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WATER *and* ENVIRONMENT

Tasmania

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Water Quality In The Montagu River Catchment

Part 2

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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 Current Study

The following water quality data was collected between January 1999 and December 2001. The main aim of sampling in the Montagu River catchment was to collect current data on the ambient quality of water and report on background conditions in the river system. These data, when viewed along with land use and river condition information, should assist in identifying sites or areas that could be targeted for remediation activities or a different management approach in the future. The data will also assist in the future development of *water quality objectives* (WQO's) that may be developed for the catchment under the '*State Policy for Water Quality Management*' (1997).

The collection of data was carried out at several levels. Monthly visits were undertaken at sixteen sites to determine the physico-chemical nature of water quality. The location and grid references of these sites is listed in the Table 2.1, and shown geographically on the map in Figure 2.1. Due to the costs associated with laboratory analysis, sampling for nutrients was carried out on a monthly basis at a subset containing six of these sites. Sampling for dissolved salts and general ionic composition was also performed at these six sites on a quarterly basis.

Table 2.1: Location of sites where monthly water quality monitoring was carried out during the present study. Sites in bold were sampled monthly and tri-monthly for Nutrients and General Ions respectively.

Site Name	Code	Easting	Northing
Montagu at Stuarts Road	MR1	325375	5482900
Un-named tributary at Barcoo Road	MR2	327000	5477275
Montagu off Barcoo Rd at Thorpes Plains	MR3	324300	5475500
Farnhams Creek at Barcoo Road	MR4	324800	5474700
Canal, off Barcoo Rd at 14 Mile Plain	MR5	322850	5470800
Montagu at Rennison Road at Togari	MR6	321100	5468200
Galeford Ck. 700 m d/s of dam	MR7	318800	5463800
Montagu at Bass Highway at Togari	MR8	321700	5463400
Fixters Ck at Bass H'way at Brittons swamp	MR9	328800	5467500
Fixters Creek at Riseborough Road	MR10	326850	5469300
Farnhams Ck at Bass H'way at Brittons swamp	MR11	329800	5469950
Montagu off Eldridges Rd at Montagu Swamp	MR12	323300	5461200
Montagu at Christmas Hills Road u/s of bridge	MR13	327700	5455300
Montagu at Christmas Hills Road d/s of bridge	MR14	327700	5455300
Montagu at Donalds Road	MR15	331000	5453300
Montagu at Roger River Rd	MR16	332150	5451400

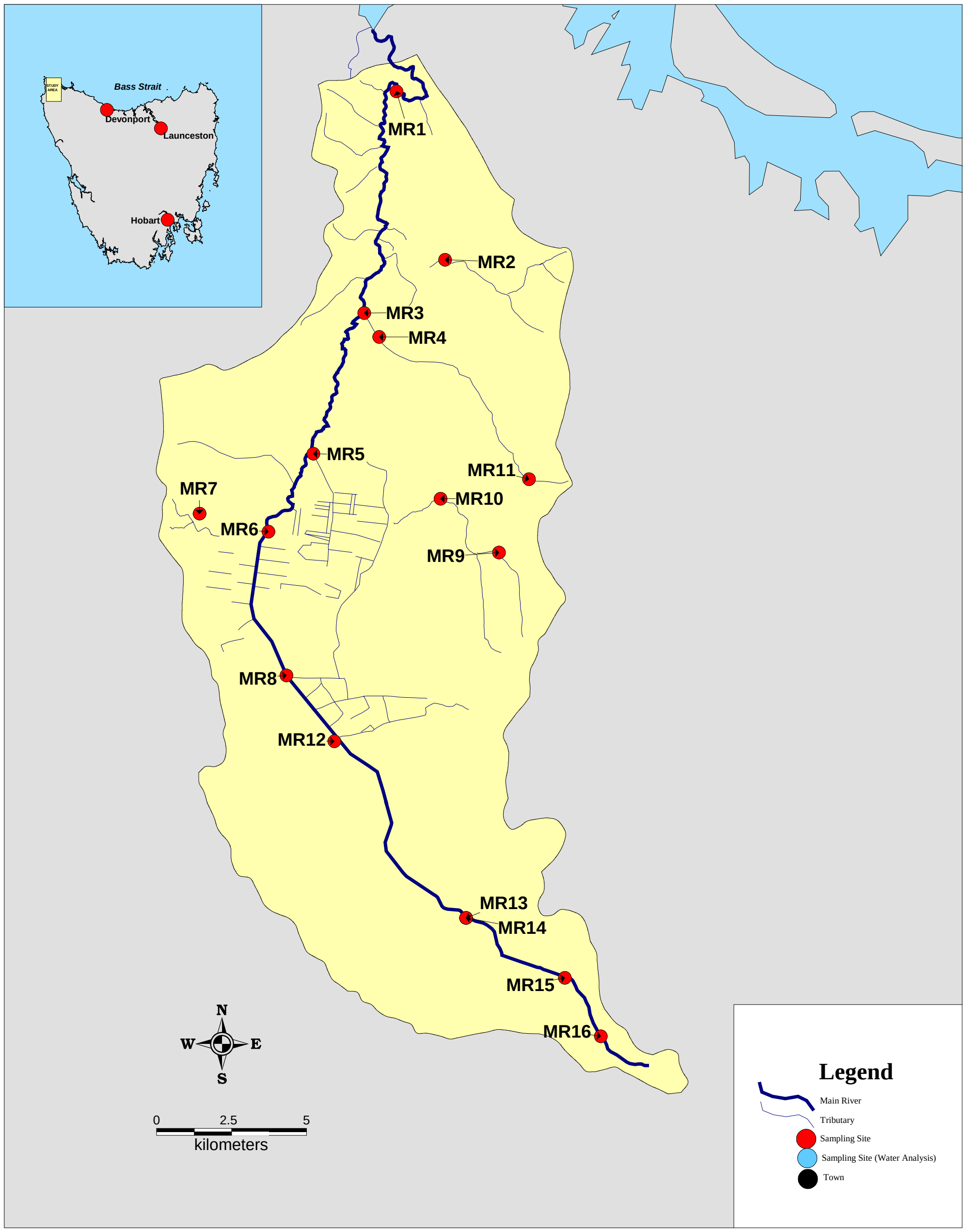

Figure 2.1: Location of the 16 sites monitored in the Montagu River catchment during the 'State of Rivers' investigations (1999-2001).

The second level of sampling involved two catchment-wide 'snapshot' surveys, during which all sites in the main river and its tributaries were more comprehensively sampled. As well as sampling for the normal suite of physico-chemical parameters, sampling also encompassed nutrients, bacteria (Presumptive Faecal Coliform counts) and seven key heavy metals. These snapshots were carried out once each in summer and winter and were undertaken during 'stable' hydrological conditions, to avoid potential discrepancies that may have been caused by the patchy or uneven distribution of rainfall. The aim of this technique is to allow comparisons to be made at the catchment level so as to highlight sites or reaches of relative water quality degradation. This technique has been utilised in previous 'State of Rivers' projects (Bobbi, *et al.*, 1996; Bobbi, 1997; Bobbi, 1998; Bobbi, 1999) and has been adapted from earlier work elsewhere in Australia (Grayson, *et al*., 1993).

The third level of monitoring consisted of monthly sampling of faecal bacteria at three selected sites between January 2000 and June 2001.

The fourth tier of monitoring involved the use of in-stream logging equipment to examine short-term variations in water quality, principally dissolved oxygen and pH, which are known to undergo diurnal fluctuations. Spot samples were also collected during the course of the study for a number of purposes, but were generally taken to assist with the estimation of nutrient export loads for the catchment, and to provide additional data for determining particular site-related impacts.

The physico-chemical parameters tested in the field included pH (compensated for temperature), electrical conductivity (corrected to reference temperature 25^oC), water temperature, turbidity (as nephelometric turbidity units standardised against Formazin) and dissolved oxygen. Bottled water samples were taken and analysed in a NATA registered laboratory for the following nutrients; ammonia nitrogen (NH_3/N), nitrate nitrogen (NO_3/N), nitrite nitrogen (NO_2/N), Total nitrogen (TN), dissolved reactive phosphorus (DRP) and total phosphorus (TP). General ions analysis, tested quarterly, included the following variables;

Laboratory pH	
Laboratory Conductivity (@ 25^oC)	μS/cm
Colour (Apparent)	Hazen Units
Total Dissolved Solids	mg/L
Total Suspended Solids	mg/L
Hardness (calc. as $CaCO_3$)	mg/L
Total Alkalinity (to pH 4.5 as $CaCO_3$)	mg/L
Chloride (Cl)	mg/L
Fluoride (F)	mg/L
Sulphate (SO_4)	mg/L
Iron (Fe)	mg/L
Manganese (Mn) - Total	mg/L
Calcium (Ca)	mg/L
Magnesium (Mg)	mg/L
Potassium (K)	mg/L
Sodium (Na)	mg/L
Silica (SiO_2) (Molybdate Reactive)	mg/L

2.1 Monthly Monitoring

Monthly sampling of the Montagu River was carried out at the 16 sites listed in Table 2.1, although not all sites were monitored each month. Site MR3 (Montagu off Barcoo Rd at Thorpes Plains) was sampled only six times, while site MR2 (Unnamed tributary at Barcoo Rd) was sampled 28 times. The remaining sites were sampled 34-35 times during the period of this study.

2.1.1 Site Locations

The location of each of the monitoring sites will affect the parameter values measured. Those at the upstream end of the catchment will receive high quality water from the relatively undisturbed headwaters. As the river progresses through the catchment it will collect nutrients and other effluents. The sites in the downstream end of the catchment will be demonstrating the combined effects of all the contaminants from the main channel and upstream tributaries. Figure 2.1 indicates that the monitoring sites can be broken down into a number of groups, related to their position in the catchment and the adjacent land uses.

Sites MR16 & MR15 are the furthest upstream and could be expected to have good water quality. They may be usable as reference sites for those downstream locations being affected by various land-use practices.

Sites MR14 & MR13 are further downstream and could be expected to show some impacts from adjacent land-use practices (forestry).

Sites MR12, MR8 & MR6 are located in the middle reaches of the Montagu River, where the river begins to receive water from the drained agricultural area around Togari. MR6 is located in the middle of the Togari drainage district.

Site MR7 is located on the small tributary stream of Galeford Creek on which there is water supply storage that provides water to farms of the Togari district.

Sites MR9 & MR10 are located on Fixters Creek and receive water from the surrounding drainage district of Brittons Swamp. Discharge from Fixters Creek enters the Montagu through a heavily channelised and intensive dairying district. Site MR5 is located on one of these canals, near its confluence with the Montagu, and receives the majority of its flow from Fixters Creek.

Sites MR11 & MR4 are on Farnham’s Creek and receive water from the surrounding agricultural and grazing area. Discharge from Farnham’s Creek enters the Montagu near site MR3.

Site MR2 is located on an unnamed tributary flowing from a more forested part of the catchment, and its discharge flows into the Montagu between sites MR 3 and MR1.

Sites MR3 & MR1 are located at the downstream end of the Montagu River and receive all of the discharge from the upstream sites. While there are patches of grazing land along this lower reach of the river, this part of the catchment generally contains more forest and native bush-land.

2.1.2 Discharge

The values of the water quality parameters monitored during this study all depend, to a greater or lesser extent, on stream flow. Discharge in the Montagu River varies seasonally, with conspicuous periods of little discharge (usually <0.5 cumecs) in the summer and autumn months. During the period of the study, discharge increased markedly during the winter and spring, with a number of flood peaks (>20 cumecs) recorded. Figure 2.2 shows the discharge pattern for the Montagu (as recorded at MR1) between January 1999 and December 2001.

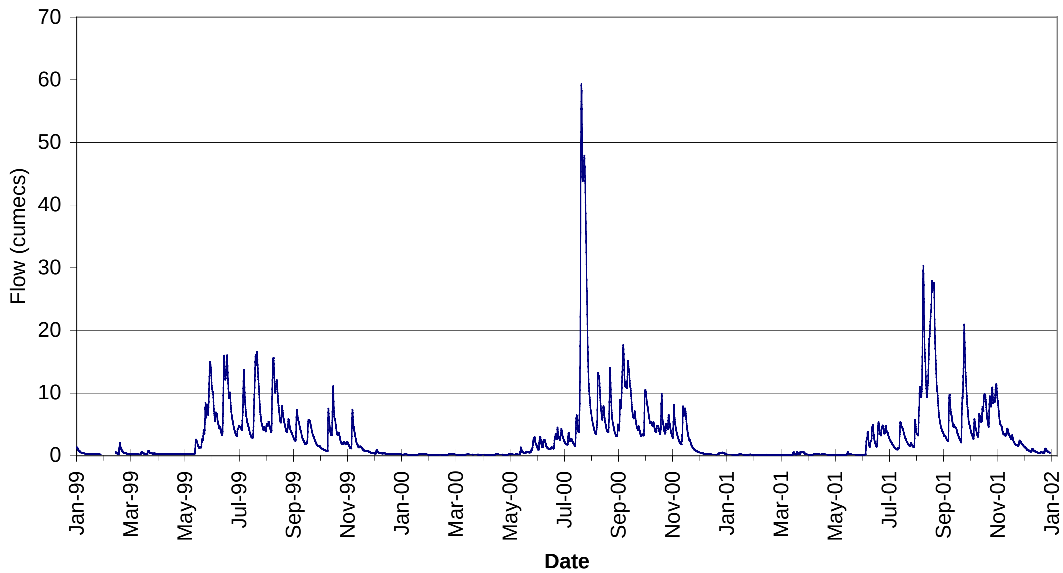

Figure 2.2: Discharge pattern for the Montagu River at Stuarts Rd (MR1) from January 1999 to December 2001, clearly illustrating the seasonal pattern of flow in the river.

The strong seasonality of discharge in this river means that many of the water quality and nutrient parameters will also exhibit marked seasonal changes. Nutrients and other contaminants tend to build up during the dry season. They are usually flushed downstream during the initial part of the wet season or during flood flows, and then remain at lower levels until the discharge tapers off into the dry season.

2.1.3 Electrical conductivity

Electrical conductivity is an indicator of the cumulative contributions of the natural and artificial processes to which the stream is subject as it progresses to the sea. As a measure of the ions dissolved in the water, it indicates the influences of natural catchment processes, such as geology and soils, and artificial processes, such as effluent and chemical runoff.

Under natural conditions, the conductivity of Tasmanian rivers is very low in the headwaters and gradually increases as the river progresses downstream. In lowland areas, where the stream meanders with a relatively low gradient, conductivity tends to increase to its maximum.

The pattern of conductivity in the Montagu River (Figure 2.3) shows evidence of this underlying cumulative process. Values are lowest at the upstream sites on the Montagu River (MR16 & 15) and at site MR11, which is in the upper reaches of Farnham’s Creek.

Figure 2.3 shows that there is a trend for increase in both median and extreme values with distance down the main river channel (sites MR16, 15, 14, 13, 12, 8, 6, 3 & 1), although these tend to reach a peak at site MR6 (Montagu at Rennison Rd). Site MR3 (Montagu off Barcoo Rd) shows little variation in values, but this is due to the small number of samples collected at this site (n = 6). The large increase in median conductivity from MR8 (Montagu at Togari) to MR6 (Montagu at Rennison Rd) is likely to be due to the combined influence of dolomite outcropping in the river channel and increased discharge to the river of contaminants from the Togari drainage district. However, this does not explain the elevated conductivity readings at the tributary sites.

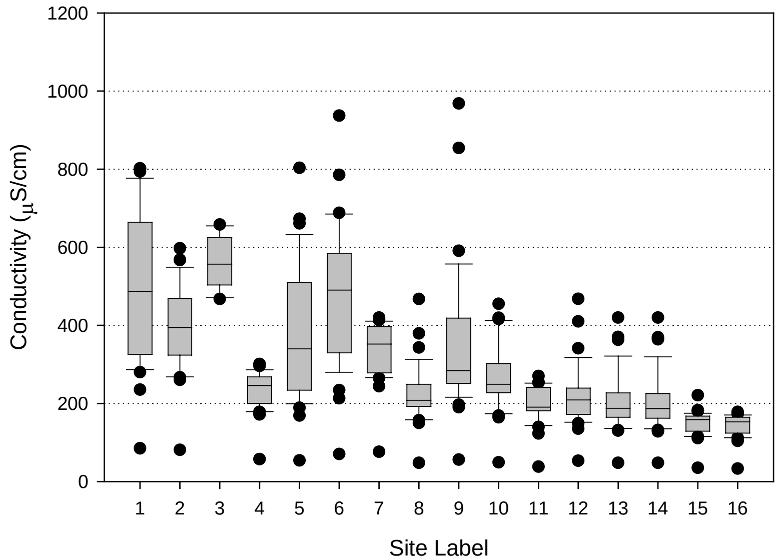

Figure 2.3: Statistical plot of conductivity at sites in the Montagu River catchment recorded during monthly monitoring between February 1999 and December 2001.

The higher conductivity recorded at sites MR9 (Fixters Creek at Brittons Swamp) & MR5 (Canal off Barcoo Rd), and to a lesser extent at sites MR6 (Montagu at Rennison Rd) & MR1 (Montagu at Stuarts Rd), suggest that these sites may be affected by dolomite outcrops or effluent discharge to the river upstream of these sites. The median electrical conductivity values for these sites are elevated and the extreme values are much higher than at other sites.

Figure 2.4 shows the seasonal pattern of change of electrical conductivity using all the data from monitoring sites in the Montagu catchment.

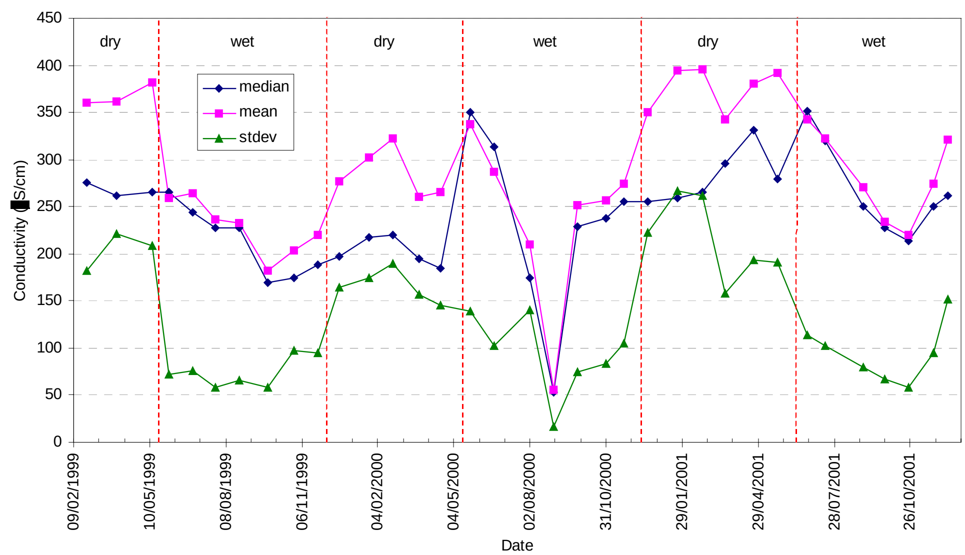

Figure 2.4. Median, mean and standard deviation values of conductivity data from all 16 sites in the Montagu catchment for the period February 1999 to December 2001.

In general, the highest values tend to occur during the summer season, and the lowest during the winter. This is also true of the standard deviation values (a measure of the variation in the measurements), which indicates that conductivity not only decreases, but becomes more similar across all sites during the higher flows of winter. At the end of each spring, as stream flow begins to decline, the mean values for conductivity start to diverge from the medians, indicating that some extreme values have been recorded. This divergence tends to disappear once again upon arrival of the autumn rains.

Analysis of the seasonal pattern indicates that, during the summer, conductivity is highest at sites lower on the main river (sites MR6, MR3 & MR1), primarily because of a lack of inflow from tributary streams, although discharge from Fixter’s Creek can have a major influence on conductivity at MR6 (Montagu at Rennison Rd). Early in the winter, increased flow in the main river causes dilution and reduces the influence of dolomite outcrops on conductivity, while conductivity tends to be higher in tributary streams such as MR2 (Un-named creek at Barcoo Rd) and MR7 (Galeford Creek). By the middle of winter tributary streams tend to be the main cause for elevated conductivity at located lower in the Montagu River.

Two points of interest emerge from the above analysis. Firstly, sites MR15 & 16, those furthest upstream in the main river channel, may be used as reference sites for electrical conductivity values. Secondly, should conductivity trigger values be required, a local value of 600 μS/cm would be a good starting point for the most heavily impacted sites (eg. MR9 – Fixters Creek, MR5 – Canal off Barcoo Rd, MR3 – Montagu off Barcoo Rd and MR1 – Montagu at Stuarts Rd), as it corresponds approximately with the 80th percentile values at most of these sites. More information is required on the effects of local geology (eg. dolomite outcropping) to better determine the extent of anthropogenic causes of increased conductivity in the catchment.

2.1.4 In-stream pH

The pH of river waters varies, depending on such factors as geology, location in catchment, levels of instream plant production, surrounding land use and artificial inputs. The national water quality guidelines (ANZECC, 2000) indicate that a pH range of 6.5 – 8 is appropriate for lowland streams such as the Montagu. For the 16 sites sampled all except site MR2 (unnamed creek) have mean and median values within this range (Figure 2.5).

Site MR2 (Un-named Creek of Barcoo Rd) has a median value of 5.2, and its pH values were the lowest of all sites on most sampling occasions. The very low pH at this site may be linked to the fact that the creek flows through reasonably intact native forest, which retains some swamp-like characteristics. The depositional nature of the creek at this site and the periodic low oxygen levels that also occur at this site may lead to low pH values in the water, though this should be further investigated. Another potential influence may be the presence of acid sulphate soils, which a recent study has shown are found in the northwest region (Gurung, 2001). If acid sulphate soils are present, any future plans to harvest trees from the forest upstream of this site could lead to a further lowering of pH in this stream.

Two outlier values are evident in Figure 2.5. The lowest, 4.2 measured at site MR4 (Farnhams Ck at Barcoo Rd) in June 2001 appears anomalous, as no other readings from that site recorded such low values. It occurred just at the start of increased stream flow in autumn 2001, and may be related to acidic compounds stored on land which were consequently washed into the creek. Site MR11 (Farnhams Creek at Brittons Swamp), did not exhibit the same pattern.

The other outlier value for pH (8.8) was recorded at site MR8 (Montagu at Togari) in December 1999. This value coincided with a supersaturated dissolved oxygen reading (see Figure 2.10). When supersaturation of oxygen is caused by excessive photosynthesis (usually by instream plants and algae), the resultant consumption of carbonic acid from the water column drives the pH values to extremes such as that recorded at this site. It appears likely that such conditions occurred in this case.

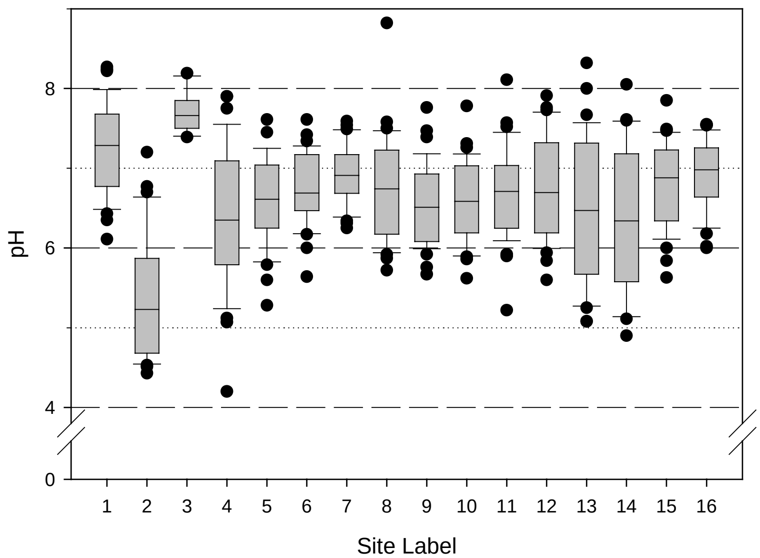

Figure 2.5: Statistical plot of pH at sites in the Montagu River catchment recorded during monthly monitoring between February 1999 and December 2001.

2.1.5 Turbidity

Turbidity in flowing water is an indicator of the amount of suspended and dissolved material being transported by the river at the time of sampling. In lowland rivers turbidity values can be expected to range up to 50 NTU under normal seasonal conditions (see the summary of National Guidelines, in Part B of this document), especially during flood flows when water velocity is higher and the river is able to transport silt and sediment from surface runoff and bank erosion.

Turbidity at sites in the main channel (MR1, MR3, MR6, MR8, and MR12 - 16) tended to follow a broad seasonal pattern, with low values generally recorded at most sites during low summer flows and higher values during winter and spring, with marked peaks in June and November of 2001. The median value for turbidity at sites in the main river ranged from 6 NTU to 10 NTU (Figure 2.6). Extremely high values were not generally recorded at main channel sites, although peak values in excess of 30 NTU were recorded at MR12 (Montagu at Montagu Swamp) and MR15 (Montagu at Donalds Rd) when overnight rain or disturbance to the river caused unexpectedly high turbidity.

Figure 2.6 also shows that MR9 (Fixters Ck at Brittons Swamp) had the highest median and extreme values of all the sites monitored. The median turbidity at the other 2 sites associated with Fixters Creek (MR10 & MR5) was also elevated, with site MR5 recording a maximum of 81.9 NTU. This stream is highly modified by drainage works and this is likely to create very turbid water for extended periods of time, usually during the dry season when stream flows are minimal. Cattle access to the drain is also likely to be a factor causing excessive turbidity. Figure 2.7 shows the time series of turbidity data for sites MR5, MR9 and MR10, with reference to the furthest upstream Montagu River site (MR16) for comparison.

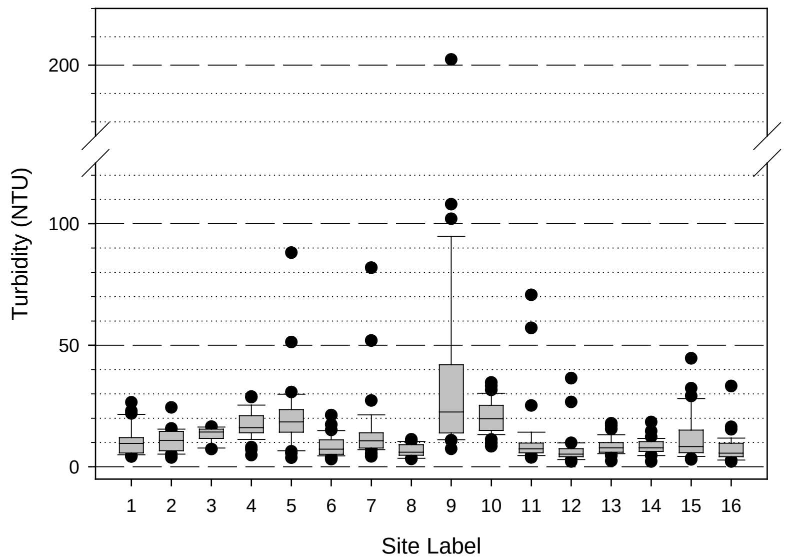

Figure 2.6: Statistical plot of turbidity at sites in the Montagu River catchment recorded during monthly monitoring between February 1999 and December 2001.

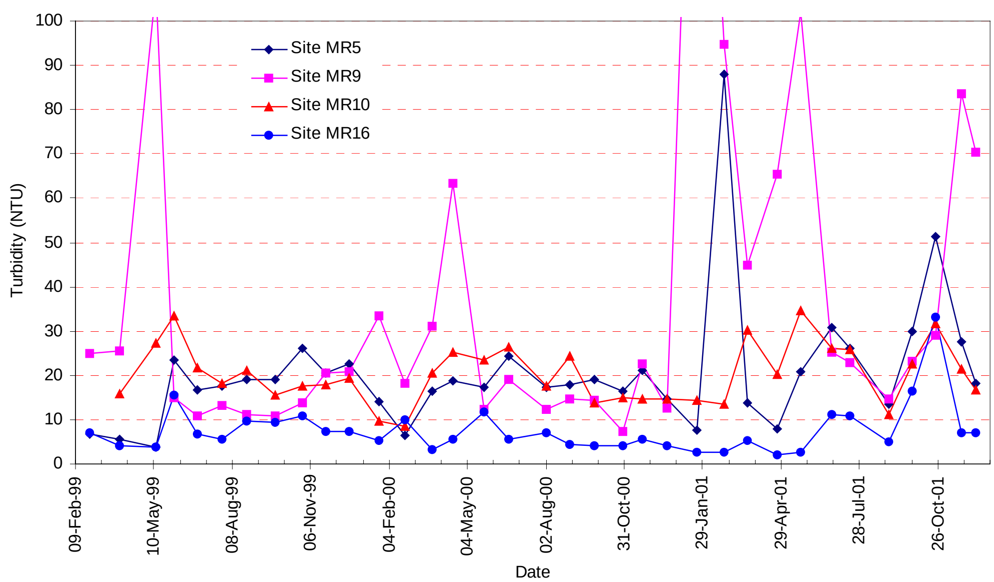

Figure 2.7: Turbidity values (NTU) recorded at sites MR5 (Canal at 14-Mile Plain, downstream of Fixters Creek), MR9 and MR10 (Fixters Creek), and MR16 (Montagu River at Roger River Rd).

The sites on the adjacent Farnhams Creek (MR11 & MR4) differ markedly from each other. Site MR11(Farnhams Ck at Brittons Swamp), the furthest upstream, has a pattern of turbidity similar to that of the Montagu River sites, but with a couple of additional peak values recorded during dry periods that appear to have been caused by light rain or local disturbance. The pattern at site MR4 (Farnhams Ck at Barcoo Rd) was inverted to that recorded at MR11, with high turbidity recorded during dry periods and lower values recorded during winter flows.

Broadly speaking, the turbidity data indicate that relatively lower turbidity exists within the Montagu River, with varying levels of degradation evident in tributary streams. Fixters Creek stands out as the waterway with the most degraded water quality in terms of turbidity, with site MR9 (Fixters at Brittons Swamp) recording the most extreme values. The turbidity values at this site are indicative of the level of disturbance in this catchment and the degree to which modifications (drainage management and land use activities) have impacted on water clarity.

2.1.6 Dissolved Oxygen

Dissolved oxygen values indicate the availability of oxygen to biota within the water column. The amount of oxygen that can be held by the water varies with temperature: colder water can hold more oxygen than warmer water. This means that dissolved oxygen levels can vary seasonally, with water temperature, and diurnally, with photosynthesis during the daylight hours and respiration. The organic load entering a stream and the level of decomposition also has a significant influence on dissolved oxygen levels in waterways. To help present a more complete picture, dissolved oxygen values are often expressed in two forms. Absolute values are expressed in mg/L, and this is important because low absolute levels can cause the death of organisms as the water column becomes depleted. Percent saturation values adjust for the solubility changes caused by temperature and so present a more consistent scale for comparison between sampling times and sites. Because of the temperature effects, the new ANZECC (2000) water quality guidelines have been established using % saturation as the assessment criteria, with 85% being the lowland river trigger value. The original trigger value for concentration was 6 mg/L (ANZECC, 1992). Figures 2.8 and 2.10 show the concentration and saturation data (respectively) for sites in the Montagu catchment.

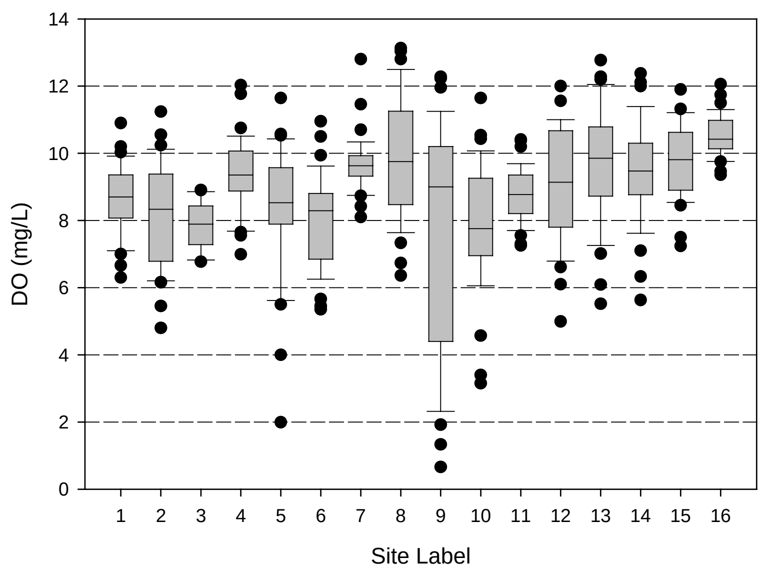

Figure 2.8: Statistical plot of dissolved oxygen concentration at sites in the Montagu River catchment recorded during monthly monitoring between February 1999 and December 2001.

Figure 2.8 shows that sites in the Montagu River (sites from headwaters to catchment outlet - MR16, MR15, MR14, MR13, MR12, MR8, MR6, MR3 & MR1) all recorded adequate dissolved oxygen concentrations, with median values between about 8 to 10 mg/L. Sites MR14 (Montagu u/s Christmas Hills Rd), MR13 (Montagu d/s Christmas Hills Rd), MR12 (Montagu at Montagu Swamp) & MR6 (Montagu at Rennison Rd) all recorded oxygen concentrations below 6 mg/L during the June 1999 monitoring round. This was part of a catchment-wide pattern on this date, when all sites except MR16 (Montagu at Roger River Rd) recorded a drop in dissolved oxygen compared to previous and following monitoring visits. On the same date (June 1999), nutrient values showed a catchment-wide spike (see Section 2.3) in response to the first major river flow event for that season. This may have deposited a substantial load of contaminants (nutrients and suspended solids) in the river system at that time and led to increased oxygen demand and a concurrent drop on dissolved oxygen.

Figure 2.9 shows the time series data for all the sites on Fixters Creek (MR5, MR9 and MR10) along with the time series for the relatively unimpacted site MR16 (Montagu at Roger River Rd) for comparison. This figure illustrates the much more pronounced seasonal pattern of change in dissolved oxygen at sites in Fixters Creek and the much lower concentrations that are found there during the summer months.

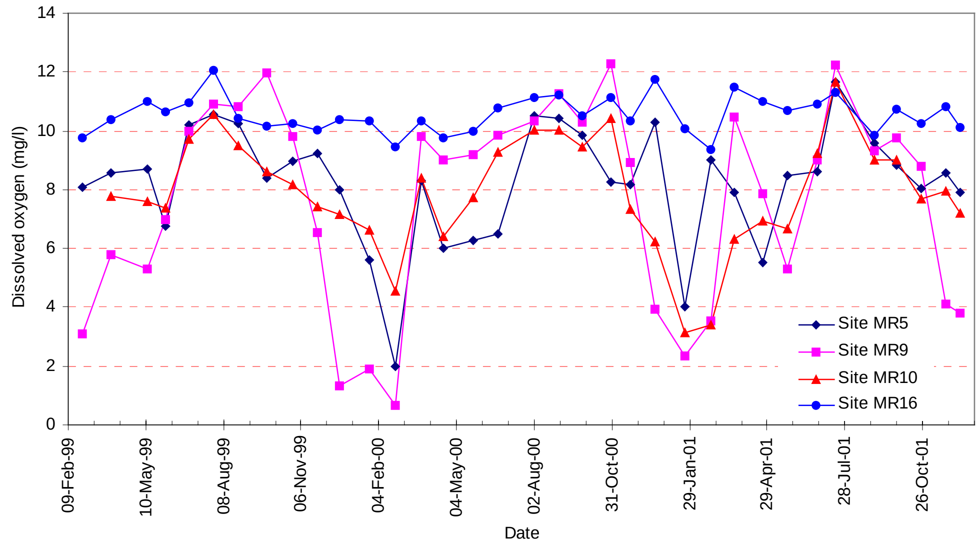

Figure 2.9: Time series plots for dissolved oxygen concentration at sites MR10, MR9 and MR5 (Fixters Creek) and site MR16 (Montagu River at Roger River Rd).

The sites on Fixters Creek (MR10, MR9 and MR5) recorded some extremely low dissolved oxygen concentrations during each of the dry, summer periods. Those at site MR9 (Fixters Ck at Brittons Swamp) were critically low (<2 mg/L) from December 1999 to February 2000. These low seasonal values represent a major ‘stress event’ to the aquatic ecosystem and the prolonged low concentrations of 1999-2000 is likely to have resulted in fish deaths or mortality of more sensitive aquatic invertebrate species. Macroinvertebrate sampling at this site indicated that ‘aquatic health’ is significantly impaired (see Aquatic Ecology report).

The tributary streams Galeford Creek (site MR7) and Farnhams Creek (sites MR4 & 11) showed relatively good dissolved oxygen concentrations (7 - 13 mg/L) throughout the study, and is likely to reflect the lesser organic load entering these streams. The unnamed creek crossing Barcoo Rd low in the catchment (MR2) recorded a couple of values below 6 mg/L during dry periods, but was generally good (median value 8.3 mg/L).

The data for percent saturation (Figure 2.10) is very similar to the pattern shown by the concentration data in Figure 2.8, but when assessed in terms of the 85% trigger value from ANZECC (2000), shows that 7 sites are below the trigger level.

A more significant difference is evident in the box & whisker plot for MR8 (Montagu at Togari), which recorded extremely high values for percent saturation (Figure 2.10). These reflect the high water temperatures recorded at this site, which, during the summer months, are often significantly higher than those recorded at other sites. Water of such high temperatures should not, in theory, hold as much dissolved oxygen as was measured. This suggests that local factors, such as the presence of algae or prolific aquatic plant growth, may be pumping huge amounts of oxygen into the water column during warm summer days, resulting in supersaturation. In situ monitoring carried out in March 2000 (Section 2.5) illustrates the large daily variation that occurs at this site. The absence of flow or other turbulence may be preventing the oxygen from coming out of solution. The site also has no riparian vegetation to shade the river and along with the excessive amounts of nutrient entering from the Togari drainage system, provides ideal conditions for the massive proliferation and growth of aquatic plants and algae in the river-bed.

If this apparent supersaturation is the result of excessive photosynthesis, then oxygen sags would be expected to occur during the night, when algal and plant respiration consumes this oxygen (see Section 2.5). This can have a deleterious effect on aquatic fauna and indicates an aquatic system that is out of balance. Extremely low levels of oxygen saturation were also recorded at other sites (MR5 – Canal at 14 Mile Plain, MR9 – Fixters Ck at Brittons Swamp, MR10 – Fixters Ck at Riseborough Rd), suggesting that aquatic fauna at these sites also experience some stress.

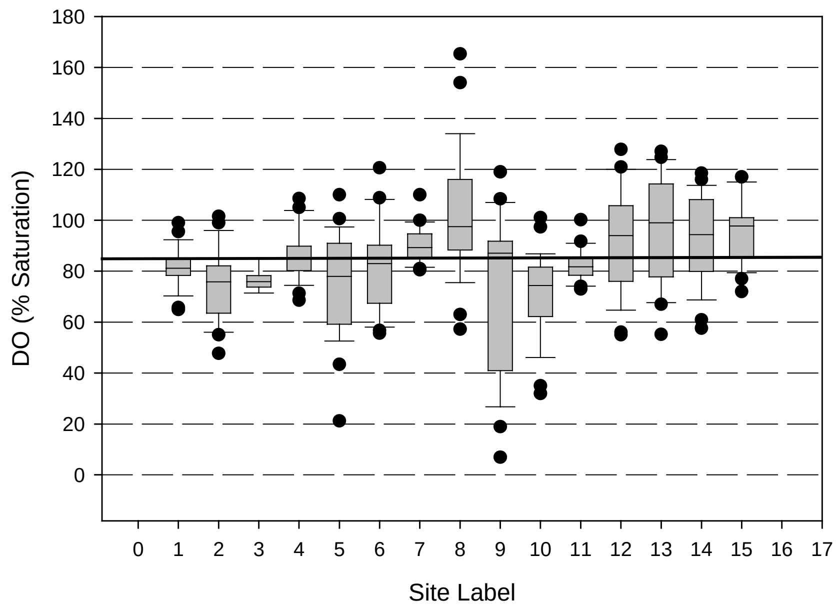

Figure 2.10: Statistical plot of percent oxygen saturation at sites in the Montagu River catchment recorded during monthly monitoring between February 1999 and December 2001. #Bold line indicates the lower trigger value for lowland river systems (ANZECC, 2000)

The ANZECC guidelines for dissolved oxygen (see Part B at the start of this document), suggest that a range between 85% and 110 % saturation is appropriate for lowland rivers such as the Montagu. The median values for 10 of the 16 sites were near to or above the 85% level, indicating that dissolved oxygen levels at these sites were within the ‘healthy limits as defined by ANZECC (2000). It is principally sites MR5, MR8, MR9 and MR10 that are the cause of some concern, as oxygen levels at these sites spend some length of time well outside these ‘safe’ trigger levels. These sites are on Fixters Creek (MR10, MR9 & MR5), in terms of low absolute values, and site MR8 (Montagu at Togari), in terms of supersaturation.

2.2 General Ionic Composition

Samples for characterising the ionic composition of waters in the catchment were collected on a quarterly basis from a subset of sites in the catchment. These sites are listed below.

Site Label	**Site Name**
MR1	Montagu at Stuarts Road
MR4	Farnhams Creek at Barcoo Road
MR5	Canal, off Barcoo Rd at 14 Mile Plain
MR6	Montagu at Rennison Road at Togari
MR12	Montagu off Eldridges Rd at Montagu Swamp
MR16	Montagu at Roger River Rd

The box plots presented in Figures 2.11 to 2.15 summarise selected parameters that are normally used to characterise water on a catchment level. They are a subset of all parameters that were actually tested. Many of these are influenced by the composition of local soils and geology, though some may be impacted by land use and other catchment activities.

The apparent colour of water gives some indication of the level of dissolved and fine organic material in water. Colour can also be affected by the presence of natural minerals such as iron hydroxides and naturally occurring large, complex organic compounds such as humic or fulvic acids. The data for colour in the Montagu catchment (Figure 2.11) shows that with the exception of water high in the catchment, most water is moderately to highly coloured.

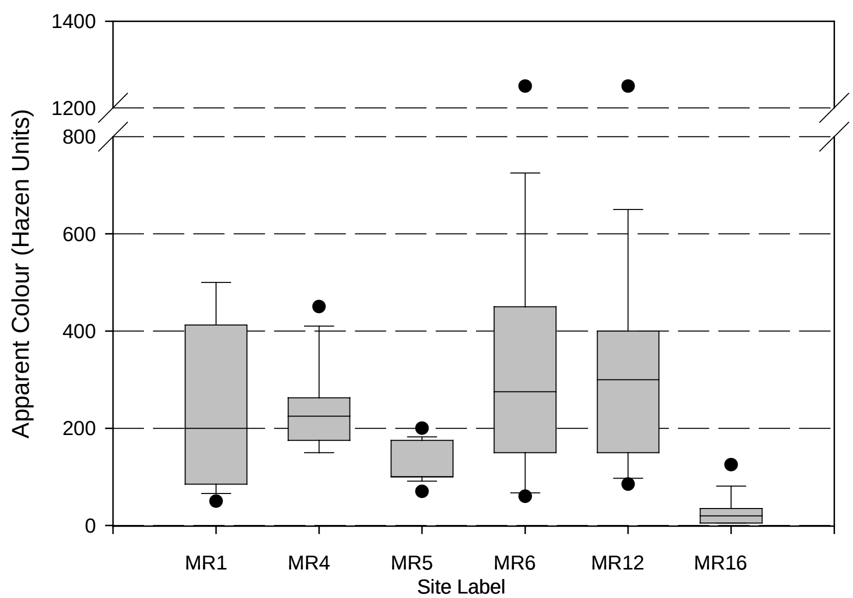

Figure 2.11: Statistical plot of apparent colour at 6 sites in the Montagu River catchment recorded quarterly from February 1999 and December 2001.

Sites MR6 and MR12 (on the Montagu River within the Togari area) recorded the highest values for colour and showed the greatest variability. The values at MR6 tended to mirror those of site MR12 throughout the sampling period, indicating that the cause of the high colour was occurring upstream of site MR12, and persisting in the water column down as far as site MR6. It is likely that the dense tea-tree and swampy area on both sides of the Montagu River upstream from the cleared pastureland of Togari is a major source of organic material leading to these high levels of colour in the river. The nature of the vegetation in the upper catchment near to site MR16 does not appear to provide similar organic input, and MR16 routinely recorded the lowest apparent colour values.

An extreme value of over 1200 Hazen Units was recorded at both MR6 and MR12 on 24 August 1999. Site MR1, the furthest downstream site on the main river channel does not reflect this peak value, but reflects the patterns and values of sites MR12 and MR6 during the remainder of the sampling.

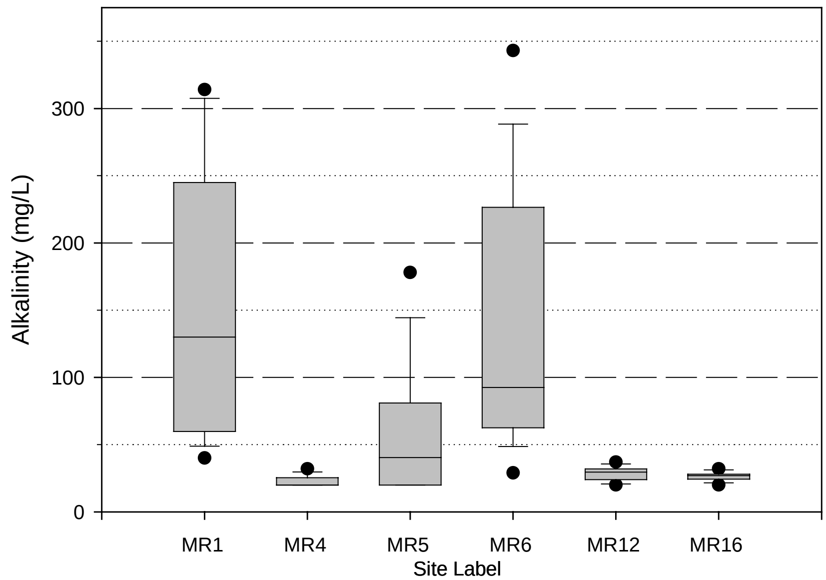

Figure 2.12: Statistical plot of alkalinity at 6 sites in the Montagu River catchment recorded quarterly from February 1999 and December 2001.

The median alkalinity at MR12 and MR16, both of which are located in the main river in the upper half of the catchment, as well at MR4 (Farnhams Creek), was low (Figure 2.12). The variability at these sites was also low, indicating that the water in these parts of the catchment was dilute and not well buffered. In contrast, alkalinity at MR6 and MR1, both of which are located in the lower reaches of the Montagu River, showed very high median and upper values, suggesting that alkalinity is added to the river upstream of site MR6 but downstream of site MR12. This pattern is consistent with the appearance of dolomite outcrops in the river channel downstream of site MR8 (Montagu at Bass Hwy).

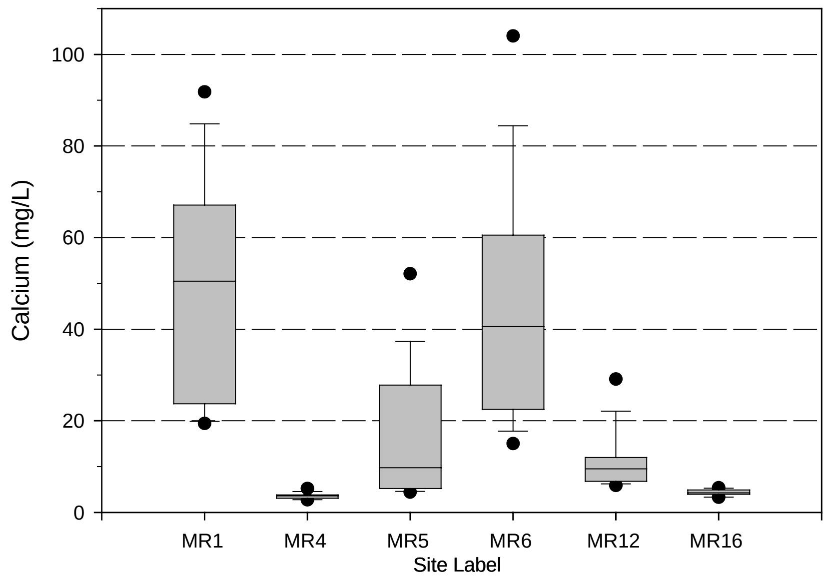

Figure 2.13: Statistical plot of calcium concentration at 6 sites in the Montagu River catchment recorded quarterly from February 1999 and December 2001.

The calcium plot (Figure 2.13) shows an almost identical pattern to the alkalinity data, suggesting that the sources of the elevated levels are similar in location and distribution. As with alkalinity, it appears that dolomite outcrops in the river channel are responsible for much of the increase.

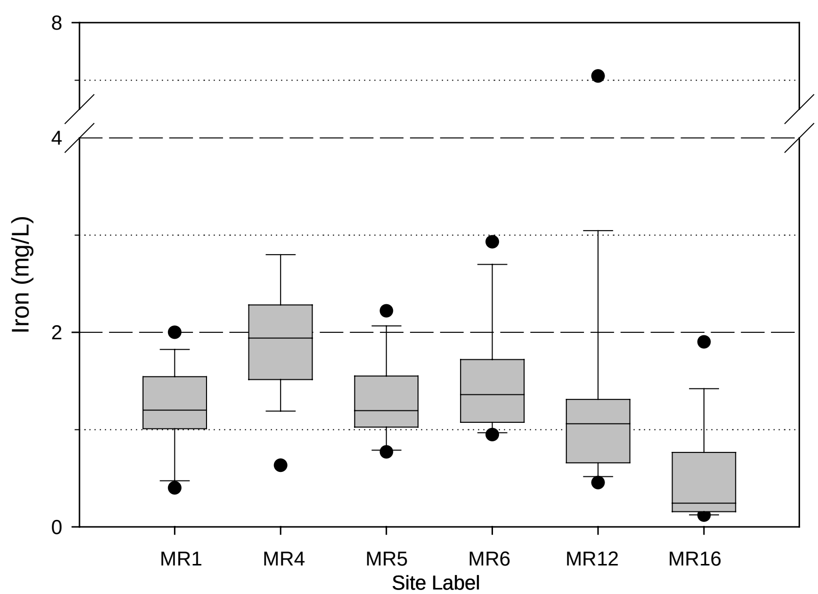

Figure 2.14: Statistical plot of iron at 6 sites in the Montagu River catchment recorded quarterly from February 1999 and December 2001.

Along the Montagu River main channel, iron values increased significantly between MR16 (median of 0.243 mg/L) and MR12 (median of 1.1 mg/L). From there, median concentrations remained relatively stable to the downstream site at MR1 (median of 1.2 mg/L). The values recorded at site MR12 were skewed by one high reading of 7.07 mg/L, recorded on 30 August 2000.

Site MR5, in the canal downstream of Fixters Creek also recorded elevated iron values, but these were not significantly different from those recorded in the main river channel in that area. Farnham Creek (MR5) recorded the highest mean and median iron values of the six sites (1.94 mg/L median value). While none of these levels pose any environmental threat, iron concentrations of this magnitude may impact negatively on domestic and agricultural water use, as iron concentrations in excess of 0.3 mg/L can affect the taste of water and stain laundry (ANZECC, 1992). Iron concentrations above 1.0 mg/L can also lead to iron bacteria coating irrigation piping and clogging distribution system.

Sulphate is naturally present in surface waters as SO_4^{2-}, and generally originates from ocean aerosols or geological sources such as leaching from sulphite minerals or sedimentary rocks (UNESCO, 1992). Previous 'State of Rivers' studies, and monitoring elsewhere on the northwest coast have shown that Tasmanian rivers generally contain sulphate in concentrations less than about 5 mg/L (Bobbi, *et al.*, 1996; Bobbi, 1999c; and Bobbi, 1999d). The concentration of sulphate in the Montagu catchment (Figure 2.15) is slightly above this range (median at sites of between 5-10 mg/L), although it appears that very high concentrations (>50 mg/L) periodically occur across the catchment. These tend to occur primarily during the winter, and may be linked to rain-bearing fronts, as sampling visits that take place immediately following significant rainfall tend to show much higher sulphate concentrations. This is also most apparent at sites in the most modified drainage areas. The direct cause of these high sulphate concentrations is not clear, and while ocean aerosols may be the main source of this sulphate, another major contributor to these high concentrations may be the application of fertilisers to pasture in the Togari district.

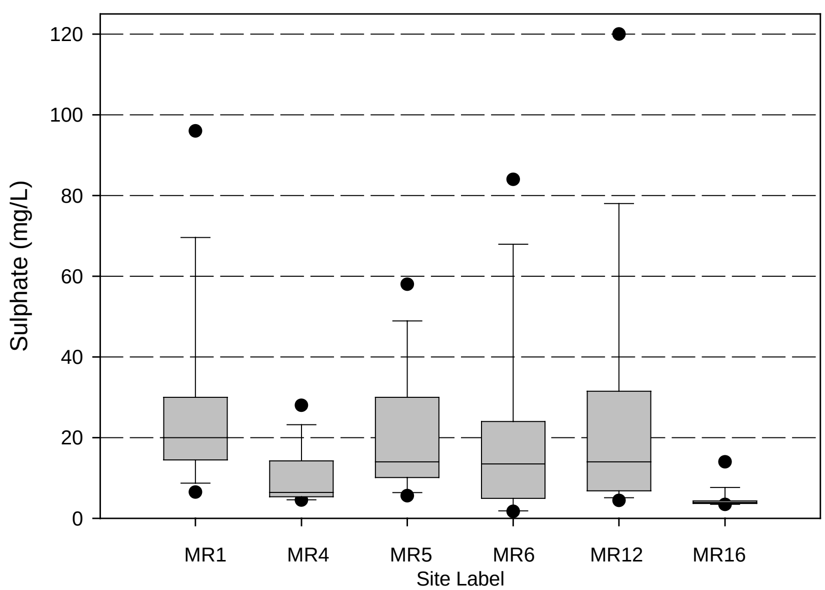

Figure 2.15: Statistical plot of sulphate at 6 sites in the Montagu River catchment recorded quarterly from February 1999 and December 2001.

In summary, the general ion data indicate that conditions diverge from the 'natural' values recorded at the upstream site (MR 16) and reach their highest values at site MR6, which is located in the middle of the highly modified agricultural land. The elevated levels tended to be maintained all the way down to site MR1 at the downstream end of the study area. The source of this ionic input can be generally linked to water being discharged from low-lying swamps and tea-tree thickets alongside the middle and upper half of the Montagu River, and the salts being generated from dolomite outcrops in the Togari area.

2.3 Nutrient Results

Monthly sampling for nutrients was carried out at a subset of 6 sites in the catchment (see Table 2.1). While the main focus for testing was total concentrations of nitrogen and phosphorus, laboratory testing included analysis for nitrate, nitrite, ammonia and dissolved reactive phosphorus. The discussion in this report will generally be limited to total nitrogen (TN), nitrate-N, which generally forms the largest portion of dissolved nitrogen, ammonia-N, and total phosphorus (TP).

Nutrient concentrations in waterways located in agricultural areas are typically variable and may be heavily impacted by specific activities (eg. drain inflows, stock access for watering, etc) or site conditions (eg. river bank erosion, silt deposition, etc). In areas where human activities are less, baseline water quality generally tends to be more stable and concentrations of nutrients tends to be markedly lower. It is therefore important that water quality data are viewed in conjunction with local land-use and river management information.

2.3.1 Total Nitrogen

Total nitrogen (TN) in environmental waters is the sum of organic nitrogen, nitrate nitrogen (NO_3-N) and nitrite (NO_2-N), both of the latter being present in the dissolved form. In most cases, organic nitrogen is the dominant form and tends to be present in the water column as fine particulate material. Total nitrogen levels in the Montagu River during the study period were generally quite high, reflecting the area's intensive agricultural land use (Figure 2.16). The national water quality guidelines indicate that 0.5 mg/L should be used as a trigger to further investigate nutrient levels. Figure 2.16 shows that the median concentration of TN at all sites but MR16 were well in excess of this trigger level. Median concentration at MR5 was 1.75 mg/L.

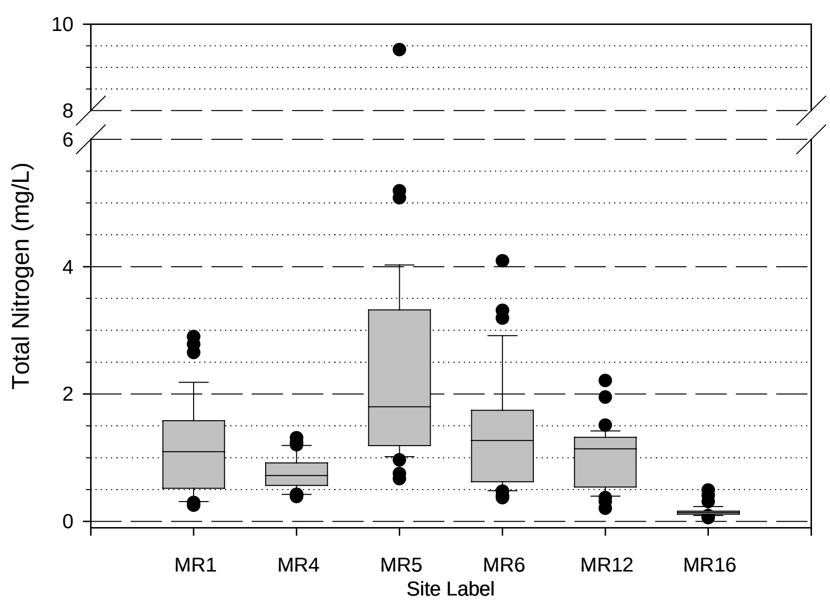

Figure 2.16: Statistical plot of TN concentration at 6 sites in the Montagu River catchment recorded monthly (n = 28-35) from February 1999 and December 2001.

All sites recorded a uniform spike in TN values on 2 June 1999, which followed the first major discharge in the river for that season. A peak value of 4.1 mg/L was recorded at site MR6 on this date. In the reverse of this pattern, values at all sites declined to their lowest winter-time values in August 2001, following a large flood event earlier that month that appears to have significantly flushed the drainage systems. The time series plots in Figure

2.17 illustrates these events and shows that there is a broad change between the dry condition of summer and the high flow conditions of winter.

Of the 6 sites monitored, the site that recorded the highest TN concentration was site MR5 (Canal off Barcoo Rd), which is located at the downstream end of the drainage system that collects runoff from Brittons Swamp (Fixters Creek) and a large part of the Togari drainage district. This area contains some of the most intensive dairy farming in the catchment, and high nitrogen concentrations at this site are to be expected. Closer inspection of the time series for MR5 suggests that some significant change in land management activity occurred in the vicinity of this site late in 1999. Prior to December 1999, the values at site MR5 were indistinguishable from the other sites monitored (except MR16). However, from December 1999 onwards, MR5 recorded greater TN concentrations than other sites on a more frequent basis. Its median value over this latter period increased by almost 1.0 mg/L, with a maximum value of 9.4 mg/L measured in October 2000. This coincided with better than average dairy production (DPIWE, pers comm.), and much higher concentrations of phosphorus, indicating increased production and loss of nutrients from this part of the catchment over that period.

Although only the 6 sites were sampled regularly, spot samples suggest that other sites in the catchment have higher nutrient levels than those monitored. Site MR9, on Fixters Creek at Brittons Swamp recorded one value of 17.2 mg/L in only three samples taken, suggesting that extreme nutrient enrichment may be a serious issue in this reach of the tributary. It indicates that losses of nutrients from the Brittons Swamp area may be as large or even greater than those for Togari.

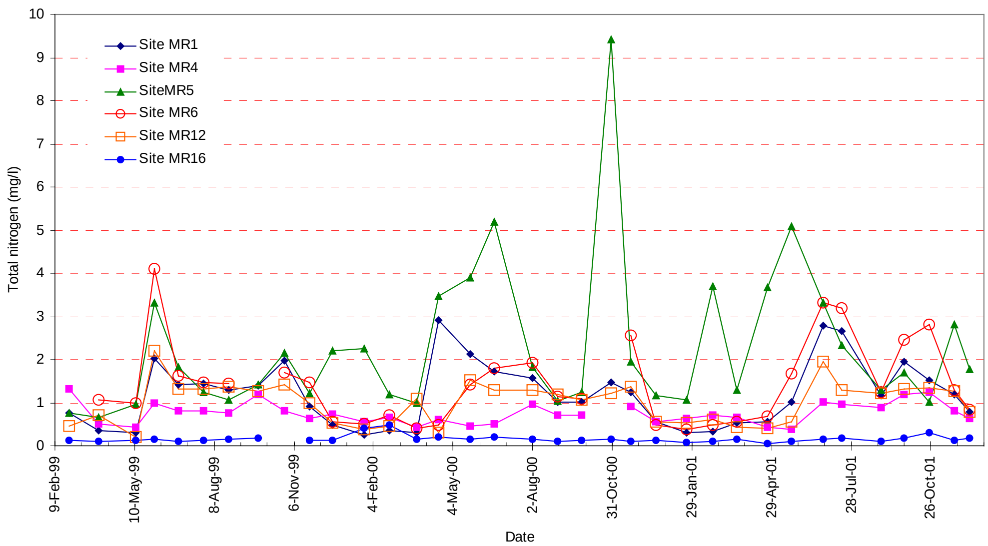

Figure 2.17: Time series of TN concentrations recorded monthly for 6 sites in the Montagu catchment from February 1999 to December 2001.

2.3.2 Nitrate/N

Nitrates form a part of the group of nitrogenous compounds reported under total nitrogen. The national water quality guidelines suggest 0.04 mg/L as the trigger level for this nutrient. Of the six sites monitored, only the furthest upstream site (MR16) remained below this trigger level. The median value at that site was 0.022 mg/L, and the maximum recorded was 0.41 mg/L. Figure 2.18 gives a statistical representation of these data, and shows that nitrate-N concentration at MR5 (Canal off Barcoo Rd) was highest both in terms of median and maximum values.

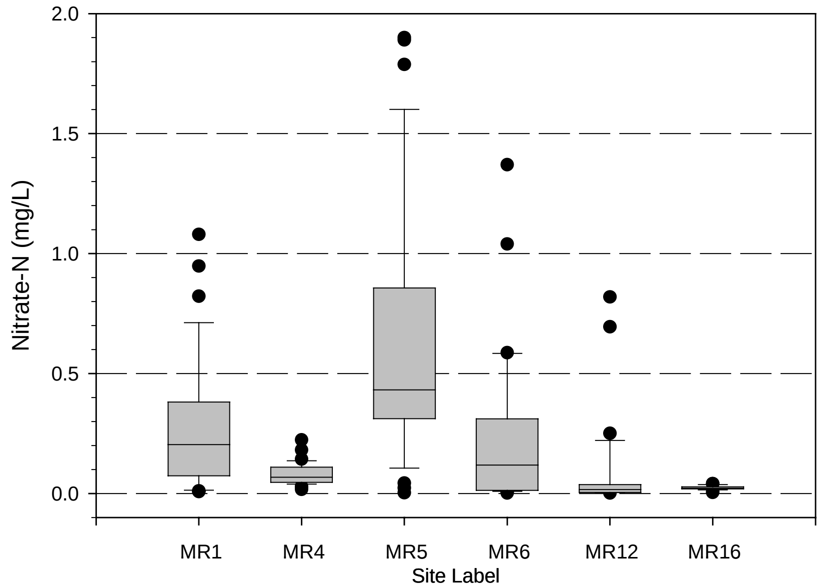

Figure 2.18: Statistical plot of nitrate-N concentration at 6 sites in the Montagu River catchment recorded monthly (n = 28-35) from February 1999 and December 2001.

Nitrate-N concentrations showed a clear seasonal pattern of change (Figure 2.19), with the highest readings being recorded in early autumn, when the nitrate-N that had built up in the soil profile was flushed into waterways during the first autumn rains. Concentrations then gradually decreased over the winter and spring seasons, reaching minimum values towards the end of the summer. This pattern was consistent across all sites in the middle and lower catchment, but was absent at MR16 in the headwaters, indicating that the processes influencing nitrate movement are quite different.

Nitrate values were consistently higher at site MR5 (Canal off Barcoo Rd) than any other site, although the mid- to downstream Montagu River sites (MR12, MR6 and MR1) also recorded seasonal peak values greater than an order of magnitude above the trigger level.

In the lower catchment sites, it is very likely that the intensity of dairy farming, the altered soil water retention times and the increased use of fertilisers has a major influence on the magnitude of the nitrate-N released to waters in this part of the catchment. Similar patterns of nitrate-N concentration have been recorded in waterways draining dairy districts in New Zealand (Wilcock, *et. al*., 1999) where similar intensively drained pastures occur. These authors suggest that extensive drainage works and lack of riparian zones allow little opportunity for natural attenuation processes to mitigate nitrate-N concentrations. Similar comments could be made regarding large parts of the Montagu catchment.

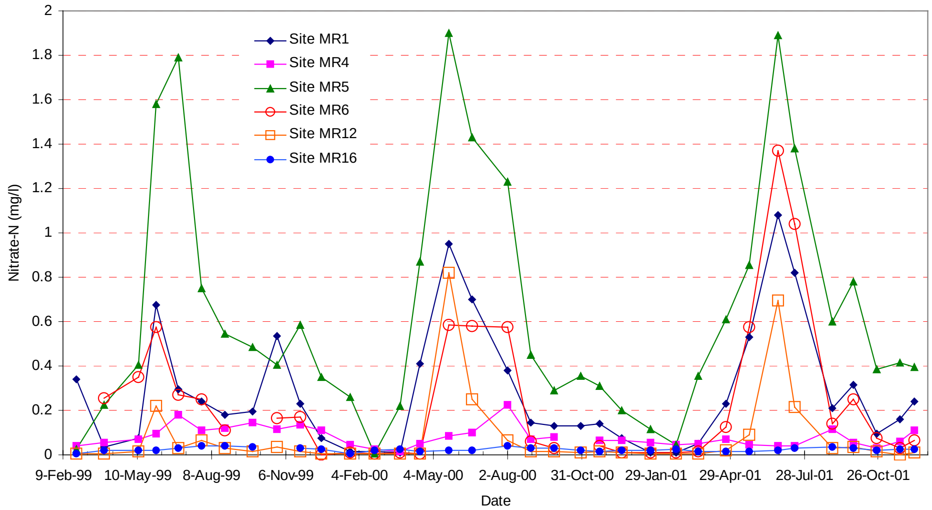

Figure 2.19: Time series of nitrate-N concentrations recorded monthly for 6 sites in the Montagu catchment from February 1999 to December 2001.

2.3.3 Ammonia-N

Ammonia-N is another significant nitrogenous compound found in streams. Ammonia is known to be toxic to aquatic biota at high concentration, and this toxicity increases with decreases in dissolved oxygen concentration, higher water temperature and higher pH (>8.0). The ANZECC (2000) guideline for protecting 'moderately disturbed' ecosystems is about 0.90 mg/L (at pH >8) although at more neutral pH this increases to about 2.0 mg/L. As the pH of water in the Montagu is generally near to 7, the latter value is an appropriate trigger for most waterways in the Montagu catchment.

Figure 2.20 gives the ammonia-N data for the 6 sites sampled monthly. This figure shows a pattern similar to both total and nitrate nitrogen. All sites showed median concentrations that are well below the Montagu trigger value of 2.0 mg/L, and although site MR5 (Canal off Barcoo Rd) recorded the highest median value (0.24 mg/L), the ammonia-N concentration in two samples exceeded 2.0 mg/L. The maximum ammonia-N vales recorded at this site was 2.5 mg/L, and given the pH at the time of these samples was slightly over 7, concentrations as high as these were likely to have had some toxicological impact on aquatic biota.

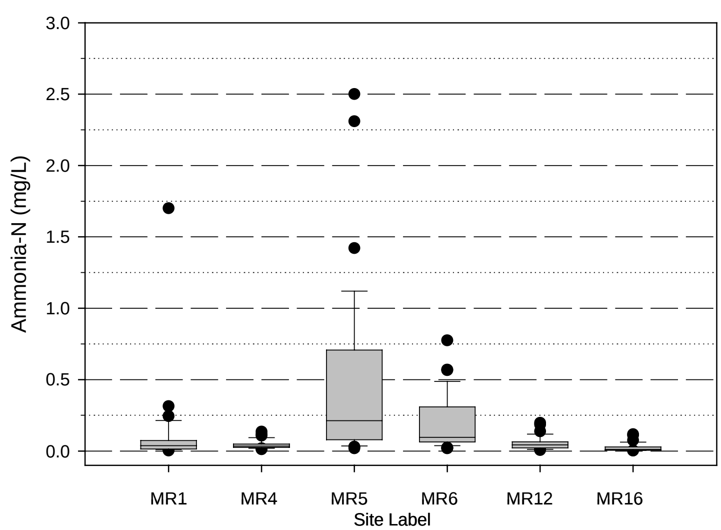

Figure 2.20: Statistical plot of ammonia-N concentration at 6 sites in the Montagu River catchment recorded monthly (n = 28-35) from February 1999 and December 2001.

2.3.4 Total Phosphorus

Like the various nitrogen readings, total phosphorus (TP) values were elevated at five of the six monitoring sites, with only site MR16 (Montagu at Roger River Rd) consistently recording values below the ANZECC (2000) water quality guideline trigger threshold of 0.05 mg/L. Figure 2.21 shows these values, and from this plot it can be seen that concentrations ten times greater than the trigger threshold have recorded at 3 of the 6 sites.

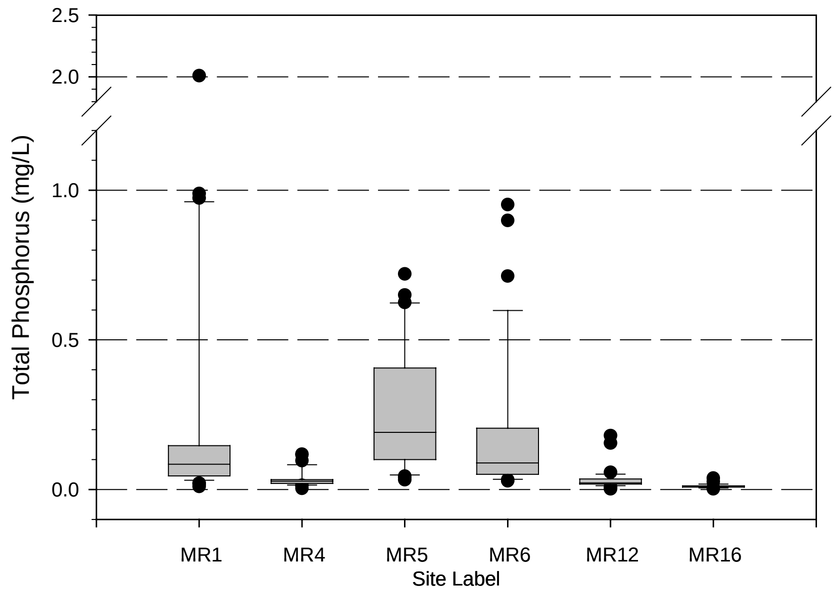

Figure 2.21: Statistical plot of TP concentration at 6 sites in the Montagu River catchment recorded monthly (n = 28-35) from February 1999 and December 2001.

In a pattern similar to that for TN, peaks in TP concentration were recorded at all sites in June 1999 and a flow-related decline occurred in August 2001. Figure 2.22 shows the time series data for the six regularly sampled sites.

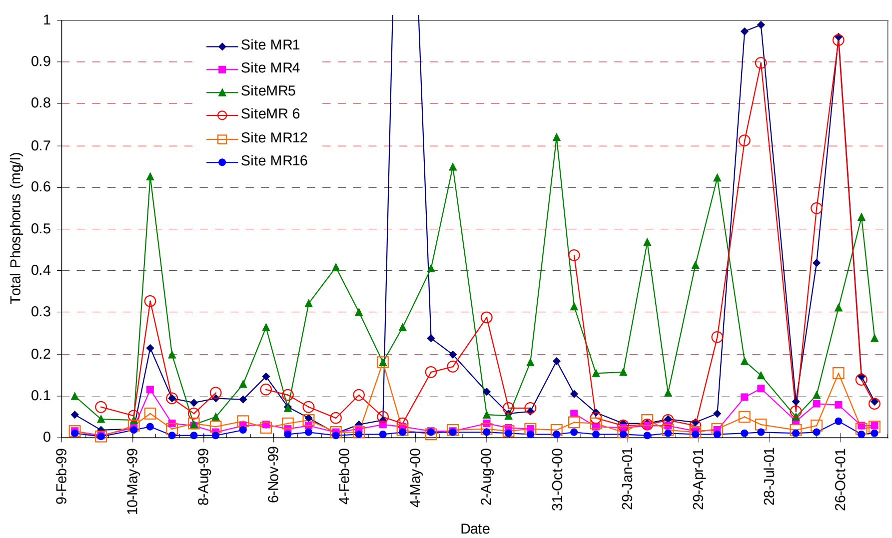

Figure 2.22: Total phosphorus concentration recorded for 6 sites on the Montagu River monthly from February 1999 to December 2001.

It can be seen from Figure 2.22 that MR5 (Canal off Barcoo Rd) recorded consistently highest TP concentrations, often an order of magnitude greater than the 0.05 mg/L ANZECC (2000) trigger level and generally more than 3 times the concentration measured at the other sites.

Site MR1 (Montagu at Stuarts Rd) recorded one extreme value of 2.01 mg/L in April 2000, which appears to have been caused by rainfall over the previous couple of days causing surface runoff to the river. Most other values at this site were <0.2 mg/L.

Sites MR1 and MR6 (Montagu at Rennison Rd) recorded TP concentrations around 1 mg/L throughout the winter of 2001 (June to October). The cause of this sudden and unusually large increase in TP is not known, although this broadly coincides with the elevated TN concentrations discussed in Section 2.3.1 and may have resulted from increased dairy production in the catchment over that period. Its persistence throughout the remainder of the study suggests a continuous inflow of nutrients, originating at, or upstream of, site MR6 and flowing downstream to site MR1 with minimal dilution.

Figure 2.23 presents the longitudinal change in median TP concentration in the Montagu River. The plot clearly shows the dramatic increase in TP concentration caused by the inflow from the Togari and Brittons Swamp dairy districts (the latter contributing through Fixters Creek). Although actual load estimates from these drainage systems cannot be made, it is apparent that drains from these districts have a major impact on loads in the main river downstream.

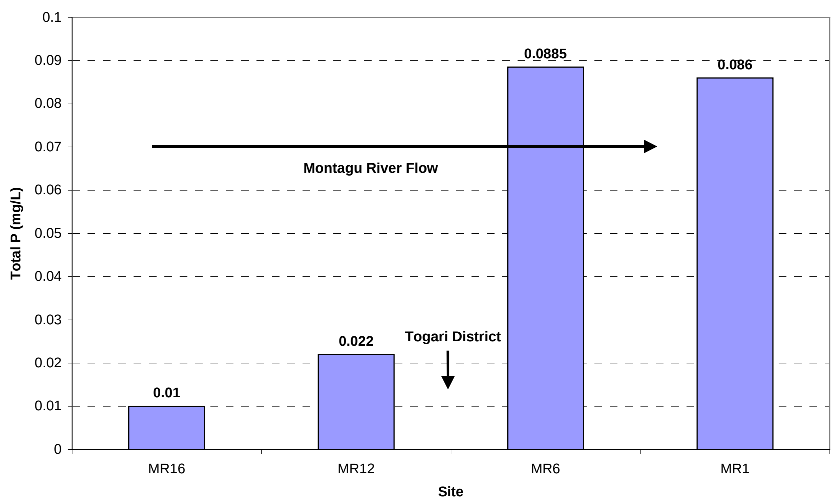

Figure 2.23: Longitudinal change in median TP concentration in the Montagu River illustrating dramatic increase below input from the Togari and Brittons Swamp dairy districts.

2.3.5 Nutrient summary

It is quite clear from the nutrient data that the Togari and Brittons Swamp areas are the major factors causing nutrient enrichment and water quality degradation in the Montagu River. In particular, site MR5, which collects drainage from both Fixters Creek and a portion of the lower Togari area, demonstrates that water from these two areas has consistently high concentrations of all nutrients. Spot readings at other locations on Fixters Creek confirm this.

Some comment is made later in this document on the potential impact the ‘hump & hollow’ drainage system that is characteristic of these two areas, has on the movement of TN and TP. This system of drainage optimises the velocity of drainage water from pasture and this obviously increases the capacity of this water to transport nutrients and other contaminants from dairy pasture.