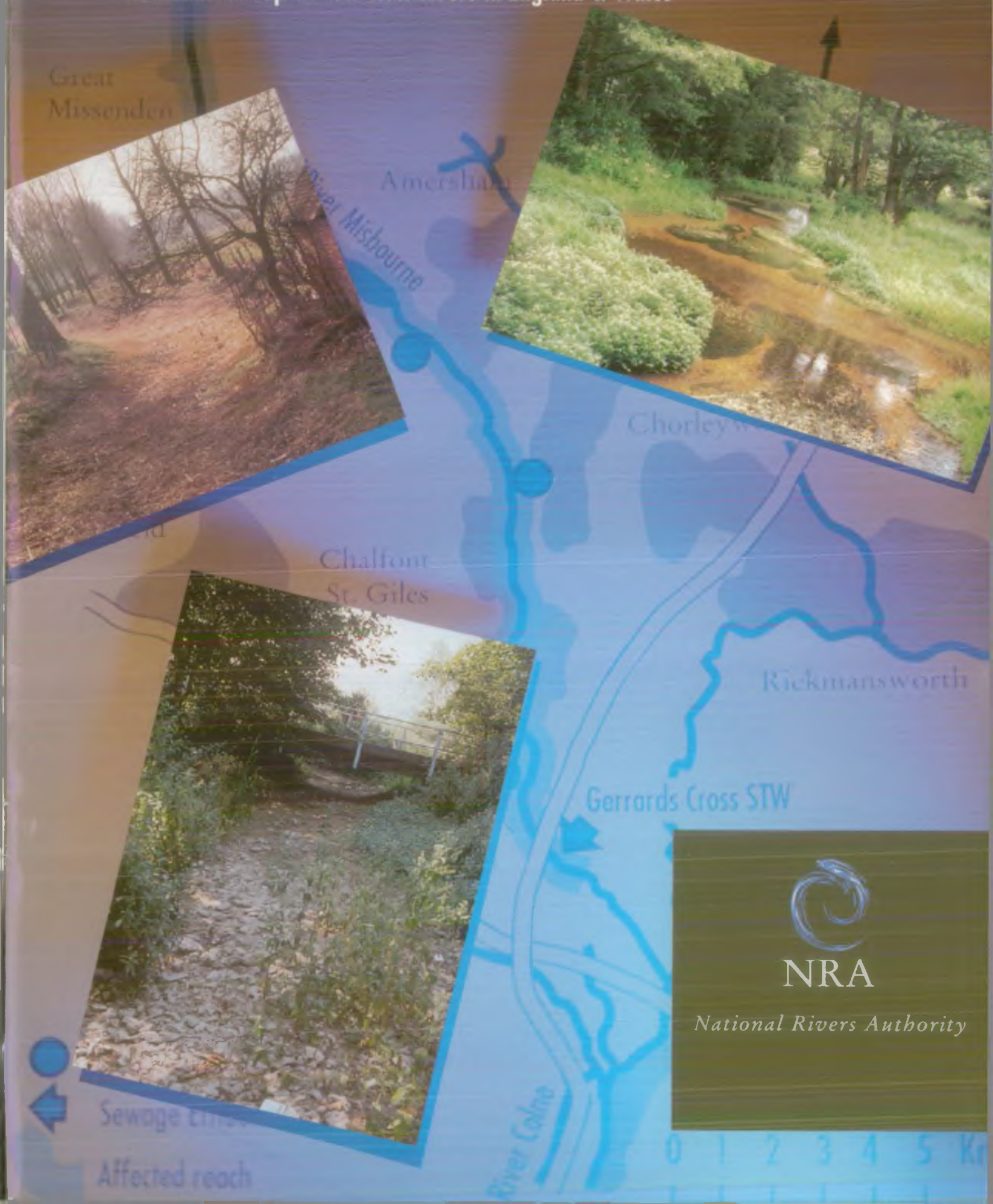


LOW FLOWS AND WATER RESOURCES

Facts on the top 40 low flow rivers in England & Wales



NRA

National Rivers Authority

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LOW FLOWS AND WATER RESOURCES

**FACTS ON THE TOP 40 LOW FLOW RIVERS
IN ENGLAND AND WALES**

MARCH 1993



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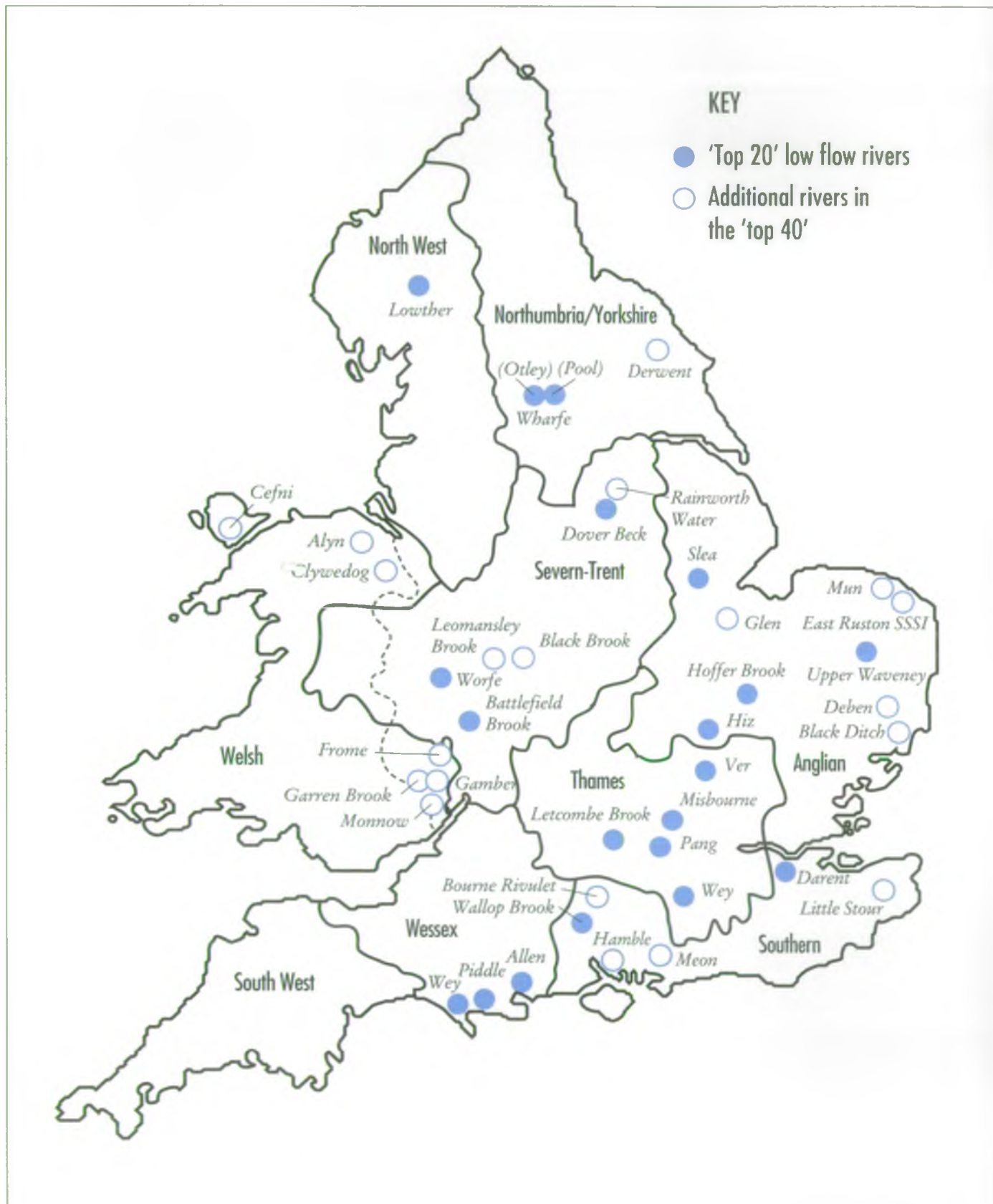
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FIGURE 1: LOCATION OF 'TOP 40' LOW FLOWS



INTRODUCTION

Since the formation of the National Rivers Authority (NRA) in September 1989, considerable attention has been given both internally and externally to the problem of unacceptably low flows in some of our rivers. These are problems caused by excessive authorised abstractions rather than due to drought, although of course, drought will exacerbate such problems.

Most of the abstractions were authorised under the Water Resources Act 1963 which gave existing abstractors the right to a licence regardless of any environmental implications.

As a first step in tackling these problems the NRA drew up a priority list of 40 locations perceived as suffering from excessive abstraction. An indication of the geographic positions of these 'Top 40' sites is shown in Figure 1. From this list a 'top 20' schedule was drawn up representing those locations which would receive the most urgent attention. In most cases the cause of the low flows has been groundwater abstractions which have resulted in groundwater seepage to the surface being reduced or halted in some instances.

In formulating its original list of 40 rivers the NRA considered a variety of information describing quantitative and qualitative aspects of the water environment relating to each case of reduced flows. The list represented a best estimate of the most severe cases in England and Wales. However since this list was compiled the NRA have made some significant progress in dealing with these problems and as a result the original list is no longer an accurate representation of the low flow problems which are a priority for action. Nevertheless, presenting information on the status and basis of the original listing is seen as an important process since it sets the scene for future reporting of low

flow problems, and it is for this reason that this publication has been produced.

POSSIBLE METHODS OF LOW FLOW ALLEVIATION

There are a number of methods which can be employed to add more water to a low flow location. Perhaps the most direct approach is to reduce or totally revoke the licences causing the problem. The NRA has powers under the Water Resources Act 1991 to vary or revoke licences. Where this approach is applied to a licence which is being used, then the NRA is liable to compensate the licence holder. If an agreement on compensation cannot be agreed by the NRA and the licence holder, then it is determined by the Lands Tribunal. However, to date it has not been necessary to refer such matters to this Tribunal.

There are a number of technical measures which can be used to augment flows. In some instances river bed lining is a possibility but this form of solution is not without its environmental problems.

Another technical solution can be the introduction of a new source of water from elsewhere. Sometimes it is technically possible to pump water from the same groundwater source that is also being drawn upon by the abstraction causing the problem. This form of solution may appear to be a nonsense but by judicious design of the augmentation scheme a net gain in surface water flow can be achieved in summertime, and the groundwater allowed to recover in winter.

In certain cases, consideration can be given to recycling of water within the river system whereby water from higher flowing downstream reaches is pumped and piped upstream to augment flows.

A further technical solution is to relocate the offending abstractions within the same water source. For example it can be possible to alleviate low flows by moving groundwater abstraction locations further downstream within the catchment, thus allowing upstream recovery. Although downstream flows could diminish because of the relocation, the impact of this reduction is minimised due to higher natural downstream flows.

In many instances a combination of solutions is anticipated. The NRA seeks the co-operation of abstractors in arriving at the most cost effective and environmentally acceptable solution and the NRA is delighted with the co-operation it has received so far.

STEPS LEADING TO A SOLUTION

Except in a few cases it is not possible to achieve a solution in a short space of time.

The first step in moving towards the alleviation of a low flow problem is to establish that a problem really exists. This can involve detailed investigation and complex hydraulic modelling. Other complicating factors include the recent drought which has altered peoples' perceptions of the problem. Similarly, water quality and river management practices have also influenced the perception of potential low flow problems. Indeed, lack of fish or low water levels may be due to factors other than reduced flows. For example, in some rivers lack of weed growth has caused levels to drop without loss of flow.

Having established that a low flow problem exists the next step is to find a possible solution. This entails consideration of options and their costs. This may entail field trials, monitoring,

test pumpings, and hydraulic modelling studies (particularly for groundwater problems). Invariably it will also involve the use of detailed cost benefit analysis to assess the viability of each solution in economic terms. Normally this is an essential procedure since significant NRA expenditure is subject to Department of the Environment and Treasury approval.

The next stage is to consult interested parties regarding the possible solutions and, where appropriate, to seek agreement as to the best way forward. Having arrived at a solution it is then often necessary to invest further time in detailed planning. This may involve design work, seeking planning permission or acquiring land. Where the solution involves the revocation or downward variation of an abstraction licence it is the NRA's policy to allow sufficient time for alternative sources and infrastructures to be constructed before licences are varied. Only after this planning phase is completed can solutions be constructed and/or implemented and successful alleviation achieved.

REVIEW OF PROGRESS

Since presenting its original 'Top 40' listing in February 1990 the NRA has made good progress in moving towards a satisfactory resolution of these problems. A summary of this progress is shown in Figure 2. In almost all cases an extensive programme of work has been implemented in order to achieve an understanding of the problem and possible solutions. Moreover, in fourteen cases a solution has been identified and in ten of these it is under implementation or has been completed. Twenty one other sites are having further detailed investigations carried out in order to answer outstanding questions about the nature of the

problem and/or the type of solution which may be suitable. In the remaining five locations the initial investigation indicated that no 'low flow' problem existed or that there was significant doubt over the economic feasibility of attempting to pursue a full solution for what was a very minor problem.

A more detailed review of progress is given in the following pages. Each original 'Top 40' low flow site is catalogued by NRA region and is discussed with reference to the progress and current status of alleviation work.

FIGURE 2: SUMMARY OF PROGRESS IN ALLEVIATING LOW FLOWS

| River/Site | Region | Initial investigations completed | No low flow problem exists or solution uneconomic | Further investigation work ongoing | Solution identified | Implementation underway | Implementation complete |
|--------------------------|-------------------------|----------------------------------|---|------------------------------------|---------------------|-------------------------|-------------------------|
| <i>Battlefield Brook</i> | Severn Trent | ● | | | ● | | ● |
| <i>Leomansley Brook</i> | Severn Trent | ● | | | ● | | ● |
| <i>Glen</i> | Anglian | ● | | | ● | | ● |
| <i>Letcombe Brook</i> | Thames | ● | | | ● | | ● |
| <i>Pang</i> | Thames | ● | | | ● | | ● |
| <i>Black Ditch</i> | Anglian | ● | | | ● | ● | |
| <i>Slea</i> | Anglian | ● | | | ● | ● | |
| <i>Lowther</i> | North West | ● | | | ● | ● | |
| <i>Ver</i> | Thames | ● | | | ● | ● | |
| <i>Darent</i> | Southern | ● | | | ● | ● | |
| <i>Bourne Rivulet</i> | Southern | ● | | | ● | | |
| <i>Wallop Brook</i> | Southern | ● | | | ● | | |
| <i>Wharfe at Pool</i> | Northumbria & Yorkshire | ● | | | ● | | |
| <i>Wharfe at Otley</i> | Northumbria & Yorkshire | ● | | | ● | | |
| <i>Dover Beck</i> | Severn Trent | ● | | ● | | | |
| <i>Hiz</i> | Anglian | ● | | ● | | | |
| <i>Mun</i> | Anglian | ● | | ● | | | |
| <i>Allen</i> | Wessex | ● | | ● | | | |
| <i>Derwent</i> | Northumbria & Yorkshire | ● | | ● | | | |
| <i>East Ruston SSSI</i> | Anglian | ● | | ● | | | |
| <i>Deben</i> | Anglian | ● | | ● | | | |
| <i>Upper Waveney</i> | Anglian | ● | | ● | | | |
| <i>Worfe</i> | Severn Trent | ● | | ● | | | |
| <i>Rainworth Water</i> | Severn Trent | ● | | ● | | | |
| <i>Hamble</i> | Southern | ● | | ● | | | |
| <i>Little Stour</i> | Southern | ● | | ● | | | |
| <i>Meon</i> | Southern | ● | | ● | | | |
| <i>Misbourne</i> | Thames | ● | | ● | | | |
| <i>Wey</i> | Thames | ● | | ● | | | |
| <i>Cefni</i> | Welsh | ● | | ● | | | |
| <i>Clywedog</i> | Welsh | ● | | ● | | | |
| <i>Garren Brook</i> | Welsh | ● | | ● | | | |
| <i>Gamber</i> | Welsh | ● | | ● | | | |
| <i>Piddle</i> | Wessex | ● | | ● | | | |
| <i>Wey</i> | Wessex | ● | | ● | | | |
| <i>Hoffer Brook</i> | Anglian | ● | ● | | | | |
| <i>Black Brook</i> | Severn Trent | ● | ● | | | | |
| <i>Alyn</i> | Welsh | ● | ● | | | | |
| <i>Frome</i> | Welsh | ● | ● | | | | |
| <i>Monnow</i> | Welsh | ● | ● | | | | |

ANGLIAN REGION



Black Ditch

East Ruston SSSI

Hoffer Brook

River Deben

River Glen

River Hiz

River Mun

River Slea

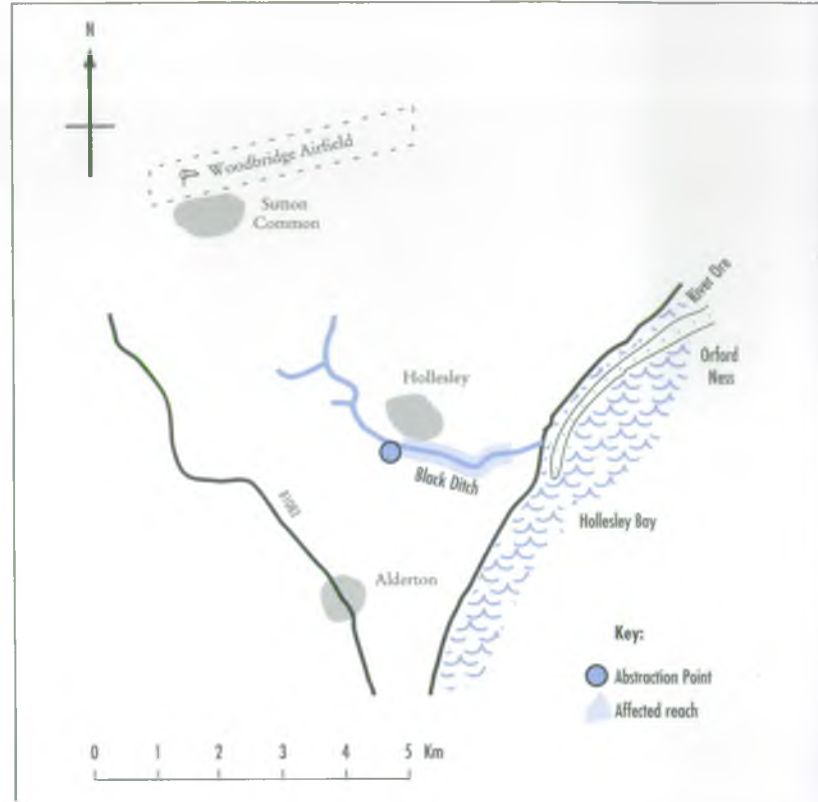
Upper Waveney
(Redgrave & Lopham Fen)

BLACK DITCH

The Black Ditch is a small spring fed coastal watercourse which runs through Hollesley. The lower reaches form an embanked channel prior to the flow being pumped into the sea at the confluence with the River Ore.

The catchment supports a number of abstractions for spray irrigation and there is one particular abstraction on the lower river which can have a significant effect on flows and water levels. This particular abstraction licence is subject to a condition whereby abstraction must cease when the flow falls below a specified rate. However, inadequate flow gauging and monitoring has made the condition difficult to enforce and therefore at times the abstraction causes unacceptably low flows and levels.

The remedy to the problem, identified in 1991, is to construct a new low flow gauging station, fitted with telemetry to allow twenty four hour monitoring of flows. This combined with strengthened enforcement will prevent abstractions which break licence conditions and cause unacceptably low flows.



Installation of the new gauging station is scheduled for 1993 but is dependent on completing the purchase of land for the site.

EAST RUSTON SSSI

The East Ruston Common Site of Special Scientific Interest (SSSI) comprises of some 38 hectares of unimproved heathland and fen situated in the valley of the Hundred Stream; a tributary of the River Ant in Norfolk.

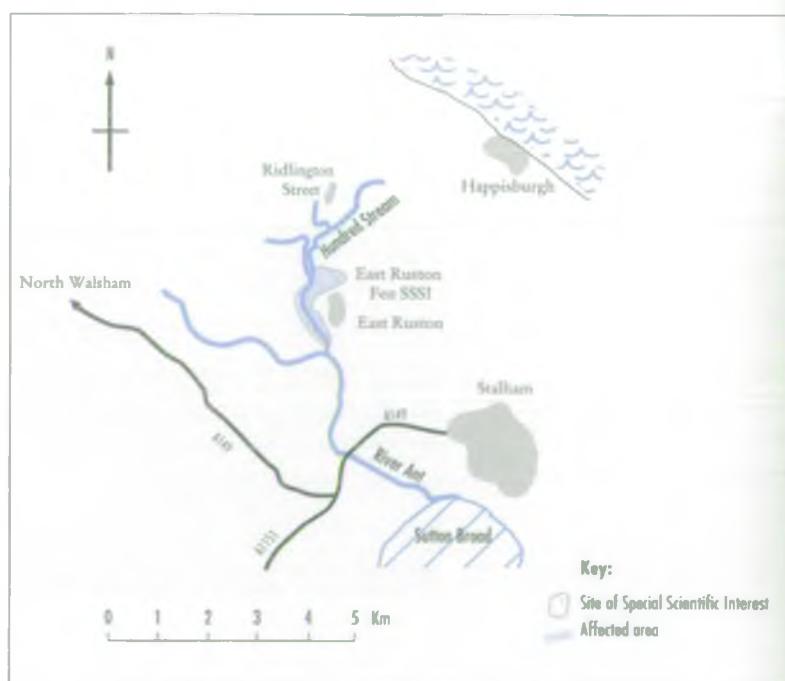


Wetland parts of the fen are characterised by acidic flushes emerging from sands and gravels at the base of surrounding higher ground. The site has a diverse ecology and is home to two rare species of spider.

It is alleged that the progressive drying out of the fen is attributed to a nearby groundwater abstraction for public water supply by Anglian Water Services at East Ruston. Abstraction is authorised by a licence of right and is subject to aggregate limitation with other sources in the catchment. The particular sensitivity of the SSSI to the abstraction is recognised by an informal agreement between English Nature and Anglian Water Services relating to abstraction practices in the catchment. The National Rivers Authority has also recently refused an application to increase abstraction at East Ruston.

A similar situation exists in Suffolk at Redgrave and Lopham Fen SSSI where nearby abstraction has been proven to affect groundwater levels at the site. As Redgrave and Lopham is something of a test case, (ie. 'public water supply versus the environment'), progress at East Ruston has been held in abeyance. Investigations and final decisions taken to implement a solution at East Ruston are likely to benefit from the experience gained at Redgrave, including resolving the debate over who should pay.

Potential solutions are likely to include relocation of public water supply abstraction away from the fen, revocation of the public water supply licence or a substantial reduction in general abstraction in the area. The NRA is committed to highlighting the exact nature of the problem by 1993/94 and to identifying and implementing a solution between 1994 and 1996.

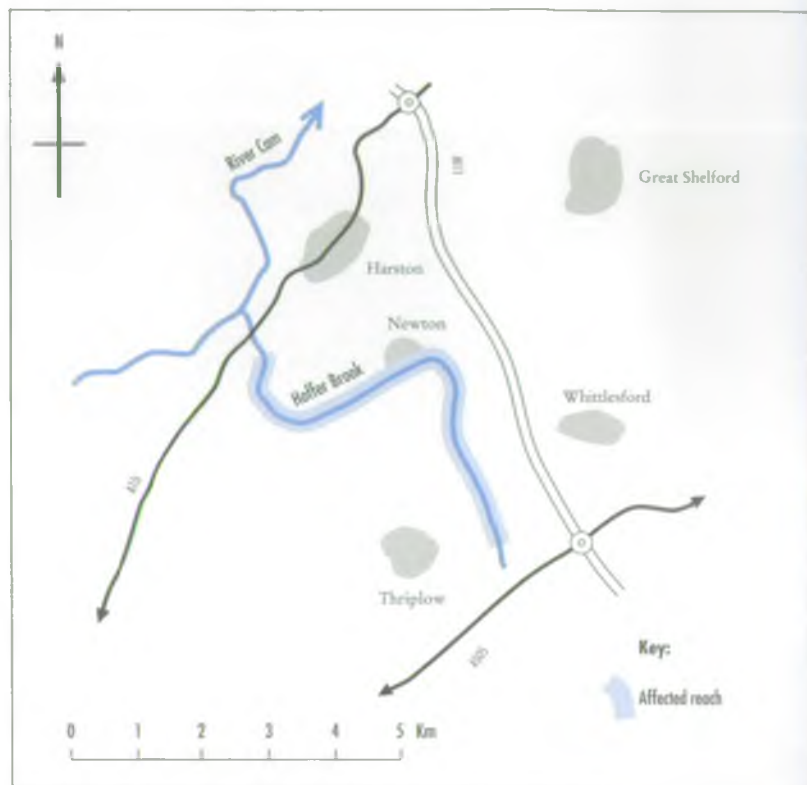


HOFFER BROOK

The Hoffer Brook is a small stream rising very near Thriplow then flowing on through Newton and into the River Cam upstream of Harston.

Upper reaches of the stream frequently dry out for prolonged periods partly due to natural processes. As a result of this a small number of complaints are received from local residents. There appears to have been a small localised loss of amenity and lowered groundwater levels have affected wetland SSSI's in the vicinity.

Preliminary appraisal of the problem in 1992 suggested that flow has been reduced by abstraction. Part of the problem was resolved in the 1970's by schemes which enabled groundwater pumping into the wetland areas. Other than this the upper reaches of the stream are too small to be significant for fisheries and conservation.



Loss of flow in this stream does not have a significant effect on the environment or amenity use and it now appears inappropriate that the Hoffer Brook was categorised with rivers requiring priority action. Resources are therefore now being directed to the other priority rivers.

No further investigation or work is planned at present. Priority for any future work will be established in comparison with other potential problems which have become apparent during the drought.

RIVER DEBEN

The Deben is a rural river in a Boulder Clay covered Chalk catchment. It rises near Debenham in Suffolk and flows for about 35km to the Deben Estuary east of Ipswich. It is part of the Suffolk River Valleys Environmentally Sensitive Area.

The lower parts of the river (around Wickham Market) frequently suffer extremely low flow during the summer. Natural low flows are exacerbated by seasonal surface abstraction for spray irrigation. The irrigation licences (10 in total) were issued as licences of right and do not have effective cessation controls written into them in order to protect river flows.

The NRA already has two augmentation boreholes in the upper catchment. These were drilled in 1977 and 1982 as part of earlier attempts by the then Anglian Water Authority to deal with the problem, however neither of the boreholes are licensed. One borehole has a relatively low yield, the other has a high yield but the water requires expensive iron removal treatment. The

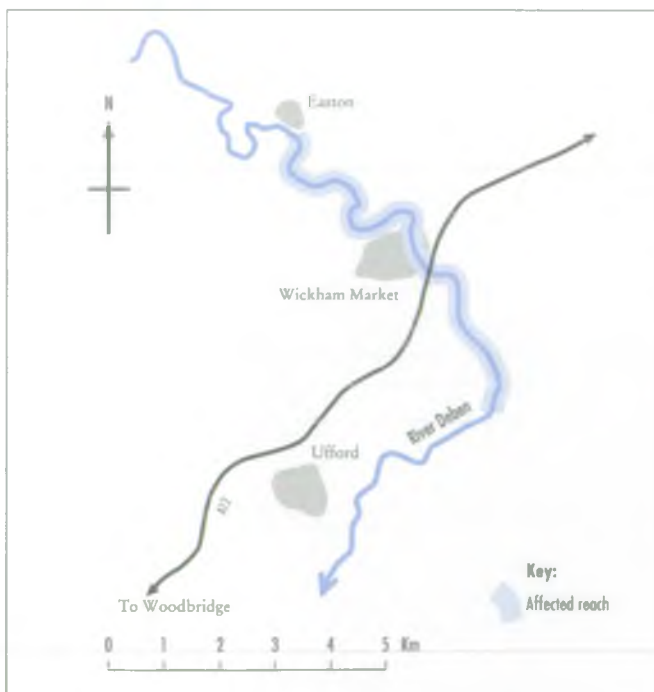


NRA is now re-appraising the problem and potential solutions along with other aspects of water resource management in the catchment.

Solutions which are currently under consideration are as follows:

- 1 Develop and licence the existing augmentation boreholes; this will include costly iron removal treatment.
- 2 Abandon the high iron borehole and find another site to develop a second augmentation borehole.
- 3 Revoke the irrigation licences and re-issue with effective cessation controls, and/or switch to alternative sources of water (winter storage or groundwater).

The NRA has commissioned an investigation by consultants into the groundwater resources of the Deben and the associated management options for development. The final report was received in February 1993. Feasibility and cost benefit appraisal of the potential solutions will now follow and the target date for identifying the preferred solution is December 1993. The timescale for the implementation of a solution will depend on the option selected, but is expected to be sometime during the period of 1994 - 1996. Partial easing of the low flows may be achieved sooner (1993 - 1994) if the NRA proceed to obtain a licence for the low yield borehole in advance of other decisions.



WEST GLEN & LOWER RIVER GLEN

The West Glen rises to the south-east of Grantham and runs southwards to Essendine. The East Glen runs roughly parallel about 3 miles away and joins the West Glen at Wiltthorpe. Both rivers originate from Limestone springs and run over Limestone for much of their length.

Parts of the West and East Glen experience low or zero flows. It is apparent from recent work that this is a natural phenomenon for many reaches and is typical of rivers flowing from, and over Limestone. However, the river downstream of Essendine experiences unacceptably low flows, a situation which is aggravated by abstraction from the Limestone aquifer.

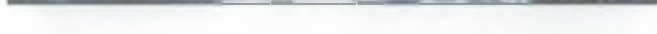
The problem of low flows in this section of the river is long standing and has been the subject of various studies and investigations dating back to 1976. These studies resulted in a remedy to resolve the problem being selected in 1990. An augmentation scheme was implemented in 1991 whereby water is released into the River Gwash from Rutland Water under an agreement negotiated with Anglian Water Services. This water is subsequently pumped from the Gwash, into the West Glen downstream of Essendine. The cost of the scheme was approximately £500,000.



Experience gained operating the scheme during the drought years of 1991 and 1992 has identified a need to review the licensed quantity and level of support needed for the river. Information from a recently completed catchment study will help address this and be used to assist with future operational management of the augmentation scheme.



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RIVER MUN

The Mun is a rural Chalk stream rising to the north-west of Southrepps in Norfolk and flowing for a distance of approximately 8km, before reaching the sea at Mundesley.

The river contains two mill ponds which are the main features appreciated by the local community and tourists. The river suffers from low flows during dry summers and this is exacerbated by abstraction for spray irrigation and the operation of a mill.

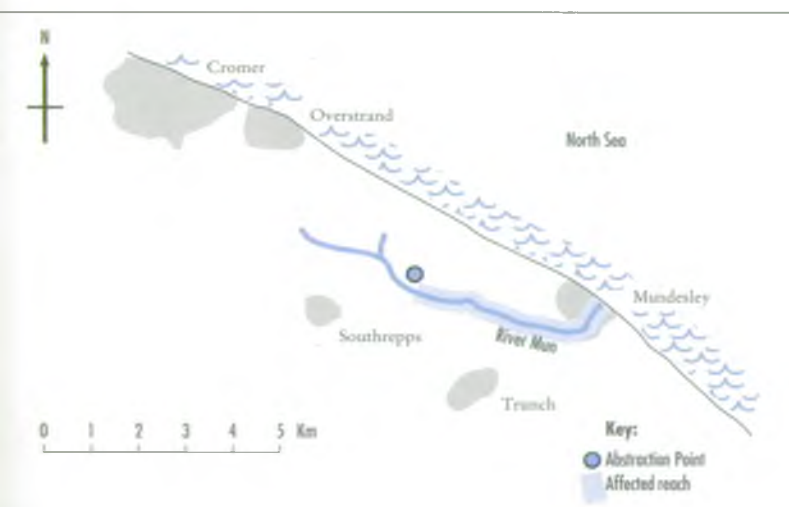
Work is under way to replace one abstraction, which affects the flows during the summer, with a new groundwater source. This will benefit flows and the water environment. However, the granting of the new licence and revocation of the existing licence is complicated by the need to resolve issues relating to the deleterious



effects on existing local abstractions. This problem is currently being looked into with a view to establishing a way forward before the summer of 1993.

The replacement water source may not be sufficient to provide a complete solution to the low flow situation and therefore further appraisal of the overall problem continues in order to establish the need for, and to identify, any further options for resolving the problem. At this stage options being considered include control of sluices, river augmentation and enhanced policing of licensed abstractions.

Licensing and further investigation work will continue to be carried out by the NRA into 1993 and, depending on any additional works identified, a planned date for implementing a solution is 1994/95.

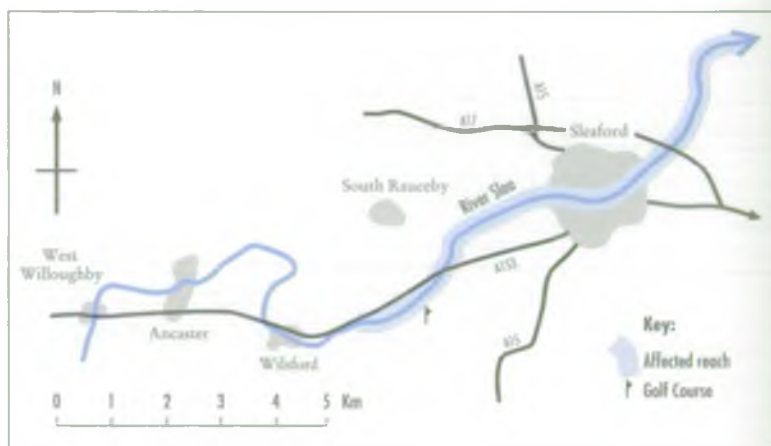


RIVER SLEA

The Slea rises from springs in the Limestone aquifer upstream of Ancaster and flows eastward, through Sleaford and beyond to its confluence with the Witham.

Between Wilsford and Sleaford the river loses water by bed leakage so that lengths of it near Rauceby Golf Course are often dry, occasionally all year round. However, before the 1960's the river through Sleaford town maintained acceptable flows and levels. Since then, increased abstraction from two public water supply boreholes on the western edge of Sleaford have increased the frequency with which the river through Sleaford dries out for unacceptably long periods.

In 1989 consulting engineers were commissioned to investigate the problem. They carried out pumping trials in consultation with local representatives, established the feasibility of river augmentation and identified solutions. Following the presentation of this report in April 1990, a remedy was selected involving



augmentation from a new borehole and limited river bed lining to minimise leakage and ensure maintenance of river levels through Sleaford.

The augmentation borehole was drilled and tested in March 1991 after which applications for licences and discharge orders were able to proceed. Resolving objections delayed issue of these documents until the autumn of 1992.

Installation of the borehole pump and associated equipment is scheduled during 1993 but is dependent on completing the purchase of land for the site. The discharge structure and bed lining are within the river channel and construction will commence when river conditions allow. Under average conditions the first opportunity to carry out this work will be in autumn 1993.

Total costs for the investigations and construction to implement the augmentation scheme are estimated at £570,000.



UPPER WAVENEY - REDGRAVE & LOPHAM FEN

Redgrave & Lopham Fen SSSI comprises some 125 hectares of spring-fed valley fen located at the watershed of the rivers Little Ouse and Waveney in Suffolk. It is a wetland site which has long been recognised for its ecological interest and for its importance in being home to the very rare Great Raft Spider. The site is designated as a Wetland of International Importance under the RAMSAR Convention and became a National Nature Reserve early in 1993.



The progressive drying out of the fen has been the subject of debate for many years. Conservationists have alleged that the major cause of the drying out is a groundwater abstraction for public water supply by Suffolk Water Company. Various studies and investigations have been conducted to identify the exact nature, extent and causes of the drying out. A report has been produced which summarises the knowledge gathered to date. This report, published in 1992, provides an agreed overview of the situation, together with conclusions and recommendations to ameliorate the situation. The report concludes that if the existing ecology of the fen is to be preserved then abstraction from the public water supply borehole should cease. Some changes to land drainage and fen management may also be required.

The preferred options for a solution are those which involve relocation of the

Redgrave public water supply abstraction to a position away from the fen. Two alternative sources have been identified, both utilising existing NRA river support boreholes (Great Ouse Groundwater Scheme and Waveney Groundwater Scheme). Both sources were originally designed to operate intermittently during drought periods and will require further investigation in order to assess their suitability for continuous public water supply use.

Depending on the outcome of further investigations, relocation costs for the two boreholes are estimated to be £1.5M and £3M respectively. These costs are a measure of the upper limit of compensation which may be payable by the NRA to the water company if the existing licence is revoked or varied. Responsibility for the payment still has to be decided. The possibility of European grant-in-aid is also being investigated. Pending further investigation and confirmation of a solution it is anticipated that remedial works should commence during 1993/94 with completion during 1994/95.



NORTH WEST REGION



River Lowther

RIVER LOWTHER

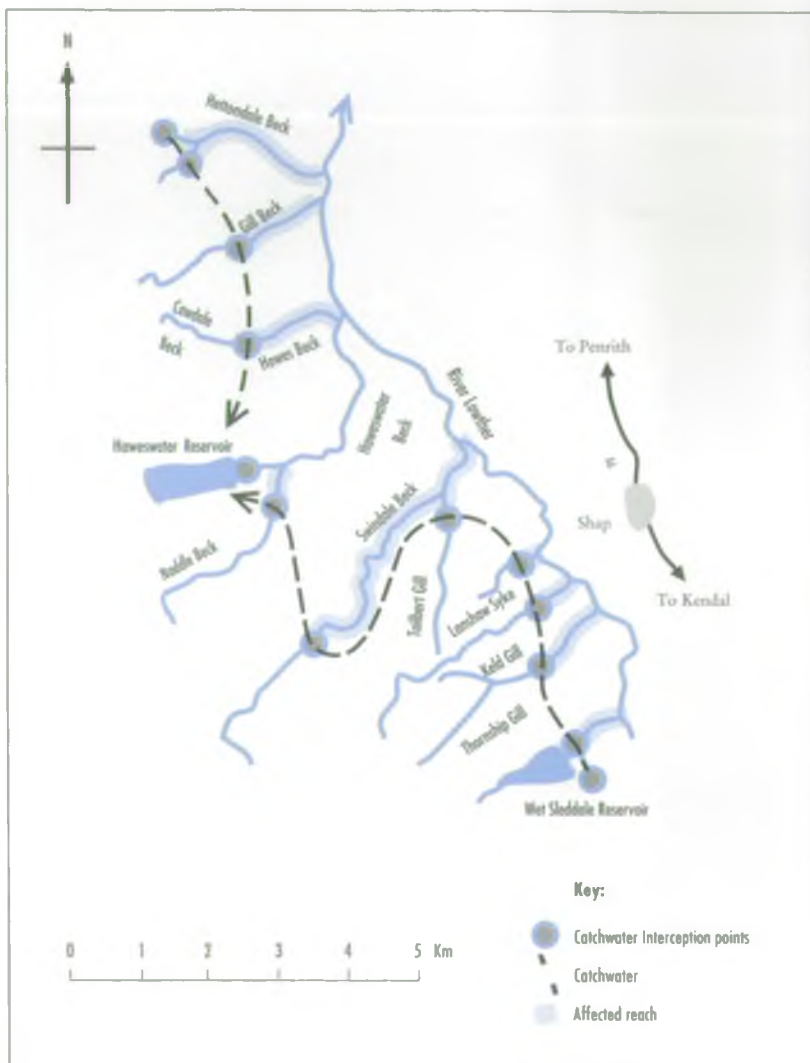
The Lowther and its tributaries rise in the Shap Fells in Cumbria.

A large proportion of the flow in the streams that feed into the main headwaters of the River Lowther is intercepted by public supply catchwaters and diverted into Haweswater Reservoir. For long periods of the year the sections of the streams below the catchwater are entirely dry.

In 1990 an extensive investigation was carried out to examine licence conditions and the effects they were having on this river and its tributaries. Recommendations were also made with regard to a possible solution. The study was completed the same year and as a result North West Water Limited met with the NRA to consider variations to the abstraction methods for Haweswater and Wet Sleddale reservoirs. In conjunction with this, compensation requirements for the catchment were also discussed.

A solution has been agreed that will:-

- 1 Provide for increased seasonal flows in some streams.
- 2 Increase the volume of water remaining in some of the tributaries beyond the abstraction points. This aims to increase the spawning and rearing habitats for migratory salmonids.
- 3 Remove some obstructions and provide a continuous strip of water below the catchwater intakes to ensure a migration route for fish.
- 4 Improve the screening arrangements at the intakes and prevent fish from entering the catchwater.



- 5 Implement a re-stocking programme by the NRA that will improve the productivity of the Lowther as a fishery.

Work has already commenced on improvements in some of the streams and this should be completed in 1993 when the new compensation conditions will come into operation.

Increased seasonal flows in the two largest sub-catchments commenced in November 1992 and increased flows in the other catchments will be implemented as soon as the



improvements in abstraction arrangements allow. This should be completed by 1994. When all the remedial works have been completed the streams will be re-stocked by the NRA as a cost of about £14,000.

The alleviation scheme was publicly launched by David Maclean, Minister for the Environment and Countryside on the 11th December 1992.

SEVERN TRENT REGION



Battlefield Brook

Black Brook

Dover Beck

Leomansley Brook

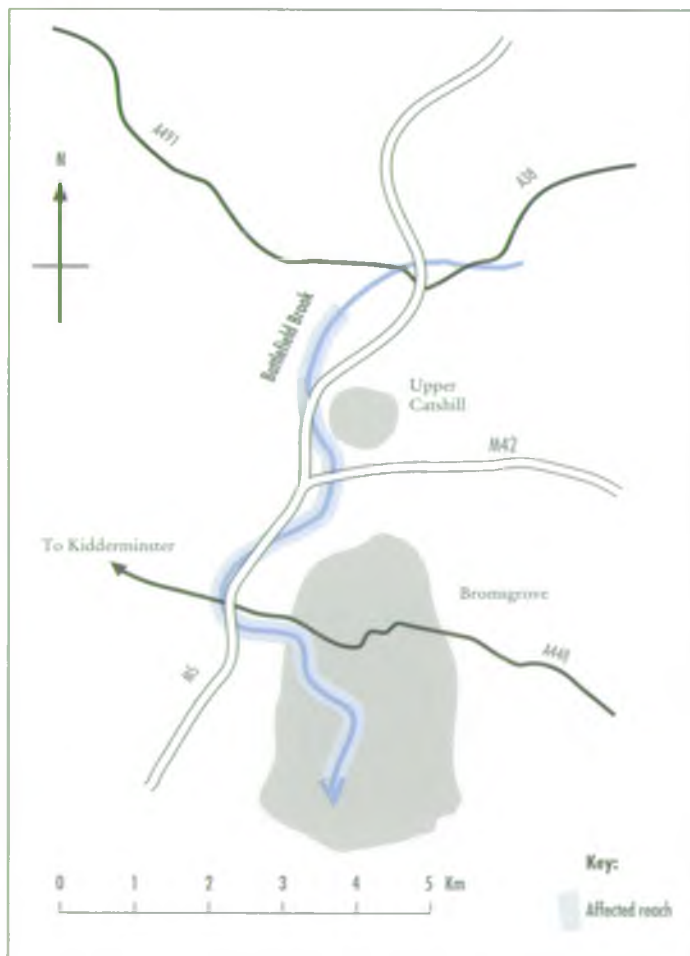
River Worfe

Rainworth Water/Rufford Lake

BATTLEFIELD BROOK

Battlefield Brook is a small watercourse which rises in the Clent Hills south of Birmingham and flows across the Triassic Sandstone outcrop for 11km to join the Sugar Brook at Bromsgrove, Worcestershire. Its catchment is approximately 34km².

The water in the Triassic Sandstones of the Bromsgrove area is extensively abstracted, primarily for public supply. A lowered water table has reduced the baseflow to Battlefield Brook and as a consequence the flow is intermittent or negligible in dry summers. For part of its length the Brook flows through a public park in Bromsgrove where it is an important amenity.



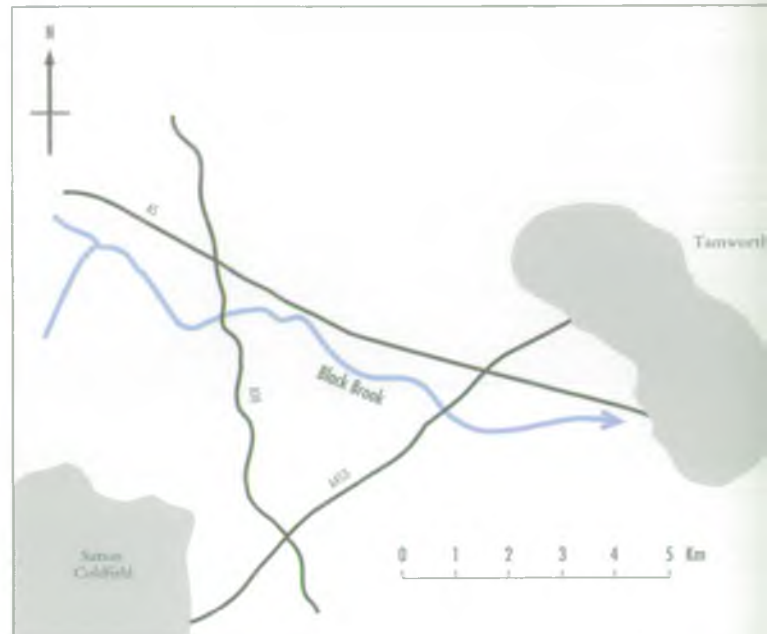
In 1989 a report was commissioned to investigate Battlefield Brook and recommend solutions to the low flow problems. It was concluded that the public park was the focus of both water quality and amenity problems caused by the loss of dry weather flow and the most effective remedial measure would be to provide flow support by borehole pumping upstream.

A borehole has now been drilled and a discharge pipeline laid at a cost of around £66,000. As with a similar scheme for the Loemansley Brook it was completed in October 1992. However due to the relatively wet autumn it has not yet been utilised for its original purpose. Discussions are proceeding with Bromsgrove District Council over the future operation of the facility.

BLACK BROOK

The Black Brook is a tributary of the River Tame. It is about 18km in length and has a catchment area of 99km² situated to the south of Lichfield in Staffordshire.

The watercourse flows across the Triassic Sandstones for much of its upper reaches. The Sandstone is utilised primarily for public water supply, and actual abstraction is significantly less than the assessed recharge. During recent years there were perceived to have been some flow problems in the Black Brook and in 1989 a report was commissioned to assess the facts and the need for remedial measures. This report found no evidence of a serious low flow problem. Although baseflow had undoubtedly diminished over time, complaints from farmers in the lower reaches related only to the management of river levels and such issues can be resolved without the need for major alleviation works. Therefore no



programme of further investigation or remedy of low flows has been promoted and the river is no longer considered to be of national significance in terms of the alleviation of low flows.



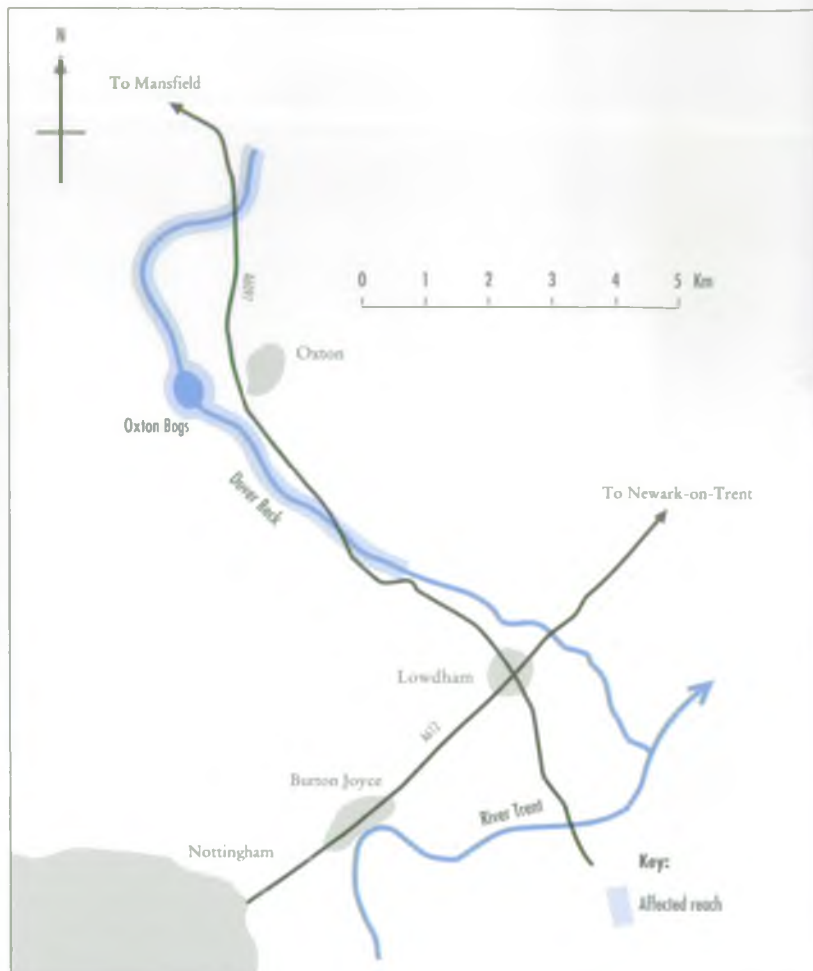
DOVER BECK

The Dover Beck is a tributary of the River Trent in Nottinghamshire. It is approximately 14km in length and has a catchment area of 74km² which lies to the north-east of Nottingham.



The initial third of the Dover Beck flows across the outcrop of the Triassic Sandstones where groundwater has been progressively and heavily abstracted since the turn of the century. Baseflows in the upper reaches have been reduced such that some 3km is now dry. Small lakes at Oxton Bogs are also disappearing and some of these are of conservation value.

In 1989 a report was commissioned to assess the situation and the need for possible solutions. Agreement has already been reached with Severn Trent Water to progressively reduce the licensed abstraction in the area by 40%



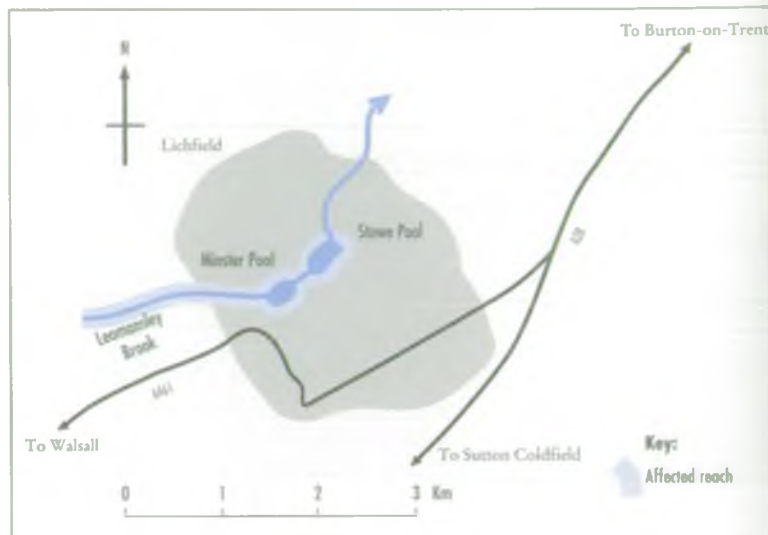
but, due to the nature of sandstone, water table recovery will be very slow. Consideration is being given to providing flow support by pumping from existing or purpose drilled boreholes and a feasibility study is planned for 1993. As yet no date for the final selection and implementation of a full solution can be given, but much will depend on the result of the 1993 study.

LEOMANSLEY BROOK

The Leomansley Brook is a small watercourse which rises on the Triassic Sandstones west of Lichfield in Staffordshire. It flows east through Lichfield and on into Minster and Stowe Pools. It is 4km in length and has a catchment area of 2.6km².

Water in the Triassic Sandstones of the Lichfield area is extensively abstracted, primarily for public water supply. A lowered water table has reduced baseflow to the Leomansley Brook and as a consequence water levels in Stowe Pool are severely depleted in dry summers. The Brook flows through a public park and both this and the pools downstream have high amenity value being close to, or within the city. The pools date back to the sixteenth century.

In 1989 an investigation was carried out to examine the Brook and its pools and recommend solutions to the low flow problem. Although the upper reaches of



the Brook were dry and once supported small fish ponds it was concluded that the most cost effective solution was to provide flow support by borehole pumping in the stretch immediately upstream of the park and the two pools.

A borehole has now been drilled and a discharge pipeline laid at a cost of around £66,000. This scheme was completed in October 1992 and has been successfully operated to refill Stowe Pool. The future operation and maintenance of the borehole will be controlled primarily by Lichfield District Council which has been supportive throughout the project.

RIVER WORFE

The River Worfe is a tributary of the River Sever joining it just north of Bridgnorth in Shropshire. It is approximately 30km long and has a number of tributaries and associated pools.

The River Worfe and its tributaries flow almost entirely on the outcrop of the Triassic Sandstones. These Sandstones are heavily utilised for public water supply purposes especially in the upper reaches and, as a result of the lowered water table, baseflows have diminished such that these upper reaches are either dry or have much reduced flow.



In 1989 a study was commissioned to report on the state of the river and recommend remedial measures for the low flow problem. The size of the catchment and the different tributaries affected give rise to a complex problem with no simple solution.

A resource development and management plan for the catchment as a whole is being considered, although the benefits of this must be seen as being for the longer term. Discussions with the water company and the farming community have been held regarding the location and intensity of abstractions with a view to developing a plan in 1993. Following the identification of a workable solution, a timetable will be drawn up for the implementation of alleviation measures.

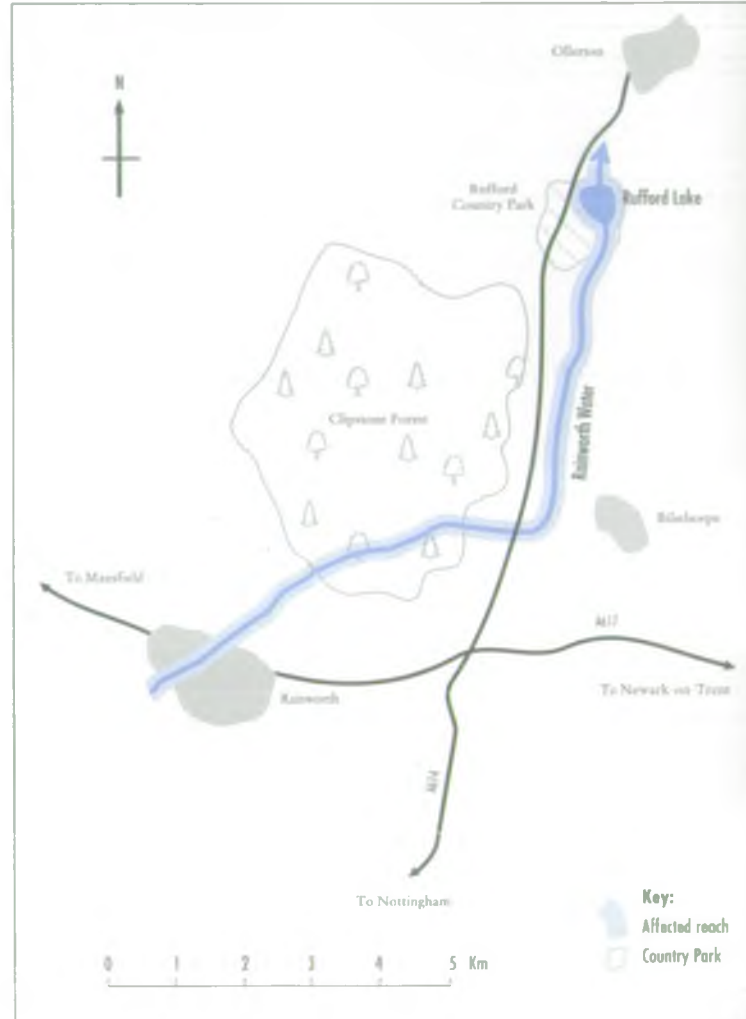


RAINWORTH WATER/RUFFORD LAKE

Rainworth Water is a tributary of the River Maun in Nottinghamshire. It is approximately 13km in length with a catchment of 74km². At its downstream end it flows into Rufford Lake which is surrounded by a Country Park.

Water in the Triassic Sandstones of Nottinghamshire is heavily abstracted, primarily for public water supplies. As a result of this abstraction the water table has been lowered over many decades and baseflow to the watercourse has disappeared. All the present flows depend upon sewage effluent and colliery discharges. The area is widely undermined and periodic subsidence gives rise to fissures which exacerbate leakage from the system and lake beds.

In 1989 the watercourse and lake were the subject of a report examining the background and possible remedies to this problem. It was concluded that additional input to Rufford Lake may be necessary by pumping from a purpose drilled borehole, but that flow support to Rainworth Water was impractical and unjustified on amenity grounds. Cessation or a significant reduction of groundwater abstraction to address the problem is not a viable option due to the nature of the strata and the very long delay in water table recovery.



Rufford Lake has recently been relined by Nottinghamshire County Council to negate the effects of subsidence. The success of this action is currently being monitored. Issues also surround the water quality of the lake particularly as a result of recent colliery closures. These added complications and the problem of maintaining levels in the lake will be assessed further in 1993, but at present it is unknown when a full solution to the problem will be identified and implemented.

SOUTHERN REGION



Bourne Rivulet

River Darent

River Hamble

River Little Stour

River Moon

Wallop Brook

BOURNE RIVULET

The Bourne Rivulet is a Chalk stream tributary of the River Test which rises to the west of Whitchurch in North Hampshire. It flows for a distance of approximately 6km to its confluence with the Test at Hurstbourne Priors. During wet winters, the stream extends a further 8km above its permanent head in St. Mary Bourne.

One kilometre downstream of St. Mary Bourne a large groundwater abstraction exists supplying a watercress growing operation. In dry years this causes the head of the stream to move downstream to below the cress farm leaving a stretch of approximately 1.5km dry. This effectively removes an attractive village amenity for very long periods of time.

In 1990 consultants were appointed by the NRA to investigate the problem and suggest solutions. The findings of the investigation were presented to residents of the valley and other interested parties during the summer of 1991.



The solution agreed involves the installation of a pipeline to circulate the water from below the watercress operation up the valley for approximately 1.5km to maintain a flow through the village.

It is hoped that a pilot scheme will be tested in 1994. The final project will cost at least £250,000.

RIVER DARENT

The River Darent is located in North Kent rising on the northern rim of the Weald of Kent in the vicinity of Westernham about 10km west of Sevenoaks. From its source the river flows first in an easterly direction to Sevenoaks and then changes direction to follow a major valley through the Chalk escarpment of the North Downs. It discharges to the River Thames near Dartford.

The river is fed by springs from the Lower Greensand aquifer and also from the Chalk aquifer of the North Downs. Both aquifers are sources for major groundwater abstraction for public water supply.

Groundwater in this area has been progressively developed during this century; typical annual abstraction is 113 megalitres a day (of which 50 megalitres a day is exported from the catchment, mainly to supply parts of south-east London). Even water consumed inside the catchment is lost from the river as treated sewage is discharged to the Thames via a trunk sewer running down the Darent valley.

The abstractions have profoundly modified the natural river regime, by reducing spring and seepage flows and consequently causing dramatic reductions in river flows particularly in the lower Darent. Indeed, during the early to mid 1970's and from 1989 to present the river has dried up completely in certain sections, sometimes for durations of several months. The reach from Lullingstone to Hawley has been particularly severely affected during these periods, with flow being lost along several kilometres of river bed. Inevitably this has reduced the diversity and recreational value of the river and has destroyed the fishery.

The NRA believes that the restoration of a natural flow regime and habitat in the River Darent is incompatible with the needs of the water supply companies to abstract large quantities of water from the aquifers, particularly from points close to the river channel; the one is in effect a competitor of the other for a limited resource. The solution may involve a reduction in abstraction quantity, effluent re-use, flow augmentation, new resource development options or some combination of these.

In order that an agreed course of action could be developed the NRA joined with Thames Water Utilities to set up a joint project team to decide upon a technical solution to the low flow problem.





As a result, working party proposals were announced in January 1993. The River Darent Action Plan includes:

- a reduction in the amount of water taken by Thames Water from the sensitive boreholes which affect flows in the Darent. This reduction will be offset by new and existing water resources - which will have no effect on the river's flows,
- a series of NRA constructed artificial springs along the banks of a river which would augment flows,
- extending the capacity and flexibility of Thames Water's distribution network in the area, bringing in water from the Thames catchment via the London Water Ring Main,
- a new NRA designed and constructed pipeline to bring extra water from Northfleet to augment flows.

Other works on the Darent include the installation of a number of small sandbag weirs at various locations. These retain a depth of water sufficient to provide a haven for all aquatic life. The NRA now intends to make some of these small weirs permanent using materials sympathetic to their surroundings.

A network of observation boreholes is being constructed in order to provide more hydrogeological data both for the calibration of the computer model and to monitor the response of underground water levels as alleviation plans are acted upon.

A river corridor survey has been carried out to identify areas where environmental enhancements can be made. The objective of this study is to draw together the conservation groups in the area and produce an environmental strategy for the future of the river. This work has been well received and has produced an important baseline describing the river after a prolonged dry period.

In 1991 NRA consultants proposed an Environmentally Acceptable Flow Regime (EAFR) for the Darent. The projected flow was obtained by working on the basis of studies of river macroinvertebrate animal populations under 'natural' and present conditions, where reduced animal abundance reflects low flows. The EAFR indicates



the flow needed to maintain the abundance and diversity of macroinvertebrates expected in a theoretically pristine Chalk stream. The methodology used to produce the EAFR is under discussion and the NRA intends that the concept will be developed and tested under current conditions. This will be the subject of a project to be started in 1993.

The NRA is also undertaking a full cost benefit exercise attempting to assign a monetary value to the changes in the environment that returning flows will bring. This project is one of the first attempts in the UK at valuing water flow benefits for wildlife, recreation and amenity features.



The £12M scheme is designed to ensure a target flow of up to 34 megalitres a day even in drought conditions. Costs will be shared between Thames Water and the water resources account of the NRA. Expenditure proposed by the NRA will be subject to the normal cost-benefit appraisal and approval by the Department of Environment. Significant improvements will be achieved by 1996, with the full scheme completed by 1998.

RIVER HAMBLE

The Hamble rises as Chalk springs feeding several tributaries close to Bishops Waltham in south-east Hampshire. It flows across sands and clays typically found in southern Hampshire for approximately 7km before reaching its tidal limit at Botley. It flows a further 10km until it reaches the sea at Hamble village.

There are two relatively large public water supply licences with borehole sources close to the springs which feed the river. Ponds exist at the heads of two of the tributaries, one of which supports a wetland Site of Special Scientific Interest. It is believed that these pond sites may be affected by the local abstractions lowering groundwater levels, reducing spring flows and depleting downstream flows.



Early in 1992 consultants were commissioned by the NRA to carry out an extensive investigation into the effects of these local abstractions upon the springs and the river. Initial studies have been completed and were presented to interested parties at a public meeting in December 1992.

Following this consultation on the preliminary findings of the investigation the final report will be published during 1993 with a decision on the final solution following soon afterwards. It is hoped that a timetable for any remedial measures necessary will be decided upon by the end of 1993.



LITTLE STOUR

The Little Stour is a rural Chalk stream rising from Well Chapel Springs and flows north-eastwards for approximately 10km to its confluence with the Great Stour.

The river between Well Chapel and Seaton Mill dried up in the summer of 1991 and did not flow again until December 1992. However the water responsible for this restoration of flow came mainly from the gravel aquifer and not the chalk. This part of the river is within a conservation area and two historic mills are without water. Groundwater levels have been consistently falling since 1989 and there are two large public water supply abstractions within 4km of the river.

A mathematical model of the East Kent Chalk Aquifer was constructed for Folkestone and District Water Company in 1991. This attempted to describe the effects of pumping on water levels throughout the aquifer. However, the nature of the hydrogeology in the area of the Little Stour Valley makes modelling difficult.



A better understanding of the groundwater contours is required in the vicinity of the Little Stour and the NRA is proposing within the next water year to place a series of observation boreholes down the reaches of the river.

The NRA is developing a Kent Groundwater Policy which will include restrictions on further chalk aquifer abstractions. Four area management schemes will be developed covering the Darent, East Kent, North Kent and the Upper Medway. Once the Darent management scheme is implemented, the North Kent (Stour and Little Stour/ Nailbourne) will be the next priority.

RIVER MEON

The Meon is one of the famous Hampshire Chalk streams. It rises to the south of East Meon and flows through several villages on its course of approximately 30km before meeting the sea at Hillhead.

The Meon is subject to low flows from West Meon to Warnford due to the changing nature of the Chalk along its course. Water is lost through the bed along these stretches to such an extent that in times of drought it dries up near West Meon. There are public supply boreholes at East Meon and West Meon, whilst the abstraction at Soberton is thought to be causing most of the problems. There is also concern over the low flows reaching the Site of Special Scientific Interest at Titchfield Haven, just upstream of where the Meon reaches the sea.

Consultants were commissioned by the NRA to investigate the extent of these problems and suggest solutions. An extensive study has been carried out into the flows and the natural conditions along the course of the river.



Preliminary investigations are complete and were presented to interested parties at a public meeting within the valley in November 1992.

Following this consultation on the findings of the investigation the final report will be published during 1993 with a decision on the final solution following soon afterwards. It is hoped that a timetable for any necessary measures will be decided upon by the end of 1993.

WALLOP BROOK

The Wallop Brook is a Chalk stream tributary of the River Test which rises to the north-west of Stockbridge in rural Hampshire. It flows for a distance of approximately 12km through the picturesque villages of Over Wallop, Middle Wallop, Nether Wallop and Broughton before it reaches its confluence with the Test close to Houghton.

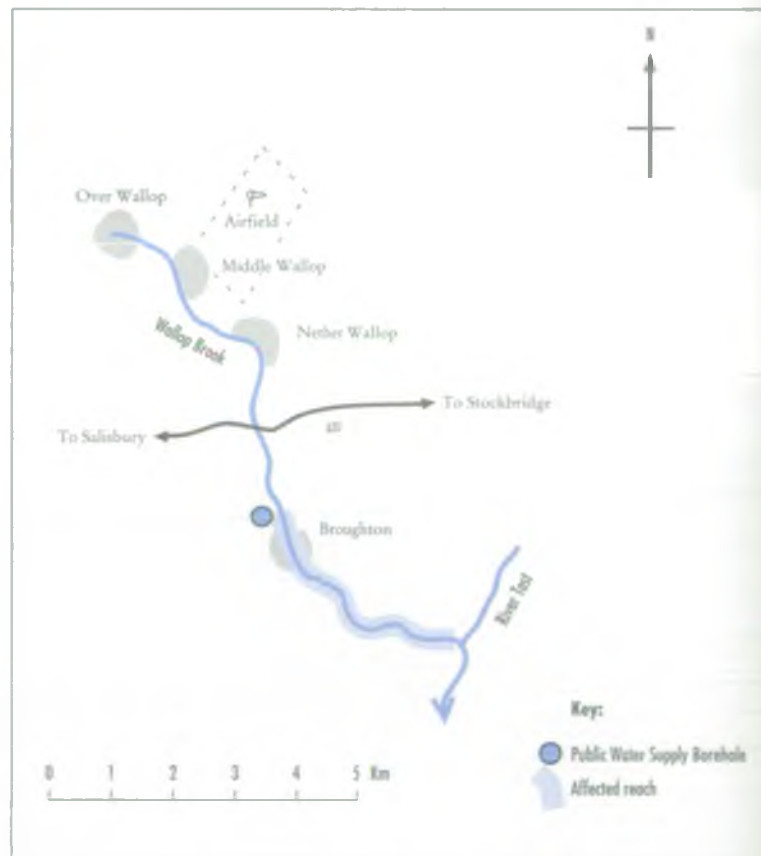


The Brook rises around Over Wallop with strong flows seen in Middle Wallop. There is a change in the nature of the Chalk bed of the stream to the north of the village of Broughton. This combines with a public water supply borehole close to the stream causing it to dry up more frequently and for longer periods than would be expected under natural conditions. The dry bed extends south through the village of Broughton where it is normally an attractive feature. Fishery and riparian interests and downstream flows are severely affected.

Consultants were appointed by the NRA in 1990 to carry out an investigation into the extent of the

problem and determine the optimum solution. The investigation was finished with the publication of the final report in 1992. The preferred remedial option was defined following consultation with interested parties in the valley. The solution involves installation of pipelines linking the Broughton water supply source with larger sources to the south. This would enable pumping from the Broughton source to cease in times of drought.

Negotiations are taking place between the NRA and Southern Water Services to define a timetable for work on the connection between sources.



THAMES REGION



Letcombe Brook

River Misbourne

River Pang

River Ver

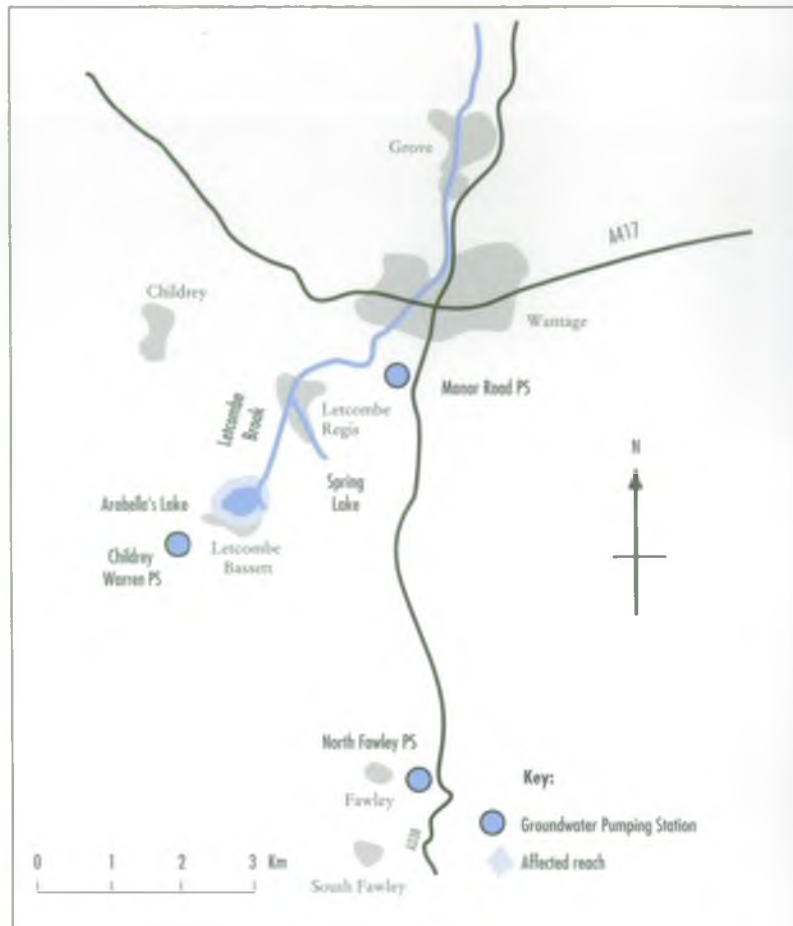
River Wey

LETCOMBE BROOK

The Letcombe Brook is a tributary of the River Ock with two branches running from Arabella's Lake in Letcombe Basset and Spring Lake in Letcombe Regis near Wantage. The Brook is fed by springs issuing from the Chalk aquifer.

A public water supply pumping station at Childrey Warren is currently abstracting some 35% of the water available to the upper Letcombe Brook and is considered to affect spring flows. Levels at Spring Lake may also be affected by a similar pumping station at Manor Road.

Abstraction began at Manor Road in about 1900 and at Childrey Warren in 1935. The licensed abstraction from both sources is 7.7 megalitres a day. Up until 1991 a licence variation was linked to a scheme to supply extra water to the lakes from the West Berkshire Groundwater Scheme using the North Fawley borehole. The proposal for alleviation involves continuing this seasonal augmentation of the flows in each tributary. This augmentation will be made more reliable by improvements to the North Fawley Pumping Station and outfalls. This work was



substantially complete by March 1993. In addition to this the NRA will be exploring with Thames Water Utilities the possibilities of reduced abstraction. Gauging stations have been installed at the two villages to monitor flow rates. In total the full alleviation scheme will cost around £110,000.

RIVER MISBOURNE

The River Misbourne is a tributary of the River Colne and runs through the Chiltern Hills in Buckinghamshire. It passes through the towns of Great Missenden, Amersham, Chalfont St. Giles and Chalfont St. Peter.



Historically the River Misbourne has always shown a tendency to lose water from its middle section. This natural variation in flow has been exaggerated by groundwater being taken from boreholes for public water supply. At present about 65% of the water available to the river in an average year is pumped out. The resulting sewage effluent is discharged outside the catchment, apart from a small amount at Gerrards Cross at the downstream end.

In 1986 consulting engineers were commissioned to carry out an extensive investigation of the conditions affecting the Misbourne and recommend a solution to the low flow problem. The options put forward have now been thoroughly considered and a decision made to examine in detail the proposals to reduce the amount of abstraction from the upper valley and bring in alternative supplies. Following discussions with Three Valleys Water Services and Thames Water Utilities, proposals and costings will be put forward to the Department of the Environment for comparison with other options and final approval.

While investigations and costings continue, a start has been made on preliminary works which will be of

benefit whatever proposal finally comes to fruition. Ten boreholes have been sunk in the river valley between Mobwell and Chalfont St. Peter in order to monitor and analyse changes in groundwater level beneath the bed of the river. The stretch between Amersham and Chalfont St. Giles (where water is lost through the bed) may require lining.

The costs associated with the development of new sources of supply could run into millions of pounds. Therefore, very careful consideration will need to be given to any proposals before submission to the Department of the Environment. If approval is forthcoming, and average rainfall is received, then it would be expected that groundwater levels could be re-established and flow returned to the upper reaches of the Misbourne within four to six years.



RIVER PANG

The River Pang is a rural Chalk stream rising to the north of Hampstead Norreys in Berkshire and flowing on for a distance of approximately 25km to its confluence with the Thames at Pangbourne.

At present about 35% of the water which feeds the upper reaches of the Pang is abstracted for public water supply by a major pumping station at Compton and a smaller station at Bradfield. As a result of this abstraction the Pang has dried out more frequently and for longer periods than would otherwise have been expected.

In 1986 consulting engineers were commissioned to carry out an extensive investigation of the conditions on the river and to recommend a solution. They completed their work in 1989.

After considering various options arising from these investigations it was voluntarily agreed by Thames Water Utilities that with effect from mid 1992 they would limit the abstraction from Compton Pumping Station. This major reduction from 13.5 to no more than 5.0 megalitres a day should bring about a substantial recovery of the water table



and river flows. A new borehole alongside the Thames at Gatehampton near Goring makes up the resulting supply deficit to Didcot. Discussions are continuing with Thames Water Utilities with a view to formalising this voluntary arrangement by means of a licence variation. It is anticipated that this will be achieved during 1993. River improvements will also be carried out, including enhancements to the channel within Hampstead Norreys and between the M4 and Frilsham Manor.

Future trends in river flows and water table levels are to be monitored through newly constructed gauging stations at Frilsham and Bucklebury and observation boreholes along the river at Hampstead Norreys, Frilsham and Bucklebury.

RIVER VER

The River Ver runs through the Chiltern Hills close to the Bedfordshire/Hertfordshire border, skirting the village of Redbourn and passing through St. Albans before joining the River Colne.



It is fed from springs and seepages discharging from the Chalk aquifer which lies beneath the catchment area. Its flow therefore, depends on the level of the underground water table. The amount of abstraction from the aquifer has risen sharply since the 1950's. Today almost 70% of the water normally available to the river is taken out for public water supply. As a result of this some 10km of its original length have dried up, while other stretches are shallow, slow flowing and suffering from associated environmental damage.

The River Ver was one of five major case studies undertaken by consulting engineers between 1986 and 1989. Four different improvement schemes were put forward, the recommended option being the augmentation of the river from a new borehole source near the confluence with the Colne. In the midst of strong representations, the Ver Valley Society proposed an alternative based on taking more water from Grafham reservoir, a source outside the Ver catchment, and thereby reducing abstraction and restoring the flow up to Flamstead.

Developing the Society's ideas and responding to the NRA's firm intent to improve flows in the Ver, Lee Valley Water, now part of Three Valleys Water Services, proposed a new scheme which

received Government approval in September 1991. This scheme, which is a joint project between the NRA and Lee Valley, started in February 1992 and will be substantially complete by April 1993 at an estimated cost of £2.5 million.

Significant environmental improvements will arise through:

- 1 Allowing the water table to recover to restore the former wildlife habitats to the river and its margins.
- 2 Allowing the Friars Wash Pumping Station to be used only to meet peak demands and in emergencies.
- 3 Enhancing the river channel down to St. Albans to improve habitats and fish life.

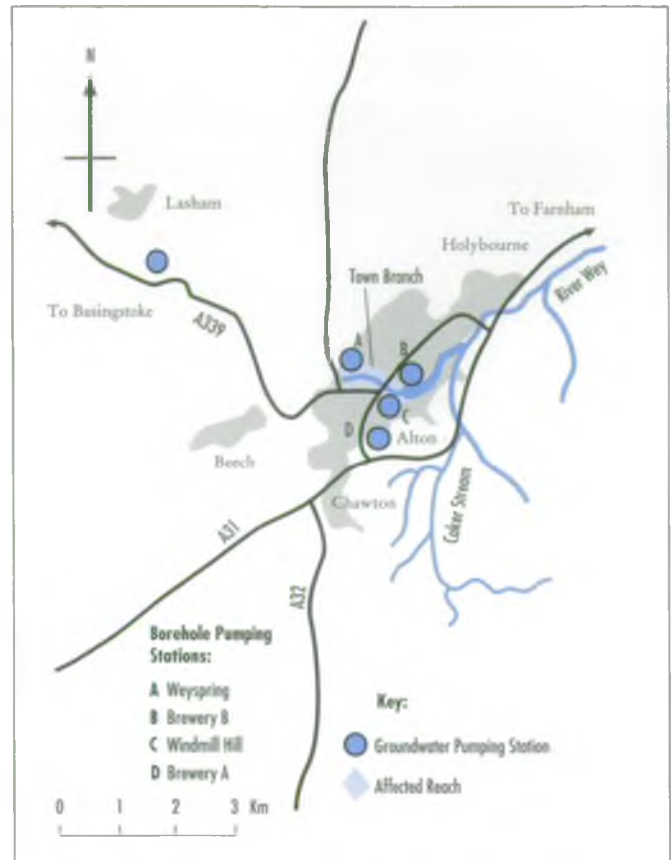


RIVER WEY

The northern branch of the river Wey begins at Alton in the Hampshire Downs and joins the larger southern branch near Farnham. There are two main tributaries to the North Wey; the Town Branch which runs through Alton, and the Caker Stream which joins the Town branch downstream of Alton.

About 65% of the water available to the Wey catchment down to Alton is pumped out for public water supplies and industrial use. The low flows in the Town Branch cause most concern since the river provides a visual and historic amenity to the people of Alton. Abstraction of groundwater began as far back as 1876 and there are now four borehole sources, two for public supply and two for a local brewery. The brewery abstractions are relatively small and are thought to have little effect on the river. However, the public water supply abstractions have a significant effect on groundwater levels.

An extensive investigation into the problems of the Wey was completed in 1989 as part of a wider survey of similar conditions on other rivers. The scheme recommended as a result of this study involves a temporary halt to pumping from the Weyspring and Windmill Hill pumping stations during times of low



river flow. The 5 megalitres a day output from the two stations will be made up from a new borehole to be sunk into the Chalk and Upper Greensand aquifers south-west of Alton, away from the river.

Studies have also started in collaboration with Mid Southern Water into other possible schemes. One is the diversion of some additional supplies from Basingstoke to Alton, the other is the use of the deeper Lower Greensand aquifer.

Whilst no firm date for the selection and implementation of a satisfactory solution can currently be given it is nevertheless expected that this will be completed by 1996.

WELSH REGION

Afon Alyn

Afon Cefni

Afon Clywedog

Garren Brook

River Frome

River Monnow

The Gamber

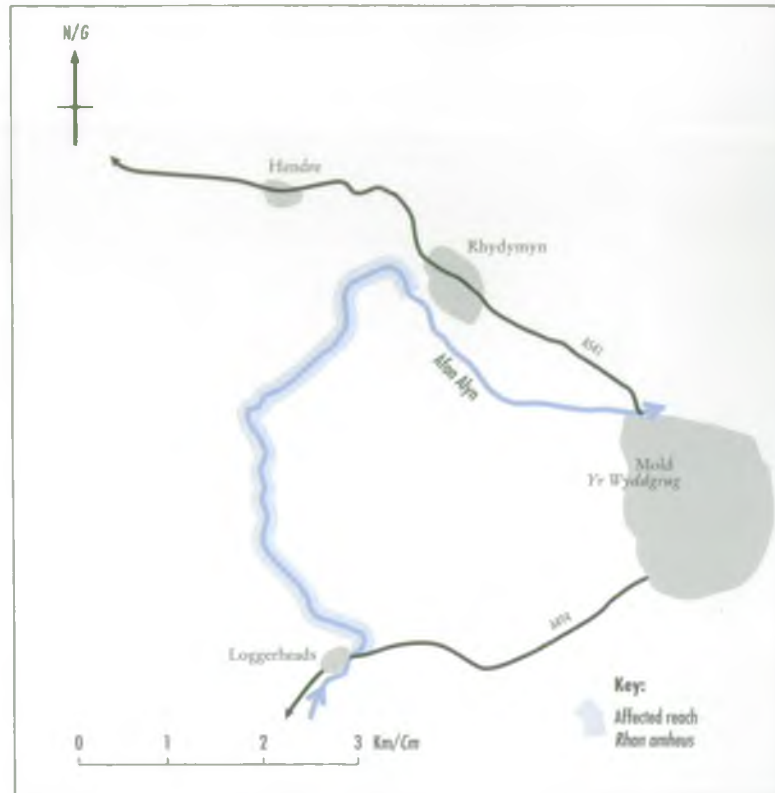
AFON ALYN

The Alyn rises near Llandegla in eastern Denbighshire in North Wales and flows north-northwest to Rhydymwyn, where it abruptly turns to the south-east and eventually joins the Dee north of Wrexham. The river is 58km long.

Lack of flow in the Alyn has been commented on for many centuries. It gave rise to the legend of a giant who, when set on fire by St. Cynhafal, jumped into the stream to extinguish the flames causing it to dry up. The Alyn loses water into the Carboniferous Limestone in the middle reach from Loggerheads to Rhydymwyn. This stretch is often dry for over 170 days a year from March to September, with the exception of minor inputs from mining adits and a sewage treatment plant. The water lost to the limestone finds its way into an old mine drainage system and is discharged from a drainage tunnel outlet at Bagillt, Deeside.

In 1990 the NRA commissioned consulting engineers to investigate the problem and recommend a solution. In December 1990 they identified the problem to be a combination of the river passing over a fissured limestone bed and historic mining activities. A solution was proposed, to redistribute the water by pipeline, but a cost benefit study by the same consultants produced in August 1991 shows that the scheme cannot be justified.

The NRA has resolved to commit no further expenditure, but in-house work to evaluate local remedial measures specific to the lower Alyn will continue.



Mae Afon Alyn yn codi ger Llandegla yn nwyrain Sir Dinbych yng Ngogledd Cymru ac yn llifo tua'r gogledd/gogledd-orllewin i Rydymwyn, lle mae'n troi'n sydyn i'r de-ddwyrain ac yn ymuno yn y man ag Afon Dyfrdwy i'r gogledd o Wrecsam. Mae'r afon yn 58km o hyd.

Bu sôn am ddiffyg dŵr yn Afon Alyn ers canrifoedd lawer. Ceir ymgais i'w esbonio mewn hen chwedl am gawr a roddwyd ar dân gan Sant Cynhafal ac a neidiodd i'r nant i'w ddiffodd gan beri iddi sychu. Mae Afon Alyn yn colli dŵr i'r Garreg Galch Garbonifferaid rhwng Loggerheads a Rhydymwyn. Mae'r rhan hon yn aml yn sych am dros 170

diwrnod y flwyddyn rhwng Mawrth a Medi, ac eithrio llifoedd bach o geuffyrdd (adits) traenio a gwaith trin carthion. Mae'r dŵr a gollir i'r garreg galch yn gwneud ei ffordd i hen system draenio'r mwynloddfeydd ac yn cael ei arllwys o dwel traenio ym Magillt, Glannau Dyfrdwy.

Yn 1990 comisiynwyd peirianwyr ymgynghorol gan yr AAC i ymchwilio i'r broblem ac argymhell ateb. Ym mis Rhagfyr 1990 adroddwyd mai cyfuniad o'r afon yn llifo dros wely carreg galch

agennog a gweithgareddau dad-ddyfrio (dewatering) yn gysylltiedig a mwynloddio hanesyddol oedd wrth wraidd y broblem. Cynigiwyd ateb, sef ailddosbarthu'r dŵr drwy bibell, ond mae astudiaeth fudd/cost a gynhyrchwyd gan yr un ymgynghorwyr ym mis Awst 1991 yn dangos na ellir cyfiawnhau'r cynllun hwn.

Mae'r AAC wedi penderfynu peidio ag ymrwymo gwariant pellach, ond bydd yn parhau i gloriannu mesurau adferol lleol ar gyfer yr Alyn isaf.

AFON CEFNI

The Cefni rises near Mynydd Bodafon in the north-east of the island of Anglesey in North Wales. It flows in a south-westerly direction into Cefni Reservoir, where it changes to south-easterly to flow through Llangefni, and south-westerly again through Malltraeth Marsh to the sea at Malltraeth Sands. The river is 31km long.

Problems were experienced with the dilution of the Llangefni Sewage Treatment Works discharge which, it was felt, could be lessened by a greater release into the river from the Cefni reservoir at times of low flows. This would be achieved by varying the compensation rates from the reservoir whilst maintaining the same release volumes over the course of the year.

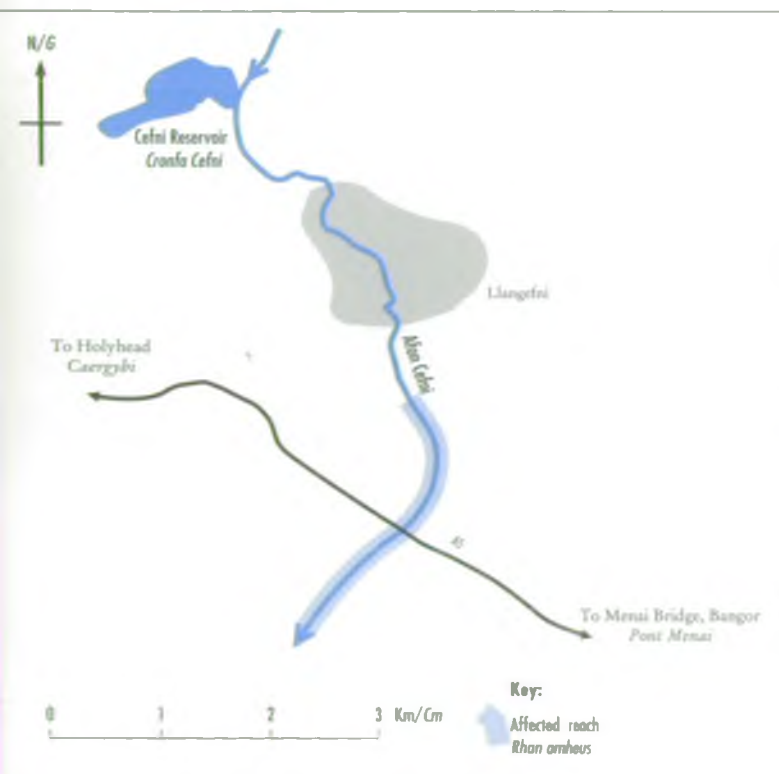
Since the commissioning of the new Llangefni Sewage Treatment Works problems have lessened but have not yet been eliminated. Consideration is still being given to the benefits - if any - that would arise from pursuing an agreement with Dŵr Cymru to seasonally vary

compensation rates of flow from the Cefni reservoir. This would be done at no cost to either party apart from those costs associated with varying licences and Water Orders. No impact on yield would result.

Mae Afon Cefni yn codi ger Mynydd Bodafon yng ngogledd-ddwyrain Ynys Môn yng Ngogledd Cymru. Mae'n llifo i'r de-orllewin i mewn i Gronfa Ddŵr Cefni, ac oddi yno mae'n llifo i'r de-ddwyrain drwy Llangefni ac i'r de-ddwyrain eto drwy Gors Ddyga i'r môr ym Malltraeth. Mae'r afon yn 30km o hyd.

Cafwyd problemau gyda gwanhad y dadlwytho o waith trin carthion yn Llangefni, a'r gred oedd y gellid eu lleihau drwy ryddhau mwy o ddŵr i'r afon o Gronfa Ddŵr Cefni pan oedd y llif yn isel. Cai hyn ei wneud drwy amrywio'r llif cyfadferol o'r gronfa tra'n parhau i ryddhau'r un cyfeintiau o ddŵr yn ystod y flwyddyn.

Mae'r sefyllfa wedi gwella ers roi'r GTC newydd yn Llangefni ar waith ond ni ddilewyd y problemau'n gyfan gwbl. Parheir i ystyried manteision posibl i cytundeb rhwng yr AAC a Dŵr Cymru i amrywio'n dymhorol y llifoedd cyfadferol o Gronfa Ddŵr Cefni. Ar wahan i'r costau sy'n gysylltiedig ag amrywio trwyddedau a gorchmynion dŵr, ni fyddai hyn yn costio dim i'r naill ochr na'r llall. Ni chai unrhyw effaith ar faint o ddŵr a gyflenwir.



AFON CLYWEDOG

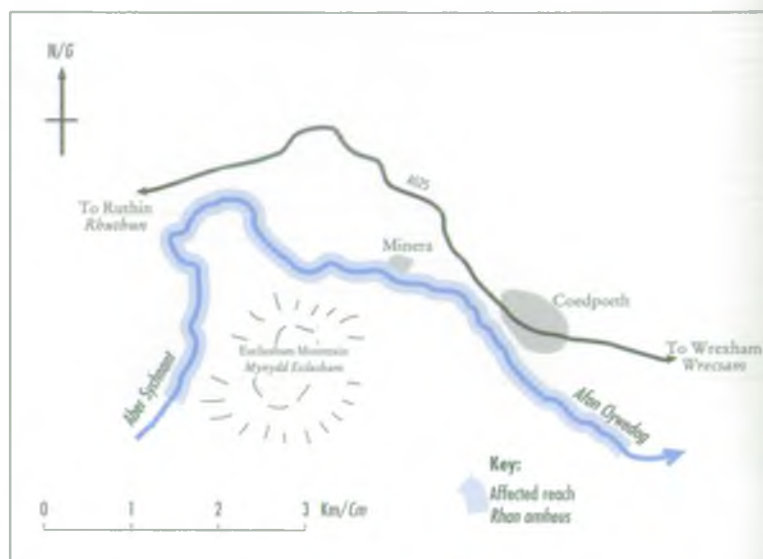
The Clywedog is a tributary of the Dee, and is 28.5km long. Its source is the Aber Sychnant which initially flows in a northerly direction to Gwynffryn, and then eastwards along the southern boundary of Wrexham, to its confluence east of Wrexham Industrial Estate. The catchment is on the slopes of the Esclusham Mountain, close to Minera.

Much of the catchment geology is Carboniferous Limestone and the river bed contains swallowholes which lose water naturally into the underlying limestone. Historic metalliferous mining activities, with associated drainage adits, have exacerbated this natural phenomenon. However, this water is discharged from adits a little further down the river.

Wrexham and East Denbighshire Water Company (WEDWCo) has utilised some of the mine drainage system for public water supply purposes. This has further added to the loss of water from the river. When their abstraction is taking place, the discharge from the adits is reduced.

Discussions with WEDWCo have considered the feasibility of abandoning the Clywedog abstractions in favour of the River Dee, where additional water could be made available. A decision is yet to be made.

Un o lednentydd Afon Dyfrdwy yw'r Clywedog, ac mae'n 20.5km o hyd. Ei tharddle yw llednant Aber Sychnant yn NGR SJ 226 496, sy'n llifo i ddechrau i'r gogledd i Gwynffryn ac yna i'r gorllewin, ar hyd ffin ddeuheuol Wrecsam, i'w chydliad i'r dwyrain o



Ystad Ddiwydiannol Wrecsam. Mae'r dalgylch ar lethrau Mynydd Esclusham ger Mwynglawdd (Minera).

Ceir Carreg Galch Garbonifferaidd mewn rhan helaeth o'r dalgylch ac mae gwely'r afon yn cynnwys llync-dyllau (swallowholes) sy'n colli dŵr yn naturiol i'r garreg galch waeledol. Mae mwyngloddio metelifferaidd hanesyddol, a'i geuffyrdd traenio cysylltiedig, wedi dwysau'r ffenomen bellach i lawr yr afon.

Mae Cwmni Dŵr Wrecsam a Dwyrain Dinbych wedi manteisio ar system draenio'r mwyngloddfeydd er mwyn tynnu dŵr at ddibenion y cyflenwad dŵr cyhoeddus. Mae hyn wedi peri i ragor o ddŵr gael ei golli o'r afon. Pan fydd wrthi'n tynnu dŵr, fe leiheir yr arllwysiad o'r ceuffyrdd traenio.

Yn ystod trafodaethau gyda'r Cwmni fe ystyriwyd y posibilrwydd o roi'r gorau i dynnu dŵr o Afon Clywedog a rhynnu rhagor o ddŵr o Afon Dyfrdwy. Ni ddaethpwyd i benderfyniad eto.

GARREN BROOK/Y GARREN

Garren Brook is a small tributary of the Wye, being 30.7km long. It rises at Garway Hill, and meanders in a narrow valley in a south-easterly direction to its confluence with the Wye, north of Symonds Yat.

The low flows in the catchment are reputed to be due to high spray irrigation demands in the summer months.

A detailed investigation of abstraction licences in the catchment undertaken during the summer of 1992 has shown that during critical periods of low flow irrigation abstraction may be having some impact. To help combat low flows, further licences for nett summer

abstractions will not be granted. These will be restricted to winter storage only.

Further work will be undertaken to evaluate the scale of the problem.

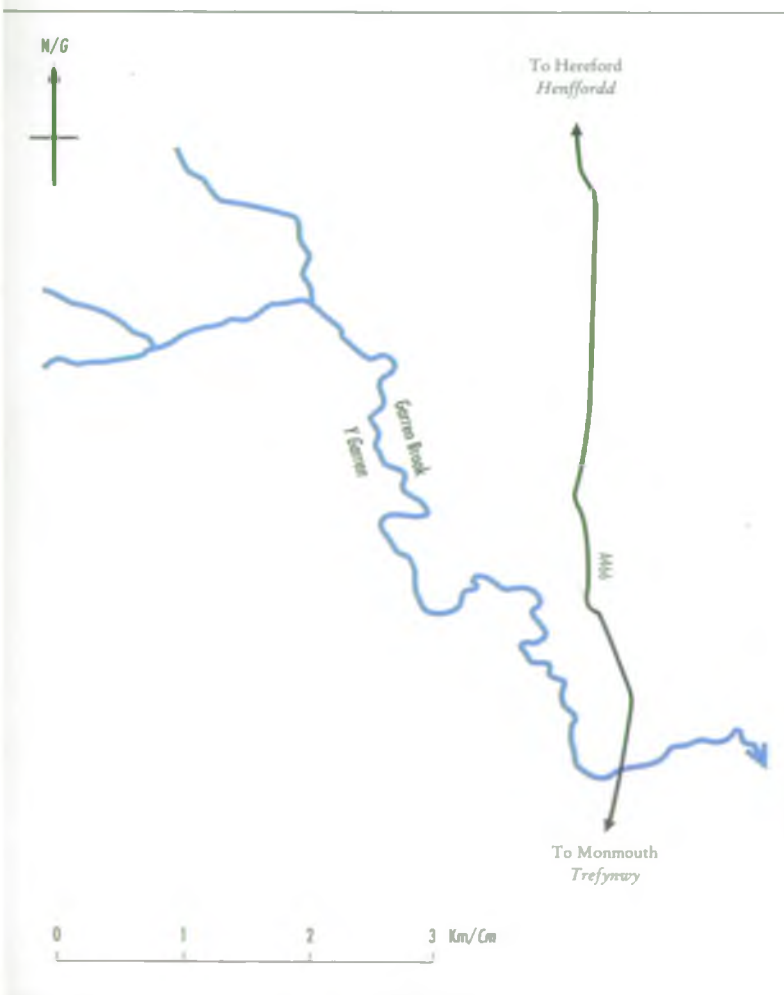
Un o lednentydd bach Afon Gwy yw'r Garren, ac mae'n 30.7km o hyd.

Mae'n codi yn Garway Hill ac yn ymddolennu mewn dyffryn cul i'r de-ddwyrain cyn cyfarfod â'r Gwy i'r gogledd o Symonds Yat.

Honnir mai dyfrhau drwy chwistrellu ar raddfa fawr yn ystod misoedd yr haf sy'n gyfrifol am y llif isel yn y dalgylch.

Mae ymchwiliad manwl o'r trwyddedau tynnu dŵr yn y dalgylch, a wnaed yn ystod yr haf 1992, wedi dangos y gall fod dyfrhau drwy chwistrellu yn cael peth effaith pan fo'r llif yn isel iawn. I helpu gwrthweithio llif isel, ni roir rhagor o drwyddedau ar gyfer tyniadau haf net. Cyfyngir y rhain i storio dŵr yn y gaeaf.

Gwneir rhagor o waith i asesu graddfa'r broblem.



RIVER FROME/AFON FROME

The Frome is a tributary of the Lugg, within the catchment of the River Wye, located north-east of Hereford and to the west of the Malvern Hills. The river rises at Thornbury and flows in a southerly direction through Bromyard down to Bishops Frome. Here it changes to a south-westerly direction and flows in a broad low valley to its confluence at Hampton Bishop, east of Hereford. The river is 43km long and has a catchment area of 171km².

The low flows in the catchment are reputed to be due to high spray irrigation demands in the summer months.

A report was prepared in March 1991 under contract between the NRA, Welsh Region and the National Environment Research Council which considered the hydrological impacts of abstraction on the River Frome. Three scenarios of abstraction rates were studied.

The conclusion was that, under each scenario, it is a limited number of the first order tributaries of the catchment which are affected rather than the main channels. Impacts of abstractions cannot simply be ascribed to any one purpose or source, so the results point to naturally occurring low flows rather than abstraction related problems. The main impact of current abstractions is restricted to tributaries of the Frome, the most affected being in the vicinity of Crowels Ash, Stretton Grandison and Shucknall. However, these effects are extremely minor and very localised.

No further action is planned.



Un o lednentydd Afon Lugg yw'r Frome, o fewn dalgylch Afon Gwy, wedi'i lleoli i'r gogledd-ddwyrain o Henffordd ac i'r gorllewin o Fryniau Malvern. Mae'r afon yn codi yn Thornbury ac yn llifo i'r de drwy Bromyard i lawr i Bishops Frome. Yma mae'n newid cyfeiriad ac yn llifo i'r de-orllewin mewn dyffryn isel llydan i'w chydliifiad yn Hampton Bishop, i'r dwyrain o Henffordd. Mae'r afon 43km o hyd ac mae ganddi ddalgylch o 171km sgwâr.

Honnir mai dyfrhau drwy chwistrellu ar raddfa fawr sy'n gyfrifol am y llif isel yn y dalgylch ym misoedd yr haf.

Paratowyd adroddiad ym mis Mawrth 1991 gan yr Awdurdod Afonydd Cenedlaethol, Rhanbarth Cymru a'r Cyngor Ymchwil Amgylcheddol Cenedlaethol ar effeithiau hydrolegol y tyniadau dŵr ar Afon Frome.

Ystyriwyd beth fyddai'n digwydd pe bai dŵr yn cael ei dynnu ar dri chyfradd gwahanol.

Y casgliad, ym mhob achos, oedd yr effeithir ar nifer fach o lednentydd pwysicaf y dalgylch yn hytrach na'r prif sianelau. Ni ellir priodoli'r llif isel i unrhyw un pwrpas na ffynnonhell, felly mae'r canlyniadau'n awgrymu mai llifoedd isel naturiol yn hytrach na gweithgareddau tynnu dŵr sy'n achosi'r broblem. Mae'r tyniadau presennol yn

effeithio'n bennaf ar lednentydd Afon Frome, yn enwedig y rhai yng nghyffiniau Crowels Ash, Stretton Grandison a Shucknall. Er hynny, mae'r effeithiau hyn yn fach iawn ac wedi eu lleoli.

Ni fwriedir cymryd camau pellach.

RIVER MONNOW/AFON MYNWWY

The Monnow is the second largest tributary of the Wye, being 57km long and having a catchment area of 433km². It rises in the Black Mountains, and flows in a general south-easterly direction to its confluence with the Wye at Monmouth.

The low flows in the catchment are reputed to be due to high spray irrigation demand in the summer months.

A detailed investigation of abstraction licences in the catchment, undertaken during the summer of 1992, has shown that the low flows sometimes experienced are a result of the natural characteristics of the catchment. The impact of abstraction is relatively minor. To help combat low flows, further licences for nett summer abstractions will not be granted. These will be restricted to winter storage only.

No further action is planned.



Afon Mynwy yw llednant fwyaf ond un Afon Gwy. Mae'n 57km o hyd ac mae ganddi ddalgylch o 433 km sgwâr. Mae'n codi yn y Mynydd Du ac yn llifo i'r de-ddwyrain nes cyfarfod ag Afon Gwy yn Nhrefynwy.

Honnir mai dyfrhau drwy chwistrellu ar raddfa fawr yn ystod misoedd yr haf sy'n gyfrifol am y llif isel yn y dalgylch.

Mae ymchwiliad manwl o'r trwyddedau dŵr yn y dalgylch, a wnaed yn ystod yr

haf 1992, wedi dangos bod y llifoed isel a geir weithiau yn ganlyniad i nodweddion naturiol y dalgylch. Nid yw tynnu dŵr yn cael llawer o effaith. I helpu gwrthweithio llif isel, ni roir rhagor o drwyddedau ar gyfer tyniadau haf net. Cyfyngir y rhain i storio dŵr yn y gaeaf.

Ni fwriedir cymryd camau pellach.

THE GAMBER/Y GAMBER

The Gamber is a tributary of Garren Brook, which in turn flows into the Wye. It is 13.8km long, rising near Llanwerne and flowing in a south-easterly direction to its confluence.

The low flows in the catchment are reputed to be due to high spray irrigation demand in the summer months.

A detailed investigation of abstraction licences in the catchment undertaken during the summer of 1992 has shown that during critical periods of low flow irrigation abstraction may be having some effect. To help combat low flows, further licences for nett summer abstractions will not be granted. These will be restricted to winter storage only. There is also a proposal to build a gauging station on the river in 1994 to monitor flows in the catchment and provide more information on the impact of abstraction.

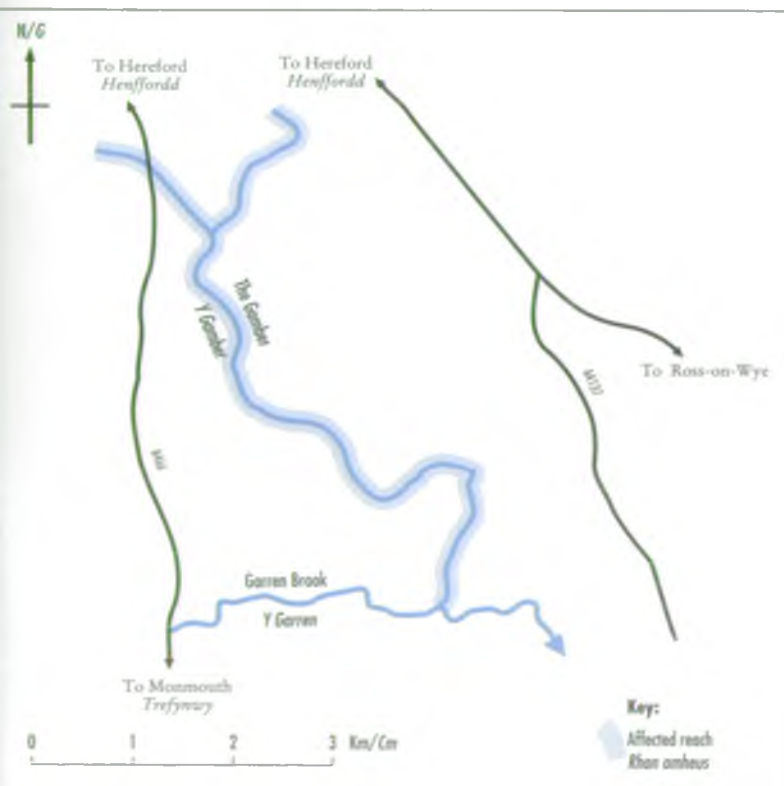
Further work will be undertaken to evaluate the scale of the problem.

Un o lednentydd Garren Brook, sydd yn ei thro'n llifo i Afon Gwy, yw'r Gamber. Mae'n 13.8km o hyd, yn codi ger Llan-wern ac yn llifo i'r de-ddwyrain i'w chydlifiad.

Honnir mai dyfrhau drwy chwistrellu ar raddfa fawr yn ystod misoedd yr haf sy'n gyfrifol am y llif isel yn y dalgylch.

Mae ymchwiliad manwl o'r trwyddedau tynnu dŵr yn y dalgylch, a wnaed yn ystod yr haf 1992, wedi dangos y gall fod dyfrhau drwy chwistrellu yn cael peth effaith pan fo'r llif yn isel iawn. I helpu gwrthweithio llif isel, ni roir rhagor o drwyddedau ar gyfer tyniadau haf net. Cyfyngir y rhain i storio dŵr yn y gaeaf. Mae cynnig hefyd i adeiladu gorsaf fedryddu (gauging) ar yr afon ym 1994 i gadw llygad ar lifoedd yn y dalgylch ac i roi mwy o wybodaeth am effaith y tyniadau.

Gwneir rhagor o waith i asesu graddfa'r problem.



WESSEX REGION



River Allen

River Piddle

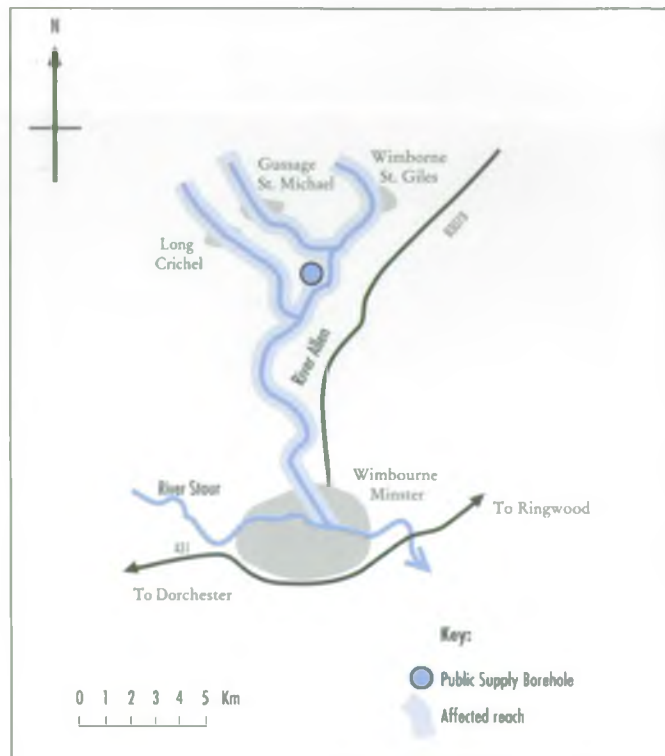
River Wey

RIVER ALLEN

The Allen rises near Wimborne St Giles, some 12km north of Wimborne Minster in Dorset. With its tributaries the Gussage and Crichel Brooks it drains a Chalk catchment of 178km². The perennial length of the river is approximately 18km, though as a winterbourne it may occasionally extend to 23km from the heights of Cranborne Chase. The river flows south from its source to join the River Stour at Wimborne Minster.

An investigation of the River Allen catchment was instigated by the NRA in 1990 as a result of a long history of representations from the River Allen Association regarding the decline of the river from its status as an exemplary trout stream. Groundwater is abstracted for public supply from boreholes near Stanbridge, and can reach a maximum of 25 megalitres a day. Extensive arrangements had been progressively put in place to augment stream flows from compensating boreholes, but these were not adequately replicating the natural river conditions.

The NRA commissioned a regional groundwater study, employing a digital computer model to simulate the effects of the various groundwater abstractions on rivers flows. The NRA has concurrently conducted biological, fishery and angling surveys in order to achieve a measure of the possible decline in the value of the river. Uniquely for this type of study it has engaged the Institute of Hydrology to use the experience of a current research project to attempt to provide a linkage between measures of flow and measures of river habitat and wildlife. A full report of the



investigation is now being concluded in preparation for the development of an Action Plan.

The NRA is concerned to demonstrate that the undeniable effects of abstraction on river flows can be accompanied by evidence of the impairment of river habitat and recreational opportunity, in order to justify any commitment to costly changes. It is not envisaged that any suitable remedies could be achieved without reconsideration of the authorised abstraction licence for the Stanbridge borehole.

The onus of proof for the extent and degree of impact on the river environment still rests with the NRA. Following a report in early 1993 it is to be expected that negotiations with the



Bournemouth and District Water Company will begin immediately to seek lasting improvements through the development of an alternative water supply operation that will yield improvements to the Allen without risk to the total resources of the water company. The identification of a solution to the problem is expected in 1993 with a target implementation date of 1996. Costs already incurred by the NRA amount to £146,000.

RIVER PIDDLE

The River Piddle rises at Alton Pancras some 12km north of Dorchester in Dorset. Chalk bedrock dominates the upper sections of the catchment. The river drains an area of 183km² and flows a distance of 37km in a south-easterly direction to its mouth at Poole Harbour near Wareham.

There are four public water supply boreholes sited in the Chalk outcrop area with an aggregate licensed abstraction of 42Ml/d. The impact of these groundwater abstractions on flows is mainly attributable to boreholes at Alton Pancras, Briantspuddle, and Dewlish. The consequences are various but reduction of river flows is confirmed as adversely affecting the amenity value of the Piddle and its Devils Brook tributary, and as seriously impairing the trout fishery of the middle reaches of the Piddle.

Investigations initiated by Wessex Water Authority were concluded by the NRA and an Action Plan was produced in April 1991. This resulted in a formal agreement, in October 1991, between



the NRA and Wessex Water to limit summer abstraction from 2 boreholes to current rates and to reduce that from Briantspuddle to 50% of its licensed quantity. During the 4 year currency of this agreement permanent remedies will be developed through a series of further investigations funded jointly by the NRA and Wessex Water.

An alternative source of water is being investigated by Wessex Water plc. The NRA has commissioned further studies from consultants to provide detailed proposals for flow augmentation and sediment control. The NRA has constructed 3 new river gauging stations to provide controls for future monitoring of acceptable flows. The NRA consults and reports on progress to the River Piddle Protection Association, a group of concerned riparian owners.

The voluntary agreement to reduce abstraction quantities has given some measure of improvement. Testing of alternative sources is due in 1993. NRA detailed studies of the upper reaches of the river will be completed by the end of 1993 when substantive permanent remedies will be prepared. The cost to the NRA to date has been £191,000.



RIVER WEY

The Wey rises at the village of Upwey, which is located between Dorchester and Weymouth in Dorset. It flows south to Weymouth, for a distance of 8.8km and drains an area of 48km². Its sources are two springs within 5m of each other, both of which emerge from Portland Stone but are recharged by drainage from Chalk to the north.

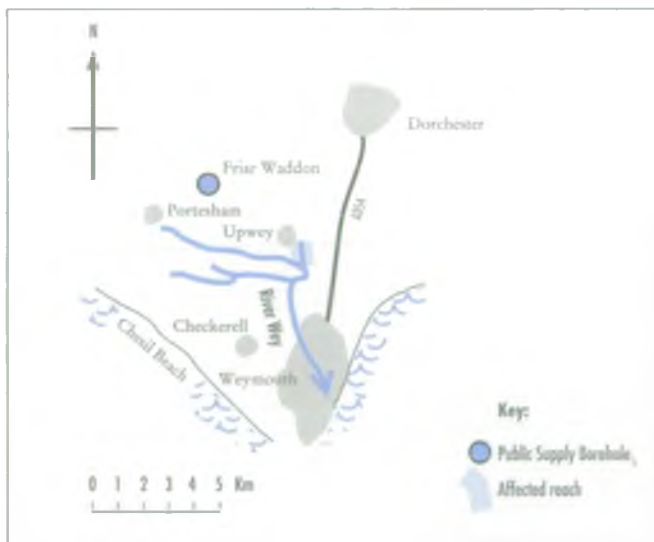
The Upwey Springs serve as an immediate tourist feature; one is known as the Upwey 'Wishing Well'. They also supply the entire flow to a fish farm established immediately downstream. Attention was drawn to the prolonged occurrence of low flows and to sudden fluctuations in river flows which were affecting the viability of the fish farm.

Public water supply boreholes are operated by Wessex Water at Friar Waddon, at which there is an abstraction licence for 14 megalitres a day. This source is almost 1km distant from the



Upwey Spring and located in a dry valley to the north-west. An investigation of the relationship between Upwey Springs and the Friar Waddon abstraction was started by Wessex Water Authority and concluded by the NRA at the end of 1991. The findings were that the boreholes exert a direct and immediate influence on the Upwey Springs and that the fluctuations in flow are attributable to changes in pumping operations at the Friar Waddon source. Extensive enquiries of fisheries and conservation interests downstream of Upwey confirmed that the problem is confined to the immediate vicinity of Upwey Springs and not to the Wey in general.

The NRA has investigated the extent and cause of variation to the flows from Upwey Springs at a cost of £20,000. The influence of groundwater abstractions is limited to users in the immediate vicinity of the springs. Negotiations continue with Wessex Water to seek effective remedies to the localised problems caused by abstraction which may yield a cost effective solution to the difficulties encountered by riparian owners.



NORTHUMBRIA/YORKSHIRE REGION



River Derwent

River Wharfe at Otley

River Wharfe at Pool

RIVER DERWENT

The Derwent rises in the North Yorkshire Moors National Park and flows southward through the Forge Valley and West Ayton into the Vale of Pickering, then south-west through the Vale of York where it joins the River Ouse between Selby and Goole. The river flows within 7km of the sea at West Ayton, but the course takes it a further 80km to join the Ouse system. The problem stretch of the river extends from the southern end of the Forge Valley, through West Ayton and on a further 6km to where the Derwent is joined by the River Hertford.

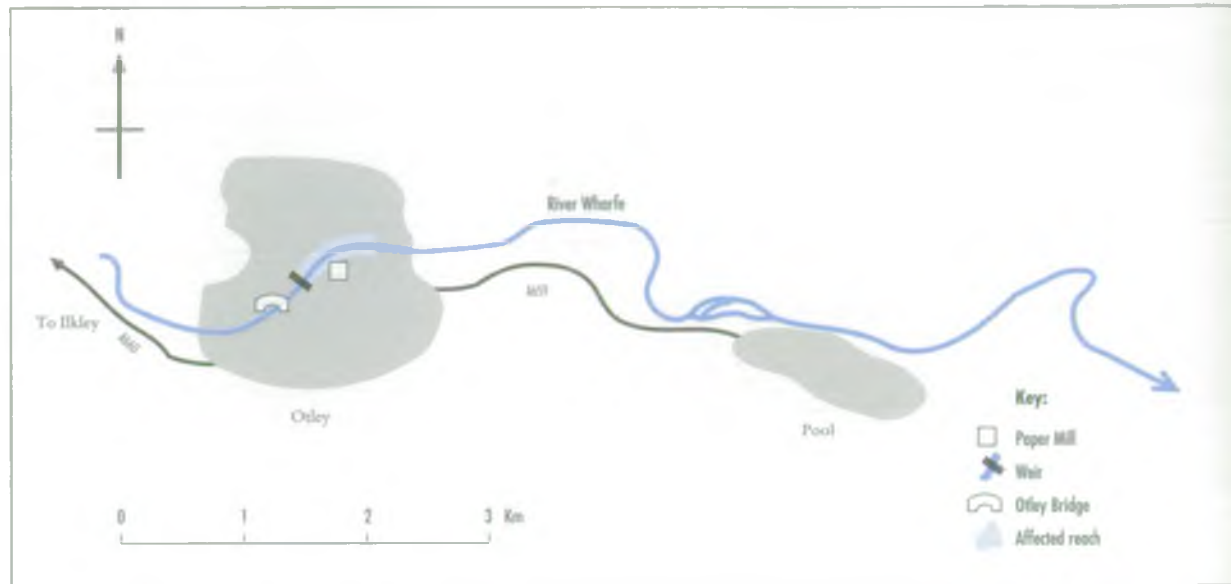
Swallowholes into the Corallian Limestone aquifer along the Forge Valley permit the river to disappear underground during periods of low flow. A significant proportion of this water flows swiftly down fissures and is abstracted from boreholes at the public water supply source of Irton about 2km away. As a consequence the river bed dries for a couple of months during late summer during drought years. Inlet control structures on the main swallowholes are intended to prevent inflow in the event of river pollution, but these are not fully effective in protecting the aquifer.



A range of possible solutions exists at this site. A combination of river flow regulation and/or a variation of the summer licence conditions from Irton pumping station may alleviate the problem. Construction of a flow control structure and lined channel to bypass the swallowholes during periods of low flow would assist in river regulation. The storage in the aquifer may be sufficient to support the operation of the public supply source throughout the summer without reliance on recharge via the swallowholes.

Yorkshire Water and the NRA have agreed to appoint consultants to conduct a feasibility study in the area. This will consider the implications and environmental impacts of possible solutions.

RIVER WHARFE at OTLEY



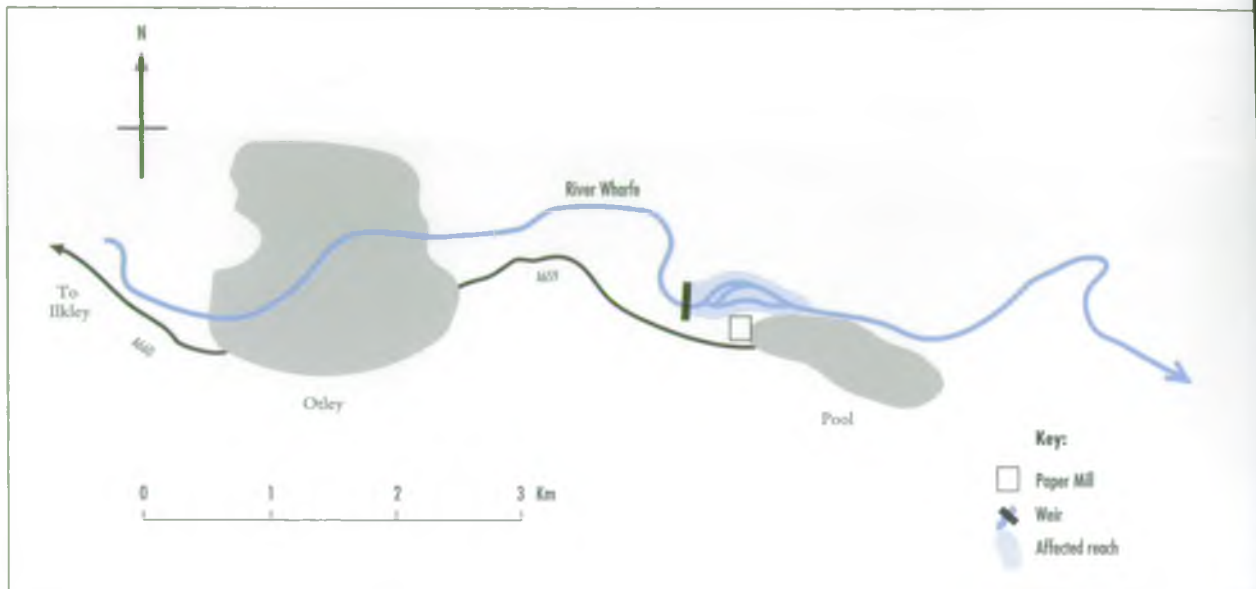
The River Wharfe rises in the Yorkshire Dales National Park and flows for approximately 100km south-eastward before reaching the confluence with the River Ouse. The upper reaches and tributaries of the river flow across moorland and through dales, whilst the lower reach passes through the Vale of York. The section with low flow problems occurs over a short length as the river flows through Otley, a small town at the lower end of Wharfedale.

The river has a major licensed abstraction in Otley where a paper mill takes water for water power and processing. The water is taken from above a weir and returned to the river a short distance downstream. During periods of low flow the mill takes all the water from the river, the flow over the weir ceases, adversely affecting the reach of the main river from the weir to the outflow from the mill.

The abstraction licence could be varied to include provision to prevent the diversion of all the stream flow through the mill. A licence condition could be introduced that would maintain a minimum head over the weir or perhaps a minimum dry weather flow over the weir at all times. Some form of licence condition(s) will be the preferred option for a solution.



RIVER WHARFE at POOL



The River Wharfe rises in the Yorkshire Dales National Park and flows for approximately 100km south-eastward before reaching the confluence with the River Ouse. The upper reaches and tributaries of the river flow across moorland and through dales, whilst the lower reach passes through the Vale of York. The section with low flow problems occurs in an area where the river flows past a paper mill west of the village of Pool.

At Pool the river divides into two channels at a weir. One channel takes the water through a mill stream, from which water is abstracted for paper manufacture, while the other is the natural channel. At certain times of the year the mill operators divert all the water through the mill stream adversely affecting a 700m length of channel on the main river. The mill stream contains a fishery and sufficient flow is said to be needed to carry away effluent.



An agreement on operating practice needs to be drawn up to prevent the diversion of all the stream flow through the mill. A condition could be included that would maintain a minimum flow or head over the weir at all times. The agreement will be negotiated with the operators of the paper mill to ensure an acceptable quantity of water flows down the main channel.

FUTURE DEVELOPMENTS IN THE ASSESSMENT AND REPORTING OF LOW FLOW PROBLEMS AND ALLEVIATION

The NRA is currently engaged in the development of an objective methodology for the evaluation of low flow problems. This methodology, once perfected, will be used in conjunction with other existing assessment approaches and will allow robust appraisal of suspected problems.

Within the next year the rivers named in this report together with any others which may subsequently come to light will be examined in this way and a new

priority list will be produced. The revised list will undoubtedly differ from the one presented here and will not be regarded as a 'top 20' or 'top 40' list but as a national schedule of progress on low flow problems.

Whatever the outcome of this exercise the NRA will remain committed to the swift alleviation of low river flow situations and to publicly reporting its progress in this area.

National Rivers Authority
March 1993

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