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

Tasmania

Water Quality of Rivers in the North Esk 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 following water quality data was collected between January 1999 and December 2000. The main aim of sampling in the North Esk catchment was to collect current data on the ambient quality of water and report on background conditions in the river system. This data, when viewed along with land use and river condition information, should assist in identifying sites or areas which could be targeted for remediation activities or a different management approach in the future. The collection of data was carried out at several levels. Monthly visits were undertaken at thirty-three sites (Figure 1.0) to determine the physico-chemical nature of water quality. The location and grid references of these sites is listed in the Table 2.1. Due to the costs associated with laboratory analysis, sampling for nutrients was carried out monthly at a subset (7) of these sites. Sampling for dissolved salts and general ionic composition was performed at these seven sites on a quarterly basis.

The second level of sampling involved two catchment-wide snapshot surveys whereby all sites monitored where also sampled for major nutrients, heavy metals and faecal bacteria. The third 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 North Esk River at Ballroom. At this site, turbidity, conductivity and temperature are monitored on a continuous basis. 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 (measured in units of mg/L and converted to percentage saturation). 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 parameters;

- Laboratory pH
- Laboratory Conductivity (μScm^{-1})
- Colour Apparent (Hazen Units)
- Total Dissolved Solids
- Total Suspended Solids
- Hardness ($CaCO_3$)
- Total Alkalinity (to pH 4.5 as $CaCO_3$)
- Chloride (Cl)
- Flouride (F)
- Sulphate (SO_4)
- Iron (Fe)
- Manganese (Mg)
- Calcium (Ca)
- Magnesium (Mg)
- Potassium (K)
- Sodium (Na)
- Silica (SiO_2) (Molybdate Reactive)

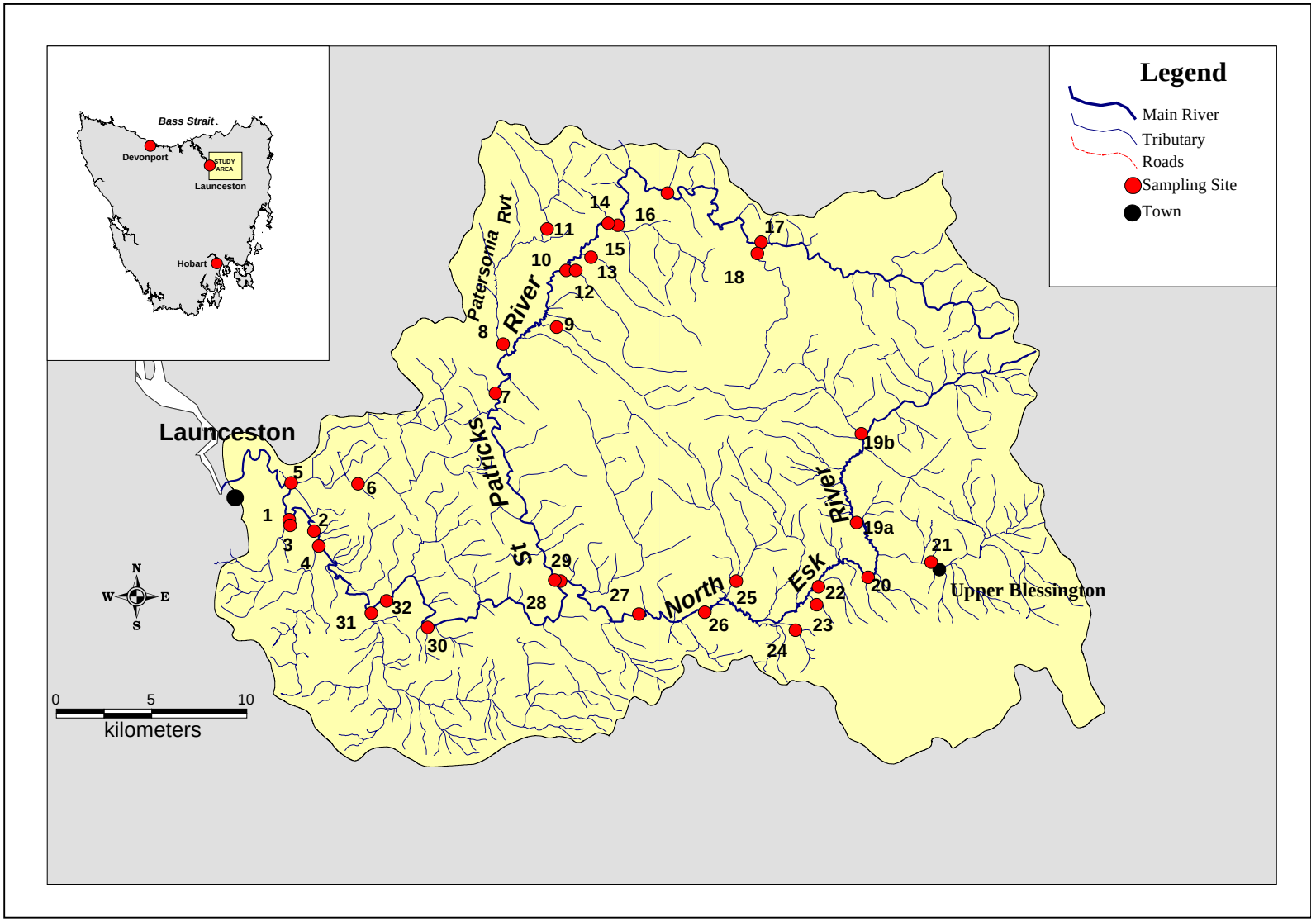

Figure 1.0: Locations of sites monitored monthly in the North Esk Catchment 1999 – 2000.

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

Site Name	Code	Easting	Northing
North Esk River d/s of Kings Meadows Rivulet	NE 1	514200	5411100
North Esk River d/s Norwood wastewater treatment plant	NE 2	515500	5410500
Kings Meadows Rivulet at Punchbowl	NE 3	514250	5410800
North Esk River upstream of Clarks Ford Bridge and riffle	NE 4	515750	5409700
Distillery Creek u/s of the North Esk River	**NE 5**	514300	5413050
Distillery Creek upstream of the filtration plant	NE 6	517800	5413000
St Patricks River at Nunamara	NE 7	525000	5417800
Patersonia Rivulet at Patersonia Road	NE 8	525400	5420400
Coquet Creek at Tasman Highway (Trout Ck)	NE 9	528200	5421300
St Patricks River at Pecks Hill Road	NE 10	528700	5424300
Patersonia Rivulet at Targa Hill	NE 11	527700	5426500
Barrow Creek at Tasman Highway	**NE 12**	529200	5424300
Bennies Creek at Tasman Highway	NE 13	530000	5425000
St Patricks River at Targa Hill Road	NE 14	530900	5426800
Seven Mile Creek at Tasman Highway	NE 15	531400	5426700
St Patricks River at Corkerys Road	**NE 16**	534000	5428400
St Patricks River at East Diddleum Road	NE 17	538900	5425800
Camden Rivulet at Diddleum Road	NE 18	538700	5425200
North Esk River off Camden Road	NE 19a	543900	5410950
North Esk River at Phillps Road	NE 19b	544150	5415650
North Esk River at Camden Road	**NE 20**	544500	5408050
Ford River at Upper Blessington	NE 21	547800	5408850
North Esk River at Burns Creek Road	NE 22	541900	5407550
River O'Plain Creek at Blessington Road	NE 23	541800	5406600
Old Mill Creek at Blessington Road	NE 24	540700	5405250
Musselboro Creek upstream of the North Esk River	NE 25	537600	5407850
North Esk River at Musselboro Road	NE 26	535950	5406200
North Esk River at Ballroom	**NE 27**	532500	5406100
North Esk River u/s of the St Patricks River	NE 28	528400	5407850
St Patricks River u/s of the North Esk River	**NE 29**	528100	5407900
North Esk river at White Hills	NE 30	521450	5405400
Rose Rivulet above Patersons Island	NE 31	518500	5406150
North Esk River at Corra Linn	**NE 32**	519300	5406800

2.1 Physico-chemical properties

2.1.1 Water Temperature

Water temperature at all monthly monitored sites showed a distinct seasonal pattern as illustrated from continuous temperature records at North Esk River at Ballroom (Figure 2.1.1). Temperatures ranged from a winter average of 6.5 °C to a summer average of 16.8°C. Highest maximum summer temperatures of 29°C and 28.3°C were recorded at Old Mill Creek at Blessington Road (NE24). This site also recorded the highest median temperature compared to all other sites sampled. Old Mill Creek runs predominantly through pasture where there is little to no riparian vegetation. Lack of shading combined with low water levels contributed significantly to the higher temperatures recorded at this site.

During winter, water temperature at sites in the upper catchment of the North Esk and St Patricks Rivers was generally 1°C to 2°C cooler compared to sites lower in the catchment. During the height of summer, this difference increased to 6°C to 8°C. Figure 2.1.2 illustrates the difference in seasonal variation of temperature in the upper North Esk River at Phillips Road (NE19b) and the North Esk River downstream of the confluence of Kings Meadow Rivulet (NE 1).

A seasonal duration analysis has been used to summarise the time series data for water temperature recorded by the in-situ probe at North Esk River at Ballroom (NE 27) for the entire length of record from 1996 to 2001 (Table 2.1.1). Duration analysis partitions data according to the percentage of time spent within a defined range. The results show that during the winter months of July and August, water temperature is less than 5°C for more than 40% of the time, while during the hotter months of summer (January to February), water temperature is in excess of 20°C approximately 16% of the time.

Table 2.1.1: Seasonal duration analysis for water temperature (°C) in the North Esk River at Ballroom based on the entire length of time series data (1996 to May 2001- 1870 days) as recorded from an 'in situ' monitoring device.

Bounds	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct	Nov-Dec
0.0 to 5.0	0.0	0.0	19.1	40.1	0.8	0.0
5.0 to 10.0	0.1	23.7	77.0	59.5	69.1	7.1
10.0 to 15.0	12.9	54.5	3.9	0.4	29.3	54.4
15.0 to 20.0	71.2	21.4	0.0	0.0	0.7	37.6
20.0 to 25.0	15.8	0.4	0.0	0.0	0.0	1.0
>= 25.0	0.0	0.0	0.0	0.0	0.0	0.0

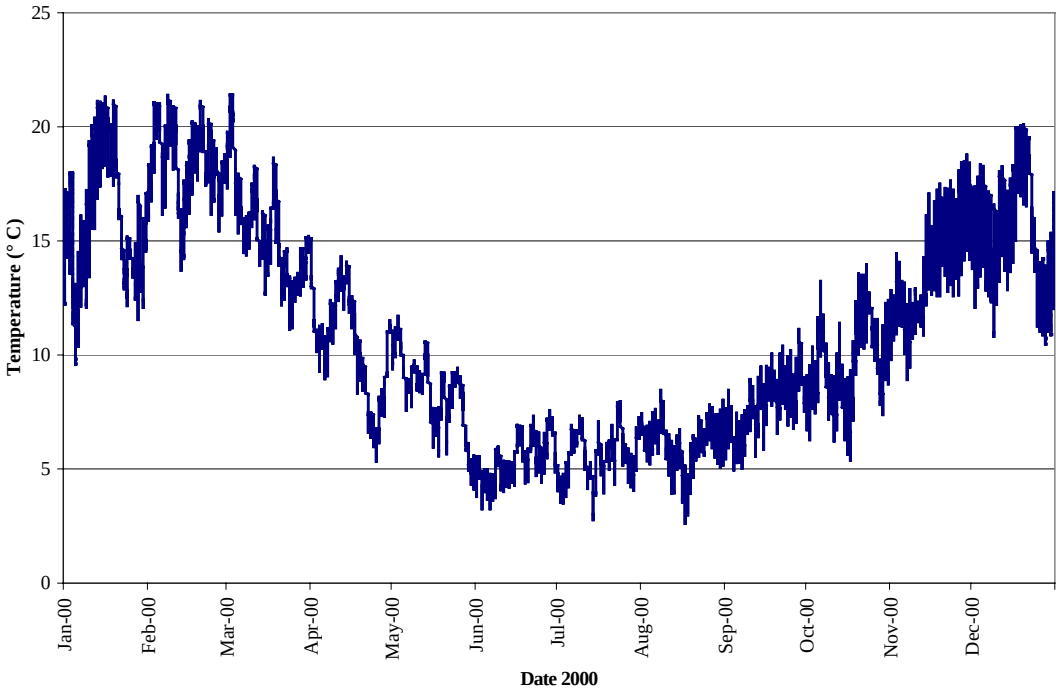

Figure 2.1.1: Seasonal change in water temperature in North Esk River at Ballroom as recorded by 'in situ' water quality monitoring equipment during 2000.

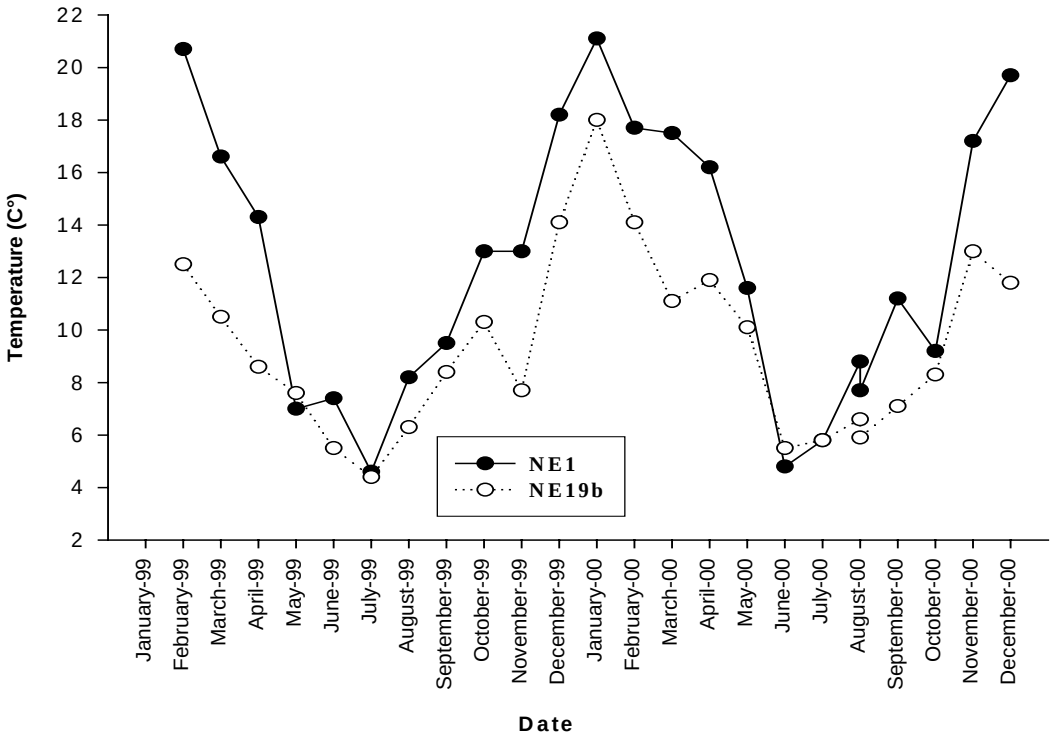

Figure 2.1.2: Comparison of temperature (C°) between bottom of catchment, North Esk River downstream of the confluence of Kings Meadows Rivulet (NE1) and top of catchment, North Esk River at Phillips Road (NE 19b).

2.1.2 In-stream pH

Instream pH values are strongly influenced by a variety of factors relating to biological and atmospheric processes, catchment geology, soil chemistry, vegetation and land use practices (Cresser & Edwards, 1988). The degree to which these factors affect pH and its buffering capacity against changing environmental conditions are inter-related with levels of acidity and alkalinity (UNESCO, 1992). Waters of low alkalinity (< 24 ml 1^{-1} as CaCO3) have a lower buffering capacity and are therefore more susceptible to fluctuations in pH. In naturally dilute waters where buffering capacity is limited pH can vary substantially as a result of biological and atmospheric processes (UNESCO, 1992).

As the following sections will show, rivers throughout the North Esk catchment are relatively dilute with low concentrations of dissolved mineral and salts (carbonates, calcium, sodium, magnesium etc). Also representative of dilute waters is the relative absence of carbonate and bicarbonate ions which is reflected by low alkalinity levels. These waters by nature have a very low buffering capacity and can display reasonably large fluctuations in pH levels.

Analysis of the data from monthly monitoring reveals that median pH levels in the catchment varied between 6.6 and 7.8 (Figure 2.1.3). The lowest median pH was recorded at Patternsonia Rivulet (NE 11), and the highest median pH (7.85) was recorded at Rose Rivulet (NE31) low down in the catchment. The very low value (pH 4.5) recorded at North Esk River at Museselboro Road (NE26) may indicate the influence of the Holocene sediments in that region, which can cause low pH during periods of low baseflow. Rose Rivulet (NE 31) drains a region extensively cleared for agriculture, and while no data for hardness, calcium, or other ions was collected at this site, the high conductivity recorded at this site indicates that there are increased levels of dissolved minerals and salts relative to other sites. The local geology of the region as (discussed in 2.1.3) also supports the previous comment. Though a pH value of 7.8 does not warrant concern, further investigations at this site could include analysis of the before mentioned parameters.

Seasonal fluctuations of pH in rivers is a natural phenomenon and has been observed in other Tasmanian rivers (Bobbi, 1999b), but appears to be less marked in rivers of the North Esk catchment. Samples taken during the snapshot surveys (Section 2.4) in July 1999 and January 2000 did show that there is a broad difference between the winter and summer of about 2 pH units. Reasons for the lower pH values in winter are likely to relate to the low buffering capacity of waters in the North Esk catchment combined with increased rainfall. It is also important to note that the underlying geology of the headwaters of both the St Patricks River and North Esk River consists mainly of Devonian granite and this can be potentially acid forming under weathering processes. Thus an increase in runoff during the wetter months of winter may contribute to a lowering of pH in these rivers.

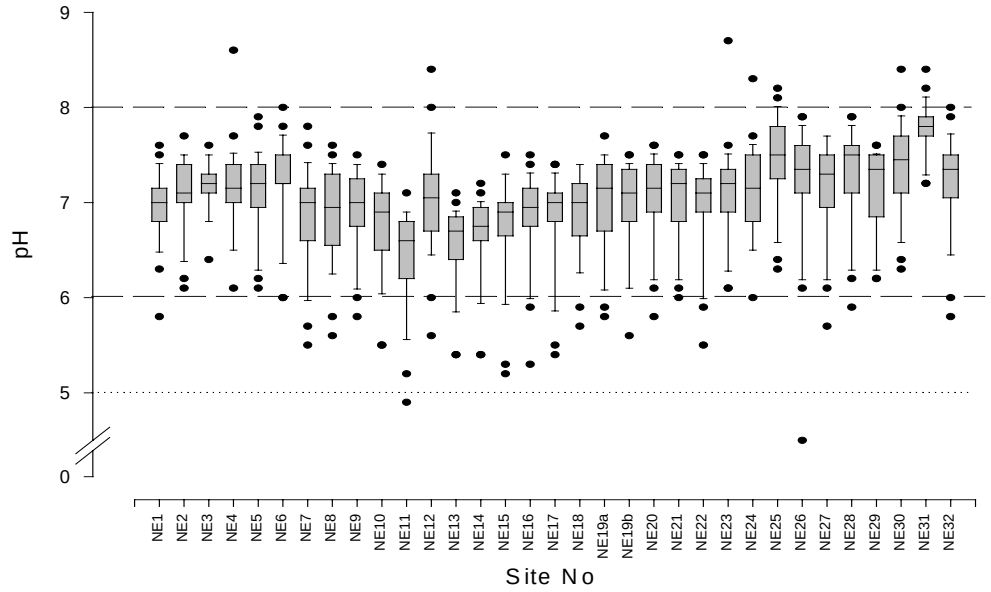

Figure 2.1.3: Boxplot showing pH variations of monthly monitoring across all sites in the North Esk catchment. Note: 50% of the data range lies between pH 6 and pH 8.

2.1.3 Electrical Conductivity

Electrical conductivity at the majority of sites was low (between 50µS/cm and 70µS/cm) reflecting the dilute nature of rivers in this catchment. Comparison of the data from both the St Patricks River and North Esk River above their confluence show that waters in the St Patricks River are slightly more dilute (Figure 2.1.4). Conductivity progressively increases downstream, a feature that is common in many unregulated Tasmanian rivers (Bobbi, 1999a, 1999b, 1999c, 1999d). During periods of low flow, when ground water sustains river levels (ie. summer periods) conductivity in the river usually increases. Time series data obtained by an in-situ probe in the North Esk River at Ballroom (NE27) shows that dilution occurs during and following rainfall – runoff events in the upper North Esk River (Figure 2.1.5).

Conductivity of water throughout the North Esk catchment is suitable for irrigating most crops, however three sites stand out as having medium (280µS/cm-800µS/cm) to high (800µS/cm-2300µS/cm) levels of salinity (ANZECC, 1992) which may require some form of salinity management. Two of the three sites are located in the lower end of the catchment and may not be a significant source of irrigation water. These sites are Kings Meadows Rivulet (median = 1691µS/cm) and Rose Rivulet (median = 1548µS/cm). The elevated salt concentrations at both these sites can be partially explained by the underlaying geology of the area, which consists of Tertiary sediments that have high levels of exchangeable sodium and magnesium. Extensive clearing for agricultural purposes in Rose Rivulet catchment and the effects of urbanisation and stormwater runoff in Kings Meadows Rivulet will have further contributed to the high salinity in these sub-catchments.

The conductivity recorded at Old Mill Creek (NE24) is appreciably higher compared to all other sites in the middle catchment area. Analysis of these data shows that NE24 recorded a distinct increase in conductivity levels immediately following channel modifications in mid-1999 (Figure 2.1.6). This suggests that there was some mobilisation of mineral salts from the

soil profile at this site due to improved drainage of the surrounding land. However as these modification occurred during the early stages of this program, it is difficult to determine what the pre-modification values were.

Duration analysis for conductivity at North Esk River at Ballroom (NE27) from data gained by the in-situ conductivity probe reflects measurements taken during monthly field trips. These data support earlier comments that water in this region of the catchment is dilute with conductivity levels generally below 70µS/cm (Table 2.1.2). Comparisons at this site made between the entire period of record (1997- 2000), shows that conductivity at Ballroom is spending an increasing percentage of time between 50µS/cm to 70 µS/cm (Table 2.1.3).

Table 2.1.2: Duration analysis for the North Esk River at Ballroom (Total length of record).

Value Range	% Time Within Range	
	Total Record	1999/2000 Data
0 to 50 (µS/cm)	2.316	2.627
50 to 70 (µS/cm)	60.437	68.066
70 to 100 (µS/cm)	36.896	28.967
100 to 150 (µS/cm)	0.343	0.339
>= 150 (µS/cm)	0.007	0

Table 2.1.3: Yearly Duration Analysis for the North Esk River at Ballroom 1997 –2000.

Value Range	% Time Within Range			
	1997	1998	1999	2000
0 to 50 (µS/cm)	1.276	4.688	2.295	2.959
50 to 70 (µS/cm)	48.064	62.321	65.074	71.051
70 to 100 (µS/cm)	50.360	32.951	32.072	25.871
100 to 150 (µS/cm)	.300	0.037	0.56	0.119
>= 150 (µS/cm)	0	0.002	0	0

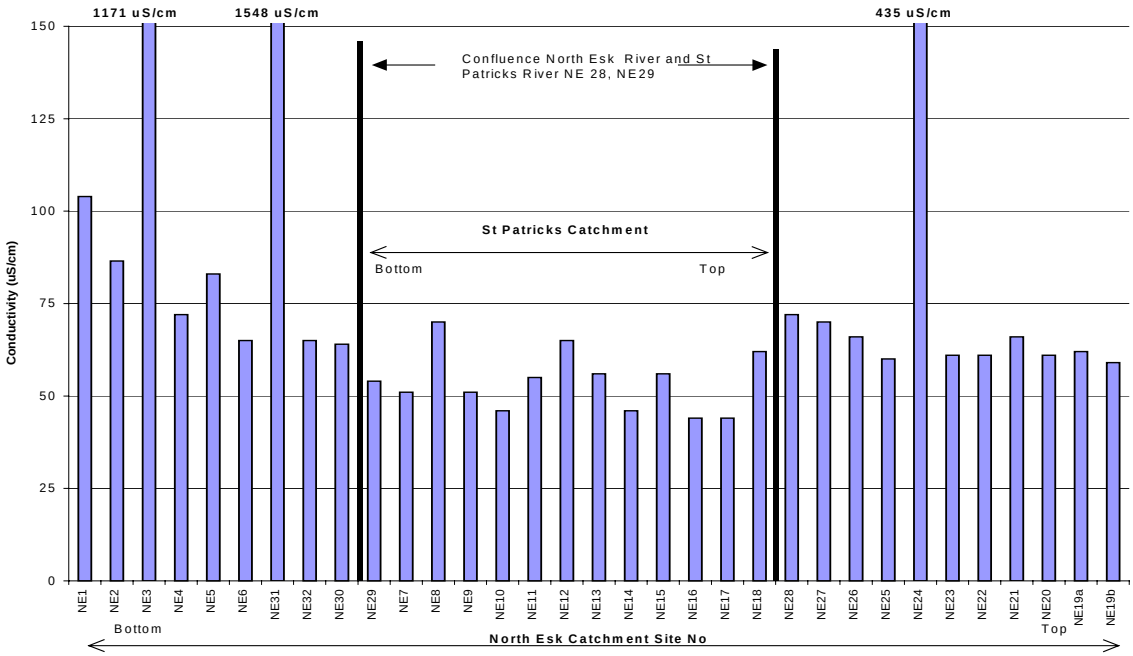

Figure 2.1.4: Median conductivity levels in the North Esk catchment. Note: NE28 (North Esk River) and NE29 (St Patricks River) are both upstream of the confluence of these two rivers.

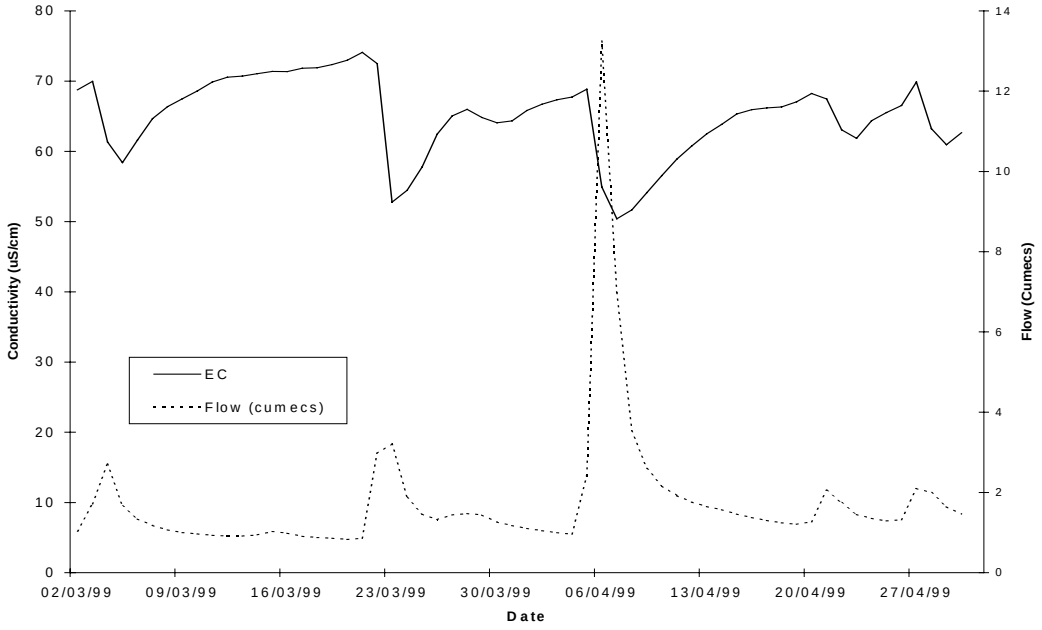

Figure 2.1.5: Time series showing changes in daily flow and conductivity in the North Esk River at Ballroom during March/April 1999. NOTE: conductivity is temperature compensated to 25°C.

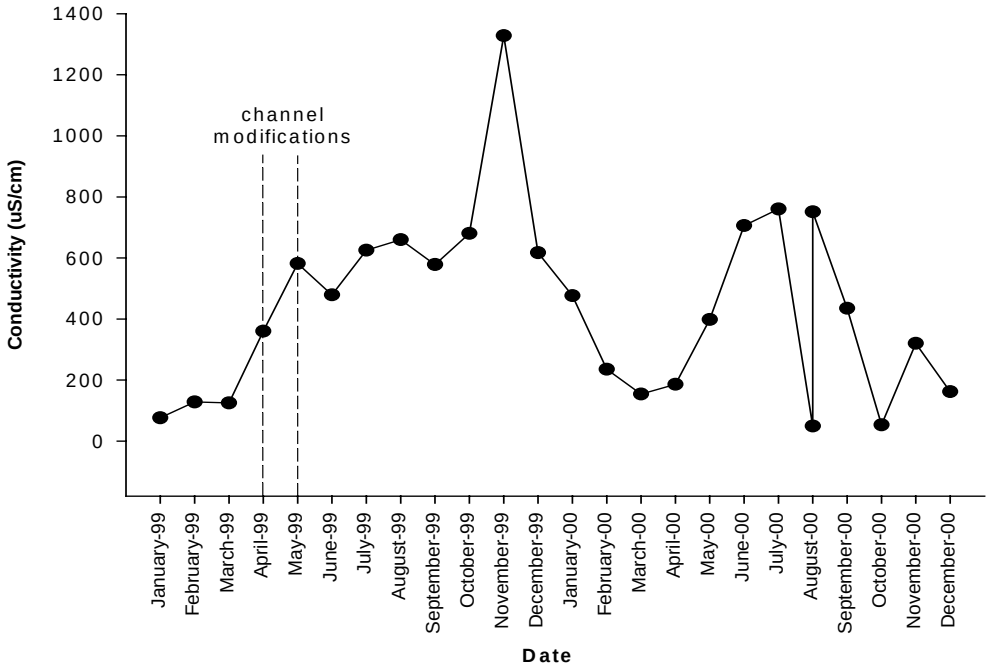

Figure 2.1.6: Conductivity levels at Old Mill Creek (NE 24) between January 1999 and December 2000. NOTE: Two dashed parallel lines denote the time period when channel modifications occurred.

2.1.4 Turbidity

Turbidity is an indicator of the amount of suspended material in the water column. When establishing 'baseline' turbidity levels it is important to avoid sampling during periods of heavy rainfall or following a rainfall event when higher velocities in the river actively erode stream banks. Separate sampling during 'flood' events was undertaken to compare turbidity

levels to 'normal' conditions in the river. This is useful for determining export loads and in showing how sediment levels in the rivers increase during periods of runoff. This shall be discussed in Section 2.5.

In the North Esk catchment major land uses include farming and forestry. Major sources of turbidity are most likely to originate from stream bank erosion and erosion from surrounding slopes and paddocks. In some sections of the North Esk catchment, erosion is likely to be exacerbated by stock access to waterways and soil disturbance due to cultivation, land clearance and drainage line modifications.

Water clarity in the North Esk catchment is generally reflective of a healthy system with median levels usually below 5NTU (Figure 2.1.7). During high flow events turbidity levels in the rivers were elevated particularly in the upper St Patricks River and at sites around North Esk River at Ballroom (ie. NE26, NE27) where run off from surrounding paddocks and ploughed sections of land appears to have increased sediment input into the waterways. Upper catchment sites in both the St Patricks River and North Esk River generally had lower turbidity levels compared to bottom catchment sites. This is likely due to a greater percentage of riparian cover of stream side zones in the upper catchment and hence greater bank stability in these areas (refer to the Index of River Condition Section of this report).

Within the St Patricks catchment, Patersonia Rivulet at Patersonia Road (NE8) and Barrow Creek at Tasman Highway (NE12) both exhibited higher median levels of turbidity compared to other sites sampled within the catchment. These sites are located downstream of agricultural regions where the percentage of riparian vegetation stabilising stream bank sides was also found to be very low (Index of River Condition).

Similar patterns can also be seen on the North Esk River where sites of relatively higher turbidity can be found in areas classified as either highly modified or having had major modification (ie. NE3 - Kings Meadows Rivulet at Punchbowl; and NE24 - Old Mill Creek at Blessington Road). The higher median level in Kings Meadows Rivulet (9.62 NTU) is most likely due to storm water runoff from the Launceston area.

During May 1999 it was observed that Old Mill Creek, which runs predominantly through agricultural pasture, was deepened and straightened. The impact this disturbance had on water quality was detected in the May sampling round where a turbidity level of 85.8 NTU was recorded compared to pervious runs of 13.3 NTU and 6.15 NTU. Unfortunately this disturbance occurred early during this monitoring program and therefore it cannot be confidently determined what the base levels previously were at this site. However, turbidity at Old Mill Creek was the highest in the North Esk catchment with a median value of 19.1 NTU. During high flow events this site appears to have contributed significantly to downstream turbidity levels. This shall be discussed in Section 2.5.3.

While an effort was made during monthly sampling to avoid higher flow events, several small events during 1999 and 2000 made this difficult. This resulted in higher than expected turbidity levels at some sites. These include those in the upper St Patricks catchment during October 1999 and May 2000 (Figure 2.1.8). An increase in turbidity levels at St Patricks River at Corkerys Road (NE16) and St Patricks River at East Diddleum Road (NE17) during the monthly sampling program are likely due to soil disturbance from vegetation clearance in plantation areas upstream in the Diddleum Plains area. These effects appear to have been short-lived as these sites generally maintained low turbidity with median values of 2.42 NTU and 2.26 NTU respectively. This contrasts markedly with Old Mills Creek (NE24) where drainage line disturbance clearly has a longer-term impact.

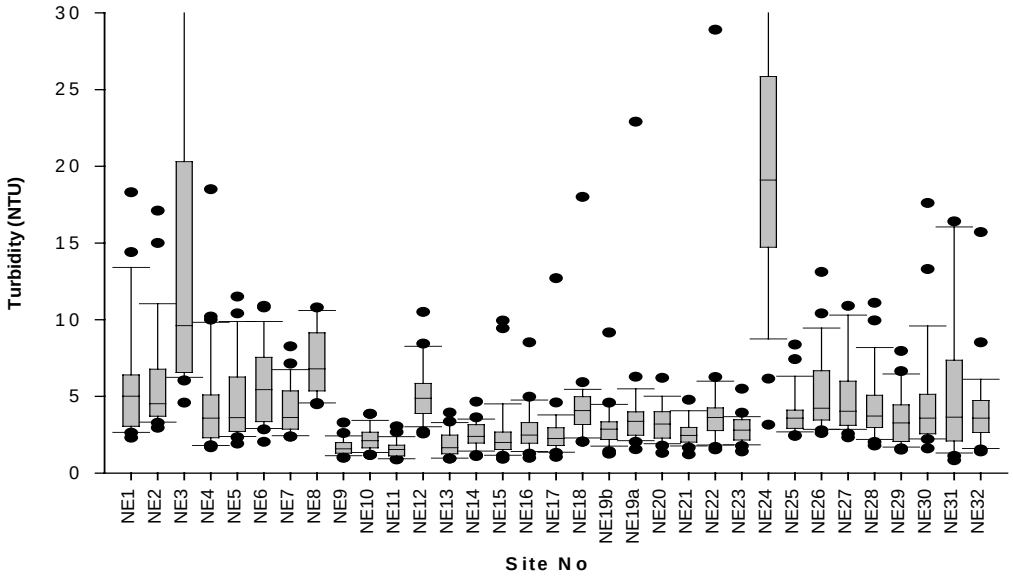

Figure 2.1.7: Statistics of monthly turbidity at sites in the North Esk catchment January 1999 to December 2000.

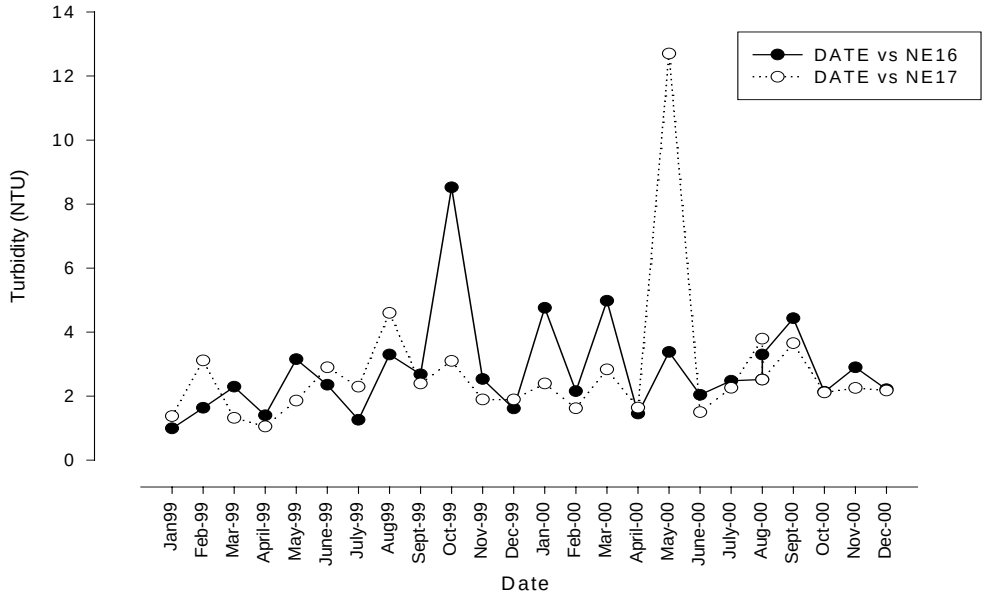

Figure 2.1.8: Monthly change in turbidity levels at two sites in the upper St Patricks catchment recorded during monitoring visits in 1999 and 2000.

2.1.4 Dissolved Oxygen

Dissolved oxygen is a parameter commonly used to indicate the health of an aquatic ecosystem. A decline in dissolved oxygen concentration is often the first sign of stress in an aquatic environment and should be prevented where possible. Low levels of dissolved oxygen reduce the physiological efficiency of fish and aquatic invertebrates (ANZECC, 1992). Limited data in Australia exists regarding tolerance of fish and aquatic invertebrates to low dissolved oxygen. A review on freshwater fish in Victoria (Koehn and O'Connor, 1990) suggests that dissolved oxygen levels below 5mg/L can be stressful to many fish species. The

1992 ANZECC guidelines recommended that levels of dissolved oxygen not be permitted to fall below 6mg/L or 80% to 90% saturation. The newly released 2000 ANZECC guidelines (refer section B) recommend a default trigger level of <90% or >110% saturation for substantially natural and slightly disturbed ecosystems.

Monthly dissolved oxygen concentrations in the North Esk catchment were measured using hand held probes employing membrane diffusion along with silver/gold anode for oxygen detection. At all sites, oxygen was measured in flowing water, avoiding backwaters as this can result in inaccurate readings. Median dissolved oxygen concentration at all sites were between 79% saturation (8.25mg/L) and 100% saturation (11.25mg/L). Analysis of these data (Figure 2.1.9) shows that median levels for the majority of sites falls between the optimal recommend trigger level of 90% and 110% saturation. This is with the exception of Rose Rivulet above Patersons Island (NE31), which had a median level of 79% (8.25mg/L), minimum level of 26% (1.1mg/L) and maximum level of 122% (13.5mg/L). Further analysis of the data shows that for approximately 68% of the sampling period, Rose Rivulet was below 90% saturation. This site was prone to low flows and high levels of organic input that would in part explain the low dissolved oxygen concentrations experienced at this site.

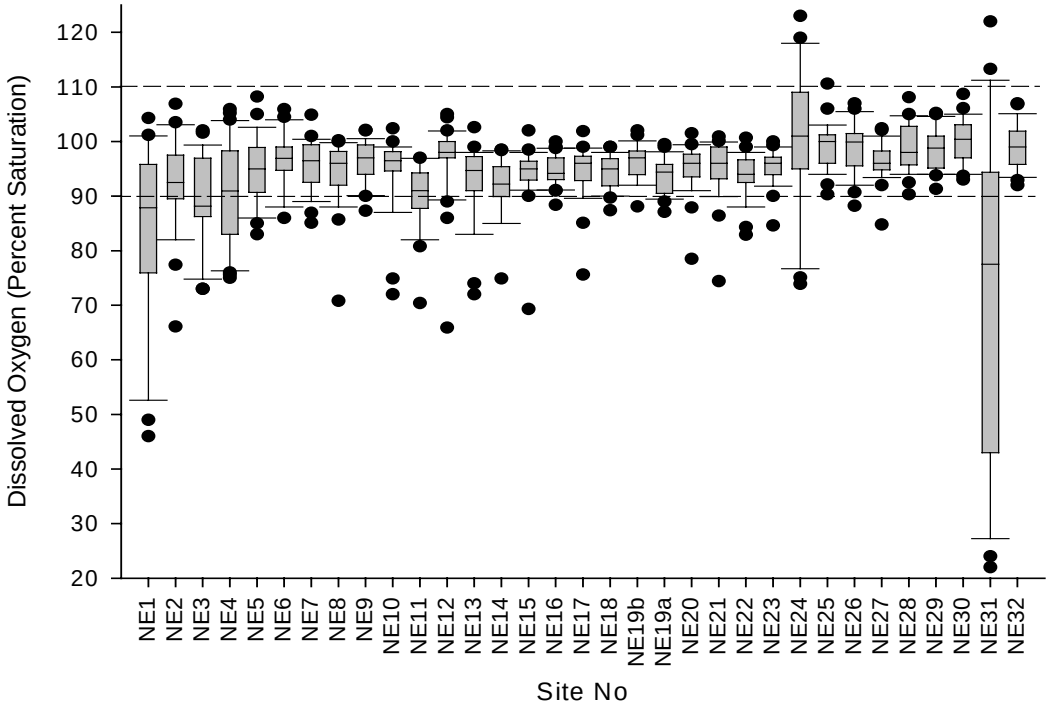

Figure 2.1.9: Statistics of monthly oxygen concentrations at all sites between January 1999 and December 2000.

North Esk River downstream of Kings Meadows Rivulet (NE1) also showed low oxygen levels that are likely to be detrimental to aquatic health. For approximately 56% of the sampling period dissolved oxygen concentration at this site was below 90% saturation with a minium level of 54.7% (4.4mg/L) recorded during February 2000. At the time of this study, this reach of the North Esk River was heavily infested with Crack Willow (*Salix fragilis)*. As a deciduous species it has been widely acknowledged that willows contribute significant amounts of organic material into streams over a short period of time (Lester 1992), in contrast to native species which contribute a relatively continuous input of leaf material. Past studies in Tasmanian streams (Bobbi *et al*, 1999b and Bobbi, 1999e) have shown how depressed oxygen concentrations often develop within willow stands. Low concentrations of dissolved oxygen were attributed to low summer flows and the bacterial breakdown of accumulated

organic material in willow infested reaches. In addition it was also suggested that total canopy cover restricts photosynthetic activity that may contribute oxygen to surface waters. Nutrient levels have also been found to be elevated in willow infested areas where the root mass of the willows act as an effective trap for sediments and organic material and act as a storage for nutrients (Bobbi, 1999e).

Higher dissolved oxygen concentrations throughout the rest of the catchment typically occurred during winter flows when cooler water temperatures and higher turbulent flows increase levels of dissolved oxygen in the water. Two out of the three sites recorded greater than 110% during autumn and spring. These were Musselboro Creek 110.6% (NE25) and Rose Rivulet 122% (NE 31). Abundant instream algae and aquatic plants at NE31 may explain the high oxygen content recorded at this site.

Old Mill Creek at Blessington Road (NE24) recorded the highest concentration of 123% in January 2000 (Section 2.4.2). Further analysis of this site shows that after heavy modification of its channel (refer Section 2.1.3) seasonal oxygen concentrations did not generally follow low summer and high winter values as seen in other areas of the catchment. Following disturbance at this site, observations suggest that macrophyte (namely Cumbungi - *Typha spp*) density increased dramatically. Photosynthetic activity from instream flora would greatly contribute to the elevated dissolved oxygen concentrations at this site, particularly during the longer daylight hours in summer. It is also possible that the respiratory activity at night, which generally reduces oxygen levels (Refer Section 2.6), were dampened at this site .

2.2 General Ionic Composition

The chemical constituents of soils and underlying geology influence the ionic composition of river water. Where water flows through a limestone landscape it can be expected that the ionic character of the water will generally have a higher concentration of calcium and magnesium and therefore a higher hardness and alkalinity. Where water drains through a predominantly dolerite landscape, it will generally have lower amounts of dissolved salts while iron and silica may be more elevated (Bobbi, 1999d). Water that drains through a landscape dominated by Tertiary sediments is likely to have high levels of exchangeable sodium and magnesium (Doyle, 1993).

The underlying geology of the North Esk River and St Patricks River upper catchment is dominated by lower Carboniferous – upper Devonian granodiorite. The mudstone and quartzwacke of the Mathinna beds are present in the middle to upper catchment regions. In the middle to lower catchment, the geology consists primarily of alluvium beds which are surrounded by dolorite hills; with small pockets of basalt, glacio-marine sequence of pebbly mudstone, sandstone, limestone and tasmanite oil shale and basal tillite (Mines Tasmania, 1975). The geology of the lower catchment from White Hills through to Launceston consists of pockets of dolerite with lower slopes dominated by tertiary non-marine sequences and beds of alluvium. As conductivity results show, the majority of sites on the North Esk River and St Patricks River are low in 'salts' with conductivity increasing slightly towards the bottom of the catchment.

The general ionic composition of the North Esk catchment not only reflects its dilute nature but also the geochemical composition of the soil, rock types, and to some degree impacts from human based activities (ie. agriculture and forestry). A summary of these results are presented in Table 2.2.

Although more dilute, surface waters in the North Esk River and St Patricks River are similar in ionic composition to those in the neighbouring catchments of the Ringarooma River and Great Forester River (Bobbi, 1999a; Bobbi, 1999b). Alkalinity (and Hardness) across all sites was low (Table 2.2) with the highest median levels (20.5 mg/L) reported at NE5 (Distillery Creek upstream confluence of the North Esk River). At these low levels water at all sites can be considered very 'soft' and hence susceptible to fluctuations in pH. These low levels of hardness are further highlighted by low concentrations of calcium and magnesium (Figure 2.2.1 and 2.2.2). With the exception of NE12 (Barrow Creek at Tasman Highway) those sites sampled within the St Patricks catchment are generally lower in both calcium and magnesium concentrations compared to those sites within the North Esk River. These data support conductivity records for all sites sampled (Figure 2.1.4).

Concentrations of iron and potassium (Table 2.2) and other constituents such as chloride and sodium (Fig 2.2.3 and 2.2.4) were low, although the latter two constituents show a slight to moderate increase in concentration downstream, with levels in the North Esk River higher than those in the St Patricks River. The impact of the more diluting water of the St Patricks River on the North Esk River can be seen when comparing all of the above mentioned statistics between sites above (NE27, NE20) and sites immediately below (NE32) the confluence of the two rivers (Figures 2.2.1 to 2.2.4).

Table 2.2: Summary statistics for ionic parameters from the North Esk catchment. Samples collected every three months (n=10).

Parameter	Units	Median	Maximum	Minimum
Lab pH		6.25	7.7	5.5
Lab EC @ 25°C	μScm^{-1}	63.3	119	43
Total Dissolved Solids	mg/L	50	80	30
Total Suspended Solids	mg/L	<10	34	<10
Apparent Colour	mg/L	30	125	20
Total Alkalinity	CaCO3 mg/L	<20	33	<20
Chloride	mg/L	7.1	14	4.7
Fluoride	mg/L	<0.1	<0.1	<0.1
Sulphate	mg/L	1.2	3.3	<0.5
Hardness	mg CaCO3/L	16	26	0.68
Iron (	mg/L	0.3	1.1	0.109
Manganese)	mg/L	0.015	0.033	0.002
Calcium	mg/L	3.3	5	1.48
Potassium	mg/L	0.5	0.78	0.25
Magnesium	mg/L	2	3.31	0.88
Sodium	mg/L	5.185	8.94	3.1
Silica	mg/L	9.55	15	7.5

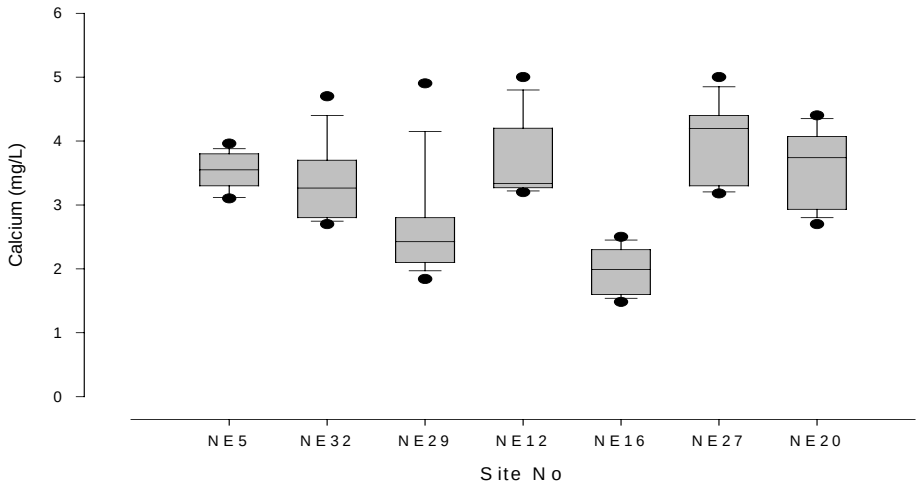

Figure 2.2.1: Statistics for calcium in the North Esk catchment. Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

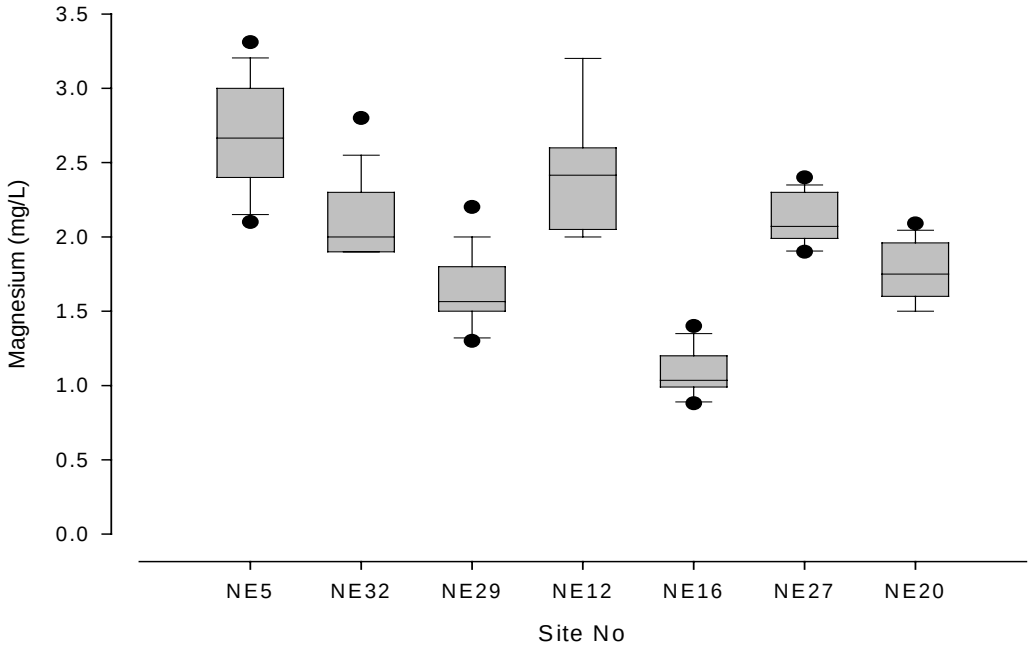

Figure 2.2.2: Statistics for magnesium in the North Esk catchment. Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

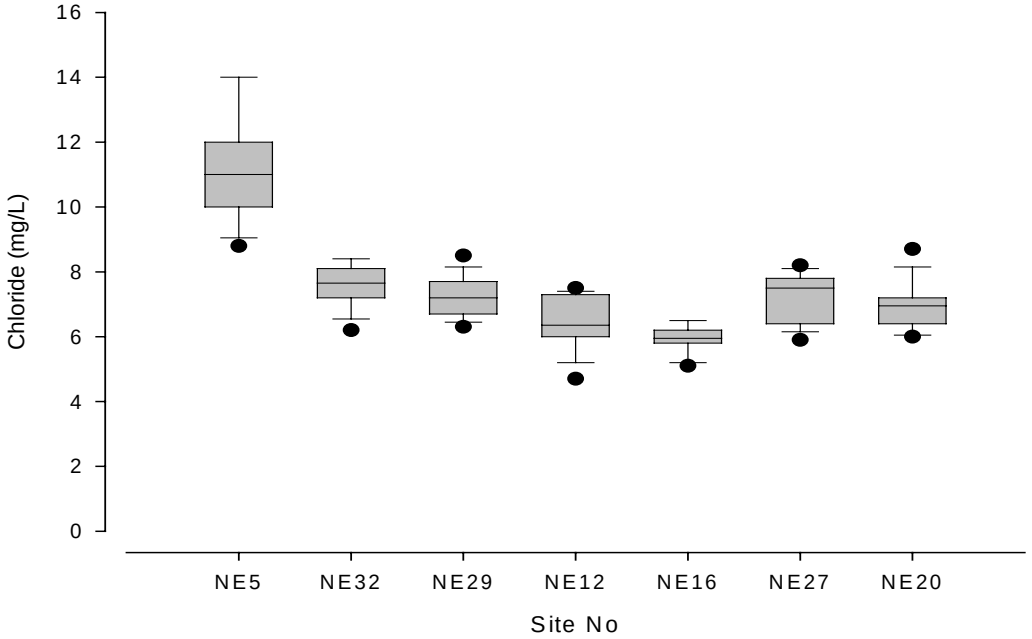

Figure 2.2.3: Statistics for chloride in the North Esk catchment. Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

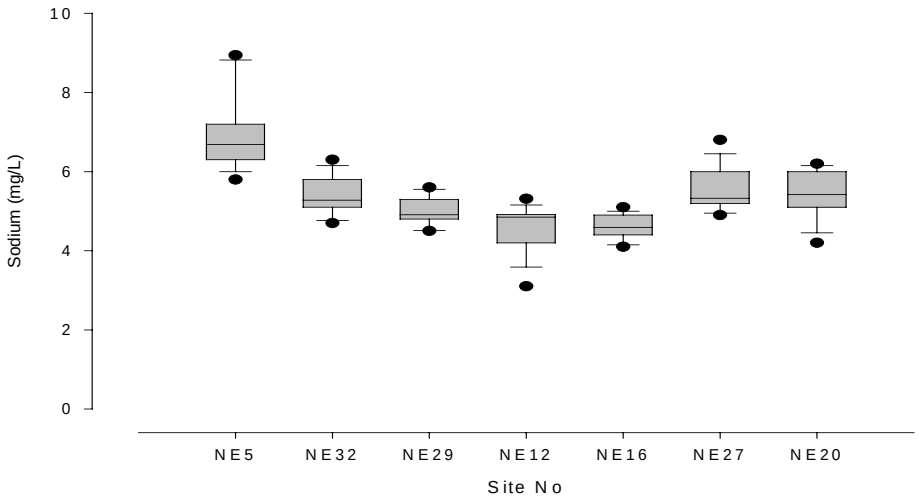

Figure 2.2.4: Statistics for sodium in the North Esk catchment. Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

2.2.1 Sulphate

Sulphate is naturally present in surface waters as SO_4^{2-} and originates from the atmospheric deposition of ocean aerosols or from geological processes such as the leaching of sulphite minerals from sedimentary rocks (UNESCO, 1992). In Tasmania several studies have shown that sulphate levels in natural waters are usually around 5mg/L (Bobbi, Fuller & Oldmeadow, 1996). Streams which receive some form of polluting effluent often have higher sulphate concentrations (15-30mg/L) such as those found in the Huon River Catchment (Bobbi, 1998). All sites monitored in the North Esk catchment recorded levels well below this.

Sulphate concentrations in the North Esk catchment are generally similar to or less than those found in the neighbouring Ringarooma and Great Forester catchments (Bobbi, 1999a; Bobbi, 1999b). Sulphate concentrations increase from the top to the bottom of the North Esk catchment (Fig 2.2.5). This is with the exception of Barrow Creek (NE12) in the St Patricks catchment.

2.2.2 Apparent Colour

Apparent colour, measured in Hazen Units, generally reflects the amount of dissolved organic matter (ie. humic substances) and suspended particles in the water column. In natural waters this can range from <5 in very clear waters to 300 in dark peaty waters (UNESCO 1992). Colour can generally be related to flow with higher levels recorded during flood events.

In both the North Esk River and St Patricks River median levels are generally below 40 and can be considered as moderate compared to rivers in western Tasmania which drain button grass areas. As shown in Figure 2.2.6 colour generally increases down both rivers. Similar to the Great Forester River these low levels reflect the relative good clarity of these waters.

2.2.3 Suspended Solids

Total suspended solids (TSS) consist of silt, clay, fine particles of organic and inorganic matter, soluble compounds, plankton and other microscopic organisms. The type and concentration of these two parameters control the level of turbidity and transparency in surface waters (UNESCO 1992). Therefore they can be used as an indirect measure of turbidity. As Table 2.2 shows, results for total suspended solids demonstrates the generally good level of clarity of surface waters in the North Esk catchment (<10mg/L). The maximum level of 34 mg/L occurred when a monitoring round coincided with a rainfall event on the 23rd August 2001. The low levels of TSS support the statistical information as reported in section 2.1.4.

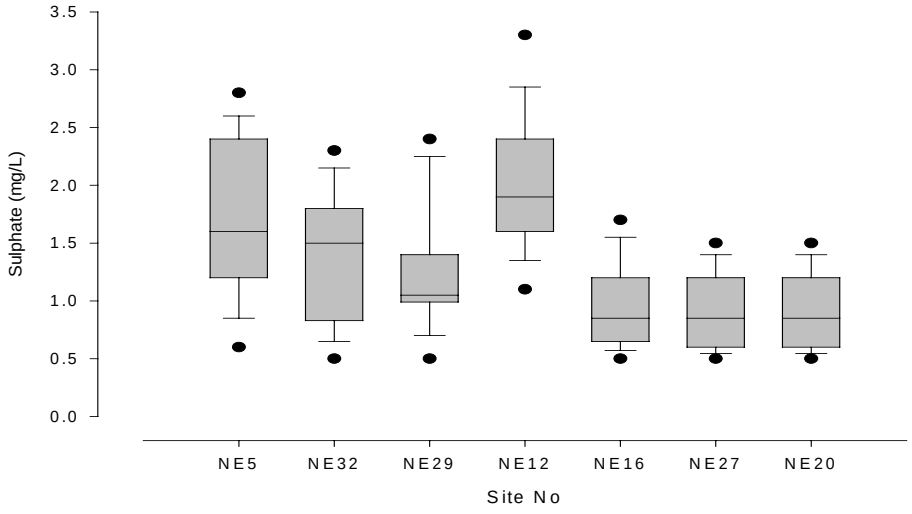

Figure 2.2.5: Statistics for sulphate in the North Esk catchment (Jan 1999-Dec 2000). Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

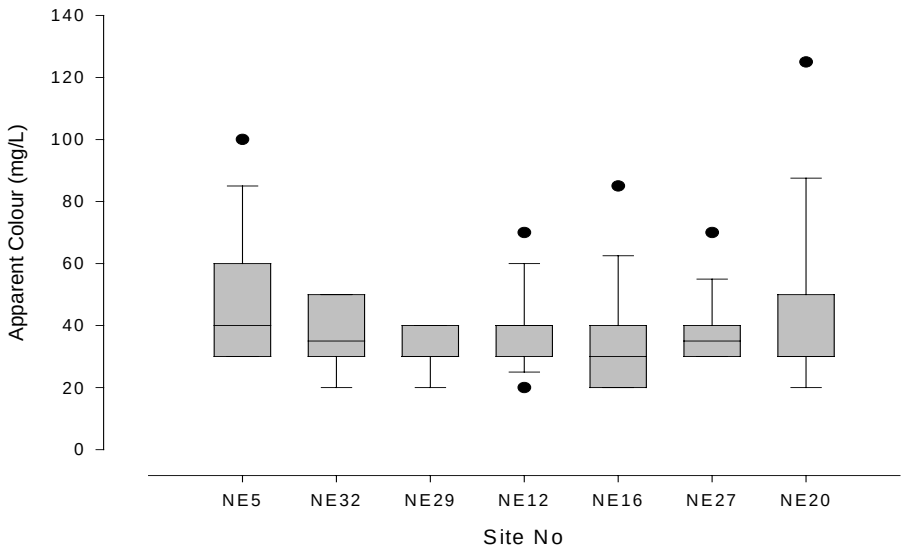

Figure 2.2.6: Statistics for apparent colour in the North Esk catchment (January 1999 to December 2000). Site numbers as follows: Distillery Creek u/s North Esk River (NE5); North Esk River at Corra Linn (NE32); St Patricks River u/s North Esk River (NE29); Barrow Creek at Tasman Highway (NE12); St Patricks River at Corkerys Road (NE16); North Esk River at Ballroom (NE27); North Esk River at Camden Road (NE20).

2.3 Nutrients

Concentrations of nutrients such as nitrate, ammonia, organic nitrogen and various forms of phosphorus in waters draining most areas of Tasmania are usually present in low levels. Such low levels generally preclude field-based analysis, as field testing kits cannot operate accurately at the sometimes ultra-low levels which occur in rivers. Therefore samples were collected and delivered to a registered laboratory which could measure down to the required levels (around the 5µg/L level). These laboratories operate under strict quality control and are able to deliver results which are quality assured under NATA (National Association of Testing Accreditation). Duplicates and blank samples were also taken as a means of checking field sampling and preservation operations as well as for quality assurance checks on laboratory processing.

It is important to note that during January 2000 duplicate and blank sampling quality assurance controls detected discrepancies in duplicate results. As a results all nutrients analysed post January 2000 took the following into account. Total nitrogen levels vary between 20 µg/L and 40 µg/L (standard error +- 20µg/L) and total phosphorus levels vary between 2 and 4 µg/L (standard error +/- 2µg/L).

2.3.1 Total Nitrogen

Total nitrogen (TN) in environmental waters is the sum of organic nitrogen, nitrate nitrogen (NO_3/N) and nitrite nitrogen (NO_2/N), although NO_2/N is normally detected only at very low levels unless there is some form of local point source discharge entering the waterway. Nitrogen in natural environments is generally derived from the atmosphere and incorporated into organic forms through the process of nitrogen fixation by plants. Nitrogen levels in waterways can be influenced by human activities such as intensive animal husbandry (ie. dairy), sewage effluent treatment discharges and agricultural fertiliser application. Runoff

from these activities have the potential to increase the concentration of various forms of nitrogen in rivers and streams substantially.

Across most of the North Esk catchment, agricultural activity is relatively low in comparison to nearby catchments like the Ringarooma, Great Forester and Pipers Rivers. Although there are some localised areas where cropping occurs, cattle and sheep graze in a relatively dispersed manner. The data for TN tend to reflect this, with TN concentrations at most sites generally well below the recommended ANZECC 2000 guideline trigger level for Tasmanian rivers of 480µg/L (Figure 2.3.1). Higher concentrations of TN at all sites generally occurred when sampling coincided with a rainfall event. On two separate monitoring trips grab samples taken at North Esk River at Ballroom (NE27) and North Esk river at Camden Road (NE20) recorded TN concentrations of 1080µg/L (26th August 1999) and 1390µg/L (23rd August 2000) respectively. Rainfall recorded during both occasions indicates that these data represent localised inputs from surface runoff.

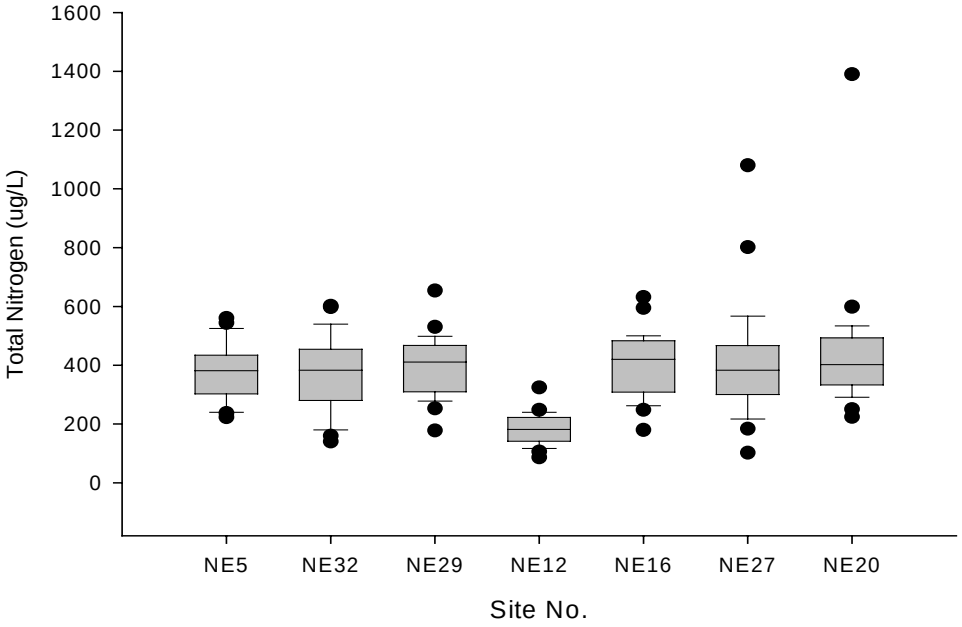

Figure 2.3.1: Summary of statistics for total nitrogen concentrations in the North Esk catchment January 1999 to December 2000. N = 25. Site numbers as follows Distillery Creek upstream of the confluence of the North Esk River (NE5), North Esk River at Corra Linn (NE32), St Patricks River upstream of the North Esk River (NE29), Barrow Creek at Tasman Highway (NE12), St Patricks River at Corkerys Road (NE16), North Esk River at Ballroom (NE27), North Esk River at Camden Road (NE20).

2.3.2 Nitrate Nitrogen

Nitrate Nitrogen (NO_3/N) is the soluble form of TN and easily passes from soils into groundwater where it can influence surface water concentrations during base flow conditions. Natural sources of NO_3/N originate from geological processes, the breakdown of plant and animal material and in rural environments from the use of organic fertilisers and increased levels of animal and plant wastes (UNESCO 1992). Land clearing for pasture and cropping increases soil aeration, which enhances the action of nitrifying bacteria and can result in an increase of NO_3/N concentrations in the soil.

Variations in NO_3/N concentrations across the North Esk Catchment was similar in distribution to TN (Fig 2.3.2). Further analysis of the data revealed that NO_3/N was seasonal

with a strong link to base flow levels in rivers and streams throughout the North Esk catchment (Figure 2.3.3). Higher levels of NO_3/N were typically found during late winter and early spring, when rainfall flushes NO_3/N from the soil profile. These higher concentrations are also illustrated by outliers in Figure 2.3.2. This pattern has been documented in other catchments such as the Ringarooma, Great Forester and Pipers Rivers (Bobbi, 1999a, Bobbi, 1999b).

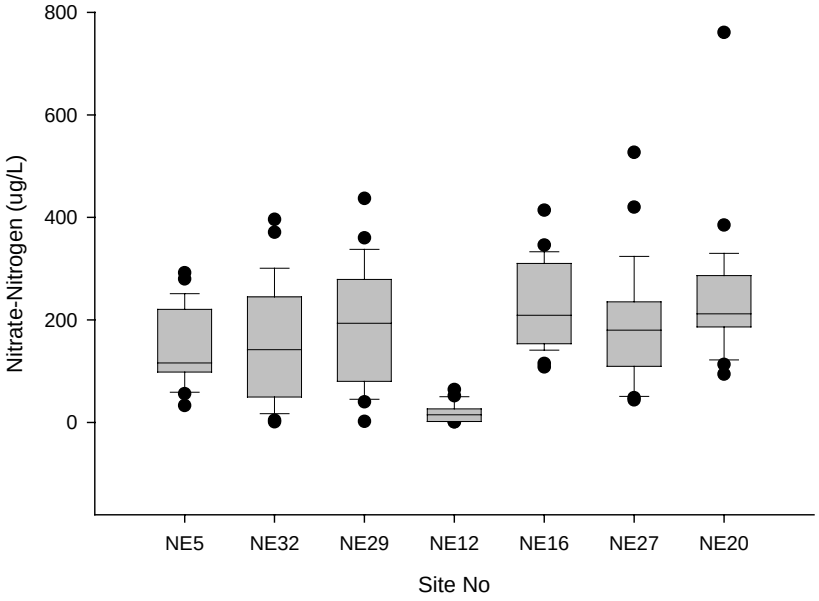

Figure 2.3.2: Summary of statistics for nitrate-nitrogen concentrations in the North Esk catchment January 1999 to December 2000. N = 25. Site numbers as follows Distillery Creek upstream of the confluence of the North Esk River (NE5), North Esk River at Corra Linn (NE32), St Patricks River upstream of the North Esk River (NE29), Barrow Creek at Tasman Highway (NE12), St Patricks River at Corkerys Road (NE16), North Esk River at Ballroom (NE27), North Esk River at Camden Road (NE20).

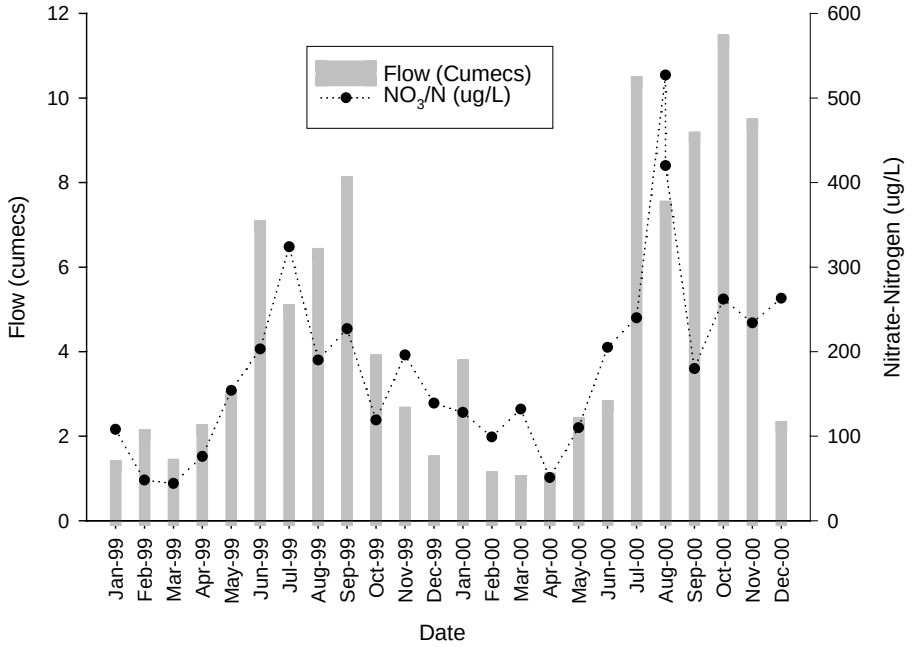

Figure 2.3.3: Monthly change in flow and nitrate-nitrogen concentrations at the North Esk River at Ballroom (NE 27) during 1999 and 2000.

2.3.3 Ammonia Nitrogen

Ammonia (NH_3/N) naturally occurs in surface water as a result of the breakdown of organic and inorganic materials and excretion from biota. High concentrations of NH_3/N can be an indicator of organic pollution and in countries such as the United Kingdom are used as an indicator of intensive dairy impact on water quality (UNESCO 1992). Concentrations of NH_3/N in unpolluted surface waters are typically less than 0.2mg/L but may reach 2-3mg/L (UNESCO 1992). The ANZECC 2000 guideline for protecting 'moderately disturbed' aquatic ecosystems suggest a trigger value of 900µg/L dependant upon pH.

All sites sampled in the North Esk catchment recorded concentrations of NH_3/N below 900µg/L, with sites varying between 2µg/L - 601µg/L with a median of 11µg/L for the whole catchment. Higher NH_3/N concentrations were generally observed towards the bottom of both the St Patricks River (NE29) and North Esk River (NE5), where cumulative impacts from land use activities are more likely (Figure 2.3.4). The maximum concentration of NH_3/N (601µg/L) was recorded at North Esk downstream of the Norwood sewerage treatment plant (NE2). Monthly sampling of this site only began in July 2000 (n=7) when duplicate samples showed high levels of NH_3/N. In comparison with other sites originally selected for monthly nutrient sampling, NH_3/N concentrations at NE2 may be an indication of organic pollution from activities such as domestic sewerage, industrial waste and fertiliser runoff.

Throughout the routine sampling period (January 1999 to December 2000) most sites recorded higher levels of NH_3/N periodically with St Patricks River at Corkerys Road (NE16) recording the highest concentration of 157µg/L in March 1999. Samples taken in February 1999 and April 1999 were of 7µg/L and 12µg/L respectively. This site is downstream of stock access points and forestry operations with observed changes in concentrations suggesting a short term localised increase in NH_3/N levels possibly due to stock access to the stream side zone.

Unlike the Ringarooma catchment, where there is a distinct difference between median levels of NH_3/N at all sites (Bobbi 1999a), the median values throughout most of the North Esk catchment vary between a restricted range (8-12 µg/L). If this range of concentration is indicative of background levels in the North Esk, it can be stated that locations such NE1 and perhaps Distillery Creek upstream of the confluence of the North Esk River (NE5) show evidence of impact from localised activities.

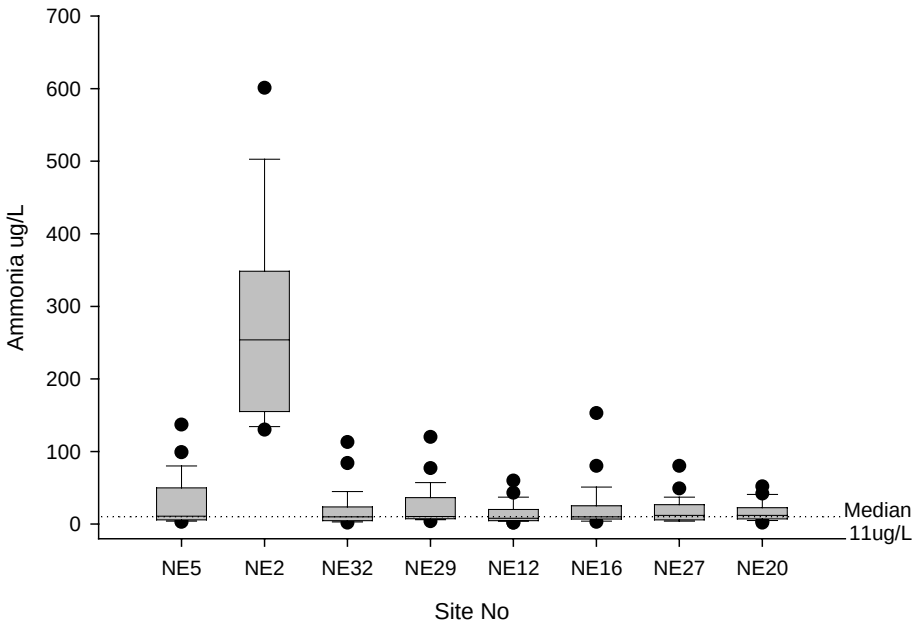

Figure 2.3.4: Summary of Statistics for NH_3/N Concentrations in the North Esk Catchment January 1999 to December 2000. Site numbers as follows Distillery Creek upstream of the confluence of the North Esk River (NE5), North Esk river downstream Norwood sewerage treatment plant (NE2), North Esk River at Corra Linn (NE32), St Patricks River upstream of the North Esk River (NE29), Barrow Creek at Tasman Highway (NE12), St Patricks River at Corkerys Road (NE16), North Esk River at Ballroom (NE27), North Esk River at Camden Road (NE20). N=25 at all sites with the exception of NE2 where N=7.

2.3.4 Phosphorus

Phosphorus is one of the nutrients essential for growth of aquatic plants and animals, and is often the underlying factor driving ecosystem productivity. However, in surface waters phosphorus is normally present at very low levels and is usually the nutrient which limits the growth of algae. When it is present in excess due to land use practices or disturbance, it can trigger algal blooms which are a feature of eutrophication. Although algae and aquatic plants generally require phosphorus in its dissolved form, once present in the waterway it can change between dissolved and particulate forms depending on environmental conditions and biological processes (UNESCO, 1992). Therefore where there is a catchment activity which may produce increases in phosphorus, it is best to measure total phosphorus (TP), which includes both particulate and dissolved forms, as at some stage all of this may become available for plant uptake.

Concentrations of total and dissolved forms of phosphorus in the North Esk catchment were generally low (Figure 2.3.5), with the majority of sites recording median concentrations below the recommended trigger level of 13µg/L TP (figure for upland rivers - ANZECC, 2000). Concentrations of TP tended to be higher in the upper and lower reaches of the North Esk River where two sites from the data set recorded median TP concentrations above the recommended trigger value (Figure 2.3.5). These are Distillery Creek upstream of the confluence of the North Esk River (NE 5: TP = 14µg/L) and North Esk River at Camden Road (NE20: TP = 15µg/L). Samples from sites in the St Patricks River were generally lower compared to those in the North Esk River. The highest recorded concentration of 120µg/L was sampled at Distillery Creek upstream of the confluence of the North Esk (NE5). As there was no rainfall and turbidity levels were low (2.74 NTU) at the time, this spike may represent a localised event possibly originating from a domestic point source. It is also possible that

cross contamination may have occurred during sampling though measures were taken to minimise such a risk.

Comparison of the monthly nutrient data in the North Esk catchment with that from other catchments in northeast Tasmania (ie. Ringarooma, Great Forester), shows that concentrations in the North Esk are slightly lower. Sites located in areas where stock access and cropping influence the movement of nutrients though the soil profile generally had higher concentrations of nitrate.

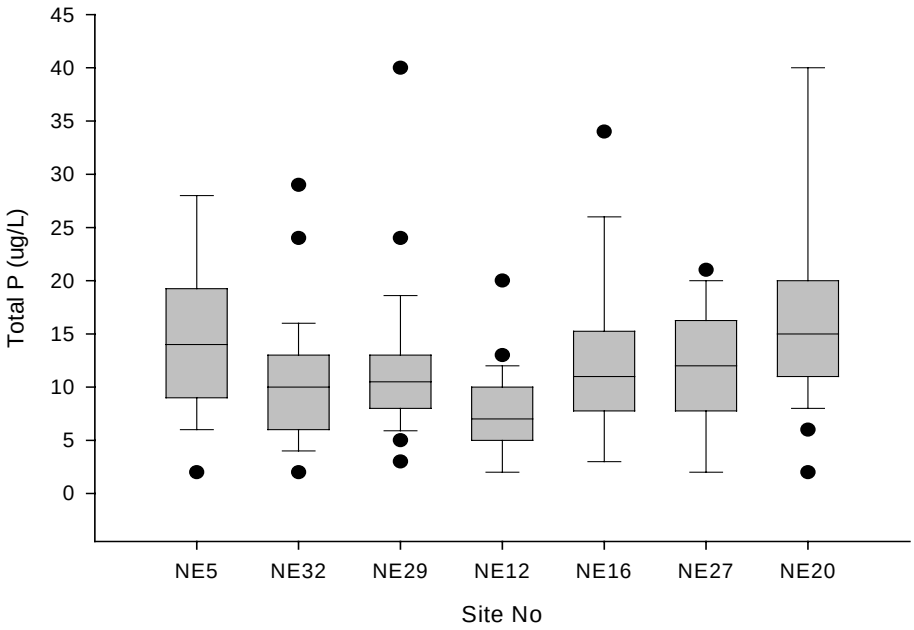

Figure 2.3.5: Statistics of monthly TP concentration at sites in the North Esk Catchment. NOTE: Outliers for NE5 (120µg/L & 86µg/L), NE16 75µg/L and NE20 60µg/L and 61µg/L) exceed scale used. Site numbers as follows Distillery Creek upstream of the confluence of the North Esk River (NE5), North Esk River at Corra Linn (NE32), St Patricks River upstream of the North Esk River (NE29), Barrow Creek at Tasman Highway (NE12), St Patricks River at Corkerys Road (NE16), North Esk River at Ballroom (NE27), North Esk River at Camden Road (NE20).