

National Rivers Authority
Inland Waterways Centre
Hull Office
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THE DROUGHT OF 1988 - 1992 IN ANGLIA



A REVIEW



NRA

*National Rivers Authority
Anglian Region*

FOREWORD

This document provides an overview of the drought of 1988/1992 as it affected the Anglian Region of the National Rivers Authority. The impact of the drought upon users of the water environment is described and some lessons for the future are identified.

The following reports give more detailed information and are available from the National Rivers Authority (Anglian Region)

- Results of Questionnaire to Irrigators affected by restrictions on abstraction
- Results of Questionnaires to Environmental Bodies on the impact of drought upon conservation sites

A detailed statistical analysis of the drought over the U.K. can be obtained from the Institute of Hydrology, Wallingford.



River Glen, 1991.

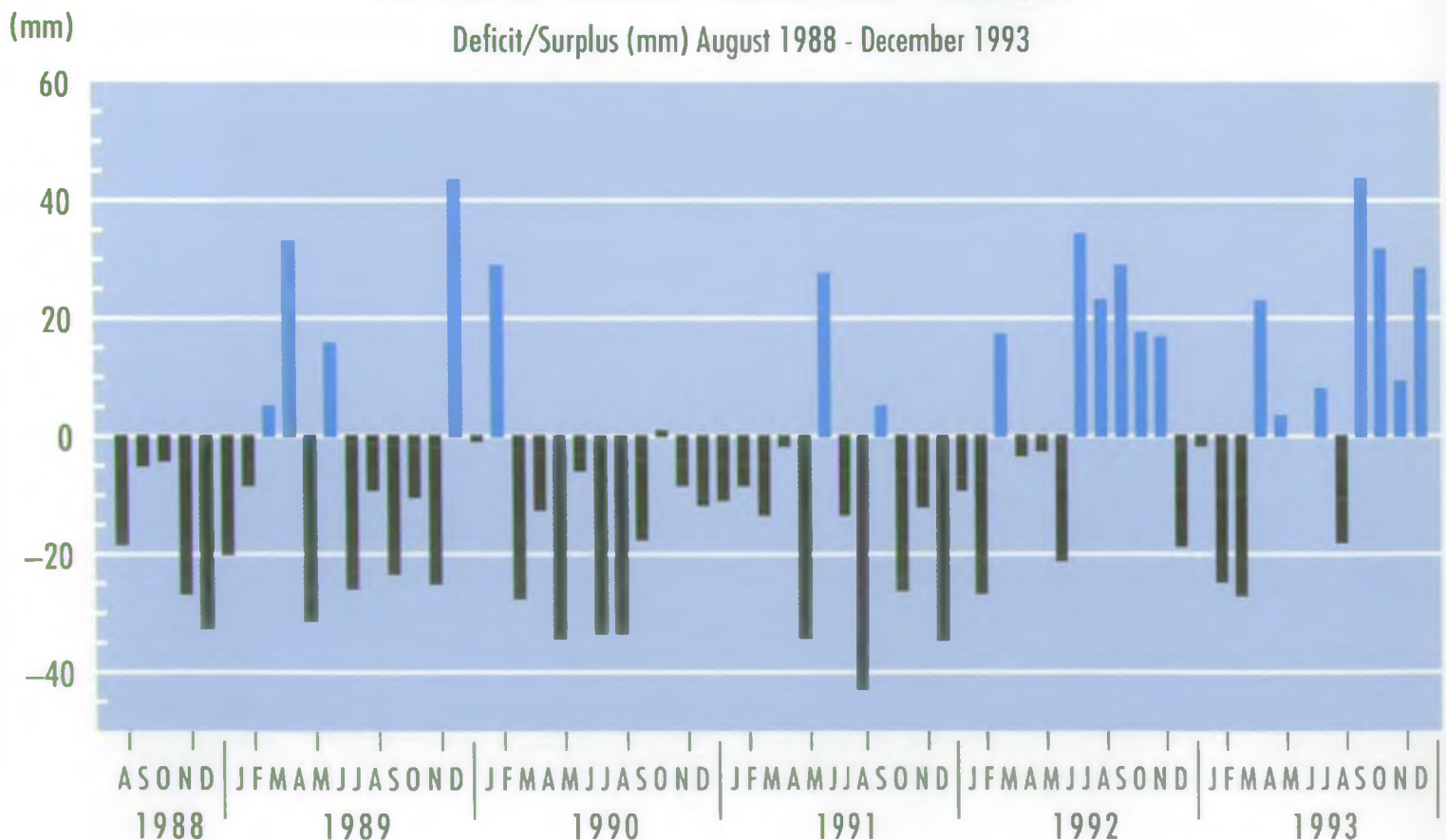
THE DROUGHT

Over much of South East England, the driest sequence of weather recorded this century began in August 1988 and continued until the closing months of 1992. In areas such as Norfolk and parts of Cambridgeshire the sequence was even more exceptional. The drought conditions which

resulted were aggravated by the fact that 1989 and 1990 were, on average, the warmest ever recorded.

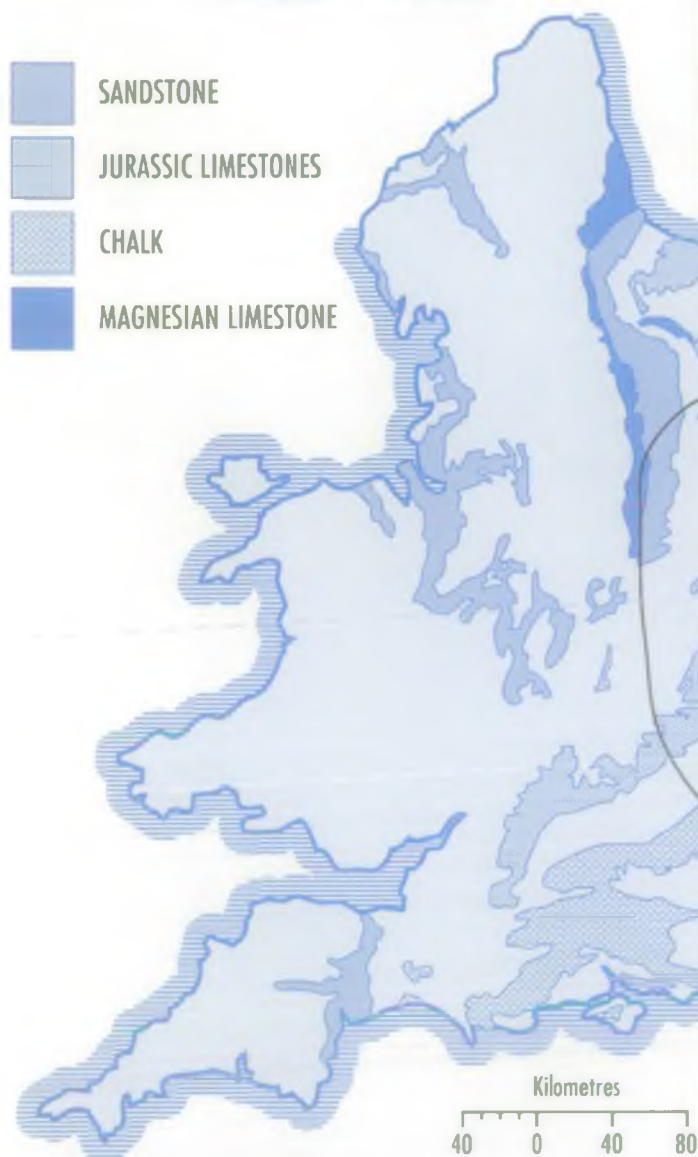
The graph below shows how rainfall varied from the long term average. From August of 1988 to June of 1992 rainfall was only 79% of normal.

ANGLIAN REGION RAINFALL SUMMARY



Dry winters were another highly significant feature resulting in the soil remaining relatively dry and this continued in places for four years which is remarkable. As a result, what little rain fell had only limited beneficial effect upon flows in rivers. More significantly, the prolonged spell of dry ground conditions resulted in water bearing rocks (aquifers) receiving little or no benefit from the limited rainfall. Regional variations in this recharge are shown below with Norfolk being effectively the "epicentre" of the drought.

RECHARGE TO AQUIFERS 1988 - 1992



Areas most severely affected by the drought. 1988/1992 recharge to the areas east of the contours was only 50% and 25% respectively of the long term average. (Based on data collated by BGS).

As the drought continued, views were expressed that it was symptomatic of climatic change. However, analysis of past records indicates that droughts have occurred regularly in the past with the drought of the early 1900's being somewhat similar in both severity and duration.



Measuring low flow.

IMPACT ON THE WATER ENVIRONMENT

Droughts are not unusual events and vary in extent, duration and severity. This drought was particularly significant because of its duration and the predominantly dry warm winters. These factors combined to produce a drought which particularly affected the aquifers, associated groundwaters and spring flows.

Unlike a flood, which is both short and sharp, a drought is slow to develop and the impact is even slower to materialise. This is particularly the case with a drought affecting underground resources which are out of sight. Only when spring-fed streams and wetlands start to dry out does the impact of the drought start to become visible. Although the drought began in 1988 the environmental impact did not start to become evident until 1990 or later.

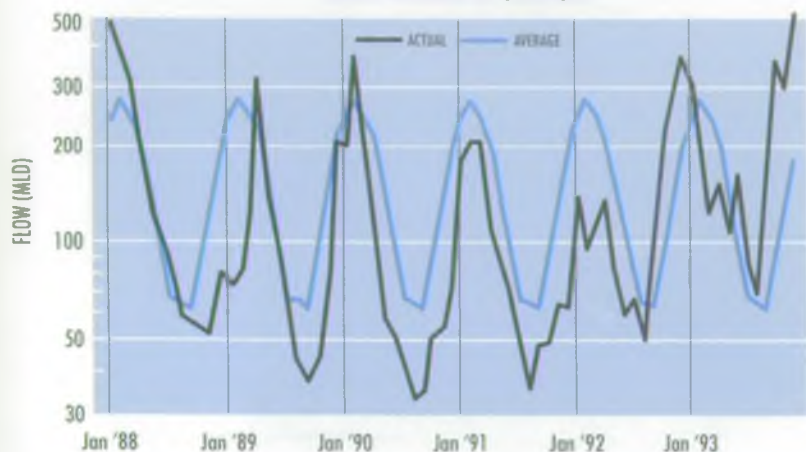
RIVERS

a) **FLOWS:** Many factors affect river flows. These include run-off from the catchment, spring flows, abstraction, and discharges. Rivers in the centre of the Region, such as the Bedford Ouse, Nene and Welland, have clay catchments and depend heavily upon discharges from sewage treatment works and industry (effluents) to maintain flows in Summer. Those rivers in the north and east, such as the Lymn, Wissey and Wensum receive much of their summer flow from springs.

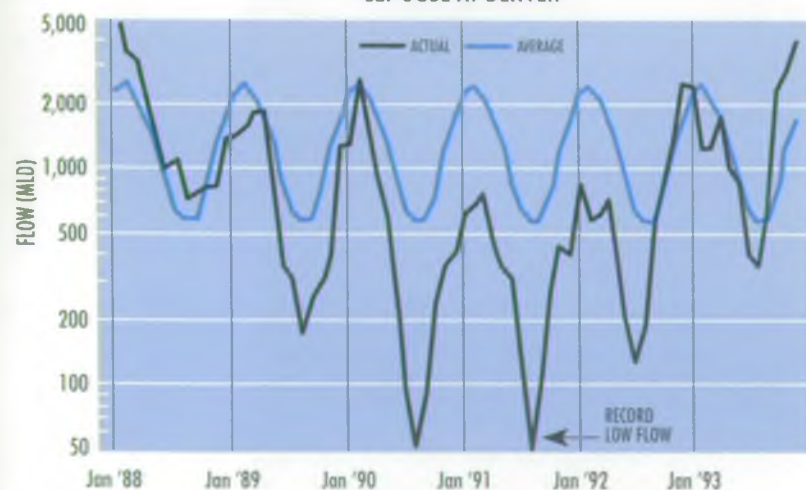
As a result, the impact of the drought varied widely between rivers but most had flows which were the lowest ever recorded. The graphs below show flows in various rivers. Flows in rivers draining clay catchments started to recover significantly in September 1992 and others a little later.

RIVERS FLOWS (1988 - 93)

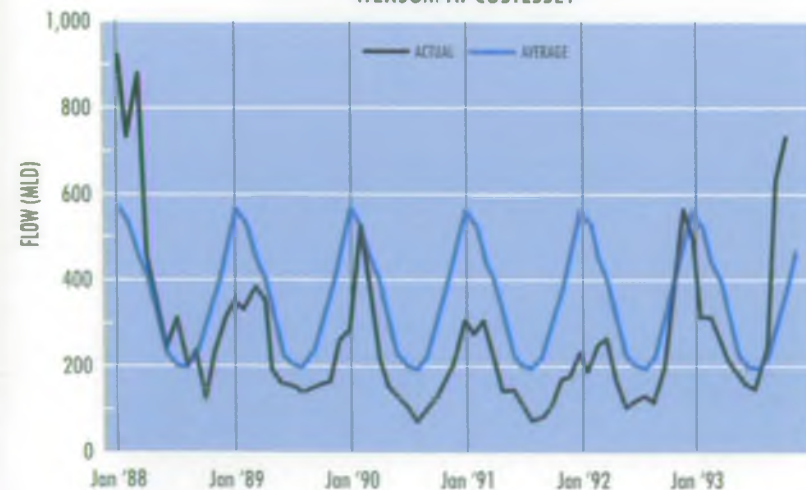
RIVER WITHAM AT CLAYPOLE



ELY OUSE AT DENVER



WENSUM AT COSTESSEY



ANGLIAN REGION

Throughout the drought a great many small streams, which in normal circumstances would flow, either dried out completely or were reduced to very small flows. In some clay catchments the summer of 1990 was most severe. In others where streams are dependant upon groundwater, depletion was more gradual and, once dry, the flow did not return until after the end of the drought as aquifers refilled and spring flow resumed. Some streams which are naturally intermittent such as the Rivers Burn and East Glen were dry for longer. The map shows those parts of the region where streams were essentially dry at some time during the drought.

Many lakes and ponds were badly affected by the drought. Levels in lakes fell as the drought continued. Numbers are not available but it is clear that numerous ponds and small lakes were completely dry.

- b) **RIVER WATER QUALITY:** The drought caused a small but widespread reduction in the amount of oxygen dissolved in the water. This was caused by a combination of low flows and high temperatures particularly in upper reaches of rivers. Conversely, the high temperatures made effluents easier to treat and their quality improved. By adding to river flows, effluents also helped to reduce the impact of the drought.



Lack of rain also meant reduction in the discharge of polluted storm water. This was beneficial.

Low flows in the lower reaches of some rivers meant that sea water intruded farther upstream than normal. Examples include the Rivers Ancholme, Freshney, Witham and Cut-Off Channel. The Broads and rivers such as the Bure were also affected.

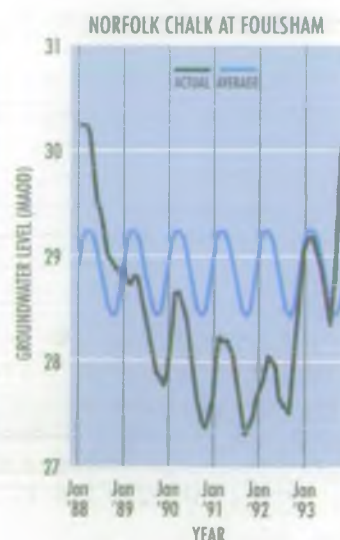
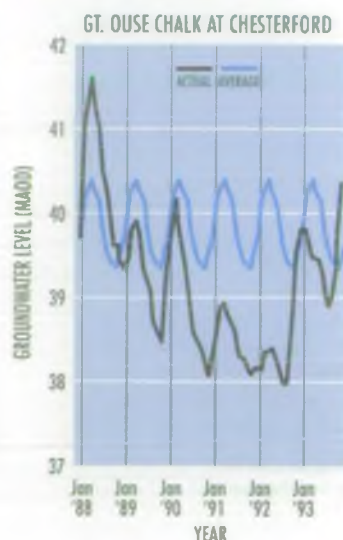
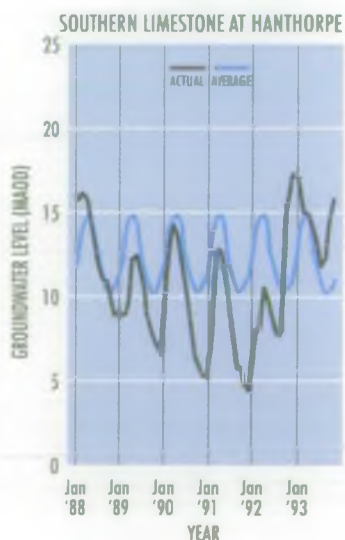
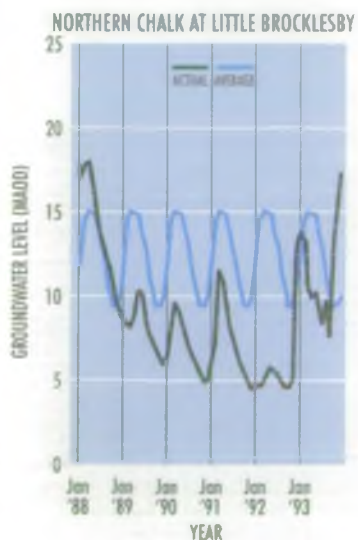
AQUIFERS

a) **WATER LEVELS:** The state of aquifers is best judged from water levels measured in observation boreholes. Shown below are several typical graphs from various parts of the Region.

Pumping oxygen to preserve river ecology.

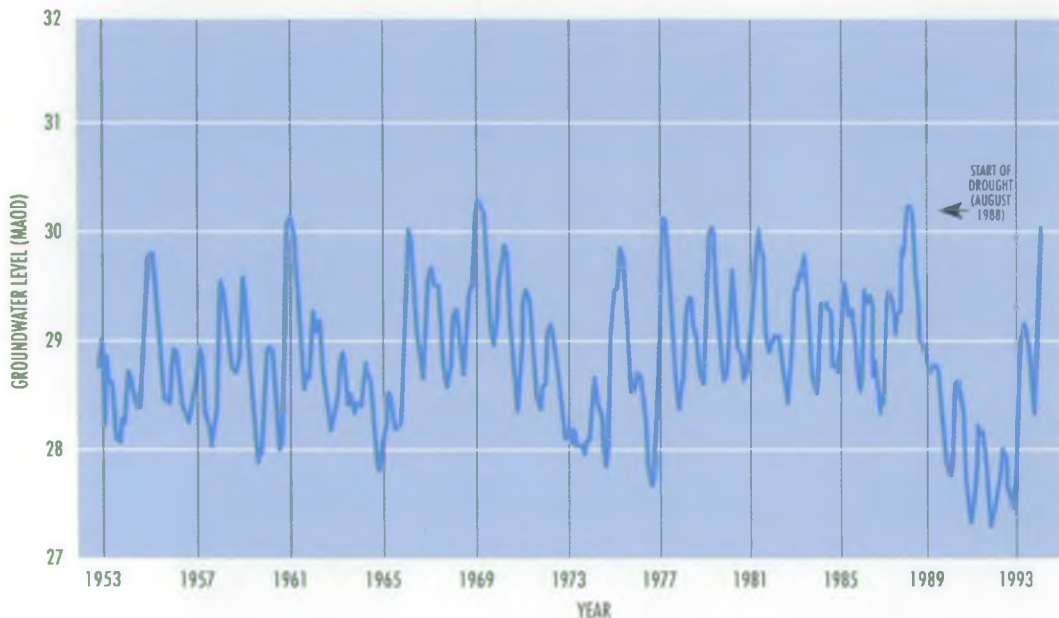
Winters prior to the drought were unusually wet which resulted in aquifer levels being at or near record high levels. Thereafter, especially in the Chalk, levels declined progressively to the lowest ever recorded. In some winters there was very limited recharge without which depletion would have been more severe. This situation eased somewhat in September 1992 when heavy and prolonged rain initiated recharge to the aquifers and water levels started to recover. The recovery was virtually completed by the Autumn and Winter rains of 1993.

WATER LEVELS IN AQUIFERS (1988 - 93)



The graph below shows a long record of levels in the Norfolk Chalk and illustrates both the severity and prolonged nature of the drought.

RECORD OF GROUNDWATER LEVELS IN NORFOLK CHALK AT FOULSHAM (1953 - 1993)



b) GROUNDWATER QUALITY: The principal threat to groundwater quality during the drought was increasing salinity because boreholes were pumping water from record low levels. In earlier years much had been done to limit or reduce salinity by reducing or

relocating abstractions. The benefits of this action became very evident during the drought because there were no instances of significant increases in salinity. On South

Humberside improved control was particularly successful. In the Sleaford and Lincoln areas a potential problem was contained whilst in the Spalding area salinity levels increased but to nowhere near the levels of the 1970's. During the drought, nitrate concentrations in groundwater tended to reduce. This is believed to be due to a reduction in nitrate draining from soil and is likely to be temporary. Boreholes were also pumping from record low levels which likewise caused nitrates to reduce. Establishment of two Nitrate Sensitive Areas in Lincolnshire and five Nitrate

Advisory Areas happened to coincide with the drought. In these areas changes in farming practice are intended to reduce nitrate concentrations in groundwater but the effects of the drought could be difficult to separate from the beneficial effects of changing farm practice.



Chippenham Fen.

WETLANDS

In the Anglian Region there are many Wetlands, both natural and man made, which are areas of environmental importance where the water table is at or near the surface. These range from sites of international importance (Ramsar sites) such as Redgrave and Lopham Fen to sites managed by County and local Wildlife Trusts such as Hinderclay and Roydon Fens.

Being sensitive to changes in water table, many such wetlands dried out to an unprecedented degree as the drought progressed. This put the associated ecology under stress. Considerable concern was expressed by environmental bodies and individuals about the combined impact of the drought and increasing abstraction of water. Wildlife Trusts in conjunction with English Nature provided a list of 108 wetlands which they believe to be suffering from low water tables, the cause of which could be either natural (i.e. drought), gravel working, drainage, abstraction or a combination of several. English Nature in conjunction with Sheffield University undertook a selective investigation to identify wetlands suffering from groundwater supply. The 17 sites identified are listed as follows:-

WETLANDS PERCEIVED TO BE SUFFERING FROM REDUCTION IN GROUNDWATER SUPPLY

Name	Location	Statutory Status
Aslacton Parish Land	Norfolk	SSSI
East Ruston Common	Norfolk	SSSI
Redgrave and Lopham Fen	Suffolk	Ramsar, NNR and SSSI
Roydon Fen	Norfolk	Proposed SSSI
Shotesham Common	Norfolk	SSSI
Smallburgh Fen	Norfolk	SSSI
East Walton Common	Norfolk	SSSI
Middle Harling Fen	Norfolk	SSSI
Scoulton Mere	Norfolk	SSSI
Cornard Mere	Suffolk	SSSI
Hinderclay Fen	Suffolk	Ex SSSI
Pashford Poors Fen	Suffolk	SSSI
Chippenham Fen	Cambridgeshire	SSSI
Thriplow Meadows	Cambridgeshire	SSSI
Caudle Common	Norfolk	Proposed SSSI
Strumpshaw Fen	Norfolk	SSSI
Fulbourne Fen	Cambridgeshire	SSSI

Note: Derived from report for English Nature by Sheffield University

SSSI = Site of Special Scientific Interest



Fish rescue in progress.

To try and ascertain exactly what adverse effects have been experienced, the NRA canvassed environmental bodies in the Region. Results indicate the following:-

- There is a lack of ecological data against which to judge the impact of low water tables.
- The impacts at specific locations are based largely upon subjective judgement.
- Abstraction and land drainage tend to emphasise the impact of drought on wetlands.
- In most cases it is too early to judge if permanent damage has occurred.

FISH

The Table below shows fish mortality and rescue incidents arising from all causes such as drought, pollution etc. Impact of the drought was most severe on fish in still waters.

FISH RESCUES AND MORTALITIES -1988 (ALL CAUSES)

Area	Fish Rescues		Fish Mortalities	
	Incidents	No. of Fish	Incidents	No. of Fish
Northern	52	63,000	77	296,000 †
Central	34	25,700	37	17,700
Eastern	76	773,000 *	379	37,000 †
Region	162	861,700 *	493	345,700 †‡

* Includes 600,000 at Abberton Reservoir

† Includes 10,000 at Abberton Reservoir

‡ Includes 200,000 at Louth Fish Farm

Most incidents took place in the earlier years of the drought when summer temperatures and oxygen depletion were greatest. One notable incident was the rescue of an estimated 600,000 fish from part of Abberton Reservoir in Essex. Another was the loss of 200,000 fish at a farm near Louth. As the drought continued, the number of incidents declined since many susceptible ponds and watercourses had been subject to mortality or rescues. Prolific weed growth tended to make matters worse with excessive blanket weed in some areas leading to deoxygenation beneath the weed. Lincolnshire rivers were particularly badly affected.

Given the widespread record low flows in rivers and the number of small streams that dried out completely, it is surprising that there were not more problems. Many fish were apparently able to survive the drought, if only by retreating downstream as levels and flows reduced in the headwaters.

Any long term impact of the drought upon fisheries will become clearer through the rolling programme of surveys which are done on a three yearly cycle. However, preliminary indications are that fish, with the exception of Dace and to a lesser extent Trout and Chub, bred well during the drought.

ECOLOGY

Use of a nationally recognised method to assess river biology shows that continuation of the drought into its second year interrupted a long term improving trend. Results are given in the Table below which indicates that the improvement between 1990 and 1991 was not repeated in 1992. This is largely attributed to low flows. During the

RESULTS OF BIOLOGICAL SURVEYS 1990 to 1992

	1990 Survey		1991 Survey		1992 Survey	
Category	Length (km)	%	Length (km)	%	Length (km)	%
A	2,983	51.6	3,212	52.8	3,049	50.5
B	1,917	33.2	1,954	32.1	1,960	32.5
C	696	12.1	782	12.8	841	13.9
D	178	3.1	139	2.3	189	3.1
Total	5,774		6,087		6,039	

Note: Rivers in Category A are the best biologically, those in category D the worst



River Lark, September 1991.



Rutland Water.

drought, saline intrusion of the lower reaches of some rivers resulted in saltwater species moving upstream.

With the recent onset of increased flows the improving trend has resumed. This has occurred on rivers such as the Wensum, Mun and Ouse tributaries. Increased flow has also diluted effluents and improved the biology. Other sites, for example on the Rivers Nene and Welland, have improved because flood water flushed away silt and vegetation clogging the channels. Increased freshwater flows have also diluted saltwater in lower reaches or pushed it downstream improving the biological quality. Some of the fen drains are good examples.

IMPACT ON WATER USERS

A key aim of the NRA is :-

To manage water resources to achieve the right balance between the needs of the environment and those of the abstractors.

To meet this aim the NRA is required to balance competing needs of those who take water out of the water environment against those who would wish the opposite. When the NRA was formally created in September 1989 the drought was beginning to bite and the NRA was immediately required to balance these competing needs. This had to be achieved in the absence of a clear order of priorities other than that implied in legislation which states that the NRA "shall have particular regard to the duties of any water undertaker".

ABSTRACTORS - PUBLIC WATER SUPPLY

Some 75% of water abstracted in the Region is used for public supply and there is a roughly equal split between surface water and groundwater abstraction. Much of the water abstracted is returned to rivers as effluent.

Over the last thirty years Grafham and Rutland Waters have been completed and, prompted in part by the drought of 1975/6, there has been significant investment interlinking major storage reservoirs and zones of supply which had previously been discrete. The benefit of this action was very apparent during the drought with the central part of the region being resilient and avoiding restrictions. Many water company customers received a level of service better than that laid down by the Water Industry Regulator (OFWAT) of hosepipe bans not more frequent than 1 year in 10.

In Essex, where existing reservoirs such as Abberton and Hanningfield are approaching full utilisation, there was particular concern and hose-pipe bans were introduced. To safeguard supplies, the NRA obtained Drought Orders so that more water could be transferred from the tidal limit of the River Ouse near King's Lynn into Essex.

As water levels in aquifers sank to record low values, concern grew about supplies to areas dependent upon groundwater. Areas of concern included Humberside, Central Lincolnshire and East Cambridgeshire. Water

HOSEPIPE BANS IMPOSED BY WATER COMPANIES DURING THE DROUGHT

Water Company	Area Affected	Pop of Area	Start (Year)	End (Year)
Anglian Water Services	East Lindsey DC, Breckland DC, Forest Heath DC, Kings Lynn DC, West Norfolk DC, East Cambs DC, St Edmundsbury DC	560,000	1990	1991
	Fenland DC, Broadland DC, South Norfolk DC, North Norfolk DC, Norwich DC	500,000	1991	1992
Essex Water Company	Entire Supply Area	1,400,000 *	1990	1992
Three Valleys Water Company	Parts of N. London, Essex, N. Herts, Epping, Harlow, Royston, & Buntingford	130,000 *	1990	1992
	Extended to Entire Supply Area	2,300,000 *	1991	1992
Cambridge Water Company	Entire Supply Area	270,000 *	1991	1992

* Part or majority of population resides outside NRA Anglian Region

companies invested heavily in duplicate and deeper boreholes. Main laying programmes were accelerated to provide added flexibility and allow the supply of surface water to some areas dependent upon groundwater.

Hosepipe bans were introduced for a lengthy period in Cambridge and areas to the north and south. The Table above gives details. Parts of Norfolk and Suffolk also had hosepipe bans during 1991 and in the same year the NRA obtained Drought Orders enabling the use of boreholes

and overland mains to increase flows in the Nar and the Wensum. This safeguarded supplies to King's Lynn, Norwich and the water environment.

As the drought progressed, there was concern that the quality of water available for public supply would deteriorate. Apart from a few isolated instances, the concerns proved unfounded which reflects, in part, the tight control on discharges into rivers.



Spray irrigation.

ABSTRACTORS - INDUSTRY

Industrial supplies, other than those provided by the water companies, are obtained from boreholes and some river intakes.

As the drought continued, concern amongst industrial abstractors grew and many embarked upon a programme of self help prompted by the NRA. Actions included cleaning intakes, lowering borehole pumps and investigating alternative supplies. Some abstractors incurred additional costs but there is little or no evidence that industry suffered major interruptions.

ABSTRACTORS - AGRICULTURE

In recent years, agriculture in the Region which is essentially arable, has become increasingly dependent upon irrigation. There has been a move towards producing high quality vegetables often under contract for major retail outlets. In some areas irrigation has led to increased yields from land previously regarded as relatively infertile.

The Anglian Region has half of the national demand for irrigation water, much of it concentrated in the Fens and surrounding areas. This demand arises in the driest and warmest times of the year when resources are most stretched. When water is being abstracted, the rate on a hot summer day is similar to that for public supply but little or none is returned to the rivers.

Because very little of the water abstracted for spray irrigation finds its way back to the rivers the NRA has powers to restrict abstraction. During the drought many farmers were faced with limits on abstraction through licence conditions, or by statutory restrictions imposed by the NRA. Abstraction often needed to be cut back to avoid or reduce adverse environmental impact to wetlands and watercourses. The following table shows the number of licences affected by restrictions on the abstraction of water for spray irrigation. Farmers who had provided their own on-farm storage faced fewer such difficulties.

In parts of the region, such as Breckland and the River Lark catchment, farmers set up self-help groups and worked closely with the NRA. This resulted in improved use of scarce supplies sometimes achieved by voluntary restrictions.

LICENCES AFFECTED BY SPRAY IRRIGATION RESTRICTIONS

YEAR	NUMBER OF BANS	
1990	Total Bans	1000
	Partial Bans	244
1991	Total Bans	80
	Partial Bans	306

ABSTRACTORS - PRIVATE

It is believed that there are some 10,000 small wells and boreholes in the Region used mainly for private domestic supply. Some of these are relatively shallow and particularly prone to drought.

The number of wells that ran dry each year and of which the NRA became aware, are shown in the Table below and are probably an underestimate. Most were in Norfolk, Suffolk and Cambridgeshire. In many cases the owners employed contractors to either clean or deepen the well or borehole.

WELL FAILURES

AREA	1989	1990	1991	1992
Northern	1	3	2	1
Central	5	24	12	16
Eastern	8	23	30	35
Region	14	50	44	52

Note: Includes only those of which the N.R.A. was made aware

DISCHARGERS

As the drought continued there was less and less water available to dilute effluents from the 6000 discharges in the Region. The importance of dischargers complying with their discharge consent was stressed repeatedly by the NRA and there were very few cases of poor water quality caused by the combination of low flow and poor discharge.

NAVIGATORS

A combination of low flows and siltation combined to give local problems for navigators. In some rivers such as the Ouse, during the Summer of 1991, navigation became difficult, although not impossible.

Siltation became a problem at several locations including the Great Ouse at Denver and some of the Havens in Lincolnshire, such as Tetney and Winteringham Havens. Cutting of weed became more difficult because of the increased development of floating algae as opposed to bed-rooted weeds.

ANGLERS

During the drought fishermen provided an invaluable service, being quick to report incidents of all types. This was combined with a general perception that, in their opinion, insufficient action was being taken to curb the amount of water being abstracted.

Angling was affected by low flows in rivers and badly affected in lakes and ponds where levels fell or, as at Cockley Cley, dried out. An indication of the severity of the impact is given by the increase in numbers of fish rescues and mortalities.



Redgrave and Lopham Fen.

Weed growth also had a great impact, restricting access to clear water with blanket weed being particularly prevalent in rivers such as the Colne. Conversely, weed growth was sometimes beneficial by retaining water and level in rivers.

Increasing salinity in the lower reaches of some rivers caused a short term migration of freshwater species with replacement by those resistant to salt water.

ENVIRONMENTAL BODIES

Organisations such as English Nature, R.S.P.B. and the various Wildlife Trusts became particularly concerned about the impact of the drought upon wetlands. As with fishermen, the view was expressed that insufficient action was being taken to curb water abstraction.

A review of wetlands was carried out by a consortium of trusts with the objective of identifying the wetlands suffering from either or both drought and over-abstraction. As the drought progressed, it became apparent that historical information about the flora, fauna and hydrology of many sites is lacking. Efforts were made by all organisations, including the NRA, to increase monitoring of environmental impact on specific sites but these were limited by manpower availability.

AMENITY

Rivers, lakes and especially the Norfolk Broads are widely used by the public for amenity purposes. Because the drought developed gradually and persisted over a number of years the public became conditioned to the relative absence of rain. This meant that organisations including the NRA were required to stress continuously the potential severity of the drought.

Impact upon amenity included a wide range of mainly visual effects. These included low river levels and flows, dry streams and ponds, plant growth on river margins and objectionable smells.

Most rivers in the Region reach the sea through tidal sluices or barriers which give reasonable security against salt water. Large sluices are at Ferriby, Boston, Denver and Cattawade. The absence of such structures on the Broads combined with low incoming river flows resulted in some general deterioration of amenity.

An important matter, related in part to the drought, has been the incidence of blue-green algae which thrive in a combination of high temperature, sunlight and water rich in nutrient. Where this occurred there was a decline in visual amenity and at times an unpleasant smell. Places affected were ponds, lakes, drains and reservoirs including Rutland Water and some of the Broads. Recreational impact upon water sports and angling was particularly significant to the public for two consecutive summers.

IMPACT ON THE NRA

Management of water resources, both in our rivers and underground in our aquifers, is a prime responsibility of the NRA. General duties are to protect the water environment and to further conservation. Other more specific responsibilities include the control of abstractions and adding to flows in rivers.

During the drought, these responsibilities assumed an



Blue-green algae on the Broads.

importance and public profile far in excess of that which exists in more normal times. As a result, the impact on the newly formed NRA was considerable, spread over many activities and lasted for four years.

As the drought continued and deepened there was growing recognition of a real emergency. This culminated in the appointment by the NRA of local "Drought Managers" to co-ordinate the many actions.

During the four year period the NRA:-

- Chaired regular meetings to brief major abstractors and ensure contingency plans were implemented.
- Operated major pumping stations to get water to areas in need e.g. transfer from the River Trent into rivers in Lincolnshire and South Humberside; transfer from the Ely Ouse into Essex rivers.
- Sought and obtained Drought Orders to improve the reliability of supplies and protect the water environment.
- Advanced expenditure on major pumps to improve supplies e.g. £1.3m pump at Kennett.
- Prepared detailed emergency plans for major water transfers from the River Trent into Rutland Water and to Essex. These could have been implemented rapidly if required.
- Worked in conjunction with Drainage Boards to retain water rather than pump it to sea.
- Installed temporary structures to retain water levels e.g. Maxey Cut.
- Moved water around the fens to better meet local requirements.
- Increased monitoring of rivers and aquifers and provided an information service on the state of the drought and its impact.
- Provided a focus for reports to Government.
- Supported flows in key rivers to enable continued use for a variety of purposes eg the Rhee (SSSI), Waveney, Thet and Little Ouse (public water supply, agriculture, local amenity and environment) and Gwash-Glen transfers (public water supply, agriculture and environment).
- Managed abstraction from the Lincolnshire Northern Chalk aquifer with the aid of a computer model and with the co-operation of abstractors, to minimise the risk of saltwater getting into the groundwater.
- Sealed sluices to control saltwater getting into rivers e.g. South Forty Foot, Maude Foster Drain, River Ancholme, Tail Sluices.
- Canvassed the views of environmental bodies about the impact of the drought upon conservation sites.
- Injected oxygen into Rivers Nene, Ouse and others to combat low oxygen levels.

- Rescued numerous fish at widespread locations.
- Played a leading role in producing a new guide for spray irrigators and organising local consultation with farming groups in key risk areas, to plan the sensible management of water resources.
- Canvassed the views of farmers, where abstraction was restricted, about how the NRA had managed the drought.
- Increased dredging to maintain navigations e.g. Denver.
- Introduced a moratorium on the issue of licences where resources were under stress.
- Initiated a three year study into rivers in North Norfolk.
- Attended over 120 public information meetings and issued regular news updates.

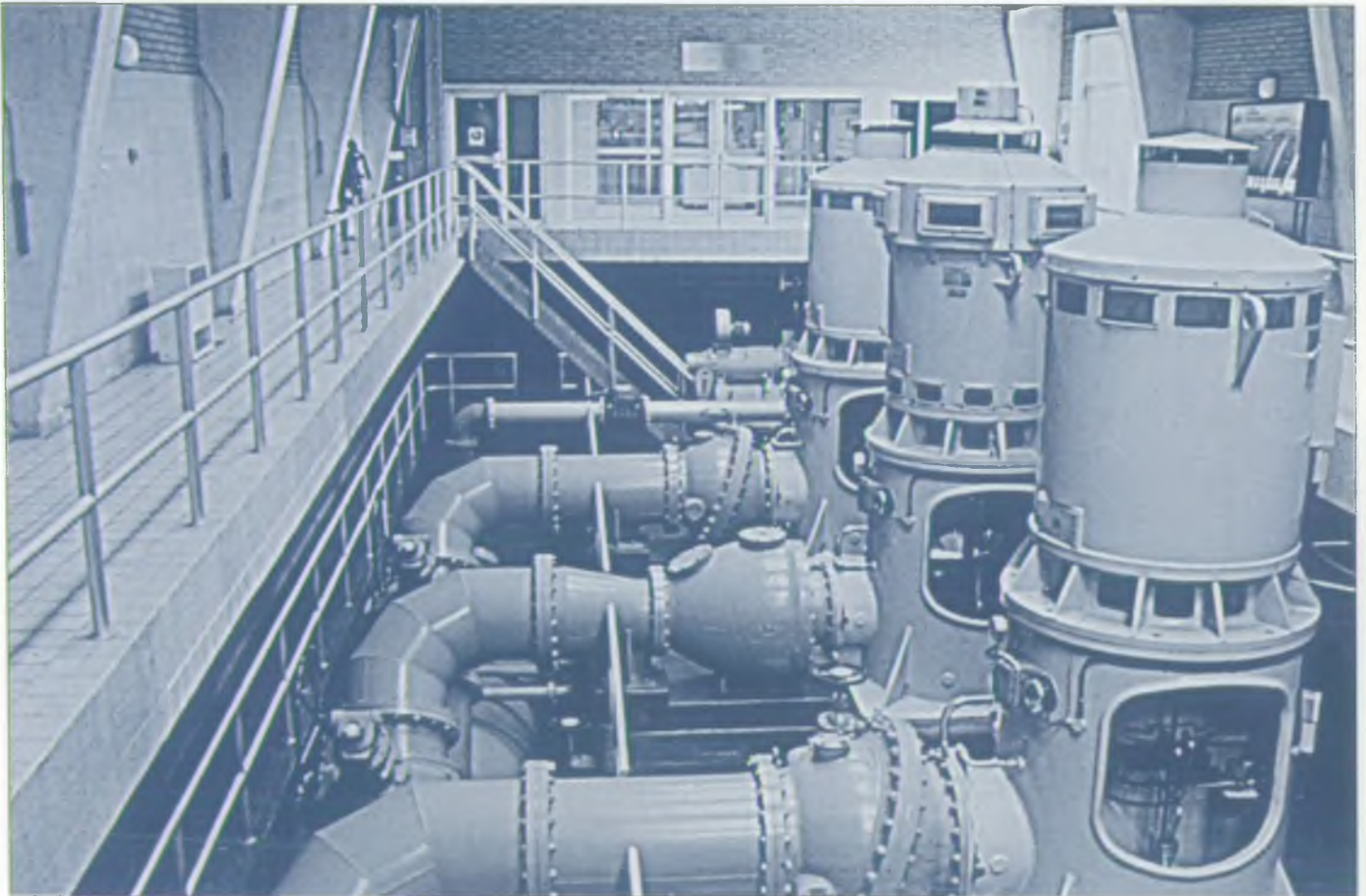
Because the drought focused attention on the importance of water, there was growing concern about the future. These concerns have been addressed by the publication, for consultation purposes, of a draft Water Resources Strategy. This sets out how future needs for water can be met sustainably whilst also protecting the water environment.

LESSONS FOR THE FUTURE

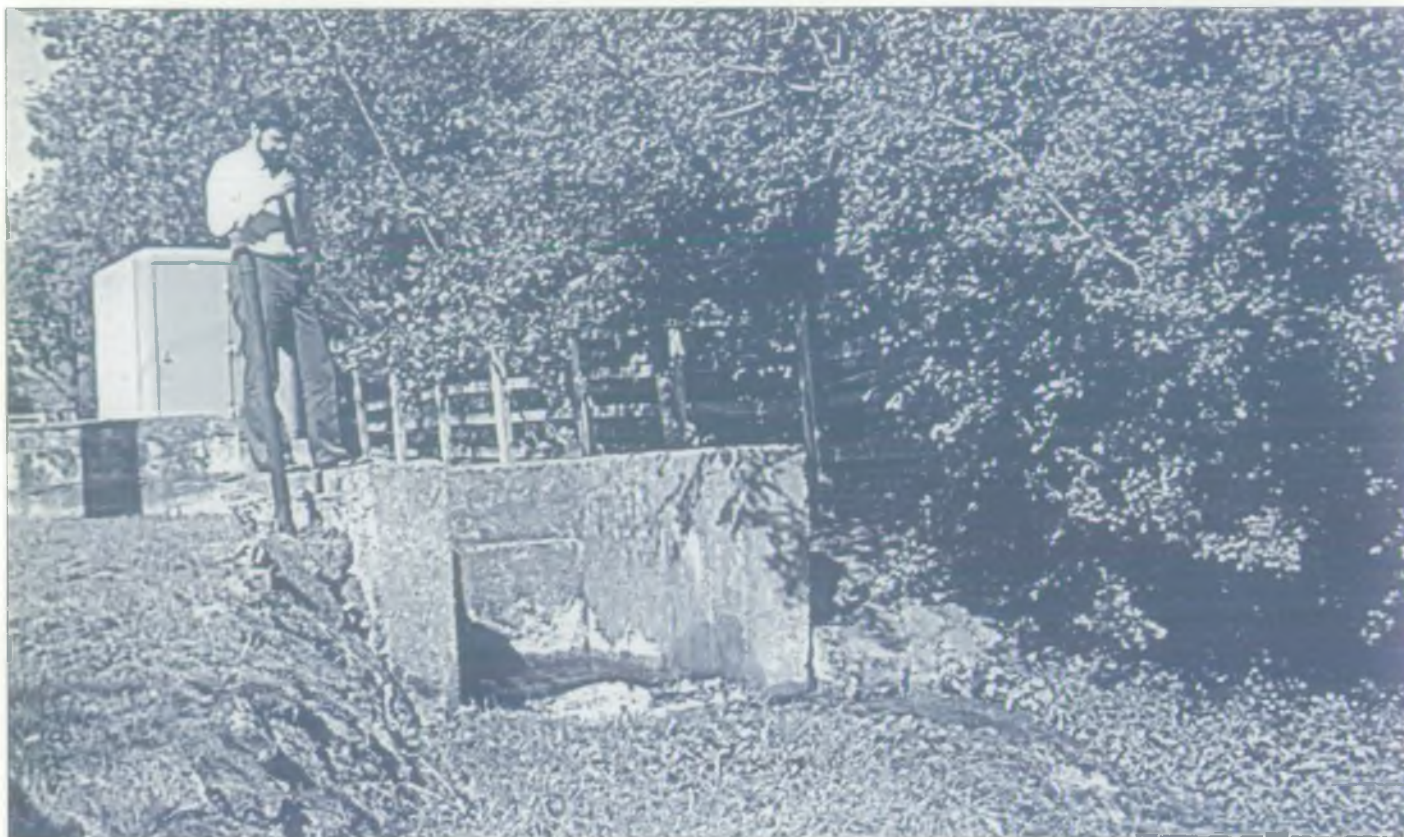
We do not know when the next drought will start, how serious it will be or how long it will last. It is essential that the experience gained from the last drought is used to manage the next. Action will be taken by the NRA and hopefully by others based upon the experience gained.

These actions include the following:-

- **Documentary Evidence** - many statistics and other such information were collected during the drought by the NRA. This document is based upon a collation of data by the NRA. Other organisations should also document soundly based information for future use.
- **Drought Recognition** - appreciation that a drought of significance has started will always be difficult with the inherent risk of over-reaction. However, it is essential that those organisations responsible for managing a drought and its impact take early action. The NRA will continue to give early warning of impending drought.
- **User Liaison** - early and frequent liaison with all users of water and the water environment is a key element in effective drought management. Formation of self-help groups to better manage dwindling resources is beneficial. Existing lines of communication will continue and be enhanced.



Pumping station used to maintain supplies in Essex.



Maintaining flow in river by pumping from borehole.

- **Value of Infrastructure** - the value of storage reservoirs was clearly demonstrated. If the reliability of supplies to agriculture is to be increased then additional storage is required in those areas where reservoirs can be built economically.
- **Priorities for Use of Water** - competition for supplies is increased during a drought. Those who wish to abstract water are often in conflict with those who wish the opposite. The NRA will seek further clarification of priorities to be applied to the use of water during a drought.
- **Drought Orders** - water undertakers can obtain drought orders to restrict demand. Both undertakers and the NRA can obtain orders to empower increased abstraction for providing water supplies. Indications are that the NRA has no powers to obtain a Drought Order specifically to protect the water environment. More clarification is required.
- **Rivers and Wetlands** - there is a shortage of information about the ecology and hydrology of rivers and wetlands in particular. Views on the changes and the reasons are often subjective. The NRA has initiated research which will lead to a better understanding. This should lead to clearer policies on protection of wetlands.
- **Water Availability** - the drought cast doubt upon water availability and especially the balance between water abstracted and water for the environment. Water availability has been addressed in the Draft Water Resources Strategy.

- **Abstraction Capabilities** - some abstractors discovered that they were unable to abstract the quantity of water to which they were accustomed. All abstractors should review abstraction capability and their water requirements.
- **Manpower** - the overriding need for abstractors to comply with licence conditions during a drought produces a very high workload. To ensure effective enforcement the NRA will review priorities.

In many respects, it is too early to establish whether any of the impacts made by the drought upon the water environment are permanent. It is also difficult to establish the precise reasons for changes. As time progresses a clearer picture should emerge. Much will depend also upon continuing co-operation between the NRA, water users, and all those who care for the water environment to ensure this happens.

Given the extreme nature of this drought it is perhaps surprising that, on present indications, the impact on users of water was not more severe. This is undoubtedly due in part to sound planning and investment by users of water over many decades.

If the impact of future droughts is to be kept to a minimum it is essential that all those responsible for management of water resources heed the experience gained during the drought of 1988 to 1992.

The National Rivers Authority

Guardians of the Water Environment

The National Rivers Authority is responsible for a wide range of regulatory and statutory duties connected with the water environment.

Created in 1989 under the Water Act it comprises a national policy body coordinating the activities of 8 regional groups.

The main functions of the NRA are:

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| Water resources | — The planning of resources to meet the water needs of the country; licensing companies, organisations and individuals to abstract water; and monitoring the licences. |
| Environmental quality and Pollution Control | — maintaining and improving water quality in rivers, estuaries and coastal seas; granting consents for discharges to the water environment; monitoring water quality; pollution control. |
| Flood defence | — the general supervision of flood defences; the carrying out of works on main rivers; sea defences. |
| Fisheries | — the maintenance, improvement and development of fisheries in inland waters including licensing, re-stocking and enforcement functions. |
| Conservation | — furthering the conservation of the water environment and protecting its amenity. |
| Navigation and Recreation | — navigation responsibilities in three regions — Anglian, Southern and Thames and the provision and maintenance of recreational facilities on rivers and waters under its control. |



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