B SOUTH ESK CATCHMENT

1.0 Hydrology

The South Esk River rises in the North Eastern highlands near Mathinna initially travelling southwards before passing through the Fingal Valley and finally turning northwards and draining into the Tamar River estuary at Launceston. Upstream of the confluences with the Macquarie and Meander rivers the major tributaries include the Break O'Day, St Pauls and Nile rivers. Many smaller streams contribute water to the South Esk mainly from the North-East highlands around Ben Lomond (eg Storeys Creek and Buffalo Brook).

1.1 Historical Background

Measurement of river heights in the South Esk River has a long history. Unfortunately these measurements are not always useful indicators of flow due to changes in the channel such as growth and destruction of vegetation, aggradation and scouring of river beds, etc. Such changes provide unstable relationships between gauge height and flow. Nevertheless, many of the gauge height stations continue to be maintained and in many instances are the major tools used for flood warning.

The South Esk is a relatively flat river for much of its length and there are often large areas where natural backwaters occur. There are therefore limited opportunities along the river to collect stream flow information and it was not until the 1950's that two reasonable locations were instrumented. These two sites - one at Llewellyn and the other at Perth - have collected streamflow information for around 40 years and are therefore invaluable in assessing the water yields, flood and drought behaviour of the river system. Unfortunately the early record at Llewellyn (prior to 1973) is subject to a major review by the Hydro-Electric Commission and could not be used for this study.

The following table provides a summary of sites in the South Esk River catchment. Some of these sites are used to illustrate various features of the catchment hydrology in the following sections.

TABLE Stream Flow and Stream Height Monitoring Sites in the South Esk catchment.

Tributary	Station Name	Station Number	Period of Record	Catchment Area (Km^2)
South Esk River				
	South Esk at Fingal ^{H}	33	1921 - 1995	880
	South Esk at Avoca ^{H}	107	1991 - 1995	
	Buffalo Brook	839	1984 - 1990	63.4
	South Esk at Llewellyn	150	1953 - 1995	2242
	Nile River at Deddington	25	1982 - 1995	226
	South Esk at Perth	181	1956 - 1995	3280
	South Esk at Longford $^{H+}$			
	South Esk at Launceston $^{H+}$	72	1901 - 1955	8997

H - Gauge Height Only Monitored at this Location
\+ - Sites with altered catchments due to water diversions for irrigation schemes or HEC operations.

1.2 Catchment Yields and Distribution of Flows

There are no major storages in the catchment so that, apart from the irrigation period, the flows monitored in the South Esk River catchment are essentially natural flows. During the irrigation period (November - March) pumping has a significant effect on flows in the river. The major land use effects on water yields are likely to have occurred during pioneering times when there was substantial clearing of low lying areas. The effects of current land uses (eg plantation forestry) on water yields are unknown.

Excluding diversions into the Basin from Great Lake, the South Esk River contributes on average some 37% of the total outflow at Launceston.

Annual Yields

Figures 1.1a to 1.1e show the average annual, average winter, and average summer flows at key flow monitoring sites throughout the catchment. All sites exhibit a high variability in average flow from year to year.

Flows at Perth and Llewellyn are highly correlated (Figure 1.2a & b) with approximately 27% more flow at Perth. There is strong statistical evidence to suggest that this increase in average flow is not consistent with a simple catchment area ratio which would predict approximately 46% more runoff at Perth than Llewellyn. The area between Llewellyn and Perth contributes approximately 40% less runoff per unit area than the catchment upstream of Llewellyn over a year. This result is not surprising since the average rainfall in the upper part of the catchment tends to be greater than that in the lower part.

Analysis of summer average flows indicates a very similar relationship. In this case flows at Perth are approximately 23% larger than those at Llewellyn suggesting approximately twice the contribution to flow per unit area from the upper catchment compared with the catchment between Llewellyn and Perth. This result was a little surprising since groundwater is usually assumed to dominate flows over summer and hence this would imply quite different groundwater regimes in the two parts of the catchment. Nevertheless, inspection of the relationship between average monthly flows suggests that the relationship is relatively constant and insensitive to the removal of flood flows.

Matthews (1983) has investigated the geological structure and groundwater capacity of the Longford Tertiray Basin which is a distinct area of Tertiary sediments running from as far west as Westbury through to Snow Hill (ie circa Llewellyn), and from Hadspen south to around Campbelltown. The Longford Basin is the largest continuous areas of unconsolidated Tertiray sediments in Tasmania and its total groundwater storage capacity has been estimated at 5850 million cubic metres.

It seems evident that the presence of this basin affects the surface water records significantly.

During the period of the study the annual average flows at Llewellyn and Perth appear to represent the long term average annual flow regime quite well. Inspection of the winter and summer plots at Perth shows that winters during the study period are drier than average and summers tend to be wetter.

Average annual flows in the Break O'Day River appear to fluctuate from high to low on a three year cycle. However these "cycles" are most probably an artifact of the short period of record; substantially longer periods of record are required to identify cyclic behaviour. Variability in annual flows is quite high and is heavily influenced by the variability of winter and summer flows. Due to the short period of record the true range of variability is likely to

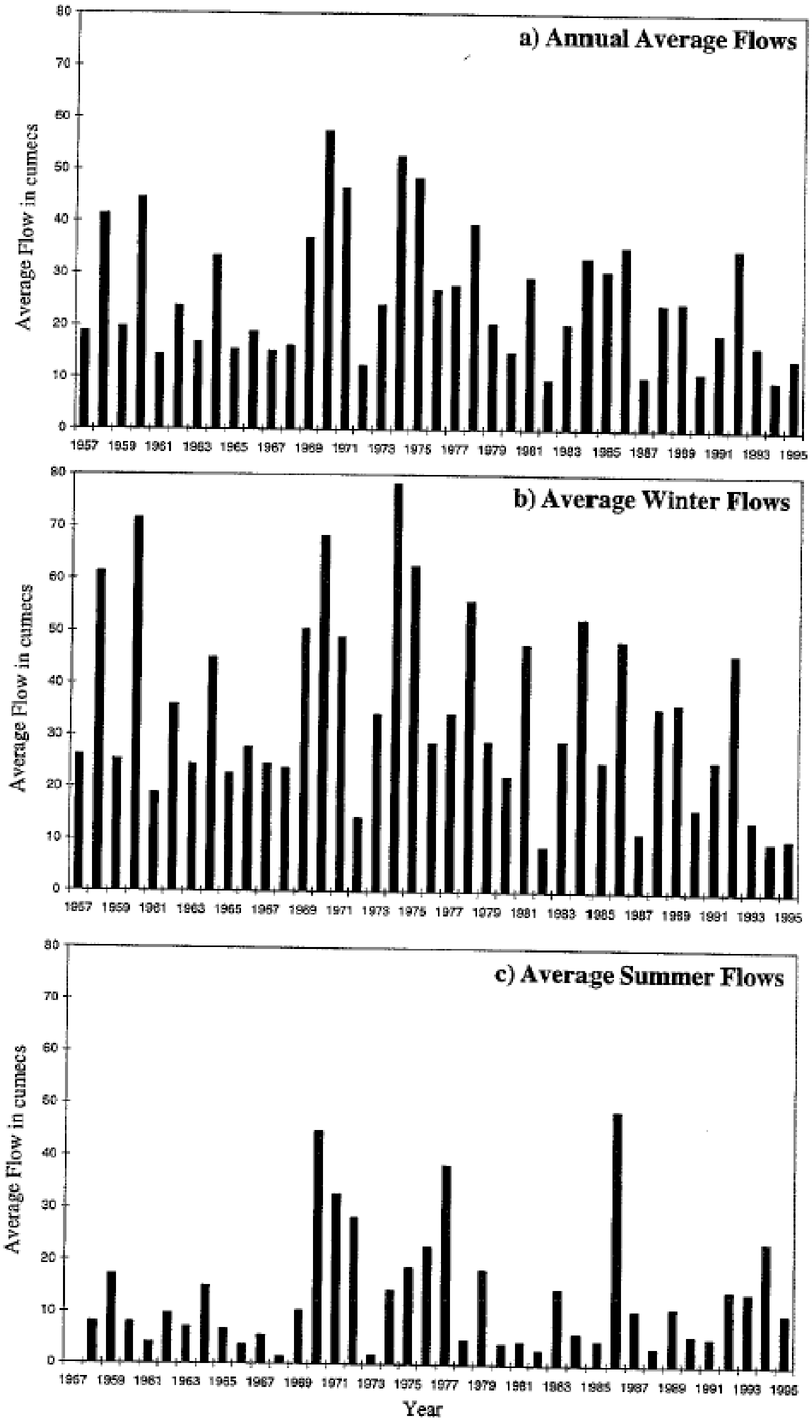


Figure 1.1a Average annual, winter and summer flows in the South Esk at Perth.

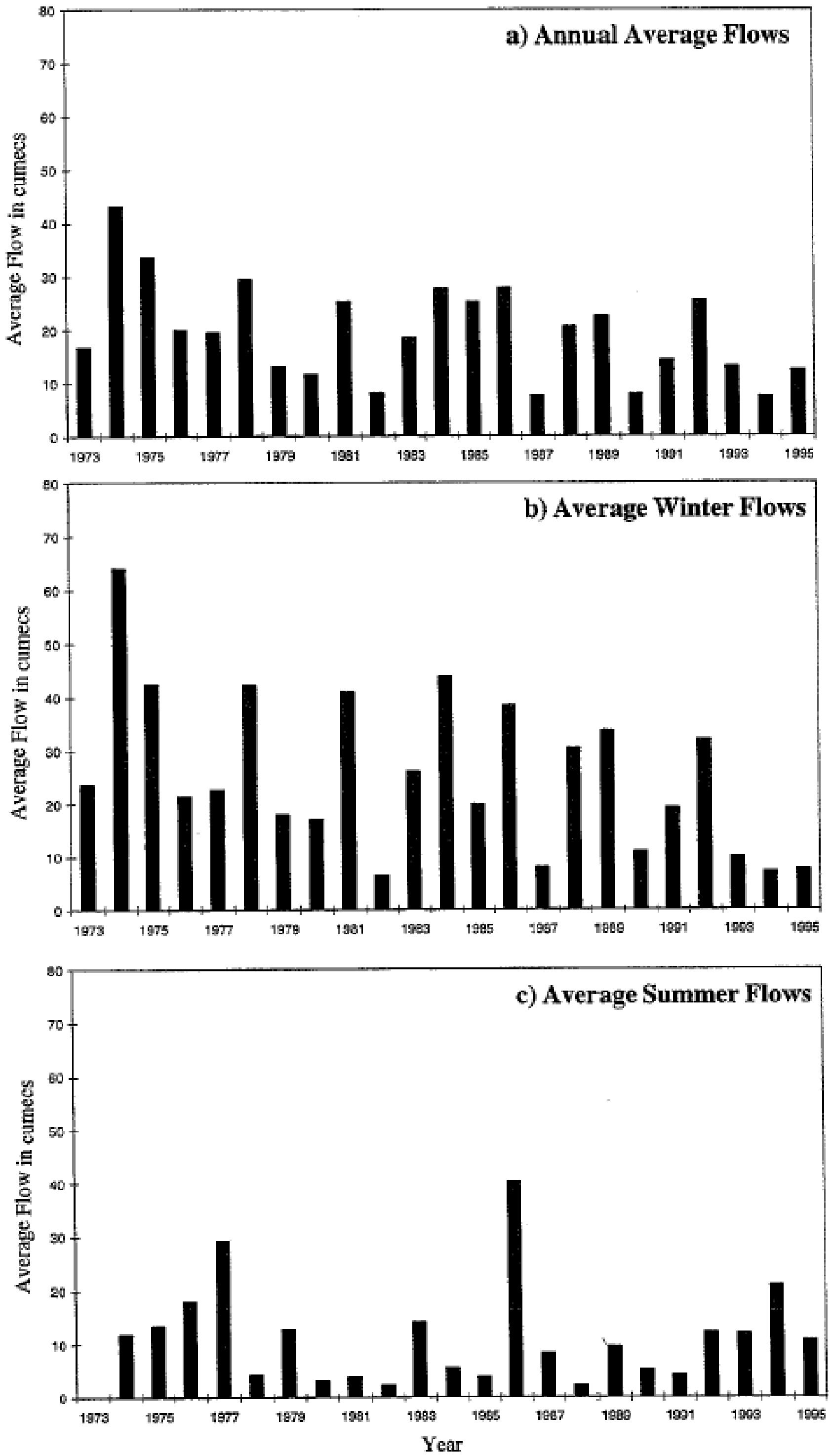


Figure 1.1b Average annual, winter and summer flows in the South Esk at Llewellyn.

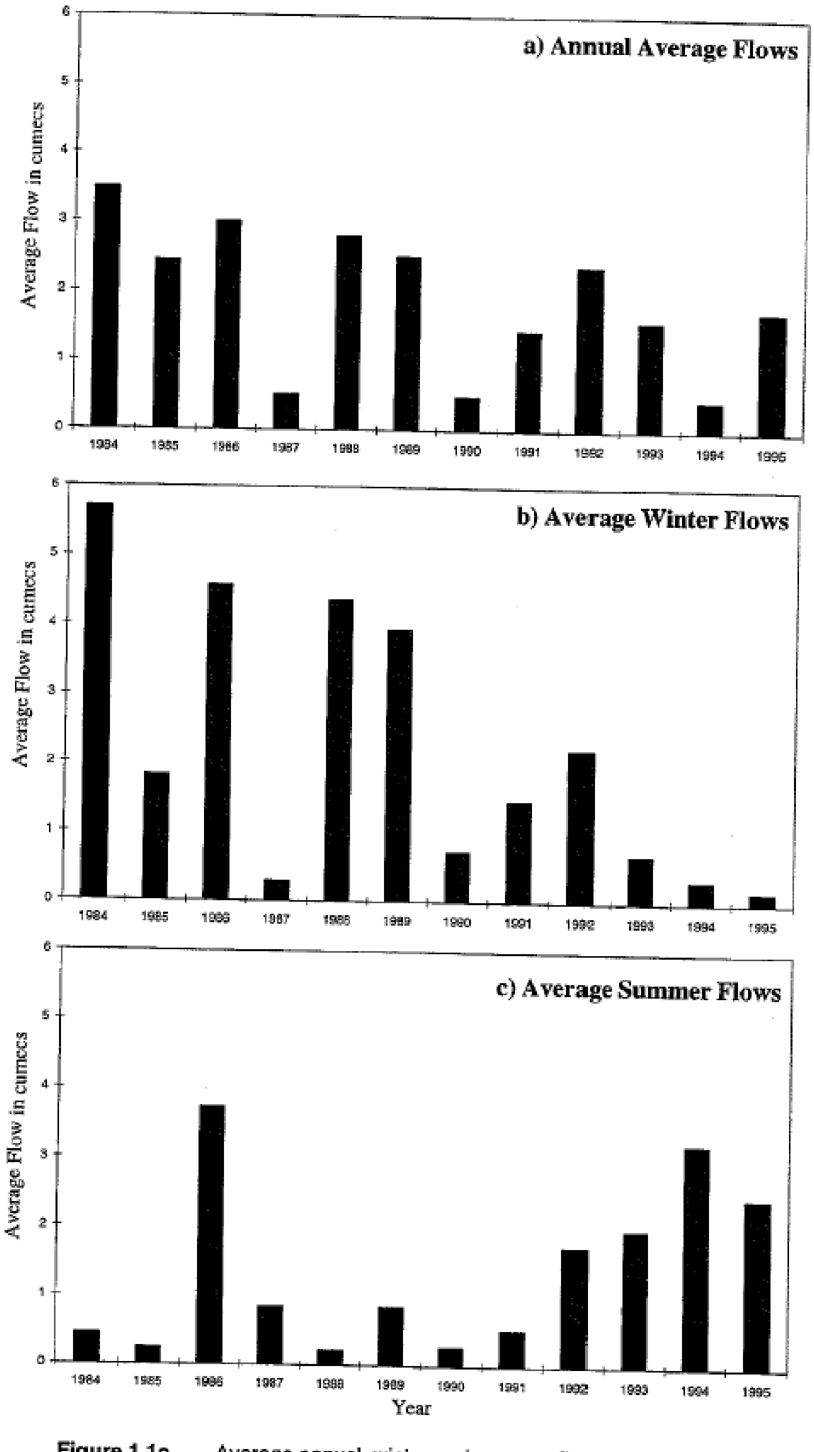


Figure 1.1c Average annual, winter and summer flows in the Break O'Day River.

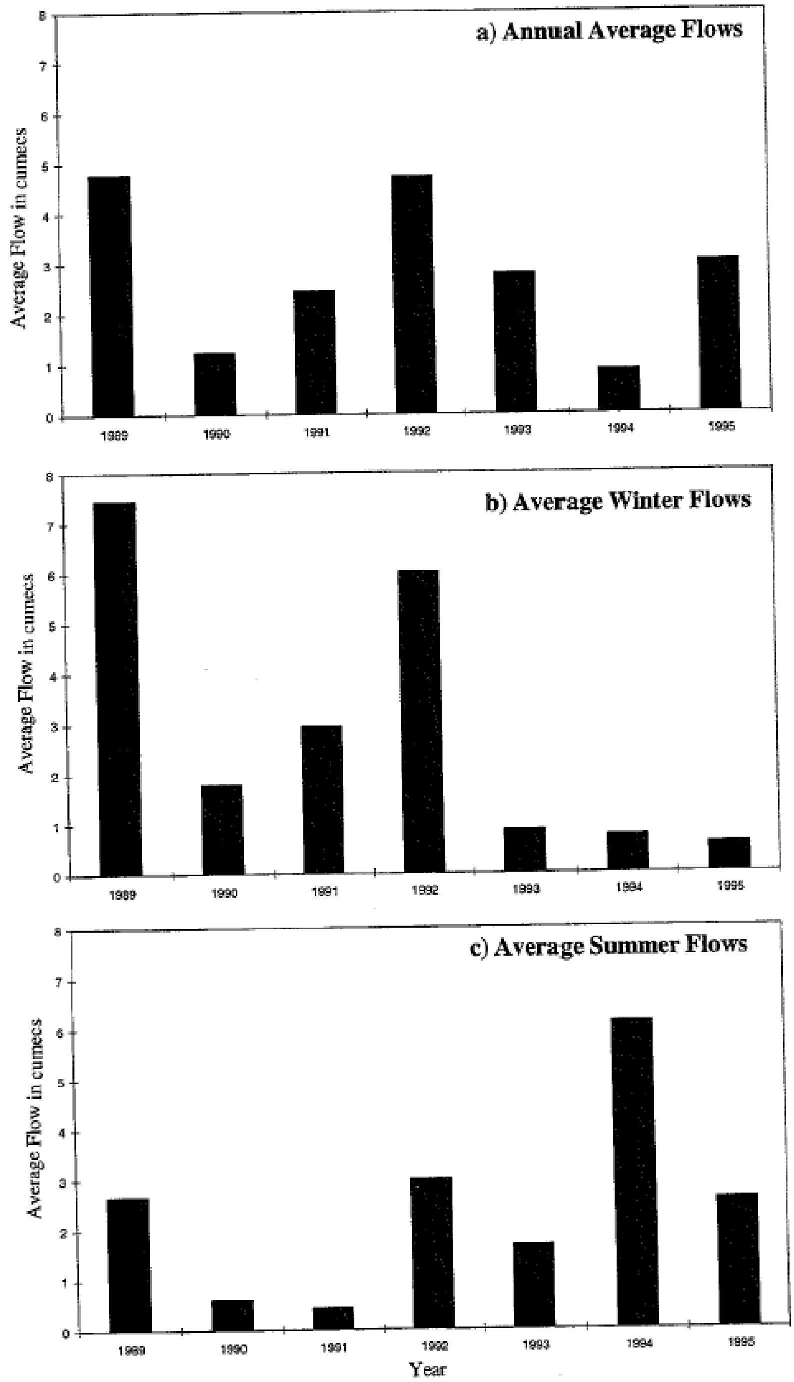


Figure 1.1d Average annual, winter and summer flows in the St. Pauls River.

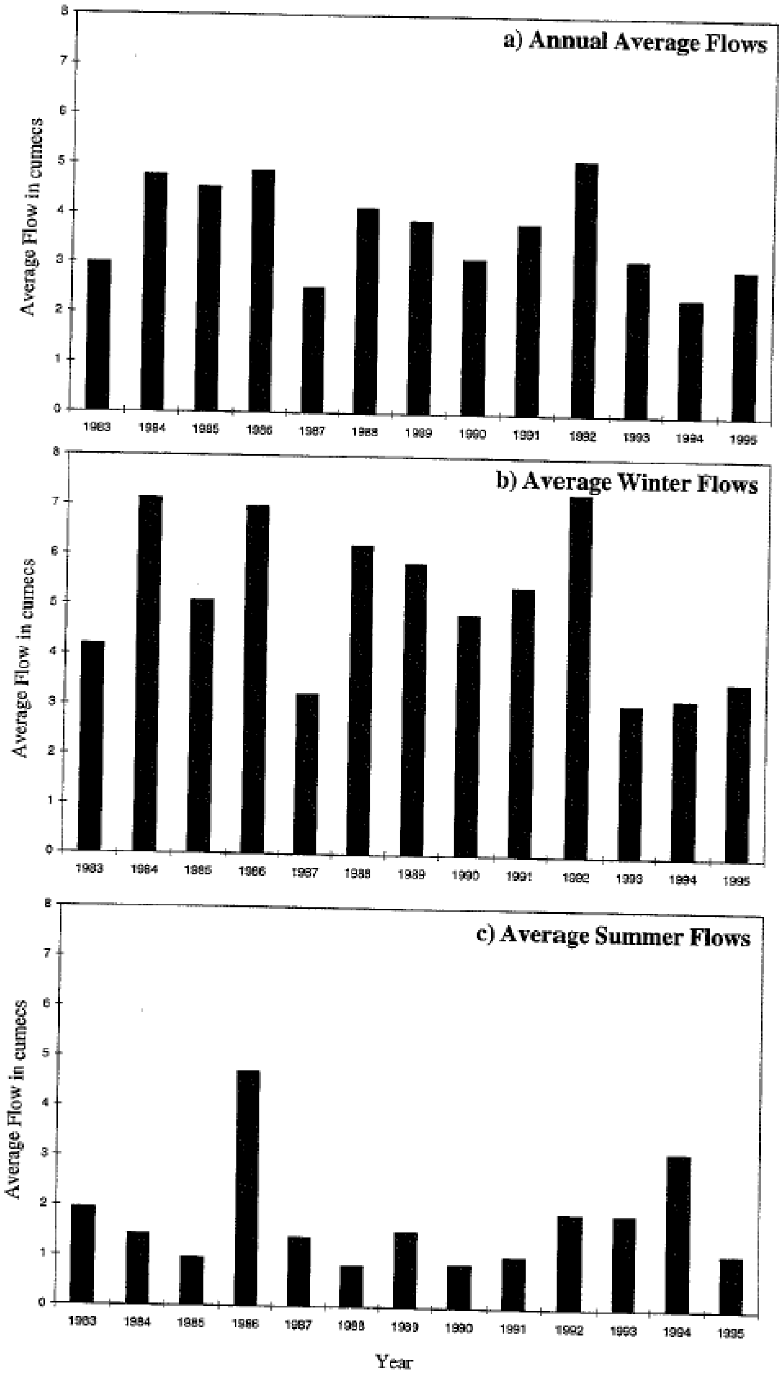


Figure 1.1e Average annual, winter and summer flows in the Nile River at Deddington.

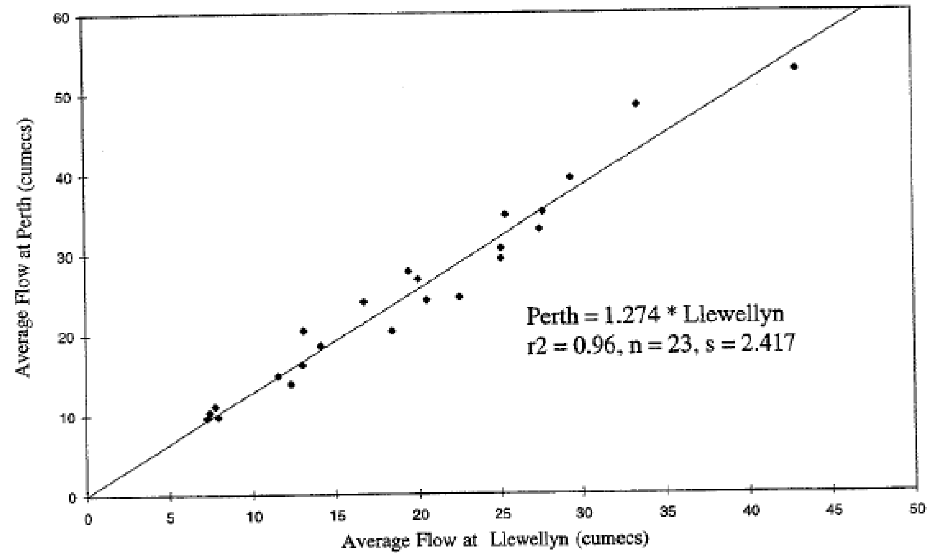


Figure 1.2a Relationship between average annual flows at Perth and Llewellyn.

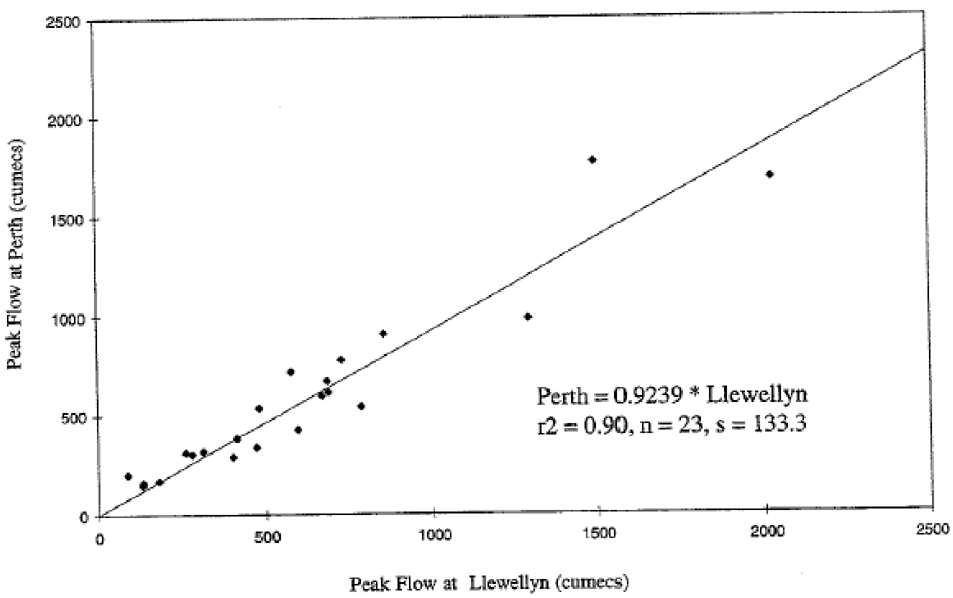


Figure 1.2b Relationship between peak flows at Perth and Llewellyn.

be even greater than that shown in Figure 1.1c. Average winter flows during the period of the study are very dry in comparison with the full record, bur average summer flows are much wetter than those experienced over the full record.

The short period of record for the St Pauls River is also unlikely to have defined the true range of variability of average flows from that sub-catchment. Annual and winter average flows are highly correlated with those from the Break O'Day catchment, however there is substantial variation in summer flows between the two sites.

The record available from Buffalo Brook is difficult to interpret due to missing record and the short period of measurements.

Flows in the Nile River at Deddington appear to be less variable than at other sites in the South Esk catchment. Nevertheless, the record exhibits strong correlations with flows at Perth and Llewellyn. Again during the period of the study winter flow appear to be lower than those experienced over the remainder of the record while summer flows are wetter.

Monthly Yields

The variability of monthly flows in the South Esk catchment is shown in Figures 1.3a to 1.3c which provide box and whisker plots for each of the study sites.

Box and whisker plots for Perth and Llewellyn(Figures 1.3a and 1.3b) exhibit strong seasonal patterns generally peaking in the period July through September. Lowest flows are experienced between February and April. Flows at Perth appear more variable especially during the winter months which is probably indicative of the concentration of rainfall generation in the North East highlands with less consistent rainfall in the lower reaches of the South Esk River catchment. Both Figures are dominated by the occurrence of many high monthly average flow "outliers" throughout the year.

Figures 1.3c and 1.3d for the Break O'Day and St Pauls River catchments are biased by the short periods of record, however, these plots reflect the high variability of flows in these river systems. The Break O'Day River is dominated by very low and extremely high monthly flows as exhibited by the number of "outliers" above each box and whisker plot. The St Pauls River is highly variable during summer - particularly December and January. Both rivers exhibit lowest flows in March and April, although May and October/November are often periods of low flow reflecting the essentially random occurrence of subtropical low pressure systems which tend to feed storm activity at these times. There is a discernable seasonal pattern of monthly average flows in these rivers with flows typically peaking in July.

The Nile River at Deddington also exhibits a strong seasonality in its monthly flows with very low flows in February and March and peak median flows in July through September. September shows the highest variability in flows, particularly with respect to high flows. It seems likely that the effect of subtropical lows, or perhaps input from snowmelt is the cause of increased variability at this time of year.

1.3 Droughts and Low Flows

Analysis of the recession limbs of hydrographs at Llewellyn suggest that low flows in the upper South Esk River catchment are supplied from a single ground water storage. This storage seems to act relatively consistently from year to year so that it is possible to predict available low flows in any irrigation season year given knowledge of the amount of water in the ground water store at the commencement of summer.

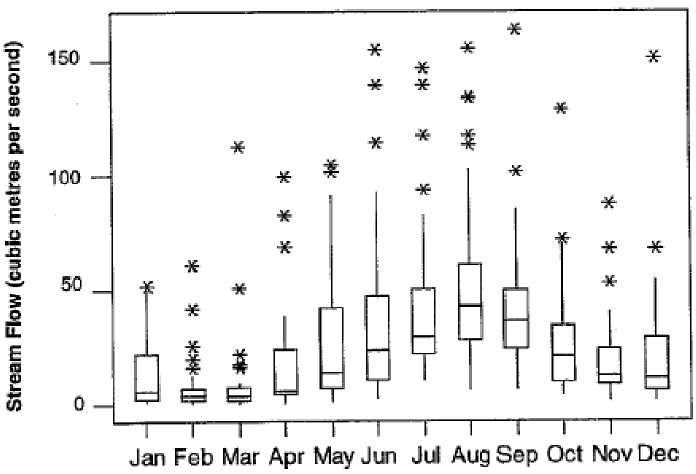


Figure 1.3a Monthly Flows - South Esk at Perth.

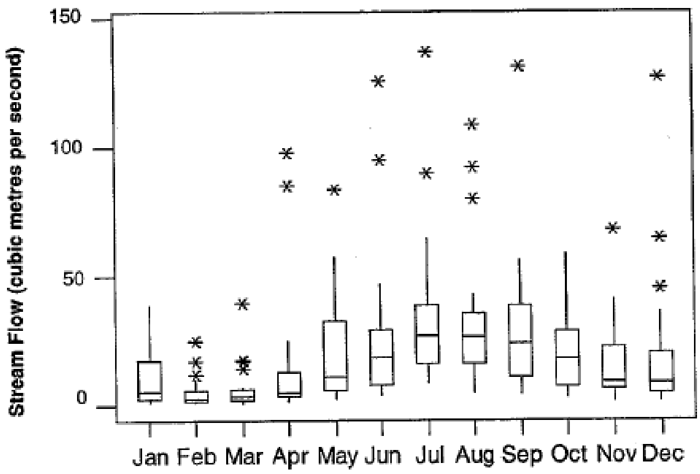


Figure 1.3b Monthly Flows - South Esk at Llewellyn.

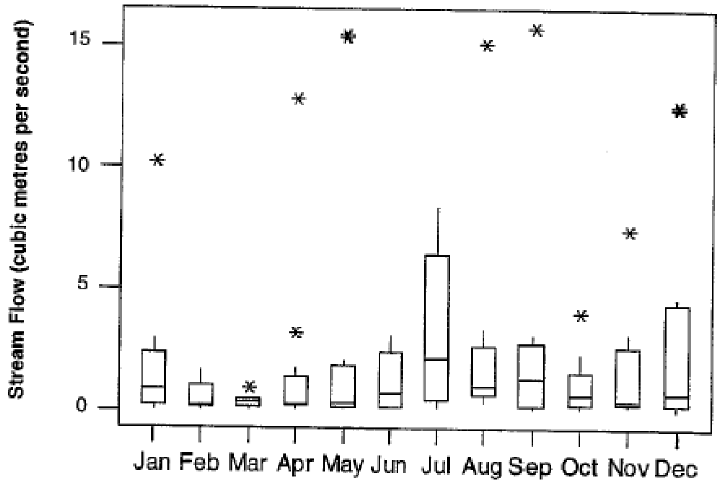


Figure 1.3c Monthly Flows - Break O'Day River at Killymoon Bridge.

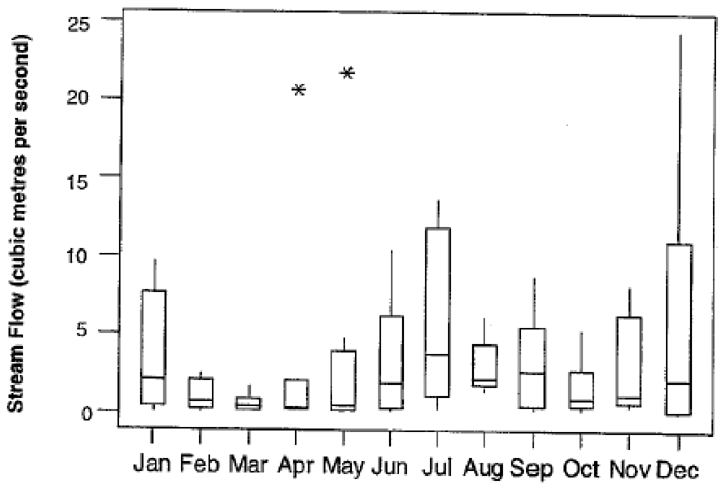


Figure 1.3d Monthly Flows - St. Pauls River.

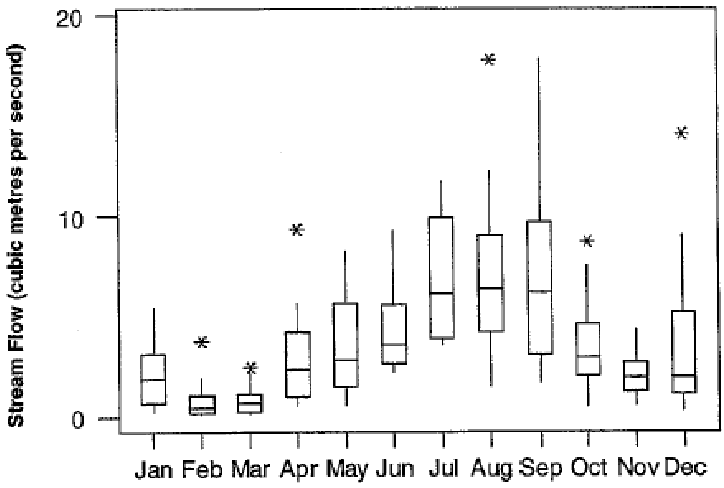


Figure 1.3e Monthly Flows - Nile River at Deddington.

Low flow frequency curves have been derived for various periods (1, 5, 10, 30, 60 and 90 days) using both the Perth and Llewellyn stream flow records (Figures 1.4a [i - vi] and 1.4b [i -iv]). Records from other sites were of insufficient length to allow similar analyses. In some periods (typically 60 days and 90 days) it was necessary to adopt the skewness of the 30 day low flow series in order to constrain calculations within analytical bounds.

1.4 Floods

The South Esk River is the main source of major flood flows affecting the low lying areas of the Fingal Valley, Longford, Hadspen and Launceston. The areas around Gray near St Marys (ie in the upper reaches of the Break O'Day River) and near Mathinna are well known as locations of high rainfall events and flash flooding.

The flood hydrology of the South Esk River is dominated by two major weather systems, namely frontal activity from the west and the occasional intrusion of sub-tropical low pressure systems carrying much greater quantities of precipitable water from the East. The dominance of these systems is reflected in the seasonal fluctuation of the extreme events in the catchment.

Nevertheless, inspection of the histograms of the annual flood peak series for both Llewellyn and Perth failed to identify significantly different flood behaviour for these two storm mechanisms. For this reason a single probability distribution was estimated for each site - no attempt was made to partition series according to flood generation method. In both instances, the sample coefficient of skew was insignificant at the 95% level so a 2 parameter log normal distribution was fitted (see Figures 1.5a and 1.5b).

Large error bands are evident for each site probably due to the influence of the small annual flood peaks in the recorded series (not shown in the Figures). Unfortunately the non-linear logarithmic scale used in these figures tends to distort the visual presentation of error bands.

Nevertheless, the "eye fit" of the distribution to the high flow series is considered excellent in each case. Further investigation of flood frequencies could be carried out in the future to ascertain the effectiveness of partitioning the annual peak flow series on the basis of storm generating mechanism.

1.5 The Effect of HEC Regulation

Trevallyn Power station draws water from Lake Trevallyn at the Basin outlet and as mentioned in Part II has been a declared HEC water district since 1957. It is only under agreement between the Rivers and Water Supply Commission and Hydro-Electric Corporation that water can be allocated from the South Esk River for uses other than hydro-electric generation.

The Maquarie River carries with it substantial inflows to the Basin from the Great Lake Power Scheme. Most of this inflow joins the South Esk River and hence flows into Lake Trevallyn. The diversion of water into the South Esk Basin is aseasonal in that little water is diverted into the Basin during winter periods while during summer flows are maintained at artificially high levels. Details of diversions are discussed in Section 3.6 on the Macquarie River.

Lake Trevallyn is a small storage and as such is only able to regulate approximately 66 % of inflows. The result is that in any year there is some water which, rather than passing through

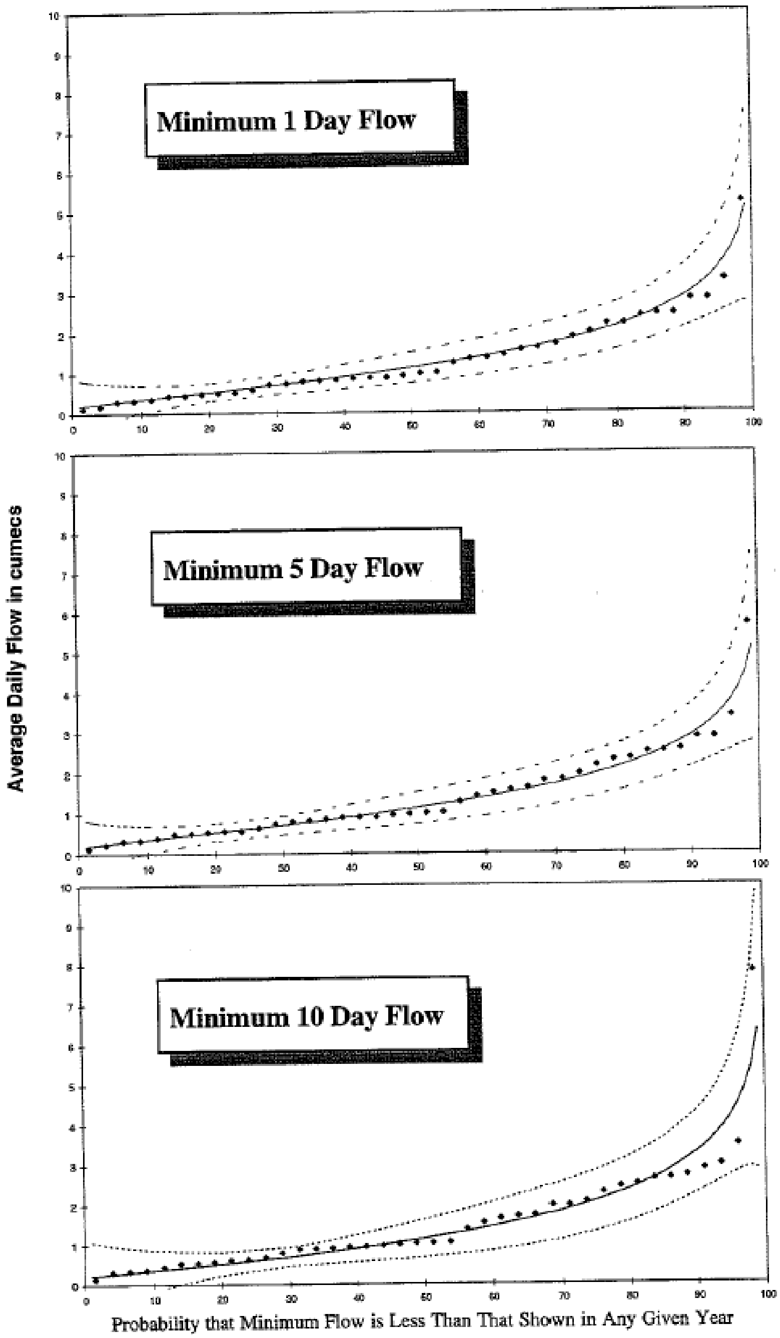


Figure 1.4a (i - iii) Low flow frequency curves for the South Esk at Perth.

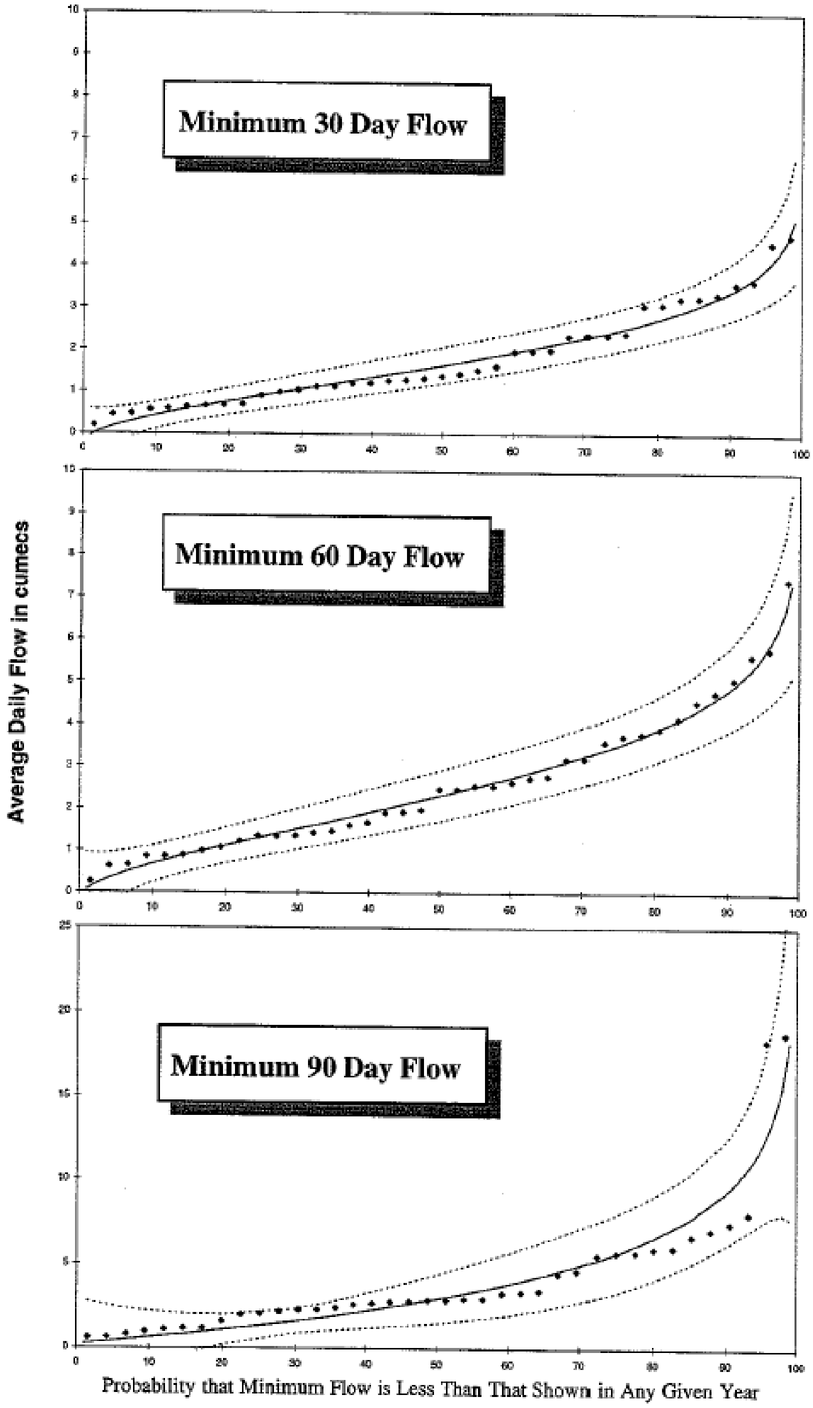


Figure 1.4a (iv - vi) Low flow frequency curves for the South Esk at Perth.

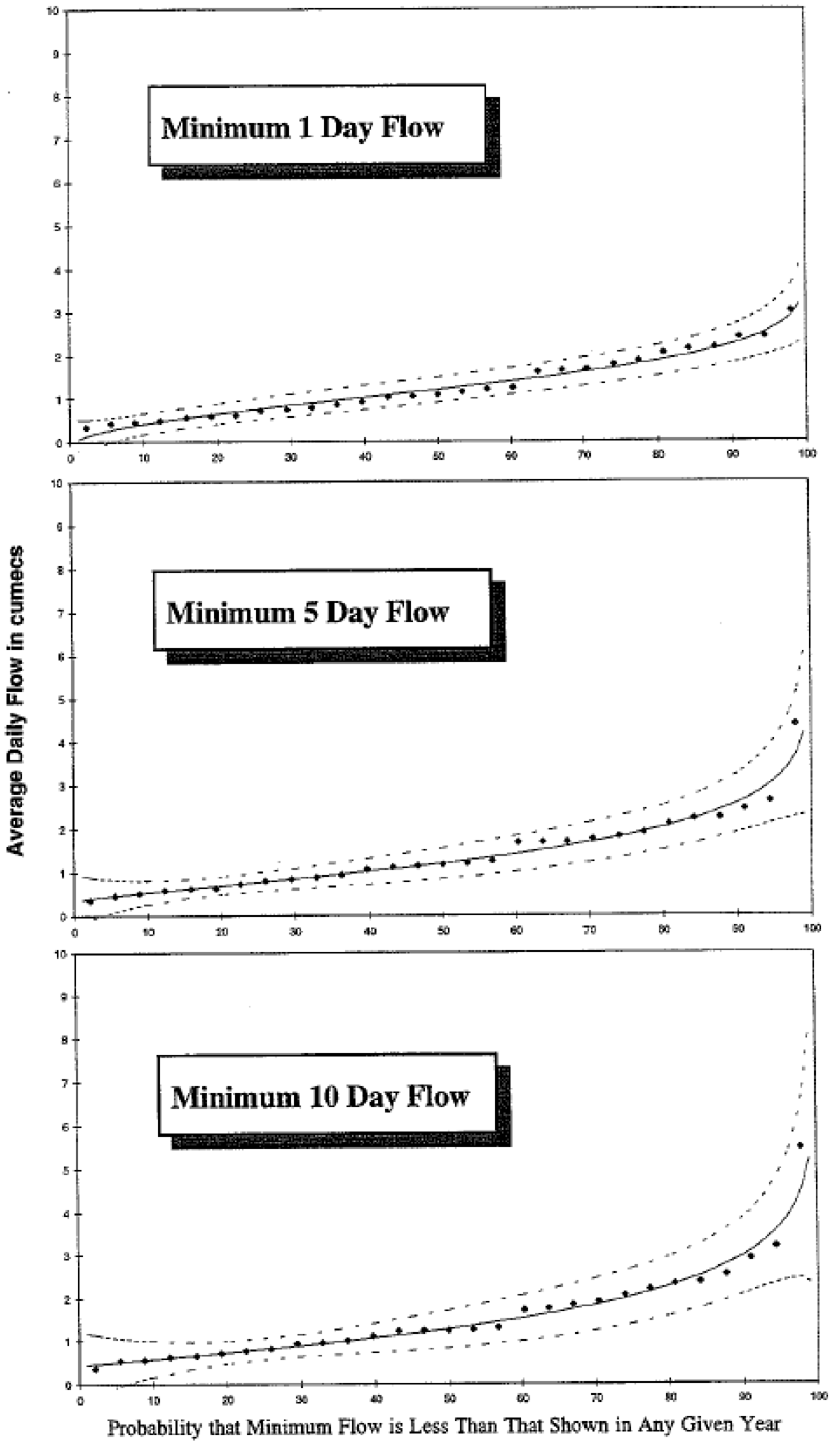


Figure 1.4b (i - iii) Low flow frequency curves for the South Esk at Llewellyn.

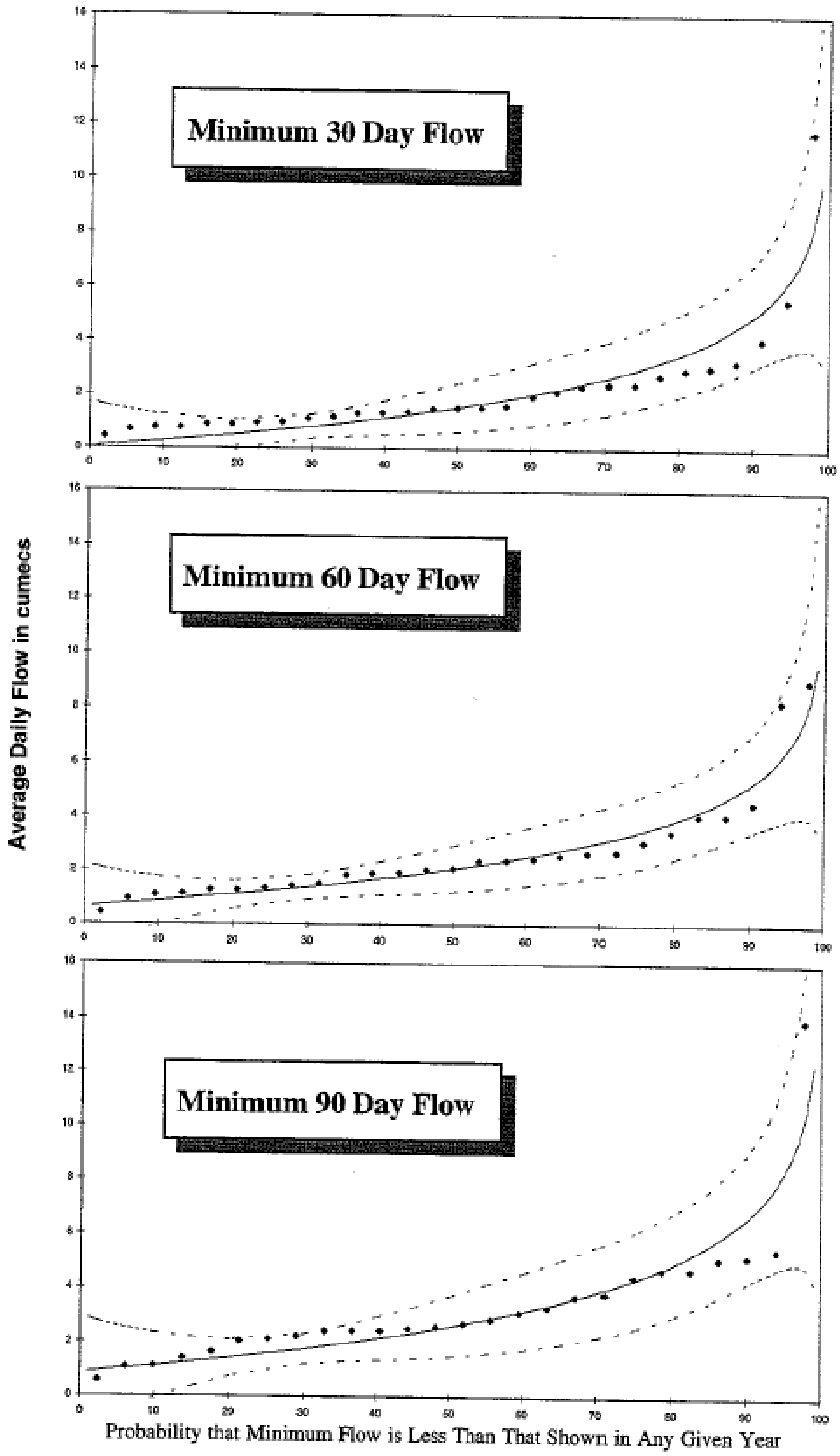
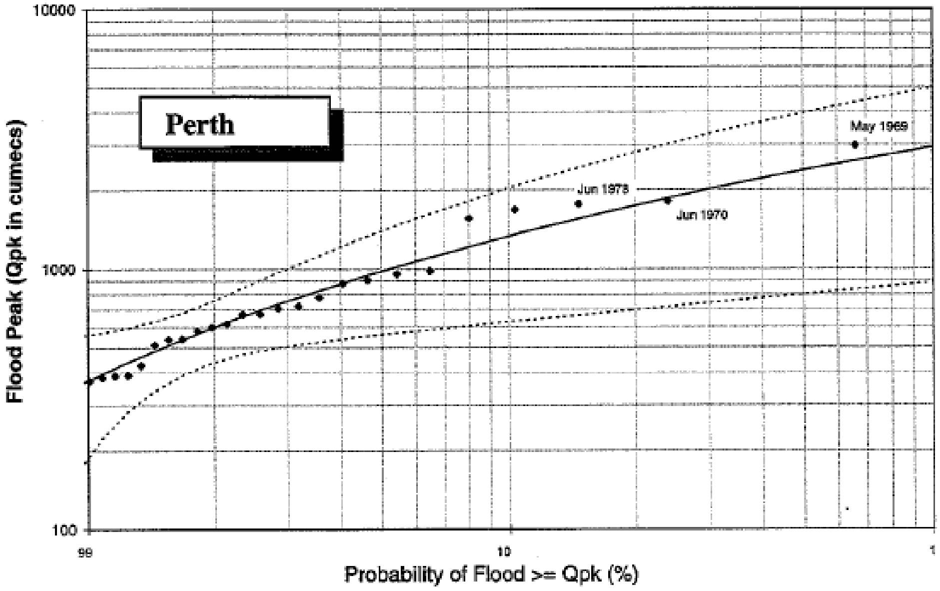


Figure 1.4b (iv - vi) Low flow frequency curves for the South Esk at Llewellyn.



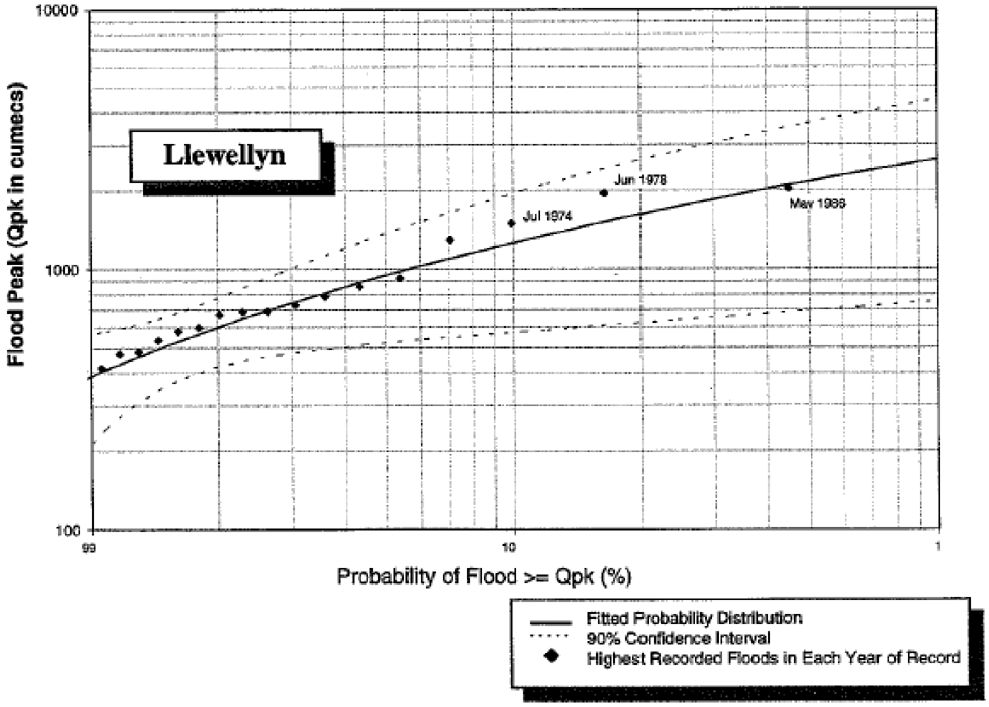


Figure 1.5a & b Flood frequency curves for the South Esk River.

the power station, flows over the spillway and travels down the original riverbed. In all years of operation the average storage loss over the spillway is 879 Mm^3.

2.0 Water Quality

2.1 Historical Background

In addition to the collection of data on the current water quality in the South Esk catchment, data gathered in the past by other agencies was collected and processed. The aim was to update the State database and to get some idea of the amount and type of data collected in the past. The following is a brief discussion of the results.

In the past water quality monitoring in the South Esk River and its tributaries has been mainly carried out on a project basis. During the late working years of the Storys Creek and Aberfoyle Creek mines and at several times since, various agencies have monitored water and sediment quality of rivers and creeks in the area (Dept Mines unpubl., 1990), analyzing heavy metal pollution which is still leaching from the mine and tailing dumps. Various reports are available on pollution from this area, the most recent being that of Locher (1993) for the Dept of Environment and Land Management.

Most studies into the effects of heavy metal pollution were carried out during the 1970's examining the effects of this pollution on riverine biota of the South Esk (Tyler and Buckney, 1973; Norris, et al., 1980; 1981). The main conclusion from these studies was that the impact of pollution from Aberfoyle and Storys Creeks has affected aquatic communities in the South Esk river from the confluence of Storys Creek downstream as far as Evandale.

In the 1980's during a period when the Hydro-Electric Commission was considering the possibility of a thermal power station in the area, extensive water sampling was also carried out in the South Esk downstream of Fingal and encompassed a wider range of water quality parameters, including heavy metals, general ionic parameters and nutrients. This data appears not to have been formally reported on although feasibility studies on the thermal power station may contain this data.

Some data was also collected in the area of Perth and Longford during the period 1974 to 1984 when Federal funding was made available for such work through the Australian Water Resources Council. This data was summarised in an unpublished report by Curtis (1987). This dataset includes most physical parameters, filterable and non-filterable residues. Eight samples were also collected during the period and analysed for a wide variety of chemical and bacterial parameters.

The quality of raw water has also been monitored since 1962 at the Reatta Road water supply, where water is extracted from Lake Trevallyn for domestic supply of the West Tamar area. At this station, this amounts to a continuous record read at least daily for the past thirty years. Entry of this data on the State database will allow an analysis of changes in turbidity during this time. Unfortunately the apparatus used to read turbidity changed in about 1974, going from hellige units to formazin units, restricting trend analysis to the last 20 years only. Further work will be needed to make adjustments for this, as it may be possible to recover the original instrument and perform some comparative tests to allow conversion of the record prior to 1974 to formazin units, which will permit longer term trend analysis of the data.

A portion of the time series (from 1984 - 1992) is presented here (Figure 2.1), and shows that there is a strong seasonal component to the series, with highest turbidity occurring during the

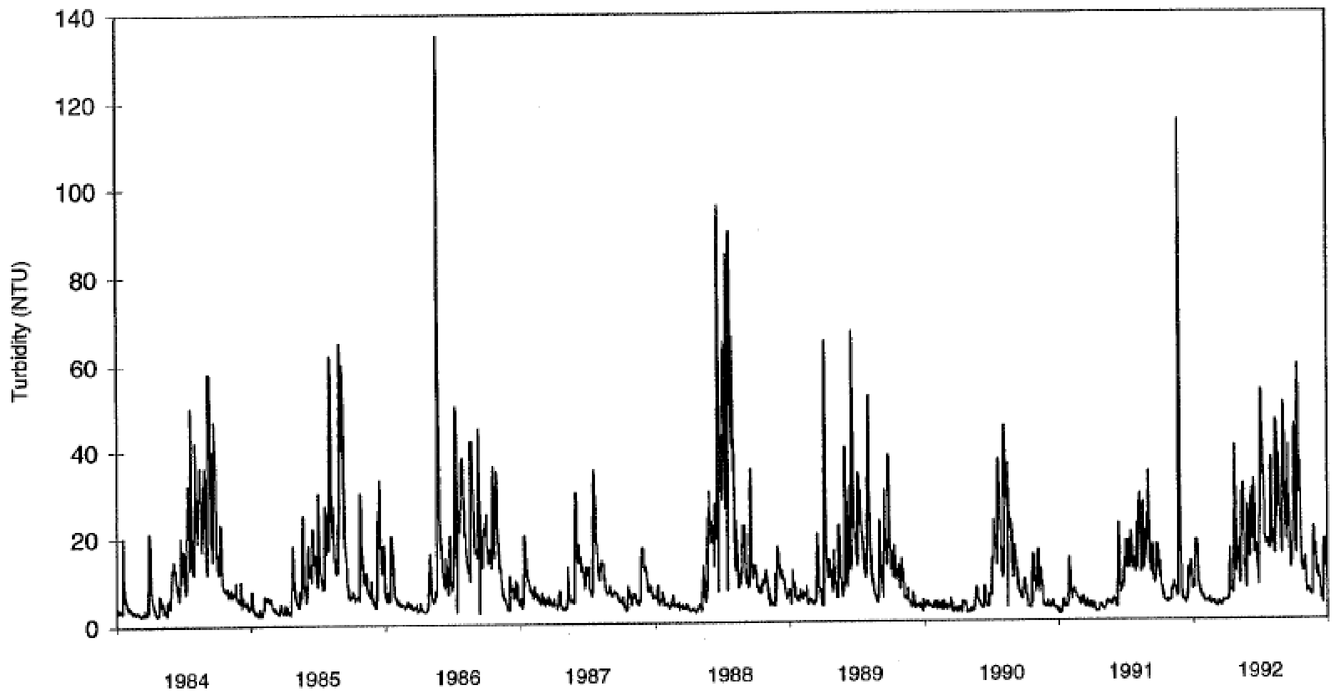


Figure 2.1 Turbidity (NTU) measured in water withdrawn from Lake Trevallyn by the West Tamar Water Supply 1984 - 1992.

winter- spring period. The plot also highlights the years of below average rainfall, when peak turbidity levels are lower as a result of decreased runoff (eg 1987). Although the data can be de-seasonalized, this climatic variability may hinder analysis for longer term changes in turbidity.

A report into siltation in the Tamar Estuary commissioned in 1986 estimated that for the period 1924 to 1979, the average annual sediment discharge into the Tamar River from the South Esk basin was 39, 300 tonnes (Foster, et. al., 1986). This report found that during wet years, such as the year of exceptionally high rainfall in 1956, up to 122, 370 tonnes of sediment was discharged into the estuary. The concluded that while catchment measures to inhibit sheet and gully erosion are always desirable, problem areas tended to be relatively small in comparison to the total catchment size and that no substantial reduction in silt load could be achieved from general catchment erosion control measures.

A summary of all the data collected from other sources during this study and presently entered on the State database is to be collated and presented in a separate document. The following section will present and discuss the data collected during monthly monitoring in the catchment during this study. A table of the descriptive statistics for the data from each site is given in Appendix A.

The Present Study

During this study, water quality data on nutrients and general ions were collected routinely at eleven sites throughout the basin. (Figure 2.2). All sites are located at either stream flow monitoring stations or at locations where river level is monitored for the purposes of flood warning. In the South Esk catchment, river flow is only measured continuously at four sites (denoted by an * in Figure 2.2) and therefore annual nutrient loads could only be estimated at these sites. At Back Creek, which is a small subcatchment draining into the South Esk below the Macquarie River, flow was measured during each sampling visit, giving instantaneous loads. The flows during the irrigation season are highly regulated at this site due to irrigation control. Water is artificially introduced from the Poatina Power Station tailrace into the top of this system and is fed through a complex system of channels which then rejoin the main drain before entering the South Esk River below Longford.

Sites were visited on a monthly basis, with field collection commencing in May 1992 and finishing in October 1995. Not all sites were monitored for the full duration of the study, with some being visited for only one year. Most of the discussion in the following sections is based on routine monthly data and represents baseline conditions. The data from flood samples collected during high flow events at each site will be discussed in a later section on nutrient load estimates. Because of the large difference in WQ found at Back Creek compared to the rest of the catchment, data from this site will be presented in a separate section.

Longitudinal sampling along the length of the South Esk River was also carried out during stable summer (March) and winter (August) flows in 1995 to give a snapshot view of the relative conditions in the river at these times. The aim of these surveys was to highlight any changes in water quality due to tributaries or point source inputs to the river and reveal any trends in water quality down the length of the river.

Also included in this project was the establishment of probes in the South Esk River at Perth and at the junction of the South Esk and Macquarie rivers at Longford to collect continuous data on temperature and electrical conductivity. The data from these instruments will also be discussed.

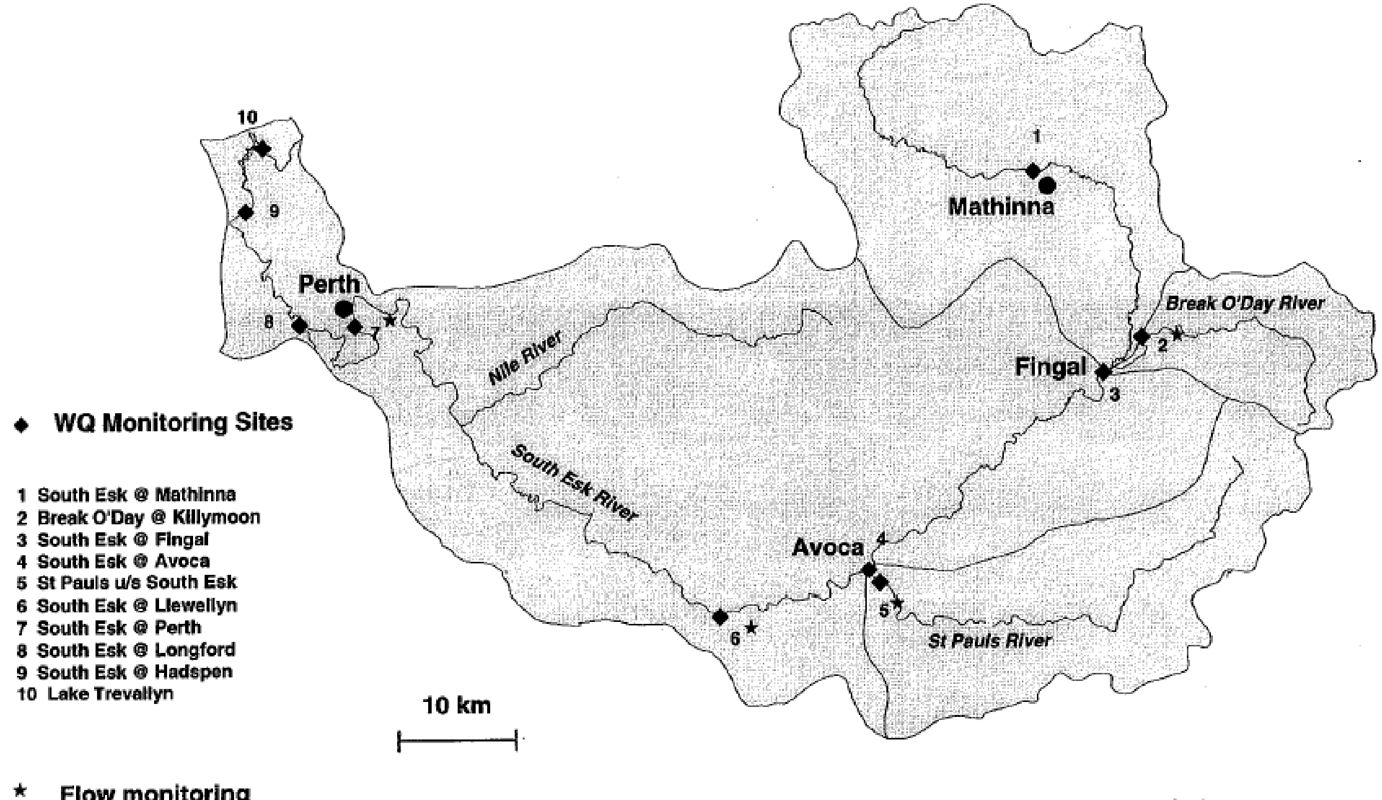


Figure 2.2 South Esk catchment area showing sites where water monitoring was carried out.

2.2 Physical Parameters

Temperature

Water temperature at all monitoring sites showed a distinct seasonal pattern (Figure 2.3) with temperatures ranging from a low in mid-winter of about 5 ^{o}C (generally around July - August) to a high in mid-summer of around 23 ^{o}C (in February - March). Water temperature showed little gradation from the top of the catchment to the bottom, with the exception of Mathinna which, being the uppermost site (elevation 280m), had the lowest seasonal maxima. The two major tributary sites (Break O'Day and St Pauls) also show a similar temperature range to sites in the South Esk River (Figure 2.4).

Equipment to collect continuous data on water temperature was installed at the Perth and Longford sites in late May, 1994. A trace of the data from the first year indicates that during winter, minimum temperatures are somewhat dependent on river flows (Figure 2.5a & 2.5b). Longer periods of stable flows will produce lowest water temperature with temperature increasing temporarily following rain events. The traces also show that during winter diurnal fluctuations are minimal and during summer these fluctuations can be as large as 10 ^{o}C. Examination of air temperature data recorded at Launceston Airport by the Bureau of Meteorology show that during low river flows, minimum water temperatures are generally governed by the prevailing air temperature.

Another influence on water temperatures at Longford, especially during the summer, is discharge of Great Lake water from the Poatina Power Station. Discharge of this water during the summer has the effect of lowering the temperature by 2-4 ^{o}C from that at Perth which is only 10 km upstream.

Electrical Conductivity

Electrical Conductivity (EC) throughout the catchment is relatively low (Figure 2.6) with median values ranging from as low as 44 μScm^{-1} in the upper catchment at Mathinna, to about 97 μScm^{-1} at Perth in the lower catchment prior to the input of the Macquarie and the associated discharge from Poatina. At Longford and sites below, the median EC is lowered as a result of the operation of the Poatina Power Station which introduces very dilute water from the Great Lake. The median EC value at Lake Trevallyn, at the very bottom of the South Esk Basin below the junction of all three major rivers in the basin is only 81 μScm^{-1} .

At odds with this trend, EC at the sites in the Break O'Day and St Pauls rivers is higher than in the South Esk River (Mean conductivity of 180 μScm^{-1} and 128 μScm^{-1} respectively). The higher conductivity in these tributaries is a result of the greater concentrations of dissolved ions (principally chloride, calcium and sodium) in these rivers. These levels are well within normal ranges for freshwaters and are only higher relative to the very dilute water of the South Esk River. Although underlying geology of these catchments will influence conductivity in these rivers, it is likely that evaporation is a major determinant of conductivity, as for long periods (especially during this study) flows in both these tributaries can be very low.

The effect of these tributaries on conductivity in the South Esk River is very evident in the plots of EC from longitudinal transects taken of the South Esk during March and August of 1995 (Figure 2.7). In the winter plot, EC increases abruptly in the South Esk River downstream of the Break O'Day from about 51 μScm^{-1} to 103 μScm^{-1}. Though still evident, the effect from the St Pauls River is less marked.

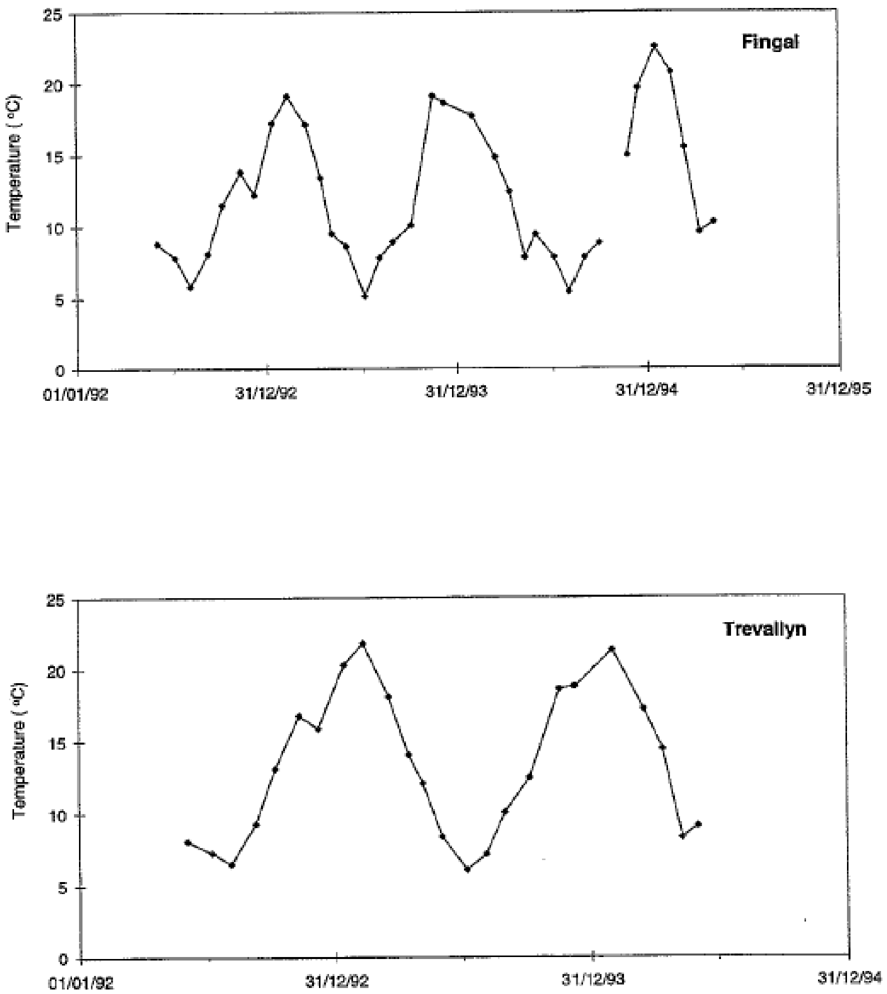


Figure 2.3 Seasonal changes in water temperature at Fingal and Lake Trevallyn.

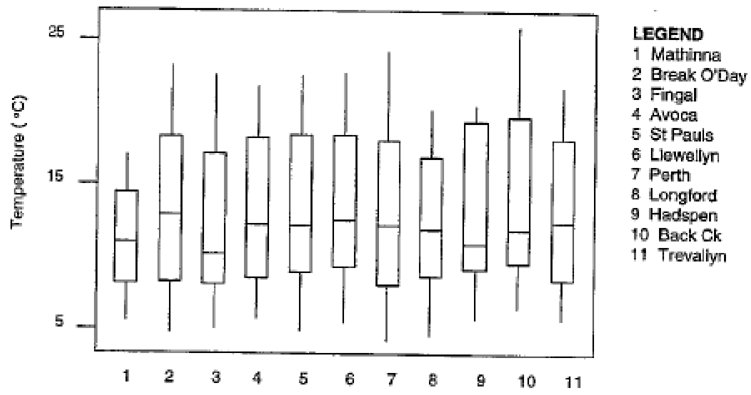


Figure 2.4 Box and whisker plots showing statistics for water temperature from monthly monitoring at sites in the South Esk catchment.

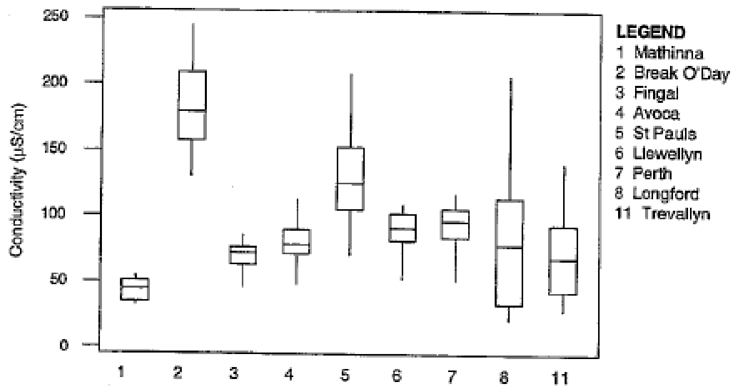


Figure 2.6 Summary statistics on electrical conductivity from monthly monitoring at sites in the South Esk catchment.

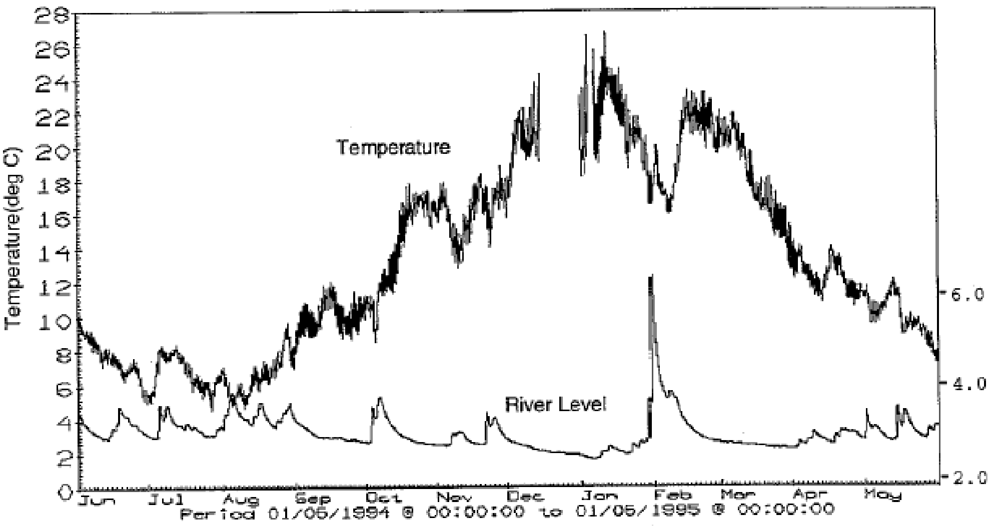


Figure 2.5a Time series of Water Temperature and River Level in the South Esk River at Perth between June 1994 and June 1995.

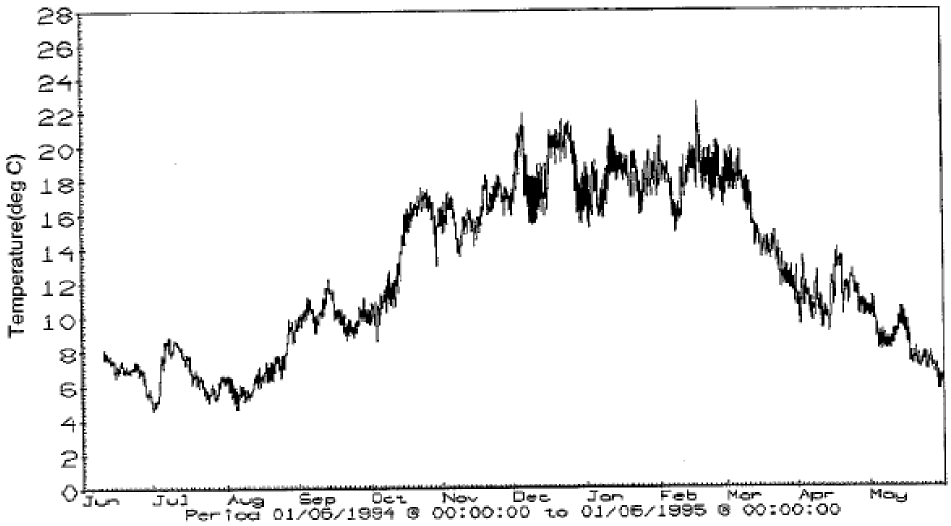


Figure 2.5b Time series of Water Temperature in the South Esk River at Longford between June 1994 and June 1995.

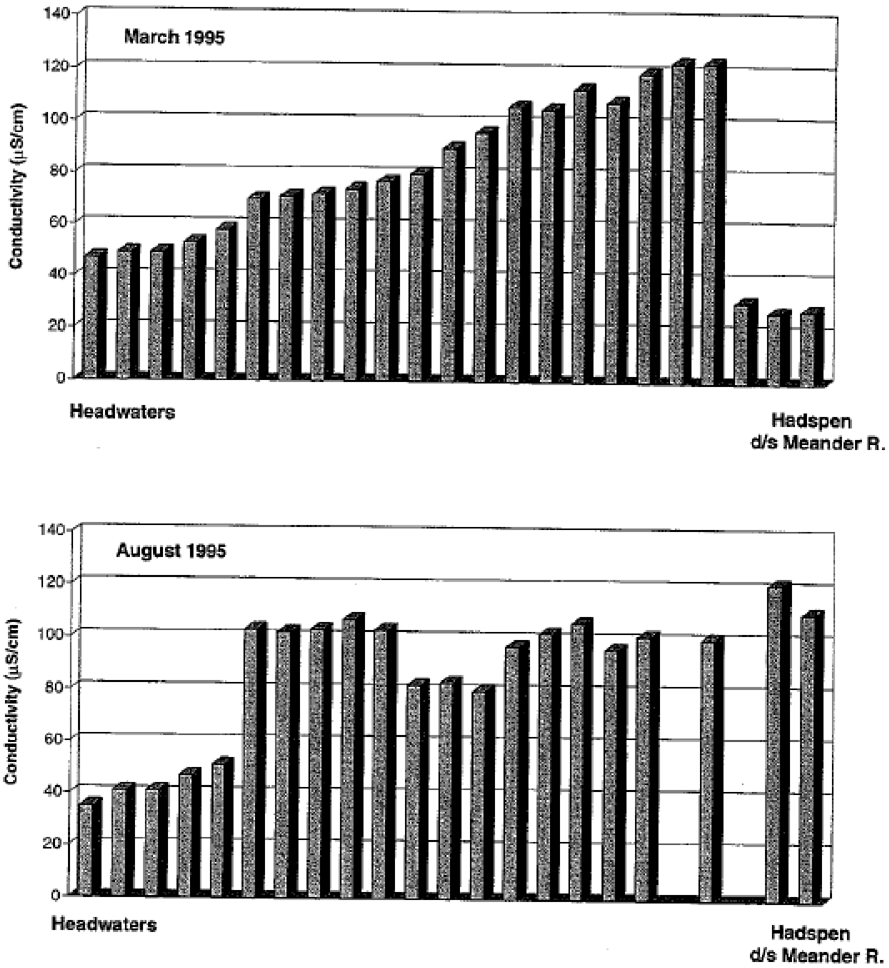


Figure 2.7 Longitudinal transects of electrical conductivity along the South Esk River performed in 1995.

During the March transect, the most noticeable change in EC is the drop from 123 μScm^{-1} to 31 μScm^{-1} just below the Macquarie junction. This drop is due to discharge of Great Lake water into the lower Macquarie as a result of Poatina Power Station operation.

Although a distinct seasonal pattern was shown for EC at most sites in the South Esk catchment, there appeared to be no significant change in EC at any of the sites over the period of the study. A greater length of record is required for rigorous trend analysis to be performed.

The traces of continuous EC measured at Perth and Longford (Figure 2.8a & 2.8b) reveal the vastly different behavior at these two sites. At Perth, EC typically rises during prolonged periods of stable flow, with rapid dilution occurring during high flow events. In some cases this dilution may be temporary, if the event is relatively isolated, with EC returning to previous levels following the event. However if several events occur in rapid succession, EC will generally fall and begin rising only when stable baseflows are re-established.

The variation in EC at Longford is markedly different to that at Perth. At Longford EC tends to fluctuate wildly mainly as a result of the very dilute Great Lake water expelled from the Poatina Power Station (flowing into the lower Macquarie River through Brumby's Creek). This is most noticeable during summer when the power station is most likely to be operating. When the power station is not in operation, EC generally reflects the relative influence of water from the South Esk River (lower EC) and the Macquarie River (higher EC).

Reaction (pH)

The pH of South Esk catchment water is fairly typical of poorly buffered water with field pH ranging between 5 and 8.4 (Figure 2.9). Median conditions at most sites was close to 6.5. Story's Creek water, which is well known to be acidic due to acid drainage from the mine (refer Locher, 1993), appears to have very little influence on pH levels in the South Esk river downstream, as no change downstream of this tributary was noticed.

A consistent difference between field pH measurements and laboratory tested pH was found, with pH measured in the laboratory on stored samples being up to 0.75 units higher (Figure 2.10). It is likely that this difference was caused by chemical changes to water samples during storage and highlights the necessity of noting the method of measurement of pH in monitoring studies.

Turbidity and Suspended Solids

Turbidity is related to the amount of suspended particles in the water that contribute to its cloudiness. Analytically, it is a measure of the light scattering properties of particles in the water and is influenced by particle size and shape and therefore cannot be directly related to suspended solids concentrations (Hart, 1974). In the South Esk River turbidity was only monitored during the last 12 to 18 months of the study. At Trevallyn Dam, where domestic water treatment requires the testing of turbidity, results from the plant were adopted after correlation was found with field measurements.

The rivers of the South Esk catchment, like the rest of those in the basin, are very clear for much of the time. Baseline turbidity is very low throughout the catchment (Figure 2.11) with median levels of between 1.41 and 5.35 NTU's. The sites with higher median turbidity are those of Perth, Longford and Hadspen which are low down in the catchment. The median turbidity in all cases is lower than the mean. This data reflects the low concentrations of suspended solids that measured. Median concentrations of suspended solids at all sites was below 3 mg/L.