TABLE Nutrient concentrations measured during flood events.

	Minimum (Small Events) mg/L	**Maximum** (Large Events) mg/L
Turbidity	20	>1000
Total Suspended Solids	18	1200
Nitrate-N	0.13	1.1
Ammonia-N	0.009	0.95
Total N	0.51	7.44
Dissolved Reactive P	0.007	0.075
Total P	0.058	1.9

When compared to the flood data collected in other parts of the South Esk Basin during this study, these are the highest measured. Several factors contribute to these higher flood concentrations of nutrients not least of which is the fact that there is a greater level of intensive agriculture in the Meander than is present in either the South Esk or Macquarie catchments.

Peak concentrations of suspended solids measured during floods in rivers of the Meander catchment (Table below) reveal that the amount of suspended matter mobilised during flooding can be substantial. This material is mostly made up of organic matter, stream sediment and soil either remobilised from the stream bed or entering the stream through surface runoff or streambank erosion. The values shown tend to reflect areas where active erosion is occurring upstream, although the peak loads given here also depend on the size of the flood measured at each particular site.

TABLE Peak concentrations, calculated loads of SS and corresponding soil volumes measured at various sites during flood events. (Bulk density factor used for conversion to soil volumes was 1.2).

	SS Concentration (mg/L)	**Instantaneous SS Load** (kg/min)	**Equivalent Soil Volume** (m^3/Hr)
Western Creek	640	1048	52.2
Jackey’s Creek	34	7.74	0.36
Meander at Deloraine	110	674	33.6
Meander at Strath Bridge	47	429	21.6
Liffey at Carrick	230	356	18
Quamby at Upper Site	140	91.5	4.8
Quamby at Westbury	50	34.8	1.8

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 solids to be calculated. Although much lower than the peak loads measured during larger floods in the South Esk catchment, these loads are from frequently occurring floods and give some indication of the level of transport of sediment occurring during regular high flow events in rivers in the Meander catchment.

Point Sources

To obtain an estimate of the nutrient load from sewage treatment plants, some spot samples were collected from the three treatment plants in the catchment. A summary of the range of concentrations of nutrients being discharged to the river system is presented below. Concentrations of most parameters are well above what are found in rivers, even during flood flows. While during high river flows the impact of this concentration of effluent may be minimal due to dilution, during low summer flows there may be localised nutrient enrichment of the receiving waters.

TABLE Nutrient concentration measured from sewage treatment plant effluent

	Minimum	**Maximum**
Suspended solids (mg/L)	35	56
Total Phosphorus (mg/L)	4.7	9.7
Dissolved Reactive P (mg/L)	2.4	5.4
Ammonia-N (mg/L)	7.5	23
Nitrate-N (mg/L)	< 0.1	5.1
Total N (mg/L)	2.91	10.84

These nutrient concentrations, 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 based on limited spot readings

Location	**Annual Water Discharge** (ML)	**Annual P Discharge** (kg)	**Annual N Discharge** (kg)
Deloraine	283.8	1,705	6,683
Westbury	111.3	522	4,435
Carrick	252.3	2,446	10,238

Phosphorus Export

Using the additional data collected during river flooding to estimate export loads for P from the stream gauging sites and the estimated discharge from the three STP's in the Meander Catchment, the total P export for the entire period of the study is presented graphically in Figure 2.26. The lowest site in the catchment from which export loads could be calculated was the site on the Meander at Strath Bridge, which covers a total catchment area of 1012 Km^2. To arrive at a total export figure for P export from the Meander Catchment, the export load from the Liffey River (224 Km^2) and the discharge load of the Carrick Sewage Treatment plant must be added to the estimated load from the Strath Bridge site.

The total estimated export load of P from the Meander River system for the period 5/5/1992 to 10/10/1995 was 147.1 tonnes. This is roughly equivalent to an average 49 tonnes per year leaving the catchment. Approximately 11% of this P load is estimated to originate from sewage treatment plants in the catchment.

The 147.1 tonnes of TP leaving the Meander catchment combines with the 100.7 tonnes leaving the South Esk and the estimated minimum of 24.5 tonnes from the Macquarie over the same period, to give a total phosphorus load leaving the South Esk Basin of at least 272.2 tonnes during the period of the project. (# 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 km^2 could be calculated due to a lack of streamflow stations in the lower reaches of the river).

The P load for the period 1/8/94 to 8/7/95 was also calculated to allow the measured load from Western Creek and Lower Quamby Brook to be included in total catchment export calculations (Figure 2.27). This figure shows the estimated load from Western Creek was about 3.08 tonnes which is about 55% of the load passing through Deloraine while only 31% of catchment area upstream of Deloraine is made up by Western Creek. In comparison,

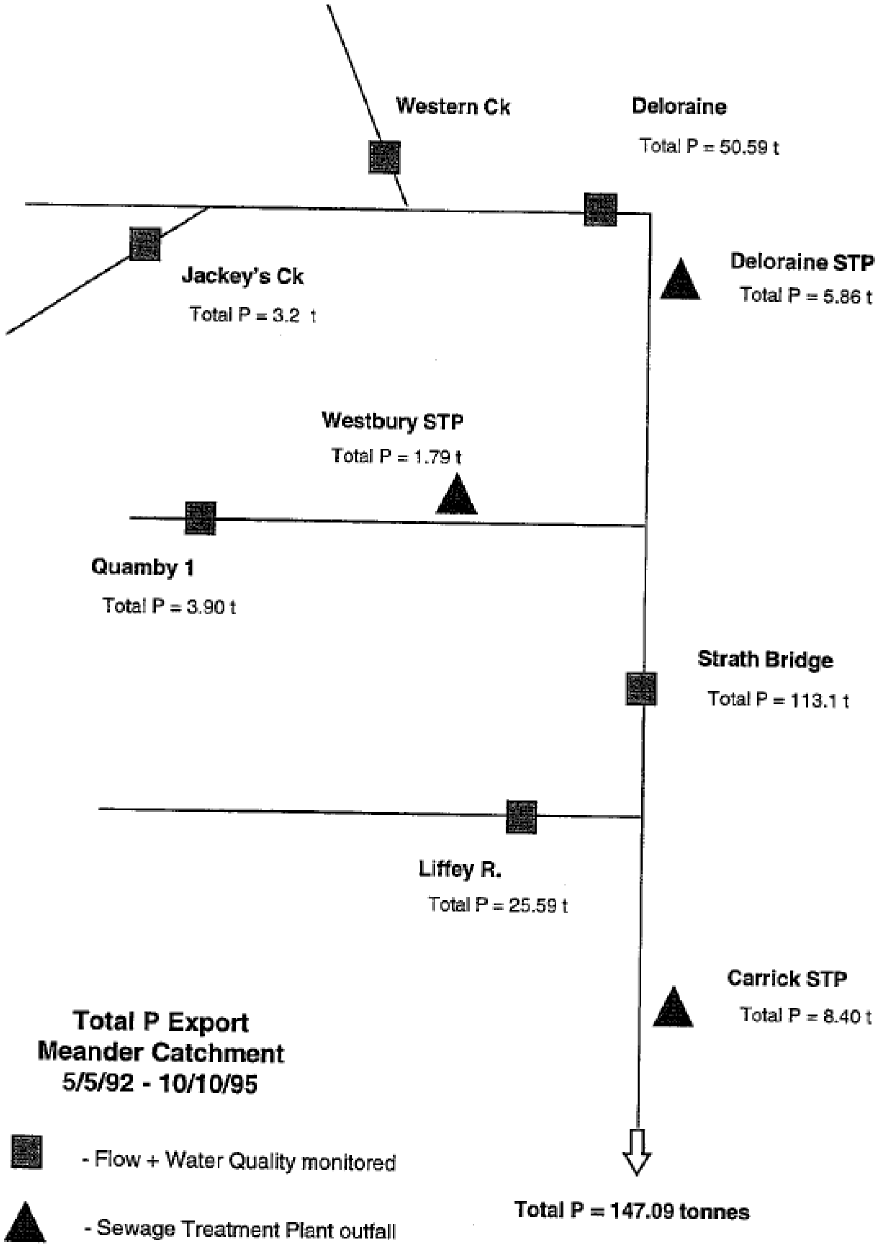


Figure 2.26 Estimated export loads of Total Phosphorus for sites in the Meander catchment over the entire study period.

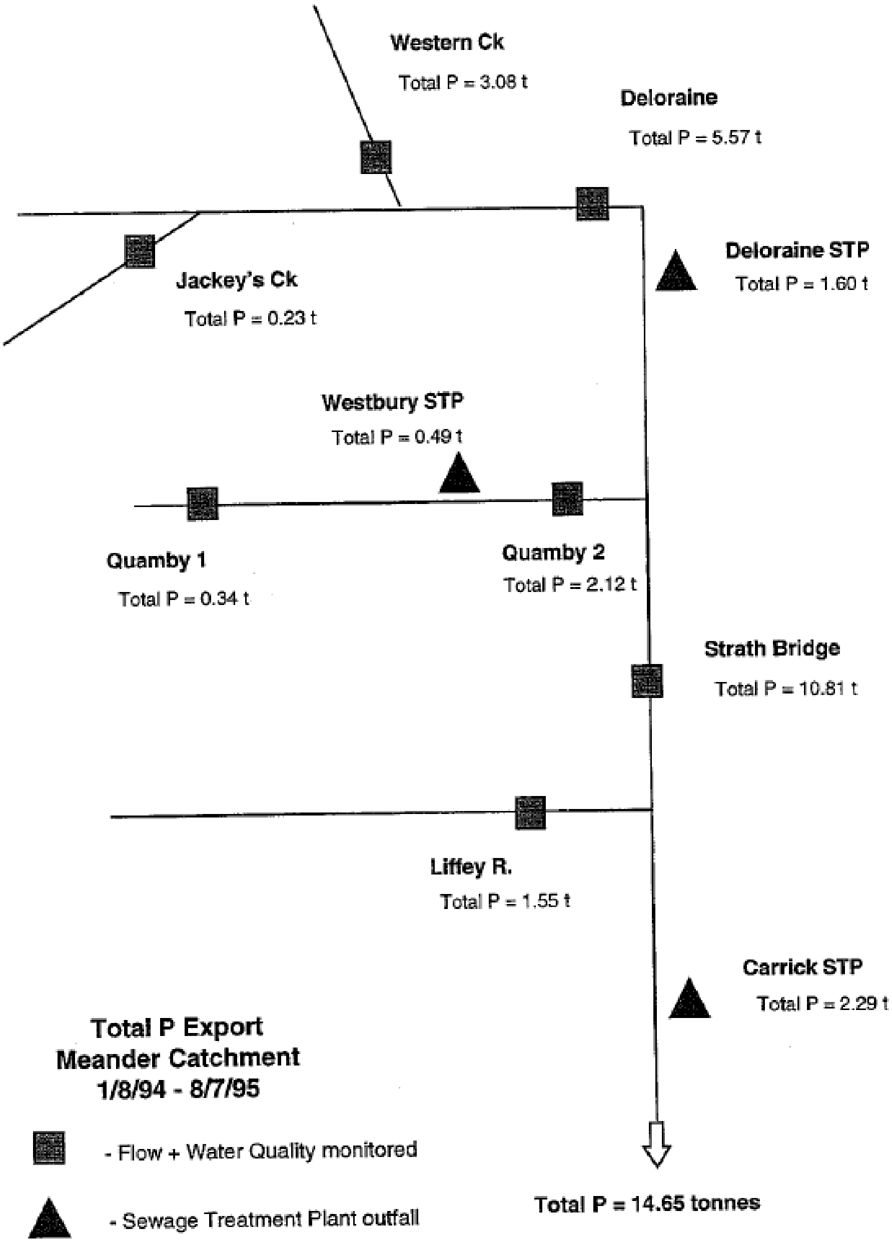


Figure 2.27 Estimated export loads of Total Phosphorus for sites in the Meander catchment over eleven months of 1994 - 95.

Jackeys Creek contributes about 4% of the P load and is 6% of the catchment area upstream of Deloraine. The rest of the upper Meander Catchment (above Deloraine) comprises 61% of the catchment and contributed 41% of the P load. This indicates that loads of P leaving the Western Creek sub-catchment is relatively higher than for other sections of the upper catchment.

For the same period, the total estimated P load passing Strath Bridge was 10.8 tonnes, 2.12 tonnes (or 19.6%) of which was estimated to have come from the Quamby Brook sub-catchment. The area contributing this load is about 19.4% of the catchment area upstream of Strath Bridge.

Examining Quamby Brook further, the estimated 0.34 tonnes of P (16% of the load for Quamby Brook at Westbury) originated from the top 82 km^2 (42% of the catchment). This shows that a significant portion of the P load entering the Meander River from Quamby Brook is from the lower part of the Quamby Brook sub-catchment, with 23% of the load coming from the sewage treatment plant at Westbury.

The Liffey River, which adds a further 224 km^2 (22%) of catchment area to the Meander catchment downstream of Strath Bridge, also adds a further 14.3% to the load of P for the period. Of greater significance however, is the 2.29 tonnes of P added to the Meander River downstream of all monitoring sites by the Carrick sewage treatment plant. This increases the load of P by a further 18% just prior to the junction of the South Esk River.

The following table gives the figures for the estimated export loads for P and the Total Discharge which carried the load during each of the years of the study. Along with the annual export estimates are export coefficients for the corresponding periods. These coefficients correct for catchment area and discharge volume and allow comparisons between years and between catchments. Nutrient export for the single year during which Western Creek was monitored is also included.

The table shows the various periods during which export estimates were calculated, the total discharge of water occurring during that period, the total estimated export of Phosphorus and the derived export coefficients for these periods. These coefficients correct for river discharge and catchment size and allows rivers of different sizes to be compared.

The table clearly demonstrates that years of greatest discharge (i.e. rainfall) results in highest export loads and largest export coefficients. The highest export loads occurred during 1992 when discharge was very high in all rivers. The resultant export coefficients were also generally higher during this period with the highest being that of Liffey at Carrick with a coefficient of 0.136 $kg/mm/km^2$.

The lowest coefficients occurred at all sites during 1994, which corresponds with a drought in the area. During the latter part of the study, the export load of P from the lower Quamby Brook site stands out, having an export coefficient of 0.134 $kg/mm/km^2$ which is at least twice that which was calculated for any other site. It clearly demonstrates the influence of the STP effluent from Westbury on export loads in the lower section of the brook.

	Area	Period	Discharge	P Export	Coefficient
	(Km^2)		(ML)	(kg)	kg/mm/km^2
					(=kg/ML)
Jackeys Ck	29	1/6/92 31/12/92	23,689	1,724	0.073
		1/1/93 - 31/12/93	21,569	883	0.041
		1/1/94 - 31/12/94	12,809	223	0.017
		1/1/95 - 12/10/95	12,786	368	0.029
Western Ck	151	1/8/94 - 8/7/95	46,118	3,075	0.067
Deloraine	475	5/5/92 - 31/12/92	490,785	20,387	0.042
		1/1/93 - 31/12/93	428,215	13,824	0.032
		1/1/94 - 31/12/94	281,397	7,328	0.026
		1/1/95 - 12/10/95	284,725	9,047	0.032
Quamby 1	82	1/6/92 - 31/12/92	33,826	1,840	0.054
		1/1/93 - 31/12/93	28,395	1,091	0.038
		1/1/94 - 31/12/94	14,643	315	0.022
		1/1/95 - 12/10/95	18,738	658	0.035
Quamby 2	196	4/8/94 - 31/12/94	6,450*	864	0.134
		1/1/95 - 12/10/95	25,642*	3,436	0.134
Strath Bridge	1,012	5/5/92 - 31/12/92	550,223	46,786	0.085
		1/1/93 - 31/12/93	499,270	32,923	0.066
		1/1/94 - 31/12/94	291,971	13,833	0.047
		1/1/95 - 12/10/95	314,957	19,522	0.062
Liffey River	224	1/5/92 - 31/12/92	118,011	16,049	0.136
		1/1/93 - 31/12/93	83,555	5,236	0.063
		1/1/94 - 31/12/94	49,262	1,586	0.032
		1/1/95 - 30/9/95	50,742	3,020	0.06

Few studies elsewhere in Australia give values for export coefficients, however Cosser (1989) calculated export coefficients for his and other studies against which Meander 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 Meander are lower than those of the South Pine by almost an order of magnitude, however the South Pine is a tropical catchment and as such is of limited use in any other way than for a broad comparison.

In similar catchment types in Poland, where mixed cropping, grazing and forest activities occur (Taylor, et al., 1986), export coefficients for TP ranged between 0.061 and 0.125 which gives some indication that export levels in the Meander catchment are typical of small, temperate catchments with agricultural activity.

Nitrogen Export

In a similar fashion to TP, the total load of nitrogen leaving the Meander catchment was estimated as 1,593.1 tonnes for the period 5/5/1992 to 10/10/1995 (Figure 2.27). This amounts to an annual average export load of about 530 tonnes per year. Approximately 4.6% of this N load is estimated to originate from sewage treatment plants in the catchment, which is less than half the estimated load of P mentioned earlier.

The 1,593.1 tonnes of TN leaving the Meander catchment combines with the 1,480.4 tonnes from the South Esk and the minimum of 417.1 tonnes estimated from the Macquarie over the same period, to give a minimum estimated TN load leaving the South Esk Basin of 3,490.6 tonnes of nitrogen (# The estimate from the Macquarie is for the upper 2000 km^2 only).

As for phosphorus, nitrogen export was also calculated for the shorter period of 1/8/94 to 8/7/95 to allow the estimates of export load for Western Creek and lower Quamby Brook to be combined with export figures for the same period from sites in the rest of the catchment (Figure 2.29).

The total load of N estimated to be leaving the Meander catchment for this period was 163.85 tonnes. Of this load, a significant proportion (87.5%) came from the catchment above Deloraine. Unlike what was found for Total P, the source appeared to be more evenly distributed, with both Western Creek and Jackey's Creek exporting loads of N proportional to their catchment areas.

Of the load of N originating from Quamby Brook, a larger proportion of N originated from the upper catchment, with 47% of the estimated N load coming from the upper 41% of the catchment. The sewage treatment plant at Westbury also contributed significantly to the total N load estimated to be leaving Quamby Brook. The total load from Quamby Brook was only 9.7% of the Total N load for the Meander catchment and contributes proportionally less than the upper Meander when considered in terms of catchment area (Quamby Brook is approximately 16% of the Meander catchment monitored).

The following table of N export loads and the derived export coefficients reveals the much higher levels of N being exported when compared to P. Nitrogen export coefficients ranged from 0.51 to 1.465 kg P /mm/km^2. As was found for P export, N export is generally greatest during years of higher discharge, however the difference in export coefficients between wet and dry years is less marked than was found for P. This is most probably due to the higher proportion of dissolved N making up TN, resulting in greater contribution of base and low flows to the total annual export load.

Few published data is available on Nitrogen export coefficients from elsewhere in Australia, but some data is available from similar 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.

When compared to values for TN export calculated for sites in the South Esk River catchment, the Meander TN export coefficients are generally less variable and peak values are lower.

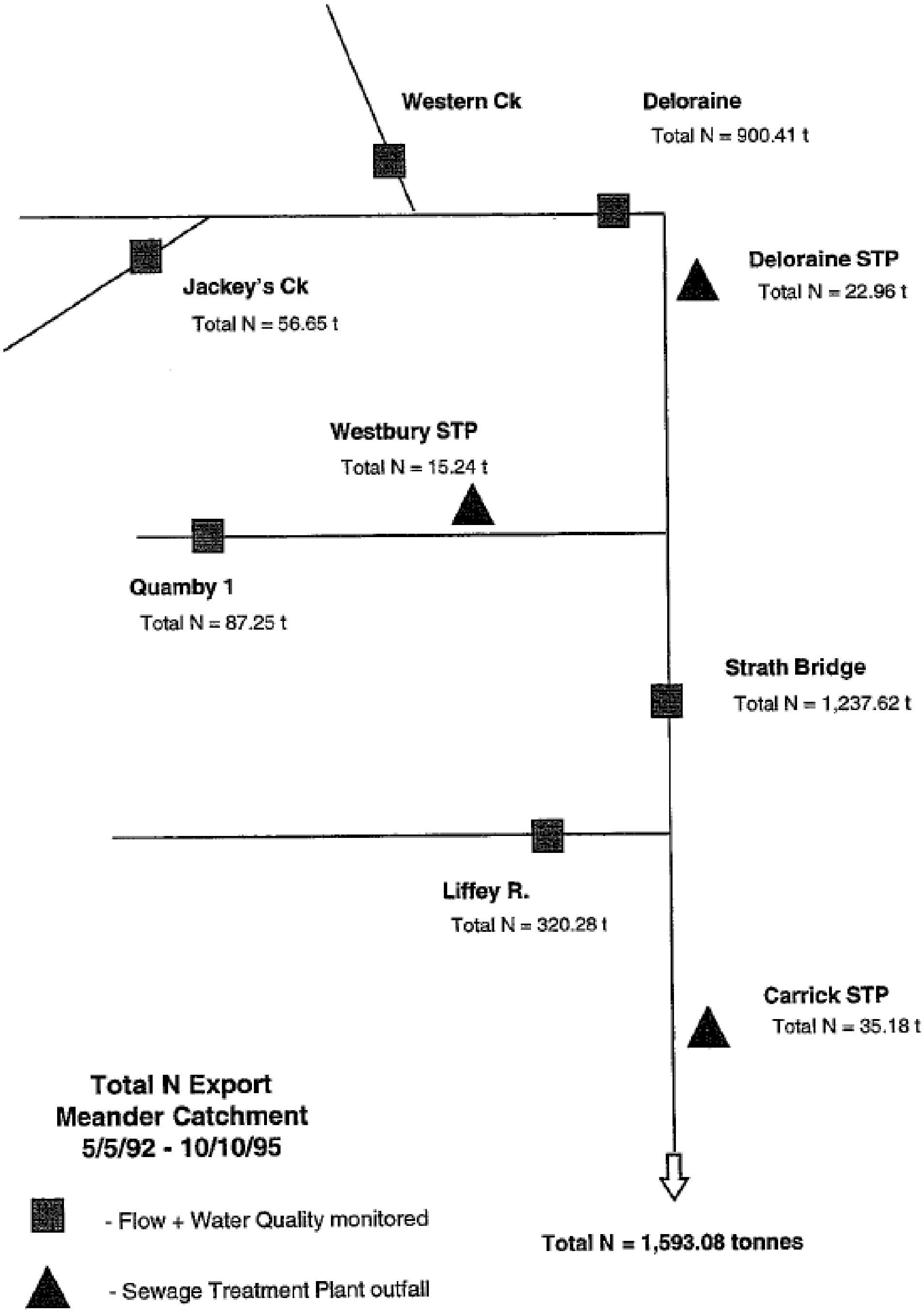


Figure 2.28 Estimated export loads of Total Nitrogen for sites in the Meander catchment over the entire study period.

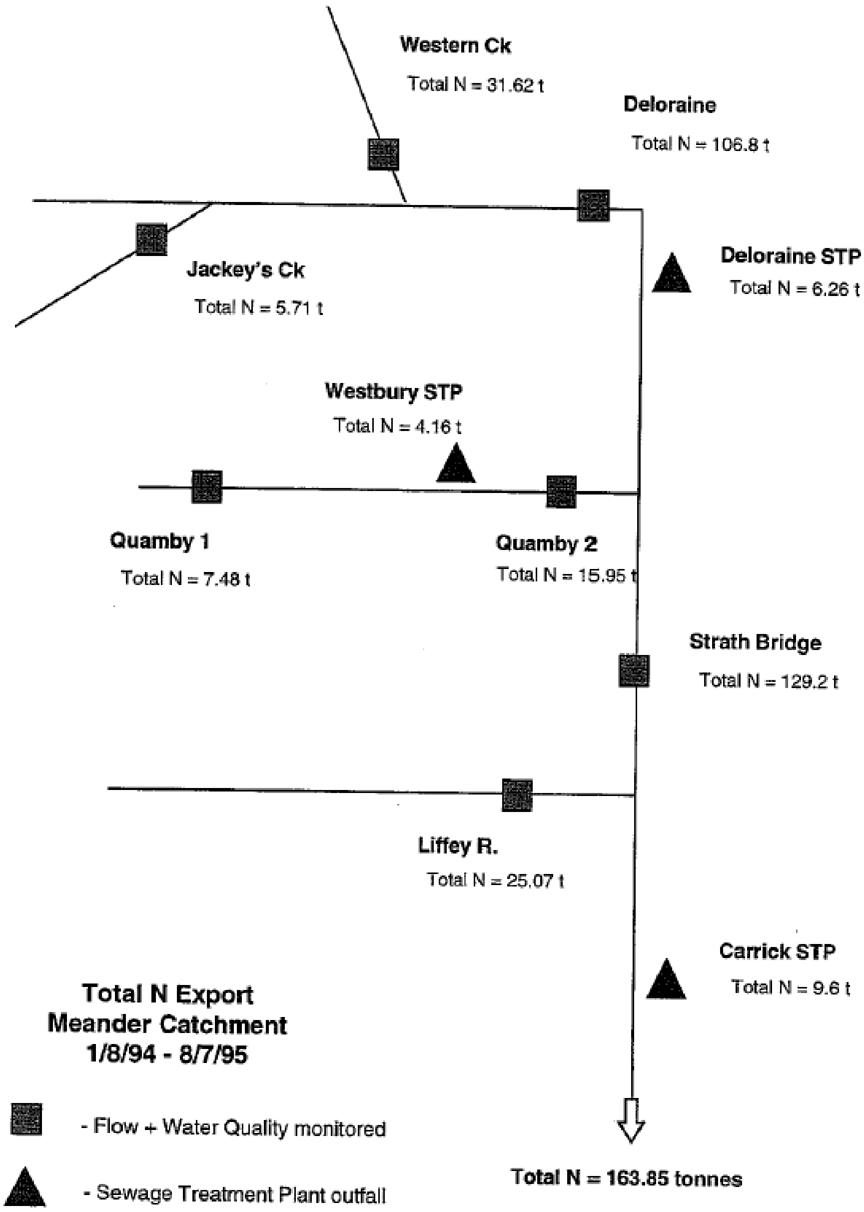


Figure 2.29 Estimated export loads of Total Nitrogen for sites in the Meander catchment over eleven months of 1994 - 95.

	Area	Period	Discharge	N Export	Coefficient
	(Km^2)		(ML)	(kg)	kg/mm/km^2
					(=kg/ML)
Jackeys Ck	29	1/6/92 31/12/92	23,689	23,376	0.987
		1/1/93 - 31/12/93	21,569	16,128	0.748
		1/1/94 - 31/12/94	12,809	7,770	0.607
		1/1/95 - 12/10/95	12,786	9,378	0.733
Western Ck	151	1/8/94 - 8/7/95	46,118	31,616	0.686
Deloraine	475	5/5/92 - 31/12/92	490,785	349,230	0.712
		1/1/93 - 31/12/93	428,215	245,690	0.574
		1/1/94 - 31/12/94	281,397	143,427	0.510
		1/1/95 - 12/10/95	284,725	162,058	0.569
Quamby 1	82	1/6/92 - 31/12/92	33,826	32,423	0.959
		1/1/93 - 31/12/93	28,395	22.480	0.792
		1/1/94 - 31/12/94	14,643	8,212	0.555
		1/1/95 - 12/10/95	18,738	24,223	1.293
Quamby 2	196	4/8/94 - 31/12/94	6,450*	6,495	1.007
		1/1/95 - 12/10/95	25,642*	35,822	1.397
Strath Bridge	1,012	5/5/92 - 31/12/92	550,223	484,335	0.880
		1/1/93 - 31/12/93	499,270	365,291	0.732
		1/1/94 - 31/12/94	291,971	185,692	0.636
		1/1/95 - 12/10/95	314,957	202,305	0.642
Liffey River	224	1/5/92 - 31/12/92	118,011	172,908	1.465
		1/1/93 - 31/12/93	83,555	75,469	0.903
		1/1/94 - 31/12/94	49,262	29,440	0.598
		1/1/95 - 30/9/95	50,742	42,464	0.837

2.5 Microbiological data

Although not a specific objective of this study, some sampling for bacteria was carried out throughout the catchment during the study as there was some community concern over the quality of water in the catchment. A survey was carried out in late November 1994 and included most sites later used in longitudinal transects for metals and nutrients. The survey involved sampling of both ‘ambient’ water (that is natural, undisturbed flowing water) and ‘sediment disturbed’ water (that is water containing sediment which has been resuspended from the river bed). 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. The technique of sampling water containing resuspended sediment has been used elsewhere (Sherer, et. al., 1988) to help assess the longer term impact of animal waste entering streams in agricultural areas, as bacteria are known to survive for longer in sediments than in the overlying water (Sherer, et. al., 1992).

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, but in this case has simply been used to gain some insight into the pattern of bacterial degradation of streams in the Meander catchment at the time of the survey.

It should also be noted here that coliforms are simply indicators of faecal pollution (pollution from animal waste) and while *E. coli* and faecal streptococci give better indication of the level of faecal contamination, total coliforms, faecal coliforms and faecal streptococci are only indicators of the level of pathogenic organisms in water, not a direct measure of their presence.

The ANZECC Guidelines of 1992 give the following recommendations for bacterial limits for various activities;

	Faecal coliforms (count per 100ml)	**Total coliforms** (count per 100ml)
Recreation		
Primary Contact	<150 or 80% < 600	
Secondary Contact	<1000 or 80% < 4000	
Raw Drinking Water		
Humans	None should be detected	<10 or 95% < 1
Livestock	< 1000 or 4/5 < 5000	

It should also be stressed that the guidelines require larger numbers of samples to be collected at sites over a longer time period. The single values discussed below should be viewed in light of this.

Meander River (Figure 2.30)

In sediment disturbed samples, the pattern of change in the Meander River is for gradually increasing bacterial levels from the top of the river to reach a peak at the Deloraine Weir. Downstream of Deloraine *E. coli* levels remain significantly higher than faecal streptococci, which gradually decrease again. In the 'undisturbed' water samples this pattern is also apparent, with both indicators reaching a peak level of over 400 counts per 100ml at Deloraine weir. At most sites, samples of sediment disturbed water show higher levels of coliforms than undisturbed samples, however at Deloraine this was not found to be the case. No explanation is apparent but it highlights the need to take more than single samples when trying to determine the level of bacterial contamination of sites.

The evidence from 'disturbed' samples clearly suggest that long term contamination of the river bed occurs toward the bottom of the catchment and that the potential for recontamination of the water column during disturbance or high flow events is greater. It also reflects the fact that sites lower in the river would also have larger stores of finer sedimentary material which can harbour bacteria. This may or may not be responsible for the pattern of change in bacterial levels in the 'undisturbed' water.

At the Deloraine weir, where peak bacterial levels were encountered, impact from the township would account for a proportion of these higher levels along with the impact of excreta from the local duck population. Sedimentation within the weir would also contribute to the higher bacterial levels at this site. Historical data indicate that this site has long had high levels of faecal and coliform bacteria.

Liffey River (Figure 2.31)

The general pattern in both sets of data show that increasing faecal contamination occurs towards the bottom of the catchment. The high numbers of *E. coli* in 'disturbed' samples at

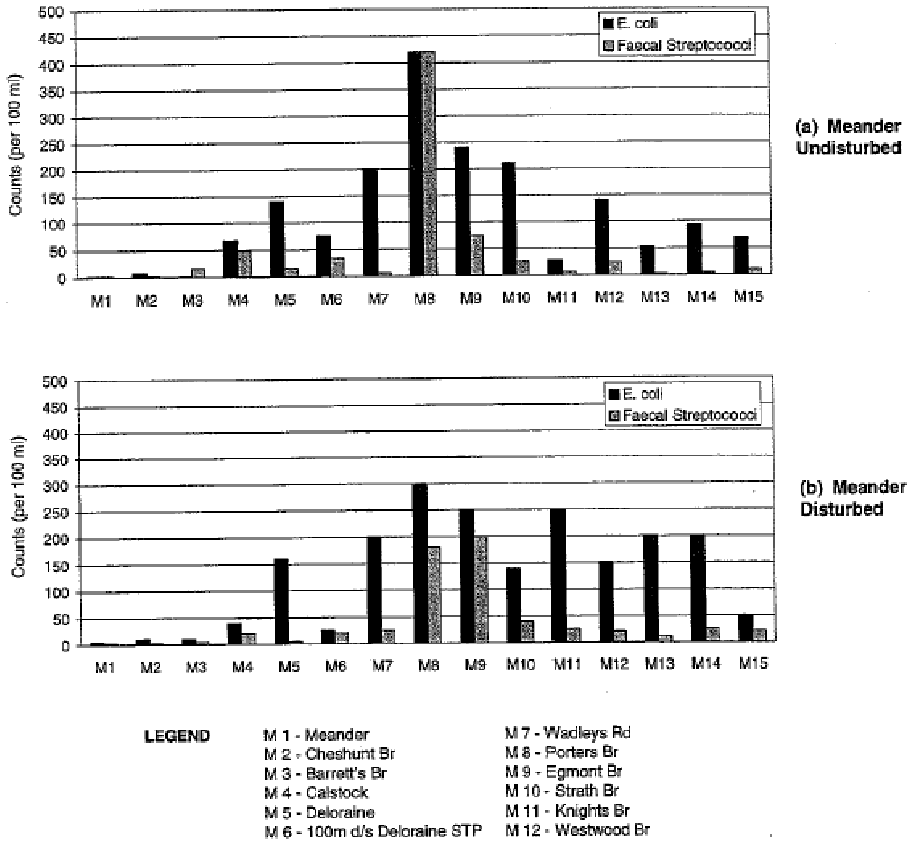
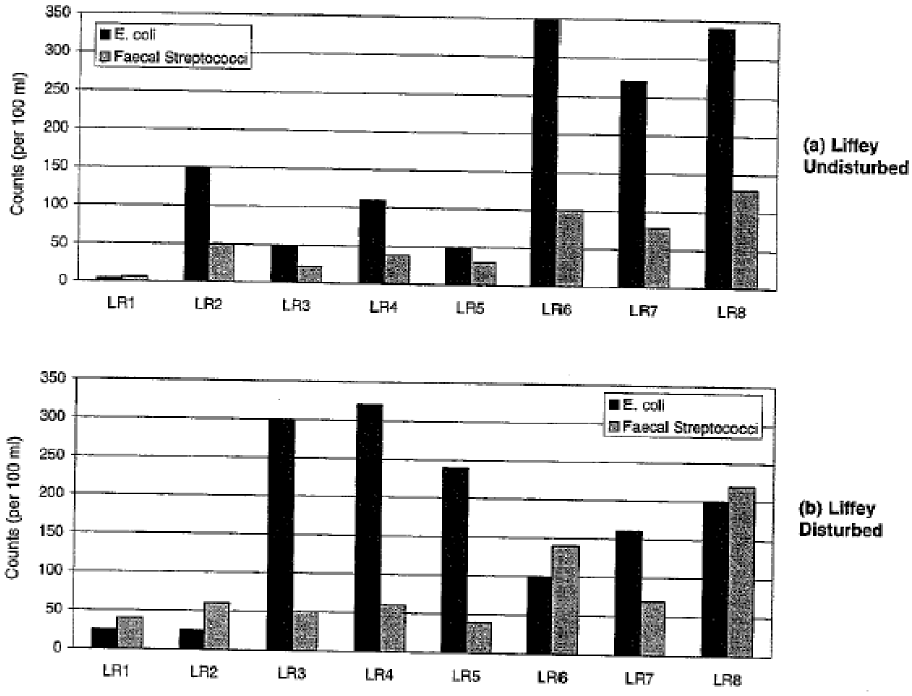


Figure 2.30 Longitudinal transect of the Meander River sampling undisturbed flowing water (a) and sediment disturbed water (b) for faecal coliforms and faecal streptococci. Survey carried out in late November, 1994.



LEGEND

LR 1 - Liffey Reserve
LR 2 - d/s Coalmine Ck
LR 3 - @ Liffey
LR 4 - @ Bracknell Picnic area
LR 5 - @ Bracknell Rd
LR 6 - Pitts Lane Br
LR 7 - 'Moreton Cottage'
LR 8 - @ Carrick

Figure 2.31 Longitudinal transect of the Liffey River sampling undisturbed flowing water (a) and sediment disturbed water (b) for faecal coliforms and faecal streptococci. Survey carried out in late November, 1994.

all but two sites indicates that the ability to harbour bacteria is relatively high throughout the length of the river. However the levels of *E. coli* and faecal streptococci was highest at the lower sites indicating that animal waste contamination was greater lower in the catchment.

Although the general pattern of change is similar for both sets of data, distinct differences occur, especially at sites low in the catchment. High levels of *E. coli* measured in undisturbed samples is not similarly reflected in the disturbed samples at those sites. There is no obvious explanation for this and once again highlights the need for greater numbers of samples to obtain a clearer picture of river conditions.

Quamby Brook (Figure 2.32)

Five sites on Quamby Brook were sampled for faecal indicators and the results show that while no definite pattern of change in bacterial levels exists, three of the five sites on Quamby Brook have a significant potential for contamination from the stream bed. This suggests that long term faecal contamination may occur at these sites. It is interesting to note that the second lower-most site has reduced bacterial levels both in disturbed and undisturbed samples, indicating that faecal contamination is relatively low at this site.

From the undisturbed sample data, it is apparent that 'undisturbed' water at only two sites show significant bacterial contamination. These sites are at Quamby Brook Bridge and at the Birralee Rd Bridge at the bottom of the brook. Both these sites had the highest bacteria levels in sediment disturbed samples.

Sampling of 'undisturbed' water at Deloraine and Meander was also carried out monthly by DPIF staff between September '94 and January '95 (Figure 2.33). Monitoring at both sites clearly show a gradual increase in bacterial contamination heading into summer. Lower flows and higher temperatures will assist in growth and survival of bacteria, but the increase in numbers is most likely to be influenced by the increasing impact of animal activities on the river at this time.

Monthly monitoring ceased in January '95 following a large flood in the Meander River on the 20th of that month. However, samples were taken prior to and following the flood and the results show the impact of flooding on bacterial numbers in the river (Figure 2.34). Increased runoff from the land and the resuspension of material in the river as a result of flooding caused a dramatic increase in bacteriological contamination of the river. Levels which were already well above the ANZECC (1992) Guidelines for bathing and livestock use became substantially worse as a result. As monitoring ceased soon after the flood, it is unknown how long elevated bacterial levels in the river persisted.

Other sampling for bacteria was carried out at Western Creek as part of a more detailed investigation of water quality in the area and the results are discussed in the section 'Special Studies'.

2.6 Heavy Metals

Samples for heavy metals analysis were taken during longitudinal sampling for nutrients and physical parameters during March 1995, under low baseflow conditions. Additional sampling carried out as part of another program monitoring invertebrates in the Meander also collected samples for metals in October, 1994 and March, 1995 under stable baseflow conditions. Analysis of all samples was for total concentrations of Cadmium, Copper, Lead, Zinc and Arsenic. The detection level for the first three metals was 1 μg /L with a detection limit for Zinc and Arsenic of 5 μg/L and 10 μg/L respectively.

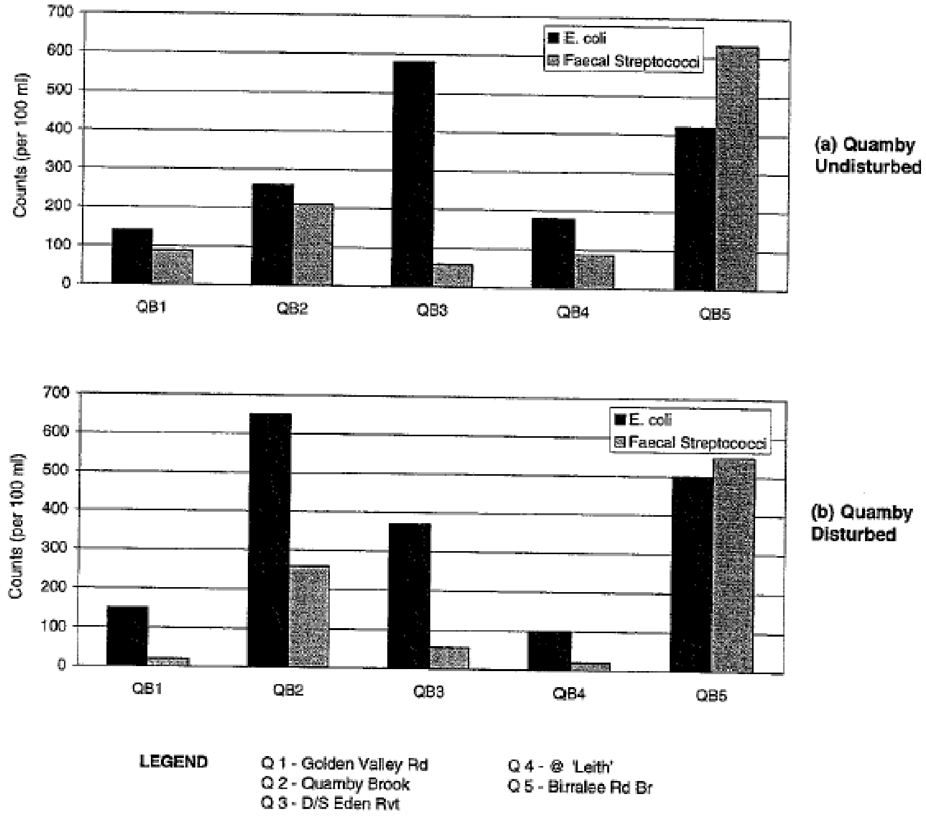
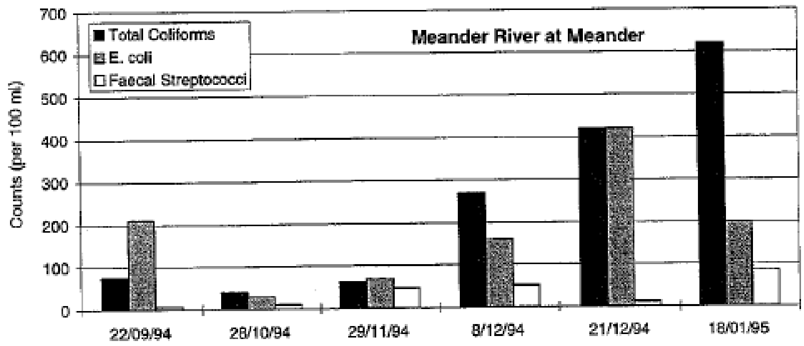


Figure 2.32 Longitudinal transect of Quamby Brook sampling undisturbed flowing water (a) and sediment disturbed water (b) for faecal coliforms and faecal streptococci. Survey carried out in late November, 1994.



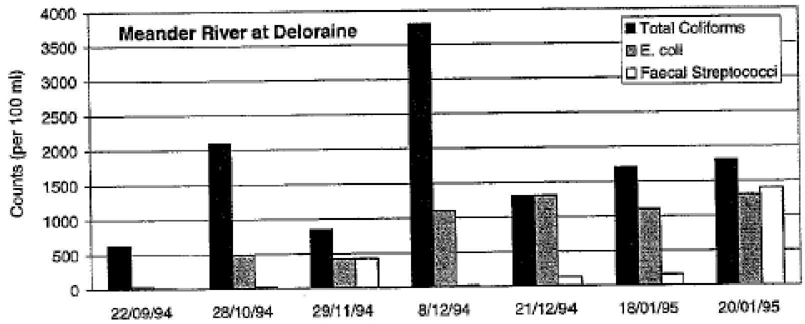


Figure 2.33 Monthly changes in bacterial levels monitored in the Meander River at Meander and Deloraine townships during spring and early summer of 1994 - 95.

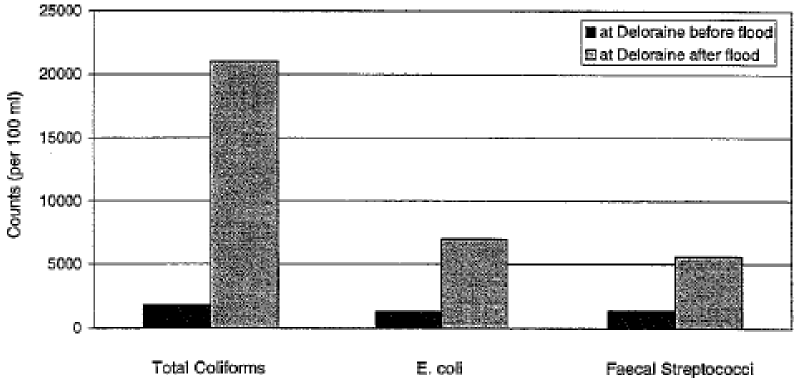


Figure 2.34 Changes in bacterial levels monitored in the Meander River at Deloraine township pre - and post - flooding in January, 1995.

In all 50 samples were analysed from 30 sites throughout the Meander and Liffey rivers, Quamby Brook and Western Creek. No significant levels of Cadmium, Lead or Arsenic were detected.

	Cadmium (µg/L)	**Copper** (µg/L)	**Lead** (µg/L)	**Zinc** (µg/L)	**Arsenic** (µg/L)
Maximum	< 1	17	2	20	< 10
Minimum	< 1	< 1	< 1	< 5	< 10
No. Samples	50	50	50	40	27

Only two significant readings were made. A reading for copper of 17 µg/L was made at Western Creek and a reading for zinc of 20 µg/L was made at Quamby Brook below Westbury. The high copper reading was one of three taken at that site and may possibly have been an error, while the 20 µg/L detected in Quamby Brook is still a very low reading and well within the ANZECC (1992) guidelines for the protection of aquatic ecosystems (< 50 µg/L).

2.7 Special Studies

2.7.1 Western Creek

When monitoring was initiated at the Montana Rd bridge site on Western Creek in mid 1994, it was decided that a more detailed investigation of this catchment to try and identify areas of significant diffuse pollution might be useful. This catchment was in the process of being mapped to collect data for the purposes of catchment management planning and this data might be beneficial in identifying any specific land use activities which were impacting water quality in the catchment.

At the time of the study, the catchment comprised the following broad categories of land use;

Pasture	8351.6 ha
Crops	317.7 ha
Bare Ground	1840.4 ha
Forest	4988.2 ha
Water (dams)	15.3 ha
Total Catchment area	15,513 ha

An on-farm survey carried out at the time gave the following data for animal stocking in the catchment;

	Number	Density
Dairy Farms	16	1: 522 ha
Total dairy cows	3090	1: 2.7 ha
Total pigs	6521	1: 1.28 ha
Beef cattle	6470	1: 1.3 ha
Sheep	36150	1: 0.23 ha

Density based on animals per amount of cleared pasture (8351.6 ha).

The following map shows the location of dairies in the catchment and the location of sampling sites (Figure 2.35). It shows that the majority of dairy farming occurs in the very western side and the very eastern side of the catchment, with most dairies located in the Dale Brook and Leiths Creek drainage systems. Free range pig grazing is generally confined to the western side of the catchment. Most of the upper catchment, to the south, is natural forest in

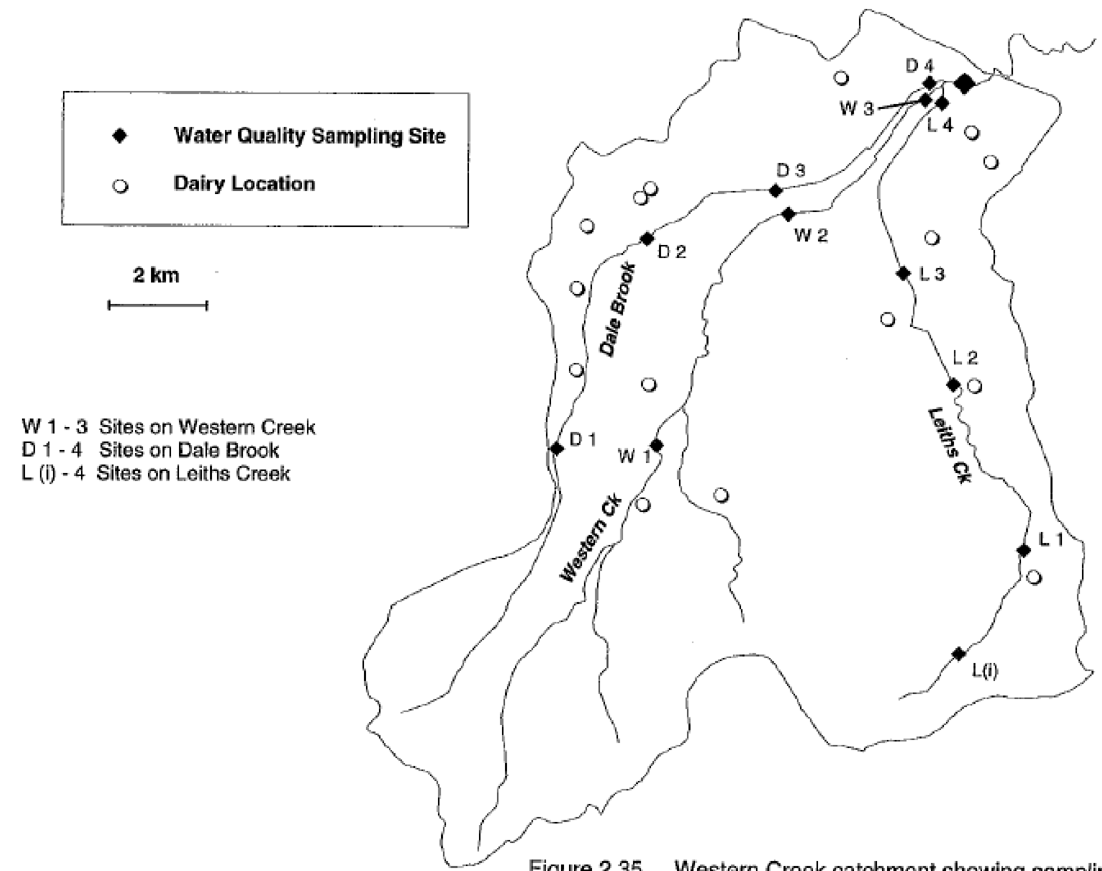


Figure 2.35 Western Creek catchment showing sampling locations and distribution of dairys.

which some logging activity takes place. (More detailed information of land use activities in the catchment can be obtained from the Catchment Management Study of the Meander Valley - 1996).

Thirteen sites were selected covering the three major tributaries draining Western Creek. Five sites in the Leiths Creek tributary, three in the Western Creek tributary and four in the Dale Brook tributary. The last site was the monitoring site at the Montana Rd bridge across Western Creek, below the junction of all three tributaries (refer Figure 2.33). The catchment area above this bottom site is about 15,100 hectares.

All sites in the catchment were visited three times during the spring and summer of 1994 - 95, with the surveys being carried out on a single day. Sampling for nutrients, bacteria, as well as in situ measurements of turbidity, electrical conductivity, temperature and flow, was carried out at each site. The relative utility of this approach and the prerequisites of its application are discussed in Grayson, et al. (1993). The major requirement to be satisfied when using this method is that sampling be performed during periods of stable flows throughout the catchment to allow reliable identification of areas where elevated load inputs occur.

Additional sampling for bacteria was also performed at about monthly intervals between surveys.

Physical Parameters

A general increase in conductivity was found from headwaters to the valley with values high in the catchment of around 35 μS/cm and lower in the valley reaching only 80 μS/cm (Figure 2.36). This trend was unusually well pronounced in the winter (August '94) survey and progressively less so during the latter two surveys. All three tributaries had similar levels of conductivity.

A similar pattern was found for turbidity (Figure 2.37), with levels in all tributaries increasing towards the bottom of the catchment. Overall levels of turbidity were greatest in Leiths Creek with the bottom site in this tributary being between 20% and 300% higher than in the other two tributaries.

High spot readings of turbidity were recorded at individual sites in all three tributaries during separate surveys which indicated disturbance upstream. This was most notable in Dale Brook during the August '94 survey where a turbidity reading of 70 NTU was a direct result of stock access in the section of stream directly above the sampling site at that time. During the January '95 survey, a high turbidity recording at the uppermost site in Western Creek may have resulted from stock access upstream, as there is a dairy not far upstream. There had also been recent land clearing upstream of this site. A significant increase was also recorded in Leiths Creek between sites L2 and L3 in the January survey. The cause of this is not clear as the creek is fenced off immediately upstream of L3.

Phosphorus and Nitrogen Loads

The load of P measured at each site relative to the total load measured leaving the catchment at Montana Rd bridge during each of the surveys is given in the following Figure 2.38. The load at each site is given as a percentage of the load measured at Montana Rd bridge and is based on the assumption that loads will be cumulative down the length of each tributary. The percentage given for L4, D4 and W3 on each plot is the percentage contribution of each tributary to the total load leaving the catchment.

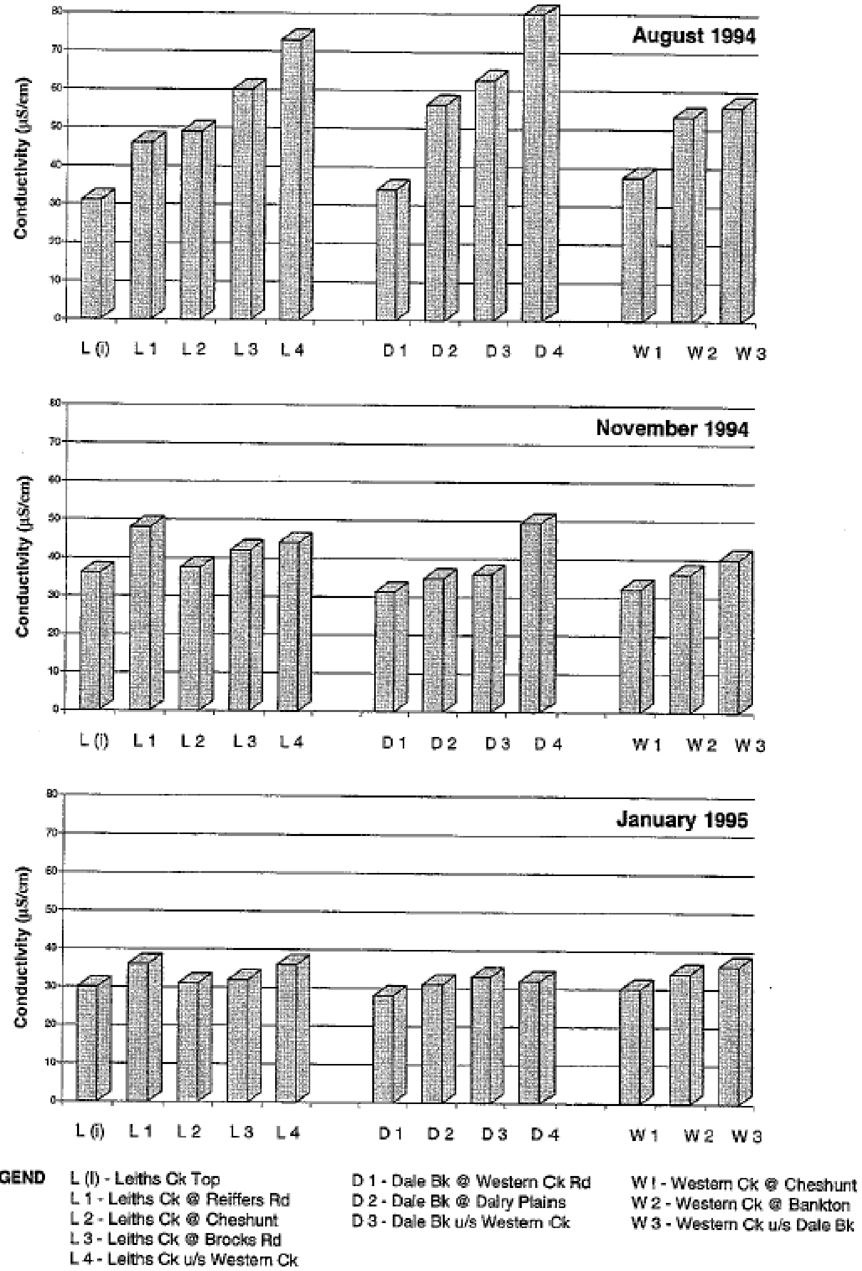


Figure 2.36 Pattern of electrical conductivity along the length of each tributary of Western Creek on the three surveys carried out in 1994 - 95.

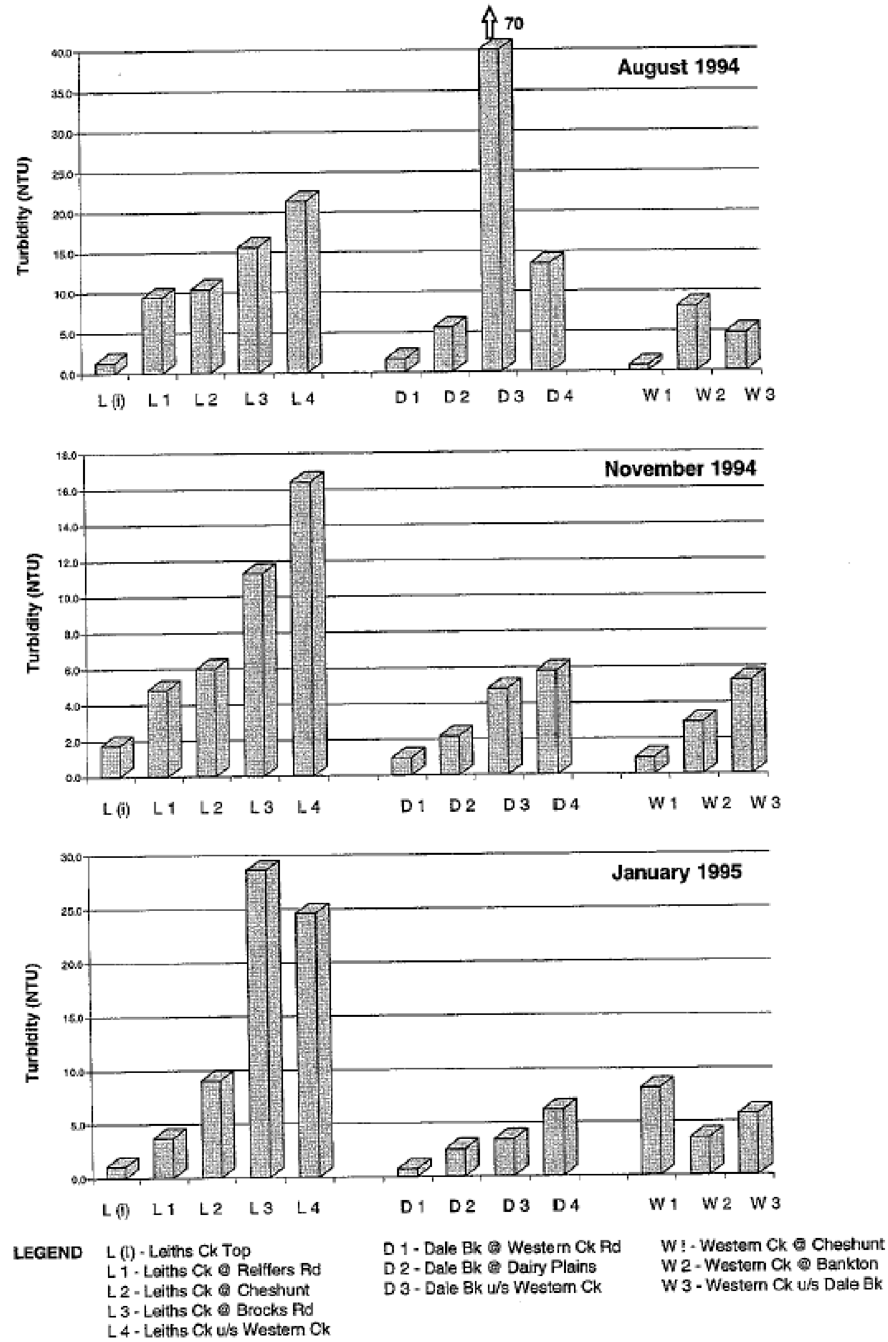


Figure 2.37 Turbidity levels at sites along the length of each tributary of Western Creek on the three surveys carried out in 1994 - 95.

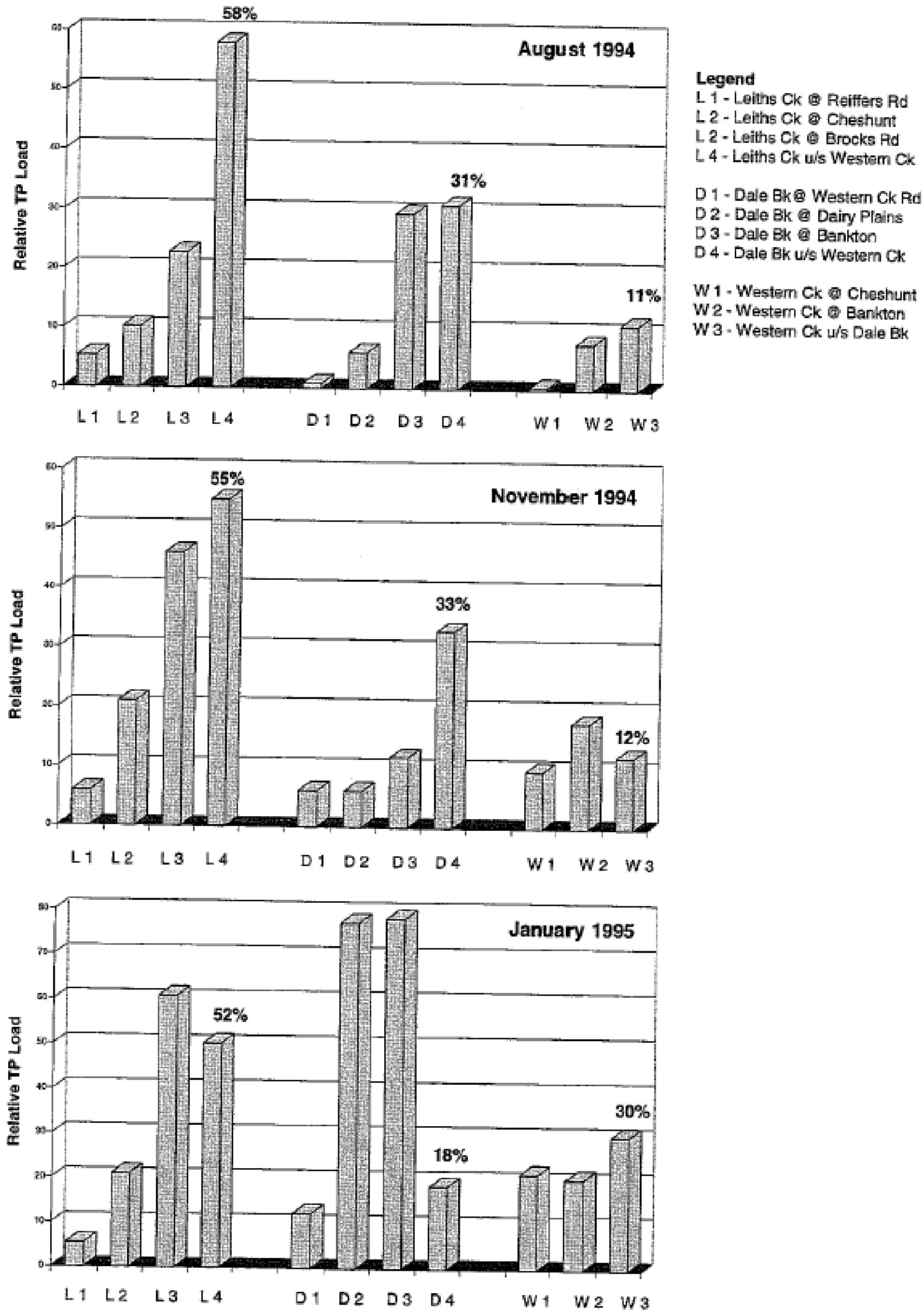


Figure 2.38 Load of Total P measured at each site relative to that leaving the catchment at Montana Road Bridge. The figure given at the lowest site in each tributary is the contribution of each to the total load measured at Montana Bridge.

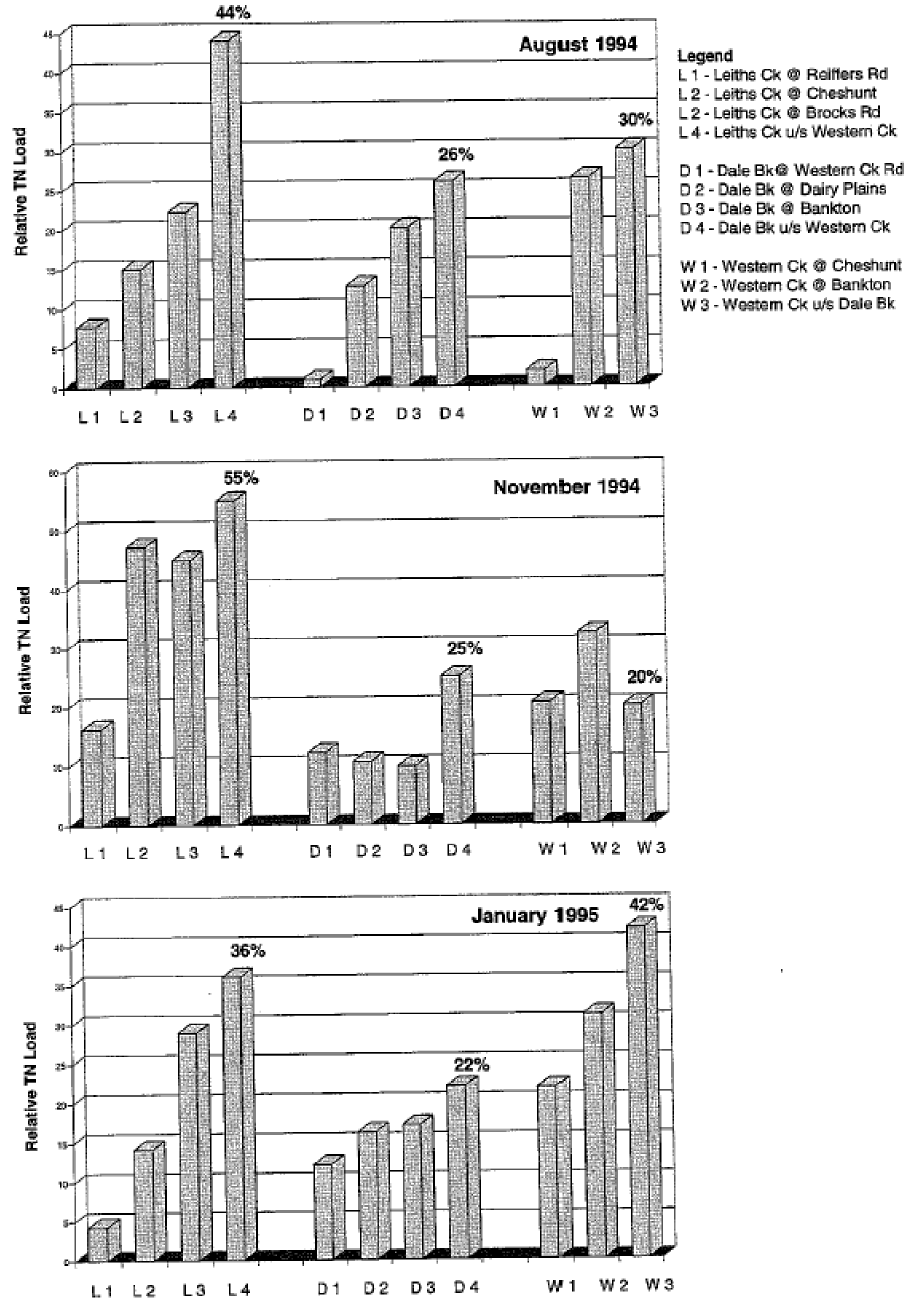


Figure 2.39 Load of Total N measured at each site relative to that leaving the catchment at Montana Road Bridge. The figure given at the lowest site in each tributary is the contribution of each to the total load measured at Montana Bridge.

Highest instantaneous loads of P were measured during the August, '94 survey when baseflows were greatest, and lowest loads were measured when baseflows were lowest in January, '95. In most cases the pattern of P load was for increasing loads lower in the tributaries. This was especially so for Leiths Creek where P load increased around seven-fold in all three surveys. In the results for January '95 this pattern was disrupted in Dale Brook where instantaneous loads in the middle of the catchment were unusually elevated, possibly due to influent of nutrient rich water.

The relative contribution of each tributary to the total catchment load of P was similar for the first two surveys, with Leiths Creek contributing most to P export (58% and 55%) and Western Creek contributing least (11-12%). In January '95 this pattern was slightly different, with Western Creek contributing 30% to P export as a result of increased flows in this tributary.

In all three plots it is clear that the greatest contribution to P export is from Leiths Creek, which consistently contributed over 50% of the export loads. In this catchment it was found that TP is closely related to river flows (Bobbi and Fuller, 1996) and while it is true that tributaries with higher flow will naturally tend to contribute more to P export, in this case higher concentrations in Leiths Creek and not higher flows have resulted in the greater P loads relative to the other tributaries.

The pattern for nitrogen export was similar to that for phosphorus (Figure 2.39), with Leiths Creek contributing most (35-57%) and Dale Brook contributing least (21-27%) to TN export in the catchment during th first two surveys. Western Creek also showed a significant increase in the relative contribution of N to catchment export load during January '95 as a result of both increased TN concentrations and increased flow.

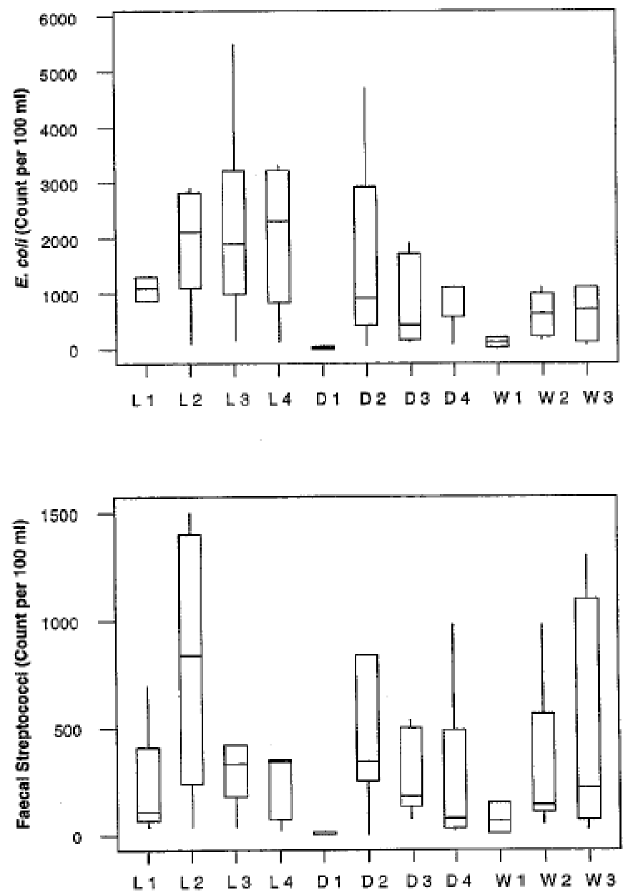
Bacteria

All sites were visited 7 times in the period August '94 to January '95. The data show (Figure 2.40) that all but the upper-most sites in the three tributaries had *E. coli* levels in excess of 400 counts per 100 ml, and faecal streptococci in excess of 100 counts per 100ml.

These levels are well above the recommended levels for drinking water (NHMRC, 1995) and primary contact for recreational purposes (ANZECC, 1992). The data show that Leiths Creek is most affected, with *E. coli* levels which limit its use even for the purposes of watering livestock (Guideline of < 1000 per 100 ml - ANZECC, 1992). This has serious implications for farm productivity as contaminated water can carry parasites and pathogens which limit growth rates and increase mortality, particularly in young stock (Smith, et al., 1974).

In conclusion, the results from this small sub-program show that significant impact has been made on water quality in tributaries in this catchment, with greatest degradation occurring in the Leiths Creek tributary. The higher turbidity and nutrient load in this tributary, in addition to the bacterial contamination along its length, indicate the nature of its source. Along large stretches of this creek livestock has uncontrolled access, resulting in the loss of streamside vegetation and increased erosion. There is also a greater level of drainage activity in this area than in other parts of the catchment, which may be acting to facilitate both nutrient export and faecal contamination. It is suggested that measures to control erosion in this area would contribute greatly towards limiting both these factors.

While it would be inappropriate to suggest that water within an intensively farmed catchment such as Western Creek should be of drinking water standard, it would benefit farm productivity and hygiene to manage stock so as to limit the level of faecal contamination of



Legend

L 1 - Leiths Ck @ Reiffers Rd
L 2 - Leiths Ck @ Cheshunt
L 2 - Leiths Ck @ Brocks Rd
L 4 - Leiths Ck u/s Western Ck

D 1 - Dale Bk@ Western Ck Rd
D 2 - Dale Bk @ Dairy Plains
D 3 - Dale Bk @ Bankton
D 4 - Dale Bk u/s Western Ck

W 1 - Western Ck @ Cheshunt
W 2 - Western Ck @ Bankton
W 3 - Western Ck u/s Dale Bk

Figure 2.40 Box and whisker plots showing the statistics on *E. coli* and Faecal streptococci levels at sites in the Western Creek catchment. Seven samples were collected from each site between Aug '94 and Jan '95.

waterways in the area. Such actions would most likely also provide benefits in terms of nutrient loss from the catchment.

2.7.2 Quamby Brook

Following the discovery of chronically depressed dissolved oxygen levels in lower Quamby Brook, a more intensive investigation was carried out to further outline the extent of this condition and attempt to identify the factors contributing to these low DO levels.

Through routine monitoring at this site between August 1994 and May 1995, dissolved oxygen was known to be severely low at the monitoring site at Birralee Rd, downstream of Westbury township. It was known that immediately upstream of this site treated effluent from the Westbury Sewage Treatment plant was discharged to the river. Although it was thought that this input would increase nutrient concentrations in the stream, concentrations measured during surveys of Quamby Brook on 18/1/95 and 28/3/95 showed that during summer baseflows and extreme low flows, significant enrichment of Quamby Brook occurs well upstream of the sewage treatment plant (Figure 2.41). However the levels of nutrients was not thought to be the main cause of the depressed oxygen levels. Rather, it was thought that the degree of willow infestation in the area might be the main factor causing the low DO levels through increased shading and reduced flow in the stream. Intense growth of riparian vegetation has been found to influence DO levels in streams in New Zealand (Wilcock, et al., 1995). A midday longitudinal survey of Quamby Brook during summer low flows in 1994 (Figure 2.42) clearly revealed the affect willows have on dissolved oxygen concentrations in in the stream.

In areas where willow infestation is particularly dense, DO levels were found to be severely depressed (below 6 mg/L). However, in areas where willows have been removed, such as the short area upstream of the Bass Highway, DO levels were quite high (above 12 mg/L), most likely as a result of photosynthesis of aquatic plants at these sites. Temperature at these sites was also appreciably higher.

Dissolved oxygen, which varies on a diurnal cycle (Goldman and Horne, 1983), was also monitored in situ using a Hydrolab multi-parameter logger. This instrument was deployed in the stream over night to measure temperature and dissolved oxygen hourly. Sites within willows and outside of willow infestation were chosen.

Figures 2.43a and 2.43b show the different behaviour of DO within and outside of willow infestation during periods of low flow. The trace from within the willow infested area shows how DO mimics temperature, with levels reaching a minimum around 6 am and peaking in the late afternoon. Traces taken later in the summer showed that DO levels overall were much lower with a less distinctive diurnal pattern. In areas where willows have been removed, the pattern for dissolved oxygen is reversed, with DO peaking in the middle of the day. The magnitude of these changes is also much larger than changes within willow infested areas.

Where willows have been removed, photosynthesis by aquatic plants and algae cause DO levels to increase during the day and decrease at night. This is because photosynthesis during the day by aquatic plants produces oxygen. At night these plants are net consumers of oxygen causing oxygen levels to fall. Excessive growth of aquatic plants and algae can also result in extraordinarily high dissolved oxygen levels during the day and very low levels at night, causing stress to fish and other aquatic organisms.

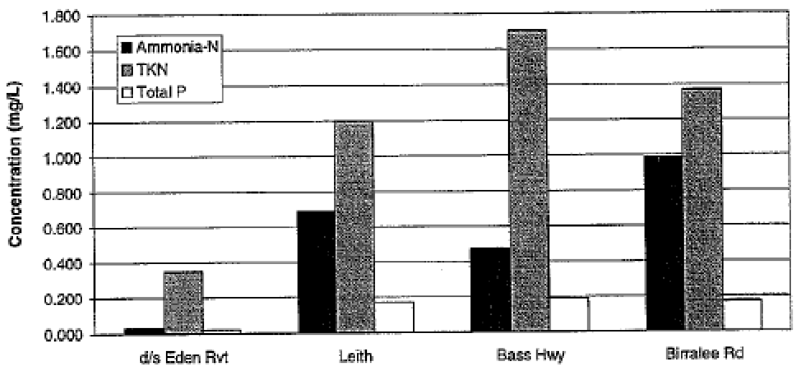


Figure 2.41 Nutrient concentrations at sites on Quamby Brook, measured during extremely low flows on 18 January, 1995.

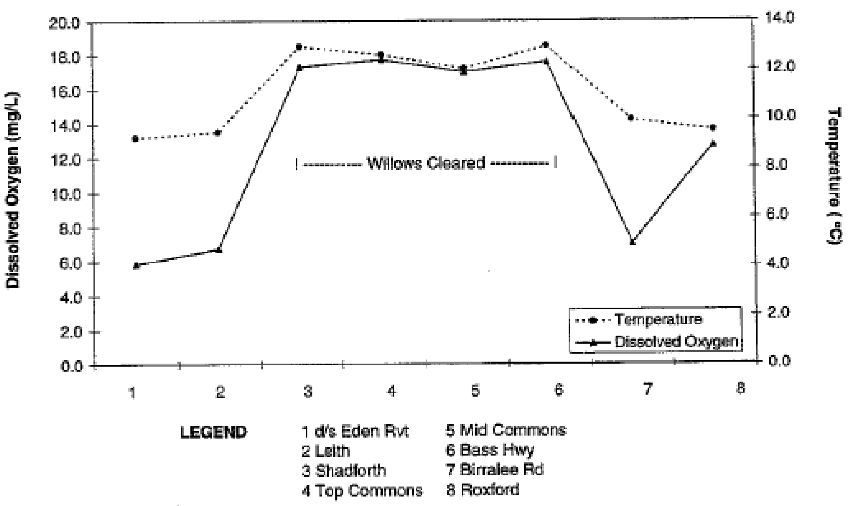


Figure 2.42 Results of a survey of Quamby Brook during low flows of December, 1994, when there was a noticable increase in dissolved oxygen in areas where willow removeal had occurred.

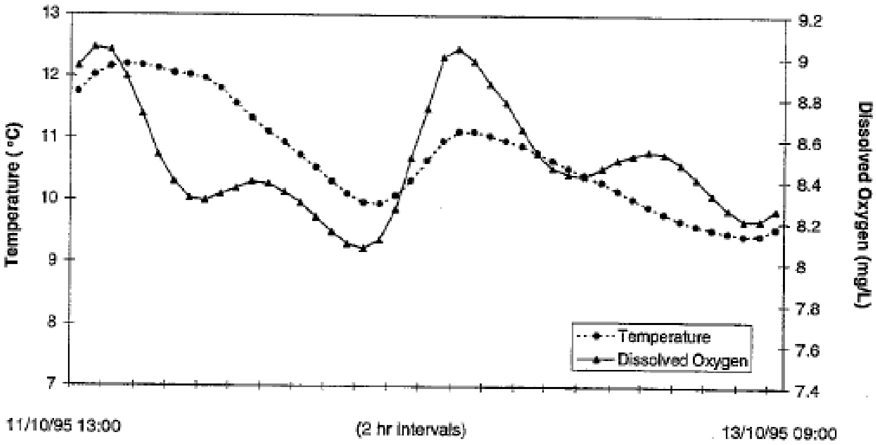


Figure 2.43a Time series of Temperature and Dissolved Oxygen recorded in a willow infested area of lower Quamby Brook in October, 1995.

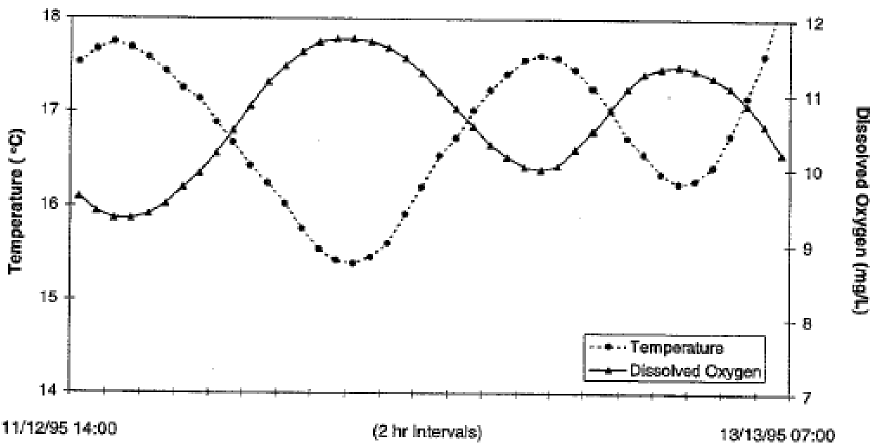


Figure 2.43b Time series of Temperature and Dissolved Oxygen recorded in an area of lower Quamby Brook cleared of willows. Recorded in December, 1995.

Within heavy willow infestations, aquatic plants and algae are virtually absent due to the lack of light penetration. In addition, there is also a substantial organic load within the stream at these sites. The oxygen demand of this matter causes permanent oxygen depletion to occur. In the absence of aquatic plants, diurnal changes in dissolved oxygen is influenced more by the change in water temperature, to which oxygen solubility is related. The lack of turbulence during periods of low flow also limits the level of oxygenation which usually occurs.

From thse results from Quamby Brook it can be concluded that during low flows infestations of willows have a dramatic effect on dissolved oxygen levels in the stream. The aquatic invertebrate community in this area (as shown in a later section on aquatic health) is profoundly affected by this, with many species absent from the stream. While the removal of willows from the area will restore oxygen to the stream and improve stream condition and aquatic habitat, it may present different problems as greater light is suddenly allowed to penetrate the stream. This can facilitate the rapid and pervasive growth of aquatic weeds and algae, which can also drastically affect dissolved oxygen levels. A more sensitive method whereby willows are gradually replaced with more suitable vegetation may circumvent such problems.

3.0 River Ecology

3.1 Macroinvertebrates

As part of the South Esk Catchment Management project macoinverterbates were sampled seasonly from 10 sites in the Meander catchment during 1994/1995 with the aim of assessing the biological status of the Meander River and its main tributaries. Six sites were located on the Meander River and two on Quamby Brook and Western Creek. The sites were selected so as to be evenly distributed throughout the catchment and to allow a longitudinal characterisation of the river, particularly in relation to input sources from land use activities.

Information for this report was also obtained from a national bioassessment program called the Monitoring Riverine Health Iniative (MRHI). An additional three sites, one each on Liffey river and Brushy and Eden rivulets, were sampled during spring and autumn in 1994/1995. Sampling of all 13 sites (Figure 3.1, Map of study sites) was continued through this program until mid 1996. Overall coverage of the basin, while not extensive, does provide a good range of sites from small tributaries in the upper and mid catchment areas to the larger lowland river sites on the Meander. While emphasis was not placed on sites that were known to be ecologically stressed, a small number were selected in disturbed areas, for instance lower Quamby brook downstream from Westbury. More sites will be sampled during 1997 through the continuation of the MRHI. The emphasis during this phase of the program will be on rivers and streams in disturbed environments.

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.

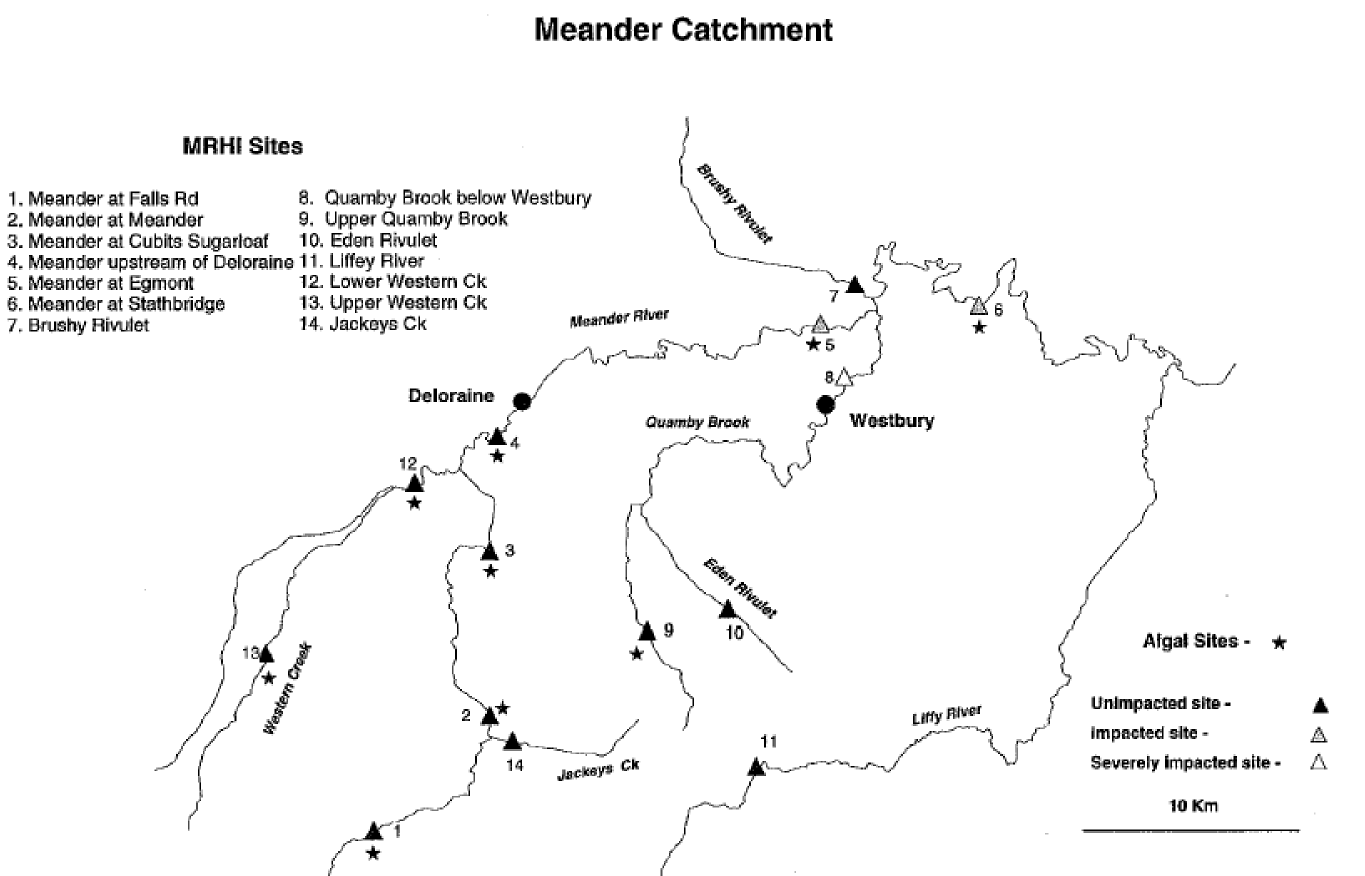


Figure 3.1 Sites in the Meander catchment where macroinvertebrate and algal communities were sampled in 1994 - 95.

- 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 observed 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 unimpacted, slightly impacted or impacted is based on all the infomation available.

3.2 Macroinvertebrate Communities of the Meander Catchment

During the South Esk Catchment Management study all macroinvertebrates were identified to Family level. A total of 50 Families were identified, representing all the major taxonomic groups typical of freshwater streams. Insects were the most dominant, representing around 76% of the total number of taxa collected and accounting for 95% of the total number of individuals collected. The two most dominant Families were Baetidae (Mayflies) and Chironomidae (Midges).

Upper Catchment Tributaries

Much of the upper Meander Catchment is forested and relatively undisturbed with forestry and minor agricultural activities the only land use practices. The macroinvertebrate communities sampled from sites in the upper catchment reflect the relatively unimpacted status of this area. In particular, the sites in Upper Quamby Brook, Liffey River upstream of Liffey, Western Creek at Cheshunt Rd. and Jackeys Creek below Jackeys Marsh all have diverse communities and a number of macroinvertebrate Families indicative of a healthy environment such as Eusthenidae, Austroperlidae and Blepharceridae.

Two tributaries slightly lower in the catchment, Eden Rivulet and Brushy Rivulet have macroinvertebrate assemblages which indicate slightly poorer riverine conditions. Families indicative of clean waters found elsewhere within the catchment, such as Blepharceridae, Austroperlidae and Glossosomatidae, were notably absent from both sites on all sampling occasions. Other common Families such as Eusthenidae and Leptoceridae were only sampled from Eden Rivulet.

Summary statistics for each site, inculding the Signal Index and MRHI score.

Site	Number of invertebrate Families sampled	No. of individuals sampled	Signal Index	*MRHI O/E*
Meander Falls Rd.	25	808	6.80	*0.96*
Meander at Meander	27	957	6.80	*0.99*
Meander at Cubits Sugarloaf	27	841	6.96	*1.15*
Meander upstream of Deloriane	20	639	6.30	-
Meander at Egmont Bridge	**27**	**1148**	**6.16**	***0.77***
Meander at Strath Bridge	**27**	**927**	**6.27**	***0.63***
Upper Western Ck.	27	639	6.93	-
Western Ck. at Montana Falls	25	954	6.76	*0.95*
Upper Quamby	25	602	6.87	*1.07*
Quamby at Westbury *	**14**	**190**	**5.05**	***0.44***
Brushy Rt at Birralee Rd.	20	341	6.40	-
Jackies Ck below Jackies Marsh	25	421	7.05	*1.01*
Upper Liffey	23	346	7.07	*1.02*
Eden Rt.	24	402	6.40	*0.88*

Sites in bold are impacted.
* - Severely impacted sites.

There is evidence to suggest that the macroinvertebrate communties from these two sites are stressed. Both have recorded elevated turbidity and conductivity levels relative to other parts of the catchment. Lower Eden Rivulet under base flows has recorded a turbidity of 22.2 NTU's during spring 1994, some 20 times that recorded in the upper catchment, and both sites have recorded conductivities greater than 100 microsemens, 3 to 4 times higher than that in the upper catchment.

Lower Catchment Tributaries

Quamby Brook downstream of Westbury

The site in Quamby Brook just downstream from Westbury is severely impacted. The typical cobble/boulder substrate found throughout the catchment has been replaced with a mud/silt matrix. An extensive willow infestation has choked the creek and fibrous roots extend across the main channel forming a compact mat. The alteration in habitat, together with numerous water quality problems (see water quality chapter) has meant the probable elimination of a number of key macroinvertebrates from this section of river, such as the ubiquitous mayfly Leptophelbiibae. In fact during the dry season of Autumn 1995 no Trichopterans, Plecopterans or Ephemeropterans were sampled. In the Meander catchment these three groups usually accounted for over 50 percent of the taxa at any site.

Western Creek, Montana Falls

Western Creek at Montana falls, low in the catchment, was suspected to show evidence of an impact because of high turbidity and nutrient loads (see water quality chapter), however the faunal assemblage which was sampled suggests that this section of the creek is in reasonable health. Macroinvertebrate Families indicative of a healthy environment such as Eusthenidae, Blepharceridae, and Glosossomatidae have been found at this site on all sampling occasions. Even though the water quality has been described as poor, the riverine habitat at this site is in reasonable condition with a good boulder/cobble substrate and native riparian vegetation cover. Upstream from the site the habitat is severely degraded with extensive channelisation resulting in the loss of riparian vegetation and the development of a silt/mud substrate. The health of the macroinvertebrate community in this section of the creek is unknown and could possibly be degraded.

Meander River

The upper Meander River at Falls Rd., Meander township and Cubits Sugarloaf all have faunal assemblages indicative of a healthy environment. This is in keeping with water quality data collected during both the MRHI and South Esk Catchment Management program, both of which identified low nutrient and turbidity levels for the upper catchment. It appears that the inflow of Muddy Creek, just upstream of Cubits Sugarloaf, does not adversely affect the macroinvertebrate fauna at the downstream site. This creek drains the majority of Stockers Plain between Native Hop Hill and Meander township, and often has turbidity levels considerably higher than the Meander River. Many of the Families indicative of a healthy riverine environment, such as Philorithridae, Blepharceridae, Glossosomatidae, Austroperlidae and Eustheniidae are found in the upper reaches of the Meander river.

There is a deterioration in the condition of the macroinvertebrate community downstream of Cubits Sugarloaf and it is first noted at the site just upstream of Deloraine (Figure 3.1, Map). A number of macroinvertebrate Families found in the upper catchment, such as Blepharceridae, Eustheniidae, Helicopsychidae, Calocidae and Philopotamidae were not sampled from this site across all four seasons and only one individual each of Glossosomatidae and Philorithridae were found. The reduction in the number of taxa at this site (Table 1.1) occurs over a relatively small length of river, only 10 km separates Cubits Sugarloaf from Deloraine, and is more likely due to land use change rather than natural longitudinal variations in the environment. There are some notable changes in habitat at this site with the introduction of macrophytes, willows and gorse and a general reduction in native riparian vegetation. Perhaps the most noteable feature of this section of the river is that Western Creek enters approximately 4.5 Kms upstream. This creek drains the majority of Dairy Plains and carries a large sediment and nutrient load into the Meander River.

The macroinvertebrate communities at the two sites downstream from Deloraine (Egmont Bridge and Strath Bridge) are not severely degraded, however there is evidence to suggest that they may be responding to an impact. Scirtidae and two sub Families of Chironomidae, Diamesinae and Tanypodinae, were found at all the Meander sites but these two. Glosossomatidae and Blepharceridae were not sampled at the Strath Bridge site and only one specimen of each were sampled from the Egmont Bridge site across all four seasons. Other common Families not sampled from these two sites include Eusthenidae, Philopotamidae and Notonemoridae. The low O/E ratios for both sites suggest that the macroinvertebrate communities are certainly stressed. In this part of the catchment there is some water quality problems, with increased total phosphorous concentrations recorded below Deloraine in summer and turbidity levels around 100 NTU's recorded during flood flows. The riparian zone is degraded in most areas with extensive willow infestation and land clearing, particularly around the Strath Bridge site. There is certainly evidence to suggest that activities in the catchment have altered the riverine environment and biology in the lower sections of the river.

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 (a clustering technique) 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 between sites.

Two main groups were identified and are shown in the Table 1.2 below, their position within the catchment is shown in Figure 3.1.

Membership of each UPGMA Group.

Group 1	**Group 2**
Meander at Falls Rd.	Meander at Egmont Bridge
Meander at Meander	Meander at Strath Bridge
Meander at CubitsSugarloaf	Brushy Rt.
Western Ck. at Montana Falls	Eden Rt
Upper Western Ck.	
Upper Liffy	
Upper Quamby Brook	
Jackeys Ck.	

Group 1 represents 'clean water' sites, sites which predominately occur in the upper catchment. The exception is Western Creek at Montana falls, a creek with known water quality problems but one which exhibits all the biological signs of a healthy river. All the sites in this group have Signal values between 6.76 and 7.06 and MRHI scores above 0.95. Families such as Glossosomatidae, Philorithridae, Blepharceridae, Tipulidae, Eustheniidae and the Chironomidae Sub Family Podonominae characterise this group.

Group 2 represents sites, which are suspected of being impacted. All the sites in this group have Signal values between 6.4 and 6.16. Even though Chessman (1995) describes rivers with an index value greater than 6.0 as 'clean' and less than 6.0 as 'doubtful', there is evidence to suggest that most of the sites in this group are of 'doubtful' quality (see above). Families indicative of a healthy riverine environment, such as Glossosomatidae and Blepharceridae were absent from these sites in Spring and Autumn, and other 'clean water' Families such as Philorithridae and Eustheniidae were only sampled from Eden Rivulet. The dragonfly Aeshnidae and the amphipod Parameletidae characterise this group. The UPGMA grouping provides direct evidence that the macroinvertebrate communities in the lower catchment are different from those in the upper catchment.

Two outlying sites were identified, sites which do not fit into the two groups described above. Quamby Brook at Westbury, the only site in the catchment, which is severely impacted, and the site just upstream of Deloraine. The macroinvertebrate community at this site differs from those found in the upper catchment (Group 1) because of the absence of a number of upper catchment Families, however the macroinvertebrate community is not as stressed as those found lower in the catchment and differs from those found in Group 2 also.

Matching the community structure with the water quality information available using an Ordination procedure and Principal Axis Correlation revealed a significant relationship between conductivity and macroinvertebrate assemblage. Similar but weaker relationships between both total N and total P and macroinvertebrate assemblage were also observed. These relationships separate the upper Meander sites (group 1) , which have low conductivity and low total N and total P concentrations, from the sites lower in the catchment (group 2), which have high conductivity and total N and total P concentrations.

SUMMARY

In general the Meander River and tributaries are in reasonable health, particularly sites in the upper catchment. There is evidence to suggest that the macroinvertebrate communities of the lower Meander (Egmont Bridge, Strath Bridge and perhaps just upstream of Deloraine) are impacted as a result of activities which have degraded the river system. There is a definite change in the macroinvertebrate community from the upper Meander sites to these lower sites, a shift which is more than likely due to anthropogenic disturbances rather than natural longitudinal changes in habitat. It occurs over a small length of river, between Cubits Sugarloaf and Deloraine, and is associated with the demise of a number of macroinvertebrate Families indicative of a healthy environment, such as Eusthenidae, Blepharceridae, Philorithridae and Glosossomatidae. The latter three taxa have infact been sampled below Cubits Sugarloaf, however only six specimens in total have been found after four sampling seasons. The change in the macroinvertebrate community is also associated with the degradation of the riparian zone from one which is predominantly native to one dominated by introduced species, and also associated with a general decrease in water quality.

The status of the lower Meander River, while not badly degraded, is one of concern. Land use practices appear to have affected the macroinvertebrate fauna and continued habitat degradation and water quality and quantity problems will only stress the ecosystem further.

Lower Quamby Brook near Westbury is severely impacted. The macroinvertebrate community in this section of the river is severely degraded and reflects the poor water quality and riverine habitat in this area. An extensive willow infestation has choked the river and removed most of the suitable habitat for macroinvertebrates and the water quality in this section of the river is considered to be the worst in the catchment (see chapter on water quality). In contrast, according to the macroinvertebrate fauna, lower Western Creek at Montana Falls shows all the biological signs of a healthy river. This river is typically turbid and carries a large nutrient load, and upstream of Montana Falls extensive habitat alteration has taken place. The macroinvertebrate fauna however appears to be relatively unaffected by the land use activities in the catchment. This may be due to the good stable substrate and native vegetation cover at the sampling site and the fact that the river does not suffer extreme low flows during dry periods.

Endangered or Threatened Aquatic macroinvertebrates

No endangered or threatened macroinvertebrates have been found within the catchment. Because of poor taxonomic and distributional knowledge, it is very difficult to identify which species are threatened or endangered. This knowledge will be greatly improved through a number of recently commisioned taxonomic studies. To apply this knowledge, macroinvertebrates sampled from broad scale programs such as the MRHI need to be identified to the lowest taxomonic level possible.

3.3 Fish

A limited amount of work on fish populations has been completed in the basin. The age structure of brown trout populations in the Liffey River has been investigated by the Inland Fisheries Commission and the effects of insecticide spaying on trout in the upper Meander was investigated by Davies and Cook (1993). Other species sampled from the basin include *Gadopsis marmoratus* (Black fish) and *Anguilla australis* (Short-finned eel). For a general distribution of freshwater fish throughout Tasmania see 'Tasmanian Freshwater Fishes' (Fulton 1990).

The study by Davies and Cook (1993) investigated the effect of cypermethrin spraying on stream populations of brown trout, *Salmo trutta*, in Sales Rivulet, Bessells Road Creek and Dunning Road Creek in the upper Meander catchment. The resident fish were adversly affected by heavy feeding on dead and dying invertebrates. A number of physiological responses were observed including loss of self-righting ability and startle response, lethargy and a strong 'striped' colouration pattern accompanied by hardening of muscle tissue. These responses were transient, only observed for the first three weeks after spraying, and appeared to be related to the dietary uptake of cypermethrin rather than the direct effects of water-borne cypermethrin.

3.4 Algae

Freshwater algae are simple plants that inhabit just about every freshwater body. They are extremely varied in size, shape and colour and form the basis of food chains in aquatic ecosystems. There are four main types of freshwater algae: Green Algae (Chlorophyceae), of which the threadlike Filamentus Green is the most common, Blue-green Algae (Cyanophyceae), Diatoms (Bacillariophyceae) and Euglenoids (Euglenieae). Excessive growth of algae can cause numerous problems in waterways. Blooms can severely reduce the oxygen content of the water and cause the death of fish and other aquatic animals. Mats of filamentus algae can clog irrigation channels and pipes and severely reduce flow and certain blue-green algal blooms (in particular *Anacystis cyanea*) are toxic and have been known to kill live stock, including cattle, sheep, horses and domestic fowl.

As part of this project algal samples were collected from nine sites in the Meander catchment (Figure 3.1) during 17- 20 January 1995. Samples were taken from both riffle and edgewater habitats by scaping the top surface of a cobble. They were preserved in 5% Formalin and identified to genus level under a compound microscope in the laboratory. Although a comprehensive survey of the catchment was considered beyond the scope of this project, the information gained from the nine sites is invaluable, as very few surveys of this kind have been conducted in Tasmania. Algae have been used to assess the health of rivers, however most work has been in the Northern Hemisphere. Whitton and Kelly (1995) give a brief account of the methods developed for the use of algae to monitor rivers and streams, including the description of several indices. The application of these indices to the Meander data is not possible as the majority are based on species lists derived in the northern hemisphere, however several basic trends can be identified.

Thirty-six Families encompassing 70 genera of algae were identified from the Meander catchment, including Diatoms, Green algae, Blue-green algae and Euglenoids. During the extreme low flows of the 1994-95 summer, many sites throughout the basin showed signs of pervasive blooms of attached filamentous algae (*Spirogyra*, *Mougeotia* and *Zygogonium*). Under favourable conditions, such as those experienced during the summer of 94/95, strands of these genera can grow to over 1 m in length. These three species are common throughout Tasmania (unpublished data) and pose no health problems.

The number of genera of algae recorded per site ranged from 12 to 36, with the lowest numbers recorded from the relatively undisturbed sites in the upper catchment (Figure 3.2). This was the case for both green algae and diatoms and is more than likely due to nutrient limitation in the upper catchment. A strong correlation exists between total Nitrogen and the number of algal taxa, with high total N recorded from all sites in the lower catchment. A similar pattern was found by Chessman (1986) with Diatoms from sites in the LaTrobe valley in Victoria. He also found the Genera *Cymbella*, *Fragilaria*, *Gomphonema*, *Navicula* and *Synedra* were characteristic of the upper catchment sites in the LaTrobe valley. These five genera were all found in the upper catchment of the Meander. The genus *Fragilaria* was only sampled above Cubits Sugarloaf.

The use of Diatoms as indicators of riverine health has been highlighted by a number of workers (see above) and in some cases their response to pollutants may be fundamently different to that of macroinvertebrates (Chessman, 1986), providing extra information that can be used to assess the health of a river. However, currently this information is sparse and not widely used.

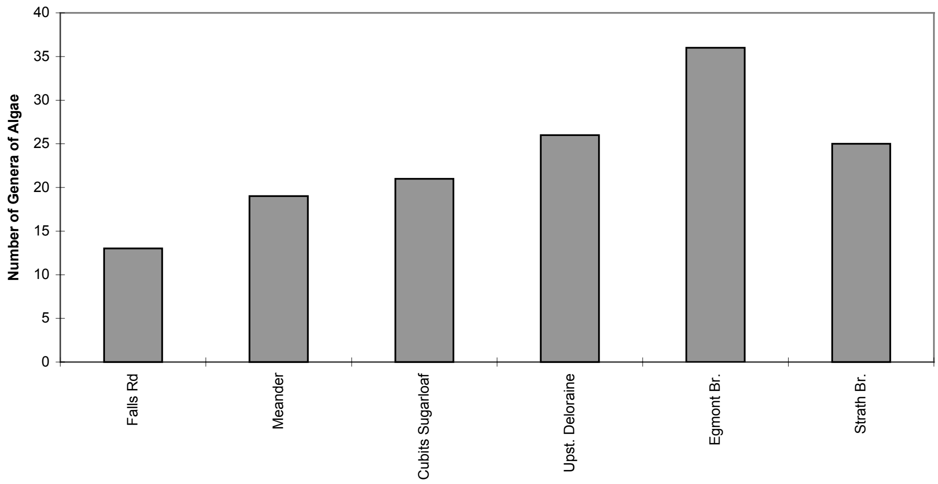


Figure 3.2 Number of Algal Genera sampled along the Meander River.