Final Report to European Commission
Contract No. 867UK(H)

Episodic variations in stream water chemistry associated with acid rainfall and run-off and the effect on aquatic ecosystems, with particular reference to fish populations in N.W. England

Contractor: North West Water Authority

Warrington, U.K.

Project Leader: E.Harper

North
West
Water

FINAL REPORT TO EUROPEAN COMMISSION

CONTRACT NO. ENV.867 UK (H)

TITLE: EPISODIC VARIATIONS IN STREAM WATER CHEMISTRY ASSOCIATED WITH ACID RAINFALL AND RUN-OFF AND THE EFFECT ON AQUATIC ECOSYSTEMS, WITH PARTICULAR REFERENCE TO FISH POPULATIONS IN N.W. ENGLAND.

CONTRACTOR: NORTH WEST WATER AUTHORITY,
WARRINGTON U.K.

PROJECT LEADER: E.HARPER

CO-AUTHORS D.H.Crawshaw, R.F.Prigg, M.Diamond, J.F.Robinson and D.Cragg-Hine

GRAPHICS A.M.Davies

This project was also part funded
by the Department of the Environment
whose support is gratefully acknowledged.

June 1986

Frontispiece : River Duddon at Duddon Hall looking upstream towards fish counter.

FINAL REPORT TO EUROPEAN COMMISSION

CONTRACT NO. ENV.867 UK(H)

Abstract

1. In the North West region, biological, physical and chemical information was collected over a five year period from over 100 sites on upland streams most of which drained rocks of low buffering capacity.

2. In both Lake District and South Pennine sites striking differences were found between the composition of invertebrate communities inhabiting acid-stressed and less acid-stressed streams. In streams of very low pH (geometric mean pH < 4.5) only Nemouridae, Limnephilidae, *Dicranota*, Chirononidae and Simulidae were found. As geometric mean pH increased above pH 4.5 the abundance and diversity of macroinvertebrates increased. The diversity and abundance of acid-sensitive taxa (those which showed a strong statistical correlation with mean pH) increased with stream pH above 5.0.

3. Principal component analysis applied to the Pennine data indicated that approximately 50% of the variation in the acid sensitive species Baetidae, Heptagenidae, *Gammarus*, Hydropsychidae and Gastropoda could be explained by variation in a principal component "representing" pH, calcium, alkalinity and aluminium (negatively). A more detailed analysis including more sites and salmonid abundance is planned as part of future work.

4. It is suggested that the presence of Baetidae, Heptagenidae, *Gammarus*, Hydropsychidae and Gastropoda can be used to indicate that a water is suitable for salmonids with respect to acid-stress.

5. Electric fishing surveys showed that acidic streams (geometric mean pH < 5.5) generally had abnormally low densities of salmonids ($< 0.2 m^{-2}$) and that 0+ fish were very few or absent. The latter indicates recruitment failure. Salmon were more sensitive than trout to low pH.

6. The fisheries of the Esk and Duddon have declined over recent decades. Whilst this may not be solely due to acidification, on two occasions in recent years there have been simultaneous salmonid mortalities associated with low pH events. On the second of these, a complete record of pH changes was obtained from continuous monitoring equipment. So far as is known, such a record of a mortality of fresh run salmonids is unique, in Britain at least. No further mortalities have been observed in the Esk or Duddon catchments, although a suspected acid related mortality was investigated on the River Glenderamachin (R. Derwent catchment) in June 1984.

7. A number of streams and standing water bodies including Levens water have been identified where fish were present in catchable numbers prior to 1970, but which now appear to be fishless.

8. Preliminary analysis of data from a new fish counter on the River Esk suggests that upstream migration of salmonids may be inhibited by spates when the pH drops to 5.3.

9. Continuous river monitoring has demonstrated a remarkably consistent relationship between river pH and river flow, which appears to be independent of rainfall pH. The change in the nature of this relationship from one year to the next is being investigated as a possible tool for examining trends in acidity by eliminating the effects of seasonal and meteorological factors.

10. Liming of a small acid tributary of the Esk (Spothow Gill) has enabled fish to survive (after restocking) in a stream which had become fishless since around 1970.

11. A combination of selective tributary liming (Esk and Duddon) and restoration of agricultural liming levels to pre 1975 levels (Esk catchment only) shows promise as a short term measure for halting the decline of fisheries in these two catchments. The Authority has now commenced a programme of experimental liming along these lines.

CONTENTS

LIST OF FIGURES AND APPENDICES

EEC ACID RAIN REPORT

1. INTRODUCTION

1.1 Historical perspective of acid rain events in Europe

The enormous increase in public concern over "acid rain" and its reported effects in the last decade could give the misleading impression that it is a new phenomenon. In fact it is now generally acknowledged that the onset of acidification of sensitive surface waters most probably coincided with the start of the industrial revolution in the 1850's. Diatom records from lake sediments support this view (Battarbee 1984). Loss of fish populations resulting from an increase in the acidity of natural waters was reported in Norway as long ago as the 1920s (Dahl 1926) and in England acid rainfall was recorded locally over 100 years ago (Smith 1872).

However, concern over the acidification of surface waters on a regional basis did not emerge until the early 1970s. In the space of a few years, surface water acidification was recognised in southern Scandinavia (e.g. Gjessing et al 1976), Canada (e.g. Conroy et al 1976) and USA (e.g. Schofield 1976). The effect of acidification on fish populations has caused particular concern. Leivestad et al (1976) documented the decline of Atlantic Salmon populations in rivers in Southern Norway, while a detailed analysis of 700 lakes in this region revealed an association between fishery stocks and water chemistry (Wright & Snekvik 1978). Populations were sparse or absent at pH 5.5 or less. As many as one-third of 2000 lakes assessed in S.Norway are considered to have lost their fish populations since the 1940s (Sevaldrud and Muniz 1980).

1.2 Evidence of potential problems in the UK

Until recently relatively little information was available concerning the effects of acidification in the UK. However, work in geologically sensitive (i.e. susceptiable to acidification) areas of Scotland (Harriman & Morrison 1982) and Wales (Stoner et al 84) has shown that fish have become sparse or absent in acidic waters. A comprehensive summary of observations in the UK is given by Warren et al (1986).

In SW Cumbria acid related fish mortalities in 1980 and 1983 in the River Esk and Duddon catchments have been documented (Prigg, 1983a; Crawshaw, 1984). It was these observed mortalities, coupled with a dramatic decline in the numbers of migratory salmonids returning to these two rivers, which initially led to the research programme that is described in this report.

Many previous studies have concentrated on the effects on lakes or tarns and possible remedial measures relevant to standing water bodies. It was felt that a detailed study of effects on streams would add a new perspective to this work, in particular the possibility of monitoring the water quality in detail during the course of a mortality of salmonid fish.

Particular emphasis was placed on an investigation of episodic variations in stream water chemistry and their role in aquatic ecosystems, particularly fish populations.

1.3 The Research proposal

The project formed the initial stages of a planned long-term investigation into the acidification of waters in the North West of England and was integrated with relevant studies being carried out by other organisations in the U.K.

In general, the emphasis of the project was to quantify the importance of short-term episodic variations in stream chemistry associated with rainfall, snowmelt and run-off and to place these variations in the context of longer term changes in water quality, particularly acidificatioon, which were receiving more widespread scientific attention. Specifically the project focussed attention on two critical river catchments and measured in-river changes in water chemistry associated with run-off events and the biological impact in the short and medium term. The project was complemented by detailed studies on rainfall chemistry, on soil modifications and on effects in lakes being undertaken by other research institutes (Freshwater Biological Association; Institute of Terrestrial Ecology) and by studies on other waters throughout the north-west of England by the Authority.

One of the areas of the UK receiving the largest input of acidity from the atmosphere has been identified as S.W.Cumbria where surface waters are generally poorly buffered on account of the underlying geology. A decline in migratory salmonid fish populations in the Rivers Esk and Duddon has been observed in recent years and the recorded occurrences of intermittent fish mortalities has been associated with pulses of acidic run-off. These two river catchments offered a combination of features unique within the UK and possibly Europe where precise relationships between river flow, water chemistry, fish movement and biological status could be determined and critical conditions identified. Furthermore, it was proposed to determine the effects of remedial actions, such as changes in agriculture and forestry practices on the catchments, to improve conditions for fauna and flora. The results of this work may have widespread significance.

The work proposed in the project involved:

(i) Continuous monitoring and data logging at one site in each catchment of pH, temperature, river level (flow) and upstream fish movement; together with automatic sampling of water for chemical analysis in response to rises in river level. Flow gauging facilities already existed at one site on each river, but only the Duddon had an existing fish movement recording weir and station. An early requirement was therefore the construction of such a facility on the Esk.

(ii) Surveys of invertebrate and fish population distributions in surface waters in the catchments. Population structure, reproductive success, growth rate and movement of fish to compare the status of fisheries in affected and unaffected waters.

(iii) Collection and chemical analysis of water samples from streams, lakes and tarns in and around the study catchments with the use and development of analytical techniques as appropriate for particular deteminands such as monomeric aluminium and humic content. The range of analyses at particular sites included major cations and anions relevant to an understanding of the relationships between deposition and surface water chemistry. Background levels and seasonal trends were determined.

(iv) Collection and analysis of rainfall samples at suitable sites for each separate rainstorm.

(v) The co-ordination of data collection; evaluation of records for trend analysis; integration with other research and evaluation of results; proposals for remedial action.

2. STUDY AREAS IN THE NORTH WEST

2. STUDY AREAS IN THE NORTH WEST

2.1 Description of catchments

See Appendix Io for outline maps.

The study areas focussed on three regions of North West England - S.W.Cumbria,the Lake District and the Southern Pennines. Each region is described in more detail below:

2.1.1 The English Lake District

The streams of the English lake District vary from highly acidic to extremely alkaline. All of the acid streams drain bedrock of the Borrowdale volcanic series, Skiddaw slates and igneous intrusions (eg Eskdale granite). The Silurian slates of the Southern Lake District have a higher buffering capacity producing streams of higher alalinity. Hard alkaline waters drain the carboniferous limestone at the edge of the Lake District.

In the North and West of the central Lake District, acid and alkaline streams have a patchy distribution with alkaline and acid soft water streams occurring in close proximity to each other eg streams in the upper Esk and Duddon catchment described below. Acid streams are rare in the Eastern Lake District (Sutcliffe and Carrick)

2.1.2 S.W.Cumbria (Esk and Duddon)

These two catchments were identified as critically sensitive catchments on the basis of geology and known fishery problems.

The Esk rises on the southern slope of Scafell Pike and is a relatively short river being some 23.6 km to the tidal limit. At the gauging station at Cropple How, 3.4 km above the tidal limit, its catchment area is 70.2 km^2 and its average daily flow (ADF) is approximately 5.6 m^3/s.

The Duddon rises some 6 km to the south east of the source of the Esk at the top of Wrynose Pass. The distance to the tidal limit is 22.0 km and at Duddon Hall, 1.5 km above the tidal limit the catchment area is 78.2 km^2 and the ADF is approximately 6.2 m^3/s.

Whilst the ADFs and maximum flows are approximately in the ratio of the catchment areas, the minimum flow on the Esk of 0.09 m^3/s is approximately one-third of that on the Duddon. This is mainly due to a release of compensation water from Seathwaite Tarn but may also be influenced by a greater proportion of groundwater than the Esk.

2.1.3 The South Pennines

The South Pennine region has been classified as being of high to medium suscceptibility to acid deposition (Kinniburgh and Edmunds 1984). The catchments of the streams under study were of two main types, those dominated by blanket peat bog and those dominated by acidic upland grassland, both overlying hard rock of low buffering capacity. Two exceptions were Hurst Reservoir catchment of heather and cranberry moorland and Earnsdale Reservoirs catchment of alkaline grassland.

2.2 Solid geology

The upper reaches of the Esk rise on rock of the Borrowdale Volcanic series but lower down the catchment, granite is the dominant feature apart from alluvium and river gravel in the valley bottom. The Duddon catchment is also virtually all underlain by rocks of the Borrowdale Volcanic series. A narrow band of Coniston Limestone does cross the catchment at the southern extremity but it is unlikely that this affects the chemistry of any of the sampling sites in the catchment. Another rock type worthy of mention is the substantial area of Skiddaw Slates to the north of the Esk and Duddon. A number of streams at the eastern end of this area including the upper River Caldew, Grainsgill Beck, and the River Glenderamackin within the Derwent catchment, have some of the lowest calcium concentrations found in the sampling programme.

Crummock Water, Ennerdale Water and Buttermere which are often regarded as "sensitive lakes", lie at the western end of the area of Skiddaw Slates. Wastwater, Thirlmere, Haweswater and Ullswater lie on the Borrowdale volcanics, but the latter two lie on the eastern side of this area which appears to be less susceptible to acidification than the western side.

Coniston Water and Windermere to the south are both in an area of Bannerdale slates, Coniston flags and Stockdale shales which are considerably richer in calcium. These two lakes may therefore be regarded as less sensitive to the effects of acidification.

The underlying rocks in the Southern Pennines are millstone grits and coal measures. The acidic sites under study drained the former. Millstone grits are made up of granites, quartz and cements and would be expected to contribute little buffering capacity to waters draining them.

2.3 Soil Series

The chemistry of the surface waters in a catchment is likely to be as much affected by the soils overlying the solid geology as by the underlying rock itself. A brief description is therefore included, the soil series quoted being from the Soil Survey of England and Wales.

Both the Upper Esk and Duddon rise on thin soil described as "humic rankers", a soil type not found elsewhere in northern England apart from parts of the upper Ribble and Lune catchments. The rest of the Esk catchment is mainly typical brown podzolic soils, although in the valley bottom there is the alluvial band already referred to, composed of brown earths or alluvial gleys.

One extra feature in the Duddon catchment is the presence of Cambric stagnohumic gley soils in the Cockley Beck, Seathwaite area and on the western slopes in the Ulpha area. Much of Corney Fell, also in this area, is composed of raw oligo-fibrous peat soils from which the streams with the highest humic content flow.

2.4 Land Use

The Valley bottoms of both the Esk and Duddon are used extensively for permanent pasture and were limed extensively in the past though this has declined significantly in the last 10 years. (See Section 7 for changes in this and other uses). The little afforestation in the Esk is restricted to two small coniferous plantations. In the Duddon there is a fairly extensive plantation of 400 hectares (Dunnerdale Forest) consisting of mature conifers and this is being extended to include a further 200 hectares around Grassguards Gill. The existing plantation comprises about 5% of the catchment above Duddon Bridge. There are also deciduous woodlands in the lower parts of the catchment.

In the upper parts of these catchments, the remaining Lake District sites and those of the Pennines, the land is used almost entirely for sheep grazing. Generally, these pastures are on unimproved moorland which in most catchments are dominated by acidic upland grass with some areas of heather (*Erica cinerea*), bracken (*Pteridium aquilinium*), peat bog and rocky outcrops. The poorly drained catchments on the Pennines are covered in blanket peat bogs. Two catchments on the Pennines comprise improved dairy/sheep pasture (Earnsdale Reservoir and Turton and Entwistle Reservoir). The land is generally too wet for forestry and where plantations occur they are undergrazed by sheep.

3. DATA COLLECTION

3.1 Chemical sampling programme

3.2 Continuous water quality monitors

3.3 Biological surveys for distribution of macroinvertebrates

3.4 Fish surveys

3.5 Fish counters

3.6 Other information on fish abundance

3. DATA COLLECTION

3.1 Chemical sampling programme

3.1.1 S.W.Cumbria and Lake District

In order to provide baseline data, 100 sites were selected to be sampled quarterly. These included all 75 sites where biological data were also collected and where, in some cases, extra water samples were taken for more limited analysis. The other 25 sites included, for comparison, sites in largely non-sensitive catchments such as the Lune, and in all cases the sites were chosen at points as far up the catchment as it was reasonably practicable to sample. This programme commenced in 1982.

Analysis of water samples included pH, alkalinity, calcium magnesium; aluminium (total and unacidified); ammoniacal nitrogen; nitrite and nitrate nitrogen; conductivity; chloride; and humic substances (carried out by gas chromatographic comparison with a standard sample of humic and maleic acids).

3.1.2 S.Pennines

One of the objectives of the study was to carry out a comparison of the chemistry of the generally very clear Lake District waters, with the highly coloured peaty Pennine waters and to assess the possible role of these humic substances in modifying the toxic effects of high aluminium concentrations. Accordingly, analysis of samples was as described for the Lake District samples.

A total of 30 sites were selected consisting of 20 reservoirs and 10 stream sites which were either inflows to or outflows from reservoirs. The programme allowed for collection of both chemical and biological data from these sites. (The biological data included separate assessment of the individual feeder streams to any particular reservoir). The programme started in 1984 and all sites were sampled quarterly.

3.2 Continuous water quality monitors

Continuous monitoring of water quality took place at two sites, the River Esk at Cropple How and the River Duddon at Duddon Hall. Both sites were towards the bottom of the catchments at existing flow measurement stations (see Appendix 1).

The Duddon station included an existing nearby fish counting weir, whilst the Esk fish counting weir was constructed during 1985 and commissioned in October 1985. The data currently gathered (April 1986) at both stations is thus:

pH, temperature, electrical conductivity,

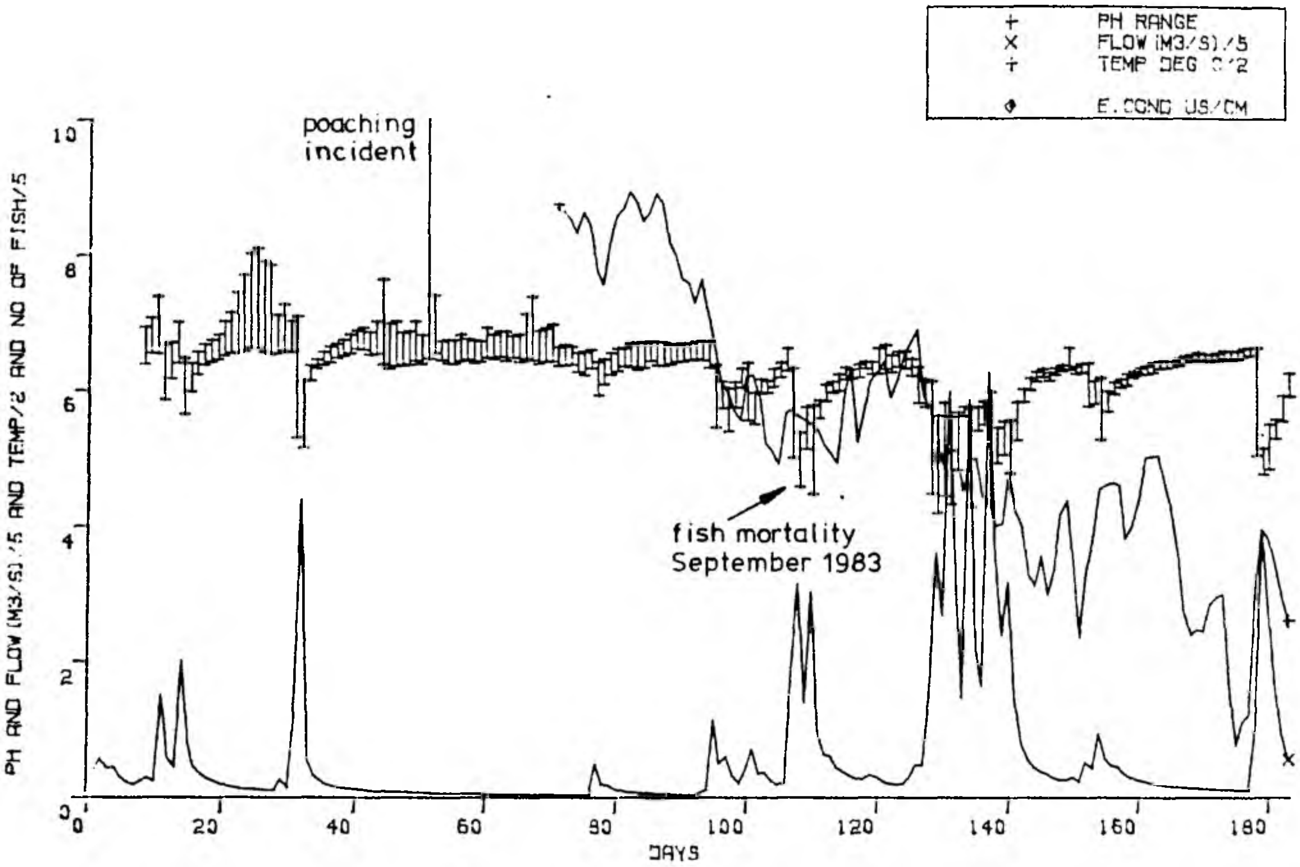
river level at 15 minute intervals

fish counts in previous 15 minutes 4 lbs (1.8kg)

fish counts " " " 4 lbs (1.8kg)

Figure 7 Summary of data from continuous monitors for the period 1/6/83 to 30/11/83

RIVER ESK AT CROPPLE HOW



RIVER DUDDON AT DUDDON HALL

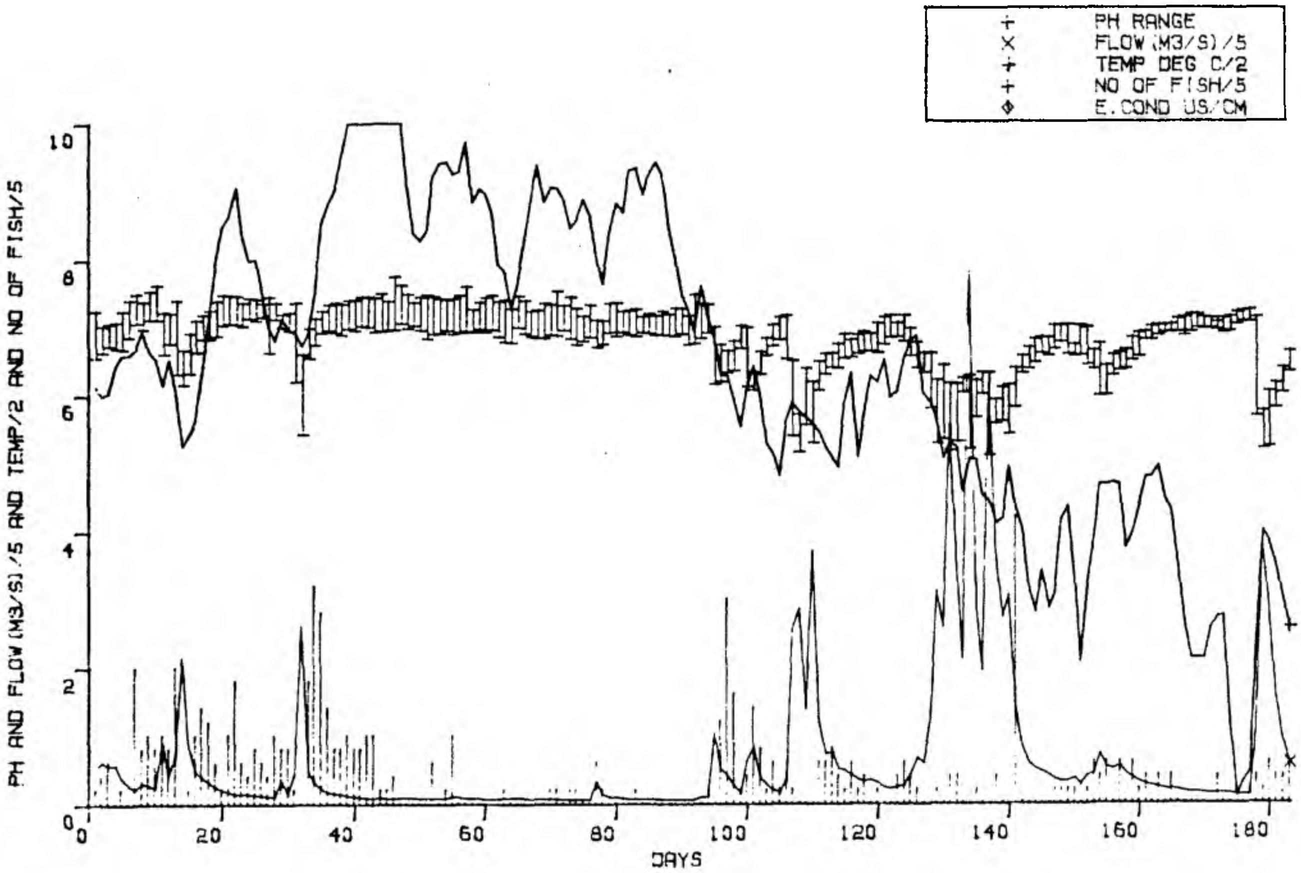
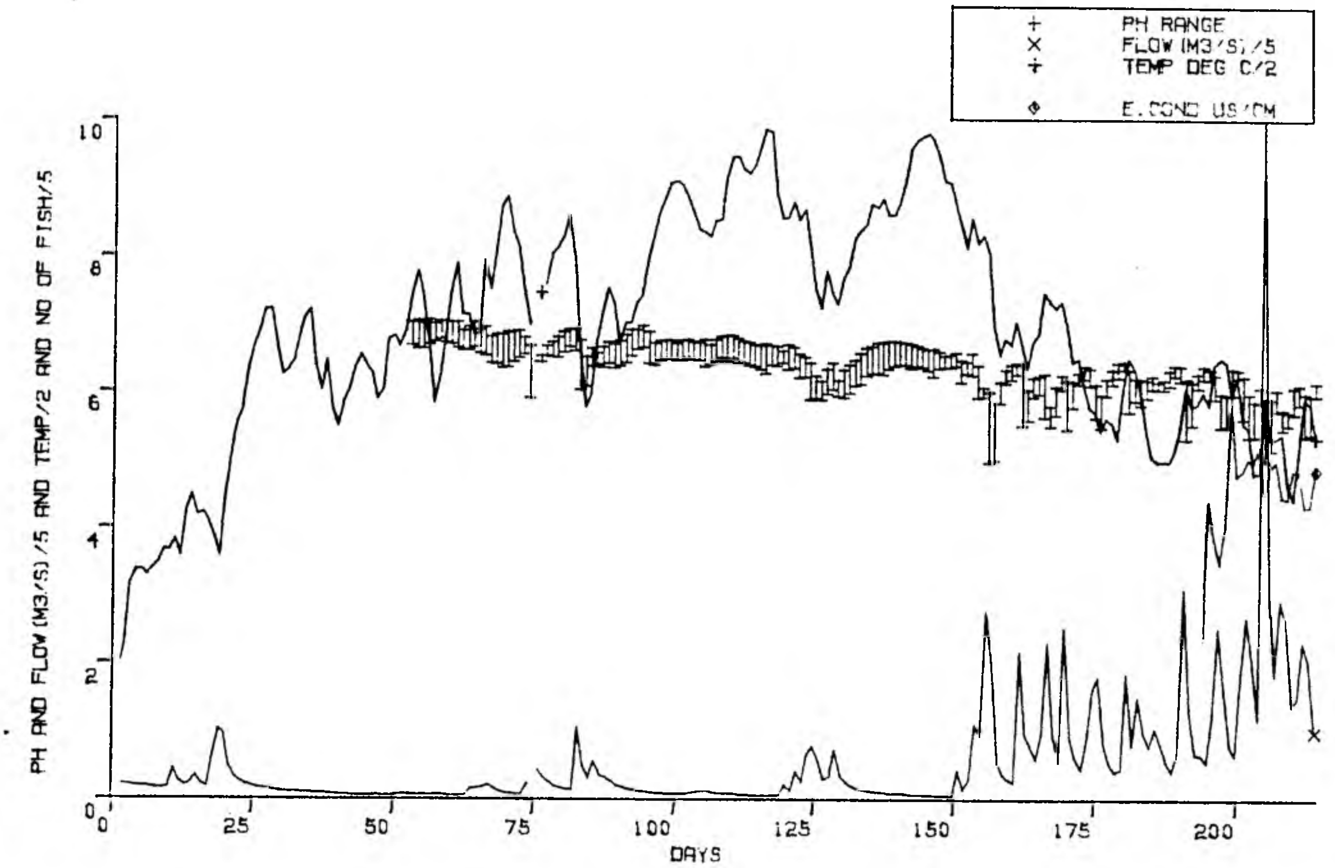


Figure 8 Summary of data from continuous monitors for the period 1/4/84 to 31/10/84


RIVER ESK AT CROPPLE HOW

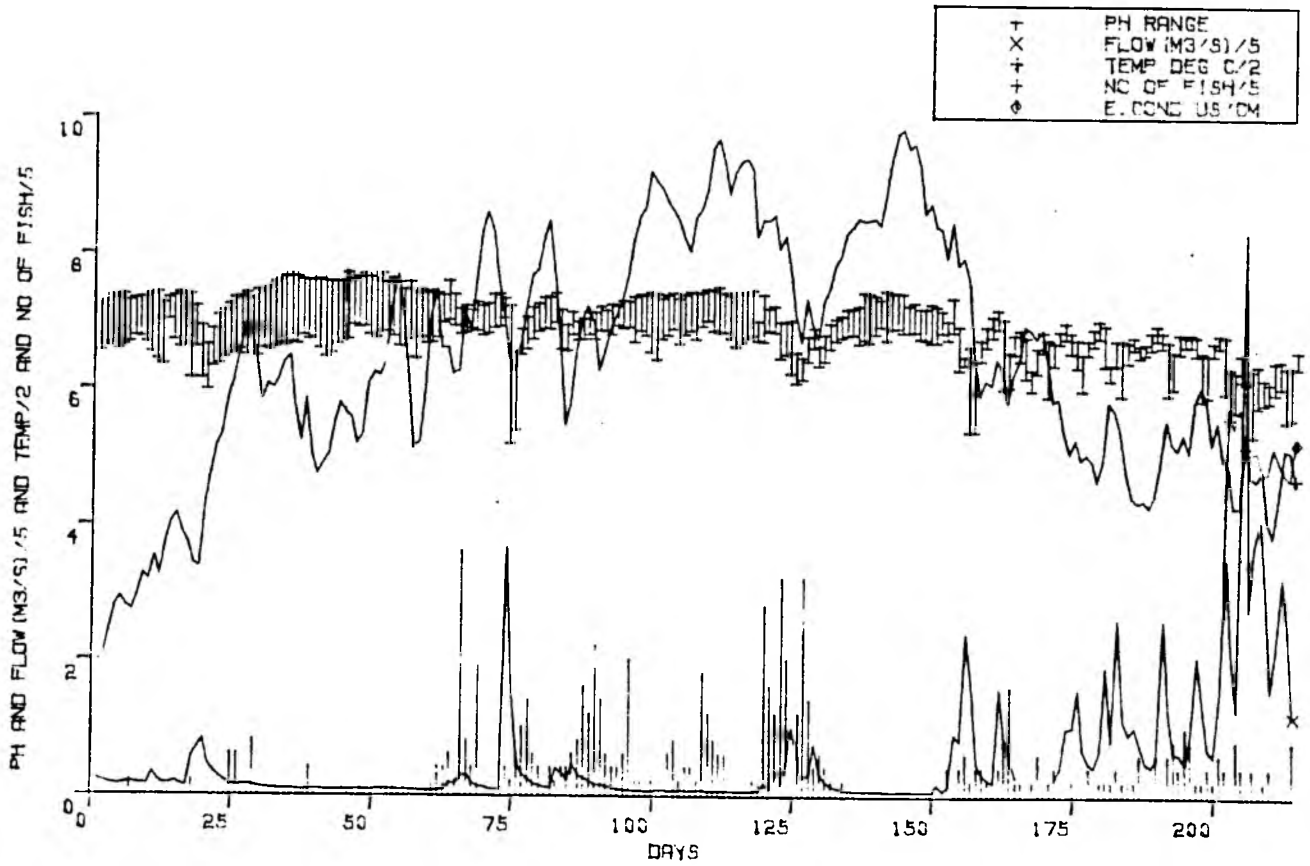
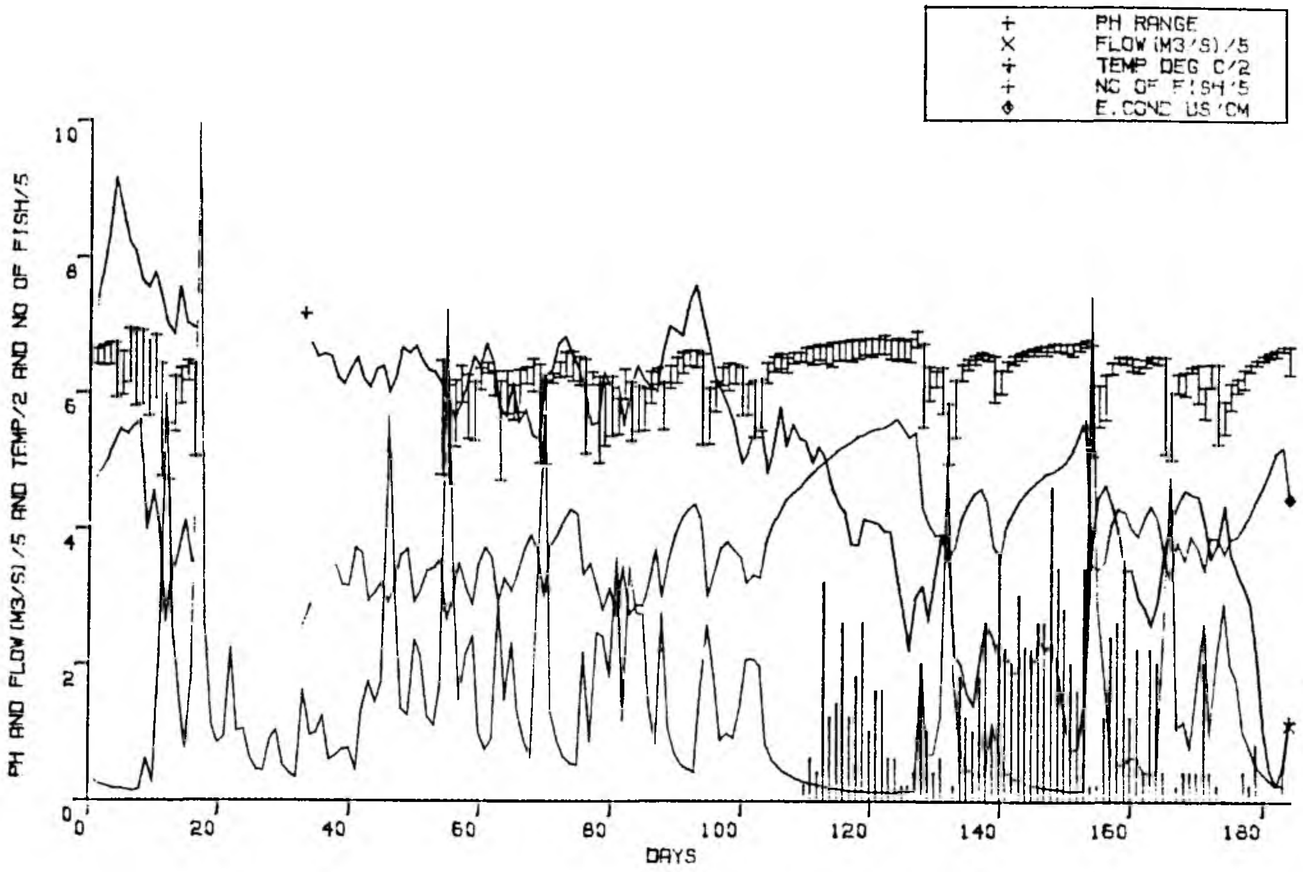

RIVER DUDDON AT DUDDON HALL

Figure 9 Summary of data from continuous monitors for the period 1/7/85 to 31/12/85

RIVER ESK AT CROPPLE HOW



RIVER DUDDON AT DUDDON HALL

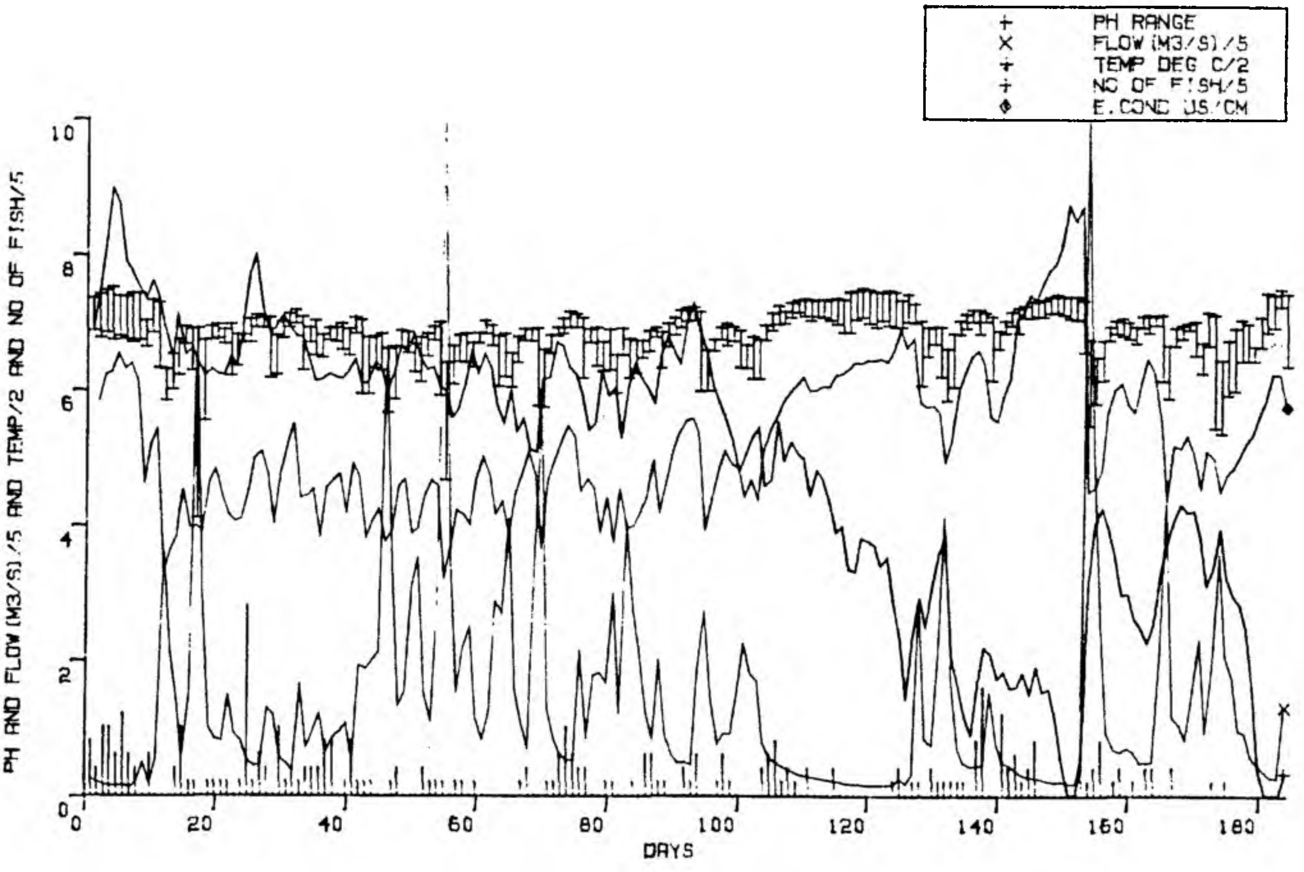
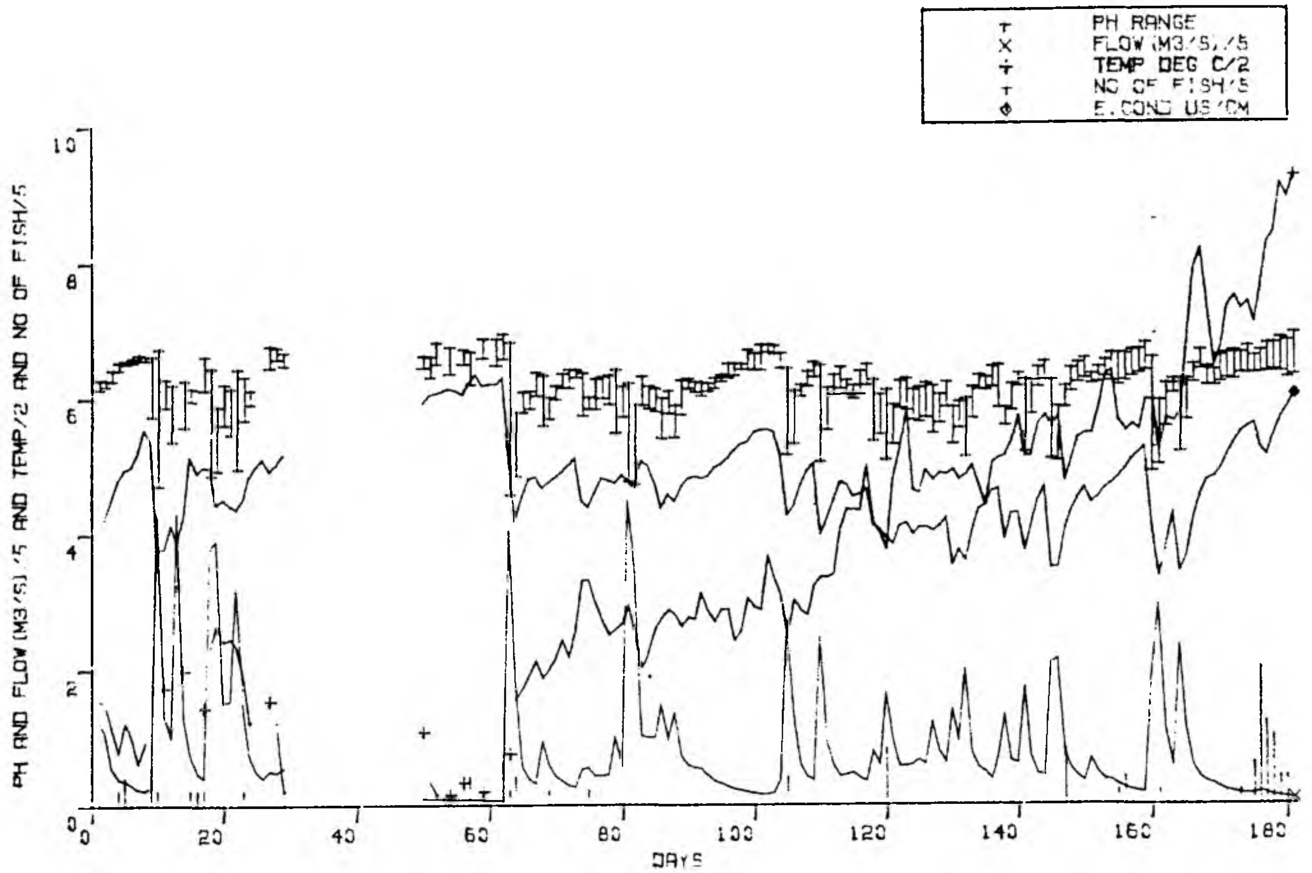
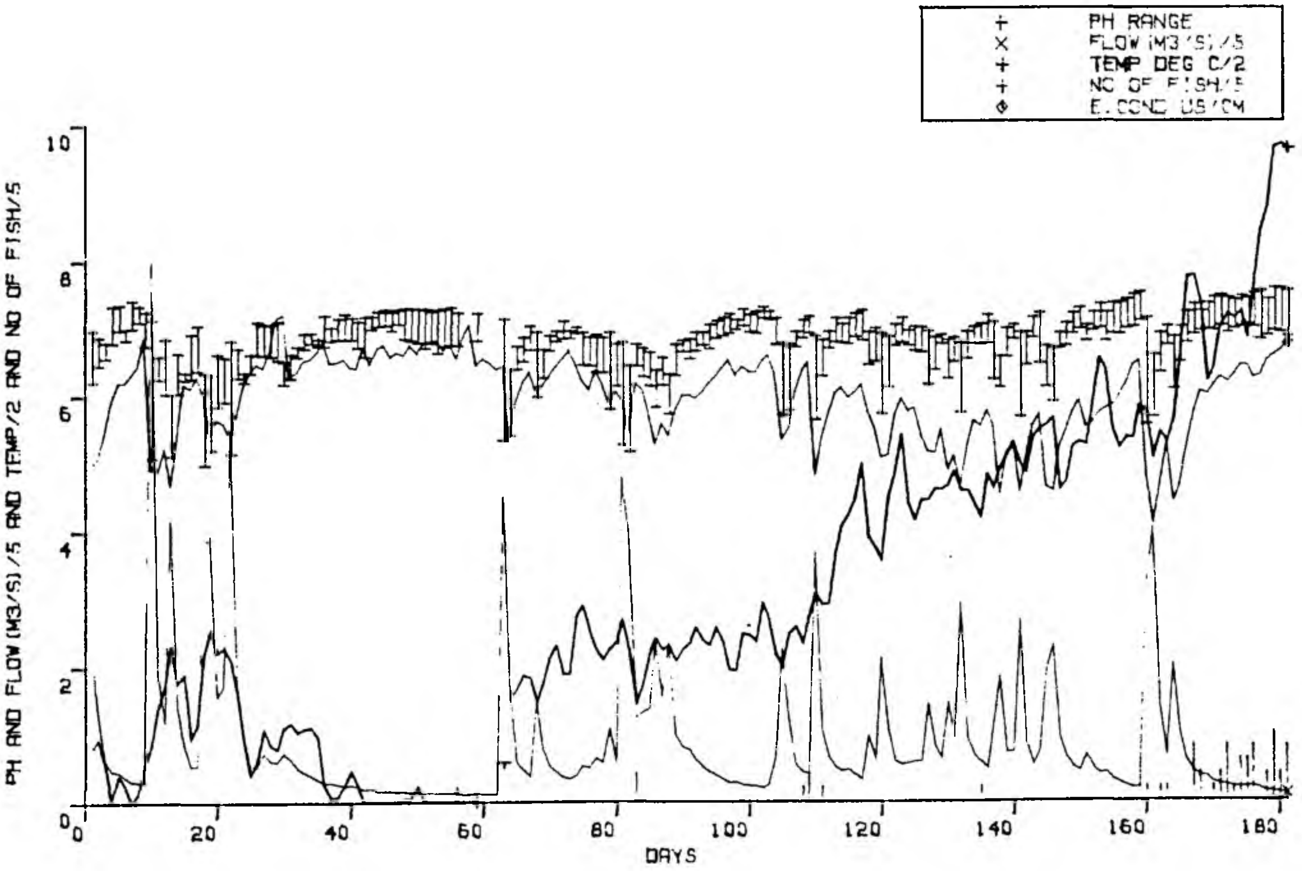


Figure 10 Summary of data from continuous monitors for the period 1/1/86 to 30/6/86

RIVER ESK AT CROPPLE HOW



RIVER DUDDON AT DUDDON HALL



Automatic water samplers at each site were triggered when the water level reached a pre-set height (which could be varied). Composite samples (made up of 4 half-hourly sub-samples) were then taken at 2 hour intervals for 48 hours. These samples, which gave valuable evidence of the changes in water chemistry during episodic events, were analysed for pH, alkalinity, calcium, aluminium (total and unacidified), magnesium, conductivity, chloride and humic substances.

3.2.1 Maintenance of pH probes

The pH probes were replaced at 6 monthly intervals and great care was taken to select probes which did not display a "streaming potential" in the laboratory (i.e. changes in output related to velocity of water past the probe).

Particular care was also taken during the 3 weekly calibration exercise. Low conductivity buffer solutions were utilised, and these were cooled to river water temperature before the calibration took place. This was in order to minimise errors due to rapid changes in the automatic temperature compensation mechanism.

3.2.2 Data storage and processing

All the 15 minute readings (which included an indication of when the automatic sampler had operated) were stored on Golden River 10 channel data loggers which were capable of storing up to 40 days data. In practice data was retrieved at 3 weekly intervals on the maintenance and calibration visits. Data were subsequently transferred to an ICL 2970 mainframe computer where all subsequent processing was carried out.

3.3 Biological surveys for distribution of macroinverbetrates

3.3.1 Structure of sampling programme

The structure of the biological sampling programme developed from initial concern about influences of acidification on the Esk and Duddon, and was extended to cover other likely sensitive areas in the Lake District. This produced data from 75 upland stream sites, typically salmonid nursery streams within the Lake District National Park, divided equally between the Esk, Duddon and a group of other hill-stream sites. The sampling aimed to generate numerical data descriptive of the fish stocks, benthic macroinvertebrates and relevant water chemistry parameters at all sites. (Prigg 1983a).

Subsequent work has sought to provide more detailed biological data on sites which appeared to have acid restricted faunas and to investigate linear (upstream/downstream) changes within these acidified streams. The geographical coverage of streams draining the western mountain mass of the Lake District has been improved by sampling of additional sites.

The study area covering acid streams in the S. Pennines used similar methodology to that employed in the Lake District work.

3.3.2 Invertebrate Sampling

Benthic macro-invertebtrates were "kick sampled" from riffles in the 75 hill stream sites in the Lake District, in most cases, once in winter, once in late spring and once in late summer during 1982. One kick-sample of invertebrates was collected from riffles at each of the forty-eight sites in the Southern Pennines during the period December 1985 to February 1986. "Kick-Sampling" involved the operator vigorously kicking the substrate immediately upstream of the mouth of a standard pond net (square mesh size = 0.7 mm) for a duration of three minutes whilst moving in an upstream direction sampling all of the apparent micro-habitats present. The samples were preserved in 70% methanol (Pennine sites) or formaldehyde solution (Lake District sites) for later examination in the laboratory where the identification and abundance of invertebrates was recorded using the standard NWWA scale (1=1, 2=2-5, 3=6-20, 4=21-100, 5=101-500, 6=500). (The actual number of animals per sample was recorded for the Pennine sites only and used in the principal component analysis section 5.2.2)

3.4 Fish Surveys

3.4.1 Structure of Sampling Programme

The programme for the investigation of wild fish stocks in the study area was closely associated with the invertebrate survey work and thus the structure of the programme was as described in 3.3.1, above.

3.4.2 Electric Fishing

Fish populations of flowing water sites in the study area were surveyed using multi-catch depletion methods in measured, stop-netted sections. The gear used was a Honda 300E 220v 50 Hz. 300VA A.C.generator and a rectifier unit providing a D.C. output, with on most sites, a stationary cathode and single mobile anode.

The multi catch depletion method used involved either 2 or 3 repeated fishings. In assessing population size from the two catch data, Seber and Le Crens (1967) two catch formula was used, and for three catch data, Zippin's (1956) procedure was applied.

It was readily possible by length/frequency analysis to distinguish 0+ age class salmonids from older age groups, and estimates were made of the population sizes of both age groups independently.

The fork lengths of all salmonids caught were measured to the nearest millimeter. In order to relate fish length data to actual biomass of fish present at a site, crude biomass density estimates were produced for comparative purposes based on the assumption that

$W = 0.01 \times 1^3$ where W = weight g.
and 1 = length cms

When compared to estimated biomass density based on measured length/weight relationships which were available for the Esk sites, it was clear that the crude estimate underestimated the field estimate by 7%-41% (i.e. mean condition factor exceeded unity at the Esk sites).

3.4.3 Gill Netting

Fish populations of four acid upland tarns in the S.W. Lake District were sampled by gill netting. The nets used were monofilament sinking gill nets, 36.5m long, and composed of twelve panels of different mesh size ranging from 19mm to 150mm stretched mesh.

In the larger water bodies sampled, Levers Water and Seathwaite Tarn, seven such nets were set and left fishing for one day. Any fish caught were retained for length and weight determination and gut content examination. Tributary streams which could have been utilised by trout as spawning streams were surveyed by electric fishing.

3.4.4 Fish Cages and Trial Stocking

As part of an investigation of three adjacent tributaries of the River Esk differing in their ability to support trout, brown trout were placed in the streams enclosed in cylindrical Netlon plastic mesh cages, 0.65m long with a radius of 0.15m. Each cage held five fish and was staked in the stream in a suitable sheltered location. The survival of the fish and stream water chemistry was monitored in a number of exposures of up to several weeks duration (Prigg 1985a).

Trial stocking with hatchery-reared salmonid fry was carried out on four streams. In the Duddon catchment salmon fry were introduced into the upper reaches of Tarn Beck and Grassguards Gill and their survival monitored by electric fishing survey (Prigg 1983b). In the Esk catchment Spothow Gill and an adjacent unnamed tributary were stocked with trout fry following the application of crushed limestone to the upper catchment of Spothow Gill. The survival of the fry was monitored. (See 6.6.2)

3.5 Fish Counters

The fish counter at Duddon Hall on the River Duddon has been in use since 1980, although it is switched off during the winter and spring months when no migratory salmonids are entering the river.

The River Esk counter at Cropple How was commissioned in October 1985.

The purpose of these counters is to record the numbers of adult salmon and sea trout migrating upstream. The counters are fully automatic and operate on the resistivity principle (Lethlean 1951 and Bussell,1978). They are of the "wide gap" type and span the full width of the river.

Downstream movement of fish is not recorded because of practical constraints with this type of counter which make it impossible to obtain a reliable count of fish moving downstream. Both counters discriminate fish into two size groups, i.e. fish less than 4 lb (1.8 kg) in weight, and fish over 4 lb. The majority of fish under 4 lb are sea trout and those over 4 lb are likely to be salmon.

The data from the counters at both sites were recorded on the Golden River data loggers which also stored data on river level and water quality parameters. As information on fish movement, river level and water quality was collected simultaneously, it was possible to relate upstream movement of salmon and sea trout to the prevailing environmental conditions.

3.6 Other Information on Fish Abundance

A number of other sources of information relating to the past state of the fish stocks in the study area have been considered These include official returns of migratory salmonid catches by licence holders, references in past River Board reports to mortalities in areas we now know to be susceptible to acidification (Prigg 1983a), and recollections and records of individual anglers, riparian owners, local water authority staff etc.(Robinson 1984)

4. WATER QUALITY CONDITIONS

4. WATER QUALITY CONDITIONS

4.1 Classification of sampling sites

A detailed classification of the sampling sites has been carried out (Bull & Hall,1985) which demonstrated that the sites fell in general into identifiable groups as follows, judged on physical characteristics only although there was some overlap.

Esk & Duddon tributaries

Esk & Duddon main river sites

Other lake district sites

S.Pennine sites

It was noted that the Duddon tributaries included more sites at higher altitude than the Esk, and that the Lake District sites tended to be larger streams than the Esk and Duddon tributaries. This was not unexpected, but needs to be borne in mind when making comparisons between sites.

The sites in the S.Pennines were substantially different for a variety of reasons. Most of the streams in this area are utilised as public water supply reservoirs and are renowned for the highly coloured peaty water they produce as they drain the thick layer of sphagnum bog that covers this part of the S.Pennines.

4.2 pH

S.W.Cumbria

The most consistently acid tributaries sampled were a group of Upper Duddon tributaries, Doe House Gill, Gaitscale Gill, Troughton Gill, Mosedale Beck, Dale Head Gill and Black Beck. The group on the Esk in equivalent positions on the catchment exhibited a wider range of pH although the lowest pHs found were similar.

On the Duddon catchment, a marked increase in pH of both tributaries and the main river is found downstream of the confluence with Tarn Beck. There is also a gradual downstream increase in pH on the River Esk but it is much less pronounced.

The net effect is that whilst the upper Duddon is generally slightly more acid than the Esk, the lower Duddon is generally more alkaline (in fact the Duddon Hall site is generally about 1 pH unit more alkaline than the Esk at Cropple How).

Lowest pH recorded in these catchments during routine quarterly sampling was 4.0 on Spothow Gill (tributary of R.Esk).

S.Pennines

There are a substantial number of extremely acidic sites in the S.Pennine group. Lowest pH recorded at any site was pH <u>3.6</u> at Whiteholme Reservoir but 17% of sites had a minimum pH of less than 4.0 and 37% were less than pH 4.5 whereas in the Lake District group (inc.Esk and Duddon) only 11% were below pH 4.5 and none below pH 4.0. (See Figs 1 & 2)

Figure 1 Histograms showing the numbers of South Pennines sites with particular chemical characteristics

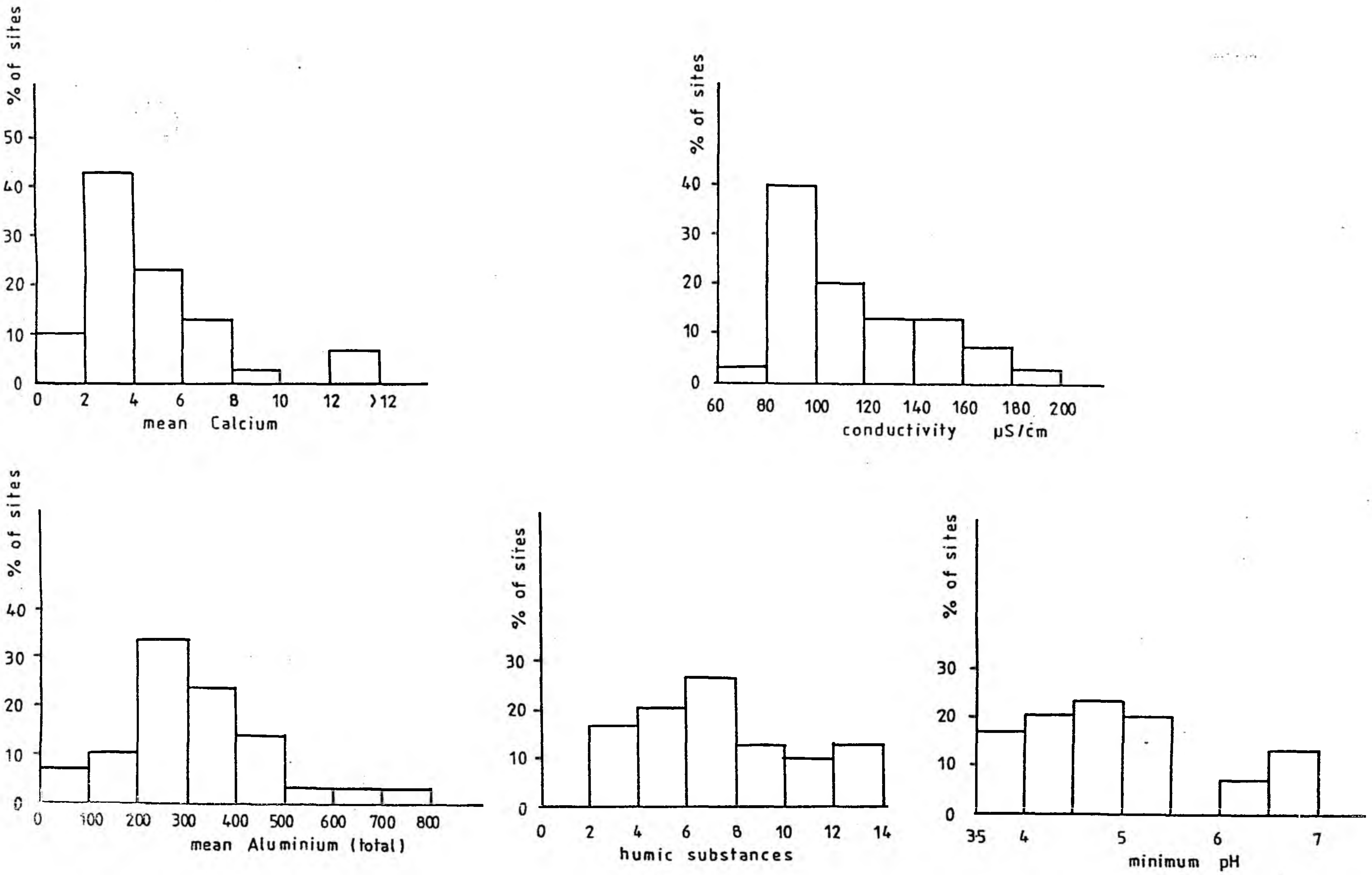
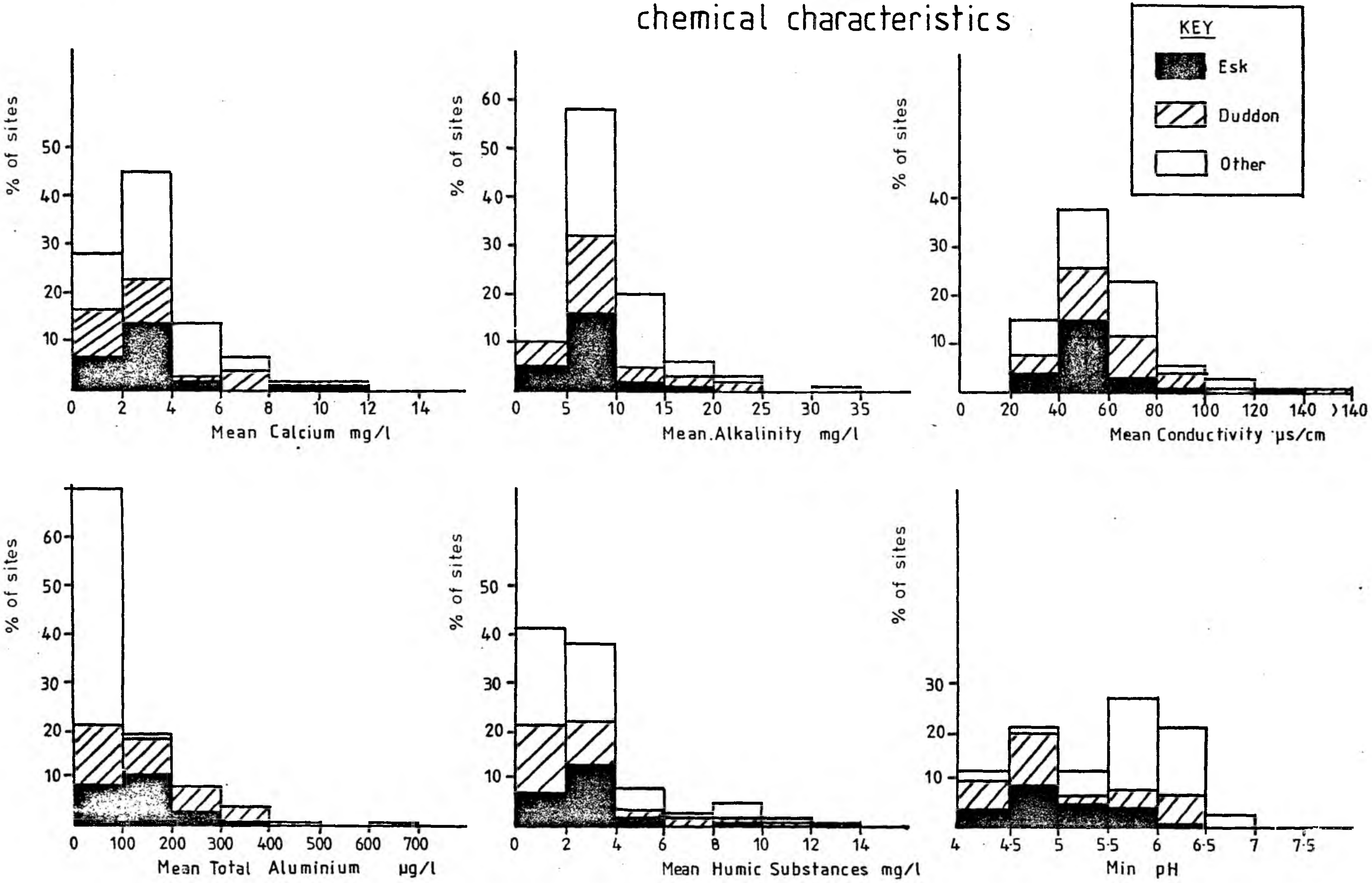


Figure 2
Histograms showing the numbers of Lake District sites with particular chemical characteristics



4.3 Aluminium

In "acid sensitive" catchments where the bedrock is resistant to weathering, and the overlying soils are low in calcium and magnesium, there may be insufficient time, or insufficient calcium, for normal buffering mechanisms to operate. In these circumstances, aluminium and manganese from alumino-silicates in clay and soil particles may exchange with some of the hydrogen ions present in the water flowing through or over the soil, and pass into the surface waters initially as Al^{3+} and Mn^{2+}.

Speciation of aluminium is extremely complex and may well have considerable influence on the subsequent effects on biota. For example, aluminium complexes can be formed with organic acids of humic origin which greatly reduce its toxicity.

S.W.Cumbria and Lake District

For the reasons outlined above, aluminium shows in general a close inverse correlation with pH (see Fig.3) and sample points with low pH nearly all had elevated aluminium levels.

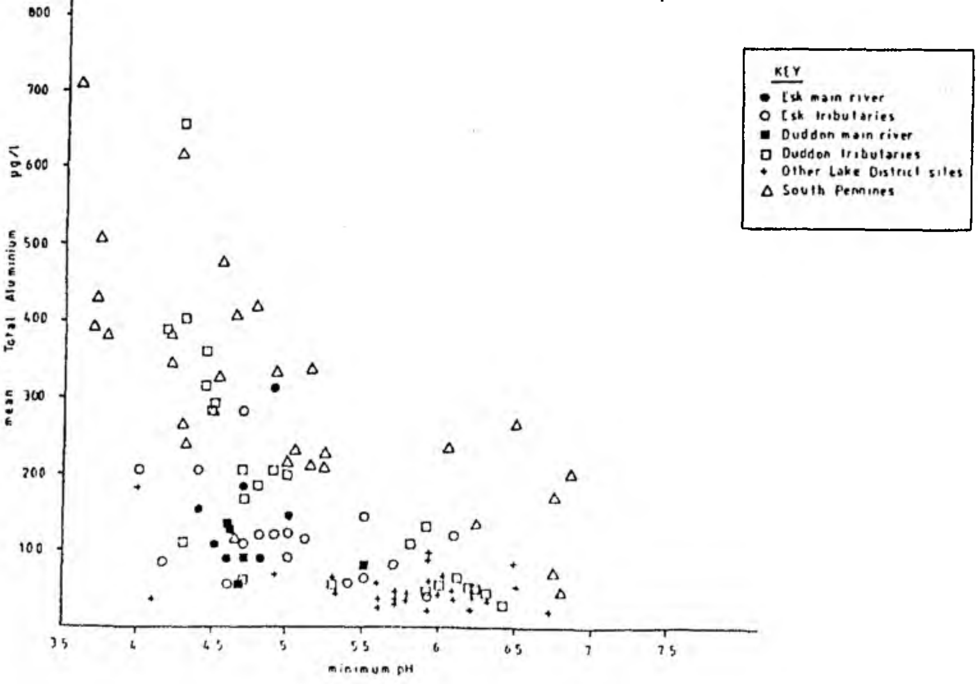
The indications are, from the relatively few samples on the Esk tributaries taken in high flow acid conditions, that despite the evident very rapid fall in pH there was still time for the appropriate exchange reactions to operate, and aluminium to be released into solution.

Thus the concept of "unmodified" rainfall seems an unlikely possibility even in high flows, and it is likely that there will always be aluminium available if there are hydrogen ions available in the surface water to exchange with it.

S.Pennines

In line with the low pH, aluminium concentrations in the S.Pennine group were generally much higher. 83% had a mean aluminium concentration greater than 200 ug/l as compared with 14% of Lake District sites. In addition to this, however, for any given pH the S.Pennine group tended to have a higher aluminium concentration than the Lake District sites. For instance in the pH range 4.0-5.0 only 26% of sites in the Lake District had mean aluminium greater than 200 ug/l compared to 93% of the Pennine sites. (See Figs 1 & 2)

Figure 3
Mean aluminium concentration v minimum pH

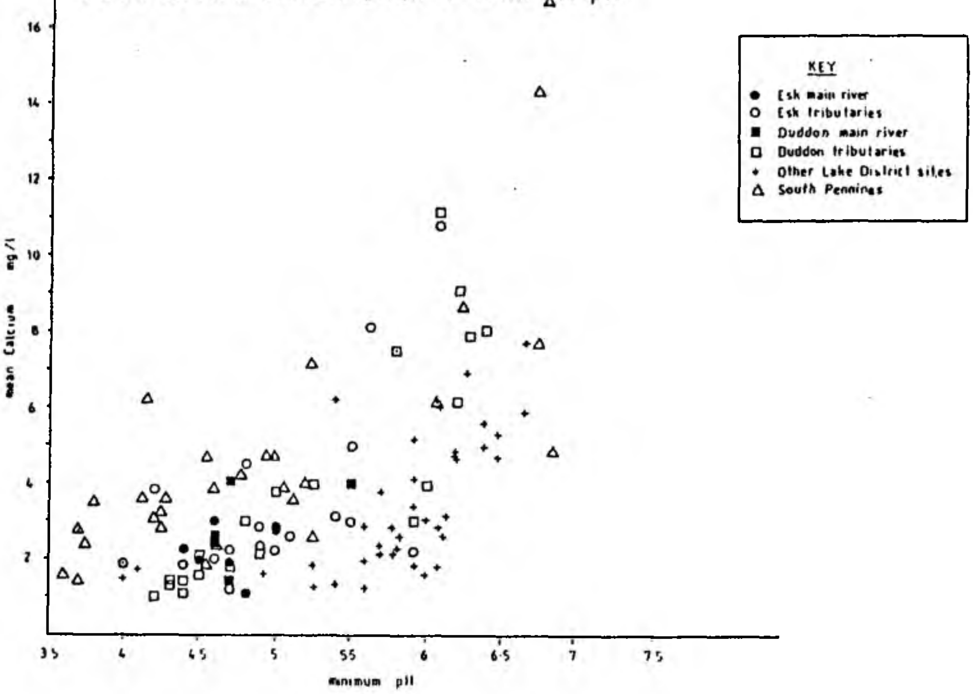


In the Pennine group, none of the sites had such a low conductivity. Although there was a tendency for the higher pH sites to have a higher conductivity, there was a large degree of scatter, and the most acid site (Whiteholme Reservoir) had the third highest conductivity. (See Fig 5).

4.6 Calcium

Lake District

Figure 6
Mean calcium concentration v minimum pH



In general a similar pattern for calcium distributions was found as for pH, (See Fig. 6) with notable exceptions being Grainsgill Beck and the River Caldew immediately downstream, which along with the upper Esk and upper Duddon, had minimum values of around 0.5 mg Ca/l and mean values below 2.0 mg Ca/l. At these levels the toxicity of aluminium is much enhanced (Brown 1983).

S.W.Cumbria

Calcium concentrations in the Duddon increased considerably between the sampling point downstream of Tarn Beck (mean 2.6 mg Ca/l) and Ulpha (mean 3.8 mg Ca/l). This was mainly due to the influence of a fairly large tributary, Crosby Gill (mean 7.3 mg Ca/l) which drains Ulpha Fell. Calcium levels and to a lesser extent pH continued to rise between Ulpha and Duddon Hall so that the water chemistry of the Duddon at the latter point was very different to the river at the upper sampling sites. Once again, on the Esk there was a downstream increase in calcium but it was less marked than on the Duddon and the mean concentration at the lowest site was only 2.8 mg Ca/l.

Fig.4 demonstrates a weak positive correlation between pH and humic substances, for the Lake District sites showing that it is highly unlikely that organic acids were making a significant contribution to the acidity at the points sampled in the Lake District and S.W.Cumbria.

S.Pennines

Another major difference between the Lake District and Pennine Groups was the levels of humic substances. For example 79% of the Lake District group had mean humic levels of less than 4mg/l, in contrast to the Pennine group, where only 17% were less than 4 mg/l. Also 23% were greater than 10 mg/l as compared with only 3% of the Lake District sites. (See Figs 1 & 2).

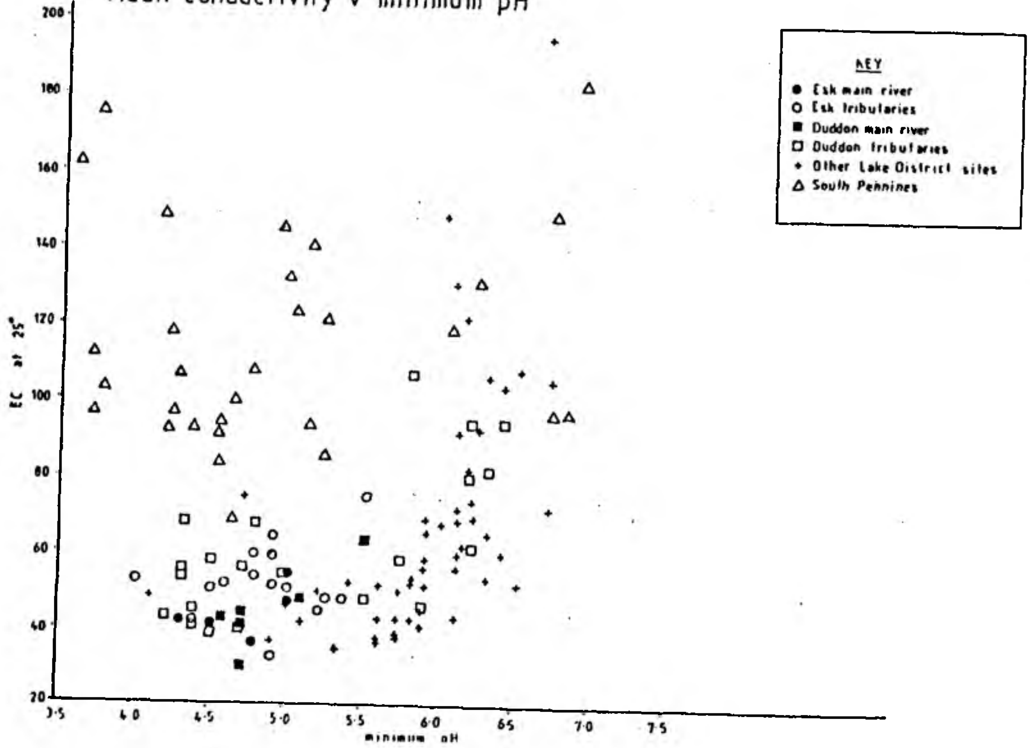
One of the findings of the Lake District sampling was that the higher humic levels were associated with the less acid sites. In the Pennine group a different picture emerged. The sites which were "peatiest" (mean humic substances concentration greater than 10 mg/l) could be divided into two groups, one north of Manchester where the pH was generally high (min. 6.5) and a second group south of Manchester all with pH 5.0.

Overall there does not seem to be a strong correlation between the acidity and the levels of humic material. However, the presence of high humic levels along with high aluminium levels at some sites gave a good opportunity to assess the role of humics in reducing the toxicity of aluminium by complexing, so that the biology of these sites was of particular interest.

4.5 Electrical conductivity

Again there was a marked difference between the Lake District and Pennine groups - not solely related to acidity. Over half of the Lake District group were "very pure" waters where the mean conductivity was less than 60 s/cm. The more acid sites were virtually all in this low conductivity band.

Figure 5
Mean conductivity v minimum pH



Thus, whilst it is clear from Fig 3 that there is a substantial degree of correlation between pH and aluminium concentrations within each group, the actual pH/aluminium relationship is not the same for both groups.

4.4 Humic substances

S.W.Cumbria

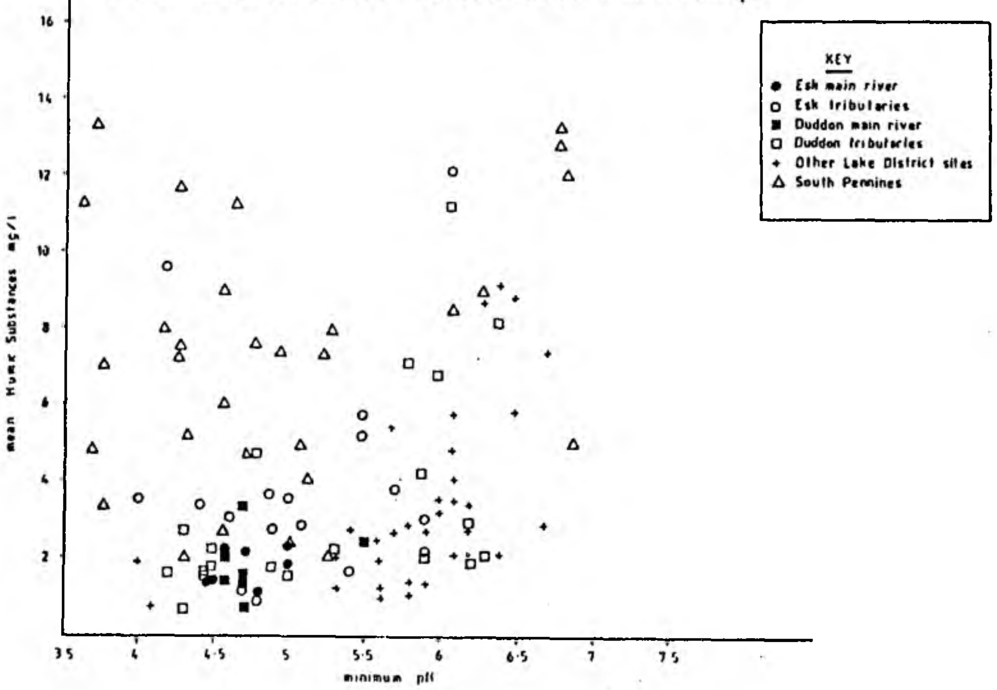
Despite the fact that the Esk passes through the Great Moss,which is an area of peat bog where the river gradient is relatively low the concentrations of humic substances were low throughout. Higher concentrations were found in one or two tributaries such as Mere Beck.

The results from the upper part of the Duddon were very similar to the Esk, but several tributaries, notably Blea Beck (mean 9.7 mg/l, range 5.5-17 mg/l) increased concentrations in the main river between Ulpha and Duddon Bridge.

Lake District

Of the other streams and tributaries sampled, Stock Ghyll (Leven catchment) had the highest concentrations (mean 9.1 mg/l, max.35.0 mg/l), together with Swindale Beck and other tributaries in the Eamont catchment.

Figure 4
Mean humic substances concentration v minimum pH



Pennines

As might be expected, there was a correlation between calcium and pH, with the most acid sites having the lowest calcium concentrations. However, the Pennine group once again displayed a different pattern from the Lake District sites.

Within the pH range 4-5 only 7% of Pennine sites were below 2 mg Ca/l mean calcium concentration. In the Lake District group over half the sites in this pH range were below 2 mg/l. (See Fig 6).

The calcium concentrations of the streams sampled in both the Lake District and Pennine groups were of course extremely low compared with streams draining limestone areas or other calcium rich rocks. (c.f. River Lune at Wath mean 26.2 mg Ca/l) But even the sites with lowest calcium concentrations mentioned above (where there was the possibility of increased aluminium toxicity) had higher concentrations than some Norwegian lakes draining hard granite catchments where mean concentrations as low as 10-20uEq/l (0.2-0.4 mg Ca/l) are common.

4.7 Discussion of Results

Presumably these increased calcium (and aluminium) concentrations and the associated anions, were partly responsible for the higher electrical conductivity of the Pennine sites as compared to the Lake District group. The fact that so many of the Pennine reservoirs had an extremely low pH despite these increased calcium concentrations indicates that the input of acidity into the system must be extremely high. This is, of course, entirely consistent with the proximity to large emission sources and urban areas known to have caused substantial damage to vegetation in this area (Ferguson and Lee 1983).

4.8 Summary of Observations

Taken as a whole, there were consistent patterns in water quality throughout the region. Significant differences were seen between Lakeland and S.Pennine streams and lakes. The S.Pennine sites tended to be more acid, with higher aluminium concentrations but also with higher concentrations of humic substances. However, there was little correlation between pH and the concentration of humic materials.

The observation that some sites in the S.Pennines were extremely acid, despite higher calcium concentrations and electrical conductivity than at sites of comparable or less acidity in the Lake District, suggested that the S.Pennines was subject to a high acid loading. This was quite consistent with observed effects on vegetation in the area.

4.9 Discussion of results from continuous monitors. (River Esk and Duddon).

Figs 7 to 10 show summaries of typical data from the two stations. Mean daily flow, temperatures and conductivity are plotted together with the daily pH range and total daily fish count where it was available.

It can be seen at once that virtually every substantial rise in river flow is accompanied by a fall in the pH. This is true for both stations, except that the Duddon (at this point) tends to be about 1 pH unit more alkaline than the Esk throughout the record. Apart from this, the records are remarkably similar.

Figure 11 Distribution of minimum pH at both sites

River Esk at Cropple How

River Duddon at Duddon Hall

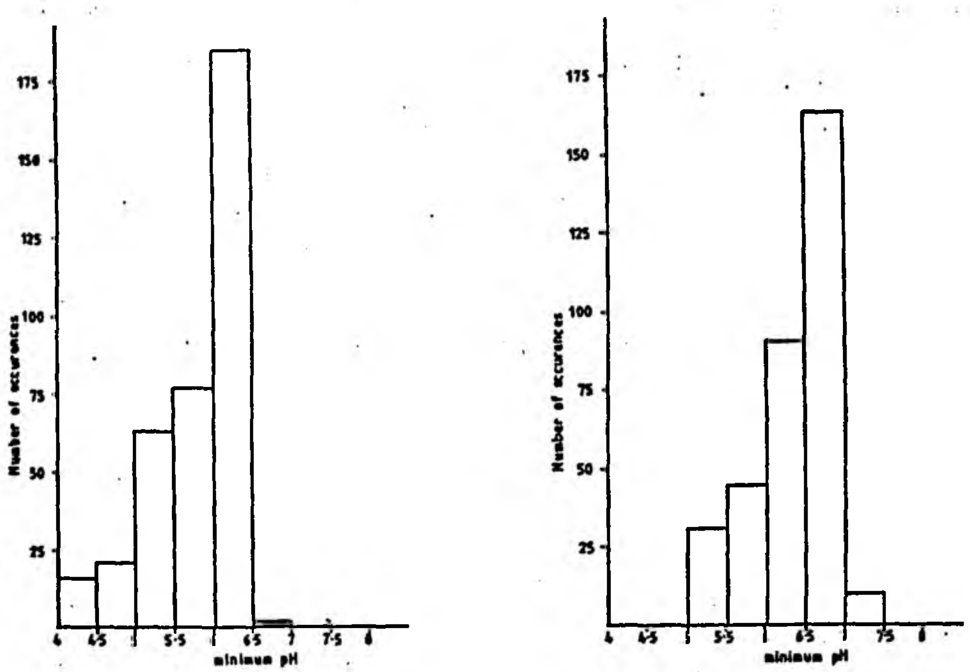


Fig 11 shows the overall distribution of minimum daily pH at both sites, but the most interesting feature is the very strong correlation between flow and pH demonstrated in Figs 12 to 15.

Newson (1984) presented similar data from spot sampling in the Wye (grassland) and Severn (forested) catchments in Plynlimon (Mid Wales). The Severn (and tributaries) showed similar relationships between flow and pH to the Esk and Duddon, but the Wye behaved differently and the pH declined much less at high flows. Newson attributed this to bicarbonate buffering by solution of Calcite and to liming as part of pasture improvements. Those streams not buffered in this way were constantly acid, especially from peaty sources.

The fact that the Esk and Duddon do not behave in this way adds support to the conjecture that humic acids contribute little to the acidity in these two catchments. (See Section 4.4).

Figure 12 Relationship between Flow and pH during 1983

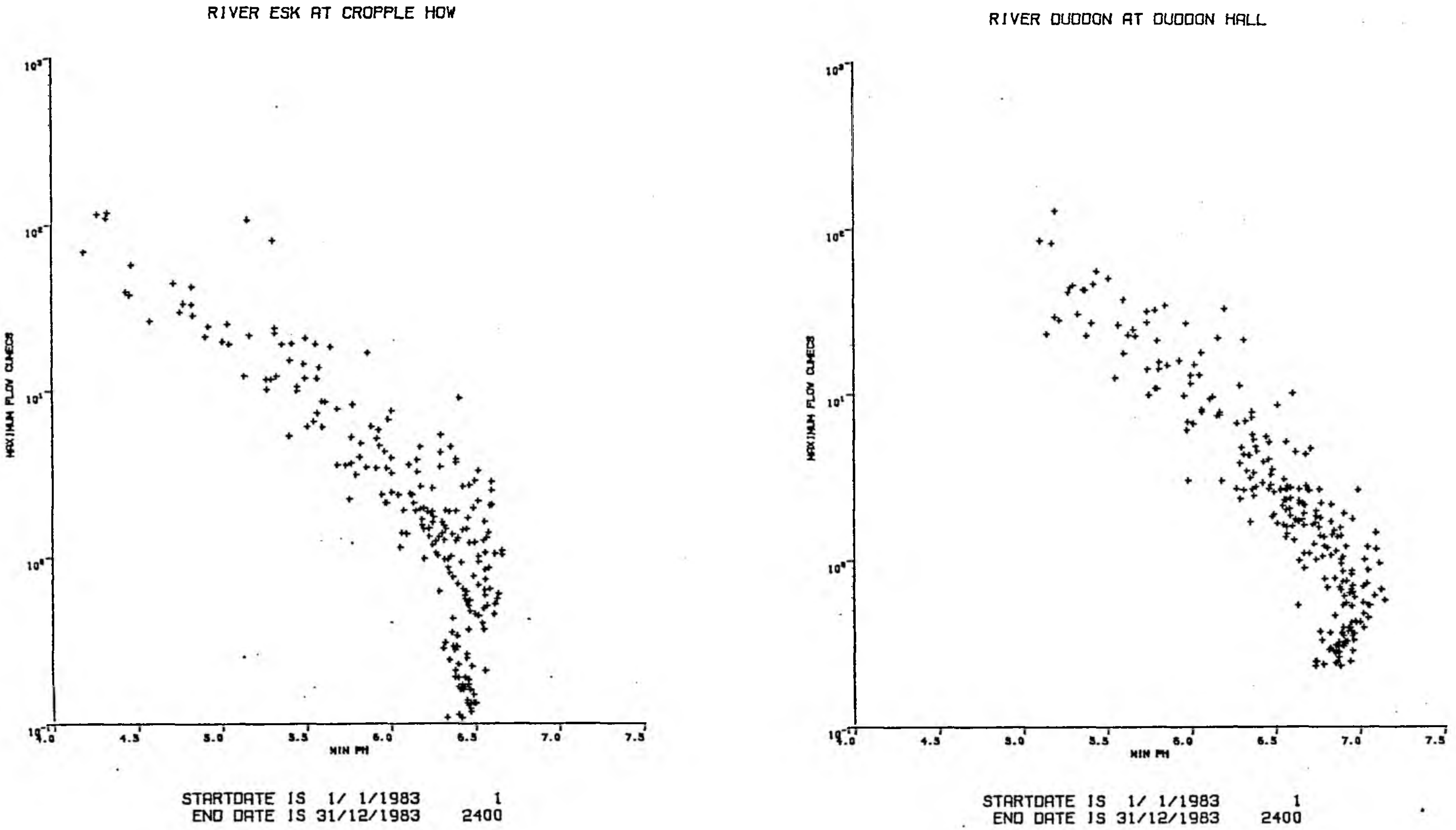


Figure 13 Relationship between Flow and pH during 1984

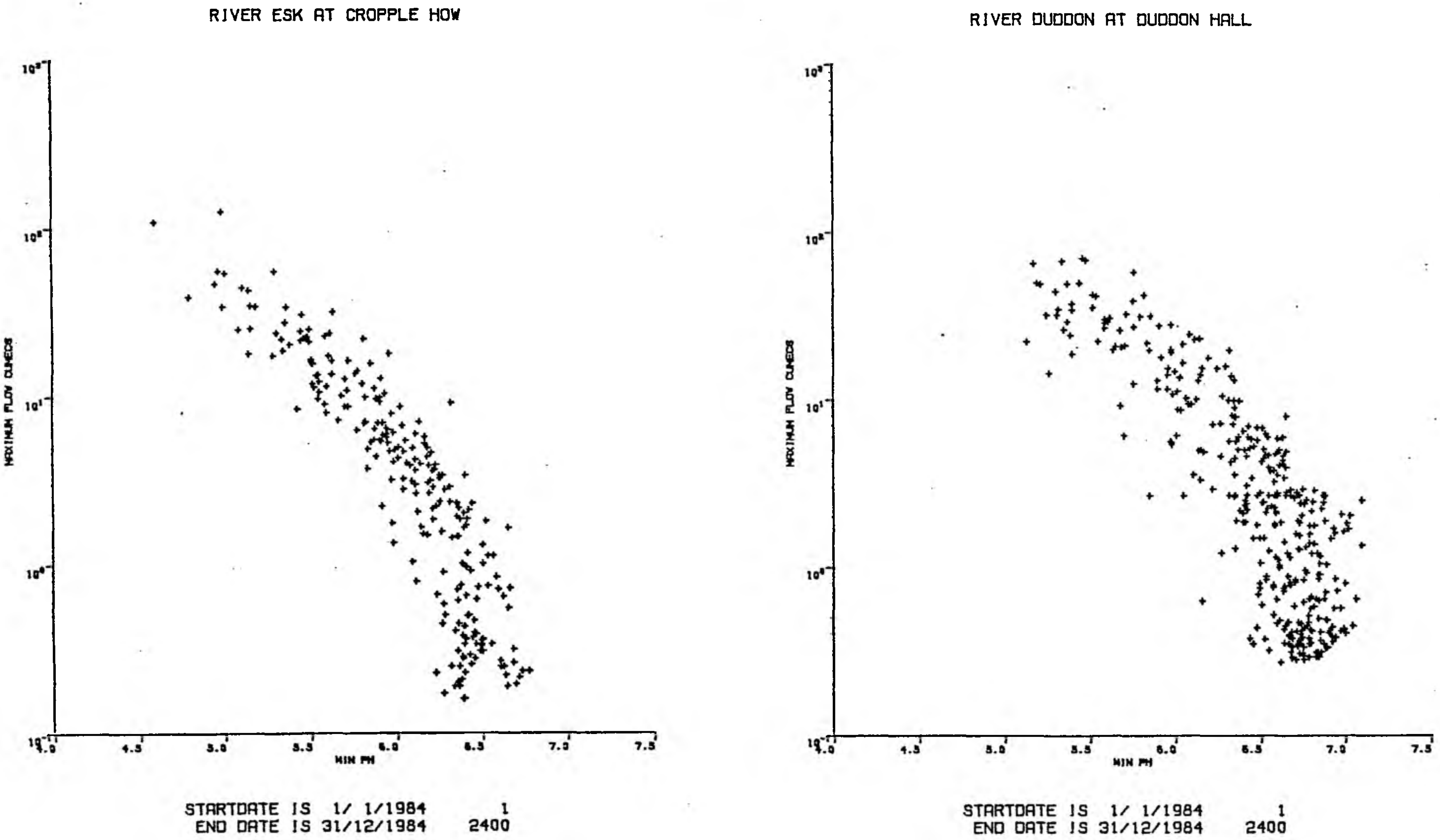
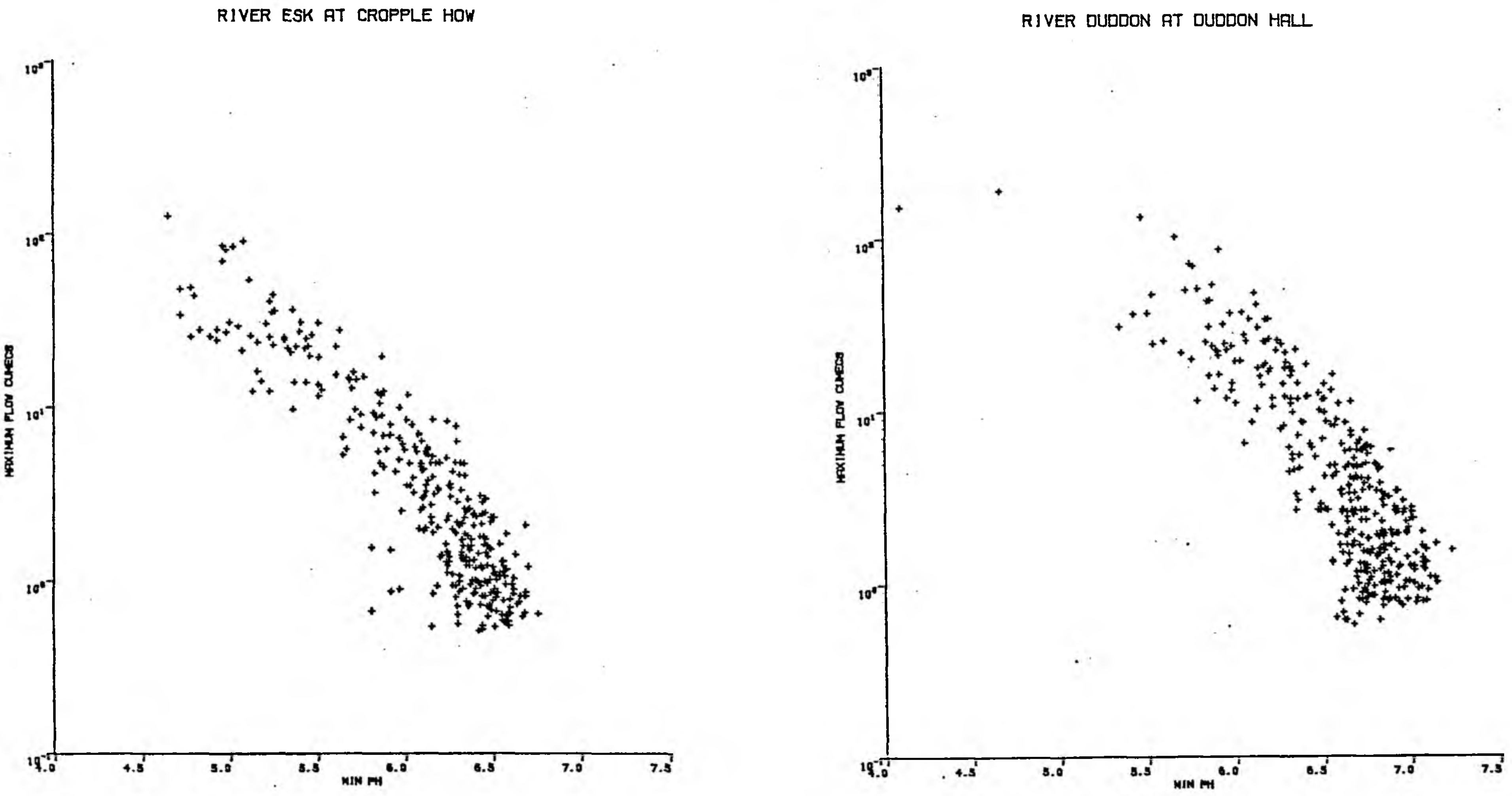


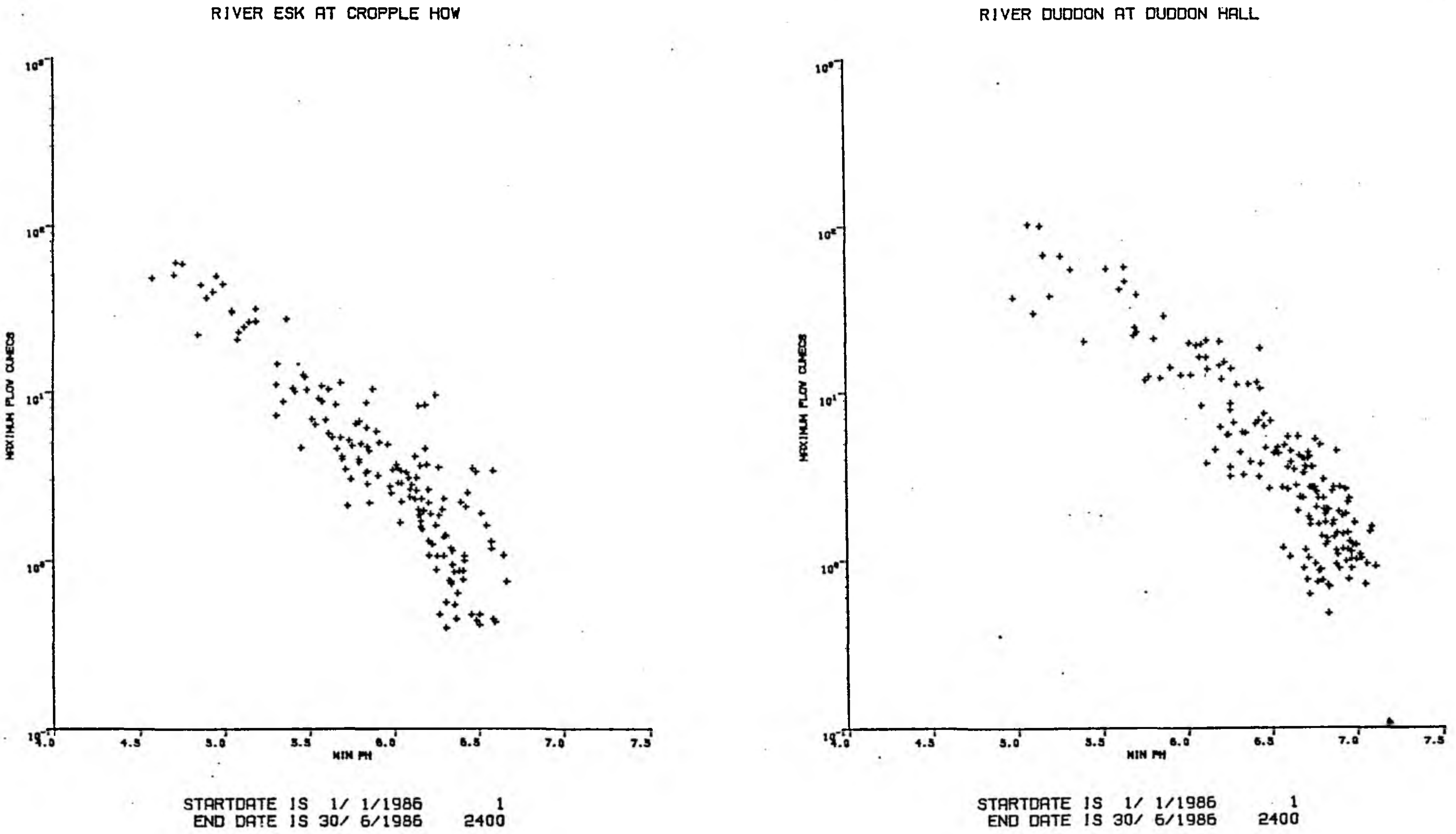
Figure 14 Relationship between Flow and pH during 1985



STARTDATE IS 1/ 1/1985 1
END DATE IS 31/12/1985 2400

STARTDATE IS 1/ 1/1985 1
END DATE IS 31/12/1985 2400

Figure 15 Relationship between Flow and pH during 1986



The observed pH/flow relationships are consistent with the behaviours to be expected from an acidicied soil which has a reduced ability to release calcium, or other cations, in exchange for H^+ in rain water.

Ca^{2+} (soil) + H^+ (in flowing water) $\rightarrow$ Ca^{2+} (surface water) + H^+ (soil) Equ. (1).

Soil samples taken from a selection of fields in the Esk Catchment have shown that a substantial number of fields are extremely acid (minimum observed pH 4) so that there is plenty of scope for acidification of inflowing water both in the valley bottom and on unimproved land at higher attitude.

Ca^{2+} (inflowing water) + soil H^+ $\rightarrow$ Ca^{2+} (soil) + H^+ (surface water). Equ. (2).

When rainfall is more acid than the soil, mechanism (1) comes into operation to reduce the acidity. When rain is less acid than the soil however, a relatively common occurrence on the Esk catchment, mechanism (2) operates, and the surface run-off becomes more acid than the incident rainfall.

The net effect therefore is that the final pH of the run-off is governed by the residence time (which is determined primarily by the rate of flow) and not by the initial pH.

Figure 16 Relationship between rainfall pH at Cropple How and river pH

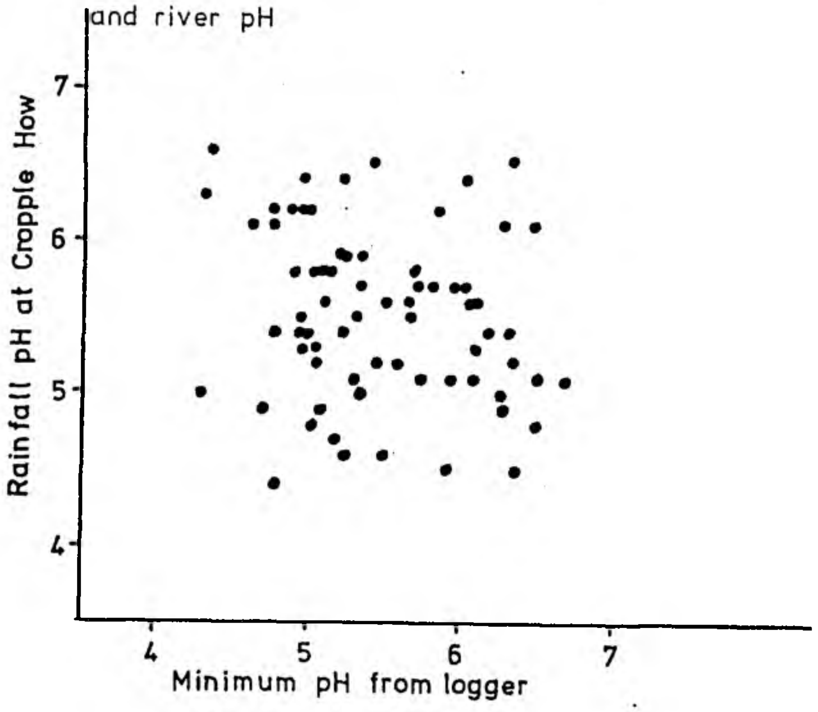
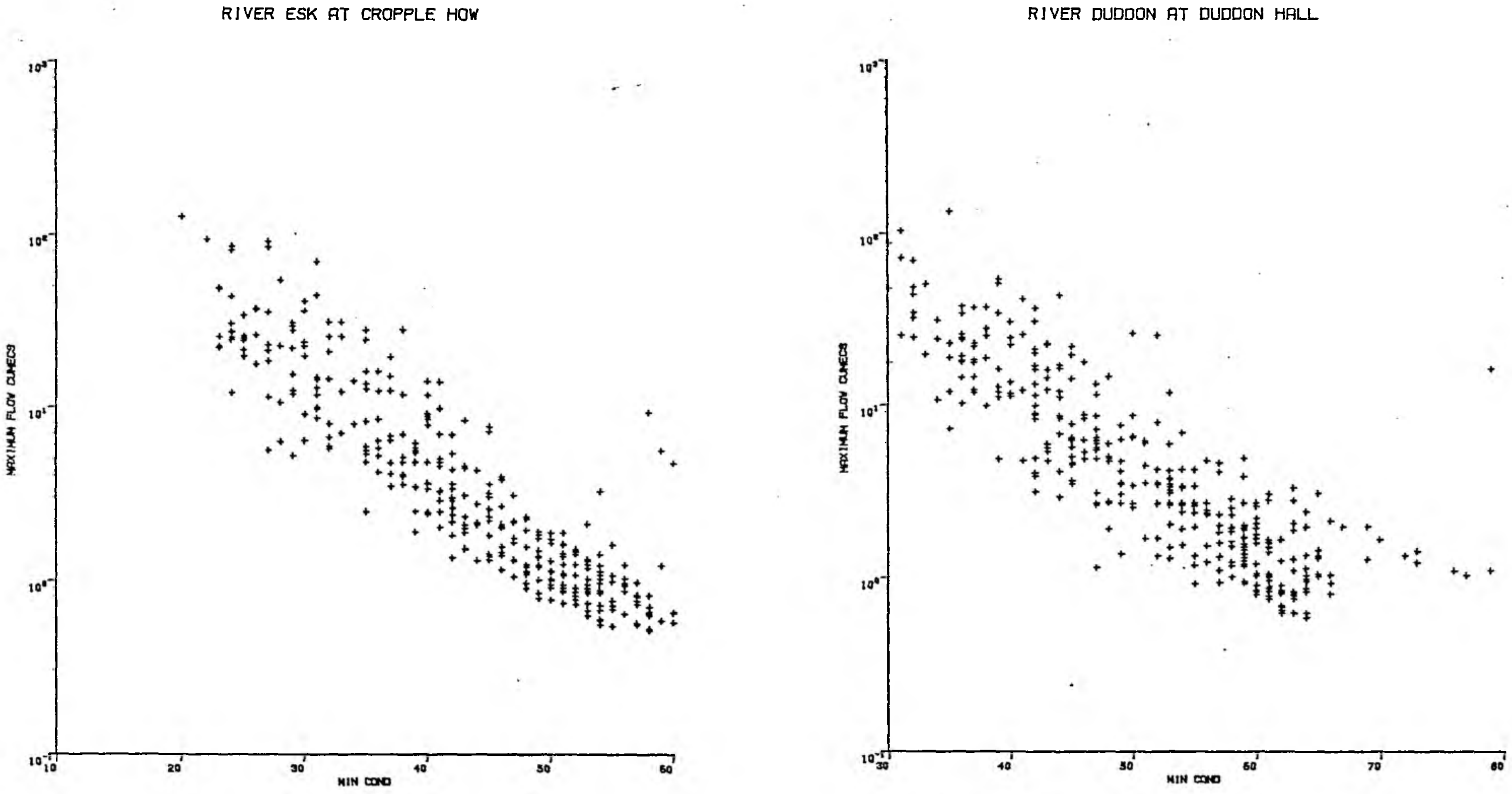


Figure 17 Relationship between Flow and Conductivity during 1985



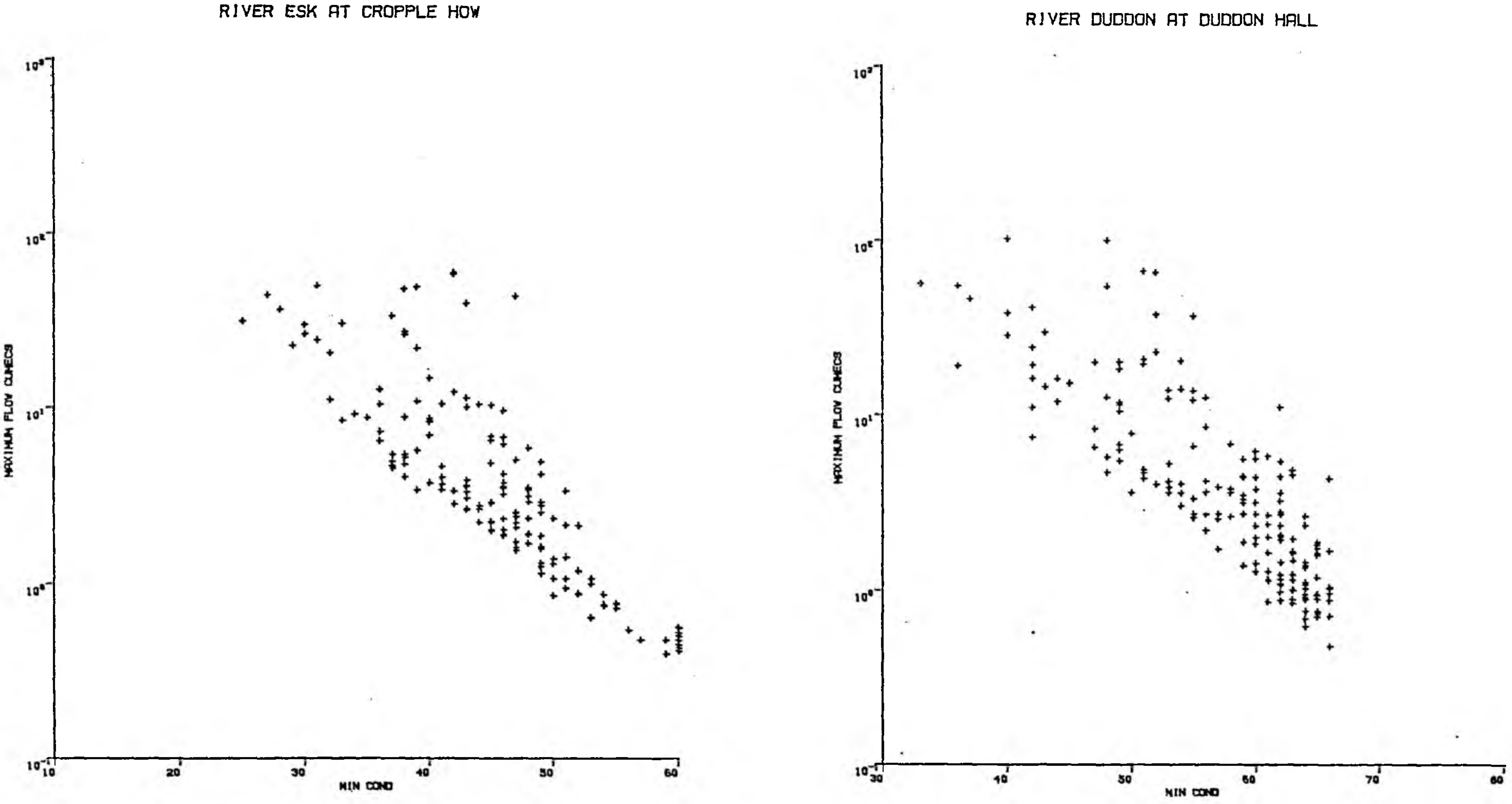
RIVER ESK AT CROPPLE HOW

STARTDATE IS 1/ 1/1985 1
END DATE IS 31/12/1985 2400

RIVER DUDDON AT DUDDON HALL

STARTDATE IS 1/ 1/1985 1
END DATE IS 31/12/1985 2400

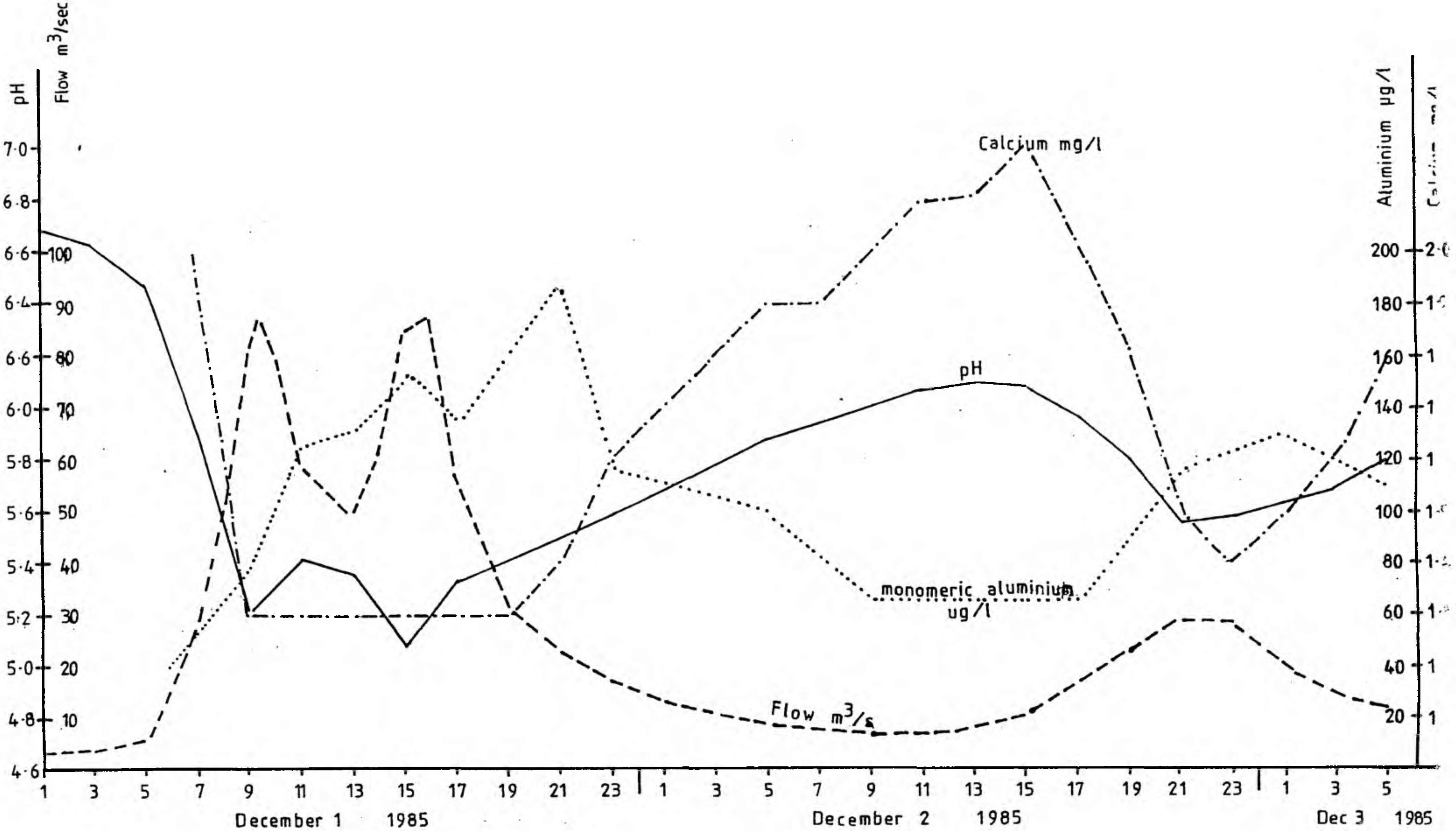
Figure 18 Relationship between Flow and Conductivity during 1986



STARTDATE IS 1/ 1/1986 1
END DATE IS 30/ 6/1986 2400

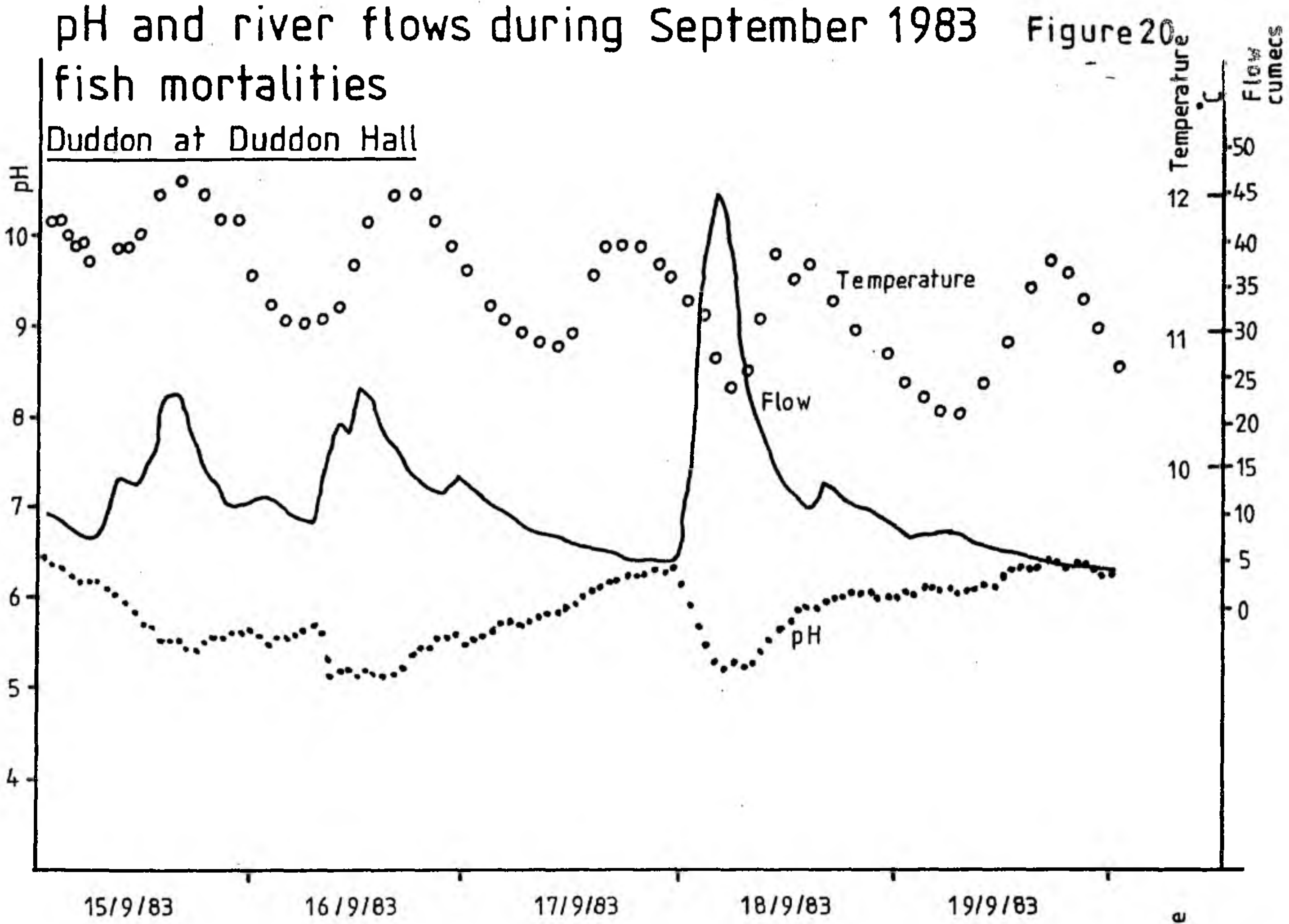
STARTDATE IS 1/ 1/1986 1
END DATE IS 30/ 6/1986 2400

Figure 19 Changes in water quality during a typical episode - from automatic sampler data

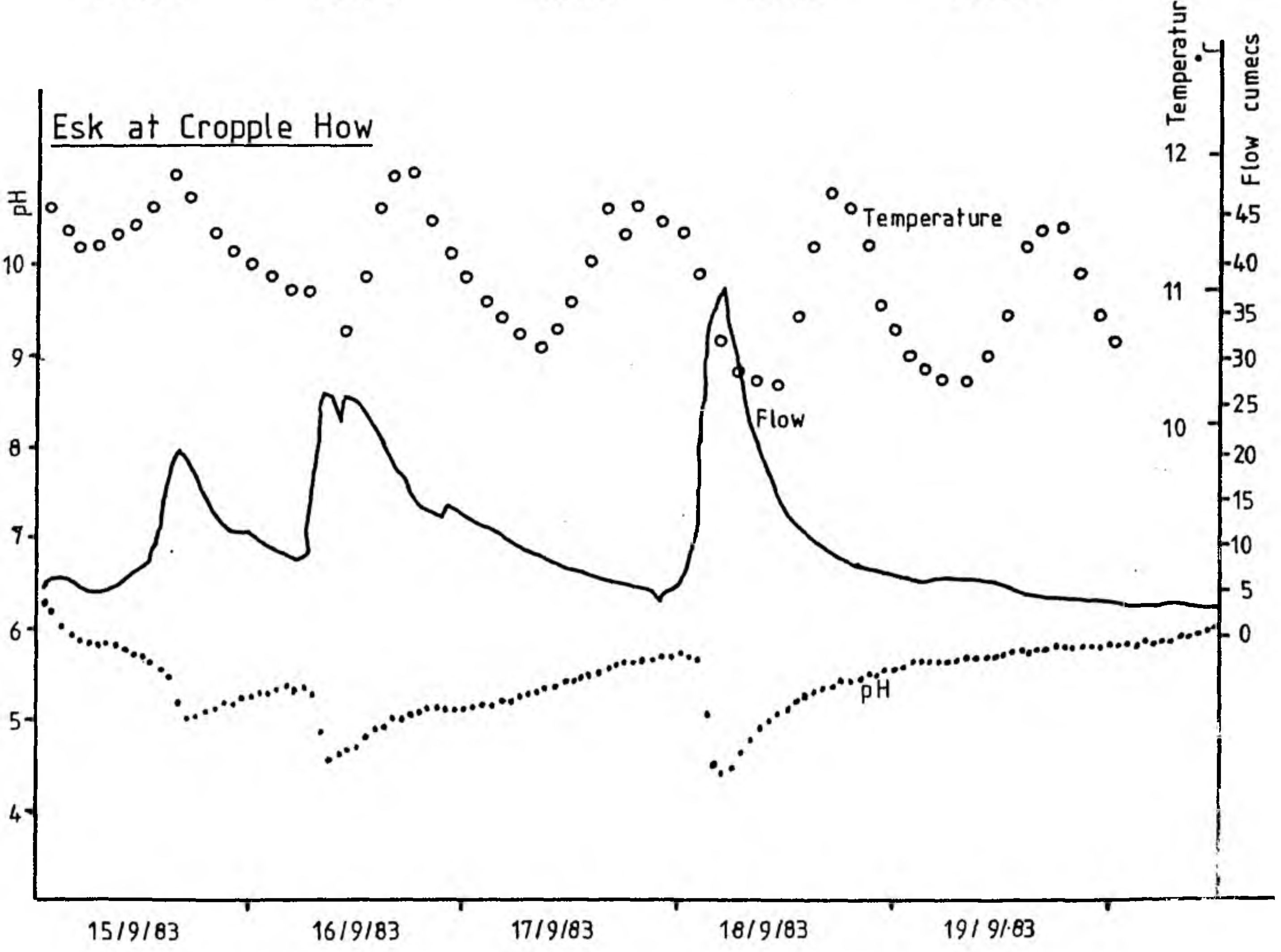


pH and river flows during September 1983 fish mortalities

Figure 20



Duddon at Duddon Hall



Esk at Cropple How

Fig. 16 demonstrates the complete lack of any obvious correlation between the rainfall pH and the river pH as measured at Cropple How.

The ability for either mechanism (1) or (2) to operate will depend on the amount of acid deposition or the extent (in a limited area of the catchment) to which agriculgural liming has counteracted this. How rapidly changes in either of these factors will communicate themselves to the surface water is not known but some of the year to year variation evident in Figs 12 - 15, may well be explained by variation in the net deposition pattern. It is intended to pursue this particular aspect in future working, notably in relation to the marked shift towards higher pH evident throughout the flow range in 1984. If this shift in pH was found to be associated with a decrease in the local deposition pattern from 1984 it would of course be a very significant finding.

4.10 Episodic Changes - results from automatic samplers

The discussion in the preceeding section centred round pH and demonstrated that, in these two catchments at least, the pH of episodes is reasonably predictable and determined by the river flow. In October 1984 conductivity monitors were installed at both sites and the conductivity/flow relationships are demonstrated in Figs. 17 and 18.

Again a remarkably consistent pattern is evident. There does not seem to be any evidence of significant high conductivity episodes such as caused by sea salt. In all cases a rise in river flow was accompanied by a fall in the conductivity. This was somewhat unexpected in view of the reporting of regular sea salt episodes at Loch Dee in Galloway, (pers comm. R. Harriman).

A large amount of information has also now been obtained from automatic samplers triggered by a rise in river level to a present value. As for pH and conductivity the behaviour of cations such as calcium and aluminium during episodes has been found to be remarkably consistent.

The pattern observed has been that as the flow rises so pH, conductivity and the calcium concentration falls, whilst the aluminium levels rise. A typical episode is shown in Fig 19.

The adverse combination of these various changes would be more than sufficient to explain the observed mortalities of fresh run salmonids in 1980 and 1983. (Fig 20).

5. BIOLOGICAL CONDITIONS

5. BIOLOGICAL CONDITIONS

5.1 The Structure of macro-invertebrate communities

5.1.1 Cumbrian hill streams

An analysis of data from a survey carried out in 1982 from 75 hill stream sites showed that most acid streams had macroinvertebrate communities lacking many common and widely distributed Ephemeroptera, Trichoptera, Crustacea and Mollusca in many cases with exceptionally low diversity in terms of number of species present. The acid hill stream faunas were invariably insect dominated, with the Plecoptera providing most species, an average of five or six species being taken in a winter kick sample. Common species apparently unrestricted in their occurrence in the most acid stream (see also Appendix 2) included Plecoptera such as *Amphinemura sulcicollis, Protonemura meyeri, Leuctra inermis, Leuctra hippopus* and *Chloroperla torrentium,* caddis including *Plectrocnemia conspersa* and *Rhyacophila dorsalis*, and Diptera incuding *Dicranota* sp., Chironomidae and Simuliidae.

5.1.2 Pennine Hill Streams

In the Southern Pennines the structure of the invertebrate communities inhabiting hill streams was clearly influenced by pH. Three types of communities could be distinguished and related to changes in pH.

(i) In streams of very low geometric mean pH (between 3.6 and pH 4.4) only insects from the following families were found and they were neither abundant or diverse : Nemouridae, Limnephilidae, *Dicranota* sp., Chironomidae and Simulidae. Streams of this type generally drained peat bogs and were more acidic than any of the Lake District sites.

(ii) In streams of low geometric mean pH (between pH 4.5 and 5.5) the fauna was often abundant and diverse and included species from those groups mentioned above plus Annelida, Hydracarina, *Protonemura* sp., *Amphinemura* sp., *Leuctra* spp, *Chloroperla* spp, Dytiscidae, *Sialis* sp., *Rhyacophila* spp, *Plectrocnemia* sp and Tipulidae,. All of the above groups had distributions which appeared to be independant of pH above pH 4.5

(iii) As geometric mean stream pH increased above pH 5.0 there was a general trend for the insect fauna to become more abundant and diverse. The increase in diversity with pH was due to the appearance of species particularly sensitive to low pH including most species of Ephemeroptera plus *Ancylus* sp., Gastropoda, *Gammarus* sp, Taeniopterygidae and Perlodidae.

5.2 The distribution of indicator species

5.2.1 Cumbrian hill streams

Because of the interest in salmonid fish populations it was of particular note that two common and widespread taxa, Baetis sp. and Gammarus sp., important in the diet of salmonids in streams in which they occur, also appeared to have a distribution pattern closely related to the geometric mean. Both genera were conspicuously and consistently absent from the most acid sites.

Gammarus was the most restricted in distribution, and did not occur in streams where the geometric mean pH was lower than 5.9. The lowest recorded pH from sites with Gammarus came from Fisher Beck and Hardknott Gill (Duddon) where the minimum recorded pH was 5.5. In both these instances the occurrence was sporadic. Such a sporadic occurence in Hardknott Gill (Duddon) is noted in the literature (Sutcliffe and Carrick, 1973).

The observed distribution of Gammarus in our sites is in general accord with the statement regarding G. pulex that in Britain it has not been found in water with pH consistently below 5.7 (Gledhill et al., 1976).

With the exception of the sporadic occurence noted above in Hardknott Gill (Duddon), Gammarus was absent from the upper Esk and upper Duddon catchments, and has not been encountered in the main river sampling on either system.
All sampled sites with Gammarus had a healthy salmonid fish population, but conversely absence of Gammarus, though noted in all fishless or very low fish density streams, did not specifically indicate such a state, many streams without Gammarus having a good standing crop of juvenile salmonids.

Baetis sp. distribution was less restricted than Gammarus, and all sampled sites with Gammarus present had Baetis recorded at some time. In the most acid sites where it occurred, Baetis was sporadic, not occurring on all sample occasions; this was the case at Linbeck and on the Esk upstream of Hardknott Gill, both with mean pH 5.5. Where an animal is found infrequently or in low numbers at a site it is possible that it has drifted in from a more suitable (more alkaline) tributary upstream. For example, in a South Pennine site, Hurst Reservoir, mayflies were not found in the main feeder (pH 5.25, spot measurement at time of sampling) except downstream of a minor feeder stream (pH 6.74) in which Siphlonurus lacustris was abundant. Baetis was not recorded at any sites where the mean pH was less than 6.0 and where the lowest pH recorded was less than 5.5.

The foregoing generalisations derive from 1982 data, but later extensions of the sampling programme support them. Thus, for example, in the upper Glenderamackin catchment (Prigg 1985b) Baetis rhodani was absent from the Glenderamackin upstream of Bannerdale Beck, with mean pH 5.4, sporadic in the Glenderamackin upstream of Bullfell Beck with mean pH 5.9, and present on all sample occasions in Bullfell Beck with mean pH 6.0.

The specific records from which the Baetis occurrences were generalised included B.rhodani, B. scambus, B. muticus, B. tenax, and B. niger, in that order of abundance; distribution relative to pH for all Baetis sp is shown in appendix 3, which also shows the distribution of other mayflies found.

Excluding the markedly seasonal Ephemerellidae, nymphs of the genus Baetis and of the family Heptageniidae were generally the most numerically significant Ephemeropterans in the salmonid nursery streams in Cumbria. It is interesting that in the 1982 survey no samples with Baetis sp. absent had Heptageniidae or Ephemerellidae present, except for one winter sample from the Esk at Cropple How which had an isolated specimen of Rhithrogena semicolorata present.

'For absence of Baetis read absence of mayflies' would be a very attractive generalisation and it is only confounded by the presence of Leptophlebidae and/or Siphlonurus lacustris in some of the very acidic upper catchment sites where Baetis sp is absent in the upper Esk (and Black Beck, Duddon), and by infrequent occurrences of Ameletus inopinatus in sites lacking Baetis at River Duddon (Troutal) and River Derwent (Seathwaite).

Siphlonorus lacustris was the only mayfly nymph found in the most acid streams in summer collections in a study of a group of upland stream in central Scotland (Harriman and Morrison, 1982). Regarding Leptophlebidae, our own studies on a highly acidic 'acid mine drainage-type' polluted stream (Prigg, 1978) showed live, ochre-coated Habrophlebia fusca in some of the acidified sites, and it may be that the family is relatively acid resistant; at the upper Esk sites referred to, the species noted were Paraleptophlebia submarginata and Leptophlebia vespertina.

In the sampling to date, all sites with Baetis sp. present on at least one sampling occasion had trout similarly present. It must be stresed that the sample sites, except for a few very small tributaries in the Upper Duddon catchment which were sampled partly because of their occurrence in an earlier study, were selected as likely to contain trout, with no known physical or chemical environmental limitations on a juvenile trout stock. Within streams meeting such broad environmental criteria as potential upland salmonid nursery streams it is reasonable to propose that the presence of Baetis sp will be associated with the presence of trout. It is unreasonable, and factually incorrect, to suggest that Baetis sp. presence will indicate trout presence in all other stream types.

Total salmonid density in streams with Baetis sp present was in excess of 0.2 salmonids/m^2 in all cases but one, that of an upper site on Mosedale Beck (Wastwater catchment survey, Prigg 1985c) with only 0.1 salmonids/m^2.

Twenty of the sites without Baetis sp. had trout present, though most of these were sites with very low stock densities.

5.2.2 Pennine Hill Streams

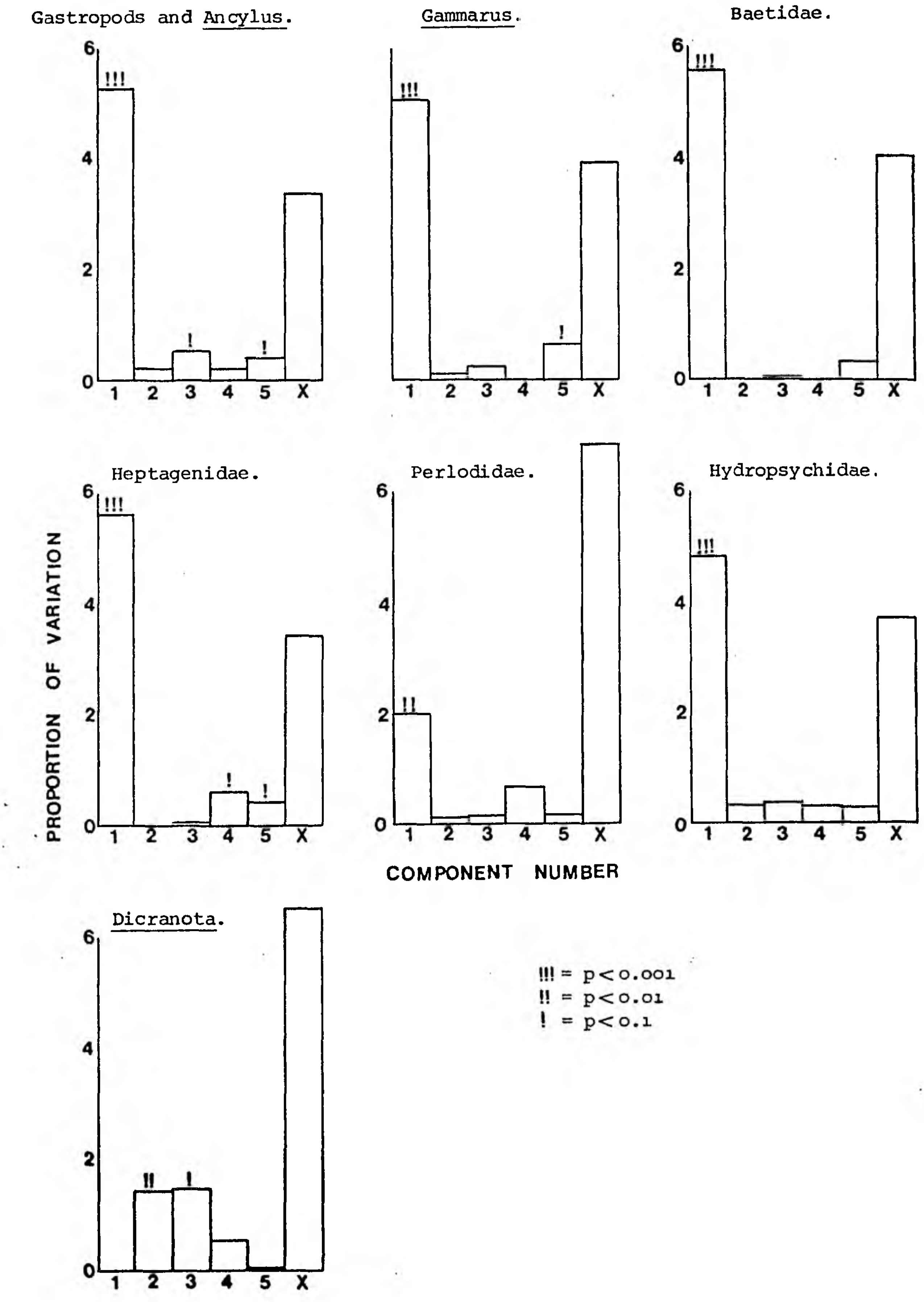
Although the distributions of many of the macroinvertebrate taxa appeared to change with pH some of them occurred too infrequently to be considered as useful indicator species. For example Siphlonurus lacustris and Leptophlebia vespertina, mayflies which are known to be tolerant of low pH were only found at two and three of the sites respectively in the Southern Pennines. Some taxa, such as Gammarus sp and Helodidae, are known to be common and widespread in the North West but they were found at few of the sites in this study, perhaps because the sites were predominantly of low pH. However, for completeness some of these taxa are included in Table 5.2 which attempts to use macroinvertebrates to indicate the lower limits of geometric mean of stream pH . The table is based on the survey of the whole North West Water region summarised in Appendices 2, 3 and 4

It is interesting to note that four of these taxa, Heptagenidae, Gastropoda, Ancylus fluviatilis and Gammarus sp all have pH 5.9 as their lower limit of distribution. The presence of these four common and widespread taxa and Baetis rhodani can be used to indicate whether or not the pH of the water is suitable for salmonids (see 5.2.1). Baetis is particularly useful because it can disperse in flight to all suitable sites.

TABLE 5.2.1 The indication of the lower limits of hill-stream mean (Based on a survey 123 hill-streams in the North West Water region)

Invertebrates present	Indicated pH
Nemouridae, Limnephilidae, Dicranota, Chironomidae and Simulidae, present in the absence of other macroinvertebrates	pH 4.4
Siphlonurus lacustris	pH 4.6
Leptophlebia vespertina	pH 5.0
Isoperla grammatica	pH 5.0
Sphaeridae	pH 5.1
Brachyptera risi	pH 5.3
Hydropsyche instabilis	pH 5.3
Baetis rhodani	pH 5.5
Heptagenidae	pH 5.9
Gastropoda	pH 5.9
Ancylus fluviatilis	pH 5.9
Gammarus pulex	pH 5.9

Figure 21 Proportion of variation in the numbers of invertebrates in kick samples attributable to principal components of chemical and physical factors in South Pennine streams. (Only cases where more than 30% of the variance is explained by principal components are included).



3) Not all of the measured physico-chemical parameters have yet been included in the principal component analysis. The amount of variation attributable to the principal components may be increased when the remaining variables and the data from the Lake District sites are added.

Table 5.2.2 Eigenvectors of chemical and physical components with principal components. High Eigenvectors indicate a strong correlation within any one component.

	Component Number				
	1	2	3	4	5
Alkalinity	0.4586	0.0925	0.1253	0.5583	-0.2029
Calcium	0.4891	0.0987	0.0675	0.0283	-0.4368
Aluminium	-0.4189	0.2158	0.4048	0.0769	-0.6785
Humic Acids	0.2671	0.5641	-0.3157	-0.6144	-0.1868
pH	0.4560	-0.2331	-0.1858	0.1255	0.0072
Magnesium	0.1557	-0.7086	0.2334	-0.4990	-0.2957
Conductivity	0.2674	0.2458	0.7920	-0.1985	0.4305

5.3 Discussion of the spatial and temporal patterns of distribution.

5.3.1 Cumbrian hill streams

Given the good indicator status of Baetis, it is justifiable to consider the distribution of acid restricted invertebrate communities as evidenced by lack of Baetis. The geographical pattern of its distribution in Cumbria was broadly comparable to that found for impoverished fish populations (See 6.6.1)

Most of the sites lacking Baetis were found in the headwaters of stream systems radiating from the western mountain mass of the Lake District.

Besides the upper Esk and upper Duddon catchments, affected sites included the extreme upper catchment of the Brathay, the upper main tributaries of Great Langdale Beck, the River Liza, and upper Lingmell Beck.

The main outlying sites lacking Baetis were in the upper Glenderamackin and upper Blea Beck (Lune) catchments. Where Baetis rhodani was not present on all sampling occasions the data showed that it was most likely to be encountered in mid-late summer samples. There were some indications that the frequency of occurrence was notably lower in spring samples from the more acid sites.

An interesting example of what may be a real change in distribution during our survey was noted at the upper Derwent site at Seathwaite. No Baetidae were present in three separate seasonal samples during 1982, but a single autumn sample in 1985 yielded a number of specimens of Baetis rhodani and a single specimen of the caddis Hydropsyche instabilis, not recorded at the site in 1982. This improvement in macroinvertebrate fauna was matched by an increase in juvenile samonid population as noted in 6.1.3

When considering limited historic data from a series of sites down the River Liza (Prigg 1986b) in relation to recent kick sample records, it is concluded that whilst Baetis rhodani was found at middle and lower sites on the Liza prior to 1980, it was not found subsequently, possibly reflecting a critical acidification trend.

The invertebrate fauna of Spothow Gill on the Esk catchment was monitored before and after the liming exercise (See 6.6.2). The monitoring of the biota is continuing, but no recolonisation by mayflies or other acidification sensitive indicators has yet been observed.

5.3.2 Southern Pennines

As each of the sites has so far only been sampled on one occasion, no comments can be made on the temporal and spatial patterns of distribution of macroinvertebrates in the Southern Pennines.

5.4 Summary

1. Great differences were found between the invertebrate communities inhabiting "acidic" (pH < 5.5) and non acidic (pH > 5.5) hillstreams in the Lake District and South Pennines

2. In streams of very low geometric mean pH (< 4.5), which only occurred in the Pennines, only Nemouridae,Limnephilidae Dicranota sp., Chironomidae and Simulidae were found.

3. In streams of pH between 4.5 and 5.5 fauna was often abundant and diverse and included, in addition to those mentioned above, Annelida, Hydracarina, Protonemura sp, Amphinemura sp., Leuctra sp, Chlorperla sp, Dytiscidae, Sialis sp, Rhyacophila sp, Plectrocnemia sp and Tipulidae.

4. "Acid-sensitive" taxa occurred in streams with geometric mean pH's above 5.0. The abundances of these taxa gave statistically significant correlations with geometric stream pH and included Baetidae, Heptagenidae, Gammarus sp,Mollusca and Perlodidae. Principal component analysis applied to the Pennine data indicated that the abundance of these animals was related to a component loaded by pH, alkalinity, calcium and aluminium (negatively) and this component could be attributed with approximately 50% of the variation in the numbers of these animals.

5. The presence of Baetidae, Heptagenidae, Gastropoda, Ancylus fluviatilis and Gammarus sp can be used to indicate whether the pH of a water is suitable for salmonids.

6. A more thorough analysis of the data is necessary and will be presented in the future.

6. FISH AND FISHERIES

6. FISH AND FISHERIES

6.1 Fish Distribution

6.1.1 Esk Fish Populations

In summer 1981, an electric fishing survey covering 23 sites through the Esk catchment drew attention to the apparently fishless state of the upper Esk catchment above the upstream limit of migratory salmonid access, and demonstrated a lack of salmonids in two streams readily accessible to upstream migrants and with a physical character that would be associated with salmonid nursery areas (Spothow Gill and unnamed tributary downstream of Spothow).

Futhermore, several tributary sites had abnormally low densities of resident juvenile salmonids, notably Blea Beck and Whillan Beck. In the case of Blea Beck there was no evidence of successful recruitment that year (no 0+ trout were captured).

Juvenile salmonid densities in the main river sites were very low, most notably at the most upstream site quantitatively sampled, Wha House Bridge.

The juvenile salmonids encountered were largely trout,salmon being found only at one tributary site, Whillan Beck (very low density of 0+ fish), and in one main river site at Forge Bridge.

The 1982 survey again indicated the fishless state of the upper Esk and its tributaries in all sampled sites above impassable falls downstream of the Esk/Lingcove beck confluence.

Spothow Gill still lacked salmonids and had only eels present, but one 1+ or older trout was found in the unnamed tributary downstream of Spothow Gill

The latest survey, in 1984 again showed no salmonids in Spothow Gill or the unnamed tributary downstream.

An interesting observation is that although the tributary streams retained comparable relative ranking in terms of fish stock density as between 1981-1982, in most cases there was evidence of an improved stock of 0+ fish in 1984. 0+ fish were present in Blea Beck and Whillan Beck had more trout, in both the 0+ and 1+ and older grouping than in 1981.

Many of the more acid tributaries and main stream sites had notably higher population densities of 1+and older salmonids in 1984 than in 1982 or especially 1981.(Prigg 1986a).

Another pointer to an improvement in fish stock between 1981 and 1984 was the distribution of salmon (salmon being more sensitive to acidification effects than trout). Salmon were present at only 2 sites in 1981, 5 sites in 1982 and 6 sites in 1984. However, juvenile salmon were still absent from the upper part of the Esk catchment,the most "upstream" record being a single individual from Birker Beck in 1984.

No fish could be found in Blea Beck (Lune catchment) or Great Langdale Beck at the sites sampled. An abnormally low trout density was recorded from the River Liza site, and the salmonid stock density was even poorer on the River Derwent at Seathwaite.

These streams with poor fish stocks were subject to more detailed investigation. It soon became apparent that the Great Langdale Beck site was subject to complete drying under moderate drought conditions and that the total absence of fish was directly attributable to these physical conditions. However, it was also clear from a survey in July 1983 on a major tributary, Oxendale Beck, not so susceptible to droughting at the survey location, that the trout stock, although present in moderate density, had an unusual population structure, with younger age clases poorly represented relative to older fish, and fry of the year were absent.

Repeat sampling of the Blea Beck (Lune) site in June 1983 produced only three old large trout and a large eel in a 76 m long site. No juvenile trout or fry were present. An additional site 500 m further upstream was fishless,whereas some 500 m downstream, below the A6 road a reasonable trout population with a high proportion of yong fish was present. On several occasions in 1983 chemical samples taken through this reach demonstrated a rapid increase of calcium levels and pH with passage downstream.

The fish population of River Liza site was sampled again in October 1985 when a comparable impoverished stock was found. On this occasion two further sites downstream had slightly better trout stocks, though still relatively poor.

The River Derwent at Seathwaite was sampled again in October 1985, and had a markedly improved stock relative to 1982, with both juvenile trout and salmon densities increased. A site identified as of special interest in the 1982 survey was on the River Brathay at Fell Foot, where despite low mean pH and calcium (5.5 and 1.8 mg/l Ca respectively) a reasonable stock of trout was present. It was speculated that the stock might benefit by upstream migration from Little Langdale Tarn, which probably had a less extreme pH regime.

Sampling in June 1983 demonstrated a roughly comparable population at the Fell Foot site, which surprisingly included a number of American Brook Trout (Salvelinus fontinalis). It was later learnt that these fish had been stocked into Little Langdale Tarn in 1982. Two sample points, upstream of both Fell Foot farm and drainage from improved land in the vicinity, were also sampled on the Brathay in June 1983, and both yielded exceptionally low salmonid densities. Interestingly, at one site the four salmonids present were all specimens of Salvelinus fontinalis. The documented greater resistance of this species than Salmo trutta to acidification effects seems relevant in this location.

6.1.2 Duddon Fish Populations

In 1982 no evidence could be found of juvenile salmonid populations in Doe House Gill, Gaitscale Gill, Black Beck, and, more significantly, Tarn Beck at the site above Tongue House. Moasdale Beck and The Syke had abnormally low trout densities, with no evidence of 0+ fish, and Castlehow Beck had an odd population structure, having only 0+ fish present. The upper main river had a very sparse trout population. No eels were found at any sites in the catchment further upstream than Grassguards Gill, yet all other sites had eels present. Juvenile salmon were present in Tarn Beck upstream of Gobling Beck, Crosby Gill, Holehouse Gill and Logan Beck, and in the main river sites at Ulpha Bridge and Duddon Bridge.

Many of the tributary streams in the lower half of the catchment were quite productive nursery areas; in the upper catchment Hardknott Gill was the most productive trout nursery area, but its exceptionally high stock density in 1982 was partly an artefact due to drying up of large areas of the stream which concentrated of fish in residual flowing reaches.

The absence of juvenile salmon in the upper Duddon catchment above the Tarn Beck confluence was not anticipated by local Fisheries staff. To further investigate possible restrictive influences on salmon survival 5000 fed salmon fry were stocked into Tarn Beck upstream of Tongue House Farm, and a similar number was released into the upper reaches of Grassguards Gill, above impassable falls. The stocking was undertaken in May 1983. A follow-up survey in Tarn Beck in August 1983 showed no in situ survival, and similar findings were made on Grassguards Gill in September 1983. Three fish samplings in upper Grassguards Gill in 1982-83 failed to produce any salmonids; in fact the only fish found was one eel on one occasion.

A series of samplings of upper Tarn Beck between 1982 and 1986 showed at best exceptionally low trout densities above Tongue House Farm consisting of largely 1+ or older fish which may derive from a stock upstream in Seathwaite Tarn. Below Tongue House Farm, and particularly below the confluences of Long House and Sunny Pike Gills, trout densities improved, and evidence of successful recruitment as judged by the presence of trout fry of the year was noted.

6.1.3 Other Cumbrian Stream Sites - Fish Populations

In 1982 fish stock data was acquired on 25 Cumbrian hill streams covering a relatively wide range of stream productivity, but which had no previously known physical or water quality limitation precluding a resident juvenile salmonid population and were expected to contain such a fish fauna. The survey attempted to give a broad cover of possibly sensitive catchments and so for example, relatively harder water hill streams draining from the N.Pennines into the R. Eden catchment,(for which previous data showed uncompromised juvenile salmonid stocks) were not included.

As a result of a fish mortality in June 1984 on the upper reaches of the River Glenderamackin, electric fishing surveys were subsequently conducted in this catchment in May and November 1985. The circumstances of the probable acid event causing the mortality have been described (Prigg 1985b). It is clear from the fish surveys that the upper reaches of the Glenderamackin above Bannerdale Beck are virtually fishless, with no evidence of successful trout recruitment, but that following addition to the flow of the less acidic Bannerdale and Bullfell Becks the main river improves. The latter becks sustain trout (and salmon in the case of Bullfell Beck) and show evidence of successful trout recruitment.

In extending coverage of Lake District catchments, fish surveys were carried out in the Wastwater Catchment(Prigg 1985c), additional sites in the upper Derwent catchment (Langstrath Beck and Greenup Gill), and Buttermere tributaries (Warnscale Beck and Gatesgarthdale Beck). Trout were present at all of these sites (and salmon in abundance in Gatesgarthdale Beck); the only one to show no evidence of trout fry of the year present was Langstrath Beck, though trout densities were low at several of the Wastwater Catchment sites.

6.1.4 Acid Tarns - Fish Populations

The most striking finding of the gill netting surveys was the failure to demonstrate the presence of fish in Levers Water despite significant netting effort in October 1984 and September 1985. On both these occasions electric fishing of the two main tributaries Hawse Beck and Cove Beck also failed to find any trace of fish. (See 6.5.3 for information on historic fish populations).

The Seathwaite Tarn netting (using the same 7 survey nets used at Levers Water) of June 1983 yielded fifteen trout between 18.5 and 32.0 cm long, in good condition. Electric fishing of the main tributary, Tarn Head Moss Beck, demonstrated a fair population of juvenile trout, with fry of the year present.

In June 1985 no fish were found in Stony Tarn, but the Blea Tarn netting yielded large numbers of stunted perch.

6.2 Fish Growth and Recruitment

6.2.1 Growth and Condition of Fish

Consideration of the data on mean length of 0+ salmonids shows a number of upper catchment streams in the Esk and Duddon catchments to have very small 0+ trout present by comparison with generally more productive streams sampled at about the same time. There is also a clear tendency for trout fry in the main river sites on the Esk and Duddon to be larger at the more downstream sites.

Considering only the Esk data, there is a moderate consistency of relative ranking of sites based on 0+ trout length in 1981 and 1982, with for example Fisher Beck and Lin Beck producing 0+ trout over 2 cm longer on average when measured in July than Hardknott Gill and Dodknott Gill fish.

The 1982 data were based on electric fishing the Esk sites slightly later in the season than the 1981 sampling (from four to nineteen days later depending on site), and despite the generally greater fry density in the 1982 survey, half of the 1982 sites had recorded mean length of 0+ trout greater than in 1981, though in many cases the differences are not statisticaly significant.

In all cases where 0+ salmon were recorded on the Esk, their mean length was lower than that of the 0+ trout with which they were competing.

The need to take account of density-dependent influences, and the problems of accounting for different times of sampling make a formal assessment of the role of pH in influencing the mean 0+ salmonid lengths a difficult exercise. However, inspection of the data does suggest that where 0+ trout populations exist in relatively highly acidic upper catchment streams they may well be of low mean length, but there seems to be no very clear and consistent general relationship between this quantity and stream pH regime as defined by our measurements of geometric mean pH or lowest recorded pH.

In considering biotic effects observed in acid hill streams it should be made clear that some of the factors that contribute to acidification susceptibility, such as minimal ground water contribution to stream flow, will also influence other aspects of the stream environment which are potentially limiting, including susceptibility to drought induced loss of wetted bed area, and temperature regime. The latter factor is particularly important to considerations of fish growth in waters of different chemical composition (Edwards et al. 1979). It is also noteworthy that an earlier study on the Duddon showed that temperatures of the upper basin were generally cooler than the lower basin and the cool periods persisted longer (Minshall and Kuehne, 1969). Moreover, certain Plecopteran life cycles were several weeks longer in the upper basin than in the lower basin (Minshall, 1969).

Another aspect of the growth performance of the fish stock observable in the course of the fish population survey was the length/weight relationship in the fish sample. Athough this was only formally investigated in the 1982 Esk catchment sampling, it was visually obvious in the course of measuring the fish in other samplings, that the condition factor of 1+ and particularly older fish in some of the highly acid streams was extremely poor. Field notes refer specifically to very thin older specimens in Duddon catchment sites at Moasdale Beck, Duddon downstream of Doe House Gill, and Duddon upstream of Cockley Beck Bridge

6.2.2 Recruitment

The sampling of salmonid fry of the year during electric fishing survey in summer or autumn gave a qualitative indication of successful recruitment at the sampled site in that year. In a number of the acidified sites no such evidence of recruitment was recorded, and in a number of cases the sparse population present was strongly biased in favour of older fish. Such findings might arise in a relict resident population which failed to recruit new stock in some "bad" years (due to e.g. higher susceptibility of early life stages to acidification-related stresses) or in a situation where a more or less fishless stream benefitted from upstream immigration of adults perhaps as potential spawners.

Sites at which a very low density of trout was present on some or all sampling occasions but no 0+ trout at the times of sampling include the Glenderamackin above Bannerdale Beck, Tarn Beck upstream of Tongue House, Moasdale Beck, River Brathay sites upstream of Fell Foot, Langstrath Beck, and Blea Beck (Lune).

6.3 Migration and Movement Patterns

6.3.1 River Duddon:

Data on pH, water temperature, and river discharge, as well as fish counts, have been available from the Duddon Hall counter site since May 1983. Fish movement over the counter has been recorded at a wide range of flows, but typically increases in discharge encourage upstream movement of fish. Most of this movement takes place during the few days following a spate when flows are declining, and in fact at peak flows, fish movement is reduced (See Figs.7-10 Duddon) As it is at these peaks at which the minimum pH values have been recorded it would be possible to conclude that low pH was inhibiting fish migration. However, an apparent inhibition of upstream movement of migratory salmonids at the peak of spates has also been reported for rivers such as the Lune where there is no evidence of significant reduction of pH during the peaks of spates (Stewart, 1973) Nevertheless, there is some evidence that low pH may be affecting fish migration in the Duddon because in 1983 and summer 1985, when lower minimum pH figures were recorded than in other periods, the failure of fish to move upstream at the peaks of spates was more pronounced. Initial observations suggest that fish movement is inhibited by pH 5.3 or less.

From the data obtained to date there is no evidence that water temperature is having any significant effect on migratory behaviour of salmon and sea trout in the Duddon.

6.3.2 River Esk:

Records of fish movement, flow, pH, water temperature and conductivity have been available from Cropple How site since mid-October 1985. By the end of December 1985 some 425 fish under 4 lb (1.8kg) and 61 fish over 4 lb had been recorded over the counter. Even the limited amount of data available to date has shown a pronounced inhibition of upstream movement of salmon and sea trout at peak flows when the minimum pH values were recorded. On the few occasions when an increase in flow did not result in a substantial drop in pH, inhibition of fish movement did not occur. Examples of this occurred on 5th November and 18th December 1985 when flows rose to 19.6 m^3s^{-1} and 28.16 m^3s^{-1} respectively, but the minimum pH values recorded were 5.50 and 5.62 (see Fig.9 Esk) On both these dates, 10 fish were recorded over the counter, whereas in the preceding few days only one or two fish per day had been recorded. On the basis of the small number of observations available to date, it would seem that fish movement is reduced when the pH falls below about 5.5

6.3.3 General Comments:

As yet it is not possible to state categorically that low pH flushes are inhibiting upstream movement of salmonids, because these low pH events coincide with peak flows which may in themselves be an inhibitory factor. However, collection of more data should help to resolve this matter. Observations on behaviour of fish when increased flows occur without a significant drop in pH will be particularly valuable.

The data runs available to date are not long enough to determine any trends in the abundance of salmon or migratory trout in these two rivers.

Reported catches of Salmon and Sea Trout - Rivers Esk and Duddon

	1981	1982	1983	1984	1985
Duddon:					
Salmon - nets	5	1	59	51	10
Salmon - rods	5	23	5	7	31
Sea trout - nets	11	15	84	101	38
Sea trout - rods	43	31	13	13	20
Esk					
Salmon - rods	15	7	4	2	38
Sea trout - rods	85	27	27	19	80

6.4 Fish Mortalities

On two occasions in recent years there have been simultaneous fish mortalities in the Rivers Esk and Duddon associated with low pH events.

In June 1980, when a spate occurred following a prolonged dry period, there was a serious mortality in the Esk involving over 100 adult fish and a much larger number of juvenile salmonids. Most of the adults killed were sea trout which had just entered the river from the sea, but a few salmon were also killed. The mortality occurred over several days, and pH levels of 5.0 were recorded. It is suspected that during the peak flows the pH fell even lower. At the same time, there was a report of six dead adult sea trout being found in the River Duddon.

A second set of mortalities occurred in mid-September 1983 when 34 fresh run sea trout and 2 salmon were killed in the lower reaches of the Esk, and 2 dead sea trout and one dead salmon were reported from the Duddon. On this occasion there were no reports of dead juveniles being found.

Records of pH were available for both rivers at this time. In the Esk the pH fell to below 4.5, and then lay for several days between 5.0 and 5.5. (See Fig 20).

Conditions were not as extreme in the Duddon, but on two days in mid-September the pH fell to 5.0.

It is suspected that the actual cause of the fish deaths was elevated concentrations of aluminium,(which is also at its most toxic at pH 5) exacerbated by the reduction in calcium concentrations.

6.5 Historical Information

6.5.1 Electric Fishing Surveys

Numerical fish stock data should provide the best evidence for the historic fishery status of the streams under study, but unfortunately the majority of these clean hill streams received little survey attention in the past.

In the period 1972-75, sites on Smithy Beck, Whinlatter Gill and Aiken Beck, which are all catchments with conifer plantations, were examined to investigate the success of salmon fry planting in hill streams, and detailed data on fish and invertebrates is available (Prigg 1973, Prigg 1976) There was no evidence in the 1982 survey of a decline in the juvenile salmonid nursery potential of any of these streams relative to the 1972-75 surveys.

A limited electric fishing investigation was carried out on the River Liza (another catchment dominated by conifer plantations) in August 1973. A repeat survey at this site in October 1985 showed no significant differences, with a comparable low density trout population and fry of the year still present. Although it was clear from a full consideration of recent chemical and biological data on the Liza (Prigg 1986b) that the fauna was notably restricted by acidification, it was concluded that there was no evidence for a decline in trout stocks over the period concerned.

6.5.2 Catch Returns by Licence Holders

Another source of historical information is fish catch data for salmon and sea trout, provided as licence returns by anglers and commercial fishermen. Failure of a high proportion of licensees to make returns, and the relatively uncritical reliance on accurate licensee response, serve to make such records an index of catch rather than a precise measure of it. The records present an even more tenuous picture in relation to stock, when major variables such as effort, catchability, and channel conditions are not subject to detailed analysis.

However, even allowing for such major provisos, it was considered worthwhile to look in rather broad terms at the migratory fish catch returns in the Esk and Duddon in their own right and in relation to other local game fisheries. Most local migratory fisheries showed high catches in the mid 60's falling away dramatically as the onset of 'salmon disease', U.D.N. (first observed in Cumbria in the River Calder, Ehen and Irt in June 1966), influenced local fisheries. During the late 60's and early 70's there was a general trend of decreasing returns for migratory fish. Further, although it could be argued that whereas the Eden and Derwent salmon returns, both in total and for rods only, show some signs of recovery the group of South West Cumbrian salmon fisheries, comprising the Ehen, Irt, Calder, Esk and Annas and some minor streams, show no clear evidence of recovery.

Salmon rod catch data for these latter rivers show that the greatest decline has been on the Ehen, which provided the largest returns in this group in the early sixties. In contrast the relatively small returns from the Esk appear proportionately less affected with 1977 a particularly good year. Official records also show very high sea trout returns for the year 1977 on the Esk. Both these findings seem odd in relation to reported angler complaints concerning the Esk. It seems possible, on closer examination (Prigg 1982), that the 1977 data for the south west Cumbrian River Esk may have benefitted by mis-assignment of some returns referring to the Border Esk.

The salmon returns for the S.W. Cumbrian nets and fixed engines, largely attributable to the fixed engine (garth) operating on the estuary of the Esk, show a marked decline in the late 70's, though variable fishing effort may be a contributory factor Salmon returns from the Duddon estuarine fishery,(three draw nets), show some recovery from the post U.D.N. decline, though 1981 returns were particularly low. (It is known, however, that the efficiency of this fishery is highly susceptible to changes in channel configuration). Longer term records of sea trout catches in the Duddon are available than for the Esk where returns for sea trout were not sought prior to 1976. Again a post U.D.N. decline is noted though it is not as marked as that reported by Egremont and District Anglers' Association from their own catch records on the Ehen (evidence submitted to Ennerdale Water Public Enquiry, 1980). In view of claims that the Ehen fishery has been adversely affected by water abstraction, its status as a control against which to judge the Esk and Duddon is in doubt.

It is also true that although the Esk and Duddon are the most acidified major river catchments in our area, the Ehen system is not unaffected. Thus, although an extensive electric fishing survey in 1982 showed no evidence of fish stock restriction attributable to pH regime in the main river Ehen downstream of Ennerdale Lake, observations show that the River Liza upstream of Ennerdale Lake has a chemical regime which is restrictive for salmonids. The historic role of the Liza in the migratory fish economy of the Ehen is unclear, but it has been suggested that its contribution to the salmon production of the Ehen system was once more significant than it is today.

6.5.3 Records and Recollections of Local Observers

During a survey of land use and farming practice (Robinson 1984), local anglers and farmers in these two catchments were asked to give their views on the past status of angling and for their general observations on the numbers of fish seen, migratory fish spawning and the areas in which the main spawning was concentrated. In addition it was possible to examine the angling diary of a fisherman who fished the Esk from 1898 to about 1945. Anglers and farmers reports indicated that in the last 10 years or so there has been a dramatic decline in the numbers of migratory fish caught and in the numbers of fish in the river. The decline is well illustrated by the marked reduction in the numbers of migratory fish now seen in the main spawning areas on both rivers; above Wha House Bridge on the Esk, and above Dale Head on the Duddon. In these upper reaches in the main rivers there has also been a substantial decline in the numbers of fish observed spawning in the tributaries. Fish now spawn only in those streams least affected by acidification and even in these, numbers are reduced.

The once viable trout fishery on the Esk has completely disappeared. Of the tributaries only two can now be said to hold stocks of takeable trout, those in Whillan Beck and Birker Beck, both streams relatively unaffected by acidification. However, the once productive trout fishery in Hardrigg Gill at the top of Whillan Beck has now ceased to exist. While a trout fishery is still present in Devoke Water and Burnmoor Tarn, Stoney Tarn which still had a population of trout in 1951 is now completely fishless. This probably indicates the the upper reaches of Blea Beck are similarly affected.

Notable sites where there is no longer a fish population but which local sources describe as yielding trout to anglers historically are:-

Stony Tarn ("still had a population of trout in 1951")

Lingcove Beck ("late 60's")

Upper Esk on Great Moss ("up to mid 60's")

Upper Grassguards Gill (information in 1983 that "fish caught above falls thirty years ago")

The most significant record of such apparent loss, though is in relation to Levers Water. In "The Tarns of Lakeland" by W. Heaton Cooper first published in 195 , the author states:- "There are plenty of good trout in Levers Water, and many more have been taken out of it, sometimes with a rod and sometimes by the deadly and illegal otter or lath, a board with a keel and several hooks, that is guided by two lines and so can cover most of the tarn". Such poaching activity would nowadays be fruitless as judged from the gill netting surveys. Levers water is operated as a water supply reservoir, and long serving staff at the reservoir recollect two small trout being found on a filter screen from the source about ten years ago. There have been no more recent indications of the presence of fish.

Data published by the Freshwater Biological Association (Carrick and Sutcliffe 1982) show Levers Water with mean pH of 4.7 and negative alkalinity in the period August 1974 - March 1978. A single record from nearby Seathwaite Tarn during that period, noted in the same publication, shows pH 5.1 and negative alkalinity. The recent netting and electric fishing surveys in Seathwaite Tarn during which pH values in the Tarn as low as 4.5 were recorded, showed a viable native trout population to be present. However, given the likely borderline status of this tarn's water quality in relation to trout survival it is interesting to note the description of an unusual fish mortality which occurred in this water in June 1956. The event is recorded in the Lancashire River Board 6th Annual Report 1957, and in the aforementioned "The Tarns of Lakeland" by W. Heaton Cooper. The accounts do not conflict, but the latter is much fuller, as follows:- "Albert Dixon, of the Freshwater Biological Association, told me that a few years ago they received a request from the Barrow Corporation to go up immediately and investigate there. A large number of trout had been found dead in one place near the outlet, and poisoning was suspected. They found no trace of any impurity in the water or the fish. They did find, however, that all the inlet streams were packed with trout. There had been a drought followed by thunderstorms the day before the fish were discovered, and it was thought that lightning had struck the water in one part of the tarn, killing the fish, and that the shock throughout the whole tarn had frightened all the other trout". With our present knowledge of acidification effects, such an event nowadays involving, apparently, heavy precipitation following a drought and localised aggregation of fish in havens with preferred conditions, would certainly require us to consider some type of acid event.

6.6 Discussion of observations

6.6.1 Geographical distribution of sites with impoverished fish stock

Sites with no demonstrable fish population or exceptionally low stock densities are mostly found congregated in our study area in a relatively tight spatial grouping in the upper parts of the drainage systems associated with the western mountain mass of the Lake District, in areas where the underlying rock is of the Borrowdale Volcanic series, and where annual rainfall exceeds 2200 mm/year and in many sites 2800 mm/year.

Two main outlying areas with comparable faunal restrictions have been identified: the upper Glenderamackin which drains a steep upland catchment underlain by Skiddaw Slates and notable for very low calcium levels (mean ca 0.6 mgCa/l), and the upper catchment of Blea Beck (Lune) draining a region of Shap granite.

The most affected sites, listed in Appendix B, are near or above the limit of human settlement in the valleys where they occur. They have no improved agricultural land in their catchment and the commonest land use on the poor acid soils is rough grazing for sheep. The catchment of Black Beck, and to a lesser extent upper Grassguards Gill is dominated by coniferous plantation, and the upper Blea Beck (Lune) area is a grouse moor.

The streams with few or no salmonids had no marked geographical distribution within the South Pennines. Except for Hurst Reservoir's feeder streams, they were all very brown waters draining peat bogs or peaty soils overlying steep unimproved uplands (In contrast to the Lake District sites, trout were not detected in any of the noticeably peat-coloured waters in the South Pennines). The feeder streams of Hurst Reservoir were clear waters draining steep heather/cranberry moorland.

6.6.2 Chemical condition of sites with impoverished fish stock

The affected sites were characterised by low mean pH and low calcium concentrations, and often elevated aluminium levels in clear water (low humic) conditions. Early work in 1981 and 1982 suggested that there was a clear relationship between the pH regime of a stream and the probability of it being fishless or having an exceptionally low fish density or odd population structure, with streams showing geometric mean pH at or below pH 5.6 likely to be affected. More recent surveys support this general view, and have given good examples of improving fish stocks over short downstream distance as chemical conditions become improved by less acidic drainage inputs. Such improvements have been observed on Tarn Beck, Blea Beck (Lune), and the upper Brathay.

The impact of land use patterns and resultant drainage water chemistry is demonstrated in two small adjacent sub-catchments of the Esk, Doddknott Gill and Spothow Gill, the streams joining prior to a common confluence with the Esk. Dodknott Gill differs from Spothow in that it flows through improved drained grassland in the valley bottom, the upper catchments of both streams being comparable. Dodknott Gill is less acid and has a low density trout population; Spothow Gill lacks salmonids. In July 1982 five trout from Doddknott Gill were placed in a fish cage in Spothow Gill. They survived a 48 hour exposure apparently unharmed, demonstrating the absence of acute toxicity to the life stage exposed (1+ and 2+ fish) within Spothow Gill.

Subsequently a series of caged fish exposures of longer duration, extending in some cases through periods of high flow with increased acidity and aluminium, and diluted calcium levels have been undertaken and reported (Prigg 1985a). The resulting survival times of trout in Spothow Gill, and an unnamed tributary downstream of Spothow Gill, are relatively consistent with predicted survival times calculated using the regression equation developed from observation of pH, aluminium and calcium effects on mortality in Welsh streams in the acidified Upper Tywi catchment (Gee and Stoner 1984).

The final demonstration of the beneficial role of calcium came with the liming of the upper catchment of Spothow Gill in June 1985. In July 1985 trout fry were stocked in Spothow Gill, and in the unlimed unnamed tributary downstream Spothow Gill as control. At the end of September 1985 a high density of stocked trout fry remained in the lower reaches of Spothow Gill, but no trout could be found in the unnamed tributary. When last surveyed in March 1986 a good population of stocked trout still remained in Spothow Gill, a stream in which, prior to liming, no wild trout had been found and in which caged trout died under high flow conditions.

Figure 22 Relationship between Flow at Cropple How and pH at Spothow Gill

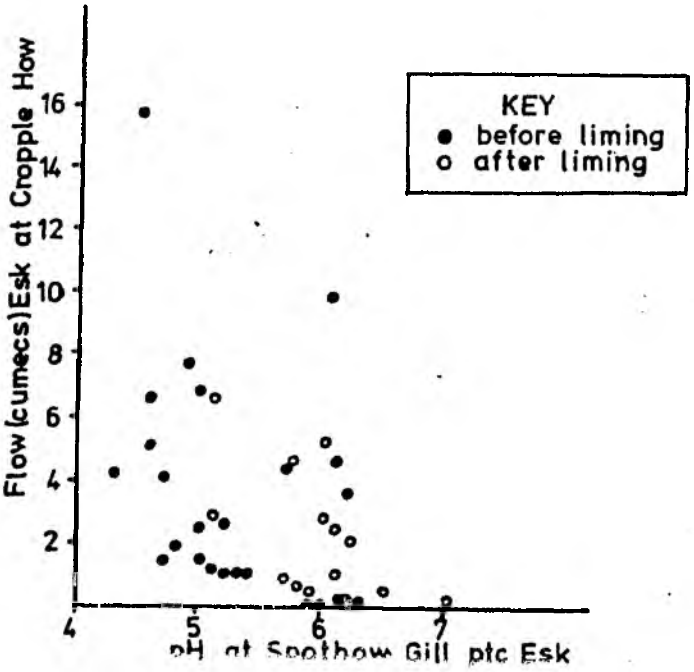


Fig. 22 shows how the relationship between observed pH in Spothow Gill and river flow (at a downstream site) has altered since the liming. In general the pH appears to have increased by around 1 pH unit (probably rather less at high flows). It certainly seems that the applied limestone has been capable of reducing the severity of acid episodes by increasing the pH and calcium concentrations, and reducing both the concentration and the toxicity of dissolved aluminium present.

6.7 Summary

1. An electrofishing survey of the River Esk system showed a lack of salmonids in two accessible acidic tributaries and abnormally low densities in several other acidic tributaries. A particularly low relative abundance, or absence, of 0+ salmonids in such streams indicated recruitment failure.

2. There was a noticeable general improvement in 0+ salmonid stocks in the Esk system between 1981 and 1982 and an increase in the densities of 1+ and older fish between 1981 and 1984.

3. In the upper half of the Duddon catchment fish stocks appeared to be more severely affected by acid-stress than in the Esk there being generally very low salmonid densities in both the tributaries and main rivers. Even eels, which appeared to be more acid tolerant than salmonids, were not found in any sites in the catchment upstream of Grassguards Gill. 0+ salmon planted into two of these fishless sites in May 83 were not recaptured in September 1983.

4. Further work indicated that low pH and associated factors had similar pathological effects on salmonids in other Lake District hill streams.

5. There were indications that the growth and condition of brown trout was less in acidic than non-acidic hill streams.

6. Although not conclusive, early evidence suggests that upstream migration of salmonids was inhibited more during the peak of spates in acidic than non-acidic streams. Initial observations on the Esk and Duddon suggest that movement was inhibited by pH 5.3 or less. No relationship between fish movement and temperature was found.

7. On two occasions in recent years there have been simultaneous mortalities of salmon and sea-trout in the River Esk and Duddon associated with low pH events.

8. Although anecdotal records and catch-returns indicate a decline in the fisheries of the Esk and Duddon this decline may not be solely attributable to acidification. Unfortunately although scientific surveys of the relevant fisheries have been performed in recent years, there is a general paucity of relevant historic data.

9. There are indications that liming of Spothow Gill has resulted in conditions becoming more suitable for trout. Planted fry have survived for almost a year.

10. At the present time the fish data for the S.Pennines are still being evaluated, but there is a consistent relationship emerging between water quality conditions and aspects of the fish status in acidified streams and lakes. Fish densities generally decrease below geometric mean pH 5.8 and waters with geometric mean pH below 5.0 are likely to be fishless.

7. LAND USE CHANGES IN S.W. CUMBRIA

7. LAND USE CHANGES IN S.W. CUMBRIA

7.1 General

Land use in the three areas Esk and Duddon Valley and Wasdale Head was studied in detail. In each area hill farming was the general farming activity, though some dairy farming was carried out in the lower parts of the Esk and Duddon Valleys. There was no significant afforestation in the Esk Valley or at Wasdale Head. However, extensive planting by the Forestry Commission has taken place in the Duddon Valley. The most significant was the Dunnerdale Plantation planted between 1937 and 1954 covering an area of some 400 hectares. During 1984 and 1985 this was extended to 600 hectares by the completion of an extension area and filling of deciduous woodland in the lower part of the Duddon Valley further contributed to the total area. Coniferous plantations amounted to 5% of the overall area of the Duddon catchment.

7.2 Industrial activity

A major change in industrial activity in the Esk Valley related to mining and quarrying. Two main haematite mines North Gill (1870-1922) and Ghyll Moss (1870-1877) with a further small mine at Christcliffe operated in the valley. This mining resulted in the construction of a mineral line from Ravenglass to Boot. Following the closure of the mines it continued in industrial use until 1950 conveying granite from Beckfoot Quarry to Ravenglass. The line was subsequently replaced with a narrow gauge and still operates conveying visitors between Ravenglass and Boot.

Much of the deciduous woodland in the middle and lower reaches of the valley were until the beginning of this century, managed as coppice woodland producing timber suitable for charcoal making for the local smelting industry at Duddon Bridge, Millom and Haverigg. This coppice woodland has been allowed to revert and much was in poor condition.

Industry in the Duddon Valley was in the past limited to quarrying at Walna Scar and the management of deciduous woodland as coppices for charcoal production. Much of this was for the smelter at Duddon Bridge but also for iron production at Haverigg and Millom.

7.3 Agricultural activity

In both valleys agriculture largely comprised hill farming, sheep and some cattle. While the sheep farming has varied little this century, changes have occurred in relation to cattle. Originally cattle were limited to hill breeds which grazed the open fell land during the summer months, being brought down to lower land during the winter. Many farms have now changed or were changing to pedigree beef stock. This was kept on the lower pasture during the summer and housed over the winter months in byres. There has therefore, in the last few years, been a reduction in the numbers of cattle grazing the open fell.

A major change in general farming practise has resulted in. a reduction in the quantity of lime applied to by-land grazing in the last 10 years. Between 1940 and 1976 when the general liming subsidy operated, annual application at rates up to 5 tons/acre was common throughout the whole of the Esk Valley and the upper half of the Duddon Valley above Ulpha. Since 1976 the area of land in these areas which has been limed has fallen significantly and in addition rates of application were limited to 2 tons/acre. Liming of grazing land in the lower part of the Duddon Valley was not so great as in the Esk during the period between 1940 and 1976. Rates of 2 tons/acre at 2 to 3 year intervals were the norm. This no doubt reflected the generally less acidic nature of the soil in this area.

In the Wasdale Head area, farming in this area was typical hill farming, with cattle, (Robinson,1986) with little significant change in the general pattern of cattle rearing. Cattle were grazed on the fell land in summer and only brought to the lower pasture in winter. Most were over wintered in byres. The general usage of lime did not appear to have changed as significantly as on the Esk and Duddon catchments. Between 1940 and 1976 liming was undertaken at 2 to 3 yearly intervals, applied at 2 tons/acre. In the last 10 years there has, however, been some reduction in the frequency of application.

7.4 Summary

Whilst there have been a number of changes in land use in S.W.Cumbria in the last century, the most significant with regard to water quality is thought to be the reduction in agricultural liming since 1976. Calculations (Crawshaw, 1984) suggest that the amount of lime applied per annum prior to 1976 would have comprised a major component in the calcium budget of the catchment. This situation is peculiar to the Esk Catchment and leads to a possible strategy for improving water quality in the middle and lower reaches of the catchment, namely restoring the levels of agricultural liming to their former levels. This, and other possible remedial measures are discussed more fully in Section 8.

8. DISCUSSION

8.1 Possibilities for Future Remedial Action

8.1.1 Stream Liming

Since at least part of the problem of reduced salmonid populations is likely to be due to recruitment failure, it follows that any option for remedial action which can affect recruitment directly is worth investigating. Stream liming, whilst it is labour intensive, has the advantage of being capable of being directed towards specific vulnerable streams. It is not necessary to carry out a blanket liming of all tributary streams.

Following what appear to be encouraging results from a pilot stream liming exercise on a fairly acidic tributary (Spothow Gill), efforts are now being directed towards less acid streams where spawning success is marginal. One stream in the Esk (Fisher Beck) and one in the Duddon (Tarn Beck) have been selected for further study. Following liming and restocking in May-June 1986, both biological and chemical quality will be monitored over the next few years.

In all cases 15 mm limestone chippings were used. The intention was to select a size range that would be large enough not to be washed out in a spate, but not too large that the surface area to volume ratio was unfavourable. On the result to date this choice seems a reasonable one.

8.1.2 Liming of standing water bodies

This is an option which has not been actively pursued for practical reasons and because the effect on overall salmonid populations in the most affected catchments was likely to be minimal. However, two small acidic trout fisheries which came to our notice as a result of acidification-related trout mortality have been successfully limed. By controlled useage of any necessary top-up water from the highly acid inflow stream (avoiding flow addition under high flow condition) and by a programme of liming begun in 1983 the owner of a trout lake at Knott End Farm, Eskdale has developed a first class stillwater trout fishery. Monitoring on this site reflected both the improvement in chemical conditions and in the invertebrate fauna, the latter including colonisation by the mayflies Cloeon dipterum and Centroptilum luteolum.

The other site was a small moorland tarn, Flodders Tarn, near Appleby, outside our most vulnerable geographical area, but susceptible to acidification by virtue of level maintenance being dependent on direct precipitation, intermittent inflows of surface water from local peaty soil, and very limited groundwater storage in a perched aquifer of a thin layer of glacial sands.

Both stocking failures involved hatchery reared rainbow trout succumbing in waters circa pH 5, obviously inappropriate to this relatively acid sensitive salmonid.

After liming, rainbow trout thrived in Flodders Tarn, but regrettably in the exceptional July conditions in 1983 upper lethal temperature limits were exceeded in this small, unshaded water.

8.1.3 Catchment liming

The River Esk catchment is one of very few rivers where not only have acid related mortalities of fresh run salmonids taken place, but continuous records of pH are available for the duration of one of these mortalities.

Land use changes in the catchment during the last 50 years have been studied in detail, and a change in the pattern of agricultural liming was one of the major changes identified.

It is unlikely that catchment liming will prove to be a practical proposition in many catchments affected by or threatened with acidification. However, where there is a substantial agricultural area in the affected catchment, and the overall levels of calcium are very low, then it is certainly worthy of consideration. In the case of the Esk, as was indicated in para 7, a liming strategy which simply reverts to what was normal agricultural pratice for some decades prior to 1975 may well have a substantial effect on the main river.

It is hoped that this agricultural catchment liming strategy, together with a selective stream liming strategy will prove of considerable value in restoring the depleted fisheries of the Esk catchment. It will also provide valuable information, not available from other studies, as to the rate of loss of calcium to surface waters from an application of limestone, to soils of varying degrees of acidity, in an area of high acid deposition. This information is an essential component in predicting the impact of agricultural liming as a counter to the effects of acid deposition.

8.2 The Impact of Acid-Stress on Macro-Invertebrates and Salmonids in Hill Streams

8.2.1 Benthic Macroinvertebrates

The results of this investigation support the generalisation that benthic invertebrate communities are impoverished in acid-stressed environments (e.g. Haines, 1981; Sutcliffe, 1983; Stoner, Gee and Wade, 1984; Aston et al 1985; Simpson, Bode and Colquhoun, 1985). However, many of the streams sampled in this study contained extremely few (<6) taxa. A nation survey of hill-stream invertebrate communities in Great Britain indicated that samples from the North West were drawn from very soft waters (< 10 mgl^{-1} CaC03) and had fewer taxa than those from any other region (Warren et al 1986).

Sutcliffe and Carrick (1973) reported that in the River Duddon (one of the catchments sampled in this study) the faunas of streams with pH always less than pH 5.7 or fluctuating below pH 5.7 were characterised by 13 common or abundant taxa (the "Plecopteran Community") including six Plecoptera, four Trichoptera and three diptera, while in streams of pH greater than 5.7 the same taxa were common but in addition Ephemeroptera, the Trichopterans Wormaldia and Hydropsyche, the limpet Ancylus and Gammarus occurred. The same generalisation can be applied to the invertebrate faunas of the catchments in the present study with the minor addition of Nemura species to Sutcliffe and Carrick's "Plectopteran Community."

The use of benthic macroinvertebrate as indicators of stream pH (Table 5.2.2) will generally be more meaningful than a limited number of point chemical measurements because the invertebrate community will be sensitive to the recent history of stream pH and, in particular, to episodic events which are likely to be missed by point chemical measurements. Certainly, whether a stream experiences "acid-stress" or not can be determined with far greater confidence by the analysis of a single three-minute kick-sample than by the analysis of a single sample of water. The tolerances of the various invertebrate taxa to stream pH indicated in this study (Table 5.2.2) are similar to those found by other workers (for review see Haines 1981). A TWINSPAN (Hill 1979) classification of hill stream invertebrate communities based on the results of a national survey selected Perlodidae, Hydropsychidae, Heptagenidae and Baetidae as the first level dichotomy separating soft acidic waters from harder more alkaline waters. (Warren et al 1986).

The use of Baetis rhodani to indicate the suitability of streams for salmonids as suggested here was discussed by Raddum and Fjellheim (1984) and a detailed account of the use of Ephemerophtera as indicators of stream pH is given by Engblom and Lingdell (1983).

Principal component analysis of the Pennine invertebrate data indicated that component 1 (alkalinity, aluminium, pH and calcium) accounted for approximately 50% of the variation in the abundance of acid-sensitive taxa (Gastropoda and Ancylus, Gammarus, Baetidae, Heptagenidae and Hydropsycidae) and the unexplained variation in these cases was less than 41% In contrast, Aston et al (1985) found that the principal components could only be attributed with more than 20% of the variation in the case of Ephemeroptera where component 1 (total dissolved solids) accounted for approximately 25% and component 2 (pH, aluminium and alkalinity) accounted for approximately 20% and in the case of Coleoptera where component 2 accounted for approximately 30% of the variation. The small amount of variation explained by Aston et al (1985) may be partly due to the pooling of data for acid-intolerant taxa within groups such as Plecoptera and Trichoptera. However, as Aston et al (1985) suggest, the importance of component 1 in their study is probably due to the inclusion of some Peak District streams with relatively high calcium concentrations (contributing to component 1) which probably reduces the impact of component 2 (pH, alkalinity and aluminium) on the invertebrate communities.

As previously mentioned the inclusion of more variables and all of the North West Region's sites in a Principal Component Analysis should prove valuable.

8.2.2 Fish

This investigation was initiated by mortalities of migratory salmonids simultaneously in the Rivers Esk and Duddon during a period of low pH, low alkalinity and high aluminium concentration - an acid episode. However, the major effort was expended in an investigation into the extent of acid-stressed hill streams in the North West Water region. Such streams are typified by the characteristic macroinvertebrate faunas previously mentioned and poor salmonid populations (<0.2 m^{-2}) with particularly low densities or an absence of 0+ fish (e.g. Stoner, Gee and Wade, 1984; Turnpenny,1985)

In the laboratory it has been shown that acid-stress in salmonids is caused by the direct effects of pH and to a greater extent by the increased toxicity of aluminium ions (particularly Al^{3+} and hydroxides of aluminium (>250 gl^{-1}) at low pH (for short review see Warren et al,1986) Brown (1983) notes that in general pH 5.5 is less toxic than pH 4.5 at low aluminium concentrations but more toxic at high aluminium concentrations. Calcium concentrations of 1 to 2 mgl^{-1} reduce the pathological effects of low pH and high aluminium concentration (Brown 1983).

It is difficult to determine whether or not the poor salmonid populations in acid streams in the North West region are the result of chronic or acute acid stress. However, the lack or extremely low densities of salmonids in these streams may be due to the acid induced mortalities of eggs and alevins during the winter and early spring when these particularly sensitive forms are present and acid episodes are more likely

Although there has been a notable decline in the salmonid fisheries of the Esk and Duddon over recent decades this may not be solely attributable to acidification as declines have also occurred in nearby non-acidified catchments. However, it can be concluded that hill streams in these catchments and many others in the North West Water region experience acid stress because (1) Salmonid mortalities associated with acid episodes have been observed; (2) abnormally low density salmonid populations with characteristic Plecopteran dominated acid-tolerant invertebrate communities have been found in many such hill streams; (3) the distribution and abundance of salmonids and acid-intolerant invertebrates is statistically significantly correlated with pH and associated parameters; (4) experimental liming of such streams has improved conditions sufficiently for salmonids to survive, and (5) early evidence suggests that salmonid migration is inhibited by low pH.

As a Water Authority is is our duty to maintain and improve fisheries within our region. Towards this end we intend to continue experimental liming to assess its use in the amelioration of the effects of acid stress in nursery streams.

8.3 Use of continuous monitors in assessing trends in acidity

One of the principal difficulties in Britain at least, in identifying the impact of acid deposition on surface waters has been to establish trends in acidity. Whilst Batterbee (1983) has been able to reconstruct the historic pH records of some standing waters from examination of the sediment diatom records, very little relevant data exist for rivers and streams. Even where data are available, the problem of interpreting the effect of short and long term weather variations, makes identification of trends difficult.

However, since a key question in scientific and governmental circles has been the extent to which reduction in acid emissions would influence pH of surface waters, the identification of trends in a period when emisions are changing becomes increasingly important.

Whilst the main intention of the work using continuous monitors in SW Cumbria, was to discover more about episodic changes and their significance, it may well be that the monitors can be developed as useful tools for identifying trends.

In the relatively few years that the monitors have been operating since 1983, significant differences have been observed in the flow/pH relationship from one year to the next (see Para 4.9), although variations within a year seem less significant. If these differences between one year and another can be related to changes in likely local deposition patterns, then an important link between emission changes and surface water quality changes would be established.

This work is at an early stage and is being developed with the co-operation of the UK. Acid Waters Review Group.

9. CONCLUSIONS

9.1 The results of chemical monitoring during the period 1982-86 at a total of 130 sites in North West England have been examined. When taken together with available biological data especially historic fisheries information, they are consistent with the hypothesis that a number of these sites, with sensitive geology, have become acidified during the last twenty years.

9.2 A substantial number of the most acid sites were found to be fishless or had abnormally low densities of salmonids ($<0.2m^{-2}$) often with distorted population structures indicating recruitment failure.

9.3 It is suggested that the presence of Baetidae, Heptagenidae, Gammarus, Hydropsychidae and Gastropoda can be used to indicate that a water is suitable for salmonids with respect to acid-stress.

9.4 The fisheries of the Esk and Duddon have declined over recent decades and whilst this may not be solely due to acidification, on two occasions in recent years there have been simultaneous salmonid mortalities associated with low pH events. On the second of these two occasions a complete record of pH changes was obtained from continuous monitoring equipment. So far as is known such a record of a mortality of fresh run salmonids is unique, in Britain at least.

9.5 Since 1980 trends in fish populations have tended to improve in the catchments shaded and no mortality of fresh run fish has been observed since September 1983.

9.6 Preliminary analysis of the data from the fish counters suggests that upstream movement of fish is inhibited by low pH episodes, where the pH drops to 5.3.

9.7 Continuous river monitoring has demonstrated a remarkably consistent relationship between river pH and river flow, which appears to be independent of rainfall pH. Changes in the nature of this relationship from one year to the next are being in investigated as a possible tool for examining trends in acidity by eliminating the effect of seasonal and meteorological factors.

9.8 A combination of selective tributary liming (Esk and Duddon) and restoration of agricultural liming to pre 1975 levels (Esk catchment only) shows promise as a short-term measure for halting the decline in fisheries in these two catchments.

REFERENCES

Aston,R.J.; K.Sadler; A.G.P.,Milner and Shyman (1985). The effects of pH and related factors on stream invertebrates. Central Electricity Research Laboratories Report TPRD/L/2792/N84.

Battarbee (1984). Diatom analysis and the acidification of lakes, Phil.Trans R.Soc Lond.B. 305, 451-477.

Brown,D.J.A. (1983) Effects of calcium and aluminium concentrations on the survival of brown trout (Salmo trutta) at low pH. Bull.Env.CONCAM. TOKICOL 30,582-587.

Bull,K.R. & Hall,J.R. (1985). Effects of acid rain on freshwater ecosystes in NW England. (Interim report to Department of the Environment).

Bussell,R.B., 1978. Fish Counting Stations. Notes for guidance in their design and use. Department of the Environment, Central Water Planning Unit, Reading.

Carrick T.R. and Sutcliffe D.W. (1982) Concentrations of major ions in lakes and tarns of the English Lake District (1953-1978) Freshwater Biological Association Occ.Pub.No.16

Conroy,N.K. et al (1976). Influences of the atmosphere on Lakes in the Sudbury area. J.Int. ASSOC. Great Lakes Res 2, 146-165.

Crawshaw,D.H. (1984). The effect of acid run-off on the chemistry of streams in Cumbria. Ref TSN/84/3 NWWA.

Dahl,K. (1926). Acidity of water and the effect on trout fry. Tidsskrift. Norste Landbr., 232-242.

Edwards R.W., Densem J.W. and Russell P.A. (1979) An assessment of the importance of temperature as a factor controlling the growth rate of brown trout in streams. J.Anum. Ecol. 48 501-507

Engblom E and P-E. Lingdell (1983) Botton faunas anvandbarhet som pH-indikator. NATURVARDVERKET REPORT SNV pm 1741.

Ferguson and J.Lee (1983). At The Annual General Meeting of the British Ecological Society, Durham.

Gee,A.S. and Stoner J.H. The effects of seasonal and episodic variations in water quality on the evology of upland waters in Wales. Paper presented at IWPC/IWEC meeting on Acid Rain. Birmingham, March 1984.

Gjessing et al (1976). Effects of acid precipitation on freshwater chemistry from Research Report FR6/76. SNSF Project, As, Norway, pp65-85.

Gledhill T., Sutcliffe D.W. and Williams W.D. (1976). A revised key to the British species of Crustacea : Malacostraca occurring in freshwater with notes on their ecology and distribution. Freshwater Biological Association Scientific Pub. No. 322.

Haines,T.A. (19891) ACidic precipitation and its consequences for aquatic ecosystems : A review. Transactions of the American Fisheries Society. V110:669-707

Harriman R. and Morrison B.R.S. (1982). Ecology of streams draining forested and non forested catchments in an area of central Scotland subject to acid precipitation. Hydrobiologia 88 251-263.

Heaton Cooper W. "The Tarns of Lakeland" Third Edn.1983 Frank Peters Publishing, Kendal.

Hill,M.O. (1979) TWINSPAN - a FORTRAN programme for grouping multi variate data in an ordered two-way table by classification of the individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York.

Kinniburgh D.G. & Edmunds W.M. (1984). "The Susceptibility of UK Groundwater to Acid Deposition" In Warren S.C. et Al (1986) Acidity in UK Fresh Waters, UAWRG, Interim report (DOE).

Lethlean,N.G. 1951. An investigation into the design and performance of electric fish screens and an electric fish counter. Trans.R.Soc.Edinb. 62(13), 479-526.

Leivestad,H. et al (1976). Effects of acid precipitation on fresh water organisms from Research Report FR6/76, SNSF Project, As, Norway pp86-111.

Minshall G.W. (1969) The Plecoptera of a headwater stream (Gaitscale Gill, English Lake District) Archiv.fur Hydrobiologie 65 494-514

Minshall G.W. and Kuehne R.A. (1969) An ecological Study of invertebrates of the Duddon, an English mountain stream. Archiv. fur Hydrobiologie 66 169-191

Newson M.D. Slope and Channel Run off processes in upland catchments. Interfaces between percipitation and streamflow acidity. Paper presented at IWPC/IWES meeting on Acid Rain, Birmingham. March 1984.

Prigg R.F. (1973) Interim report on nursery stream project. Fishery Department Report Cumberland River Authority.

Prigg R.F. (1976) Summary of main practical implications of salmon nursery stream investigations 1972-1975. Internal rpt. Fisheries Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1978). Water Quality Biology of the River Keekle. Rpt. ref BN29 (10/78). Scientists Dept. Rivers Div. N.W.W.A.

Prigg R.F. (1982) Problems in utilising rod catch statistics from the River Esk (S.W.Cumbria). Tech. Note NC123(10/82) Scientists Dept. Rivers Division, N.W.W.A.

Prigg R.F. (1983a) Juvenile salmonid populations and biological quality of upland streams in Cumbria with particular reference to low pH effects. Report BN 77-2-83 Scientists Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1983b) Follow-up to 1983 salmon fry planning in the Duddon catchment. Tech.Note NC 176 (10/83) Scientists Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1985a) Preliminary report on caged trout experiments in Spothow Gill and Doddknott Gill, Eskdale. Tech. Note NC 260 (5/85) Scientists Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1985b) Faunal and chemical observations on the River Glenderamackin above Mungrisdale following a probable acid event. Tech. Note NC 299 (12/85) Scientists Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1985c) Acid rain project biosurveys of streams in the Wastwater catchment. Tech.Note NC 297 (12/85) Scientists Dept. Rivers Division, N.W.W.A.

Prigg R.F. (1986a) Length data on S.W.Cumbrian Esk trout. Tech. Note NC301 (1/86) Scientists Dept., Rivers Division, N.W.W.A.

Prigg R.F. (1986b) Preliminary note on the present fish population and potential of Ennerdale Water tributaries, with special reference to salmon. Tech.Note NC 306 (2/86) Scientists Dept.,Rivers Division, N.W.W.A

Radum G.G. and A.Fjellheim (1984) Acidification and early warning organisms in freshwaters in Western Norway. p 1973-1980

Robinson J.F. (1984) A review of land use, farming and fisheries in the Esk and Duddon valleys. Scientists, Dept., (Water Quality North) N.W.W.A.

Schofield,C.L. (1976) Acid precipitation : Effects on fish. Ambio 5, 228-230.

Seber G.A.F. & Le cren E.D. (1967). Estimating population parameters from catches large relative to the population. J.Anim.Ecol.36,631-643.

Sevaldrud,I.H. and Muniz,I.P. (1980). Research Report IR 77/80 SNSF Project, As, Norway.

Simpson,K.W.; R.W.,Bode and J.K.,Colquhoun (1985) The macro-invertebrate fauna of an acid-stressed headwater stream system in the Adirondack Mountains, New York. Freshwater Biology 15, 671-681.

Smith,R.A. (1872). Air and rain: the beginnings of a chemical climatology. Longmans, Green and Co., London.

Stewart,L. 1973 Environmental engineering and monitoring in relation to salmon management. Prc. The Int.Atl.Salmon Found and AFl. Salmon Res.Trust Symp, St.Andrews, New Brunswick, Canada, 1972, 297-316.

Stoner,J.H. and A.S.Gee (1985). Effects of forestry on water quality and fish in Welsh rivers and lakes. J.Water Engineers and Scientists 39, 27-45.

Stoner,J.H., A.S.Gee and K.R.Wade (1984) "The effects of acidification on the ecology of streams in the Upper Tyivi Catchment in West Wales. Environmental Pollution (Series A) 35 125-157.

Sutcliffe D.W. and Carrick T.R. (1973). Studies on mountain streams in the English Lake District. I. pH, calcium and the distribution of invertebrates in the River Duddon. Freshwater Biology 3 437-462.

Sutcliffe, D.W. (1983) Acid precipitation and its effects on aquatic ecosystems in the English Lake District (Cumbria) F.B.A. Annual Report No.51 p30-62.

Sutcliffe D.W. & Carrick T.R. Acidity and Alkalinity of Water Bodies in the English Lake District. FBA 1pp.

Turnpenny,A.W.H. (1985). The fish populations and water quality of some Welsh and Pennine streams. CEGB Report TPRD/L/2859/N85

Warren et al (1986) Acidity in United Kingdom Fresh Waters, UKAWRG Interim Report. April '86, 57pp D.O.E.

Wright,R.F. and Snekvik (1978). Acid precipitation. Chemistry and fish populations in 700 lakes in S.Norway. Verh.Int. Verein. Limnol 20, 765-775.

Zippin C. (1956) An evaluation of the removal method of estimating animal populations. Biometrics 12 163-189.

Reference sources for data presented in Appendix 6

1. Survey of salmonid stocks of River Ehen and tributaries with special reference to sea trout - late summer 1975.

2. Survey of brown trout population of the upper part of the Petteril catchment and of Dacre Beck - May 1975.

3. Internal F.B.A. report on Caldew electric fishing survey July 1971, by D.T. Crisp.

4. N.W.W.A. Rivers Division Technical Note NC68(7/81) 1981.

5. M-way survey 1976, N.W.W.A. Rivers Division (R.F.P. unreported).

6. Survey of salmonid stocks of Greta and Glendermackin tributaries with particular reference to juvenile salmon, Autumn 1974.

7. Juvenile salmon populations and Biological quality of upland streams in Cumbria with particular reference to low pH effects. 1982 data.

7*. Ditto - 1981 data.

8. Survey of trout stocks in River Liddel, 1974.

9. Interim report on Nursery Stream Project.

   Summary of main practical implications of salmon nursery stream investigations 1972-75.

10. Faunal and chemical observations on the River Glenderamackin above Mungrisdale following a probable acid event. Technical Note NC 299 (12(/85).

11. Acid rain project biosurveys of streams in the Wastwater Catchment. Technical Note NC 297 (12/85).

12. Data from N.W.W.A. survey of upper Derwent and Buttermere tributaries, October 1985 (R.F.P. unreported).

13. Data from N.W.W.A. Rivers Division survey of Esk catchment summer 1984 (R.F.P. unreported).

14. Data from N.W.W.A. Rivers Division survey of upper River Brathay June 1983 (R.F.P. unreported).

References 1, 2, 4, 6, 8, 9, 10 and 11 are internal reports of N.W.W.A. Rivers Division or its predecessors by R. F. Prigg.

Ranking of a selection of salmonid nursery (type) stream sites in N.W.W.A Northern Area based on total 1+ and older Salmonid density estimates

Beck	Catchment	Ref.	Fish/m^2
Melmerby Beck(a)	Eden	9	1.96
Whinlatter Gill	Cocker	7	1.83
Melmerby Beck(b)	Eden	9	1.19
Hardknott Gill	Duddon	7	1.07
Aiken Beck	Cocker	9	.84
Troutbeck	Greta	9	.75
Glenderaterra Beck	Greta	7	.75
Raven Beck	Eden	9	.73
Black beck	Ehen	9	..72
Whinlatter Gill	Cocker	9	.60
Mere Beck	Esk	7	.51
Mere Beck	Esk	7*	.48
Hollins Beck	Ehen	1	.45
Kirk Beck (a)	Ehen	1	.43
Blck Burn	Liddle	8	.42
Aiken Beck	Cocker	7	.42
Greendale Beck	Irt	7	.42
Tinnis Burn	Liddle	8	.42
Newlands Beck	Derwent	7	.41
Black Beck	Ehen	1	.40
Grainsgill Beck(a)	Caldew	4	.40
Logan Beck	Duddon	7	.38
Smithy Beck	Ehen	7	.38
River Bleng	Bleng	7	.38
Sparrishaw Beck(e)	Bela	5	.38
Mere Beck	Esk	13	.38
Latterbarrow Beck	Esk	7	.36
Sparrishaw Beck (d)	Bela	5	.35
Sparrishaw Beck (b)	Bela	5	.33
Worm Gill	Calder	7	.33
Grainsgill Beck (b)	Caldew	4	.32
Gatesgarthdale Beck	Buttermere	12	.32
Croasdale beck (b)	Ehen	1	.30
Eel Beck	Esk	7*	.28
Muir Burn	Liddle	8	.27
Raise Beck	Rothay	7	.27
Sparrishaw Beck(b)	Bela	5	.26
Mere Beck	Ehen	1	.26
Blea Beck	Duddon	7	.26
Dacre Beck	Eamont	2	.25
Mosedale Beck	Greta	6	.25
Holehouse Gill	Duddon	7	.25
Fisher Beck	Esk	7*	.25
Sparrishaw Beck(f)	Bela	5	.25
Keskadale Beck	Derwent	7	.25
Latterbarrow Beck	Esk	13	.25
Croasdale Beck(c)	Ehen	1	.24
Parkend Beck	Caldew	3	.23
Thackthwaite Beck	Eamont	2	.23
Croasdale Beck (a)	Ehen	1	.23
Kirk Beck (b)	Ehen	1	.23
Sparrishaw Beck (c)	Bela	5	.23

Beck	Catchment	Ref.	Fish/m^2
Skitwath Beck	Eamont	2	.22
Rowland Beck (a)	Ehen	1	.21
Rowland Beck (b)	Ehen	1	.21
Fall BEck (b)	Bela	5	.21
Gobling Beck	Duddon	7	.21
Lin Beck	Esk	13	.21
Lingmell Beck	Irt	7	.20
Sparrishaw Beck(a)	Bela	5	.20
Troutbeck	Greta	6	.20
Helm Beck	Eden	9	.20
Birker Beck	Esk	13	.19
Old Petterill	Petteril	5	.18
Stonethwaite Beck	Derwent	7	.18
Borrow Beck	Lune	7	.17
River Brathay	Brathay	7	.17
Birker Beck	Esk	7	.17
Fall Beck (a)	Bela	5	.17
River Calder	Calder	7	.16
Hardknott Gill	Esk	13	.16
St. Johns Beck	Greta	6	.15
Old Park Beck	Duddon	7	.15
Grassguards Gill	Duddon	7	.15
Dub Beck (b)	Keekle	1	.14
Cooper Beck	Eamont	2	.14
Hollow Moss Beck	Duddon	7	.14
Smithy Beck	Ehen	9	.14
Sling Beck	Duddon	7	.13
Crosby Gill	Duddon	7	.13
Cockley Beck	Duddon	7	.13
Aira Beck	Eamont	7	.13
River Brathay	Brathay	14	.13
Bulfell Beck	Glenderamackin	10	.13
Greenup Gill	Derwent	12	.13
Warnscale Beck	Buttermere	12	.12
Grainsgill Beck (c)	Caldew	4	.12
Sparrishaw Beck (d)	Bela	5	.12
River Mite	Mite	7	.12
Tarn Beck (ptc Gobling)	Duddon	7	.12
Kershope Burn	Liddle	8	.12
Hardknott Gill	Esk	7	.12
Troutbeck	Leven	7	.11
Mosedale Beck	Irt	7	.11
Swindale Beck	Lowther	7	.11
Waterside Beck	Ehen	1	.11
Doddknott Gill	Esk	13	.11
Bulfell Beck	Glenderamackin	10	.10
Black Beck (b)	Ehen	1	.10
Blackdyke Beck	Eamont	2	.10
Lin Beck	Esk	7	.10
Latterbarrow Beck	Esk	7*	.10
Fisher Beck	Esk	7	.10
Lin Beck	Esk	7*	.09
Hardknott Gill	Esk	7*	.09
Derwent (Seathwaite)	Derwent	12	.09

Beck	Catchment	Ref.	Fish/m^2
Blea Beck	Esk	13	.09
Whillan Beck	Esk	13	.09
Eel Beck	Esk	13	.09
Lingmell Gill	Irt	11	.09
Nether Beck	Irt	11	.08
Mosedale Beck (upper)	Irt	11	.07
Old Petteril (b)	Petteril	5	.07
Dodknott Gill	Esk	7	.06
Dub Beck (a)	Keekle	1	.06
Birker Beck	Esk	7*	.06
Fisher Beck	Esk	13	.06
Bannerdale Beck	Glenderamackin	10	.06
Over Beck	Irt	11	.04
Bannerdale Beck	Glenderamackin	10	.04
Blea Beck	Esk	7	.04
The Syke	Duddon	7	.04
Lingmell Beck (upper)	Irt	11	.03
Langstrath Beck	Derwent	12	.03
Whillan Beck	Esk	7	.03
Dodknott Gill	Esk	7*	.03
Blea Beck	Esk	7*	.02
Moasdale Beck	Duddon	7	.02
Whillan Beck	Esk	7*	.02
Brathay, upper (a)	Brathay	14	.02
Brathay, upper (b)	Brathay	14	.01
Glenderamackin (upper)	Glenderamackin	10	.01
R. Liza	Ehen	7	.01
Derwent (Seathwaite)	Derwent	7	.01
trib d/s Spothow	Esk	7	.01
Spothow Gill	Esk	7*	0
Spothow Gill	Esk	7	0
Spothow Gill	Esk	13	0
Glenderamackin (upper)	Glenderamackin	10	0
trib d/s Spothow	Esk	13	0
trib d/s Spothow	Esk	7*	0
Esk (Great Moss)	Esk	7*	0
Esk (Great Moss)	Esk	7	0
Lingcove Beck	Esk	7*	0
Lingcove Beck	Esk	7	0
Blea Beck	Lune	7	0
Gt. Langdale Beck	Brathay	7	0
Tarn Beck (Tongue H.)	Duddon	7	0
Black Beck	Duddon	7	0
Castlehow Beck	Duddon	7	0
Gaitscale Gill	Duddon	7	0
Doe House Gill	Duddon	7	0

Appendix 2

DISTRIBUTION OF CERTAIN ACID-TOLERANT AND ACID-INTOLERANT MACROINVERTEBRATES IN KICK SAMPLES TAKEN FROM 75 CUMBRIAN HILL STREAM SITES OF GIVEN pH DURING 1982

			PERCENTAGES OF TOTAL KICK SAMPLES WITH SPECIES NOTED								
Geometric mean pH	Number of streams	Total no. of kick samples	Amphinemura sulcicollis	Protonemura meyeri	Leuctra inermis	Chloroperla torrentium	Plectrocnemia conspersa	Rhyacophila dorsalis	Baetis rhodani	Gammarus sp.	Ancylus fluviatilis
4.5	2	5	60	40	40	40	20				
4.6	1	3	67	33	67	33	100				
4.7	1	3	33	33	33		100				
4.8	1	3	67	33	33	33	33	67			
4.9	1	3	33	33	67	33	67	33			
5.0	2	5	80	40	40	80	80	40			
5.1	1	2	50				100	50			
5.2	0	0	-	-	-	-	-	-	-	-	-
5.3	3	8	75	63	38	38	25	38			
5.4	2	5	60	60	40	20	60	20			
5.5	5	14	64	57	50	36	29	64	14		
5.6	6	15	60	53	47	27	33	33			
5.7	3	8	88	50	38	25	25	13			
5.8	2	5	60	60	20	20	40	60			
5.9	3	9	67	67	22	78	33	22	22	11	11
6.0	4	12	75	75	33	42	25	33	58	17	17
6.1	2	6	67	67	67	33	50	33	50		
6.2	6	18	50	39	61	33	28	17	78		11
6.3	5	15	87	47	27	53	33	40	87	20	
6.4	4	10	30	80	50	40		60	80	30	20
6.5	7	20	45	40	30	35	30	50	75	50	30
6.6	5	15	73	60	60	33	40	73	93	40	7
6.7	4	12	67	42	58	17	17	58	100	42	25
6.8	1	3	67	33	67	33		67	67	67	33
6.9	3	9	67	56	33	33	11	56	100	78	11
7.0	0	0	-	-	-	-	-	-	-	-	-
7.1	0	0	-	-	-	-	-	-	-	-	-
7.2	0	0	-	-	-	-	-	-	-	-	-
7.3	1	2	50	50	50	50			50	100	

Note: (1) an empty cell in the body of the tables indicates a value of 0%

(2) - indicates no samples in streams of this geometric mean pH

DISTRIBUTION OF MAYFLIES IN KICK SAMPLES TAKEN FROM 75 CUMBRIAN HILL STREAM SITES OF GIVEN pH DURING 1982

Geometric mean pH	Number of streams	Total no of kick samples	PERCENTAGE OF TOTAL KICK SAMPLES WITH SPECIES NOTED PRESENT																						
			Baetis sp	Baetis rhodani	Baetis scambus	Baetis muticus	Baetis tenax	Baetis niger	Centroptilum luteolum	Centroptilum pennulatum	Siphlonurus lacustris	Ameletus inopinatus	Rhithrogena semicolorata	Heptagenia lateralis	Ecdyonurus sp	Ecdyonurus venosus	Ecdyonurus torrentis	Leptophlebia vespertina	Paraleptophlebia sp	Paraleptophlebia submarginata	Ephemerella ignita	Ephemera danica	Caenis sp	Caenis rivulorum
4.5	2	5																						
4.6	1	3									33													
4.7	1	3																						
4.8	1	3																						
4.9	1	3																						
5.0	2	5																						
5.1	1	2									100							50		50				
5.2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.3	3	8																						
5.4	2	5																						
5.5	5	14		14							7							7			7			
5.6	6	15																		7				
5.7	3	8										13												
5.8	2	5			60																60			
5.9	3	9		22	44									11							33			
6.0	4	12		58	50	17	8						17	17	8						42			
6.1	2	6		50	17	17						17	33	17	17						17			
6.2	6	18		78	17	6						6	11	22	17	6					11			
6.3	5	15		87	53						7		20	13	13						20			13
6.4	4	10		80	40	10							30		30						30			
6.5	7	20	5	75	45	30							25	15	25	15				5	35			15
6.6	5	15		93	47	20						7	60	33	20		7				27			13
6.7	4	12	8	100	50	33							58	8	67	25			8		50		8	17
6.8	1	3		67	67	67			33	33			67		67	33					33			
6.9	3	9		100	56	44		11					44	11	56	11	11				67	22		56
7.0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7,3	1	2		50	50	50							50	50	50						50			

Note: 1. an empty cell in the body of the table indicates a value of 0%

2. - indicates no samples in streams of this geometric mean pH

THE NUMBER OF INVERTEBRATES FOUND IN 3 MINUTE KICK-SAMPLES TAKEN FROM SOUTH PENNINE SITES DURING WINTER 1985-86 WITH SOME ASSOCIATED PHYSICO-CHEMICAL PARAMETERS

SITE NUMBER	GASTROPODA & ANCYLUS	SPHAERIDAE	ANNELIDA	GAMMARUS	BAETIDAE	HEPTAGENIDAE	LEPTOPHLEBIDAE	PROTONEMURA	AMPHINEMURA	NEMOURIDAE	LEUCTRA NERMIS	LEUCTRA HIPPOPUS	PERLODIDAE	CHLOROPERLA	DYTISCIDAE	SIALIS	RHYACOPHILA	PLECTROCNEMIA	HYDROPSYCHIDAE	LIMNEPHILIDAE	DICRANOTA	CHIRONOMIDAE	SIMULIDAE	ALKALINITY (mgl^{-1}Calo$_3$)	CALCIUM (mgl^{-1})	ALUMINIUM (gl^{-1})	HUMICS (mgl^{-1})	GEOMETRIC MEAN pH	MAGNESIUM (mgl^{-1})	CONDUCTIVITY (S cm^{-1})
4	0	0	3	0	10	0	0	0	0	10	0	10	0	1	0	0	0	1	0	0	1	3	3	8.2	6.2	161	13.5	5.7	1.5	92
5	0	0	0	0	0	0	0	10	3	3	250	0	1	0	0	0	3	0	0	0	10	0	3	5.5	3	137	13	5.4	1.6	90
6	0	0	3	0	50	3	0	1	0	10	50	3	0	0	0	0	0	1	1	0	3	50	50	23	12.4	98	15.6	6.9	2.2	130
8	10	0	3	50	250	250	0	10	50	0	0	50	10	0	0	0	0	0	10	0	0	1	0	61	17.6	46	12	7.4	1.4	182
9A	15	12	14	244	79	3	0	0	0	3	0	0	1	0	0	1	0	1	0	19	1	11	43	26.2	14.5	70	13.2	7.3	3.1	150
9B	2	0	15	267	184	349	0	73	25	22	0	98	19	0	0	2	7	6	12	13.	4	13	11	26.2	14.5	70	13.2	7.3	3.1	150
10A	0	0	0	0	0	0	0	0	0	3	0	37	0	0	1	0	0	4	0	0	5	0	0	2.5	5	280	8.9	4.8	1.4	93
10B	0	0	0	0	0	0	0	550	41	0	0	65	0	0	1	0	5	1	0	1	1	3	0	2.5	5	280	8.9	4.8	1.4	93
11	0	7	6	0	63	1	3	1	4	1	0	212	5	0	1	0	4	4	0	22	15	10	12	9.6	8	170	12.8	6.8	1.4	99
12	0	0	0	0	0	0	0	209	3	20	158	56	0	0	0	0	14	4	0	26	3	0	0	5.6	4.1	212	7.2	5.9	2.1	81
13	0	0	0	0	0	0	0	93	260	4	237	235	0	0	0	0	7	2	0	2	11	5	2	4.6	4.5	405	11.3	4.9	1.5	99
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3.7	3.6	612	2	4.4	1.6	100
15A	0	0	0	0	0	0	0	1	0	3	0	0	0	0	1	1	0	1	0	0	0	7	1.	3.3	2.4	505	7	3.9	1.0	170
16	0	0	0	0	0	0	0	0	0	10	0	20	0	0	0	0	0	19	0	0	6	0	0	5.4	5	212	2.4	5.4	5.0	135
17A	0	9	17	0	0	0	2	0	0	10	0	2	0	0	5	0	0	1	0	2	0	333	0	5	5.1	330	7.4	5.2	1.5	140
17B	0	0	3	0	0	0	0	50	0	372	0	458	0	0	0	0	0	53	0	0	5	0	36	5	5.1	330	7.4	5.2	1.5	140
17C	0	0	0	0	0	0	5	81	26	18	0	43	2	0	1	3	3	4	0	0	1	2	0	5	5.1	330	7.4	5.2	1.5	140
18	0	0	8	0	0	1	0	68	184	4	56	141	6	12	0	0	7	10	0	2	5	1	74	5	2.8	222	2.0	5.9	2.4	86
19A	0	0	1	0	0	0	0	0	0	25	0	0	0	0	3	5	0	0	0	100	0	15	0	5.4	4	332	4	5.7	2.9	141
19B	0	0	12	0	0	0	0	0	0	5	0	6	0	0	0	0	0	0	0	1	6	1	1	5.4	4	332	4	5.7	2.9	141
20A	0	0	1	0	0	0	0	6	3	10	4	41	0	0	1	0	0	12	0	9	0	0	2	5	1.9	475	2.7	4.7	2	83
20B	0	0	7	0	0	0	0	7	1	13	18	50	0	0	0	0	0	11	0	2	3	3	0	5	1.9	475	2.7	4.7	2	83
20C	0	0	0	0	0	0	0	1	0	18	1	86	0	0	0	0	2	8	0	0	16	0	1	5	1.9	475	2.7	4.7	2	83
22	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	1	2	0	2.5	1.4	390	13.3	4	0.8	105
23	0	0	3	0	0	0	0	0	0	34	0	6	0	0	0	1	0	0	0	5	1	146	0	2.5	1.6	707	11.2	3.8	0.8	150
24	0	0	16	0	0	0	0	7	0	9	0	80	0	0	0	0	0	0	0	4	12	1	1	13	6.4	207	7.9	5.9	2	112
25	0	4	6	0	0	2	17	532	550	1	0	47	0	1	0	0	19	6	0	7	2	80	3	20	8.1	135	8.9	6.9	2.6	122
26	0	0	0	0	0	0	0	565	169	2	78	48	0	0	0	4	30	8	0	105	12	2	2	4	3.4	241	5.2	4.8	2.5	94
27	0	0	0	0	10	0	0	15	25	1	4	18	0	0	0	0	4	0	0	6	6	0	0	3.3	3.1	262	7.2	4.5	1.8	100
28	1	1	12	0	65	0	3	4	21	3	0	54	0	0	0	1	3	38	1	0	6	70	0	17	6.5	265	8	5.9	2.8	162
29C	0	0	3	0	0	0	0	74	139	1	93	63	2	0	1	0	4	8	0	1	7	1	0	5	4	230	4.9	5.2	2.5	125
30A	0	0	12	0	0	0	0	0	2	1	0	279	0	0	1	0	1	5	0	1	11	0	4	4	3.7	369	3.3	4.4	2.4	101
30B	0	0	37	0	0	0	0	9	0	10	0	45	0	0	0	1	0	1	0	2	0	1	0	4	3.7	369	3.3	4.4	2.4	101
30C	0	0	4	0	0	0	0	227	0	352	0	281	0	5	1	0	1	12	0	3	6	10	0	4	3.7	369	3.3	4.4	2.4	101
31	0	0	6	0	1	0	1	0	10	13	2	15	0	0	2	0	0	21	0	3	8	31	0	4.6	4.2	412	7.6	5.2	2.3	105
32	0	0	3	0	0	0	0	29	0	0	0	67	0	0	0	0	5	0	0	2	4	0	0	3	2.2	380	7.5	4.4	2.0	115
33	0	0	4	0	2	0	12	33	18	0	0	425	23	1	0	1	1	51	0	6	9	3	2	3.5	3.8	326	5.9	5.0	2.4	92
34	0	0	3	0	0	0	0	145	1	134	3	87	0	0	1	0	0	3	0	15	14	4	0	3	2.5	345	11.7	4.5	1.8	94
35	0	0	0	0	41	1	0	49	24	0	7	12	0	0	1	0	2	1	0	11	12	0	1	8.1	6.4	234	8.5	6.3	3.3	129
36A	0	0	1	0	45	11	0	214	6	0	11	5	4	1	1	0	21	0	0	63	16	5	7	12.7	4.9	202	5	6.9	2.7	96
36B	0	0	0	0	0	1	0	4	2	4	6	7	0	0	0	0	0	0	0	2	12	1	0	12.7	4.9	202	5	6.9	2.7	96
36C	0	0	25	0	370	40	0	51	26	0	0	15	11	0	3	0	11	0	0	31	24	2	2	12.7	4.9	202	5	6.9	2.7	96

For site details see Appendix 8. A,B,C's refer to reservoir feeder streams

APPENDIX 5

PROPORTION OF VARIANCE IN THE NUMBER OF ANIMALS TAKEN BY KICK SAMPLING ATTRIBUTABLE TO PRINCIPAL COMPONENTS OF SOME CHEMICAL AND PHYSICAL FACTORS IN STREAMS IN THE SOUTH PENNINES

	COMPONENT NUMBER					
	1	2	3	4	5	UNEXPLAINED VARIATION
GASTROPODA PLUS ANCYLUS	0.526 ***	0.024	0.052 *	0.020	0.041 *	.0.337
SPHAERIDAE	0.128 *	0.009	0.000	0.016	0.000	0.847
ANNELIDA	0.079	0.015	0.017	0.005	0.004	0.880
GAMMARUS	0.505 ***	0.012	0.027	0.000	0.064 *	0.392
BAETIDAE	0.556 ***	0.000	0.003	0.000	0.034	0.407
HEPTAGENIDAE	0.560 ***	0.000	0.001	0.060 *	0.041 *	0.338
LEPTOPHLEBIDAE	0.015	0.000	0.000	0.003	0.005	0.979
PROTONEMURA	0.000	0.035	0.084	0.000	0.015	0.866
AMPHINEMURA	0.056	0.026	0.033	0.033	0.030	0.822
NEMOURIDAE	0.034	0.018	0.017	0.053	0.012	0.866
LEUCTRA INERMIS	0.000	0.019	0.184	0.000	0.000	0.797
LEUCTRA HIPPOPUS	0.004	0.031	0.031	0.033	0.006	0.895
PERLODIDAE	0.199 **	0.012	0.016	0.068	0.020	0.685
CHLOROPERLA	0.004	0.066	0.027	0.022	0.002	0.879
DYTISCIDAE	0.030	0.001	0.015	0.000	0.003	0.951
SIALIS	0.005	0.000	0.128 *	0.039	0.007	0.821
RHYACOPHILA	0.009	0.073	0.128 *	0.001	0.033	0.756
PLECTROCNEMIA	0.014	0.078	0.007	0.005	0.891	
HYDROPSYCHIDAE	0.483 ***	0.037	0.041	0.035	0.032	0.372
LIMNEPHILIDAE	0.011	0.101 *	0.034	0.009	0.018	0.827
DICRANOTA sp	0.000	0.141 **	0.149 *	0.055	0.005	0.650
CHIRONOMIDAE	0.056	0.088 *	0.047	0.035	0.002	0.772
SIMULIDAE	0.161 **	0.002	0.056	0.013	0.005	0.763

* = P 0.05 ** = P 0.01 *** = P 0.001

Fish and invertebrate fauna - Esk catchment 1982

a) Tributary Sites

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca. mg/l
Mere Beck	6.5	6.1	√√√	√√√	1.413	√	X	12.0
Eel Beck	6.4	6.1	X√-	√√-	-	-	-	9.1
Birker Beck	6.3	6.0	√√√	√√√	.300	√	X	5.3
Latterbarrow Beck	6.2	5.8	√√√	XXX	.800	√	√	4.2
Hardknott Gill	6.0	5.4	XX√	XXX	.616	√	X	3.4
Fisher Beck	5.9	5.5	X√√	√XX	.748	√	X	3.1
Whillan Beck	5.9	5.1	X√√	XXX	.065	√	√	2.4
Doddknott Gill	5.7	5.3	XXX	XXX	.257	√	X	4.9
Trib d/s Spothow	5.6	5.3	XXX	XXX	.006	X	X	2.5
Spothow Gill	5.5	5.2	XXX	XXX	0	X	X	2.0
Linbeck	5.5	4.9	XX√	XXX	.384	√	√	2.4
Blea Beck	5.3	4.9	XXX	XXX	.066	√	X	2.1
Trib from Blea Tarn	5.0	4.9	XXX	XXX	-	-	-	2.4

b) Main river sites

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca. mg/l
Esk - Cropple How	6.0	5.0	+ X√√	XXX	.077	√	√	3.7
Esk - Forge Bridge	5.8	5.0	X√√	XXX	.064	√	√	3.4
Esk - Dalegarth	5.8	5.2	X-√	X-X	.064	√	X	3.8
Esk - Wha House Bridge	5.4	4.9	X-X	X-X	.015	√	X	2.0
Esk - u/s Hardknott	5.5	5.2	√XX	XXX	-	-	-	1.7
Esk - Doctor Bridge	5.3	4.7	X-X	X-X	.085	√	X	2.0

c) Upper Esk - limited samples

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca. mg/l
Catcove Beck	6.4	6.3	X√	XX	√	-	X	2.8
Unnamed trib Long Crag	5.6	5.6	* XX	XX	0	X	X	1.8
Lingcove Beck	5.6	5.3	XX	XX	0	X	X	1.4
Unnamed trib Great Moss	5.5	5.4	** XX	XX	0	X	X	2.8
Esk - Great Moss	5.1	4.8	XX *	XX	0	X	X	1.1

Key

+	1 Rhithrogena semicolorata present	) Ephemeroptera presence in samples
*	Leptophlebidae and/or Siphlonurus present	) lacking Baetis sp.

√ presence demonstrated by sampling
X not present in sample
- no record

Note that the sequence of invertebrate records refers to 1) winter, 2) late spring - early summer, and 3) mid-late summer samples, in that order.

Fish and invertebrate fauna - Duddon catchment 1982

a) Tributary Sites

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca, mg/1
Hollow Moss Beck	7.3	7.1	-✓✓	-✓✓	1.638	✓	X	11.0
Holehouse Gill	6.9	6.3	✓✓✓	✓✓✓	.848	✓	✓	8.6
Crosby Gill	6.9	6.3	✓✓✓	✓X✓	.555	✓	✓	8.1
Gobling Beck	6.7	6.3	✓✓✓	XXX	1.904	✓	X	8.1
Logan Beck	6.7	6.2	✓✓✓	✓✓X	.609	✓	✓	3.8
Sling Beck	6.6	6.1	✓✓✓	XXX	.612	✓	X	3.0
Tarn Beck (ptc Gobling)	6.5	6.2	-X✓	-XX	.181	✓	✓	2.3
Blea Beck	6.5	6.1	✓✓✓	✓✓✓	1.568	✓	X	5.8
Old Park Beck	6.5	6.0	✓✓✓	✓✓✓	1.788	✓	X	7.8
Cockley Beck	6.1	5.6	XXX	XXX	.192	✓	X	5.3
Hardknott Gill	6.0	5.5	✓✓✓	✓X✓	2.040	✓	X	4.4
Grassguards Gill	5.9	5.3	XXX	XXX	.177	✓	X	3.5
Tarn Beck (Tongue H.)	5.4	5.2	XXX	XXX	0	X	X	2.2
The Syke	5.3	4.9	XXX	XXX	.037	X	X	2.3
Castlehow Beck	5.0	4.7	XXX	XXX	.323	✓	X	2.7
Troughton Gill	4.9	4.4	XXX	XXX	-	-	-	1.5
Moasdale Beck	4.8	4.5	XXX	XXX	.022	X	X	1.2
Doe House Gill	4.7	4.4	XXX	XXX	0	X	X	1.2
Black Beck	4.6	4.3	XXX•	XXX	0	X	X	1.5
Dale Head Gill	4.5	4.3	XX-	XX-	-	-	-	.8
Gaitscale Gill	4.5	4.2	XXX	XXX	0	X	X	1.1

b) Main river sites

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca, mg/1
Duddon - Duddon Bridge	6.5	5.6	✓✓✓	XXX	-	✓	✓	4.9
Duddon - Ulpha	6.3	5.5	✓✓✓	XXX	.305	✓	✓	4.5
Duddon - Troutal	5.7	5.7	XXX•	XXX	.078	✓	X	3.7
Duddon - u/s Hall Bridge	5.7	5.1	XX-	XX-	-	-	-	3.0
Duddon - ptc Moasdale	5.1	4.7	XXX	XXX	.032	X	X	1.9

Key

• 1 Ameletus present) Ephemeroptera presence in samples
• 1 Siphlonurus lacustris present) lacking Baetis sp

✓ presence demonstrated by sampling
X not present in sample
- no record

Note that the sequence of invertebrate records refers to 1) winter, 2) late spring - early summer, and 3) mid-late summer samples, in that order.

Fish and invertebrate fauna - 'Other catchments' 1982

Site	Mean pH	lowest pH	Baetis sp	Gammarus sp	total salmonid density	salmonid fry	juvenile salmon	Mean Ca. mg/1
Bannerdale Beck	6.9	6.5	✓✓✓	X✓✓	1.055	✓	✓	7.3
Swindale Beck	6.8	6.5	✓✓✓	X✓✓	.554	✓	X	8.1
Borrow Beck	6.7	6.3	✓✓✓	XXX	1.232	✓	✓	8.1
Troutbeck	6.7	6.1	✓✓✓	✓✓✓	.503	✓	✓	7.4
Aiken Beck	6.6	6.5	✓✓✓	XX✓	.423	X	X	2.2
Raise Beck	6.6	6.4	✓✓✓	XXX	.358	✓	X	5.0
Aira Beck	6.6	6.1	✓✓✓	✓✓X	.224	✓	X	4.5
Whinlatter Gill	6.6	6.0	✓✓✓	✓✓✓	4.018	✓	X	3.7
River Calder	6.5	6.1	✓✓✓	X✓X	.312	✓	✓	3.0
Worm Gill	6.5	6.1	✓✓✓	XXX	.396	✓	✓	2.6
River Bleng	6.4	6.0	✓✓✓	✓XX	.687	✓	✓	3.0
Newlands Beck	6.4	5.9	✓✓✓	XXX	1.834	✓	✓	2.9
River Mite	6.3	5.9	✓✓✓	XXX	.409	✓	✓	2.8
Mosedale Beck	6.3	5.9	✓✓✓	XXX	.233	✓	✓	2.8
Blea Beck	6.3	5.8	X✓✓	XXX	0	X	X	14.1
Stonethwaite Beck	6.2	5.9	✓✓✓	XXX	.320	✓	✓	2.3
Lingmell Beck	6.2	5.9	✓✓✓	XXX	.417	✓	✓	2.1
Greendale Gill	6.2	5.9	✓✓✓	XXX	.611	✓	✓	1.7
Smithy Beck	6.2	5.8	✓✓✓	XXX	.395	✓	X	2.2
River Derwent (Seathwaite)	6.2	5.7	*XXX	XXX	.009	✓	✓	2.2
Glenderaterra Beck	6.1	5.6	✓✓✓	XXX	1.440	✓	✓	1.3
Keskadale Beck	6.0	5.7	✓✓✓	XXX	.737	✓	✓	1.6
Great Langdale Beck	5.6	5.4	XXX	XXX	0	X	X	2.3
River Liza	5.6	5.2	XXX	XXX	.016	✓	X	1.5
River Brathay (Fell Foot)	5.5	5.0	XXX	XXX	.216	✓	X	1.8

Key

* 1 Ameletus present (Ephemeroptera presence in samples lacking Baetis sp)

✓ presence demonstrated by sampling
X not present in sample
\- no record

Note that the sequence of invertebrate records refers to 1) winter, 2) late spring - early summer, and 3) mid-late summer samples, in that order.

Mean length of 0+ salmonids

Esk 1982

Site	Species	Date	Mean	SD	Range	N
Doddknott Gill	Trout	6.7.82	3.54	.396	2.8-4.2	16
Latterbarrow Beck	Trout	7.7.82	5.39	.528	4.5-6.5	14
Latterbarrow Beck	Salmon	7.7.82	4.73	.525	3.8-5.4	10
Mere Beck	Trout	7 7.82	5.38	.664	4.3-6.4	54
Blea Beck	Trout	8.7.82	5.48	.206	5.2-5.7	4
Whillan Beck	Trout	8.7.82	5.61	.304	5.0-6.0	13
Hardknott Gill	Trout	9.7.82	4.05	.578	3.1-6.7	79
Birker Beck	Trout	9.7.82	4.35	.567	4.2-6.1	32
Fisher Beck	Trout	12.7.82	6.29	.569	4.8-7.5	61
Linbeck Gill	Trout	12.7.82	5.83	.535	4.8-6.7	24
Linbeck Gill	Salmon	12.7.82	5.24	.297	4.9-5.7	5
Esk at Doctor Br.	Trout	12.7.82	4.63	.435	4.0-5.0	4
Esk at Cropple How	Trout	19.7.82	5.36	.560	4.2-6.4	23
Esk at Cropple How	Salmon	19.7.82	5.30	.295	4.7-5.9	26
Esk at Forge Br.	Trout	19.7.82	5.35	.389	4.7-6.0	8
Esk at Forge Br.	Salmon	19.7.82	4.83	.568	4.2-5.4	4
Esk at Whahouse Br.	Trout	20.7.82	4.40	.693	3.6-4.8	3
Esk at Dalegarth	Trout	20.7.82	4.18	.715	3.5-5.4	12

Esk 1981

Latterbarrow Beck	Trout	16.7.81	5.26	.589	4.1-6.7	43
Fisher Beck	Trout	16.7.81	6.10	.415	5.2-6.5	11
Doddknott Gill	Trout	17.7.81	3.69	.398	3.1-4.3	8
Hardknott Gill	Trout	17.7.81	3.56	.385	2.8-4.6	38
Mere Beck	Trout	21.7.81	5.29	.575	4.3-6.5	26
Eel Beck	Trout	21.7.81	6.10	.814	4.7-7.2	8
Whillan Beck	Trout	27.7.81	5.50	.455	4.9-5.9	4
Whillan Beck	Salmon	27.7.81	4.90		4.8-5.0	2
Birker Beck	Trout	27.7.81	6.09	.564	5.4-6.8	7
Lin Beck	Trout	28.7.81	5.98	.512	5.1-7.0	10
Esk Cropple How A	Trout	30.7.81	5.57	.691	4.1-6.4	31
Esk Cropple How B	Trout	30.7.81	5.70	.446	4.8-6.5	16
Esk Wha House Br.	Trout	31.7.81	4.25		3.9-4.6	2
Esk Doctor Br.	Trout	31.7.81	4.10	.200	3.9-4.3	3
Esk Forge Br.	Salmon	4.8.81	4.57	.345	4.1-5.0	7
Esk Forge Br.	Trout	4.8.81	5.63	.519	4.8-6.5	12
Esk Dalegarth Br.	Trout	4.8.81	5.10	.646	3.9-5.8	10

Mean length of 0+ salmonids

Duddon

Site	Species	Date	Mean	SD	Range	N
Duddon d/s Doe House	Trout	23.7.82	4.5			1
Cockley Beck Gill	Trout	26.7.82	4.9		4.8-5.0	2
Hardknott Gill	Trout	26.7.82	6.14	.464	5.0-7.1	43
Castlehow Beck	Trout	26.7.82	4.60	.495	3.8-5.3	13
Grassguards Gill	Trout	27.7.82	5.63	.115	5.5-5.7	3
Gobling Beck	Trout	27.7.82	5.23	.462	4.1-6.0	52
Sling Beck	Trout	28.7.82	5.70	.614	4.6-6.8	18
Old Park Beck	Trout	28.7.82	5.14	.530	4.2-6.6	57
Tarn Beck (u/s Gobling)	Trout	28.7.82	4.80	.363	3.9-5.3	13
Hollow Moss Beck	Trout	29.7.82	6.02	.507	5.1-7.0	46
Crosby Gill	Trout	29.7.82	6.56	.456	5.2-7.2	29
Crosby Gill	Salmon	29.7.82	6.08	.493	4.8-7.1	40
Blea Beck	Trout	2.8.82	5.33	.532	4.0-6.5	51
Logan Beck	Trout	3.8.82	6.10	.603	5.0-7.2	11
Logan Beck	Salmon	3.8.82	6.13	.448	5.4-6.8	12
Hole House Beck	Trout	3.8.82	6.68	.676	5.4-8.2	44
Hole House Beck	Salmon	3.8.82	6.0			1
Duddon (Duddon Br.)	Salmon	2.8.82	5.98	.522	5.2-6.5	5
Duddon (Ulpha Br.)	Trout	4.8.82	6.72	.437	5.9-8.0	41
Duddon (Ulpha Br.)	Salmon	4.8.82	6.74	.450	5.8-8.0	48
Duddon (Troutal)	Trout	4.8.82	5.07	1.16	4.0-6.3	3

Appendix 6

Mean length of 0+ salmonids

Other sensitive sites

Site	Species	Date	Mean	SD	Range	N
Aira Beck	Trout	5.8.82	5.95	.542	5.4-6.8	8
Borrow Beck	Trout	5.8.82	6.08	.561	4.8-7.0	63
Borrow Beck	Salmon	5.8.82	6.20	.373	5.3-7.1	56
Derwent (Seathwaite)	Salmon	10.8.82	4.3			1
Stonethwaite Beck	Trout	10.8.82	5.25		4.7-5.8	2
Stonethwaite Beck	Salmon	10.8.82	5.77	.469	4.9-6.6	23
Newlands Beck	Trout	11.8.8	5.32	.574	3.7-6.6	76
Newlands Beck	Salmon	11.8.82	5.07	.395	3.9-5.8	56
Keskadale Beck	Trout	11.8.82	6.349	.490	5.2-7.1	47
Swindale Beck	Trout	12.8.82	6.38	.478	5.5-7.5	48
Bannerdale Beck	Trout	12.8.82	6.56	.677	5.3-8.2	116
Bannerdale Beck	Salmon	12.8.82	5.5			1
Glenderaterra Beck	Trout	13.8.82	5.72	.655	4.2-6.9	50
Glenderaterra Beck	Salmon	13.8.82	5.49	.472	4.7-6.4	22
Smithy Beck	Trout	17.8.82	6.0			1
Whinlatter Gill	Trout	17.8.82	5.03	.551	3.8-6.3	41
River Brathay	Trout	1.9.82	6.63	.058	6.6-6.7	3
Troutbeck	Trout	2.9.82	6.36	.588	5.1-7.8	67
Troutbeck	Salmon	2.9.82	6.83	.346	6.4-7.4	9
Raise Beck	Trout	2.9.82	5.72	.410	5.1-6.3	8
Lingmell Beck	Trout	3.9.82	5.09	.556	4.2-6.6	21
Lingmell Beck	Salmon	3.9.82	5.46	.365	4.9-5.9	5
Mosedale Beck	Trout	3.9.82	5.90	.346	5.4-6.2	4
Mosedale Beck	Salmon	3.9.82	6.03	.717	5.2-7.2	6
Greendale Gill	Trout	3.9.82	5.98	.423	5.4-6.6	15
Greendale Gill	Salmon	3.9.82	5.6			1
River Calder	Trout	8.9.82	5.69	1.042	4.1-7.1	7
River Calder	Salmon	8.9.82	6.35	.757	5.3-7.9	20
Worm Gill	Trout	8.9.82	6.68	.518	5.9-7.4	10
Worm Gill	Salmon	8.9.82	6.85		6.7-7.0	2
Mite	Trout	10.9.82	6.89	.620	5.9-7.9	26
Mite	Salmon	10.9.82	6.25		6.1-6.4	2
Bleng	Trout	10.9.82	5.90	.654	4.6-7.4	29
Bleng	Salmon	10.9.82	5.68	.456	4.9-7.1	25

Comparison of two expressions for juvenile salmonid biomass applied to 1982

Esk Data

Site	Estimated biomass density from measured length/weight regressions - gms/m^2	Crude index of biomass density - gms/m^2	Biomass density ÷ Crude index
Mere Beck	9.98	7.72	1.29
Latterbarrow Beck	5.89	4.26	1.38
Fisher Beck	4.25	3.01	1.41
Birker Beck	3.92	3.12	1.26
Lin Beck Gill	2.92	2.37	1.23
Hardknott Gill	2.14	1.92	1.11
Esk at Doctor Bridge	1.55	1.19	1.30
Blea Beck	1.01	.94	1.07
Whillan Beck	.99	.68	1.46
Doddknott Gill	.94	.66	1.42
Esk at Cropple How	.36	.28	1.29
Esk at Dalegarth	.31	.26	1.19
Esk at Whahouse Br.	.18	.15	1.20
Esk at Forge Br.	.16	.13	1.23
Unnamed trib d/s Spothow	.14	.12	1.17

Cumbrian hill streams with abnormally low trout densities and no known point sources of pollution

	Catchment	Mean Ca mg/l	Geometric Mean pH	Lowest pH	Ready Access to fish recolonists from d/s sources
a) exceptionally low density and no evidence of recruitment					
Moasdale Beck	Duddon	1.2	4.8	4.5	✓
upper Brathay	Brathay	1.4*	5.0*	5.0*	✓
b) no salmonids on some occasions					
Tarn Beck (U.S. Tongue House)	Duddon	2.2	5.4	5.2	✓
Blea Beck (Lune)	Lune	2.3'	5.7'	5.5'	?
trib. D.S. Spothow Gill	Esk	2.5	5.6	5.3	✓
upper Glenderamackin	Glenderamackin	0.6	5.4	5.3	✓
c) no salmonids present					
upper Grassguards Gill	Duddon	1.9*	5.0*	4.8*	x
Spothow Gill	Esk	2.0	5.5	5.2	✓
Esk, Great Moss	Esk	1.1	5.1	4.8	x
upper Blea Beck (Lune)	Lune	2.0*	5.3*	5.0*	?
Lingcove Beck	Esk	1.4	5.6	5.3	x
Black Beck	Duddon	1.5	4.6	4.3	✓
Gaitscale Gill	Duddon	1.1	4.5	4.2	✓
Doe House Gill	Dudon	1.2	4.7	4.4	✓

Note * Very limited data
' Limited data specific to fishing site, earlier reported summary data included some downstream improvement influences.

MAIN RIVER SAMPLING SITES ON THE RIVER ESK AND DUDDON

Archive Code	SPT No.	Grid Reference	Description
0174808719C	M1	NY 27100 02500	River Duddon at Wrynose - d/s of Rough Crag Gill
0174808719T	M2	NY 24700 01800	River Duddon PTC Moasdale Beck
017480872U	M3	NY 24600 01700	River Duddon at Cockley Beck Bridge.
0174808722V	M4	SD 23400 98400	River Duddon near troutal u/s of Cattle Grid.
0174808740	M5	SD 21300 95300	River Duddon d/s of Tarn Beck.
0174808760	M6	SD 19600 93000	River Duddon at Ulpha.
0174808780	M7	SD 19900 88200	River Duddon at Duddon Bridge.
0174808880E	M8	NY 21850 05100	River Esk in Great Moss.
0174808882	M9	NY 21200 01300	River Esk u/s Hardknott Gill.
0174808883C	M10	NY 20350 00900	River Esk at Whahouse Bridge.
017480885B	M11	NY 18900 00700	River Esk at Doctors Bridge.
0174808885GK	M12	NY 17160 00370	River Esk at Dalegarth Bridge.
0174808886	M13	SD 14900 99600	River Esk at Forge Bridge.
0174808888	M14	SD 13100 97700	River Esk at Cropple How Gauging Stations.

LAKE DISTRICT TRIBUTARY SAMPLING SITES

Archive Code	SPT No.	Grid Reference	Description
0172806990	T1	NY 68450 05150	River Lune at Wath
0172807055	T2	NY 56000 10100	Blea Beck u/s of A6 - u/s of Plantation.
0172807095	T3	NY 55000 04000	Borrow Beck u/s of High Borrow Bridge.
0173807769	T4	NY 44600 0770	River Kent as discharges from Kentmere Reservoir.
0173807785	T5	NY 42200 01600	Dubbs Beck as discharges from Dubbs reservoir.
0173808240	T6	NY 32700 11600	Raise Beck at foot of Dunmail Raise.
0173808242	T7	NY 33200 10300	Raise Beck 40m u/s of Dunmaile Raise WTP.
0173808284	T8	NY 39800 07650	Stuck Ghyll at Ambleside - Kirkstone Road Bridge.
0173808310	T9	NY 30000 03200	River Brathay at Fell Foot.
0173808315	T10	NY 29250 04250	Bleamoss Beck as discharges from Blea Tarn.
0173808335	T11	NY 28500 06000	Great Langdale Beck near Middlefell Place - 20m u/s of bridge.
0173808368	T12	NY 42000 05700	Trout Beck at Troutbeck Park - 20m u/s of bridge.
0174808719F	T13	NY 25900 02100	Doe House Gill PTC River Duddon - u/s of Road bridge.
0174808719J	T14	NY 25800 02100	Gaitscale Gill 10m PTC River Duddon.
0174808719R	T15	NY 25700 02000	Troughton Gill PTC River Duddon - immed. u/s of Road Bridge.
0174808719W	T16	NY 24650 01750	Moasdale Beck 10m PTC River Duddon.
0174808722H	T17	NY 24600 01400	Cockley Beck Gill 10m u/s of Road Bridge.

0174808722E	T18	NY 24100 01200	Hardknott Gull 10m u/s of River Duddon.
0174808722R	T19	NY 24100 00700	Dale Head Gill 5m u/s of Road Bridge.
0174808722L	T20	NY 25900 00200	Castlehow Beck 10m u/s of River Duddon.
0174808722P	T21	SD 23650 99750	Black Beck 10m u/s of River Duddon.
0174808722T	T22	SD 23400 96600	The Syke 20m d/s of Road Bridge.
0174808722Y	T23	SD 22800 97500	Grassguards Gill PTC River Duddon.
0174808725	T24	SD 25050 96600	Tarn Beck Overflow from Seathwaite Tarn.
0174808728E	T25	SD 23600 97500	Tarn Beck at Tongue House d/s of farm effluent influence.
0174808728V	T26	SD 22600 96100	Tarn Beck PTC Gobling Beck.
0174808728X	T27	SD 22600 98000	Gobling Beck PTC Tarn Beck.
0174808735E	T28	SD 21950 95900	Old Park Beck 5m d/s of Road Bridge.
0174808735K	T29	SD 21300 95500	Sling Beck 10m PTC River Duddon.
0174808745	T30	SD 20400 93700	Hollow Moss Beck 25m u/s of River Duddon.
0174808750	T31	SD 20100 93700	Crosby Gill PTC River Duddon.
0174808763	T32	SD 19050 92550	Holehouse Gill 10m d/s of Bobbin Mill Bridge.
0174808765	T33	SD 19400 92100	Blea Beck 150m u/s of River Duddon.
0174808768	T34	SD 18400 90300	Logan Beck d/s of Logan Beck Bridge.
0174808880G	T35	NY 22030 05000	Unnamed trib. of River Esk on Great Moss.
0174808880M	T36	NY 22600 04700	Unnamed trib. of River Esk from Long Crag.
0174808880R	T37	NY 22740 03650	Lingcove Beck.
0174808881	T38	NY 21520 02250	Catcove Beck.

0174808885	T39	NY 21200 01300	Hardknott Gill d/s River Esk.
0174808883G	T40	NY 20330 00700	Dodknott gill PTC River Esk.
0174808883M	T41	NY 20340 00650	Spothow Gill PTC River Esk.
0174808883R	T42	NY 20280 00650	Trib of River Esk (d/s of Spothow Gill).
0174808885	T43	NY 19400 01000	Blea Beck PTC River Esk.
0174808885D	T44	NY 17300 00200	Birker Beck at Dalegarth Hall (Boiler Beck).
0174808885G	T45	NY 17350 00400	Eel Beck 50m u/s River Esk.
0174808885H	T46	NY 16900 00400	Whillan Beck PTC Esk.
0174808885K	T47	NY 15700 00200	Trib. of River Esk 1 km d/s Blea Tarn.
0174808886G	T48	14350 99500	Mere Beck d/s of Track from Stn.
0174808886M	T49	SD 14650 98700	Fisher Beck u/s of Road Bridge.
0174808887	T50	SD 14050 98200	Linbeck Gill d/s Devuke Water
0174808889M	T51	SD 12350 97300	Latterbarrow Beck d/s Hinning House.
0174808897	T52	NY 13200 00300	River Mite 20m u/s of Powerhouse Bridge.
0174808904F	T53	NY 18400 07700	Lingmell Beck 20m PTC Mosedale Beck.
0174808904K	T54	NY 18400 08200	Mosedale Beck 10m u/s of Down-in-the-Dale Bridge.
0174808906	T55	NY 16500 06700	Wastwater at Bowderdale.
0174808911G	T56	NY 14300 05600	Greendale Beck at Greendale.
0174808919	T57	NY 06600 05500	River Bleng t Blengdale - u/s of Forestry Commission Bridge.
0174808933G	T58	NY 06500 09100	River Calder 20m u/s of Worm Gill.
0174808933M	T59	NY 06600 09100	Worm Gill 20m u/s of River Clader.
0174808953F	T60	NY 19200 12300	River Liza 400m d/s of YAA (10m u/s of Ford).

1074808955L	T61	NY 13050 14250	River Liza PTC Ennerdale Water
0174808953P	T62	NY 12400 15000	Smithy Beck 30m u/s of Forestry Commission Bridge.
0174808953V	T63	NY 11400 15000	Ennerdale Water Near Howness Knott.
0174808960	T64	NY 06900 15800	River Ehen at Ennerdale Bridge.
0175809026H	T65	NY 23400 12200	River Derwent PTC Sour Milk Gill, Seathwaite.
0175809027K	T66	NY 36300 30300	River Glenderamackan at Hungrisdale.
0175809029P	T67	NY 32100 14900	Thirlmere - Surface Water at draw-off tower.
0175809029Y	T68	NY 29600 25400	Glenderaterra Beck at Derwent Folds.
0175809045F	T69	NY 23150 19450	Newlands Beck d/s of Bridge at Little Town.
0175809045M	T70	NY 22300 19400	Keskadale Beck Near Gillorow.
0175809065B	T71	NY 22400 13580	Gatesgarthdale Beck u/s Buttermere Green Slate Quarry.
0175809065M	T72	NY 19000 13500	Buttermere Below Lower Gateswarth.
0175809066B	T73	NY 16200 18200	Crummock Water at Mause Point.
0175809066CD	T74	NY 12800 21800	Loweswater
0175809060DR	T75	NY 19200 24500	Whinlatter Gill 10m u/s of F.C. Bridge.
0175809066DV	T76	NY 18900 26250	Aiken Beck 200m u/s of Darling Row Plantation.
0175809088K	T77	NY 09500 19500	Congra Moss
0175809119T	T78	NY 25400 35300	River Ellen at Overwater.
0176809519G	T79	SD 78000 98800	River Eden at B6259 Roadbridge - at Ing Heads.
0176809403C	T80	NY 40300 09500	Kirkstone Beck at Kirkstone Pass.
0176809403K	T81	NY 40200 13200	Goldrill Beck at Brotherswater Outlet - u/s of Pasture Beck.

01768094030	T82	NY 47000 24400	Ullswater - R.Eamont at B5320 Road bridge (Pooley Bridge).
0176809404H	T83	NY 37150 20750	Aira Beck 50m d/s of Footbridge near Dowthwaitehead.
0176809404R	T84	NY 43550 16880	Bannerdale Beck u/s of Footbridge at Dalehead.
0176809417F	T85	NY 55300 11650	Wet Sleddale Reservoir - Compensation water at weir.
0176809417M	T86	NY 50750 12350	Swindale Beck 20m u/s of Trib. from Swindale Head Farm.
0176809417R	T87	NY 50300 15700	Haweswater as discharging to Haweswater Beck.
0176809612	T88	NY 32000 44000	Grainsgill Beck u/s Carrock Fell Mine.
0176809014	T89	NY 32800 32600	River Caldew 50m d/s Grainsgill Beck.
0175809026HE	T90	NY 233 122	Sour Milk Gill ptc. River Derwent.
0175809026P	T91	NY 254 139	Coombe Gill at B5289 ptc River Derwent.
0175809026T	T92	NY 273 131	Stonethwaite Beck d/s Greenup Gill.

APPENDIX 8

SOUTH PENNINE SAMPLING SITE

Archive Code	SPT No.	Grid Reference	Description
0172806479R	P 4	SD 566 553	River Grizedale at Grizedale Br.
0172806479K	P 5	SD 589 556	Tarnbrook Wyre at T
0172806567	P 6	SD 536 491	Grizedale Beck
0171804420	P 7	SD 702 590	R.Hodder at Cross of Great Br.
0171804160	P 8	SD 794 778	Cam Beck ptc Ribble.
017805234	P 9	SD 671 222	Earnsdale*
0171804638	P10	SD 888 315	Hurstwood*
0171804976	P11	SD 798 276	Mitchell's House No.1*
0171804707	P12	SD 806 397	Upper Ogden Reservoir*
0170806002	P13	SD 628 160	R.Yarrow imm. u/s Yarrow Res.
0169081192	P14	SD 832 156	Ashworth Moor*
0169800995	P15	SD 970 180	Blackstone Edge*
0169801083	P16	SD 897 164	Brownhouse Wham*
0169800708	P17	SD 846 269	Clough Bottom*
0169800695	P18	SD 842 202	Cowpe*
0169801055	P19	SD 968 124	Hanging Lees*
0169801188	P20	SD 851 171	Naden Higher*
0169810245	P21	SD 916 214	Ramsden Clough*
0169810247	P22	SD 961 204	Warland*
0169810248	P23	SD 974 201	Whiteholme*
0169801327	P24	SD 668 177	Inflow to Belmont Res u/s A675.
	P25		Inflow to Turton & Entwistle Res u/s A666 Rd. Bridge
0169800009	P26	SK 017 980	Arnfield Brook u/s Arnfield Res.
0169800002	P27	SK 112 999	R.Etherow u/s Woodhead Res.
	P28	SK 020 970	R.Etherow d/s Bottoms Res. at Tintwistle
0169800024	P29	SK 055 938	Hurst Res*.
0159800303	P30	SD 995 101	Castleshaw Upper*
0169800348	P31	SE 019 032	Chew Brook d/s Chew Res. u/s Dove Stone Res.
0169800342	P32	SE 028 055	Greenfield Res.*
016800292	P33	SD 986 122	Readycon Dean.*
0169800384	P34	SK 004 996	Higher Swineshaw*.
016980084	P35	SK 011 744	R.Goyt u/s Errwood Res.
0169800184	P36	SK 056 880	Kinder Res*.

* Reservoir Sites.

Appendix 9

WATER QUALITY SAMPLE SUMMARIES
FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

SPT :- 0174808719C NGR :- NY 27100 02500 RIVER DUDDON AT WRYNOSE - D/S OF ROUGH CRAG GILL

M1

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		5.632	3.666	.0195	.3712	.0015	136.5	103.6	1.672	.6			41.09	.0056		6.222	1.57
S.D.		.4857	2.466	.0366	.3932	.0005	109.9	101.3	.4944	.1219			10.41	.0018		5.047	.4191
MAX		6.6	9	.11	1.32	<.004	330	310	2.5	.83			63	<.01		12	2.5
MIN		4.7	<1	<.004	.1	<.002	10	<10	.4	.37			22	<.004		<4	.9
5%ILE NORM		4.833	-VE	-VE	-VE	.0007	-VE	-VE	.8589	.3995			23.96	.0027		-VE	.8806
95%ILE NORM		6.431	7.723	.0797	1.018	.0023	317.4	270.2	2.485	.8005			58.22	.0086		14.52	2.259
5%ILE LOG		4.87	1.113	.0012	.0612	.0009	33.24	19.26	.996	.4224			26.42	.0032		1.5	.9852
95%ILE LOG		6.465	8.311	.0692	1.061	.0024	340.3	285	2.581	.8185			60.04	.0089		15.56	2.335
NO.OF OCCURS.		20	17	8	8	8	18	11	18	18			16	7		3	10

SPT :- 0174808719T NGR :- NY 24700 01800 RIVER DUDDON PTC MOASDALE BECK

M2

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		5.25	7.75	.0067	.35	.0013	57.5		1.866	.6			30	.0067		2.666	.6
S.D.		.4435	4.573	0.0	0.0	0.0	38.89		.5508	0.0			0.0	0.0		0.0	0.0
MAX		5.7	11	<.01	.35	<.002	85		2.5	.6			30	<.01		<4	.6
MIN		4.7	1	<.01	.35	<.002	30		1.5	.6			30	<.01		<4	.6
5%ILE NORM		4.52	.2271	.0067	.35	.0013	-VE		.9607	.6			30	.0067		2.666	.6
95%ILE NORM		5.979	15.27	.0067	.35	.0013	121.4		2.772	.6			30	.0067		2.666	.6
5%ILE LOG		4.553	2.715	.0067	.35	.0013	17.35		1.113	.6			30	.0067		2.666	.6
95%ILE LOG		6.009	16.4	.0067	.35	.0013	130.7		2.879	.6			30	.0067		2.666	.6
NO.OF OCCURS.		4	4	1	1	1	2		3	2			1	1		1	1

SPT :- 0174808720 NGR :- NY 24600 01700 RIVER DUDDON AT COCKLEY BECK BRIDGE

M3

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		5.763	3.495	.0148	.3696	.0018	214	182.5	1.294	.5859	1.116	5.912	45.06	.0108	8.684	3.166	1.377
S.D.		.8391	2.251	.0177	.2856	.0007	153.8	155.9	.2536	.1194	.689	7.494	11.98	.0101	3.416	2.592	.2438
MAX		8	10	.08	1.29	<.005	440	440	1.9	.85	2.6	34	83	.04	20	5	1.9
MIN		4.7	<1	<.004	.05	.001	<20	<10	.8	.39	.2	2	24	<.004	4	<2	1.1
5%ILE NORM		4.383	-VE	-VE	-VE	.0006	-VE	-VE	.8769	.3894	-VE	-VE	25.34	-VE	3.064	-VE	.9767
95%ILE NORM		7.143	7.198	.0439	.8395	.0029	467.1	439	1.711	.7823	2.249	18.24	64.79	.0274	14.3	7.431	1.778
5%ILE LOG		4.494	1.115	.002	.0949	.0009	60.13	41.03	.9228	.4119	.3732	.7318	28.32	.0021	4.33	.7543	1.016
95%ILE LOG		7.237	7.743	.0447	.9014	.0031	502.5	469	1.747	.8	2.418	18.32	66.96	.029	15.08	7.959	1.811
NO.OF OCCURS.		38	35	26	26	26	18	12	17	17	19	19	26	25	19	2	9

SPT :- 0174808722V NGR :- SD 23400 98400 RIVER DUDDON NEAR TROUTAL U/S OF CATTLE GRID

M4

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		5.603	5.053	.0205	.4687	.002	215.3	178.7	2.109	.6775			45.82	.0094		3.444	1.37
S.D.		.6893	3.913	.0308	.3988	.0013	180.3	166	1.124	.2262			9.998	.0074		1.895	.6093
MAX		7.1	16	.095	1.4	.005	600	460	5.5	1.5			66	.02		5	2.4
MIN		4.6	<1	<.004	.18	<.002	<10	<10	1	.42			27	<.004		<2	.4
5%ILE NORM		4.469	-VE	-VE	-VE	-VE	-VE	-VE	.26	.3055			29.38	-VE		.3267	.3678
95%ILE NORM		6.737	11.48	.0712	1.124	.0041	511.8	451.8	3.958	1.049			62.27	.0216		6.562	2.372
5%ILE LOG		4.546	1.294	.0019	.106	.0006	49.76	35.79	.8177	.3765			31.4	.0024		1.295	.6224
95%ILE LOG		6.803	12.33	.0679	1.201	.0044	547.5	479.2	4.236	1.096			63.83	.0232		7.032	2.517
NO.OF OCCURS.		28	25	8	8	8	21	12	22	20			19	7		3	10

SPT :- 0174808740 NGR :- SD 21300 95300 RIVER DUDDON DOWNSTREAM OF TARN BECK

M5

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.324	4.861	.0217	.4092	.002	135.9	104.6	2.288	.7618	1.207	8.129	50.57	.0217	8.166	4.888	1.855
S.D.		.596	2.587	.0301	.2743	.0007	111.4	105.4	.6144	.1271	.7534	12.45	10.74	.0636	1.977	2.168	1.205
MAX		7.6	12	.135	1.29	<.005	330	320	4.1	1	2.4	49	76	.325	12	7	4.3
MIN		5.1	1	<.005	.05	<.002	10	<10	1.4	.55	.3	<4	30	<.005	4	<4	.8
5%ILE NORM		5.344	.6052	-VE	-VE	.0009	-VE	-VE	1.278	.5526	-VE	-VE	32.9	-VE	4.913	1.321	-VE
95%ILE NORM		7.304	9.117	.0712	.8605	.0031	319.2	278	3.299	.9709	2.446	28.61	68.24	.1263	11.42	8.456	3.838
5%ILE LOG		5.394	1.887	.0023	.1248	.0011	32.34	18.63	1.432	.5721	.3988	.7291	35.02	.0006	5.359	2.225	.5864
95%ILE LOG		7.349	9.757	.0697	.9259	.0032	341.9	292.1	3.411	.9869	2.63	27.09	69.89	.083	11.75	8.974	4.129
NO.OF OCCURS.		37	36	26	26	26	17	11	18	17	18	18	26	25	18	3	9

SPT :- 0174808760 NGR :- SD 19600 93000 RIVER DUDDON AT ULPHA

M6

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN	3.724	6.653	6.975	.0276	.4142	.002	144.5	80.6	3.51	.8868	1.246	8.037	60.72	.0125	9.944	4.333	2.462
S.D.	4.801	.6318	4.154	.0403	.2732	.0008	205.1	77.21	1.09	.1818	.8211	13.19	11.38	.016	3.539	2.357	1.054
MAX	25.25	8.3	22	.155	1.26	<.005	930	225	5.4	1.25	2.8	58	85	.08	20	6	4.3
MIN	.152	5.5	1	<.005	.05	<.002	<10	<10	1.9	.55	.3	<4	39	<.005	6	<4	1.2
5%ILE NORM	-VE	5.614	.1421	-VE	-VE	.0008	-VE	-VE	1.716	.5878	-VE	-VE	42	-VE	4.122	.4563	.7285
95%ILE NORM	11.62	7.692	13.8	.0938	.8636	.0033	481.9	207.6	5.303	1.185	2.597	29.73	79.44	.0388	15.76	8.21	4.196
5%ILE LOG	.4483	5.667	2.421	.0027	.1287	.0011	14.77	15.43	2.034	.6222	.3876	.6379	43.96	.0015	5.308	1.647	1.152
95%ILE LOG	11.62	7.74	14.83	.0903	.9292	.0034	468.5	219.4	5.521	1.213	2.794	27.41	81.01	.0389	16.53	8.794	4.445
NO.OF OCCURS.	41	43	40	26	26	26	20	11	20	19	18	18	30	25	18	2	8

SPT :- 0174808780 NGR :- SD 19900 88200 RIVER DUDDON AT DUDDON BRIDGE

M7

	37 FLOW INST M3/S	61 PH	162 ALKALINITY M.O. MG/L CACO3	111 AMMONIA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALUMINIUM UG/L	9509 AL MONOMERIC UNAC UG/L	241 CALCIUM MG/L CA	237 MAGNESIUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLORIDE MG/L CL	183 SULPHATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN	8.288	6.721	9.217	.0225	.3039	.0049	119.8	66.11	4.634	1.055	1.113	5.845	66.58	.0106	8.73	5.222	3.342
S.D.	18.16	.5584	3.53	.0383	.2518	.0074	215	61.29	3.071	.3259	.5036	4.703	34.99	.0133	3.707	2.269	1.22
MAX	93.97	8.3	22	.28	1.32	.064	1100	190	29	3.2	2.6	29	350	.09	37	7	5.6
MIN	.246	4.7	1	<.005	<.05	.001	20	10	1.7	.5	.2	<4	26	<.005	4	<4	1.9
5%ILE NORM	-VE	5.803	3.41	-VE	-VE	-VE	-VE	-VE	-VE	.5198	.2845	-VE	9.025	-VE	2.632	1.49	1.334
95%ILE NORM	38.16	7.64	15.02	.0856	.7182	.0171	473.6	166.9	9.686	1.591	1.941	13.58	124.1	.0326	14.82	8.954	5.35
5%ILE LOG	.3885	5.844	4.683	.0017	.0712	.0004	8.109	13.27	1.431	.6142	.4985	1.424	26.16	.0013	4.113	2.416	1.754
95%ILE LOG	30.47	7.677	15.81	.0777	.7687	.0163	419.9	177.1	10.42	1.657	2.062	14.55	132.8	.0328	15.69	9.492	5.619
NO.OF OCCURS.	158	138	124	138	138	138	25	12	82	81	108	108	97	137	115	3	14

Appendix 9

```
                                        WATER QUALITY SAMPLE SUMMARIES
                                   FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                  37     61     162    111    117    118    7760   9509   241    237    85     92     77     180    172    183    9968
                  FLOW   PH     ALKAL  AMMON  NO3-N  NO2-N  ALU    AL     CAL    MAGNES BOD 5  COD    COND   ORTHO  CHLOR  SULPHTOTAL
                  INST          INITY  IA N                 MIN    MONO   CIUM   IUM    ATU           AT     PHOSP  IDE     ATE HUMIC
                                M.O.   MG/L   MG/L   MG/L   IUM    MERIC                MG/L   MG/L   25C    MG/L   MG/L   MG/LSUBS
                  M3/S          MG/L          N      N      UG/L   UNAC   MG/L   MG/L   O      O      US/CM  P      CL     SO4    MG/L
                                CACO3                              UG/L   CA     MG

SPT :- 0174808880E      NGR :- NY 21850 05100    RIVER ESK IN GREAT MOSS
 -----                  ------
EAN                      5.266  3.733  .0055  .2247  .0017  180.3  162.2  1.113  .5227                37.92  .0055  1      3.333  .9875
.D.        M8            .4952  2.25   .0018  .1325  .0006  119.6  131.6  .2232  .0744                9.827  .0018  0.0    .9428  .5276
MAX                      6.6    8      <.01   .35    <.004  420    380    1.5    .65                  58     <.01   1      4      1.9
MIN                      4.8    1      <.004  <.05   <.002  35     20     .7     .39                  24     <.004  1      <4     0.0
 5%ILE NORM              4.452  .0308  .0026  .0067  .0008  -VE    -VE    .7462  .4003                21.75  .0026  1      1.782  .1196
 5%ILE NORM              6.081  7.435  .0084  .4426  .0027  377.1  378.8  1.48   .645                 54.08  .0084  1      4.884  1.855
 5%ILE LOG               4.493  1.279  .0032  .0788  .0009  55.69  39.07  .7875  .4099                24.13  .0032  1      2.032  .382
95%ILE LOG               6.118  7.99   .0088  .4754  .0028  405.7  405.9  1.513  .6532                55.83  .0088  1      5.062  1.986
NO.OF OCCURS.            15     15     5      5      5      13     9      15     15                   13     5      1      2      8

 T :- 0174808882        NGR :- NY 21200 01300    RIVER ESK U/S HARDKNOTT GILL
 -----                  ------
EAN                      5.548  3.063  .0149  .2954  .0015  203.3  131.9  1.676  .6824                45.12  .0062  3      5.666  1.995
S.D.       M9            .658   2.409  .023   .26    .0004  159    95.7   .7796  .2007                13.53  .0019  0.0    4.652  1.144
MAX                      7.8    9      .09    1.11   <.004  680    330    4      1.1                  71     .01    3      14     5.5
IN                       4.4    <1     <.004  .06    <.002  <10    <10    .8     .45                  28     <.004  3      <2     .8
5%ILE NORM               4.466  -VE    -VE    -VE    .0008  -VE    -VE    .3939  .3523                22.85  .0031  3      -VE    .1125
5%ILE NORM               6.631  7.027  .0528  .7231  .0022  464.9  289.4  2.958  1.012                67.38  .0093  3      13.31  3.879
 5%ILE LOG               4.536  .7685  .0013  .0638  .001   51.44  36.67  .734   .4076                26.66  .0037  3      1.344  .72
95%ILE LOG               6.692  7.54   .0499  .7707  .0023  499    311.2  3.147  1.051                70.04  .0096  3      14.26  4.162
.OF OCCURS.              39     37     13     13     13     35     16     38     38                   35     12     1      6      24

 T :- 0174808883C       NGR :- NY 20350 00900    RIVER ESK AT WHAHOUSE BRIDGE
------                  ------
MEAN                     5.579  3.047  .0197  .3375  .0016  181.2  132.2  1.842  .6908                46.54  .0088  4.333  8.095  2.244
 D.        M10           .5287  2.741  .0249  .2308  .0005  165    85.13  .5974  .1559                11.5   .0059  2.516  3.224  1.997
 X                       6.9    16     .09    1.11   <.004  750    340    3.4    1.1                  73     .02    7      12     10.6
 N                       4.5    <1     <.004  .15    <.002  <10    <10    1      .45                  29     <.004  2      <4     .7
 5%ILE NORM              4.709  -VE    -VE    -VE    .0007  -VE    -VE    .86    .4343                27.62  -VE    .1938  2.791  -VE
95%ILE NORM              6.449  7.556  .0608  .7171  .0024  452.8  272.2  2.825  .9472                65.47  .0186  8.472  13.39  5.53
 %ILE LOG                4.754  .6387  .0025  .1006  .0009  37.33  42.21  1.042  .467                 30.27  .0027  1.543  4      .4772
 %ILE LOG                6.489  8.039  .0611  .7716  .0025  481.2  292.9  2.948  .9722                67.44  .02    9.095  14.13  5.889
 .OF OCCURS.             58     56     16     16     16     49     23     54     52                   48     15     3      7      27
SPT :- 0174808885B      NGR :- NY 18900 00700    RIVER ESK AT DOCTORS BRIDGE
------                  ------
 AN                      5.585  3.478  .0218  .3323  .0015  260.5  124.1  2.023  .7292                48.67  .0079  5      5.666  2.169
 D.        M11           .6915  2.548  .0267  .2503  .0006  335.3  102.7  .6442  .1761                11.96  .0044  0.0    2.357  1.049
 X                       7.4    11     .1     1.11   <.004  1800   380    3      1.1                  70     .02    5      8      4
MIN                      4.3    <1     <.01   .15    .001   <10    <10    .7     .4                   30     <.005  5      <4     .6
 5%ILE NORM              4.447  -VE    -VE    -VE    .0006  -VE    -VE    .9635  .4396                29     .0006  5      1.789  .4441
 5%ILE NORM              6.722  7.671  .0657  .744   .0025  812.1  293.1  3.082  1.018                68.35  .0152  5      9.543  3.895
 %ILE LOG                4.524  .9546  .0029  .0881  .0008  31.43  29.17  1.156  .4792                31.74  .0029  5      2.712  .919
 %ILE LOG                6.789  8.248  .0666  .7995  .0026  812.4  313.7  3.214  1.048                70.39  .0163  5      10.09  4.151
 .OF OCCURS.             40     39     13     13     13     36     16     39     38                   34     12     1      4      23
SPT :- 0174808885GK     NGR :- NY 17160 00370    RIVER ESK AT DALEGARTH BRIDGE
 ----                   ------
 AN                      5.892  4.7    .0222  .376   .0016  196.8  112.7  2.859  .8762                59.31  .0074  7      5.222  3.387
 D.        M12           .8767  3.968  .0368  .2516  .0007  176.1  85.63  1.872  .2959                25.35  .0028  0.0    2.673  2.455
MAX                      8.8    17     .125   1.05   <.004  740    325    10.6   1.8                  159    <.02   7      8      11.7
MIN                      4.7    <1     <.01   .15    .001   <10    <10    .85    .45                  34     <.005  7      <4     .9
 %ILE NORM               4.45   -VE    -VE    -VE    .0005  -VE    -VE    -VE    .3894                17.61  .0028  7      .8244  -VE
 %ILE NORM               7.334  11.22  .0827  .7899  .0028  486.6  253.5  5.939  1.363                101    .012   7      9.62   7.426
 %ILE LOG                4.569  1.074  .0017  .1149  .0008  41.52  29.56  .8952  .4835                27.8   .0038  7      2.102  .9418
95%ILE LOG               7.434  12     .0759  .85    .0029  518    272.4  6.39   1.425                106.9  .0126  7      10.27  7.987
NO.OF OCCURS.            39     39     10     10     9      36     19     38     37                   34     9      1      3      24

 T :- 0174808886        NGR :- SD 14900 99600    RIVER ESK AT FORGE BRIDGE
 ----                   ------
MEAN                     5.989  5.05   .0333  .33    .0017  219.4  98.59  2.687  .8895                54.07  .0098  9      6.777  2.644
S.D.       M13           .7317  3.717  .0658  .2301  .0006  247    75.1   1.095  .2552                13.5   .0057  2.828  3.88   1.171
 X                       8.4    19     .255   1.05   <.004  1050   270    5.2    1.4                  78     .02    11     15     4.9
 N                       4.9    <1     <.01   .15    <.002  <10    <10    .95    .4                   33     <.005  7      <2     1.1
 %ILE NORM               4.786  -VE    -VE    -VE    .0007  -VE    -VE    .8853  .4697                31.85  .0004  4.347  .3953  .7173
95%ILE NORM              7.193  11.16  .1416  .7084  .0028  625.7  222.1  4.489  1.309                76.29  .0192  13.65  13.16  4.571
 5%ILE LOG               4.866  1.378  .0019  .0961  .0009  32.9   25.77  1.305  .5384                35     .0035  5.182  2.45   1.205
95%ILE LOG               7.263  12     .1198  .7623  .0029  645.4  238.6  4.743  1.358                78.63  .0206  14.22  14.12  4.851
 .OF OCCURS.             48     46     16     16     16     42     19     44     42                   37     15     2      9      27

SPT :- 0174808888       NGR :- SD 13100 97700    RIVER ESK AT CROPPLE HOW GAUGING STATIONS
------                  ------
MEAN              16.16  5.936  5.982  .0136  .4304  .0019  146    78.17  2.285  .7504  .9816  4.196  41.22  .014   10.08  18.35  3.732
 D.     M14       113.3  .5018  2.705  .0228  .2041  .0011  173.6  45.72  2.352  .4606  .4842  2.456  14.21  .0603  14.11  32.03  1.479
 X                3014   9.2    12     .21    2.1    .007   2400   285    54     11     3      13     200    <1     90     133    9.6
 N                .126   4.35   <1     <.005  <.05   <.002  2.9    <10    .8     .4     .4     <4     20     <.005  4      <2     1.1
 5%ILE NORM       -VE    5.111  1.531  -VE    .0947  .0001  -VE    2.965  -VE    -VE    .1852  .1563  17.83  -VE    -VE    -VE    1.297
95%ILE NORM       202.5  6.762  10.43  .051   .7662  .0036  431.7  153.3  6.155  1.507  1.778  8.236  64.6   .1133  33.3   71.04  6.166
 %ILE LOG         .0882  5.149  2.68   .001   .1854  .0007  20.06  27.65  .3937  .2523  .4086  1.483  22.45  .0002  1.056  1.305  1.85
 %ILE LOG         59.15  6.796  11.08  .0467  .8158  .0039  440.3  164.6  6.446  1.62   1.896  8.844  67.63  .0541  32.51  63.79  6.504
 .OF OCCURS.      715    692    170    121    121    121    583    416    597    596    78     78     564    120    131    15     171
```

```
                                   WATER QUALITY SAMPLE SUMMARIES
                               FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                 37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
             FLOW      PH ALKAL AMMON NO3-N NO2-N ALU     AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
             INST         INITY IA N              MIN   MONO  CIUM  IUM    ATU         AT    PHOSP  IDE   ATE HUMIC
                          M.O.  MG/L  MG/L  MG/L  IUM   MERIC              MG/L  MG/L  25C    MG/L MG/L  MG/LSUBS
             M3/S          MG/L         N     N   UG/L  UNAC   MG/L  MG/L   0     0    US/CM P      CL   804  MG/L
                          CACO3                         UG/L   CA    MG

T :- 0172807095          NGR :- NY 55000 04000    BORROW BECK D/S OF HIGH BORROW BRIDGE
------                   ------
MEAN               6.53  13    .0167 .0838 .0024 39.76 21.66 5.857 1.221             70    .0072       10    8.085
 D.      T3        .4923 6.146 .017  .079  .0011 23.5  14.33 3.791 .7382             24.49 .0014       0.0   3.512
 X                 7.2   25    .05   .25   .004  70    40    12    2.6               110   .01         10    13.1
 N                 5.9   4     <.01  <.05  <.002 <10   <10   2     .5                50    <.01        10    4.3
 5%ILE NORM        5.72  2.889   -VE   -VE .0006 1.106   -VE   -VE .0072             29.7  .005        10    2.307
95%ILE NORM        7.339 23.11 .0446 .2138 .0041 78.41 45.24 12.09 2.435             110.2 .0095       10    13.86
  %ILE LOG         5.753 5.613 .0029 .0164 .0011 13.91 6.705 1.858 .4175             37.77 .0052       10    3.742
  %ILE LOG         7.369 24.6  .0468 .2264 .0044 84.22 48.68 13.01 2.617             115.5 .0096       10    14.69
 .OF OCCURS.         10    10     7     7     7     7     4     7     7                 5     6           2     7

T :- 0173807769          NGR :- NY 44600 07700    RIVER KENT AS DISCHARGES FROM KENTMERE RESERVOIR
-----                    ------
AN                 6.692 11    .0133 .3014 .0018 21.61 6.666 4.433 .7583             53.66 .0067       6     1.985
.D.      T4        .3372 2.768 .0128 .1096 .0005 26.34  0.0  .6623 .0917             5.507  0.0        1.414 .5429
MAX                7.2   15    .04   .4    <.004 73    <10   5.1   .9                60    <.01        7     3
MIN                6.3   7     <.01  .16   <.002 <10   <10   3.7   .65               50    <.01        5     1.2
 5%ILE NORM        6.138 6.445   -VE .1211 .001    -VE 6.666 3.343 .6074             44.6  .0067       3.673 1.092
 5%ILE NORM        7.247 15.55 .0343 .4817 .0026 64.95 6.666 5.522 .9092             62.72 .0067       8.326 2.878
 5%ILE LOG         6.153 7.095 .0026 .1587 .0011 2.851 6.666 3.434 .6174             45.11 .0067       3.983 1.231
95%ILE LOG         7.261 16.03 .0363 .5058 .0027 65.86 6.666 5.598 .9179             63.17 .0067       8.56  2.979
NO.OF OCCURS.         7     7     7     7     7     6     4     6     6                 3     6           2     7

PT :- 0173807785         NGR :- NY 42200 01600    DUBBS BECK AS DISCHARGES FROM DUBBS RESERVOIR
------                   ------
MEAN               6.857 26.42 .0129 .4257 .0022 39.71 7.5   11.28 2.5               103.3 .0072       20    2.928
.D.      T5        .378  8.657 .0164 .204  .0009 58.71 1.666 2.241 .4761             5.773 .0014       1.414 1.035
AX                 7.5   40    .05   .75   .004  168   10    15    3.4               110   .01         21    4.3
IN                 6.4   18    <.01  .1    <.002 <10   <10   8.4   1.9               100   <.01        19    1.4
 5%ILE NORM        6.235 12.18   -VE .0901 .0007   -VE 4.758 7.598 1.716             93.83 .005        17.67 1.225
95%ILE NORM        7.478 40.66 .0398 .7613 .0037 136.2 10.24 14.97 3.283             112.8 .0095       22.32 4.632
 5%ILE LOG         6.253 14.85 .0016 .1817 .001  3.787 5.102 8.009 1.8               94.11 .0052       17.76 1.569
 5%ILE LOG         7.496 42.46 .0399 .8111 .0039 130.7 10.5  15.29 3.349             113   .0096       22.4  4.856
0.OF OCCURS.          7     7     7     7     7     7     4     7     7                 3     6           2     7
```

```
                                      WATER QUALITY SAMPLE SUMMARIES
                                 FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                            37     61    162    111    117    118   7760   9509    241    237     85     92     77    180    172    183   9968
                        FLOW   PH     ALKAL  AMMON  NO3-N  NO2-N  ALU    AL     CAL    MAGNES BOD 5  COD    COND   ORTHO  CHLOR  SULPH  TOTAL
                        INST          INITY  IA N                 MIN    MONO   CIUM   IUM    ATU           AT     PHOSP  IDE    ATE    HUMIC
                                      M.O.   MG/L   MG/L   MG/L   IUM    MERIC                MG/L   MG/L   25C    MG/L   MG/L   MG/L   SUBS
                        M3/S          MG/L          N      N      UG/L   UNAC   MG/L   MG/L   O      O      US/CM  P      CL     SO4    MG/L
                                      CACO3                              UG/L   CA     MG

SPT :- 0173808284                     NGR :- NY 39800 07650   STOCK GHYLL AT AMBLESIDE - KIRKSTONE ROAD BRIDGE
------                                ------
 EAN          T8              6.792  13.28  .0119  .3314  .0017  16.66  7.5    5.485  1.078                94.33  .0072         8      7.3
 .D.                          .4382  4.191  .0094  .1068  .0006  10.32  1.666  1.897  .258                 14.01  .0014         1.414  12.22
MAX                           7.3    19     .03    .55    <.004  <40    10     8      1.4                  110    .01           9      35
MIN                           6.25   8      <.01   .2     .001   <10    <10    2.4    .7                   83     <.01          7      2
 5%ILE NORM                   6.072  6.39      -VE .1557  .0007     -VE 4.758  2.364  .6542                71.28  .005          5.673     -VE
'5%ILE NORM                   7.513  20.18  .0274  .5072  .0026  33.65  10.24  8.607  1.502                117.3  .0095         10.32  27.4
 5%ILE LOG                    6.097  7.633  .003   .1881  .0009  5.546  5.102  2.982  .7117                73.18  .0052         5.903  .559
/5%ILE LOG                    7.536  21.03  .0294  .5291  .0027  36.18  10.5   9.013  1.546                118.9  .0096         10.51  25.05
NO.OF OCCURS.                     7      7      7      7      7      6      4      7      7                    3      6             2      7

SPT :- 0173808310                     NGR :- NY 30000 03200   RIVER BRATHAY AT FELL FOOT
------                                ------
MEAN          T9              6.1    5.256  .0441  .2833  .005   193.6  116.6  1.545  .5182  .9143  5.41   45.14  .0124  6.071  7.666  1.785
S.D.                          .9391  2.48   .0604  .292   .0031  127.9  129.3  .5556  .1347  .6096  2.789  8.05   .0094  2.017  9.837  .5242
MAX                           7.4    12     .25    1.3    <.02   363    300    2.6    .7     2.3    14     55     <.05   10     19     2.6
MIN                           4      2      <.01   .02    .001   <10    <10    .7     .3     <.5    <4     30     <.01   2      <2     1.2
 5%ILE NORM                   4.555  1.175     -VE    -VE 0.0       -VE    -VE .6315  .2967     -VE .822   31.9      -VE 2.752     -VE .9235
95%ILE NORM                   7.645  9.336  .1434  .7636  .0101  404.1  329.4  2.459  .7397  1.917  9.998  58.38  .0278  9.39   23.84  2.647
 5%ILE LOG                    4.687  2.273  .0048  .0487  .0017  60.01  17.91  .8196  .3293  .2805  2.163  33.21  .0033  3.383  .9301  1.067
95%ILE LOG                    7.755  9.939  .141   .7996  .0108  434.8  340.7  2.58   .7637  2.062  10.68  59.45  .0299  9.812  23.87  2.749
NO.OF OCCURS.                    26     26     22     22     22     10      4     11     11     14     13      7     21     14      3      7

SPT :- 0173808315                     NGR :- NY 29250 04250   BLEAMOSS BECK AS DISCHARGES FROM BLEA TARN
------                                ------
MEAN          T10             6.303  6.583  .0233  .1157  .0035  46.11  30.18  2.476  .5946                45.33  .0117         3.333  2.637
S.D.                          .4621  3.058  .018   .0963  .0044  27.28  21.99  .589   .1236                7.778  .0107         2.403  .7745
MAX                           6.9    13     .05    .25    <.02   90     80     3.4    .8                   56     <.05          6      4.1
MIN                           5.2    2      <.01   <.04   .001   <10    <10    1.6    .4                   29     <.01          <2     1.5
 5%ILE NORM                   5.543  1.552     -VE    -VE    -VE 1.225     -VE 1.508  .3913                32.53     -VE           -VE 1.363
95%ILE NORM                   7.063  11.61  .0529  .274   .0107  90.99  66.35  3.445  .7979                58.12  .0293         7.287  3.911
 5%ILE LOG                    5.573  2.885  .006   .027   .0004  16.11  8.34   1.638  .4151                33.76  .0024         .9326  1.576
95%ILE LOG                    7.091  12.35  .0568  .2933  .0107  97.73  71.36  3.544  .8165                59.12  .0311         7.838  4.061
NO.OF OCCURS.                    13     12      7      7      7     12      9     13     13                    9      6             3      8

SPT :- 0173808335                     NGR :- NY 28500 06000   GREAT LANGDALE BECK NEAR MIDDLEFELL PLACE - 20M U/S OF BRIDGE
------                                ------
MEAN          T11             5.837  4.587  .0133  .3011  .003   52.43  44.62  1.883  .5661                38.07  .01           3.833  1.257
S.D.                          .3954  2.734  .0133  .1454  .0039  47.52  39.59  .6474  .1238                7.69   .0094         1.649  .4036
MAX                           6.4    12     <.05   .6     <.02   160    110    3.1    .8                   50     <.05          5      1.7
MIN                           5.1    1      <.01   .1     <.002  <10    <10    .7     .3                   22     <.01          <4     .6
 5%ILE NORM                   5.187  .0901     -VE .062      -VE    -VE    -VE .8184  .3625                25.42     -VE        1.119  .5933
95%ILE NORM                   6.487  9.085  .0353  .5403  .0094  130.6  109.7  2.948  .7697                50.72  .0255         6.547  1.921
 5%ILE LOG                    5.21   1.591  .0024  .1277  .0004  10.87  9.532  1.027  .3876                26.85  .002          1.787  .7151
95%ILE LOG                    6.509  9.759  .0371  .5758  .0095  138.8  116.9  3.086  .7891                51.85  .027          6.937  2.003
NO.OF OCCURS.                    19     19      9      9      9     16      9     18     18                   14      8             2      7

SPT :- 0173808368                     NGR :- NY 42000 05700   TROUT BECK AT TROUTBECK PARK - 20M U/S OF BRIDGE
------                                ------
MEAN          T12             6.733  12.77  .0148  .2157  .0017  33.33  9.583  6.025  .9125                58.5   .0072         5.111  4.371
S.D.                          .5315  6.457  .0141  .0934  .0006  25.9   3.938  2.448  .2937                16.6   .0014         3.271  1.767
MAX                           7.5    23     .04    .4     <.004  85     15     10     1.4                  80     .01           7      7
MIN                           6.1    5      <.01   .15    .001   <10    <10    3      .5                   40     <.01          <2     1.9
 5%ILE NORM                   5.859  2.156     -VE .062   .0007     -VE 3.105  1.997  .4294                31.18  .005             -VE 1.464
95%ILE NORM                   7.607  23.39  .038   .3694  .0026  75.95  16.06  10.05  1.395                85.81  .0095         10.49  7.278
 5%ILE LOG                    5.896  5.204  .0028  .1001  .0009  8.494  4.628  2.933  .5183                35.6   .0052         1.641  2.137
95%ILE LOG                    7.641  24.98  .0402  .3915  .0027  81.53  16.97  10.61  1.455                88.95  .0096         11.28  7.685
NO.OF OCCURS.                     9      9      7      7      7      7      4      8      8                    4      6             3      7

SPT :- 0174808719F                    NGR :- NY 25900 02100   DOE HOUSE GILL PTC RIVER DUDDON - U/S OF ROAD BRIDGE
------                                ------
MEAN          T13             4.852  3.148  .0214  .436   .0015  344.7  341.3  1.037  .5276                43.61  .0061         2.666  1.433
S.D.                          .2118  1.934  .0391  .4522  .0005  170    174    .2464  .1306                11.6   .0014         1.333  .5679
MAX                           5.3    8      .11    1.4    <.004  600    600    1.6    .8                   66     <.01          4      2.8
MIN                           4.4    <1     <.01   <.003  <.002  100    130    .6     .33                  24     <.005         <2     .9
 5%ILE NORM                   4.504     -VE    -VE    -VE .0007  65.02  55.03  .632   .3129                24.52  .0039         .4735  .4992
95%ILE NORM                   5.201  6.329  .0857  1.179  .0024  624.3  627.6  1.442  .7424                62.71  .0083         4.859  2.367
 5%ILE LOG                    4.512  1.057  .0014  .0742  .0009  143.4  137.9  .6864  .343                 27.4   .0042         1.096  .7111
95%ILE LOG                    5.208  6.804  .0754  1.234  .0025  666    670.6  1.483  .7648                64.81  .0086         5.187  2.497
NO.OF OCCURS.                    19     18      7      7      7     17     11     18     17                   13      6             3      9

SPT :- 0174808719J                    NGR :- NY 25800 02100   GAITSCALE GILL 10M PTC RIVER DUDDON
------                                ------
MEAN          T14             4.93   3.925  .0226  .4643  .0016  374.6  339    .9471  .505                 42.58  .0061         2.666  1.622
S.D.                          .566   2.638  .0331  .4409  .0005  174.1  169.4  .2809  .1349                12.25  .0014         1.333  .4026
MAX                           7      10     .095   1.42   <.004  600    600    1.7    .8                   66     <.01          4      2.3
MIN                           4.2    <1     <.01   .08    <.002  155    130    .6     .32                  25     <.005         <2     1
 5%ILE NORM                   3.999     -VE    -VE    -VE .0008  88.19  60.28  .485   .2832                22.41  .0039         .4735  .9603
95%ILE NORM                   5.861  8.265  .077   1.189  .0025  661.1  617.8  1.409  .7268                62.74  .0083         4.859  2.284
 5%ILE LOG                    4.058  1.193  .0022  .09    .0009  164.1  139.4  .5632  .3168                25.72  .0042         1.096  1.053
95%ILE LOG                    5.912  8.894  .0742  1.258  .0026  703.2  659.5  1.463  .7513                65.09  .0086         5.187  2.353
NO.OF OCCURS.                    18     18      7      7      7     15     11     17     16                   12      6             3      9
```

```
                                  WATER QUALITY SAMPLE SUMMARIES
                            FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                           37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
                        FLOW  PH    ALKAL AMMON NO3-N NO2-N ALU    AL   CAL   MAGNES BOD 5 COD  COND  ORTHO CHLOR SULPHTOTAL
                        INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                                    M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L  MG/LSUBS
                        M3/S        MG/L         N     N    UG/L  UNAC  MG/L  MG/L   O     O    US/CM P     CL    SO4  MG/L
                                    CACO3                         UG/L  CA    MG

SPT :- 0174808719N        NGR :- NY 25700 02000     TROUGHTON GILL PTC RIVER DUDDON - IMMED U/S OF ROAD BRIDGE
------                    ------
 EAN                          5.189 3.777 .018  .4225 .0016 304.7 303.3 1.269 .65               42.46 .0056       3     1.49
 .D.        T15               .5195 2.454 .0211 .4393 .0005 256.4 251.2 .396  .1292             11.68 .0018       1.855 .4383
 AX                           6.4   10    .065  1.4   <.004 720   600   2     .9                63    <.01        5     2.3
MIN                           4.4   <1    <.004 <.03  <.002 <10   <10   .8    .38               23    <.004       <2    1
 5%ILE NORM                   4.334   -VE   -VE   -VE .0008   -VE   -VE .6181 .4374             23.24 .0027         -VE .769
95%ILE NORM                   6.044 7.815 .0527 1.145 .0024 726.6 716.5 1.92  .8626             61.67 .0086       6.052 2.211
 5%ILE LOG                    4.381 1.193 .0026 .0716 .0009 69.99 71.16 .7341 .4612             26.25 .0032       1     .89
95%ILE LOG                    6.085 8.408 .054  1.197 .0025 776.9 766.9 2     .8813             63.84 .0089       6.507 2.296
NO.OF OCCURS.                    19    18     8     8     8    15    11    18    17                13     7           3    10

SPT :- 0174808719W        NGR :- NY 24650 01750     MOASDALE BECK 10M PTC RIVER DUDDON
------                    ------
MEAN                          5.034 3.151 .0116 .2847 .0015 290   231.2 1.138 .5195             39.69 .0056       6.555 1.66
S.D.        T16               .359  2.433 .0156 .3513 .0005 153.8 174.3 .5343 .1004             9.55  .0018       4.857 .5502
MAX                           5.8   9     .05   1.13  <.004 530   530   3.2   .7                58    <.01        12    3
MIN                           4.5   <1    <.004 .008  <.002 30    20    .5    .35               27    <.004       <4    1
 5%ILE NORM                   4.443   -VE   -VE   -VE .0007 36.88   -VE .2592 .3543             23.98 .0027         -VE .7551
95%ILE NORM                   5.624 7.154 .0372 .8626 .0023 543.1 518   2.017 .6847             55.4  .0086       14.54 2.564
 5%ILE LOG                    4.466 .8098 .0013 .0369 .0009 112.9 61.24 .4944 .3722             26.12 .0032       1.774 .9265
95%ILE LOG                    5.645 7.682 .0368 .8723 .0024 581.2 556.6 2.146 .699              57.01 .0089       15.63 2.679
NO.OF OCCURS.                    25    22     8     8     8    19    12    21    20                17     7           3    10

SPT :- 0174808722B        NGR :- NY 24600 01400     COCKLEY BECK GILL 10M D/S OF ROAD BRIDGE
------                    ------
MEAN                          5.947 7.263 .0186 .3857 .0015 164   80.45 2.784 .8733             50.26 .0072       3     1.444
S.D.        T17               .6878 5.546 .0315 .4622 .0005 136.9 64.43 2.09  .3269             14.64 .0014       1.855 .5028
MAX                           7.5   20    .09   1.39  <.004 430   200   9.5   1.6               70    .01         5     2.3
MIN                           4.95  1     <.01  .06   <.002 15    10    .9    .4                24    <.01        <2    .9
 5%ILE NORM                   4.816   -VE   -VE   -VE .0007   -VE   -VE   -VE .3357             26.17 .005          -VE .6174
95%ILE NORM                   7.078 16.38 .0704 1.146 .0024 389.3 186.4 6.222 1.411             74.35 .0095       6.052 2.271
 5%ILE LOG                    4.887 1.893 .0014 .0523 .0009 38.07 19.72 .7412 .4509             30.17 .0052       1     .7821
95%ILE LOG                    7.141 17.6  .064  1.166 .0025 416.5 199.9 6.687 1.483             77.17 .0096       6.507 2.379
NO.OF OCCURS.                    20    19     7     7     7    16    11    19    18                15     6           3     9

SPT :- 0174808722E        NGR :- NY 24100 01200     HARDKNOTT GILL 10M U/S OF RIVER DUDDON
------                    ------
MEAN                          5.977 7.561 .0226 .4125 .0015 39    20    3.526 .7722             52.4  .0056       3.333 1.65
S.D.        T18               .4618 3.794 .0454 .4076 .0005 34.16 13.92 1.068 .1595             10.53 .0018       2.403 .8223
MAX                           6.7   17    .135  1.34  <.004 150   50    6.9   1                 72    <.01        6     3.6
MIN                           5.15  <1    <.004 .1    <.002 <10   <10   1.7   .4                29    <.004       <2    .5
 5%ILE NORM                   5.217 1.32    -VE   -VE .0007   -VE   -VE 1.769 .5099             35.07 .0027         -VE .2975
95%ILE NORM                   6.737 13.8  .0974 1.083 .0023 95.19 42.9  5.283 1.034             69.72 .0086       7.287 3.002
 5%ILE LOG                    5.249 3.099 .0012 .0755 .0009 8.479 5.834 2.073 .5403             37.02 .0032       .9326 .6806
95%ILE LOG                    6.766 14.73 .0816 1.14  .0024 101.5 46.16 5.494 1.058             71.27 .0089       7.838 3.204
NO.OF OCCURS.                    20    19     8     8     8    17    12    19    18                15     7           3    10

SPT :- 0174808722H        NGR :- NY 24100 00700     DALE HEAD GILL 5M D/S OF ROAD BRIDGE
------                    ------
MEAN                          4.906 4.187 .0222 .4883 .0016 445   395.9 1.25  .6093             48.63 .0093       5     2.112
S.D.        T19               .5615 3.442 .0381 .5413 .0005 244.2 241.6 1.132 .2449             13.18 .006          0.0 1.177
MAX                           6.8   14    .1    1.55  <.004 730   720   4.7   1.31              69    .02         5     4.9
MIN                           4.3   <1    <.01  .03   <.002 20    15    .6    .35               27    <.01        5     1.2
 5%ILE NORM                   3.982   -VE   -VE   -VE .0007 43.28   -VE   -VE .2064             26.94   -VE       5     .1753
95%ILE NORM                   5.829 9.85  .0849 1.378 .0025 846.7 793.3 3.112 1.012             70.32 .0191       5     4.049
 5%ILE LOG                    4.04  .992  .0016 .075  .0008 167.7 133.9 .2597 .2991             30.29 .003        5     .7841
95%ILE LOG                    5.88  10.54 .0768 1.426 .0026 907.2 852.7 3.31  1.068             72.74 .0206       5     4.341
NO.OF OCCURS.                    16    16     6     6     6    14    11    15    14                11     5           1     8

SPT :- 0174808722L        NGR :- NY 23900 00200     CASTLEHOW BECK 10M U/S OF RIVER DUDDON
------                    ------
MEAN                          5.161 4.277 .0129 .4371 .0015 328   296.8 2.064 .7694             55.46 .0061       5.5   2.288
S.D.        T20               .5564 3.455 .0164 .4011 .0005 202.4 192.6 .6937 .1605             14.39 .0014       2.121 .4676
MAX                           6.5   11    .05   1.32  <.004 650   590   4.1   1.1               80    <.01        7     3.2
MIN                           4.5   <1    <.01  .09   <.002 60    15    1     .47               33    <.005       4     1.8
 5%ILE NORM                   4.245   -VE   -VE   -VE .0007   -VE   -VE .9237 .5053             31.78 .0039       2.01  1.519
95%ILE NORM                   6.076 9.961 .0398 1.096 .0024 661   613.7 3.205 1.033             79.13 .0083       8.989 3.058
 5%ILE LOG                    4.299 1.037 .0016 .0891 .0009 109.6 93.87 1.142 .5363             35.27 .0042       2.781 1.608
95%ILE LOG                    6.123 10.67 .0399 1.164 .0025 710.6 660.2 3.351 1.057             81.69 .0086       9.468 3.127
NO.OF OCCURS.                    18    18     7     7     7    16    11    17    16                13     6           2     9

SPT :- 0174808722P        NGR :- SD 23650 99750     BLACK BECK 10M U/S OF RIVER DUDDON
------                    ------
MEAN                          4.743 3.15  .0152 .4871 .0015 613.5 565.4 1.415 .6822             55.87 .0061       8.555 2.555
S.D.        T21               .2761 2.808 .0139 .4257 .0005 219.9 228.5 .3877 .1285             12.43 .0014       6.801 .4953
MAX                           5.6   10    .04   1.42  <.004 890   870   2.3   1                 80    <.01        16    3.5
MIN                           4.3   <1    <.01  .14   <.002 250   160   .9    .47               39    <.005       <4    1.8
 5%ILE NORM                   4.289   -VE   -VE   -VE .0007 251.7 189.4 .7781 .4709             35.42 .0039         -VE 1.76
95%ILE NORM                   5.197 7.77  .038  1.187 .0024 975.3 941.4 2.053 .8936             76.32 .0083       19.74 3.37
 5%ILE LOG                    4.303 .6682 .0031 .1063 .0009 325.9 276.4 .8774 .4931             37.99 .0042       2.118 1.829
95%ILE LOG                    5.21  8.273 .0404 1.266 .0025  1023 994.1 2.125 .9115             78.29 .0086       21.17 3.44
NO.OF OCCURS.                    23    20     7     7     7    17    11    19    18                16     6           3     9
```

Appendix 9

```
                                             WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

               37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
            FLOW    PH  ALKAL  AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD  COND  ORTHO CHLOR  SULPHTOTAL
            INST        INITY  IA N              MIN   MONO  CIUM  IUM   ATU        AT    PHOSP  IDE    ATE HUMIC
                        M.O.   MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L 25C    MG/L  MG/L   MG/LSUBS
            M3/S         MG/L         N     N    UG/L  UNAC  MG/L  MG/L   O     O   US/CM P      CL     SO4  MG/L
                         CACO3                         UG/L  CA    MG

SPT :- 0174808722T       NGR :- SD 23400 98600    THE SYKE 20M D/S OF ROAD BRIDGE
------                   ------
MEAN               5.416 4.425 .0255 .46   .0016 241.4 229   1.905 .7687             52.53 .0061       5     1.633
 .D.      T22      .5205 3.652 .0442 .5191 .0005 173   177.6 .626  .1267             11.43 .0014       1.414 .6285
 AX                6.4   15    .125  1.61  <.004 540   540   4     1                 75    <.01        6     3.2
 IN                4.7   <1    <.01  .06   <.002 20    20    1.2   .52               32    <.005       4     1.1
 5%ILE NORM        4.56    -VE   -VE   -VE .0008   -VE   -VE .8762 .5603             33.72 .0039       2.673 .5995
95%ILE NORM        6.272 10.43 .0981 1.313 .0025 526   521.2 2.935 .9772             71.34 .0083       7.326 2.667
 5%ILE LOG         4.605 1.043 .0018 .0687 .0009 68.05 58.57 1.069 .5794             36.03 .0042       3.048 .8273
 5%ILE LOG         6.312 11.17 .0884 1.354 .0026 565.9 559.6 3.065 .993              73.13 .0086       7.593 2.808
 0.OF OCCURS.        18    18     7     7     7    15    11    17    16                13     6           2     9

SPT :- 0174808722Y       NGR :- SD 22800 97500    GRASSGAURDS GILL PTC RIVER DUDDON
-----                    ------
 EAN               6.083 6     .0333 .156  .002  200.9 160.8 2.758 1.188             68.11 .0153       4.833 5.042
 .D.      T23      .8244 4.69  .0487 .1115 .0005 151.3 154.3 1.108 .3369             11.46 .0141       3.064 2.307
MAX                7.3   13    .12   .3    <.004 490   400   4.9   1.9               83    .04         7     8.1
MIN                4.8   2     <.01  .05   <.002 20    10    1.1   .79               50    <.01        <4    2.3
 5%ILE NORM        4.727   -VE   -VE   -VE .0012   -VE   -VE .9355 .6342             49.25   -VE         -VE 1.246
 5%ILE NORM        7.439 13.71 .1134 .3394 .0028 449.9 414.7 4.581 1.742             86.96 .0385       9.873 8.839
 5%ILE LOG         4.828 1.517 .0032 .0441 .0013 53.29 30.71 1.354 .7237             51.02 .0031       1.569 2.238
95%ILE LOG         7.526 14.72 .1092 .3651 .0029 483.5 438.3 4.836 1.806             88.41 .0409       10.61 9.395
NO.OF OCCURS.        12    11     5     5     5    12     6    12    12                 9     5           2     7

 PT :- 0174808725        NGR :- SD 25050 98600    TARN BECK OVERFLOW FROM SEATHWAITE TARN
 -----                   ------
MEAN               5.163 3.933 .0362 .3771 .002  175.9 152.5 1.154 .64               50.15 .0088 5     4     .8267
S.D.      T24      .4821 1.831 .0322 .1312 .0007 59.86 61.75 .2252 .0949             30.77 .006  3.605  0.0  .3515
MAX                6.1   7     .09   .55   <.004 270   215   1.6   .8                150   .02   9     4     1.2
 IN                4.3   1     .01   .2    <.002 50    70    .9    .45               32    <.004 2     4     <.5
 5%ILE NORM        4.37  .9216   -VE .1613 .0008 77.43 50.91 .7841 .484                -VE   -VE   -VE 4     .2485
 5%ILE NORM        5.956 6.945 .0891 .593  .0031 274.3 254   1.525 .796              100.7 .0186 10.93 4     1.404
 5%ILE LOG         4.41  1.721 .0077 .2043 .0011 96.6  74.45 .8246 .4968             16.87 .0026 1.398 4     .3891
95%ILE LOG         5.992 7.388 .0949 .6212 .0032 287   268.3 1.557 .8068             108.3 .02   11.75 4     1.487
 0.OF OCCURS.        19    15     7     7     7    11     8    11    11                13     6     3     1     5

 PT :- 0174808728E       NGR :- SD 23600 97500    TARN BECK AT TONGUE HOUSE U/S OF FARM EFFLUENT INFLUENCE
------                   ------
MEAN               5.275 4.719 .0187 .4262 .0016 173.7 156.6 1.513 .6776             42.81 .0114       3     1.311
 .D.      T25      .3697 3.96  .0251 .2883 .0005 78.32 69.19 .8289 .1424             8.328 .0086       1.855 .6133
 AX                6.3   15    .08   1.08  <.004 290   290   4.5   1.02              61    .03         5     2.2
 IN                4.7   <1    <.01  .15   <.002 <10   90    .8    .5                30    <.01        <2    .5
 5%ILE NORM        4.666   -VE   -VE   -VE .0008 44.87 42.84 .1505 .4434             29.11   -VE         -VE .3023
95%ILE NORM        5.883 11.23 .0601 .9005 .0024 302.5 270.4 2.877 .9119             56.51 .0255       6.052 2.319
 5%ILE LOG         4.689 1.087 .0021 .1287 .0009 78.03 71.56 .572  .4711             30.6  .003        1     .5714
 5%ILE LOG         5.904 12.01 .0594 .969  .0025 321.3 286.9 3.082 .9335             57.7  .0274       6.507 2.468
 0.OF OCCURS.        20    19     8     8     8    18    12    18    17                16     7           3     9

SPT :- 0174808728V       NGR :- SD 22600 96100    TARN BECK PTC GOBLING BECK
------                   ------
 EAN               6.39  5.21  .0312 .415  .0023 211.8 69.54 2.252 .7747             57.47 .0105       3     1.837
 .D.      T26      .5195 2.439 .0563 .3492 .0012 363.4 43.95 .5966 .1297             38.32 .0091       1.855 1.189
 AX                8.2   12    .17   1.26  .005   1600 150   3.4   1.1               200   .03         5     3.5
MIN                5.9   2     <.01  .15   <.002 30    10    1.5   .55               35    <.005       <2    .6
 5%ILE NORM        5.535 1.197   -VE   -VE .0003   -VE   -VE 1.271 .5614               -VE   -VE         -VE   -VE
 5%ILE NORM        7.245 9.224 .1239 .9893 .0044 809.6 141.8 3.234 .9881             120.5 .0255       6.052 3.793
 5%ILE LOG         5.573 2.268 .0021 .0953 .0009 15.54 22.65 1.418 .5813             17.62 .0023       1     .5831
 5%ILE LOG         7.279 9.815 .1096 1.057 .0047 732.6 152.5 3.341 1.004             129.6 .0272       6.507 4.081
NO.OF OCCURS.        21    19     8     8     8    17    11    19    19                17     7           3     8

 PT :- 0174808728X       NGR :- SD 22600 96000    GOBLING BECK PTC TARN BECK
 -----                   ------
 EAN               6.79  13.05 .0271 .3243 .0017 34.19 17.87 5.505 1.519             68.56 .0164       5.555 1.75
S.D.      T27      .3837 8.083 .0498 .3785 .0005 27.05 9.489 2.504 .5965             15.82 .015        2.694 .7635
MAX                7.5   35    .14   1.16  <.004 108   40    13    2.6               106   .045        8     2.8
 IN                6.2   4     <.01  .1    <.002 <10   <10   2.7   .89               44    <.01        <4    1
 5%ILE NORM        6.158   -VE   -VE   -VE .0009   -VE 2.269 1.385 .5383             42.53   -VE       1.123 .4942
 5%ILE NORM        7.421 26.35 .109  .9469 .0026 78.7  33.48 9.625 2.5               94.59 .0411       9.987 3.005
 5%ILE LOG         6.177 4.348 .0018 .0459 .001  8.518 6.959 2.455 .7588             45.92 .0034       2.347 .8073
95%ILE LOG         7.439 28.33 .0957 .9696 .0027 84.42 35.83 10.22 2.636             97.17 .0436       10.64 3.187
 0.OF OCCURS.        20    18     7     7     7    17    11    18    17                16     6           3     8

 PT :- 0174808735E       NGR :- SD 21950 95900    OLD PARK BECK 5M D/S OF ROAD BRIDGE
------                   ------
MEAN               6.815 14.16 .025  .3875 .0022 27.68 13.93 6.438 1.533             79.31 .0119       14.66 1.737
 .D.      T28      .3436 6.827 .0361 .3513 .0012 20.77 6.113 2.602 .4543             16.32 .0127       11.59 .7891
 AX                7.4   27    .11   1.24  .005  93    20    14    2.2               108   .04         28    3
 IN                6.2   6     <.01  .15   <.002 10    <10   3.3   .9                50    <.005       7     1
 5%ILE NORM        6.25  2.935   -VE   -VE .0002   -VE 3.883 2.158 .786              52.46   -VE         -VE .4395
95%ILE NORM        7.381 25.39 .0844 .9654 .0042 61.85 23.99 10.71 2.28              106.1 .0329       33.73 3.035
 5%ILE LOG         6.265 6.017 .0025 .0803 .0008 7.378 6.403 3.148 .9123             55.57 .0019       3.659 .776
 5%ILE LOG         7.395 27.06 .0816 1.026 .0045 66.47 25.44 11.31 2.369             108.5 .0342       36.18 3.225
 0.OF OCCURS.        19    18     8     8     8    16    11    18    18                16     7           3     8
```

```
                                                  WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                      37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
                    FLOW    PH ALKAL AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
                    INST       INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                               M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L   MG/LSUBS
                    M3/S       MG/L         N     N    UG/L  UNAC  MG/L  MG/L   O     O    US/CM P      CL     SO4  MG/L
                               CACO3                         UG/L  CA    MG

SPT :- 0174808735K            NGR :- SD 21300 95500    SLING BECK 10M PTC RIVER DUDDON
------                        ------
 EAN                     6.368 5.666 .0437 .3037 .0023 32.91 18.63 2.627 1.059             55.93 .011        5.666 3.637
 .D.          T29        .3931 3.087 .0995 .3183 .0012 19.74 10.61 .9827 .2754             13.3  .009        2.081 1.961
MAX                      7     12    .29   .95   .005  75    40    5.3   1.7               74    .03         8     6.3
MIN                      5.7   2     <.01  <.05  <.002 <10   <10   1.4   .65               32    <.005       4     1.5
 5%ILE NORM              5.721 .5889   -VE   -VE .0003 .4402 1.175 1.011 .6064             34.05   -VE       2.242 .4118
 5%ILE NORM              7.015 10.74 .2074 .8273 .0044 65.39 36.09 4.244 1.512             77.82 .0257       9.09  6.863
 5%ILE LOG               5.743 2.151 .0019 .0509 .0009 11.34 6.771 1.357 .6733             36.99 .0026       2.962 1.395
 5%ILE LOG               7.034 11.5  .162  .8641 .0047 70.25 38.72 4.462 1.561             80.04 .0275       9.55  7.349
NO.OF OCCURS.               19    18     8     8     8    16    11    18    18                16     7           3     8

 PT :- 0174808745             NGR :- SD 20400 93700    HOLLOW MOSS BECK 25M U/S OF RIVER DUDDON
 -----                        ------
 EAN                     7.075 19.13 .0221 .3337 .0019 31.53 11.66 8.58  1.792             94.08 .0457       10.66 3.212
S.D.          T30        .4058 9.753 .0358 .2712 .0007 40.81 5.634 3.165 .6056             21.78 .0905       2.516 1.672
MAX                      7.7   39    .11   .95   .003  160   20    14    3                 131   .25         13    6.3
 IN                      6.2   2     <.01  .15   <.002 <10   <10   4.2   .92               52    <.01        8     1.5
 5%ILE NORM              6.407 3.09    -VE   -VE .0007   -VE 2.398 3.373 .7965             58.24   -VE       6.527 .4623
 5%ILE NORM              7.742 35.17 .081  .7798 .0031 98.67 20.93 13.78 2.788             129.9 .1946       14.8  5.962
 5%ILE LOG               6.428 7.732 .0018 .0803 .001  3.772 4.946 4.473 .989              62.93 .0026       7.079 1.273
95%ILE LOG               7.761 37.58 .075  .8356 .0033 98.57 22.31 14.48 2.916             133.4 .1643       15.22 6.376
O.OF OCCURS.                16    15     8     8     8    13     8    15    15                12     7           3     8

PT :- 0174808750              NGR :- SD 20100 93700    CROSBY GILL PTC RIVER DUDDON
------                        ------
MEAN                     7.044 13.73 .0317 .2765 .0024 68.41 24.16 6.572 1.411 1.366 8.185 79.1  .0137 9.666 4.833 6.4
S.D.          T31        .4815 6.844 .0838 .2047 .0008 125.5 17.64 2.625 .5758 .6384 6.878 18.5  .0187 1.87  3.064 2.799
AX                       8.3   31    .355  .82   .004  520   50    12    2.5   2.2   23    114   .08   12    7     10.6
IN                       6.3   1     <.005 .1    <.002 <10   <10   3.2   .7    .7    <4    43    <.005 7     <4    2.3
 5%ILE NORM              6.252 2.472   -VE   -VE .0012   -VE   -VE 2.253 .464  .3166   -VE 48.66   -VE 6.589   -VE 1.795
95%ILE NORM              7.836 24.98 .1695 .6132 .0037 274.9 53.18 10.89 2.358 2.416 19.49 109.5 .0444 12.74 9.873 11
 5%ILE LOG               6.281 5.662 .001  .0749 .0014 4.442 6.66  3.241 .6851 .5963 1.883 52.68 .0015 6.923 1.569 2.946
 5%ILE LOG               7.863 26.67 .12   .6593 .0038 241.2 57.19 11.49 2.491 2.571 20.85 112.6 .0438 13.01 10.61 11.66
O.OF OCCURS.                27    26    17    17    17    16    10    18    17     9     9    19    16     9     2     9

SPT :- 0174808763             NGR :- SD 19050 92550    HOLEHOUSE GILL 10M D/S OF BOBBIN MILL BRIDGE
------                        ------
MEAN                     6.98  17.68 .0387 .3237 .002  24.9  18.05 7.068 1.735 1     8     89.26 .014        5     8.277
S.D.          T32        .4753 10.24 .0814 .298  .0006 22.45 14.1  2.719 .7101   0.0   0.0 25.04 .0096       2.828 4.197
MAX                      7.8   35    .24   1     <.004 80    40    12    3.1   1     8     121   .03         7     15
MIN                      6.4   3     <.01  .1    <.002 <10   <10   3.2   .8    1     8     44    <.01        3     3.4
 5%ILE NORM              6.198 .8285   -VE   -VE .0011   -VE   -VE 2.594 .567  1     8     48.07   -VE       .3475 1.373
95%ILE NORM              7.761 34.53 .1727 .8139 .003  61.83 41.25 11.54 2.903 1     8     130.4 .0299       9.652 15.18
 5%ILE LOG               6.226 6.314 .002  .0657 .0012 5.203 4.572 3.58  .8405 1     8     54.65 .0042       1.829 3.361
95%ILE LOG               7.788 37.07 .1412 .8641 .0031 65.78 44.28 12.15 3.067 1     8     135.1 .0321       10.35 16.21
NO.OF OCCURS.               20    19     8     8     8    18    12    19    18     1     1    15     7           2     9

PT :- 0174808765              NGR :- SD 19400 92100    BLEA BECK 150M U/S OF RIVER DUDDON
------                        ------
EAN                      6.785 22.16 .0363 .789  .0081 56.54 33.33 8.644 2.442 1.1   9     163.8 .0298 103   8.5   9.983
S.D.          T33        .4356 27.97 .0473 .7154 .0116 43.7  29.62 9.057 4.536 .7211 5.567 255.6 .0358 135.9 4.949 4.097
MAX                      7.6   105   .14   2.16  .037  160   100   44    20    1.7   15     1050 .12   260   12    17
MIN                      6.1   4     <.01  .2    <.002 1.5   <10   2.3   .8    .3    4     33    <.01  24    5     5.5
 5%ILE NORM              6.068   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE   -VE .3582 3.244
95%ILE NORM              7.501 68.17 .1141 1.965 .0272 128.4 82.06 23.54 9.904 2.286 18.15 584.3 .0887 326.6 16.64 16.72
 5%ILE LOG               6.093 2.764 .0043 .1635 .0008 14.51 7.101 1.448 .1552 .3441 3     14.23 .004  11.91 3.019 4.826
95%ILE LOG               7.524 68.56 .1138 2.09  .0264 137.9 87.4  24.58 8.639 2.459 19.52 549.5 .0902 324.5 17.86 17.67
NO.OF OCCURS.               20    18    10    10    10    15     9    18    17     3     3    15     9     3     2     6

SPT :- 0174808768             NGR :- SD 18400 90300    LOGAN BECK D/S OF LOGAN BECK BRIDGE
------                        ------
MEAN                     6.683 9     .0356 .2275 .0019 43.82 30    3.383 1.292 1     8     77.13 .0171       3.833 6.466
S.D.          T34        .609  5.442 .0767 .277  .0007 29.29 19.93 1.236 .4293   0.0   0.0 64.15 .0196       1.649 3.439
MAX                      8     20    .225  .89   <.004 90    60    6.2   2.1   1     8     300   .06         5     12.3
MIN                      5.8   2     <.01  .08   <.002 <10   <10   1.7   .8    1     8     23    <.01        <4    2.7
 5%ILE NORM              5.681 .047    -VE   -VE .0008   -VE   -VE 1.349 .5861 1     8       -VE   -VE       1.119 .8097
95%ILE NORM              7.685 17.95 .1617 .6831 .003  92    62.79 5.417 1.998 1     8     182.6 .0493       6.547 12.12
 5%ILE LOG               5.731 3.074 .0017 .0301 .001  13.4  9.239 1.775 .7202 1     8     17.99 .0025       1.787 2.512
95%ILE LOG               7.729 19.29 .1305 .693  .0031 99    67.56 5.689 2.088 1     8     195.4 .0508       6.937 12.97
NO.OF OCCURS.               18    17     8     8     8    17    12    18    18     1     1    15     7           2     9

SPT :- 0174808880G            NGR :- NY 22030 05000    UNNAMED TRIB OF R ESK ON GREAT MOSS
------                        ------
MEAN                     5.407 4.615 .0211 .0875 .0015 116.8 80.95 1.723 .5885             41.66 .0053       5.222 2.628
S.D.          T35        .3861 3.014 .0187 .1218 .0003 109.1 90.52 .913  .1429             9.253 .0023       2.269 1.529
MAX                      6.1   10    .046  .27   .002  370   270   3.9   .8                58    <.01        7     4.3
MIN                      4.7   1     <.01  <.03  <.002 10    <10   .7    .35               25    <.004       <4      0.0
 5%ILE NORM              4.772   -VE   -VE   -VE .001    -VE   -VE .2213 .3533             26.44 .0015       1.49  .1129
95%ILE NORM              6.042 9.574 .0519 .2878 .002  296.3 229.8 3.224 .8236             56.88 .0091       8.954 5.144
 5%ILE LOG               4.796 1.449 .0045 .0093 .001  23.19 12.26 .6717 .3857             28.34 .0025       2.416 .9347
95%ILE LOG               6.065 10.3  .0553 .2816 .0021 314.1 237.4 3.45  .8478             58.35 .0097       9.492 5.522
NO.OF OCCURS.               13    13     4     4     4    12     7    13    13                11     3           3     7
```

```
                            WATER QUALITY SAMPLE SUMMARIES
                      FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                    37      61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
                FLOW      PH    ALKAL AMMON NO3-N NO2-N ALU     AL   CAL   MAGNES BOD 5 COD   COND  ORTHO CHLOR  SULPHTOTAL
                INST            INITY IA N              MIN   MONO  CIUM  IUM    ATU         AT    PHOSP IDE      ATE HUMIC
                                M.O.  MG/L  MG/L  MG/L  IUM   MERIC              MG/L  MG/L  25C   MG/L. MG/L    MG/LSUBS
                M3/S             MG/L     N     N   UG/L  UNAC  MG/L  MG/L     O     O   US/CM P     CL       SO4  MG/L
                                 CACO3                    UG/L  CA    MG

SPT :- 0174808880M          NGR :- NY 22600 04700    UNNAMED TRIB OF R ESK FROM LONG CRAG
----                        ------
  AN                    5.337 4.187 .0078 .0519 .0018 102.6 101.4 1.775 .7519             49.96 .0092       3.833 2.587
..D.      T36           .4303 2.737 .0056 .0341 .0006 70.88 76.73 1.231 .5275             22.2  .0047       1.649 1.556
MAX                     6.4   9     .02   .1    <.004 260   200   5.1   2.3               100   <.02        5     5.4
MIN                     4.7   1     <.004 <.03  <.002 20    <10   .8    .4                25    <.004       <4      0.0
  %ILE NORM             4.629   -VE   -VE   -VE .0008   -VE   -VE   -VE   -VE             13.44 .0015       1.119 .028
  %ILE NORM             6.045 8.691 .017  .108  .0029 219.2 227.6 3.799 1.619             86.48 .0168       6.547 5.147
. %ILE LOG              4.66  1.313 .0022 .0162 .001  30.25 26.76 .5203 .2174             22.71 .0037       1.787 .8891
95%ILE LOG              6.073 9.35  .0183 .1162 .003  235.9 244.6 4.088 1.742             91.78 .018        6.937 5.53
NO.OF OCCURS.              16    16     7     7     7    15     8    16    16                14     7           2     8

  T :- 0174808880R          NGR :- NY 22740 03650    LINGCOVE BECK
----                        ------
MEAN                    5.516 3.733 .0065 .2007 .0015 140.2 141.2 1.306 .54               36.57 .0057 2     3.333 1.25
S.D.      T37           .5818 2.463 .0026 .1169 .0006 129   129.8 .3634 .0774             8.179 .002    0.0 .9428 .4276
  X                     7     9     .01   .32   <.004 360   330   1.8   .65               55    <.01  2     4     2
  N                     4.9   1     <.004 <.05  .001  <10   <10   .6    .4                25    <.004 2     <4    .8
  %ILE NORM             4.559   -VE .0023 .0084 .0005   -VE   -VE .7088 .4127             23.12 .0024 2     1.782 .5466
95%ILE NORM             6.473 7.784 .0108 .393  .0026 352.4 354.8 1.904 .6673             50.03 .009  2     4.884 1.953
 5%ILE LOG              4.614 1.159 .0032 .0713 .0007 28.47 28.73 .8035 .4228             24.81 .003  2     2.032 .6843
95%ILE LOG              6.522 8.376 .0114 .4219 .0028 374.2 376.7 1.972 .6758             51.33 .0094 2     5.062 2.044
  .OF OCCURS.              15    15     5     5     5    13     9    15    15                13     4     1     2     8

SPT :- 0174808881           NGR :- NY 21520 02250    CATCOVE BECK
------                      ------
MEAN                    6.339 7     .0065 .0927 .0019 47.08 35    2.342 .8157             48.51 .0055 7     5.222 2.7
 .D.      T38           .5204 3.551 .0026 .0691 .0008 29.88 27.83 .6548 .1681             6.985 .0018   0.0 2.673 1.143
  IX                    7.4   12    .01   .2    <.004 105   70    3.5   1.1               62    <.01  7     8     4.5
MIN                     5.25  2     <.004 .03   <.002 <10   <10   1.3   .55               36    <.004 7     <4    1
 5%ILE NORM             5.483 1.157 .0023   -VE .0006   -VE   -VE 1.265 .5392             37.02 .0026 7     .8244 .8184
95%ILE NORM             7.195 12.84 .0108 .2063 .0033 96.23 80.78 3.42  1.092             60    .0084 7     9.62  4.581
 5%ILE LOG              5.521 2.84  .0032 .0249 .0009 15.26 8.661 1.437 .5712             37.94 .0032 7     2.102 1.274
 5%ILE LOG              7.229 13.71 .0114 .2217 .0035 103.5 86.64 3.542 1.117             60.78 .0088 7     10.27 4.85
 J.OF OCCURS.              14    14     5     5     5    12     8    14    14                12     5     1     3     8

SPT :- 0174808883           NGR :- NY 21200 01300    HARDNOTT GILL U/S RIVER ESK
------                      ------
 EAN                    6.183 5.666 .0137 .2578 .0015 128   56.77 3.065 .8726             56.32 .0086 7.5   7.7   1.752
 .D.      T39           .6452 3.917 .0128 .2745 .0004 148   59.65 .8217 .1523             11.33 .0068 6.364 3.574 .88
MAX                     8.6   18    .055  1.26  <.004 580   210   4.8   1.2               75    .03   12    13    4
MIN                     5     <1    <.004 <.05  .001  <10   <10   1.7   .65               39    <.004 3     <2    .8
 5%ILE NORM             5.121   -VE   -VE   -VE .0008   -VE   -VE 1.713 .622              37.67   -VE   -VE 1.82  .3046
 5%ILE NORM             7.244 12.11 .0348 .7094 .0022 371.5 154.8 4.416 1.123             74.96 .0199 17.96 13.57 3.199
 3%ILE LOG              5.182 1.667 .0027 .0422 .0009 18.39 9.475 1.919 .6464             39.78 .0021 1.703 3.377 .7177
95%ILE LOG              7.297 13.03 .0369 .739  .0023 381.2 161.7 4.566 1.143             76.63 .0213 19.2  14.44 3.416
NO.OF OCCURS.              44    43    17    17    17    34    15    40    38                34    16     2    10    23

 PT :- 0174808883G          NGR :- NY 20350 00700    DODKNOTT GILL PTC R ESK
------                      ------
 EAN                    5.581 4.603 .0101 .4745 .0015 223.4 71.66 3.471 .8843             62.52 .0061 6.666 7.222 1.084
S.D.      T40           .4543 3.161 .0073 .2464 .0005 259   110.8 1.281 .1528             8.347 .002  2.081 5.274 .5737
MAX                     6.2   12    .03   1.18  <.004 990   420   7.3   1.4               82    .01   9     13    2.4
 IN                     4.6   <1    <.004 .3    <.001 <10   <10   1.3   .7                47    <.004 5     <4    .3
 5%ILE NORM             4.834   -VE   -VE .0693 .0007   -VE   -VE 1.363 .633              48.79 .0027 3.242   -VE .1405
 5%ILE NORM             6.328 9.803 .0221 .8798 .0024 649.4 254   5.579 1.135             76.25 .0095 10.09 15.89 2.028
 5%ILE LOG              4.867 1.364 .0028 .1886 .0008 31.97 6.315 1.809 .6572             49.8  .0034 3.853 1.989 .4232
95%ILE LOG              6.358 10.54 .0238 .9407 .0025 666   239.6 5.862 1.155             77.12 .0099 10.51 17.09 2.17
 O.OF OCCURS.              65    63    11    11    11    57    20    60    58                57    10     3     3    19

 PT :- 0174808883M          NGR :- NY 20340 00650    SPOTHOW GILL PTC R ESK
------                      ------
MEAN                    5.525 3.153 .0163 .3282 .0015 270.8 201.4 1.897 .8312             52.43 .0076 5.666 6.555 3.554
 .D.      T41           .663  2.291 .0152 .277  .0005 423   181.9 .5221 .1806             8.981 .0048 3.785 3.686 .8466
 AX                     7     11    .045  1.11  <.004  2800 730   3.4   1.2               76    .02   10    10    4.7
 IN                     4     <1    <.004 .1    <.001 20    20    1     .5                33    <.004 3     <4.   2.3
 5%ILE NORM             4.434   -VE   -VE   -VE .0006   -VE   -VE 1.038 .5341             37.66   -VE   -VE .4911 2.162
95%ILE NORM             6.615 6.923 .0413 .7838 .0023 966.6 500.7 2.755 1.128             67.2  .0155 11.89 12.62 4.947
 5%ILE LOG              4.506 .8742 .0032 .075  .0008 23.46 41.99 1.172 .5705             39.07 .0025 1.734 2.412 2.349
 5%ILE LOG              6.678 7.446 .0438 .838  .0024 908.7 532.5 2.852 1.156             68.36 .0167 12.79 13.53 5.088
 O.OF OCCURS.              54    52    11    11    11    46    27    52    50                46    10     3     3    11

SPT :- 0174808883R          NGR :- NY 20280 00630    TRIB OF RIVER ESK (D/S OF SPOTHOW GILL)
-----                       ------
 EAN                    5.485 2.858 .021  .4287 .0021 251.4 268   2.189 .8532             56.39 .006  5.5   4.444 1.93
 .D.      T42           .5498 2.359 .0342 .4013 .002  214.3 232.3 .5951 .1339             9.369 .0013 4.949 2.873 .4373
MAX                     6.5   11    .105  1.39  .007  780   780   3.3   1.1               76    <.01  9     7     2.5
MIN                     4.6   <1    <.01  .09   <.001 <20   15    1.3   .6                40    <.005 2     <2    1.1
 5%ILE NORM             4.58    -VE   -VE   -VE   -VE   -VE   -VE 1.21  .6329             40.97 .0038   -VE   -VE 1.21
 5%ILE NORM             6.389 6.739 .0774 1.088 .0055 604.1 650.2 3.168 1.073             71.8  .0081 13.64 9.171 2.649
 5%ILE LOG              4.629 .6735 .0017 .0849 .0004 56.73 59.13 1.362 .6521             42.4  .0041 1.151 1.411 1.302
95%ILE LOG              6.433 7.214 .0716 1.154 .0058 645.4 693.9 3.278 1.089             72.97 .0083 14.51 9.867 2.719
NO.OF OCCURS.              40    40     8     8     8    36    19    39    38                35     7     2     3    10
```

Appendix 9

```
                                              WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

             37     61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
           FLOW     PH ALKAL AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
           INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                       M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L  MG/LSUBS
           M3/S         MG/L         N     N   UG/L  UNAC  MG/L  MG/L    O     O   US/CM P     CL     SO4  MG/L
                        CACO3                        UG/L  CA    MG

SPT :- 0174808885           NGR :- NY 19400 01000    BLEA BECK PTC RIVER ESK
------                      ------
 EAN               5.011 2.641 .0303 .193  .002  312.5 219.1 1.83  .8957             62.9  .0072 3     5.583 4.384
 .D.      T43      .6216 2.78  .0535 .3317 .0009 194.4 117.6 .4791 .1692             13.6  .0029 1.414 3.745 1.762
 AX                6.9   12    .18   1.12  .004  690   350   3.1   1.2               81    <.02  4     10    7.9
MIN                4.3   <1    <.01  <.03  <.002 25    25    .7    .42               30    <.005 2     <2    2.3
 5%ILE NORM        3.988   -VE   -VE   -VE .0004   -VE 25.53 1.042 .6173             40.52 .0025 .6738   -VE 1.484
 5%ILE NORM        6.033 7.215 .1183 .7387 .0035 632.3 412.7 2.618 1.174             85.27 .012  5.326 11.74 7.283
 5%ILE LOG         4.058 .4393 .0021 .0141 .0008 103.5 84.33 1.159 .6468             43.25 .0036 1.298 1.701 2.151
 5%ILE LOG         6.094 7.53  .1057 .6678 .0038 679.8 441.8 2.704 1.197             87.38 .0126 5.669 12.63 7.689
NO.OF OCCURS.        40    39    10    10    10    34    17    39    37                 34     9     2     4    25

 T :- 0174808885D           NGR :- NY 17300 00200    BIRKER BECK AT DALEGARTH HALL (BOILER BECK)
-----                       ------
 EAN               6.485 10.3  .0337 .3389 .0019 70.01 35.83 4.547 1.341             72.42 .0087       6.666 5
S.D.      T44      .4404 5.506 .0737 .2986 .0006 51.87 28.42 1.511 .4268             12.87 .0053       2.516 1.804
MAX                7.1   19    .23   .89   <.004 210   100   7.9   2.4               94    .02         9     8.5
 IN                5.5   2     <.01  .05   <.002 <10   <10   2     .7                44    <.005       4     3.2
 5%ILE NORM        5.76  1.241   -VE   -VE .0009   -VE   -VE 2.061 .6391             51.24 0.0         2.527 2.031
 5%ILE NORM        7.209 19.35 .155  .8301 .0029 155.3 82.59 7.033 2.043             93.6  .0175       10.8  7.968
 5%ILE LOG         5.787 3.981 .0016 .0731 .0011 18.95 8.894 2.533 .7667             53.35 .003        3.421 2.645
95%ILE LOG         7.233 20.72 .1239 .8847 .003  167   88.59 7.349 2.13              95.31 .0188       11.36 8.362
NO.OF OCCURS.        20    20     9     9     9    17    10    19    18                 14     8           3    11

 PT :- 0174808885G          NGR :- NY 17350 00400    EEL BECK 50M U/S RIVER ESK
------                      ------
MEAN               6.248 10    .0483 .695  .0058 226.7 39.29 6.937 1.455             95.95 .0191 15    9     5.876
 .D.      T45      .379  5.742 .0598 .4495 .0064 270.5 23.45 2.059 .2777             15.75 .0142  0.0  1     2.415
 AX                7.3   26    .16   1.89  .02   920   80    12    2.2               125   .045  15    10    9.8
 IN                5.5   1     <.01  .25   <.002 <10   <10   3     1.1               69    <.01  15    8     2.2
 5%ILE NORM        5.625 .5546   -VE   -VE   -VE   -VE .7185 3.55  .9983             70.02   -VE 15    7.355 1.902
95%ILE NORM        6.872 19.44 .1467 1.434 .0163 671.7 77.87 10.32 1.911             121.8 .0425 15    10.64 9.849
 5%ILE LOG         5.645 3.603 .0062 .2207 .0009 30.96 13.61 4.123 1.047             72.39 .0051 15    7.455 2.837
 5%ILE LOG         6.89  20.86 .1482 1.543 .0169 684.6 83.66 10.72 1.95              123.8 .0456 15    10.73 10.41
 O.OF OCCURS.        39    38    10    10    10    37    19    37    36                 34     9     1     3    25

SPT :- 0174808885H          NGR :- NY 16900 00400    WHILLAN BECK PTC ESK
------                      ------
 EAN               6.303 7.148 .0208 .2092 .0018 97.18 48.48 2.357 .9762             52.23 .0105 5     8.444 2.511
 .D.      T46      .6003 4.035 .0363 .2552 .0007 63.57 40.02 .8677 .3125             9.192 .0077  0.0  6.119 .9062
 AX                7.2   18    .135  1     <.004 250   160   4     1.7               71    .03   5     20    4.2
MIN                5     2     <.01  .1    <.002 15    15    1.1   .55               34    .005  5     <4    1.5
 5%ILE NORM        5.316 .5102   -VE   -VE .0007   -VE   -VE .9304 .4621             37.11   -VE 5       -VE 1.02
 5%ILE NORM        7.291 13.78 .0806 .6289 .003  201.7 114.3 3.785 1.49              67.35 .0231 5     18.51 4.001
 5%ILE LOG         5.367 2.62  .0015 .0276 .0009 30.46 11.42 1.231 .5562             38.6  .0029 5     2.348 1.328
 5%ILE LOG         7.336 14.78 .0724 .6377 .0031 217   122.3 3.976 1.554             68.56 .0248 5     19.9  4.199
NO.OF OCCURS.        28    27    12    12    12    22    11    26    24                 19    11     1     6     9

 PT :- 0174808885K          NGR :- NY 15700 00200    TRIB OF RIVER ESK 1 KM D/S BLEA TARN
------                      ------
 EAN                5.593 6.833 .0219 .3695 .0017 350.2 224.5 2.706 1.06             65.36 .0105       8.4   3.3
S.D.      T47      .6894 4.802 .0186 .701  .0006 232.3 248.8 .9714 .336              18.77 .0068       2.073 1.052
MAX                7.2   15    .06   1.95  .003  760   760   4.8   1.9               114   .02         11    4.9
 IN                4.9   1     <.01  <.01  <.002 <10   <10   1.4   .65               45    <.005       6     2.3
 5%ILE NORM        4.459   -VE   -VE   -VE .0006   -VE   -VE 1.108 .5073             34.48   -VE       4.989 1.568
 5%ILE NORM        6.727 14.73 .0525 1.522 .0027 732.4 633.9 4.304 1.612             96.24 .0216       11.81 5.031
 5%ILE LOG         4.536 1.971 .005  .0226 .0008 108   34.51 1.437 .6074             39.53 .0033       5.466 1.884
95%ILE LOG         6.794 15.85 .0561 1.314 .0029 788.1 655.8 4.516 1.681             99.82 .0233       12.16 5.246
 O.OF OCCURS.        16    16     7     7     7    13     8    15    14                 11     7           5     6

 PT :- 0174808886G          NGR :- SD 14350 99500    MEHE BECK D/S OF TRACK FROM STN
------                      ------
MEAN               6.6   16.26 .0281 1.302 .0073 109.6 53.78 10.37 2.048             141.5 .0389 21.5  18    10.68
 .D.      T48      .3232 4.931 .0311 .5739 .006  59.74 26.25 2.201 .6357             27.18 .0377 9.192 7     3.799
 AX                7.3   24    .09   2     .02   230   95    15    3.2               189   .11   28    26    19.1
 IN                6.1   9     <.01  .6    .003  10    <10   7.9   1.4               100   .01   15    13    5.9
 5%ILE NORM        6.068 8.152   -VE .3588   -VE 11.39 10.59 6.756 1.003             96.81   -VE 6.379 6.485 4.43
95%ILE NORM        7.131 24.37 .0793 2.246 .0171 207.9 96.98 13.99 3.094             186.2 .1009 36.62 29.51 16.93
 5%ILE LOG         6.082 9.555 .0043 .5964 .0017 41.63 22.59 7.188 1.188             101.6 .0073 10.07 9.049 5.702
 5%ILE LOG         7.144 25.34 .0821 2.383 .0184 222.7 103.4 14.33 3.221             190   .1065 38.78 31.1  17.75
 O.OF OCCURS.        19    19     7     7     7    15    11    17    16                 13     6     2     3    10

SPT :- 0174808886M          NGR :- SD 14650 98700    FISHER BECK U/S OF ROAD BRIDGE
------                      ------
 EAN               5.951 4.863 .0405 .2107 .0021 295.4 81.14 3.133 1.329             77.44 .0158 8.333 10.75 4.688
S.D.      T49      .5275 3.366 .0541 .2182 .0009 286.7 49.48 .794  .2816             17.12 .0132 2.081 3.105 1.463
MAX                7     15    .21   .92   .004  920   180   4.7   1.9               110   .05   10    17    8.8
MIN                4.9   1     <.01  .05   <.002 >10   <10   1.3   .6                40    <.01  6     7     2.2
 5%ILE NORM        5.083   -VE   -VE   -VE .0006   -VE   -VE 1.827 .8662             49.27   -VE 4.909 5.642 2.281
95%ILE NORM        6.818 10.4  .1295 .5696 .0035 767   162.5 4.439 1.792             105.6 .0374 11.75 15.85 7.096
 5%ILE LOG         5.125 1.429 .0046 .036  .001  55.49 27.46 2.015 .9214             52.78 .0037 5.394 6.482 2.71
95%ILE LOG         6.856 11.19 .1282 .596  .0038 809.6 174.6 4.578 1.835             108.3 .04   12.11 16.45 7.39
NO.OF OCCURS.        47    44    14    14    14    41    19    45    42                 38    13     3     8    27
```

WATER QUALITY SAMPLE SUMMARIES

FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

SPT :- 0174808887 NGR :- SD 14050 98200 LINBECK GILL D/S DEVOKE WATER

T50

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		5.734	4.204	.017	.1747	.0016	153.5	52.83	2.46	1.217	.4	2.666	68.32	.0161	11	10.12	2.883
S.D.		.5608	3.513	.0231	.1047	.0004	129.1	32.62	.3855	.2167	0.0	0.0	11	.0207	5.291	4.086	.7911
MAX		7.1	16	.095	.53	<.004	480	130	3.3	1.6	.4	<4	86	.08	15	16	4.8
MIN		4.9	<1	<.01	.1	<.002	15	<10	1.5	.8	.4	<4	45	<.005	5	4	2
5%ILE NORM		4.811	-VE	-VE	.0024	.0009	-VE	-VE	1.826	.8606	.4	2.666	50.22	-VE	2.296	3.403	1.582
95%ILE NORM		6.656	9.983	.055	.3469	.0023	365.9	106.4	3.094	1.573	.4	2.666	86.42	.0501	19.7	16.84	4.184
5%ILE LOG		4.86	.9747	.0019	.0602	.001	35.29	17.65	1.881	.8961	.4	2.666	51.84	.0019	4.68	4.956	1.785
95%ILE LOG		6.7	10.68	.0542	.3728	.0024	391.3	114.4	3.14	1.602	.4	2.666	87.76	.0501	20.99	17.78	4.331
NO.OF OCCURS.		47	44	15	15	15	40	20	43	41	1	1	38	14	3	8	24

SPT :- 0174808889M NGR :- SD 12350 97300 LATTERBARROW BECK D/S HINNING HOUSE

T51

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.1	6.947	.0131	.0986	.002	88.11	60	3.847	1.651			105.8	.0211	11	13	9.162
S.D.		.5132	4.313	.0092	.0549	.0011	51.04	19.68	.8896	.4259			74.45	.0293	1.414	3.605	2.132
MAX		7	17	.03	.19	.004	200	80	5.8	2.6			350	.08	12	16	12.6
MIN		5.2	3	<.01	.05	<.002	30	15	2.1	1.02			58	<.01	10	9	6.7
5%ILE NORM		5.255	-VE	-VE	.0083	.0001	4.142	27.62	2.383	.9507			-VE	-VE	8.673	7.069	5.655
95%ILE NORM		6.944	14.04	.0281	.1889	.0038	172	92.37	5.31	2.351			228.2	.0694	13.32	18.93	12.66
5%ILE LOG		5.294	2.307	.0038	.0366	.0007	31.46	33.69	2.575	1.053			30.48	.0022	8.838	8.005	6.116
95%ILE LOG		6.978	15.09	.0303	.2025	.004	184.7	96.46	5.455	2.427			245.5	.0679	13.46	19.6	13.01
NO.OF OCCURS.		19	19	7	7	7	15	9	17	16			13	6	2	3	8

SPT :- 0174808897 NGR :- NY 13200 00300 RIVER MITE 20M U/S OF BOWERHOUSE BRIDGE

T52

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.3	6.857	.0086	.3714	.0015	70.19	40.55	3.062	1.121			66	.0093		8	1.933
S.D.		.3279	2.609	.0018	.0699	.0003	42.56	36.98	.6391	.1868			7.527	.006		6.082	.8454
MAX		6.8	12	.01	.45	.002	130	80	4.4	1.4			74	.02		15	3.1
MIN		5.9	4	<.01	.25	<.002	<10	<10	2.4	.8			57	<.01		4	.6
5%ILE NORM		5.76	2.564	.0056	.2565	.001	.169	-VE	2.011	.8142			53.61	-VE		-VE	.5428
95%ILE NORM		6.839	11.14	.0115	.4863	.0021	140.2	101.3	4.113	1.428			78.38	.0191		18	3.323
5%ILE LOG		5.775	3.499	.006	.2686	.0011	23.9	8.335	2.134	.8427			54.39	.003		2.096	.8902
95%ILE LOG		6.853	11.73	.0118	.4961	.0021	150.6	107.7	4.21	1.452			79.05	.0206		19.34	3.524
NO.OF OCCURS.		9	7	7	7	7	7	3	8	7			4	5		3	6

SPT :- 0174808904F NGR :- NY 18400 07700 LINGMELL BECK 20M PTC MOSEDALE BECK

T53

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.158	5.941	.0081	.3771	.0018	16.66	11	2.312	.654			41.83	.01		3.333	.9042
S.D.		.2293	2.749	.0018	.1048	.001	21.19	7.036	.4603	.0745			6.017	.0058		.9428	1.196
MAX		6.5	12	.01	.54	.004	90	30	3.1	.75			48.2	.02		4	3.8
MIN		5.8	3	<.01	.2	<.002	<10	<10	1.3	.49			29	<.01		<4	<.3
5%ILE NORM		5.781	1.418	.0052	.2047	.0002	-VE	-VE	1.555	.5314			31.93	.0005		1.782	-VE
95%ILE NORM		6.536	10.46	.011	.5496	.0035	51.52	22.57	3.069	.7766			51.73	.0195		4.884	2.872
5%ILE LOG		5.789	2.612	.0055	.232	.0007	2.052	3.536	1.64	.5391			32.72	.0036		2.032	.1042
95%ILE LOG		6.543	11.12	.0113	.5692	.0037	51.71	24.28	3.136	.7833			52.4	.0209		5.062	2.851
NO.OF OCCURS.		17	17	7	7	7	15	10	16	15			11	5		2	8

SPT :- 0174808904K NGR :- NY 18400 08200 MOSEDALE BECK 10M D/S OF DOWN-IN-THE-DALE BRIDGE

T54

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.2	7.2	.0088	.3571	.0014	15.95	8.75	2.3	.6312			44.25	.0063		2.333	.8571
S.D.		.2357	1.988	.0052	.1367	.0003	9.9	4.166	.8617	.185			3.5	.0007		.4714	.6705
MAX		6.5	10	.02	.6	.002	<40	15	3.9	.8			48	<.01		<4	2.3
MIN		5.9	3	.005	.2	<.002	<10	<10	.5	.2			40	.005		2	<.3
5%ILE NORM		5.812	3.928	.0003	.1323	.001	-VE	1.896	.8826	.3269			38.49	.0051		1.557	-VE
95%ILE NORM		6.587	10.47	.0173	.582	.0018	32.23	15.6	3.717	.9356			50	.0076		3.108	1.96
5%ILE LOG		5.82	4.442	.0031	.1815	.0011	5.3	3.755	1.186	.3777			38.73	.0052		1.645	.2167
95%ILE LOG		6.595	10.84	.0186	.6128	.0019	34.66	16.61	3.909	.9714			50.23	.0076		3.178	2.103
NO.OF OCCURS.		10	10	7	7	7	7	4	9	8			4	5		2	7

SPT :- 0174808906 NGR :- NY 16500 06700 WASTWATER AT BOWDERDALE

T55

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.233	5.166	.0081	.3186	.0018	48.86	18.14	1.966	.6383			41.94	.0083		2.333	1.091
S.D.		.3339	1.85	.0018	.0724	.001	63.54	12.48	.5883	.1622			7.324	.0037		.4714	1.408
MAX		6.9	8	.01	.4	.004	240	40	2.4	.77			50.5	.015		<4	4.5
MIN		5.7	2	<.01	.2	<.002	<10	<10	.7	.2			27	<.01		2	<.3
5%ILE NORM		5.684	2.122	.0052	.1994	.0002	-VE	-VE	.999	.3715			29.89	.0022		1.557	-VE
95%ILE NORM		6.782	8.21	.011	.4377	.0035	153.3	38.68	2.934	.9051			53.99	.0145		3.108	3.407
5%ILE LOG		5.699	2.746	.0055	.2147	.0007	5.796	5.37	1.164	.41			31.06	.0038		1.645	.1313
95%ILE LOG		6.797	8.613	.0113	.4494	.0037	153	41.62	3.049	.9336			54.94	.0154		3.178	3.407
NO.OF OCCURS.		12	12	7	7	7	12	9	12	12			9	5		2	8

SPT :- 01748089116 NGR :- NY 14300 05600 GREENDALE BECK AT GREENDALE

T56

	37 FLOW INST M3/S	61 PH	162 ALKAL INITY M.O. MG/L CACO3	111 AMMON IA N MG/L	117 NO3-N MG/L N	118 NO2-N MG/L N	7760 ALU MIN IUM UG/L	9509 AL MONO MERIC UNAC UG/L	241 CAL CIUM MG/L CA	237 MAGNES IUM MG/L MG	85 BOD 5 ATU MG/L O	92 COD MG/L O	77 COND AT 25C US/CM	180 ORTHO PHOSP MG/L P	172 CHLOR IDE MG/L CL	183 SULPH ATE MG/L SO4	9968 TOTAL HUMIC SUBS MG/L
MEAN		6.3	6.9	.0429	.1971	.0014	23.75	12.5	1.711	.975			49.5	.0067		4.333	1.985
S.D.		.359	2.424	.0786	.1011	.0003	15.05	11.66	.3333	.1558			2.38	.0024		2.357	.9263
MAX		7.1	11	.22	.3	.002	50	30	2.3	1.2			51	.01		6	3.1
MIN		5.9	4	<.01	.05	<.002	<10	<10	1.2	.7			46	<.005		<4	.4
5%ILE NORM		5.709	2.912	-VE	.0308	.001	-VE	-VE	1.162	.7187			45.58	.0028		.4563	.462
95%ILE NORM		6.89	10.88	.1722	.3635	.0018	48.52	31.69	2.259	1.231			53.41	.0105		8.21	3.509
5%ILE LOG		5.727	3.713	.0028	.0792	.0011	7.709	2.485	1.222	.7414			45.68	.0036		1.647	.8673
95%ILE LOG		6.907	11.41	.1511	.3884	.0019	52.18	33.59	2.307	1.25			53.51	.0111		8.794	3.733
NO.OF OCCURS.		10	10	7	7	7	8	4	9	8			4	5		2	7

```
                                                  WATER QUALITY SAMPLE SUMMARIES
                                               FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                  37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
               FLOW     PH ALKAL AMMON NO3-N NO2-N ALU     AL  CAL   MAGNES BOD 5 COD  COND  ORTHO CHLOR SULPHTOTAL
               INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                           M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C   MG/L  MG/L  MG/LSUBS
               M3/S        MG/L        N     N     UG/L  UNAC  MG/L  MG/L  O     O     US/CM P     CL    SO4  MG/L
                           CACO3                         UG/L  CA    MG

SPT :- 0174808919          NGR :- NY 08600 05500    RIVER BLENG AT BLENGDALE - D/S OF FORESTRY COMMISSION BRIDGE
------                     ------
EAN                  6.56  9     .0081 .2429 .0017 61.87 14.16 3.111 1.375             67.75 .006        4.833 3.685
.D.         T57      .3893 3.858 .0018 .1097 .0006 95.91 6.871 .888  .2726             5.315 .0015       3.064 1.274
AX                   7.3   15    .01   .4    .003  295   20    4.7   1.8               74    <.01        7     5.2
MIN                  6     5     <.01  .1    <.002 <10   <10   2     1                 62    <.005       <4    2.2
 5%ILE NORM          5.919 2.653 .0052 .0625 .0006   -VE 2.863 1.65  .9267             59    .0035         -VE 1.589
95%ILE NORM          7.2   15.34 .011  .4232 .0027 219.6 25.47 4.571 1.823             76.49 .0085       9.873 5.782
 5%ILE LOG           5.94  4.208 .0055 .109  .0008 5.433 5.984 1.887 .9765             59.37 .0039       1.569 2.003
 5%ILE LOG           7.219 16.25 .0113 .4495 .0029 207   27.14 4.74  1.862             76.83 .0087       10.61 6.054
NO.OF OCCURS.           10    10     7     7     7     8     4     9     8                 4     5           2     7

SPT :- 01748089336         NGR :- NY 06500 09100    RIVER CALDER 20M U/S OF WORM GILL
-----                      ------
MEAN                 6.62  11.4  .0157 .2157 .0018 35    13.33 3.155 1.431             68.5  .0083 11    3.833 3.842
S.D.        T58      .4237 4.718 .0136 .1028 .001  36.25 11.22 .8472 .3644             8.386 .0037   0.0 1.649 1.541
MAX                  7.5   20    .04   .4    .004  120   30    4.5   2                 80    .015  11    5     6
MIN                  6.1   6     <.01  .1    <.002 <10   <10   2.1   1.05              60    <.01  11    <4    1.7
 5%ILE NORM          5.923 3.638   -VE .0467 .0002   -VE   -VE 1.762 .8318             54.7  .0022 11    1.119 1.307
95%ILE NORM          7.317 19.16 .038  .3848 .0035 94.63 31.79 4.549 2.03              82.29 .0145 11    6.547 6.378
 5%ILE LOG           5.946 5.476 .0035 .0925 .0007 5.968 3.061 1.974 .9184             55.63 .0038 11    1.787 1.889
95%ILE LOG           7.339 20.26 .0406 .4098 .0037 99.01 33.99 4.703 2.094             83.09 .0154 11    6.937 6.732
NO.OF OCCURS.           10    10     7     7     7     8     4     9     8                 4     5     1     2     7

SPT :- 0174808933M         NGR :- NY 06600 09100    WORM GILL 20M U/S OF RIVER CALDER
------                     ------
MEAN                 6.681 10.27 .0104 .1625 .0018 30.18 8.888 2.81  1.338             64    .0093 11    4.333 2.35
S.D.        T59      .3371 3.69  .006  .0744 .0008 37.19 1.924 .7909 .2643             6.48  .006    0.0 2.357 .8191
MAX                  7.1   16    .02   .3    .003  125   10    4     1.6               70    .02   11    6     3.4
MIN                  6.1   5     <.01  .1    <.002 <10   <10   1.7   .8                56    <.01  11    <4    1.4
 5%ILE NORM          6.127 4.202 .0005 .0401 .0006   -VE 5.723 1.509 .9041             53.33   -VE 11    .4563 1.002
95%ILE NORM          7.236 16.34 .0203 .2849 .0031 91.37 12.05 4.11  1.773             74.66 .0191 11    8.21  3.697
 5%ILE LOG           6.142 5.45  .0037 .0721 .0009 3.914 6.109 1.717 .9523             53.92 .003  11    1.647 1.271
95%ILE LOG           7.25  17.14 .0218 .3028 .0033 92.42 12.35 4.259 1.811             75.18 .0206 11    8.794 3.873
NO.OF OCCURS.           11    11     8     8     8     9     3    10     9                 5     5     1     2     6

SPT :- 0174808953F         NGR :- NY 19200 12300    RIVER LIZA 400M D/S OF YHA (10M U/S OF FORD)
------                     ------
MEAN                 5.666 3.888 .0095 .25   .0017 56.05 38.78 1.405 .6075 1.9   2.666 37.91 .0067 9     3.833 1.066
S.D.        T60      .4406 2.323 .0049 .0866 .001  44.78 33.56 .4643 .2584   0.0   0.0 6.964 0.0     0.0 1.649 1.156
MAX                  6.5   9     .02   .4    .004  150   110   2.3   1.27  1.9   <4    52    <.01  9     5     3.9
MIN                  4.9   1     <.01  .15   <.002 <10   <10   .7    .35   1.9   <4    23    <.01  9     <4    .3
 5%ILE NORM          4.941 .0669 .0015 .1075 .0001   -VE   -VE .6421 .1825 1.9   2.666 26.45 .0067 9     1.119   -VE
95%ILE NORM          6.391 7.71  .0176 .3925 .0034 129.7 94    2.169 1.032 1.9   2.666 49.37 .0067 9     6.547 2.969
 5%ILE LOG           4.972 1.345 .0038 .1358 .0006 13.78 8.574 .7863 .2859 1.9   2.666 27.63 .0067 9     1.787 .1696
95%ILE LOG           6.419 8.283 .0188 .411  .0036 139.1 100.3 2.266 1.093 1.9   2.666 50.32 .0067 9     6.937 3.083
NO.OF OCCURS.           18    18     7     7     7    17    11    17    16     1     1    13     4     1     2     9

SPT :- 0174808953L         NGR :- NY 13050 14250    RIVER LIZA PTC ENNERDALE WATER
------                     ------
MEAN                 5.923 4.254 .0095 .3833 .0019 27.7  19.09 1.952 .8329 1.6   2.666 48.33 .0093 8.5   4.888 .6
S.D.        T61      .5368 1.876 .0049 .0408 .001  17.4  9.29  .5125 .1984   0.0   0.0 6.663 .006  2.121 2.775 .3041
MAX                  6.6   9     .02   .45   .004  75    40    3.2   1.3   1.6   <4    60    .02   10    8     1.2
MIN                  4.1   2     <.01  .35   <.002 <10   <10   1.2   .45   1.6   <4    33    <.01  7     <4    <.3
 5%ILE NORM          5.04  1.168 .0015 .3162 .0003   -VE 3.809 1.109 .5067 1.6   2.666 37.36   -VE 5.01  .3234 .0997
95%ILE NORM          6.806 7.341 .0176 .4505 .0035 56.33 34.37 2.795 1.159 1.6   2.666 59.29 .0191 11.98 9.454 1.1
 5%ILE LOG           5.083 1.946 .0038 .3201 .0008 9.087 8.041 1.235 .5506 1.6   2.666 38.2  .003  5.504 1.782 .2437
95%ILE LOG           6.845 7.788 .0188 .4539 .0038 60.58 36.64 2.887 1.192 1.6   2.666 60    .0206 12.35 10.14 1.175
NO.OF OCCURS.           17    17     7     6     7    16    11    17    17     1     1    13     5     2     3     9

SPT :- 0174808953P         NGR :- NY 12400 15000    SMITHY BECK 30M U/S OF FORESTRY COMMISSION BRIDGE
------                     ------
MEAN                 6.423 7.062 .0081 .2857 .0021 31.44 16.5  2.246 1.165 .9    2.666 56.17 .0067 10    5     1.112
S.D.        T62      .3833 2.294 .0018 .1107 .0013 29.31 10.13 .723  .3795   0.0   0.0 7.635 0.0     0.0 3.464 .3834
MAX                  7.4   13    .01   .4    .004  115   40    4.1   2     .9    <4    68    <.01  10    9     1.8
MIN                  5.8   4     <.01  .1    <.002 <10   <10   1.4   .56   .9    <4    41    <.01  10    3     .7
 5%ILE NORM          5.793 3.289 .0052 .1036   0.0   -VE   -VE 1.057 .5415 .9    2.666 43.61 .0067 10      -VE .4819
95%ILE NORM          7.054 10.83 .011  .4679 .0042 79.65 33.17 3.435 1.789 .9    2.666 68.73 .0067 10    10.69 1.743
 5%ILE LOG           5.813 3.989 .0055 .144  .0007 6.264 5.542 1.276 .6576 .9    2.666 44.55 .0067 10    1.467 .6062
95%ILE LOG           7.072 11.3  .0113 .4929 .0046 84.46 35.66 3.584 1.868 .9    2.666 69.53 .0067 10    11.51 1.824
NO.OF OCCURS.           17    16     7     7     7    15    10    15    14     1     1    11     5     1     3     8

SPT :- 0174808953V         NGR :- NY 11400 15000    ENNERDALE WATER NEAR BOWNESS KNOTT
------                     ------
MEAN                 6.253 4.6   .011  .3286 .0023 34.42 16.66 2.08  .8213 1.5   2.666 51.51 .0093 8     2.833 1.233
S.D.        T63      .2503 2.164 .0063 .0756 .0015 35.51 10.74 .4057 .1783   0.0   0.0 10.57 .006    0.0 .2357 1.333
MAX                  6.6   9     .02   .45   .005  148   40    2.9   1.1   1.5   <4    80    .02   8     <4    4.6
MIN                  5.8   1     <.01  .25   <.002 <10   <10   1.5   .4    1.5   <4    39    <.01  8     3     .4
 5%ILE NORM          5.841 1.039 .0006 .2042   -VE   -VE   -VE 1.412 .5281 1.5   2.666 34.12   -VE 8     2.445   -VE
95%ILE NORM          6.665 8.16  .0213 .4529 .0048 92.84 34.33 2.747 1.114 1.5   2.666 68.9  .0191 8     3.221 3.426
 5%ILE LOG           5.85  1.994 .0039 .2204 .0007 5.904 5.312 1.485 .564  1.5   2.666 36.13 .003  8     2.463 .197
95%ILE LOG           6.673 8.686 .0229 .4652 .0052 97.2  36.94 2.805 1.142 1.5   2.666 70.48 .0206 8     3.236 3.56
NO.OF OCCURS.           15    15     7     7     7    15    10    15    15     1     1    12     5     1     2     9
```

```
                          WATER QUALITY SAMPLE SUMMARIES
                  FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                     37     61    162    111    117    118   7760   9509    241    237     85     92     77    180    172    183   9968
                 FLOW     PH   ALKAL  AMMON  NO3-N  NO2-N  ALU      AL   CAL    MAGNES BOD 5  COD    COND   ORTHO  CHLOR  SULPHTOTAL
                 INST          INITY  IA N                 MIN    MONO   CIUM   IUM    ATU           AT     PHOSP  IDE     ATE HUMIC
                               M.O.   MG/L   MG/L   MG/L   IUM    MERIC                MG/L   MG/L   25C    MG/L   MG/L   MG/LSUBS
                 M3/S          MG/L            N      N    UG/L   UNAC   MG/L   MG/L     O      O    US/CM  P      CL     SO4  MG/L
                               CACO3                              UG/L   CA     MG

SPT :- 0174808960             NGR :- NY 06900 15800     RIVER EHEN AT ENNERDALE BRIDGE
------                        ------
MEAN             2.167  6.747  8.71   .0262  .4069  .005   30.94  15.18  2.466  .8692  1.204  4.987  68.52  .0118  7.629  4.833  1.225
S.D.      T64    2.915  .5569  10.14  .0263  .1304  .0061  38.33  10.25  .4141  .1248  .6205  3.588  48.83  .0127  1.924  3.064  .3882
MAX              12.75  8.7    60     .1     .9     .028   143    40     3.3    1.2    2.3    18     280    .055   11     7      1.7
MIN              .381   5.7    3      <.005  .25    <.002  <10    <10    1.9    .7     .1     <4     41     <.005  3      <4     .6
 5%ILE NORM         -VE 5.831     -VE    -VE .1924     -VE    -VE    -VE 1.785  .6639  .1843     -VE    -VE    -VE 4.464     -VE .5864
95%ILE NORM      6.962  7.663  25.4   .0694  .6214  .0151  93.99  32.05  3.147  1.074  2.225  10.89  148.8  .0327  10.79  9.873  1.863
 5%ILE LOG       .243   5.872  1.237  .0047  .2317  .0006  3.978  4.591  1.849  .6802  .4824  1.399  19.44  .0019  4.916  1.569  .702
95%ILE LOG       6.88   7.7    26.02  .073   .6481  .0153  94.95  34.49  3.2    1.088  2.378  11.71  160.1  .034   11.13  10.61  1.942
NO.OF OCCURS.        36     38     38     33     33     33     12      9     12     12     27     27     25     31     27      2      8

SPT :- 0175809026H            NGR :- NY 23400 12200     RIVER DERWENT PTC SOUR MILK GILL, SEATHWAITE
------                        ------
MEAN                    6.37   5.842  .011   .3043  .0014  38.61  11.94  1.85   .5059                36.55  .0073  9      2      1.337
S.D.      T65           .4714  3.131  .0085  .2341  .0003  79.38  5.404  .3761  .0788                6.612  .0015   0.0   .9428  1.047
MAX                     7.4    16     .03    .8     .002   350    20     2.5    .62                  50     .01    9      <4     3.8
MIN                     5.6    2      <.01   .1     <.002  <10    <10    1      .38                  24     <.01   9      <2     .5
 5%ILE NORM             5.594  .6909     -VE    -VE .001      -VE 3.054  1.231  .3762                25.67  .0049  9      .4492     -VE
95%ILE NORM             7.145  10.99  .025   .6893  .0018  169.1  20.83  2.468  .6355                47.42  .0098  9      3.55   3.06
 5%ILE LOG              5.625  2.252  .0028  .0786  .0011  2.036  5.35   1.302  .3874                26.77  .0052  9      .8659  .3376
95%ILE LOG              7.173  11.76  .0268  .7403  .0019  140    22.13  2.524  .6449                48.31  .01    9      3.779  3.284
NO.OF OCCURS.               20     19      7      7      7     18     12     18     17                   16      5      1      2      8

SPT :- 0175809027K            NGR :- NY 36300 30300     RIVER GLENDERAMACKIN AT MUNGRISDALE
------                        ------
MEAN                    5.925  5.625  .0214  .1305  .0023  42.22  30.41  1.1    .8857                34     .0063         3.333  2.171
S.D.      T66           .4713  2.326  .0271  .0986  .0025  28.49  20.56  .3416  .0476                4.415  .0007         2.403  .8361
MAX                     6.6    10     .08    .33    .008   80     50     1.8    .95                  40     <.01          6      3.2
MIN                     5.3    3      <.01   <.05   <.002  <10    <10    .9     .8                   30     .005          <2     1.1
 5%ILE NORM             5.149  1.798     -VE    -VE    -VE    -VE    -VE .5382  .8075                26.73  .0051            -VE .7961
95%ILE NORM             6.7    9.451  .0661  .2927  .0064  89.09  64.24  1.661  .9639                41.26  .0076         7.287  3.546
 5%ILE LOG              5.183  2.704  .0027  .0345  .0004  12.77  9.184  .6378  .8097                27.25  .0052         .9326  1.099
95%ILE LOG              6.73   9.992  .0664  .3145  .0067  95.86  69.13  1.73   .9661                41.71  .0076         7.838  3.735
NO.OF OCCURS.                8      8      7      7      7      6      4      7      7                    5      5             3      7

SPT :- 0175809029P            NGR :- NY 32100 14900     THIRLMERE - SURFACE WATER,AT DRAW-OFF TOWER
------                        ------
MEAN                    6.3    6.571  .0098  .2143  .0018  49.76  9.583  2.783  .55                  37.5   .0083         3.333  2.328
S.D.      T67           .383   2.07   .0028  .0244  .001   75.88  3.938  .5193  .0447                3.785  .0037         2.403  .637
MAX                     6.7    9      .015   .25    .004   220    15     3.7    .6                   40     .015          6      3.2
MIN                     5.6    3      <.01   .2     <.002  <10    <10    2.2    .5                   32     <.01          <2     1.5
 5%ILE NORM             5.67   3.166  .0052  .1742  .0002     -VE 3.105  1.929  .4764                31.27  .0022            -VE 1.28
95%ILE NORM             6.929  9.976  .0144  .2544  .0035  174.5  16.06  3.637  .6236                43.72  .0145         7.287  3.376
 5%ILE LOG              5.69   3.778  .0059  .1767  .0007  4.497  4.628  2.018  .4797                31.61  .0038         .9326  1.443
95%ILE LOG              6.949  10.39  .0149  .2566  .0037  165.5  16.97  3.709  .6265                44.03  .0154         7.838  3.493
NO.OF OCCURS.                7      7      7      7      7      7      4      6      6                    4      5             3      7

SPT :- 0175809029Y            NGR :- NY 29600 25400     GLENDERATERRA BECK AT DERWENTFOLDS
------                        ------
MEAN                    6.222  8.125  .0095  .1214  .0014  29.04  13.33  1.212  1.137                44     .01           3      2.428
S.D.      T68           .4147  2.85   .0049  .0488  .0003  25.65  11.22  .4016  .228                 15.11  .0058         1.855  1.314
MAX                     6.9    12     .02    .2     .002   80     30     2.1    1.6                  70     .02           5      5.2
MIN                     5.6    5      <.01   .05    <.002  <10    <10    .9     .9                   33     <.01          <2     1.4
 5%ILE NORM             5.54   3.436  .0015  .0412  .001      -VE    -VE .552   .7625                19.13  .0005            -VE .2656
95%ILE NORM             6.904  12.81  .0176  .2017  .0018  71.24  31.79  1.873  1.512                68.86  .0195         6.052  4.591
 5%ILE LOG              5.564  4.377  .0038  .0596  .0011  6.243  3.061  .6771  .8047                24.02  .0036         1      .9275
95%ILE LOG              6.926  13.42  .0188  .2129  .0019  75.92  33.99  1.956  1.545                72.08  .0209         6.507  4.917
NO.OF OCCURS.                9      8      7      7      7      7      4      8      8                    5      5             3      7

SPT :- 0175809043F            NGR :- NY 23150 19450     NEWLANDS BECK D/S OF BRIDGE AT LITTLE TOWN
------                        ------
MEAN                    6.34   6.888  .0179  .0929  .0015  20     8.333  2.8    .7912                47.4   .0063         4.222  1.6
S.D.      T69           .3864  3.1    .0213  .0535  .0007  14.14  1.924  .5568  .0864                12.99  .0007         1.347  1.43
MAX                     6.7    13     .065   .2     .003   50     10     3.6    .9                   66     <.01          5      4.8
MIN                     5.6    3      <.01   .05    .001   <10    <10    2      .6                   30     .005          <4     .7
 5%ILE NORM             5.704  1.789     -VE .0049  .0004     -VE 5.167  1.884  .6491                26.02  .0051         2.006     -VE
95%ILE NORM             6.975  11.98  .0529  .1808  .0026  43.26  11.49  3.715  .9334                68.77  .0076         6.438  3.953
 5%ILE LOG              5.725  3.099  .0024  .0334  .0007  5.729  5.58   1.986  .6576                29.36  .0052         2.41   .3381
95%ILE LOG              6.995  12.73  .0539  .194   .0028  46.54  11.81  3.796  .9409                71.17  .0076         6.713  4.208
NO.OF OCCURS.               10      9      7      7      7      8      4      9      8                    5      5             3      7

SPT :- 0175809043M            NGR :- NY 22300 19400     KESKADALE BECK NEAR GILLBROW
------                        ------
MEAN                    6.29   7.111  .0148  .1143  .0018  21.87  10     2.066  .825                 45.2   .008          4.555  2.516
S.D.      T70           .3725  3.62   .0088  .069   .0006  20.69  6.666  .6     .1363                10.82  .0018         1.71   .5699
MAX                     6.8    15     .03    .2     .003   70     20     3.2    1                    52     .01           6      3.5
MIN                     5.7    3      <.01   .05    <.002  <10    <10    1.1    .6                   26     <.01          <4     1.9
 5%ILE NORM             5.677  1.155  .0003  .0008  .0007     -VE    -VE 1.079  .6008                27.39  .005          1.741  1.578
95%ILE NORM             6.902  13.06  .0292  .2278  .0028  55.9   20.96  3.053  1.049                63     .011          7.369  3.451
 5%ILE LOG              5.696  2.876  .0051  .0391  .0009  4.266  3.068  1.243  .6214                29.8   .0054         2.346  1.696
95%ILE LOG              6.92   13.95  .0314  .2448  .0029  59.19  22.56  3.168  1.066                64.82  .0113         7.75   3.543
NO.OF OCCURS.               10      9      7      7      7      8      4      9      8                    5      5             3      7
```

```
                                              WATER QUALITY SAMPLE SUMMARIES
                                            FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                 37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
              FLOW    PH  ALKAL AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
              INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                          M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L  MG/LSUBS
              M3/S         MG/L         N     N   UG/L  UNAC  MG/L  MG/L   O     O    US/CM P     CL    SO4  MG/L
                           CACO3                       UG/L  CA    MG

  PT :- 0175809065B       NGR :- NY 22400 13580        GATESGARTHDALE BECK D/S BUTTERMERE GREEN SLATE QUARRY
------                    ------
MEAN        T71     6.614 14.71 .0857 .2829 .0058 55.19 13.88 5.185 .6643             55.75 .0357       3.222 1.983
 .D.                .3848 5.407 .1508 .1614 .0107 46.87 9.765 2.061 .118              9.178 .0392       .6939 1.571
 AX                 7.1   23    .42   .6    .03   143   25    7.9   .8                61    .09         4     5.1
 IN                 5.9   7     <.01  .15   <.002 <10   <10   2     .5                42    <.01        3     .7
  5%ILE NORM        5.981 5.819   -VE .0173   -VE   -VE   -VE 1.794 .4702             40.65   -VE       2.08    -VE
95%ILE NORM         7.247 23.6  .3338 .5484 .0234 132.2 29.95 8.577 .8584             70.84 .1002       4.363 4.568
  5%ILE LOG         6.001 7.691 .006  .1026 .0004 12.51 4.005 2.566 .4894             42.03 .0055       2.219 .4931
  5%ILE LOG         7.265 24.8  .2986 .5884 .0204 141.3 32.22 9.049 .8741             71.98 .1038       4.471 4.9
  0.OF OCCURS.          7     7     7     7     7     7     3     7     7                 4     5           3     6

SPT :- 0175809065M        NGR :- NY 19000 15500        BUTTERMERE BELOW LOWER GATESGARTH
------                    ------
 :AN        T72     6.414 6.285 .0098 .1586 .0019 38.57 8.75  2.285 .6714             39    .0093       7.222 1.2
 .D.                .6256 2.36  .0068 .0367 .001  43.75 4.166 .2478 .0488             5.773 .006        5.984 1.216
 AX                 7.5   10    .025  .21   .004  130   15    2.7   .7                46    .02         14    3.9
MIN                 5.7   3     <.01  .1    <.002 <10   <10   2     .6                32    <.01        <4    .4
  5%ILE NORM        5.385 2.403   -VE .0982 .0003   -VE 1.896 1.878 .5912             29.5    -VE         -VE   -VE
  %ILE NORM         7.443 10.16 .021  .219  .0035 110.5 15.6  2.693 .7517             48.49 .0191       17.06 3.201
  %ILE LOG          5.439 3.237 .0028 .1061 .0008 5.714 3.755 1.902 .5943             30.28 .003        1.693 .2114
  5%ILE LOG         7.492 10.69 .0226 .225  .0038 113.8 16.61 2.714 .7546             49.15 .0206       18.26 3.359
NO.OF OCCURS.           7     7     7     7     7     7     4     7     7                 4     5           3     7

  T :- 0175809066B        NGR :- NY 16200 18200        CRUMMOCK WATER AT HAUSE POINT
  ----                    ------
 EAN        T73     6.328 5.714 .0107 .1957 .002  82.85 10    2.185 .7786             41.25 .0143       4.222 1.614
 .D.                .5024 1.603 .0051 .0215 .0007 162.9 6.666 .1952 .0567             5.058 .0171       1.677 1.046
 AX                 7.1   8     .02   .22   .003  450   20    2.5   .85               47    .045        6     3.9
  N                 5.9   3     <.01  .15   <.002 <10   <10   2     .7                35    <.01        <4    .8
  %ILE NORM         5.502 3.076 .0024 .1604 .0008   -VE   -VE 1.864 .6853             32.93   -VE       1.462   -VE
  %ILE NORM         7.154 8.352 .0191 .2311 .0032 350.9 20.96 2.506 .8718             49.56 .0425       6.981 3.335
  5%ILE LOG         5.537 3.498 .0046 .1625 .001  4.741 3.068 1.88  .689              33.49 .002        2.09  .5114
95%ILE LOG          7.187 8.653 .0203 .2329 .0034 297.4 22.56 2.52  .8752             50.05 .0433       7.366 3.588
 .OF OCCURS.            7     7     7     7     7     7     4     7     7                 4     5           3     7

 PT :- 0175809066CD       NGR :- NY 12800 21800        LOWESWATER
------                    ------
MEAN        T74     6.857 11.71 .0094 .39   .0025 15.33 6.666 5.4   1.335             72    .0113       6.333 3.271
 .D.                .4392 2.138 .0049 .0993 .0013 14.6  0.0   .5715 .0748             9.798 .0104       3.214 .877
  X                 7.4   16    .02   .58   .005  44    <10   6.4   1.4               80    .03         10    4.7
  N                 6.2   9     .009  .25   <.002 <10   <10   4.5   1.2               60    <.01        4     2.1
  5%ILE NORM        6.134 8.197 .0014 .2266 .0004   -VE 6.666 4.459 1.212             55.88   -VE       1.045 1.828
95%ILE NORM         7.579 15.23 .0174 .5534 .0046 39.35 6.666 6.34  1.458             88.11 .0285       11.62 4.713
  %ILE LOG          6.159 8.556 .0037 .2502 .001  2.962 6.666 4.514 1.216             57.09 .0023       2.569 2.048
  %ILE LOG          7.602 15.52 .0186 .5708 .005  41.62 6.666 6.388 1.462             89.14 .0303       12.41 4.873
 .OF OCCURS.            7     7     7     7     7     7     4     7     7                 4     5           3     7

SPT :- 0175809066DR       NGR :- NY 19200 24500        WHINLATTER GILL 10M U/S OF F.C.BRIDGE
 -----                    ------
 :AN        T75     6.516 9.636 .0642 .3837 .002  57.77 14.16 3.32  1.805             72.14 .0111       12    3
 .D.                .4489 3.264 .1599 .1286 .001  60.57 10.67 .5266 .248              9.191 .0093       4     1.059
MAX                 7.3   15    .46   .5    .004  160   30    4.2   2.1               87    .03         16    5
MIN                 5.9   6     <.01  .17   <.002 <10   <10   2.4   1.35              63    <.01        8     2
  5%ILE NORM        5.778 4.267   -VE .1722 .0003   -VE   -VE 2.453 1.397             57.02   -VE       5.42  1.256
  %ILE NORM         7.255 15    .3273 .5953 .0036 157.4 31.72 4.186 2.213             87.26 .0265       18.57 4.743
  %ILE LOG          5.805 5.307 .0024 .2127 .0008 9.673 3.756 2.53  1.428             58.08 .0026       6.674 1.609
  %ILE LOG          7.28  15.69 .2412 .6223 .0039 164.4 34.08 4.249 2.239             88.17 .0283       19.41 4.972
NO.OF OCCURS.          12    11     8     8     8     9     4    10     9                 7     6           3     7

 T :- 0175809066DV        NGR :- NY 18900 26250        AIKEN BECK 200M U/S OF DARLING ROW PLANTATION
 -----                    ------
 :AN        T76     6.44  7.9   .0179 .1714 .0021 20.66 10.83 2.225 1.407             59.33 .01         7.333 2.616
S.D.                .3169 3.247 .0137 .0756 .0017 10.58 6.309 .3196 .1539             6.25  .0058       2.886 1.455
MAX                 7     16    .04   .25   .006  <40   20    2.8   1.6               68    .02         9     5.8
 IN                 5.9   4     <.01  .1    <.002 <10   <10   1.9   1.1               50    <.01        4     1.5
  5%ILE NORM        5.918 2.558   -VE .0471   -VE 3.248 .4542 1.699 1.154             49.05 .0005       2.584 .2204
  5%ILE NORM        6.961 13.24 .0404 .2958 .005  38.08 21.21 2.75  1.66              69.61 .0195       12.08 5.008
  5%ILE LOG         5.932 3.814 .0046 .0784 .0005 8.312 3.848 1.741 1.169             49.64 .0036       3.654 .9718
95%ILE LOG          6.974 13.99 .0434 .3138 .0053 40.69 22.77 2.786 1.673             70.13 .0209       12.73 5.369
NO.OF OCCURS.          10    10     7     7     7     8     4     8     7                 6     5           3     7

 T :- 0175809088K         NGR :- NY 09500 19500        CONGRA MOSS
 -----                    ------
MEAN        T77     6.071 6.714 .011  .1167 .0021 32.85 8.333 1.485 1.228             51.75 .0093       4     2.657
 .D.                .4645 4.191 .0063 .0861 .0014 30.93 1.924 .3288 .1113             2.362 .006        3.527 .7547
 AX                 6.7   15    .02   .25   .005  90    10    1.9   1.3               55    .02         8     3.7
 IN                 5.4   3     <.01  <.05  <.002 <10   <10   1.1   1                 50    <.01        <2    2
  5%ILE NORM        5.307   -VE .0006   -VE   -VE   -VE 5.167 .9449 1.045             47.86   -VE         -VE 1.415
95%ILE NORM         6.835 13.6  .0213 .2582 .0044 83.74 11.49 2.026 1.411             55.63 .0191       9.802 3.898
  5%ILE LOG         5.338 2.216 .0039 .0317 .0006 6.451 5.58  1.012 1.054             47.95 .003        .8615 1.616
  5%ILE LOG         6.864 14.63 .0229 .2776 .0048 88.7  11.81 2.078 1.419             55.72 .0206       10.44 4.041
  0.OF OCCURS.          7     7     7     7     7     7     4     7     7                 4     5           3     7
```

Appendix 9

```
                                             WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                  37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
               FLOW  PH    ALKAL AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
               INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                           M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L   MG/LSUBS
               M3/S         MG/L        N     N    UG/L  UNAC  MG/L  MG/L   O     O    US/CM P     CL    SO4   MG/L
                           CACO3                         UG/L  CA    MG

SPT :- 0175809119T       NGR :- NY 25400 35300     RIVER ELLEN AT OVERWATER
------                   ------
MEAN                 7.016 22.83 .0117 .4044 .0047 26.94 8.333 7.666 2.8               105   .01         9.444 7.12
S.D.    T78          .2317 3.544 .0066 .2342 .0016 17.2  2.357 1.22  .429              7.071 .0058       7.042 1.505
MAX                  7.3   29    .02   .65   .007  60    10    8.8   3.6               110   .02         14    9.3
MIN                  6.7   19    <.01  <.04  .002  10    <10   5.3   2.5               100   <.01        <2    5.6
 5%ILE NORM          6.635 17    .0008 .0192 .002    -VE 4.456 5.658 2.094             93.36 .0005         -VE 4.643
95%ILE NORM          7.397 28.66 .0225 .7897 .0074 55.24 12.21 9.675 3.505             116.6 .0195       21.02 9.596
 5%ILE LOG           6.642 17.5  .0043 .1445 .0025 8.678 5.08  5.836 2.154             93.78 .0036       2.536 4.938
95%ILE LOG           7.404 29.08 .0241 .8477 .0077 59.42 12.65 9.822 3.555             117   .0209       22.6  9.826
NO.OF OCCURS.           6     6     6     6     6     6     2     6     6                 2     5           3     5

SPT :- 0176809319G       NGR :- SD 78000 98800     RIVER EDEN AT B6259 ROADBRIDGE - AT ING HEADS
------                   ------
MEAN                 6.75  11.5  .105  .475  .014  68.33       4.55  1.5               50    .01         12    8.8
S.D.    T79          .3536 7.778 .1061 .1061 .0156 58.92       3.04  .8485             0.0   0.0         0.0   0.0
MAX                  7     17    .18   .55   .025  110         6.7   2.1               50    .01         12    8.8
MIN                  6.5   6     .03   .4    .003  <40         2.4   .9                50    .01         12    8.8
 5%ILE NORM          6.168   -VE   -VE .3005   -VE   -VE         -VE .1043             50    .01         12    8.8
95%ILE NORM          7.331 24.29 .2795 .6495 .0396 165.2       9.551 2.895             50    .01         12    8.8
 5%ILE LOG           6.184 3.47  .0186 .3225 .0021 15.17       1.392 .5488             50    .01         12    8.8
95%ILE LOG           7.346 26.14 .2935 .6664 .0409 176.4       10.27 3.106             50    .01         12    8.8
NO.OF OCCURS.           2     2     2     2     2     2           2     2                 1     2           1     1

SPT :- 0176809403C       NGR :- NY 40300 09500     KIRKSTONE BECK AT KIRKSTONE PASS
------                   ------
MEAN                 6.871 10.14 .0157 .3386 .0015 33.04 7.777 4.328 .7                82    .0067 4     8.333 2.783
S.D.    T80          .4821 4.67  .0202 .1614 .0004 23.21 1.924 2.097 .1443             15.87 .0021 0.0   1.527 1.26
MAX                  7.6   17    .06   .6    .002  68    10    7.7   .95               100   .01   4     10    4.6
MIN                  6.2   5     <.005 .16   .001  <10   <10   1.8   .5                70    <.005 4     7     .8
 5%ILE NORM          6.078 2.461   -VE .0731 .0009   -VE 4.612 .8786 .4626             55.88 .0032 4     5.82  .7094
95%ILE NORM          7.664 17.82 .049  .604  .0021 71.23 10.94 7.778 .9374             108.1 .0101 4     10.84 4.857
 5%ILE LOG           6.108 4.478 .0019 .1452 .0009 9.539 5.056 1.83  .4901             58.72 .0038 4     6.078 1.245
95%ILE LOG           7.691 18.95 .049  .6433 .0022 76.64 11.27 8.291 .959              110.3 .0106 4     11.05 5.16
NO.OF OCCURS.           7     7     7     7     7     7     3     7     7                 3     6     1     3     6

SPT :- 0176809403K       NGR :- NY 40200 13200     GOLDRILL BECK AT BROTHERSWATER OUTLET - U/S OF PASTURE BECK
------                   ------
MEAN                 6.971 12    .0195 .2586 .0019 26.19 7.777 4.842 .8357             60    .01   3     11.66 1.883
S.D.    T81          .4461 2.516 .0174 .1398 .0006 15.56 1.924 1.411 .1676             0.0   .0099 0.0   8.144 .801
MAX                  7.7   15    .05   .4    .003  50    10    7.3   1.15              60    .03   3     21    3
MIN                  6.4   9     <.01  .08   <.002 <10   <10   2.8   .6                60    <.005 3     6     .8
 5%ILE NORM          6.237 7.86    -VE .0286 .0009 .5845 4.612 2.52  .56               60      -VE 3       -VE .5657
95%ILE NORM          7.705 16.13 .0481 .4885 .0029 51.79 10.94 7.164 1.111             60    .0263 3     25.06 3.201
 5%ILE LOG           6.262 8.348 .0042 .0989 .001  9.11  5.056 2.906 .5911             60    .0018 3     3.393 .8862
95%ILE LOG           7.728 16.52 .0512 .5232 .003  55.63 11.27 7.437 1.136             60    .0277 3     26.96 3.389
NO.OF OCCURS.           7     7     7     7     7     7     3     7     7                 3     6     1     3     6

SPT :- 0176809403U       NGR :- NY 47000 24400     ULLSWATER - R.EAMONT AT B5320 ROAD BRIDGE (POOLEY BRIDGE)
------                   ------
MEAN                 7.342 14.42 .0133 .274  .0023 19.76 6.666 5.785 1.071             70    .0089 4     7.666 2.5
S.D.    T82          .6399 2.149 .0162 .1696 .0008 10.38 0.0   1.091 .115              10    .0058 0.0   4.041 .6419
MAX                  8.2   16    .05   .5    <.004 <40   <10   7.3   1.2               80    .02   4     12    3.3
MIN                  6.7   11    <.01  .008  <.002 <10   <10   4     .9                60    <.005 4     4     1.6
 5%ILE NORM          6.29  10.89   -VE   -VE .0011 2.683 6.666 3.99  .8823             53.55   -VE 4     1.018 1.444
95%ILE NORM          8.395 17.96 .04   .553  .0036 36.84 6.666 7.581 1.26              86.44 .0185 4     14.31 3.555
 5%ILE LOG           6.339 11.18 .0018 .0913 .0013 7.765 6.666 4.179 .8934             54.84 .0028 4     3.003 1.598
95%ILE LOG           8.44  18.2  .0406 .5946 .0038 39.4  6.666 7.733 1.27              87.54 .0199 4     15.31 3.669
NO.OF OCCURS.           7     7     7     7     7     7     3     7     7                 3     6     1     3     6

SPT :- 0176809404H       NGR :- NY 37150 20750     AIRA BECK 50M D/S OF FOOTBRIDGE NEAR DOWTHWAITEHEAD
------                   ------
MEAN                 6.822 12.55 .0081 .0548 .002  31.66 6.666 3.857 .8429             50    .0067 2     5.888 4.666
S.D.    T83          .4969 5.525 .0054 .034  .0006 14.81 0.0   1.965 .2745             9.354 .0021 0.0   4.476 3.028
MAX                  7.5   21    .02   <.16  .003  55    <10   7.4   1.3               60    .01   2     11    10.3
MIN                  5.7   6     <.005 <.04  <.002 10    <10   1.7   .4                35    <.005 2     <4    2.1
 5%ILE NORM          6.004 3.467   -VE   -VE .001  7.299 6.666 .6242 .3913             34.61 .0032 2       -VE   -VE
95%ILE NORM          7.639 21.64 .017  .1107 .0029 56.03 6.666 7.09  1.294             65.38 .0101 2     13.25 9.647
 5%ILE LOG           6.036 5.752 .0025 .0182 .0012 13.79 6.666 1.559 .4754             36.22 .0038 2     1.543 1.476
95%ILE LOG           7.669 22.95 .0183 .119  .003  59.62 6.666 7.574 1.351             66.68 .0106 2     14.23 10.37
NO.OF OCCURS.           9     9     7     7     7     7     3     7     7                 5     6     1     3     6
```

```
                                                  WATER QUALITY SAMPLE SUMMARIES
                                             FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                           37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
                        FLOW  PH    ALKAL AMMON NO3-N NO2-N ALU.   AL   CAL   MAGNES BOD 5 COD  COND  ORTHO CHLOR SULPHTOTAL
                        INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                                    M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C   MG/L  MG/L   MG/LSUBS
                        M3/S        MG/L        N     N     UG/L  UNAC  MG/L  MG/L   O     O    US/CM P     CL     S04  MG/L
                                    CACO3                         UG/L  CA    MG


SpT :- 0176809404R                  NGR :- NY 43550 16800    BANNERDALE BECK U/S OF FOOTBRIDGE AT DALEHEAD
------                              ------
  AN                          6.927 15.8  .009  .0828 .0021 28.52 13.33 6.112 1.143             71.4  .0067 3     6.333 5.216
 D.          T84              .5424 4.541 .0053 .071  .0007 9.352 5.773 2.455 .3343             9.736 .0021 0.0   1.527 2.627
MAX                           7.9   22    .02   .2    .003  40    20    9.5   1.7               80    .01   3     8     9.5
MIN                           6.1   9     <.005 <.004 <.002 15    10    2.9   .6                60    <.005 3     5     2.1
 5XILE NORM                   6.035 8.33  .0003   -VE .001  13.13 3.836 2.074 .5939             55.38 .0032 3     3.82  .8953
  XILE NORM                   7.819 23.26 .0178 .1996 .0032 43.9  22.83 10.15 1.693             87.41 .0101 3     8.846 9.538
  XILE LOG                    6.072 9.553 .0032 .0185 .0012 16.02 6.187 3.002 .6855             56.58 .0038 3     4.163 2.131
  XILE LOG                    7.853 24.13 .0192 .2132 .0034 45.84 24.19 10.71 1.758             88.44 .0106 3     9.103 10.18
NO.OF OCCURS.                    11    10     7     7     7     7     3     8     8                 5     6     1     3     6

 T :- 0176809417F                   NGR :- NY 55300 11650    WET SLEDDALE RESERVOIR - COMPENSATION WATER AT WEIR
-----                               ------
MEAN                          6.228 9.285 .041  .0666 .003  70.27 20    2.985 .7929             91.66 .0117 4     7.555 11.6
S.D.         T85              .1604 3.147 .0376 .0387 .0016 25.3  10    .8649 .179              85.19 .0139 0.0   4.682 3.678
MAX                           6.5   14    .12   .1    .006  105   30    4.3   1                 190   .04   4     12    15.5
 IN                           6.1   6     <.01  <.004 <.002 <40   10    2     .6                40    <.005 4     <4    6.7
 5XILE NORM                   5.964 4.108   -VE .0029 .0004 28.64 3.551 1.563 .4985               -VE   -VE 4       -VE 5.55
 5XILE NORM                   6.492 14.46 .1029 .1303 .0056 111.9 36.44 4.408 1.087             231.8 .0346 4     15.25 17.65
 5XILE LOG                    5.968 5.112 .0083 .0237 .0012 37.23 8.224 1.797 .536              18.33 .0016 4     2.514 6.645
95XILE LOG                    6.495 15.12 .1092 .1398 .006  117.4 38.9  4.574 1.115             245.8 .0353 4     16.4  18.39
 .OF OCCURS.                      7     7     7     7     7     6     3     7     7                 3     6     1     3     6

SpT :- 0176809417M                  NGR :- NY 50750 12350    SWINDALE BECK 20M U/S OF TRIB FROM SWINDALE HEAD FARM
------                              ------
 EAN                          7.03  17.66 .0157 .0751 .0021 42.61 13.88 6.85  1.481             108   .0067 3     3.666 7.866
 .D.         T86              .6584 11.41 .0202 .1006 .001  25.38 6.735 3.714 .7986             89.2  .0021 0.0   2.962 3.682
 X                            8     40    .06   .3    .004  80    20    14    2.9               260   .01   3     7     13
MIN                           6.3   5     <.005 <.004 <.002 <10   <10   2.6   .6                45    <.005 3     <2    4
 5XILE NORM                   5.947   -VE   -VE   -VE .0005 .866  2.809 .7395 .1676               -VE .0032 3       -VE 1.809
95XILE NORM                   8.112 36.43 .049  .2406 .0038 84.37 24.96 12.96 2.794             254.7 .0101 3     8.54  13.92
 5XILE LOG                    6.002 5.617 .0019 .0085 .0009 14.79 5.867 2.612 .568              25.42 .0038 3     .8887 3.426
 5XILE LOG                    8.162 39.2  .049  .2381 .0041 90.63 26.61 13.88 2.992             272.6 .0106 3     9.152 14.81
 .OF OCCURS.                     10     9     7     7     7     7     3     8     8                 5     6     1     3     6

 PT :- 0176809417R                  NGR :- NY 50300 15700    HAWESWATER AS DISCHARGING TO HAWESWATER BECK
 -----                              ------
 EAN                          6.771 14.71 .0167 .2443 .002  44.76 7.777 4.985 .9571             106.6 .0117 4     7.888 5.6
S.D.         T87              .2059 3.251 .028  .031  .0007 77.59 1.924 .9173 .0535             89.62 .0139 0.0   5.718 1.228
MAX                           7.1   19    .08   .3    .003  220   10    6.6   1                 210   .04   4     14    7.4
 IN                           6.5   10    <.005 .2    <.002 <10   <10   3.5   .9                50    <.005 4     <4    4.3
 5XILE NORM                   6.432 9.366   -VE .1933 .0008   -VE 4.612 3.476 .8692               -VE   -VE 4       -VE 3.58
 5XILE NORM                   7.11  20.06 .0626 .2953 .0032 172.4 10.94 6.494 1.045             254   .0346 4     17.29 7.619
 5XILE LOG                    6.438 10.03 .0013 .1968 .001  3.221 5.056 3.632 .8718             24.54 .0016 4     2.193 3.829
95XILE LOG                    7.115 20.57 .0572 .2984 .0034 155.2 11.27 6.619 1.047             271.7 .0353 4     18.6  7.812
NO.OF OCCURS.                     7     7     7     7     7     7     3     7     7                 3     6     1     3     6

 PT :- 0176809612                   NGR :- NY 32000 33000    GRAINSGILL BECK U/S CARROCK FELL MINE
------                              ------
MEAN                          6.825 17.38 .0131 .1669 .0019 38.52 8.888 2.5   1.314 1.966 3.4   55    .0094 5     2.666 3.2
 .D.         T88              .372  10.25 .0176 .0675 .0009 29.8  1.924 1.595 .3848 2.329 1.064 13.22 .0076 .8944 1.333 1.161
 AX                           7.4   41    .07   .3    .004  103   10    5.5   1.8   6.6   5     70    .03   6     4     5
 IN                           6.1   9     <.005 .1    <.002 20    <10   .9    .8    .6    <4    45    <.005 4     <2    1.8
 5XILE NORM                   6.213 .5222   -VE .0559 .0004   -VE 5.723   -VE .6813   -VE 1.648 33.24   -VE 3.528 .4735 1.29
95XILE NORM                   7.437 34.24 .042  .278  .0034 87.55 12.05 5.125 1.947 5.798 5.151 76.76 .022  6.471 4.859 5.109
 5XILE LOG                    6.23  6.097 .0015 .0816 .0008 9.874 6.109 .8055 .7869 .2719 1.962 36.2  .0023 3.675 1.096 1.686
 5XILE LOG                    7.453 36.77 .0415 .2935 .0036 94.01 12.35 5.512 2.021 5.919 5.365 78.98 .0236 6.59  5.187 5.364
 O.OF OCCURS.                    12    13    13    13    13     7     3     7     7     6     5     3    12     6     3     6

 PT :- 0176809614                   NGR :- NY 32800 32600    RIVER CALDEW 50M D/S GRAINSGILL BECK
-----                               ------
 EAN                          6.723 9.615 .0113 .1692 .0017 35.66 9.444 1.757 1.178 .9333 7.277 43.33 .0094 5.166 2.666 2.833
 .D.         T89              .4362 3.453 .01   .0727 .0005 25.06 4.811 .7934 .2942 .367  10.65 2.886 .0053 .7528 1.333 1.493
MAX                           7.4   17    .04   .3    .003  73    15    2.9   1.6   1.4   29    45    .02   6     4     4.6
MIN                           6.1   5     <.005 .08   <.002 <10   <10   .6    .8    .4    <4    40    <.005 4     <2    1.3
 5XILE NORM                   6.005 3.935   -VE .0496 .0009   -VE 1.53  .452  .6947 .3297   -VE 38.58 .0007 3.928 .4735 .3766
 5XILE NORM                   7.44  15.29 .0278 .2889 .0026 76.89 17.35 3.062 1.662 1.537 24.8  48.08 .0181 6.404 4.859 5.29
 5XILE LOG                    6.03  5.103 .0024 .079  .001  10.29 3.818 .7885 .7631 .4656 .706  38.75 .0035 4.028 1.096 1.11
95XILE LOG                    7.463 16.04 .0296 .3061 .0026 82.72 18.54 3.252 1.713 1.62  23.86 48.23 .0195 6.489 5.187 5.659
NO.OF OCCURS.                    13    13    13    13    13     7     3     7     7     6     6     3    12     6     3     6
```

```
                              WATER QUALITY SAMPLE SUMMARIES
                         FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                    37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
            FLOW     PH ALKAL AMMON NO3-N NO2-N ALU     AL  CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
            INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                        M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L 25C    MG/L MG/L  MG/LSUBS
            M3/S         MG/L     N     N     UG/L  UNAC  MG/L  MG/L   O     O   US/CM P     CL     SO4  MG/L
                         CACO3                      UG/L  CA    MG

  T :- 0175809026HE      NGR :- NY 23300 12200    SOUR MILK GILL PTC RIVER DERWENT
  ----                   ------
  AN               6.111 3.666                   65.41 46.11 1.422 .4356             35.93        8           1.4
S.D.     T90       .6509 1.658                   71.2  44.94 .5974 .1412             9.462         0.0         0.0
MAX                7.4   7                       210   130   2.3   .75               50           8           1.4
  N                5.3   1                       10    <20   .6    .3                19           8           1.4
 %ILE NORM         5.04  .9389                     -VE   -VE .4395 .2034             20.36        8           1.4
 %ILE NORM         7.181 6.394                   182.5 120   2.405 .6678             51.49        8           1.4
 5%ILE LOG         5.102 1.643                   10.33 8.61  .6756 .2464             22.69        8           1.4
95%ILE LOG         7.236 6.792                   189.4 126.6 2.544 .6968             53.2         8           1.4
N .OF OCCURS.          9     9                       8     6     9     9                 9            1           1

  T :- 0175809026P       NGR :- NY 25450 13950    COOMBE GILL AT B5289 PTC RIVER DERWENT
------                   ------
MEAN               6.7   6.3                     30    13.33 2.71  .643              45.13        7           1.5
  D.     T91       .5558 2.451                   46.15 12.17 .788  .1791             9.615         0.0        .7071
  X                7.6   10                      150   40    4.3   .95               58           7           2
  N                5.7   3                       <10   <10   1.5   .37               30           7           1
 5%ILE NORM        5.785 2.267                     -VE   -VE 1.413 .3483             29.31        7           .3369
95%ILE NORM        7.614 10.33                   105.9 33.35 4.006 .9377             60.94        7           2.663
 %ILE LOG          5.826 3.165                   2.669 2.736 1.628 .3951             31.21        7           .6494
  %ILE LOG         7.651 10.88                   100.1 35.43 4.157 .9712             62.42        7           2.834
  .OF OCCURS.         10    10                       9     7    10    10                10            1           2

SPT :- 0175809026T       NGR :- NY 27350 13050    STONETHWAITE BECK D/S OF GREENUP GILL
  ----                   ------
  AN               6.78  8.1                     52.03 23.09 2.64  .687              43.8         7           3
 .D.     T92       .5959 4.931                   79.17 12.56 .9629 .2385             12.18         0.0         0.0
MAX                8.1   20                      260   40    4     1.05              63           7           3
MIN                5.9   4                       <10   10    1.1   .34               26           7           3
 %ILE NORM         5.799   -VE                     -VE 2.432 1.056 .2947             23.76        7           3
 %ILE NORM         7.76  16.21                   182.2 43.75 4.223 1.079             63.83        7           3
 %ILE LOG          5.846 2.747                   4.72  8.781 1.386 .3726             26.93        7           3
95%ILE LOG         7.8C2 17.42                   173   46.87 4.435 1.13              66.11        7           3
NO.OF OCCURS.         10    10                       9     7    10    10                10            1           1
```

Appendix 9

```
                                             WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                   37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183 9968
             FLOW     PH ALKAL AMMON NO3-N NO2-N ALU     AL   CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR   SULPHTOTAL
             INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE      ATE HUMIC
                         M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L    MG/LSUBS
             M3/S         MG/L         N     N   UG/L  UNAC  MG/L  MG/L   0      0   US/CM P     CL      SO4   MG/L
                          CACO3                        UG/L  CA    MG

SPT :- 0172806479R       NGR :- SD 56600 55300    RIVER GRIZEDALE AT GRIZEDALE BRIDGE
------                   ------
MEAN               6.058 6.937 .0333 .5333 .0133 153.3 93.12 5.788 1.39        2.666 92.88 .0333 8            13.5
S.D.     P4        .6702 6.405  0.0  .2843  0.0  84.66 71.76 2.212 .393         0.0  19.64  0.0  1.414        10.6
MAX                6.8   19    <.05  .85   <.02  260   190   8.1   2.33        <4    120   <.05  9            21
MIN                5.1   1     <.05  .3    <.02  50    20    3.1   1           <4    53    <.05  7            6
 5%ILE NORM        4.956   -VE .0333 .0657 .0133 14.06   -VE 2.149 .7436       2.666 60.57 .0333 5.673          -VE
95%ILE NORM        7.161 17.47 .0333 1.001 .0133 292.6 211.1 9.428 2.036       2.666 125.2 .0333 10.32        30.94
 5%ILE LOG         5.023 1.4   .0333 .2067 .0133 57.45 23.99 2.945 .8477       2.666 64.42 .0333 5.903        3.393
95%ILE LOG         7.219 18.54 .0333 1.071 .0133 313.6 226.7 9.926 2.11        2.666 128.1 .0333 10.51        33.2
NO.OF OCCURS.          9     8     3     3     3     9     8     9     9           1     9     3     2            2

SPT :- 0172806479K       NGR :- SD 58900 55600    TARNBROOK WYRE AT TARNBROOK
------                   ------
MEAN               6.383 6.041 .0333 .4167 .0133 132.5 75    2.977 1.572       7     83    .0389 5            13
S.D.     P5        .7541 3.026  0.0  .1607  0.0  89.72 51.72 .4324 .1915        0.0  48.41 .0096 4.242        11.31
MAX                7.2   11    <.05  .6    <.02  280   160   3.9   1.8         7     210   .05   8            21
MIN                4.74  2     <.05  .3    <.02  30    20    2.5   1.25        7     48    <.05  2            5
 5%ILE NORM        5.142 1.064 .0333 .1523 .0133   -VE   -VE 2.266 1.257       7     3.358 .0231   -VE          -VE
95%ILE NORM        7.623 11.01 .0333 .681  .0133 280   160   3.689 1.887       7     162.6 .0547 11.97        31.6
 5%ILE LOG         5.223 2.48  .0333 .2107 .0133 39.93 22.13 2.323 1.278       7     29.43 .0253 1.135        2.851
95%ILE LOG         7.693 11.76 .0333 .7174 .0133 301.3 172.2 3.737 1.905       7     174.6 .0564 12.8         33.72
NO.OF OCCURS.          9     8     3     3     3     8     7     9     9           1     9     3     2            2

SPT :- 0172806567        NGR :- SD 53650 49150    GRIZEDALE BROOK ABOVE GRIZEDALE RESERVOIR
------                   ------
MEAN               7.153 28.68 .0389 .4944 .0222 105.5 45.62 13.4  2.456       6     139.4 .0333 5            15.55
S.D.     P6        .4938 12.98 .0096 .436  .0154 76.01 21.61 2.623 .6677        0.0  20.74  0.0  5.656        11.95
MAX                8.3   50    .05   .9    .04   240   75    17    3.8         6     170   <.05  9            24
MIN                6.5   8     <.05  <.05  <.02  30    20    7.9   1.41        6     109   <.05  1            7.1
 5%ILE NORM        6.341 7.326 .0231   -VE   -VE   -VE 10.06 9.085 1.358       6     105.3 .0333   -VE          -VE
95%ILE NORM        7.965 50.04 .0547 1.211 .0475 230.5 81.18 17.71 3.554       6     173.5 .0333 14.3         35.2
 5%ILE LOG         6.371 12.84 .0253 .1065 .0065 29.58 19.66 9.559 1.528       6     108.1 .0333 .7438        4.02
95%ILE LOG         7.993 53.16 .0564 1.291 .0512 248   86.44 18.09 3.677       6     175.9 .0333 14.74        37.81
NO.OF OCCURS.          9     8     3     3     3     9     8     9     9           1     9     3     2            2

SPT :- 0171804420        NGR :- SD 70200 59000    RIVER HODDER ABOVE STOCKS RESERVOIR AT CROSS GREET BRIDGE
------                   ------
MEAN               7.018 14.97 .0486 .5501 .0106 140.6 86.87 2.412 1.55  .8833 13.25 93.09 .0262 8.16         7.32
S.D.     P7        1.056 15.43 .0381 .8994 .0035 97.63 68.7  .6978 .4375 .4365 9.623 68.52 .0121 1.972        6.225
MAX                8.4   67    .2    5     .02   300   200   3.5   2.1   1.7   44    317   .05   11           17.3
MIN                4.67  2     .01   <.05  <.01  20    <15   1.6   .9    <.5   7     57    <.01  3            2.3
 5%ILE NORM        5.28    -VE   -VE   -VE .0049   -VE   -VE 1.264 .8303 .1654   -VE   -VE .0063 4.915          -VE
95%ILE NORM        8.757 40.36 .1113 2.029 .0163 301.2 199.8 3.56  2.269 1.601 29.08 205.8 .046  11.4         17.56
 5%ILE LOG         5.425 2.573 .0123 .044  .006  41.16 21.65 1.453 .946  .3671 3.68  25.4  .0115 5.359        1.656
95%ILE LOG         8.878 42.26 .1195 1.874 .017  324.1 214.4 3.694 2.352 1.708 31.28 221.2 .049  11.73        18.76
NO.OF OCCURS.         27    27    27    27    27     8     8     8     8    18    18    13    27    25            5

SPT :- 0171804160        NGR :- SD 79350 77800    CAM BECK PTC RIVER RIBBLE
------                   ------
MEAN               7.795 56.96 .0562 .4922 .0136 63.22 33.44 18.38 1.455 .96   27    162.1 .0391 13.38        15
S.D.     P8        .6253 48.59 .0592 .7865 .0078 33.85 22.92 9.83  .8443 .5941 13.71 80.8  .0183 16.8         8.854
MAX                8.9   184   .25   3.1   .04   120   80    40.5  3.4   2     38    320   .1    64           29.8
MIN                6.8   15    .03   <.05  <.01  20    11    7.1   .8    .6    8     81    .02   4            8
 5%ILE NORM        6.766   -VE   -VE   -VE .0007 7.539   -VE 2.218 .0668   -VE 4.446 29.26 .009    -VE        .4358
95%ILE NORM        8.823 136.9 .1535 1.786 .0264 118.9 71.15 34.55 2.844 1.937 49.55 295   .0692 41.02        29.56
 5%ILE LOG         6.811 12.84 .0094 .041  .0049 24.4  9.939 7.109 .5192 .3199 10.94 66.9  .0171 1.683        5.255
95%ILE LOG         8.864 146.2 .1603 1.664 .0283 127.2 76.56 36.99 3.053 2.082 52.93 314.9 .0736 41.31        31.75
NO.OF OCCURS.         15    15    15    15    15     9     9     9     9     5     4    10    15    13            6
```

```
                                        WATER QUALITY SAMPLE SUMMARIES
                                 FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                     37     61   162    111    117    118    7760   9509   241    237    85     92     77     180    172    183  9968
                   FLOW     PH   ALKAL  AMMON  NO3-N  NO2-N  ALU    AL     CAL    MAGNES BOD 5  COD    COND   ORTHO  CHLOR  SULPHTOTAL
                   INST          INITY  IA N                 MIN    MONO   CIUM   IUM    ATU           AT     PHOSP  IDE     ATE HUMIC
                                 M.O.   MG/L   MG/L   MG/L   IUM    MERIC                MG/L   MG/L   25C    MG/L   MG/L   MG/LSUBS
                   M3/S          MG/L          N      N      UG/L   UNAC   MG/L   MG/L   O      O      US/CM  P      CL     SO4  MG/L
                                 CACO3                              UG/L   CA     MG

SPT :- 0171804420          NGR :- SD 70200 59000     RIVER HODDER ABOVE STOCKS RESERVOIR AT CROSS GREET BRIDGE
------                     ------
MEAN           P7        7.018  14.97  .0486  .5501  .0106  140.6  86.87  2.412  1.55   .8833  13.25  93.09  .0262  8.16          7.32
S.D.                     1.056  15.43  .0381  .8994  .0035  97.63  68.7   .6978  .4375  .4365  9.623  68.52  .0121  1.972         6.225
MAX                      8.4    67     .2     5      .02    300    200    3.5    2.1    1.7    44     317    .05    11            17.3
MIN                      4.67   2      .01    <.05   <.01   20     <15    1.6    .9     <.5    7      57     <.01   3             2.3
 5%ILE NORM              5.28     -VE    -VE    -VE  .0049    -VE    -VE  1.264  .8303  .1654    -VE    -VE  .0063  4.915           -VE
95%ILE NORM              8.757  40.36  .1113  2.029  .0163  301.2  199.8  3.56   2.269  1.601  29.08  205.8  .046   11.4          17.56
 5%ILE LOG               5.425  2.573  .0123  .044   .006   41.16  21.65  1.453  .946   .3671  3.68   25.4   .0115  5.359         1.656
95%ILE LOG               8.878  42.26  .1195  1.874  .017   324.1  214.4  3.694  2.352  1.708  31.28  221.2  .049   11.73         18.76
NO.OF OCCURS.               27     27     27     27     27      8      8      8      8     18     18     13     27     25             5

SPT :- 0171804160          NGR :- SD 79350 77800     CAM BECK PTC RIVER RIBBLE
------                     ------
MEAN           P8        7.795  56.96  .0562  .4922  .0136  63.22  33.44  18.38  1.455  .96    27     162.1  .0391  13.38         15
S.D.                     .6253  48.59  .0592  .7865  .0078  33.85  22.92  9.83   .8443  .5941  13.71  80.8   .0183  16.8          8.854
MAX                      8.9    184    .25    3.1    .04    120    80     40.5   3.4    2      38     320    .1     64            29.8
MIN                      6.8    15     .03    <.05   <.01   20     11     7.1    .8     .6     8      81     .02    4             8
 5%ILE NORM              6.766    -VE    -VE    -VE  .0007  7.539    -VE  2.218  .0668    -VE  4.446  29.26  .009     -VE         .4358
95%ILE NORM              8.823  136.9  .1535  1.786  .0264  118.9  71.15  34.55  2.844  1.937  49.55  295    .0692  41.02         29.56
 5%ILE LOG               6.811  12.84  .0094  .041   .0049  24.4   9.939  7.109  .5192  .3199  10.94  66.9   .0171  1.683         5.255
95%ILE LOG               8.864  146.2  .1603  1.664  .0283  127.2  76.56  36.99  3.053  2.082  52.93  314.9  .0736  41.31         31.75
NO.OF OCCURS.               15     15     15     15     15      9      9      9      9      5      4     10     15     13             6

SPT :- 0171805234          NGR :- SD 67100 22200     EARNSDALE RESERVOIR
------                     ------
MEAN           P9        7.238  25     .07    .68    .0147  58.75  16.66  14.37  3.075                153    .0333  8.75          13.83
S.D.                     .4473  8.66   .0532  .4324  .003   19.31  7.817  1.17   .25                  12.56  0.0    1.5           5.248
MAX                      7.96   40     .15    1.2    .02    70     25     15.9   3.4                  163    <.05   11            18.4
MIN                      6.74   20     <.05   .1     <.02   30     <10    13.1   2.8                  132    <.05   8             8.1
 5%ILE NORM              6.502  10.75    -VE    -VE  .0098  26.98  3.807  12.45  2.663                132.3  .0333  6.282         5.2
95%ILE NORM              7.973  39.24  .1576  1.391  .0196  90.51  29.52  16.29  3.486                173.6  .0333  11.21         22.46
 5%ILE LOG               6.526  13.57  .0183  .22    .0103  32.95  7.246  12.53  2.681                133.2  .0333  6.518         7.075
95%ILE LOG               7.996  41.09  .1693  1.496  .02    94.52  31.42  16.37  3.502                174.5  .0333  11.41         23.64
NO.OF OCCURS.                5      5      5      5      5      4      4      4      4                    5      5      4             3

SPT :- 0171804638          NGR :- SD 88800 31500     HURSTWOOD RESERVOIR
------                     ------
MEAN           P10       5.23   3.277  .0778  .3333  .0133  298    324    4.62   1.3                  100.8  .0361  14.8          8.95
S.D.                     .84    .1361  .0344  .1169  0.0    164.8  116.9  .2387  .0707                11.95  .0068  5.974         5.02
MAX                      6.84   <5     .1     .5     <.02   510    480    5      1.4                  122    .05    25            12.5
MIN                      4.54   3      <.05   .15    <.02   50     170    4.4    1.2                  88     <.05   10            5.4
 5%ILE NORM              3.848  3.053  .0211  .141   .0133  26.86  131.6  4.227  1.183                81.16  .0249  4.971         .6918
95%ILE NORM              6.611  3.501  .1344  .5256  .0133  569.1  516.3  5.012  1.416                120.5  .0473  24.62         17.2
 5%ILE LOG               3.971  3.058  .0355  .1796  .0133  111.4  171.4  4.238  1.187                82.44  .0261  7.242         3.301
95%ILE LOG               6.714  3.506  .1426  .5508  .0133  610    541.8  5.022  1.419                121.6  .0482  26            18.45
NO.OF OCCURS.                6      6      6      6      6      5      5      5      5                    6      6      5             2

SPT :- 0171804976          NGR :- SD 78800 27600     MITCHELL'S HOUSE NO1 RESERVOIR
------                     ------
MEAN           P11       6.717  8.714  .0833  .3905  .0133  184.1  63.33  7.9    1.383                99.12  .0333  8.5           13.55
S.D.                     .3424  1.889  .0687  .2269  0.0    55.71  39.45  1.812  .3061                6.936  0.0    1.87          2.199
MAX                      7.1    10     .2     .65    <.02   270    130    9.4    1.6                  109    <.05   11            15.9
MIN                      6      5      <.05   <.05   <.02   130    20     4.5    .8                   91     <.05   6             11.3
 5%ILE NORM              6.154  5.605    -VE  .0173  .0133  92.52    -VE  4.919  .8799                87.71  .0333  5.422         9.932
95%ILE NORM              7.28   11.82  .1964  .7636  .0133  275.8  128.2  10.88  1.886                110.5  .0333  11.57         17.16
 5%ILE LOG               6.169  5.985  .0197  .1391  .0133  108.3  20.95  5.305  .9427                88.14  .0333  5.804         10.25
95%ILE LOG               7.294  12.11  .2102  .8198  .0133  286.8  137.8  11.17  1.935                110.9  .0333  11.87         17.43
NO.OF OCCURS.                7      7      7      7      7      6      6      6      6                    7      7      6             4

SPT :- 0171804707          NGR :- SD 80600 39700     UPPER OGDEN RESERVOIR
------                     ------
MEAN           P12       6.21   5.027  .0528  .9     .0678  240    73     4.02   2.14                 84.33  .0333  8             7.25
S.D.                     .5703  2.227  .0476  .1703  .1334  72.19  86.57  .3194  .2302                4.179  0.0    2.345         4.737
MAX                      6.78   8      .15    1.05   .34    365    225    4.5    2.4                  89     <.05   12            10.6
MIN                      5.16   3      <.05   .6     <.02   180    <15    3.6    1.8                  78     <.05   6             3.9
 5%ILE NORM              5.272  1.364    -VE  .6199    -VE  121.2    -VE  3.494  1.761                77.45  .0333  4.142           -VE
95%ILE NORM              7.148  8.691  .1311  1.18   .2871  358.7  215.4  4.545  2.518                91.2   .0333  11.85         15.04
 5%ILE LOG               5.318  2.291  .011   .6496  .0039  141.6  10.07  3.517  1.783                77.64  .0333  4.787         2.275
95%ILE LOG               7.19   9.222  .1395  1.203  .2433  372.9  219.8  4.565  2.538                91.37  .0333  12.31         16.18
NO.OF OCCURS.                6      6      6      6      6      5      5      5      5                    6      6      5             2

SPT :- 0170806002          NGR :- SD 62800 16000     RIVER YARROW IMMEDIATELY U/S OF YARROW RESERVOIR
------                     ------
MEAN           P13       5.432  3.333  .125   .4062  .0133  370    323.3  4.62   1.52          24.5   99.03  .0333  18.28         13,02
S.D.                     .8589  1.259  .138   .1841  0.0    105.5  55.07  1.103  .3564         20.5   4.859  0.0    22.9          4.333
MAX                      6.87   5      .45    .7     <.02   520    380    5.5    1.8           39     108    <.05   70            18.3
MIN                      4.63   <2.5   <.05   .15    <.02   230    270    2.7    .9            10     92     <.05   6             8.1
 5%ILE NORM              4.019  1.261    -VE  .1035  .0133  196.3  232.7  2.805  .9338           -VE  91.04  .0333    -VE         5.896
95%ILE NORM              6.845  5.405  .352   .709   .0133  543.6  413.9  6.434  2.106         58.23  107    .0333  55.95         20.15
 5%ILE LOG               4.143  1.709  .0193  .1818  .0133  224.5  241.3  3.05   1.011         5.666  91.25  .0333  2.308         7.252
95%ILE LOG               6.948  5.687  .3644  .7533  .0133  563.7  420.9  6.619  2.165         62.28  107.2  .0333  56.37         21.06
NO.OF OCCURS.                8      8      8      8      8      5      3      5      5             2      8      8      7             4
```

```
                                            WATER QUALITY SAMPLE SUMMARIES
                                    FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172     183  9968
             FLOW    PH  ALKAL AMMON NO3-N NO2-N ALU    AL    CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR  SULPHTOTAL
             INST        INITY IA N              MIN   MONO   CIUM  IUM   ATU         AT    PHOSP  IDE   ATE HUMIC
                         M.O.  MG/L  MG/L  MG/L  IUM   MERIC              MG/L  MG/L  25C    MG/L MG/L   MG/LSUBS
             M3/S         MG/L     N     N   UG/L  UNAC   MG/L  MG/L   O     O    US/CM P     CL      SO4  MG/L
                          CACO3                    UG/L   CA    MG

SPT :- 0169801192         NGR :- SD 83200 15600     ASHWORTH MOOR RESERVOIR
-------                   -------
MEAN                4.49  3.333 .0833 .4357 .0133 595.7 541.6 3.562 1.625             109   .0357 10          2.06
S.D.      P14       .2932 .8909 .0408 .1107  0.0  56.52 76.26 .7328 .2915             13.8  .0063 1.581       1.436
MAX                 5.13  5     .15   .6    <.02  660   630   4.8   2                 142   .05   12          3.5
MIN                 4.26  <2.5  <.05  .3    <.02  520   420   2.1   1                 101   <.05  8           <.3
 5%ILE NORM         4.007 1.867 .0162 .2536 .0133 502.7 416.2 2.357 1.145             86.29 .0254 7.399         -VE
95%ILE NORM         4.972 4.798 .1505 .6179 .0133 688.6 667.1 4.767 2.104             131.7 .0461 12.6        4.422
 5%ILE LOG          4.024 2.09  .0349 .2798 .0133 507.5 425.9 2.496 1.193             87.87 .0264 7.627       .6001
95%ILE LOG          4.988 4.96  .1605 .6373 .0133 692.9 675.3 4.877 2.143             133   .0469 12.79       4.758
NO.OF OCCURS.          8     8     7     7     7     7     6     8     8                 8     7     5           5

SPT :- 0169800995         NGR :- SD 97000 18000     BLACKSTONE EDGE RESERVOIR
-------                   -------
MEAN                3.988 3.095 .5792 .5625 .0133 422.5 356.2 2.312 .9562             179.3 .0375 31.42       7.26
S.D.      P15       .2484 .6299 .2693 .1598  0.0  142.1 138.4 .879  .5165             22.98 .0077 8.58        2.649
MAX                 4.58  <5    1     .8    <.02  630   500   4.2   2.2               205   .05   41          11
MIN                 3.76  <2.5  <.05  .35   <.02  130   130   1.1   .5                147   <.05  18          4
 5%ILE NORM         3.58  2.059 .1362 .2996 .0133 188.7 128.5 .8666 .1067             141.5 .0248 17.31       2.902
95%ILE NORM         4.397 4.131 1.022 .8254 .0133 656.2 583.9 3.758 1.805             217.1 .0502 45.54       11.61
 5%ILE LOG          3.593 2.177 .2537 .3422 .0133 233.7 179.1 1.181 .3661             144.2 .0263 19.5        3.812
95%ILE LOG          4.41  4.224 1.087 .8556 .0133 686.1 615.3 3.955 1.933             219.4 .0513 47.12       12.2
NO.OF OCCURS.          8     7     8     8     8     8     8     8     8                 8     8     7           5

SPT :- 0169801083         NGR :- SD 89700 16400     BROWNHOUSE WHAM RESERVOIR
-------                   -------
MEAN                5.971 5.166 .1479 .1542 .0133 218.1 86.42 5.785 6.028             143.5 .0479 7.25        2.98
S.D.      P16       .6192 2.532 .2042 .1419  0.0  173.8 85.96 2.195 2.091             22.84 .0412 1.165       1.917
MAX                 6.65  10    .6    .45   <.02  510   250   8.5   9.6               185   .15   9           5.5
MIN                 4.99  <5    <.05  <.05  <.02  30    20    2.6   3.7               112   <.05  5           1
 5%ILE NORM         4.952 1.001   -VE   -VE .0133   -VE   -VE 2.173 2.589             105.9   -VE 5.333         -VE
95%ILE NORM         6.989 9.332 .4838 .3876 .0133 504   227.8 9.397 9.468             181   .1158 9.166       6.134
 5%ILE LOG          5.01  2.162 .0159 .0313 .0133 53.83 15.66 2.958 3.271             109.2 .0107 5.504       .9517
95%ILE LOG          7.04  9.952 .4745 .4115 .0133 540.5 239.7 9.889 9.915             183.8 .1236 9.308       6.598
NO.OF OCCURS.          8     8     8     8     8     8     7     7     7                 8     8     8           5

SPT :- 0169800708         NGR :- SD 84600 26900     CLOUGH BOTTOM RESERVOIR
-------                   -------
MEAN                5.372 4.238 .0714 .45   .0133 341.6 191.6 5.758 1.566             162.5 .0333 28.16       8.325
S.D.      P17       .2193 2.543 .0356 .1826  0.0  101.6 117.8 1.447 .2875             47     0.0  16.98       3.156
MAX                 5.6   10    .1    .65   <.02  470   380   7     1.8               221   <.05  54          11.1
MIN                 4.93  3     <.05  .2    <.02  210   110   3.5   1                 114   <.05  14          5.3
 5%ILE NORM         5.012 .0538 .0128 .1497 .0133 174.4   -VE 3.376 1.093             85.25 .0333 .2243       3.133
95%ILE NORM         5.733 8.422 .13   .7503 .0133 508.9 385.5 8.14  2.039             239.8 .0333 56.1        13.51
 5%ILE LOG          5.019 1.459 .0294 .2194 .0133 202.8 64.3  3.716 1.142             97.99 .0333 9.649       4.26
95%ILE LOG          5.741 9.049 .1388 .7925 .0133 528.7 414.4 8.392 2.078             248.8 .0333 60.29       14.22
NO.OF OCCURS.          7     7     7     7     7     6     6     6     6                 7     7     6           4

SPT :- 0169800695         NGR :- SD 84200 20200     COWPE RESERVOIR
-------                   -------
MEAN                6.07  4.666 .0646 .6775 .0217 211.6 94.16 2.933 2.483             86.87 .0333 6.5         2.14
S.D.      P18       .3746 2.274 .0458 .2502 .0236 104   110.1 1.114 .5565             3.226  0.0  .5477       1.137
MAX                 6.35  10    .15   1.1   .08   360   300   3.8   3                 90    <.05  7           3.8
MIN                 5.24  4     <.05  .27   <.02  90    20    1.1   1.4               82    <.05  6           1.1
 5%ILE NORM         5.453 .9249   -VE .2659   -VE 40.59   -VE 1.099 1.568             81.56 .0333 5.599       .2696
95%ILE NORM         6.686 8.408 .1399 1.089 .0604 382.7 275.2 4.767 3.398             92.18 .0333 7.4         4.01
 5%ILE LOG          5.474 1.962 .0184 .3529 .0034 88.4  13.29 1.498 1.683             81.67 .0333 5.64        .8321
95%ILE LOG          6.705 8.965 .1505 1.144 .0627 408.2 281.7 5.017 3.487             92.28 .0333 7.438       4.292
NO.OF OCCURS.          8     8     8     8     8     6     6     6     6                 8     8     6           5

SPT :- 0169801055         NGR :- SD 96850 12400     HANGING LEES RESERVOIR
-------                   -------
MEAN                5.77  4.166 .0952 .6429 .0133 293.7 107.1 4.214 2.857             145   .0357 22.28       4.12
S.D.      P19       .6176 2.519 .0692 .3047  0.0  100.7 87.12 1.327 .6399             11.61 .0063 5.219       1.892
MAX                 6.68  10    .2    1.2   <.02  440   280   5.8   3.8               169   .05   30          6.9
MIN                 5.01  <2.5  <.05  .3    <.02  130   10    2.5   1.7               133   <.05  15          2.2
 5%ILE NORM         4.754 .0219   -VE .1416 .0133 128.1   -VE 2.031 1.804             125.8 .0254 13.7        1.006
95%ILE NORM         6.786 8.311 .2091 1.144 .0133 459.3 250.4 6.397 3.909             164.1 .0461 30.87       7.233
 5%ILE LOG          4.813 1.423 .0264 .277  .0133 160.5 25.75 2.423 1.937             126.7 .0264 14.83       1.822
95%ILE LOG          6.838 8.931 .2248 1.218 .0133 480.8 268.3 6.666 4.011             164.8 .0469 31.73       7.689
NO.OF OCCURS.          8     8     7     7     7     8     7     7     7                 8     7     7           5

SPT :- 0169801188         NGR :- SD 85150 17150     NADEN HIGHER RESERVOIR
-------                   -------
MEAN                4.784 4.047 .0619 .4    .0133 432.8 280   2.178 2.128             82.85 .0333 6.857       3.54
S.D.      P20       .291  2.697 .0459 .1384  0.0  105.4 172   .7336 .4071             3.338  0.0  1.463       2.308
MAX                 5.35  10    .15   .6    <.02  570   520   3     2.5               87    <.05  8           7
MIN                 4.55  <2.5  <.05  .2    <.02  240   20    .95   1.3               78    <.05  5           1.5
 5%ILE NORM         4.305   -VE   -VE .1723 .0133 259.3   -VE .9718 1.459             77.36 .0333 4.449         -VE
95%ILE NORM         5.262 8.484 .1373 .6277 .0133 606.3 562.9 3.385 2.798             88.34 .0333 9.265       7.336
 5%ILE LOG          4.321 1.242 .0168 .2174 .0133 283.3 94.03 1.204 1.53              77.48 .0333 4.738       1.113
95%ILE LOG          5.277 9.129 .1476 .6573 .0133 624.2 605.2 3.539 2.855             88.45 .0333 9.49        7.893
NO.OF OCCURS.          7     7     7     7     7     7     7     7     7                 7     7     7           5
```

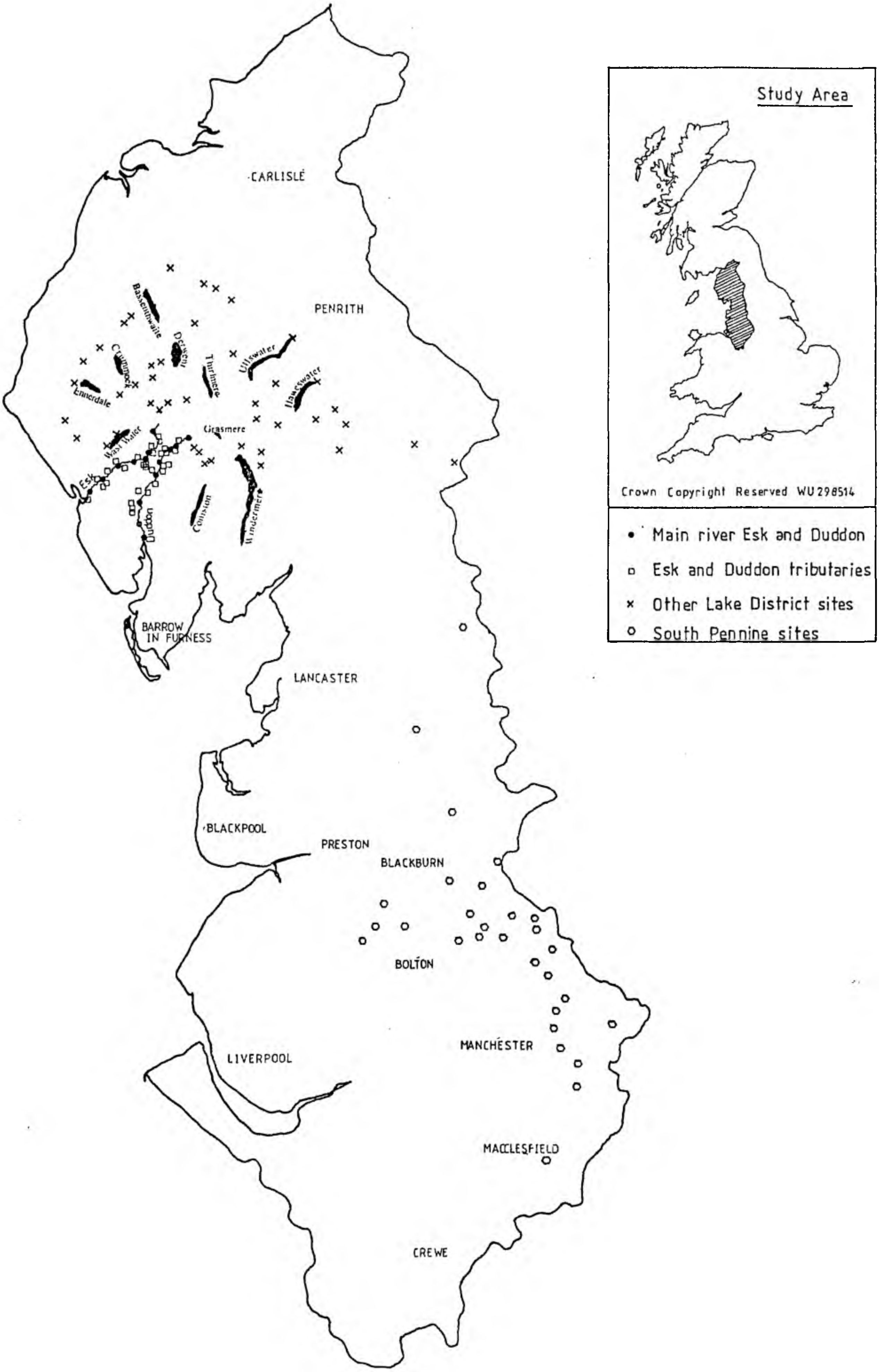
```
                                  WATER QUALITY SAMPLE SUMMARIES
                             FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                     37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
                  FLOW     PH ALKAL AMMON NO3-N NO2-N ALU     AL  CAL  MAGNES BOD 5 COD   COND  ORTHO CHLOR SULPHTOTAL
                  INST        INITY IA N              MIN   MONO  CIUM  IUM   ATU         AT    PHOSP IDE    ATE HUMIC
                              M.O.  MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L  25C    MG/L MG/L  MG/LSUBS
                  M3/S         MG/L        N     N    UG/L  UNAC  MG/L  MG/L   O     O    US/CM P     CL     SO4  MG/L
                              CACO3                         UG/L  CA    MG

SPT :- 0169810245             NGR :- SD 91600 21400   RAMSDEN CLOUGH RESERVOIR (DUMMY H.R.)
------                        ------
MEAN                    4.776 3.428 .2042 .5937 .0133 461.2 325   3.287 1.775             91.25 .0333 7             4.52
  D.        P21         .454  .252  .2045 .1522   0.0 141.8 101.2 .9156 .4652             15      0.0 1.825         3.61
  X                     5.1   <5    .55   .75   <.02  770   440   4.1   2.2               128   <.05  10            10.8
  N                     3.72  4     <.05  .35   <.02  300   150   1.7   1                 83    <.05  4              1.8
 5%ILE NORM             4.029 3.014   -VE .3434 .0133 227.8 158.4 1.781 1.009             66.57 .0333 3.996          -VE
95%ILE NORM             5.523 3.843 .5405 .8441 .0133 694.6 491.5 4.793 2.54              115.9 .0333 10           10.45
  %ILE LOG              4.068 3.03  .0366 .3798 .0133 268.8 188   2.02  1.123             68.82 .0333 4.441        1.112
  %ILE LOG              5.557 3.858 .5682 .871  .0133 722.9 511.9 4.964 2.623             117.7 .0333 10.32        11.21
  .OF OCCURS.               8     7     8     8     8     8     8     8     8                 8     8     7            5
SPT :- 0169810247             NGR :- SD 96100 20400   WARLAND RESERVOIR (DUMMY H.R.)
  ----                        ------
  AN                    4.071 3.095 .4187 .5375 .0133 352.8 298.3 1.387 .8062             107   .0458 6.571        13.76
  D.        P22         .4959 .6299 .1831 .1685   0.0 82.2  41.67 .6424 .2757             17.57 .0231 1.812        2.464
MAX                     4.91  <5    .65   .9    <.02  490   360   2.8   1.4               124   .1    9             16.6
MIN                     3.71  <2.5  .1    .35   <.02  230   230   .6    .4                79    <.05  4             10.6
  %ILE NORM             3.255 2.059 .1176 .2603 .0133 217.6 229.7 .3308 .3527             78.09 .0078 3.589        9.706
  %ILE NORM             4.886 4.131 .7199 .8147 .0133 488   366.8 2.444 1.259             135.9 .0839 9.553        17.81
  %ILE LOG              3.31  2.177 .1928 .31   .0133 235.4 235   .6099 .4414             80.73 .0187 4.057        10.11
  %ILE LOG              4.934 4.224 .7634 .8487 .0133 501.5 371.3 2.599 1.318             138   .0896 9.889        18.14
NO.OF OCCURS.               8     7     8     8     8     7     6     8     8                 8     8     7            5

  T :- 0169810248             NGR :- SD 97400 20100   WHITEHOLME RESERVOIR (DUMMY H.R.)
  ----                        ------
  EAN                   3.806 3.055 .4104 .5    .0133 588.7 452.8 1.487 .7375             139.6 .0437 12           12.48
S.D.        P23         .1392 .6804 .2594 .189    0.0 259.7 94.11 .4734 .2066             31.02 .0235 4.32         3.875
MAX                     4.07  <5    .85   .85   <.02   1200 560   2.3   1.1               197   .1    18            17.4
  N                     3.6   <2.5  <.05  .3    <.02  350   320   1     .4                95    <.05  5              8.9
  %ILE NORM             3.577 1.936   -VE .1891 .0133 161.4 298   .7088 .3977             88.59 .0052 4.893        6.105
  %ILE NORM             4.035 4.174 .8371 .8109 .0133  1016 607.6 2.266 1.077             190.6 .0823 19.1         18.85
 5%ILE LOG              3.581 2.076 .1337 .2564 .0133 269.1 316.1 .8504 .4519             94.99 .0169 6.357        7.235
95%ILE LOG              4.039 4.282 .9003 .8531 .0133  1077 621.8 2.362 1.116             195.5 .0882 20.05        19.63
  .OF OCCURS.               8     6     8     8     8     8     7     8     8                 8     8     7            5

  T :- 0169801327             NGR :- SD 66800 17700   INFLOW (EAGLEY BROOK) TO BELMONT RESERVOIR U/s OF A675
------                        ------
MEAN                    6.648 13.02 .0354 .1708 .0143 195.7 101.6 7.283 2.133             119.7 .1714 11.85        12.35
  D.        P24         .713  9.04  .0059 .1408 .0025 135.2 132.6 3.636 .6186             25.17 .3654 4.775        9.719
  X                     7.59  25    .05   .4    .02   430   360   12    3                 149   1     21            25.8
  N                     5.25  <5    <.05  <.05  <.02  40    <15   2.3   1.5               80    <.05  7              4.5
 5%ILE NORM             5.476   -VE .0257   -VE .0101   -VE   -VE 1.302 1.115             78.34   -VE 4.001          -VE
95%ILE NORM             7.821 27.89 .0451 .4024 .0184 418.2 319.8 13.26 3.15              161.1 .7724 19.71        28.33
 %ILE LOG               5.544 3.811 .0266 .0403 .0105 57.6  12    2.999 1.284             83.24 .0085 5.812        3.097
 %ILE LOG               7.882 30.01 .0458 .4308 .0188 450   318.8 14.15 3.269             164.9 .6267 20.81         30.4
  .OF OCCURS.               8     8     8     8     7     7     6     6     6                 8     7     7            4

SPT :- 0169801407             NGR :- SD 70400 18300   INFLOW (CADSHAW BROOK) TO TURTON & ENTWISTLE RESERVOIR U/S OF A666
  ----                        ------
  AN                    7.261 24.54 .1143 .3119 .0189 107.5 24.16 10.05 3.15              135.5 .0361 8.722         8.95
  .D.       P25         .5107 13.05 .1335 .2894 .0107 89.31 9.174 4.855 1.186             24.45 .0068 2.67         5.272
MAX                     7.74  43    .4    .85   .04   270   40    16.5  5.1               171   .05   10            16.5
MIN                     6.25  <5    <.05  <.05  <.02  25    15    3.2   1.9               92    <.05  <5             4.7
 5%ILE NORM             6.421 3.077   -VE   -VE .0013   -VE 9.076 2.064 1.198             95.33 .0249 4.33         .2777
  %ILE NORM             8.101 46.01 .3339 .788  .0365 254.4 39.25 18.03 5.101             175.8 .0473 13.11        17.62
  %ILE LOG              6.453 9.538 .0162 .0625 .0069 25.11 12.35 4.26  1.619             99.39 .0261 5.097        3.142
  %ILE LOG              8.13  49.25 .3418 .8359 .0391 272.2 41.31 19.22 5.366             179   .0482 13.64        18.92
NO.OF OCCURS.               7     7     7     7     6     6     6     6     6                 7     6     6            4

  T :- 0169800009             NGR :- SK 01700 98000   ARNFIELD BROOK U/S OF ARNFIELD RESERVOIR
  ----                        ------
MEAN                    5.518 3.645 .0542 .6375 .0133 235   145   3.458 2.55              95.76 .0333 7.291         7.64
S.D.        P26         .8208 .8839 .0589 .133    0.0 139.1 119.5 1.035 .5925             6.598   0.0 2.528        7.493
MAX                     6.38  5     .2    .75   <.02  400   310   4.9   3                 103   <.05  12            17.6
 IN                     4.33  2.5   <.05  .45   <.02  75    10    1.9   1.5               86    <.05  <5             1.6
 5%ILE NORM             4.168 2.191   -VE .4188 .0133 6.138   -VE 1.754 1.575             84.9  .0333 3.132          -VE
 5%ILE NORM             6.869 5.099 .1511 .8562 .0133 463.8 341.6 5.161 3.524             106.6 .0333 11.45        19.96
 5%ILE LOG              4.279 2.391 .0086 .4445 .0133 82.07 34.21 2.045 1.703             85.31 .0333 3.957        1.413
95%ILE LOG              6.962 5.249 .1568 .8763 .0133 498.2 365.7 5.364 3.621             106.9 .0333 11.99        21.04
 0.OF OCCURS.               8     8     8     8     8     7     7     6     6                 8     8     8            5

SPT :- 0169800002             NGR :- SK 11200 99900   RIVER ETHEROW U/S OF WOODHEAD RESERVOIR
------                        ------
 EAN                    5.66  8.809 .0357 .6643 .0143 261.6 160.8 3.08  1.8               128.4 .0333 16.28         10.8
 .D.        P27         1.292 13.8  .0063 .1069 .0025 166.7 133.3 .8672 .4848             79.02   0.0 15.52        10.09
 AX                     7.55  40    .05   .8    .02   510   330   3.7   2.2               307   <.05  51            25.1
MIN                     3.97  <2.5  <.05  .5    <.02  100   30    1.9   1.1               90    <.05  7              2.5
 5%ILE NORM             3.534   -VE .0254 .4884 .0101   -VE   -VE 1.653 1.002               -VE .0333   -VE          -VE
95%ILE NORM             7.785 31.51 .0461 .8401 .0184 536   380.1 4.506 2.597             258.4 .0333 41.81         27.4
 5%ILE LOG              3.808 .7593 .0264 .5042 .0105 84.44 37.67 1.882 1.124             43.1  .0333 3.142        2.142
 5%ILE LOG              7.994 29.58 .0469 .8532 .0188 576.5 406.9 4.669 2.686             277.8 .0333 44.23        29.05
NO.OF OCCURS.               7     7     7     7     7     6     6     5     5                 7     7     7            5
```

```
                          WATER QUALITY SAMPLE SUMMARIES
                   FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

                      37     61    162    111    117    118   7760   9509    241    237     85     92     77    180    172    183  9968
                  FLOW       PH ALKAL  AMMON  NO3-N  NO2-N  ALU      AL   CAL    MAGNES BOD 5  COD    COND   ORTHO  CHLOR  SULPHTOTAL
                  INST          INITY  IA N                 MIN    MONO   CIUM   IUM    ATU           AT     PHOSP  IDE    ATE HUMIC
                                M.O.   MG/L   MG/L   MG/L   IUM    MERIC                MG/L   MG/L   25C      MG/L MG/L   MG/LSUBS
                  M3/S           MG/L            N      N   UG/L   UNAC   MG/L   MG/L     0      0    US/CM  P      CL     SO4  MG/L
                                 CACO3                             UG/L   CA     MG

SPT :- 0169800010          NGR :- SK 02000 97000     RIVER ETHEROW BELOW BOTTOMS RESERVOIR
-----                      ------
:AN               .4833  7.133  15.6   .0763  .7966  .0151  256.2  93.33  6      2.828  1.76   17.44  156.6  .0385  14.66         7.84
.D.        P28    .5893  .8177  8.562  .0579  .5727  .0072  105.7  113.4  2.631  1.071  1.707  10.9   177.4  .0344  8.562         2.787
MAX               .9     9.02   45     .3     4.9    .06    470    315    10.9   4.5    10.8   79       1480 .3     60            12.3
MIN               <.1    4.17   <5     <.05   .29    <.02   130    10     2.8    1.4    .3     5      82     <.05   5             5.5
5%ILE NORM           -VE 5.788  1.518     -VE    -VE .0032  82.23     -VE 1.67   1.065     -VE    -VE    -VE    -VE .5828         3.255
5%ILE NORM        1.452  8.478  29.68  .1716  1.738  .027   430.2  279.9  10.32  4.591  4.568  35.37  448.5  .0951  28.75         12.42
5%ILE LOG         .0638  5.872  5.881  .0201  .2237  .0064  123.3  12.37  2.755  1.447  .3312  5.749  23.23  .0082  5.197         4.188
95%ILE LOG        1.473  8.552  31.8   .1844  1.87   .0287  454.8  284    10.95  4.831  4.822  38.04  462    .1012  30.86         13.02
NO.OF OCCURS.          2     62     62     62     62     62      8      6      7      7     53     52     62     61     60             5

T :- 0169800024            NGR :- SK 05500 93800     HURST RESERVOIR
-----                      ------
MEAN                     5.376  4.541  .0437  .5937  .0133  227.1  125    4.241  2.816                139.9  .0333  19.25         6.16
S.D.       P29           .465   1.622  .0235  .2367  0.0    114    86.94  1.261  .8864                33.56  0.0    7.516         4.302
AX                       6.3    8      .1     .95    <.02   400    275    5.5    3.5                  185    <.05   32            11.1
IN                       4.79   <5     <.05   .15    <.02   80     40     2.4    1.5                  71     <.05   8             1.9
5%ILE NORM               4.611  1.872  .0052  .2044  .0133  39.48     -VE 2.166  1.358                84.73  .0333  6.885            -VE
95%ILE NORM              6.141  7.21   .0823  .9831  .0133  414.8  268    6.317  4.274                195.1  .0333  31.61         13.23
5%ILE LOG                4.647  2.418  .0169  .2932  .0133  93.03  36.51  2.518  1.62                 92.23  .0333  9.649         1.79
95%ILE LOG               6.173  7.563  .0882  1.037  .0133  442.8  288.3  6.563  4.454                200.8  .0333  33.32         14.24
O.OF OCCURS.                 8      8      8      8      8      7      6      6      6                    8      8      8             5

SPT :- 0169800303          NGR :- SD 99500 10100     CASTLESHAW UPPER RESERVOIR
------                     ------
EAN                      5.273  3.472  .0583  .5417  .0133  414.1  217.5  3.716  2.45                 100    .0333  8.166         3.26
.D.        P30           .8985  1.335  .0329  .1281  0.0    247.8  153.8  .8773  .5753                19.04  0.0    2.562         1.487
AX                       6.24   5      .1     .7     <.02   810    430    4.8    3.1                  138    <.05   12            5.7
MIN                      3.78   <2.5   <.05   .4     <.02   200    20     2.2    1.4                  85     <.05   6             1.8
5%ILE NORM               3.795  1.276  .0042  .3309  .0133  6.429     -VE 2.273  1.503                68.69  .0333  3.951         .813
95%ILE NORM              6.751  5.668  .1125  .7524  .0133  821.9  470.6  5.159  3.396                131.3  .0333  12.38         5.707
5%ILE LOG                3.935  1.759  .0214  .3591  .0133  143    62.26  2.466  1.629                72.03  .0333  4.706         1.45
5%ILE LOG                6.866  5.969  .1206  .7737  .0133  883    506.3  5.305  3.491                134    .0333  12.89         6.065
NO.OF OCCURS.                6      6      6      6      6      6      6      6      6                    6      6      6             5

PT :- 0169800348           NGR :- SE 01900 03150     CHEW BROOK D/S OF CHEW RESERVOIR U/S OF DOVE STONE RESERVOIR
-----                      ------
EAN                      5.602  4.833  .0979  1.187  .0133  338.5  143.5  4.321  2.571                104.8  .0333  10.62         8.78
S.D.       P31           .7052  2.513  .0491  .4816  0.0    198.2  82.9   .9626  .8712                11.86  0.0    3.113         4.325
MAX                      6.81   9      .15    2.1    <.02   590    270    5.4    3.9                  123    <.05   15            13.4
MIN                      4.78   <2.5   <.05   .7     <.02   60     15     2.4    1.2                  85     <.05   7             2.7
5%ILE NORM               4.442  .6989  .0171  .3953  .0133  12.42  7.207  2.738  1.138                85.33  .0333  5.502         1.665
5%ILE NORM               6.762  8.967  .1788  1.979  .0133  664.7  279.9  5.904  4.004                124.3  .0333  15.74         15.89
5%ILE LOG                4.522  1.917  .0401  .5791  .0133  119.5  51.44  2.937  1.416                86.54  .0333  6.358         3.658
95%ILE LOG               6.831  9.588  .1909  2.09   .0133  713.7  300.4  6.057  4.188                125.4  .0333  16.34         16.95
NO.OF OCCURS.                8      8      8      8      7      7      7      7      7                    8      7      8             5

PT :- 0169800342           NGR :- SE 02800 05500     GREENFIELD RESERVOIR
------                     ------
MEAN                     4.826  2.963  .1481  .7833  .0133  342.1  297.5  3.318  2.225                119.3  .0333  17.66         8.14
.D.        P32           .6786  .7349  .0856  .1     0.0    69.27  70.97  .9008  .4979                17.65  0.0    7.968         3.989
AX                       6.33   <5     .3     .9     <.02   470    420    4.5    3                    151    <.05   36            13.7
IN                       4.22   <2.5   <.05   .65    <.02   280    225    1.7    1.2                  89     <.05   11            4.1
5%ILE NORM               3.71   1.754  .0074  .6188  .0133  228.1  180.7  1.837  1.406                90.29  .0333  4.559         1.578
95%ILE NORM              5.942  4.171  .2889  .9478  .0133  456    414.2  4.8    3.043                148.3  .0333  30.77         14.7
5%ILE LOG                3.797  1.924  .0531  .6304  .0133  241.1  196.5  2.065  1.509                92.67  .0333  7.934         3.407
5%ILE LOG                6.016  4.298  .3101  .9578  .0133  466.3  426.1  4.965  3.123                150.3  .0333  32.68         15.67
O.OF OCCURS.                 9      9      9      9      8      7      6      8      8                    9      8      9             5

PT :- 0169800292           NGR :- SD 98700 12200     READYCON DEAN RESERVOIR
------                     ------
EAN                      5.497  9.895  .2562  .5937  .0133  300    177.8  3.678  2.385                90.61  .0357  8.125         6.42
S.D.       P33           .7063  18.23  .2112  .1474  0.0    104.7  110.9  1.242  .521                 12.88  .0063  2.531         2.325
MAX                      6.61   55     .65    .8     <.02   440    345    6      3.1                  120    .05    12            9.2
MIN                      4.56   2.5    .05    .35    <.02   175    40     2      1.4                  79     <.05   5             4
5%ILE NORM               4.335     -VE    -VE .3512  .0133  127.6     -VE 1.634  1.528                69.41  .0254  3.96          2.595
95%ILE NORM              6.659  39.89  .6036  .8363  .0133  472.3  360.2  5.723  3.242                111.8  .0461  12.28         10.24
5%ILE LOG                4.417  .6376  .0605  .3853  .0133  162.1  58.79  2.029  1.634                71.07  .0264  4.701         3.388
95%ILE LOG               6.73   34.93  .6463  .8617  .0133  494.8  387.3  5.985  3.324                113.2  .0469  12.79         10.75
NO.OF OCCURS.                8      8      8      8      7      7      7      7      7                    8      7      8             5
```

Appendix 9

```
                                             WATER QUALITY SAMPLE SUMMARIES
                                          FOR PERIOD 01/01/1982 00:01 TO 25/09/1986 01:17

               37    61   162   111   117   118  7760  9509   241   237    85    92    77   180   172   183  9968
            FLOW   PH   ALKAL  AMMON NO3-N NO2-N ALU    AL   CAL  MAGNES BOD 5 COD  COND  ORTHO CHLOR  SULPHTOTAL
            INST        INITY  IA N              MIN   MONO  CIUM  IUM   ATU        AT    PHOSP IDE     ATE HUMIC
                        M.O.   MG/L  MG/L  MG/L  IUM   MERIC             MG/L  MG/L 25C    MG/L MG/L   MG/LSUBS
            M3/S         MG/L         N     N    UG/L  UNAC  MG/L  MG/L   0     0   US/CM  P    CL     SO4   MG/L
                         CACO3                         UG/L  CA    MG

 PT :- 0169800384        NGR :- SK 00400 99600    HIGHER SWINESHAW RESERVOIR
-----                    ------
MEAN               4.708 2.916 .1729 .725  .0133 342.8 280   2.807 1.928             94.58 .0333 6.875       11.04
S.D.      P34      .6271 .7715 .0921 .1225  0.0  75.65 117.8 .8937 .6651             10.21  0.0  2.416       6.213
MAX                6.01  <5    .35   .9    <.02  470   500   4     2.9               107   <.05  11          22
'IN                4.23  <2.5  <.05  .5    <.02  220   130   1.4   1                 72    <.05  3           6.9
 5%ILE NORM        3.677 1.647 .0214 .5235 .0133 218.4 86.06 1.337 .8345             77.79 .0333 2.9         .82
)5%ILE NORM        5.74  4.185 .3245 .9265 .0133 467.3 473.9 4.277 3.022             111.3 .0333 10.84       21.26
 5%ILE LOG         3.752 1.838 .0671 .5425 .0133 233.8 132.7 1.604 1.05              78.78 .0333 3.699       4.059
95%ILE LOG         5.805 4.324 .3473 .942  .0133 479.2 501.5 4.459 3.164             112.2 .0333 11.37       22.8
'O.OF OCCURS.         8     8     8     8     8     7     7     7     7                   8     8     8           5


SPT :- 0169800084        NGR :- SK 01100 74400    RIVER GOYT U/S OF ERRWOOD RESERVOIR
------                   ------
MEAN               6.296 7.104 .05   .6375 .0133 239.2 116.4 7.683 3.75        35    170   .0354 24.62       11.22
S.D.      P35      .4617 3.517 .0309 .2774  0.0  100.6 73.8  3.521 1.5          0.0  77.58 .0059 20.85       7.971
MAX                7.08  15    .1    1.1   <.02  390   210   14    6           35    303   .05   60          22.1
MIN                5.6   <5    <.05  .25   <.02  125   15    3.3   1.8         35    110   <.05  9           2
 5%ILE NORM        5.536 1.318   -VE .1812 .0133 73.74   -VE 1.89  1.282       35    42.4  .0257   -VE         -VE
95%ILE NORM        7.055 12.89 .1008 1.093 .0133 404.8 237.8 13.47 6.217       35    297.6 .0451 58.93       24.33
 5%ILE LOG         5.566 2.947 .0167 .2947 .0133 113.5 37.8  3.405 1.847       35    75.63 .0266 5.604       3.196
95%ILE LOG         7.083 13.75 .1083 1.159 .0133 428.4 255.8 14.32 6.562       35    316.3 .0458 62.99       26.17
NO.OF OCCURS.         8     8     8     8     8     7     7     6     6           1     8     8     8           5


SPT :- 0169800184        NGR :- SK 05600 88000    KINDER RESERVOIR
------                   ------
MEAN               6.687 13.37 .0562 .6125 .0142 157.5 118.3 4.933 2.833       17    98.77 .0354 7.428       5.46
S.D.      P36      .4842 6.717 .0388 .2232 .0024 220   236.1 .7633 .8042        0.0  8.298 .0059 2.299       3.674
MAX                7.17  26    .15   .95   .02   600   600   5.6   3.7         17    111   .05   12          11
MIN                5.78  5     <.05  .3    <.02  10    10    3.5   1.4         17    86    <.05  5           2.4
 5%ILE NORM        5.891 2.325   -VE .2453 .0103   -VE   -VE 3.677 1.51        17    85.12 .0257 3.646         -VE
95%ILE NORM        7.484 24.42 .12   .9797 .018  519.5 506.8 6.188 4.156       17    112.4 .0451 11.21       11.5
 5%ILE LOG         5.922 5.478 .0166 .3219 .0106 16.55 6.59  3.785 1.724       17    85.74 .0266 4.315       1.657
95%ILE LOG         7.512 26.07 .1291 1.028 .0183 507.5 426.2 6.278 4.308       17    112.9 .0458 11.67       12.37
NO.OF OCCURS.         8     8     8     8     8     6     6     6     6           1     8     8     7           5
```

Appendix 10


Study Area
Crown Copyright Reserved WU 298514
• Main river Esk and Duddon
▫ Esk and Duddon tributaries
× Other Lake District sites
○ South Pennine sites
CARLISLE
PENRITH
Bassenthwaite
Derwent
Crummock
Thirlmere
Ullswater
Haweswater
Ennerdale
Wast Water
Grasmere
Esk
Duddon
Coniston
Windermere
BARROW IN FURNESS
LANCASTER
BLACKPOOL
PRESTON
BLACKBURN
BOLTON
LIVERPOOL
MANCHESTER
MACCLESFIELD
CREWE