NATIONAL RIVERS AUTHORITY SOUTH WESTERN REGION

RIVER OTTER ENVIRONMENTAL STUDY - 1993/94

CONSULTANTS REPORT : RIVER OTTER : ENVIRONMENTAL DATA REVIEW

W S Atkins February 1994

Volume 1 : Summary

NRA

National Rivers Authority

South West Region

FOREWORD TO THE W.S.ATKINS RIVER OTTER ENVIRONMENTAL DATA REVIEW REPORT

Background

This report has been drafted by W S Atkins as consultants to the NRA. It has been undertaken as part of a wider review of the environmental status of the Otter catchment in East Devon. The consultant's report has been circulated to members of the River Otter Catchment Action Group for information as previously agreed.

The consultant's brief was:

- to examine the adequacy of available data for environmental studies,

and where that data is available:

- to identify significant changes which have occurred over the 1973 - 1992 period.

The opinions expressed in the report are the consultant's views. They have not been modified by the NRA and do not represent the opinions of the NRA.

The next phase of the NRA review

Recommendations will be carefully reviewed. Particular attention will be paid to the necessary further studies which are required to confirm that identified changes have occurred.

Related studies

Groundwater modelling is being carried out in parallel with the environmental data review to identify impacts of abstraction from the Otter Valley Triassic aquifer on river flow.

Catchment Management

The long term aim is to develop an appropriate Catchment Management Plan for the River Otter.

A Groundwater Management Strategy covering the resources of the Otter Valley Triassic aquifer is already in place. The opportunity will be taken to review this as part of the work associated with the Plan if the results of the environmental and modelling studies identify the need for this to be done.

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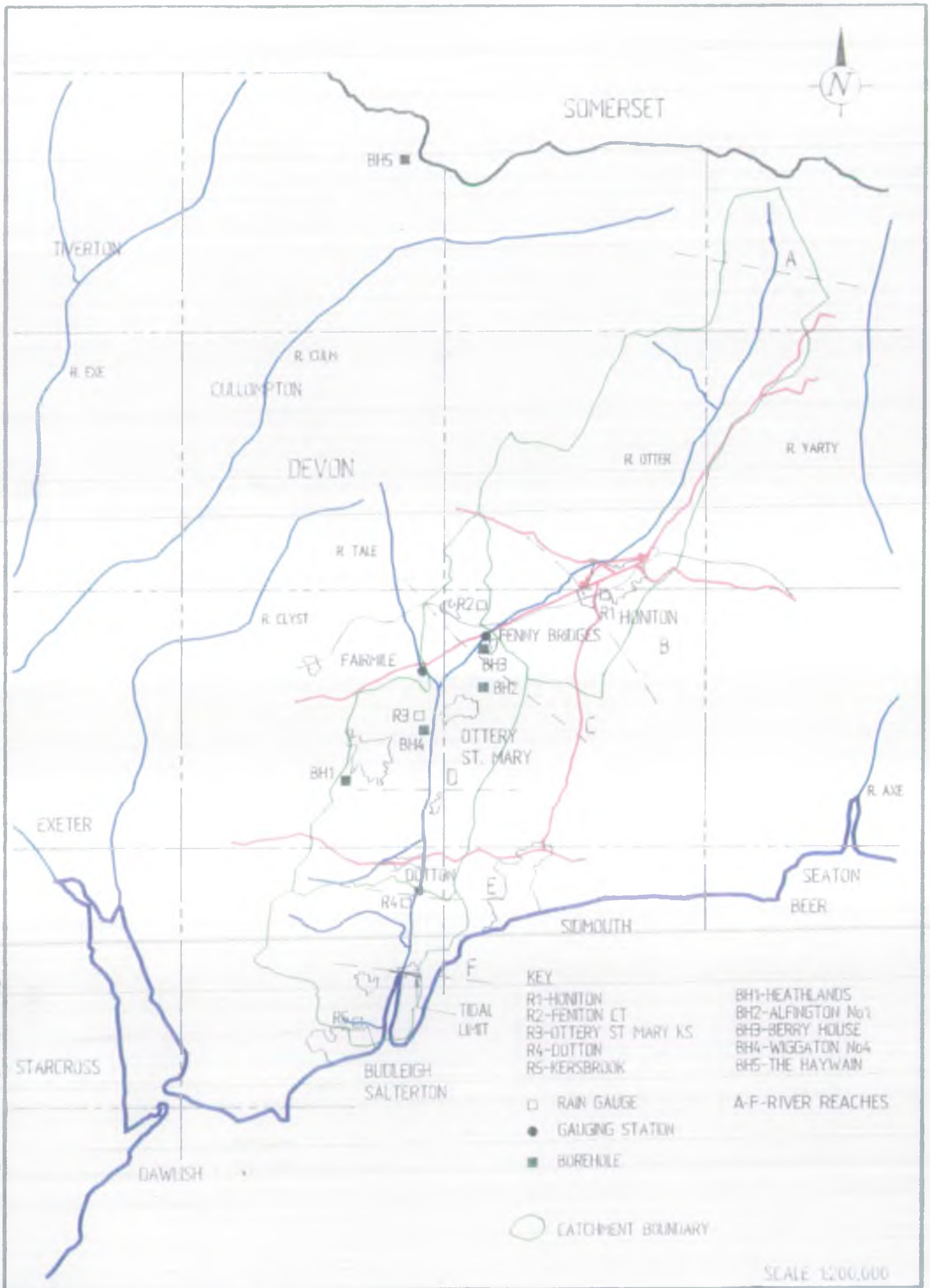

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NATIONAL RIVERS AUTHORITY
RIVER OTTER
HYDROLOGY MONITORING LOCATIONS

FIGURE 2.2.2

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0. SUMMARY

This document considers the changes and impacts that have occurred over the last 20 years in the River Otter Catchment. This review has been undertaken as a result of concern expressed over low flows, increased sedimentation, poor water quality, overfishing and increased abstraction from the catchment. The approach to the review has been to analyse the data held by the NRA for the last 20 years, to consult with concerned organisations and to recommend environmental studies to confirm, where necessary, that identified changes have occurred.

The following areas of interest were examined: hydrology, water quality, aquatic invertebrates, aquatic plant life, fisheries, sedimentation, eutrophication and drainage patterns. Each of these areas of interest was examined and an assessment of change and impact made. In many cases data inadequacy did not allow a full assessment to be made. In these cases recommendations are made for additional data analysis, which in many cases require the gathering of those data.

The River Otter has been divided into several reaches, each containing sample locations as follows:

A – River Otter to just downstream of Otterhead Lakes
B – River Otter from just downstream of Otterhead Lakes to Honiton
C – Honiton to Fenny Bridges
D – Fenny Bridges to Ottery St Mary
E – Ottery St Mary to Dotton
F – Dotton to the tidal limit
G – Salston Stream to confluence with River Otter
H – Blackbrook to confluence with River Otter
I – Colaton Raleigh Stream to confluence with River Otter
J – Kersbrook Stream to confluence with River Otter

Each of the areas of interest are discussed below. For each subject the main findings are presented and the proposed recommendations for additional work included.

HYDROLOGY

There are significant amounts of hydrological data available for the River Otter, including rainfall, river flows, spot gaugings, and ground water levels. Only a limited number of these have been considered within this study due to time constraints.

Analysis of rainfall data has shown rainfall at the Dotton raingauge was significantly less in the decade 1983-92 than in the decade 1973-82. Rainfall in both periods was less than the 1941-70 long term mean. Rainfall at the selected Otter catchment raingauges is homogeneous with rainfall from Axe catchment raingauges.

Both mean and low flows in the River Otter were lower in the 1980s and 1990s than in the 1970s. However, the comparison with rainfall records in the Otter catchment and flows in the River Axe suggests that this phenomenon was not unique to the River Otter and is likely to be related primarily to climatological effects.

The variation in both annual and summer mean flows has been less in the last ten years than in the previous ten for both the Otter and Axe catchments.

River flows in the Otter at Dotton and Fenny Bridges are not homogeneous with rainfall or Axe flows. The Dotton records reveal that a significant (at the 2.5% level) change in gauged flows occurred around 1984/5.

River levels and velocities appear to have been lower in the last 10 years in line with river flows. Water levels for a given flow have varied by more than 30% from year to year in the past.

Ground water levels since the early to mid 1980s are generally slightly lower than those prior to this period. This is shown by ground water levels and velocities of the hydrographs at Heathlands, Berry House, and Wiggaton No 4 in the Otter Catchment.

Both average and minimum annual ground water levels between 1984 and 1992 at Heathlands in the Otter Catchment, are the lowest since 1953.

The scale and pattern of recharge and recession at Heathlands is very similar to that at the Haywain in the Culm catchment.

Maximum ground water levels at Wiggaton No 4 and Berry House do not appear to be explained by the aquifer recharge estimates alone, as derived from the recharge model.

Calibration of the existing Otter Valley ground water model was difficult to achieve.

The total annual volume of water licensed for consumptive abstraction for the whole catchment rose by 23% between 1973 and 1992, from 13,286Ml to 16,361Ml. 94% of the licensed volume for consumptive abstraction in 1992 was for intended public water supply. Actual abstractions in the Otter catchment are estimated to have increased by 25% between 1972 and 1992, from 8,140Ml to 10,130Ml. 90% of the volume abstracted is taken from ground water. The annual volume of water abstracted is equivalent to around 10% of the average volume of water that discharges from the Otter to the sea in a year. The bulk of the water abstracted is taken from reaches D, E, and F, downstream of Fenny Bridges. The uptake of licences above Dotton has increased from 54% in 1973 (and 53% in 1982) to 78% in 1992. Actual discharge data for the Otter catchment were not available. Discharge consent data were unreliable.

A large number of recommendations are made addressing additional analysis of available data and data not yet collected. In addition the requirement for a modelling approach to address the catchment hydrology is noted. The recommendations are listed below.

For rainfall further analysis of available rainfall data should be undertaken. In particular, catchment averaged daily (or weekly, if insufficient data are available) rainfall should be derived as far back as rainfall records reasonably allow for both the Otter and the Axe catchments.

Catchment averaged rainfall data should be used to investigate historical cumulative rainfall deficit events. An analysis of the frequency of these events should be carried out.

Similarly, frequency analysis of rainfall totals for various different durations ranging from one month to 60 months should be performed. These analyses should be carried out for both fixed and floating starting dates, particularly for durations less than 36 months. The results from such an exercise would show whether climatic conditions over the Otter catchment have been unusual in recent years.

The river flow records of ground water support gauging stations should be analysed for evidence of any changes to help in identifying impacts within the catchment. If changes are identified, the cause of these should be investigated, and their influence on flows in the main river identified.

Further analyses should be undertaken in order to understand the nature of seasonal variability of runoff in the Otter catchment. These studies should be complemented by similar analyses of rainfall and recharge. In particular, the frequency of low flows of different durations should be investigated over at least the full period of record, and be compared to similar plots from surrounding river flow gauges. If flow records are to be extended back using rainfall, evaporation, and a rainfall-runoff model, then the frequency analysis should include these data.

The historical interaction of river flows and ground water along the river should be initially investigated through the use of river flow accretion curves, spot gaugings, and recorded river flows.

The implied change in mean flows in the Otter at Dotton requires confirmation through comparisons with other flow records. Further analysis of the Otter flow record should then be focused to see whether the change can be attributed to the earlier (pre 1985) or later (post 1985) part of the record, and to a particular range of flows (eg floods, low flows, or a general reduction in all flows). This analysis should be performed both at Dotton and at Fenny Bridges. Once the results from these analyses are available, the need for catchment modelling can be more clearly defined in order to investigate the causes of the change. It is recommended that these analyses should be undertaken before moving on to investigate any possible effects due to artificial influences using catchment modelling techniques.

A much longer period of analysis is required to set the annual rainfall and runoff totals in perspective. It is important to consider the inherent variability of climatic and hydrological phenomena in a long term context.

The extension of rainfall records could be achieved by calibration with other longer term raingauges in the region. Appropriate raingauges should be carefully selected to achieve this.

Evaporation records could be estimated from temperature records using empirical relationships. Alternatively, a standard monthly evaporation profile based on existing data could be assumed, with a sensitivity analysis carried out on the evaporation profile to investigate the validity of the assumption.

Flow records could then be extended back using these derived rainfall and evaporation records and a calibrated rainfall-runoff model. Calibration of the rainfall-runoff model should be undertaken either using naturalised flow data or using part of the flow record during which the volume of water possibly abstracted could not be expected to significantly influence low flows: for example when the average daily abstraction rate during the summer months in any part of the catchment was less than 5% of the Q95 flow in the river at that point in the catchment. The optimisation function for model calibration should be based on low flows rather than mean or peak flows.

The cause of the increase in catchment losses between Fenny Bridges and Dotton should be investigated. This should be considered in stage two with the help of a catchment ground water-surface water interaction model.

Abstractions are licensed from both the Rivers Otter and Axe. In order to achieve a fair comparison between them, and also to allow model calibration, both river flow records should be naturalised as far as possible. This will assist in determining which effects are due to catchment processes and which are due to artificial influences, such as abstractions and discharges.

As part of this above exercise, residual flow diagrams should be produced for two different weeks in recent years. The diagrams will show how much water in the river is derived from natural inflows, and how much is derived from the nett effect of abstractions and discharges, in any one reach on that particular week. Both diagrams should be based on a week in which base flows are predominant throughout the catchment. There should not have been any significant rainfall for four or five weeks before the selected periods of analysis. One of the diagrams should cover a period when abstractions were operating under normal licence conditions. The other diagram should be set in a period when the majority of licences tied to prescribed flows or water levels were restricted by these conditions. Reaches identified on the residual flow diagrams should be taken from the Micro Low Flows system and coordinate with the reaches defined in this study, as far as possible. Natural inflows to each reach can then be estimated from the 'natural' Q95 flows provided in Micro Low Flows. If insufficient abstraction and discharge data are available to accomplish this exercise then consideration should be given to collecting such information in the summer of 1994.

For river levels and velocities original data collected during spot gauging exercises, (undertaken both by the NRA, South West Water Authority and MRM Consultants), should be analysed to investigate the variability of water levels and velocities, and channel geometry, through time at locations along the river for various flows.

The cause of any significant changes in river levels and velocities, not directly attributable to a change in flows, and any significant changes in channel geometry, should be investigated. This would include looking at changes in field drainage practices and land drainage patterns through time, as well as changes in land use, and examination of any available documentary evidence including photographs, reports, books, and river corridor surveys.

The need for any further studies, including field surveying, should be reviewed.

For ground water levels the sites identified as 'control' sites should be reviewed. This should include an assessment of whether the present monitoring network provides adequate coverage for model calibration. Results from past model runs should be used to help identify areas where further data are required.

The results from the aquifer recharge model should be reviewed and analysed. They should then be used as a first stage assessment of whether 'control' sites appear to be affected by ground water pumping. The possibility of regional aquifer drawdown through the long term effects of pumping should not be overlooked during this process.

The calibration of the Otter Valley ground water model should be reviewed as follows. The assumption of regional homogeneity and isotropy in the aquifer should be tested. Variations in regional porosity/storativity suggested by differences in the annual fluctuation of water levels at different sites suggest that the aquifer is far from homogeneous or isotropic. Transmissivities were assumed constant during the transient runs. This assumption is clearly in error and the sensitivity of this assumption should therefore be tested. The model was based on a 250m x 250m square grid. This grid size is probably too coarse to adequately describe the interaction between a number of pumping boreholes in close proximity to each other and/or the river. Consideration should therefore be given to refining the grid size to, for example, a 50m, or even 20m, spacing along the river corridor to include the Greatwell, Harpford, Dotton, Colaton Raleigh, and Otterton groups of boreholes.

For abstractions and discharges the availability of actual abstraction data back to the late 1960s should be investigated in order to allow naturalisation of gauged river flows. Where data are poor, other methods of estimating actual abstractions should be considered, such as estimating demand for water supply from population and town development data.

The availability of information on discharges to the River Otter through time should be investigated. Unfortunately, flow data on discharges to the Otter are not kept by the NRA. Further investigative work should be carried out in order to gain an understanding of how much water has been discharged into the Otter through time.

An alternative, but less reliable, method of estimating nett abstractions from the catchment involves assessing the operation of the water distribution system (supply) and the water reticulation system (sewage collecting) through time. This approach would provide an independent check on the abstraction/discharge water balance.

The extent to which other abstracted water is genuinely used consumptively should be investigated, although it is recognised that this might be difficult to accomplish.

Full monitoring of the major abstractions and river flows in reaches A, D, E, and F should be undertaken in order to ensure that any adverse effects are identified and reliable data are collected for future modelling purposes. In addition, consideration should be given to quantitatively monitoring of all major discharges to the Otter, or requesting the dischargers to do so.

The availability of abstraction data on the River Axe has not been investigated as part of this study. The effects of artificial influences on characteristics of the Axe catchment should be more thoroughly investigated before comparisons between the two catchments can be relied upon.

The use of a calibrated catchment ground water/river flow interaction model should be considered to investigate the effects of ground water abstractions in reaches D, E, and F on river flows.

WATER QUALITY

Water quality assessment is confined to monitoring sites where a twenty year record is available. Biochemical oxygen demand (BOD) atu (allyl thio-urea) values are absent prior to 1977 when BOD was recorded as BOD non-atu. Numbers of samples per annum are low prior to 1983 except at Dotton Mill (Reach E).

No historical water quality data were available for Reach A although this reach is now being monitored.

Within Reach B, dissolved oxygen (DO) levels, pH values and nitrate concentrations were found to have increased whilst ammonia, orthophosphate and suspended solids concentrations were found to have decreased. In all cases these trends were more pronounced at the upper end of the reach. No significant trends were found for temperature or BOD although temperature shows a possible long term decline and BOD exhibits a possible long term increase.

Within Reach C, DO levels were found to have decreased, whilst nitrate and orthophosphate concentrations had increased. Possible trends were found for temperature (decline), pH (increase), BOD (increase), ammonia (increase) and suspended solids (increase).

Within Reach D, DO levels were found to have decreased whilst nitrate and orthophosphate had increased. Possible trends were found for temperature (decline), pH (increase), BOD (increase), ammonia (decline) and suspended solids (increase).

Within Reach E, DO levels were found to have decreased whilst nitrate and orthophosphate had increased. Temperature was found to have decreased at the lower end of the Reach. Possible trends were found for pH (increase), BOD (increase), ammonia (increase) and suspended solids (varied).

Within Reach F, DO levels were found to have decreased whilst nitrate and orthophosphate concentrations had increased. Possible trends were found for temperature (decline), pH (increase), BOD (decline), ammonia (decline) and suspended solids (decline).

Whilst some deterioration in water quality was apparent between the upper and lower ends of Reach B, particularly during the 1980s, the most marked change in quality throughout all the reaches was found to occur between Reach B and Reach C.

No specific trends for water quality in terms of NWC classification were found. However, there were low NWC River Classifications in Reaches D - F between 1980 - 1982 and 1986 - 1988 due to high values of BOD and suspended solids respectively. Particularly low pH levels occurred in 1980 and 1982 in Reach B. An unusual year in Reach C in 1981 was characterised by low BOD, low ammonia and high DO. (Occasional high BOD values contributed to the low NWC River Classification for that year). Low DO levels occurred in 1980 and 1991 in Reach D. There were also a steep increase in nitrate levels until 1982 in Reach D. There was low mean oxygen levels in 1982 and 1988 in Reach E. High mean concentration of both BOD and ammonia occurred in 1980 and 1986 in Reach F.

Examination of water quality discharge data from South West Water Services Ltd and other sources may, but are unlikely to, identify possible causes of these historical events.

With respect to those trends shown to be confirmed, it is recommended that the present water quality monitoring programme be continued. The data gathered can then be used to monitor changes in these trends as a result of any management strategies employed in the future.

Specific recommendations for water quality data gathering activities to confirm possible trends include the following:-

The possible impact of Honiton STW on the River Otter should be addressed by the installation of a continuous water quality monitor downstream from the works. The data gathered should be correlated with flow and volume data so that dilution effects can be taken into account.

An impact of suspended sediment on NWC Classification is suspected, particularly in the early and late 1980s. The present monitoring of suspended solids has not allowed the isolation of the reasons for recent improvements in suspended solid extremes. As part of the sedimentation recommendations below, continuous sediment loggers should be installed at Hoemoor, at the location of the continuous water quality monitor downstream of Honiton STW and finally at Otterton.

A short term expanded water quality monitoring programme should be undertaken to examine the input of nutrients from the many tributaries to the River Otter.

Further data analysis should be undertaken on the water quality data presented in this report to isolate the effect of season on water quality.

AQUATIC INVERTEBRATE DATA

Within Reach B there are no marked fluctuations in ASPT (Average Score per Taxon). Much of the invertebrate data was considered to be unreliable. The ASPT was utilised to give an indication of biological quality. Within Reach B no marked fluctuations occurred at Hoemoor Farm except for a deterioration in 1977 and 1980. Within Reach B at Monkton the ASPT fluctuates but generally indicates a good quality water course. At Clapperlane Bridge within Reach B the ASPT also fluctuates indicates a good quality water course. In Reach C at Fenny Bridges the ASPT and again was low in 1983. Stations upstream of Fenny Bridges typically have an ASPT of 6.0 and above. In Reach D at Ottery St Mary the ASPT was low in 1983. Reach E at Tipton St John had a low ASPT in 1983. The 1990 ASPT indicates pollution. In Reach E at Dotton Mill there was a slight fall in ASPT for 1983. In Reach F at Otterton the ASPT may be unreliable, with a relatively high score in 1983.

The apparent increase in BMWP (Biological Monitoring Working Party) score over the last 24 years probably reflects an improvement and greater consistency of sampling technique and effort and has therefore been ignored.

It is recommended that reliable and useful data for the analysis of changes in invertebrate ecology be gathered. The recommendations are therefore to continue improving the quality of the invertebrate monitoring and to undertake surveys as soon as possible on an annual basis. In addition a RIVPACS approach should be developed to establish the expected biological quality of the River.

AQUATIC PLANT DATA

The macrophyte data available for 1991 and 1992 does not appear to provide any consistent patterns from which to deduce changes in the aquatic environment of the River Otter over this short period. Previous macrophyte records are very limited, and not detailed enough to enable monitoring of changes in the aquatic macrophyte populations over time.

It is recommended that quantitative methods be employed to assess changes in plant ecology. These surveys should be undertaken on an annual basis.

FISHERIES

Salmon have returned to the River Otter below Otterton Weir. Sea Trout catches below Otterton Weir show no trend. Electrofishing results suggest that parr catches of brown trout are improving when 1992 is compared to 1986. Fry catches are variable in those years sampled. Wild trout rod catches at Honiton suggest an improvement in latter years; however these data are unsupported by effort data.

It is recommended that a continued electrofishing programme on a yearly basis should be undertaken. This programme would provide a means of monitoring improvements in the river system in terms of both physical and chemical characteristics.

SEDIMENTATION

Insufficient data are available to enable a useful analysis of sedimentation to be undertaken.

It is recommended that continuous suspended sediment data loggers should be installed at strategic locations on the River Otter to enable the problem of sedimentation to be addressed. This has the added benefit of addressing concerns over the possible impact of high suspended solid concentrations on NWC River Classification scores.

EUTROPHICATION

Orthophosphate levels are high enough at all stations below Cottarson Farm to consider that the River Otter is in a state of eutrophication. DO also indicates that the River Otter can be considered to be in a state of eutrophication.

Eutrophication effects are difficult to quantify in flowing water. The NRA South West has been investigating the relationship between benthic diatom growth and eutrophication. This approach should be encouraged.

DRAINAGE PATTERNS

The available information suggests that farming activity will change from arable to livestock farming. Associated with this change, the incidence of pollution incidents can be expected to rise. The levels of nitrate used as fertiliser are expected to decline thereby reducing the nitrate levels in the River Otter.

A second land use survey would provide additional information on trends in land use. This is of relevance when nutrients are considered. Given the concern expressed over orthophosphate levels in the River Otter, a fuller understanding of the distribution of intensive livestock facilities would be extremely relevant.

In addition the 1992 aerial photographic survey should be fully interpreted and compared to the Phase I Habitat Survey of 1983.

Additional data, held by the Ministry of Agriculture Fisheries and Food, concerning farming practices should be analysed to assess the changes in drainage patterns over the past two decades.

CHANGES

The hydrological analysis has identified a number of changes as noted in the above sections. In addition, many of the other factors considered in detail have also identified changes. Many of these changes have been brought together in the form of a summary table. This table has identified the following years as being of particular concern in various reaches; 1980, 1982, 1985 and 1986. These years of concern have been identified primarily on the basis of water quality information supported by information on abstraction, river flow and ASPT (invertebrate biology). Of the identified years, 1980 is poor in many of the reaches, 1982 is poor at two locations and 1985 and 1986 at single locations.

A number of trends have also been identified, some of which give cause for concern. Nitrate levels show an increase in all reaches, phosphate levels increased in lower reaches, dissolved oxygen has decreased in lower reaches. None of the other determinands show a confirmed trend and include; biological oxygen demand, total ammonia, suspended solids, temperature and pH.

Biological data are considered unreliable for the most part. Trend analysis has therefore proved unreliable. There appear to be no long term trends that can be identified.

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