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

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Water Quality of Rivers in the Duck River Catchment

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

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 water quality data for the 'State of Rivers' study in the Duck catchment was collected between January 1999 and December 2001. The main aim of sampling 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 further investigations, 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 29 sites to determine the physico-chemical nature of water quality. The names and grid references for these sites are 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 monthly at a subset (11) of these sites. Sampling for dissolved salts and general ionic composition was performed at these eleven sites on a quarterly basis.

Table 2.1: Location of sites where monthly water quality monitoring was carried out during the 'State of River' study (1999-2001). Sites in bold were sampled monthly and tri-monthly for nutrients and general ions respectively.

Site Name	Code	Easting	Northing
Duck at Bass Highway	DR1	339800	5475500
Gaeles Creek at Bass Highway	DR2	336700	5473075
Coventry Creek at Trowutta Road	DR3	341200	5475150
Duck at SG station at Scotchtown	DR4	341450	5473700
Gaeles Creek at Trowutta Road	DR5	340900	5473200
Duck at Trowutta Road u/s Gaeles Creek	DR6	340900	5472400
Duck at Lades Road	DR7	339950	5469700
Copper Creek at Trowutta Road	DR8	340750	5467700
Allen Creek at Allandale Farm	DR9	339450	5465850
Edith Creek at Trowutta Road at Edith Creek	DR10	339700	5463100
Edith Creek at Huetts Road (via Maxwells)	DR11	337700	5464700
Duck at Huetts Road	DR12	337200	5464150
Drive Creek at Trowutta Road at Edith Creek	DR13	339700	5463100
Edith Creek at quarry 1 off South Road	DR14	340700	5462800
Edith Creek at Moores Road	DR15	343100	5461350
Edith Creek at quarry 2 off South Road	DR16	343700	5461400
Allens Ck d/s confluence Allen &Blizzards Creek	DR17	343700	5465500
White Water Creek at Poilinna Road	DR18	336300	5461800
Duck at Poilinna Road	DR19	335200	5461700
Duck at Trowutta Road at Roger River	DR20	337300	5458600
Roger River at Roger River Road	DR21	333050	5455150
Roger River at Buffs Road	DR22	333200	5452550
Roger River at Croles Road	DR23	335900	5451600
Faheys Creek at Maguires Road near Jones Road	DR24	340900	5457800
Duck at Maguires Road	DR25	342000	5457900
Lairds Creek at Maguires Road	DR26	342750	5458800
Muckeye Creek at Faheys Road	DR27	346990	5470500
Deep Creek u/s Lake Mikany (at Shaws Road)	DR28	349400	5471010
Deep Creek d/s Lake Mikany (at Pump house Road)	DR29	344550	5476450

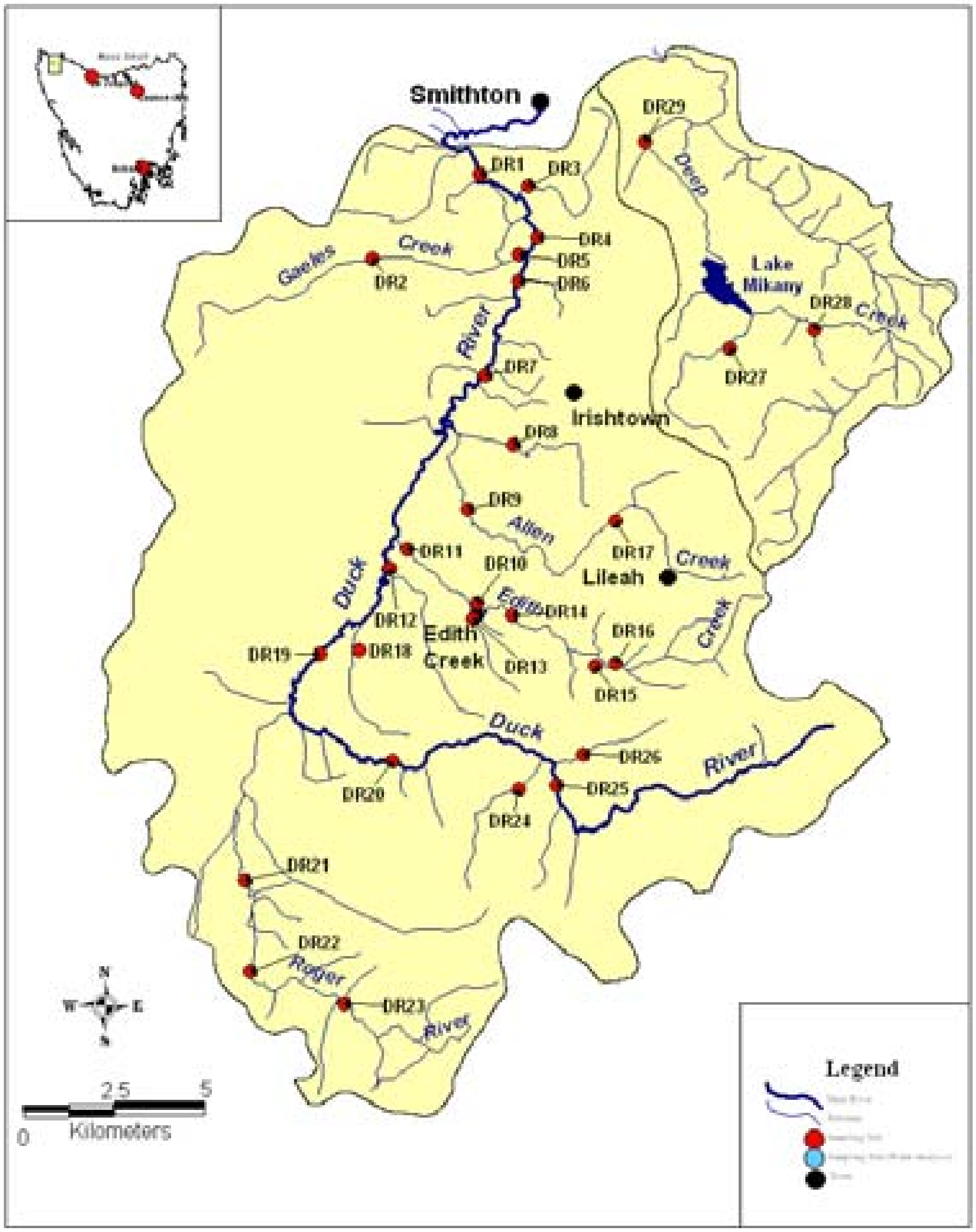

Figure 2.1: Location of all 29 sites monitored in the greater Duck River catchment (including Deep Creek) during the 'State of Rivers' investigations (1999-2001).

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 a number of the main 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 involved the sampling of faecal bacteria at four selected sites during the periods of January 2000 to June 2001 in conjunction with the Circular Head Council.

The fourth tier of monitoring involved the use of in-stream logging equipment to examine short-term variations in water quality such as dissolved oxygen and pH, which are known to undergo diurnal fluctuations. In-stream monitoring of some water quality variables was also performed in association with stream flow monitoring in the Duck River at Scotchtown Road. At this site, turbidity, conductivity and temperature are monitored on a continuous basis. As these probes are permanently immersed in the river, it is necessary to both clean them regularly and also check the accuracy of the data they collect against other regularly calibrated field instruments. When the data from this source is combined with nutrient concentrations from samples collected during flood events, calculations of nutrient fluxes for the period can be made.

The physico-chemical parameters tested in the field included pH (compensated for temperature), electrical conductivity (corrected to reference temperature 25 ^{o}C), 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^{o}C)	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
Flouride (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 monitoring for water temperature, pH, conductivity, dissolved oxygen (concentration and percent saturation) and turbidity was carried out at all 29 sites in the combined Duck River and Deep Creek catchment. The following boxplots show the range and statistical features of these data, and allow comparison between sites. The sites have been arranged from DR1 to DR29 from left to right. For details of the site names and their locations, refer to Table 2.1 and Figure 2.1 above.

2.1.1 Water Temperature

Water temperature throughout the Duck catchment is typical of the smaller, unregulated coastal rivers and streams of north-west Tasmania. The median temperature at most sites monitored within the Duck catchment during this study were found to be around 11.5-12.5 ^{o}C, with the exception of sites on Deep Creek, which were marginally warmer (Figure 2.1). The greatest seasonal range was recorded at monitoring sites located on Deep Creek and on smaller tributary creeks of the Duck River (DR10 – Edith Creek & DR24 – Faheys Creek). The highest water temperature (23.4 ^{o}C) was recorded in Faheys Creek in late November 2000, immediately prior to this stream ceasing flow. Lowest median and minimum water temperature (11.5 ^{o}C & 7.1 ^{o}C respectively) was recorded at the top of the Roger River (DR23) where the river lies within mature native forest. It can be seen from the data that sites that are heavily shaded by vegetation tend to have lower maximum temperatures compared to sites on the same drainage line that are cleared and exposed (eg DR14 & DR15 on Edith Creek). There is also a distinct trend within the Duck River, with median temperature increasing towards the catchment outlet (median temperature at DR25 – Duck at Maguires Rd = 11.7 ^{o}C, median temperature at DR1 – Duck at Bass Hwy = 12.8 ^{o}C).

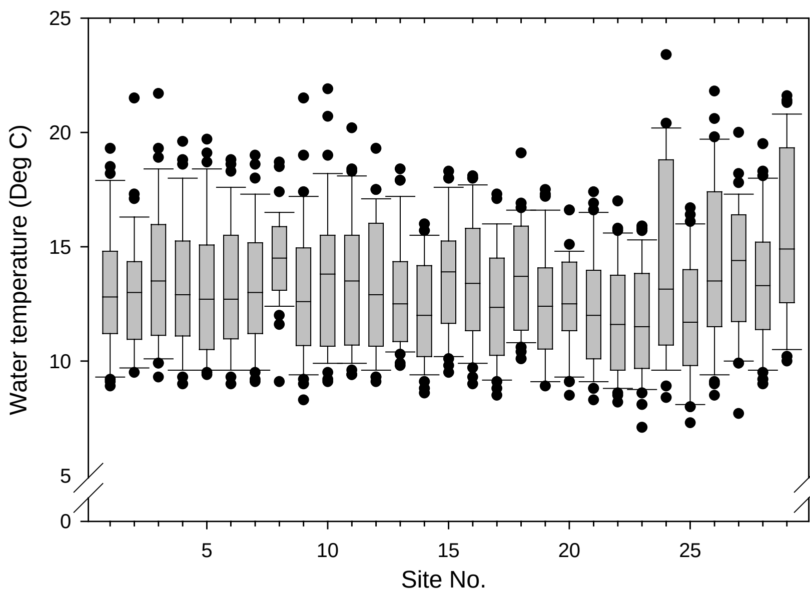

Figure 2.2: Statistical plot of water temperature at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.

The seasonal variation in water temperature at a subset of sites is shown below in Figure 2.3. The temperature variation at two sites in the Duck River is plotted (black), along with two sites located on tributary streams (blue). The figure shows that the seasonal change is not smooth, being markedly influenced by short-term climatic conditions. This is most clearly seen during the summer of 1999-2000, when the peak temperature at most sites is clearly reduced when compared to the data from summer 2000-2001.

Water temperature at the two sites within the main river tend to track each other quite closely and are quite similar, despite DR25 being almost 25 km up-river from DR4. As expected, the greatest difference in water temperature occurs during summer, when temperature lower in the river (DR4) can be up to 4 ^{o}C warmer, however for most of the year the difference between the two sites is less than 2 ^{o}C.

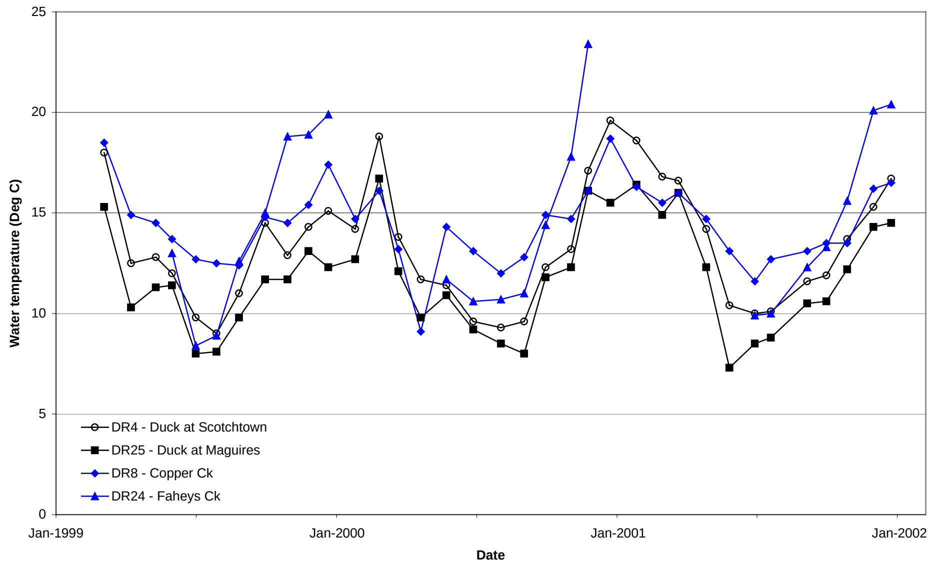

Figure 2.3: Time series plot showing seasonal variation in water temperature at four sites in the Duck catchment (January 1999 – December 2001).

As highlighted by the boxplot in Figure 2.2, the temperature of tributary streams is clearly much more influenced by short-term climatic variation because of their smaller size and generally greater exposure. Faheys Creek (located in the upper catchment of the Duck River) is an exposed, ephemeral stream in a section of the catchment where there has been substantial forest plantation development and there are also a large number of dams. As the plot shows, this stream tends to dry up early in the spring and only recommences flowing in the early winter. Despite this, springtime water temperature in this stream can exceed 23 ^{o}C.

Water temperature has been continuously recorded at DR4 in the Duck River since 1996 as part of the State-wide water quality monitoring system managed by DPIWE. Plots of water temperature recorded at this site during the period of this study are presented for comparison in Figure 2.4a-c. The plots show that temperature in the lower Duck River rarely exceeds 20 ^{o}C during summer and rarely drops below 7 ^{o}C during winter. The main feature present in each of the time series plots is the pronounced cyclical change that is evident during Febraury/March each year, when the 7-10 day passage of cold fronts causes cooling followed by gradual re-warming of water in the river. This pattern is typical of small, unregulated coastal rivers in Tasmania (Bobbi, 1999c; Bobbi, 1999d).

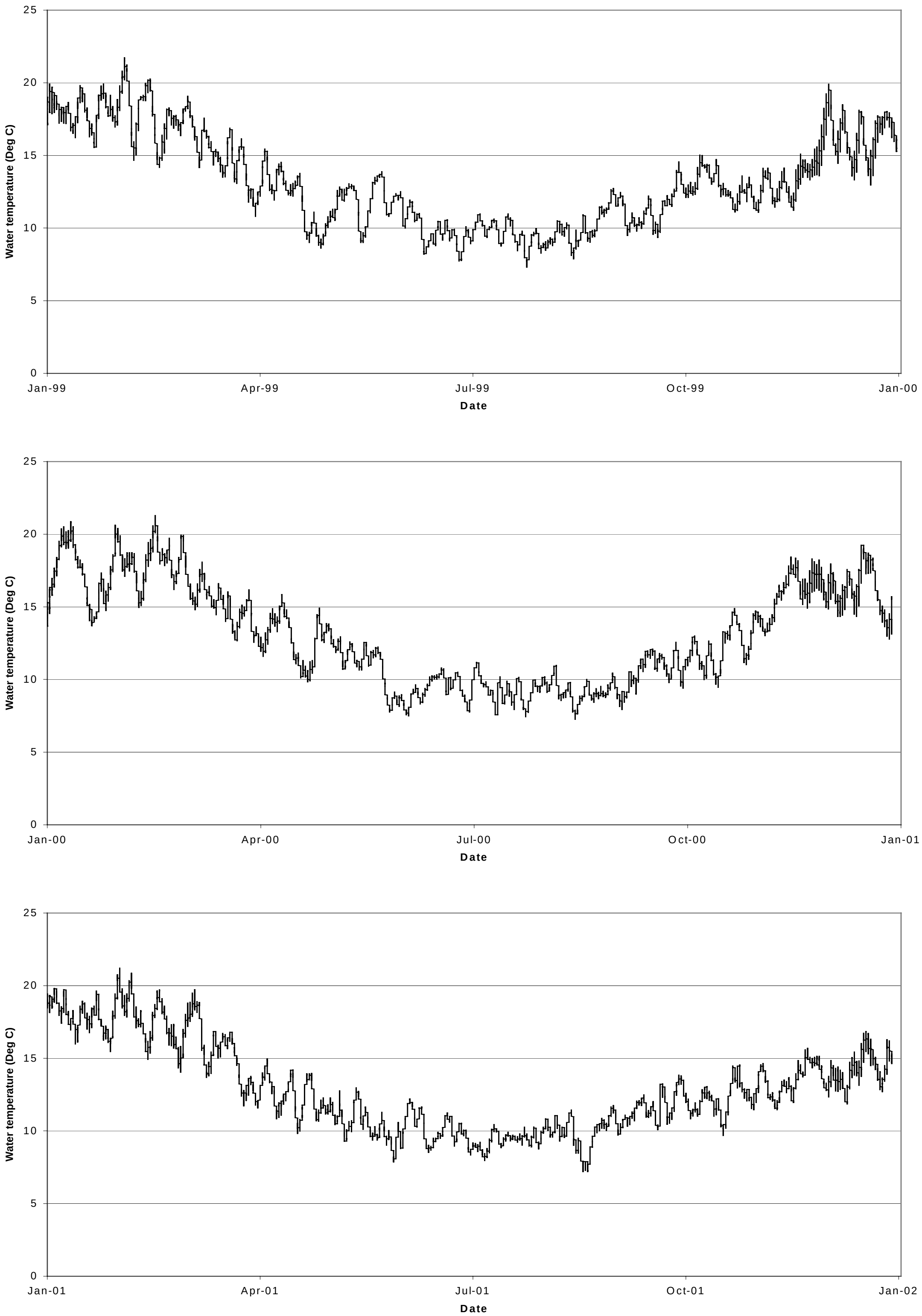

Figure 2.4a-c: Time series plots of water temperature in the Duck River at DR4 recorded by permanently stationed sensors between January 1999 and December 2001.

2.1.2 In-stream pH

The pH of river waters varies considerably across the catchment (Figure 2.5), with median values at DR26 (Lairds Creek) and DR2 (Gaeles Creek) relative outliers compared to other monitoring sites. Both of these sites have median pH values that are mildly acidic. During the course of the monitoring, a fish kill incident in Scopus Creek (to the north of Gaeles Creek) appears to have been caused by drainage from acid sulphate soils. This acid drainage may also have some influence on pH levels in Gaeles Creek. The issue of acid sulphate drainage in the Mella area was investigated during this study and results are discussed in a later section of this report, but it appears that parts of the lower catchment may be prone to periodic acid generation from soils in the area.

Most of the other sites in the Duck River catchment tend to have median pH that is neutral or slightly alkaline. DR9, DR18 and DR19 all have median pH that is greater than 7.5, and values in excess of 8 were measured at many sites. The source of these alkaline values is not clear, but may indicate the periodic influence of drainage from pockets of dolomite in the middle catchment. Edith Creek appears to be the exception to this, with noticeably lower median values than other nearby monitoring sites.

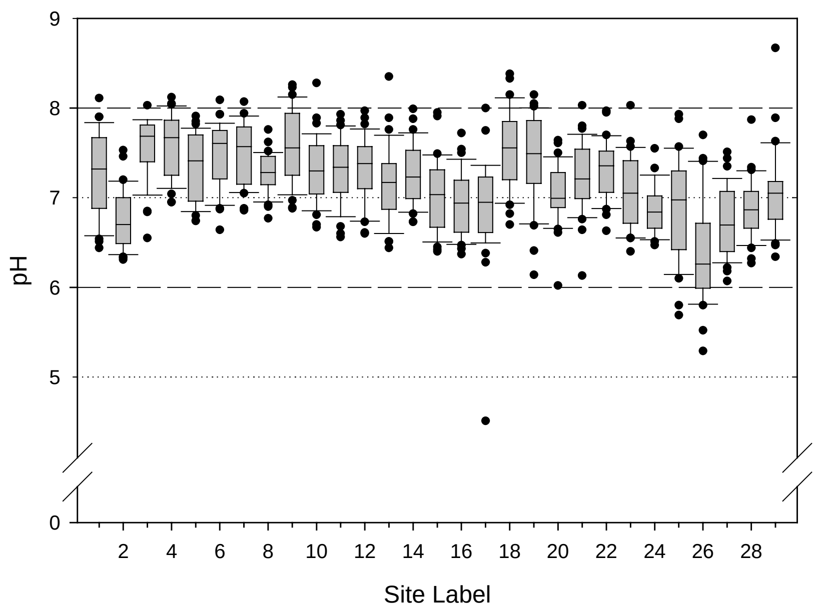

Figure 2.5: Statistical plot of field pH (temperature corrected) at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.

2.1.3 Conductivity

Conductivity of waters in the catchment varies greatly (Figure 2.6), with values in excess of 1300 μS/cm being recorded at DR3 (Coventry Creek) low in the catchment. High conductivity was also recorded at DR8 (Copper Creek) and DR18 (White Water Creek) and this has some implications for irrigation use of water from these tributaries. While the recently revised National water quality guidelines (ANZECC, 2000) classify these waters as having ‘low’ or ‘very low’ salinity, previous guidelines (ANZECC, 1992; Victorian Soil Conservation Authority, 1980) would classify these waters as medium salinity and suggest that use of water with this level of salt may have long term impacts on soils with reduced drainage and may reduce productivity of salt sensitive plant species.

The very high conductivity recorded in Coventry Creek is likely to be at least partially a result of leachate from the Blue Ribbon Meats abattoir located upstream, which is likely to have produced leachate high in BOD, metals and nutrients (Green, 2001).

Median conductivity at all other sites is quite low (100-400 μS/cm), with lower median values in tributary streams than at sites in the main river. There is a broad trend for increasing conductivity down the length of the Duck River.

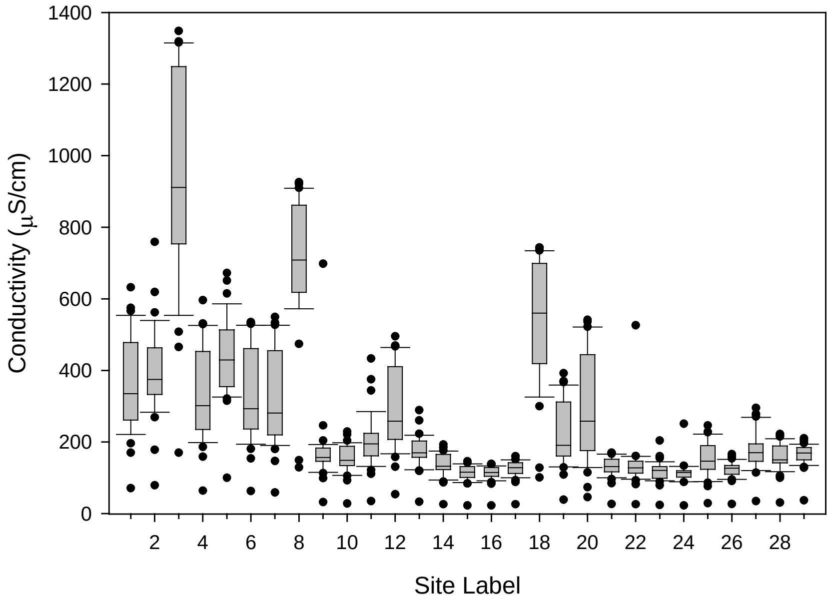

Figure 2.6: Statistical plot of conductivity (T_{ref} 25^{o}C) at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.

Conductivity has also been continuously recorded in the Duck River (site DR4) since 1996 as part of the State-wide water quality monitoring system. Annual time series plots of conductivity at this site during the period of this study are presented for comparison in Figure 2.4a-c. The plots show seasonal trends in dissolved salt concentrations in the Duck River. During the spring and early summer months, conductivity steadily increases from a mid-winter low of around 220 μS/cm to a mid-summer high of about 550 μS/cm. This steady increase is frequently interrupted by rainfall events that cause temporary dilution. Larger rainfall events can cause conductivity to decrease by as much as 180 μS/cm within a 48-hour period.

Figure 2.7c also shows the impact of the unusually dry autumn in 2001, which held conductivity in the Duck River above 500 μS/cm until the second week of June, when late rain finally 'flushed' the river system.

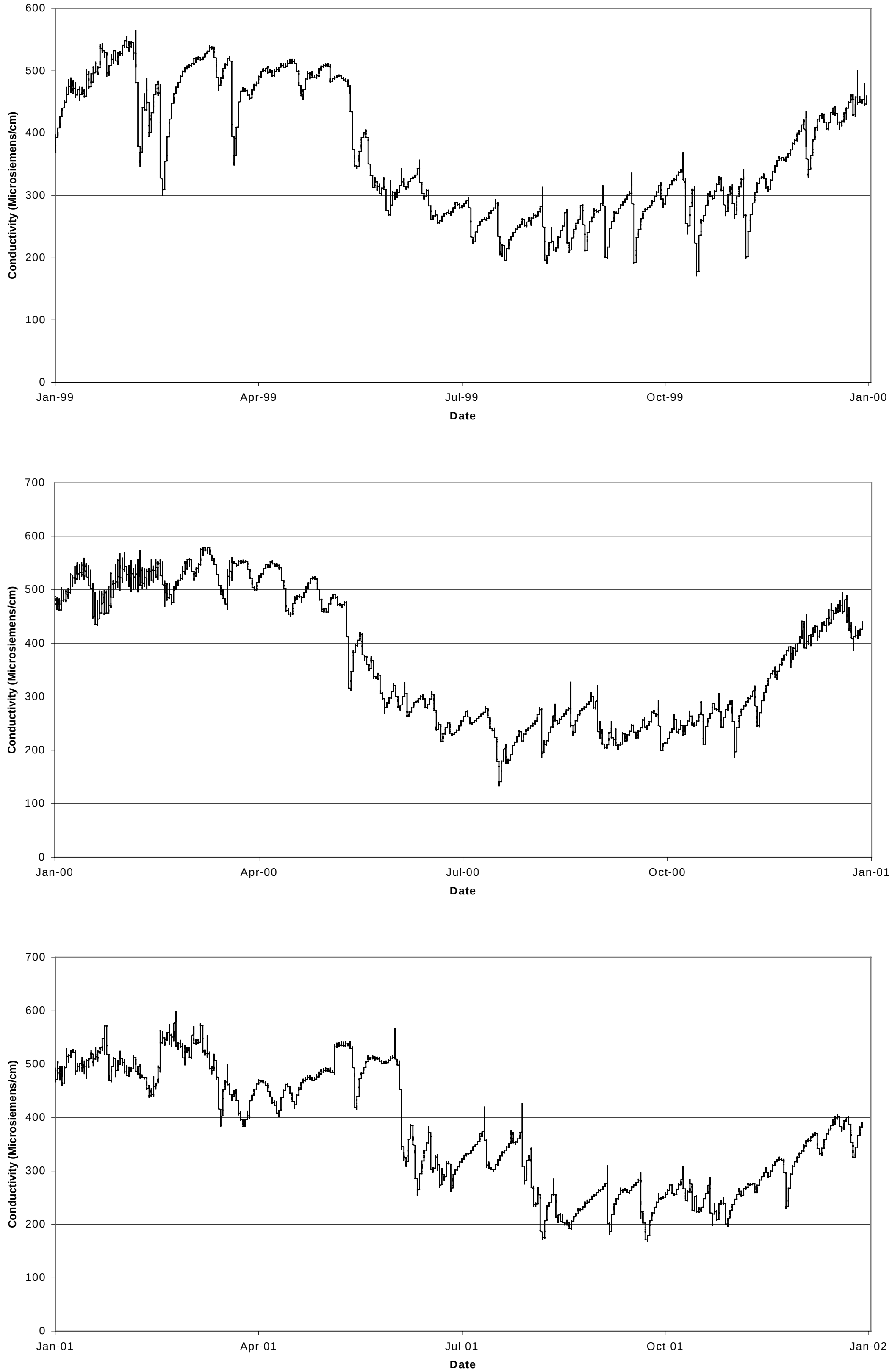

Figure 2.7a-c: Time series plots of conductivity in the Duck River at DR4 recorded by permanently stationed sensors between January 1999 and December 2001.

2.1.4 Turbidity

Turbidity in flowing water is an indicator of the amount of suspended material being transported by the river at the time of sampling. This material may be fine suspended clay particles, colloidal material or larger organic and inorganic particulates. In agricultural areas, drainage improvements and stock access to rivers and riparian zones often result in an increase in the delivery of this material to waterways, while in the steeper headwater areas roads and forest harvesting activities may cause increased turbidity. Turbidity in the Duck catchment (Figure 2.8) is at the upper end of the range recorded in other agricultural catchments around Tasmania (Bobbi, *et al.*, 1996; Bobbi, 1997; Bobbi, 1998; Bobbi, 1999). Median turbidity at sites within the Duck River downstream from White Water Creek (DR18) is above 10NTU, with median turbidity at the catchment outlet (DR1) of 13.2NTU. The main influence on turbidity in the Duck River appears to be discharge from White Water Creek, (median turbidity of 22NTU) where winter turbidity measurements were routinely in excess of 35NTU. Tree felling and drainage works were responsible for the very high reading taken at this site (227NTU) in June 2000.

Median turbidity at Gaeles Creek was also much greater than elsewhere in the catchment, and reflects both the level of drainage works that have been carried out on this creek and the level of agricultural activity occurring there.

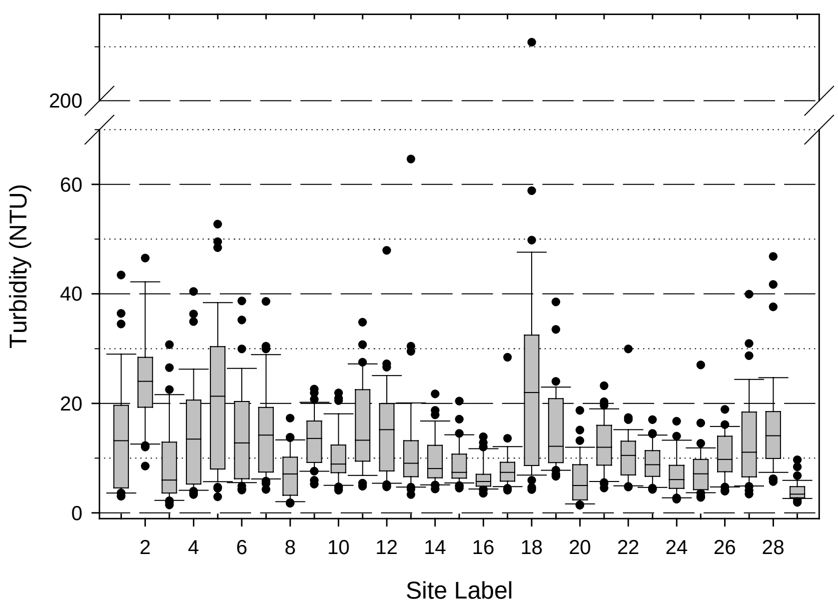

Figure 2.8: Statistical plot of nephelometric turbidity at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.

As expected, turbidity at most sites was found to be highly flow dependent, with a distinct seasonal variation seen in the time series plots for most sites. Figure 2.9 illustrates this for two sites in the Duck River. As the time series shows, during the summer months, turbidity at the catchment outlet (DR1) is only marginally higher than that occurring in the upper reaches of the river (DR20). However during the higher flows that occur between May and November, turbidity increases markedly in the lower reaches of the river.

Turbidity was also recorded continuously at DR4, as part of the State-wide water quality monitoring system, and the data from this location for the year 2000 (Figure 2.10) also shows the distinct seasonal change in turbidity in the Duck River. This trace shows the large changes that occur during flood events, with turbidity values in excess of 300NTU being recorded. More comments on flood characteristics are made in a later section of this report.

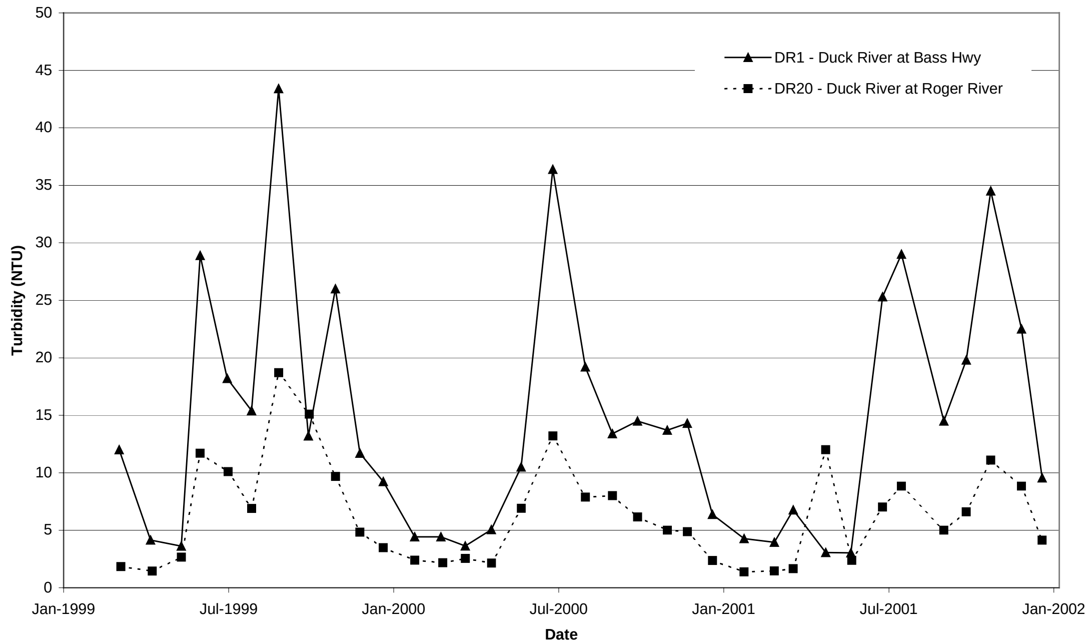

Figure 2.9: Time series plot showing the seasonal variation in turbidity at two sites in the Duck River as displayed by monthly monitoring data from January 1999 – December 2001.

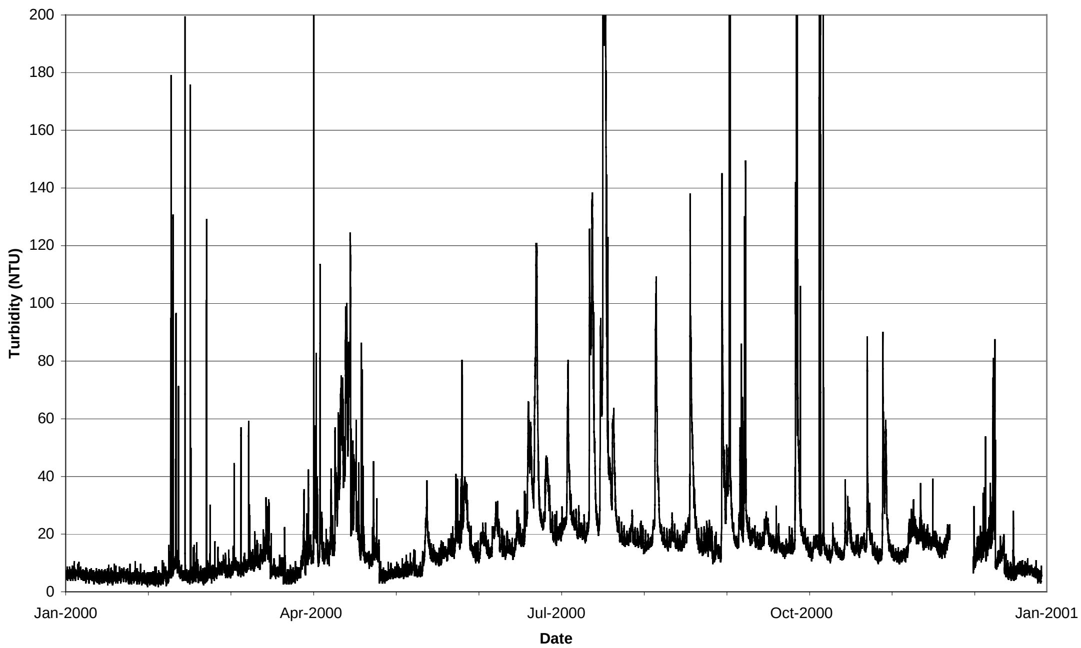

Figure 2.10: Continuous time series of turbidity in the Duck River at DR4 during 2000 recorded by permanently situated water quality sensors.

2.1.5 Dissolved Oxygen

The level of dissolved oxygen in environmental water is influenced by biological processes such as organic decomposition and primary productivity. In waters that are not subject to human-induced pollution or disturbance, these processes are in balance and vary in a cyclical fashion on a daily and seasonal basis. Unnatural organic enrichment of waterways often creates an imbalance to the system such that extremes in dissolved oxygen are created. Daily and seasonal cycles in dissolved oxygen concentrations in rivers and streams can be exaggerated by organic enrichment or increased exposure to sunlight, and this can have a severe impact on the ability of aquatic biota to survive in these conditions. The spread of dissolved oxygen data at a site can therefore be used as a basic indicator of 'environmental imbalance'.

A summary of the monthly data from sites in the Duck catchment is displayed in Figure 2.11, where the size of the boxplots indicates the range of oxygen concentrations measured at each individual site. This plot shows that at the majority of sites, 75% of the oxygen measurements (as represented by the shaded boxes) tend to fall within a 2 mg/L range, with median values of between 8-10 mg/L. These sites can be broadly classified as 'healthy', despite having outliers that may be below the commonly accepted 'unhealthy' concentration limit of 6mg/L (ANZECC, 1992).

Sites that show some signs of oxygen 'imbalance', are sites DR11 and DR15 on Edith Creek, DR20 (Duck River at Roger River), DR26 (Lairds Creek) and DR27 (Muckeye Creek). At all four of the tributary sites there were several values below 6 mg/L, with measurements as low as 3 mg/L being recorded during low summer flows at DR11. Oxygen concentrations as low as this are likely to cause severe stress or death to aquatic organisms, and may be the reason for the lower AusRivAS score for this site (see separate chapter).

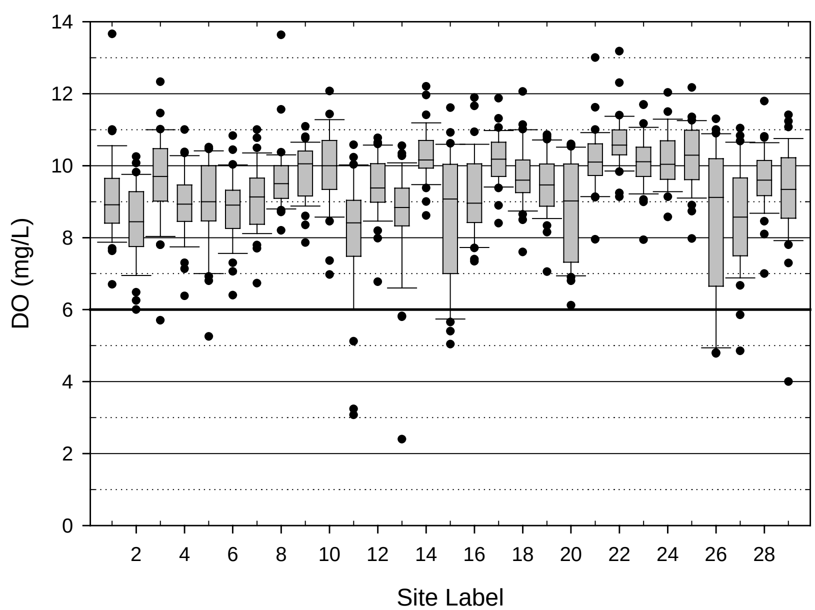

Figure 2.11: Statistical plot of dissolved oxygen concentration at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.

Recent revisions to the National water quality guidelines have seen the adoption of a 90% saturation level as the 'trigger' below which there is likely to be stress to aquatic life (ANZECC, 2000). While saturation levels of oxygen were not as consistently recorded during monitoring, the data that was collected is presented for discussion in Figure 2.12.

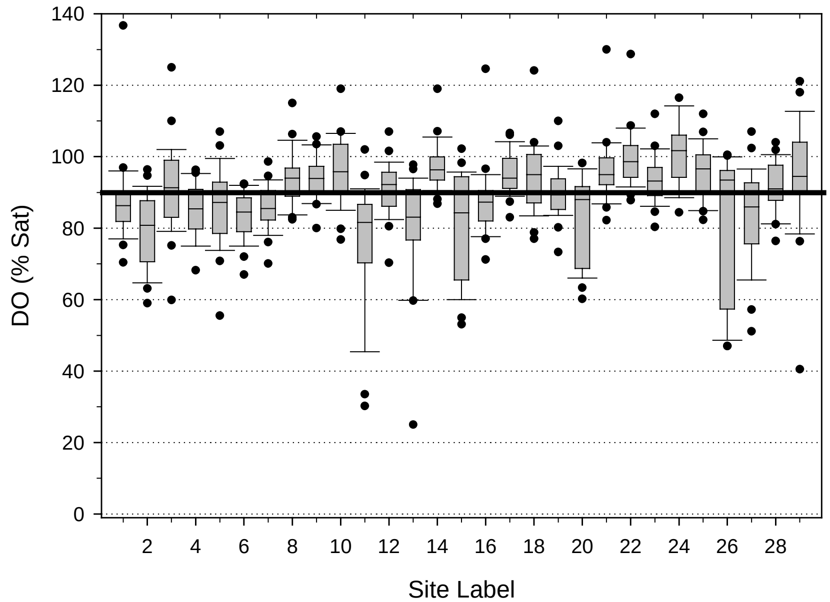

Figure 2.12: Statistical plot of dissolved oxygen (as percent saturation) at sites in the Duck catchment, recorded during monthly monitoring between January 1999 and December 2001.
#Bold line denotes lower trigger level for ecosystem protection as recommended by ANZECC 2000.

Assessing ecosystem 'health' using the 90% trigger level for percent saturation of dissolved oxygen (ANZECC, 2000) rather than the 6 mg/L trigger for concentration (ANZECC, 1992) gives markedly different results. Using the 90% saturation level as the assessment criteria, many more sites appear to be 'impacted' or 'disturbed', with median values at 12 sites falling below the 90% saturation level. While the 5 sites highlighted in Figure 2.11 as 'stressed' are also identified as stressed in Figure 2.12, a further 7 sites (mainly located in the lower catchment) are identified as at least marginally 'stressed' or 'depressed' in terms of oxygen content. This is to be expected in the main river, as depositional processes in the lower reaches would lead to slightly depressed oxygen levels compared to sites in the upper reaches of the river. The only other site that is highlighted by the 90% trigger is DR2 (Gaeles Ck), which is a small, low gradient drainage channel that flows through intensive dairy land and is likely to receive some organic and nutrient inputs.

The seasonal variation in dissolved oxygen concentrations at two sites in the Duck River is shown in Figure 2.13. Some seasonal pattern is clearly evident at both sites, and concentrations are consistently about 1 mg/L higher in the upper reaches of the river (as displayed by DR25). The unexpectedly high reading at both sites in February 2001 cannot be clearly explained, as hydrological and climatic conditions prior to and during the day of sampling were stable. It appears that this may be due to poor instrument calibration during that monitoring run.

It is worth noting that the seasonal pattern of change that is shown by sites in the main river is absent from many of the sites located on smaller tributary streams (Figure 2.14), irrespective of their ecosystem 'health'. Sites that appear to have reasonably healthy oxygen concentrations (DR8 and DR18) also tend to maintain consistent levels throughout the year, without any noticeable seasonal cycle. In contrast to this, greatly disturbed sites (eg. DR11) have more variation in oxygen concentration, although this does not appear to be linked to any seasonal pattern. The reason for this is not clear, but may relate to variations in the organic loads between sites, along with different patterns of flow in each creek.

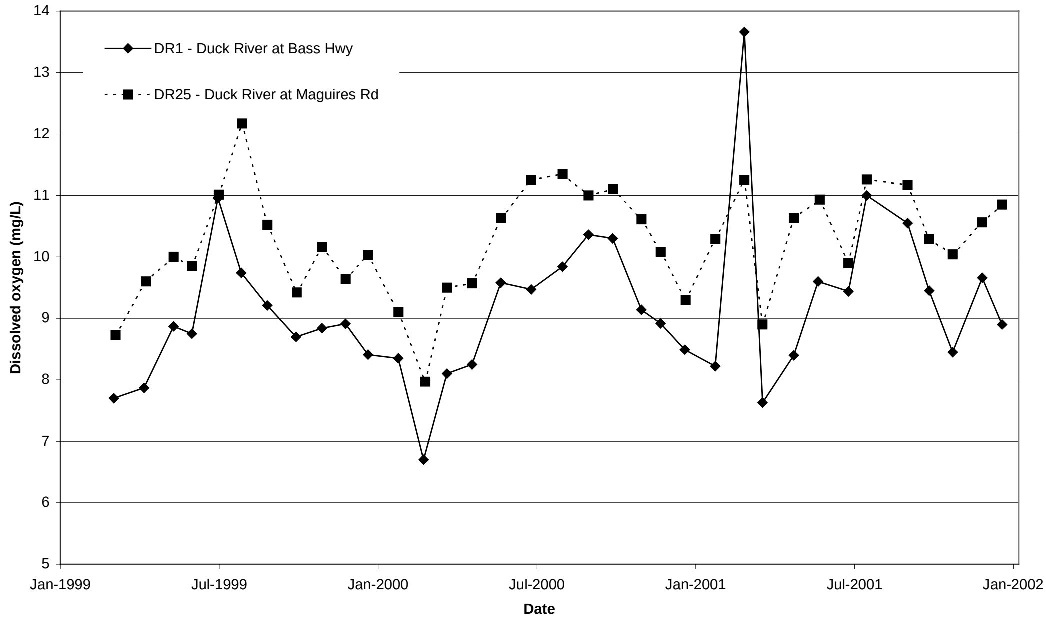

Figure 2.13: Time series plot showing the seasonal variation in dissolved oxygen concentration at two sites in the Duck River using monthly monitoring data from January 1999 – December 2001.

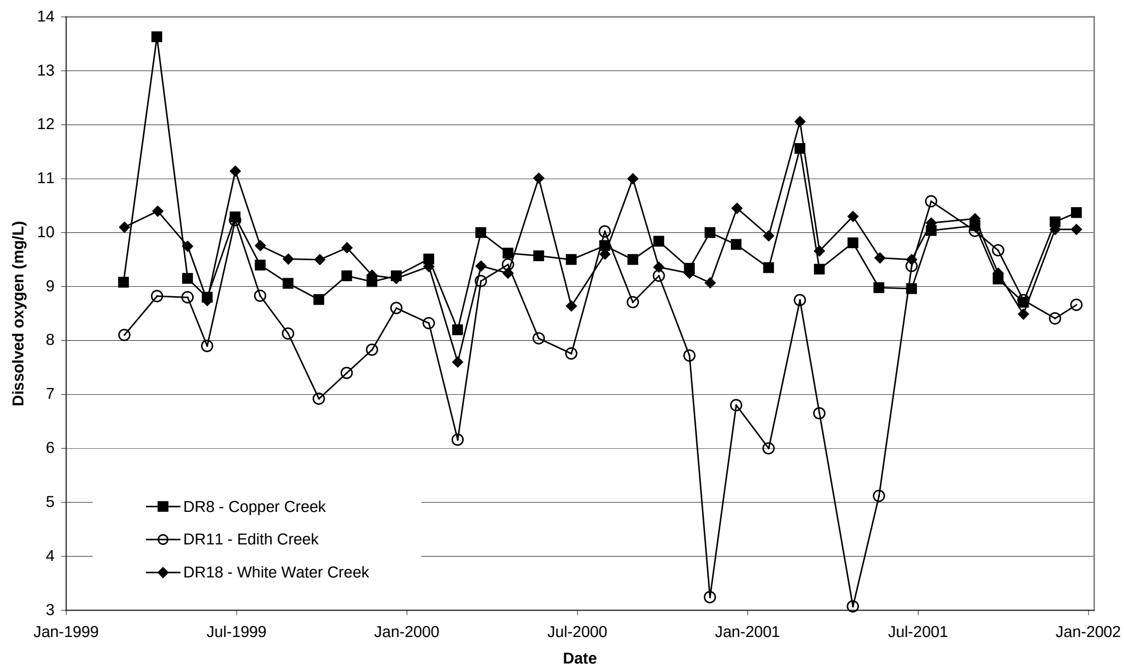

Figure 2.14: Time series plot showing the variation in dissolved oxygen concentration at three sites located on tributaries to the Duck River (January 1999 – December 2001).

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 in detail below and referred to by their labels in the following graphs.

Site Label	Site Name
DR1	Duck River at Bass Highway
DR3	Coventry Creek at Trowutta Rd
DR4	Duck River at Scotchtown
DR7	Duck River at Lades Road
DR9	Allen Creek at Allandale Farm
DR11	Edith Creek at Huetts Road
DR12	Duck River at Huetts Road
DR18	White Water Creek at Poilinna Road
DR20	Duck River at Roger River
DR21	Roger River at Roger River Road
DR25	Duck River at Maguires Road

The boxplots presented in figures 2.15 and 2.16 summarise selected parameters that are normally used to characterise the ionic composition of water, and is only 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. The waters in the Duck catchment contain varying levels of dissolved organics and dissolved minerals, and this is reflected in the plots below, especially those for apparent colour (Figure 2.15) and alkalinity (Figure 2.16). Both Allens Creek (DR9) and Edith Creek (DR11) have consistently lower colour, with values ranging from about 40-75. While other sites within the catchment have median values for colour that are not markedly greater than this, most show much greater variability, with individual values at all other sites being recorded in excess of 200 units. White Water Creek showed the greatest range in values, with summer values as low as 15 units and winter values as high as 450 units.

These data also show that as the Duck River emerges from the predominantly forested upper catchment it has a high median colour (as exemplified by DR25), which rapidly declines in a downstream direction. The much greater variation in the downstream sites means that the difference between colour at DR25 and sites downstream is not statistically significant. Examination of the time series for these lower sites shows that there is a distinctly seasonal pattern of change with higher values during elevated winter flows and low values during the summer. No such seasonal change was apparent in the data from site DR25, indicating that there is a steady supply of dissolved organics to the river in the upper catchment.

The data for alkalinity has some similarities to that for colour, with low median concentrations at DR9 and DR11 and greater variability displayed by most other sites. Alkalinity at Coventry Creek (DR3) is very much higher than elsewhere in the catchment, reflecting the much higher concentrations of dissolved salts (see data for calcium in Figure 2.17 and sulphate in Figure 2.18) in this stream.

Alkalinity in White Water Creek is also elevated, relative to other sites in the catchment. With the exception of DR25 at the top of the catchment, sites in the Duck River (DR1, DR4, DR7, DR12 & DR20) all have very similar levels of alkalinity, and there is no downstream trend. The marked increase in alkalinity between site DR25 and DR20, along with the increased concentrations of calcium (Figure 2.17) and magnesium, tends to indicate the presence of dolomite in this part of the catchment.

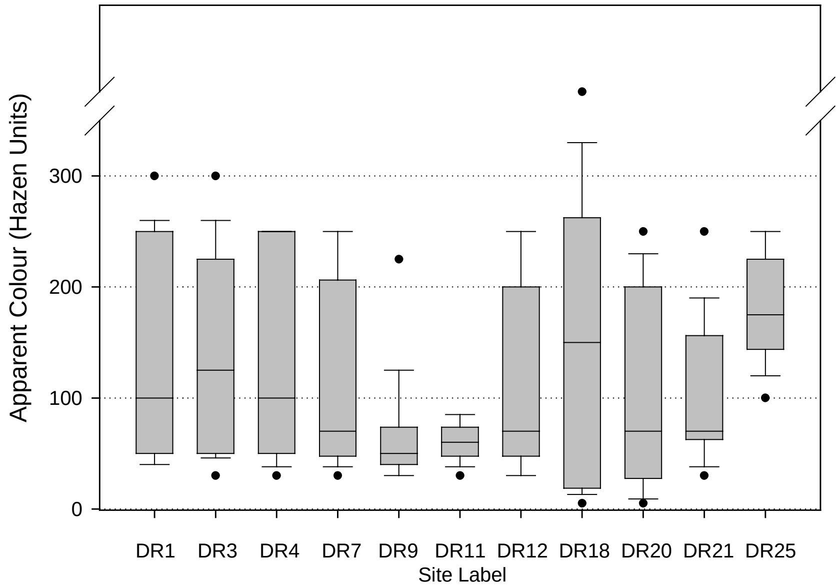

Figure 2.15: Statistical plot of apparent colour sampled quarterly (n = 13) at sites in the Duck catchment, between January 1999 and December 2001.

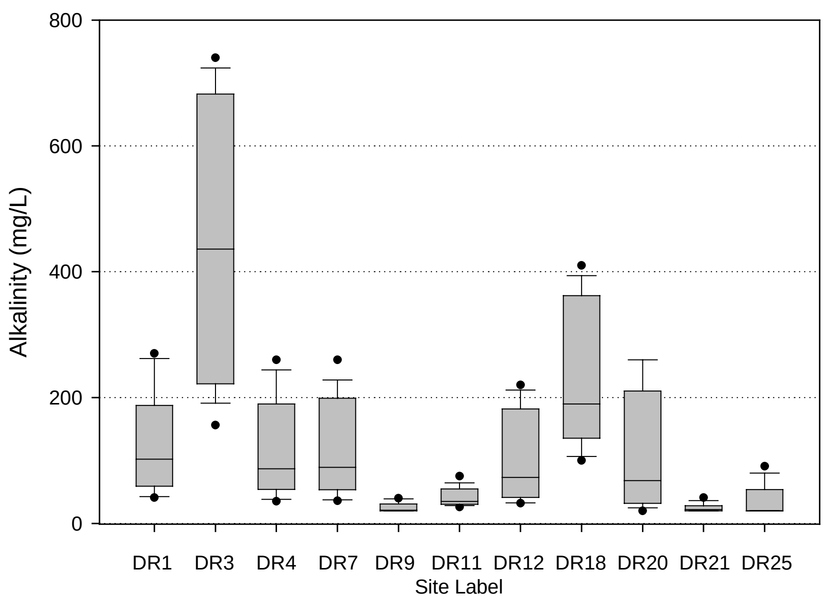

Figure 2.16: Statistical plot of alkalinity sampled quarterly (n = 13) at sites in the Duck catchment, between January 1999 and December 2001.

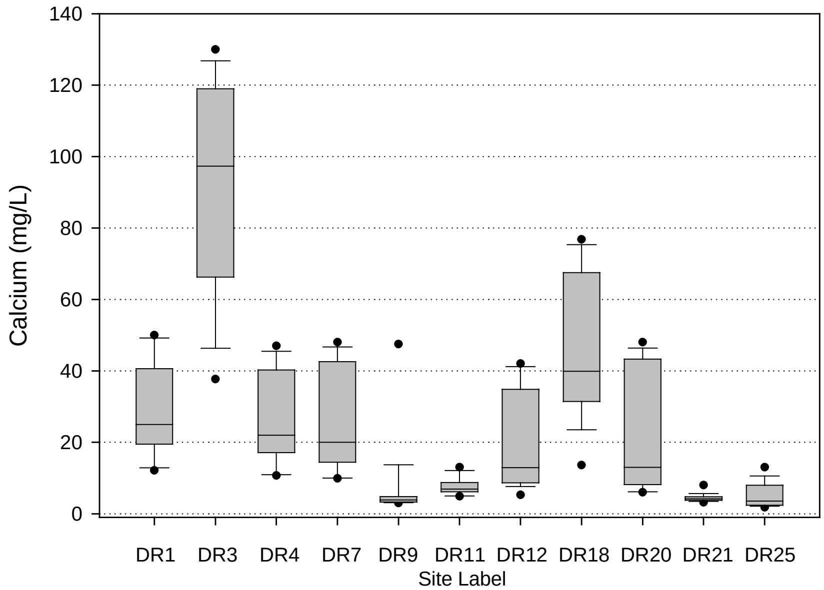

Figure 2.17: Statistical plot of calcium concentration sampled quarterly (n = 13) at sites in the Duck catchment, between January 1999 and December 2001.

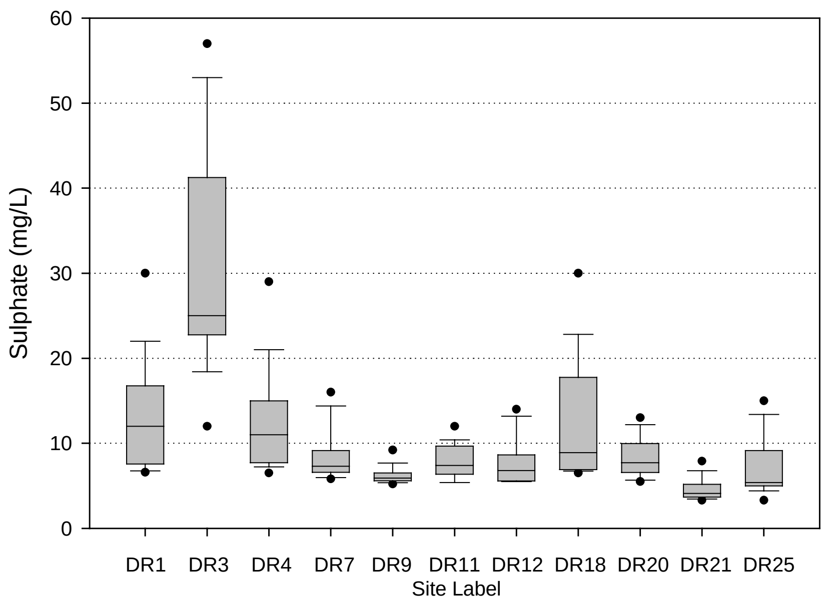

Figure 2.18: Statistical plot of sulphate concentration sampled quarterly (n = 13) at sites in the Duck catchment, between January 1999 and December 2001.

Iron concentrations throughout the catchment tend to be high in comparison to data collected from other rivers in Tasmania (Fuller and Katona, 1993). The median iron concentration at most sites in the Duck catchment are near to or above 1 mg/L (Figure 19), which has some implications for use of this water for domestic use.

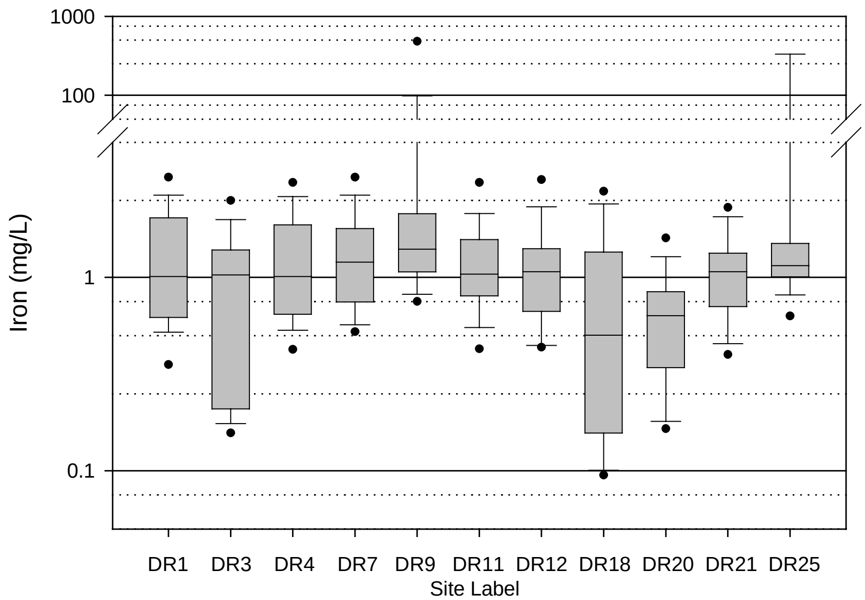

Figure 2.19: Statistical plot of iron concentration sampled quarterly (n = 13) at sites in the Duck catchment, between January 1999 and December 2001.

2.3 Nutrient Results

Monthly sampling for nutrients was carried out at a subset of 11 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 nitrate-N (NO_3-N), which generally forms the largest portion of dissolved nitrogen, total N (TN) and total phosphorus (TP). Where significant or unusual concentrations of other parameters have been recorded, specific mention may be made where these add to the discussion regarding water quality conditions at particular sites.

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 induced activities are less, baseline water quality tends to be more stable and concentrations of nutrients tends to be markedly lower. It is therefore important that water quality data is 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. Nitrate often varies on a seasonal basis (Bobbi. *et al.*, 1996), with higher concentrations generally occurring in winter when NO_3-N is leached from the soil profile by groundwater movement (Kladivko, *et al.*, 1991) and lower plant uptake (Neill, 1989; Wright, *et al.*, 1991). On the other hand, NO_2-N is generally only present in the natural environmental in measurable concentrations when there is some form of organic pollution (eg. sewage effluent discharge).

The data for monthly sampling of TN in the Duck catchment is presented in Figure 2.20. The median concentrations of TN at all sites exceed the National guidelines for Tasmanian rivers (0.5 mg/L) as stipulated in ANZECC 2000, and tend to reflect the high organic load of rivers in the catchment. The plot highlights Edith Creek (DR11) as having a significantly higher median TN concentration (1.47 mg/L), although elevated concentrations were also intermittently recorded at White Water Creek (DR18) and Coventry Creek (DR3). The much higher concentrations of TN found in Edith Creek are likely to reflect the level of intensive dairying that occurs in this area and the subsequent load of faecal pollution that enters this creek. This conclusion is supported by the TP data (Figure 2.22) as well as snapshot data collected on faecal coliform concentrations (see later section).

These data also show that there is a general trend for increasing median concentrations in a downstream direction in the Duck River. The median concentration of TN at sites in the upper catchment is about 0.6 mg/L, and this increases to about 0.9 mg/L at sites in the lower catchment. Downstream from DR20 there is also increased variability in TN concentrations at individual sites, with variability being greatest at sites located on tributaries (DR18, DR11 & DR3). This variability is more easily demonstrated in the time series plots in Figure 2.21, which compares monthly monitoring data from two sites on the Duck River with that from monitoring on Edith Creek. While all three sites show a clear seasonal pattern of change, which correlates approximately with river/streamflow, the scale of seasonal change at Edith Creek is clearly much greater. This seasonal variation appears to be driven by nitrate concentrations rather than changes in organic nitrogen concentrations (see next section).

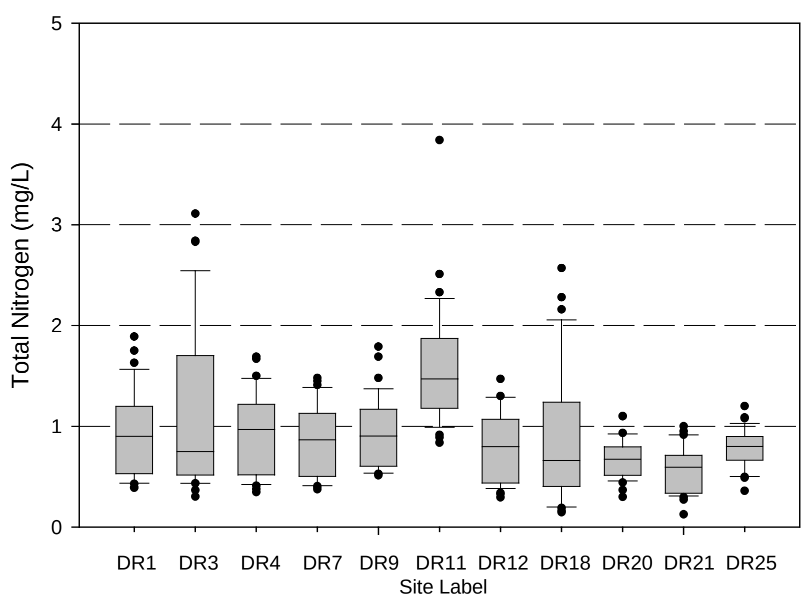

Figure 2.20: Statistical plot of TN concentration sampled monthly (n = 34) at sites in the Duck catchment, between January 1999 and December 2001.

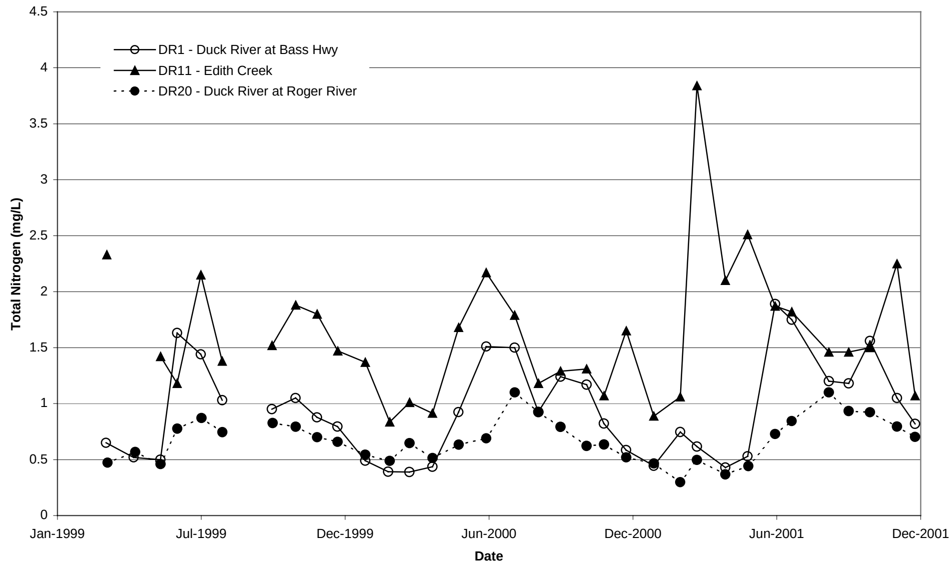

Figure 2.21 Time series plot of TN concentration at three sites in the Duck catchment (January 1999 – December 2001).

2.3.2 Nitrate-N

The spatial pattern for NO_3-N concentrations across the catchment is shown in Figure 2.22, and mirrors that of TN concentrations shown in Figure 2.20, with the minor exception of DR3 (Coventry Creek), where variability of NO_3-N concentrations is markedly higher. Once again, the median concentration at DR11 (0.645 mg/L) is significantly greater than most other sites and may be some indication of greater impact from fertiliser use in this part of the catchment. Comparison of median concentrations recorded in the Duck catchment with National guidelines for the protection of ecosystems (ANZECC, 2000) shows that concentrations in this catchment exceed recommended trigger levels for both upland and lowland rivers across all States (and including New Zealand). Concentrations in excess of 1.4 mg/L were recorded at Coventry Creek (DR3), Allen Creek (DR9) and Edith Creek (DR11).

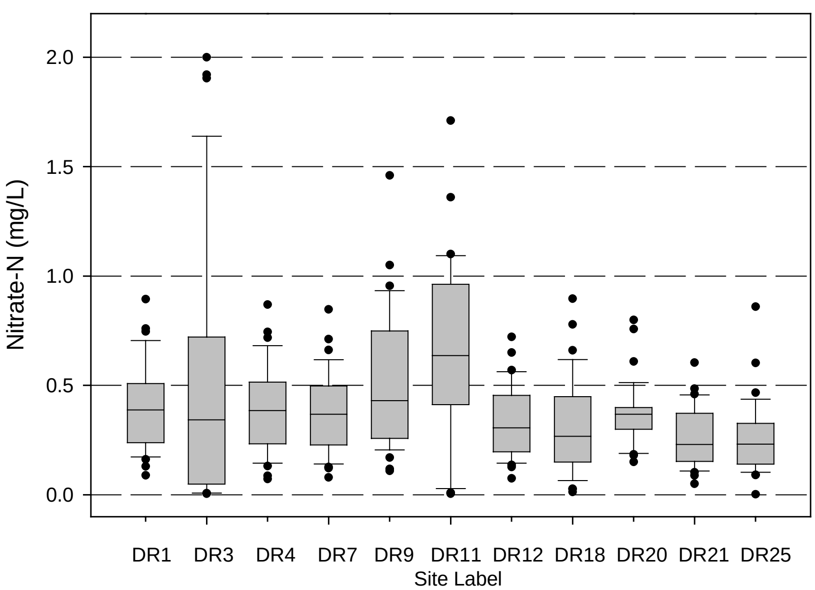

Figure 2.22 Statistical plot of NO_3-N concentration sampled monthly (n = 34) at sites in the Duck catchment, between January 1999 and December 2001.

The seasonal pattern of change in NO_3-N concentration was apparent at all monitoring sites and is much more pronounced than was shown by TN. Seasonal variation in the Duck River at DR1 and DR25 is shown in Figure 2.23, and these show that the magnitude of seasonal change tends to be greater at sites lower in the river. The other feature that can be seen in Figure 2.23 is the apparent 'lag' in the seasonal cycle at the headwater site (DR25). Peak NO_3-N concentrations at DR25 appear to occur later in winter than at sites lower downstream (as represented by DR1), and tend to be sustained at higher concentrations well into summer. This 'lag' is not easily explained, however the differences in land use (and resulting vegetation cover) may be a major factor. The catchment above DR25 has greater cover of native vegetation, which is likely to have a markedly different rate of nitrogen fixation and NO_3-N release to that of the catchment lower down, where forest removal and pasture management have created a vastly different system. Increased evapotranspiration rates, reduced soil water retention and the use of fertilisers are all important factors that would explain the greater concentration and different pattern of release of NO_3-N to waters lower in the catchment (Wright, *et al*., 1991).

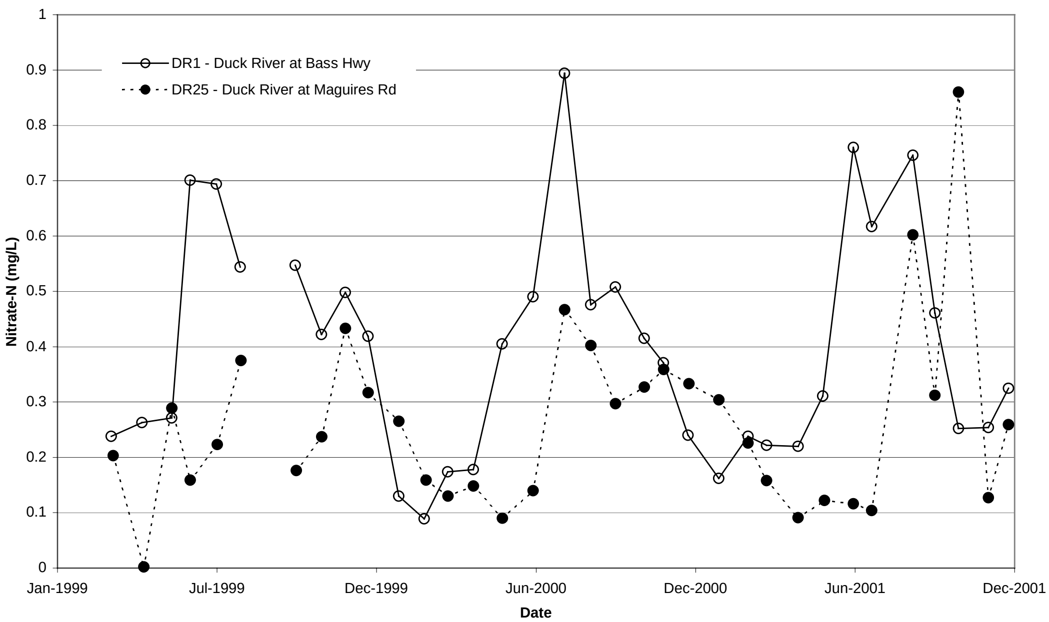

Figure 2.23 Time series plot of Nitrate-N concentration at two sites on the Duck River (January 1999 – December 2001).

2.3.3 Ammonia-N

Ammonia-N at the majority of sites in the Duck catchment was much higher than has been routinely measured in rivers elsewhere in Tasmania during previous 'State of Rivers' investigations. Ammonia is known to be toxic to aquatic biota at high concentration, and this toxicity increases with decreases in dissolved oxygen concentrations and higher pH (>8.0). The ANZECC 2000 guideline for protecting 'moderately disturbed' ecosystems is about 0.90 mg/L depending on pH. At sites DR3 and DR11 (Figure 2.24), ammonia-N concentrations in excess of 0.3 mg/L were recorded and combined with the periodically low DO and high pH recorded at both these sites, is likely to cause periodic stress to the aquatic biota inhabiting these two locations. A single very high concentration (1.83 mg/L) was recorded at Edith Creek (DR11), and this is likely to have had a severe impact on aquatic biota.

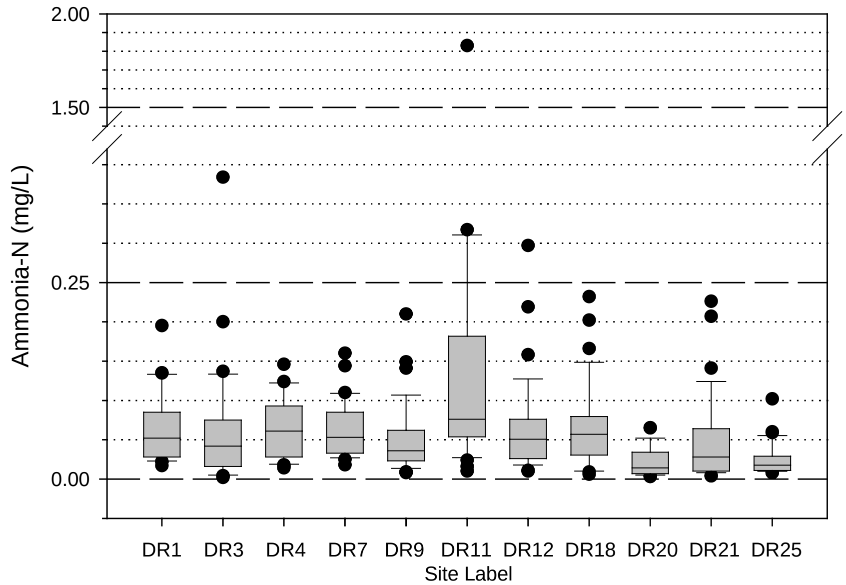

Figure 2.24 Statistical plot of ammonia-N concentration sampled monthly (n = 34) at sites in the Duck catchment, between January 1999 and December 2001.

2.3.4 Total Phosphorus

Phosphorus in the freshwater environment is derived from natural processes such as the fall of leaf litter and chemical weathering, however in catchments where there are significant human-related activities this can be dwarfed by inputs from both diffuse sources (fertiliser use and stock grazing) and point sources (sewage effluent discharge and urban runoff). Phosphorus exists in water in both the dissolved and particulate forms. The main forms of dissolved phosphorus include inorganic orthophosphates, polyphosphates and organic colloids, while particulate phosphorus is usually bound to complex organic compounds such as proteins or adsorbed to suspended material such as clays and organic detritus (dead and decaying plant and animal matter). A significant increase in the concentrations of this important plant nutrient in freshwaters generally has the effect of causing prolific growth of aquatic plants (algal and macrophyte), which in turn have indirect impacts on aquatic ecosystems (UNESCO, 1992).

Figure 2.24 shows the concentration of TP at monthly monitoring sites in the Duck catchment during 1999-2001. The median concentration of TP throughout the catchment is generally higher than other predominantly agricultural catchments in Tasmania that have been investigated under the 'State of Rivers' program (Bobbi, *et al.*, 1996; Bobbi, 1997; Bobbi, 1999a; Bobbi, 1999b; Bobbi, 1999c: Bobbi, 1999d). Comparison of these data with data from the Meander catchment, where similar (though less intense) levels of agricultural activity occur, shows that TP concentrations in the Duck catchment are generally more than double those in the Meander catchment.

Figure 2.25 also shows that sites higher in the catchment (DR20, DR21 and DR25) have markedly lower concentrations of TP than most sites lower down in the catchment. These are likely to represent probable 'natural' baseline concentrations of TP in rivers of the catchment in the absence of agricultural activity, and may be useful targets for any future management to improve water quality. Of the 8 sites downstream from Roger River, 5 sites exceed the most lenient trigger (0.055 mg/L) for lowland rivers in Australia (ANZECC, 2000) and 11 sites exceed recommended trigger levels for Tasmanian rivers.

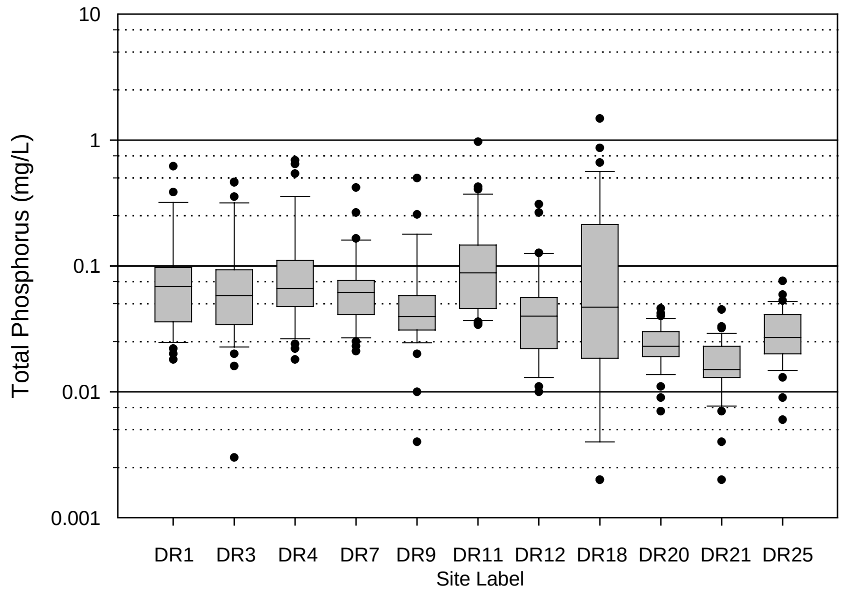

Figure 2.25 Statistical plot of Total P concentration sampled monthly (n = 34) at sites in the Duck catchment, between January 1999 and December 2001.