35
Mean	10.8	10.71	1.189	0.278	0.012	0.110	0.226	0.109
95% conf. Int.	1.3	2.01	0.255	0.096	0.005	0.098	0.139	0.081
Median	10	9.85	1.170	0.196	0.007	0.038	0.086	0.025
Minimum	10	4.20	0.252	0.008	0.002	0.002	0.010	0.002
Maximum	16	26.50	2.900	1.080	0.067	1.700	2.010	1.100

3.3 Flood sampling

Figure 3.1 shows the near continuous hydrographic record of flows at MR1 recorded between January 1999 and December 2001. Data from several weeks in late February and early March of 1999 are missing from the record, but it is highly likely that flows were low during this period and reflected summer baseflow conditions. Seasonal patterns in discharge are clear, with flows increasing in May/June each year and subsequently falling to low levels in the following December of each year, showing a similar seasonal pattern to that recorded from the Duck River at Scotchtown Rd (Bobbi *et. al*. 2003-in press). The largest flow event occurred in late July and peaked at ~59 cumecs. The time series plot for this event is detailed in Figure 3.2 and includes TN concentrations from samples taken at the beginning and end of the event. Loads associated with this event are discussed later in this section.

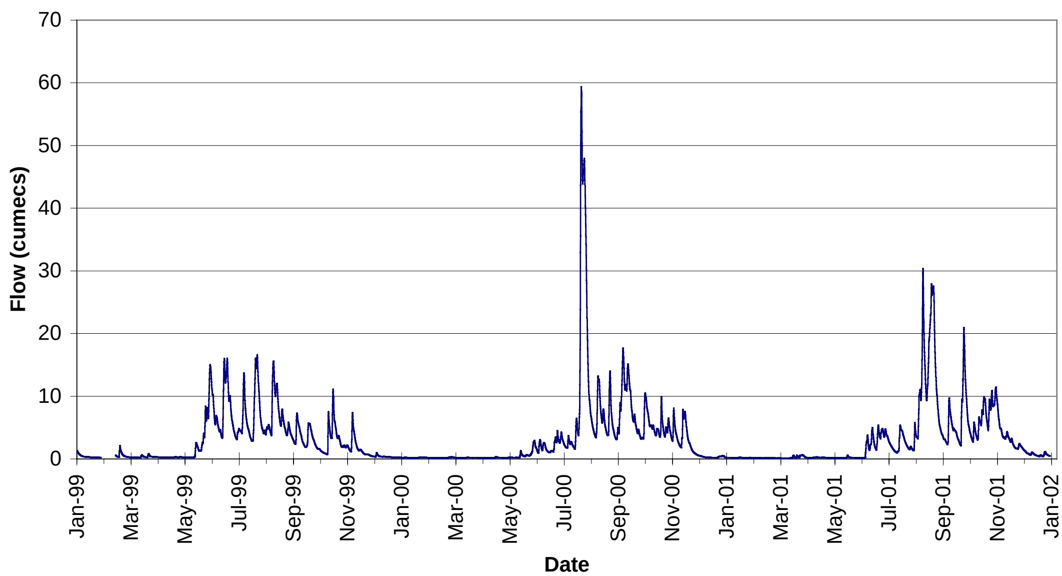

Figure 3.1: Rated flows at the Montagu River at MR1 between January 1999 and December 2001.

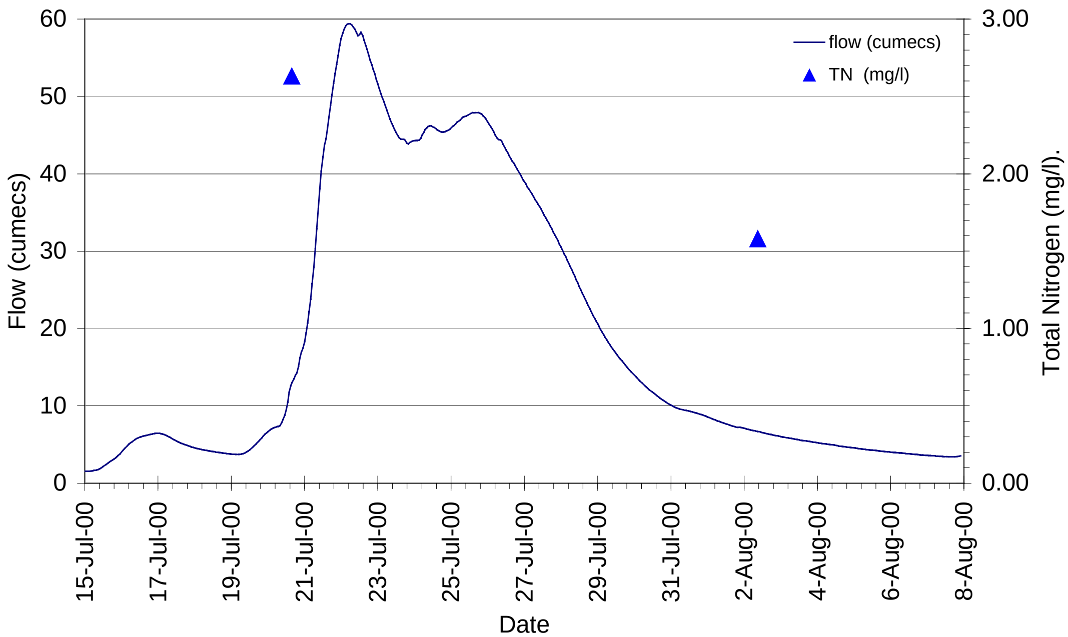

Figure 3.2: A high flow event recorded from the Montagu River at MR1 between 15 July and 8 August 2000.

Twenty-six high flow samples were manually collected at MR1 between March 1999 and August 2001. Total phosphorus and total nitrogen concentrations were analysed from 11 of these samples.

Table 3.2 shows a summary of the nutrient concentrations from samples that were collected during elevated flow events at MR1. Some comparison can be made between the data presented in this table and that collected in the Pipers River in 1998 (Bobbi, 1999d), which lies at a similar altitude and has a similar catchment area (298 km^2) and mean annual discharge (96,700 ML). Comparison of data collected in the Montagu with that from the Pipers River showed that mean and median flood turbidity levels in Pipers River were approximately twice as high as those recorded from the Montagu River. However, mean and median TN levels were approximately 50% and 100% higher respectively in the Montagu River at MR1, and mean and median TP concentrations were around 500% higher. Nitrate-N, ammonia-N and to a lesser extent dissolved reactive phosphorus levels were also more elevated during flood flows in the Montagu River compared to the Pipers River.

Table 3.2: Summary statistics for nutrients and suspended solids collected from the Montagu River (MR1) during flood sampling conducted between March 1999 and August 2001.

	Total suspended solids (mg/L)	Turbidity (NTU)	Total N (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	Total P (mg/L)	DRP (mg/L)
N=	7	24	11	9	9	9	11	9
Mean	34.29	23.41	1.985	0.512	0.023	0.267	0.331	0.167
95% conf. Int.	13.98	7.49	0.420	0.298	0.015	0.184	0.154	0.129
Median	40	16.75	2.090	0.492	0.017	0.214	0.277	0.076
Minimum	10	4.34	0.770	0.005	0.003	0.020	0.079	0.018
Maximum	50	71.7	2.640	1.181	0.067	0.730	0.750	0.445

3.4 Load estimation

As continuous turbidity was not recorded at this site, the calculation of load estimates for the Montagu could not be derived using turbidity/nutrient relationships as was done for the Duck River (Bobbi *et. al*. 2003-in press). This is unfortunate as load estimates based on continuous turbidity records and turbidity/nutrient relationships are an efficient and accurate method for deriving load estimates.

Load estimate calculations for the Montagu River were based on nutrient flow relationships calculated individually for rising and falling flows based on flood and monthly nutrient concentration data. These were then applied to the hydrographic record to produce a derived time series of instantaneous loads. The equations describing the relationship between flows and nutrient concentrations are shown below;

Total nitrogen

Rising flows $y = 0.1214x + 1.189$ ($R^2 = 0.7044$), n = 7

Falling flows $y = 0.196x + 0.4832$ ($R^2 = 0.7097$), n = 21

Total phosphorus

Rising flows $y = 0.0495x + 0.1131$ ($R^2 = 0.9071$), n = 7

Falling flows $y = 0.0777x - 0.0198$ ($R^2 = 0.5234$), n = 21

Reliable total suspended solid/flows relationships could not be developed from the data.

Derivation of these equations relies heavily on adequate samples covering a range of flows. It should be noted that while the correlation coefficients are reasonable, the relationships are based on a relatively low number samples and loads derive from them should only be considered as generally indicative of the Montagu catchment. As mentioned above, load estimates also rely on accuracy of the flow record, which is ‘rated’ from river level monitoring. The characteristics of this site make the conversion of river ‘level’ to ‘flow’ difficult, and this is especially important at higher flows when the major loads are normally transported. The load estimates presented in the following discussion must therefore be treated as only generally indicative for this catchment, and may be in error by as much as +/- 20%.

To derive monthly load estimates from these relationships, the flow record was divided into rising and falling flow components and the above equations were applied to each subset of the flow record. Table 3.3 shows monthly load estimates and mean monthly total phosphorus and nitrogen concentrations from January 1999 to December 2001. Variations in both TN and TP loads followed seasonal patterns that reflected changes in discharge for the catchment. Peak loads were associated with events, with highest loads typically occurring in July and August of each year. Inspection of the table shows that the highest monthly nutrient load occurred in July 2000, when 259 079 kg of nitrogen and 93 364 kg of phosphorus were transported past MR1 over the month. In comparison, peak phosphorus and nitrogen load of 29 043 kg and 2 645 kg were calculated for the Pipers River catchment (Bobbi *et. al*., 1999) in September 1998.

Table 3.3: Estimated monthly nutrient loads at the Montagu River @ Stuarts Rd between January 1999 and December 2001.

Date	Monthly discharge (ML)	Mean monthly TN (mg/L)	Total monthly TN (kg)	Mean monthly TP (mg/L)	Total monthly TP (kg)
Jan-99	1,053	0.634	673	0.025	32
Feb-99	1,228	0.619	854	0.026	58
Mar-99	876	0.684	620	0.031	32
Apr-99	652	0.708	463	0.033	22
May-99	7,714	1.258	16,079	0.224	4,219
Jun-99	20,097	2.008	46,769	0.549	13,471
Jul-99	18,795	1.895	42,699	0.500	12,140
Aug-99	17,725	1.827	36,991	0.471	10,102
Sep-99	8,881	1.247	12,121	0.253	2,648
Oct-99	8,272	1.190	12,504	0.227	2,874
Nov-99	4,374	0.897	5,026	0.122	950
Dec-99	914	0.744	683	0.042	41
Jan-00	522	0.821	427	0.053	27
Feb-00	476	0.872	412	0.062	29
Mar-00	484	0.790	380	0.048	23
Apr-00	469	0.655	309	0.024	12
May-00	1,825	0.868	1,887	0.077	240
Jun-00	5,466	1.092	6,430	0.169	1,088
Jul-00	38,249	3.122	259,079	0.988	93,364
Aug-00	17,110	1.776	34,412	0.459	9,392
Sep-00	20,784	2.084	50,618	0.567	14,663
Oct-00	14,752	1.641	25,774	0.401	6,525
Nov-00	8,496	1.183	12,470	0.234	2,848
Dec-00	833	0.730	614	0.039	35
Jan-01	480	0.760	366	0.043	21
Feb-01	330	0.744	245	0.040	13
Mar-01	688	0.791	550	0.051	38
Apr-01	530	0.722	388	0.036	20
May-01	511	0.706	363	0.033	18
Jun-01	6,802	1.216	9,474	0.209	1,881
Jul-01	6,365	1.029	7,155	0.175	1,369
Aug-01	35,710	2.924	131,897	0.896	42,753
Sep-01	15,930	1.707	35,507	0.438	10,148
Oct-01	17,130	1.788	33,283	0.450	8,627
Nov-01	9,710	1.321	15,231	0.280	3,698
Dec-01	2,102	0.767	1,632	0.064	149
Jan-02	1,053	0.634	673	0.025	32
Totals	**296,335**		**804,385**		**243,568**

3.5 Export coefficients

The assessment of peak loads made in the above paragraph allow general comparisons between events in different catchments if discharge and catchment areas are similar, however the conclusions that can be drawn from such comparisons are limited. The derivation of export coefficients, however, allows a valid comparison of nutrient loss between catchments with different area and discharge characteristic, by standardising estimates to take these variables into account. Typically, data used in the derivation of export coefficients is collected over an extended period to take into account seasonal variation in discharge. The equations used to determine export coefficients are included in the glossary at the beginning of this report.

Table 3.4 shows export coefficients that were calculated for each year of the 3-year data set collected for the Montagu River. These results show that highest nutrient loads occurred in 2000, and were approximately double those recorded in the first year of the study, and export coefficients for 2001 fell midway between those recorded for 1999 and 2001.

Table 3.4: Annual export coefficients for the Montagu River at Stuarts Rd from 1999 to 2001.

Year	Catchment area (km^2)	Discharge (ML)	Total P ($kg/mm/km^2$)	Total N ($kg/mm/km^2$)
1999	323	90581	0.514	1.94
2000	323	109467	1.172	3.59
2001	323	96287	0.714	2.45

Table 3.5 shows a list of export coefficients estimated for 11 Tasmanian rivers examined during 'State of River' studies conducted over the last decade. Comparison of the export coefficients for these rivers confirms that the Montagu River has excessively high nitrogen and phosphorus export, and exceeds all other rivers listed in the table. The Duck River catchment, which is located adjacent to the Montagu, also has very high nitrogen and phosphorus export coefficients. Both of these catchments support intensive agriculture, particularly dairy production, and this is reflected in the export coefficients for these catchments. The ratio of nitrogen to phosphorus in these catchments is around 3:1, and is indicative of the high phosphorus inputs into these catchments. The remaining sites listed in Table 3.5 have N:P ratios ranging from 12:1 (Meander) up to 33:1 (Huon River above Judbury) reflecting total phosphorus coefficients an order of magnitude lower than those calculated for the Montagu River.

Table 3.5: Export coefficients for a variety of Tasmanian rivers. Results for rivers where data has been collected over several years have been averaged.

Catchment	Years of data	Catchment area (km^2)	Mean annual dishcharge (ML)	Total P ($kg/mm/km^2$)	Total N ($kg/mm/km^2$)
Montagu River @ Stuarts Rd	3	323	98,778	0.800	2.66
Inglis @ railway bridge	3	175	116,030	0.081	1.16
Duck River @ Scotchtown	3	339	141,172*	0.532	1.71
Pipers River	1	298	96,700	0.083	1.17
Brid River	1	136	40,986	0.066	1.13
Meander River @ Strath Bridge	3	1,012	427,904	0.058	0.67
Liffey River	3	224	80,661	0.052	0.78
South Esk @ Perth	3	3,280	624,508	0.034	0.66
Break O'Day River	3	240	53,177	0.065	0.94
Huon River above Judbury	1	2,097	2,562,475	0.010	0.33
Kermandie River	1	130	36,760*	0.122	1.42

* Modelled flow data. Historical data was obtained from previous 'State of River' reports – see Section 6 (References).

3.6 Summary

In summary, the Montagu catchment shows high levels of nutrient enrichment, particularly total phosphorus levels. Excessive enrichment is evident in both high flow and in routine monthly sampling. Not only do phosphorus and nitrogen concentrations exceed ANZECC (2000) guidelines for lowland rivers, they are particularly high in comparison to other Tasmanian rivers, and showed nutrient enrichment similar to intensively utilised dairy farming catchments in New Zealand (Wilcock, *et. al*., 1999). The very high phosphorus export coefficients for the Montagu catchment are therefore not unexpected given that intensive dairy agriculture is the primary land use in the catchment, and these high nutrient losses will remain elevated until land management practices are improved.

4 Special Investigations

During the course of the study, some assistance was provided to another study being conducted by DPIWE examining nutrient runoff from ‘hump & hollow’ dairy pasture in Togari. The results of this brief study have been published (Cotching, 2000), but will be summarised here, as they give some indication of the level of nutrients leaving this intensively farmed area.

The main aim of this small study was to ascertain the level of nutrients in runoff from dairy pastures on hump and hollow drained land. Pasture production in low-lying, drained swampland in the Montagu catchment is constrained by high groundwater levels during the winter/spring period. In the worst affected areas, where ponding of surface water is a big issue, an artificial drainage system called ‘hump and hollow’ is used. This involves forming ridges and swales in a parallel fashion across pasture which results in larger proportion of pasture lying above-water during wet periods. The swales of this system store excess water following heavy rains and then discharge this water to larger open ditches which carry this water to the river system (in this case the Montagu River).

To examine the nutrient concentrations in the water leaving these hump and hollow areas, an automated sampler was set up to collect samples from runoff following heavy rainfall events between March and September 1999. Over this period, the pasture was used under the normal grazing rotation by dairy cattle and fertiliser was applied as part of normal pasture management practices in January, May and July.

The results of this sampling are shown in Table 4.1. These data show that as would be expected, nutrient concentration in drainage water from this pasture is very high compared to those measured in the tributaries and the main river of the Montagu catchment.

Table 4.1: Nutrient concentrations in runoff from hump and hollow pasture in Togari.

Sample Date	Ammonia-N (mg/L)	Nitrate-N (mg/L)	Total N (mg/L)	DRP (mg/L)	Total P (mg/L)	DRP:TP %
31 Jan 99	2.74	0.075	6.6	0.94	7.9	12
7 May 99	1.47	0.261	1.8	1.82	6.6	28
12 May 99	4.57	0.274	6.1	0.84	1.9	44
14 May 99	1.55	0.035	5.5	1.07	2.1	51
26 July 99	0.76	0.084	4.2	1.89	2.3	82
15 Sept 99	26.1	0.008	47.0	2.37	5.6	42

* Dissolved Reactive Phosphorus

While the volume of water could not be measured (precluding the calculation of export loads), this drainage technique is aimed at maximising runoff. During this study it was estimated that approximately 50% of the rainfall occurring during the period May to September would have departed the pasture as runoff. Using the lowest concentration of TP measured (1.9 mg/L), a conservative estimate of 6.7 kg P/ha being lost in runoff from the hump and hollow system was made (Cotching, 2000). If the average of the concentrations is used, this estimate becomes 15.5 kg P/ha. For nitrogen, the corresponding figures are 6.3 kg N/ha and 11.8 kg N/ha. These loads are very high compared to overall catchment export loads (see Section 4), and indicate that areas where hump and hollow drainage has been developed are probably the largest contributor to nutrient loads being exported from the Montagu catchment. Cotching estimates that for the average 120 ha dairy farm in Togari, this amounts to an annual load of between 798 – 1,860 kg P per annum being generated, depending on whether the lowest or the average concentration of TP is used.

If we assume that there are about 30 farms in the catchment using hump and hollow drainage (Water Management Officer, DPIWE, pers comm.), then the total load being delivered to the Montagu River from hump and hollow in the Togari district could be as high as 55,000 kg P per annum. If the annual average load for P leaving the Montagu catchment (from Section 4) is 81,000 kg P, then this converts to about 70% of the total catchment load originating from the Togari district alone.

Measures to minimise this have been proposed by Cotching (2000) and are focused on improved timing of fertiliser application to avoid heavy rainfall periods, and better knowledge of soil nutrient levels so that excessive or needless fertiliser application can be avoided.

5 Discussion and Summary

The data collected during the three years of study of the water quality of rivers in the Montagu catchment has overwhelmingly illustrated the negative impact intensive dairy farming has had on the condition of water quality throughout the middle and lower catchment. These impacts range from elevated water temperatures and wildly fluctuating dissolved oxygen levels at sites where riparian vegetation has been completely removed, to chronically enriched waterways that deliver massive loads of nitrogen and phosphorus to the main river. The delivery of these nutrients is further increased by the development of extensive drainage systems in the middle of the catchment that have enabled efficient and very productive dairy farming to take place. While this study has shown that water quality throughout the middle and lower reaches of the river system is very degraded, there is also some evidence (from previous studies) that the groundwater resource is also subject to similar contamination from dairying and the application of fertilisers that allow such high production.

In the face of this information it must also be recognised that the river system has been vastly modified from that which would have existed prior to agricultural development. A large portion of the Montagu catchment was previously Blackwood swamp, and the Montagu River and many of its tributaries are likely to have been quite different in both physical characteristics and in water quality. The main river is now managed to control flooding and is essentially a canal for much of its length. This has allowed prime dairy land to be developed and has resulted in the Montagu becoming one of the most productive milk producing areas in Tasmania.

The challenge for those seeking to manage the water resource and the river into the future is therefore to determine what level of impact is acceptable and achievable given the high value agricultural production that takes place in the catchment and the importance that flood control in enabling this to take place. While there are a number of techniques that can be used to improve water quality, such as the establishment of riparian vegetation and wetlands, the land treatment of dairy shed wastes and the more effective use and application of fertilisers, the management of flood waters (through drainage management) is likely to be the over-riding process that governs the movement of contaminants in the system. Given the very low gradient of the catchment, the extensive use of drains cannot be avoided if dairy production is to continue, however this creates the most effective mechanism for delivering pollutants (nutrients and faecal bacteria) directly to rivers. Future management should therefore focus on developing and implementing techniques that will improve the on-farm retention of nutrients and bacteria while allowing drains to continue to function as flood-water removal mechanisms. Without this focus on drains and their capacity to deliver contaminants to waterways, other strategies to improve water quality in the Montagu River are not likely to reach their full potential. This will require additional studies; to identify how nutrients and faecal bacteria are lost from the land, to more accurately determine the major processes influencing nutrient loss from pasture and how these are transported in the drainage system; and pilot projects to test potential techniques for retaining or processing these on the land with little risk to groundwater. It must be stressed that there is very little knowledge on how groundwater is currently being impacted by land use in this catchment, but the little information that is available indicates that the groundwater resources in the area may be as degraded as the surface waters.

6 References

ANZECC (1992) *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australian and New Zealand Environment and Conservation Council, Canberra., Canberra.

ANZECC (2000) *Australian Water Quality Guidelines for Fresh and Marine Waters.* Australian and New Zealand Environment and Conservation Council, Canberra., Canberra.

Bobbi, C., Fuller, D. & Oldmeadow, D. (1996) *South Esk Basin 'State of River Report'. Technical Report of Data Collected between 1992 and 1995.* No. WRA 96/02. Department of Primary Industry and Fisheries, Hobart, Tasmania.

Bobbi, C. (1997) *Water Quality of Rivers in the Mersey Catchment.* No. WRA 97/02. Department of Primary Industry and Fisheries, Hobart, Tasmania.

Bobbi, C.J. (1998) *Water quality of rivers in the Huon catchment.* No. WRA 98/01. Department of Primary Industry and Fisheries, Hobart, Tasmania.

Bobbi, C.J. (1999a) *Water quality of rivers in the Ringarooma catchment.* No. WRA 99/01. Department of Primary Industries, Water and Environment, Hobart, Tasmania.

Bobbi, C.J. (1999b) *Water quality of rivers in the Great Forester catchment.* No. WRA 99/05. Department of Primary Industries, Water and Environment, Hobart, Tasmania.

Bobbi, C.J. (1999c) *Water quality of the Brid River.* No. WRA 99/09. Department of Primary Industries, Water and Environment, Hobart, Tasmania.

Bobbi, C.J. (1999d) *Water quality of Pipers River.* No. WRA 99/19. Department of Primary Industries, Water and Environment, Hobart, Tasmania.

Bobbi, C.J., Andrews, D. and Bantich, M. (2003 – in press) *Water Quality of Rivers in the Duck River catchment.* **WRA 03/07** Department of Primary Industries, Water and Environment, Hobart, Tasmania.

Cotching, B. (2000) Nutrient rinoff from a dairy pasture on a hump and hollow drainage system at Togari, north west Tasmania. *Natural Resource Management*, **3:2** pp18-24

Grayson, R.B., Gipple, C.J., Finlayson, B.L. & Hart, B.T. (1997) Catchment-wide impacts on water quality: The use of 'snapshot' sampling during stable flow. *Journal of Hydrology,* **199,** 121 - 134.

Gurung, S. (2001) Tasmanian Acid Drainage Reconnaissance – Report 2: Distribution of acid sulphate soils in Tasmania. Tasmanian Geological Survey Record 2001/06.

NHMRC, A. (1996) *Australian Drinking Water Guidelines.* No. No. 6. National Health and Medical Research Council and the Agricultural and Resources Management Council of Australia and New Zealand, Canberra, ACT.

UNESCO (1992) *Water Quality Assessments: A Guide To The Use of Biota, Sediments and Water in Environmental Monitoring*. 1st ed. Chapman and Hall, London,

Wilcock, R.J., Nagels, J.W., Rodda, H.J.E., O'Connor, M.B., Thorrold, B.S. and Barnett, J.W. (1999) Water quality of a lowland stream in a New Zealand dairy farming catchment. *New Zealand Journal of Marine and Freshwater Research,* **33,** pp683 - 696.