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 1

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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.

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Executive Summary

The North Esk Catchment is used extensively for agriculture and forestry and provides domestic water supply for Launceston. The catchment is approximately 1,065 km² and is composed of two major drainage systems, the North Esk River and the St Patricks River. The North Esk River originates in the foothills of the Ben Nevis and Ben Lomond Ranges travelling south though forestry plantations until it reaches the confluence of the Ford River where it turns west draining dispersed agricultural pastures. The smaller tributaries of Burns Creek, Musselboro Creek, Weavers Creek, Pig Run Creek and River O'Plain Creek contribute flow to the North Esk River before it reaches the confluence of the St Patricks River where flow dramatically increases. The offtake for the Esk Waters Chimney Hill Water Treatment Plant is located upstream of the confluence with the St Patricks River. The North Esk River then continues in a westerly direction through a predominantly agricultural landscape receiving flows from Roses Rivulet. As the North Esk continues west through the city of Launceston it receives flow from the partially urbanised Distillery Creek region and the heavily urbanised region of Kings Meadows Rivulet before it discharges into the Tamar River.

The head waters f the St Patricks River originate between the foot hills of Mount Maurice and Ben Nevis. The St Patricks River flows through a landscape dominated by forestry operations and dispersed grazing picking up contributing flows from Camden Rivulet. Travelling in a north westerly direction the river hooks around the foothills of Mount Barrow and flows in a south westerly direction through primarily agricultural lands where is receives flows from Seven Time Creek, Barrow Creek, Coquet Creek and Patersonia Rivulet before it passes through the township of Nubeena. The St Patricks River continues to flow south where it joins the North Esk River at Water Plains.

This report presents and discusses in detail the results of a 2-year study of water quality of the rivers and streams within the North Esk River catchment. From 1999 to 2000 water quality sampling was conducted on a monthly basis at a number of sites on the North Esk River, St Patricks River and several smaller tributaries. More intensive "snapshot' surveys were conducted during summer and winter, and multi-sensored Sondes were deployed at a number of sites to examine short-term fluctuations in selected water quality variables.

The information contained in this report should be viewed together with the associated reports on aquatic ecology, hydrology and river condition. These four reports together form the "State of River" report for the North Esk Catchment.

The major findings from this component of the "State of River" study are;

- Trend analysis of long term data provided by Esk Water from the Chimney Saddle plant (which extracts water from the North Esk River below Ballroom) shows that water temperature has progressively increased by 3.5°C over the past 24 years. Similar trend analysis for pH from Esk Water records at both the Chimney Saddle (North Esk River) and Distillery Creek (St Patricks River) sites show a slight decrease in pH levels. Causes for this are not clear and may be related to catchment activities such as vegetation clearance or larger scale climactic changes.

- Median statistics for turbidity show that clarity in the North Esk Catchment is reasonably with higher levels occurring during high flow events. Baseline turbidity levels are generally good with median values below 5 NTU. Sites with unrestricted stock access, disturbed drainage lines and recently cultivated soils exhibited higher levels of turbidity, particularly during high flow events.

- Historic and study data shows that water throughout the upper catchment is indicative of a dilute system (electrical conductivity between 50µS/cm and 70µS/cm), and is characteristic of the higher catchment which receives clean water from a undisturbed regions (namely the Ben Lomond and Ben Nevis massifs).

- Dissolved oxygen levels at many sites exhibited seasonal fluctuations with lower levels in summer and higher levels in winter. Instream modifications at Old Mill Creek appears to have altered this normal seasonal pattern of change. Two sites located in highly modified areas had extremely low dissolved oxygen concentrations during summer. These were Kings Meadows Rivulet at Punchbowl and Rose Rivulet above Patersons Island. Short-term deployment of continuous monitoring equipment at Kings Meadows Rivulet at Punchbowl revealed that this site is subject to very low levels of dissolved oxygen indicative of an impacted ecosystem.

- Total nitrogen concentrations throughout the catchment were generally below the recommended ANZECC guideline of 480µg/L reflecting the relatively dispersed nature of agricultural activities. Snapshot sampling of nutrients showed a gradual increase towards the bottom of the catchment, with higher levels recorded within the suburban areas of Launceston, reflecting the impact of runoff and possible effects from the Norwood sewerage treatment plant.

- Elevated concentrations of aluminium independent of turbidity levels were detected at the majority of sites suggesting that these levels may pose some risk to the aquatic environment. Elevated concentrations of zinc were also detected at Kings Meadows Rivulet at Punchbowl and may be indicative of this site receiving urbanised runoff. Due to the low hardness of these waters zinc concentrations detected at this site may pose some risk to the aquatic environment. Further analysis of the above mentioned metals should include the dissolved fraction.

- Export coefficients for phosphorus in the North Esk catchment are well below those that have been estimated for other agricultural catchments in Tasmania. Export coefficients for nitrogen are in the lower to middle end of the range of estimates made for other agricultural catchments in Tasmania.

A GLOSSARY OF TERMS

Baseflow
Flow in a stream is essentially a function of overland flow, sub-surface flow and groundwater input. During periods when there is no contribution of water from precipitation, flow in a stream is composed of water from deep sub-surface and groundwater sources and is termed 'baseflow'.

Box and Whisker Plots
One common method of examining data collected at varous sites is to plot the data from each site as a 'box and whisker' plot. These plots display the median (or the middle of the data) as a line across the inside of the box. The bottom and top edges of the box mark the first and third quartiles respectively, indicating the middle 50% of the data. The ends of the whiskers show the extremes of the data and together enclose 95% of the data.

Catchment
The land area which drains into a particular watercourse (river, stream or creek) and is a natural topographic division of the landscape. Underlying geological formations may alter the perceived catchment area suggested solely by topography (limestone caves are an example of this).

Discharge
The volume of water passing a specific point during a particular period of time. It usually refers to water flowing in a stream or drainage channel, but can also refer to waste water from industrial activities.

Dissolved Oxygen
Oxygen is essential for all forms of aquatic life and many organisms obtain this oxygen directly from the water in the dissolved form. The level of dissolved oxygen in natural waters varies with temperature, turbulence, photosynthetic activity and atmospheric pressure. Dissolved oxygen varies over 24 hour periods as well as seasonally and can range from as high as 15 mg/L to levels approaching 0 mg/L. Levels below 6 mg/L will begin to place stress on aquatic biota and below 2 mg/L will cause death of fish.

Ecosystem
An environment. The physical and chemical parameters that define it and the organisms which inhabit it.

Electrical Conductivity (EC)
Conductivity is a measure of the capacity of an aqueous solution to carry an electrical current, and depends on the presence of ions; on their total concentration, mobility and valence (ie. the amount of electrical charge on each ion). Conductivity is commonly used to determine salinity and is mostly reported in microSiemens per centimetre (µS/cm) or milliSiemens per metre (mS/m) at a standard reference temperature of 25^{o} Celsius.

Export Loads / Export Coefficients
The calculation of export loads of nutrients, or any other parameter, involves using nutrient concentration data collected over a wide variety of flow conditions and from various seasons. This information, when plotted against flow at the time of collection, can reveal relationships between flow and concentration which can then be used to estimate the load of a particular nutrient leaving the catchment (estimates of export loads should be regarded as having no greater accuracy than +/- 15%).

The export coefficient (also known as the Runoff Coefficient) corrects for catchment size so that export loads from variously sized catchments can be compared. The most commonly used formula to perform this correction is;

Discharge (ML) / **Catchment Area** (km^2) = **X** ($mm\ km^{-2}$)

Total Load (kg) / **X** = **Y** ($kg\ mm^{-1}$)

Y / **Catchment Area** (km^2) = **Export Coefficient** ($kg\ mm^{-1} km^{-2}$)
[The Export Coefficient and is equivalent to Total Load (kg) / Discharge (ML)].

Faecal Coliforms (also known as 'thermotolerant coliforms' - eg. *E.coli*)
Faecal coliform bacteria are a sub-group of the total coliform population that are easy to measure and are present in virtually all warm blooded animals. Although measurement of this group is favoured by the NHMRC (1996) as suitable indicators of faecal pollution, it is recognised that members of this group may not be exclusively of faecal origin. However their presence in samples implies increased risk of disease. Pathogenic bacteria are those which are considered capable of causing disease in animals.

Hydrograph
A plot of flow (typically in a stream) versus time. The time base is variable so that a hydrograph can refer to a single flood event, to a combination of flood events, or alternatively to the plot of all flows over a month, year, season or any given period.

Median
The middle reading, or 50^{th} percentile, of all readings taken.

> i.e. Of the readings 10, 13, 9, 16 and 11
> {Re-ordering these to read 9, 10, 11, 13 and 16}
> **The median is 11.**

The **Mean** (or Average), is the sum of all values divided by the total number of readings (which in this case equals 11.8).

Nutrients
Nutrients is a broad term which encompasses elements and compounds which are required by plants and animals for growth and survival. In the area of water quality the term is generally used with only phosphorus and nitrogen in mind, though there are many other elements that living organisms require for survival.

pH and Alkalinity
The pH is a measure of the acidity of a solution and ranges in scale from 0 to 14 (from very acid to very alkaline). A pH value of 7 is considered 'neutral'. In natural waters, pH is generally between 6.0 and 8.5. In waters with little or no buffering capacity, pH is related to alkalinity which is controlled by concentrations of carbonates, bicarbonates and hydroxides in the water. Waters of low alkalinity (< 24 ml/L as CaCO3) have a low buffering capacity and are susceptible to changes in pH from outside sources.

Riparian Vegetation
Riparian vegetation are plants (trees, shrubs, ground covers and grasses) which grow on the banks and floodplains of rivers. A 'healthy' riparian zone is characterised by a homogeneous mix of plant species (usually native to the area) of various ages. This zone is important in protecting water quality and sustaining the aquatic life of rivers.

Suspended Solids
Suspended solids are typically comprised of clay, silt, fine particulate organic and inorganic matter and microscopic organisms. Suspended solids are that fraction which will not pass through a 0.45µm filter and as such corresponds to non-filterable residues. It is this fraction which tends to contribute most to the turbidity of water.

Total Nitrogen (TN)
Nitrogen in natural waters occurs as Nitrate, Nitrite, Ammonia and complex organic compounds. Total nitrogen concentration in water can be analysed for directly or through the determination of all of these components. In this report, Total Nitrogen has been calculated as the sum of Nitrate-N + Nitrite-N + TKN.

Total Phosphorus (TP)
Like nitrogen, phosphorus is an essential nutrient for living organisms and exists in water as both dissolved and particulate forms. Total phosphorus can be analysed directly, and includes both forms. Dissolved phosphorus mostly occurs as orthophosphates, polyphosphates and organic phosphates.

Turbidity
Turbidity in water is caused by suspended material such as clay, silt, finely divided organic and inorganic matter, soluble coloured compounds and plankton and microscopic organisms. Turbidity is an expression of the optical properties that cause light to be scattered and absorbed rather than transmitted in a straight line through the water. Standard units for turbidity are 'nephelometric turbidity units' (NTU's) standardised against Formazin solution.

Units and Conversions

mg/L = milligrams per litre (1000 milligrams per gram)
μg/L = micrograms per litre (1000 micrograms per milligram)
e.g. 1000 μg/L = 1 mg/L
μS/cm = Microsiemens per centimeter
m^3s^{-1} = cubic metre per second (commonly referred to as a 'cumec')
ML = 1 million litres (referred to as a 'megalitre')

Acronyms

ANZECC - Australian and New Zealand Environment and Conservation Council
ARMCANZ - Agricultural and Resource Management Council of Australia and New Zealand
DPIWE - Department of Primary Industries, Water and Environment
DPIF - Department of Primary Industry and Fisheries (replaced by DPIWE)
NHMRC - National Health and Medical Research Council

B SUMMARY OF NATIONAL GUIDELINES FOR WATER QUALITY

Australian Water Quality Guidelines as per ANZECC (2000)

As part of a National strategy to 'pursue the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development' the Australian and New Zealand Environment and Conservation Council (ANZECC) has been developing guidelines for water quality for a range of Australian waters. Since 1992, a document titled 'Australian Water Quality Guidelines for Fresh and Marine Waters (1992)' has been available for use as a reference tool for catchment management plans and policies. Since 1995, these guidelines have been under review and have now been superseded by new and more rigorous guidelines (ANZECC, 2000). The new approach has changed the emphasis of guideline setting, suggesting a 'risk assessment' approach which utilises the concept of increased risk with increasing departure from 'safe' levels. It also restates the principle that they are simply guidelines to be used in the absence of local data, and that where local data can be obtained, they should be used to develop local water quality standards.

For some water quality parameters, this approach has been taken, with data from Tasmanian systems (where available) being used to develop guidelines for use in Tasmania. In the National document, Tasmanian rivers have been broadly classified as upland or alpine rivers. It was considered that virtually no Tasmanian rivers can be categorised as lowland, when compared with mainland Australia, so only the guidelines for upland rivers have been used. A summary of these 'Tasmanian specific' guidelines is presented below.

Table 1: Trigger Levels for Nutrients, pH and Dissolved Oxygen (ANZECC 2000).

Ecosystem Type	TP µg/L	FRP µg/L	TN µg/L	NOx µg/L	pH	DO (%sat)
Upland River	13	5	480	190	6.5 to 7.5	<90 & >110
Lakes and Reservoirs	10	5	350	10	6.5 to 8.0	<90 & >110

Table 2: Trigger Levels for Conductivity and Turbidity (ANZECC 2000).

Ecosystem type	Salinity (µS/cm^{-1})	Explanatory notes
Upland Rivers	**30–350**	Conductivity in upland streams will vary depending upon catchment geology. Low values found in Victorian alpine regions (30 µScm^{-1}) and eastern highlands (55 µScm^{-1}), high value (350 µScm^{-1}) in NSW rivers. Tasmanian rivers mid-range (90 µScm^{-1}).
Lakes/ Reservoirs	**20–30**	Conductivity in lakes and reservoirs are generally low, but will vary depending upon catchment geology. Values provided are typical of Tasmanian lakes and reservoirs.

Ecosystem type	Turbidity (NTU)	Explanatory notes
Upland Rivers	**2–25**	Most good condition upland streams have low turbidity. High values may be observed during high flow events.
Lakes & Reservoirs	**1–20**	Most deep lakes and reservoirs have low turbidity. However shallow lakes and reservoirs may have higher natural turbidity due to wind-induced resuspension of sediments. Lakes and reservoirs in catchment with highly dispersable soils will have high turbidity.

Proposed Microbiological Guidelines

Primary contact

The median bacterial content in samples of fresh or marine waters taken over the swimming season should not exceed:

- *150 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100 mL);*

- *35 enterococci organisms/100 mL (maximum number in any one sample: 60-100 organisms/100 mL).*

Pathogenic free-living protozoans should be absent from bodies of fresh water. (It is not necessary to analyse water for these pathogens unless the temperature is greater than 24°C.)

Secondary contact

The median bacterial content in fresh and marine waters should not exceed:

- *1000 faecal coliform organisms/100 mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100 mL);*

- *230 enterococci organisms/100 mL (maximum number in any one sample 450 - 700 organisms/100 mL).*

National Health and Medical Research Council - Drinking Water

For drinking water, guidelines published by the National Health and Medical Research Council (NHMRC, 1996) suggest that no thermotolerant coliforms (eg *E. coli*) should be present in water used for drinking.

Water Quality of the North Esk Catchment

1 Historical and Other Data

1.1 Chimney Saddle & Distillery Creek Water Quality

Some water quality monitoring is carried out by Esk Water as part of its standard operations. Their two major diversions for town water supply in the North Esk catchment are at Chimney Saddle (which extracts water from the North Esk River below Ballroom) and Distillery Creek (which extracts water from the St Patricks River at Nunamara). As part of their process control operations at these two sites, Esk Water measures turbidity, colour, water temperature and pH on intake water at both these plants. These parameters have been collected on a daily basis for almost 30 years and this provides a valuable source of historical data from which water quality changes in the lower St Patricks River and middle North Esk River may be detected.

Tables 1.1. and 1.2 below illustrate some of the characteristics of the data from both the Chimney Saddle and Distillery Creek treatment plants. From the data it can be seen that water temperatures at the Chimney Saddle plant (North Esk River) are generally warmer, slightly more ‘coloured’ but is less turbid, and has roughly the same pH as water entering the Distillery Creek plant from the St Patricks River.

Table 1.1: Summary statistics of daily water quality data collected by Esk Water at Chimney Saddle treatment site. Period of record July 1976 – April 2000.

	Water Temp (C°)	**Colour (Hazen)**	**Turbidity (NTU)**	**pH**
No. Samples	5,886	5879	5,885	5,886
Maximum	25.0	500	200	7.8
Minimum	1.0	2	0.8	5.2
Median	12.0	30	2.9	7.3
Average	12.3	43	5.0	7.3
ST Deviation	4.7	43	6.7	0.2

Table 1.2: Summary statistics of daily water quality data collected by Esk Water at Distillery Creek treatment site. Period of record March 1971 – February 2000.

	Water Temp (C°)	**Colour (Hazen)**	**Turbidity (NTU)**	**pH**
No. Samples	9,992	10,578	10,496	10,527
Maximum	22.0	220.0	79.0	9.5
Minimum	0.0	5.0	0.5	5.0
Median	9.0	30.0	4.1	7.3
Average	9.3	37.3	6.1	7.3
Std Deviation	4.2	27.4	5.3	0.3

Examination of the time series for water temperature from Chimney Saddle, shows that there has been a relatively consistent trend for increasing temperature over the entire period of record (Figure 1.1.1). Trend analysis on the data after converting it to weekly averages and removing the obvious seasonal pattern (ie. de-seasonalising the record), indicates that the data best fits a linear model and that over the 24 years of record, mean annual water temperature has increased by about 3.5 ^{o}C. No such long term pattern was seen in the record of water temperature from Distillery Creek, although water temperature since 1996 appears to have increased noticeably. The reason for these increases is not clear, but may be caused by factors such as land clearing or longer term patterns of climate change.

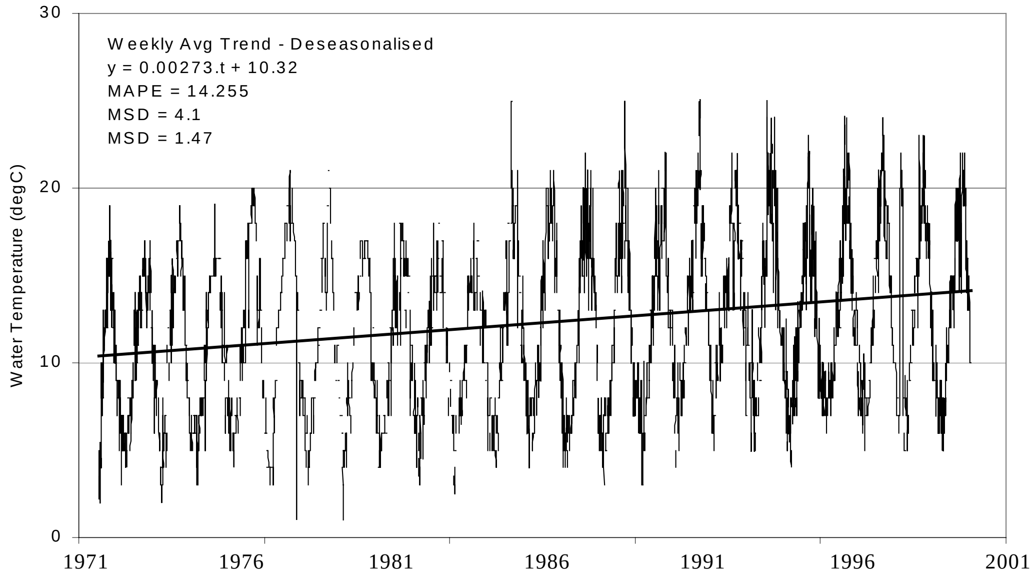

Figure 1.1.1: Time series plot and trend analysis results for water temperature at Chimney Saddle water intake (1976 – 2000).

Examination of the time series for pH shows a decreasing trend at Chimney Saddle (Figure 1.1.2). The pH record shows less of a seasonal pattern than that of water temperature, but there appears to be a roughly linear change in pH between the start of record (1976) and mid-1997. Using weekly averages for trend analysis, there appears to have been a decrease in pH of almost 0.5 of a unit over the 26 years of record. During the following period (mid-1997 to 2000) there has been a significant jump in pH levels, remaining relatively constant at around 7.3. Communication with Esk Water has confirmed that this is not due to a change in testing procedure or equipment, which would appear at first glance to be a possibility.

Analysis of the time series of pH from the Distillery Creek plant (Figure 1.1.3) shows that the pattern of change over the same period is quite different. The pH of water from the St Patricks River between 1971 and 1992 was fairly stable, fluctuating around 7.4 with some short-term drops down to about 6.6. However in the period following April 1992, the pH of water from the St Patricks dropped significantly, to average about 6.9 but periodically falling as low as 6.3 for sustained periods. This pattern of change is quite different to that found at Chimney Saddle.

The reason for these changes is not clear, but might relate to changes in catchment characteristics such as vegetation cover. Loss of cover through catchment clearing and deforestation has been shown elsewhere to have impacts on pH levels in surface waters. In a comprehensive article on natural processes in freshwater acidification, Cresser & Edwards (1988) state that increased leaching and lowering of evapotranspiration can lead to increases in surface water acidity. They state that leaching and soil acidification, are also favoured by high precipitation and thin permeable soils on steep slopes, both of which are features of the North Esk catchment.

The time series plots for turbidity at Chimney Saddle (Figure 1.1.4) and Distillery Creek (Figure 1.1.5) highlight the variability which is characteristic of this parameter with higher levels of turbidity experienced during high flow events. The data from both sites are quite similar in that the majority of moderate events tend to generate peaks of around 20NTU. Turbidity at Distillery Creek exceeds 50NTU only eight times over the entire period of record, while at Chimney Saddle turbidity has exceeded 50NTU about 15 times. The median turbidity however (Table 1.1.1 & 1.1.2), which is more representative of turbidity under baseflow conditions, shows that water clarity is slightly better at Chimney Saddle (North Esk River River) than at Distillery Creek (St Patricks River).

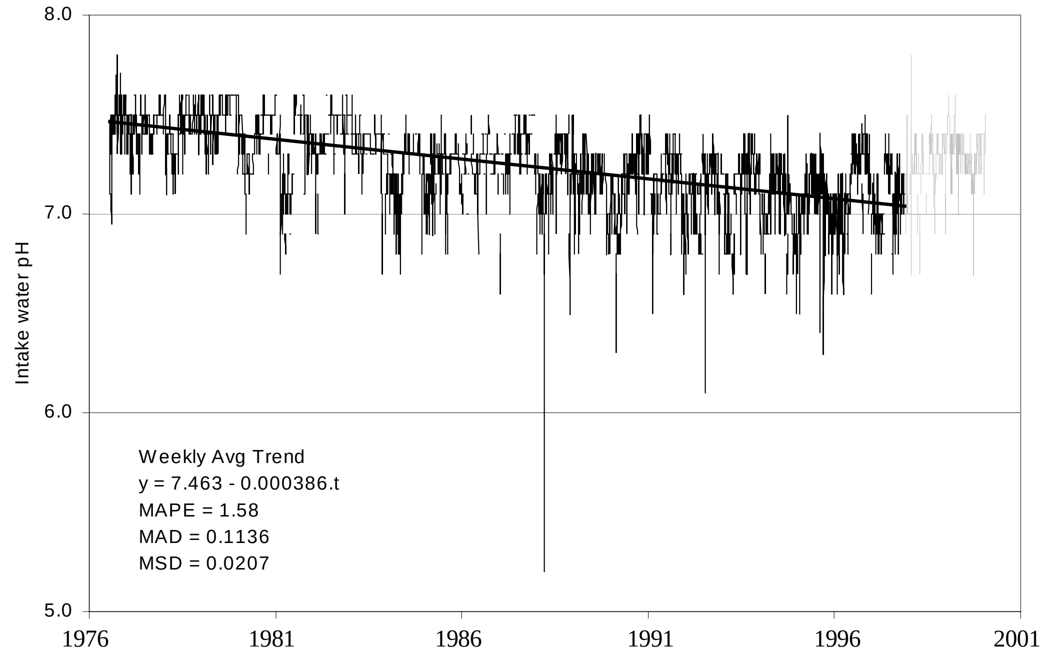

Figure 1.1.2: Time series plot and trend analysis results for water pH at Chimney Saddle water intake (1976 – 2000).

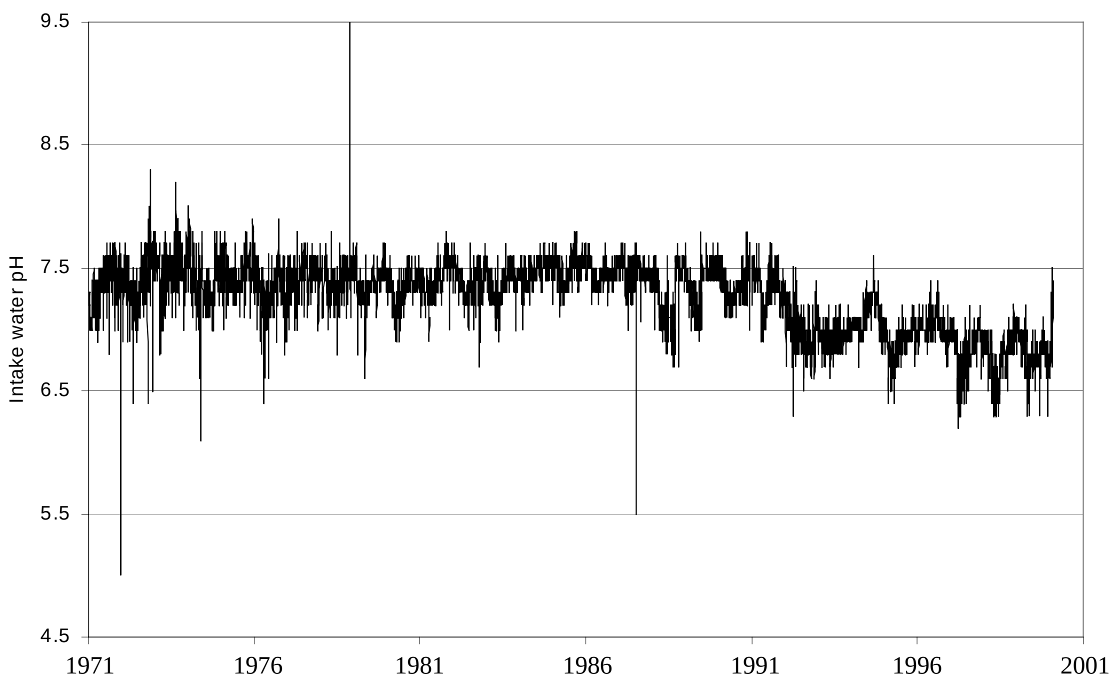

Figure 1.1.3: Time series plot of pH at Distillery Creek water intake (1971 – 2000). Note the significant drop in pH series following April 1992.

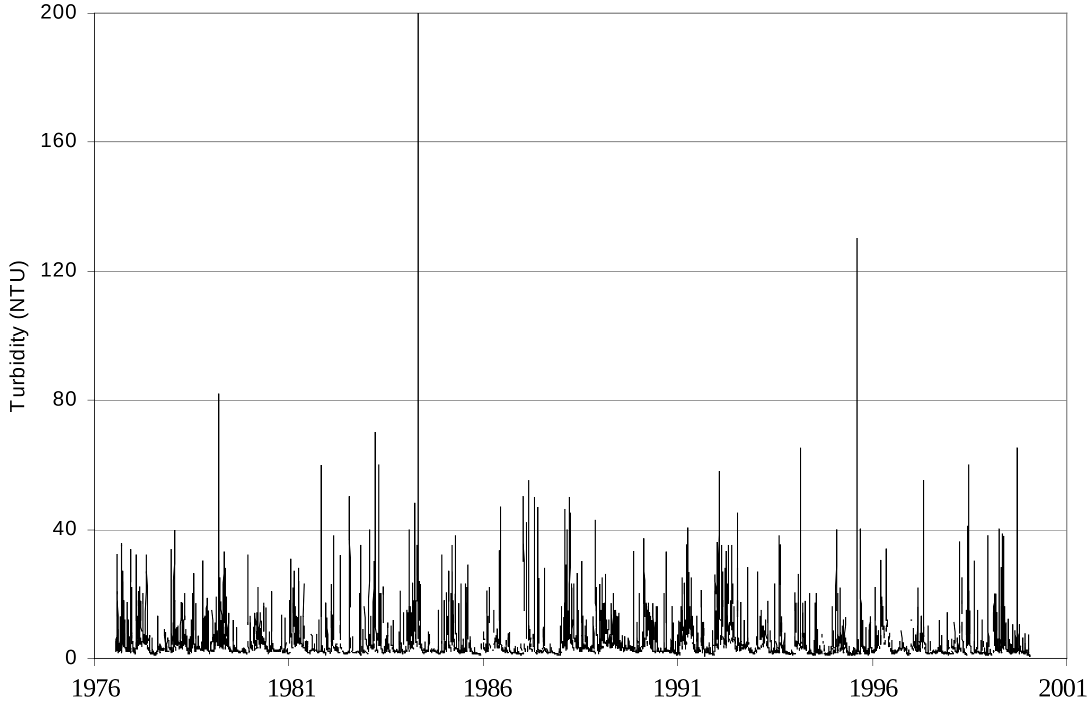

Figure 1.1.4: Time series plot of turbidity at the Chimney Saddle water intake (1976 – 2000).

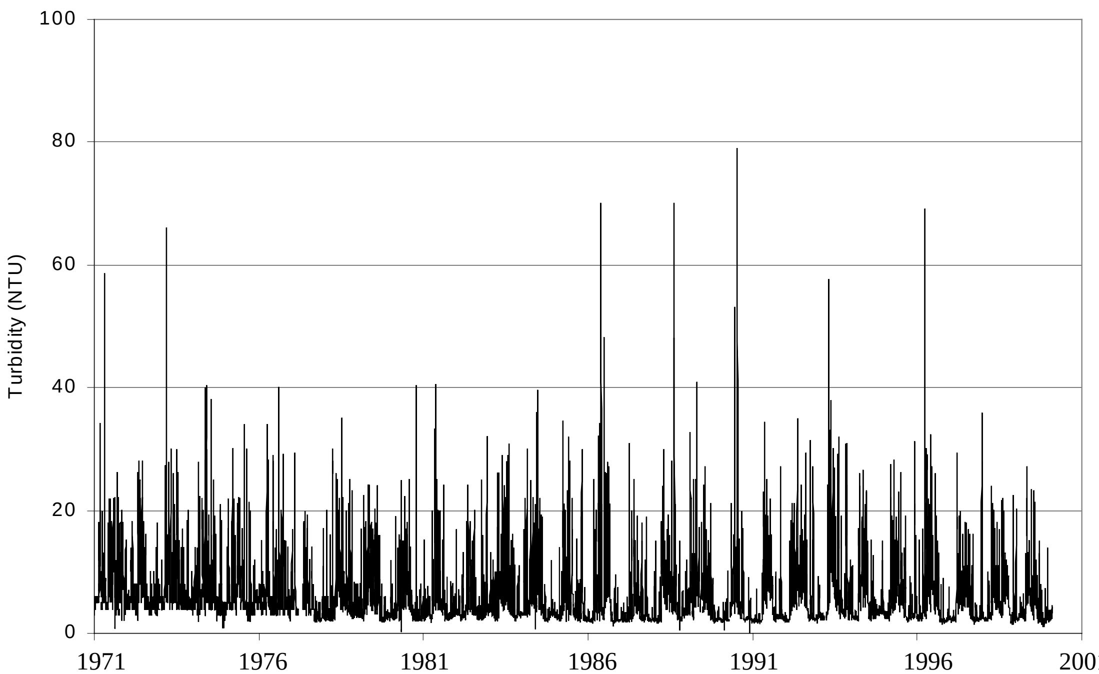

Figure 1.1.5: Time series plot of turbidity at the Distillery Creek water intake (1971 – 2000).

1.2 Tamar River Sediment Study

Skirving (1986) carried out a sampling program to estimate suspended sediment transport at two sites in the North Esk catchment (North Esk River at Ballroom and North Esk River at Corra Linn). This study was aimed at quantifying the amount of sediment entering the Tamar River estuary from both the North Esk River and South Esk River. Skirving was able to generate a time series for suspended solids concentrations over a short period (7th September 1986 to 17th October 1986) and this was able to be plotted against flow in the river at the time. Part of this data is plotted in Figure 1.2.1 and illustrates the change in suspended solids concentration with flow during several events in September 1986.

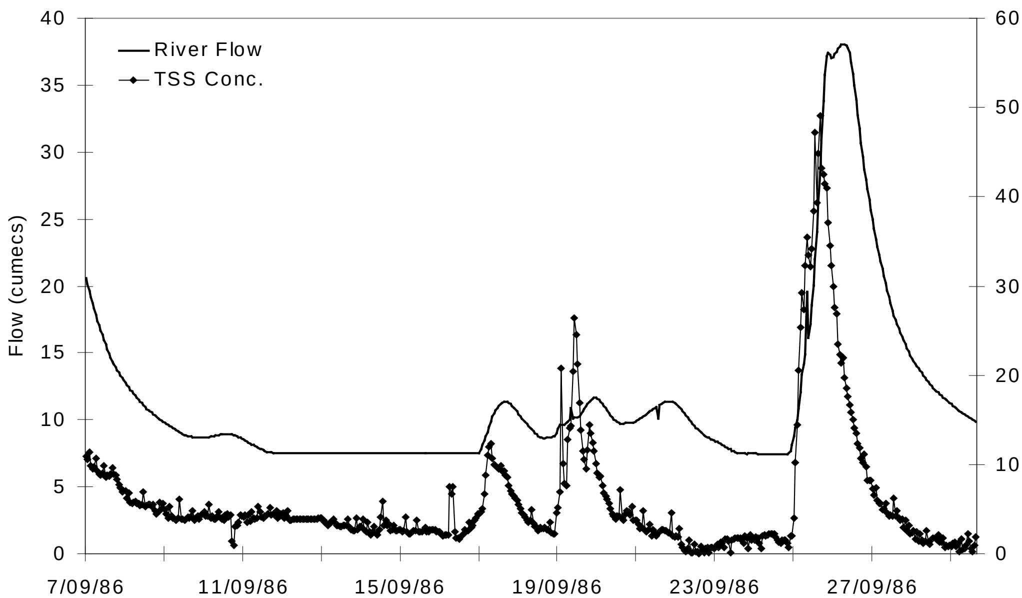

Figure 1.2.1: Time series of suspended solids concentration & flow in the North Esk at Ballroom as measured by Skirving (1986).

At Corra Linn, the only data available was from opportunistic grab sampling during higher river flows. Skirving's data suggests there are several key results which are relevant to this report. One of these is the derivation of linear regressions between suspended sediment transport and discharge (shown in Table 1.2.1), which can be applied to the more extensive flow record from each of these sites to generate annual suspended sediment export loads at both Ballroom and Corra Linn. Histograms of these data (from Skirving) are shown in Figure 1.2.2 & 1.2.3, and indicate that there is almost an order of magnitude difference between transport loads at Corra Linn and those at Ballroom, and that annual suspended sediment loads leaving the catchment at Corra Linn can be as high as 17,000 tonnes per year.

Table 1.2.1: Regression equations for deriving suspended sediment transport in kilograms per second (Y) from river flow in cubic metres per second (X) [from Skirving, 1986].

	Linear Regression	**Statistics**
North Esk at Ballroom	LogY = 0.2138 +2.3486*LogX	R^2 = 0.663, SE = 0.29
North Esk at Corra Linn	LogY = -2.9 + 1.7*LogX	R^2 = 0.95, SE = 0.19

Skirving (1986) identified sheet, gully and rill erosion as widespread in the North Esk catchment and the major source of river sediment to the North Esk drainage basin. He found that sheet erosion was particularly severe on upper slopes and the crests of hills and mountains, where soils are most susceptible to erosion processes. These areas are also subject to intensive rainfall events (IEA, 1987) which would impact on the degree of erosion and hence sediment input into the catchment. Sampling of a single flood event in December 1985 showed that concentrations of suspended solids in runoff were highest in the upper catchment. Skirving also noted that this tended to reflect the impacts of logging, since the highest measurements of suspended solids were found in areas of the upper North Esk River and Camden Rivulet where logging was being undertaken at the time. These data provide a valuable background to this study and will also provide a platform for direct comparison between current and historic conditions.

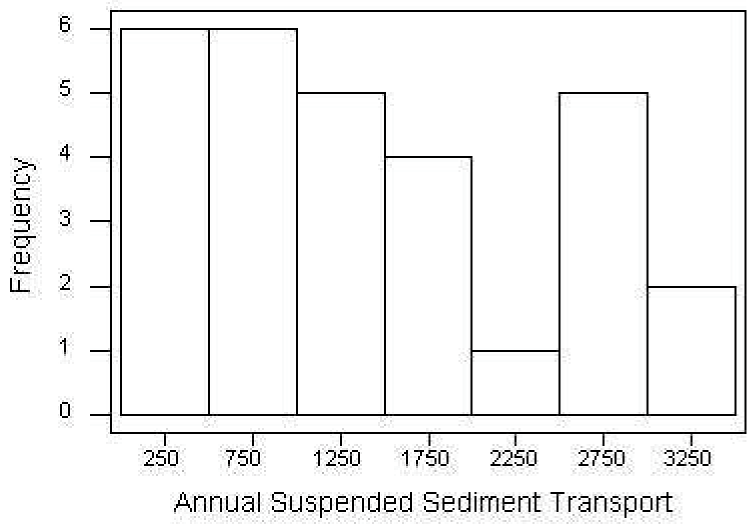

Figure 1.2.2: Histogram of estimates of annual suspended sediment transport (tonnes/yr) from the North Esk River at Ballroom derived from 29 years of discharge data, 1950 – 1978. (from Skirving, 1986).

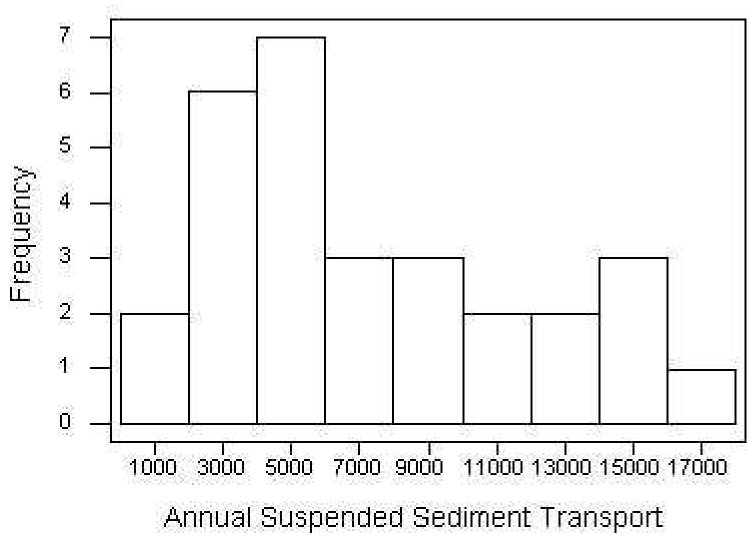

Figure 1.2.3: Histogram of estimates of annual suspended sediment transport (tonnes/yr) from the North Esk River at Corra Linn derived from 29 years of discharge data, 1950 – 1978. (from Skirving, 1986).

1.3 Launceston City Council monitoring

The Launceston City Council (LCC) currently conducts baseline monitoring of flow, conductivity, rainfall and temperature in three urban catchments. Data has been collected for Kings Meadows Rivulet at Hobart Road, Allenvale Drainage Channel at Camira Street and Newnham Rivulet at Newnham Drive. The primary purpose of this monitoring program is to determine the impacts of urbanisation on waterways. For the purposes of this report the data from Kings Meadow Rivulet at Hobart Road has been discussed only.

Data was collected from Kings Meadow Rivulet at half hourly intervals from January 1999 until February 2001. Tables 1.3.1 and 1.3.2 below illustrate some of the characteristics of the data for this site. Median water temperature and conductivity levels in 1999 were slightly lower than those experienced in 2000, while median turbidity and rainfall levels in 1999 were higher than those experienced in 2000.

Table 1.3.1: Summary statistics of water quality data collected by LCC at Kings Meadow Rivulet at Hobart Road. Period of record January 1999 – December 1999.

1999	**Water Temp (C°)**	**Conductivity µS/cm**	**Turbidity (NTU)**	**Rainfall (ml)**	**Flow (Cumecs)**
Maximum	23.2	1599	248	1.2	1.9
Minimum	5.8	359	5.2	0.0	0.004
Median	13.4	1088	75.8	0.08	0.07

Table 1.3.2: Summary statistics of water quality data collected by LCC at Kings Meadow Rivulet at Hobart Road. Period of record January 2000– March 2001.

2000	**Water Temp (C°)**	**Conductivity µS/cm**	**Turbidity (NTU)**	**Rainfall (ml)**	**Flow (Cumecs)**
Maximum	21.6	2137	377	0.6	2.04
Minimum	7.0	19.6	4.5	0.0	0.002
Median	14.8	1254	66.8	0.06	0.07

1.3.1 Time series Analysis

Conductivity at this site does not appear have a strong seasonal pattern, however variations in conductivity (Figure 1.3.1) are reflected by variations in flow (Figure 1.3.3) with periods of higher conductivity occurring during periods of lower flow.

The time series for water temperature exhibits a distinct seasonal pattern with temperatures recorded varying between a maximum of 23.3C° in January 1999 to a minimum of 5.8C° in August 1999.

The time series plot for turbidity illustrates a high degree of variability characteristic of this parameter (Figure 1.3.2) with high turbidity events occurring between May and August corresponding high flow events. The majority of events tend to generate peaks of around 70 NTU corresponding with an increase in flow and a decrease in conductivity. This is evident for an event in mid July 2000 (Figures 1.3.1, 1.3.2, 1.3.3).

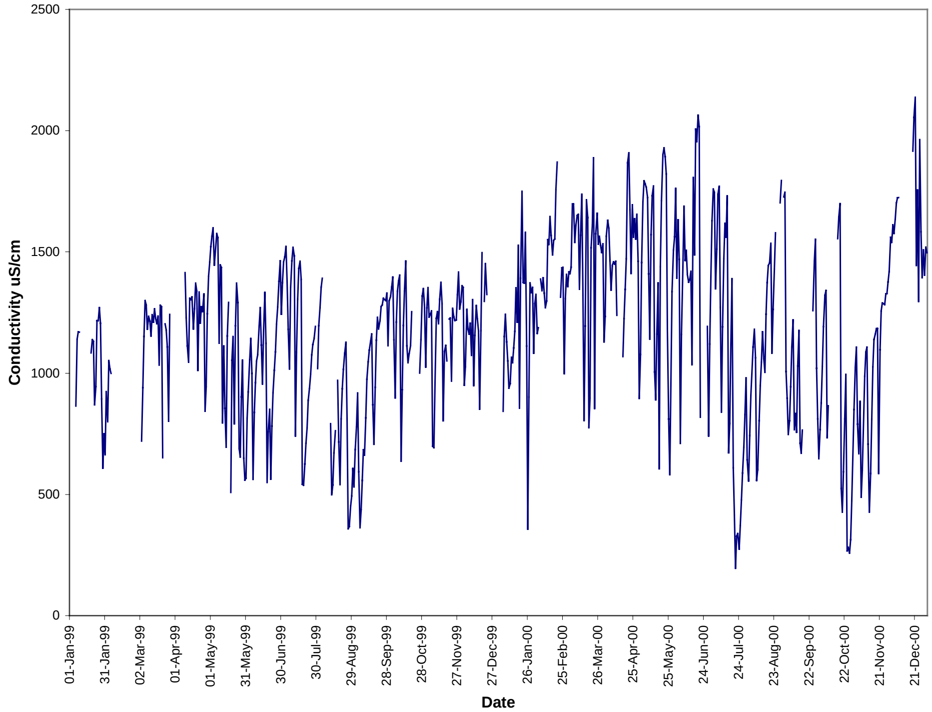

Figure 1.3.1: Time series plot of conductivity (μS/cm) at Kings Meadow Rivulet (1999-2001).

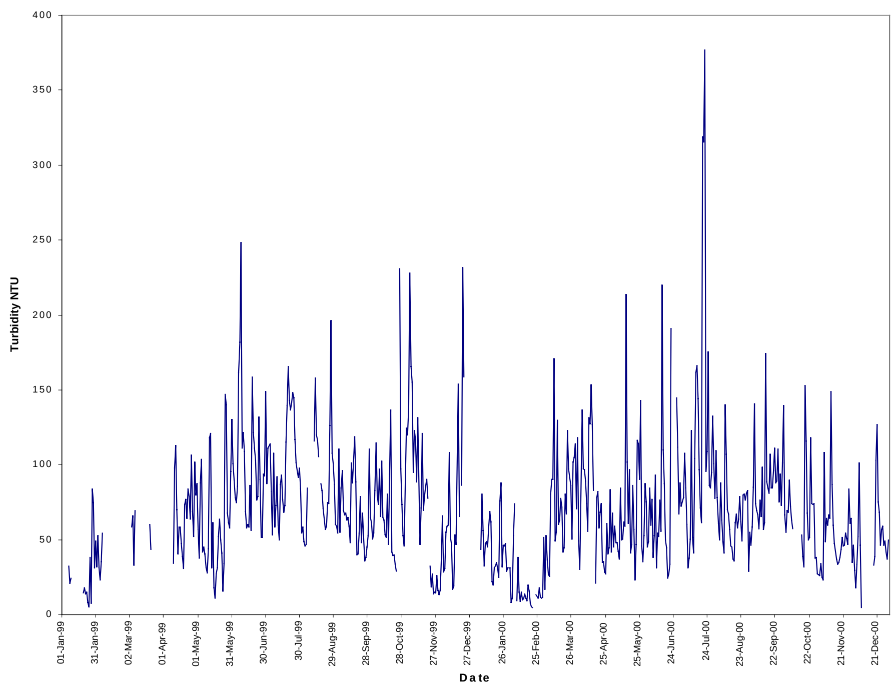

Figure 1.3.2: Time series plot of turbidity (NTU) at Kings Meadow Rivulet (1999-2001).

Time series plots for rainfall and flow exhibit a strong seasonal pattern with higher flows and rainfall events occurring during the winter months. Analysis of these data reveals that while total discharge (megalitres) in 1999 was greater than that recorded for 2000, this was not reflected in total rainfall (mm) (Table 1.3.3). Comparison between both flow and rainfall traces reveal that rainfall in 1999 peaked more frequently than in 2000 (Figure 1.3.3 and 1.3.4). This suggests that rainfall events in 1999 were perhaps more localised resulting in a greater chance of runoff reaching Kings Meadows Rivulet whereas the dispersed manner of rainfall in 2000 resulted in lower total discharge recorded for that year.

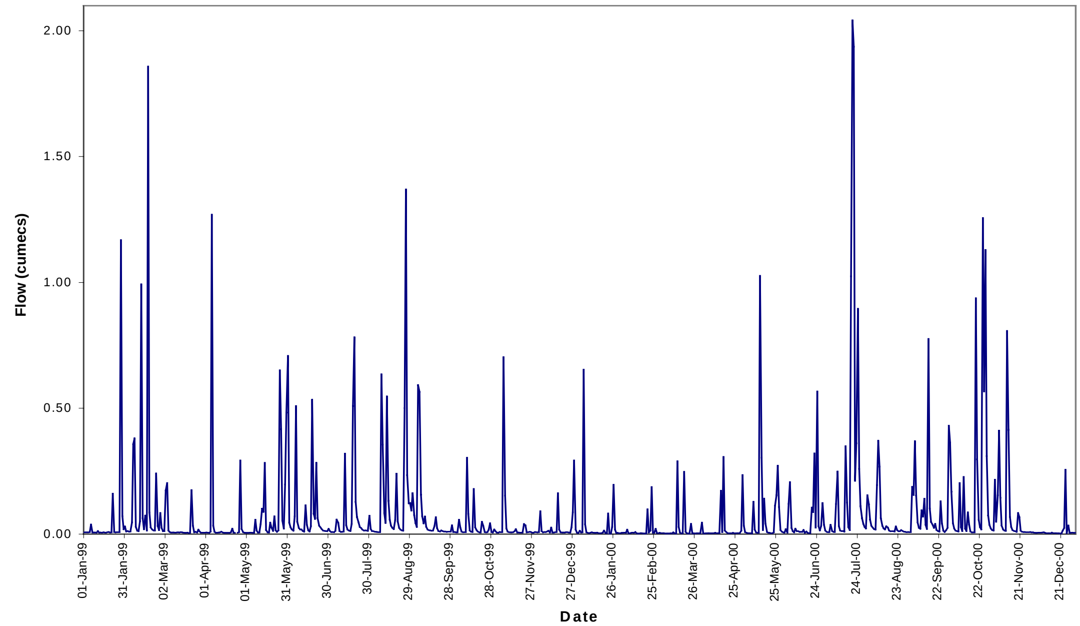

Figure 1.3.3: Time series plot of Flow (cumecs) at Kings Meadow Rivulet (1999-2001).

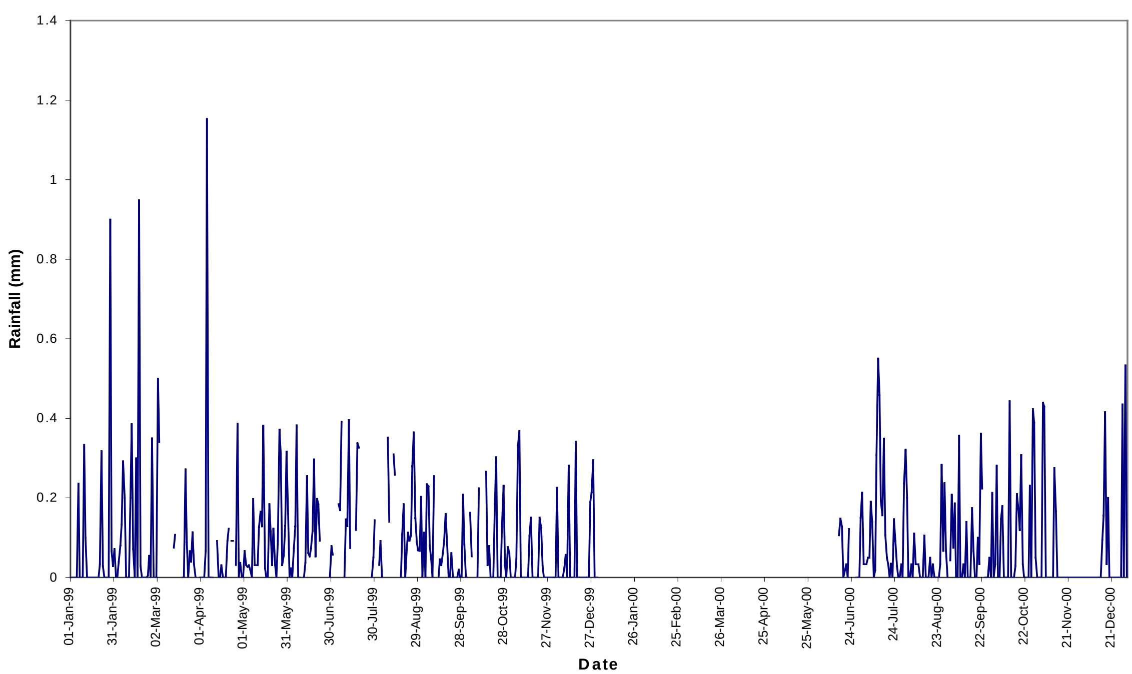

Figure 1.3.4: Time series plot of Rainfall (mm) at Kings Meadow Rivulet (1999-2001).

Table 1.3.3: Total rainfall (mm) and discharge (ML) for Kings Meadows Rivulet at Hobart Road for 1999 and 2000.

Month	Total Rainfall (mm) 1999	Total Flow (ML) 1999	Total Rainfall (ml) 2000	Total Flow (ML) 2000
January	50.80	144.17	58.14	100.09
February	120.40	390.84	18.74	38.53
March	38.00	67.69	25.34	64.83
April	57.13	154.95	28.81	73.41
May	97.92	292.29	40.78	213.55
June	47.39	190.16	42.27	161.88
July	72.47	206.32	141.20	709.35
August	125.58	434.14	24.20	129.75
September	45.18	175.31	71.00	296.11
October	42.41	87.65	86.60	490.59
November	37.26	99.46	68.60	231.20
December	44.77	77.66	16.20	39.78
Total	**779.3**	**2320.6**	**621.9**	**2549.1**

1.4 Analysis of Water Quality in Response to Forest Harvesting in the Musselboro Creek Catchment.

Studies into the impacts of logging activities on water quality have been undertaken in the Musselboro Creek catchment by Forestry Tasmania and the CSIRO between 1991 and 1995 (Thompson, *et al.*, 2002). Various water quality parameters including turbidity, total dissolved solids (TDS), total suspended solids (TSS), total kjeldahl nitrogen (TKN) and total phosphorus (TP) were measured during pre-treatment, road construction, logging and post-logging phases. Sites monitored included control, treatment, agricultural and supplementary stations as detailed in Table 1.4.

Results from this work showed that there was only a marginal increase in turbidity throughout the logged areas with highest turbidity in the agricultural sections of the catchment. Data for TDS and TSS were only recorded during the end phase of the logging period and post logging. Results from these data showed that TDS and TSS were correlated to land use with the supplementary station recording the highest concentrations after these data were normalised for catchment area. Post logging data for these variables suggested that TSS concentrations were not propagated downstream due to the effect of dilution. Increases in TSS and TDS concentrations were detected at the agricultural station with TP and TKN concentrations following a similar pattern. From this these data it was concluded that forest harvesting, when undertaken within the guidelines of the 'Forest Practices Code' did not adversely impact on the levels of turbidity, TDS, TSS, TP or TKN in the Musselboro Creek catchment.

Table 1.4: Details of monitoring stations in the Musselboro catchment during Forestry operations (from Thompson, *et al.*, 2002)

Site	Station No.	Sub-catchment Landuses	Area (ha)
Control	331	No disturbance from forestry operations	186
Treatment	330	90ha of forestry operations (10%) + undisturbed areas (including control)	984
Agricultural	329	Agriculture + 90 ha of forestry operations + undisturbed sub-catchments + treatment + control	2795
Supplementary	743	31 ha of forestry opperations	31

1.5 Historical Data from the State database HYDROL

The DPIWE managed water database HYDROL was interrogated to extract water quality data from sites in the North Esk River and St Patricks River catchments. Substantial records were found for three sites (Tables 1.5.1 to 1.5.3), with data being stored for a wide variety of parameters. In the North Esk sub-catchment, the only sample data that is archived is from the North Esk River at Ballroom, with data collected between 1974 and 1995. While data on parameters such as pH and temperature spans most of this period, there are shorter time periods when more intensive sampling was undertaken as part of individual studies in the catchment. Two such periods are 1974-'81 and 1985-'89. During the earlier period, sampling appears to have occurred on an infrequent basis, but samples were analysed for a wider range of parameters. During the second sampling period (1985-'89), sampling was more intensive, but analyses were limited to suspended solids, filterable residues, turbidity and colour. It is clear that the sampling at that time was aimed at the investigation of sediment movement. Some of this data is likely to have been used in Skirving's study (1986), as the bulk of the data was collected in 1985 and 1986.

Interrogation of the database also showed that sampling has taken place in the St Patricks River at Camden Road, and lower down the river at Nunamara. The data from these two sites is summarised in Table 1.5.2 and 1.5.3 below. Data collection at both sites probably began in 1971 as part of the same program, however data from the St Patricks River at Nunamara was continued for another seven years following termination of monitoring at Camden Road. The parameters measured at Nunamara are also more extensive than those that were measured at the Camden Road site.

There are several features of the data presented in Table 1.5.3 for North Esk River at Ballroom. The median statistic for turbidity and colour tends to indicate that clarity is reasonably good for the majority of the time, although samples taken during high flows (as indicated by maximum values) show that conditions can get quite turbid. The maximum value for both turbidity (130 NTU) and colour (250 Hazen Units) respectively was recorded during flood flows of 78 cubic metres per second at the Ballroom streamflow monitoring station.

The data for pH at Ballroom shows that conditions are slightly acidic, and dissolved salt concentrations and conductivity data show that the North Esk water is quite dilute. The alkalinity and hardness data are also indicative of a dilute system and are characteristic of a higher catchment site receiving clean runoff from a relatively undisturbed area (Ben Lomond Massif). The dissolved oxygen data clearly shows that the river system in this reach is very healthy, with the minimum value measured being 8.5 mg/L. The data from the major nitrogen and phosphorus parameters also show that nutrient levels are fairly low, although nitrate and ammonia concentrations can be moderately elevated at times (maximum of 0.542 mg/L and 0.28 mg/L respectively).

The data from both sites shows that water quality in the St Patricks River is very similar to that in the North Esk River. As would be expected, the data from St Patricks at Camden Road is indicative of a more elevated catchment site, with lower levels of dissolved salts, better clarity and slightly greater acidity. A comparison between selected water quality characteristics at the three sites in the North Esk catchment is presented in Figure 1.5.1 and 1.5.2. These figures best demonstrate the differences between the sites, though the water at all three (as represented by hardness and filterable residue) can be considered very dilute.

Table 1.5.1: Summary statistics for data contained on HYDROL database for the St Patricks River at Camden Road between 1971 and 1976.

St Patricks at Camden Road (1974 – 1976)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
pH lab		33	6	7.4	6.69	6.70
Total suspended solids	mg/l	33	0.5	37	5.44	3.20
Colour	Hazen Units	33	5	60	14.85	10.00
Turbidity	Hellige	33	0.5	22	4.35	2.10
Total Calcium as Ca	mg/l	29	0.73	4.8	2.00	1.90
Total chloride as Cl	mg/l	32	0.8	8.6	5.29	5.60
Total Magnesium as Mg	mg/l	29	0.1	2.2	0.63	0.50
Total Potasium as K	mg/l	31	0.3	1.6	0.54	0.50
Alkalinity BGMR	mg/l	31	4.4	15	8.21	8.40
Total Hardess as CaCo3	mg/l	29	5	17	7.78	7.00
Filtered residue	mg/l	31	19	59	34.26	34.00

Table 1.5.2: Summary statistics for data contained on HYDROL database for the St Patricks River at Nunamara between 1971 and 1976.

St Patricks at Nunamara (1971 – 1983)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
pH lab		40	6.4	7.8	7.11	7.10
Total suspended solids	mg/l	72	0.5	37	6.57	4.00
Colour	Hazen Units	71	5	85	25.4	15
Conductivity at 25°C field	µS/cm	6	38	47	43.0	43.50
Turbidity	Hellige Units	72	0.7	34.5	7.11	3.30
Dissolved Oxygen	mg/l	33	8.5	12	10.2	10.00
BOD	mg/l	10	0.5	2.6	1.44	1.50
Boron as B	mg/l	10	0.01	0.19	0.06	0.05
Total Calcium as Ca	mg/l	29	1.6	4.8	2.67	2.50
Free Chlorine	mg/l	10	4.5	8.7	6.53	6.30
Total chloride as Cl	mg/l	32	0.8	10.7	6.56	6.40
Total Flouride	mg/l	10	0.002	0.03	0.02	0.02
Total Magnesium as Mg	mg/l	39	0.12	2.4	1.19	1.10
Total Iron as Fe	mg/l	10	0.16	1.6	0.43	0.30
Total Manganese as Mn	mg/l	6	0.008	0.036	0.02	0.012
Nitrite as NO2	mg/l	8	< 0.005	0.016	0.005	0.004
Nitrate as N03	mg/l	10	< 0.005	0.6	0.24	0.224
Album. Ammonia as NH3	mg/l	10	0.08	0.24	0.16	0.170
Total Phosphate	mg/l	10	< 0.005	0.02	0.01	0.005
Total Potasium as K	mg/l	42	0.3	1.8	0.58	0.56
Silica as SiO2	mg/l	10	6.5	29	10.58	8.60
Total Sodium as Na	mg/l	10	3.3	5.1	4.37	4.50
Total Sulphate as SO4	mg/l	10	0.3	1.7	0.96	1.00
Alkalinity as CaCO3	mg/l	41	7	17.6	11.72	11.20
Total Hardness as CaCo3	mg/l	38	6	19	11.53	11.00
Filtered Residue	mg/l	70	4.5	326	50.32	44.40
Anionic surfacants	mg/l	10	0.01	0.16	0.04	0.02
Tannins and Lignins	mg/l	33	0.2	1.44	0.50	0.40
Total Coliforms	Count/100ml	10	82	1600	315	165
E. coli	Count/100ml	10	30	1200	243	130
Faecal Streptococci	Count/100ml	10	2	314	66	44

Comment HCB, Lindane, Dieldrin and DDT were tested for but not detected

Table 1.5.3: Summary statistics for data contained on HYDROL database for the North Esk River at Ballroom between 1974 and 1995.

North Esk at Ballroom (1974 – 1995)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Temperature	degC	164	2	20	10.24	10
Apparent Colour	Hazen Units	57	5	250	37.5	30
pH lab		122	5.7	8.4	6.29	6.9
pH field		38	5.7	7.9	6.55	6.4
Total suspended solids	mg/l	58	1	190	10.9	4.4
Conductivity at 25c Field	mS/cm	24	44	151	70.1	66.9
Turbidity	Hellige Units	47	0.7	43.5	6.9	3.1
Turbidity	NTU	13	1.2	130	17.4	3
Dissolved Oxygen	mg/l	27	8.5	12.2	10.5	10.3
ORP	mv	4	49	85	66	65
Boron as B	mg/l	8	0.01	0.05	0.037	0.045
Total Calcium as Ca	mg/l	8	3	4.8	3.95	4.05
Free Chlorine	mg/l	8	5	8.4	6.67	6.55
Flouride as F	mg/l	8	<0.002	0.04	0.023	0.02
Total Magnesium as Mg	mg/l	8	1.3	2.2	1.83	1.95
Total Iron as Fe	mg/l	8	0.25	1.4	0.51	0.375
Total Manganese as Mn	mg/l	4	0.011	0.015	0.013	0.013
Nitrite as NO_2	mg/l	6	< 0.005	0.01	0.003	0.0018
Nitrate as NO_3	mg/l	8	< 0.005	0.542	0.185	0.174
Free ammonia as NH3	mg/l	8	0.02	0.28	0.108	0.1
Album. ammonia as NH3	mg/l	8	0.1	0.2	0.153	0.15
Total Phosphate	mg/l	8	< 0.005	0.011	0.005	0.005
Total Potasium as K	mg/l	8	0.36	0.8	0.52	0.49
Total Sodium as Na	mg/l	8	4	5.8	4.98	4.95
Silica as SiO2	mg/l	8	8.7	14.7	11.18	10.6
Total Sulphate as SO4	mg/l	8	0.4	1.3	0.86	1
Alkalinity as CaCO3	mg/l	8	14	21.8	18.4	18.6
Total Hardess as CaCo3	mg/l	7	13.5	20	17.3	17.8
Filtered residue	mg/l	58	3	263	56.9	52
BOD	mg/l	8	1.2	3.1	2.0	1.9
Bacteria 72/22	Count/100ml	8	420	8100	2045	1150
Faecal streptococci	Count/100ml	6	4	68	37.6	38
E. coli	Count/100ml	2	56	66	61	61

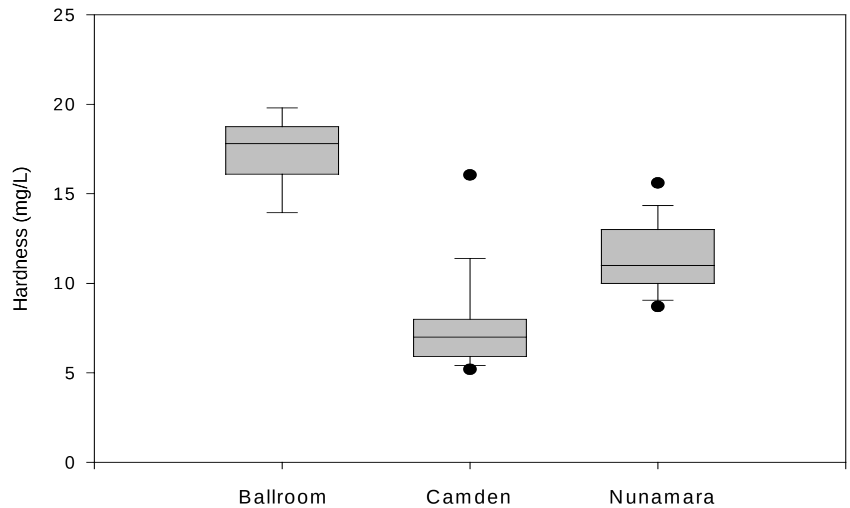

Figure 1.5.1: Boxplot showing the statistics for water hardness in the North Esk River at Ballroom and the St Patricks River at Camden and Nunamara (data from HYDROL database, DPIWE).

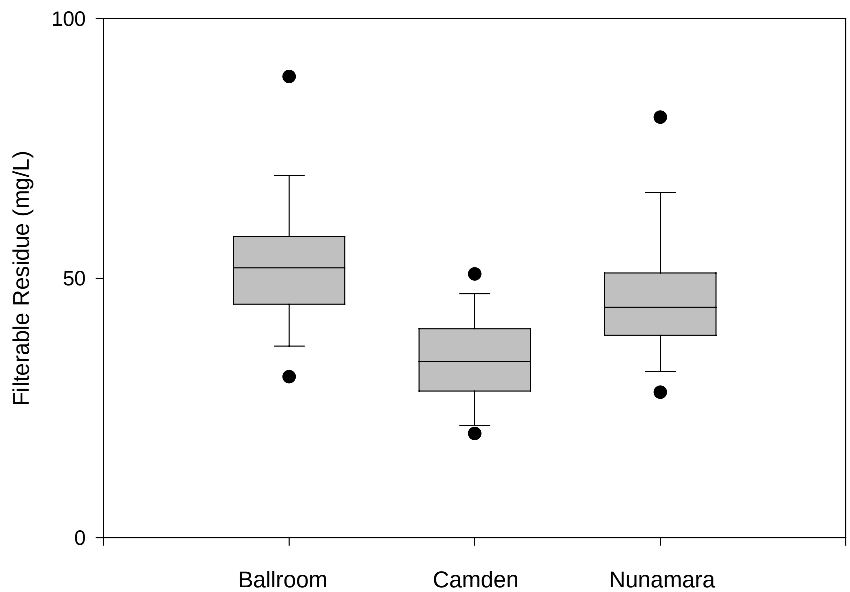

Figure 1.5.2: Boxplot showing the statistics for filterable residue in the North Esk River at Ballroom and the St Patricks River at Camden and Nunamara (data from HYDROL database, DPIWE).

1.6 Launceston Waterwatch – St Patricks River Monitoring

This group has collected water quality data from 25 sites in the St Patricks River with many of these sites sampled only occasionally. The majority of the sampling and field testing has taken place at about 8 key sites. Unlike many other groups, the Launceston Waterwatch group have combined field testing using normal Waterwatch equipment with bottled sampling which has been analysed by laboratory means. Their total dataset therefore includes a wide variety of parameters, including bacterial counts, some of the common heavy metals, ionic salts and some of the common nutrients. Although at first glance this might appear to be a very robust dataset, a detailed examination has shown that the levels of detection used for some of the laboratory based analyses have not been adequate for the purposes of ambient water analysis. This is most apparent for total phosphorus and copper analysis, with much of the data failing to meet the standard required. The data which will be discussed in this section of the report will therefore be limited to that which appears most reliable and is of a worthwhile standard.

A boxplot of pH as recorded from the major 8 sites (Figure 1.6.1) shows that the acidity of water in the St Patricks catchment is quite variable, with the median pH ranging between about 6.3 and 7.7. The pH of Patersonia Rivulet appears to increase towards the junction with the St Patricks River, where pH levels are slightly above neutral (Figure 1.6.1). The large box for the data from Patersonia Rivulet at RDS 495 (PTR 035) is a result of the low number of records at that site (only 3 records).

Table 1.6.1: Sites in the North Esk catchment sampled by the Launceston Waterwatch group between 1992 and 1998.

Site Code	Site Name	Easting	Northing
PTR005	Patersonia Rivulet	527500	5427500
PTR029	Tributary of Patersonia Rivulet	526550	5425640
PTR030	Patersonia Rivulet at bridge on Mt Arthur Road	526550	5425640
PTR045	Patersonia Road (C827) bridge on Patersonia Rivulet	525400	5420400
SPR006	St Patricks River past Gunns Mill site	547500	5422900
SPR008	Small Tributary of St Patricks River	547500	5423900
SPR011	Caldeck Brook	546000	5422850
SPR013	St Patricks River below Wombat Plain	544750	5424100
SPR019	St Patricks River near Diddleum Plains	539800	5425750
SPR027	Branch of Camden Rivulet at bridge	538500	5425250
SPR028	Camden Rivulet at Diddleum Road	538700	5425200
SPR036	St Patricks River at Corkerys Road	534200	5428400
SPR045	Seven Mile Creek at Tasman Highway	531400	5426700
SPR047	St Patricks River at Myrtle Park Rec ground at BBq site 1	530300	5426500
SPR056	Bennies Rivulet at Tasman Highway	530000	5425000
SPR063	Barrow Creek at Tasman Highway	529200	5424300
SPR064	St Patricks River at Pecks Hill Road	528700	5424300
SPR074	Coquet Ck (Trout Ck) at bridge on Tasman Hwy (A3)	528200	5421300
SPR083	Unnamed crk at bridge on Tasman hwy (A3), at Weavers Ck Road	525980	5418600
SPR087	St Patricks River at bridge on Tasman hwy at Nunamara	525000	5417800
SPR091	St Patricks River near Redbanks	525500	5414700
SPR099	St Patricks River near junction with South Esk	528100	5407900
PTR035	Patersonia Rivulet west of RSD495 on C827, (McMurry's)	525135	5422752
PTR040	Patersonia Rivulet at derelict bridge site on Scotts Road.	525015	5421523
	Ellis Road Patersonia Rivulet	525040	5423920

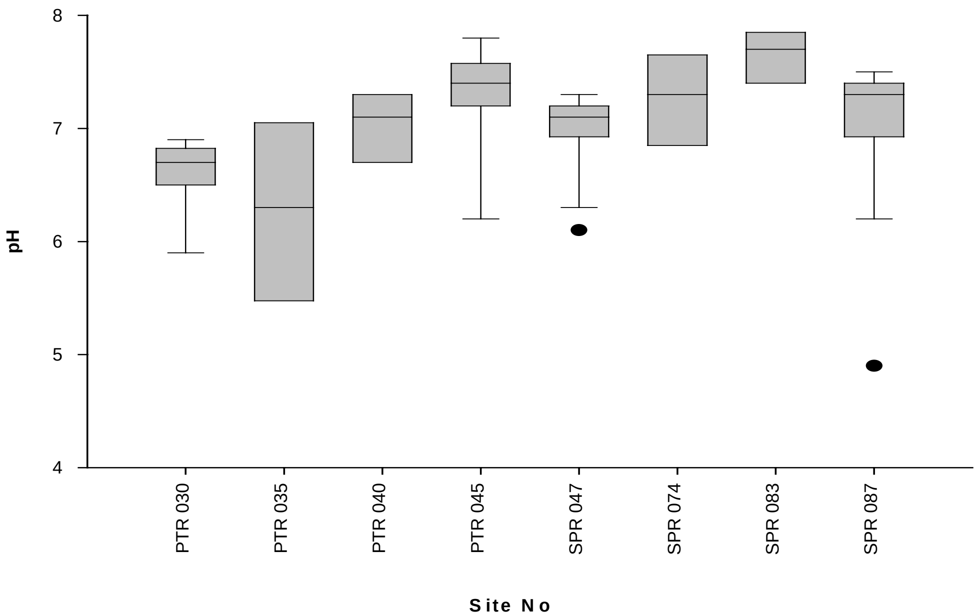

Figure 1.6.1: Boxplot of pH data from sites in the St Patricks catchment collected by the Launceston Waterwatch group between 1992 - 1998. Site numbers are as follows: Patersonia Rivulet at Mt Arthur (PTR 030), Patersonia Rivulet at RSD 495 (PTR 035), Patersonia Rivulet on Scotts Road (PTR 040), Patersonia Rivulet at C827 (PTR 045), St Patricks River at Myrtle Park (SPR 47), Coquet Creek at Tasman Highway (SPR 074), Un-named Creek at Tasman Highway (SPR 083), St Patricks River at Nunamara (SPR 087).

Turbidity records from this group is the most extensive of all the data collected and clearly demonstrates the high degree of variability which is typical of this parameter (Figure 1.6.2). The median turbidity level across all sites is about 2.4 NTU, indicating that the clarity of water in this area is generally good. The highest readings (> 30 NTU) have been recorded in Patersonia Rivulet, which correspond with runoff into the rivulet on the 25th April 1996 following significant rainfall. Higher turbidity levels have also been recorded at Un-named Creek at Tasman Highway (SPR 083). Of the 11 records, 3 were greater than 25 NTU, which suggests that there may be some local catchment activity which could be impacting on suspended sediment levels to the creek. The lowest turbidity readings appear to be consistently recorded from Coquet Creek (SPR 074), which flows northwest off the slopes of Mt Barrow.

Nitrate nitrogen (NO_3-N) concentrations have also been recorded from all of the major Waterwatch sites. The statistical distribution of the data from each of the major sites is shown in Figure 1.6.3. The plot shows that there may be a clear trend for decreasing concentrations towards the bottom of Patersonia Rivulet. Nitrate concentrations are clearly lower in the St Patricks River and near detection limits in the small tributaries draining the northern slopes of Mt Barrow.

Median levels of hardness across all sites were low reflecting the poor buffering capacity and hence fluctuations in pH of Patersonia Rivulet and St Patricks River. Faecal coliform records were generally above the recommended level for primary contact of 150 per 100mls (Figure1.6.4).

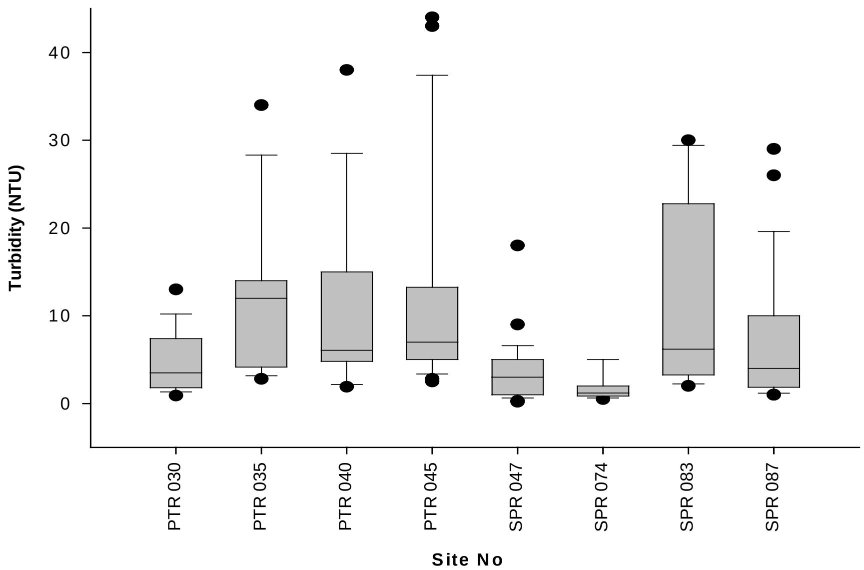

Figure 1.6.2: Boxplot of turbidity data from sites in the St Patricks catchment collected by the Launceston Waterwatch group between 1992 - 1998. (sample numbers range between 4 and 15). Site numbers as follows: Patersonia Rivulet at Mt Arthur (PTR 030), Patersonia Rivulet at RSD 495 (PTR 035), Patersonia Rivulet on Scotts Road (PTR 040), Patersonia Rivulet at C827 (PTR 045), St Patricks River at Myrtle Park (SPR 47), Coquet Creek at Tasman Highway (SPR 074), Un-named Creek at Tasman Highway (SPR 083), St Patricks River at Nunamara (SPR 087).

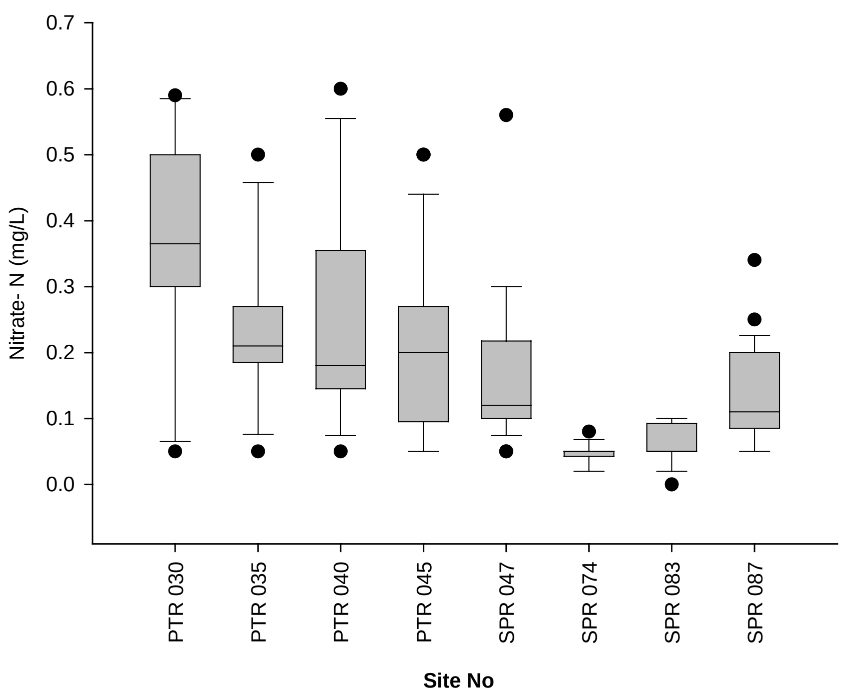

Figure 1.6.3: Boxplot of nitrate (as N) data from sites in the St Patricks catchment collected by the Launceston Waterwatch group between 1992 - 1998. (Sample numbers range between 7 and 23). Site numbers as follows: Patersonia Rivulet at Mt Arthur (PTR 030), Patersonia Rivulet at RSD 495 (PTR 035), Patersonia Rivulet on Scotts Road (PTR 040), Patersonia Rivulet at C827 (PTR 045), St Patricks River at Myrtle Park (SPR 47), Coquet Creek at Tasman Highway (SPR 074), Un-named Creek at Tasman Highway (SPR 083), St Patricks River at Nunamara (SPR 087).

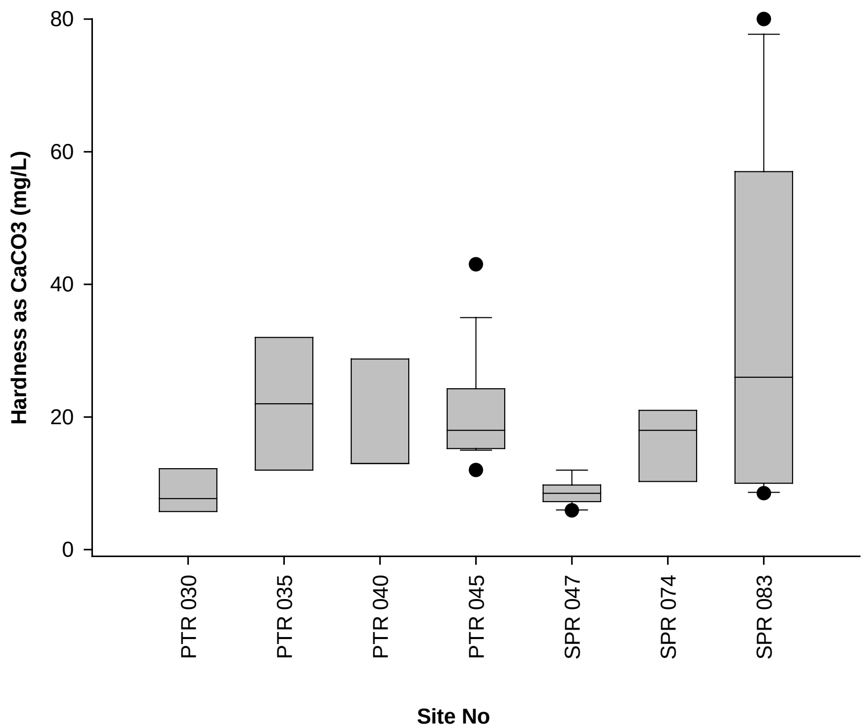

Figure 1.6.4: Boxplot of hardness data from sites in the St Patricks catchment collected by the Launceston Waterwatch group between 1994 - '98. (Sample numbers range between 4 and 15). Site numbers as follows: Patersonia Rivulet at Mt Arthur (PTR 030), Patersonia Rivulet at RSD 495 (PTR 035), Patersonia Rivulet on Scotts Road (PTR 040), Patersonia Rivulet at C827 (PTR 045), St Patricks River at Myrtle Park (SPR 47), Coquet Creek at Tasman Highway (SPR 074), Un-named Creek at Tasman Highway (SPR 083), St Patricks River at Nunamara (SPR 087).

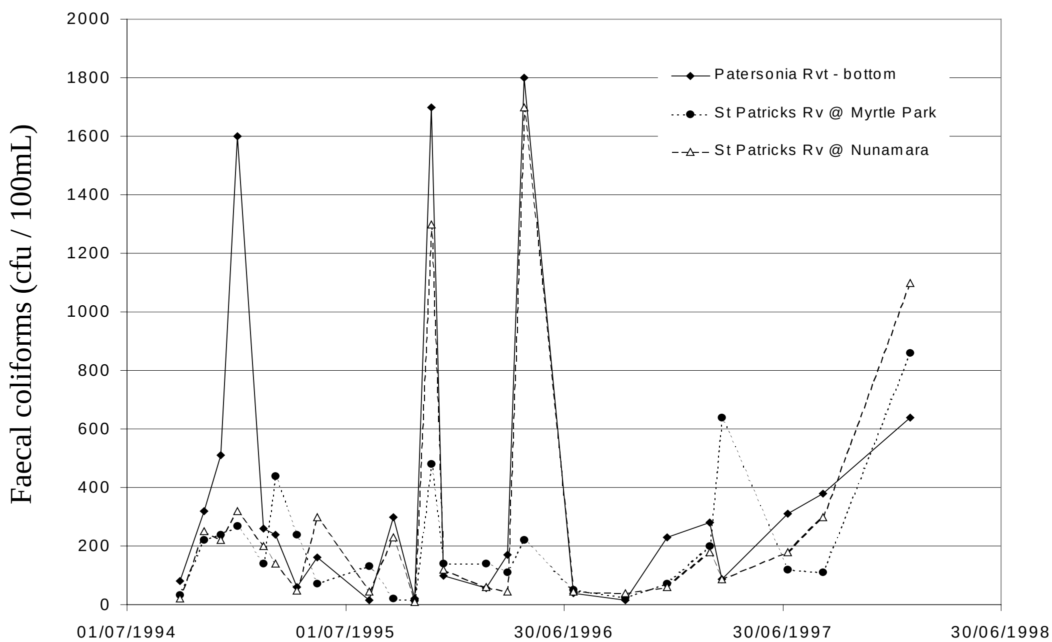

Figure 1.6.5: Variation in faecal coliform concentrations at three sites in the St Patricks River as recorded by the Launceston Waterwatch between 1994 and 1998.