Water Quality of the Pipers River

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

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Executive Summary

The Pipers River catchment is an area extensively used for agriculture and forestry. The catchment covers approximately 298 km² and drains northward into Bass Strait through Weymouth. This report presents and discusses the results of a 1yr study of water quality in the catchment that was undertaken in 1998 as part of a program of ‘State of Rivers’ studies in the north-east of Tasmania. The results should also be examined in the light of other studies into hydrology, stream condition and aquatic ecology which were also undertaken concurrently and which are reported separately.

Some of the major findings of this study are:

⇒ Water temperature shows a distinctive seasonal change, with minimum temperatures of 5 °C occurring during July and maximum temperatures of up to 25 °C occurring during late January. Large short-term changes can occur due to passage of cold fronts across the catchment.

⇒ Conductivity, which is an indicator of salt concentrations, tends to be highest during low summer flows but drops dramatically during and following any significant rainfall and is generally much lower during winter and spring. The ions contributing most to surface water salinity are chloride and sodium.

⇒ Turbidity levels were variable at sites where monitoring was undertaken, with clearest water occurring during the period January to May, when flows were lowest. During the high flows of winter, turbidity at some sites was significantly higher demonstrating the impact of runoff and erosion on water quality. At the bottom of the catchment, turbidity readings of over 350 NTU were measured.

⇒ Dissolved oxygen concentrations at many sites in the catchment were extremely low during low summer flows and was indicative of an ecosystem under significant stress. Oxygen concentrations recovered well during late autumn and winter. Short-term monitoring also showed that oxygen concentration is lowest during the early hours of the morning.

⇒ Nutrient concentrations were monitored routinely at only one site towards the bottom of the Pipers River. Results show strong evidence of seasonal changes in nitrate concentrations related to river flows and may reflect flushing of this nutrient from the soil profile during autumn and winter.

⇒ Phosphorus levels in Pipers River are generally highest during flood events, when suspended sediment carries large loads of phosphorus towards the catchment outlet. There is also some evidence that sediment stored in the river releases dissolved phosphorus during very low summer flows, sustaining aquatic plant and algal growth.

⇒ Sampling of flood waters in Pipers River allowed catchment export loads to be estimated near the catchment outlet. During a single flood in September 1998, the estimated loss of nitrogen and phosphorus from the catchment was 25.7 tonnes and 2.5 tonnes respectively. The estimated loss of suspended solids (mainly composed of soil and sediment) during this event was 1,828 tonnes. This is roughly equivalent to 1,500 cubic metres of soil.

⇒ During the year of the study, it is estimated that 91.8 tonnes of nitrogen, 6.5 tonnes of phosphorus and 4,142 tonnes of suspended solids was lost from the Pipers River catchment. When compared against estimates from other catchments in Tasmania, these are towards the higher end of the scale. The implications of this in terms of catchment loss and environmental risk to the estuary at Weymouth are discussed.

⇒ Opportunistic sampling during an intense thunderstorm provided evidence that there can be significant losses of nutrients and soil from cleared land during these events and that management of runoff from these types of events may need to be considered.
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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 various 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. 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 25º Celsius.

Eutrophication
The enrichment of surface waters with nutrients such as nitrates and phosphates, which cause nuisance blooms of aquatic plants and algae.

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 \( \pm 15\% \)).

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;

\[
\frac{\text{Discharge (ML)}}{\text{Catchment Area (km}^2\text{)}} = X (\text{mm km}^{-2})
\]
\[
\frac{\text{Total Load (kg)}}{X} = Y (\text{kg mm}^{-1})
\]
\[
Y / \text{Catchment Area (km}^2\text{)} = \text{Export Coefficient (kg mm}^{-1}\text{km}^{-2}\text{)}
\]

Where \( Z \) is the Export Coefficient and is equivalent to Total Load (kg) / Discharge (ML).

**Faecal Coliforms (also known as ‘thermotolerant coliforms’ - eg. \textit{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.

**General Ions**

General ions are those mineral salts most commonly present in natural waters. They are primarily sodium, potassium, chloride, calcium, magnesium, sulphate, carbonates and bicarbonates. Their presence affects conductivity of water and concentrations variable in surface and groundwaters due to local geological, climatic and geographical conditions.

**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.

**Macroinvertebrate**

Invertebrate (without a backbone) animals which can be seen with the naked eye. In rivers common macroinvertebrates are insects, crustaeans, worms and snails.

**Median**

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

\( \text{i.e. Of the readings 10, 13, 9, 16 and 11} \)

\{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
m³ s⁻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 (draft - 1998)**

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. At the time of its release, the guidelines were based on the best scientific information available.

Since 1995, that document has been under review, and a new draft has recently been released for public comment (ANZECC, draft 1998). The updated version 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. This needs to be kept in mind when examining the following tables which summarise the new draft guidelines. The figures quoted are suggested as interim trigger levels for assessing risk of adverse effects on different ecosystem types (for essentially natural ecosystems).

1. **Proposed Trigger Levels for Nutrients**

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>TP (µg/L)</th>
<th>TN (µg/L)</th>
<th>Key Ecosystem-specific factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowland River</td>
<td>37</td>
<td>1600</td>
<td>- light climate (turbidity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- grazing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- bioavailable nutrient [ ]</td>
</tr>
<tr>
<td>Upland River</td>
<td>35</td>
<td>340</td>
<td>- light climate (turbidity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- substrate type</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- bioavailable nutrient [ ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- grazing</td>
</tr>
<tr>
<td>Lakes and Reservoirs</td>
<td>50</td>
<td>440</td>
<td>- light climate (turbidity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- mixing (stratification)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- bioavailable nutrient [ ]</td>
</tr>
</tbody>
</table>

2. **Proposed Trigger Levels for Dissolved Oxygen, Suspended Particulate Matter and Turbidity.**

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>DO (%sat)</th>
<th>Susp. Solids# (mg/L)</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowland River</td>
<td>90</td>
<td>6*</td>
<td>10</td>
</tr>
<tr>
<td>Upland River</td>
<td>92</td>
<td>2*</td>
<td>5</td>
</tr>
<tr>
<td>Lakes and Reservoirs</td>
<td>90</td>
<td>2*</td>
<td>4.5</td>
</tr>
</tbody>
</table>

# Recommend additional work to establish load based trigger levels;
* Professional judgement
3. **Proposed Trigger Levels for Conductivity, Temperature and pH.**

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>EC (µS/cm)</th>
<th>Temp. Increase</th>
<th>Temp. Decrease</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowland River</td>
<td>&gt; 500*</td>
<td>&lt; 80&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>&gt;20&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>6.6 - 8.0</td>
</tr>
<tr>
<td>Upland River</td>
<td>&gt; 110*</td>
<td>&lt; 80&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>&gt;20&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>6.5 - 7.5</td>
</tr>
<tr>
<td>Lakes and Reservoirs</td>
<td>&gt; 60*</td>
<td>&lt; 80&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>&gt;20&lt;sup&gt;th&lt;/sup&gt; %ile</td>
<td>7.8 - 8.3</td>
</tr>
</tbody>
</table>

* Professional judgement

4. **Proposed Microbiological Guidelines**

The new guidelines for recreational waters propose a ‘Bacterial Indicator Index’ which requires routine sampling (at least 5 samples over a regular period not exceeding one month). It utilises statistics of the entire dataset to form the index in the following manner;

\[
\text{Bacterial Indicator Index} = 2.5 \times \text{median}/100\text{mL} + 80\text{th percentile}/100\text{mL}
\]

Using this formula to calculate the index, the following guideline has been suggested;

*Primary Contact (eg swimming)*

Bacterial Indicator Index should not exceed 800 for thermotolerant coliforms

or 300 for enterococci

Where more intensive monitoring is carried out the index should not exceed 550 for thermotolerant coliforms, or 200 for enterococci

*Secondary Contact (eg boating)*

Bacterial Indicator Index should not exceed 5000 for thermotolerant coliforms

or 2000 for enterococci

*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 Pipers River Catchment

1 Historical Data

Water quality data from three sites in Pipers River is stored on the DPIWE Hydrol database. At all three sites river flow has also been recorded. These sites are list in Table 1.1, from top to bottom of the catchment, and the periods during which data on river flow and water quality is available is indicated.

Table 1.1 Period of record available for river flow and selected water quality for sites in Pipers River.

<table>
<thead>
<tr>
<th>Site</th>
<th>Site No.</th>
<th>Catchment Area</th>
<th>Flow Record</th>
<th>Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipers River at Underwood</td>
<td>116</td>
<td>50 km²</td>
<td>1952 - 1993</td>
<td>1985 - 1993</td>
</tr>
<tr>
<td>Pipers River u/s Colgraves Ck</td>
<td>19208</td>
<td>198 km²</td>
<td>1980 - 1990</td>
<td>1981 - 1990</td>
</tr>
<tr>
<td>Pipers River d/s Yarrow Ck</td>
<td>19204</td>
<td>298 km²</td>
<td>1972 - present</td>
<td>1974 - present</td>
</tr>
</tbody>
</table>

The majority of water quality data has been collected from the lowermost site on the river (Site 19204) where a major stream-flow monitoring station has been in operation since 1972. A reasonable amount of data has also been collected from the site at Underwood (Site 116), but this is generally limited to only a few parameters which were monitored during the period 1985 – ’93.

A summary of data from Site 19204 is presented in tabular form in Table 1.2. While the record for many of the variables is patchy, a fair record has been collected for temperature and pH. This is due to the fact that both of these have been measured during routine stream gauging maintenance visits. Although there is a significant amount of field data for pH, it must be kept in mind that the quality of this data is unknown due to a lack of knowledge about how measurements were taken.

Table 1.2 Statistics of Historical Data - Pipers River d/s Yarrow Ck (Hydrol 19204)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Lab pH</th>
<th>Field pH</th>
<th>Turbidity*</th>
<th>EC at 25°C*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10100</td>
<td>15401</td>
<td>15408</td>
<td>13601</td>
<td>14101</td>
</tr>
<tr>
<td>Number of Readings</td>
<td>101</td>
<td>52</td>
<td>52</td>
<td>7</td>
</tr>
<tr>
<td>Maximum</td>
<td>24.0</td>
<td>7.7</td>
<td>8.2</td>
<td>69</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.0</td>
<td>5.7</td>
<td>5.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Average</td>
<td>12.6</td>
<td>6.75</td>
<td>6.70</td>
<td>19.2</td>
</tr>
<tr>
<td>Median</td>
<td>13.0</td>
<td>6.8</td>
<td>6.7</td>
<td>6.1</td>
</tr>
</tbody>
</table>

* Infrequent records during the period.

Table 1.2 continued

<table>
<thead>
<tr>
<th>Apparent Colour*</th>
<th>Total Solids*</th>
<th>Suspended</th>
<th>Filterable Residues*</th>
</tr>
</thead>
<tbody>
<tr>
<td>12301</td>
<td>17100</td>
<td>32901</td>
<td></td>
</tr>
<tr>
<td>Number of Readings</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Maximum</td>
<td>200</td>
<td>115</td>
<td>162</td>
</tr>
<tr>
<td>Minimum</td>
<td>50</td>
<td>1</td>
<td>105</td>
</tr>
<tr>
<td>Average</td>
<td>97.9</td>
<td>22.0</td>
<td>130.3</td>
</tr>
<tr>
<td>Median</td>
<td>85</td>
<td>2</td>
<td>130</td>
</tr>
</tbody>
</table>

# Infrequent records during the period.
The historical data shows that water temperature in Pipers River at the bottom of the catchment have ranged between 1 - 24 °C. The time series plot of this data (Figure 1.1) shows more clearly the seasonal changes in water temperature over the period. It is interesting to note that in the period 1974 – '82 there is an apparent trend for increasing water temperature while during the period 1988 - '95 there appears to be a decrease in average water temperature. However, this is not statistically

![Water Temperature (°C)](image)

**Figure 1.1** Variation in water temperature in Pipers River downstream of Yarrow Creek (HYDROL Site 19204) between July 1974 and July 1996. Data was not collected on a routine basis.

![Box & Whisker plots](image)

**Figure 1.2** Box & Whisker plots displaying the statistics for historical field pH data from all three sites in Pipers River (HYDROL sites 116, 19208 & 19204). The number of records from each site is displayed in brackets below the figure.
The statistics for water temperature at the three sites is shown in Figure 1.2. While the median temperature at each site increases towards the bottom of the catchment, the outliers (as indicated by the individual dots) show that minima and maxima at each are very similar.

Although pH measured in the laboratory on bottled samples is not strictly comparable to that measured on site using field equipment, the data for both these has been plotted as a time series to better demonstrate the variation in pH at Site 19204 over the period (Figure 1.3). Comparing the two sets of data, it can be seen that pH measured on site at the river is more variable than pH measurements made back in the laboratory on bottled samples. In broad terms however, the data indicates that the pH of water in Pipers River generally fluctuates between 6 and 7.5, which is very similar to that of the nearby Brid River (In press), but higher than the more acidic waters of the Great Forester and Ringarooma rivers (Bobbi, 1996a; Bobbi, 1996b).

In Figure 1.4 the field pH data from all three sites on Pipers River are compared. It is clear that while the median pH of water at the middle site (Pipers River u/s Colgraves Creek) is slightly lower than for the other two sites, the spread of the data at all three sites is very similar.

![Figure 1.3](image)

**Figure 1.3** Variations in laboratory and field pH in Pipers River downstream of Yarrow Creek (HYDROL Site 19204) between July 1974 and July 1994. Data was not collected on a routine basis.

Much less data has been recorded for the other parameters of turbidity, conductivity, colour, suspended solids and filterable residues. Most of these data appear to have been recorded during an ‘ad hoc’ sampling program in the late 1980’s. The conductivity data from all three sites is summarised by the box & whisker plots in Figure 1.5, and shows that levels of conductivity (which is an indicator of salt concentrations) generally increase towards the bottom of the catchment. At the lowest site, conductivity levels can get as high as 320 µS/cm, although the median at this site is much lower at 180 µS/cm. The data from the site at Underwood (Site 116) illustrates the dilute nature of water higher in the catchment, where the median conductivity is only 88 µS/cm.
Figure 1.4  Box & Whisker plots displaying the statistics for historical field pH data from all three sites in Pipers River (HYDROL sites 116, 19208 & 19204). The number of records from each site is displayed in brackets below the figure.

Figure 1.5  Box & Whisker plots displaying the statistics for conductivity from all three sites in Pipers River (HYDROL sites 116, 19208 & 19204). The number of records from each site is displayed in brackets below the figure.
The visible colour of water reflects the level and character of dissolved and very fine particulate matter present. Naturally occurring minerals and organic compounds such as humic acids give water what is termed ‘true colour’. Apparent colour includes not only colour due to these dissolved substances, but also that caused by very fine suspended material (APHA, 1992).

From the historical data stored on the DPIWE database, it appears that water in Pipers River is low to moderately coloured. Highest levels of colour were measured at the lower site (Site 19204), with the higher readings being taken at this site during high flow events when runoff would have been bringing fine suspended material and dissolved organic matter into the river. It should be pointed out that high values for colour do not impede water use or its acceptability in terms of the environment.

Filterable residues data from the late 1980’s is also available from sites 116 and 19204. Although this term is no longer used with respect to water quality, it equates roughly with the newer term ‘total dissolved solids’ (TDS). Filterable residues generally reflect the degree of mineralisation of water, and as such show similar patterns to that of conductivity. In Pipers River, the historical data for both these parameters shows that the river at the bottom of the catchment contains more dissolved solids (or salts) than at site 116 near the top. This could be due either to its proximity to the coast, where oceanic aerosols from Bass Strait may be having more of an impact, or it may reflect the pick-up by the river of saline inflows from either groundwater or smaller tributaries.

![Box & Whisker plots displaying the statistics for colour from all three sites in Pipers River (HYDROL sites 116, 19208 & 19204). The number of records from each site is displayed in brackets below the figure.](image-url)
In summary, the historical data is fairly limited in extent, although it has shown some basic patterns which are characteristic of most catchments, like a strong seasonal pattern of change in temperature. It is clear that the water quality of the upper part of Pipers River is moderately dilute, with low dissolved salt and conductivity levels. This increases substantially by the bottom of the catchment, as salt levels in the river pick up. Although the data quality for pH is unknown, it tends to indicate that there are no obvious changes in pH down the length of the river nor is there any trend for change through time at Site 19204.

2 Current Study

The following water quality data was collected during 1998 in conjunction with a studies of rivers in the Ringarooma and Great Forester catchments. The main aim of sampling in the Pipers River catchment was to collect current data on the ambient quality of water and report on background conditions in the river. These data, when viewed in conjunction 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 three sites to determine the physico-chemical nature of water quality. The location and grid references of these sites is listed in the Table 2.1. Due to resource limitations, sampling for nutrients and dissolved salts was carried out at only one of these sites.

The second level of sampling involved two catchment-wide ‘snapshot’ surveys covering a multitude of sites along the length of the river. During these surveys, field testing was performed at 12 sites, with samples for laboratory analysis being taken at a subset of these. The third tier of monitoring involved the use of in-stream logging equipment to examine short-term variation such as diurnal changes in dissolved oxygen and other water quality parameters. In-stream monitoring of some water quality
variables was also performed in association with streamflow monitoring at the lowermost site on Pipers River (PR1 - Piper d/s Yarrow Creek). At this site, turbidity, conductivity and temperature is currently monitored on a continuous basis. As these probes are permanently immersed in the river, it is necessary to both clean them regularly and also check the accuracy of the data they collect against other regularly calibrated field instruments. When the data from this source is combined with nutrient concentrations from samples collected during flood events, calculations of nutrient fluxes for the period can be made.

Table 2.1 Location of sites where monthly water quality monitoring was carried out during the present study.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Code</th>
<th>Easting</th>
<th>Northing</th>
<th>Monitoring Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipers River d/s Yarrow Creek PR1</td>
<td>PR1</td>
<td>509400</td>
<td>5453300</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at Colgraves Rd PR7</td>
<td>PR7</td>
<td>510225</td>
<td>5441100</td>
<td>Phys-chem</td>
</tr>
<tr>
<td>Pipers River at Lalla Rd (Karoola) PR10b</td>
<td>PR10b</td>
<td>513400</td>
<td>5432125</td>
<td>Phys-chem</td>
</tr>
</tbody>
</table>

The physico-chemical parameters tested in the field included pH (compensated for temperature), electrical conductivity (corrected to reference temperature 25 °C), water temperature, turbidity and dissolved oxygen. Water samples were taken and analysed in a NATA registered laboratory for the following nutrients; ammonia nitrogen (NH3/N), nitrate nitrogen (NO3/N), nitrite nitrogen (NO2/N), Kjeldahl nitrogen (TK/N), dissolved reactive phosphorus (DR/P) and total phosphorus (TP). Total nitrogen (TN) was derived using the formula;

\[ TN = TK/N + NO3/N + NO2/N. \]

Every 2 months samples were also taken for laboratory analysis to determine general ion content and factors affected by levels of dissolved salts. These included determination of iron, calcium, magnesium, sulphate, chloride, sodium, potassium, silica, hardness, colour, alkalinity and suspended solids concentrations.

2.1 Physico-chemical properties

Water Temperature

Water temperature at all three sites was measured monthly during monitoring trips, as well as being recorded every 20 minutes at the streamflow monitoring site where equipment was permanently located to monitor water quality. The data from monthly visits to the three sites is shown in Figure 2.1 and displays both the seasonal variation common to all sites and the differences in temperature between sites.

It is interesting to note that for most of the study period, the difference between sites was relatively consistent, with the uppermost site (PR10b - Pipers at Lalla) generally having a water temperature 1-2 °C lower than that of the lowest site (PR1 - Piper d/s Yarrow Ck). However, during the warmer periods at both the beginning and end of the study, the temperature difference was unexpectedly negligible. During summer periods, water temperature is usually much lower at sites in the top ends of rivers, where there is normally better riparian cover shading the stream. However, the data from Pipers River does not show this, and this difference may be due to the site characteristics of the upper monitoring site, which flows through a farming area and may have insufficient riparian vegetation.

The time series of temperature from PR1, as recorded by the ‘in situ’ equipment, is plotted in Figure 2.2 and shows both the large seasonal change in water temperature and the strong diurnal pattern of change which occurs during the warmer months. This is especially apparent during the month of March, when night time temperatures in the river often dropped by more than 3 degrees. During the
Figure 2.1  Seasonal change in water temperature at three sites in Pipers River as recorded during monthly monitoring visits in 1998.

Figure 2.2  Seasonal change in water temperature in Pipers River as recorded by ‘in situ’ water monitoring equipment during 1998.
winter months, short term variation in water temperature tends to be driven by climatic changes as cold fronts from the west and south bring in both colder air and precipitation which can cause quite large changes in river temperature (as seen in plot around early July).

To summarise the temperature time series, a duration analysis has been done for the entire record to date (Table 2.2). This is an analysis which partitions the data according to time spent within defined temperature ranges. The results show that during the winter months (May - August) the temperature of the river is between 5 - 10 °C about 80% of the time, while during January and February temperature is between 15 - 25 °C for more than 95% of the time.

**Table 2.2** Seasonal duration analysis for water temperature (in °C) in the lower Pipers River using all record from ‘in situ’ monitoring device (March-1996 to Aug-1999).

<table>
<thead>
<tr>
<th>Bounds</th>
<th>Jan-Feb</th>
<th>Mar-Apr</th>
<th>May-Jun</th>
<th>Jul-Aug</th>
<th>Sep-Oct</th>
<th>Nov-Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5.0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.60</td>
<td>13.98</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>5.0 - 10.0</td>
<td>0.00</td>
<td>7.92</td>
<td>79.68</td>
<td>82.00</td>
<td>31.34</td>
<td>0.00</td>
</tr>
<tr>
<td>10.0 - 15.0</td>
<td>2.24</td>
<td>65.44</td>
<td>19.72</td>
<td>4.02</td>
<td>67.35</td>
<td>55.72</td>
</tr>
<tr>
<td>15.0 - 20.0</td>
<td>75.40</td>
<td>25.95</td>
<td>0.00</td>
<td>0.00</td>
<td>1.31</td>
<td>43.92</td>
</tr>
<tr>
<td>20.0 - 25.0</td>
<td>22.20</td>
<td>0.69</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.36</td>
</tr>
<tr>
<td>&gt;25.0</td>
<td>0.16</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**In-stream pH**

The monthly pH data collected during the study (Figure 2.3) confirms what was shown by the historic data off the DPIWE database; that is that water in Pipers River is generally near neutral (pH of 7). However, there is a slight difference between site PR10b and sites lower down the river. The variation in pH at PR10b is larger than at the other two sites, with both the highest (pH = 8.3) and lowest (pH = 6.3) levels being recorded at this site. The variation at PR7 and PR1 was much less. No seasonal pattern is apparent from the data from any of the three sites.

![Boxplot showing statistics of monthly monitoring of pH at three sites in Pipers River during 1998.](image-url)
**Conductivity**

The variation in conductivity at all three sites in Pipers River was similar, with highest levels recorded early in the study period (Figure 2.4). At all sites there was a noticeable drop in conductivity over the first 6 months of the study, with levels stabilising somewhat for the remainder. The median conductivity was highest at PR1 (median = 183 µS/cm) and lowest at PR10b (median = 128 µS/cm). Although this is generally a feature of all unregulated rivers, the proximity of this catchment to the coast means that a significant component of salt levels in the catchment are likely to be derived from ocean aerosols rather than geological in origin.

As is shown in Figure 2.5, conductivity levels in the lower reaches of the river show a distinctive and sometimes rapid pattern of short-term change. During long periods of low flows, when groundwater is sustaining river flows, conductivity levels in the river are maintained at a higher level (180 - 200 µS/cm). The plot also shows that any type of rainfall produces a dramatic drop in conductivity in the river. On May 16th a localised thunderstorm which produced only a slight rise in river flow, resulted in a significant drop in conductivity. However, the conductivity in the river was quick to recover near to previous levels. A larger rain event later in the month resulted in flood conditions which produced a similar drop in conductivity, however the flushing from this event helped to maintain a longer term depression in conductivity in the river.

![Figure 2.4](image)

**Figure 2.4** Monthly change in conductivity at three sites in Pipers River as recorded during monitoring visits in 1998.
Like the record for water temperature, the continuous conductivity data recorded at PR1 can be examined through duration analysis. The results of this analysis are given in Table 2.3, where the record from 1998 has been compared to the entire record to August 1999. Although the pattern is similar in both datasets, it is interesting to note that during 1998 conductivity in the river was above 300 $\mu$S/cm for more than 11% of the time compared to only 3.6% over the longer term. This means that for more than 40 days in 1998, water in the lower Pipers River was within the Class 2 category for salinity (medium salinity) under the ANZECC (1992) guidelines. Examination of the time series shows that this occurred during the period February to March, when there was an extended period of low flow in the river.

Table 2.3 Duration Analysis for Conductivity at Pipers River station.

<table>
<thead>
<tr>
<th>Band</th>
<th>Value Range</th>
<th>All Record</th>
<th>1998 Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0 - 100 ($\mu$Scm$^{-1}$)</td>
<td>1.07</td>
<td>0.82</td>
</tr>
<tr>
<td>2</td>
<td>100 - 150 ($\mu$Scm$^{-1}$)</td>
<td>26.55</td>
<td>24.02</td>
</tr>
<tr>
<td>3</td>
<td>150 - 200 ($\mu$Scm$^{-1}$)</td>
<td>48.36</td>
<td>46.16</td>
</tr>
<tr>
<td>4</td>
<td>200 - 250 ($\mu$Scm$^{-1}$)</td>
<td>13.89</td>
<td>9.39</td>
</tr>
<tr>
<td>5</td>
<td>250 - 300 ($\mu$Scm$^{-1}$)</td>
<td>6.56</td>
<td>7.92</td>
</tr>
<tr>
<td>6</td>
<td>300 - 350 ($\mu$Scm$^{-1}$)</td>
<td>2.32</td>
<td>7.31</td>
</tr>
<tr>
<td>7</td>
<td>350 - 400 ($\mu$Scm$^{-1}$)</td>
<td>1.18</td>
<td>4.10</td>
</tr>
<tr>
<td>8</td>
<td>&gt; 400 ($\mu$Scm$^{-1}$)</td>
<td>0.07</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Turbidity
Turbidity in water is a measure of the amount of suspended material, whether it is organic (i.e., plant material or algal particles) or inorganically derived (i.e., clays, silt, etc.). In Pipers River, where land use ranges from forestry to farming and viticulture, the main source of turbidity is most likely to be generated by riverbank erosion. In some sections this is exacerbated by unrestricted cattle access and soil disturbance due to land clearing and cultivation.
When attempting to establish 'baseline' turbidity levels in rivers, it is necessary to avoid as much as possible higher flow events, when the higher velocities result in active erosion and allow the river to carry higher loads of suspended material. Separate sampling during 'flood' events was undertaken and results from that part of the study are discussed in a later section of this report. During monthly monitoring, effort was made to avoid higher flows, however during June several small events made this impossible, resulting in turbidity readings slightly higher than expected.

The graph in Figure 2.6 shows the monitoring results from all three sites, and turbidity at all sites was elevated well above normal levels during the June visit. However, it is clear that levels in the period prior to the June monitoring run are much lower than those in the proceeding period, which tends to indicate greater movement of sediments during the second half of the study. River flows during site visits after June were higher than in the first half of the year. There is a discussion of export loads from the catchment later in this report.

The data in Figure 2.6 also shows that turbidity levels in the upper river were substantially lower than further down the catchment during the wetter months between June and November. During the drier periods, turbidity at all three sites was roughly similar though variable. A large peak at site PR7 during the November visit indicates some localised disturbance at or above the site at Colgraves Road.

![Figure 2.6](image_url)

**Figure 2.6** Monthly change in turbidity at three sites in Pipers River as recorded during monitoring visits in 1998.

Turbidity is also one of the parameters monitored at PR1, where equipment is permanently situated in the river. During the study there was intermittent failure of the probe which records turbidity, making a detailed analysis of the data difficult. However an example of the type of data collected by the turbidity probe is given in Figure 2.7. This time series trace of turbidity and river flow recorded during September 1998, shows two events of different shapes and magnitudes. The first event, on about the 16th of September, shows the results of a smaller and possibly more localised rain event which has
produced only a very slight rise in river flow but a more significant change in turbidity. The form of the rise in turbidity is also markedly different to that of the event later in September, where there was a large increase in turbidity due to a significant flood event. The shape of this event is more typical of rivers, where there is a dramatic increase in turbidity some hours before the actual peak in river flows. Like the rising limb, the falling limb of the 'turbidigraph' is also fairly steep, dropping faster than the falling limb of the hydrograph. This event also indicates how high turbidity levels can get during significant floods in Pipers River.

No duration analysis of the turbidity time series could be carried out.

Figure 2.7  'In situ' changes in turbidity in Pipers River during September 1998, when a major flood event produced turbidity levels of close to 400 NTU. The peak flow recorded during the flood was estimated at 144 cumecs (m$^3$s$^{-1}$).

**Dissolved Oxygen**

Dissolved oxygen is one of the parameters most commonly used to measure the health of the aquatic ecosystem. During this study oxygen concentrations in the river were measured on site using portable field probes which employ membrane diffusion along with silver/gold anode for oxygen detection. At all sites, dissolved oxygen was measured in flowing water as measurement of oxygen levels in backwaters can lead to inaccurate results.

The boxplot in Figure 2.8 displays the statistics for dissolved oxygen at sites in Pipers River from monthly monitoring in 1998. The data shows that oxygen concentrations are healthiest at the upper site, where levels ranged between 8.3 mg/L and 12.2 mg/L. Lower down the catchment, median concentrations are lower (around 9 mg/L) and both sites showed minimum concentrations of about 3 mg/L on the January monitoring trip, indicating that these sites experience conditions which cause stress to the aquatic ecosystem during low summer flows.

Looking at the monitoring results as a time series (Figure 2.9), this the seasonal pattern of change and the difference between sites is more easily seen. The similarity between PR7 and PR1 is also clear, as they closely follow each other. This tends to indicate that conditions in the middle and lower
Figure 2.8  Boxplot showing statistics of monthly monitoring of dissolved oxygen at three sites in Pipers River during 1998.

Figure 2.9  Monthly change in dissolved oxygen at three sites in Pipers River as recorded during monitoring visits in 1998.
catchment are similar and that the factors that cause the low oxygen concentrations are operating at both sites. Visual examination reveals that the stream bed at both sites is affected by sedimentation which is indicative of a depositional environment. Such conditions encourage bacterial decomposition and aquatic plant growth, which can lead to diurnal oxygen depletion. Short term intensive monitoring at PR7 was carried during the study, and the results will be discussed in a later section dealing with daily changes in water quality (Section 2.6).

2.2 General Ionic Composition

As chemical testing was routinely carried out at only one site on Pipers River, monitoring results will only be briefly discussed. During this study, samples for ionic analysis were taken every two months, as these constituents are generally considered to be ‘conservative’ and vary only slightly over time. The ionic character of water typically reflects the influence of soils and the underlying geology of a catchment. Where water flows through limestone rock types, it will generally have a higher concentration of calcium and magnesium, and consequently have a higher hardness and alkalinity. Where rivers flow through a dolerite dominated landscape, they will generally have lower amounts of dissolved ‘salts’, though silica and iron can be greater.

In Pipers River, the underlying geology of the upper catchment is a mix of dolerite and related rocks. Mudstone and quartzwacke of the Mathinna Beds are present in the upper and middle catchment; other sedimentary rocks and alluvium dominate in the middle catchment, and towards the bottom of the catchment the geology is further complicated by pockets volcanic basalt (Mines Tasmania, 1983). As the conductivity results from the data indicate, salt levels are reasonably low in the upper catchment, but increase towards the bottom. It is likely that at least some of this increase is due to the geology in the middle and lower catchment. Another influence on ion concentrations may also be ocean aerosols, which could have more of an influence on the river nearer to the catchment outlet.

The data for ionic composition (Table 2.4 and Figure 2.10) shows that Pipers River water has moderate levels of dissolved salts and has a moderate to low level of buffering capacity (as indicated by the statistics for alkalinity). Compared to water in the nearby Brid River, levels of salts are slightly higher. As a comparison, chloride and calcium concentrations in the Brid River vary between 20-40 mg/L, and 3-6 mg/L respectively.

Table 2.4 Summary statistics for ionic parameters from Pipers River downstream of Yarrow Creek. Samples collected every 2 months during 1998 (n=6).

<table>
<thead>
<tr>
<th>App. Colour (Hazen Units)</th>
<th>Alkalinity (mg/L)</th>
<th>TDS (mg/L)</th>
<th>Hardness (mg/L)</th>
<th>Suspended Solids (mg/L)</th>
<th>Iron (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>100</td>
<td>76</td>
<td>200</td>
<td>82</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Minimum</td>
<td>50</td>
<td>20</td>
<td>100</td>
<td>31</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Median</td>
<td>65</td>
<td>46</td>
<td>130</td>
<td>44</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

Table 2.4 continued

<table>
<thead>
<tr>
<th>Magnesium (mg/L)</th>
<th>Potassium (mg/L)</th>
<th>Chloride (mg/L)</th>
<th>Calcium (mg/L)</th>
<th>Sodium (mg/L)</th>
<th>Sulphate (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>12</td>
<td>2.4</td>
<td>58</td>
<td>13</td>
<td>33</td>
</tr>
<tr>
<td>Minimum</td>
<td>4.6</td>
<td>1.1</td>
<td>28</td>
<td>4.8</td>
<td>17</td>
</tr>
<tr>
<td>Median</td>
<td>6.4</td>
<td>1.35</td>
<td>35</td>
<td>6.8</td>
<td>20</td>
</tr>
</tbody>
</table>

Sulphate concentrations are also slightly higher than those recently measured in both the Great Forester and lower Ringarooma rivers (Bobbi, 1999a; Bobbi, 1999b). Sulphate is naturally present in surface
waters as $\text{SO}_4^{2-}$, and generally originates from ocean aerosols or geological sources such as leaching from sulphite minerals in sedimentary rocks (UNESCO, 1992). In Tasmania, several studies have shown that concentrations in many natural waters is around 5 mg/L (Bobbi, Fuller & Oldmeadow, 1996) (Bobbi, 1997) (Bobbi, 1998) (Bobbi, 1999a) with streams receiving some form of polluted effluent having sulphate concentrations significantly higher than this (15 - 30 mg/L).

![Boxplot showing statistics of bi-monthly monitoring of selected ionic parameters at site PR1 on Pipers River during 1998.](image)

2.3 Nutrient Results

The concentrations of nutrients in water draining agricultural areas can be quite variable. Nutrients such as nitrate, ammonia, organic nitrogen and the various forms of phosphorus are generally present at levels which preclude field based analysis, as field testing kits cannot operate accurately at most environmental levels and often lack the precision needed. Therefore samples were collected and delivered to a registered laboratory which could measure down to the required levels (around the 0.005 mg/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 Authorities). Occasional duplicates and blank samples were also tested as a means of checking field sampling and preservation operations.

Due to limitations in resources, samples were taken from only one site in Pipers River (PR1 - downstream of Yarrow Creek) at the bottom end of the catchment.

**Nitrogen**

Total nitrogen (TN) in environmental waters is the sum of organic nitrogen, nitrate nitrogen ($\text{NO}_3/N$) and nitrite nitrogen ($\text{NO}_2/N$), though $\text{NO}_2/N$ is not normally detectable unless there is some form of local pollution. In most cases it is therefore relevant to talk only of the TN and $\text{NO}_3/N$ content of river waters. These two variables also behave in quite different ways. In most rivers, organic material makes up the large proportion of TN concentration and this can often be linked to suspended solids.
On the other hand, NO$_3$/N is a dissolved form of nitrogen and easily passes from soils and into the groundwater and from there into rivers during baseflow conditions.

Figure 2.11 presents the statistics for TN and NO$_3$/N concentrations at PR1 on Pipers River from monthly sampling data. It is clear from this that TN concentrations are much higher than NO$_3$/N, and it is very likely that the organic fraction of TN is the cause. Concentrations of TN ranged between about 0.3 mg/L and 0.8 mg/L, while concentrations of NO$_3$/N were quite low for much of the study, resulting in a median of 0.034 mg/L. It has been stated that concentrations of TN within the range measured in Pipers River have been known to cause algal blooms (ANZECC, 1992).

![Figure 2.11](image)

**Figure 2.11**  Boxplot showing statistics of monthly monitoring of Nitrate/N and Total N at PR1 in Pipers River during 1998.

While the data in Figure 2.11 indicates that NO$_3$/N concentrations are low relative to TN, further examination of the data shows that there appears to be a strong link between NO$_3$/N concentration and levels of baseflow in the river (Figure 2.12). During the first 5 months of the study, NO$_3$/N levels were very low (< 0.03 mg/L), when baseflow in the river was also extremely low. This changed markedly once baseflows in the river increased following significant rain in late May and June. Nitrate nitrogen is very mobile in the environment and easily passes into groundwater, where it can strongly influence concentrations in rivers during baseflow conditions. Natural sources of NO$_3$/N included geology and plant and animal breakdown products. In the rural environment, the use of inorganic fertilisers can also have an impact on NO$_3$/N concentrations in rivers (UNESCO, 1992). Clearing of land for cultivation and grazing also increases soil aeration, enhancing soil NO$_3$/N concentrations. Nitrate levels in rivers often varies on a seasonal basis (Bobbi, Fuller & Oldmeadow, 1996; Bobbi, 1999b; Jaynes, Hatfield & Meek, 1999; Kladivko *et al*., 1991), with concentrations higher during winter when factors including flushing of NO$_3$/N from the soil profile (Cambardella *et al*., 1999) and the lack of plant uptake due to dormancy (Neill, 1989), result in higher flushing of NO$_3$/N into groundwater. Processes such as these are likely to be operating in the Pipers catchment.
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 a 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.

Most phosphorus is also normally found attached to organic and inorganic particulate matter and can often be related to turbidity levels. Once a sufficient amount of data is collected, turbidity can in many cases be monitored as a surrogate for phosphorus analysis. In Pipers River a relationship between TP and turbidity has been developed and this is discussed in Section 3.3.

Monthly monitoring results from site PR1 in lower Pipers River show that TP concentrations were variable during 1998 (Figure 2.13), with levels varying between the detection limit (< 0.005 mg/L) and a high of 0.051 mg/L. The median concentration was 0.026 mg/L, which is less than the 0.034 mg/L measured in the lower Brid River during the same period. This can also be compared to maximum concentrations of around 0.24 mg/L measured in Pipers River during flood events (as presented in a later section). The high TP concentration recorded during the January visit, when flows were very low and may be indicative of phosphorus release from the sediments in the river at that site (as mentioned earlier). The low dissolved oxygen levels at that site during January would have facilitated this release of phosphorus.
Figure 2.13 Total phosphorus (TP) concentrations measured during monthly monitoring at Pipers River downstream Yarrow Creek (PR1) in 1998.

These data show that concentrations of TP are moderately elevated in lower Pipers River and may reflect the level of catchment disturbance in the catchment. It is thought that sediment movement into the river from both the hill slopes and riverbanks may be the major cause. In many sections along the river, unrestricted stock access and willow infestation is causing riverbank damage and erosion. A later section discusses changes in water quality during high flow events and the loads of nutrients and sediments transported down the river during floods.

2.4 Catchment Surveys

The catchment for Pipers River is a long and narrow valley (about 40km in length and only 12km at its widest), and many of the smaller feeder streams and tributaries are dry for at least part of the year. As a result of this, ‘catchment snapshot’ surveys of the Pipers River catchment covered only about 10 sites on the main stream and 6 sites on tributaries. The location of all sample sites is shown in Figure 2.14 and site coordinates are listed in Table 2.5. The aim of these ‘snapshot’ surveys is to highlight areas where water quality is degraded relative to the rest of the catchment. This technique has been used in the past both in Tasmania (Bobbi, Fuller & Oldmeadow, 1996) (Bobbi, 1997) (Bobbi, 1998) and interstate (Grayson et al., 1997), and has been shown to be quite informative in giving a catchment view of water quality.
Table 2.5  Sites included in catchment ‘snapshot’ surveys in the Pipers River catchment during summer and winter, 1998.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Code</th>
<th>Easting</th>
<th>Northing</th>
<th>Monitoring Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipers River d/s Yarrow Creek</td>
<td>PR 1</td>
<td>509400</td>
<td>5453300</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at Bridport Rd</td>
<td>PR 2</td>
<td>508550</td>
<td>5451300</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Pipers River at Baxters Rd</td>
<td>PR 3</td>
<td>508075</td>
<td>5448800</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at Security Rd</td>
<td>PR 4</td>
<td>507975</td>
<td>5447200</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Pipers River at Lewis Rd</td>
<td>PR 6</td>
<td>508975</td>
<td>5443675</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Pipers River at Colgraves Rd</td>
<td>PR 7</td>
<td>510225</td>
<td>5441100</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at Bangor Rd (lower)</td>
<td>PR 9</td>
<td>510500</td>
<td>5437850</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at Bangor Rd (upper)</td>
<td>PR 10</td>
<td>512350</td>
<td>5433625</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Pipers River at Lalla Rd (Karoola)</td>
<td>PR 10b</td>
<td>513400</td>
<td>5432125</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Pipers River at North Eastern Line</td>
<td>PR 11</td>
<td>513600</td>
<td>5430700</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Yarrow Ck u/s Pipers River</td>
<td>PR 15b</td>
<td>509600</td>
<td>5453350</td>
<td>Phys-chm only</td>
</tr>
<tr>
<td>Dead Horse Creek at Pipers River Rd</td>
<td>PR 17</td>
<td>507425</td>
<td>5447200</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Montgomery Creek at Lewis Rd</td>
<td>PR 18</td>
<td>509575</td>
<td>5443900</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Third River at Bangor</td>
<td>PR 23b</td>
<td>511850</td>
<td>5437550</td>
<td>Phys-chem only</td>
</tr>
<tr>
<td>Second River at Bangor Rd</td>
<td>PR 26</td>
<td>511400</td>
<td>5436675</td>
<td>Phys-chem+ Samples</td>
</tr>
<tr>
<td>Turquoise Ck at Weymouth Rd</td>
<td>PR 35</td>
<td>508350</td>
<td>5457075</td>
<td>Phys-chem only</td>
</tr>
</tbody>
</table>

Surveys of these sites were carried out on two occasions. The first was undertaken during very low summer flows on January 20, 1998. Due to the dry conditions, several tributary sites were unable to be sampled. The second survey was carried out during stable winter flows on August 24th, 1998 and all 16 sites were visited. During both surveys field physical-chemical testing was performed at all sites. Of these, a subset were also tested (as indicated in Table 2.54) for a range of nutrient and bacterial parameters as well as some heavy metals. During the summer survey, samples for ionic composition (determination of dissolved salts) was also undertaken.

During both summer and winter surveys, the pH of water throughout the catchment was similar, with pH at most sites ranging between 6.5 and 8. The exception to this was Deadhorse Creek, which although dry in summer, showed a pH of 5.6 during winter flows. It is not clear why this creek was so acidic, though the colour of the water was noticed as being reasonably dark, indicating the possible presence of tannins which could cause acid conditions. This was unusually acidic compared to the rest of the catchment. A plot of the pH along the length of Pipers River shows that the pattern of variation was similar during each survey (Figure 2.15), although pH at PR4 was much lower during the winter survey.

The pattern of variation in conductivity along the length of Pipers River was also similar during both summer and winter surveys (Figure 2.16) with conductivity decreasing with increasing elevation as expected. The only difference between the two surveys is that conductivity levels at all sites was 25% to 55% lower during winter than summer. During the summer survey Yarrow Creek was most saline, with a conductivity of 1556 µS/cm, which is much higher than was measured at any other site. During winter, conductivity levels in Yarrow Creek were more like those seen in other tributaries in the catchment, with the exception of Turquoise Creek (422 µS/cm) and Third River (684 µS/cm) which showed moderately saline winter flows. Figure 2.17 shows conductivity levels throughout the catchment as recorded during the winter survey.
Figure 2.15  Longitudinal profile of pH in Pipers River during summer and winter surveys, 1998. Sites are from bottom to top of catchment in order from left to right.

Figure 2.16  Longitudinal profile of conductivity in Pipers River during summer and winter surveys, 1998. Sites are from bottom to top of catchment in order from left to right.
Figure 2.17: Pipers River Winter Conductivity Levels (μS/cm)

Legend
- Main River
- Tributary
- Roads
- Sampling Sites
- Towns

Conductivity (μS/cm)
- 600
- 400
- 200

Towns:
- Weymouth
- Swansea
- Launceston
- Hobart
- East Strait

Kilometers
The variation in turbidity across the catchment recorded during both surveys is shown in Figures 2.18a&b. During the summer snapshot, turbidity at most sites was below 5 NTU, reflecting the clarity of most sites under low flow conditions. During higher winter flows, it is obvious that there is a pick-up of suspended material down the length of Pipers River (Figure 2.19), especially between PR10 (Bangor Rd – upper) and PR9 (Bangor Rd – lower) which picks up input from Second River, (turbidity 13 NTU). The area upstream of PR9 was also characterised by heavy willow infestation and bank erosion, which would also contribute to high turbidity in the river. Of the tributaries, Deadhorse Creek and Third River had turbidity levels above 20 NTU while all other tributary sites showed levels similar to those in Pipers River.

![Turbidity Graph](image)

**Figure 2.19** Longitudinal profile of turbidity in Pipers River during summer and winter surveys, 1998. Sites are from bottom to top of catchment in order from left to right.

Dissolved oxygen levels throughout the catchment during the summer survey were variable (Figure 2.20), with some sites showing very low oxygen concentrations. Most notably, three sites in the main river showed levels below 6 mg/L (or less than 70% saturation), which indicates that these sections of the river are under a significant level of stress. In two tributaries, where flows were extremely low, oxygen levels less than 3 mg/L were recorded. Subsequent investigations into the diurnal change in oxygen were carried out at PR7 (Colgraves Rd) and the results are discussed in Section 2.6 under Diurnal Water Quality Variations.

As mentioned above, nutrient samples were taken at a subset of sites. The results were mixed, with some sites showing a distinct difference between summer and winter conditions, while others were similar on both occasions. One parameter which showed a marked seasonal difference, was ammonia nitrogen (NH$_3$/N), which was very high at 4 of the 5 sites sampled during the summer (Figure 2.21). The highest concentrations were recorded at PR9 (Pipers at Bangor Rd – lower) and PR26 (Second River), both of which also had high organic content. During the winter survey, levels at all but PR26 were much lower. This data tends to indicate that there is a significant organic load in the river during summer and breakdown processes are more active due to lower flows and warmer temperatures. High NH$_3$/N concentration was also recorded at PR26 during the winter survey, implying that the Second River may be a significant source of organic nitrogen. High ammonia
Figure 2.21: Pipers River. Summer Ammonia Levels (mg/L)
concentrations in other parts of the world have been used as an indicator of organic pollution from cattle (NRA, 1992) (Foy & Kirk, 1995). This may also be an issue in several parts of the Pipers River catchment.

The seasonal difference in nitrate (NO$_3$/N) concentrations was very large (Figure 2.22), with average concentrations in winter more than 5 times higher than in summer. At PR1, NO$_3$/N concentration in winter was 10 times higher. This seasonal change has been discussed in an earlier section (Section 2.3) and this data clearly indicates that the processes discussed earlier are operating on a catchment-wide basis. In winter, NO$_3$/N made up about 35% of TN concentration at sites, while during summer this was much lower at around 7%, when organic nitrogen was the more dominant form of nitrogen. The average concentration of TN across all 5 sites in summer was 0.604 mg/L and during winter the average at the 6 sites sampled was only slightly higher at 0.731 mg/L.

The data for TP measured at sites in the catchment during both surveys is shown in Figure 2.23. The most significant variation occurred at site PR10b (Pipers River at Karoola), where TP concentration during winter was half that measured during the summer survey. The site with highest TP concentrations on both occasions was PR26 (Second River), which together with other nutrient data supports the conclusion that there is significant enrichment of this tributary.

Coliform samples were also taken during each survey. The results are shown in Figure 2.24, which gives both summer and winter survey results for comparison. During summer, *E. coli* counts (as cfu per 100mL) were higher in the catchment above Third River. During winter, concentrations of *E. coli* were less at most sites, with the exception of PR1 at the bottom of the catchment. These data are purely indicative of conditions throughout the catchment and it is not valid to use this information in comparison with guidelines, as more routine monitoring data is required. From the data it is clear that coliform levels are higher during summer despite lower flows. Factors influencing this would be the warmer water temperatures during summer, which prolong the survival of *E. coli* outside their normal environment (the stomach of warm-blooded animals), and the lack of dilution following deposition of coliforms (via faecal waste) in the river system. It is well known that faecal coliforms can exist in the sediments of rivers (Howell *et al.*, 1996) especially during periods of warmer temperatures, and resuspension of the sediments can influence concentrations in overlying waters (Sherer *et al.*, 1992).

The summary statistics for major metals sampled during the surveys is given in Table 2.6. The table shows that with the exception of aluminium, all other metals are present at concentrations near or below the detection limits of the analysis. Aluminium concentrations were very high and some of the results for zinc are also slightly elevated. Of the total 11 samples taken during both surveys, 4 samples showed total zinc levels between 6 and 7 µg/L, which is well above the ‘Trigger Value’ of 2.4 µg/L recommended by the new National Water Quality Guidelines (ANZECC, 1999) for the protection of aquatic ecosystems. All of the metal analyses were for ‘total metal’ concentrations, while it is only the ‘dissolved’ form which is generally a hazard to aquatic life. Therefore further testing to determine the level of ‘dissolved’ zinc in the river is needed if the risk to the environment is to be properly assessed.

<table>
<thead>
<tr>
<th></th>
<th>Aluminium</th>
<th>Cadmium</th>
<th>Copper</th>
<th>Lead</th>
<th>Zinc</th>
<th>Nickel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(µg/L)</td>
<td>(µg/L)</td>
<td>(µg/L)</td>
<td>(µg/L)</td>
<td>(µg/L)</td>
<td>(µg/L)</td>
</tr>
<tr>
<td>Maximum</td>
<td>864</td>
<td>&lt; 1</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Minimum</td>
<td>&lt; 50</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Median</td>
<td>272</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

# n = 11 from six sites across the catchment
Figure 2.22: Pipers River. Summer and Winter Nitrate Levels (mg/L)
The data for aluminium collected during catchment surveys is plotted in Figure 2.25 and show that during winter concentrations of total aluminium at all sites was higher. Aluminium concentrations in almost all samples showed levels well above the trigger level of 1.2 µg/L recommended in the National Water Quality Guidelines (ANZECC, 1999). However, the guidelines suggest that this trigger should be used for aluminium in a ‘dissolved’ or un-associated form, when its toxicity to the aquatic community is greatest. In Pipers River aluminium appears to be linked to suspended solids (turbidity) with higher concentrations occurring when turbidity is higher. When aluminium concentrations are plotted against the turbidity at the time of sampling (Figure 2.26), there is a clear relationship between the two. A similar relationship has been observed in the Ringarooma River (Bobbi, 1999b), where it was proposed that aluminium levels were linked to clays. This is also likely to be the explanation for high aluminium in Pipers River and it is therefore unlikely that these levels of aluminium pose any significant risk to the aquatic ecosystem. It is also probable that the zinc which is present, is similarly bound up in clays and poses little or no risk to aquatic health.

![Aluminium vs. Turbidity in Pipers River and tributaries](image)

**Figure 2.26** Aluminium vs. Turbidity in Pipers River and tributaries (using data collected during summer and winter catchment surveys, 1998.

In summary, the snapshot surveys demonstrate that during low summer flows several stresses are apparent in the river. Low dissolved oxygen and high nitrate concentrations are clearly evident. While turbidity is also reasonably low during the summer, there are some sites where localised impacts occur, and may reflect river bank degradation through erosion or stock access. Sites which stand out as having poorer water quality relative to the rest of the catchment are those in the middle sections of the catchment (PR9, PR23b & PR26) where the river condition is more highly impacted (see Index of River Condition report).

While higher concentrations of aluminium were detected at sites throughout the catchment, it is likely that much of it is present in the water column as part of the suspended sediment component and as such may pose little threat to the environment. Sampling to determine the proportion of aluminium which is in the dissolve form should resolve this question.

**2.5 Nutrient Load Estimates**

As mentioned in the preceding section, turbidity was monitored in Pipers River using an ‘in situ’ sensor. A wiper mechanism was used to help maintain a clean sensor surface, ensuring that data collected
remained relatively free of interference from algal growth and sediment deposition. Regular checking against a portable meter was performed, both during flooding and during low flows. An example of the type of turbidity data collected during a single flood event was presented in the previous section.

The turbidity equipment at Pipers River has been in operation since March 1996, however between late-April and early September of 1998 intermittent failures of this equipment meant that data was either not recorded, or the data which was recorded was of poor quality. This problem was overcome on September 8th, after which good data was once again collected. For the period during which data quality was unsatisfactory, field readings and flood sample data was used to assist in modelling turbidity changes and this synthesised record was then used to estimate loads for that period.

To develop estimates of nutrient loads leaving Pipers River catchment, flood samples were collected from the monitoring station downstream of Yarrow Creek, using an automated Sigma sampling device. This machine was triggered to collect water samples from the river during flood events, recording the data and time of each sample taken. Samples were later collected, had their turbidity levels recorded (for comparison against the ‘in situ’ monitoring equipment) and were then taken to a laboratory for determination of nutrient concentrations.

In total, 118 flood samples were collected using the automated sampler, 36 of which were taken back to the laboratory for further analysis. A summary of the flood sample data collected during the study is given in Table 2.7, and shows that during high flows, concentrations of all variables can get very high. The peak flood event measured during the study was 144 cumecs, which occurred on September 24th, 1998.

Table 2.7 A summary of concentrations of Suspended Solids, Total N and Total P recorded during flood flows in Pipers River during 1998.

<table>
<thead>
<tr>
<th></th>
<th>Suspended Solids (mg/L)</th>
<th>Turbidity (NTU)</th>
<th>Total N (mg/L)</th>
<th>Total P (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Samples</td>
<td>18</td>
<td>118</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Median</td>
<td>48</td>
<td>30.5</td>
<td>1.14</td>
<td>0.061</td>
</tr>
<tr>
<td>Average</td>
<td>54</td>
<td>48.6</td>
<td>1.24</td>
<td>0.075</td>
</tr>
<tr>
<td>Maximum</td>
<td>160</td>
<td>238</td>
<td>2.24</td>
<td>0.24</td>
</tr>
<tr>
<td>Minimum</td>
<td>10</td>
<td>4.3</td>
<td>0.6258</td>
<td>0.022</td>
</tr>
</tbody>
</table>

# Does not include turbidity recorded by ‘in situ’ monitoring equipment.

This data was then used for two purposes. The first of these was to calibrate and check the quality of the turbidity data recorded by the ‘in situ’ probes. In all, 118 field readings were taken (using a HACH portable turbidimeter) and used to correct the turbidity time series. The results from laboratory analysis of samples was also used to derive relationships between turbidity and the major parameters of TN, TP and suspended solids. It was found that significant relationships existed between all three parameters and turbidity (p < 0.05).

These are:

Total suspended solids

\[
[TSS] = 0.7482\cdot\text{turbidity} -0.1585
\]

\[R^2 = 0.7439, \ n = 22.\]

Total Nitrogen

\[
[\text{TN}] = 0.2727\cdot\text{turbidity}^{0.3722}
\]

\[R^2 = 0.7647, \ n = 41.\]
Total Phosphorus

\[ [\text{TP}] = 0.0009 \times \text{turbidity} - 0.0191 \]

\( R^2 = 0.8601, \ n = 43. \)

Using these derived relationships for Pipers River, the time series of turbidity recorded downstream of Yarrow Creek was then able to be transformed to a synthetic record of TN, TP and total suspended solids concentrations, which could then be used to estimate export loads. As an example, the total estimated load from the single event of September 23rd to 27th, 1998 has been calculated at:

- Total Suspended Solids = 1,828,226 kg
- Total Nitrogen = 25,765 kg
- Total Phosphorus = 2,486 kg

The total discharge volume of this event was 14,881 megalitres, which was about 19% of the total discharge from the Pipers River catchment for the year 1998.

There are some inaccuracies and assumptions associated with this load estimation method. The first of these is that the turbidity record is an accurate record of turbidity in the river, and although there were various checks of the ‘in situ’ sensor against another instrument, it is fair to state that some of the record is likely to deviate from the true turbidity levels in the river. During low flows the affect of this on load estimates should be fairly inconsequential, however during high flows there are fewer checks on the sensor readings. Checks that were made did show the ‘in situ’ sensor to be accurate to within 15% during most higher turbidity events.

Another source of inaccuracy is the estimation of turbidity (and hence nutrient loads) during periods when the sensor did not collect good data, and the turbidity time series had to be synthesised using field samples and modelling. Although there is some error involved, collection of field samples during many events when the ‘in situ’ probe was not providing reliable data, allowed reasonable modelling of the time series to be undertaken, and it is therefore considered that estimation of loads was still within the 15% error band mention above.

Another common source of error in load estimates is the recording of flow in the river, and there is significant growth of aquatic weed at the gauging station which might have reduced the accuracy of ratings. However regular gaugings of the river during the period of the study were able to ensure that the flow record was within +/- 5% of the rating.

Bearing these assumptions in mind, Table 2.8 gives the estimated export load of suspended solids, TN and TP for Pipers River for 17 months of turbidity record. Also included is the total monthly discharge volume for the river in megalitres (10^6 litres).

From the figures in Table 2.8 it is clear that export loads are greatest during August and September, when discharge from the catchment is highest. It is also interesting to note that although the discharge volume for September 1997 and September 1998 are comparable, the loads of TP and Suspended Solids are quite different. Loads of these parameters leaving the catchment in September 1998 were much higher (97% higher for TSS). One explanation for this is that during September 1998 there was a significant flood event which exported a very large load, while in 1997 the discharge in September was due to a series of smaller events. Increased catchment disturbance may also have had some impact, as this catchment is currently experiencing expansion in the viticulture sector. Land cleared for wine production tends to leave large areas of soils exposed to erosion during intense storms, and this can lead to significant losses of soil and nutrients. One such storm was sampled during July, 1998.
Table 2.8  Estimated monthly nutrient load, suspended solids load and discharge for Pipers River between August 1997 and December 1998.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>TSS Load (kg)</th>
<th>TN Load (kg)</th>
<th>TP Load (kg)</th>
<th>Discharge (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug-97</td>
<td>321,908</td>
<td>12,301</td>
<td>638</td>
<td>13,017</td>
</tr>
<tr>
<td>Sep-97</td>
<td>959,833</td>
<td>22,985</td>
<td>1,535</td>
<td>19,706</td>
</tr>
<tr>
<td>Oct-97</td>
<td>9,538</td>
<td>1,035</td>
<td>48</td>
<td>1,908</td>
</tr>
<tr>
<td>Nov-97</td>
<td>25,671</td>
<td>1,411</td>
<td>69</td>
<td>2,001</td>
</tr>
<tr>
<td>Dec-97</td>
<td>1,260</td>
<td>178</td>
<td>9</td>
<td>371</td>
</tr>
<tr>
<td>Jan-98</td>
<td>568</td>
<td>84</td>
<td>4</td>
<td>179</td>
</tr>
<tr>
<td>Feb-98</td>
<td>1,160</td>
<td>178</td>
<td>9</td>
<td>382</td>
</tr>
<tr>
<td>Mar-98</td>
<td>235</td>
<td>30</td>
<td>1</td>
<td>62</td>
</tr>
<tr>
<td>Apr-98</td>
<td>12,141</td>
<td>663</td>
<td>32</td>
<td>920</td>
</tr>
<tr>
<td>May-98</td>
<td>16,925</td>
<td>920</td>
<td>46</td>
<td>1,338</td>
</tr>
<tr>
<td>Jun-98</td>
<td>160,310</td>
<td>6,665</td>
<td>336</td>
<td>7,397</td>
</tr>
<tr>
<td>Jul-98</td>
<td>1,102,282</td>
<td>26,820</td>
<td>1,753</td>
<td>22,115</td>
</tr>
<tr>
<td>Aug-98</td>
<td>152,073</td>
<td>7,331</td>
<td>356</td>
<td>8,996</td>
</tr>
<tr>
<td>Sep-98</td>
<td>1,896,891</td>
<td>29,043</td>
<td>2,645</td>
<td>18,831</td>
</tr>
<tr>
<td>Oct-98</td>
<td>485,602</td>
<td>13,227</td>
<td>818</td>
<td>12,131</td>
</tr>
<tr>
<td>Nov-98</td>
<td>272,591</td>
<td>5,113</td>
<td>408</td>
<td>4,135</td>
</tr>
<tr>
<td>Dec-98</td>
<td>41,462</td>
<td>1,726</td>
<td>91</td>
<td>2,144</td>
</tr>
<tr>
<td>TOTALS</td>
<td>5,460,450</td>
<td>129,710</td>
<td>8,798</td>
<td>115,633</td>
</tr>
</tbody>
</table>

when 10-15 mm of rain fell during a 15 minute period. Samples of runoff were taken from two distinct areas for general comparison; a recently cleared and ploughed area of land and an established dairy paddock. The results of analysis are given in Table 2.9 and show that runoff from the newly cleared land was much more turbid and carried much higher concentrations of TP and TN. Concentrations of NO$_3$N and DR/P (dissolved reactive phosphorus) are higher in runoff from the dairy paddock, reflecting the influence of excreta on water quality.

Table 2.9  Results from analyses of samples taken during storm runoff from areas undergoing two different land uses in Pipers River catchment.

<table>
<thead>
<tr>
<th>Area</th>
<th>Turbidity (NTU)</th>
<th>Ammonia (mg/L)</th>
<th>Nitrate (mg/L)</th>
<th>Total N (mg/L)</th>
<th>Total P (mg/L)</th>
<th>DR/P (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Paddock</td>
<td>185</td>
<td>0.14</td>
<td>0.02</td>
<td>2.83</td>
<td>0.81</td>
<td>0.22</td>
</tr>
<tr>
<td>Newly cleared vinyard</td>
<td>&gt;&gt; 1000</td>
<td>0.074</td>
<td>0.17</td>
<td>43.2</td>
<td>8.10</td>
<td>0.012</td>
</tr>
</tbody>
</table>

While these data are only indicative, they are useful in demonstrating the potential for loss of soil and nutrients from exposed soils and the need for careful soil management in any areas where there is minimal grass cover. Grassed buffer strips and grassed open drains would be one positive step towards lowering the erosion hazard in these situations.

The export load estimates presented in Table 2.8 provide a reasonable estimation of the nutrients being exported from the Pipers River catchment. To compare this level of nutrient and sediment loss with other catchments, the export figures need to be corrected for catchment area and discharge (ie catchment runoff). The derivation of these ‘export coefficients’ allow catchments of different sizes and rainfall patterns to be compared (see ‘Glossary of Terms’ at the front of this document). The export coefficients for the Pipers River catchment derived from the data from this study are given in Table 2.10.
TABLE 2.10 Export coefficients for the Pipers River derived from data collected during
the period January to December '98.

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Discharge (ML)</th>
<th>Suspended Solids (kg/mm/km²)</th>
<th>Total P (kg/mm/km²)</th>
<th>Total N (kg/mm/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipers River</td>
<td>78,630</td>
<td>52.68</td>
<td>0.083</td>
<td>1.17</td>
</tr>
</tbody>
</table>

# Pipers River catchment area = 298 km².

These coefficients can be compared to others which have been calculated for rivers elsewhere in Tasmania (Bobbi, Fuller and Oldmeadow, 1996) (Bobbi, 1998). Some of the figures in Table 3.11 are averages calculated over several years, while others were calculated from a single year’s worth of data. This is important to keep in mind when looking at export coefficients, as the amount of rainfall in a catchment will influence the level of nutrient exported, and hence the export coefficient for that catchment. If export coefficients are calculated from data collected during a period with ‘below average’ rainfall, they can underestimate the level of export, and vice versa for wetter years. It is therefore worth noting that the total discharge from the Pipers River catchment during 1998 was well below average (about 78,600 ML compared with the annual average of about 96,700 ML).

TABLE 2.11 Export coefficients for catchments in Tasmania. In some cases data are averages calculated over several years. For others coefficients are estimated from only a single year of data.

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Years of Data</th>
<th>Catchment Area (km²)</th>
<th>Mean Annual Discharge (ML)</th>
<th>Total P (kg/mm/km²)</th>
<th>Total N (kg/mm/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipers River</td>
<td>1</td>
<td>298</td>
<td>96,700</td>
<td>0.083</td>
<td>1.17</td>
</tr>
<tr>
<td>Brid River</td>
<td>1</td>
<td>136</td>
<td>40,986</td>
<td>0.066</td>
<td>1.13</td>
</tr>
<tr>
<td>Meander River at Strath Bridge</td>
<td>3</td>
<td>1,012</td>
<td>427,904</td>
<td>0.058</td>
<td>0.67</td>
</tr>
<tr>
<td>Liffey River</td>
<td>3</td>
<td>224</td>
<td>80,661</td>
<td>0.052</td>
<td>0.78</td>
</tr>
<tr>
<td>South Esk at Perth</td>
<td>3</td>
<td>3,280</td>
<td>624,508</td>
<td>0.034</td>
<td>0.66</td>
</tr>
<tr>
<td>Break O’Day River</td>
<td>3</td>
<td>240</td>
<td>53,177</td>
<td>0.065</td>
<td>0.94</td>
</tr>
<tr>
<td>Huon River above Judbury</td>
<td>1</td>
<td>2,097</td>
<td>2,562,475</td>
<td>0.010</td>
<td>0.33</td>
</tr>
<tr>
<td>Kermandie River</td>
<td>1</td>
<td>130</td>
<td>36,760*</td>
<td>0.122</td>
<td>1.42</td>
</tr>
</tbody>
</table>

* Estimated flow data

When compared to figures from other catchments in Tasmania, the Pipers River export coefficients for both phosphorus and nitrogen are near the upper end of those for other agricultural catchments in Tasmania. It should be noted that for the Kermandie River, export figures include nutrients discharged to the river from the Geeveston sewage treatment plant.

2.6 Diurnal Water Quality Variations

Remote unattended monitoring equipment was deployed in Pipers River at Colgraves Rd every month from February to May and recorded the diurnal changes in some selected water quality parameters, most notably dissolved oxygen. It is well known that various water quality characteristics undergo changes on a 24 hour cycle (diurnal) and it is possible that parameters which appear to be within acceptable limits during daylight hours may well be of concern after sunset. Where rivers are receiving organic pollution or nutrient enrichment which encourages algal and aquatic plant growth, there can be large changes in pH and dissolved oxygen (Cooke & Jamieson, 1995) which can have detrimental impacts on invertebrates and fish life. Streams in New Zealand which have depleted oxygen levels have been shown to be linked to elevated nutrients and organic loads (Wilcock et al., 1995).

In the Pipers River at Colgraves Rd, there is significant amounts of sediments in the river and during the summer this encourages a prolific growth of aquatic plants and algae, as nutrients from these
sediments are released. As low dissolved oxygen levels had been measured at this site early in the study, it was decided to examine more closely short term variations at this site.

Independent monitoring equipment was deployed in Pipers River at Colgraves Rd for a period of about 40 hours each month while other sampling in the area was carried out, and was programmed to record water temperature, dissolved oxygen, pH, and conductivity at half-hourly intervals. The results from these monitoring events is presented in Figures 2.27, 2.28 and 2.29.

Figure 2.27  Short term changes in water temperature in Pipers River at Colgraves Rd recorded each month between February and June, 1998.

Figure 2.28  Diurnal changes in dissolved oxygen in Pipers River at Colgraves Rd recorded over about 40 hours each month between February and June, 1998.
The data recorded for water temperature (Figure 2.27) clearly shows the seasonal change, with highest water temperature occurring in February and the lowest in June. In most cases there is no marked diurnal pattern of change in temperature, except for the March event, when temperature in the river showed overnight changes of about 3 °C. The February event recorded the change in temperature in the river which occurred due to the passage of a cold front across the catchment.

The data for dissolved oxygen shows a similar pattern, with larger diurnal changes occurring during the summer months and little or no patterns evident during winter. The most noteworthy feature from this plot is that although mid-afternoon oxygen levels during summer may be reflect a reasonably healthy system, during the night oxygen concentrations steadily decrease. By early morning in the Pipers River on the February monitoring event, oxygen concentrations have fallen by almost 30% to only 5 mg/L. These levels are known to cause stress to fish (ANZECC, 1992) and it has been recommended that oxygen levels not be permitted to drop below 6 mg/L or 80-90% saturation.

Figure 2.29  pH fluctuations in Pipers River at Colgraves Rd recorded for about 40 hours each month between February and June, 1998.

The record for pH is somewhat different to that for oxygen. On four of the five occasions when recording took place in Pipers River, there was a distinct though not always smooth, diurnal pattern of pH change. During the February event, a significant drop in pH (0.5 units) took place during passage of the cold front mentioned earlier. There was a noticeable smaller drop in pH during the April event, though the reason for this occurrence is not clear. Disregarding these sudden drops, the normal diurnal variation at this site in Pipers River during summer and autumn is about 0.3 units. This probably reflects the influence of primary production in the river, which during the day acts to increase pH as aquatic plants and algae produce an excess of CO₂.

These pH records indicate that pH in Pipers River at Colgraves Rd normally fluctuates between 6 and 7, and poses no risk to the aquatic ecosystem. Sudden, short term changes are possibly due to climatic changes.
3 Summary and Comments

The water quality data collected in the Pipers River catchment during 1998 shows that water quality is moderately impacted across the catchment. At sites nearer to the headwaters, water quality appears to be good, with better clarity and lower dissolved salts. In the middle and lower parts of the catchment turbidity levels indicate that suspended material is entering the river. Dissolved oxygen levels in many parts of the river system are a significant cause for concern, as oxygen concentrations measured at several sites were at or near levels known to cause stress on aquatic life.

Nutrient concentrations measured at all sites were moderate to slightly elevated, with ammonia and nitrate concentrations showing a marked seasonal pattern of change. The data also suggests that there may be significant addition of nutrients and sediments to the river in the middle sections of the catchment (around Second and Third rivers) as well as parts of the lower catchment. The nutrient load estimated to be lost from the catchment is high in relation to other catchments studied in Tasmania. This has serious implications for both the loss of productive soil and nutrients from the catchment as well as the ecological risks associated with sedimentation of the lower river and the estuary at Weymouth.

Efforts to minimise the loss of this resource should be given a high priority. Reducing the amount of sediment entering the estuary at Weymouth will provide at least two obvious benefits. The first of these is decreased silting of the estuary, which is a holiday retreat and also a recreational fishing area. The other benefit is to the environmental functioning of the estuary. Reducing the levels of nutrients and sediment being deposited in the estuary will reduce the possibility of algal blooms and benthic fouling, both of which impact on the estuary as a fish nursery ground. Eutrophication of coastal lagoons in other parts of Australia has been a significant source of both public and environmental concern (ie National State of Environment Report, 1996) and activities which can prevent it occurring are worthy of attention.

Actions to prevent soil and nutrient loss from catchments range from maintenance of healthy and effective riparian buffer zones along the actual river itself, to use of grassed swales along drainage lines to prevent paddock erosion. Minimisation of soil disturbance and maintenance of grassed cover is often the first line of defence and can cut soil loss dramatically. On the rivers and streams, restriction of stock access will reduce both the physical damage of stock to the banks (bank slumping and compaction) and the loss of riparian vegetation.

Dense willow infestations along some parts of the river system also cause erosion. This erosion is due to willows growing in the river channel and forcing the river to find other pathways to convey larger flows. Removal of willows can both reduce the active erosion of the river at these sites and improve water quality.

The poor oxygen levels recorded during the study are partly related to the issues outlined above. High levels of sediment and nutrients in the river system encourages high productivity and the resulting large fluctuations in dissolved oxygen. Reducing the sediment and nutrient input to the river will help to improve oxygen levels.

Dense stands of willow tend to cause localised sediment build up in the river. The removal of willows can therefore also improve dissolved oxygen levels. However when willows are removed and not replaced with other riparian vegetation, the excessive amount of sunlight entering the river often results in detrimental growth of algae or aquatic weeds. It is therefore important that where willows are removed they are replaced with vegetation which will provide adequate shading of the river.
Finally, some of these data also demonstrate the good quality of water in the upper parts of the catchment. This, along with the ecological data, suggest that efforts should be made to protect the river in this area through the implementation of land management activities which have least impact on the river. Measures to protect high quality resources should always be considered a priority, as once degraded it is always difficult to repair.

It is hoped that the information presented and discussed in this report will assist with the better management and use of our waterways and water resources.
4 References


