ENVIRONMENT AGENCY

RIVER CAMEL HEADWATERS NUTRIENT PROJECT

ULRIKE MARTIN AND TIM GEATCHES

OCTOBER 2000

SUMMARY

Diatom surveys in the headwaters of the River Camel in 1997 and 1998 indicated high nutrients. Declining macroinvertebrate quality was evident in the River Camel at Slaughterbridge in the period from 1991 to 1998. Total Inorganic Nitrogen data from the same site showed an increasing trend over the same period.

Further biological and chemical surveys in 1999 identified nutrient enrichment at the source of the River Camel, Hendraburnick tributaries and Starapark tributary. Further work is needed to determine the sources of nutrients.

INDEX

RIVER CAMEL HEADWATERS NUTRIENT PROJECT

1. INTRODUCTION

1.1. River Camel

The River Camel rises on Hendraburnick Downs at an altitude of 280 metres and flows for 40.5 km to the tidal limit at Polbrock (see figure 1). The De Lank River is the main tributary and drains the western edge of Bodmin Moor. The headwaters of the River Camel, De Lank River and Stannon Stream drain the igneous rocks of Bodmin Moor. In the lower catchment, the river flows over sedimentary rock of Devonian origin. There are extensive alluvium deposits in the main river valley and substantial deposits of peat over the Bodmin Moor granite.

Figure 1. River Camel catchment

The land use of the upper catchment, especially to the east, is classified as heathland or rough pasture. The lower catchment is mostly meadowland and permanent pasture, with small areas of arable land. However, between Helland and Wadebridge there are several significant areas of woodland, both coniferous and deciduous.

The River Camel valley and tributaries were notified as a site of special scientific interest (SSSI) on 22 January 1998 because of its pristine habitat. The River Camel is included on the list of candidate Special Areas of Conservation (SAC) sent to the European Commission in 1998. The River Camel and tributaries, their associated woodlands, carr, fen, heath and wet meadows are of special interest for wildlife.

1.2. Eutrophication and organic enrichment in rivers

Eutrophication is the enrichment of waters by inorganic nutrients. This can cause increased production of algae and macrophytes, leading to undesirable changes in water quality and ecology. The growth of plants in water is influenced by several factors such as the supply of nutrients, light, temperature, flow regime, turbidity, grazing and toxic substances.

Phosphorus and nitrogen are the key inorganic plant nutrients. In freshwaters, eutrophication is usually limited by phosphorus. The main anthropogenic source of phosphorus is from sewage discharges while the main source of nitrogen is from agriculture.

The main effect of organic enrichment is an increase in Biochemical Oxygen Demand (BOD) due to the breakdown of organic matter. This can lead to oxygen depletion of waters and increased stress on the ecological community. Nutrient enrichment can also occur as the organic matter is broken down into inorganic nutrients.

Pristine headwater habitats are usually low in nutrients and organic matter. Catchment management issues, such as drainage, land use, fertilisers and waste management, can have a profound effect on the ecology, as the dilution capacity of these headwaters is small.

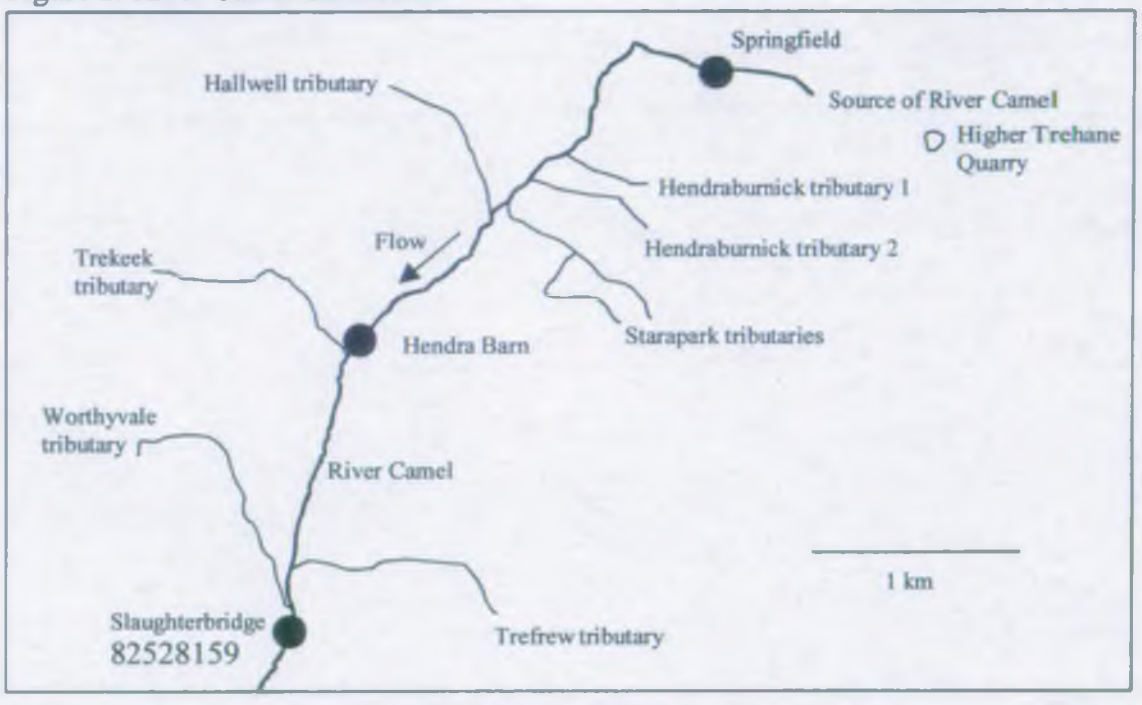
1.3. Diatom surveys (1997 and 1998)

A diatom survey of the River Camel and tributaries was undertaken in September 1997 to determine the trophic status (see reference 7.1). The survey identified evidence of high nutrients in the headwaters of the River Camel. A further survey in October 1998 indicated high nutrients to the source of the River Camel (see reference 7.2).

1.4 Macroinvertebrates

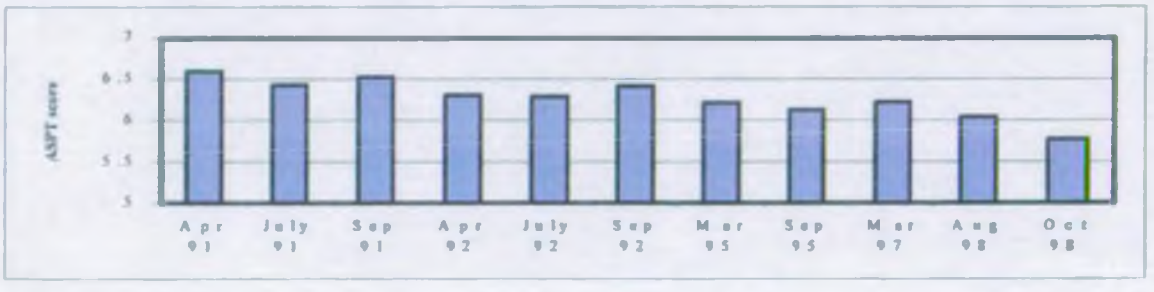
The River Camel at Slaughterbridge is the most upstream site routinely monitored (see figure 2). Macroinvertebrates were sampled using standard methods (see reference 7.3). Data was analysed by comparing actual with predicted biotic scores and calculating an Environmental Quality Index (EQI) to give an overall assessment of ecological quality (see reference 7.4).

Figure 2. River Camel headwaters



In 1991, the River Camel at Slaughterbridge had an EQI class a, indicating very good quality. In 1995 the site had EQI class b, indicating good quality. There has been an apparent decline in ASPT scores at Slaughterbridge since 1991 (see figure 3).

Figure 3. ASPT scores at Slaughterbridge since 1991

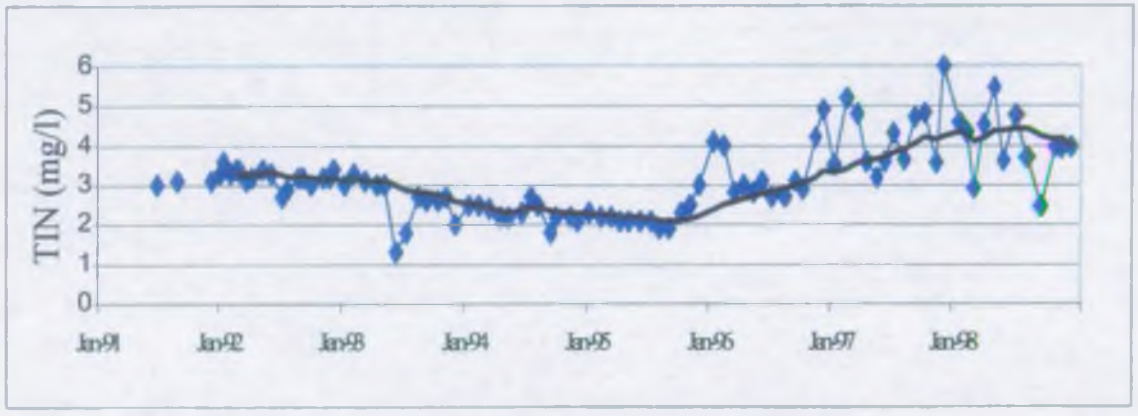


1.5 Nutrient data

Total Inorganic Nitrogen (TIN) and Soluble Reactive Phosphorus (SRP) data for 1991 to 1998 are plotted below in figures 4 and 5. The trendline is a twelve point moving average to give an indication of year on year trends.

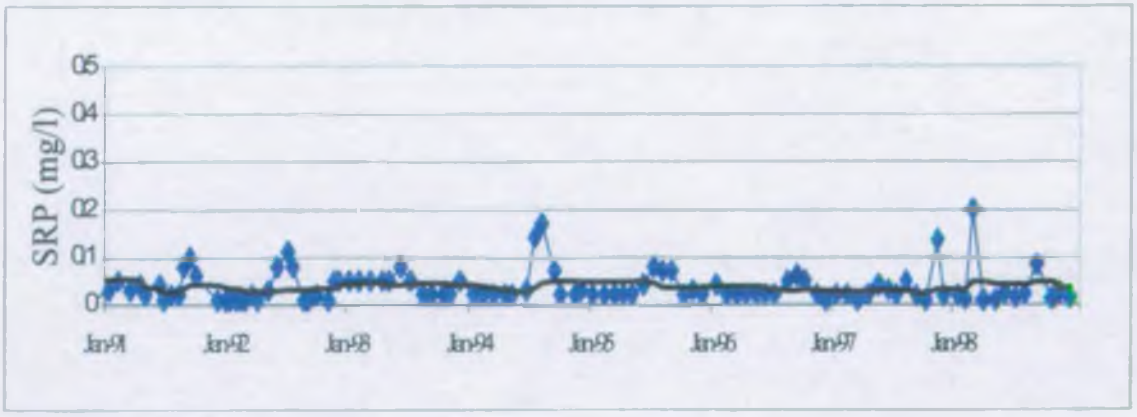
For TIN there was an apparent decreasing trend from 1991 until 1996 (see figure 4 below). Since then there has been a steady increase in TIN concentrations exceeding those in 1991.

Figure 4. River Camel at Slaughterbridge (82528159) – TIN concentrations



There was no observable trend of increasing SRP for 1991 to 1998 (see figure 5 below). This suggests that high nutrients in the headwaters of the River Camel may be due to nitrogen rather than phosphorus.

Figure 5. River Camel at Slaughterbridge (82528159) – SRP concentrations



1.6 Objective

To identify and describe nutrient issues in the River Camel headwaters.

2 METHODS

2.1 Diatoms

Diatom samples were taken on 22 September 1999 (except Higher Trehane Quarry sample taken on 26 October 1999) according to standard Environment Agency methodologies (see reference 7.3). Samples were taken in the main river and tributaries upstream of Slaughterbridge (see figure 2).

Samples were stored in the fridge and processed according to standard Environment Agency methodology (see reference 7.5). The Trophic Diatom Index (TDI) and % Pollution Tolerant Valves (%PTV) were calculated to establish the degree of eutrophication and organic enrichment (see section 1.2 and reference 7.5). Nutrient and organic pollution sensitivities are shown in appendices 8.1 and 8.2. Nomenclature in this report follows the TDI User's Manual of Bowburn Consultancy (see reference 7.5) and Hartley et al. (see reference 7.6).

2.2 Macroinvertebrates

Macroinvertebrate samples were taken in the spring, summer and autumn of 1999 according to standard Environment Agency methodologies (see reference 7.3). A three-minute kick sample was taken in the River Camel at Springfield and Hendra Barn (see figure 2). A one-minute search was conducted to look for any additional taxa in habitat not covered by the three-minute kick sample. Samples were preserved in Industrial Methylated Spirit (95%) and Glycerol (5%) for further examination in the laboratory. Site features were also recorded according to Environment Agency methodologies.

In the laboratory, samples were sieved and sorted. Taxa were enumerated and identified to family level. Macroinvertebrate data was analysed using standard Environment Agency biotic scores, prediction and comparisons (see references 7.3 and 7.4). Biological Monitoring Working Party (BMWP) and Average Score Per Taxon (ASPT) and number of scoring taxa were calculated for all three seasons combined. RIVPACS III+ was used to predict the biotic scores that would be expected for a clean site according to the recorded site features. Environmental Quality Indices (EQI) were calculated using the expected and observed scores.

2.3 Nutrients

Chemical samples were taken in the River Camel and tributaries above Slaughterbridge during September and November 1999. Spot samples were taken of the main river, tributaries and spring sources. Some chemical samples were also taken in the Davidstow Stream, River Inny, River Ottery and River Valency for comparison. The headwaters of all these catchments drain Bodmin Moor.

Data was interpreted using proposed nutrient standards for General Quality Assessment (GQA) (see reference 7.7). The zonal system splitting class boundaries into four zones for Total Inorganic Nitrogen (TIN) and Soluble Reactive Phosphorus (SRP) determined by stream order and altitude was used. Nearly all sites in the eastern half of England and low lying areas in western England would lie in zones 1

and 2. Zone 4 sites are largely restricted to upland areas whilst zone 3 sites are located in river reaches of an intermediary nature and those receiving waters from more upland areas.

There is a case for using the zone 4 standards, applicable to upland watercourses, for this project. However, without any definitive guidance on which standards are the most appropriate, zone 3 standards were adopted for the River Camel headwaters project (highlighted in appendices 8.3 and 8.4). Currently, only the national classification for SRP has been adopted. No nitrogen standards for the protection of the environment are currently in force. These standards are being used as an analytical tool only and no inference should be made that these standards will be adopted for the River Camel.

2.4 Waste spreading

Waste return forms and waste exemption maps from the waste exemption files were used to assess the exempt waste spreading in the River Camel headwaters. Permitted limits set out in the Code of Good Agricultural Practice for the Protection of Water (see reference 7.8) were used to assess the amount of exempt waste applied to the land.

3. RESULTS

3.1 Diatoms

Grid references, TDI, %PTV, number of taxa and dominant species of each sample taken in September 1999 are given in appendix 8.5.

3.2 Macroinvertebrates

Macroinvertebrate data for spring, summer and autumn 1999 are shown in appendix 8.6.

3.3 Nutrients

Site details and chemical results of each sample taken in September and November 1999 are given in appendices 8.7 and 8.8.

3.4 Waste spreading

All fields where exempt waste is spread in the area of the headwaters of the River Camel, the Davidstow Stream and the headwaters of the River Ottery, River Inny and River Valency are shown in figure 12.

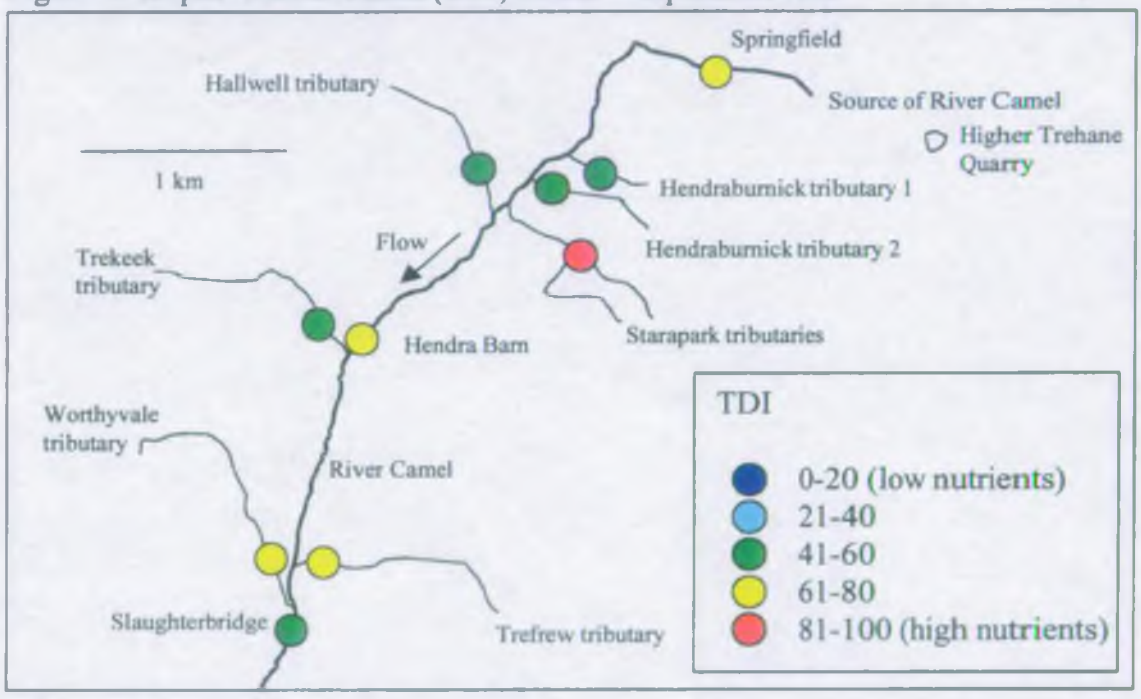
4 DISCUSSION

4.1 Diatoms

TDI scores are used to infer the degree of nutrient enrichment and are shown below in figure 6. The River Camel at Springfield and Hendra Barn, and Starapark tributary were dominated by diatom taxa favoured by very high nutrient concentrations (see table 1 and appendix 8.1). These sites had the highest TDI scores.

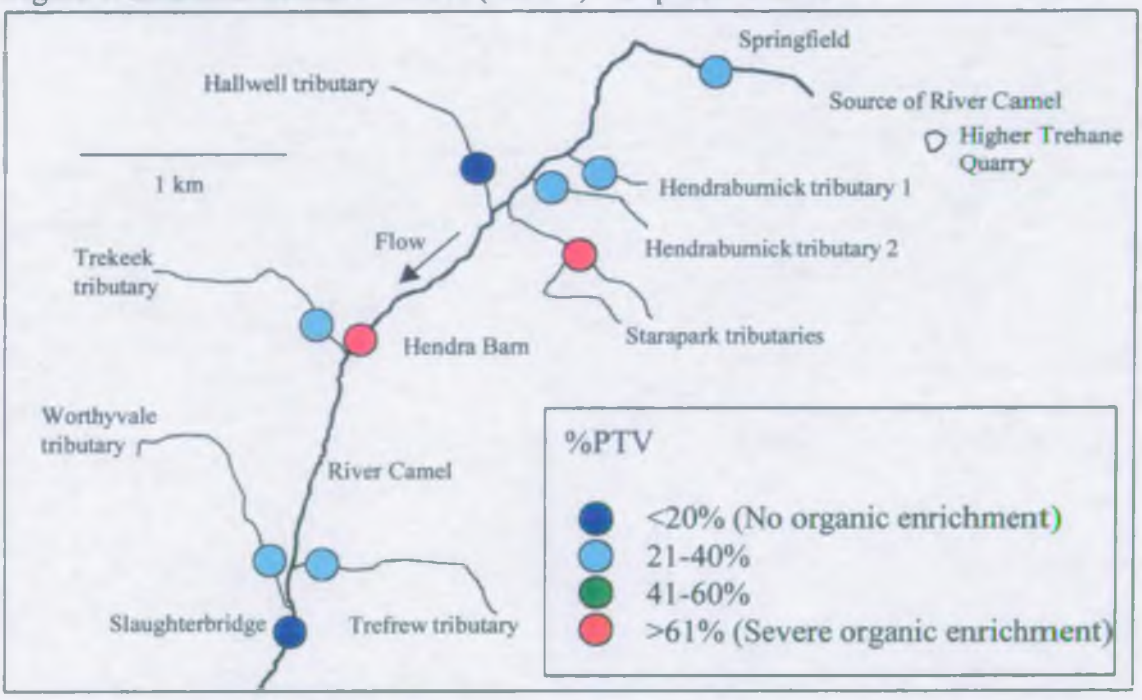
The Worthyvale tributary and Trefrew tributary also had high TDI scores but dominant diatom taxa indicated intermediate to high nutrient concentrations (see appendix 8.1). At all other sites the TDI scores and dominant diatom taxa indicated intermediate to low nutrient concentrations.

Figure 6. Trophic Diatom Index (TDI) scores – September 1999



The percentages of pollution tolerant valves (%PTV) are used to infer the degree of organic pollution and are shown below in figure 7. Severe organic enrichment was evident in the Starapark tributary and the River Camel at Hendra Barn. The Starapark tributary is possibly the source of organic pollution evident at Hendra Barn. There was no or slight evidence of organic enrichment at all other sites.

Figure 7. Pollution Tolerant Valves (%PTV) – September 1999



4.2 Macroinvertebrates

Observed, expected, EQI and EQI classes for both sites are shown below in table 1. Observed scores are below expected scores for both sites. The EQI class for both sites would be b, due to the ASPT scores, indicating good water quality. Macroinvertebrates are generally not good indicators of eutrophication especially in headwater areas where increased productivity may actually increase diversity and abundance. The lower than predicted scores are likely to be attributable to organic enrichment rather than eutrophication (see section 1.2).

Table 1. Biotic scores and EQI classes

	River Camel at Springfield				River Camel at Hendra Barn			
	Observed	Expected	EQI	Class	Observed	Expected	EQI	Class
BMWP	177.0	199.7	-	-	181.0	215.0	-	-
No. of taxa	29.0	30.5	0.95	a	30.0	32.4	0.93	a
ASPT	6.10	6.55	0.93	b	6.03	6.63	0.91	b

The seasonal biotic scores are shown in table 2. The summer and autumn biotic scores in the River Camel at Springfield are noticeably lower. This was mainly due to the almost complete absence of Ephemeroptera (Mayfly), Plecoptera (Stonefly) and Trichoptera (Caddis) families, known to be sensitive to organic pollution. It was notable that Psychodidae, Syrphidae and Ptychopteridae were recorded, with

Psychodidae particularly abundant (see appendix 8.2). These air breathing Diptera (True Flies) families are usually associated with decaying organic matter.

Table 2. Seasonal biotic scores

	River Camel at Springfield			River Camel at Hendra Barn		
	Spring	Summer	Autumn	Spring	Summer	Autumn
BMWP	144	97	87	120	114	123
No. of taxa	24	18	17	21	21	22
ASPT	6.00	5.39	5.12	5.71	5.43	5.59

4.3 Nutrients

The six General Quality Assessment (GQA) class boundaries are expressed as median values. For the purposes of this report spot samples at face value were used to give an indication of which class a sample would fall into. The GQA classes run from A (Very good) to F (Bad).

Soluble Reactive Phosphorus (SRP) results in September and November were mainly class A (Very good) or class B (Good) (see figures 8 and 9 below). Only the Higher Trehane Quarry, some of the springs of the source of the River Camel and the discharge of Davidstow Creamery into the River Inny had higher SRP concentrations. There is no indication that SRP concentrations are elevated in the River Camel headwaters.

Figure 8. GQA classes for SRP - September 1999

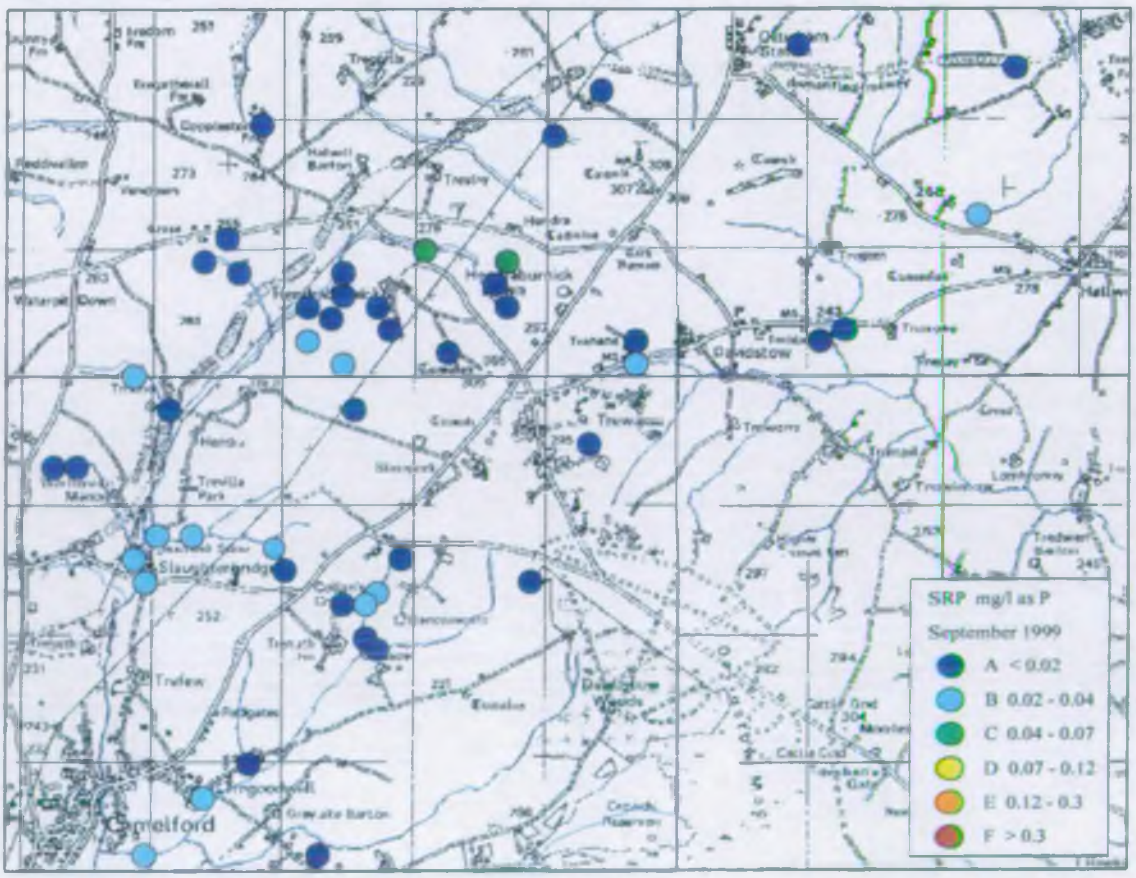
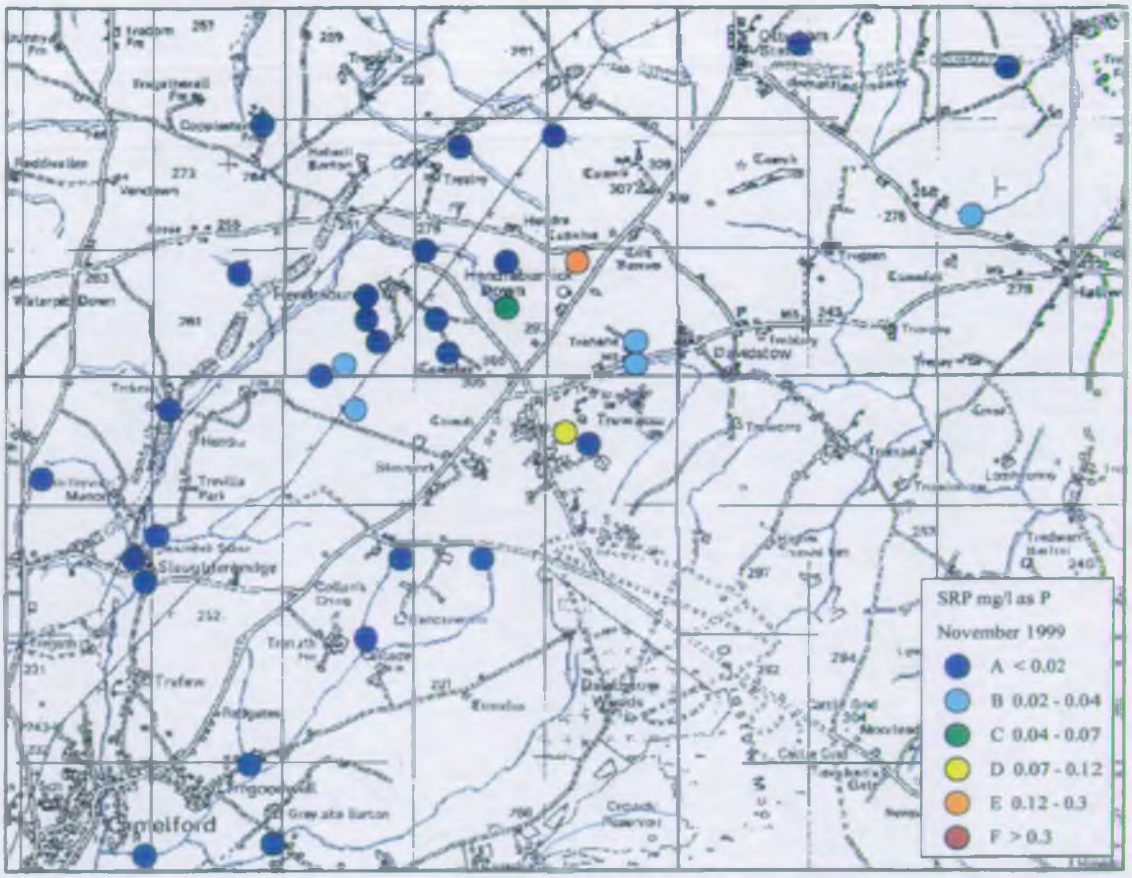


Figure 9. GQA classes for SRP - November 1999



Total inorganic (TIN) results were more variable with sample results in all six GQA classes (see figures 10 and 11 below). The most noticeable areas of poor water quality (class E and F) in September and November 1999 were the source of the River Camel, Hendraburnick tributaries and Starapark tributary. Concentrations of TIN in these areas were consistent with the increasing TIN concentrations since 1996 in the River Camel at Slaughterbridge (see section 1.5).

Figure 10. GQA classes for TIN – September 1999

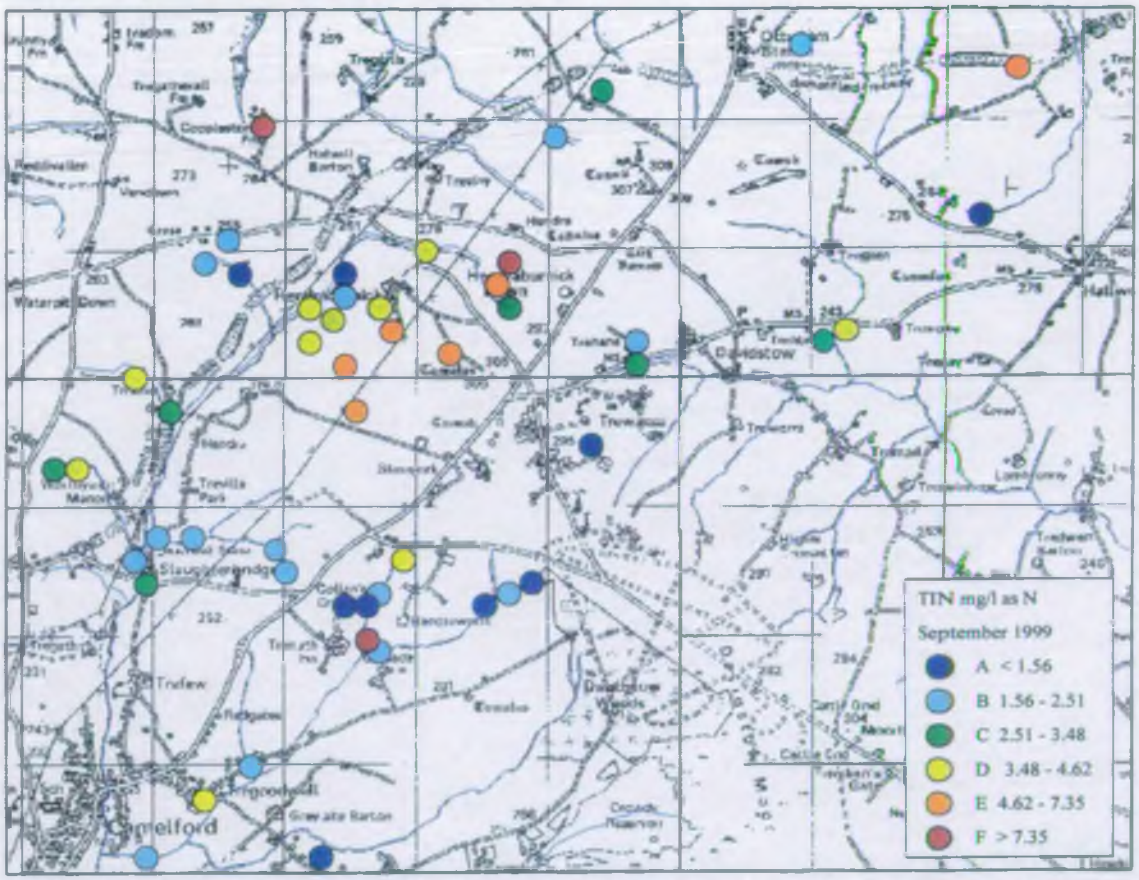
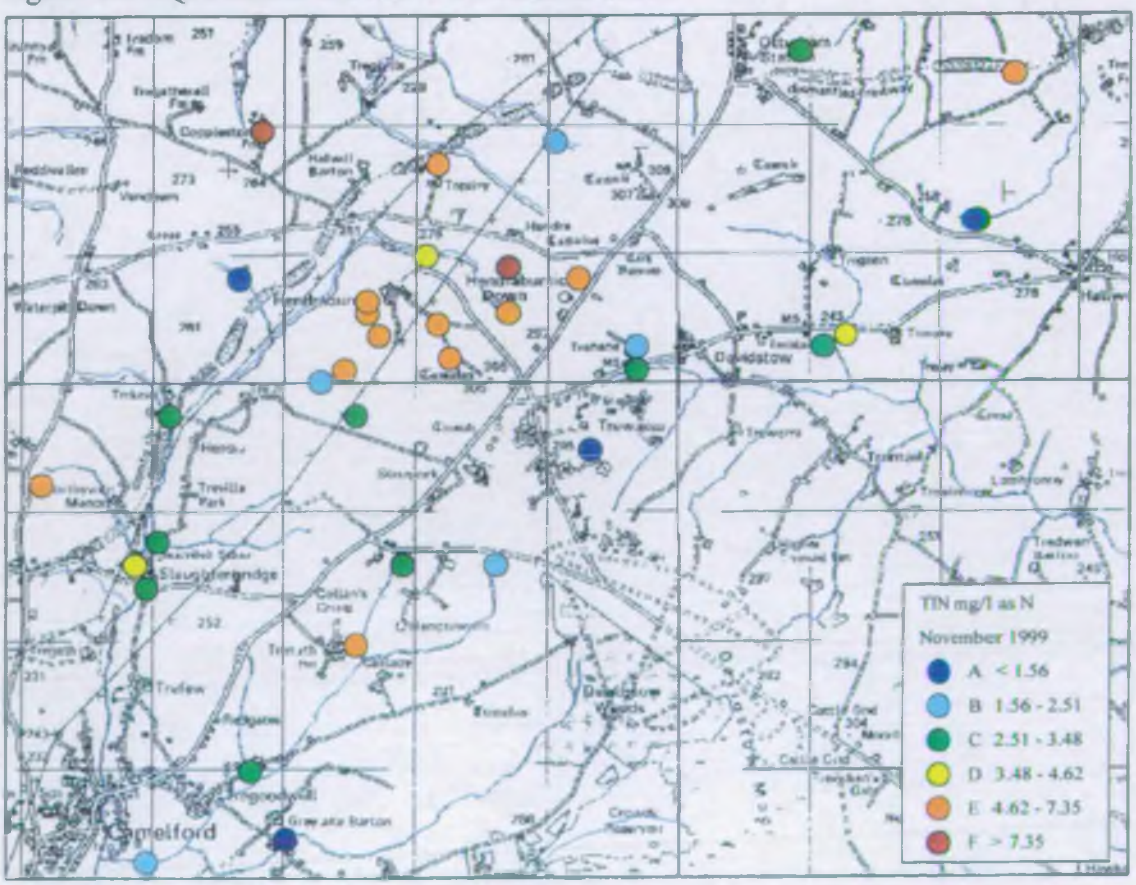


Figure 11. GQA classes for TIN – November 1999



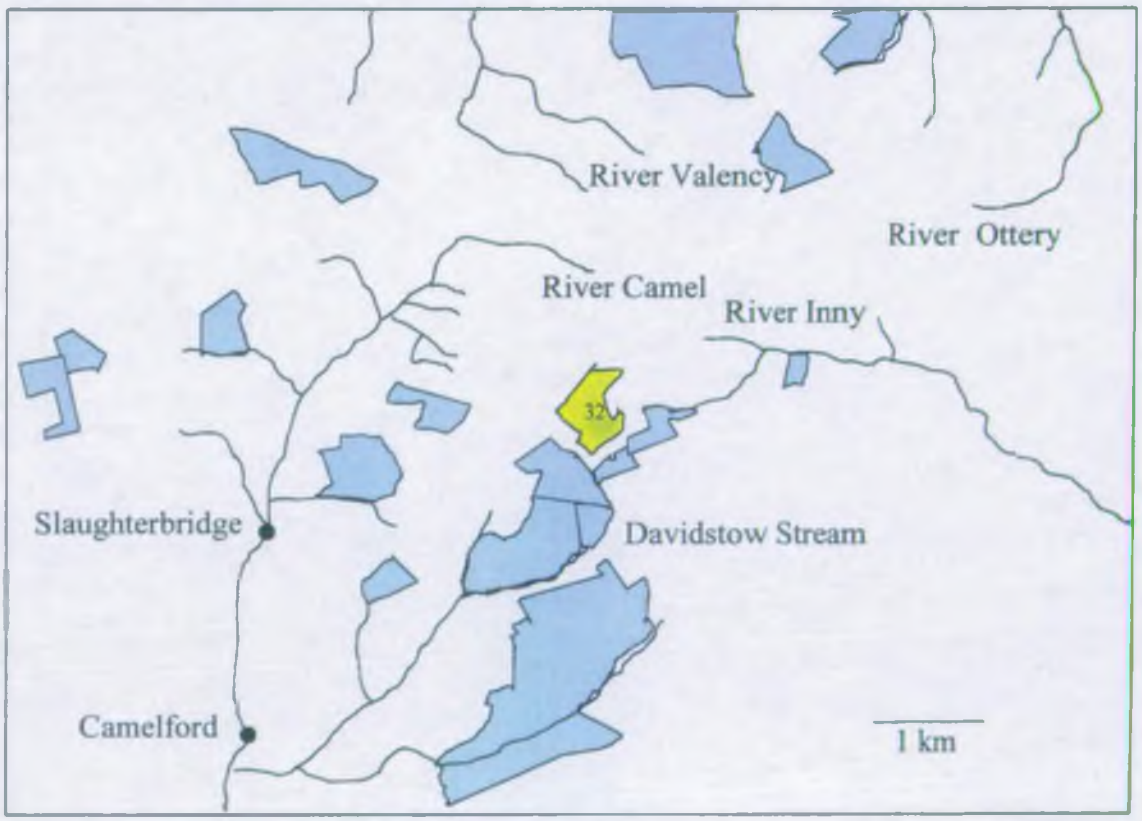
4.4 Waste spreading

Areas of exempt waste disposal are shown below in figure 12. The application of exempt waste was within permitted limits.

Davidstow Creamery has spread sludge waste from their biological effluent plant on land adjacent to the creamery (field 32 in figure 12 below). In 1992 approximately 10 tonnes of sludge waste was being spread daily. In 1996 the creamery applied for an exemption licence on the basis of the waste being for agricultural benefit. ADAS confirmed the sludge to be a valuable source of nitrogen and phosphorus. However, soil analysis of the spreading area found the land adjacent to the creamery was unsuitable for spreading, as phosphorus indices were too high. No analysis was made of nitrogen. See file WM0205 NC032, Dairy Crest Ltd. – Davidstow Creamery for further details.

Field 32 is within the Inny catchment but extends to the Inny/Camel catchment boundary. This area is adjacent to the Hendraburnick, Starapark tributaries and the source of the River Camel.

Figure 12. Exempt waste spreading areas



5 CONCLUSIONS

5.1 Diatom surveys in 1997 and 1998 indicated elevated nutrients and organic enrichment in the headwaters of the River Camel.

5.2 Routine macroinvertebrate data of the River Camel at Slaughterbridge indicated decreasing ecological quality since 1991.

5.3 Routine chemical data of the River Camel at Slaughterbridge indicated increasing concentrations of Total Inorganic Nitrogen from 1991 to 1998.

5.4 Diatom surveys in 1999 indicated very high nutrient concentrations in the Starapark tributary and the River Camel at Springfield and Hendra Barn.

5.5 Macroinvertebrate data of the River Camel at Springfield and Hendra Barn indicated good water quality, although taxa usually associated with decaying organic matter were in abundance.

5.6 Chemical data taken in 1999 indicates TIN concentrations were highest at the source of the River Camel, Hendraburnick tributaries and Starapark tributary.

5.7 One area used for exempt waste spreading known to be unsuitable for waste application is proximal to the Starapark tributary, Hendraburnick tributaries and the source of the River Camel.

6 RECOMMENDATIONS

6.1 A diatom monitoring programme to be set up to determine the extent of nutrient enrichment within Cornwall Area.

Action – Biology Team Leader

6.2 Additional water quality monitoring in the River Camel at Slaughterbridge, Springfield and Hendra Barn.

Action – Environment Protection Manager/Environment Planning Manager

6.3 Review of Total Inorganic Nitrogen data in the River Camel at Slaughterbridge since 1998.

Action – Environment Protection Manager/Environment Planning Manager

6.4 Further investigation of the Starapark tributary, Hendraburnick tributaries and source of River Camel to determine sources of Total Inorganic Nitrogen.

Action – Environment Protection Manager/Environment Planning Manager

6.5 Assessment of River Camel fishery data to determine any deleterious impact due to nutrient enrichment.

Action – Fisheries Science Team Leader

Ulrike Martin
Student
Tim Geatches
Biologist
October 2000

7 REFERENCES

7.1 M. Kelly (1997) Analysis of benthic diatom samples from the River Camel and tributaries, Cornwall. Unpublished report to Environment Agency. Durham: Bowburn Consultancy

7.2 M. Kelly (1998) Analysis of benthic diatom samples from the River Camel and tributaries, Cornwall; Report to Environment Agency, South West Region, October 1998. Durham: Bowburn Consultancy

7.3 J. Murray-Bligh (1999) Procedures for Collecting and analysing Macroinvertebrate samples. Issue No. 2.0

7.4 R. Cox, J.F. Wright, M.T. Furse, D. Moss (1995), RIVPACS III (River Invertebrate Prediction and Classification System) User Manual

7.5 Bowburn Consultancy, Martyn Kelly (1996). The Trophic Diatom Index: A User's Manual. Bristol: Environment Agency.

7.6 B. Hartley, H.G. Barber, J.R. Carter (1996) An Atlas of British Diatoms (edited by P.A. Sims). Bristol: Biopress

7.7 Mainstone C.P., Ashley S., Gunby A., Parr W., Woodrow D., Turton P. & McAllen Y. (1995) Development and Testing of General Quality Assessment scheme. Nutrients in Rivers and Canals. Draft Report by WRc for NRA. Project 469/11/HO

7.8 Ministry of Agriculture, Fisheries and Food: Welsh Office Agriculture Department (October 1998), Code of Good Agricultural Practice for the Protection of Water

8 APPENDICES

Appendix 8.1. Nutrient sensitivity of dominant diatom species

Dominant species	Pollution sensitivity	
Achnanthes lanceolata-type	5	Favoured by very high concentration of nutrients
Small *Navicula* sp.	5	
Gomphonema parvulum	5	
Navicula sp.	4	Favoured by high concentration of nutrients
Reimeria sinuata	4	
Achnanthes sp.	3	Favoured by intermediate concentration of nutrients
Cocconeis placentula	3	
Fragilaria vaucheriae	3	
Achnanthes minutissima-type	2	Favoured by low nutrient concentrations

Appendix 8.2. Inferred degree of organic pollution

% PTV	
< 20%	Free of significant organic pollution
21 – 40%	Some evidence of organic pollution
41 – 60%	Org. pollution likely to contribute significantly to eutrophication of site
> 61%	Site is heavily contaminated with organic pollution

Appendix 8.3. Proposed GQA standards – Total Inorganic Nitrogen (mg/l as N)

Zone	Class boundary				
	A / B	B / C	C / D	D / E	E / F
1	4.07	5.69	7.10	8.60	11.04
2	3.09	4.47	5.77	7.30	10.20
3	1.56	2.51	3.48	4.62	7.35
4	0.50	0.89	1.36	2.04	3.13

Appendix 8.4. Proposed GQA standards – Soluble Reactive Phosphorus (mg/l as P)

Zone	Class boundary				
	A / B	B / C	C / D	D / E	E / F
1	0.14	0.37	0.66	1.18	1.91
2	0.05	0.10	0.23	0.55	1.44
3	0.02	0.04	0.07	0.12	0.30
4	0.01	0.02	0.03	0.04	0.08

Appendix 8.5. Diatom results - September 1999

Site	Grid reference	TDI	% PTV	No. taxa	Dominant taxa (> 10%)
Springfield	1310 8802	72	37.7	29	*Reimeria sinuata* (18%), small *Navicula* sp. (13%), *Achnanthes lanceolata*-type (13%); *Navicula gregaria* (12%)
Hendraburnick1	1230 8750	42	24.8	19	*Achnanthes minutissima*-type (58%)
Hendraburnick2	1212 8750	51	32.3	23	*Achnanthes minutissima*-type (30%), small *Navicula* sp. (15%), *Fragilaria vaucheriae* (12%)
Starapark	1214 8728	89	83.5	18	small *Navicula* sp. (67%)
Hallwell	1186 8750	45	8.2	16	*Achnanthes* sp. (68%), *Achnanthes minutissima*-type (16%)
Trekreek	1112 8678	56	28.7	20	*Achnanthes minutissima*-type (34%), *Fragilaria vaucheriae* (21%), *Gomphonema parvulum* (19%)
Hendra Barn	1125 8670	80	68.8	17	small *Navicula* sp. (54%), *Fragilaria vaucheriae* (15%)
Trefrew	1096 8573	62	22.9	19	*Cocconeis placentula* (30%), *Navicula gregaria* (10%), *Reimeria sinuata* (11%)
Worthyvale	1090 8553	68	39.8	26	*Achnanthes* sp. (14%), *Cocconeis placentula* (13%), small *Navicula* sp. (11%), *Navicula gregaria* (11%)
Slaughterbridge	1093 8551	58	19.7	20	*Cocconeis placentula* (66%), small *Navicula* sp. (13%)

Appendix 8.6. Macroinvertebrate results – spring, summer and autumn 1999

	River Camel at Springfield			River Camel at Hendra Barn		
	28.04.99	6.07.99	25.10.99	28.04.99	6.07.99	25.10.99
Family	Spring 99	Summer 99	Autumn 99	Spring 99	Summer 99	Autumn 99
Scoring taxa						
Heptageniidae	C		6	1		
Leptophlebiidae	7					6
Ephemerellidae	1			2	B	
Taeniopterygidae	B					
Leuctridae	5	3	B	8	B	B
Chloroperlidae		1		2	2	
Odontoceridae	3					1
Goeridae				2		2
Sericostomatidae	1			2		
Nemouridae		1			2	3
Rhyacophilidae	1	3			7	B
Polycentropodidae	5	1				
Limnephilidae	3	8	B	B	3	7
Ancylidae			1		1	5
Gammaridae	C	C	C	B	B	B
Coenagriidae						2
Planariidae	3		B		1	
Dytiscidae		B	1		B	4
Hydrophilidae	1	C	3		B	
Scirtidae			2	2	1	
Elmidae	B	B	B	B	B	B
Hydropsychidae				1		1
Tipulidae	B	B	B	B	B	B
Simuliidae	9	B	B	4	B	B
Baetidae	C	D	C	5	C	B
Hydrobiidae	B	7	B	B	B	B
Lymnaeidae	4		B	1		B
Sphaeriidae	7	1		5	2	7
Glossiphoniidae	1			2		
Asellidae	1			4	1	5
Chironomidae	B	C	C	C	D	C
Oligochaeta	B	B	B	B	B	B
Non-scoring taxa						
Ceratopogonidae	1	3		1	1	1
Empididae	1	B	3	1	B	6
Hydracarina	1	7	5	2	B	9
Ostracoda	1			2	2	7
Collembola		2				
Veliidae		8			3	
Psychodidae		C	B	1	B	4
Syrphidae		1	1			
Ptychopteridae		5				
Orabatei		B				
Dixidae			1			
Muscidae					1	

Abundance categories

Abundance	Number of Individuals
1 – 9	1 – 9
B	10 – 99
C	100 – 999
D	1000 – 9999
E	> 10 000

Appendix 8.7. River Camel nutrient data

NGR	SX 1090 8553	SX 1090 8553	SX 1034 8632	SX 1023 8631	SX 8643 1057	SX 1096 8573	SX 1096 8573	SX 1136 8575
Site code	A	A	B	C	GGG	D	D	E
Site description	Worthyvale tributary	Worthyvale tributary	Worthyvale tributary	Worthyvale tributary	Worthyvale tributary	Trefrew tributary	Trefrew tributary	Trefrew tributary
Catchment	Camel	Camel	Camel	Camel	Camel	Camel	Camel	Camel
Date	7.Sept. 99	16.Nov. 99	7.Sept. 99	7.Sept. 99	16.Nov. 99	7.Sept. 99	16.Nov. 99	7.Sept. 99
Time	09:44	10:05	10:25	10:37	10:20	11:17	11:50	11:36
Ammonia - as N (mg/l)	<0.03	< 0.03	0.045	0.121	< 0.03	0.031	< 0.03	<0.03
Nitrogen total oxidised - as N (mg/l)	1.87	4.28	3.68	3	7.02	2.33	2.8	2.43
Nitrate (mg/l)	1.87	4.27	3.67	2.99	7.02	2.32	2.8	2.43
Nitrite (mg/l)	<0.004	0.01	0.011	0.0132	<0.004	0.007	< 0.004	<0.004
Ortho-phosphate (mg/l) SRP	0.031	< 0.01	<0.01	<0.01	<0.01	0.035	< 0.01	0.024
Phosphorus total - as P (mg/l)	0.081	0.037	0.025	0.049	0.034	0.071	0.031	0.049
Nitrogen total inorganic (mg/l) TIN	1.904	4.31	3.726	3.1242	7.05	2.358	2.83	2.464

NGR	SX 1159 8787	SX 1159 8787	SX 1139 8786	SX 1310 8802	SX 1310 8802	SX 1310 8802	SX 1365 8760	SX 1365 8760
Site code	M	M	N	O	O	O	P	P
Site description	Hallwell tributary	Hallwell tributary	pipe at Hallwell tributary	River Camel at Springfield	River Camel at Springfield	River Camel at Springfield	Source of Camel, next to spring under stone	Source of Camel, next to spring under stone
Catchment	Camel	Camel	Camel	Camel	Camel	Camel	Camel	Camel
Date	7.Sept. 99	16.Nov. 99	7.Sept. 99	7.Sept. 99	22.Sept. 99	16.Nov. 99	7.Sept. 99	16.Nov. 99
Time	14:30	10:50	14:40	15:00	12:00	11:00	15:26	11:10
Ammonia - as N (mg/l)	0.084	0.041	<0.03	0.12	0.03	< 0.03	<0.03	0.04
Nitrogen total oxidised - as N (mg/l)	1.15	1.35	0.99	3.56	5.29	3.48	3.12	4.88
Nitrate (mg/l)	1.14	1.35	0.986	3.5	5.29	3.48	3.12	4.88
Nitrite (mg/l)	0.011	<0.004	<0.004	0.0594	0.0273	< 0.004	0.0048	< 0.004
Ortho-phosphate (mg/l) SRP	0.013	<0.01	0.013	0.048	Anal. Not poss	< 0.01	<0.01	0.048
Phosphorus total - as P (mg/l)	0.082	0.022	0.071	0.127	0.092	0.031	0.027	0.133
Nitrogen total inorganic (mg/l) TIN	1.235	1.39	1.29	3.6794	5.32	3.51	3.4248	4.92

Appendix 8.7. River Camel nutrient data (continued)

NGR	SX 1212 8750	SX 1324 8722	SX 1316 8744	SX 1362 8776	SX 1362 8776	SX 1360 8772	SX 1255 8685	SX 1255 8685
Site code	Q	W	HHH	Y	Y	Z	AA	AA
Site description	Hendraburnick tributary2	well, spring for Hendraburnick Farm	ditch below well for Hendraburnick Farm	source of Camel, spring below hut	source of River Camel, spring below hut	source of River Camel in marshland	spring, probably fed by field drainage, into Starapark tributary	spring, probably fed by field drainage, into Starapark tributary
Catchment	Camel	Camel	Camel	Camel	Camel	Camel	Camel	Camel
Date	8.Sept. 99	16.Nov. 99	16.Nov. 99	8.Sept. 99	16.Nov. 99	8.Sept. 99	8.Sept. 99	16.Nov. 99
Time	10:10	12:50	12:40	12:32	11:40	12:50	13:57	14:05
Ammonia - as N (mg/l)	<0.03	< 0.03	< 0.03	0.25	< 0.03	<0.03	0.346	< 0.03
Nitrogen total oxidised - as N (mg/l)	3.88	6.02	5.95	8.07	8.04	6.64	4.87	3.28
Nitrate (mg/l)	3.88	6.02	5.95	8.05	8.04	6.64	4.85	3.28
Nitrite (mg/l)	<0.004	< 0.004	< 0.004	0.0249	< 0.004	<0.004	0.016	0.0049
Ortho-phosphate (mg/l) SRP	0.012	< 0.01	< 0.01	0.064	0.013	0.011	0.014	0.021
Phosphorus total - as P (mg/l)	0.03	< 0.02	0.029	0.111	0.035	0.026	0.067	0.049
Nitrogen total inorganic (mg/l) TIN	4.184	6.05	5.98	8.3249	8.07	6.674	5.212	3.31

NGR	SX 1254 8746	SX 1214 8728	SX 1093 8551	SX 1093 8551	SX 1186 8560	SX 1187 8557	SX 1112 8678	SX 1112 8678
Site code	KKK	BB	F	F	G	H	I	I
Site description	ditch into Starpark tributary	Starapark tributary	River Camel at Slaughterbridge	River Camel at Slaughterbridge	Trefrew tributary	Trefrew tributary	Trekeek tributary	Trekeek tributary
Catchment	Camel	Camel	Camel	Camel	Camel	Camel	Camel	Camel
Date	16.Nov. 99	8.Sept. 99	7.Sept. 99	16.Nov. 99	7.Sept. 99	7.Sept. 99	7.Sept. 99	16.Nov. 99
Time	14:00	14:10	11:55	10:10	12:12	12:16	13:35	10:30
Ammonia - as N (mg/l)	0.217	<0.03	<0.03	0.036	0.288	0.041	0.046	< 0.03
Nitrogen total oxidised - as N (mg/l)	1.49	3.69	2.77	3.19	2.01	2.36	2.79	3.11
Nitrate (mg/l)	1.47	3.69	2.76	3.19	1.96	2.36	2.75	3.11
Nitrite (mg/l)	0.021	<0.004	0.0114	< 0.004	0.0489	0.0041	0.036	< 0.004
Ortho-phosphate (mg/l) SRP	0.016	0.021	0.029	< 0.01	0.033	0.013	<0.01	< 0.01
Phosphorus total - as P (mg/l)	0.046	0.056	0.059	0.038	0.123	0.057	0.044	0.039
Nitrogen total inorganic (mg/l) TIN	1.71	3.724	3.0714	3.23	2.2969	2.4051	2.832	3.14

Appendix 8.7. River Camel nutrient data (continued)

NGR	SX 1092 8705	SX 1154 8801	SX 1209 8749	SX 1230 8760	SX 1231 8764	SX 1254 8749	SX 1254 8749	SX 1263 8741
Site code	K	L	R	S	T	U	U	NNN
Site description	Trekeek tributary	Hallwell tributary, spring below pump	River Camel downstream Hendraburnick tributary2	Hendraburnick tributary1	ditch into Hendraburnick trfbutary1	Hendraburnick tributary1	Hendraburnick tributary1	spring into Hendraburnick tributary2
Catchment	Camel	Camel	Camel	Camel	Camel	Camel	Camel	Camel
Date	7.Sept. 99	7.Sept. 99	8.Sept. 99	8.Sept. 99	8.Sept. 99	8.Sept. 99	16.Nov. 99	16.Nov. 99
Time	14:00	14:18	10:17	10:28	10:33	10:53	13:15	13:05
Ammonia - as N (mg/l)	0.286	< 0.03	<0.03	<0.03	0.035	0.038	< 0.03	< 0.03
Nitrogen total oxidised - as N (mg/l)	4.01	1.48	3.8	1.28	0.33	3.47	4.71	6.15
Nitrate (mg/l)	4	1.48	3.8	1.28	0.324	3.46	4.71	6.15
Nitrite (mg/l)	0.0142	<0.004	<0.004	<0.004	0.006	0.0064	< 0.004	< 0.004
Ortho-phosphate (mg/l) SRP	0.026	0.011	<0.01	<0.01	0.017	<0.01	< 0.01	< 0.01
Phosphorus total - as P (mg/l)	0.229	0.026	0.03	0.041	0.069	0.029	0.04	0.029
Nitrogen total inorganic (mg/l) TIN	4.3002	1.784	4.104	1.584	0.365	3.5044	4.74	6.18

NGR	SX 1271 8733	SX 1271 8733	SX 1324 8722	SX 1249 8703	SX 1249 8703	SX 1408 8768
Site code	V	V	W	CC	CC	Quarry
Site description	spring into Hendraburnick tributary2	spring into Hendraburnick tributary2	well, spring for Hendraburnick Farm	Starapark tributary below farm abstraction	Starapark tributary below farm abstraction	Higher Trehane Quarry
Catchment	Camel	Camel	Camel	Camel	Camel	Camel
Date	8.Sept. 99	16.Nov. 99	8.Sept. 99	8.Sept. 99	16.Nov. 99	16.Nov. 99
Time	11:16	13:10	11:44	14:18	13:55	11:30
Ammonia - as N (mg/l)	0.036	< 0.03	<0.03	<0.03	< 0.03	0.196
Nitrogen total oxidised - as N (mg/l)	5.18	5.11	5.38	5.13	5.52	5.89
Nitrate (mg/l)	5.17	5.11	5.38	5.13	5.52	5.83
Nitrite (mg/l)	0.0062	< 0.004	<0.004	<0.004	< 0.004	0.0595
Ortho-phosphate (mg/l) SRP	<0.01	< 0.01	<0.01	0.03	0.02	0.128
Phosphorus total - as P (mg/l)	0.032	0.022	<0.02	0.057	0.047	0.323
Nitrogen total inorganic (mg/l) TIN	5.2122	5.14	5.684	5.164	5.55	6.09

Appendix 8.8. Davidstow Stream, River Inny, River Ottery and Valency Stream nutrient data

NGR	SX 1229 8318	SX 1285 8560	SX 1285 8560	SX 1408 8625	SX 1406 8722	SX 1714 8828	SX 1714 8828	SX 1759 8942
Site code	MM	PP	PP	OOO	Inny	TT	TT	UU
Site description	pipe	pipe	pipe	discharge of Davidstow Creamery	River Inny at Davidstow	tributary	tributary	from the pool
Catchment	Davidstow Stream	Davidstow Stream	Davidstow Stream	Inny	Inny	Ottery	Ottery	Ottery
Date	10.Sept. 99	10.Sept. 99	16.Nov. 99	19.Nov. 99	19.Nov. 99	14.Sept. 99	19.Nov. 99	14.Sept. 99
Time	13:40	12:05	14:40	10:30	10:50	12:25	11:00	15:10
Ammonia - as N (mg/l)	<0.03	<0.03	< 0.03	0.756	0.038	<0.03	< 0.03	<0.03
Nitrogen total oxidised - as N (mg/l)	0.44	3.86	3.43	2.92	2.22	0.4	1.11	5.43
Nitrate (mg/l)	0.435	3.86	3.43	2.87	2.21	0.396	1.11	5.43
Nitrite (mg/l)	0.005	<0.004	< 0.004	0.05	0.0069	<0.004	< 0.004	0.004
Ortho-phosphate (mg/l) SRP	0.01	<0.01	< 0.01	0.092	0.025	0.029	0.037	0.013
Phosphorus total - as P (mg/l)	0.156	<0.02	< 0.02	0.197	0.072	0.707	0.083	0.034
Nitrogen total inorganic (mg/l) TIN	0.47	3.894	3.46	3.68	2.26	0.43	1.14	5.46

NGR	SX 1759 8942	SX 1584 8955	SX 1579 8948	SX 1890 9326	SX 1259 8494	SX 1266 8486	SX 1266 8526	SX 1275 8536
Site code	UU	VV	TTT	FFF	GG	HH	II	JJ
Site description	spring	drainage ditch	drainage ditch	River Ottery at Trengune	spring below Trenarth Farm	tributary	spring above pump	tributary
Catchment	Ottery	Ottery	Ottery	Ottery	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream
Date	19.Nov.99	14.Sept. 99	19.Nov.99	17.Sept.99	16.Nov. 99	10.Sept. 99	10.Sept. 99	10.Sept. 99
Time	11:15	15:35	11:30	13:50	15:00	11:10	11:25	12:20
Ammonia - as N (mg/l)	< 0.03	<0.03	0.124	0.033	0.419	<0.03	0.081	0.072
Nitrogen total oxidised - as N (mg/l)	5.08	1.87	2.43	1.79	5.28	1.95	1.04	1.01
Nitrate (mg/l)	5.08	1.86	2.42	1.77	5.26	1.95	1.03	1
Nitrite (mg/l)	< 0.004	0.0109	0.0059	0.0166	0.0195	<0.004	0.0064	0.006
Ortho-phosphate (mg/l) SRP	< 0.01	<0.01	< 0.01	0.028	< 0.01	<0.01	0.023	0.023
Phosphorus total - as P (mg/l)	0.025	<0.02	0.032	0.066	< 0.02	0.024	0.043	0.052
Nitrogen total inorganic (mg/l) TIN	5.11	1.9	2.55	1.82	5.7	1.984	1.1174	1.08

Appendix 8.8. Davidstow Stream, River Inny, River Ottery and Valency Stream nutrient data (continued)

NGR	SX 1030 8385	SX 1030 8385	SX 1144 8369	SX 1174 8402	SX 1174 8402	SX 1259 8494	SX 1386 8559	SX 1198 8340
Site code	DD	DD	EE	FF	FF	GG	LLL	MMM
Site description	Davidstow Stream at Tregoodwell	Davidstow Stream at Tregoodwell	spring	tributary	tributary	spring below Trenarth Farm	ditch	tributary
Catchment	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream	Davidstow Stream
Date	8.Sept. 99	16.Nov. 99	8.Sept. 99	10.Sept. 99	16.Nov. 99	10.Sept. 99	16.Nov. 99	16.Nov. 99
Time	15:10	14:30	15:30	10:05	15:10	11:03	14:45	15:20
Ammonia - as N (mg/l)	< 0.03	< 0.03	<0.03	<0.03	< 0.03	7.86	< 0.03	< 0.03
Nitrogen total oxidised - as N (mg/l)	1.81	2.14	4.49	2.32	3.02	0.54	2.18	1.28
Nitrate (mg/l)	1.8	2.14	4.49	2.32	3.02	0.525	2.18	1.28
Nitrite (mg/l)	0.006	< 0.004	<0.004	<0.004	< 0.004	0.0153	< 0.004	< 0.004
Ortho-phosphate (mg/l) SRP	0.02	< 0.01	0.026	<0.01	< 0.01	<0.01	< 0.01	0.01
Phosphorus total - as P (mg/l)	0.05	0.033	0.05	0.025	0.039	0.034	0.021	0.031
Nitrogen total inorganic (mg/l) TIN	1.84	2.17	4.524	2.354	3.05	8.4003	2.21	1.31

NGR	SX 1507 8711	SX 1517 8732	SX 1517 8732	SX 1718 8729	SX 1722 8733	SX 1427 8651	SX 1427 8651	SX 1890 9326
Site code	OO	QQ	QQ	RR	SS	AAA	AAA	FFF
Site description	spring in marshland	tributary next to Holy Well in Davidstow	tributary next to Holy Well in Davidstow	spring in marshland	tributary	source of Inny	source of Inny	River Ottery at Trengune
Catchment	Inny	Inny	Inny	Inny	Inny	Inny	Inny	Ottery
Date	10.Sept. 99	14.Sept. 99	19.Nov. 99	14.Sept. 99	14.Sept. 99	17.Sept.99	19.Nov. 99	19.Nov. 99
Time	14:45	11:15	10:45	11:40	11:50	09:45	10:15	14:00
Ammonia - as N (mg/l)	<0.03	<0.03	0.135	0.367	0.048	0.103	< 0.03	0.148
Nitrogen total oxidised - as N (mg/l)	3.17	2.44	3.11	1.99	3.68	1.29	1.6	3.19
Nitrate (mg/l)	3.17	2.44	3.11	1.97	3.68	1.28	1.6	3.18
Nitrite (mg/l)	<0.004	<0.004	< 0.004	0.0152	<0.004	0.0063	< 0.004	0.0114
Ortho-phosphate (mg/l) SRP	0.025	<0.01	0.026	<0.01	<0.01	0.012	0.012	< 0.01
Phosphorus total - as P (mg/l)	0.039	0.028	0.073	0.039	0.021	0.031	0.048	0.055
Nitrogen total inorganic (mg/l) TIN	3.204	2.47	3.24	2.36	3.73	1.39	1.63	3.34

Appendix 8.8. Davidstow Stream, River Inny, River Ottery and Valency Stream nutrient data (continued)

NGR	SX 1434 8920	SX 1418 8882	SX 1418 8882	SX 1177 8904	SX 1177 8904	SX 0990 9123	SX 0990 9123	SX 1328 8878
Site code	BBB	CCC	CCC	DDD	DDD	EEE	EEE	PPP
Site description	well	tributary	tributary	well	well	River Valency at Boscastle	River Valency at Boscastle	Spring next to Treslay
Catchment	Valency	Valency	Valency	Valency	Valency	Valency	Valency	Valency
Date	17.Sept.99	17.Sept.99	19.Nov. 99	17.Sept.99	19.Nov. 99	17.Sept.99	19.Nov. 99	19.Nov. 99
Time	11:15	11:45	11:50	12:55	13:00	13:15	13:40	12:15
Ammonia - as N (mg/l)	<0.03	<0.03	< 0.03	< 0.03	< 0.03	0.032	0.037	< 0.03
Nitrogen total oxidised - as N (mg/l)	3.16	1.69	1.66	11.3	10.1	2.56	3.57	5.72
Nitrate (mg/l)	3.16	1.69	1.66	11.3	10.1	2.55	3.56	5.72
Nitrite (mg/l)	<0.004	<0.004	< 0.04	< 0.004	< 0.004	0.0108	0.0113	< 0.004
Ortho-phosphate (mg/l) SRP	0.011	<0.01	< 0.01	0.016	0.015	0.053	0.019	0.017
Phosphorus total - as P (mg/l)	0.03	<0.02	0.03	0.022	0.044	0.095	0.05	0.039
Nitrogen total inorganic (mg/l) TIN	3.19	1.72	1.69	11.3	10.1	2.59	3.61	5.75

NGR	SX 1277 8538	SX 1385 8546
Site code	KK	LL
Site description	tributary	tributary
Catchment	Davidstow Stream	Davidstow Stream
Date	10.Sept. 99	10.Sept. 99
Time	12:22	13:12
Ammonia - as N (mg/l)	0.135	0.398
Nitrogen total oxidised - as N (mg/l)	1.67	<0.2
Nitrate (mg/l)	1.66	0.173
Nitrite (mg/l)	0.0091	0.0266
Ortho-phosphate (mg/l) SRP	<0.01	0.011
Phosphorus total - as P (mg/l)	0.045	0.088
Nitrogen total inorganic (mg/l) TIN	1.8	0.5976