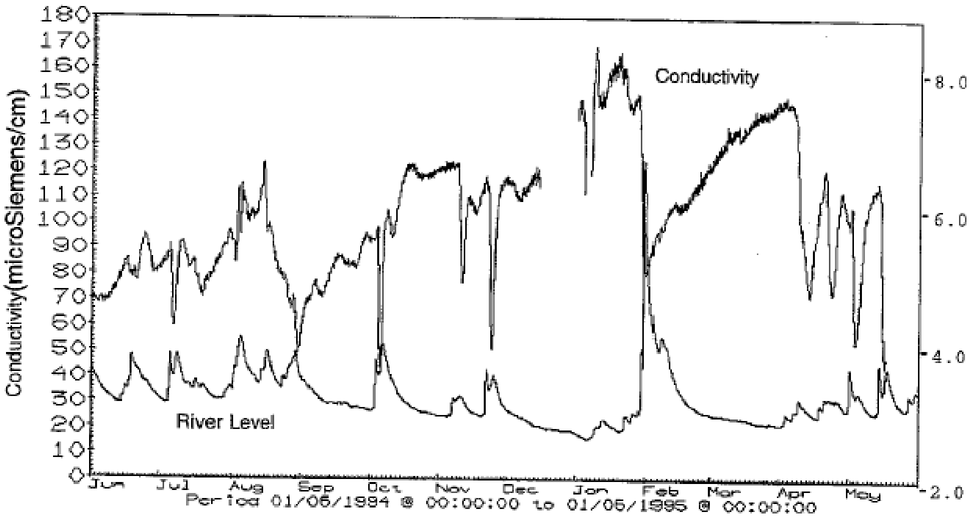


Figure 2.8a Time series of Conductivity and River Level for the South Esk at Perth between June 1994 and June 1995.

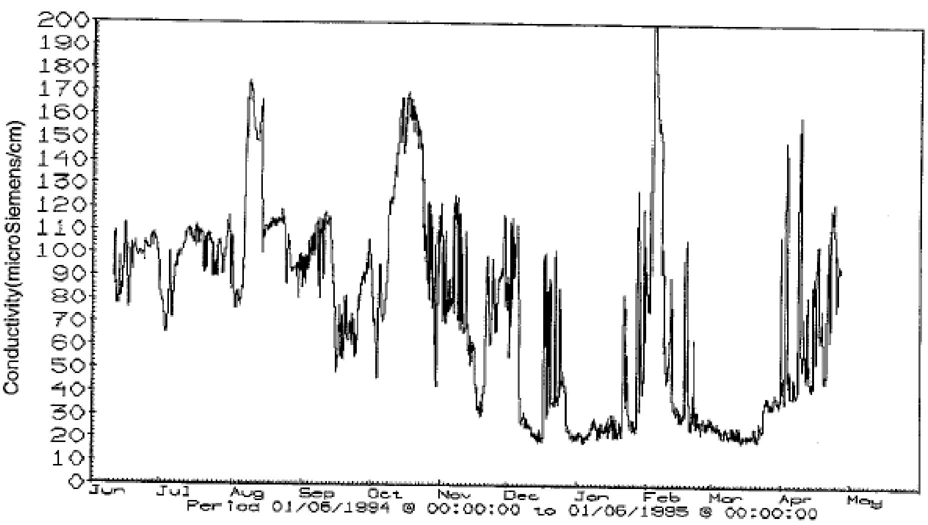


Figure 2.8b Time series of Conductivity for the South Esk at Longford between June 1994 and June 1995.

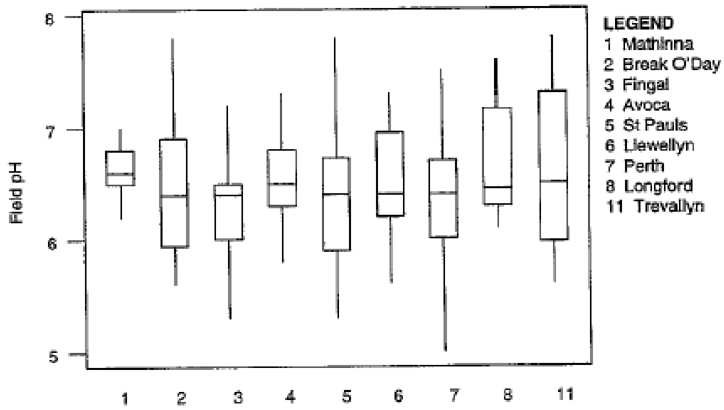


Figure 2.9 Box and whisker plots of monthly pH readings for South Esk catchment sites.

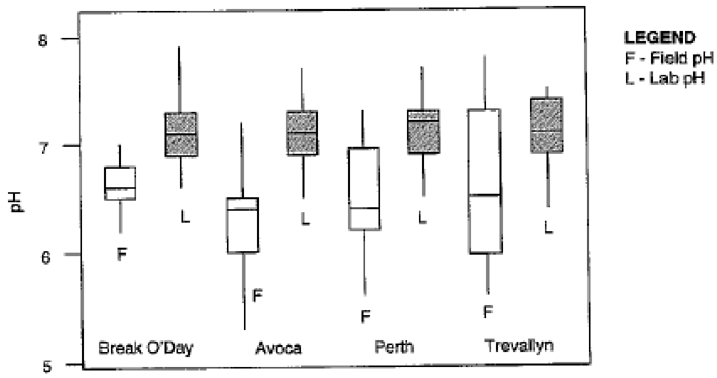


Figure 2.10 Comparison of field read pH and lab determined pH for four sites in the South Esk catchment.

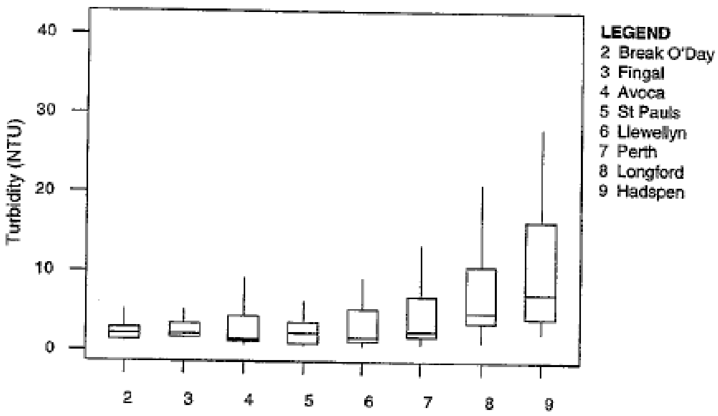


Figure 2.11 Summary statistics of monthly turbidity at sites in the South Esk catchment.

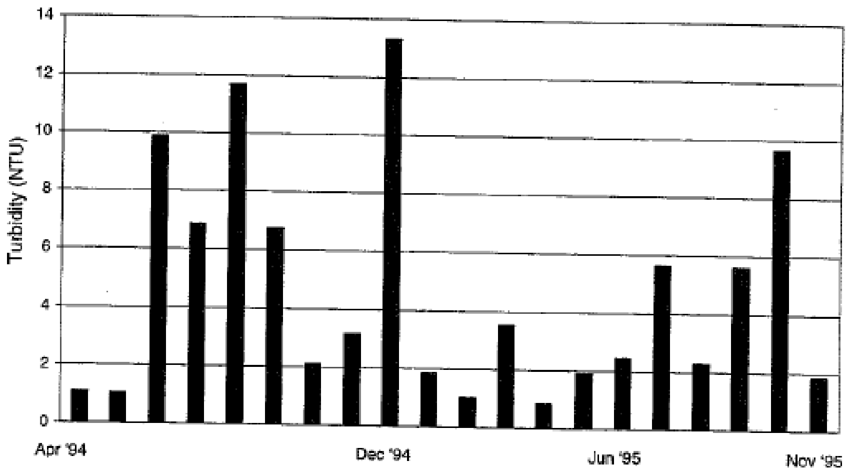


Figure 2.12 Monthly turbidity readings at Perth on the South Esk River.

Turbidity at most sites shows a distinct seasonal pattern (as demonstrated by turbidity at the Perth site shown in Figure 2.12), with higher levels occurring in the months June through to November when surface runoff is greatest. Longitudinal transect data, collected during stable winter flows, clearly shows that turbidity increases down the length of the South Esk River (Figure 2.13). Notable during winter is the decrease in turbidity when the river enters Henrietta Plains (floodplain) and the increase again below the junction with the Macquarie River, which had higher turbidity at that time due to runoff in the catchment. In summer, during low baseflows, higher turbidity occurred further up in the South Esk catchment where river velocities and the associated erosional power is greater.

Both turbidity and the concentration of suspended solids, on which the former depends, increase dramatically during flood events. Turbidity up to 340 NTU and suspended solids concentrations up to 420 mg/L were measured at sites in the South Esk catchment during flooding in 1995. Flood related increases in water quality parameters will be discussed in a later section on event sampling and nutrient loads calculations (Section 2.4.3).

Turbidity data collected by the automatic turbidity probes established at Perth and Longford proved to be unreliable as a means for collecting long term continuous data. Algae, bacteria and sediment are the primary causes of significant drift in turbidity records and modifications to these systems are in the process of being made to improve their ability to collect longer data series. Other systems are also being investigated.

These probes did demonstrate their usefulness for monitoring of turbidity during high flow events. Provided the probes were cleaned prior to events, they were capable of collecting individual event data. Data from the Perth station for the period 18 May to 14 July, 1995 clearly shows the changes in turbidity which occur during high flow events at this site (Figure 2.14).

Dissolved Oxygen

Monitoring of dissolved oxygen was only collected during the latter 18 months of the study. Generally, dissolved oxygen throughout the South Esk catchment is typical of natural rivers, with levels at all station showing a strong seasonal variation. The median dissolved oxygen concentration at most sites was within the range 9 - 10.5 mg/L (Figure 2.15), which is indicative of a healthy environment. The one exception was the Break O'Day River, where median oxygen was found to be significantly lower than most other sites.

Dissolved oxygen at this site fell below 7 mg/L three times during the 12 months of monitoring, once falling below 5 mg/L. While two of these measurements were taken during very low summer flows, one was recorded during mid-winter. It is also significant to note that the low summer readings were taken around midday, when plant photosynthesis would have been adding most oxygen to the river. The cause of these low readings is not readily apparent, though the low flows in the river and the organic load generated from the riparian vegetation in the area (mainly willows) may have had some influence.

Data from this site is of some concern and further investigations are needed to determine if oxygen concentrations regularly fall below the guideline of 6 mg/L recommended as necessary for the protection of aquatic ecosystems (ANZECC, 1992). Also, it can reasonably be expected that oxygen during the night would be lower, as plants are net consumers of oxygen at this time (Goldman and Horne, 1983). Monitoring of oxygen levels during the night may show oxygen depletion to very low levels occurring, especially during the summer season.

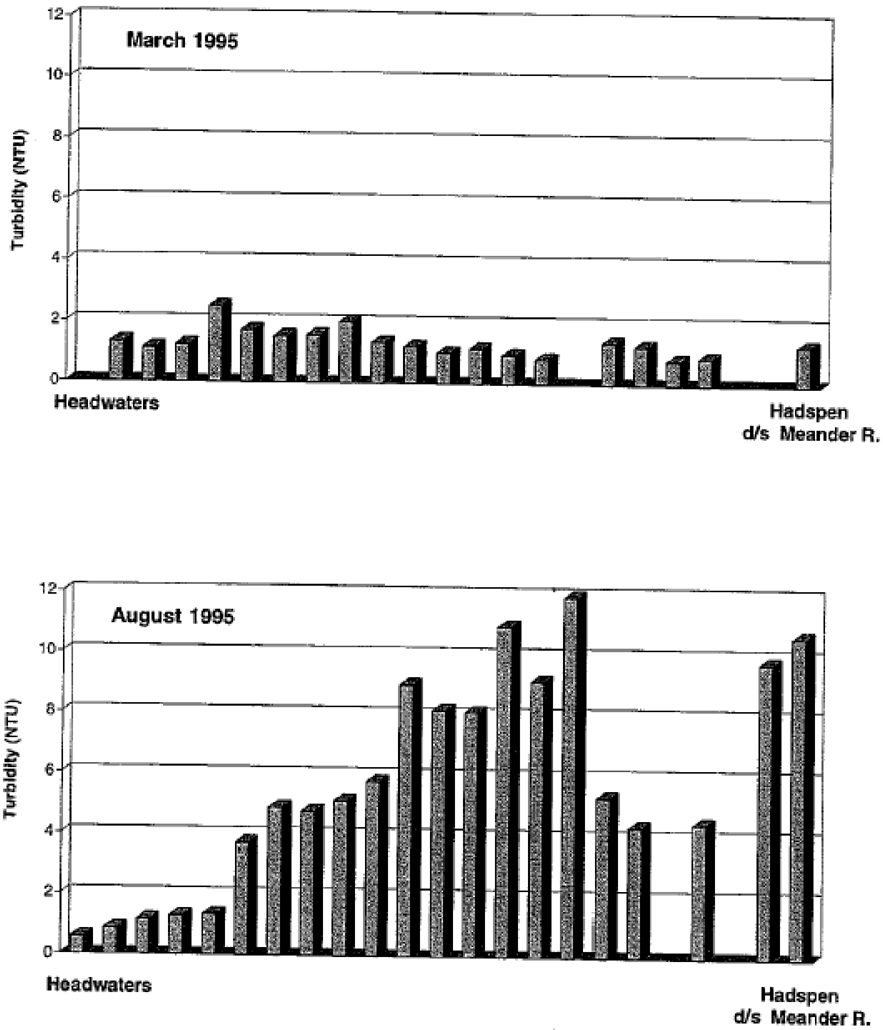


Figure 2.13 Longitudinal transects of turbidity along the South Esk River performed in 1995.

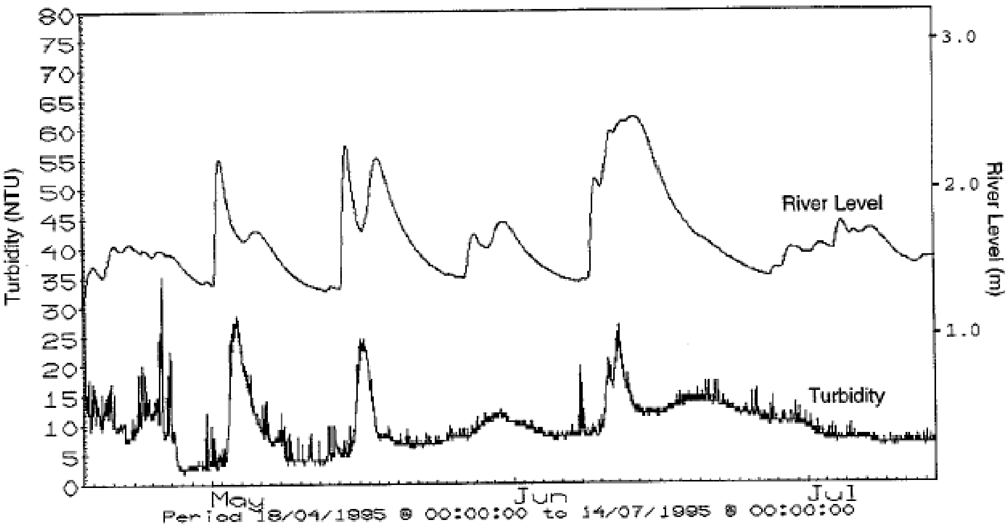


Figure 2.14 Time series of Turbidity and River Level in the South Esk at Perth from May - July, 1995.

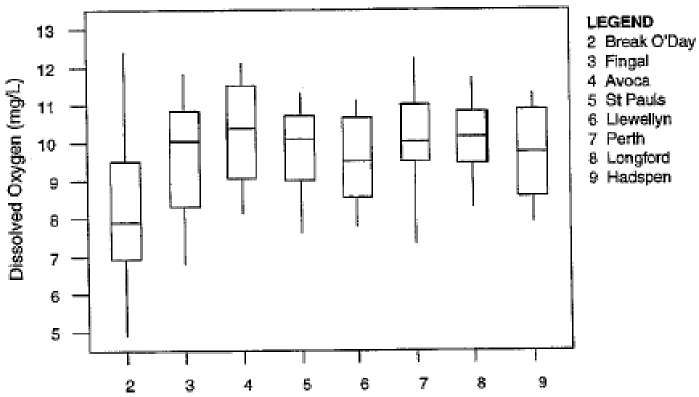


Figure 2.15 Summary statistics of monthly monitoring of dissolved oxygen at sites in the South Esk catchment.

2.3 General Ionic characterization

The chemical constituents which determine the ionic character of water in the South Esk catchment were monitored on a quarterly basis at nine of the eleven sites during the latter 18 months of the study. These are commonly referred to as the ‘dissolved salts’ of water and together make up the “Total Dissolved Salts” of the water.

The ionic character of the water generally reflects the soil and parent rock type through which the water flows. Water which flows through limestone rich land will have relatively higher concentrations of Calcium and Magnesium and will have correspondingly greater Hardness (which is a measure of the capacity of water to produce soap lather) and Alkalinity (which is a measure of the capacity of the water to resist pH changes). Water which flows through a doleritic landscape will have generally lower concentrations of salts, resulting in lower Hardness and Alkalinity but may have higher levels of such elements as silica and iron.

Data on the ionic character of sites in the South Esk Catchment were collected on a quarterly basis, as these parameters are generally considered conservative and show little variation over time. In the South Esk catchment, the South Esk River is very dilute and is characterized by very low alkalinity (little or no buffering capacity) and low hardness. This reflects the generally weather resistant dolerite and quartzwacke geology of the area.

TABLE Some Ionic Chemical Parameters

	Alkalinity (mg/L)	**Hardness** (mg/L)	**Chloride** (mg/L)	**Calcium** (mg/L)	**Potassium** (mg/L)
Break O’Day	22	58	28	13.5	0.91
Saint Pauls	15	46.5	20.5	8.45	0.45
Fingal	6.05	15.5	9.5	2.75	0.68
Llewellyn	8.5	27	12	4.95	0.6
Perth	13	26	14	4.6	0.5
Longford	8.1	24	11.5	4.4	0.36
Hadspen	5.3	17	8.3	3.25	0.38

Values are medians of dataset (n = 4).

Most parameters increase slightly in concentration from Fingal to Longford, and are then diluted downstream of Longford with input from the Macquarie (Poatina) River and then the Meander River.

Both the Break O’Day and St Pauls rivers are slightly more concentrated than the South Esk, with higher concentrations of all chemical constituents. This is to be expected as the electrical conductivity in both these rivers is higher than that of the South Esk. The main cause of this is probably due to the nature of the streams which experience very low flows during the summer period and which are probably sustained through groundwater, rather than mountain runoff. It is also probable that the underlying geology influences the ionic character of these rivers, but the degree of influence of geology is unclear. The higher concentrations of silica in the St Pauls River may be due to the greater amount of dolerite in this sub-catchment.

Colour

Median value for colour for all sites is 17 - 22 Hazen Units, with maximum values of 150 being measured at Fingal and Back Creek. This is normal for those Tasmanian rivers not greatly influenced by humic substances typically derived from button-grass areas. No seasonal variation in colour was apparent at any site.

2.4 Nutrients

In this report, the term 'nutrients' is used to describe the forms of nitrogen and phosphorus most commonly associated with plant growth and productivity. The forms of nitrogen are ammonia-N, nitrite-N, nitrate-N and Total Kjeldahl-N (TKN). The first three forms were measured at all sites in the South Esk, however TKN was only measured at 8 sites over the latter 15 months of the study.

Discussion in this report will be limited to nitrate-N, which makes up the largest portion of dissolved nitrogen, and Total N (TN) which is derived by calculation (as TKN + nitrate-N + nitrite-N). As nitrite-N and ammonia-N were generally only present at very low levels relative to nitrate-N and TKN, these forms of nitrogen will not be discussed.

The analysis of total phosphorus (TP) includes all phosphorus both bound to particulate matter and dissolved in the water. The dissolved phosphorus, measured as dissolved reactive phosphorus (DRP), is generally considered as largely free and available to aquatic plants and algae. In natural waters DRP generally makes up only a very small fraction of TP. Therefore, unless higher levels of DRP have been detected, the following discussion will focus on TP only.

2.4.1 Station conditions and Trends

Nitrate-N

All monitoring sites showed a seasonal change in nitrate-N concentration, with higher concentrations generally occurring during the higher baseflow periods of winter. This seasonal pattern was most pronounced in the South Esk at Perth (Figure 2.16). It is consistent with the theory that groundwater discharge in the catchment has higher nitrate-N concentrations than surface waters. The seasonal change in nitrate-N levels was more distinct at sites lower in the catchment (eg Perth).

Median nitrate-N concentrations at sites in the South Esk River were between 0.005 and 0.15 mg/L, with sites in the top of the South Esk river having highest nitrate-N levels (Figure 2.17). There is a distinct decrease in nitrate-N concentration with increasing distance from the headwaters in this river.

This is highlighted in the plots of nitrate-N concentrations measured in the South Esk River during the longitudinal transects of 1995 (Figure 2.18a & b). It shows peak concentrations of around 0.35 mg/L in the upper reaches of the South Esk to less than 0.005 mg/L at the catchment outlet. Higher nitrate-N levels are sustained lower in the river during the winter. It is highly likely that higher nitrate-N concentrations in the upper South Esk River reflect the influence of groundwater discharge on river flows, as it is well known that nitrate-N is easily transported in water movement below the root zone (Goldman and Horne, 1983; Webb and Walling, 1985). Higher concentrations during winter are known to occur due to reduced plant uptake and incomplete ground cover which can intercept nitrate-N released by mineralization or fertilizer application (Wright, et al., 1991). Furthermore, forestry activity in the upper catchment may have had some effect as increased leaching of nitrate-N has also been found in areas where clear felling of forests has occurred (Stevens and Hornung, 1988).

Unlike other sites high in the South Esk catchment, nitrate-N concentrations in the Break O'Day and St Pauls rivers are both very low (median < 0.01 mg/L) which suggests that groundwater in both these sub-catchments may have lower levels of nitrate-N.

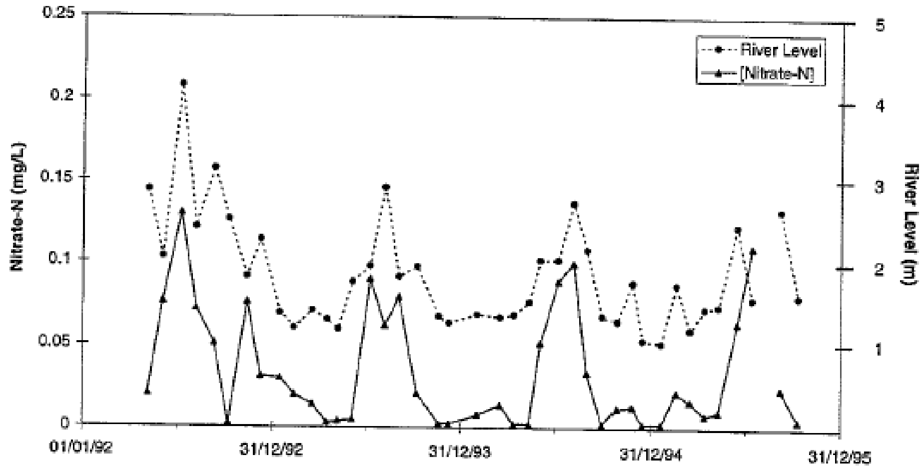


Figure 2.16 Time series of Nitrate-N concentrations and River Level in the South Esk River at Perth.

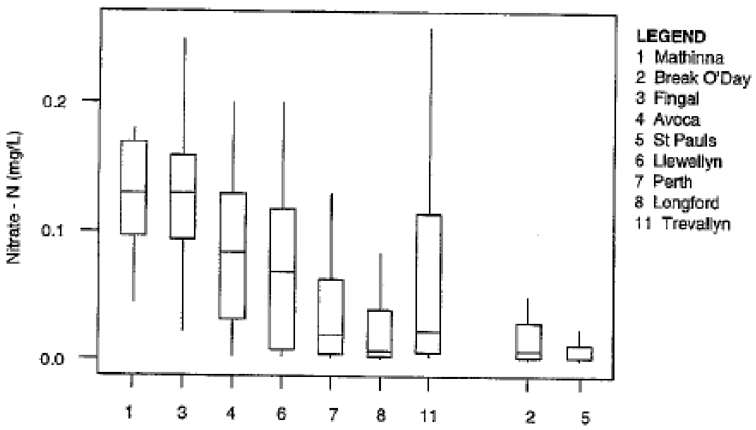


Figure 2.17 Summary statistics of monthly Nitrate-N concentrations at sites in the South Esk catchment.

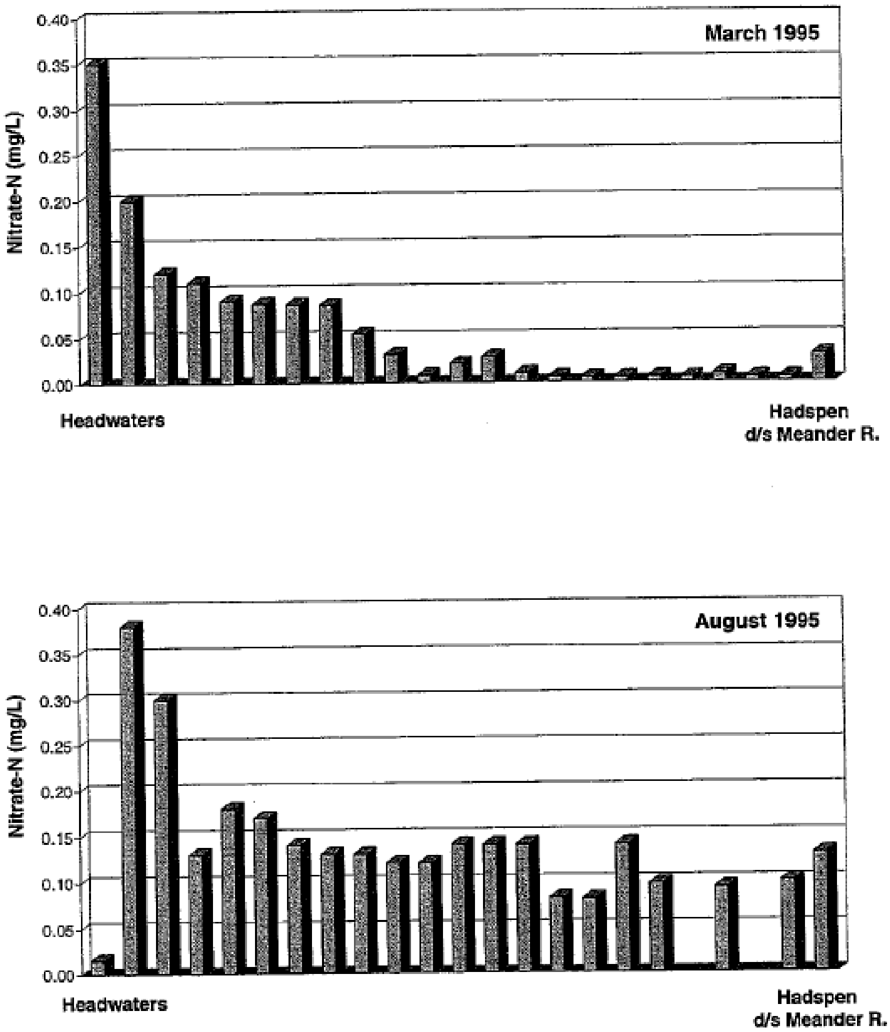


Figure 2.18a & b Longitudinal transects of Nitrate-N concentration at sites in the South Esk River performed in 1995.

Total N

All the sites for which TN could be calculated are shown in the Figure 2.19. It is evident that the influence of TKN (mainly composed of organic nitrogen) on TN concentrations is relatively greater at sites lower in the catchment where nitrate-N levels are low. At sites higher up the South Esk River where TKN concentrations are lower, TN is mainly comprised of nitrate-N. The result is that TN concentrations are reasonably uniform across all sites. The median TN concentration at most sites is between 0.17 - 0.22 mg/L while the sites at Fingal and Break O'Day are slightly higher at 0.298 and 0.329 mg/L respectively.

The guidelines for the protection of aquatic ecosystems in Australia (ANZECC, 1992) is 0.1 to 0.75 mg/L. Sites within the South Esk fall in the lower end of this range.

Total P

The pattern of TP in the South Esk was for lower concentrations in the upper parts of the catchment (Figure 2.20), with the exception of the Break O'Day River, which had the highest median TP concentration of 0.021 mg/L. When examined in terms of the ANZECC (1992) guidelines which set a guideline range of 0.01 to 0.1 mg/L for the protection of aquatic ecosystems, TP throughout the entire catchment can be considered low.

TP changes down the length of the South Esk River during the transects show that during summer TP concentrations above the Junction with Storys Creek are fairly uniform (Figure 2.21a & b). Below Storys Creek a marked dilution occurs. The situation during winter baseflows is for a more gradual increase in TP concentrations towards the catchment outlet. The largest increase in TP is the due to the inflow from the Meander River, which increases TP from 0.012 mg/L to 0.021 mg/L.

2.4.2 Back Creek d/s Longford.

Most of the above sections have not included discussion of the data collected at Back Creek, which is a tributary flowing into the South Esk to the West of Longford. The hydrology and water quality of this tributary is highly impacted by catchment activities in the Longford / Cressy area. This system drains the Cressy/Longford Irrigation Scheme, with flows during the summer maintained for irrigation by diversion of water from the Poatina tailrace high in the catchment. Monthly flow measurements at the bottom of Back Creek, below Longford, clearly show the sustained high flows during spring through autumn of 1995 (Figure 2.22).

Electrical Conductivity

The flow regulation has a dramatic impact on water quality, particularly at the bottom of the catchment. EC was elevated at Back Creek, with levels at the bottom of the catchment showing significant fluctuations resulting from the operation of the irrigation scheme (Figure 2.23). Parts of the Cressy - Lonford area suffer from high salinity, and this is reflected in Back Creek when the irrigation scheme is not operating. Electrical Conductivity during periods of 'natural' baseflow are typically over 700 μScm^{-1} and have been recorded as high as 1090 μScm^{-1}. During the period spring - late summer, when the scheme is diverting Brumby Creek water into the catchment, EC levels fall to below 150 μScm^{-1} due to the large volumes of very low EC water travelling through the system.

Like EC, Turbidity at Back Creek was much higher than found at any other site in the South Esk Catchment, with a median level of 25.7 NTU's. During the irrigation season, turbidity levels were consistently below 30 NTU's while during the off-season, turbidity was much more variable depending on the flow from natural runoff (Figure 2.24). One high flow sample collected during routine monitoring had a turbidity of 171 NTU's.

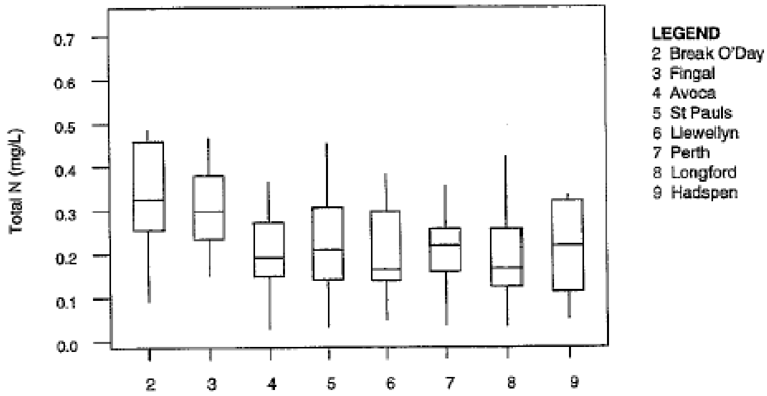


Figure 2.19 Summary statistics of monthly Total-N concentrations at sites in the South Esk catchment.

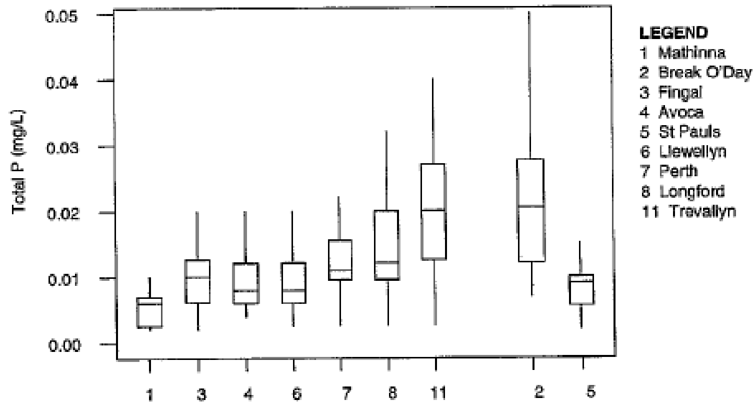


Figure 2.20 Summary statistics of monthly Total P concentrations at sites in the South Esk catchment.

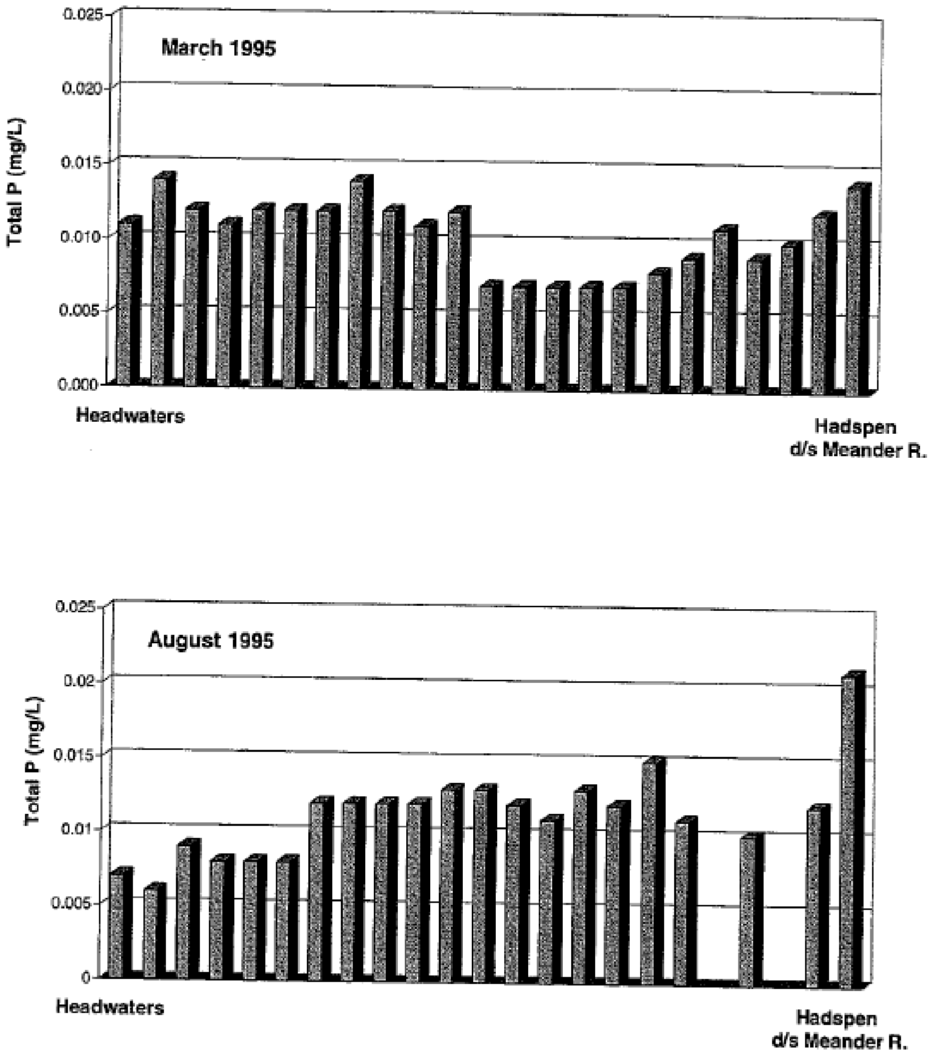


Figure 2.21a & b Longitudinal transects of Total P concentration at sites in the South Esk River performed in 1995.

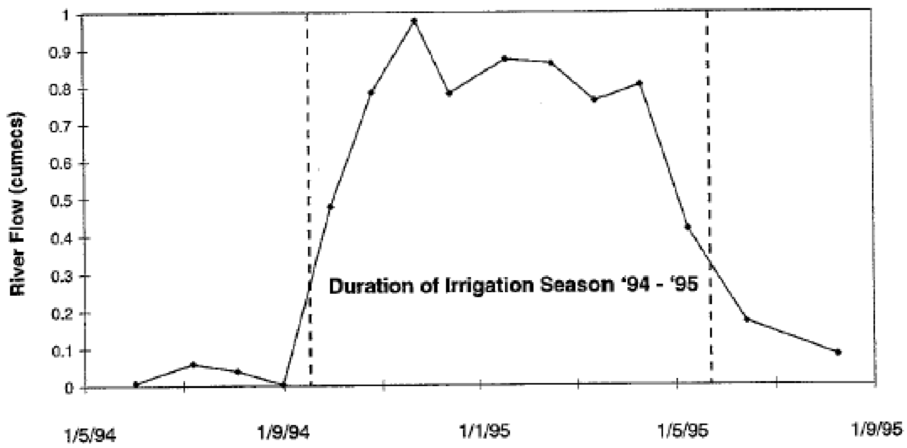


Figure 2.22 Spot measurements of river flow in Back Creek during the 1994 - '94 irrigation season.

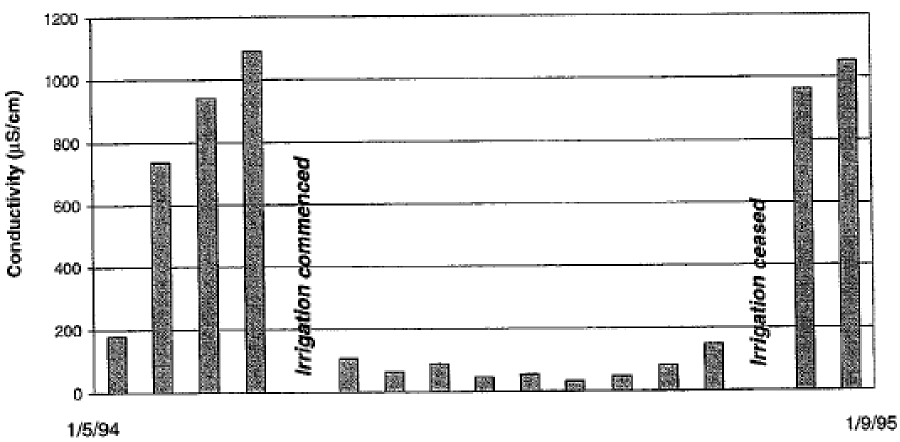


Figure 2.23 Spot measurements of electrical conductivity in Back Creek during the 1994 - '94 irrigation season.

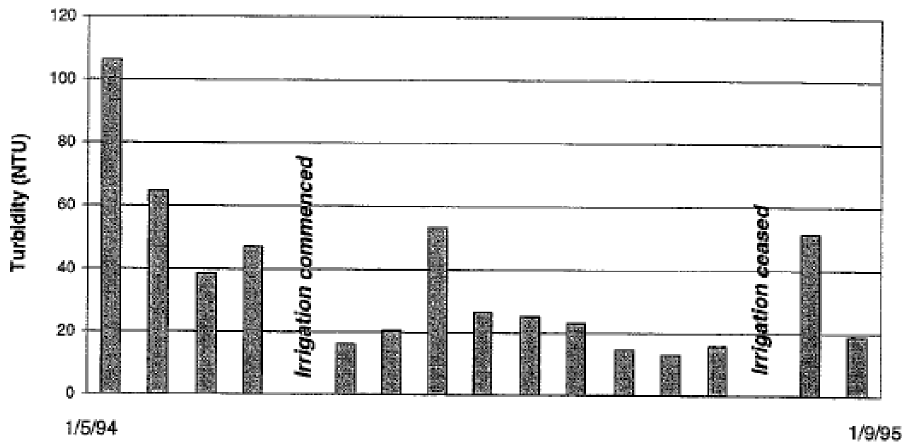


Figure 2.24 Spot measurements of turbidity in Back Creek during the 1994 - '94 irrigation season.

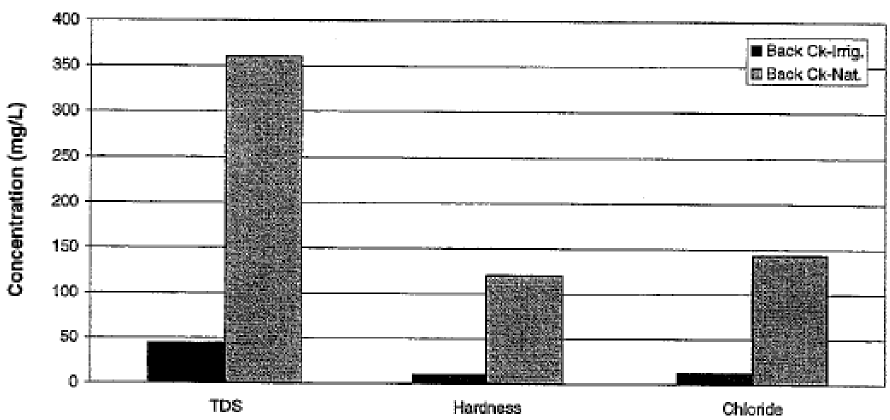


Figure 2.25 A comparison of the average concentration of some ionic parameters in Back Creek during irrigation and natural flows in 1994 - '95.

The ionic chemistry of Back Creek also shows the impact of catchment activities (Figure 2.25). During the irrigation period, the concentrations of all parameters is similar to that of the South Esk River sites. However when irrigation ceases concentrations increase more than ten-fold, illustrating the impact salinization in the catchment has on water quality in the creek. The greatest change occurs in chloride levels which increase from around 13 mg/L during the irrigation season to 145 mg/L during baseflows when the scheme is not operating.

Nutrients

In addition to any nutrient enrichment which may occur through irrigation practices in the catchment, Back Creek is also the receiving water for the sewage treatment plants of Cressy and Longford, the latter of which currently treats waste from the Longford abattoir. The actual concentrations and loads of nutrients measured leaving sewage treatment plants in the South Esk catchment is dealt with in the next section, however it can be stated that the contribution of nutrients to Back Creek from these sources is considerable. At the monitoring site below Longford, nutrient concentrations are influenced to a large degree by effluent from the Longford Treatment plant (which is only 100 m upstream of the site) and whether flows in the creek are sufficient to dilute them. The concentrations of nutrients in Back Creek are therefore closely linked to the flow conditions governed by operation of the irrigation scheme.

The median nitrate-N concentration at the Back Creek site below Longford is 0.17 mg/L, which is comparable to the upper South Esk River sites, however during irrigation, high flows dilute nitrate-N concentrations by a factor of ten. Concentrations of nitrate-N levels during the non-irrigation season ranged between 0.19 to 5.6 mg/L as a direct result of sewage treatment effluent input upstream of the site. During irrigation, flows of about 0.75 cumecs diluted concentrations significantly, with nitrate-N ranging between 0.01 to 0.15 mg/L.

The median Total N at Back Creek was more than 10 times greater than at other South Esk sites, with a maximum recorded Total N concentration of 25.6 mg/L. Significant concentrations of other nitrogen species (nitrite-N and ammonia-N) were also measured at this site, and demonstrate the impact of sewage effluent on this waterway.

TABLE Median Concentrations of Nitrogen species at Back Creek

	Nitrate-N	Ammonia-N	Nitrite-N	Total N
Irrigation ON	0.043	0.49	0.009	1.06
Irrigation OFF	1.02	6.2	0.034	13.18

The TP concentration at Back Creek also shows the influence of sewage effluent, with a median TP concentration of 0.505 mg/L and a maximum of 3.2 mg/L. Changes in concentration tend to be inversely proportional to the flow as was found for conductivity and turbidity, with much lower TP concentrations occurring during the irrigation season.

In addition, a large proportion of TP was found to be comprised of DRP, a form of phosphorus which is readily available to algae. The presence of large concentrations of DRP at this site is most likely to have encouraged the profuse growth of filamentous algae (*Spirogyra* sp.) in the creek below this site. Extensive areas of the creek upstream from Longford were also affected by nuisance growth of filamentous algae, but not to the same extent.

TABLE Back Creek at Longford

	Total P	DRP
Mean	0.505	0.34
Maximum	3.2	2.2
Minimum	0.04	0.01

In summary, water quality in Back Creek was found to be by far the most degraded of any of the tributaries of the South Esk catchment that were monitored during this study. Although further work may be required to pinpoint causes, elevated EC is most likely to be a product of salinity problems which are present in the Cressy/Longford area. While the effluent from sewage treatment plants is likely to be responsible for a proportion of the nutrient enrichment of the creek, the input of nutrients from irrigation practices is unresolved, but may also be large (see catchment loads in next section).

2.4.3 Catchment Budget + Point Inputs

Export loads of phosphorus and nitrogen were calculated for the four stream flow sites in the South Esk Catchment for the period between May 1992 and October 1995. For reasonable estimates of nutrient export loads, samples need to be collected during flood events. Without flood samples, estimates of export loads will be grossly underestimated as nutrient concentrations during high flows can be an order of magnitude higher due to surface runoff. During this study the collection of flood samples was greatly facilitated by the use of automated samplers which collected samples during the rise and fall of the river during events.

In addition to the data for TP and TN collected from monthly monitoring, data from high flow samples was collected by automatic sampling machines and grab sampling by hand. The resulting dataset at most sites was considered more than adequate for estimating TP and TN loads.

Standard regression analysis was used to estimate nutrient loads at the four sites where river flow was monitored. Relationships between P and N concentration and flow were established using either normal or log transformed data, and the resulting relationship(s) was then used to convert the flow record to a concentration time series. After visual inspection to compare modelled concentration with actual measured concentration, hourly loads were then calculated as a function of concentration and mean hourly river flow. Load estimates made in this way are known to have no greater accuracy than about +/- 15% (Yaksich and Verhoff, 1983) and the following figures should be viewed with this in mind. Some of the sources of error associated with this estimation method are related to the accuracy of flow records as well as those associated with sampling (Dolan, et al., 1981). Other errors associated with the regression model will also occur.

In addition to the estimates from the four stream flow sites, the export load for P and N was calculated (using monthly measurements) for Back Creek for the period from;

1/6/94 - 1/6/95

Flow was not recorded on a continuous basis at this site, but was gauged during every sampling visit, thus giving an instantaneous load. Discharge from Back Creek at Longford is highly regulated by the Cressy - Longford Irrigation Scheme, with flows during the irrigation season remaining fairly stable (Refer to previous figure on spot flow measurements in Back Creek). As a result, estimates of nutrient export during this period are considered reasonable. Estimated export loads for the rest of the year are based on monthly visits only and incorporated no flood sampling. The estimates of nutrient export during the period when the irrigation scheme is not operating are therefore considered lower than actually occur, as floods in the creek would have carried additional loads of nutrients.

Flood Concentrations

During flooding in rivers of the South Esk nutrient concentrations increased by up to 15 times. This was especially so for the parameters such as TP and TN which are linked to the resuspension of sediments and overland runoff. The following table shows the maximum concentrations measured for some of the major parameters during flood events.

TABLE Flood concentrations of nutrients

	Maximum (mg/L)
Turbidity	340
Total Suspended Solids	420
Nitrate-N	0.59
Ammonia-N	0.072
Total N	3.68
Dissolved Reactive P	0.034
Total P	0.32

Increases in TP, TN and Total Suspended Solids are very large. The maximum suspended solids concentration of 420 mg/L compares with median values at all sites of below 3 mg/L. Peak concentrations of suspended solids measured during floods (Table below) reveal that the amount of suspended matter mobilized during flooding can be massive. Much of this material is made up of sediment, soil and detritus which has been either picked up from the river bed, eroded from the river banks or brought in through surface runoff from the land. The data in this table was collected during the major floods following the significant drought of 1994-5.

TABLE Peak Suspended Solids Loads measured in the South Esk Catchment

	SS Concentration (mg/L)	**Instantaneous SS Load (kg/min)**	**Equivalent Soil Volume (m^3/min)**
Break O'Day River	420	12,451	10.4
St. Pauls River	350	6,252	5.21
South Esk at Llewellyn	185	6,480	5.4
South Esk at Perth	88	2,067	1.72

Conversion of SS to equivalent Soil Volume assumed a bulk density of 1.2.

Unfortunately, insufficient data was collected to allow the derivation of relationships for the conversion of flow to suspended solids concentration, which would have permitted annual export loads for solid to be calculated. However this data clearly shows that peak instantaneous loads of solids during flood events can be very large, especially when they occur after a period of drought. The corresponding loss of both nutrients and soil during such events is extraordinarily large. As would be expected, loads of suspended solids were greatest at tributary sites where river velocity and hence carrying capacity of the rivers is generally higher.

Using the additional high flow nutrient data, estimates of export loads for P and N from the four stream gauging sites as well as the seven STP's in the South Esk catchment is presented graphically in the following figures. The lowest site in the catchment from which export loads could be calculated was the site on the South Esk at Perth, which encompassed a total catchment area of 3, 280 km^2.

Point Sources

Point source inputs to the South Esk system are minimal with the only major sources being sewage treatment plants. There are six treatment plants in the catchment all of which discharge treated wastewater directly to rivers. During limited sampling of the treatment plants, concentration and flow was measured to give estimates of nutrient loads. A summary of the range of concentrations of the various nutrients in treated effluent is shown in the table below.

	Minimum	Maximum	Mean
Suspended solids (mg/L)	45	110	82.8
Total Phosphorus (mg/L)	6.4	11	8.4
Dissolved Reactive P (mg/L)	3.6	9.5	5.5
Ammonia-N (mg/L)	10	24	16.4
Nitrate-N (mg/L)	< 0.1	0.8	0.36
Total N (mg/L)	4.01	41.11	17.21

It shows that even the minimum concentrations of nutrients in effluent is greater than concentrations measured during floods (see following section) when ambient nutrient concentrations in rivers is highest. While during higher river flows the impact of this concentration of effluent may be minimal due to dilution, during low flows there may be localized nutrient enrichment of the receiving waters, resulting in nuisance algal blooms and prolific growth of aquatic weeds.

The nutrient concentrations measured in sewage treatment plant effluent, combined with the estimated volume of water flowing through the plant each year, give the following annual nutrient loads being discharged from the STP's throughout the catchment.

TABLE Nutrient discharge estimates from Sewage Treatment Plants (STP's) in the catchment based on limited spot readings.

Location	Annual Water Discharge (ML)	Annual P Discharge (kg)	Annual N Discharge (kg)
St Marys	30.2	257	21,833
Fingal	32.6	277	23,743
Evandale	189.2	1,646	15,312
Perth	30.1	329	10,056
Cressy	26.9	193	6,917
Longford	473*	803*	4,745*
Prospect Vale	473	3,026	5,168

The concentrations of nutrients in effluent from the Longford treatment plant could not be measured directly, as this plant discharges below the waterline at Back Creek. However the change in water quality (highlighted below in Figure 2.26) and flows downstream enabled an estimate to be made of loads entering Back Creek from this source.

Phosphorus Export

The total P leaving the catchment at Perth during the 3.4 years of the study was estimated at 72.3 tonnes, averaging approximately 21 tonnes per year. Of this load, 14.3% was estimated to come from the Break O'Day River (7.3% of the catchment above Perth) and 28.5% from

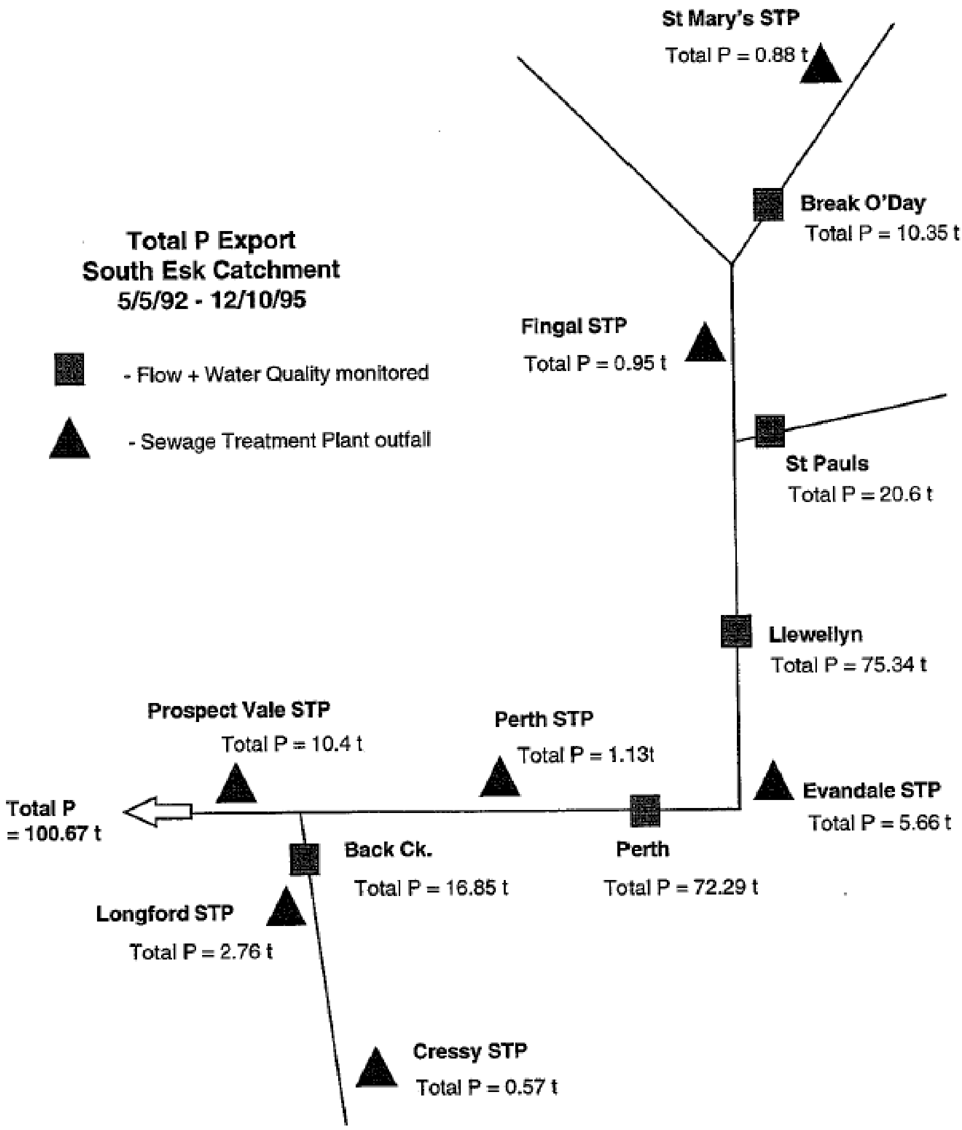


Figure 2.26 Estimated export loads of Total Phosphorus for sites in the South Esk catchment over the entire period of the study.

the St Pauls River (15% of the catchment above Perth). The rest of the load (approximately 57%) is inferred to have come from the other 78% of the catchment.

From Figure 2.26 it also appears that most of the P load enters the river upstream of Llewellyn and that very little P is picked up in the lower catchment. In fact the estimated load at Llwellyn is greater than at Perth, despite the added input of 5.66 tonnes of P from the Evandale STP. The most likely explanation for this decrease is that much of the P passing Llewellyn is deposited in the flood plain between Llewellyn and Perth and that this deposition may be greater than the amount of P input from streams between these two sites.

The total load of P being discharged from STP’s in the upper catchment (St Mary’s and Fingal) is estimated at 1.83 tonnes of P. This compares with 75.34 tonnes of P estimated to have passed through the site at Llewellyn.

A further estimated 28 tonnes of P is calculated to have entered the South Esk river below Perth, with the majority of this load coming from Back Creek (16.85 tonnes P). At Back Creek, the TP discharged from STP’s contributes approximately 20% to the total P load from this tributary, with the combined inputs from Cressy and Longford amounting to about 3.3 tonnes of P. Even taking STP inputs into account, the export load from this area is high relative to loads from the larger catchments of the Break O’Day and St Pauls rivers, reflecting the impact of irrigation on nutrient loads in this system.

The final figure for P export from the South Esk catchment is obtained by summing the estimated load from the Perth STP, Back Creek and the STP at Prospect Vale with the export estimate from the Perth gauging station. The total load of P leaving the South Esk catchment for the three year period of the study is therefore estimated at 100.67 tonnes, or about 30 tonnes per year.

Added to the 147.09 tonnes leaving the Meander catchment and the conservative estimate of 24.48 tonnes from the Macquarie catchment, the total load leaving the South Esk Basin during the period of the study was 272.24 tonnes of phosphorus. (# It must be noted that the estimate for TP export from the Macquarie is very much an underestimate as only the export from the upper 2000 km2 could be calculated due to a lack of streamflow stations in the lower reaches of the river).

To allow comparison of P export between the sub-catchments in the South Esk system, the following table gives the catchment area upstream of each site (in km^2), the volume of water passing each site during the period (in Megalitres) and the estimated total P export for each site.

The final column gives the calculated export coefficient corrected for catchment area. The export coefficient is simply a function of the catchment area and the volume of water discharged during the period. This allows valid comparison of export load, regardless of the size of the catchment and the amount of rainfall it experiences.

No coefficient has been calculated for Back Creek as any figure would be misleading due to irrigation activities which introduce water from outside the catchment (Poatina).

	Area	Period	Discharge	P Export	Coefficient
	km^2		(ML)	(kg)	kg/mm/km^2
Back Creek		1/6/94 - 1/6/95	222	5618	
Break O'Day	240	5/5/92 - 31/12/92	56,639	3,253	0.057
		1/1/93 - 31/12/93	49,734	3,397	0.068
		1/1/94 - 31/12/94	13,990	464	0.033
		1/1/95 -12/10/95	33,921	3,233	**0.095**
Saint Pauls	495	5/5/92 - 31/12/92	118,312	3,171	0.027
		1/1/93 - 31/12/93	87,495	7,441	0.085
		1/1/94 - 31/12/94	26,478	318	0.012
		1/1/95 - 12/10/95	42,595	9,672	**0.227**
Llewellyn	2230	5/5/92 - 31/12/92	661,265	28,997	0.044
		1/1/93 - 31/12/93	411,525	28,418	**0.069**
		1/1/94 - 31/12/94	231,982	3,776	0.016
		1/1/95 - 12/10/95	254,944	14,148	0.055
Perth	3280	5/5/92 - 31/12/92	930,495	31,600	0.034
		1/1/93 - 31/12/93	508,634	28,585	**0.056**
		1/1/94 - 31/12/94	201,226	2,941	0.015
		1/1/95 - 12/10/95	296,416	9,160	0.031

Figures in bold are highest export co-efficient for that site.

In general, the figures show that during dry periods, when discharge is lowest, P export is very low and during wetter periods, when discharge is high, export of P is high. However, the pattern of the flow has a significant impact on the P export coefficients and this was demonstrated in the final 10 months of the study at both the Break O'Day River and St. Pauls River sites. The significant flooding which followed the drought of '94/'95 mobilized large amounts of P relative to the discharge volume, resulting in quite large values for both P export and export coefficients (kg/mm/km^{-2}) in these catchments. The larger volumes of discharge which ocurred during the first seven months of the study were due to higher baseflows but less significant floods, which tend to carry greater loads. Export coefficients for this time are therefore lower than might be expected.

There are few studies elsewhere in Australia which give values for export coefficients, however Cosser (1989) calculated export coefficients for his and other studies against which South Esk values can be compared. During dryer periods in the ACT Cullen et al (1978) found export in the range 0.015 to 0.025 kg P /mm/km^2, with coefficients during floods increasing to about 0.125 - 0.26 kg P /mm/km^2. During his own study in the South Pine catchment, Cosser (1989) found baseflow export coefficients were about 0.025 and annual coefficients were in the range of 0.22 - 0.39 kg P /mm/km^2. Annual export coefficients for P from the South Esk are comparable with those of the South Pine, despite the South Pine catchment having a distinctly tropical climate.

Nitrogen Export

The total N load exported from the South Esk catchment during the study was estimated at 1,480.4 tonnes with annual export averaging 430 tonnes per annum (Figure 2.27). About 33% of this was estimated to be exported from the Break O'Day and St Pauls catchments. Relatively high concentrations of TN measured at Fingal during the flood event of 29/1/95 (

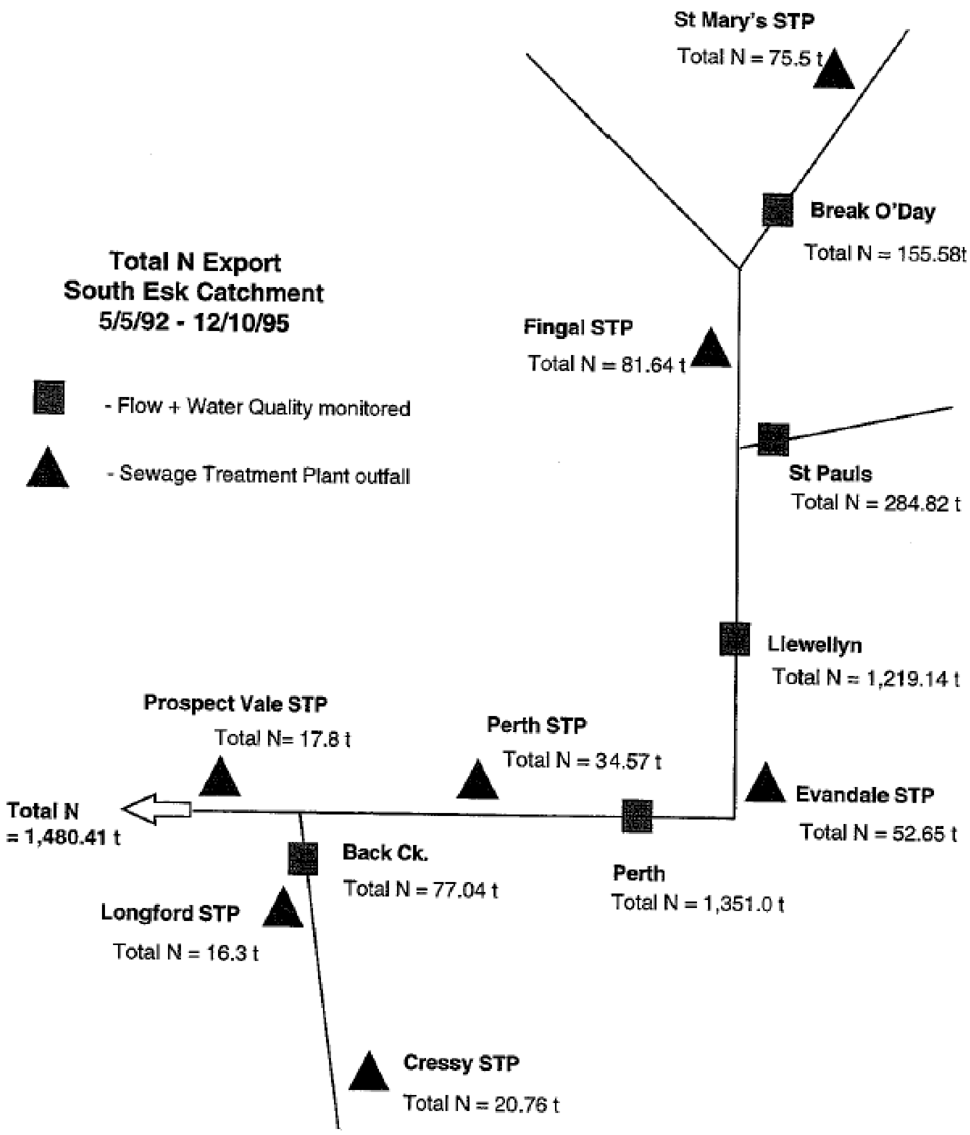


Figure 2.27 Estimated export loads of Total Nitrogen for sites in the South Esk catchment over the entire period of the study.

1.375 mg/L) suggest that a large proportion of the remaining load of TN may originate from the South Esk catchment above Fingal.

Unlike the case for phosphorus, the amount of TN discharged from STP's across the catchment is much more uniform, though the plants at St Mary's and Fingal both still discharge the greatest loads of N. In Back Creek, the relative contribution of N from the STP's is much higher than for P, with an estimated 48% of N from Back Creek estimated to originate from STP's. However, the relative contribution of N by Back Creek to the South Esk load is only 5% (as opposed to 17% of the P load). Across the whole of the South Esk, STP's contribute 20% of the N load leaving the catchment.

The combine total export of nitrogen from the South Esk, Macquarie and Meander catchments is conservatively estimated to be 3,490.62 tonnes for the 3.4 years of the study. This estimate is considered lower than the actual load as only the export from upper 2,000 km^2 of the Macquarie catchment could be calculated.

The following table gives the figures for the estimated export loads for N and the export coefficients for the corresponding periods. Nutrient export for the single year during which Back Creek was monitored is also included.

	Area	**Period**	**Discharge**	**N Export**	**Coefficient**
	(km^2)		(ML)	(kg)	kg/mm/km^2
					(=kg/ML)
Back Creek		1/6/94 - 1/6/95	222	25681	
Break O'Day	240	5/5/92 - 31/12/92	56,639	47,054	0.831
		1/1/93 - 31/12/93	49,734	58,391	1.174
		1/1/94 - 31/12/94	13,990	4,114	0.294
		1/1/95 -12/10/95	33,921	46,016	**1.357**
Saint Pauls	495	5/5/92 - 31/12/92	118,312	55,274	0.467
		1/1/93 - 31/12/93	87,495	93,533	1.069
		1/1/94 - 31/12/94	26,478	7,756	0.293
		1/1/95 - 12/10/95	42,595	128,254	**3.011**
Llewellyn	2230	5/5/92 - 31/12/92	661,265	500,732	0.757
		1/1/93 - 31/12/93	411,525	421,039	**1.023**
		1/1/94 - 31/12/94	231,982	80,949	0.349
		1/1/95 - 12/10/95	254,944	216,417	0.849
Perth	3280	5/5/92 - 31/12/92	930,495	666,101	0.716
		1/1/93 - 31/12/93	508,634	386,692	**0.760**
		1/1/94 - 31/12/94	201,226	127,942	0.636
		1/1/95 - 12/10/95	296,416	170,279	0.574

Figures in bold are highest export co-efficient for that site.

It is apparent from this table that export coefficients for N are much greater than for P, with N export coefficients 9 to 42 times greater than P coefficients. As was found for P, N export was lowest during the drought of '94/'95 when very little runoff occurred and the highest values occurred during wet years. The highest and lowest export coefficients were for the St Pauls River, which indicates that during wet periods nutrient movement is greatest in the St Pauls and that during dry periods nutrient levels in the river are much lower.

Few published data are available on nitrogen export coefficients from elsewhere in Australia, but some data are available from similar sized catchments in Poland (Taylor, et al., 1986). Results from that study show that TN export coefficients can range from 0.25 kg/mm/km^2 in dryer years to 1.18 kg/mm/km^2 in wetter years and will be affected by both the percentage arable land in the catchment and the amount of nutrients introduced in the form of fertilisers. The figures for the South Esk indicate while values are in a similar range, during dry periods such as the drought of '94/'95, N export coefficients in the South Esk are slightly higher than overseas.

2.5 Microbiological data

Although not a specific objective of this study, sampling for bacteria throughout the catchment was carried out once during the period of the study as there was some community concern over the quality of water in rivers of the South Esk with respect to human health. This survey was carried out in November 1994 and included all sites later used in longitudinal transects for metals and nutrients. The survey involved sampling both 'ambient' water (that is natural flowing water) and 'sediment disturbed' water (that is water containing sediment which has been resuspended from the riverbed). This method has been employed in other studies to assess the 'potential' population of bacteria living in the sediment and capable of contaminating the water column during high flow events. The amount of bacteria in the sediment disturbed water also gives an indication of the general level of contamination occurring in the area in the longer term.

It should be noted that while this technique gives some insight into the pattern of bacterial degradation of streams in the catchment, results will be influenced to some degree by the amount and nature of the sediment being resuspended and as such is not a rigorous technique.

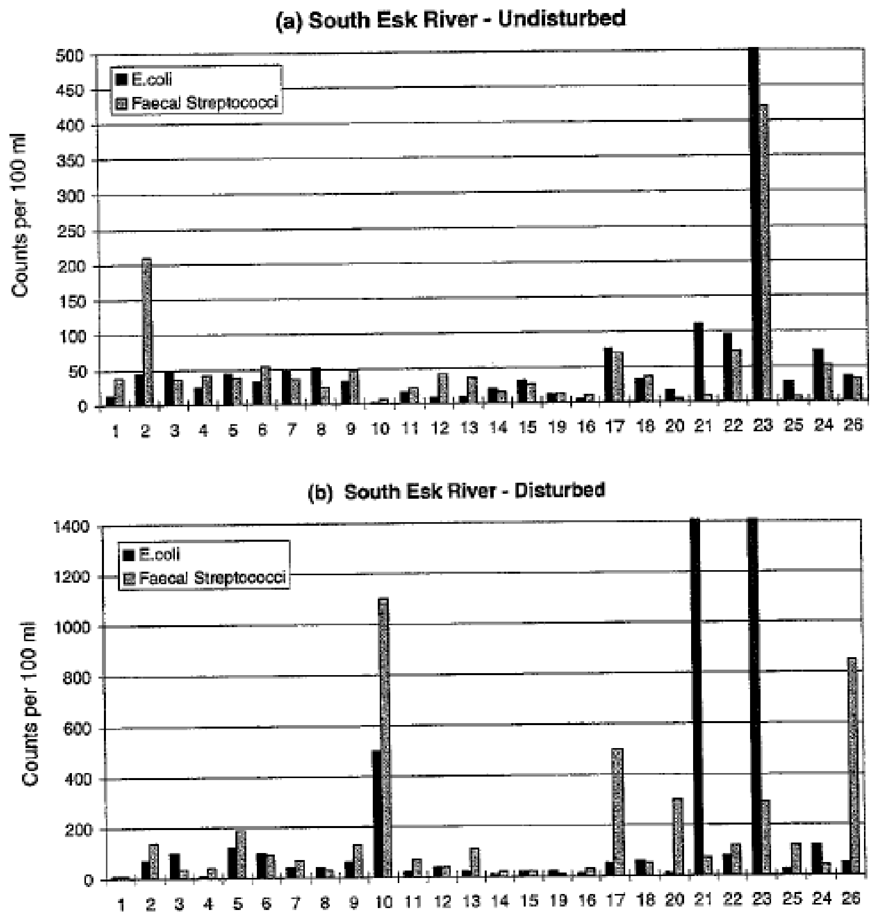
The results of the survey (Figure 2.28a & b) show that bacterial contamination of undisturbed water in the South Esk River is generally below ANZECC (1992) guidelines for primary contact (swimming and bathing) down most of its length, although levels do tend to rise in the lower sections of the river. The potential for contamination through disturbance of the river bed is greater in the bottom of the catchment, especially at sites downstream of Perth where microbial indicators in resuspended sediments was elevated. The results indicate that the river in this area may not always be suitable for primary contact (ANZECC, 1992) although it must be stressed that this is based on a single sample and that further monitoring is required to clarify this.

Sampling in the Break O'Day, the Saint Pauls and the Nile rivers show that the lower Break O'Day appears to be most degraded and has the highest potential of all sites for contamination from stream sediments (Figure 2.29a & b).

2.6 Heavy Metals and Pesticides

A snapshot survey of the South Esk Catchment was carried out for selected heavy metals in March 1995 during low flows. The selected metals included Cadmium, Copper, Lead, Zinc and Arsenic. No significant levels of Cadmium, Lead and Arsenic were detected. Low levels of Copper (< 4 micrograms/L) were detected in the South Esk River downstream of the Story's Creek junction. Zinc was also detected in the South Esk downstream of Story's Creek (Figure 2.30).

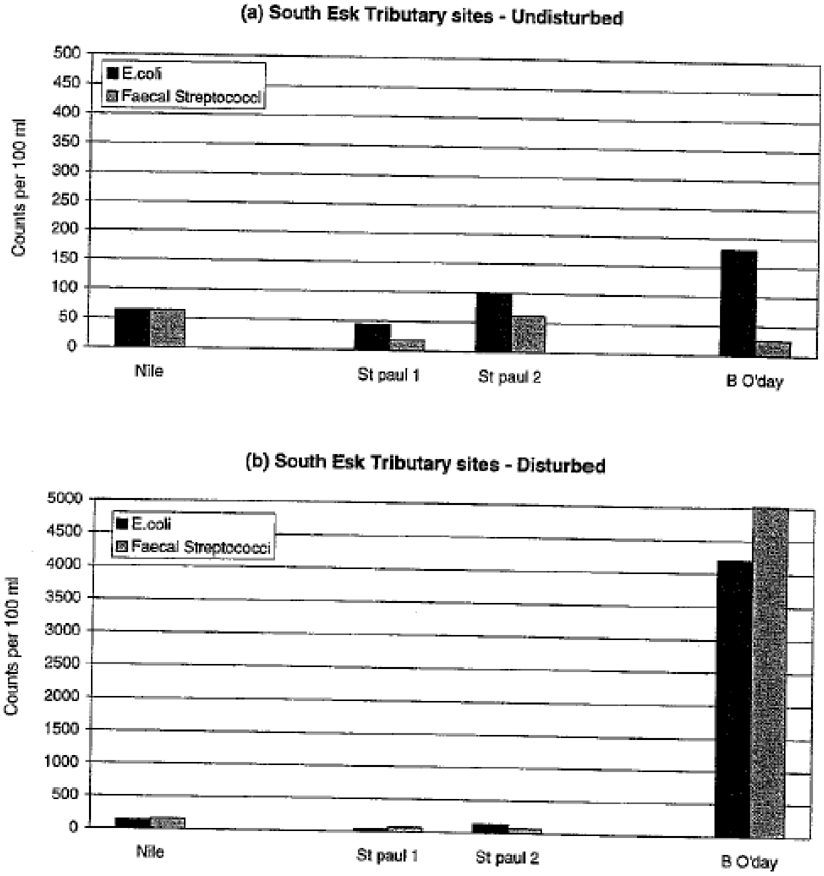
This level of copper falls into the range at which aquatic biota may be affected, while the zinc concentrations detected directly below Story's Creek are above the 5 - 50 micrograms/L



LEGEND

1 Upper Esk
2 Conroys Gap
3 Sandhurst Br
4 Mathinna
5 Evercreech
6 Giles Marsh
7 Malahide
8 Fingal
9 Tasrail Depot (Fingal)
10 Vinegar Hill
11 Heffords Br
12 u/s Storys Ck
13 Leona Br
14 Avoca
15 Hanleth
16 Llewellyn
17 Glen Esk Br
18 Clarendon
19 Evandale Res.
20 Perth WS
21 Perth Br
22 Longford
23 Pateena Br
24 Hadspen WS
25 Hadspen Picnic area
26 Hadspen d/s Meander

Figure 2.28 Longitudinal transect of the South Esk River, sampling udisturbed flowing water (a) and sediment disturbed water (b) for faecal coliforms and faecal streptococci. Survey carried out in late November, 1994.



LEGEND
Nile - Nile River at Nile
St Paul 1 - St Pauls River at Royal George
St Paul 2 - St Pauls River at Avoca
B O'day - Break O'Day at Killymoon Br.

Figure 2.29 Longitudinal transects of tributaries of the South Esk, sampling udisturbed flowing water (a) and sediment disturbed water (b) for faecal coliforms and faecal streptococci. Survey carried out in late November, 1994.

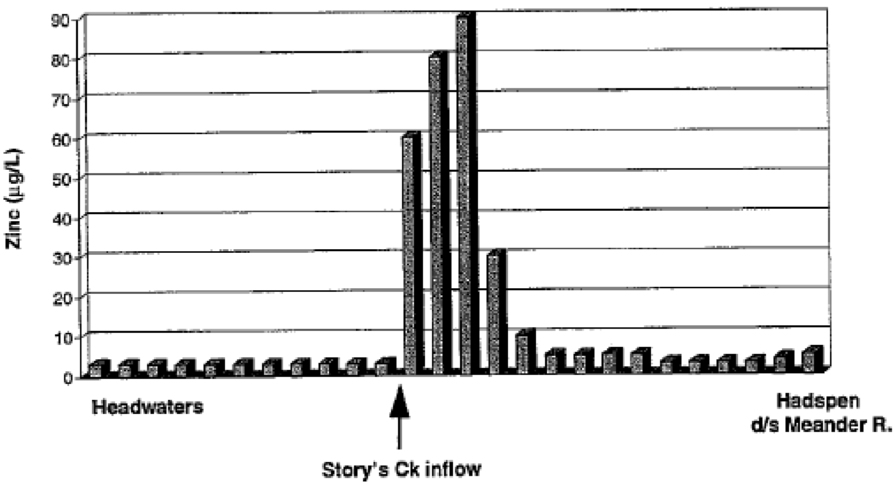


Figure 2.30 Zinc concentration in the South Esk River During low flows of March, 1995

range recommended for the protection of aquatic ecosystems (ANZECC, 1992). The results indicate that while dissolved zinc and copper concentrations are still detectable under low flows, other metals may only be detectable during higher flows attached to sedimentary material as was found in earlier studies (Norris, et al., 1981). This data is not sufficient to indicate whether heavy metal pollution from the Aberfoyle/Storys creek system is decreasing or not.

2.7 Special Studies

No special studies were carried out in the South Esk catchment during the period of this study.

2.8 Incidents

During the period of this study, the only notable incident occurring in the South Esk catchment was the accidental release of arsenic laden water from a mine near Mathinna into the South Esk River in December, 1994. Arsenic levels were reported as exceeding national guidelines for drinking water of 0.007 mg/L (NHMRC & ARMCANZ, 1994) and resulted in fish deaths and a public warning not to drink water from the South Esk River upstream of Avoca. Arsenic is known to be toxic to freshwater biota in concentrations as low as 850 micrograms/L and a recommended limit of 50 micrograms/L is recommended for the protection of aquatic life (ANZECC, 1992).

No other significant incidents relating to rivers in the South Esk were reported.

3.0 River Ecology

3.1 Macroinvertebrates

Prior to 1994 only two significant studies had been carried out in the South Esk basin, Thorp and Lake in 1973, and Norris, Lake and Swain in 1982. Both parties investigated the effects of mine effluents on the macroinvertebrate communties of the South Esk River. They found greatly reduced numbers of both individuals and taxa below the confluence of Storys Creek. The effect was reported as far downstream as Clarendon near Evandale, some 80 km downstream from the source of the metals. A number of macroinvertebrate Families, such as Hydrobiidae, Corixidae, Phreatoicodae and Calamoceratidae, found in the South Esk River upstream from Storys Creek, were absent downstream of the confluence. The factors reported to be of importance in determining the harmful effects of the contamination were trace metals, flow rate and stability of the substrata (Norris *et al.* 1982). Both reports showed that the lower South Esk was significantly impacted by the discharge of effluent into Storys Creek.

In 1984 a reconnaissance survey of the river was conducted by a team of consultants on behalf of the Hydro-Electric Commission to assess the aquatic biological conditions of the catchment. Like Thorp and Lake (1973) and Norris, Lake and Swain (1982) they found that the metal contamination from Storys creek had had a severe impact on the macroinvertebrate commmunities of the South Esk River. They found a ‘healthy fauna’ just upstream from the confluence and in several tributaries, including the St. Pauls River downstream from Royal George, Break O’Day River and Ben Lomond Creek. Buffalo Brook however, was suspected to be contaminated by metals from mining and they suggested that this creek could be contributing to the contamination of the South Esk River. The macroinvertebrate community they sampled from this creek had an extremely low diversity and abundance.

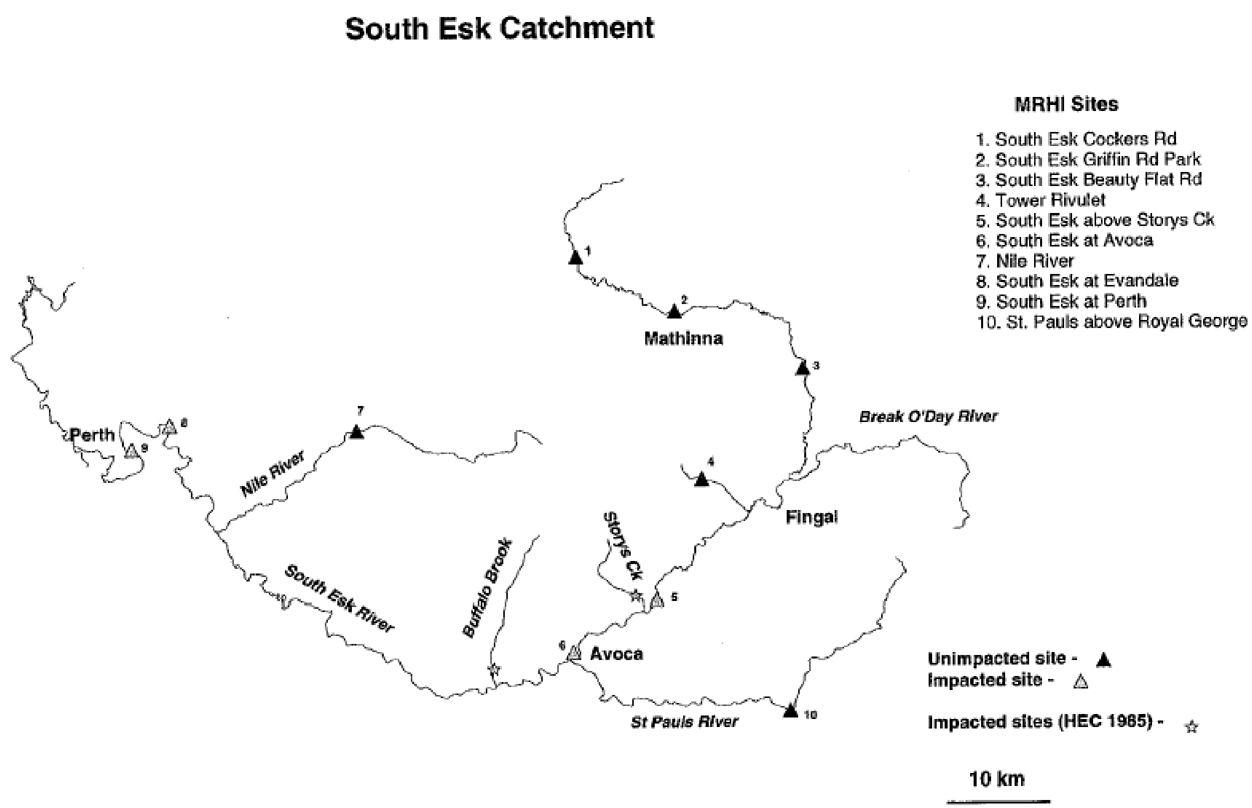


Figure 3.1 Sites in the South Esk catchment where macroinvertebrate communities were sampled during 1994 - 95. Also shown are sites where an HEC survey in 1985 concluded sites were degraded.

In spring 1994 and autumn 1995, 10 sites in the catchment were sampled through a program called the Monitoring Riverine Health Initiative (MRHI). The main objectives and sampling protocol for this iniative are outlined in the National River Health Bioassessment Manual (CEPA, 1994). Seven of the sites were on the South Esk River, three downstream from Storys Creek and four upstream as far up as Cockers Rd (Figure 3.1), and one each on Tower Rivulet, Nile River and St. Pauls River. Currently the coverage within the basin is poor, particularly in the tributaries, however it will be greatly improved with the inclusion of 8 extra sites sampled during autumn 1996 through the Regional Forestry Agreement (RFA), an agreement between the Commonwealth and State Governments concerning forest use and managment. As yet the data from this program is unavailable.

RATING THE HEALTH OF RIVERS USING MACROINVERTEBRATES

Three techniques were used in this report to assess the health of the river sites, a biotic index called the SIGNAL index (Chessman, 1995), multivariate analysis techniques, and a riverine bioassessment model produced from MRHI. The standard sampling protocol employed by both the MRHI and Sth Esk Catchment Managment program allows an objective evaluation of the environmental quality of streams and rivers based on macroinvertebrates. Numerous problems arise when attempting to evaluate the environmental status of streams using data collected and analysed in a variety of ways.

- The SIGNAL index was developed using a rapid assessment type sampling procedure similar to the one used in the MRHI and the South Esk Catchment Management project. A large number of macroinvertebrate Families have been awarded sensitivity grades according to their tolerance or intolerence to common types of pollutants. The index is calculated by averaging these grades (between 1and 10) for each site. The status of the sampling site is then classified according to the SIGNAL values as follows:

  > 6 - 'clean water'
  5 - 6 - 'doubtful quality, possible mild impact'
  4 - 5 - 'probable moderate impact'
  < 4 - 'probable severe impact'

It has been successfully used to assess the condition of rivers in NSW and was found to be mostly independant of altitude and size of river (Growns *et al.* 1995).

- Multivariate analysis techniques have been successfully used in conjuction with biotic indices such as the Signal index to help identify impacted rivers (Growns *et al.* 1995). Two techniques were used in this report, hierarchical clustering and a multidimensional scaling ordination technique. The clustering procedure groups sites together based on their macroinvertebrate assemblages and allows sites with unusual faunal communities to be identified. The ordination technique was used to identify general spatial trends in the macroinvertebrate assemblages throughout the catchment and inconjunction with principal axis correlation to determine whether any physico-chemical parameters are correlated with any trends.

- The riverine bioassessment model produced from the MRHI allows rapid, non specialist sampling techniques to be used for the evaluation of the health of a river or stream. These techniques are outlined in the National River Bioassessment Manual (CEPA, 1994). The bioassessment model essentially compares the taxonomic composition of the macroinvertebrate community sampled at a site with the composition expected if the site were unimpacted (or relatively so). The status of the site is then classified using this Observed/Expected ratio. The model used in this report has been derived from the combined Spring 1994 and Autumn 1995 datasets and the sites are classified as follows:

Observed/expected > 0.82 - 'Clean water'
0.82 - 0.65 - 'Probable impact'
0.64 - 0.47 - 'Impacted'
< 0.47 - 'Severely Impacted'

This approach allows both the presence and magnitude of an impact at a river site to be determined.

As a cautionary note each technique should be used as a guide only, and ultimately in combination with land use information and the original macroinvertebrate data. The classification as to whether a site is impacted or not is based on all the information available.

3.2 Macroinvertebrate Communities

During the MRHI all macroinvertebrates were identified to Family level. A total of 40 Families were sampled and identified from the South Esk Catchment representing all the major taxonomic groups typical of freshwater streams. Insects were the most dominant, representing around 82% of the total number of taxa collected and accounting for 96% of the total number of individuals collected.

South Esk River

The upper reaches of the South Esk are in good health. The two upstream sites, Cokers Rd. and Griffin Park, have a number of macroinvertebrate Families indicative of clean waters such as Eusthenidae, Blepharceridae, Philorithridae, Helicopsychidae and Austroperlidae. The riverine environment in the upper catchment is in good condition with extensive areas of natural riparian vegetation, a diverse natural substrate and no identified water quality problems.

There is a reduction in the number of taxa 17 kms downstream from Griffin Park at Beauty Flat Rd. (Figure 3.1), with the notable absence of the above macroinvertebrate Families. At this site a number of changes in the riverine habitat were observed, such as the presence of willows and gorse and the clearing of riparian vegetation to the waters edge. The main factor responsible for the reduced condition of the macroinvertebrate community at this site is not clear, however general activities involved with agricultural practices, such as land clearing to the rivers edge which promotes bank erosion and algal blooms and reduces the food source for certain macroinvertebrate species would certainly contribute to the problem. The macroinvertebrate community in this section of the South Esk river, while not considerably degraded, is one of concern as it is the first indication that the environment is stressed.

TABLE Statistics for each site, inculding the Signal Index and MRHI O/E score.

Site	Signal Index	MRHI O/E	No. of individuals sampled	No. of invertebrate Famlies sampled
Sth Esk at Cokers Rd.	7.2	1.09	335	23
Sth Esk at Griffin Park	6.95	0.97	408	23
Sth Esk at Beauty Flat Rd.	6.4	0.74	298	16
Sth Esk above Storys Ck.	**5.15**	**-**	**352**	**12**
Sth Esk at Avoca *	**5.0**	**0.42**	**422**	**10**
Sth Esk at Evandale	**5.8**	**0.68**	**425**	**18**
Sth Esk at Perth	**5.6**	**0.59**	**296**	**15**
Tower Rivulet	6.9	1.03	296	21
Nile at Lilyburn Rd.	6.7	1.06	415	27
St. Pauls	6.45	1.02	439	25

Sites in bold are impacted. Symbol * denotes severely impacted sites

The macroinvertebrate community 38 km downstream from Beauty Flat Rd. is clearly stressed. At this site, just above Storys Creek, as few as 8 taxa were sampled in Autumn and 12 in Spring. Four Families, Leptoceridae, Hydrobiosidae, Baetidae and Leptophlebiidae, found in relatively large abundances at upstream sites and elsewhere within the catchment, were noteably absent. Extensive areas of land upstream have been cleared for pasture, usually to the rivers edge, and riparian vegetation where it occurs consists mostly of introduced species such as cracked willow and gorse. The riverine habitat is degraded and river bank erosion is extensive in places. The marked change in the faunal composition at this site may well be linked to the condition of the riverine habitat in the surrounding area, however it is difficult to determine exactly which factor(s) are responsible.

A further degradation of the macroinvertebrate community occurs at Avoca, downstream from Storys Creek. This site was the only one sampled that was considered to be severely impacted. As few as 6 Families were sampled in Autumn 1995 and 10 in Spring 1994. The influence of Storys Creek on the macroinvertebrate fauna has been well documented in the past (Thorp and Lake 1973; Norris *et al.* 1982; and HEC, 1985) with the elimination of a large number of species below the confluence. There is certainly evidence to suggest that the effluent from Storys Creek still exerts a pressure on the system today. During both spring and autumn, no Ephemeropterans (mayflies) were found and only two Families of Trichoptera (caddisflies) and one Family of Plecoptera (stoneflies) were collected. These three groups usually account for over 60% of the taxa at any one site. Levels of Cu and Zn in the water are still considerably higher than the background levels measured elsewhere in the catchment suggesting continued leaching from the mines.

Sightly higher numbers of taxa were sampled at Evandale and Perth, however both sites still have degraded macroinvertebrate communities. Norris, Lake and Swain (1982), Thorp and Lake (1973) and the survey commissioned for the HEC (1985) all identified the reaches near Evandale as impacted. They all noted however, some recovery of the macroinvertebrate fauna along this section of the river with the presence of a number of species absent from the sites closer to Storys Creek. This recovery was also noted through the MRHI with a number of Families absent from the site at Avoca but present at both Evandale and Perth. These Families include Baetidae, Ceinidae, Leptoceridae, Leptophlebiidae, Hydrobiidae and the Chironomidae Sub-Family Chironominae. All of these Families were found in the upper catchment. It is difficult to determine the exact cause of the impact along this section of the catchment as there are obvious impacts above Storys creek and below the confluence the mine effulent enters the river.

Tributaries

The coverage of tributaries sampled through the MRHI is limited. Only three were sampled; the Nile River, Tower Rivulet and the St. Pauls River and only one site was located on each. All sites are upper catchment sites and generally have healthly macroinvertebrate communities as indicated by both the Signal Index and the MRHI O/E score. Certainly lower catchment sites for the Nile and St. Pauls rivers are required to properly assess the health of these tributaries. This coverage will improve with the inclusion of the 8 FRA sites.

The study commisioned by the Hydro-Electric-Commission in 1984 sampled five tributaries; the St Pauls River, Ben Lomond Rivulet, Break O'Day River, Storys Creek and Buffalo Brook. All the sites were located in the lower section of their catchments near the confluence with the South Esk River. The report details qualitative results only. They describe all the sites except Storys Creek and Buffalo Brook as 'healthy'. Storys Creek about 1 km above the confluence with the South Esk was characterised by a complete lack of fauna. They reported a thick layer of aqua coloured gelatinous sediment covering the cobble substrate. At Buffalo

Brook only four species of macroinvertebrates were sampled, a Leptoceridae, an Elmidae, and two species of Chironomidae. The headwaters of this stream arise in the Ben Lomond Marshes adjacent to Rossarden and Storys Creek and it appears likely that it may have been contaminated by heavy metals from mining. This creek has not been sampled since 1984 and the health of it still remains questionable.

Community Structure

The Brey-Curtis index was used to measure the similarity between sites based on their macroinvertebrate assemblages. In all cases combined data from spring 1994 and autumn 1995 was used. The classification program UPGMA in PATN (Belbin 1994) was used to group the sites based on the Brey-Curtis measure. UPGMA is a form of cluster analysis which allows the identification of clusters or groups of sites and provides direct evidence for variation in the macroinvertebrate communties bewteen sites.

Two main groups were identified and are shown in the table below. Their position within the catchment is also shown in Figure 3.1.

TABLE Membership of each UPGMA Group.

Group 1	Group 2
Sth Esk Cokers Rd.	Sth Esk Above Storys
Sth Esk Griffin Park	Sth Esk Evandale
Sth Esk Beauty Flat Rd.	Sth Esk Perth
Tower Rivulet	
St. Pauls River	
Nile River	

Group 1 represents predominantly ‘clean water’ upper catchment sites. All the sites in this group have Signal values between 6.4 and 7.2 and MRHI scores above 0.74. The macroinvertebrate Families Calocidae, Eusthenidae, Glossosomatidae, Scirtidae and Philorheithridae characterise this group and were sampled from over 80% of the sites. Austropleridae, Blephariceridae, Polycentropodidae, Helicopsychidae and Helicophidae were also sampled from sites in this group. Many of the Families mentioned above have very high pollution sensitivity grades (Chessman, 1995) and are indicative of clean waters.

Group 2 represents impacted sites in the lower catchment. The clear separation of this group from Group 1 can be attributed to the absence of a number of key macroinvertebrate Families, including all the Famlies mentioned above that characterise Group 1. All the sites in this group have a Signal index and MRHI score that indicate an impact. In the late seventies Norris, Lake and Swain (1982) sampled the site just above Storys Creek, and in combination with two other sites upstream the macroinvertebrate fauna was found to be significantly different to that sampled below the confluence. The site just above the confluence is now regarded as impacted, as evident from the macroinvertebrate community sampled there which is more closely associated with the communities downstream of the confluence than the communities above it.

The site at Avoca was considered an outlier and did not group with either group one or two. This site was considered to be the most impacted on the South Esk River with the absence of many Families found elsewhere within the catchment.

SUMMARY

In the late1970’s and early 1980’s the major impact in the South Esk basin was the heavy metal contamination from Storys Creek (Thorp and Lake, 1973; Norris *et al.* 1982; and HEC, 1985). All the sites downstream from the confluence had severely degraded macroinvertebrate communities characterised by reduced numbers of individuals and the elimination of a number of taxa sensitive to heavy metal pollution. As well as the direct effects of heavy metal contamination, the instability of the substrate causing the elimination of algal and aquatic macrophyte growth was also suggested as a major cause of the reduction in macroinvertebrate abundance (Thorp and Lake, 1973). Increased grinding and scouring of the bed can cause injury and mortality.

The samples collected during 1994/1995 through the MHRI program identified all the sites below Storys Creek to be impacted. A slight recovery of the fauna was observed at Evandale and Perth. The impact that Storys Creek now has on the macroinvertebrate community in the South Esk is not as clear cut as stated in past reports (Thorp and Lake, 1973; Norris *et al.* 1982; and HEC, 1985), as the macroinvertebrate community from the site immediately upstream from the confluence is now impacted and exhibits many of the characteristics typical of the contaminated sites. This site is situated about 1 km upstream and is not influenced by heavy metal pollution, indeed the levels of Cu, Zn and Pb in the water are the same as the backgroud levels found elsewhere within the catchment. It is the first time that a site upstream from Storys Creek has been recognised as impacted. The cause of it may be related to habitat degradation as no water quality problems (see chapter on water quality) were apparent in this part of the catchment. Forestry is also active in the upper catchment, however the site immediately downstream from all the coups and plantations (Beauty Flat Rd.) is relatively unimpacted, which most likey dispels forestry as a possible cause. Certainly more work is required in this area of the catchment the extent of impacted reaches and the most probable cause.

Downstream from the confluence with Storys Creek the levels of Cu and Zn in the water were noticably higher than the background levels. These samples were taken during the 1994/1995 MRHI sampling program and suggests continue leaching of heavy metals.

Endangered or Threatened Aquatic Macroinvertebrates

Four species of aquatic macroinvertebrates from the South Esk Catchment are known to be endangered or threatened. All have been listed in the ‘Interim list of native invertebrates which are rare or threatened in Tasmania’ (1994). It is considered to be an interim list because of the incomplete knowledge of the taxonomic classification and inventory of Tasmania’s macroinvertebrates.

Two species of Hydrobiidae snail were listed, *Beddomeia krybetes* and *Beddomeia lodderae*. *B. Krybetes* is considered to be vulnerable and has a very restricted distribution. It is only found under stable rocks in strong flows in the St. Pauls River east of Royal George. The main threats to this species are stream habitat alteration and water quality deterioration. *B. Lodderae* is considered to be rare and also has a very restricted distribution, only found under rocks in Cataract Gorge in the South Esk. The main threats are once again stream habitat alteration and water quality deterioration.

Two species of Trichoptera (caddisfly) are listed, *Hydroptila scamandra* and *Leptocerus souta*. Both are found near Evandale in the South Esk River and are considered to be rare, with the main threat agricultural activities that affect the water quality.

3.3 Fish

The majority of studies on fish in the basin have been concerned with the effect of the Storys Creek mine effluent on their distribution and health. In the early 1970’s electro-fishing surveys showed that brown trout were absent from the South Esk from the point of entry of

Storys Creek to as far downstream as Evandale (Tyler and Buckney, 1973). They were common in the South Esk both above and below the polluted reaches. The concentrations of zinc and cadmium in the South Esk were considered to be low and perhaps below the incipient lethal level for brown trout, however they greatly exceeded the levels known to deter salmonids (Tyler and Buckney, 1973). By 1976 brown trout had been recorded at Glen Esk, approximately 38 km upstream from Evandale (Norris and Lake, 1984). They were still absent however between Storys Creek and Avoca, indeed no fish species at all were recorded at Avoca.

Norris and Lake (1984) found that the mine effluent affected the distribution of all the species they sampled in the South Esk (Brown trout, Redfin perch, Tench, Short finned eel and Pigmy perch). Pigmy perch (*Nannoperca australis*) appeared to be the most sensitive and was restricted to sites upstream of Storys Creek and sites downstream of Evandale. No comprehensive study of fish in the South Esk has been conducted since Norris and Lake (1984), so the effects of the 1986 dam breaches and continued leaching are undetermined.

Other fish known to occur in the South Esk basin include the Swan Galaxias, *Galaxis fontanus*. This endemic species mostly inhabits the headwaters of a few streams in the eastern highlands, however in 1995 a popultaion was relocated to the upper catchment of the St. Pauls river as one part of a recovery plan established by the Inland Fisheries Commision (Sanger, 1993). The Swan Galaxias is listed as 'endangered' by the Australian Society for Fish Biology (Jackson 1992). The distribution of the species is presently confined to a few small populations, several natural populations of which are known to be in decline (Sanger, 1993). The major threat to the species is introduced fish, inparticular trout.

For a general distribution of freshwater fish throughout Tasmania see 'Tasmanian Freshwater Fishes' (Fulton 1990).