

1998 Easter Floods

Final assessment by the Independent
Review Team – Volume 2

EASTER 1998 FLOODS

VOLUME II

INCIDENT REPORTS

**Prepared by the Environment Agency
on behalf of the Easter Flood Review Team
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1. **INTRODUCTION**

These reports were prepared by the Environment Agency to support the work of the Independent Review Team. The Agency was guided by a methodology devised by the Independent Technical Advisor. The Review Team visited the majority of the flood incident sites and has referred to these reports in preparing its assessments for Volume I.

2. SPECIAL STUDY SITES

2.1 NORTHAMPTON (ANGLIAN REGION)

Background Information

General

Catchment geography and the physical characteristics of the river system

Northampton is located some 13km east of Daventry and 17km north west of Milton Keynes on the banks of the River Nene. This location coincides with the confluence of the River Nene's main tributaries, the Brampton Branch and Kislingbury Branch.

There are five catchments which feed the River Nene upstream of Northampton. Upton (Catchment 32006) and St Andrews (Catchment 32007) are large, gauged rural catchments. Catchments 1, 22 and 23 are more urban, ungauged catchments with shorter response times. The catchments are shown on Figure 2.1.

Any other water systems such as canals and reservoirs, the presence or operation of which could have affected flood conditions

Water Supply Reservoirs

There are three large Anglian Water water supply reservoirs within the catchment of the Brampton Branch; Pitsford, Ravensthorpe and Hollowell. Pitsford was constructed in the 1950s while the latter two were constructed at the turn of the century. On the Kislingbury branch there are two smaller British Waterways (BW) reservoirs; Daventry and Drayton, constructed in the 19th century.

Flood Storage Reservoirs

There are several smaller flood storage reservoirs within the Northampton Catchments which provide attenuation to development run-off. These are located at Duston Reservoir, Jigsaw Lakes, Lake Delapre, Dallington Brook Reservoir, Wootton Brook, Wootton Fields, Brackmills, and The Lakes, Bedford Road.

The standard of protection where known, provided by the reservoirs varies between a 1 in 50 and 1 in 100 year return period.

Grand Union Canal

The Grand Union Canal is the responsibility of British Waterways. It runs through the Northampton Catchment and interconnects with the R. Nene to provide continuous navigation to the R. Thames. The canal is served by the two BW reservoirs. The section between the R. Nene at Northampton and Braunston is approximately 20 miles long and was constructed in the 18th and 19th centuries. To the north of Braunston it continues to the summit at Foxton Locks near Market Harborough. The Northampton arm of the canal links to the River Nene navigation in Northampton.

Surface Water Systems

The responsibility for the surface water system throughout Northampton is shared between the riparian owners, Anglian Water and the Northampton Borough Council. Surface water drains enter the R. Nene via different routes. The northern area drains directly to the R. Nene via storm water outfalls while the southern area can be separated into three discrete elements:

- 1) the recent and continued development of Banbury Lane which utilises the flood storage capacity in the off line Duston Retention Reservoir.
- 2) the development of Briar Hill which discharges via two 1.2m diameter syphon sewers across the railway line after which they merge into a single 1.5m diameter pipe and discharge into the R. Nene at Duston Junction.
- 3) the development of Far Cotton drains eastwards via the Hardingstone Drain on the southern side of Ransome Rd into Lake Delapre and subsequently into the Hardingstone Dyke; and the Hardingstone Dyke which drains from the northern side of Ransome Rd eastwards into the River Nene.

Northampton Washlands

The Northampton Washlands, constructed in the 1970s, are located downstream of Northampton. They are used to mitigate the effect of development in Northampton on the valley downstream without having a detrimental effect upstream. The Washlands are controlled by primary and secondary control sluices and overflow spillways. The Primary Control Sluice consists of three gates. The centre gate is a vertical overflow gate which rises up out of the cill. The outer two are vertical underflow gates. The Secondary Control Sluice is a vertical overflow gate which controls the inlet to the Washlands and opens when water levels reach 55.15m AOD. A combination of automatic gate movements and resulting storage are used to control the downstream water levels and flows to approx 52.8m AOD and 28 cumec respectively. When storage is fully utilised downstream flows increase and water levels rise accordingly.

Catchment and flood plain environmental changes affecting the river and land in and above the flood plain

Brampton Branch

Above Northampton on the Brampton branch of the Nene, the catchment is rural in character and there has been no major development within the flood plain. Such development as has occurred has generally been small scale residential infill within the villages. The A14 trunk road crosses the northern tip of the catchment and run-off from this has been mitigated against by balancing. An attenuation reservoir has been constructed on the Dallington Brook.

No major river works have been carried out on this branch since defences were raised in the 1940s. Routine maintenance works consist of obstruction removal and occasional de-silting.

Kislingbury Branch

On the Kislingbury branch, the catchment is rural in character although there are a number of larger villages. Daventry is an expanding urban area at the head of the catchment from which increasing run-off has been mitigated against by attenuation within the Daventry and Drayton reservoirs.

Completed in the early 1960s approximately 25km of the M1 motorway drains unattenuated into the Kislingbury Branch. There is provision to accommodate flood flows where the road is embanked across the flood plain.

Major river works were carried out on this branch in the late 1960s when a two-stage channel was created between Upton and Kislingbury increasing flow capacity by some 30%. At Bugbrooke and Nether Heyford improvements were implemented to alleviate property flooding. These would have decreased the response times of the relevant sub catchments.

Northampton itself has undergone rapid growth since the 1970s. The effect of increased run-off from the developments has been mitigated against by a variety of measures including flood storage reservoirs (Duston, Jigsaw Lakes, Lake Delapre, Wootton Brook, Wootton Fields, Brackmills and The Lakes, Bedford Road) and channel improvements.

The construction of Northampton Washlands mitigated the downstream effects of increased development in Northampton.

The pattern, type and history of developments on the flood plain

The majority of the areas of Far Cotton and much of St James' were developed in or before the 19th Century and have had a history of flooding.

Significant development and redevelopment in these areas has occurred (Figure 2.2). The St James' Industrial Estate probably originated in the 1950s as did the Avon Factory at the downstream end of the Town. In 1971 the river was enlarged and diverted to accommodate the construction of the Carlsberg Brewery at Baulmsholme. In the 1980s, Foot Meadow was developed as a retail park. All the above developments generally resulted in a loss of flood plain.

Currently major expansion is underway to the south-west of the town involving the incursion into the flood plain of the Wootton Brook development, for which the Duston Mill storage reservoir has been provided.

Categorisation of why flooding occurred (on the basis described in the Preliminary Report)

A study of the flood defences throughout Northampton indicates that the flooding resulted from a combination of the explanations given in section 5.2 of the Preliminary Report.

Throughout the Main River channels, the main reason for flooding was explanation 1: 'Failure of the flood defence system due to flood characteristics more severe than those assumed in the design of the system'.

There were some lengths of defence in the South Bridge Industrial Estate where explanation 2 applies: 'Failure, other than structural, of the defence system with flood characteristics less severe than those assumed in its design'.

Failure, referred to in the explanations, means that the defences were overtopped due to water levels which exceeded the height of the defences. It does not mean that there was a structural failure of the defences, such as a breach.

Further contributions to flooding would have resulted from explanation 5: 'Reduced waterway

capacity resulting from debris, gravel accumulations, blockages or other factors detrimentally affecting hydraulic performance during the period of the flood. This was particularly relevant to the Dallington Brook, the Non-Main River Spencer Street culvert and drains at St James'.

In addition to the Main and Non-Main River sources, flood water also originated from reservoirs, the surface water system and the Grand Union Canal.

Special Studies

Critical examination of issues

The components and procedures of the flood warning system

The flood warning system for Northampton comprises: telemetered rainfall, riverflow and river level stations in and upstream of the town and associated alarm thresholds; rainfall radar; a forecasting model which predicts riverflows for Northampton based on catchment characteristics and rainfall; a Red flood warning threshold set at the defence standard and arrangements to pass flood warnings to the media and emergency services (as defined in the Flood Warning Dissemination Plan, supplied in full to the Review Team). It does not include arrangements for dissemination of warnings direct to the general public.

Procedures for initiation and implementation of the above system are prescribed in the procedural documents governing operation of the Area Control Room (supplied in full to the Review Team). The Area Control Room Manager (ACRM) is responsible for the issue of warnings in accordance with set procedures. The ACRM is assisted in this by teams of officers operating at Area and Catchment level.

Operation of the warning system and deficiencies revealed

The procedures in force at Easter were that a Red flood warning for Northampton would be issued if the flow in Northampton was predicted to reach 125 cumec. This flow equated to the estimated 100 year flood flow and the defence standard.

The Area Control Room in Lincoln was fully established on the afternoon of 9 April following telemetry alarms and implementation of procedures. Flood forecasts of peak flows in Northampton were made throughout the evening of 9 April. The peak forecast flow for Northampton was 109 cumec made at 2300 GMT on 9 April (forecast for 0500 - 0700 GMT on 10 April). On the basis of the forecast, the Area Control Room Manager in accordance with procedures, did not issue a flood warning.

The actual peak passed through Northampton earlier than expected, with flooding commencing at approximately midnight on the 9 April and the majority of emergency calls being received by the Fire Brigade before 0400 GMT on 10 April. No calls from the public had been received by the Agency at this time. By the time that the Agency became aware that property flooding was taking place the Police and other emergency services were already dealing with the major incident.

Detailed analysis after the event currently indicates that the peak flow through Northampton was in excess of 150 cumec. Around 2,500 properties in Far Cotton and St James' areas were flooded within an area of approximately 2 sq miles.

The main factors contributing to the flood were the Main Rivers, reservoirs and the canal. the

exceptional nature of the event overwhelmed the flood defences.

Following the event, the principal reasons for the forecasting model underestimate have been identified as:

- 1) A lack of information from extreme events to enable the models to be fully calibrated and validated
- 2) Telemetry gauges recording lower rainfall than actual (based on daily rain gauges). This affected the Nene Kislingbury Branch Catchment forecasts where the catchment average rainfall is now estimated to be 84.1mm compared to 57.5mm recorded at the telemetry rain gauge in the event. This is estimated to have resulted in a peak flow underestimate of some 16 cumec. There are four telemetry gauges in the catchment to Northampton. Two sites were out of commission due to site works. The telemetry rain gauge in the Nene Brampton Branch Catchment adequately represented catchment average rainfall. Northampton is poorly covered by rainfall radars at Clee, Chenies and Ingham. Rain radar data received from the Met Office in the event, underestimated actual rainfall.
- 3) Response of water supply reservoirs on the Nene Brampton Branch. This is estimated to have resulted in a peak flow underestimate of some 10 cumec. The forecasting model is based on work by the Institute of Hydrology which did not fully represent the modelling of the impact of reservoir spill in extreme flood events.
- 4) Exceptional run-off from the Wootton Brook Catchment (although the extent of this is currently subject to further investigation).
- 5) Overflow/run-off from the canal system

The monitoring of actual flows at the two river gauging structures on the principal Nene tributaries is restricted to 20-25 cumec at which stage the stations go out of range as water spills over on to the flood plain which is at a lower level. In addition, there is currently no river level telemetry in Northampton. Works to construct a full-range monitoring site in Northampton and to install telemetry at sluice sites were imminent at the time of the event.

The current colour phase warning system is based upon the type of land use. Therefore only a Red warning would be applicable to Northampton as an area where many properties would be at risk from flooding. The ACRM discussed the position with the Northamptonshire County Emergency Planning Officer late on 9 April and there was, at that time, no expectation of the flood defences overtopping. It is understood that Police in Northampton at the time were of the same view. Contact was made with the Police regarding the narrow boat incident in Northampton and regarding Billing Aquadrome.

The warning system was based upon a defence standard consistent with protection against the 100 year flood event. This assessment was based upon investigations which had been undertaken for the National Rivers Authority by Mott MacDonald consultants (and others). This work identified short lengths of defence in the vicinity of South Bridge Industrial Estate which were below the 100 year standard. Improvements to these defences were scheduled for completion as part of the Agency's 1998/99 revenue works programme.

Whilst no warning was issued, there were no specific arrangements in place at the time of the event to disseminate any warning issued to the general public. In 1996 when the

Agency took over flood warning dissemination, it did not inherit any flood warning dissemination arrangements from the Police or local authority. In line with the Agency's strategy, priority is given to providing flood warning dissemination for areas at risk of flooding up to a 1 in 50 yr frequency. Northampton, with a standard of 1 in 100 yr, was therefore given a lower priority for the implementation of a dissemination system. Where operated elsewhere, the procedures and arrangements to pass flood warnings to the emergency services, media and the general public worked successfully. It is understood that in Northampton the Police/local authority had no plans or arrangements to alert the public in the event of a flooding incident, even a major incident.

Any warning system of this nature relies upon estimates of the existing defence standards and peak flood flows derived from hydrological and hydraulic models. Models have been developed using the best data sets at that time and have not been calibrated/tested against an event of this magnitude or speed of development because of its exceptional nature.

The emergency response procedures currently in place

The emergency response procedures comprise:

- 1) Catchment (Client) procedures to alert internal/external contacts at preset operational thresholds, to open an Incident Room at Catchment Office, to undertake operational management of the flood situation, establish liaison with direct services group and deploy emergency workforce (EWF) (Catchment Operational Procedures supplied to Review Team).
- 2) Catchment (Direct Services Group/EWF) arrangements to initiate river regulation, washland operation, pumping station operation, blockage clearance, response to defence damage/breached and deployment of sandbags.(Specified in Emergency Response Service Level Agreement)

The operation of the emergency response procedure at Easter and any deficiencies revealed

The emergency response at Northampton comprised:

- 1) Establishment of Catchment Incident Room for flood event management at Kettering, including liaison with Direct Services Group and responding to calls from the general public and external organisations.
- 2) Deployment of EWF to monitor/control river structures at Nene Lock, Nunn Mills Sluice Complex, Bedford Road Sluice and Northampton Washlands.
- 3) Deployment of EWF to undertake blockage clearance works in Northampton.
- 4) Contact with external bodies and keyholders.

River control structures (largely automatic) operated as designed. One gate at each of the Nunn Mills and Bedford Road complexes had been removed for maintenance and replaced by stoplogs though it had been established beforehand that this would not significantly increase flood risk if high river level conditions were experienced whilst gates were removed. This was confirmed by hydraulic modelling prior to and after the event. Agency

staff were deployed to confirm the correct operation of structures.

Direct Service Group were deployed to undertake blockage clearance at Dallington Brook, which had been a problem area in previous events, throughout the night of the 9 and 10 of April. The severe blockage at Butt's haulage depot was located a long way into the covered box culvert. The Agency's personnel were not aware of a blockage until late on the night of the 9 April and had not been informed of a problem by any third party. By the time the blockage became apparent it was not possible to remove it because of high water levels which prevented safe access to the culvert.

Local contact was made with British Waterways and with the Northamptonshire County Emergency Planning Officer but not with other relevant local operational bodies (Anglian Water, Northampton Borough Council). Priority was given to deploying patrols upstream of Northampton, on the Dallington Brook and downstream (river regulation up to Nene Lock) where the flood risk was expected to be higher than Northampton. The Agency was not fully aware of the onset and development of the flooding nor of the full scale and speed of the event. It was a notable feature of the event that river levels rose very rapidly. Unknown to the Agency, forecasting models were underestimating flows and no information was received by the Agency from the emergency services or the public with regard to the onset of flooding in Northampton. Accordingly no emergency response from the Agency was initiated within Northampton itself.

Provisions in the current medium term capital programme relating to warning and/or defence improvements

1) Defence Improvements:-

Capital - £200K (98/99) in non-grant eligible programme for sluice refurbishment and telemetry at Nunn Mills and Bedford Road.

Revenue - £5-10K (98/99) to improve defence levels in South Bridge Industrial Estate.

2) Flood Warning:-

Capital - £234K(part of)(98/99) in grant eligible and non-grant eligible programme to construct new flow gauging sites at South Bridge and Geldarts Mill.

Capital - £338K(part of)(98/02) in grant eligible and non-grant eligible programme to improve flow forecasting in the catchment to Northampton

Consideration of defence system.

Previous significant flooding affecting the town irrespective of the ways in which it occurred

It is believed that flooding occurred within Northampton in 1933 and 1937; however only limited information is available. Major flooding occurred in Far Cotton and St James' in January and October 1939 and it was these events which brought about improvements which were completed in 1943. Flooding which followed in 1947 affected Far Cotton and St James' but to a lesser extent.

Between 1947 and 1984 the only recorded flooding was that which affected Far Cotton in 1980

which resulted from a sewer collapse. All subsequent Main River flooding was limited to several more minor incidents on the Dallington Brook which was improved in 1984. After these no further flooding events were recorded up until April 1998.

The elements and history of the existing defences and any other river works potentially influencing flood protection

The core elements of the Northampton flood defences date from the 1940s when major improvements were completed following floods in January and October 1939.

These works consisted of the raising of defences in vulnerable areas, dredging and channel diversions together with the reconstruction of bridges and various control structures. The defence height was set at a level above the highest recorded flood level in 1939 and was not based upon a particular return period. Further flood protection work was carried out following the 1947 floods. In the late 1950s the sluice capacity at Nunn Mills was increased. This approach has led to defences that were considered at the time to be adequate to protect against the historical worst event.

Specifically some of the works included:

- a) a combination of floodwall and earth embankment protecting Far Cotton on the south bank of the river extending from South Bridge to the Engine Sheds (now Airflow Streamline);
- b) the construction of Duston Flood Relief Channel, bypassing Duston Mill;
- c) the construction of Town Mills Sluices at Foot Meadow, these being removed in the 1980s when this site was developed as a retail park when channel works were undertaken and a flood wall to a 1 in 100 year standard was constructed;
- d) construction of a flood wall to the Borough Councils' West Bridge Depot together with a pumping station to ensure drainage of parts of St James' when high river levels occurred in the Brampton Branch;
- e) embankment and floodwall construction in Victoria Park.

With the designation of Northampton as a New Town in the late 1960s, major expansion brought with it further improvements which included the construction of the Northampton Washlands and associated channels. At this time the original (1933) Bedford Road Channel was abandoned.

Any inspections and surveys made of the flood defences and related works before Easter

Maintenance of flood defences in Northampton is shared between the Agency, Northampton Borough Council and a number of riparian owners.

Prior to 1980 there was a formal agreement for the annual inspection of flood defences with the Borough who were responsible for closing defined gaps in the defences during periods of high river flows. All these defined gaps were gradually eliminated as re-development took place and internal

reorganisations within Anglian Water Authority (predecessor to the Agency) led to the abandonment of the annual inspection arrangement.

The condition of control structures in Northampton was inspected by Consulting Engineers Haswells in 1995 and by Consulting Engineers Scott Wilson Kirkpatrick in 1997. The surveys concluded that although gates were generally in good condition and operated effectively, there was deterioration in the condition of the equipment. Maintenance works were ongoing at the time of the flood event.

The condition of the flood defences was inspected by the National Rivers Authority in 1994 and reviewed by Consulting Engineers Halcrow and Scott Wilson Kirkpatrick in 1995 and 1997 respectively. The surveys and studies concluded that, but for some minor areas in the South Bridge Industrial Estate (considered to be the responsibility of the riparian owners) flood defences were generally at or above the estimated 1 in 100 year flood level. Improvements to defences in the South Bridge Industrial Estate were scheduled for completion as part of the Agency's 1998/99 revenue works programme.

The defences in the South Bridge Industrial Estate had been identified for improvement as part of a redevelopment plan. Negotiations which had been ongoing between developers and the Agency for the last three years had been affected by several delays, including a planner's objection, which regarded the developer's proposals as unsuitable, lodged in the High Court. These delays affected the planning of improvement works and had they not occurred it is likely that new defences would have been constructed prior to April 1998.

The assumed defence standard prior to Easter and the basis of its assessment

Flood protection was provided to flood risk areas within Northampton subsequent to the events in the 1930s, to a height which exceeded the highest known flood level of that time. Further flood protection work was carried out following the 1947 floods. This approach has led to defences that were considered at the time to be adequate to protect against the historical worst event. More recently, investigations commissioned by the Agency and their predecessors have confirmed that the defences, with only a few exceptions, are at or above the previously-predicted 100 year flood level.

The operation of the defence system at Easter and the ways in which flooding occurred

1) Flood defence

Particular elements of the existing defences which influenced the pattern of flooding in April 1998 have been identified. The responsibility for each element varies (Figure 3.1) between the Agency, Riparian Owners and the Northampton Borough Council. Particular elements are listed below:

- a) Grand Union Canal and R. Nene right bank between the Briar Hill Railway Viaduct and the Avon Factory.
 - Briar Hill Railway Viaduct to Duston Junction:
From the Briar Hill Railway Viaduct an old retaining wall provides flood protection. This wall decreases in height but continues towards the Airflow Streamline factory. Along the rear of the factory a length of retaining wall provides a lower standard of protection. Considerable overtopping occurred along this length, however, the railway

line which passes through the factory acts as a defence protecting the urban area behind to the previously predicted 1 in 100 year standard.

- Duston Junction to South Bridge:

From Duston Junction to Lock 17 the defences are provided by the canal bank, earthen banks and the railway line which is located some way back from the canal and by walls of varying height and in poor condition. These composite defences have been previously assessed as protecting the urban areas behind to a 1 in 100 year flood level. Overtopping occurred around the Towcester Road Bridge and the Old Towcester Road.

Downstream of Lock 17 to South Bridge, the defences appear not to have been overtopped.

- South Bridge to Avon Factory:

Within the South Bridge Industrial Estate there are lengths of low defence. There are two earth bunds to the rear of the industrial estate, located north and south of South Bridge Road. It is not certain if the bunds would have contained flood water in South Bridge Road but even if this was the case, flood water would have been able to enter Cotton End via the road entrance.

The April 1998 flood was of such severity that, regardless of the areas of low defence, substantial flooding would have occurred as a result of general overtopping of the defences.

The defences fronting the Avon Factory are above the 100 year flood level and the actual levels experienced in the April 1998 event. Flooding of the Avon Factory would suggest that water entered the site via the South Bridge industrial estate.

b) R. Nene left bank at the Cattle Market area

No overtopping of defence occurred along this section. Site reports confirmed that the levels of ramped defences and walkway entrances slightly exceed observed flood levels during the 1998 event. Reports of flooding to the Morrison's car park are thought to be the result of floodwater entering this site from the Towcester Road area, in the locality of the British Gas site.

c) Brampton Branch at the Carlsberg Brewery and British Gas sites

Survey indicates that the observed flood marks were just below or equal to the ground level adjacent to the river.

d) Brampton Branch at St James' Retail Park

Overtopping of the defences occurred along this section, which are above the 100 year flood level. Flood levels exceeded the height of the riverside floodwall and poured over into the car park.

e) Brampton Branch at Victoria Park

Major overtopping of parts of the defences, which are at or above the previously predicted

100 year flood level, occurred along this section. In this area a low section of defence at the downstream end of the Dallington Brook will have contributed to the overtopping, but not substantially, as the whole area would have been inundated by water from the Main River channel. Flooding caused by the Dallington Brook due to blockages in an enclosed culvert are dealt with specifically below.

f) **Brampton Branch at St Andrews**

At St Andrews Rd., large flows of water which by-passed both of the low flow gauges at St Andrews caused flooding to a depth of approx 1.9m across the flood plain.

2) Operation of River Control Structures

There are several structures located along the Northampton reach of the River Nene which are used to maintain navigation during normal flows and to pass flood water during high flows. The main structures operate automatically and open under periods of high river flow.

Mechanically and electrically, the present structures at Bedford Road and Nunn Mills / Red House Weir date from the 1960s and 70s. Recent condition surveys concluded that, although the gates were generally in good condition and operated effectively, there was deterioration in the condition of the equipment through normal usage and exposure to the weather. As a result, a scheme was initiated by the Environment Agency at the end of 1997, to carry out a complete overhaul of the installations, in order to guarantee their efficacy for the next 25 years. Work on the overhaul began on site on 23 March 1998.

As programmed, two elements of the sluice complex had been removed for refurbishment during the April event. Sluiceway 1 at Bedford Road Sluices was stoplogged, at the upstream side with Gate 1 removed for refurbishment. At Redhouse Weir the single gate was removed with stoplogs in place. Gates 2, 3 and 4 at Bedford Road Sluice and Gates 1, 2 and 3 at Nunn Mills were fully operational. Associated scaffolding placed around the structure did not compromise the operation of the gates.

Reports from the Agency's Operations staff, confirm that both Bedford Road and Nunn Mills Sluices operated satisfactorily during the event and that the policy of limiting refurbishment to one quarter of the sluices' capacities and maintaining the operational effectiveness of the remaining sluices was correctly adhered to. Stoplogs being in place had little effect on the water levels immediately upstream of them.

3) Operation of Northampton Washlands

The Northampton Washlands were used to control the discharge downstream of Northampton during the April 1998 event. Initially the centre gate automatically controlled the downstream discharge with the outer two gates fully closed. As levels in the Nene continued to rise the Secondary Sluice opened and the Washlands began to fill. At the appropriate time the outer gates were opened automatically to increase the discharge downstream. Eventually a combination of manual and automatic gate operation was used to bring the water levels upstream and downstream of the Washlands under control.

4) Operation of Dallington Brook

Dallington Brook flows from the north west of the Spencer Industrial Estate to its confluence with

the Brampton Branch at the edge of Victoria Park. Along its course a small flood storage reservoir is located. The Brook flows in open channel and enclosed culverts. Flood water surcharged the culvert in April and to clear the main obstructions, debris including a motorbike and mattresses was removed. It is understood that this particular length of culvert was constructed without Agency consent and that the inlet to this culverted section was not protected by a debris screen.

5) Operation of Wootton Brook

The Wootton Brook is a main tributary of the River Nene which enters the Kislingbury Branch downstream of Upton Mill. During the recent flooding, flow in the Brook was restricted at culverts under the Grand Union Canal and the A43(T). It appears that the afflux at the A43(T) reduced the observed peak flows at the gauging station, giving a distorted picture of the severity of flows in the Brook.

The deficiencies revealed in the defence arrangements

For the purposes of this section, 'deficient' defences mean those which were overtopped by the Easter 1998 event. These defence sections have been identified and are summarised below:

- Grand Union Canal (Kislingbury Branch / right bank) Airflow Streamline
- Grand Union Canal (Kislingbury Branch / right bank) immediately upstream of Lock 17
- River Nene (right bank) South Bridge Industrial Estate
- River Nene (Brampton Branch / right bank) Victoria Park, St James' End
- River Nene (Brampton Branch / left bank) downstream of the old Towcester Road river bridge adjacent to the Gas Works Site
- River Nene (Brampton Branch / left bank) Gas Works Site, disused jetty access
- River Nene (Brampton Branch / right bank) St James' Retail Park

The peak rates and other characteristics of the Easter flood hydrographs at Northampton

The peak flows predicted for Northampton were determined using Micro-FSR Outputs for the April 1998 Event. These flows were used in the modelling of river flows and are summarised in Table 3.1

Table 3.1 - Peak discharges for the April 1998 storm using various data

Catchment	Peak Discharge (cumec)			
	EA Predictions	Point Rainfall	Catchment Average Rainfall	Catchment Average Rainfall with Reservoirs
32006	36.0	38.9	52.3	52.3
32007	51.0	47.9	47.6	57.3
1	22.0	19.5	40.4	40.4
Total	109.0	106.3	140.3*	150.0*
22		-	19.0	19.0
23		-	15.1	15.1

Notes:

- 1 It can be seen that the peak discharge produced using point rainfall is lower than that produced using catchment average rainfall which is subsequently lower than that produced taking into account the effect of the reservoirs. The reservoirs were all full to the top of the spillways at the start of the event and overflowing throughout.
- 2 For catchment 1 under point rainfall, peak flows have been scaled by catchment area to 50% of catchment 32006. This has been done because catchment 1 is ungauged, its characteristics have been assumed to be similar to that of catchment 32006 and its area is approximately half. The peak flow using catchment average rainfall has been calculated by two independent sources and will require further investigation.
- 3 Catchments 22 and 23 have not been calculated for point rainfall as they are quick response catchments, with a time to peak discharge of 2 - 4 hours. * For the same reason the catchment average totals do not include the peak discharges for these two catchments.

The operation of any works or water systems not under the Agency's control, but possibly influencing flood conditions

Operation of The Grand Union Canal

BW have confirmed that a large volume of water originated from the Grand Union Canal. Control structure data received from BW telemetry indicated that side weirs along the Braunston to Northampton reach were spilling into the Nene with a head of water up to 270mm. In addition both BW reservoirs are reported to have been spilling throughout the event although their contribution to flood flows is considered to be relatively insignificant when compared to the larger reservoirs on the Brampton branch.

Water levels in the canal are reported to have been rising on the 9th of April and appeared to be threatening the residential areas of Banbury Lane and Briar Hill. To avoid this flooding, the paddles in all 17 locks on the Northampton reach were opened to create a flow of approximately 6 cumec towards the town.

St James' Retail Park Pumping Facility

Drainage to St James' Retail Park car park is provided by pumps which evacuate water directly to the river via two flapped outfalls. This system is an Anglian Water adopted system. Surface water flooding in this area was probably a result of one or more of the following:

- (1) restricted pumping caused by a power failure
- (2) an under capacity pumping facility
- (3) a pumping facility which could not cope with the head of water

Operation of the Surface Water System

Information received since the 'Initial Report on The Northampton Floods' indicates that there may have been a problem with the surface water sewer network as a number of residents in St James' have reported manhole covers being lifted off during the event, before the river overtopped. The surface water system is an Anglian Water adopted system.

Operation of Flood Storage Reservoirs

No reports were received of flooding resulting from the operation of these reservoirs. It is likely that the response time would have been short in comparison with the main event. Northampton Borough Council are responsible for the Duston reservoir. Responsibility for all other flood storage reservoirs, with the exception of Dallington which is with the Agency, lies with the riparian owners.

Operation of Drain at Spencer Street, St James' End

In the vicinity of Spencer Street, surface water is discharged via an open drainage ditch to a head wall at Spencer Street then through an enclosed culvert to Mill Brook Close. The entrance and the culvert itself are severely blocked and would have restricted flood flows. Any flood water that entered the drain as a result of overland flow from the Kislingbury Branch and Jigsaw Lakes area would have met the same restriction. This drain is under riparian ownership.

Operation of Drain at Spencer Street to West Bridge St James' End

This length of drain is not 'Main River'. Silt has blocked the St James' Mill Rd Bridge to within 300mm of the soffit level and in addition the West Bridge Pumping Station did not operate during the event due to a power failure. A penstock situated along the demained length of drain, should have been closed by the Borough but was not closed, resulting in a possible contribution to the extent of flooding.

The ownership of this drain is unclear. Northampton Borough Council cleanse the drain, Anglian Water own the pumping station and the remainder of this drain is riparian owned.

Operation of Hardingstone Dyke and Drain, east of Far Cotton

The Hardingstone Dyke and Drain pick up drainage from Far Cotton and discharge into the downstream reaches of the River Nene. Both of these drains generally performed adequately throughout the event, however widespread fly tipping (in the drains) may have contributed to localised flooding, possibly in the Ransome Rd area. This drain is under riparian ownership, believed to be Railtrack.

Railway Viaduct, Foot Meadow

A timber slatted fence which had been erected in the vicinity of the railway viaduct withstood the force of river flows and caused an obstruction throughout the event. This obstruction may have contributed to higher upstream water levels.

The possible impacts of catchment and flood plain environmental changes

Developments upstream of Northampton on both the Brampton and Kislingbury branches have been on a small scale. As far as is known, major developments such as that at Daventry, have been implemented with appropriate mitigation / attenuation measures.

As in many rural areas, it is likely that agricultural drainage schemes have been implemented over the years and these would lead to an increase in the rate and speed of run-off.

Within Northampton there has been a loss of flood plain over many years. This began in 1815 with the completion of the canal and was followed by the construction of railway line embankments across the flood plain. Since the 1970s mitigation measures have been incorporated into development proposals which affect the flood plain. The extent to which this was done prior to the 1970s is unclear.

The assessed extent of inundation

The flood event which affected Northampton extended into the following main areas:

St James's End
St James'
Far Cotton
Cotton End
St Peter's

The best estimate of the extent of flooding has been derived using local knowledge, aerial photographs, survey work and local reports (Figure 3.2).

The estimated probability of the Easter flood

On the night of the April event the Agency prediction at 2300 GMT of 109 cumec was forecast against a theoretical 1 in 100 year flow of 125 cumec.

The peak discharge estimated following the April event is 150 cumec from a 'total catchment rainfall with reservoirs' analysis. This is between the 1 in 150 year and 200 year design estimations previously used by the Agency. Outline calculations carried out on Northampton Washlands have indicated that peak flows of this order could have occurred in the early hours of Friday 10 April (taking into account the spillage which occurred in Northampton and on the flood plains).

The lessons evident on warnings, response, risk assessment and defence provision

Warnings

Warning generation arrangements were substantially based on computational models (real time model for forecast of peak flow, hydraulic design model for assessment of defence standards which have been constructed using historic data sets). It had not been possible to calibrate and validate the models against an event of such magnitude as occurred at Easter due to the lack of data from similar events. It is noteworthy that the current models cannot replicate the Easter flood levels due to the exceptional nature of this event. Improved modelling, telemetry, flow gauging and monitoring presence on the ground are lessons evident.

Flood forecasting arrangements for Northampton need to be reviewed, including a review of the forecasting model which can now be calibrated against the Easter flood data.

The generation of a 'developing risk' warning at a lower threshold may, in association with flood warning dissemination arrangements. Improve public awareness of developing flood risk and flood warning arrangements, who does what and who to contact in each flood risk area. The penetration of the Agency's PR initiatives must be reviewed.

Short term adjustments to flood warning thresholds are essential while further review work is carried out.

A review of Agency strategy on priorities for the introduction of flood warning dissemination systems.

Response

The impact of Northampton flow from the Grand Union Canal, including British Waterways operational activities, was not fully assessed during the flood event. Similarly the impact of overflow at Anglian Water reservoirs had not been anticipated. Operational arrangements must be reviewed and improved in light of the Easter event.

On the ground patrols to check defences, read gauge boards and provide local information was limited. The need for early patrols such as in Northampton is now evident. Arrangements for establishing river patrols, in urban areas such as Northampton must be reviewed.

The deployment of sandbags by the Agency is primarily to strengthen or support Main River defences. However, it is expected by the general public and some of the local authorities also that the Agency will provide sandbags to protect properties. Public awareness needs to be improved as to the Agency's role in deployment of sandbags.

Risk Assessment

Flood assessments must be applied to the 'whole system' of flood defence even when flood responsibility is fragmented.

The flood event highlighted a need to reinforce arrangements for major incident plans, the clear establishment of roles particularly for the Police, Agency, County Emergency Planning and Local Authorities, and Floodwarning Plans for Northampton. These had not been established by some of the organisations.

The long term risks of development policies in the floodplain and the effectiveness of operation of mitigating works must be reviewed in the light of the Easter Flood. The opportunity must be taken to review the implementation of the Agency's Policy and Guidance on the protection of floodplains and the associated Section 105 maps.

Defence Provision

The standard and continuity of defences needs to be fully reviewed and the need for future defence improvements assessed.

Defences have been provided in Northampton by a combination of formal defences, natural features and existing development. As a result, responsibility for flood defence has become fragmented and needs to be clarified. Relevant parties include the Borough Council, the Agency and riparian owners.

Localised low defences where overtopping occurred have been identified and are being improved.

Short term actions to reduce obstructions to flow in Northampton are essential. Long term

maintenance agreements are necessary. Relevant parties include the Borough Council, Railtrack, the Agency and riparian owners.

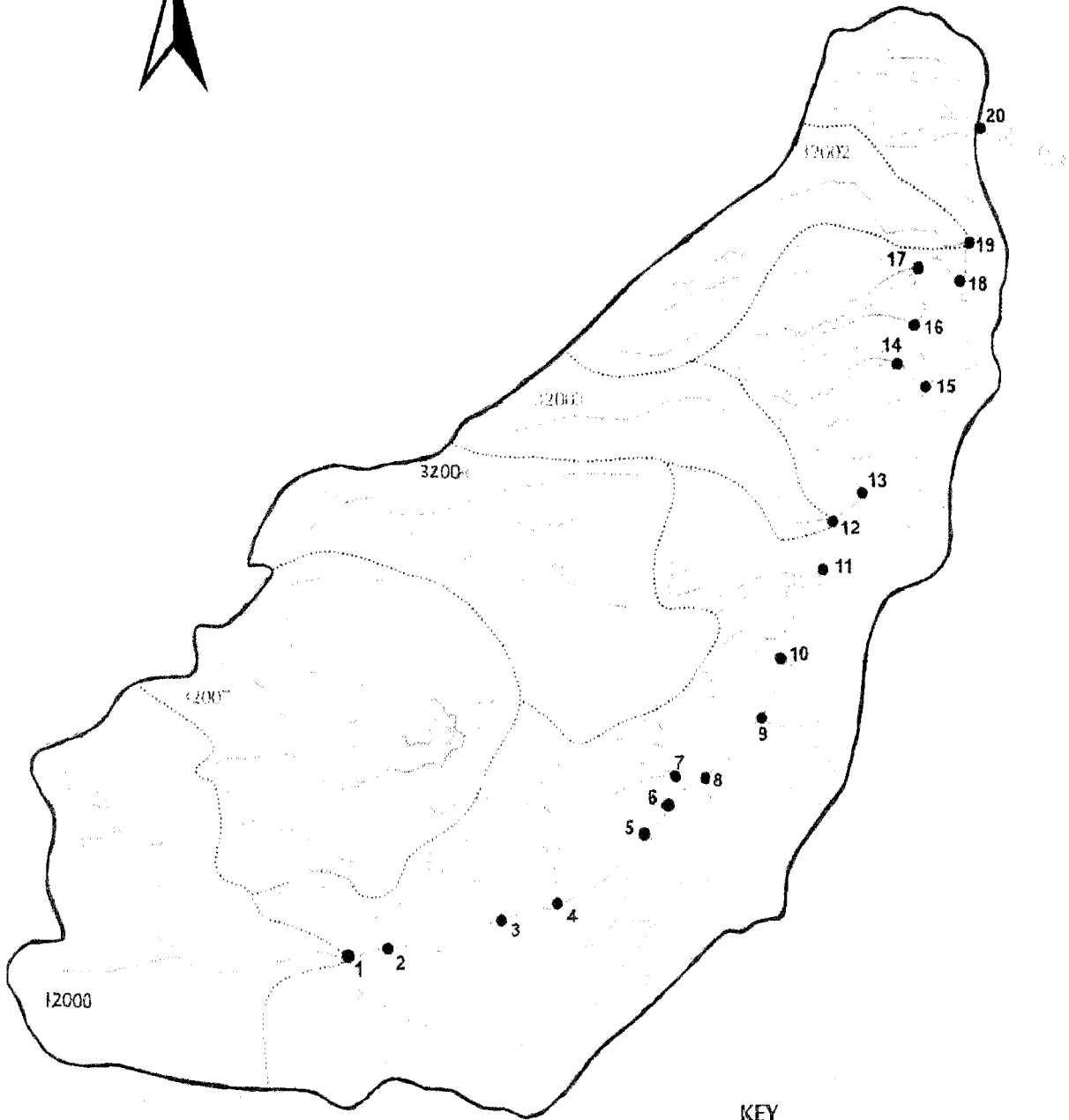
Defence provision is dependent on the accuracy and reliability of computational modelling to assess provision against current MAFF indicative defence standards. The provision of 'freeboard' to allow for predicted flood level uncertainties should be reviewed.

The 'whole system' of flood defence is dependent on several operating authorities. There is a need for more robust, effective and enduring local operating agreements.

Flood defence assets must be regularly reviewed.

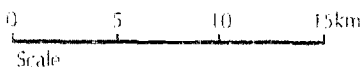
Possible alternative courses of action


- 1) Improve the level of defences in Northampton at locations where overtopping of the defences was most significant in affecting urban areas.
- 2) Clarify the responsibility for flood defence maintenance in Northampton.
- 3) Resolve non-Main River obstructions in Northampton.
- 4) Review flood warning thresholds/trigger levels for Northampton in light of April 1998 flood event.
- 5) Complete planned improvements in riverflow gauging and river level monitoring facilities upstream of Northampton. Connect to Telemetry System.
- 6) Complete planned installation of river level telemetry in Northampton at Nunn's Mill and Bedford Road.
- 7) Implement improvements in the flow forecasting model for Northampton to ensure adequate forecast accuracy now that the calibration data is available for the Easter event.
- 8) Develop and implement improved flood warning system for Northampton, agree with Emergency Services and local representatives; include in Flood Warning Dissemination Plan and publicise.
- 9) Develop written operational agreements with Northampton BC, British Waterways and Anglian Water Services to clarify operational procedures and responsibilities for Northampton.
- 10) Review system of river patrols and field condition monitoring in Northampton and implement improvements.
- 11) Clarify major incident responsibilities for Northamptonshire Dissemination Plan area.
- 12) Liaise with residents affected by flooding in Northampton and consult on acceptable warning arrangements and publicity.
- 13) Review development control policy for Northampton.



KEY

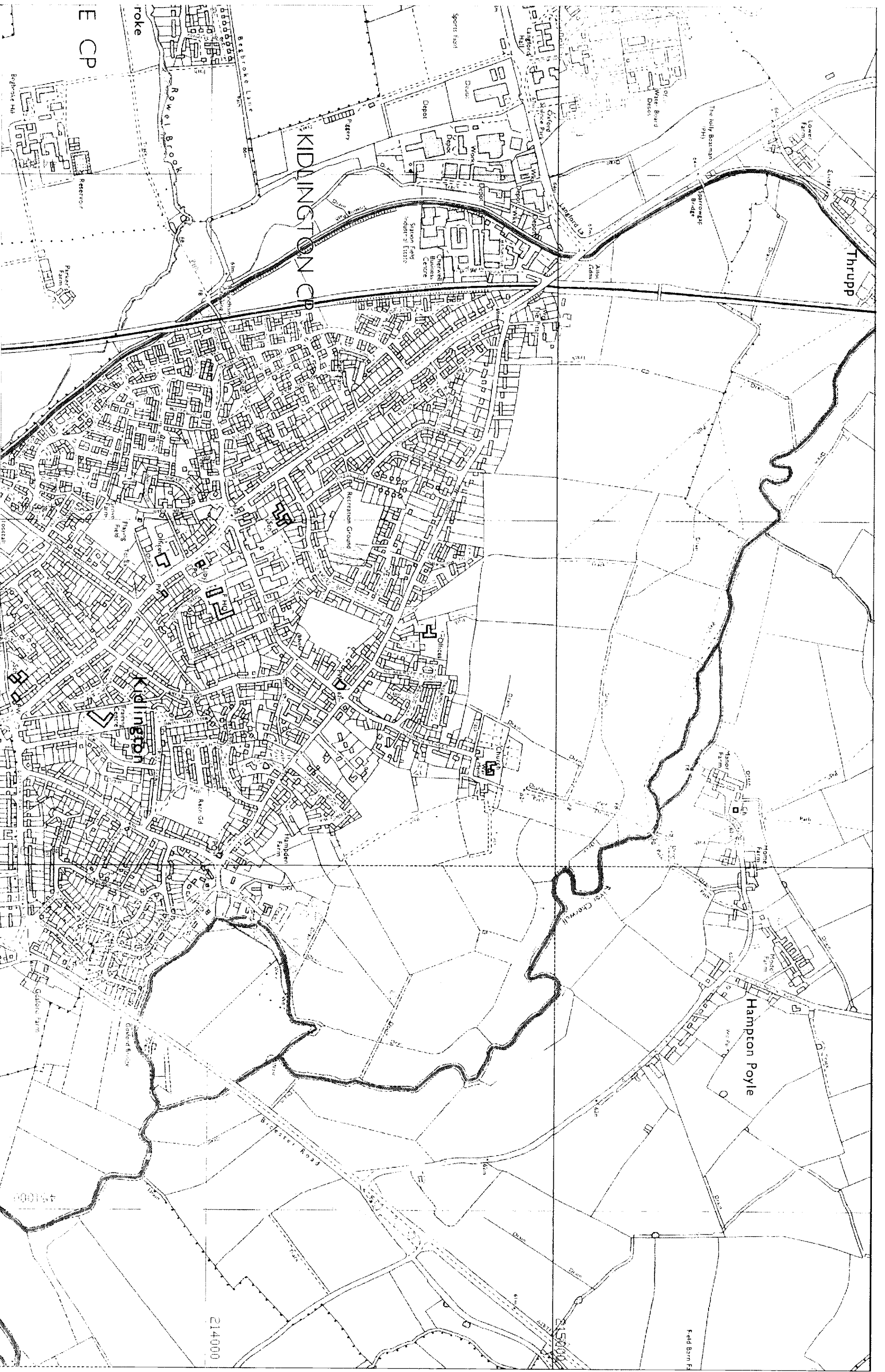
- Gauged catchment
- Ungauged subcatchment
- Input points for Nene model



 ENVIRONMENT AGENCY <small>(Anglian Region)</small>	ENVIRONMENT AGENCY (ANGLIAN REGION) INITIAL REPORT ON THE NORTHAMPTON FLOODS SCHEMATIC OF THE HYDROMETRIC SITES AND HYDROGRAPH INPUT POINTS FOR RIVER NENE MODEL	
	Date	May '98
Scale	as shown	Sir William Halcrow & Partners Ltd Consulting Engineers Peterscourt Peterborough PE1 1SA Tel. (01733) 554031 Fax. (01733) 566561
Figure No.	2.1	

Drawn by	NJA
Checked by	<i>[Signature]</i>
Approved by	<i>[Signature]</i>

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CONSULTING ENGINEERS



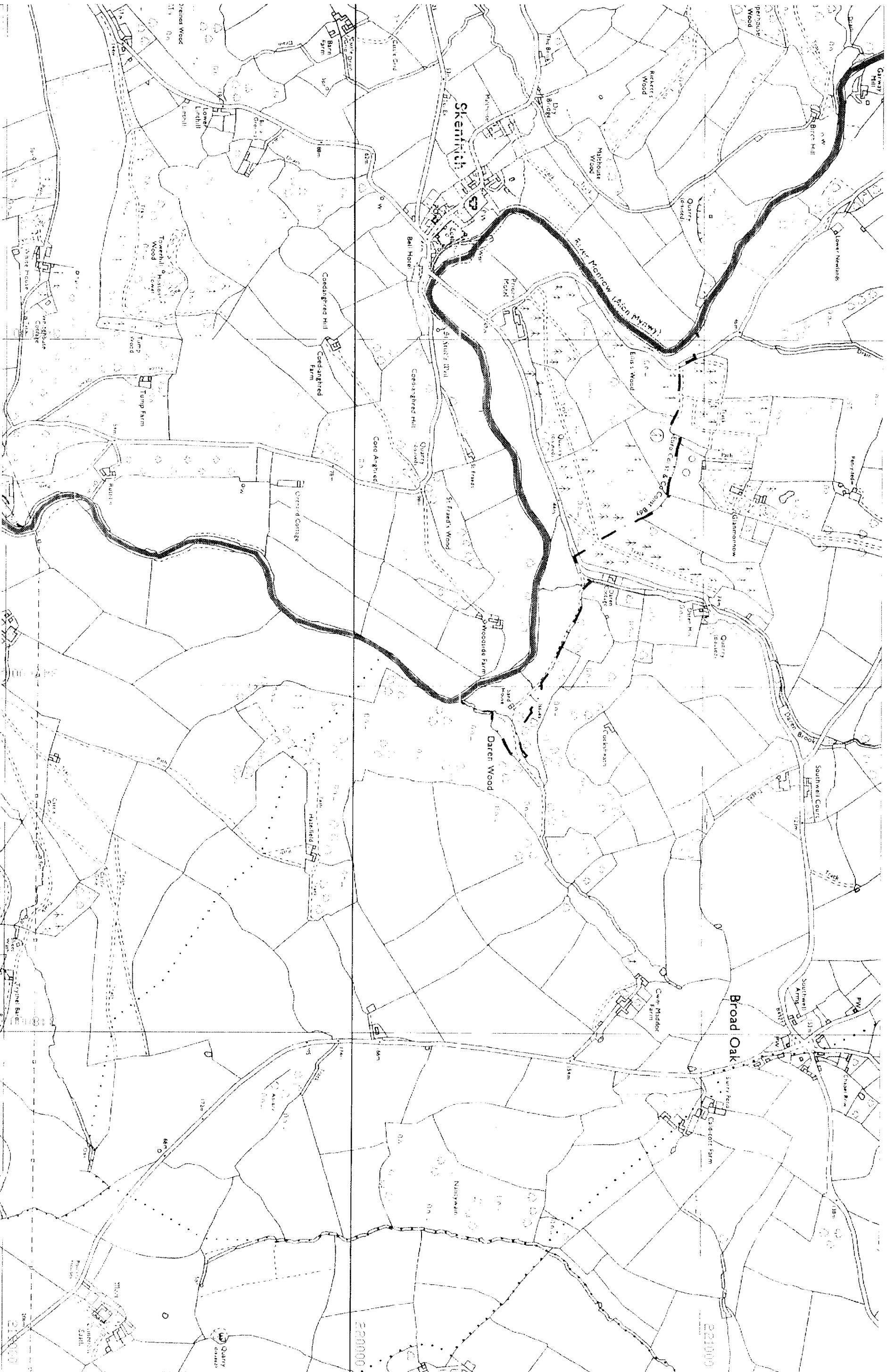
The flooded area has been recorded from the best available information. Where the edge of the floodplain is shown by a red line, this indicates that the limit is not certain.

SCALE 1:10000

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INDEPENDENT REVIEW OF EASTER FLOODS 1998
THAMES REGION SPECIAL STUDY SITE - KIDLINGTON

SEPTEMBER 1998



The flooded area has been recorded from the best available information. Where the edge of the floodplain is shown by a red line, this indicates that the limit is not certain.

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SEPTEMBER 1998

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2.2 LEAMINGTON SPA, WARWICKSHIRE (MIDLANDS REGION)

Background

Leamington Spa is a large town in Warwickshire, lying immediately to the east of Warwick, in the area of Warwick District Council. The town is situated on both banks of the River Leam immediately upstream of its confluence with the River Avon. Both are designated as Main River at this point.

There are seven bridge crossings of the Leam within the town. Working upstream they are as follows: Prince's Bridge (unclassified road), the Leamington-Coventry railway line, Adelaide Bridge (A452), York Bridge, Victoria Bridge (B4087), Mill Bridge and Willes Bridge (B4099). In addition, there are two weirs, one immediately downstream of Prince's Bridge and the other immediately downstream of Mill Bridge. A section of the Grand Union Canal also passes through the town to the South of the river.

The catchment of the River Leam, one of the principal tributaries of the River Avon, is mainly agricultural and has an area of 364km². The source of the Leam is at Hellidon, Northamptonshire, whence it flows first in a northerly direction and then in a westerly direction through mainly layers of Keuper Marl and Lower Lias as far as Leamington. The Leam is classified as Main River from the Avon confluence as far as Grandborough, a distance of 39km. The principal tributaries of the Leam are the River Itchen, River Stowe, Millholme Brook and Rains Brook.

The River Leam is used extensively for public water supply for Warwickshire. The flow regime is affected by these abstractions into the pumped storage reservoir at Draycote Water and Willes Meadow Reservoir at Leamington. The latter, which is located upstream of the town centre, restricts the width of the natural floodplain at that point. Floodplain flows to the south of this reservoir are constricted by the reservoir embankment and the boundary wall at the rear of properties in Leam Terrace. This wall partially collapsed under the pressure of the flood water during the flood event.

Historic flood records, principally levels but also extents of flooding, have formed the basis for most flood defence work in the catchment. To this end the Agency has records of flood levels on the Leam from July 1968. Other major floods occurred in January 1992, September 1992 and March 1975. On the basis of this record (excluding 1998) the floodplain through Leamington was defined, the vast majority of which is open space.

Recent work, commenced in late 1997, indicates that greater floods than July 1968 occurred in 1875, May 1932, October 1939 and March 1947.

In terms of development there have been no major works in recent years. Since 1981 the Agency and its predecessors have been consulted on 37 planning applications in Leamington. None have been objected to on flooding grounds. The applications have tended to be for renovations and small extensions. The waterfront is a conservation area with the buildings listed and hence there have been limited opportunities for development. Little development has occurred in the areas perceived as floodplain.

The River Leam is in the Environment Agency's Section 105(2) floodplain mapping programme and contracts are currently ongoing. Immediately prior to Easter the Agency was in the process of developing a mathematical model of the River Leam, using Jeremy Benn Associates as consultants,

and this was close to completion. The model study was extended in order to take on board data from the Easter event and final results are expected shortly.

Flood Warning

The flood warning service is provided by Lower Severn Area, of the Environment Agency, Midlands Region. Reach A6 (River Leam), covers Leamington Spa and the River Leam upstream of the town.

River gauging stations are situated at Leamington and Eathorpe. Yellow, Amber and Red flood warnings are issued based upon levels at Eathorpe gauge, 12 km upstream of Leamington, as follows:

Yellow	1.50m (ALD) observed level
Amber	1.90m (ALD) forecast or observed level
Red	3.00m (ALD) forecast or observed level

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Agency's Area flood warning centre at Tewkesbury. There is currently only one warden (Warwick District Council) covering Leamington town centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low-pressure area moved along the south coast on Thursday April 9th causing rain to circulate from east to west across the catchment. The rain was held over the Avon catchment by this low-pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

There are two rain gauges which are used to provide flood warnings for the Leam catchment. Braunston in the Leam catchment recorded 44.0mm during the 24hour period from 7.00am on Thursday 9 April, while Knightcote, which is in the nearby Itchen catchment, recorded 67.5mm during the same 24hour period. In general, recorded rainfall totals for the month of April for the whole of the Avon catchment, including the Leam, were between two and three times the normal totals for April.

River levels on the Leam rose very rapidly from midday on Thursday 9 April. At Eathorpe gauge the river level rose approximately 2.2m in the 12hour period to midnight on Thursday 9 April, reaching a maximum level of 3.25mALD (59.95mAOD) at 15.00 hrs on Friday 10 April 1998.

At the Leamington gauge the river level rose approximately 2.4m in the 24hour period to midday on Friday 10 April; the gauge actually reached the top of its travel at 2.50mALD (48.80mAOD) at 06.30 hrs on Friday 10 April 1998. However, by measurement on site the maximum level reached was estimated to be 2.95mALD (47.25mAOD) at approximately 11.00am on Friday 10 April 1998. This coincided almost exactly with the time of the peak level on the Warwick gauge on the Avon.

In Leamington there were two distinct phases in the flooding that occurred. The heavy rainfall initially caused surface water flooding, with foul sewers and road drainage overflowing, which affected roads and basements during the day on Thursday 9 April. This flooding then began to abate during the early evening. At the same time levels on the Leam were rising, the result of which was a second, and vastly more serious bout of flooding during the early hours of Friday 10 April, with reports of property flooding beginning at around 4.00am.

Approximately 400 residential and commercial properties were affected, although only 14 properties were known to be at flood risk. The vast majority of these 400 properties in the older areas of Leamington had, up until the Easter event, been considered to be out of the floodplain. They were therefore not included in the warning system.

The peak river level achieved at the Leamington gauge was 49.26mAOD, the highest level since the Agency's records began in 1968 and believed to be the highest level since 1875. The return period of the flood event has been assessed as being in the range 120 to 175 years.

Emergency Response

From 7.00am on Thursday 9 April, the Environment Agency's Flow Forecasting System model was run every two hours during the flood. With each succeeding run the forecast lead time of levels being exceeded became more confident, until it was agreed between the forecasting and warning duty officers that the appropriate warning should be issued.

All three flood warnings for the Leam were issued during Thursday 9 April based on the Eathorpe gauge as follows:

Yellow at 3.54pm	Eathorpe threshold exceeded at 4.00pm
Amber at 5.02pm	Eathorpe threshold exceeded at 5.15pm
Red at 11.18pm	Eathorpe threshold exceeded at midnight

Unfortunately, the Amber and Red flood warnings to Warwick DC were not received. As flood warden for this reach, Warwick DC had to warn 9 properties in Leamington which had been identified as requiring flood warnings. Investigations after the event revealed that the warnings had not been transmitted because of an administrative error relating to the pre-event programming of the Environment Agency's AVM equipment. At the public meeting held in Leamington on 24 April officers of Warwick DC stated that they were fully mobilised during the day on the Thursday dealing with flooding matters and could not have deployed any extra resources if the flood warnings had been received. Nevertheless, they may have made better use of the resources available if they had had better information on flood peaks and times.

Warwickshire Police received flood warnings issued by the Agency. The Police initiated contingency plans in response to the flooding during mid-afternoon of Thursday 9th April. By late afternoon, the Police were working closely with all other emergency services and Warwickshire County Council Emergency Planning Unit. This close liaison continued throughout the event. Since

Easter, the Warwickshire Police have advised the Agency that due to the nature of the event, their resources were deployed even prior to the Yellow warning for river flooding being received.

Flood patrols were instigated by the Environment Agency's in-house emergency workforce on 9th April, as levels rose. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

Possible Courses of Action

At present there are no flood defences at Leamington Spa. In view of the very large number of properties flooded, the issue of a flood alleviation scheme has been raised. A feasibility study into a possible scheme for the town has been initiated by the Environment Agency that will compare the costs/benefits and also take into account the amenity aspects of the river. The study will assess the impact on the flooding situation of existing bridge structures, Willes Meadow Reservoir and other historic developments. Options for possible flood alleviation works will then be developed.

The Agency understands that some residents of Leamington Spa have expressed the view that the construction of the M40 Motorway has worsened the flooding situation in the town. This view is not correct. The motorway passes well to the south of Leamington and there are no significant drainage discharges from the motorway to the River Leam or to the River Avon catchment upstream of Warwick.

The River Leam catchment is currently served by a flood warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is not available then these people will not receive direct warnings. The AVM is capable of warning all those at risk directly and recently has been enhanced to operate on an automatic cascade system. This opens up the options of direct AVM contact or AVM cascade to replace the current warden cascade system. There are however, many merits in retaining the involvement of wardens and a full review has been instigated to devise a system that maximises reliability and flexibility whilst still retaining local involvement. Whilst this investigation proceeds, an interim flood warning measure is being planned for Leamington utilising the AVM. The final system may well be a different arrangement (e.g. audible alarms).

The local authorities and emergency services were previously warned by a cascade system operating through the county police to the other emergency services and county council and on to the district councils. By agreement since Easter, all of these are now warned directly by the AVM system.

In respect of the 'missing message' to Warwick DC, a full audit of the AVM system has been undertaken. This looked at every message and recipient on the system across the Region and checked that all individuals and organisations currently being offered the warning service are programmed to receive the appropriate messages. This revised audit system will also ensure that any future changes made are fully checked.



The flooded area has been recorded from the best available information. Where the edge of the floodplain is shown by a red line, this indicates that the limit is not certain.

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INDEPENDENT REVIEW OF EASTER FLOODS 1998 ANGLIAN REGION SPECIAL STUDY SITE - NORTHAMPTON

SEPTEMBER 1998

2.3 KIDLINGTON (THAMES REGION)

Background

Description of the catchment's geography

The Cherwell catchment covers an area of 906 km² and has a population of approximately 137,000. Whilst the catchment lies largely within Oxfordshire, it also extends into Buckinghamshire to the east and Warwickshire and Northamptonshire to the north. The major urban areas include Banbury, Bicester, Kidlington and parts of Oxford.

The catchment extends southwards from the headwaters of the river at Charwelton in Northamptonshire to its confluence with the River Thames at New Hinksey, Oxford.

The Cherwell is a predominantly clay-based catchment, the headwaters of which are found on the Lower Lias clay to the north of Banbury. The flow in the River Cherwell in this upper part of the catchment is derived mainly from drainage of the clays and from springs. Further south the flow in the river is increased by springs issuing from the Inferior Oolite, which is exposed in the valley sides. The river then flows over the Inferior Oolite and Great Oolite limestones, with groundwater from these aquifers contributing to the base flow of the river.

Within the catchment, there are a number of small reservoirs at Wormleighton, Boddington and Clattercote which provide water for the Oxfordshire Canal. In addition there is a raw water storage reservoir at Grimsbury, owned by Thames Water Utilities Limited (TWUL) and used for public water supply.

The River Cherwell and the Oxford Canal

The Oxford canal shares the same valley as the river Cherwell and for much of its length runs parallel to the river, actually crossing one another at the same level at Nell Bridge and occupying the same channel for the 1.5 km between Enslow and Shipton-on-Cherwell.

When the River Cherwell and the Oxford canal reach the north of Kidlington, they move away from each other with the canal passing to the west of Kidlington and the River Cherwell to the east.

The canal continues south to the western side of Oxford and terminates at Hythe Bridge Street in the city centre. The River Cherwell passes to the east of Oxford where the channel divides in two at Christ Church Meadow and then both channels flow into the River Thames.

To the north of Oxford, the Oxford Canal connects with the River Thames via two watercourses: the Duke's Cut with the Duke's Lock on the canal as its upstream limit and Kings Lock on the River Thames is its downstream limit; and at Isis Lock on the canal, close to Hythe Bridge via the Rewley Abbey Stream, which passes to the north of Oxford Station.

The River Cherwell's Tributaries

As the River Cherwell drains southwards, tributaries include Ashby Brook, Highfurlong Brook, Hanwell Brook, Farthinghoe Stream, Sor Brook, Charlton Brook, River Swere and Deddington Brook, and River Ray. Shortly before the Thames confluence, the Bayswater Brook flows into the Main River Cherwell.

The Bloxham Brook flows into the Sor Brook at Adderbury.

Catchment and Floodplain Development s

Large scale changes to the Cherwell Catchment

The Cherwell catchment that extends down to Kidlington drains an area of approximately 565 km².

Information based on changes recorded in the Ordnance Survey 1:10,000 and 1:25,000 maps shows that of the settlements where significant development has occurred, the approximate ground coverage of those settlements has risen from 7.1 km² to 18.7 km².

This is equivalent to an additional 2% of the catchment that has either been made impermeable or is liable to have increased drainage rates due to surface water drainage networks. Nearly half of the increase is due to the development of Banbury.

There are limited available records to indicate what drainage systems were used in the older developments, however, it is unlikely that any would have had attenuation measures built in to them.

The distribution of settlements also appears to be fairly even across the catchment.

Other changes that are apparent over this time scale include:-

- Dismantling of numerous railways. This is only likely to have an effect on the hydraulics where bridges over river crossings have been removed. These may have pooled up water behind them where the capacity was insufficient and so provided attenuation storage. In other cases where embankments were removed, this could increase capacity and so lose the benefits of storage.
- Large industrial estates have been established, such as at Chipping Warden (here the industrial development equalled in area the development of the town since 1949) Grimsbury Industrial Estate and Hardwick Industrial Estate. These are liable to have greater percentages of impermeable cover than the residential developments.
- A number of lakes have been created, the major ones indicated amount to an additional 3 hectares of storage.

- Some minor woodlands appear to have been lost, e.g. at Bodicote, Willifer Covet, however, their loss has been compensated for by the apparent expansion of Tackley Wood from 55 hectares to 72 hectares.
- Quarries have continued to be abandoned after 1950. However, there are new works including the expansion of the Limestone Quarry at Shipton-on-Cherwell from a coverage of 11 hectares to 49 hectares, including the associated works areas.
- The construction of the M40, completed in 1992. This motorway has added about 2.5 km² to the impermeable area of the catchment, and has increased development pressure by making the area more accessible from London and Birmingham.

In Kidlington, there has been very little development in the area shown as liable to flooding on the Agency's Section 24 flood plain maps.

Impact of changes in the catchment

Analysis of flood models and gauging station data indicate that the effects of development, on river flows and levels, are more apparent during floods of low magnitude than in a major flood as at Easter

In conclusion, the effect of changes in the Cherwell catchment, on the flood which affected Kidlington, are insignificant when related to the severity of the flood.

Flood Warning System

Monitoring/Detection

Catchment conditions in the Cherwell and Ray are monitored with the aid of 9 remotely monitored river level/flow gauges and 3 rain gauges. Alarm trigger points have been established at the river level sites and Flood Warning duty officers are alerted via the CASCADE computer system when they are exceeded. Data are retrieved every 15 minutes and plotted as hydrographs or hyetographs to aid monitoring.

Weather radar displays are available at 5 km and 2 km resolution giving instantaneous rainfall intensities.

Forecasting

The Nimrod and Hyrad quantitative rainfall forecasting systems give Flood Warning duty officers predictions of rainfall for the next 6 and 2 hours respectively, and the Met Office supplies Heavy Rainfall Warnings and 5-day weather forecasts. A flow-forecasting model has been developed for the gauging sites at Banbury and Enslow but this is not operationally available, a higher priority being the Flood Warning Dissemination project which required the same resources. There are plans to implement a real-time flow forecasting capability in the Region.

Dissemination

The flood warning dissemination arrangements for the Cherwell and Ray catchments are set out in the Flood Warning Dissemination Plan for Oxfordshire. Colour-coded flood warnings are issued by fax to the Oxfordshire Fire Service which then notifies the Local Authorities, the Police and Rescue services. Utility companies, the Met Office and media outlets are warned direct. The general public is alerted via the media – such as ‘Teletext’ - and the Floodcall service.

There is an Agency Flood Warning five year plan whereby it is intended to set up direct warning arrangements for high-risk properties in the catchment via flood wardens or an Automatic Voice Messaging (AVM) system.

The Flood Risk Identified Prior to Easter and Reasons for Assuming Low Vulnerability to Flooding

Flood risk areas for all catchments in the Thames Region are set out in the Flood Warning Reach system, which lists properties and roads considered to be particularly vulnerable to river flooding. Properties are ranked in three categories, from Category 1 that includes those at highest risk, to Category 3 at lower risk. The details in the Reach System are intended to give an indication of areas and properties at **most** risk of flooding, and they have been forwarded to the Local Authorities, Police and Agency staff to enable them to target their resources more effectively during times of flooding.

The information in this system has been gathered from many sources, both within the Agency and from external bodies, using records extending back to 1965, and is used to prioritise those properties that will be offered a direct flood warning service. However, as policy has been to rely upon recorded flood events, hypothetical possibilities derived from models have not been used.

The Region's policy is to provide a direct flood warning service for 'high risk' properties. Properties not at high risk are informed via information leaflets, and advised to check ‘Teletext’, the media, or to use the Agency’s ‘Floodcall’ telephone service.

High risk properties include only Manor Farm, Church Lane, Kidlington, for the Flood Warning Reach System section dedicated to the lower reaches of the Cherwell river.

Other areas identified as ‘at risk’ include Cherwell Avenue and Queens Avenue, and there is anecdotal evidence that they may have flooded in the past. There is no detail on that flooding and no specific properties are identified. Flood warning leaflets would not have been distributed to these areas.

Operation of the Flood Warning System at Easter

Flood Warnings for Cherwell were issued in accordance with the Agency's systems – the only property identified as at 'high risk' received a direct warning via Agency Operations staff. A further eight properties received direct warnings even though these were not identified as 'high risk' properties prior to the Easter event. as did another eight thought to be at high risk.

Cherwell Avenue and Queens Avenue are noted in Agency documents as having flooded in 1992. As such, these areas were deemed 'at risk'. Flood warning leaflets would not have been distributed to these areas, as no specific properties were identified.

There is no evidence of Agency, Local Authority or Emergency Services staff actively considering whether property in these streets were particularly vulnerable on Good Friday, April 10th 1998.

It is evident that the Agency's Flood Warning section was concentrating on issuing warnings, and possible effects at Oxford and on the Thames. The Operations group was engaged in managing Flood Monitoring and having confirmed the situation and heard that a major flood wave was progressing downstream, were working to predict the potential effects.

It appears that, although faxes were recorded as sent, some intended recipients could not trace their receipt.

A Yellow flood warning for the whole Cherwell catchment was issued at 10.30 hrs on the 9th April, escalating on this reach to Amber at 22.30 hrs then Red at 14.45 hrs on the 10th.

Issue Of Warnings and Their Value

Flood forecasting and warning systems work on the principle of reducing flood losses through remedial action by residents and businesses prior to a flood. When the Environment Agency took over the role of warning dissemination from the police in September 1996, it not only set about improving and extending its ability to provide information to other organisations, but also to the public, businesses and utilities in the flood plain. It embarked on a 5-year project to develop new dissemination arrangements on two broad fronts; by developing a comprehensive broadcast warning service using a range of media outlets; and by using improved 'alert' schemes to directly warn those at **most** risk of flooding. The agreed strategy in the Thames Region is to offer a direct warning service to high risk properties as identified in the Flood Warning Reach System using 'alert' techniques such as flood wardens and AVM recorded warning messages.

In low risk areas other warning techniques would be adopted such as media warnings (using a range of different outlets including, local radio, Teletext, Met Office weather forecasts, AA Roadwatch, etc.), loud-hailers on vehicles and possibly sirens. These approaches would be complemented by the provision of up-to-date public information on the Floodcall service.

In the Cherwell and Ray catchments properties identified in the Reach System would be offered a direct warning service during the 5-year programme: residual areas shown on the Section 24 maps at low risk would receive warnings via the media.

In addition to the flood warnings issued by the Thames Regional Flood Warning group, Agency staff visited at least nine low - lying properties where flooding was considered likely and gave direct warnings to the residents.

Emergency Response Procedures

These procedures require the establishment of an Area Incident Room during major incidents for the co-ordination of all Agency emergency response activities. They also require frequent reports to the Agency's Head Office; provide guidance on liaison with other Agency and non Agency groups; and set out a framework for training staff in the use of the emergency procedures, among others.

The West Area of Thames Region operates a 'two tier' standby system, whereby routine calls are handled by a 'duty officer' outside office hours. A more senior member of staff - a 'duty co-ordinator' - is also available, who is delegated the authority to mobilise extra resources and open an incident room if the occasion warrants.

Operation of the Procedures at Easter

As is normal practice, the event was managed from the Operations Team's office at Wallingford during office hours on Thursday, April 9th. After hours, incident management then reverted to the duty officer on call working from home.

That evening, as events became more serious, the duty officer and duty co-ordinator consulted flood warning and operations staff, and called out staff to inspect conditions early Good Friday morning.

On Good Friday, on recognising the severity of the flood, the duty co-ordinator opened the Area Incident Room at 07.55hrs.

Agency Operations staff were in contact with the Emergency Services and Local Authorities throughout the day, and attempted to predict the outcome of the flood, as it proceeded downstream, using 1:50,000 Ordnance Survey maps.

Key Area staff, who had been trained in the use of the procedures, responded as required during the flood at Kidlington, but resources would have been stretched had the event affected more of the Area or Region or had been of greater duration.

It was evident that there had to be more use of staff familiar with the procedures in order to respond with confidence to a major and extended flood.

Capital Programme for Flood Warning and Flood Defence

West Area Operational Water Level Information (WAOLI)

For the Cherwell catchment, data from flow recorders on the Sor Brook at Bodicote, on the Cherwell at Banbury, Enslow and Oxford, and on the river Ray at Grendon-Underwood and Islip together with rain gauges at Byfield and Grimsbury are currently available via telemetry. However, this information is being enhanced by the installation of nine new flood warning sites which have been identified as critical locations and the installation of water level monitoring outstations including civil infrastructure, instrumentation and communication interfaces have been designed. *It should be noted that only one of these sites is located in the area affected by the Easter Flood.*

Flood warning improvements

Provision is made for extending and improving the warning service across the region in the capital programme. Budgets cover weather radar enhancements, back-up facilities for key computer systems, and extensions to the telemetry network (including river level and raingauges). A review of telemetry requirements for flood warning purposes has recently been completed for all catchments in the region.

As there are no plans in the current capital programme to carry out any improvements in the areas affected by the Easter floods, consultants have been engaged to undertake post flood event feasibility studies in relation to Kidlington, Banbury, Islip and Adderbury, which are all located within the Cherwell catchment. Their efforts will initially be focused on the Kidlington site, and an initial report is expected by the end of August 1998. It is intended to append these reports when available.

Flooding Mechanisms

Both during and following the thirty-six hours of rain when around 75 mm of rain fell over the Cherwell catchment, water levels rose rapidly in and around the Kidlington area, with unconfirmed reports of a tidal type surge of water flowing down the river and across fields.

Levels rose reaching a bank full situation, whereby water flowed over both banks, upstream and downstream of Gosford Bridge on the old A43. During flood monitoring, water levels were observed close to the top of the bridge arches, with approximately a 100 mm differential between the upstream and downstream levels.

It is believed that the residential properties, outbuildings and garages affected were inundated with flood water from two locations on the River Cherwell, namely from the right bank (looking downstream) close to Gosford bridge and from the area around the Mill located further upstream. Water levels in some properties rose to around 600 mm above ground floor level.

As the flooding occurred rapidly, and during the night, a more detailed account of the way in which the flooding developed is not possible. Residents who volunteered information stated their amazement as to the speed in which the water level rose. From such information and the Agency's post-event surveys, it is now apparent that water levels rose to 300mm above the soffit of Gosford bridge.

Flood Hydrograph Characteristics and Probability Assessments

Peak rate and other characteristics of the hydrograph

CHERWELL PEAKS APRIL 1998		
Site	Peak Flow - Cumec	Peak Level Local -
Cherwell at Banbury	90.8 (+/- 15 cumec?)	2.75m at 0300 on 10th
Sor Brook at Bodicote	16.6 (peak level estimated)	1.30 at 2015 on 9th
Cherwell at Enslow	103.2 (+/- 20 cumec?)	2.10 at 2045 on 10th
Ray at Islip	21.96 on 13 th (may have been bypassed)	9.30 at 0545 on 11th
Cherwell at Oxford	97.3 on 11 th (based on current meter gauging upstream)	8.44 at 1730 on 12th

The table shows the estimated peak flows and the times of the peaks at the five gauging stations in the Cherwell catchment. The precision of the flow estimates is not matched by their accuracy. None of the gauges was without problems in the 1998 flood. Levels at Banbury and Bodicote rose so high that the water level recorder floats jammed on the instrument benches, so the peaks had to be estimated; Enslow is badly bypassed even in small floods, and flow estimates above about 20 cumec cannot be relied on; and the two ultrasonic gauges at Islip and Oxford gave very erratic flow measurements during the event, and both may have been bypassed. The flows in the table are the best estimates that can be made using the extension of ratings and current meter gauging data and any other information currently available.

Only the Banbury and Enslow gauges have long records. Both started operation in the mid 1960s. The Easter flood is by far the biggest event recorded at both stations. The previous highest recorded level at Banbury was 1.72 m. In Easter it was 2.75m. At Enslow the gauge weirs are situated at an old mill site in a channel perched above the flood plain. In previous floods the gauges have recorded the flow left in the channel after water has spilled out of the channel upstream, resulting in a very flat hydrograph. In the Easter flood so much water was in the floodplain that the level rose above the perched channel, and the gauging station recorded a level of 2.1 m. The previous highest level recorded was 1.23m in December 1979.

The level at Enslow appeared to rise rapidly in the Easter flood, but, because there are no records of the levels in the floodplain in previous events, there is nothing to compare it to. However the time between the flood peak at Banbury and the peak at Enslow was shorter than it was in the 1992 event only 18 hours rather than about 24 hours in 1992. The rate of rise at Banbury was much greater than in 1992.

Estimated Probability of Recurrence

The estimation of the probability of an event being equalled or exceeded depends on having records of past events over a period that can be considered typical of the conditions that are likely to exist in the future. The estimation of the probability of an extreme event being equalled or exceeded, that is well outside the range of events previously measured in detail, is an inexact calculation, made worse by the common usage of return periods to express the result. A return period gives an unwarranted impression of accuracy and precision. The difference between a probability of 2% and 1% seems hardly worth worrying about, but expressed as a return periods of 50 years and 100 years, the difference seems enormous.

Rainfall return periods are easy to estimate using Met Office depth-duration -frequency statistics for the area concerned. The maximum return periods for rainfall recorded in the upper Cherwell catchment was between 20 and 50 years for durations of 12 to 48 hours. However rainfall return period does not necessarily correspond to the return period of the resultant flow or flood level because the catchment wetness and other factors will have a great influence on runoff.

Flows at gauging stations with a long accurate record are the best source of information for the estimation of the return period of a flood, since flows are less likely to be influenced than flood levels by local changes to the channel or flood plain. Even then the estimation of the probability of an event that is far larger than anything previously accurately recorded is problematical.

Banbury is the only station with a long and reasonably accurate record that valid statistical analysis can be carried out on. The peak flow at Banbury has been assessed at 91 cumec by creating a rating from the current meter gaugings that have been carried out (including the one carried out after the flood peak at around 2m, when 56 cumec was gauged). This estimate is subject to reassessment when more peak level data becomes available. However, the flow and level were clearly far above anything else recorded since the station opened in the mid 1960s, and frequency analysis, including comparison with Flood Studies Report regional growth curves, indicates a return period of over 100 years.

Modelling has been carried out in Banbury, and comparison of the estimated peak with the modelled design flows at the gauging station indicate a return period well in excess of 100 years (although it must be remembered that the models have been calibrated using available data, which does not include events of this magnitude). However the modelled 100 year flood map agrees well with the observed flood extent, perhaps as a result of the flood having reached the edge of the flood plain.

There are photos showing the flooding of 1947 of Banbury station and the Spiceball area indicating a flood of similar magnitude only 50 years ago. There are also historic records of very heavy rainfall on the upper Cherwell causing flooding in Oxford and destruction along the way, such as in May 1663 and 1682. If a better estimate of the return period is required then it may be worth doing a search of historic records. Where data are available, such as at Days Weir on the Thames, the 1947 event, by far the biggest since that date, can be shown to be only the 5th highest since 1809, giving it a return period of only 40 years. It is possible therefore that the event may not be quite so extreme as it appears at first sight.

Further downstream the indications from available data are that the flood return period was around 100 years. The level at Enslow was far in excess of anything else in the previous 33 years, and a resident said his father had not seen anything like it in 60 years. At Oxford 97 cumec was gauged at Marston Ferry Lane near the peak of the flood, which is slightly higher than the modelled 100

year peak (although again it must be remembered that the hydrological model was calibrated using limited hydrometric data). If it was decided to try and improve the return period estimate by the examination of historic records, then there are likely to be more available in Oxford than for sites further upstream. However, it may be difficult to distinguish between Cherwell and Thames floods.

In summary therefore this event was extremely exceptional when compared to anything else in the last 30 years, and indications are that it will have around a one percent chance of being equalled or exceeded in any year. However 30 years is not a long time when considering rare events and there are indications that the Cherwell has produced some very big floods in the past, and maybe as recently as 1947, and further information on these might bring the return period estimate down.

Operation of Non - Agency Systems

There are eight side spilling weir gates on the Oxford canal which are operated by BW staff, six of which discharge into the river Cherwell. These enable BW to regulate levels in the canal system, and provide a route for excess water – which can enter from the river system – to return to the river. If not operated correctly, there can be a dangerous risk of the canal breaching with catastrophic consequences. These weirs are located as follows:-

- i) Wormleighton Reservoir (2 locations) - both discharge into High Furlong Brook.
- ii) Cropredy Mill.
- iii) South Banbury downstream of M40 bridge.
- iv) Kings Sutton 1/4 mile south of railway station.
- v) Upper Heyford 50 yards north of the lock.
- vi) Lower Heyford near the church.
- vii) Thrupp.

All of the above weirs were opened during the Easter Flood event by BW staff commencing at 08.00 hrs on Thursday 9th April with the last weir at Thrupp being opened at 10.00 hrs on Friday 10th April. There does not appear to be an operating agreement between BW and the Agency or its predecessors, nor was there any consultation with Agency staff prior to their operation. However, bearing in mind the severity of the event and the small size of these gates, the impact is considered to have been minimal upon the River Cherwell.

There is also a separate 'floodgate' at Shipton Bridge, which prevents flow along the canal affecting that village. The operation of this gate is detailed more fully in the case study into flooding at Thrupp. The consequence of this gate being open or closed is felt to have no effect at Kidlington. In either position, flood waters would spill out of the canal and find their way back into the Cherwell system above Kidlington.

Extent of Inundation and Properties Flooded

Reference to the appendix map will show that the flood of Easter 1998 extended outside the recorded flood 'envelope' known to the Agency.

Survey data available, taken from observations and questionnaire results, indicate that 93 residential properties were subject to flooding indoors for at least 26 hours.

Preliminary assessments of flood damage from loss adjusters, based on 79 properties, implies that £500k of damage was sustained. This figure is expected to rise as more information is processed.

An Agency appointed consultant has prepared a preliminary economic analysis for a feasibility study which shows up to 280 properties affected in total with damage assessed at around £750k. This figure is based on a standard methodology developed by Middlesex University.

It is reasonable to conclude that the final damage figure for the Easter Flood will be within the range £500k to £750k at Kidlington.

Lessons Evident and Alternative Courses of Action

Specific to Kidlington:

Ensure those that may need access to flood data and information know where it is, what value it may add, and how to get hold of it during an emergency – *better use could have been made of the Flood Warning Reach System (which had been circulated to Local Authorities and Emergency Services). Closer reference to this is likely to have enabled earlier, and more specific, warnings to residents in Queens Avenue and Cherwell Avenue.*

Easter Floods Lessons Learned

Data Availability

There needs to be an improved understanding of areas at risk from flooding beyond both the “100 year” envelope and the limit of previous floods. *It was apparent that the Easter Floods were more extensive than directly experienced by all concerned; such knowledge at Easter would have resulted in a more effective flood warning, through better targeting of risk areas. Simple tools are available, such as the Institute of Hydrology indicative 100 Year flood maps, which – although dependent on a relatively ‘coarse’ model – could be extended to produce 500 year risk areas.*

The best available data should be used by those managing a flood and living in flood risk areas eg: ‘at risk’ property addresses; floodplain maps; operational databases; - *Agency operations staff relied upon basic Ordnance Survey information during the flood event in an attempt to predict the probable outcome of the flood, when better information was available; if this data – such as is available within the flood warning reach system and flood plain maps – had been referred to, it is likely that this would have enabled earlier, and more specific, issuing of warnings.*

Those managing a flood need to know what data is available, how to interpret it, and where to get hold of it. *It is evident that there are some sources of data within the Agency, which were either not known to staff, regarded as lacking in credibility, or were overlooked during the event owing to being ‘owned’ by another group. Had these data sources been cross referenced and accessible, this could have enabled an earlier, and more authoritative, issuing of warnings.*

The Agency requires better knowledge of components and systems that can affect flooding and to exercise better control over their maintenance and operation. *While the effect of the British Waterways canal floodgates and weirs apparently did not make matters worse, the Agency’s lack of awareness of the location and potential impact of these could have hampered the effectiveness of the Operational and Public Relations responses.*

More effort should be given to corroborating gauging station data with historical archives of events, such as newspaper articles, library records, parish council archives and making a link with the potential effects of flood damage. *There is a lack of confidence, and hence credibility, in determining flood return periods. These are normally based on statistical analyses of gauging station data, which are unable to produce definitive results. More confidence and cross referencing to actual history would have had the effect of enabling comparison with previous events, so allowing more confidence in predicting possible outcomes.*

The current Benefit/ Cost methodologies for justifying investment in flood defences, flood warning and maintenance activities, should be re-examined for appropriateness. *The Agency prioritises work on a benefit/ cost basis, and this has relied mainly upon flood modelling and economic criteria. The global costs of disruption to peoples’ lives, businesses and emergency measures are not fully quantified and should be explored further. This would ensure that sufficient priority is given to future studies into flooding at areas known to be at risk.*

Local knowledge within and outside the Agency has a bigger part to play in prioritisation – *there is a body of knowledge based on practical experience which could be better documented and co-ordinated, and has been relatively untapped during prioritisation and feasibility work, such as the experience of field officers and Development Control staff.*

Delivery Of Messages

Investigate how best to institute formal arrangements for disseminating flood warnings to areas at a low risk of flooding, such as the use of Parish Councils; via loud hailers on Agency or Emergency Services vehicles – *there is no agreed procedure as to how to achieve this. Given such an approach at Easter it is possible that some inhabitants in Islip and Kidlington may have been able to mitigate the effects of the flood through individual action.*

Consider the appropriateness of flood warning dissemination methods for different times of day i.e. daytime, night-time, weekends, holidays – *this event occurred on a Public Holiday weekend - it is likely that the recipients of warnings react differently according to the timing of issue of the warning.*

Forecasting

Ensure that introduction of flood forecasting models is accelerated, and publish the programme, priorities and costs of activities - *the Thames Region needs forecasting and prediction tools which are able to indicate the severity of an event at an early stage. Progress on forecasting models had been postponed as the resources were reallocated to work related to the Flood Warning Dissemination project.*

Institute thresholds/ trigger levels based on rainfall and river gauge data immediately – *this activity can be progressed given the data already available in the Agency. If trigger levels had been available based on this data, it is possible that an earlier indication of the unusual severity of the flood would have been recognised.*

Investigate how to provide guidance on reassessing flood risk *during* a flood event until forecasting models are available – *there is a short term need to provide guidance to those involved in managing floods, based on the experience of this event.*

Emergency Response Management

A need has been identified for an improved understanding between all agencies involved in flood management, including the media, by implementing a strategy of regular, multi-agency exercises - *all agencies should work closer together. Experience suggests this is best achieved by improving liaison and presence at major incident sites and at incident management control centres. The approach proposed would engender awareness of roles, responsibilities, tools available and limitations.*

Reinforce guidance for staff controlling the Agency's response, to stand back during an event and take a strategic view of issues, including the scale of the event and the associated management and publicity issues – *it was evident that, after the flood had passed, this element of incident management received less attention than warranted, leading to difficulties in responding to enquiries, and over involvement by individuals leading to stress.*

There is a need to review expertise, experience, training and the availability of staff for incident management at all levels in the Agency – *there is no doubt as to the competence and actions of those involved at Easter, however the Agency needs to ensure it has a pool of experienced, trained, senior staff available for managing serious incidents.*

Firmer guidance and training on individuals' roles in the Flood Warning, Operations, Agency Contractor and Flood Monitoring groups should be considered – *it was apparent that, despite training, there are improvements that can be made to the level of understanding and appreciation of individuals' responsibilities.*

Reconsider the coordination of incident management and how it is carried out – *at the peak of the Agency's emergency activity, there were the following centres each playing a role in managing the incident: The Regional Communications Centre; the Flood Warning/ River Control Room, both at Reading; the Area Incident Room at Wallingford and the Agency's Contractor Unit's Incident Room at Oxford. Staff worked from home and the office during the event.*

Guidance should be written for Agency staff as regards organisational responsibilities – *it is apparent Flood Warning staff concentrated on issuing warnings only, and assumed that the prediction of effects was an Operational role left to the Areas, once the Red warning had been issued; conversely the Area while actively engaged in the prediction of effects, regarded themselves as supplementing the efforts of the Flood Warning group.*

Public Awareness

There is a need to improve communications between the Agency and the public at risk through a clear understanding of individuals' needs – *it is clear that the Agency has developed policies and strategies related to guidance provided by MAFF, and so has discharged its duties in the strict sense. However, this guidance does not address the lack of awareness of the Public of the effects of flooding generally, nor the social needs of those at risk.*

Provide better practical guidance to those in flood risk areas on action to take when warnings are in force, including simple flood-proofing measures – *individuals are encouraged towards 'self help' but – without a full appreciation of the consequences of a flood – would find it difficult to know what 'self help' actions are most effective.*

Information provided through Teletext and other media needs better targeting and promotion – *it was evident that ITV Carlton displayed warnings for the Cherwell, whereas this catchment is in the reception area for ITV Central. Media outlets such as Teletext and local radio could have played a more effective part in alerting the Public to the impending flood, and a renewed effort may encourage a more positive approach by some elements of the media.*

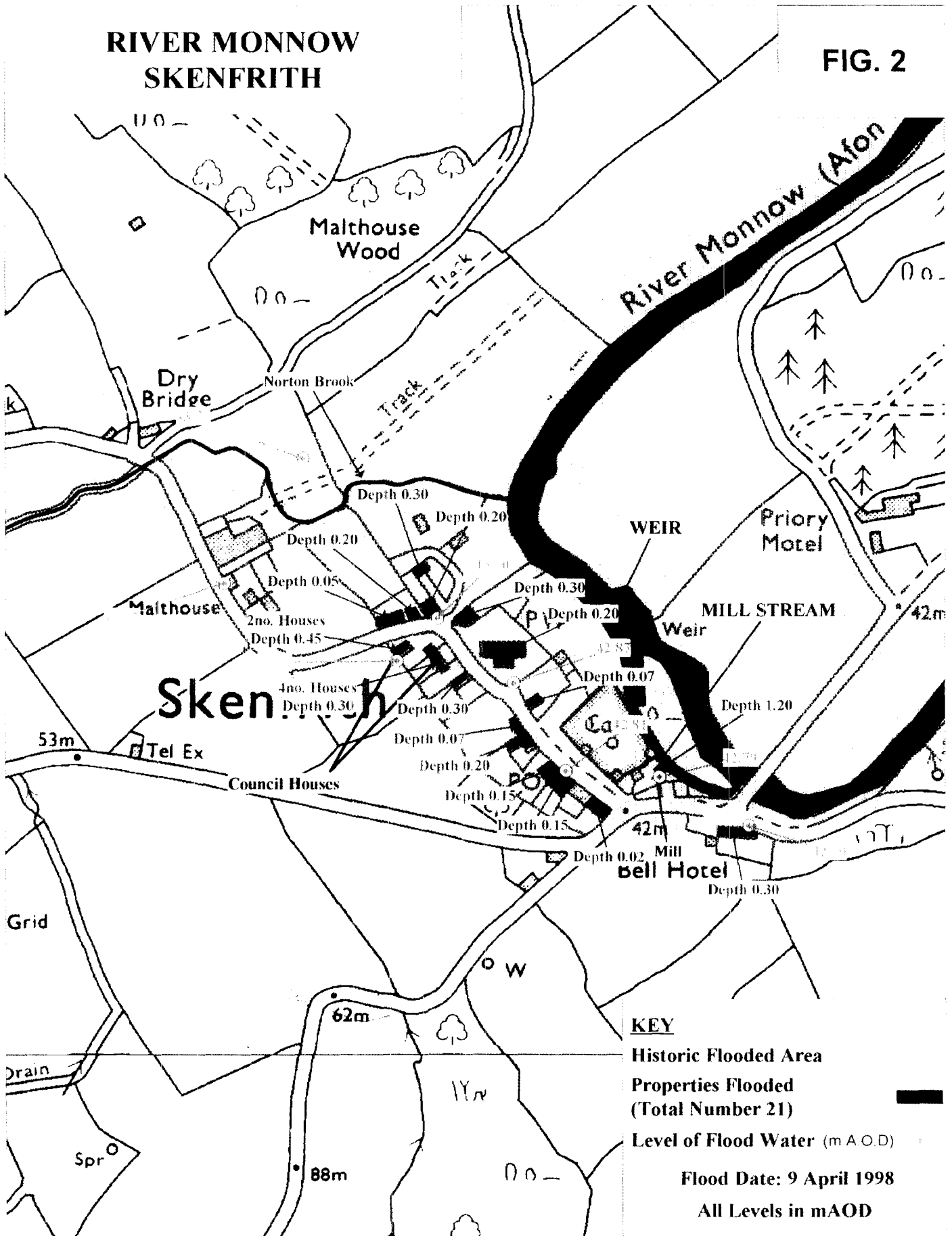
Set, publish and monitor Flood Warning, and Emergency Response standards – *if carried out in consultation and agreement with the Public, the Regional Flood Defence Committee, MAFF, Local Authorities and the Emergency Services, there will be a better understanding of roles and responsibilities. There will also be an improvement in how the boundaries of knowledge and of technology affect the standards attainable.*

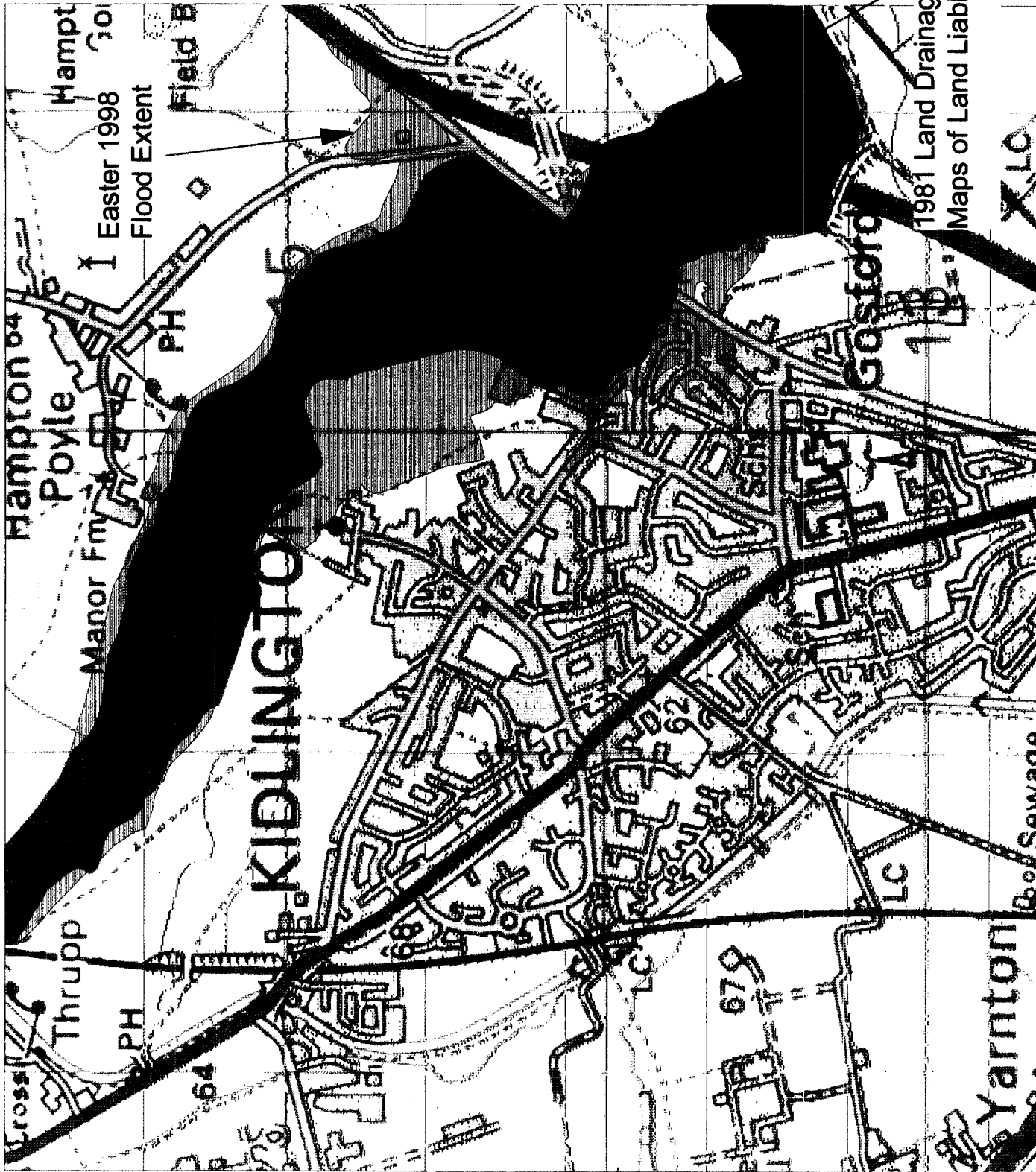
Resourcing

Review the resourcing needs for Flood Defence – *constraints on staff numbers and budgets may delay enhancements to the Flood Warning service.*

RIVER MONNOW SKENFRITH

FIG. 2





1981 Land Drainage Byelaw
Maps of Land Liable to Flood

2.4 SKENFRITH (ENVIRONMENT AGENCY WALES)

Background

Description of Area

The village of Skenfrith is located in the County of Monmouthshire and is situated on the Western bank of the River Monnow, a Main River, some 16 km upstream of its confluence with the River Wye at Monmouth. The village comprises some 25 residential properties, a village hall, public house and corn mill and is centred on its ancient Church and Castle which is owned by the National Trust. The majority of the buildings date back several centuries but recent development includes 6 council houses built in the village in 1952.

The catchment of the River Monnow is predominately rural in nature. In the upland areas above Pontrilas agriculture comprises mainly of grazing for sheep. This gradually changes to arable farming between Pontrilas and Skenfrith.

The major tributaries of the River Monnow are the Escley Brook, the River Honddu and the River Dore. The river rises in the Black Mountains at a level of some 650m AOD and falls to a level of about 43m AOD at Skenfrith an average gradient of 1 in 110. The river at Skenfrith in addition to being crossed by a mill weir, is also crossed a three arch stone bridge. The bridge carries the B4521 across the flood plain of the River Monnow which is at this location some 300 metres wide.

The area is within the boundary of the Lower Wye Internal Drainage Board. The drainage system in the village is extremely complex with flooding being influenced by a number of small watercourses in addition to the Monnow itself. These watercourses are:-

The Norton Brook

This watercourse which has a catchment of some 12.5km² discharges into the River Monnow within the confines of the village. The watercourse is regularly maintained by the lower Wye Internal Drainage Board.

The Mill Stream

The Mill Stream which powers the Corn Mill is designated as a Main River and is supplied with water by means of a 110m long weir which traverses the River Monnow opposite the castle.

Local Runoff

To the South West of the village lies Tower Hill from which during a time of heavy rainfall a number of small watercourses overflow into the village overloading the drainage system and causing flooding to a number of properties. Surface water from the high ground to the west of the village also generates flood flows which discharge along the road system through the village.

Brief Description Of Flooding

Mechanisms

As previously described, flooding of the village emanates from a number of sources, the River Monnow, the Norton Brook, from local runoff and the local drainage systems. There have been a number of recorded flooding incidents in the village and each event follows similar characteristics. Flooding generally commences from surface water discharging from the surrounding high ground onto the local roads to the inadequate drainage system in the village. This is followed by flooding from the Norton Brook, finally the River Monnow overtops its banks and further extends the flooding which by this time has already commenced. It is worth examining these separate flooding mechanisms in more detail.

Local Run-off

The rainfall which fell on the 9th of April generated very rapid and extreme run-off conditions. This was in part due to the antecedent catchment conditions indicated by reference to Lower Maescoed rainfall gauge where records show that 102% of the monthly rainfall fell in the first 7 days of April.

It should be noted that it was the persistence of the rainfall over a 12 hour period which caused the extreme run-off rates experienced. Reports throughout the catchment indicate that local run-off was even more extreme than indications derived from the Agency rain gauges although this could be caused by local variations in rainfall patterns throughout the catchment.

As with previous flood events at Skenfrith flooding commenced with flood water entering the village from local sources:

- 1 Surface water discharging directly into the village by means of the unclassified road from Norton
- 2 Runoff from Tower Hill which overtopped the inadequate drains of the Linthill Road. This run-off discharges into the village across the B4521 and floods the south side of the village which is served by a complex and poorly maintained system of local drainage ditches and culverts. Surface water which discharges from Tower Hill also directly flooded the Bell Hotel at about 15.30hrs
- 3 The drainage system within the village itself which is inadequate to discharge the surface water overflow from the surrounding land. Various modifications have taken place to this drainage system over the years but this system is overgrown and there are also reports of a collapse within the main culvert

Flooding from the Norton Brook

The Norton Brook is also a source of premature flooding. In a number of flood events flood water overtops the banks of the brook upstream of the village and flows into the village by way of the Norton Road. An example of this is shown in the photographs of the 1979 flood (Fig.5) where flood water from the Norton Brook is shown flowing down the road past Malthouse Farm. The Norton Brook also overtops its banks to the north of the village prior to the main flood occurring, primarily when the Norton Brook is backed up by the River Monnow.

Flooding From the River Monnow

This is the main source of flooding to the village. As the level of the river Monnow rises, the mill weir drowns out and the river eventually overtops its banks. During the flood of April 1998 which had a return period of approximately 1 in 20 years (refer section 6) the river Monnow peaked at the Corn Mill at 23.30hrs at a level of 42.79m AOD. The Mill itself which is generally some 1.5m lower than the other properties in the village floods from the River Monnow before any other properties. It has been determined by observations recorded during a previous flood which occurred on 29 January 1990 that flood water from the River Monnow starts to flood properties in the village when the level at the mill reaches 42.30m AOD. The precise time when this occurred on the 9th April is difficult to establish with accuracy as the village was by this time flooded by surface water. However, flooding of the Council Houses commenced between 18.30hrs and 19.00hrs from surface water and as flood waters from the River Monnow gradually overflowed into the village flooding of additional properties occurred.

In all 21 properties were flooded to various depths.

Flood Warnings

Flood Warnings were issued on 9th April 1998 for the River Monnow as follows:-

Yellow - 14.06hrs

Amber - 18.28hrs

Red - 19.12hrs

Historic Floods

There are a number of floods which are recorded in the Mill these are shown in Fig 6.

Recorded Floods

Date	Level (m AOD)	No. of Properties Flooded
1979	42.81	21
1998	42.71	21
1960	42.47	Unknown
1928	42.58	"
1992	42.58	14
1990	42.33	Threshold of Flooding

Not all of these properties will have flooded directly from the River Monnow and differing depths of flooding will have occurred depending on the coincidence of side stream and local flood waters with the Monnow Flood.

There are local reports that during the 1960 flood the causeway that carried the B4521 across the flood plain was raised. Flood waters which would previously have overflowed the road are now prevented from doing so. This effect if any can only be confirmed by detailed investigation.

Emergency Response

The SE Area does have a detailed emergency response plan which is primarily directed at ensuring that flood alleviation schemes and other assets are working satisfactorily. During the Easter floods the workforce were deployed over a wide area carrying out various operational duties.

Emergency response duties for the River Monnow were undertaken by the Environment Agency in the defended areas of Monmouth. Additionally bridges and structures throughout the Main River length are kept clear if it is possible and safe to do so during a flood.

The provision of sandbags for Skenfrith as well as the Forge Area of Monmouth is carried out by Monmouthshire County Council. Throughout the flood event the EA were in contact with the Assistant Director of Environmental Services (David Harris) regarding the developing situation. Mr. Harris was also in contact with the local residents and the Flood Warden from early afternoon, 15.00hrs and sandbags were delivered to the village between 17.00 and 18.00 hrs. Some difficulty was encountered due to the flooding of local roads which had made access to the village difficult.

In general the Agency enjoys a close relationship with the technical services department of Monmouthshire County Council and liaison and co-operation was good during the Easter Floods.

Possible Courses Of Action

The Wye Local Flood Defence Committee did consider provision of a scheme of improvement for Skenfrith following the floods of 1979 and 1992. Unfortunately a scheme of improvement could not at that time be economically justified the cost/benefit ratio being only about 0.5.

The LFDC have now, following the Easter Floods, engaged consultants WS Atkins to investigate the feasibility of providing a scheme of improvement works.

The village had been scheduled for improvement to the Flood Warning System as part of the 5 year plan. Improvements to the Flood Warning System for Skenfrith have now been advanced in the programme so that improvements can be implemented before the Winter flood season.

All residents of the village have been circulated details of the AVM service available. To date there have been 10 positive responses and these have been entered into the AVM dissemination system for these people to receive warnings direct.

Trigger levels for the issue of Red and Amber warnings have also been revised to ensure that the lead times for warnings are maximised.

The adequacy of the surface water drainage system is being investigated by Monmouth County Council who plan to undertake comprehensive maintenance works to the drainage system.

Flooded Properties

River Monnow at Skenfrith

		Threshold Level	Water Level	Depth
1.	Bell Inn	42.30m AOD	42.60m AOD	0.30m
2.	The Mill	41.56m AOD	42.76m AOD	1.20m
3.	Mill House	42.79m AOD	42.81m AOD	0.02m
4.	Old Post Office	42.76m AOD	42.92m AOD	0.16m
5.	Moat House	42.70m AOD	42.86m AOD	0.16m
6.	The Old Shop & Studio	42.76m AOD	42.84m AOD	0.07m
7.	Sarn Cottage	42.68m AOD	42.76m AOD	0.07m
8.	Sarn House	42.86m AOD	43.06m AOD	0.20m
9.	Ty-Eglwys	42.88m AOD	43.18m AOD	0.30m
10.	Church	42.78m AOD	42.99m AOD	0.20m
11.	Monnow Villa	43.01m AOD	43.30m AOD	0.30m
12.	(a) 1 Orchard Close	42.97m AOD	43.27m AOD	0.30m
	(b) 2 Orchard Close	42.92m AOD	43.24m AOD	0.30m
	(c) 3 Orchard Close	42.90m AOD	43.20m AOD	0.30m
	(d) 4 Orchard Close	42.90m AOD	43.20m AOD	0.30m
13.	Skenfrith Parish Hall	43.00m AOD	43.21m AOD	0.20m
14.	(a) 5 Orchard Close	42.88m AOD	43.34m AOD	0.45m
	(b) 6 Orchard Close	42.91m AOD	43.32m AOD	0.45m
15.	Melrose	43.12m AOD	43.44m AOD	0.30m
16.	Glebe Cottage	42.95m AOD	43.16m AOD	0.20m
17.	Old Vicarage	43.11m AOD	43.16m AOD	0.05m

Hydrological Summary

The first week of April saw persistent heavy rainfall across much of South East Wales. Many locations received more than the average rainfall for April in just the first seven days. Therefore, by the start of the second week of April the catchments were saturated.

During Wednesday 8th April a low pressure area moved south across the UK. Associated with this were two fronts, one to the north of the low's centre moving southwards and an occluded cold front wrapped around the centre moving northwards. By Thursday this had become an intense, slow moving frontal zone. As it moved northwards, widespread thunderstorms broke out ahead of it from the Welsh borders eastwards. Continuous heavy rain was reported further west.

Locally, the rain fell predominantly in an east-west band across the Wye catchment with the heaviest falls occurring over the Black Mountains (134 mm at Blaen-Bwch over the 48 hour period 8th to 9th April). The bulk of the rainfall occurred over a 10 to 12 hour period, starting about 6 am on Thursday morning. Peak rates of 8 to 9 mm per hour showed the rainfall to be "heavy" not "torrential" but that there was a longer period of moderate rainfall. To the north and south the rainfall was considerably less.

Estimates of the return period of the rainfall were made using the method recommended in the Flood Studies Report. The critical storm duration was found to be around 24 hours and had a return period of about 30 years. Totals recorded over shorter durations were not found to be exceptional: for example the peak 5 hour rainfall had a return period of only 3.5 years. This storm event was classified as "noteworthy" by the Met. Office, rather than exceptional.

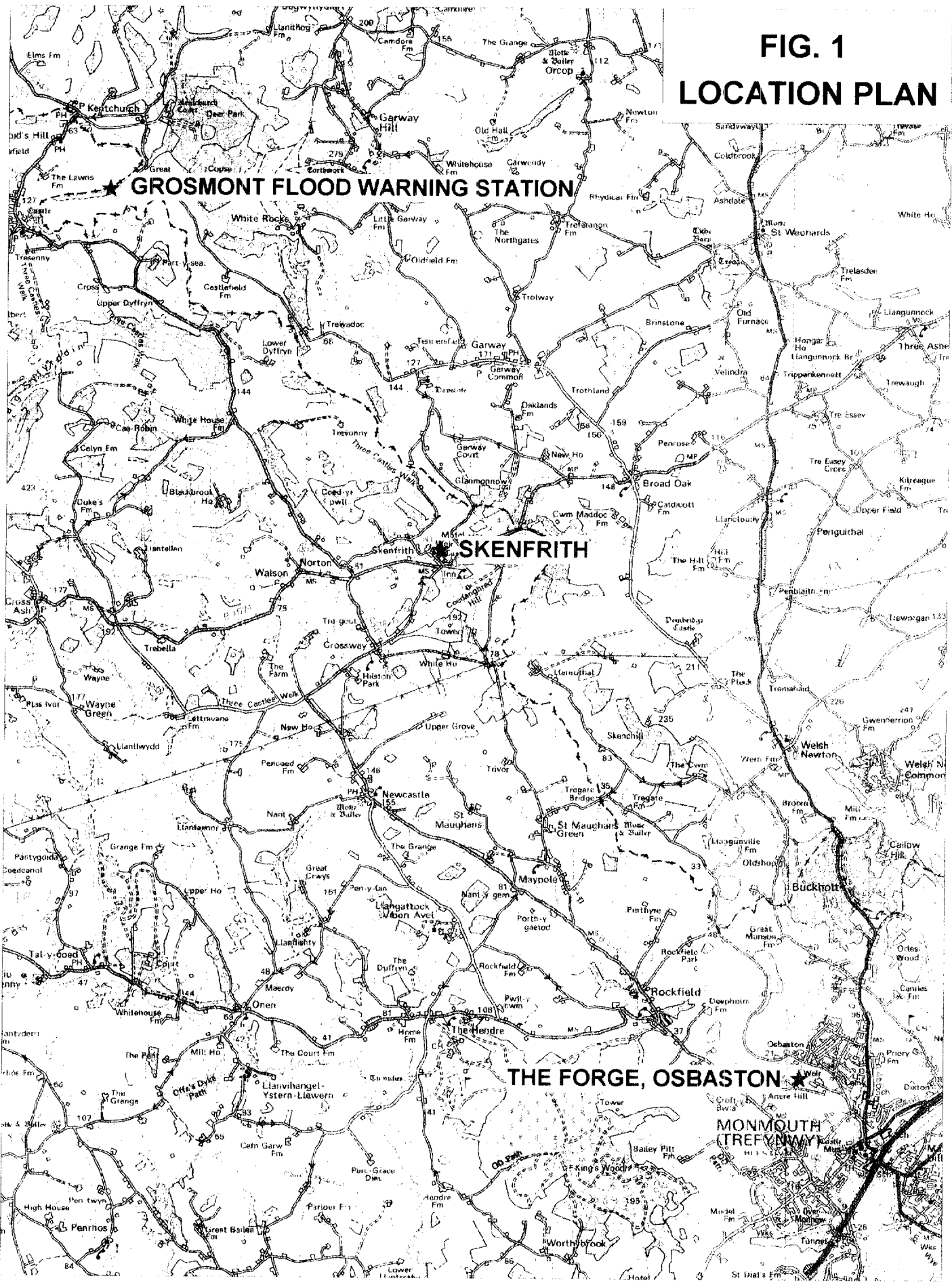
The combination of wet antecedent conditions and prolonged heavy rainfall resulted in a marked and rapid response from the River Monnow which drains much of the Black Mountains. A peak flow of 197.9 cumec was recorded at Grosmont gauging station at 19:00 hrs on the 9th, 18 hours after rainfall had started. This was the second highest flood in nearly 50 years of record dating back to 1949. Therefore, in terms of recent history it was a significant flood.

The hydrological severity of the flood over the longer term was assessed using flood frequency analyses recommended in the Flood Studies Report. These suggest that the Easter flood had a return period of around 20 years. This accords with the estimated rainfall return period of around 30 years (flood return periods are generally less than rainfall return periods). Furthermore, there have been four floods (1960, 1979, 1992 and 1998) of very similar magnitude within the last 49 years. It is unlikely, in only 49 years, that all four were high return period floods. Equally, in crude terms, four floods in a fifty year period suggests a return period of at least 12 years.

The hydrological severity of the flood at Skenfrith would be very similar to that at Grosmont (about 10 km upstream). Any effects of flood peak attenuation due to floodplain storage between Grosmont and Skenfrith would be compensated by the additional runoff entering the river between the two locations.

Therefore it is estimated that the Easter 1998 flood at Skenfrith had a return period of around 20 years and was only the second highest since 1949.

FIG. 1
LOCATION PLAN





Key:

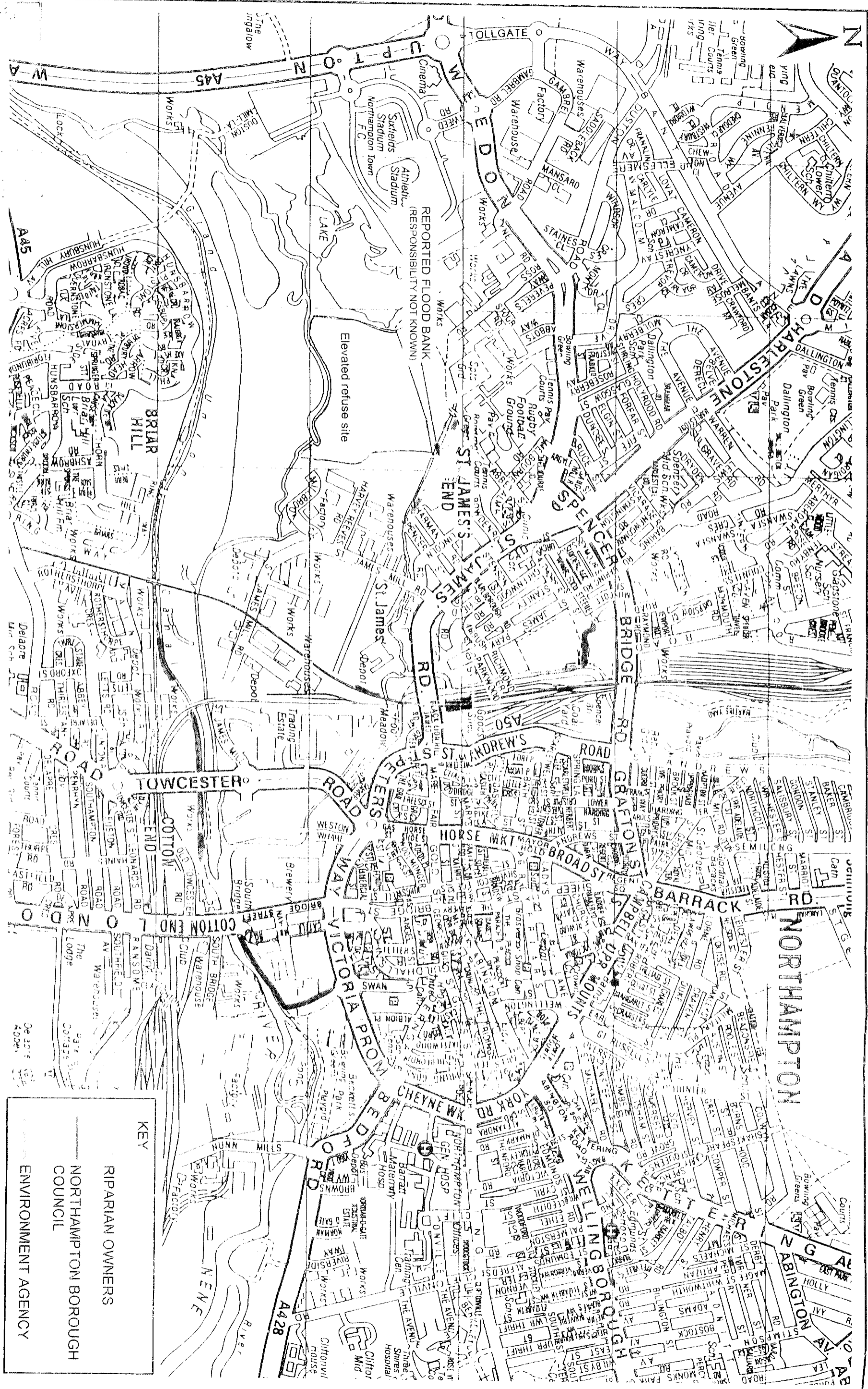
- Flooded Area
- Survey Flood Level + 58.60 m
- Direction of flood

Drawn by	NJA	Date	May 1998
Checked by	[Signature]	Scale	1:20000
Approved by	[Signature]	FIG NO	3.2

ENVIRONMENT AGENCY (ANGLIAN REGION)
INITIAL REPORT ON THE NORTHAMPTON FLOODS

EXTENT OF FLOODING

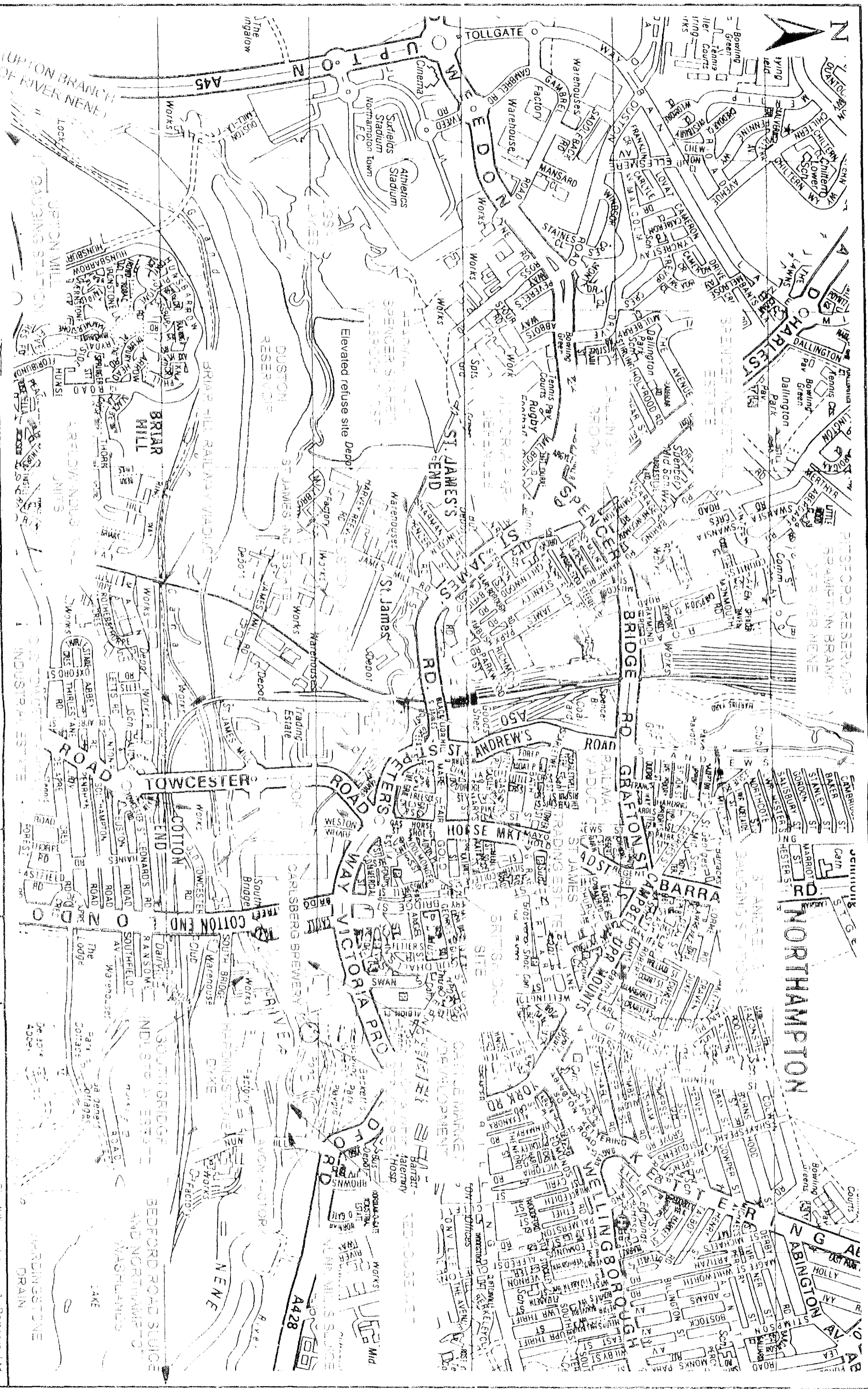
HALCROW	
Sir William Halcrow & Partners Ltd	Peterborough PE1 1SA
Tel. (01733) 554031	Fax. (01733) 566561



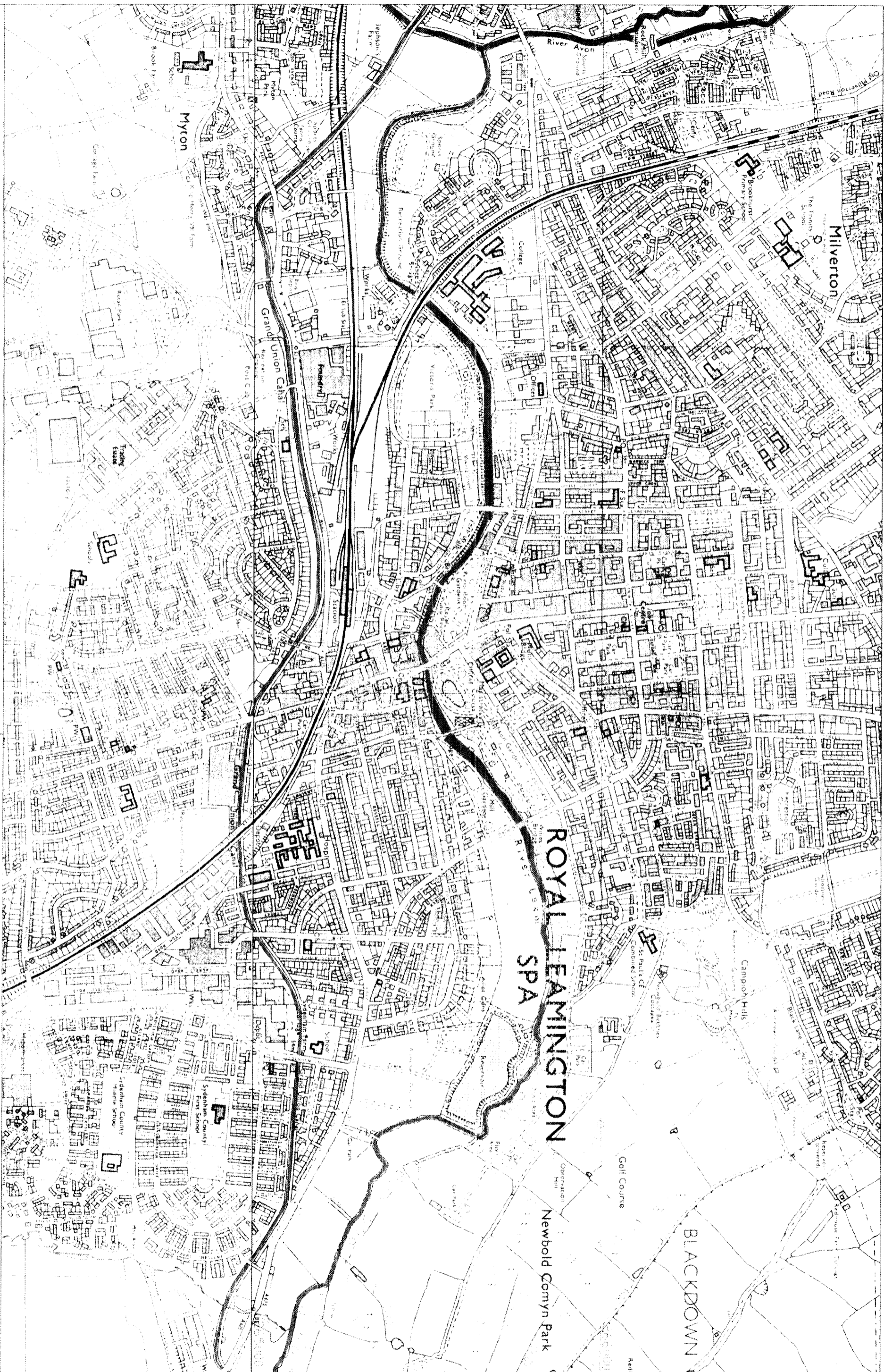
KEY

- RIPIARIAN OWNERS
- NORTHAMPTON BOROUGH COUNCIL
- ENVIRONMENT AGENCY

Drawn by	PRM		ENVIRONMENT AGENCY (ANGLIAN REGION) INITIAL REPORT ON THE NORTHAMPTON FLOODS	Date	MAY '98		HALCROW CONSULTING ENGINEERS 31 Millgate, Holwell & Partners Ltd Watlington, Oxfordshire Banbury OX15 4JG Tel: (01753) 554031 Fax: (01753) 556561
Checked by				FIG No	3.1		
Approved by		DEFENCE RESPONSIBILITY PLAN					



Drawn by	PPM		ENVIRONMENT AGENCY (ANGLIAN REGION) INITIAL REPORT ON THE NORTHAMPTON FLOODS LOCATION PLAN
Checked by			
Approved by			
Date	10/08		HALCROW CONSULTING ENGINEERS St William Halcrow & Partners Ltd Watlington Oxfordshire OX11 1SA Tel: (01235) 534031 Fax: (01753) 566561
Scale	N/S		
Fig No.	22		



The flooded area has been recorded from the best available information. Where the edge of the floodplain is shown by a red line, this indicates that the limit is not certain.

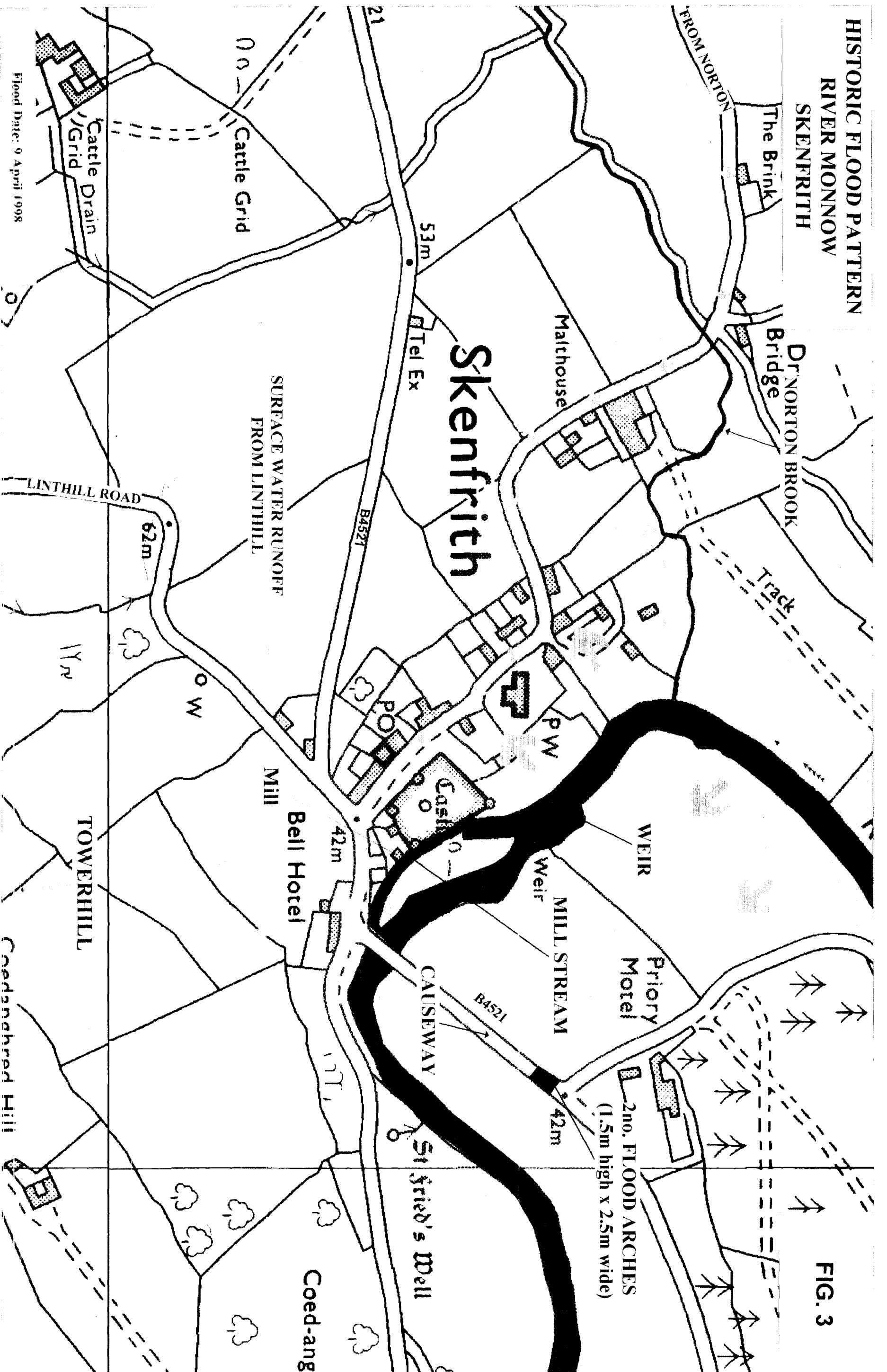
SCALE 1:10000

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**INDEPENDENT REVIEW OF EASTER FLOODS 1998
MIDLANDS REGION SPECIAL STUDY SITE - LEAMINGTON SPA**

SEPTEMBER 1998

**HISTORIC FLOOD PATTERN
RIVER MONNOW
SKENFRITH**



Flood Date: 9 April 1998

FIG. 3

FIG. 4

Prior Mote

SKENFRITH
SURFACE WATER DRAINAGE

Malthouse

Skenfrith

Tel Ex

Weir

BOX CULVERT
450mm x 375mm
(1)

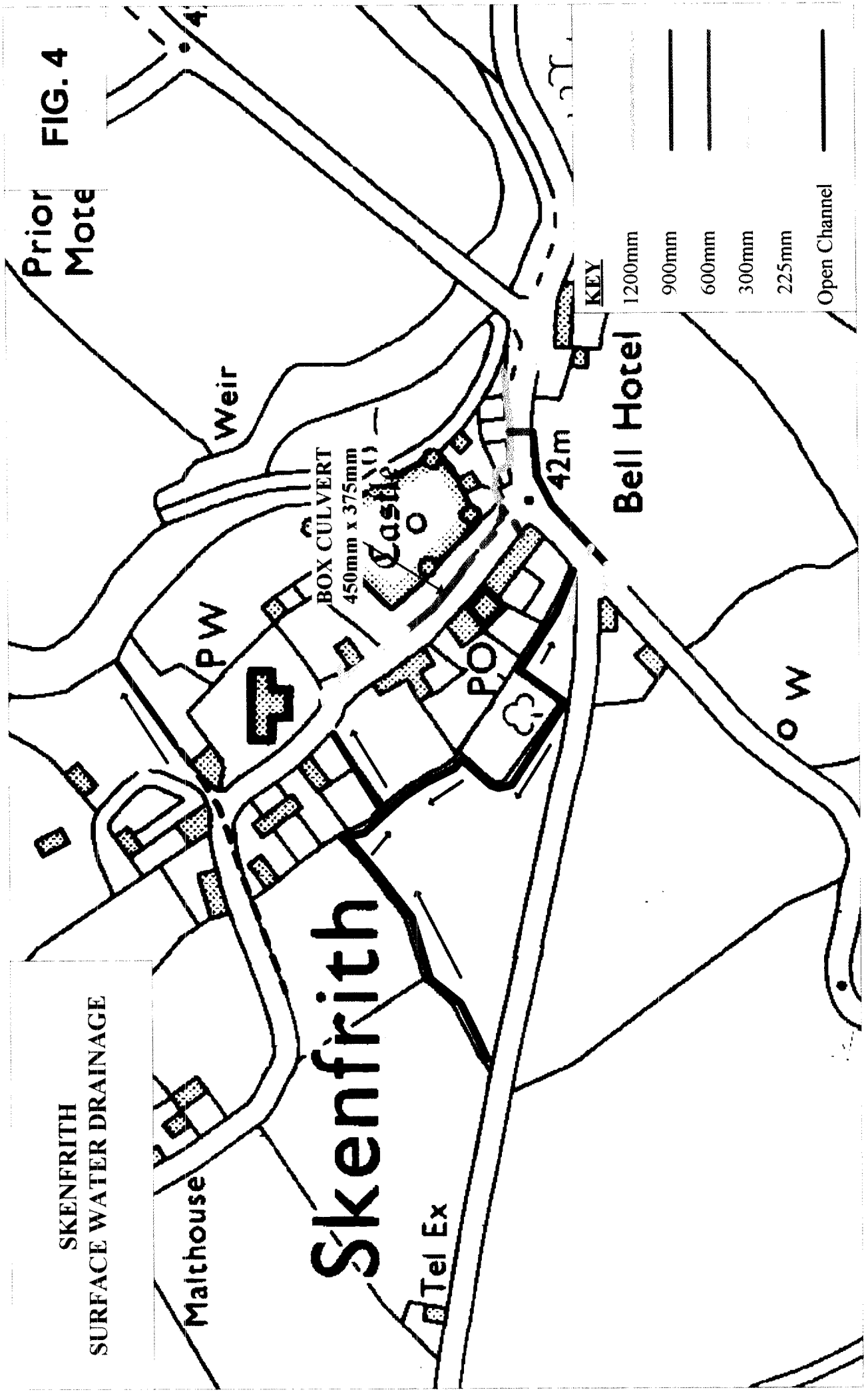
Castle

Bell Hotel

42m

KEY

- 1200mm
- 900mm
- 600mm
- 300mm
- 225mm
- Open Channel



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in original

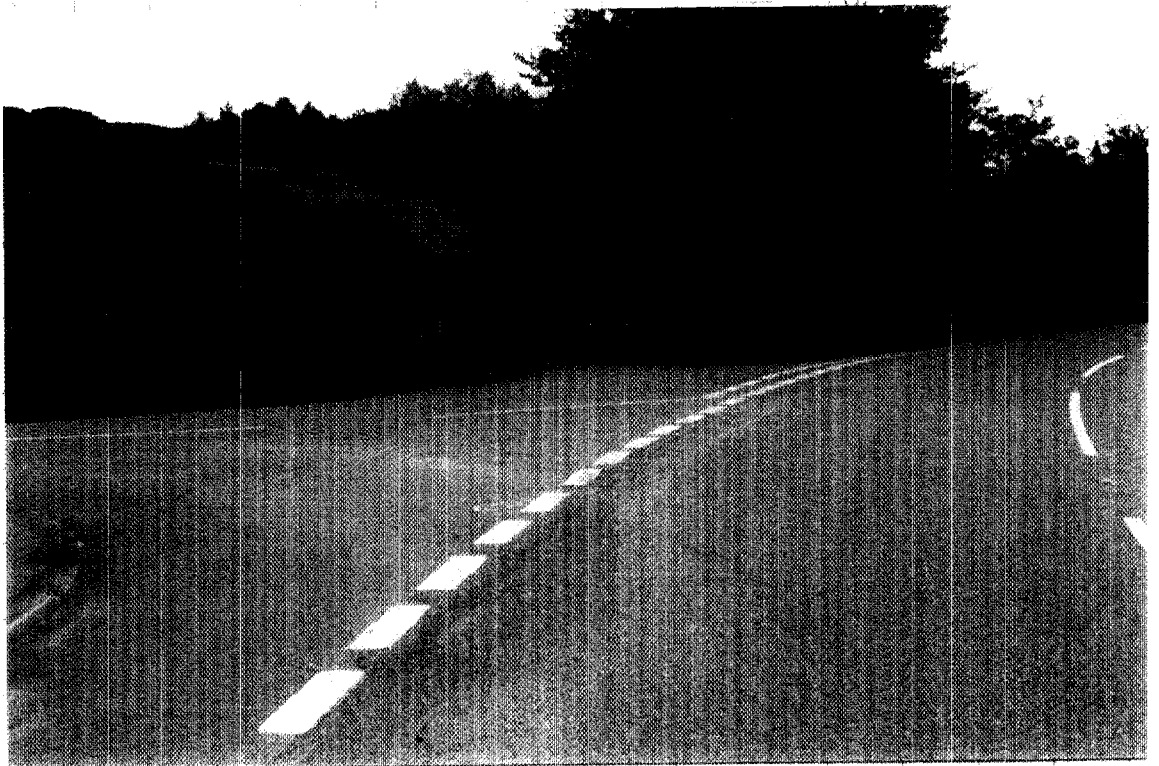
SKENFRITH

Fig 5



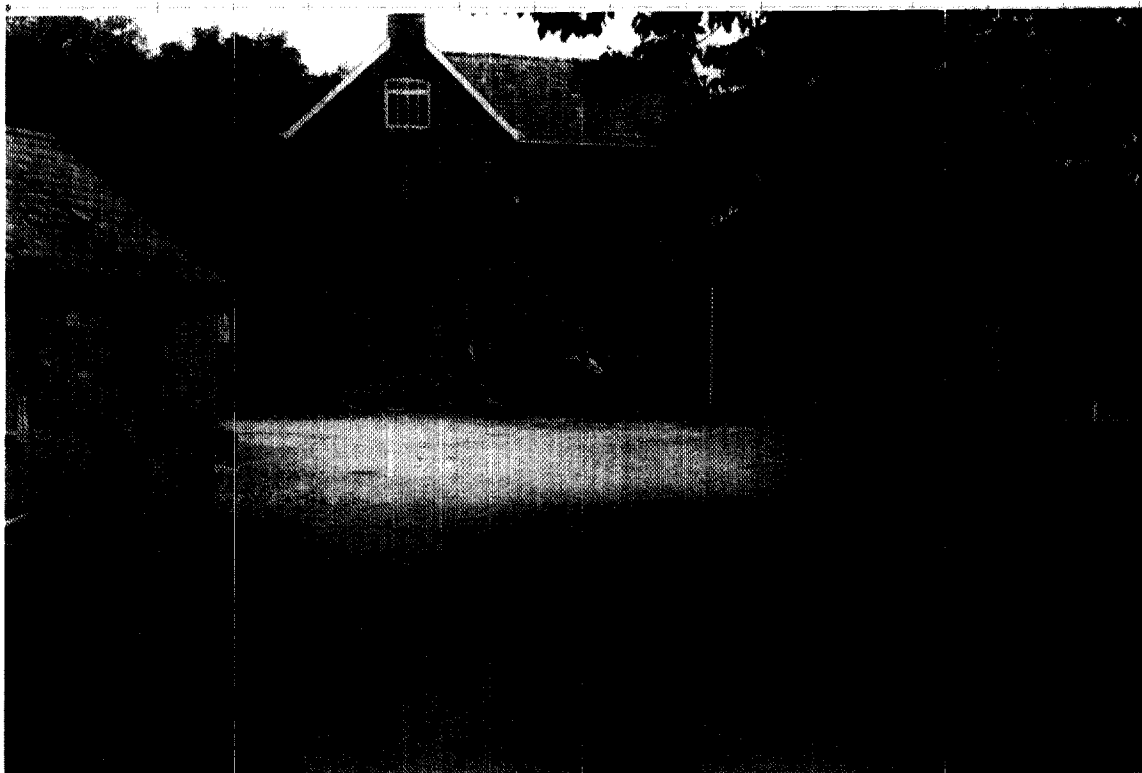
**DEC 1979 FLOOD
BELL HOTEL IN BACKGROUND**

SKENFRITH



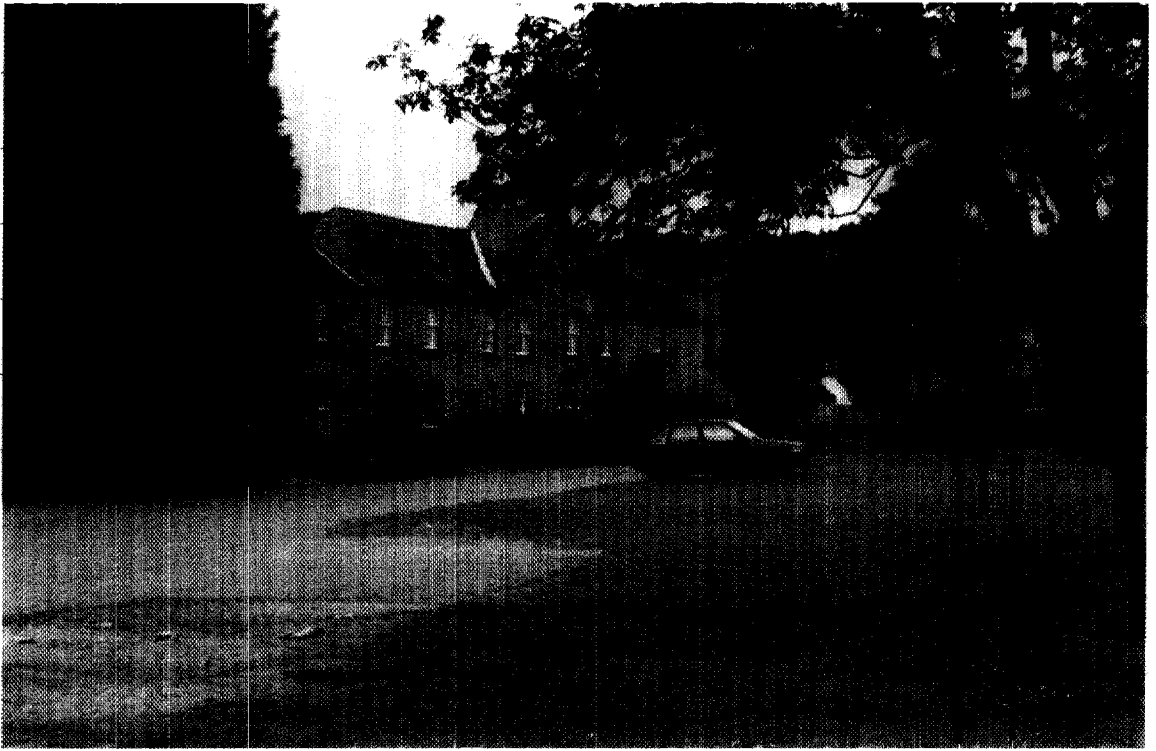
**DEC 1979 FLOOD
SKENFRITH MILL & CASTLE**

SKENFRITH



**DEC 1979 FLOOD
SKENFRITH MILL**

SKENFRITH



**DEC 1979 FLOOD
NW VIEW FROM CASTLE**

Road in front of Malt House Farm

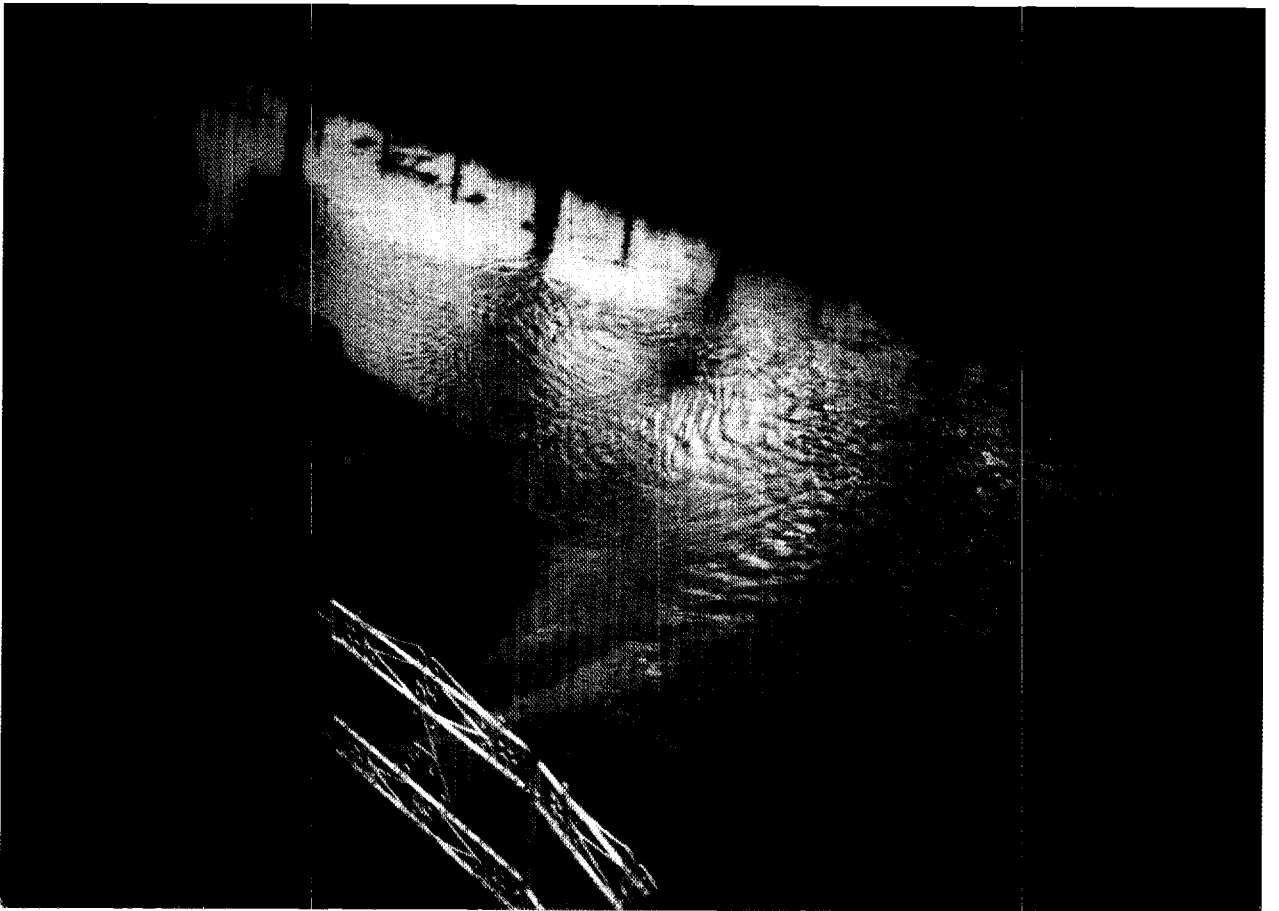
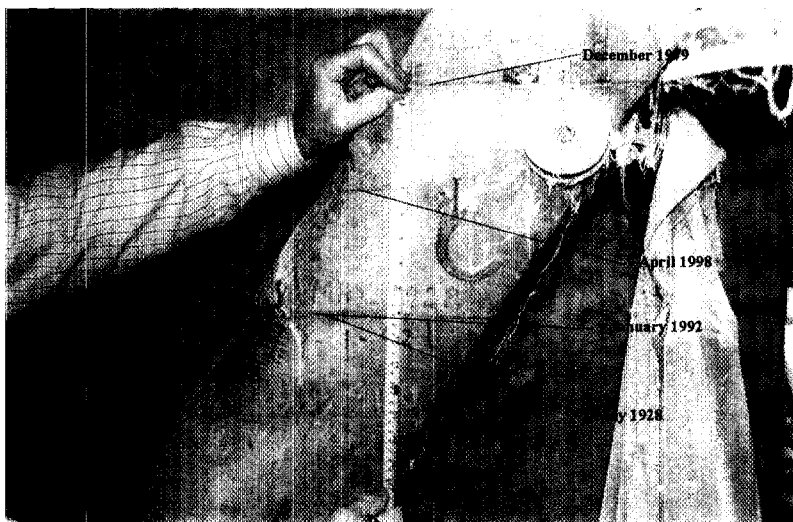
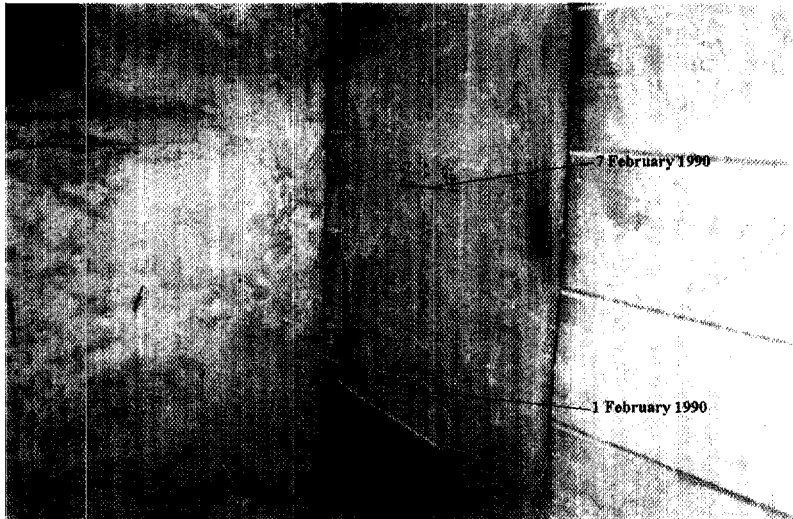
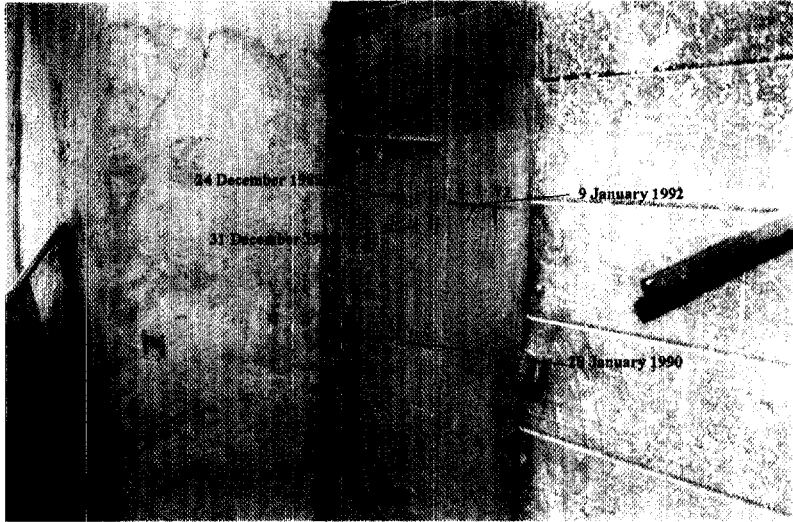


Fig 6

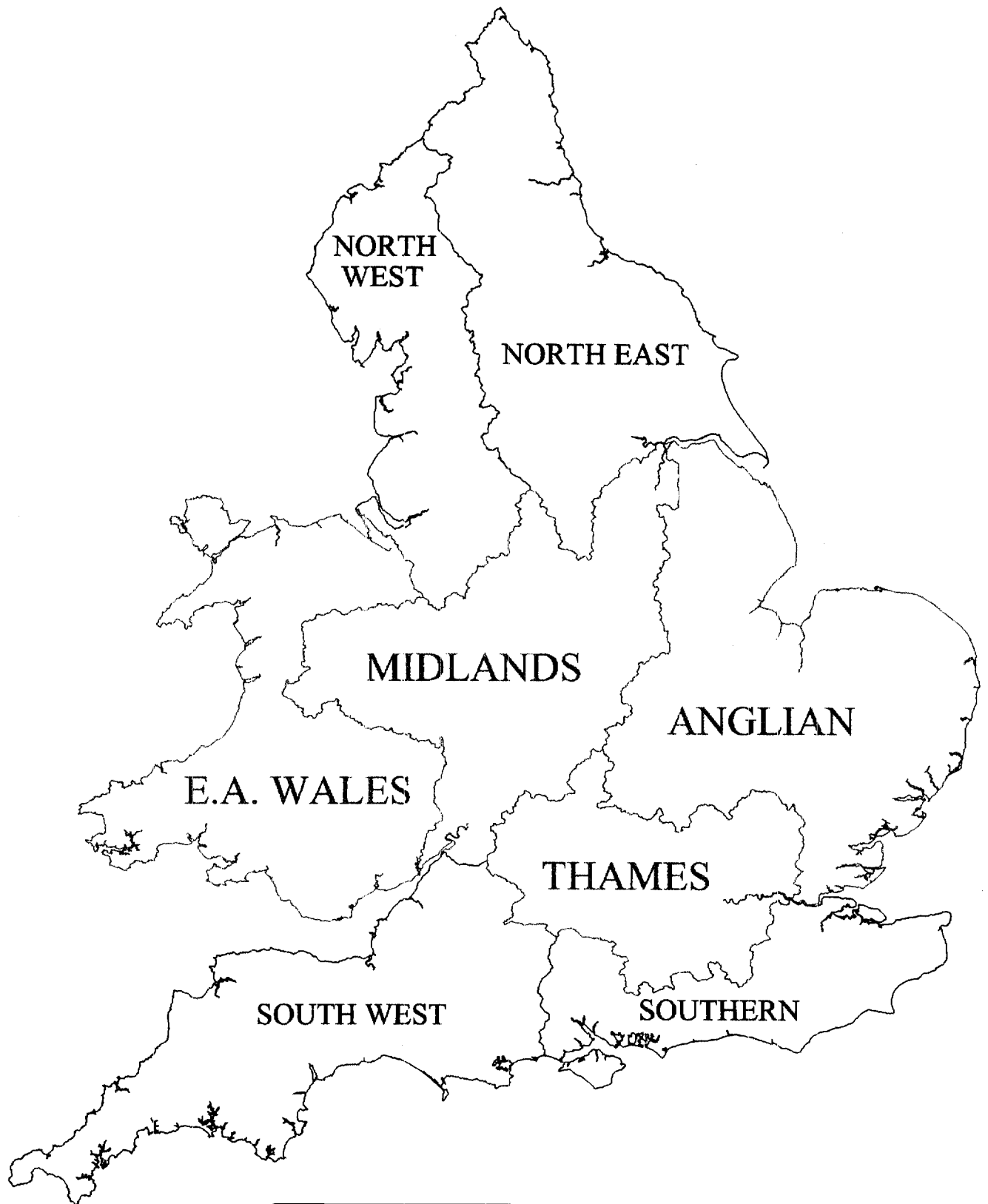
FLOOD RECORDS AT SKENFRITH CORN MILL.



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3. INCIDENT REPORTS

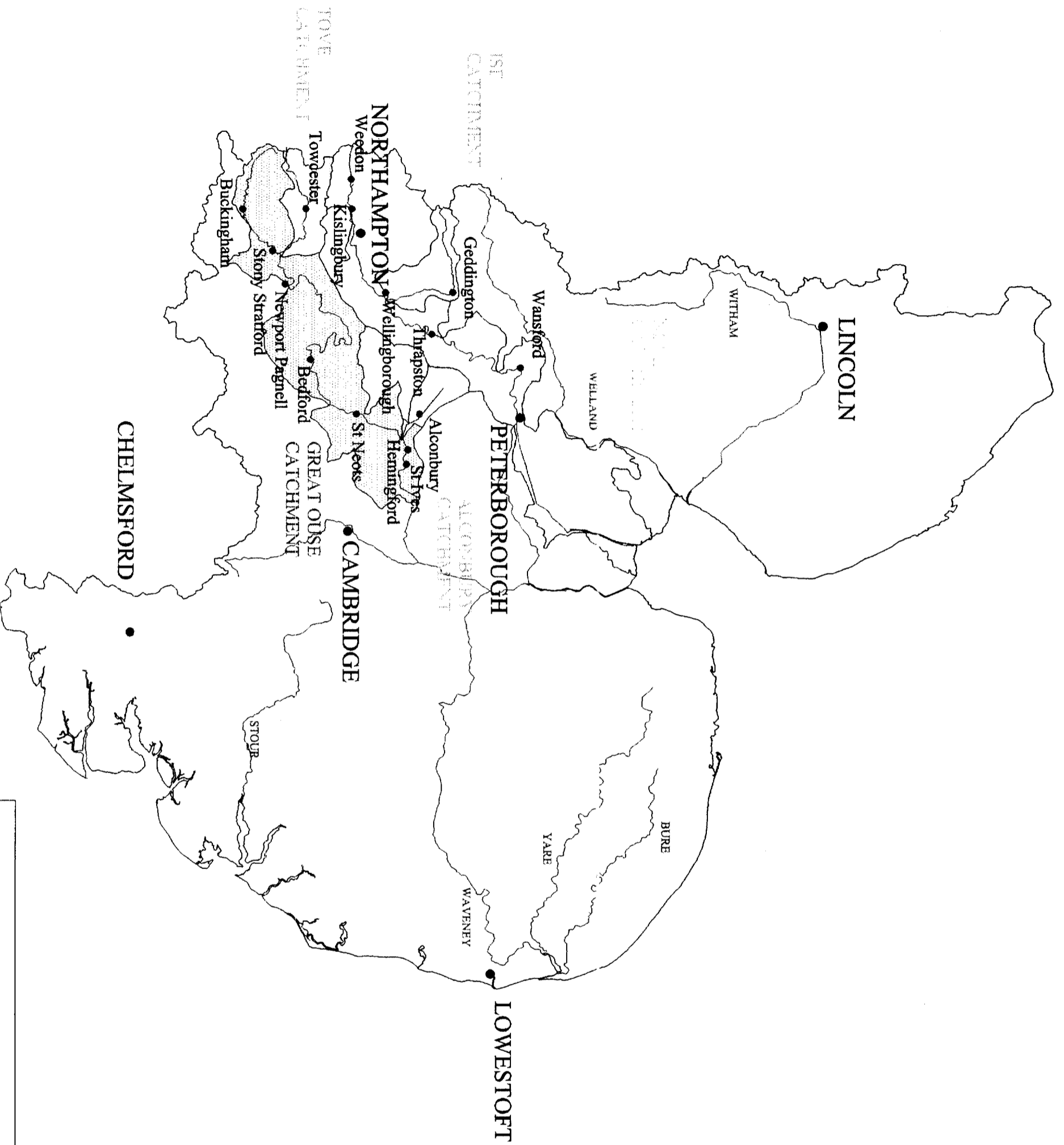


**INDEPENDENT REVIEW OF
EASTER FLOODS 1998
ENVIRONMENT AGENCY REGIONS**

Regions affected shown in red.

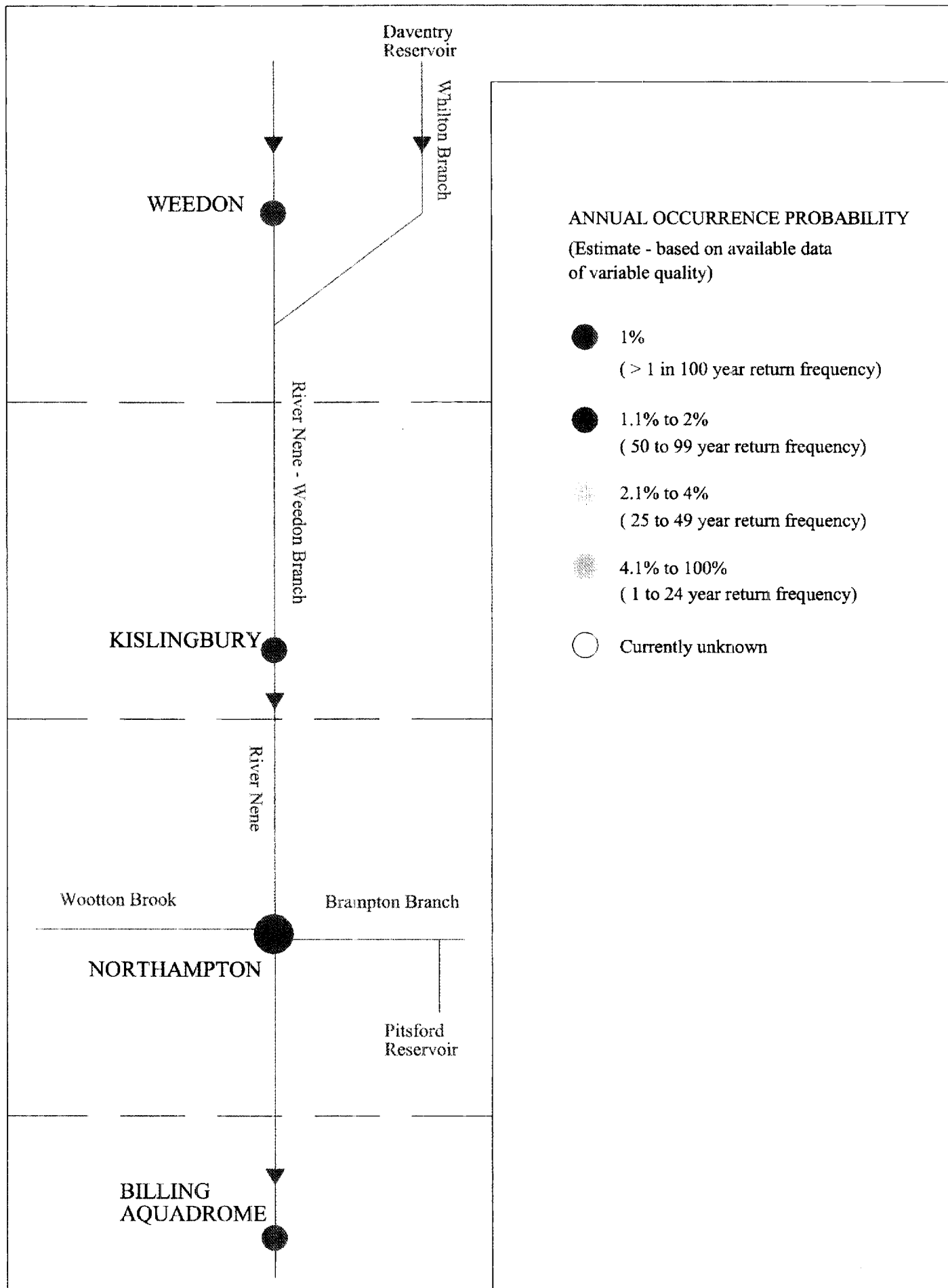
September 1998

3.1 ANGLIAN REGION



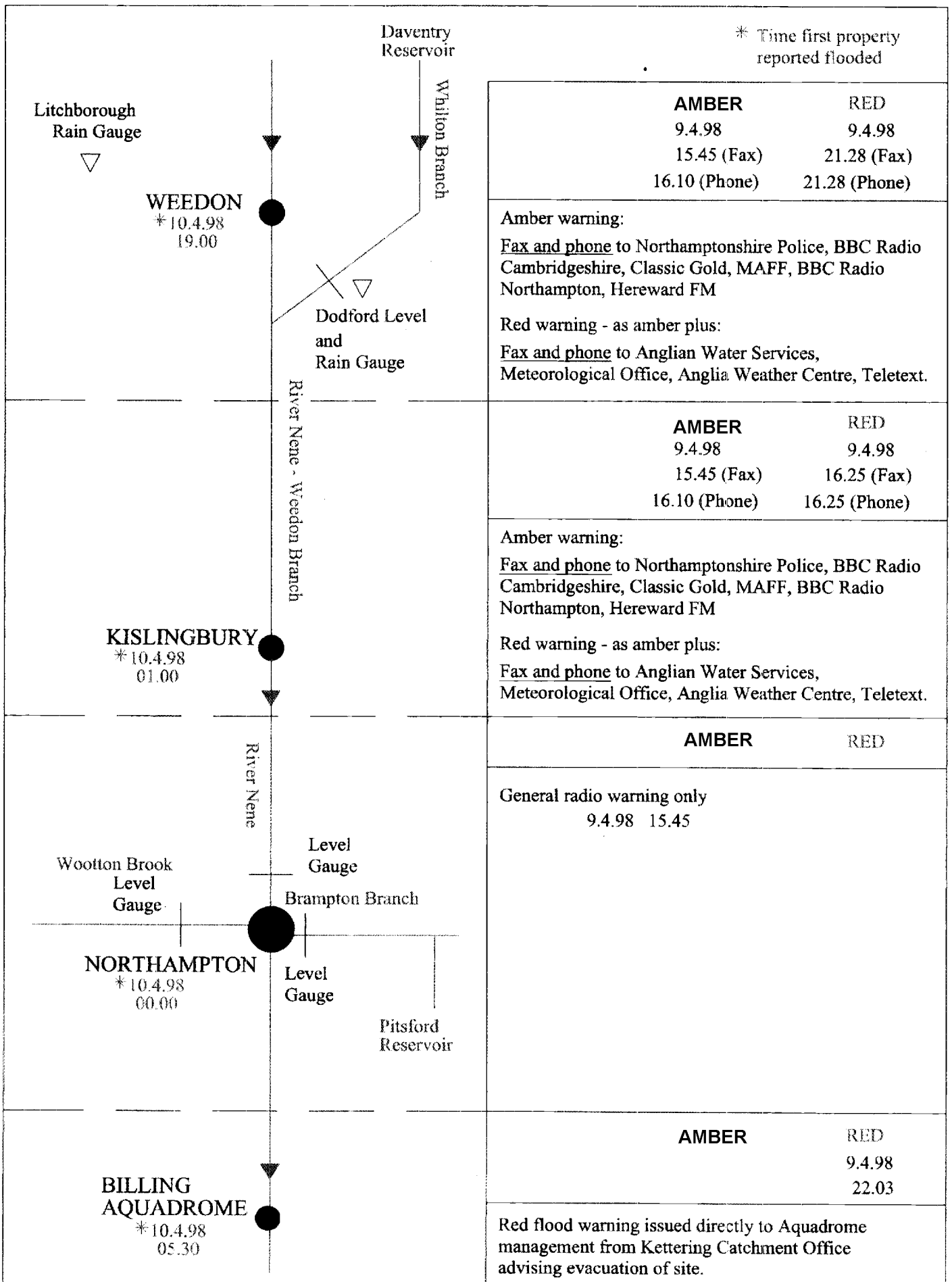
INDEPENDENT REVIEW OF EASTER FLOODS 1998
ANGLIAN REGION - CATCHMENTS AFFECTED

Northern Area



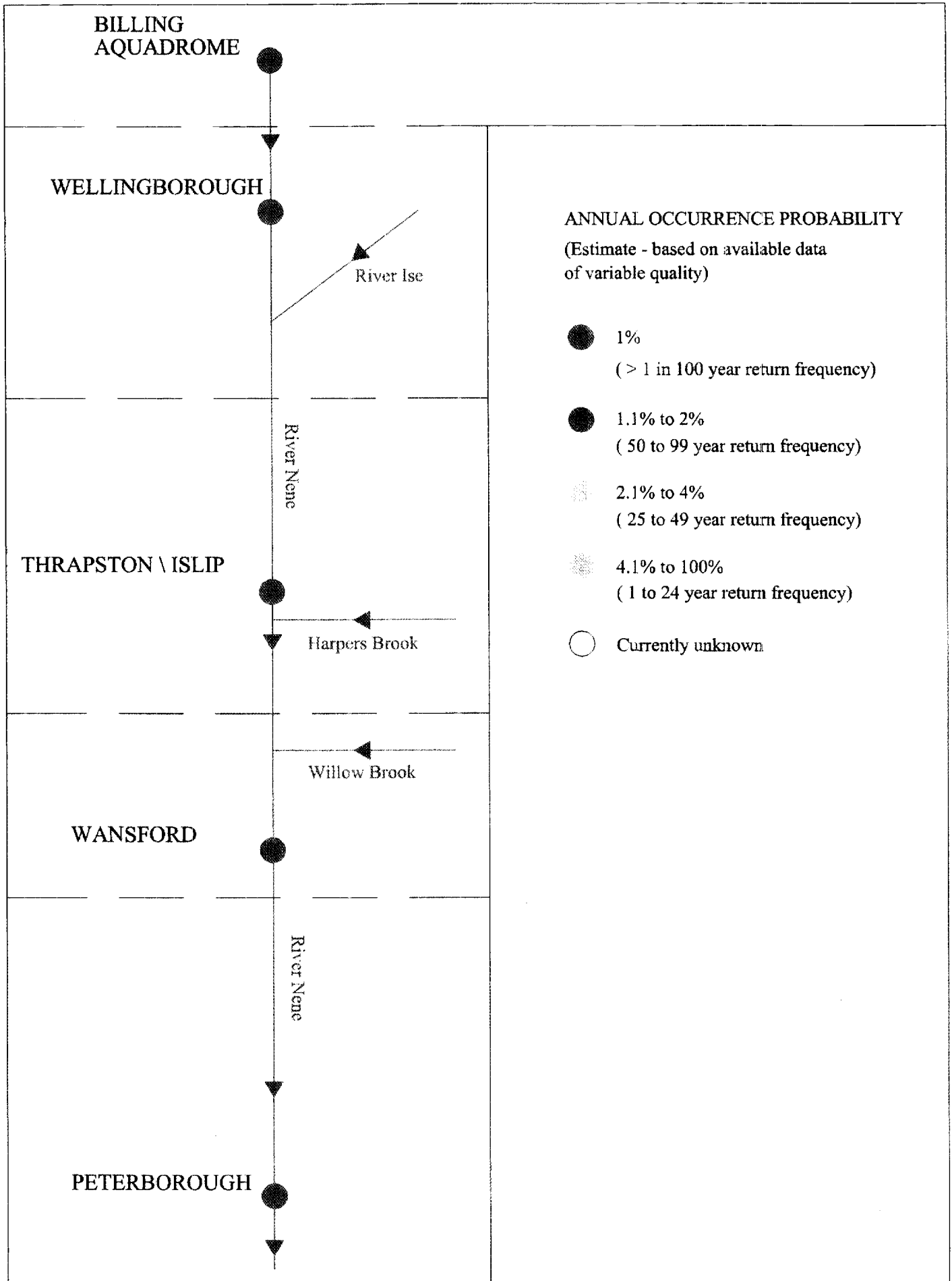
INDEPENDENT REVIEW OF EASTER FLOODS 1998
RIVER NENE CATCHMENT - FLOOD EVENTS
WELLINGBOROUGH TO WEEDON

SEPTEMBER 1998



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
RIVER NENE CATCHMENT - FLOOD WARNINGS
WELLINGBOROUGH TO WEEDON**

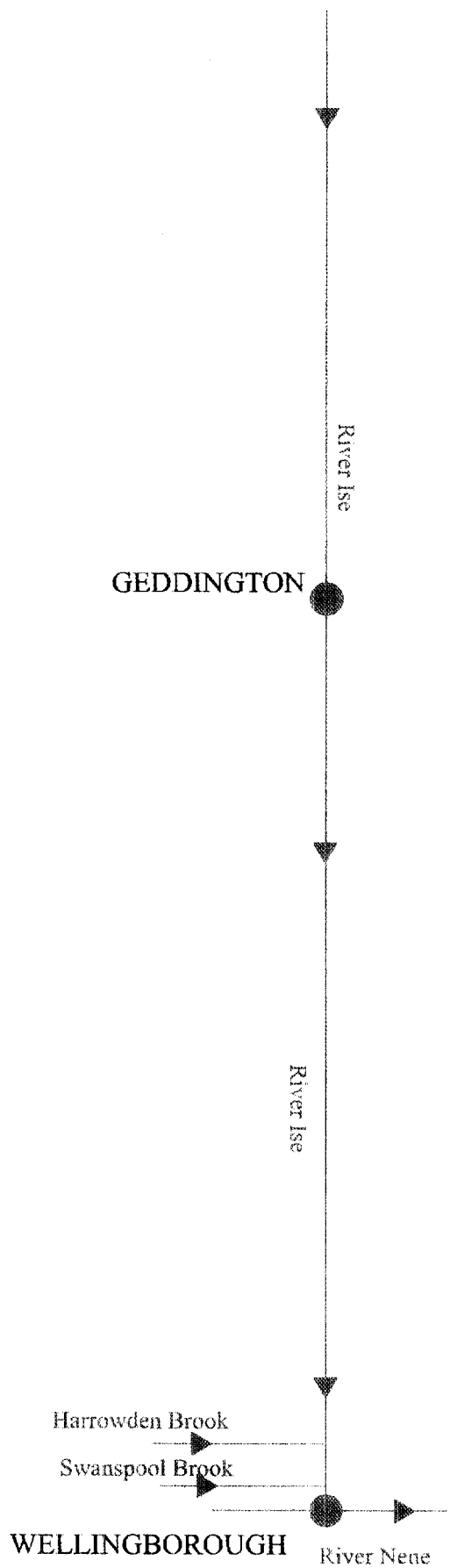
SEPTEMBER 1998



<p>BILLING AQUADROME</p>	<p>* Time first property reported flooded</p>						
<p>WELLINGBOROUGH</p> <p>*10.4.98 10.30</p> <p>River Ise</p>	<table border="1"> <thead> <tr> <th>AMBER</th> <th>RED</th> </tr> </thead> <tbody> <tr> <td colspan="2"> <p>General radio warning only 9.4.98 15.45</p> </td> </tr> </tbody> </table>	AMBER	RED	<p>General radio warning only 9.4.98 15.45</p>			
AMBER	RED						
<p>General radio warning only 9.4.98 15.45</p>							
<p>River Nene</p> <p>THRAPSTON \ ISLIP</p> <p>*11.4.98 15.00</p> <p>Harpers Brook Lilford Level Gauge</p>	<table border="1"> <thead> <tr> <th>AMBER</th> <th>RED</th> </tr> </thead> <tbody> <tr> <td> <p>10.4.98 05.57</p> </td> <td> <p>11.4.98 05.17</p> </td> </tr> <tr> <td colspan="2"> <p>Amber warning: Fax and phone to Northamptonshire Police, BBC Radio Cambridgeshire, Classic Gold, MAFF, BBC Radio Northampton, Hereward FM</p> <p>Red warning - as amber plus: Fax and phone to Anglian Water Services, Meteorological Office, Anglia Weather Centre, Teletext.</p> </td> </tr> </tbody> </table>	AMBER	RED	<p>10.4.98 05.57</p>	<p>11.4.98 05.17</p>	<p>Amber warning: Fax and phone to Northamptonshire Police, BBC Radio Cambridgeshire, Classic Gold, MAFF, BBC Radio Northampton, Hereward FM</p> <p>Red warning - as amber plus: Fax and phone to Anglian Water Services, Meteorological Office, Anglia Weather Centre, Teletext.</p>	
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<p>Willow Brook</p> <p>WANSFORD</p> <p>12.4.98 07.30</p> <p>Agency staff and police knocking on doors 12.4.98 06.10</p>	<table border="1"> <thead> <tr> <th>AMBER</th> <th>RED</th> </tr> </thead> <tbody> <tr> <td colspan="2"> <p>General radio warning only 10.4.98 01.09</p> </td> </tr> </tbody> </table>	AMBER	RED	<p>General radio warning only 10.4.98 01.09</p>			
AMBER	RED						
<p>General radio warning only 10.4.98 01.09</p>							
<p>River Nene</p> <p>PETERBOROUGH</p> <p>*12.4.98 03.00</p>	<table border="1"> <thead> <tr> <th>AMBER</th> <th>RED</th> </tr> </thead> <tbody> <tr> <td></td> <td> <p>10.4.98 12.00</p> </td> </tr> <tr> <td colspan="2"> <p>Fax to Cambridgeshire Police, Fenland District Council, Peterborough Highways, Anglian Water Services, Classic Gold, Eastern Electricity, Transco, Meteorological Office, Cambridgeshire CPU, Peterborough City Council, BBC Radio Cambridgeshire, Hereward FM, Railtrack, Anglia Weather Centre, Teletext, MAFF</p> </td> </tr> </tbody> </table>	AMBER	RED		<p>10.4.98 12.00</p>	<p>Fax to Cambridgeshire Police, Fenland District Council, Peterborough Highways, Anglian Water Services, Classic Gold, Eastern Electricity, Transco, Meteorological Office, Cambridgeshire CPU, Peterborough City Council, BBC Radio Cambridgeshire, Hereward FM, Railtrack, Anglia Weather Centre, Teletext, MAFF</p>	
AMBER	RED						
	<p>10.4.98 12.00</p>						
<p>Fax to Cambridgeshire Police, Fenland District Council, Peterborough Highways, Anglian Water Services, Classic Gold, Eastern Electricity, Transco, Meteorological Office, Cambridgeshire CPU, Peterborough City Council, BBC Radio Cambridgeshire, Hereward FM, Railtrack, Anglia Weather Centre, Teletext, MAFF</p>							

**INDEPENDENT REVIEW OF EASTER FLOODS 1998
RIVER NENE CATCHMENT - FLOOD WARNINGS
PETERBOROUGH TO WELLINGBOROUGH**

SEPTEMBER 1998



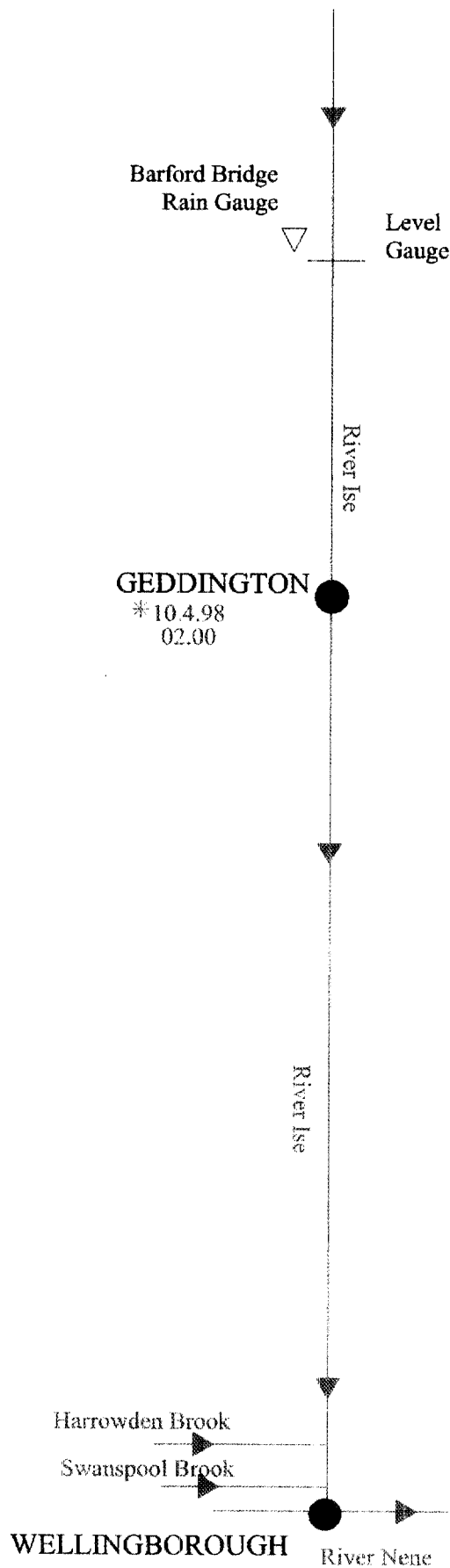
ANNUAL OCCURRENCE PROBABILITY
 (Estimate - based on available data
 of variable quality)

- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

INDEPENDENT REVIEW OF EASTER FLOODS 1998
RIVER ISE CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded



	AMBER	RED
	9.4.98	9.4.98
	18.33	22.43

Fax and phone to Northamptonshire Police, BBC Radio Cambridgeshire, Classic Gold, Anglia Weather Centre, Teletext, MAFF, BBC Radio Northampton, Meteorological Office, Hereward FM

INDEPENDENT REVIEW OF EASTER FLOODS 1998 RIVER ISE CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

BILLING AQUADROME, NORTHAMPTONSHIRE, RIVER NENE

Background

Billing Aquadrome is a major caravan and camping holiday centre which lies entirely within the natural flood plain of the River Nene at the downstream side of Northampton. Immediately upstream of the site is the Northampton Washlands flood storage reservoir, operated by the Agency. The Aquadrome is based around a number of lakes which have resulted from gravel abstraction and now form a marina and other open water bodies used for a variety of recreational purposes.

The catchment upstream extends to some 600km² and, save for Northampton, is generally rural in character. The site is at risk of flooding from either an intense urban storm occurring over Northampton or a more prolonged event over the rural catchment upstream.

The River Nene forms the southern boundary of the site where it is held at artificially retained levels by navigation locks and associated structures at Billing and Clifford Hill, both of which are within the Aquadrome site. The retention level between Billing and Clifford Hill is roughly the same as general levels within the site which is protected by a low earth embankment. Flowing through the site from the north is Billing Brook, which has an almost entirely urban catchment and from the south Hardingstone Dyke which drains large urban areas of Northampton including Far Cotton and the Brackmills Industrial Estate. Both of these watercourses are designated Main Rivers.

Given that the Aquadrome is immediately downstream of Northampton its vulnerability to flooding would have clearly been increased as each new phase of development was completed. Having regard to this, all developments which have occurred have been mitigated against by a series of measures designed to maintain the status quo in respect of flood risk to the site. For example, the Washlands were designed to attenuate increased run-off from the expansion of the eastern side of Northampton in the 1970s, run-off from Brackmills is attenuated by a series of storage ponds and the most recent development of the Riverside and Crow Lane Industrial Estates to the north have been similarly catered for.

Despite all of these mitigation measures, the Aquadrome remains liable to flood from events with a return period in excess of eight years.

During the mid 1980s two large side weirs, which were the final elements of the Washlands scheme, were constructed in the vicinity of Billing and Clifford Hill locks. These, together with associated new channel works, were designed to more efficiently convey flood flows through the site.

In 1997 a new weir was completed near Billing Mill which replaced two aged structures which were beyond economic repair. The discharge capacity of this new structure was only equal to those it replaced and therefore merely maintained the status quo.

Routine maintenance works on the river Nene are generally confined to an annual weedcut and the channel is dredged as and when required. The various structures, locks, weirs and sluices are subject to routine scheduled maintenance and inspection.

There is currently no provision in either Medium or Long Term Plan for any future scheme.

Flood Warning

Flood warnings have been issued to the Aquadrome since the Washlands storage reservoir was commissioned. This was possible since, given the proximity of the two sites and the ability to predict fairly accurately the point at which flood discharge would occur from the Washlands, warnings could be given up to 12 hours in advance. Consequently the Aquadrome management have had for many years well prepared contingency plans to evacuate people from within the site and so far as is possible, move caravans onto such higher ground as exists. This measure is only effective up to a certain level of flooding beyond which total inundation of the site occurs.

The flood warning thresholds for the Aquadrome are associated with certain discharges from the Washlands where level and gate positions can be remotely monitored by Catchment staff and Duty Officers.

On the 9 April a Red warning was issued direct to the Aquadrome at 22.03 hrs advising that evacuation plans should be put in hand. This was generated from the Catchment staff monitoring levels at the Washlands. Flooding ensued at 05.30 hrs on 10 April.

This warning was successful in that it was issued more than 2 two hours in advance of flooding thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warning was cancelled at 11.57 hrs on 13 April.

Brief Description of Flooding

Flooding occurred from the River Nene as a result of increasing discharge from the Washlands site where storage capacity was gradually taken up and ultimately exceeded with flow occurring over the emergency spillways. Flooding of the entire site followed with over 250 fully serviced static caravans being totally written off. Many others were affected to a lesser extent together with an unknown number of privately owned caravans. All of the administration and amenity buildings on the site were flooded up to a depth of 0.45m. At this point the flood level was 1.15m. above the normal river level and on the lowest parts of the site the depth was in the order of 1.74m.

The last occasion on which the site flooded was September 1992 and prior to this several other incidents of varying severity had occurred since the completion of the Washlands with perhaps the most severe event being in August 1980.

The recorded flood levels are shown in the following table for comparison with the normally retained levels, the 1947 levels and the model predicted 100 year levels.

Location	Retention level	March 1947	Model level	April 1998
Clifford Hill u/s	52.22m. AOD	53.37m. AOD	52.86m. AOD	53.09m. AOD
Billing u/s	51.08m. AOD	51.88m. AOD	51.75m. AOD	52.23m. AOD

The estimated return period of the event is, as for Northampton, between 1 in 150 and 1 in 200 years.

There was no evidence to suggest that any obstructions to flow existed at any of the structures all of which operated as designed to do.

Emergency Response

No direct action was taken by the Agency other than the issue of the flood warning previously referred to. Aquadrome management and staff responded to this warning by implementing their own evacuation plans. It is believed that the Northamptonshire Fire and Rescue Service and the Police also responded to calls for assistance.

Possible Future Action

Given the nature of the Aquadrome and its location within the flood plain it is difficult to see what can be done to alleviate future flood events. The Aquadrome management are aware of and accept the flood risk which is made known to all visitors to the site. The flood warning arrangements have worked well since they were originally implemented and for smaller floods can prevent any significant damage from occurring. However in a major event such as Easter the entire site area is inundated and severe damage follows.

It may be that future refinement to both flood forecasting and warning systems will allow a longer period of warning to be given and a more accurate assessment of the extent of flooding likely to occur, which will benefit the site. It is also possible that the investigations into the flooding in Northampton and embryonic plans to create a large wetland storage site above Northampton may result in a reduction of flows and thereby also benefit the site, although this latter is not a short term possibility.

GEDDINGTON, NORTHAMPTONSHIRE, RIVER ISE

Background

Geddington lies on the River Ise, a designated Main River, some 3km. to the north of Kettering. The catchment area above the village extends to approximately 68.0km² and is largely rural in character and run-off from developments is not an issue.

The general topography is of rolling hills with the river flowing in a relatively broad valley. The catchment is underlain by clays and run-off tends to be fairly rapid.

The highest point in the catchment is at 186m. AOD and the fall to Geddington is some 110m. over a distance of approximately 35km.

Immediately upstream of the village the river channel is a designated SSSI over some 3km. wherein routine channel maintenance works are limited in extent,. As a result the river frequently flows out of banks in this particular length.

Recent development in Geddington has been confined to small scale residential and there has been no new development in the area at risk of flooding from the River Ise.

Geddington has a history of flooding and following several floods in succession in the early 1980s a Grant - aided improvement scheme was carried out in 1984/5 which, in theory, provided a 50 year standard of protection. However despite these works, some property flooding from the river had occurred on two occasions prior to the Easter event.

The limiting factor on flood discharge capacity through the village is the road bridge in Bridge Street which is a Scheduled Ancient Monument. There is a difference in bed level of some 1.2m. on either side of this bridge and it was intended when preparing the improvement scheme to lower the inverts to gain additional capacity. However, given its status, English Heritage would not agree to the proposed alterations. Therefore an alternative but less satisfactory solution was implemented which involved the construction of low earth embankments through private gardens on the upstream side of the bridge.

The effective height of these embankments was determined by the existence of a ford, sited immediately above the bridge and the need to ensure that vehicles could continue to negotiate the ramps necessarily introduced on the approaches to the ford. As a result virtually no freeboard exists between the calculated 50 year flood level and the raised ramps. Any overtopping at the ford then immediately leads to flooding in the 'bowl' behind the defence.

The improvement scheme also extended downstream of the bridge where a two stage channel was created over approximately 1 km., the aim being to reduce water level at the downstream side of the bridge and thereby maximise discharge through it.

This channel has been well maintained and indeed was de-silted only last year and the berm level reduced to gain further capacity. Routine channel maintenance above the bridge and through the village has been largely confined to annual weedcutting since the improvements were completed.

Flood Warning

There is a river level and flow gauging station sited approximately 3km. upstream of the village at Barford Bridge and flood warnings for Geddington are triggered when predetermined thresholds are reached.

On the 9 April an Amber warning of property flooding was issued at 18.33 hrs followed by a Red warning at 22.43 hrs. The means of dissemination of these warnings and the recipients of them are given below:

Flood Warnings and Dissemination

General broadcast of flood risk AMBER affecting properties in Geddington, faxed to the following at 18.33 hrs on 9 April:

Kettering Catchment Office
MAFF
Northamptonshire Police
EA Public Relations Section at RHQ
EA Regional Comms. Centre
Spalding Catchment Office
BBC Radio Cambridgeshire
BBC Radio Northampton
Classic Gold (Radio)
Hereward FM (Radio)
Anglia Weather Centre
Met. Office (Norwich)
Newstel (Teletext)

Specific warning of flood risk AMBER affecting properties in Geddington via AVM at 18.33 hrs on 9 April.

16 calls were made of which 10 were received.

General broadcast of flood risk RED affecting properties in Geddington, faxed to those recipients listed above at 22.43 hrs on 9 April.

Specific warning of flood risk RED affecting properties in Geddington via AVM at 22.43 hrs on 9 April.

16 calls were made of which 10 were received.

The flood warnings were successful in that they were disseminated more than two hours in advance of flooding from Main River, thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warnings were cancelled at 06.17 hrs on 12 April.

Brief Description of Flooding

In the early hours of Thursday 9 April, very heavy rain was falling over the Ise catchment and

beyond - at Barford Bridge 49mm. of rain was recorded in a 12 hour period from 11.00 hrs, which had an estimated return period of 20 years. This rain, falling on an already wet catchment, led to rapidly rising levels in the River Ise in the following hours and flooding occurred at between 02.00 hrs and 02.30 hrs on 10 April, some 72 hours after the initial Amber flood warning had been issued.

Agency staff, as on previous occasions, deployed sandbags to properties known to be at risk. However levels continued to rise until the defence was overtopped, initially at the sides of the ford followed shortly by general overtopping of the embankments in the gardens upstream. The flooding was exacerbated by surcharging surface water sewers, particularly on the north side of the river. At the peak of the flood it appears that virtually no head difference existed from one side of the bridge to the other, the river having flowed across the road on the north side, a raised footpath on the southern side prevented a similar occurrence here.

In total 18 properties were affected by flooding from the River Ise although many more gardens were flooded and several more properties were at risk. Without exception these properties are all of considerable age. Additional properties in Geddington were flooded from an ordinary watercourse but the Agency has no knowledge of the numbers affected in this way.

The normal water level above the bridge is approximately 69.90m. AOD and the flood level was recorded 1.94m. above this at 71.84 m. AOD.

In September 1992 the flood level was 71.70m. AOD and the following levels have previously been calculated:

I in 50 year water level 71.3m.AOD.

I in 100 year water level 71.5m. AOD.

The return period for this event is therefore considered to have been in excess of 100 years since the calculated 100 year level was exceeded on this occasion. This is supported by an analysis undertaken for the village of Clipston some 30km. upstream where flooding also occurred at Easter and where the particular circumstances allowed a reasonably accurate assessment to be made. The event here was estimated at marginally in excess of a 100 year return period.

No deficiencies in the defences were found to exist and there was no evidence of any debris causing blockages in the bridge openings.

Emergency Response

As stated above Agency staff deployed sandbags to properties known to be at risk and across the ford ramps before overtopping from the river began. However some flooding affecting properties on the north side of the river had already occurred as a result of problems on an ordinary watercourse further to the north in the vicinity of Wood Street, where additional property flooding had occurred associated with this.

The Northamptonshire Fire and Rescue Service also responded to a number of calls for assistance.

Possible Courses of Action

It has long been recognised that the road bridge is a major obstruction to flow and it has previously been mentioned that the status of the bridge precludes any structural alteration to it. Consequently

at the time of the improvements many avenues were investigated in an attempt to improve the situation.

Should the ford not exist then bank levels above the bridge could have been raised substantially and a higher water level accommodated as a result. There were principally two reasons why this could not be done:

- the need to retain the ford for vehicular use.
- English Heritage objected to the visual impact and feared that increased pressure resulting from a higher water level, might induce structural failure of the bridge.

Other alternatives such as a bypass channel or flood storage were discounted on economic grounds. Flood proofing of individual properties was discounted for a number of reasons.

Having regard to these factors it is clear that options for the Agency are limited particularly since the flood warning arrangements are adequate and since a Capital scheme has been implemented there is no provision within either Medium or Long Term Capital Plan for future works.

However the Agency will pursue with the Local Authority and Anglian Water possible improvements to the ordinary watercourse which gave rise to flooding remote from the river. These two bodies having jointly funded past works on this system.

KISLINGBURY, NORTHAMPTONSHIRE, RIVER NENE

Background

Kislingbury lies on the south bank of the Kislingbury Branch of the River Nene, a designated Main River, some 3km. to the west of Northampton. The catchment upstream extends to approximately 217km² and is largely rural in character. The only significant urban area is Daventry some 22km. upstream where extensive recent development has taken place, although the effects of increasing surface water run-off from here have been mitigated against by attenuation within reservoirs owned by British Waterways.

The general topography is of relatively steep sided valleys underlain by clays. Run-off tends to be quite rapid. However Kislingbury itself lies within a comparatively broad valley floor and there is a considerable area of flood plain both upstream and downstream of the village.

The river divides into two major tributaries at Flore, some 6 km. to the west of Kislingbury. The Whilton Branch flows from the north and the Weedon Branch from the west. Daventry lies at the head of the Whilton Branch.

There is a fall of 160m. over approximately 16km. along the Weedon Branch to Kislingbury and on the Whilton Branch the fall is 115m. over 20km.

The area of Kislingbury with a history of flooding lies to the south of the river above the B4525 road bridge. The existing standard of defence against flooding is estimated to be 1 in 10 years and the most recent occasion on which flooding occurred prior to Easter was in September 1992.

Following this event a feasibility study was carried out to determine whether a viable flood defence scheme giving protection to a 25 year standard could be implemented. Two options, both based upon bank raising, were investigated but neither could be economically justified and consequently no works were carried out other than the clearance of silt from within the road bridge and some limited dredging of the channel downstream.

Routine maintenance of the channel in Kislingbury is confined to annual weedcutting adjacent to the bridge and the removal of obstructions as and when they occur.

Within Kislingbury itself there has been some limited residential development in recent years some of which has been affected by flooding. Most of the planning applications for these predate the establishment of the National Rivers Authority. It is believed that the Riverside Court development, which flooded in this event, but not in 1992, was granted planning permission against the advice of Anglian Water that the site was at risk of flooding. However the Agency has no proof that this was the case since the records have not survived. Of those sites commented upon by the NRA/Agency, only one has flooded and since this particular site changed from residential to offices, no objection was raised although the flood risk was made clear to the applicant.

There is currently no provision in either Medium or Long Term Plan for any future scheme.

Flood Warning

Flood warnings for Kislingbury are generated by predetermined levels recorded at Dodford gauging station situated some 7km. upstream on the Whilton Branch tributary.

On the 9 April an Amber warning was issued at 15.45 hrs followed by a Red warning at 16.25 hrs. The means of dissemination of these warnings and the recipients of them are given below:

Flood Warnings and Dissemination

General broadcast of flood risk affecting properties in Kislingbury, Weedon and Bugbrooke Mill, faxed to the following at 15.45 hrs on 9 April:

Kettering Catchment Office
MAFF
Northamptonshire Police
EA Public Relations Section at RHQ
EA Regional Comms. Centre
Spalding Catchment Office
BBC Radio Cambridgeshire
BBC Radio Northampton
Classic Gold (Radio)
Hereward FM (Radio)

Specific warning of flood risk AMBER affecting properties in Kislingbury, Weedon and Bugbrooke Mill via AVM at 16.10 hrs on 9 April.

117 calls were made of which 110 were received.

General broadcast of flood risk RED affecting properties in Kislingbury and Bugbrooke Mill, faxed to the following at 16.25 hrs on 9 April:

As above **plus**
Anglian Water Services
Anglia Weather Centre
Met. Office (Norwich)
Newstel (Teletext)

Specific warning of flood risk RED affecting properties in Kislingbury and Bugbrooke Mill via AVM at 16.25 hrs on 9 April.

28 calls were made of which 23 were received.

The flood warnings were successful in that they were disseminated more than two hours in advance of flooding from Main River, thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warnings were cancelled at 06.05 hrs on 12 April.

Brief Description of Flooding

In the early hours of Thursday 9 April very heavy rain was falling over the upper Nene catchment - at Dodford 47mm. of rain was recorded in a 12 hour period, which had an estimated return period of 15 years and at Litchborough, some 9 km. to the south-west, 64mm. of rain was recorded in a 15 hour period from 05.00 hrs, which had an estimated return period of 50 years. This rain, falling

on an already wet catchment, led to rapidly rising levels in the Nene tributaries.

During the evening of 9 April it appears that channel bank full conditions had been reached and there have been reports of flooding occurring at around this time but it is believed that this was as a result of surface water systems surcharging and actual property flooding from the river did not occur until approximately 01.00 hrs on the 10 April.

There is much evidence that a considerable out of bank flow was occurring upstream of Kislingbury with the flood plain being fully inundated and it is this water which appears to have given rise to the extensive flooding which followed. The situation was exacerbated by overflow from the canal system which is known to have occurred in a number of locations upstream and since the canal crosses the catchment boundary it seems certain that this would, in effect, have imported water from the adjacent catchment. However it has not yet been determined to what extent this may have occurred and indeed, it may not be possible to do so with any degree of accuracy.

In total 43 mainly residential but with some small retail properties flooded from the river which at the peak of the flood was some 2.95m. above normal level.

There were no reports suggesting, and no evidence was found, that any obstructions to flow existed in the channel or across the road bridge which could have contributed to the extent of flooding.

The recorded flood levels established from wrack marks and consultation with affected parties are shown in comparison with those from previous events in the following table:

Location	March 1947	September 1992	April 1998
B.4525 Bridge u/s	65.24m. AOD	not recorded	65.91m. AOD
B.4525 Bridge d/s	not recorded	not recorded	65.27m. AOD

The normal level upstream of the bridge is 62.96m. AOD.

The return period for this event is estimated to have been in excess of 150 years on the basis of the comparison between recorded levels, the 1947 event having been estimated at between 1 in 100 and 1 in 150 years.

The September 1992 event is estimated to have had a return period of 19 years but there are doubts as to the accuracy of this and consequently it will be re-assessed.

Emergency Response

No direct action was taken by the Agency other than the issue of flood warnings previously referred to. However it is understood that the Northamptonshire Fire and Rescue Service and the Police responded to a number of calls for assistance.

Possible Courses of Action

As previously stated, past feasibility studies have shown that major flood defence works could not be economically justified. However the Agency will be re-examining these studies in the light of the Easter event to determine whether an alternative approach is possible which will give some relief.

In addition while the flood warning arrangements appear to have worked satisfactorily, the existing warning thresholds at Dodford will be reviewed and it may also be that other residents will respond to a further invitation to receive flood warnings.

PETERBOROUGH, RIVER NENE

Background

Peterborough straddles the catchment boundary between the Rivers Welland and Nene. The focus of this report is the River Nene only since there was no flooding associated with tributary streams draining the north of the city to the River Welland.

Peterborough is some 90km. downstream from Northampton and the catchment area is in excess of 1550km². The River Nene is artificially retained from a manned tidal lock and sluice situated some 7km. downstream to the east at Dog-in-a-Doublet. Were it not for the presence of this structure, the river would naturally be tidal through the city. There is a change in retention level at Orton towards the western side of the city where there is also a navigation lock and associated sluices.

When fluvial flood flows coincide with high tide levels, gravity discharge is not possible. During these periods of 'tide lock' backing up can occur and threaten flooding through the city. To overcome this, flood flows can be diverted via sluices at Stanground into the Whittlesey Washes which is an area roughly 20km. long by 1km. wide and provides significant flood storage volume. The Washes are drained to the tidal river via a sluice at Rings End situated at the downstream limit.

There has been relatively little development within the natural floodplain through the city and where this has occurred it has generally been built above previously recorded flood levels.

Between Orton and the Town Bridge the flood plain is typically 300m. in width.

In comparison the flood plain upstream is quite broad within which there exist large bodies of open water resulting from past gravel abstraction and these now provide water based amenities and some measure of increased flood storage.

The valley upstream remains relatively rural in character with no significant developed urban areas until Thrapston, on the main Nene and Corby, at the head of Willow Brook which are 52km and 45km. upstream respectively.

There has been no loss of flood plain due to development between Peterborough and Thrapston. Above Thrapston there has been significant development in Northampton, Wellingborough, Rushden, Irthlingborough and Kettering which has impacted to some extent upon flood flows in the valley.

The exact effect of the undoubted changes which have taken place in the valley is not known since it is a highly complex interaction of many factors. however the approach taken with regard to new developments, certainly over the last 10 years, is that they should not lead to any increase in run-off nor loss of flood plain storage.

There have been no recent flood defence works carried out which would have directly affected the standard of protection against flooding afforded to Peterborough and there is currently no provision within either Medium or Long Term Plan for any future scheme.

Routine maintenance works include annual weed cutting and removal of obstructions. All of the structures are subject to scheduled maintenance.

Peterborough was considered to have a standard of protection against flooding of 1 in 100 years.

Flood Warning

Flood warnings for Peterborough are associated with predetermined threshold levels at Wansford Gauging Station some 10km. upstream.

No specific flood warning was disseminated for Peterborough since, as has been stated above, the risk of flooding was considered to be from events with a return period of greater than 100 years and the Agency's National Policy for Flood Warning Dissemination was that such a service would only be provided to areas at risk of flooding from events with a return period 50 years or less.

However a general Red flood warning was broadcast at 12.20 hrs on 10 April and flooding from the River Nene occurred at 03.00 hrs on 12 April.

The means of dissemination of this warning and the recipients of it are given below:

Flood Warnings and Dissemination

General broadcast of flood risk RED - affecting properties in Peterborough - evacuation to be considered, faxed to the following at 12.20 hrs on 10 April:

Cambridgeshire Police
Cambridgeshire CPU
Fenland District Council
Kettering Catchment Office
MAFF
Peterborough City Council
Peterborough Highways
EA Regional Comms. Centre
EA Public Relations Section at RHQ
Spalding Catchment Office
Anglian Water Services
BBC Radio Cambridgeshire
Classic Gold (Radio)
Hereward FM (Radio)
Eastern Electricity
Railtrack (Liverpool Street)
Transco
Anglia Weather Centre
Met. Office (Norwich)
Newstel (Teletext)

Further updating **General broadcasts** of flood risk RED were faxed to the same recipients at:
22.34 hrs on 11 April.
14.52 hrs on 12 April.
17.57 hrs on 12 April.

The flood warnings were successful in that they were disseminated more than two hours in advance of flooding from Main River thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warning was cancelled at 12.15 hrs on 16 April.

Brief Description of Flooding

The first reports of flooding of properties were received by Catchment staff shortly after mid-day on 10 April from residents in the Thorpe Meadows area although this was from an ordinary watercourse and not connected with Main River.

From the scale of flooding in the catchment upstream it became apparent that properties within the identified flood risk areas on either side of the river would become flooded and this occurred at approximately 03.00 hrs on 12 April.

Residential properties in the Thorpe Meadows area to the north and industrial/commercial units in Warley Road to the south being the first affected. Shortly afterwards some office premises adjacent to the Town Bridge were also flooded. In total 9 residential and 9 business premises were affected, although perhaps in excess of 100 were flooded from ordinary watercourses.

The peak of the flood was reached at 19.00 hrs on 12 April when the level was 1.87m. above the normal river level.

The last occasion on which Peterborough flooded from the River Nene was in March 1947.

The recorded flood levels are shown in the following table for comparison with the normally retained levels, the 1947 levels and the model predicted 100 year levels.

Location	Retention level	March 1947	Model level	April 1998
Orton sluice u/s	4.21m. AOD	5.70m. AOD	5.5m. AOD	6.23m. AOD
Orton sluice d/s	2.90m. AOD	5.46m. AOD	4.55m. AOD	5.60m. AOD
Town Bridge u/s	2.90m. AOD	4.99m. AOD	3.90m. AOD	4.77m. AOD

The flood had subsided by 13 April.

The return period for this event is considered to have been in excess of 150 years, on the basis of comparison of recorded and predicted levels, the 1947 event has been estimated to have been between 1 in 100 and 1 in 150 years. Although at Easter the levels at Town Bridge were lower than those in 1947 this is thought to have been due to more favourable tide conditions affecting freshwater discharge on this occasion.

There was no evidence to suggest that any obstructions to flow existed or any malfunctions of structures occurred which would have exacerbated the degree of flooding.

Emergency Response

Cambridgeshire Police had initiated the opening of Gold and Silver Control centres to deal with the flood threat when it became apparent. The Agency was invited to participate in both and members of Regional staff attended Gold Control with Catchment staff becoming involved with Silver

Control.

Besides the issue of the flood warning, Agency personnel were engaged jointly with Peterborough City Council staff and Regular and Territorial Army members in the deployment of sandbags and evacuation of householders.

In addition the Cambridgeshire Fire and Rescue Service and the Police responded to calls for assistance.

Possible Course of Action

Given the extreme nature of the Easter event it is unlikely that an economically viable flood prevention scheme can be found to protect against a similar future event. Nevertheless the possibility of some local works such as embanking the areas at risk will be investigated.

There are embryonic plans to create wetland storage areas in the Nene valley which, should they come to fruition, could benefit Peterborough in reducing the frequency and severity of flooding, although these are not short term possibilities.

The flood warning system appears to have performed satisfactorily and should further improve when planned improvements in flow forecasting are implemented. In any event the warning threshold will be re-examined.

Extension of the flood warning dissemination service to formally cover Peterborough will also be considered.

THRAPSTON & ISLIP, NORTHAMPTONSHIRE, RIVER NENE

Background

Thrapston and Islip lie on opposite banks of the River Nene some 41km. downstream of Northampton, the catchment area upstream is in excess of 1,000km².

There is a broad expanse of floodplain upstream although there is a distinct narrowing of this at the Nine Arches road bridge crossing of the river between the two settlements. The River Nene is artificially retained for navigation by a lock, an automatic tilting sluice and a weir at Islip Mill some 500m. downstream of this bridge.

Within the valley upstream there has been extensive gravel abstraction over a number of years which has resulted in several large open water bodies remaining, some of which provide additional flood storage. There has also been significant new development in the catchment upstream, notably at Northampton but also in Wellingborough, Kettering, Rushden, Higham Ferrers and Irthlingborough. Some of this development, but by no means all, has been drained directly into the river with no attenuation of flows. There has been some significant development in Thrapston itself mainly due to its location immediately beside the main M1 - A1 link road. This development has been a combination of residential within the town and commercial/distribution warehousing to the east alongside the new road. All of these developments drain to the River Nene, outfalling downstream of the Nine Arches Bridge and much of the run-off is un-attenuated, the reasoning being that peak run-off from these areas would not coincide with the peak flow from the large catchment upstream.

In addition there has locally been some incursion into the flood plain without compensatory storage being provided although in all recent developments where this has been proposed compensatory measures have been insisted upon

Some of the incursions into the flood plain were agreed by the Agency's predecessors and (it is alleged) others were not, although in relation to the overall volume of storage available in the valley the amount lost due to these incursions has not been significant. However there may have been local effects on flood flows and storage. This filling took place many years ago and it is not known why no action was taken at the time to restore the flood plain if infilling took place without consent.

The exact effect of the undoubted changes which have taken place in the valley overall is not known since it is a highly complex interaction of many factors. However the approach taken with regard to new developments, certainly over the last 10 years, is that they should not lead to any increase in run-off or loss of flood plain storage.

There is for example a current proposal to develop on historic flood plain to the east of the river downstream of Nine Arches bridge and mitigation measures have been agreed which should maintain the status quo.

There have been no recent flood defence works carried out in the area, other than routine channel maintenance, including annual weed cutting, clearance of obstructions as and when required.

In 1987 Anglian Water carried out an Appraisal Study to assess the standard of defence afforded to Thrapston and Islip, which concluded that there was a risk of flooding to two relatively small areas

for floods with a return period greater than 25 years. This was subsequently re-assessed and the overall standard of protection was found to be between 50 and 100 years and consequently no scheme was promoted.

There is currently no provision in either Medium or Long Term Plan for any future scheme

Flood Warning

Flood warnings for Thrapston are associated with predetermined thresholds at Lilford gauging station situated some 9.5km. downstream.

On 10 April an Amber warning was issued at 05.57 hrs. This was followed on 11 April by a Red warning issued at 05.17 hrs and a further Red warning issued at 08.04 hrs, advising evacuation.

Flooding of properties ensued at approximately 10.00 hrs on 11 April.

The means of dissemination of these warnings and the recipients of them are given below:

Flood Warnings and Dissemination

General broadcast of flood risk AMBER affecting properties in Thrapston, faxed to the following at 05.57 hrs on 10 April.

Kettering Catchment Office
MAFF
Northamptonshire Police
EA Public Relations Section at RHQ
EA Regional Comms. Centre
Spalding Catchment Office
BBC Radio Cambridgeshire
BBC Radio Northampton
Classic Gold (Radio)
Hereward FM (Radio)

Specific warning of flood risk AMBER affecting properties in Thrapston via AVM at 05.57 hrs on 10 April.

11 calls were made of which 6 were received.

General Broadcast of flood risk RED affecting properties in Thrapston, faxed to the following at 05.17 hrs on 11 April:

As above **plus**
Anglian Water Services
Anglia Weather Centre
Met. Office (Norwich)
Newstel (Teletext)

Specific warning of flood risk RED affecting properties in Thrapston via AVM at 05.17 hrs on 11 April.

11 calls were made of which 6 were received.

The flood warnings were successful in that they were disseminated more than two hours in advance of flooding from Main River, thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warnings were cancelled at 18.50 hrs on 13 April.

Brief Description of Flooding

The scale of the flood was such that a considerable volume of water was already on the flood plain as it approached Thrapston. This was exacerbated by the constriction at the Nine Arches bridge. The areas in Midland Road and Bridge Street were the first to be affected and levels continued to rise until flows by-passed the bridge and flooding of properties on the downstream side ensued. The peak level was reached in mid afternoon on the 11 April some five hours after flooding began and at this point the flood level was 2.56m. above the normal river level at Islip.

In total 23 residential and 17 commercial properties were flooded together with a Health Centre and Doctors surgery, in addition 5 caravans were flooded.

The last occasion on which property flooding occurred in Thrapston was March 1947 although in August 1980 some road flooding did occur and part of the site now occupied by the Health Centre was flooded. This building was however constructed above the level recorded during this event.

The recorded flood levels are shown in the following table for comparison with the normally retained levels, the 1947 levels and the model predicted 100 year levels.

Location	Retention level	March 1947	Model level	April 1998
Nine Arches u/s	28.19m. AOD	not recorded	not predicted	30.24m. AOD
Islip d/s	26.49m. AOD	28.86m. AOD	28.85m. AOD	29.05m. AOD

The return period for this event is estimated to have been in excess of 150 years on the basis of the comparison of recorded and predicted levels at Islip, the 1947 event having been estimated at between 1 in 100 and in 150 years.

Emergency Response

The scale of events in the valley upstream, particularly at Northampton, enabled adequate warnings to be issued and personnel and plant to be mobilised to sandbag properties and assist in the evacuation of homes.

Local Authority personnel and both Regular and Territorial Army assisted in the deployment of sandbags. Small boats were used in the evacuation of residents trapped in their homes by the rising waters.

The Northamptonshire Fire and Rescue Service and the Police are also understood to have responded to calls for assistance.

Possible Courses of Action

There is little doubt that the Nine Arches road bridge is a serious obstruction to flows of the magnitude experienced at Easter and realistically there is no prospect of being able to replace this with a structure having sufficient capacity to pass such flows.

Given the extreme nature of the Easter flood it is unlikely that an economically viable flood prevention scheme can be found to protect against a similar event in the future. However the Anglian Water scheme could be re-examined to determine whether some measure of alleviation can be provided.

There are embryonic plans to create wetland storage areas within the Nene valley which, should they come to fruition, could benefit Thrapston and Islip in reducing the frequency and severity of flooding although these are not short term possibilities.

The flood warning system appears to have performed satisfactorily and should improve in the future when planned improvements in flow forecasting are implemented. However, given this location, it is already possible to fairly accurately predict events from observing the development of flooding in the valley upstream. In any event the existing warning threshold at Lilford will be reviewed.

It may also be possible to extend the numbers of people wishing to be connected to the AVM system.

Current and future development proposals will have to be considered in the light of this flooding event.

WANSFORD, CAMBRIDGESHIRE, RIVER NENE

Background

Wansford is a village which lies on the River Nene some 79km. Downstream of Northampton and 10km upstream of Peterborough. The catchment area upstream extends to some 1,520km².

There is a broad expanse of flood plain upstream although there is a distinct narrowing in the village where the river is crossed by a single-carriageway, packhorse type road bridge. Some 350m downstream the A1 trunk road is carried over the river on a clear span structure. The river is artificially retained for navigation by a lock, weir and automatic sluices at Water Newton Mill situated some 5km. downstream.

There is a flow and level gauging station sited some 500m. downstream of the village.

Within the valley upstream there has been extensive gravel abstraction over recent years which has resulted in several large open water bodies remaining, some of which provide additional flood storage. There has also been significant new development in the catchment upstream, notably at Northampton but also in Wellingborough, Kettering, Rushden, Higham Ferrers, Irthlingborough, Thrapston and Corby. Some of this development, but by no means all, has been drained directly into the river or its tributaries with no attenuation of flows.

There has been no significant development in Wansford which would give rise to increased run-off nor has there in the immediate catchment upstream. Some un-attenuated development has taken place in Oundle some 16km. upstream but this has largely been small scale residential and is not considered to have increased the flooding risk downstream.

There has been no loss of flood plain storage due to development between Wansford and Thrapston, 38km. upstream.

The exact effect of the undoubted changes which have taken place in the valley overall, is not known since it is a highly complex interaction of many factors. However the approach taken with regard to new developments, certainly over the last 10 years, is that they should not lead to any increase in run-off nor loss of flood plain storage.

There have been no recent flood defence works carried out in the area, other than routine channel maintenance, such as annual weed cutting and clearance of obstructions as and when required.

Wansford was not considered to be at risk of flooding from events with a return period less than 100 years.

There is currently no provision within either Medium or Long Term Plan for any future scheme.

Flood Warning

No specific flood warning was disseminated for Wansford since, as has been stated above, the risk of flooding was considered to be from events with a return period of greater than 100 years and the Agency's National Policy for Flood Warning Dissemination was that such a service would only be provided to areas at risk of flooding from events with a return period of 50 years or less.

A general radio broadcast warning only was given at 01.09 hrs on 10 April which applied to the Nene valley as a whole.

However in view of the scale of flooding upstream it became obvious that some flooding would occur in Wansford. Therefore Police and Agency staff began knocking on doors at approximately 06.10 hrs on the 12 April and flooding of properties began soon after at 07.30 hrs.

Brief Description of Flooding

The scale of the flood was such that a considerable depth of water was already on the flood plain as it approached Wansford. This was exacerbated by the constriction at the old London Road Bridge which must have caused a further rise in level leading to flooding into London Road and Elton Road on the east bank of the river affecting 18 properties in total. These were mainly residential but included a hotel, public house and two small retail premises.

Flood water extended along London/Elton Road to a distance some 300m. from the river and to a depth in places of 700mm., the cellars at the Haycock Hotel becoming completely submerged. The peak of the flood occurred at 10.00 hrs on 12 April when the water level was over 3m. above normal at the bridge.

The last occasion on which Wansford was flooded was in March 1947.

The recorded flood levels are shown in the following table for comparison with the normally retained levels, the 1947 levels and the model predicted 100 year levels..

Location	Retention level	March 1947	Model level	April 1998
Wansford Lock u/s	9.94m. AOD	11.28m. AOD	not predicted	11.61m. AOD
Wansford Bridge u/s	8.08m. AOD	11.06m. AOD	10.90m. AOD	11.35m. AOD
Wansford G.S.	8.08m. AOD	11.00m. AOD	10.75m. AOD	10.83m. AOD

The flood had subsided by the evening of 12 April.

The peak flow has been estimated at 177 cumec, exceeding the previously calculated 100 year flow of 109 cumec. Therefore, on the basis of the comparison of recorded and predicted levels, the return period is considered to be in excess of 150 years since the 1947 event has been estimated at between 1 in 100 and 1 in 150 years.

There was no evidence to suggest that any obstructions to flow, other than the configuration of the London Road bridge, existed and all structures affecting flood discharge operated as designed.

Emergency Response

As stated above, Agency personnel together with the Police attempted to raise residents in the early hours of 12 April by knocking on doors to warn of the impending flood. This was followed by a joint operation with Regular Army soldiers to sand bag properties at risk and to evacuate residents

from their homes using small boats and larger vehicles. The Cambridgeshire Fire and Rescue Service together with the Police also responded to calls for assistance.

Possible Courses of Action

There is little doubt that the London Road bridge is a serious obstruction to flows of the magnitude experienced at Easter and realistically there is no prospect of replacing this with a structure having sufficient capacity to pass such flows.

Given the extreme nature of the Easter flood it is unlikely that an economically viable flood prevention scheme can be found to protect against a similar event in the future.

There are embryonic plans to create wetland storage areas within the Nene valley which, should they come to fruition, could benefit Wansford in reducing the frequency and severity of flooding, although these are not short term possibilities.

Extension of the flood warning and dissemination service to formally cover Wansford will be considered.

WEEDON, NORTHAMPTONSHIRE, RIVER NENE

Background

Weedon lies on a branch of the River Nene, a designated Main River, some 10km. to the west and upstream of Northampton. To the west of the village the river divides into the Newnham and Everdon Arms. The catchment upstream extends to approximately 27.50km and save for a few small villages, is entirely rural in character, run-off from developments is not an issue. The general topography is of relatively steep sided valleys underlain by clays giving rise to rapid run-off. There is a fall of some 147m. over approximately 10km. from the highest point in the catchment at Arbury Hill to the village.

The area of Weedon where properties are at risk of flooding, lies to the south of the river in a valley which is crossed by the main west coast railway line and the Grand Union canal both of which are carried on high embankments across the valley floor.

The river first flows beneath the railway in three narrow, poorly aligned culverts, each 61m. in length which are prone to siltation and blocking, before flowing through 46m. of open channel and then passing under the canal in a single arch opening 5m. in width and 47m. in length. Some 150m. upstream of the railway culverts is a twin arch road bridge which can also present an obstruction to flow.

There are a number of surface water outfalls and open watercourse tributaries to the river draining the developed area from the road bridge upstream over a distance of some 600m. It is possible for high levels in the river to 'back up' these systems.

Weedon has a history of flooding and prior to Easter the last occasion when serious property flooding occurred was in September 1992. Following this event a Grant-eligible improvement scheme was prepared by the National Rivers Authority which would have provided a 75 year standard of protection. The basis of this scheme was a flood wall to be constructed along the southern bank of the river which is fronted by a large number of private gardens. The individual residents affected could not be persuaded to accept the wall due to the height involved and the scheme was subsequently re-designed with a lower wall giving only a 25 year standard of protection. Unfortunately the tendered cost of this scheme exceeded the benefits deriving from it and consequently the works did not proceed.

Since public expectations had been raised, the Local Flood Defence Committee approved a budget of £200,000 in financial year 1997/98 to carry out some limited improvements. These works involved channel re-grading and re-sectioning over a distance of some 625m. In addition the inverts of the highway bridge were lowered and entry and exit conditions improved. The railway culverts were cleansed of silt and training works constructed on entry to them. The canal culvert was similarly cleansed. The channel upstream from the highway culvert was cleared of obstructions and two short lengths of dwarf flood wall were proposed at specific locations where the bank level was below the general level. With the exception of these walls and some minor works to surface water outfalls, all of the work had been completed prior to the Easter flood.

No assessment of the standard of protection afforded by these works has been made although the standard of protection prior to the works had been estimated at 1 in 5 years.

There is currently no provision in either Medium or Long Term Plan for any future scheme.

Flood Warning

There are no flow or level recording sites in the catchment above Weedon and the issue of flood warnings relies primarily upon information received from the local catchment based staff. However an Amber warning for Weedon is associated with a particular threshold level at Dodford gauging station situated some 1.5km. to the north on the Whilton Branch tributary which joins the Weedon Branch downstream of the village.

On the 9 April an Amber warning was issued at 15.45 hrs and a Red warning, following advice from the catchment that flooding was occurring, at 21.28 hrs. The means of dissemination of these warnings and the recipients of them are given below:

Flood Warnings and Dissemination

General broadcast of flood risk Amber affecting properties in Kislingbury, Weedon and Bugbrooke Mill, faxed to the following at 15.45 hrs on 9 April:

Kettering Catchment Office
MAFF
Northamptonshire Police
EA Public Relations Section at RHQ
EA Regional Comms. Centre
Spalding Catchment Office
BBC Radio Cambridgeshire
BBC Radio Northampton
Classic Gold (Radio)
Hereward FM (Radio)

Specific Warning of flood risk AMBER affecting properties in Kislingbury, Weedon and Bugbrooke Mill via AVM at 16.10 hrs on 9 April

117 calls made of which 110 were received

General broadcast of flood risk Red affecting properties in Weedon, faxed to the following at 21.28 hrs on 9 April:

As above **plus**
Anglian Water Services
Anglia Weather Centre
Met. Office (Norwich)
Newstel (Telex)

Specific Warning of flood risk RED affecting properties in Weedon via AVM at 21.28 hrs on 9 April

89 calls made of which 57 were received

The Amber flood warnings were successfully disseminated more than two hours in advance of flooding from Main River, thereby exceeding the current Target Level of Service in the Agency's Customer Charter.

The flood warning was cancelled at 06.11 hrs on 12 April.

Prior to the event the civils works element for a telemetered level recorder had been constructed in Weedon but the instrumentation had not been installed. Had this been operational an improved warning may have been possible.

Brief Description of Flooding

In the early hours of Thursday 9 April, very heavy rain was falling over the upper Nene catchment - at Litchborough some 5km. to the south of Weedon, 64mm. of rain was recorded in a 15 hour period from 05.00 hrs, which had an estimated return period of 50 years. This rain, falling on an already wet catchment led to rapidly rising levels in the Nene tributaries during the day.

During the course of the improvement works, local Agency personnel had developed a close working relationship with the Parish Council and individuals particularly affected by these works. Two of these people were regularly telephoning the Catchment office to provide updates on the developing situation and at approximately 17.00 hrs, the surface water sewers were reported to have been surcharging at the junction of West Street and Bridge Street with consequent road flooding occurring. At 19.00 hrs it was reported that water was beginning to overtop the south bank at Nos 1 & 3 West Street. The level in the river channel continued to rise until there was general overtopping of virtually the entire 500m. length of the southern bank above the road bridge. At this point the river level was some 3.16m. above normal. In total 45 properties were affected.

There are reports that the canal overtopped in Weedon which, if it did occur, can only have exacerbated the flooding. This has happened in previous flood events and it is known for certain that overtopping occurred in several other locations along the canal on this occasion. There is therefore good reason to believe that it was also the case in Weedon.

There were no reports of any obstructions to flow at the road bridge, railway culverts and canal culvert and subsequent inspection confirmed this.

The recorded levels, established from wrack marks and consultation with affected parties are shown in the following table together with those from previous events for comparison:

Location	March 1947	September 1992	April 1998
Road bridge u/s	80.76m AOD	80.74m AOD	81.16m AOD
Road bridge d/s	80.61m AOD	not recorded	80.85m AOD

Normal water level above the road bridge is approximately 78.00m. AOD.

The flood water had generally subsided by 03.00 hrs on the morning of the 10 April.

The return period for this event is estimated to have been in excess of 150 years on the basis of the comparison of recorded levels, the 1947 event having been estimated at between 100 and 150 years.

The 1992 event was estimated to have had a return period of 12 years but there are doubts as

to the accuracy of this and consequently it will be re-assessed.

Emergency Response

No direct action was taken by the Agency other than the issue of the flood warnings previously referred to. However it is understood that the Northamptonshire Fire & Rescue Service and the Police responded to a number of calls for assistance.

Possible Courses of Action

Since the event the Agency has constructed the two lengths of flood wall referred to previously, the fixing of flap valves to a number of surface water outfalls will also be carried out. The telemetry link will be completed to provide future level information to assist in the issue of flood warnings. The existing warning threshold at Dodford will be reviewed and it may also be that other residents will respond to a further invitation to receive flood warnings.

The responsibility for the maintenance of the surface water sewers in the village is unclear, Daventry District Council do not accept responsibility nor have they been adopted by Anglian Water. Enquiries are on-going in an attempt to resolve the situation.

Since on this occasion, considerably more properties were affected than the 12 which suffered flooding in 1992, it may be that the original scheme can be resurrected. Those individuals who opposed the work may now be persuaded of the benefit, since many of them suffered flooding within their homes on this occasion, whereas they were not affected in 1992.

A meeting is to be arranged with the Parish and District Councils during August, when the situation will be reviewed.

WELLINGBOROUGH, NORTHAMPTONSHIRE, RIVERS NENE & ISE

Background

Wellingborough lies on the north bank of the River Nene some 18km. downstream of Northampton, the catchment area upstream extends to approximately 845km².

The river Ise is a major tributary of the Nene and this flows to the east of the town before finally entering the Nene at Lower Wellingborough lock. Two tributaries of the Ise, Swanspool Brook and Harrowden Brook flow through the town and all three are designated Main Rivers.

Wellingborough has a history of flooding and this can occur solely as a result of high flows in any of the tributary streams, the most severe floods usually occurring when high flows in each of these tributaries coincide with a high flow in the Nene.

On the Nene valley there is a broad expanse of flood plain both upstream and downstream of the town although there is a distinct narrowing of this where the river flows beneath the London Road bridge.

The Nene is artificially retained for navigation by a lock and a weir at Lower Wellingborough approximately 1 km. downstream of the London Road bridge.

Within the valley upstream there has been extensive gravel abstraction over a number of years which has resulted in several large open bodies of water remaining, some of which provide additional flood storage. In addition to the significant development which has taken place in Northampton, Wellingborough itself has expanded considerably and is set to do so further in the future.

There has been considerable development in the natural flood plain in Wellingborough, some of which is relatively recent having taken place in the early 1980s with the construction of a retail park off London Road/Turnells Mill Lane and the re-development of a redundant Gas Works and coal yard into a small business park off The Embankment. The effects of these developments were mitigated against by a variety of measures including compensatory storage and the provision of a new river control structure.

There are current plans, approved in principal, for further large scale development within the flood plain of both the Nene and the Ise. However these approvals are conditional upon certain mitigation measures being put in place and some of these already exist in the form of lakes resulting from recent gravel abstraction which will provide compensatory storage once inlet and outlet structures have been constructed. Additional works to improve the channel capacity will also be necessary.

In addition to those works mentioned above there have, within the last 20 years, been major improvement schemes to the River Ise and in particular, Swanspool and Harrowden Brooks, to alleviate property flooding which had occurred frequently in the late 1970s and early 1980s. Both of these schemes were a combination of channel and structure improvements with the provision of flood storage.

Routine maintenance of the system in Wellingborough extends to annual weed cutting, clearance of obstructions and scheduled structure maintenance.

There is currently no provision within either Medium or Long Term Plan for any future scheme although, as has been stated, further flood defence works to combat the effects of development have been identified and, should they proceed, will be carried out at the expense of the developers.

Wellingborough was considered to have a standard of protection against property flooding of 50 years from both Swanspool and Harrowden Brooks and 100 years against property flooding from the Nene and Ise.

Flood Warning

No specific flood warnings were disseminated for Wellingborough since, as stated above the risk of flooding was from events with a return period of greater than 100 years from the Ise and Nene and the Agency's National Policy for Flood Warning Dissemination was that such a service would only be provided to areas at risk of flooding from events with a return period of 50 years or less.

There was no forecast flood risk associated with either Swanspool or Harrowden Brooks.

A general flood warning was broadcast at 15.45 hrs on 9 April in respect of both the River Nene and the River Ise.

Brief Description of Flooding

Flooding affecting five industrial premises on the Ise Valley Industrial Estate occurred on 10 April at approximately mid-morning due to backing up of the surface water sewers which were unable to discharge against high levels in the River Ise. This flood water subsided fairly quickly only for flooding to occur again in mid-afternoon when peak flows occurred in the River Ise. On each occasion four manufacturing units flooded to depths which varied between 0.6m. and 1.6m. The fifth unit suffered damage only to stock within the yard and water did not enter the building. At the height of the flood the level was 3.1m. above normal river level.

At the time the Agency was only aware of flooding affecting one of these units and some days had elapsed before the full extent of flooding here became known.

The last occasion on which flooding affected this site was in September 1992 when only one unit was affected.

This flooding was almost certainly exacerbated by the presence of temporary supports beneath the A.510 road bridge immediately below the site, which appear to have become partially blocked with floating debris and thereby reduced the discharge capacity. This bridge is due for replacement in the near future and these supports had been placed with the Agency's formal consent issued under Section 109 of the WRA 1991 in order to strengthen the bridge, which had been found to have inadequate load capacity to cater for the traffic using it.

So far as flooding from the River Nene is concerned, this began sometime in the afternoon of 10 April when a residential property and associated business premises at Nene Wharf began to flood. Flooding also affected Whitworths Victoria Mills and two other premises on London Road. Also affected were the A.45 underpass interchange and one half of the Turnells Mill Lane dual carriageway, with only the height of the central reservation limiting the extent of flooding.

No recently developed properties within the historical flood plain were affected.

Each of the properties which flooded has flooded previously although not all on the same occasion since some are prone to flooding from tributary streams, both ordinary watercourses and Main River. The degree to which they suffer is dependent upon the relative flows in each. On this occasion there were no reports of any out of bank flows occurring on the tributaries and the flooding was purely as a result of high levels in the Nene.

At the peak of the flood the level was 2.5m. above normal river level.

The recorded flood levels are shown in the following table for comparison with the normally retained levels and the 1947 levels. The levels predicted by the Nene Model in this area have long been considered suspect and have been found to be at variance with other model analyses carried out by prospective developers. The node points for which levels were produced do not in any case coincide with the sites of levels recorded in this and in the 1947 event. The model predicted levels are therefore not included in the tabulation.

Location	Retention level	March 1947	April 1998
Upper Wellingborough Lock u/s	41.15m. AOD	42.09m. AOD	42.14m. AOD
Upper Wellingborough Lock d/s	39.44m. AOD	41.82m. AOD	41.94m. AOD
Nene Wharf	39.44m. AOD	42.10m. AOD	Not yet recorded but evidently higher

The flood had subsided by 12 April.

The return period for this event is considered to have been between 100 and 150 years on the basis of comparison of recorded levels with those in 1947 which was estimated to have had a similar return period.

There was no evidence to suggest that any obstructions to flow other than the configuration of the London road bridge existed which would have exacerbated the degree of flooding and all control structures operated as designed.

Emergency Response

Other than the issue of the flood warning the Agency took no direct action. No calls for assistance were received although enquiries were made as to the possibility of flooding. The response to each of these enquiries was that flooding was likely and a best estimate of time was given.

The Northamptonshire Fire and Rescue Service and the Police did, it is believed, respond to numerous calls for assistance.

Possible Courses of Action

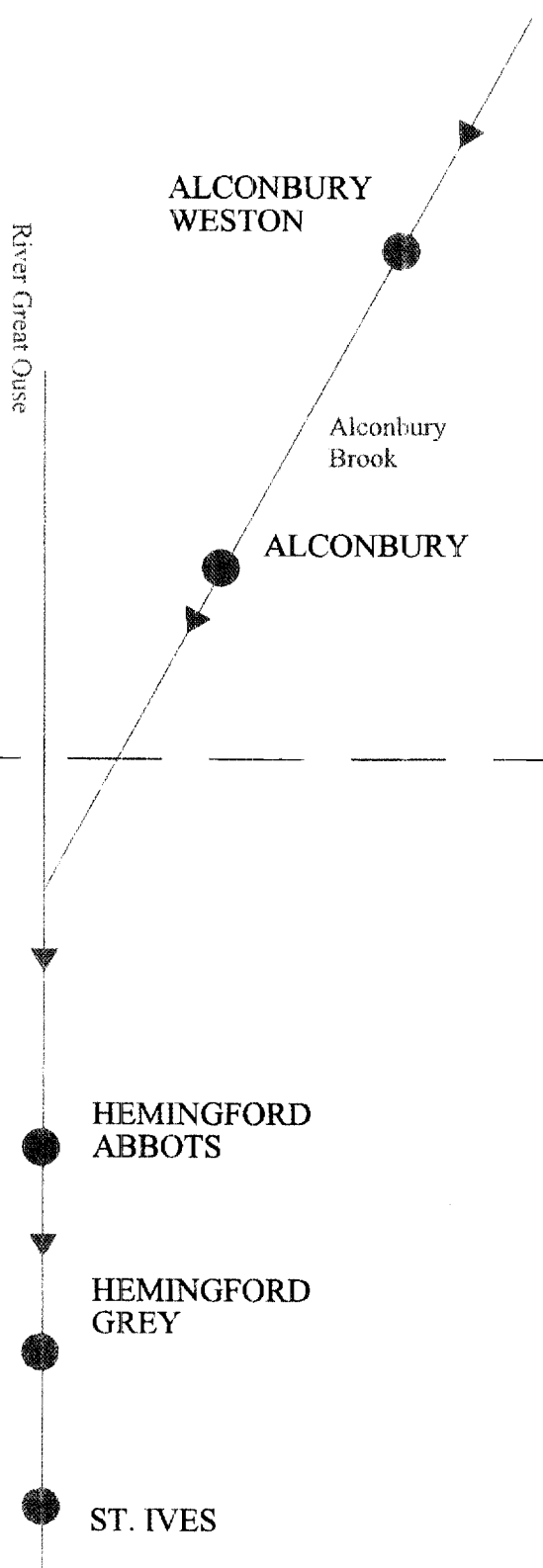
Given the extreme nature of the Easter flood it is unlikely that an economically viable flood prevention scheme can be found to protect against a similar event in the future.

There are embryonic plans to create wetland storage areas within the Nene valley which, should they come to fruition, could benefit Wellingborough in reducing the frequency and severity of flooding, although these are not short term possibilities.

Current and future development plans affecting the flood plain will be examined in the light of the Easter event.

Extension of the flood warning and dissemination service to formally cover Wellingborough will be considered.

Central Area



ANNUAL OCCURRENCE PROBABILITY

(Estimate - based on available data of variable quality)

- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

**INDEPENDENT REVIEW OF EASTER FLOODS 1998
GREAT OUSE (UPPER) CATCHMENT - FLOOD EVENTS
ST IVES TO OFFORD**

SEPTEMBER 1998

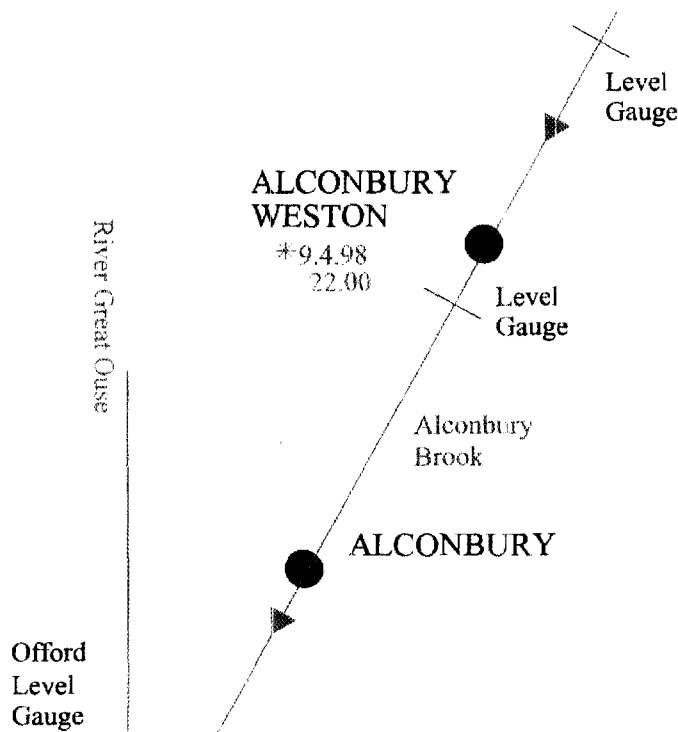
* Time first property reported flooded

AMBER	RED
9.4.98	9.4.98
16.30	19.30

Fax and phone to Cambridgeshire Constabulary

Phone to Cambridgeshire County Council Highways, Alconbury Weston Parish Council

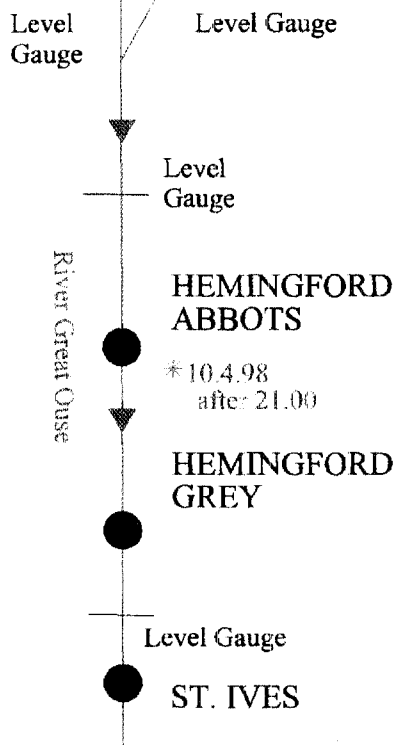
Fax to Cambridgeshire County Council (CEPO), Huntingdonshire District Council, Eastern Electricity, British Gas (Transco), Anglian Water Services, RCC, BBC Radio Cambridgeshire, Hereward Radio, Teletext, AA Roadwatch, Meteorological Office, Classic Gold, Anglia TV



AMBER	RED
10.4.98	10.4.98
02.20	08.12

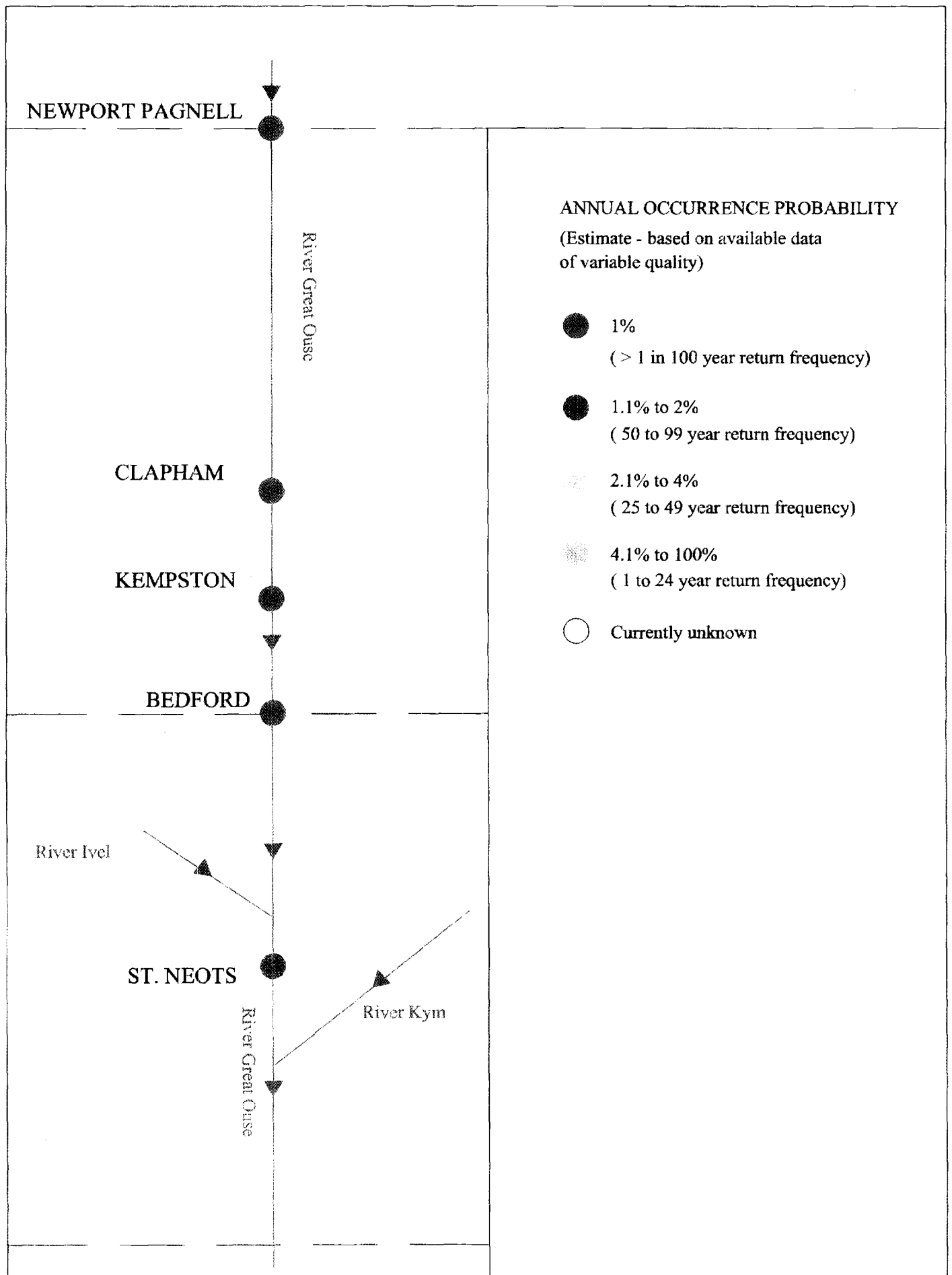
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**INDEPENDENT REVIEW OF EASTER FLOODS 1998
GREAT OUSE (UPPER) CATCHMENT - FLOOD WARNINGS
ST IVES TO OFFORD**

SEPTEMBER 1998



INDEPENDENT REVIEW OF EASTER FLOODS 1998
GREAT OUSE (UPPER) CATCHMENT - FLOOD EVENTS
OFFORD TO NEWPORT PAGNELL

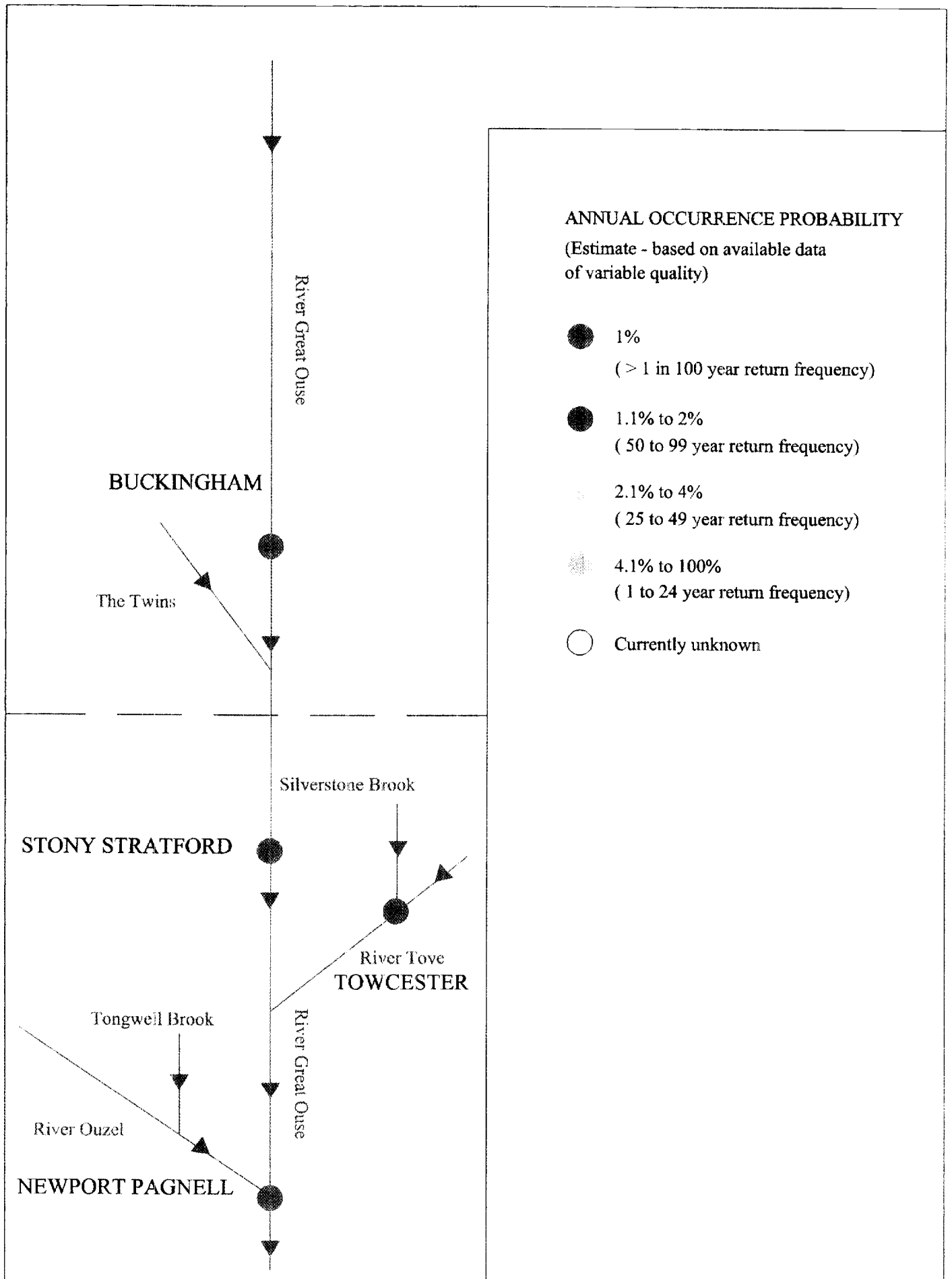
SEPTEMBER 1998

* Time first property reported flooded

<p>NEWPORT PAGNELL</p> <p>Level Gauge</p> <p>River Great Ouse</p> <p>Level Gauge</p> <p>CLAPHAM * 11.4.98 06.00</p> <p>KEMPSTON * 11.4.98 10.00</p> <p>BEDFORD * 11.4.98 12.00</p> <p>Level Gauge</p> <p>River Ivel</p> <p>Level Gauge</p> <p>ST. NEOTS</p> <p>River Great Ouse</p> <p>River Kym</p> <p>Level Gauge</p> <p>Offord</p> <p>Level Gauge</p>	<table border="1"> <tr> <td></td> <td>AMBER</td> <td>RED</td> </tr> <tr> <td>9.4.98</td> <td>9.4.98</td> <td>10.4.98</td> </tr> <tr> <td>16.41</td> <td>19.35</td> <td>05.35</td> </tr> </table> <p><u>Fax and phone</u> to Thames Valley Police, Bedfordshire Police, Bedford Borough Council Highways</p> <p><u>Phone</u> to Bedford Group of Drainage Boards, Bedford County Council Highways</p> <p><u>Fax</u> to Buckinghamshire Fire and Rescue, British Gas (Transco), Eastern Electricity, Anglian Water Services, Railtrack, RCC, BBC Three Counties Radio, Teletext, Anglia TV, AA Roadwatch, Meteorological Office Milton Keynes Council, Horizon FM103</p>		AMBER	RED	9.4.98	9.4.98	10.4.98	16.41	19.35	05.35
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9.4.98	9.4.98	10.4.98								
16.41	19.35	05.35								
<p>Level Gauge</p> <p>Level Gauge</p> <p>Level Gauge</p>	<table border="1"> <tr> <td></td> <td>AMBER</td> <td>RED</td> </tr> <tr> <td></td> <td></td> <td>11.4.98</td> </tr> <tr> <td></td> <td></td> <td>08.17</td> </tr> </table> <p><u>Fax and phone</u> to Cambridgeshire Constabulary, Bedfordshire Police, Bedford Borough Council Highways, Huntingdonshire District Council</p> <p><u>Phone</u> to Bedford Group of Drainage Boards</p> <p><u>Fax</u> to Cambridgeshire County Council CEPO, Eastern Electricity, Anglian Water Services, British Gas (Transco), RCC, BBC Three Counties Radio, Teletext, Anglia TV, AA Roadwatch, Meteorological Office BBC Radio Cambridgeshire, Hereward Radio, Classic Gold</p>		AMBER	RED			11.4.98			08.17
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**INDEPENDENT REVIEW OF EASTER FLOODS 1998
GREAT OUSE (UPPER) CATCHMENT - FLOOD WARNINGS
OFFORD TO NEWPORT PAGNELL**

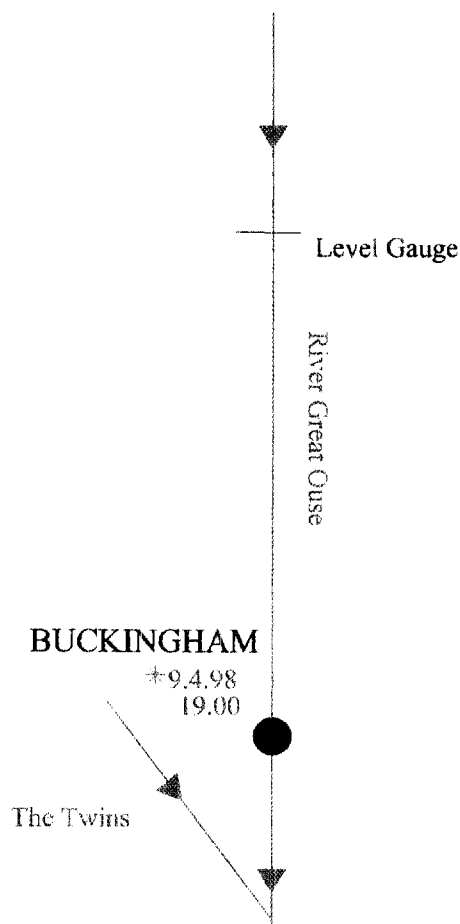
SEPTEMBER 1998



INDEPENDENT REVIEW OF EASTER FLOODS 1998
GREAT OUSE (UPPER) CATCHMENT - FLOOD EVENTS
NEWPORT PAGNELL TO BUCKINGHAM

SEPTEMBER 1998

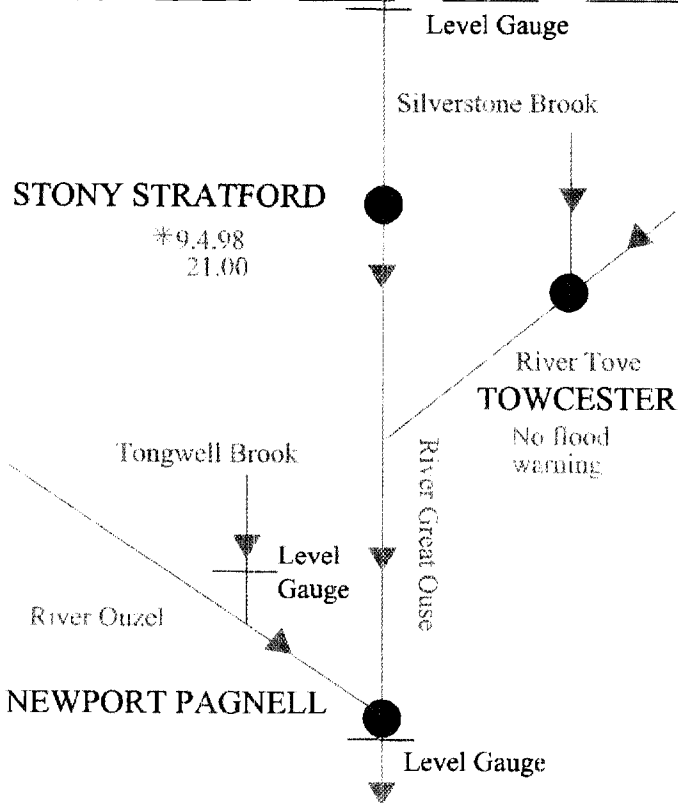
* Time first property reported flooded



AMBER	RED
9.4.98	
17.17	

Fax and phone to Thames Valley Police

Fax to Buckinghamshire Fire and Rescue, British Gas (Transco), Eastern Electricity, Anglian Water Services, Railtrack, RCC, BBC Three Counties Radio, Teletext, Anglia TV, AA Roadwatch, Meteorological Office



AMBER	RED
10.4.98	
01.15	

Fax and phone to Thames Valley Police

Phone to Bedford Group of Drainage Boards

Fax to Buckinghamshire Fire and Rescue, British Gas (Transco), Eastern Electricity, Anglian Water Services, Railtrack, RCC, BBC Three Counties Radio, Teletext, Anglia TV, AA Roadwatch, Meteorological Office, Horizon FM103

**INDEPENDENT REVIEW OF EASTER FLOODS 1998
 GREAT OUSE (UPPER) CATCHMENT - FLOOD WARNINGS
 NEWPORT PAGNELL TO BUCKINGHAM**

SEPTEMBER 1998

THE ALCONBURYS, ALCONBURY BROOK

Background

The Alconburys consist of the villages of Alconbury Weston (National Grid reference TL1877) and Alconbury (National Grid reference TL1976). They are both situated on the Alconbury Brook, which rises approximately 15 km to the north west of Alconbury Weston, of which 7 km is designated "Main River". It then flows generally in a south easterly direction through Alconbury Weston and Alconbury (which is a further 2 km downstream) until it reaches the River Great Ouse at a point 11 km downstream of Alconbury village.

The Catchment area upstream of Alconbury Weston is approximately 77 km², and 79 km² upstream of Alconbury. Both Catchment areas are predominantly clay.

The river upstream of Alconbury flows through gently undulating countryside. Downstream of Alconbury the land is flat with, in general, extensive flood plain.

Land use along the Alconbury Brook is mainly intensive arable. Localised infill housing development has taken place in the two villages over recent years.

Extensive flooding occurred in both villages in 1947, 1968 (highest on record prior to 1998) and 1987, when roads and property were affected. No records of properties flooded in 1947 are available. Minor flooding of property occurred in the villages in 1953. In 1968 approximately 87 properties were affected by flooding in the villages, to an approximate maximum depth of 1.20 m.

In 1987, the roads beside the brook in the villages became impassable for 24 hours. Few actual properties had water in them, but more than 100 plus gardens were flooded in Alconbury. The flooding of 1987 recorded the highest levels since 1968. In 1992 flooding occurred again.

In 1996 an appraisal was undertaken by the Agency's predecessor, the National Rivers Authority. This investigated the flood defence standard of service in the Alconburys but concluded that under Treasury economic appraisal guidelines improvements were not economically justified with a benefit to cost ratio below 1.0.

No formal flood defences exist in the Alconburys. The Agency aims to maintain the river channel to provide capacity for flood flows of approximately 1 in 10 year return period. Due to the topography of the flood plain significant flood plain exists both upstream and downstream of the villages. Many of the properties within the villages lie in the floodplain and can be affected by flood water during events with return periods of around 1 in 15 years and greater.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system

and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with Emergency Services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The Alconbury Brook is designated "Main River" and Alconbury and Alconbury Weston were considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Control Centre are informed. During the Easter flood event this was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations.

The warnings given for this area are based on flows at Hamerton and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
9/4/98	Amber	ON	15.30hrs	16.30hrs	
9/4/98	Red	ON	18.50hrs	19.30hrs	22.00hrs

Some delays occurred with issuing alarms for the Alconburys in part due to their triggering coinciding with significant incoming calls from members of the public. However, alarms were raised more than two and a half hours prior to the first reported property flooding.

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into the already saturated Catchment, led to the highest river levels ever seen in the Alconbury Brook at Alconbury and Alconbury Weston.

The return period of the Easter event has been estimated as 1 in 125 years. A comparison of peak water levels for this and previous exceptional events are given below. An indication of the speed with which the river level rose is also given.

Alconbury

Event	Peak Level	Indication of Water Level Rise
1947	16.85 m AODN	
1968	17.15 m AODN	
1998	17.25 m AODN	1.7m in 10 hours

Alconbury Western

Event	Peak Level	Indication of Water Level Rise
1947	18.20 m AODN	
1968	18.50 m AODN	
1998	18.64 m AODN	1.7m in 10 hours

The return period of the rainfall event in this area has been estimated at between 1 in 80 and 1 in 140 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Alconbury and Alconbury Weston, which are not protected by any flood defences, started receiving the peak flows from the upper reaches of the Brook and its tributaries during the night of Thursday, 9th April and peaked the next morning. During this time, property flooding occurred: 91 properties were affected in the Alconburys.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from midnight on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards to identify possible flood defence improvements. (In hand).
4. Develop local self help group for dissemination of flood warnings. (In hand - completion due 9/98).
5. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand).

BEDFORD, RIVER GREAT OUSE (UPPER)

Background

Bedford is a high density urban community located on the River Great Ouse in the county of Bedfordshire. The National Grid reference is TL 0549.

The River Great Ouse rises approximately 130 km to the west of Bedford, of which 124 km is designated "Main River", and flows generally in an easterly direction through numerous villages and the towns of Brackley, Buckingham, Stony Stratford, Milton Keynes, Newport Pagnell and Kempston, thence through the centre of Bedford.

The Catchment area of the River Great Ouse upstream of the town is 1467 km² and predominantly clay.

The river flows through undulating countryside supporting a mixture of arable farming and pasture.

Major development, both housing and industrial, has taken place in Bedford over recent years.

During high flows, large areas of flood plain are utilised upstream and downstream of the town. In addition through the town, open 'riverside walk' areas are flooded and assist with passing flood flows.

Bedford flooded in 1947 when large areas of the town were inundated from the River Great Ouse although there is no record available of the actual number of properties affected. Using computational and physical models the return period of the 1947 event has been estimated at between 1 in 250 years and 1 in 500 years. Despite the extent of the modelling, the wide ranging return period is due to the complexity of this determination and only 30 years' historic data being available. In 1992 it was recorded that one property was flooded in the town and a further property had its access disrupted.

No formal flood defences exist in this location. The Agency aims to maintain the river channel to provide capacity for flood flows of between a 1 in 50 and 1 in 100 year return period.

Flood Warning

In September 1996 the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date this role was carried out by the Police. Since September 1996 methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

- Red risk of serious flooding affecting properties, roads, etc.
- Amber risk of flooding to isolated properties, roads and large areas of farmland.
- Yellow flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "Main River" and Bedford was considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communication Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on the flows at Bedford and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
11/4/98	Red	ON	10.42hrs	08.17hrs	12.00hrs

The Red alarm for Bedford was predicted by flood forecasting and issued ahead of it actually triggering in order to improve the warning to recipients.

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into a largely saturated Catchment, led to the highest river levels seen in the River Great Ouse at Bedford since the historic floods of 1947.

The return period of the Easter event has been calculated by using both computational methods and a previous physical model - a return period of approximately 1 in 125 years was determined. A comparison of peak water levels for this and previous exceptional events are given below. An

indication of the speed with which the river level rose is also given.

Event	Peak Level	Indication of Water Level Rise
1947	26.27 m AODN	
1992	25.52 m AODN	
1998	26.18 m AODN	0.6 m in 12 hours

The return period of the rainfall event in this area has been estimated at a 1 in 35 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Bedford, which is not protected by any formal flood defences, started receiving the peak flows from the upper reaches of the Ouse and its tributaries on Saturday, 11th April and peaked that evening. During this time property flooding occurred: 45 houses and 9 non-residential buildings were affected and large areas of natural flood plain were inundated with flood water. Staff were unable to monitor levels at Bedford once the monitoring station had reached a level of 26.0 m AODN as the site drowned out at this level. The flood water started receding by lunchtime the following day, Sunday, 12th April.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
4. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand).
5. Develop and implement direct flood warning systems where appropriate
6. Investigate position and height of water monitoring station. (In hand).

BUCKINGHAM, RIVER GREAT OUSE (UPPER)

Background

Buckingham, (National Grid reference SP7034) in the county of Buckinghamshire, is situated on the upper reaches of the River Great Ouse which rises approximately 30 km to the west, of which 24 km is designated "Main River" and flows in an easterly direction towards the town via Brackley.

The Catchment area of the River Great Ouse upstream of Buckingham is approximately 149 km² and predominantly clay.

The river flows through undulating rural countryside supporting a mixture of arable farming and pasture.

Development, both housing and industrial, has taken place in Buckingham and Brackley over recent years.

Buckingham has a history of flooding from the River Great Ouse. Severe flooding was experienced in 1939, 1947 and in 1979, when approximately 45 residential and 8 industrial properties were affected. Property flooding has not been recorded since.

A flood alleviation scheme was carried out through Buckingham in the early 1980s to improve the efficiency of the river channel. No hard flood defences exist. The Agency aims to maintain the river channel to provide capacity for flood flows up to approximately a 1 in 20 year return period.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events

no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "Main River" and Buckingham was considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on the flows Brackley and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
9/4/98	Amber	ON	17.05hrs	17.17hrs	19.00hrs

The Brackley Gauging Station has not before experienced an event of this magnitude. The Red alarm trigger flow had been established through hydrological modelling of the local area: historic data for the model was limited and did not include events of this magnitude. The Easter flood did not reach the trigger level and hence a Red alarm was not issued.

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into a largely saturated Catchment, led to the highest river levels seen in the River Great Ouse at Buckingham since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 125 years. A comparison of peak water levels for this and previous exceptional events is given below. The Easter 1998 peak water level in Buckingham is the highest on record.

Event	Peak Level
1947	78.85 m AODN
1979	78.73 m AODN
1998	79.11 m AODN

The return period of the rainfall event in this area has been estimated at 1 in 35 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Buckingham, which is not protected by any formal flood defences, started receiving the peak flows from the upper reaches of the Ouse in the afternoon of Thursday, 9th April and peaked later on that day. During this time, property flooding occurred - 25 houses and five non-residential buildings were affected. The flood water started receding by night-time.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Revise trigger level for Red alarm at Brackley Gauging Station. (Completed)
4. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
5. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand).
6. Further develop and implement direct flood warning systems where appropriate

CLAPHAM, RIVER GREAT OUSE (UPPER)

Background

Clapham (National Grid reference TL0353) in the County of Bedfordshire, is situated 13 km upstream of the town of Bedford. The River Great Ouse rises approximately 117 km to the west, of which 111 km is designated "Main River" and flows generally in an easterly direction through Brackley, Buckingham, Stony Stratford, Milton Keynes and Newport Pagnell before reaching Clapham, where it flows along the south westerly side of the village.

The Catchment area of the River Great Ouse upstream of Clapham is approximately 1398 km² and predominantly clay.

The river flows through undulating countryside, supporting a mixture of arable farming and pasture: this extensive rural flood plain from Newport Pagnell to Clapham serves to dissipate all but exceptional flood events.

Development, mainly housing, has taken place in the town over recent years.

Clapham was affected by flooding in 1947, but there is no record available of the number of properties affected. In 1947, the A6 trunk road through the village was affected by flood water, but it was only necessary to close it for two days, when there was 450 mm of water on the road. Property flooding has not been recorded in Clapham in the last 50 years.

No formal flood defences exist in this location. The Agency aims to maintain the river channel to provide capacity for flood flows of approximately 1 in 10 year return period. Property flooding in Clapham has not occurred since 1947. Due to the topography of the flood plain in this location the return period at which property flooding occurs is greater than 1 in 50 years.

Flood Warning

In September 1996 the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets

to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "Main River" and Clapham was considered to be at risk from flooding in exceptional events. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on flows in Newport Pagnell and area listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
9/4/98	Yellow	ON	16.37hrs	16.41hrs	
9/4/98	Amber	ON	19.30hrs	19.35hrs	
10/4/98	Red	ON	05.30hrs	05.35hrs	
11/4/98					06.00hrs

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into the already saturated Catchment, especially in the upper reaches of the Bedford Ouse, led to the highest river levels seen in the River Great Ouse at Clapham since the historic floods of 1947.

The return period of the Easter event has been calculated as 1 in 125 years. A comparison of peak water levels for this and previous exceptional events is given below.

Event	Peak Level
1947	32.32m AODN
1998	32.08m AODN

The return period of the rainfall event in this area has been estimated at 1 in 35 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Clapham, which is not protected by any formal flood defences, started receiving the peak flows from the upper reaches of the Ouse and its tributaries in the early hours of the morning of Saturday, 11th April and peaked around lunchtime. During this time, property flooding occurred - 13 houses and four non-residential buildings were affected. None of the affected properties are of recent construction. The flood water started falling by the evening.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Existing flood warning arrangements will be investigated to identify possible improvements.
4. Further develop and implement Direct flood warning systems where appropriate.

THE HEMINGFORDS, RIVER GREAT OUSE (UPPER)

Background

The Hemingfords is an area consisting of the two villages of Hemingford Abbots (National Grid reference TL 2871) and Hemingford Grey (National Grid reference TL3070). The River Great Ouse runs along the north east side of Hemingford Abbots and the north west side of Hemingford Grey. Hemingford Abbots is just upstream of Hemingford Grey and both villages are approximately 3 km upstream of the town of St Ives.

The River Great Ouse rises approximately 177 km west of The Hemingfords, of which 171 km is designated "Main River" and flows towards the two villages via Buckingham, Milton Keynes, Newport Pagnell, Bedford, St Neots and Huntingdon. The main tributaries that join the River Great Ouse before it reaches the Hemingfords are the River Twins, River Tove, River Ouzel, River Ivel, River Kym and the Brampton, Alconbury and Ellington Brooks.

The Catchment area of the River Great Ouse upstream of the Hemingfords is 2836 km² and predominantly clay.

Large areas of flood meadows are an important feature of the river valley in the area and little arable farming takes place locally.

Localised housing development has taken place in the two villages during recent years.

The area in and around the Hemingfords has a history of flooding from the River Great Ouse and flooding affected the villages in 1947. Hemingford Grey Mill House was flooded in 1947; however, the total number of properties affected is not recorded.

Hemingford Abbots and Hemingford Grey, are partly protected from flooding by the Hemingford Flood Bank. This is a historic bank dating back many years and has an existing level of protection of approximately 1 in 50 years. Its origin is unknown and it has not been maintained by the Agency. The Agency aims to maintain the river channel in this location to provide capacity for flood flows of approximately a 1 in 20 year return period. Significant floodplain exists through the Hemingford area.

Flood Warning

In September 1996 the Agency took over the lead role for disseminating flood warnings and a five-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996 methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line has also been introduced, Floodcall, which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination

improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated, if necessary, as an event progresses.

The River Great Ouse is designated "Main River" and Hemingford Abbots and Hemingford Grey were considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. During the Easter flood event this was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on flows at Offord and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
10/4/98	Amber	ON	02.15hrs	02.20hrs	
10/4/98	Red	ON	08.12hrs	08.12hrs	after 21.00hrs

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling onto the already saturated Catchment, led to the highest river levels seen in the River Great Ouse at Hemingford Abbots and Hemingford Grey since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 75 years. A comparison of peak

water levels for this and previous exceptional events is given below. An indication of the speed with which the river level rose is also given.

Event	Peak Level	Indication of Water Level Rise
1947	7.62 m AODN	
1998	7.51 m AODN	1.0m in 24 hours

The return period of the rainfall event in this area has been estimated at 1 in 25 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

The villages started receiving the peak flows from the Ouse and its tributaries during the night of Friday, 10th April. The Hemingford Flood Bank overtopped in many places. During this time, property flooding occurred - 56 properties were affected and large areas of natural flood plain were inundated with flood water and peaked in the early hours of Monday, 13th April. The flood water started falling slowly over the next couple of days, but due to high tides restricting the river flow and poor drainage from low lying areas, it remained high for several days after.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Undertake a topographic survey of the Hemingford Flood Bank to identify low spots. (Completed)
3. Implement flood defence works to raise low spots and achieve full flood defence potential of bank. (In hand)
4. Prepare flood maps for Easter floods. (In hand)
5. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand)
6. Identify any potential for flood defence improvements works.
7. Establish local self help group for dissemination of flood warnings. (In hand - completion due 9/98).
8. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand).

NEWPORT PAGNELL, RIVER GREAT OUSE (UPPER)

Background

Newport Pagnell in Buckinghamshire is a high density urban community located immediately north east of Milton Keynes, at the confluence of the River Great Ouse and the River Ouzel. The National Grid reference is SP8743.

The River Great Ouse rises approximately 64 km to the west, of which 58 km is designated "Main River" and flows in an easterly direction through Brackley, Buckingham, Stony Stratford and Milton Keynes towards the town. The River Ouzel rises approximately 42 km to the south, of which 33 km is designated "Main River" and flows in a northerly direction towards the town, through Leighton Buzzard, Bletchley and Milton Keynes.

The Catchment area of the River Great Ouse upstream of Newport Pagnell is 800 km² and the River Ouzel 363 km². Both Catchment areas are predominantly clay. The River Great Ouse and River Ouzel flow through undulating countryside, supporting a mixture of arable farming and pasture.

Over the last 25 years the city of Milton Keynes has been created from open countryside and covers an area of approximately 9,000 hectares (90 km²). Development, both housing and industrial, has also taken place over recent years in all of the above towns.

Newport Pagnell has a history of fluvial flooding from both the River Great Ouse and River Ouzel. Severe flooding was experienced in March 1947 by flood waters from both rivers: the number of properties flooded is not recorded. In September 1992, nine residential and six industrial properties were flooded largely from flood waters overtopping the banks of the River Ouzel. Access was disrupted to an estimated further 100 residential and three industrial properties.

Following the floods in 1992 a detailed appraisal of the standard of flood defence in Newport Pagnell was undertaken. Flooding of the town is complex as two river systems are involved. The appraisal concluded that whilst the existing standard of flood defence was below the indicative at this location, using Treasury economic appraisal guidelines improvements were not economically justified with a benefit to cost ratio below 1.0. The Agency did however undertake significant in-channel and flood plain works from its revenue budget to improve the situation albeit that the standard of defence remains below the indicative.

No formal flood defences exist in this location. The Agency aims to maintain the river channels to provide capacity for flood flows with return periods of approximately 1 in 10 to 1 in 20 years.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996 methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system

and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. Discussions with residents and local Authorities in Newport Pagnell had commenced prior to Easter to establish a local self help group. Unfortunately, this had not been finalised and thus no Direct flood warning methods were in place at that time.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "Main River" and Newport Pagnell was considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. During the Easter flood event this was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on flows at Newport Pagnell and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
9/4/98	Yellow	ON	16.37hrs	16.41hrs	
9/4/98	Amber	ON	19.30hrs	19.35hrs	
10/4/98	Red	ON	05.30hrs	05.35hrs	18.00hrs

Brief Description of Flooding

Heavy rainfall during Thursday 9th April into Friday 10th April, falling into the already saturated Catchment, especially in the upper reaches of the Bedford Ouse, led to the highest river levels seen in the River Great Ouse at Newport Pagnell since the historic floods of 1947.

The return period for the River Ouse flooding, which largely affected the west side of Newport Pagnell, has been estimated as a 1 in 125 year event. The River Ouzel, which affected only a small number of properties on the south and east sides of the town experienced an event of around a 1 in 35 year return period. Matters were made worse on the River Ouzel as waters naturally backed up from the confluence with the River Ouse.

A comparison of peak water levels for this and previous exceptional events is given below. These levels were recorded on the River Ouse at the confluence with the River Ouzel. An indication of the speed with which the river level rose is also given.

Event	Peak Level	Indication of Water Level Rise
1947	55.12 m AODN	
1992	55.06 m AODN	
1998	55.12 m AODN	1.5m in 10 hours

The return period of the rainfall events in this area have been estimated at between 1 in 20 and 1 in 35 years. Rainfall events up to 1 in 140 year return periods were recorded to the west of Newport Pagnell in the catchments of the Ouse and Tove rivers. In general, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Newport Pagnell, which is not protected by any flood defences, started receiving the peak flows from the upper reaches of the Ouse and Ouzel (this includes surface water discharge from Milton Keynes Balancing Lakes) during the evening of Thursday, 9th April and peaked in the early hours of Friday, 10th April. During this time, property flooding occurred - 78 houses and 1 non-residential building were affected and large areas of natural flood plain were inundated with flood water. The greatest number of properties flooded in the Lakes Lane area mainly as a result of flood waters overtopping the banks of the River Ouse. High water levels in the River Ouse made water back-up in the River Ouzel which subsequently caused further flooding of a few low lying properties but was less extensive than in 1992. The flood water started falling by mid afternoon.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local

Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.

- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
4. Review previous flood defence appraisal for Newport Pagnell in light of Easter event to identify possibility of any improvement works. (In hand).
5. Undertake minor works to provide some additional flood protection improvements to Lakes Lane. (In hand - due completion 12/98)
6. Establish local self help group for dissemination of flood warnings. (In hand - completion due 9/98).
7. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand).

ST IVES, RIVER GREAT OUSE (UPPER)

Background

St Ives, in the county of Cambridgeshire, is situated on the River Great Ouse, 26 km downstream of St Neots and 50 km downstream of Bedford. The National Grid reference is TL 3172.

The River Great Ouse rises approximately 180 km west of St Ives, of which 174 km is designated "Main River" and flows generally in an easterly direction towards the town via Buckingham, Milton Keynes, Newport Pagnell, Bedford, St Neots and Huntingdon. The main tributaries that join the River Great Ouse before it reaches St Ives are the River Twins, River Tove, River Ouzel, River Ivel, River Kym and the Brampton, Alconbury and Ellington Brooks.

The Catchment area of the River Great Ouse upstream of St Ives is approximately 2845 km² and predominantly clay. The surrounding land is generally flat; large areas of flood meadow are an important feature on either side of the river with little arable farming taking place locally. Major development, both housing and industrial, has taken place in St Ives over recent years.

Parsons Drove Drain is a tributary of the River Ouse and is classed as 'Main River'. It joins the River Ouse at Holywell in St Ives. Parsons Drove Drain has two major tributaries. These are Heath Drain, serving a mainly rural catchment, and Houghton Field Drain receiving water from an intensive urban catchment. Houghton Field Drain is classed as an 'Awarded Drain' maintained by Huntingdonshire District Council.

The area in and around St Ives was affected by extensive flooding in 1947. No records of properties flooded are available. However, it was estimated at the time that at least half of St Ives went under water, with the deepest water in any house being just over 300 mm. Since 1947 during very high river flows the flood plain has been inundated upstream and downstream of the town.

No formal flood defences exist in St Ives. The Agency aims to maintain the channel of the River Ouse to provide capacity for flood flows of approximately a 1 in 20 year return period. Due to the topography of the flood plain in this location the return period at which property is flooded from the River Ouse is estimated as 1 in 50 years.

In 1996 the Agency undertook an appraisal of the flood protection afforded by the Parsons Drove Drain and the 'Awarded Drain' tributaries. The appraisal recommended dredging of the Parsons Drove Drain: this was undertaken by the Agency in 1997. Recommendations made regarding the Awarded Drains were brought to the attention of the District Council. The Council have fulfilled some of these recommendations but are currently reviewing the need for further investment. The standard of service of the Drain system is approximately 1 in 10 years.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse and Parsons Drove Drain are designated "Main River" and St Ives was considered to be at risk from flooding. During the Easter flood event broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on flows at Offord and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
10/4/98	Amber	ON	02.15hrs	02.20hrs	
10/4/98	Red	ON	08.12hrs	08.12hrs	
11/4/98					12.00hrs

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into the already saturated Catchment, especially in the upper reaches of the Ouse, led to the highest river levels seen in the River Great Ouse at St Ives since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 75 years. A comparison of peak water levels for this and previous exceptional events is given below. An indication of the speed with which the river level rose is also given.

Event	Peak Level	Indication of Water Level Rise
1947	7.00 m AODN	
1998	6.71 m AODN	1.0m in 24 hours

The return period of the rainfall event in this area has been estimated at 1 in 25 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

The River Ouse through St Ives is affected by tides. The tidal limit is approximately 8km downstream at Brownhill Sluice and as high tide approaches the evacuation of fluvial water is slowed or stopped. This situation is reversed as the tide turns. This effect will have slowed the evacuation of flood waters but is not considered to have significantly increased the depth or extent of flooding.

The area started receiving the peak flows from the Ouse and its tributaries during the night of Friday, 10th April and peaked in the early hours of Monday, 13th April. During this time, six houses and thirty caravans were affected on the south side of the river and large areas of natural flood plain were inundated. Flooding of five commercial properties near Parsons Drove Drain and Houghton Field Drain also occurred. The flood waters started falling slowly over the next couple of days, but due to high tides which restricted the discharge of water, remained high for several days after.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.

- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards on Main River. (In hand).
4. Investigate through Huntingdonshire District Council the standards of service and maintenance of the Awarded drains and their plans for possible improvements.
5. Investigations at Hemingford Grey will include the area on the River Ouse south bank where the six flooded houses are located. (In hand)
6. Existing flood warning arrangements will be investigated to identify possible improvements.

ST NEOTS, RIVER GREAT OUSE (UPPER)

Background

St Neots, (National Grid reference TL1860) in the county of Cambridgeshire, is situated on the River Great Ouse 24 km downstream of Bedford.

The River Great Ouse rises approximately 154 km west of St Neots, of which 148 km is designated "Main River" and flows generally in an easterly direction towards the town via Buckingham, Milton Keynes, Newport Pagnell and Bedford. The main tributaries that join the River Great Ouse before it reaches St Neots are the River Twins, River Tove, River Ouzel and River Ivel.

The Catchment area of the River Great Ouse upstream of St Neots is 2266 km² and predominantly clay. Between Bedford and St Neots the River Great Ouse flows through gently undulating countryside with extensive river valley flood plains. Land in the area is mainly arable with some pasture and amenity use.

Major development, both housing and industrial, has taken place in and around St Neots over recent years.

St Neots has a history of flooding and in 1947 large areas of the town and the adjacent populated areas of Eaton Socon and Eynesbury were affected by flooding, although there is no record available of properties affected. During high river flows through the town, large areas of flood plain are inundated upstream and downstream of the town.

No formal flood defences exist in this location. The Agency aims to maintain the river channel to provide a flood defence standard of service of approximately 1 in 20 years. Due to the topography of the flood plain in this location the return period at which property flooding occurs is approaching 1 in 50 years.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A

programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "main" river and St Neots was considered to be at risk from flooding. During the Easter flood event broadcast methods of flood warnings set up for this area were implemented by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The Red alarm for Bedford was predicted by flood forecasting and issued ahead of it actually triggering in order to improve the warning to recipients.

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
11/4/98	Red	ON	10.42hrs	08.17hrs	
12/4/98					03.00hrs

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into the already saturated Catchment, especially in the upper reaches of the Bedford Ouse, led to the highest river levels seen in the River Great Ouse at St Neots since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 75 years. A comparison of peak water levels for this and previous exceptional events is given below. An indication of the speed with which the river level rose is also given.

Event	Peak Level	Indication of Water Level Rise
1947	16.08 m AODN	
1998	15.84 m AODN	0.4m in 10 hours

Rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

St Neots started receiving the peak flows from the upper reaches of the Ouse and its tributaries on Sunday, 12th April and peaked about lunchtime. During this time, property flooding occurred - 20 houses, six non-residential buildings and five caravans were affected and large areas of natural flood plain were inundated with flood water. The flood water started receding by the evening.

The majority of property flooding was in The Paddocks, a new development within the 1947 flood plain. Through the statutory planning process the Agency's predecessor, the NRA, repeatedly requested that property floor levels should be constructed above the 1947 flood level. The Planning Authority refused to implement this request.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
4. Further liaise with Planning Authority to develop increased awareness of implications of flood plain development.
5. Existing flood warning arrangements will be investigated to identify possible improvements. (In hand)

STONY STRATFORD, RIVER GREAT OUSE (UPPER)

Background

Stony Stratford in Buckinghamshire is situated just within the western boundary of Milton Keynes. The National Grid reference is SP7940.

The River Great Ouse, which flows around the west and north sides of the town, rises approximately 47 km to the west, of which 41 km is designated "Main River" and flows in an easterly direction through Brackley and Buckingham towards the town.

The Catchment area of the River Great Ouse upstream of Stony Stratford is approximately 482 km² and predominantly clay.

The river flows through undulating rural countryside supporting a mixture of arable farming and pasture. Development, mainly housing, has taken place in the town over recent years.

Stony Stratford was affected by flooding in 1947, but there is no record available of the number of properties affected. Property flooding has not been recorded over the past 50 years

No formal flood defences exist in Stony Stratford. The Agency aims to maintain the river channel to provide capacity for flood flows of approximately 1 in 10 year return period. Due to the topography of the flood plain in this location the return period at which property flooding occurs is approximately 1 in 40 years.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events

no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Great Ouse is designated "Main River" and Stony Stratford was considered to be at risk from flooding. Broadcast methods of flood warnings set up for this area were issued by the Area Flood Warning Dissemination staff, in accordance with the Area Flood Warning Manual.

Once an alarm level had been reached the relevant Emergency Services, Local Council and Public Utilities for this area and the Environment Agency's local Catchment office and Regional Communications Centre were informed. This was done either by direct telephone call and/or fax facility. The media was also informed of the current alarm situations for subsequent public address

The warnings given for this area are based on flows at Thornborough and are listed below:-

Date	Alarm	Status	Time Triggered	Time Warning Issued	Time Significant Flooding Reported
9/4/98					21.00hrs
10/4/98	Amber	ON	01.10hrs	01.15hrs	

During the period of high flows at Thornborough Gauging Station the instrumentation failed and it is now believed that the red phase warning status for this area was reached but not triggered.

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling onto the already saturated Catchment, especially in the upper reaches of the Bedford Ouse, led to the highest river levels seen in the River Great Ouse at Stony Stratford since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 125 years. A comparison of peak water levels for this and previous exceptional events is given below. An indication of the speed with which the river level rose is also given. The severity of the 1998 event is highlighted by the peak water level being 500mm higher than even in 1947.

Event	Peak Level	Indication of Water Level Rise
1947	65.48 m AODN	
1998	64.98 m AODN	0.6m in 7 hours

The return period of the rainfall event in this area has been estimated at a 1 in 35 years. However, rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Stony Stratford started receiving the peak flows from the upper reaches of the Ouse and its tributaries in the evening of Thursday, 9th April and peaked shortly afterwards. During this time, property flooding occurred - nine houses and four non-residential buildings were affected. The flood water started receding during the night of Friday, 10th April.

Emergency Response

Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass flood warnings and relevant information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested.

Possible Courses of Action

1. Undertake level surveys of flood affected properties. (Completed).
2. Prepare flood maps for Easter floods. (In hand).
3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
4. Update plans used in consultations for development in the flood plain.
5. Investigate reasons for the failure of Thornborough Gauging Station and pursue works to remedy any problems. (In hand)
6. Existing flood warning arrangements will be investigated why warnings were not issued sufficiently early and identify improvements. (In hand).

TOWCESTER , RIVER TOVE

Background

Towcester (National Grid reference SP6948) in the County of Northamptonshire, is situated on the River Tove, which rises approximately 17 km to the west of the town, of which 4 km is designated "Main River".

Downstream of Towcester the river flows for 21 km before entering the River Great Ouse at Cosgrove Park. The Silverstone Brook, of which 1.6 km is designated "Main River", flows in a south easterly direction towards Towcester, joining the River Tove immediately downstream of the town.

Towcester is situated near the top of the River Tove catchment. The Catchment area upstream of the town is approximately 105 km² (126 km² including the Silverstone Brook) and is predominantly clay.

The surrounding land is undulating and supports a mixture of arable farming and pasture.

Major development, mainly housing, has taken place in Towcester over recent years.

The town has a history of flooding. In 1947 the A5 was flooded to a depth of 450 mm. Some properties were flooded, but no records are available. Higher levels were recorded in parts of the town in 1939. Roads and property were again affected by flooding in 1968 and 1992.

No formal flood defences exist in this location. The Agency aims to maintain the river channel to provide a flood defence standard of service of approximately 1 in 35 years.

Flood Warning

In September 1996, the Agency took over the lead role for disseminating flood warnings and a 5-year improvements plan commenced. Prior to this date, this role was carried out by the Police. Since September 1996, methods used to disseminate flood warnings have been developed. These methods are generally categorised as 'Broadcast' or 'Direct'. Broadcast methods of flood warning now make much greater use of the media, particularly local radio stations and Teletext services on television. A recorded telephone information line, Floodcall, has also been introduced which gives up to date information of warnings in force. Direct methods seek to offer flood warnings to individual members of the public in flood risk areas: methods include use of the telephone system and local self help groups.

The Agency's policy is to provide a flood warning service to locations known to be at risk from "Main River" flooding - priority is given to those locations where the return period is 1 in 50 years or less. This policy is currently being implemented through the 5-year flood warning dissemination improvement plan.

The first phase of the 5-year plan for flood warning dissemination improvements has been completed. The Agency now has in place Broadcast methods of flood warning dissemination to the public and Flood Warning Dissemination Plans with emergency services and Authorities. A programme was established to raise public awareness of flood risks by issuing information leaflets to those properties believed to be at risk from flooding.

The second phase of the improvements plan will establish Direct flood warning arrangements to priority areas. The Agency has only recently embarked on this phase and prior to the Easter events no Direct systems were in place.

Alarms are issued based upon the likely extent of predicted flooding and the land use. The following definitions are used :-

Red	risk of serious flooding affecting properties, roads, etc.
Amber	risk of flooding to isolated properties, roads and large areas of farmland.
Yellow	flooding of low lying farmland and roads

As information is gathered regarding the performance of rivers and flood defences during an event predictions are made as to the possible extent of any flooding and alarms are issued accordingly. Therefore, some locations may receive only a red warning while others may receive lesser warnings that are updated as an event progresses.

The River Tove is designated "Main River" and properties in Towcester are considered to be at risk from flooding; however, no warnings are currently issued specifically for Towcester as an appropriate gauging stations does not exist. This situation is under review but at the time of the Easter floods no system was in place.

Brief Description of Flooding

Heavy rainfall during Thursday, 9th April into Friday, 10th April, falling into the already saturated Catchment, led to the highest river levels seen in the River Tove at Towcester since the historic floods of 1947.

The return period of the Easter event has been estimated as 1 in 125 years. A comparison of peak water levels for this and previous exceptional events is given below. The Easter 1998 peak water level in Towcester is the highest on record.

Event	Peak Level
1947	88.00 m AODN
1992	87.83 m AODN
1998	88.41 m AODN

The River Tove catchment experienced a 1 in 140 year rainfall event. Rainfall return periods between 1 in 6 and 1 in 140 years were experienced around the wider Great Ouse catchment. The map attached identifies the rainfall spread across the Anglian Region.

Towcester started receiving the peak flows from the upper reaches of the Tove and the Silverstone Brook during Thursday, 9th April. During this time, property flooding occurred -sixteen houses and five non-residential buildings were affected. The flood water started receding that evening.

Emergency Response

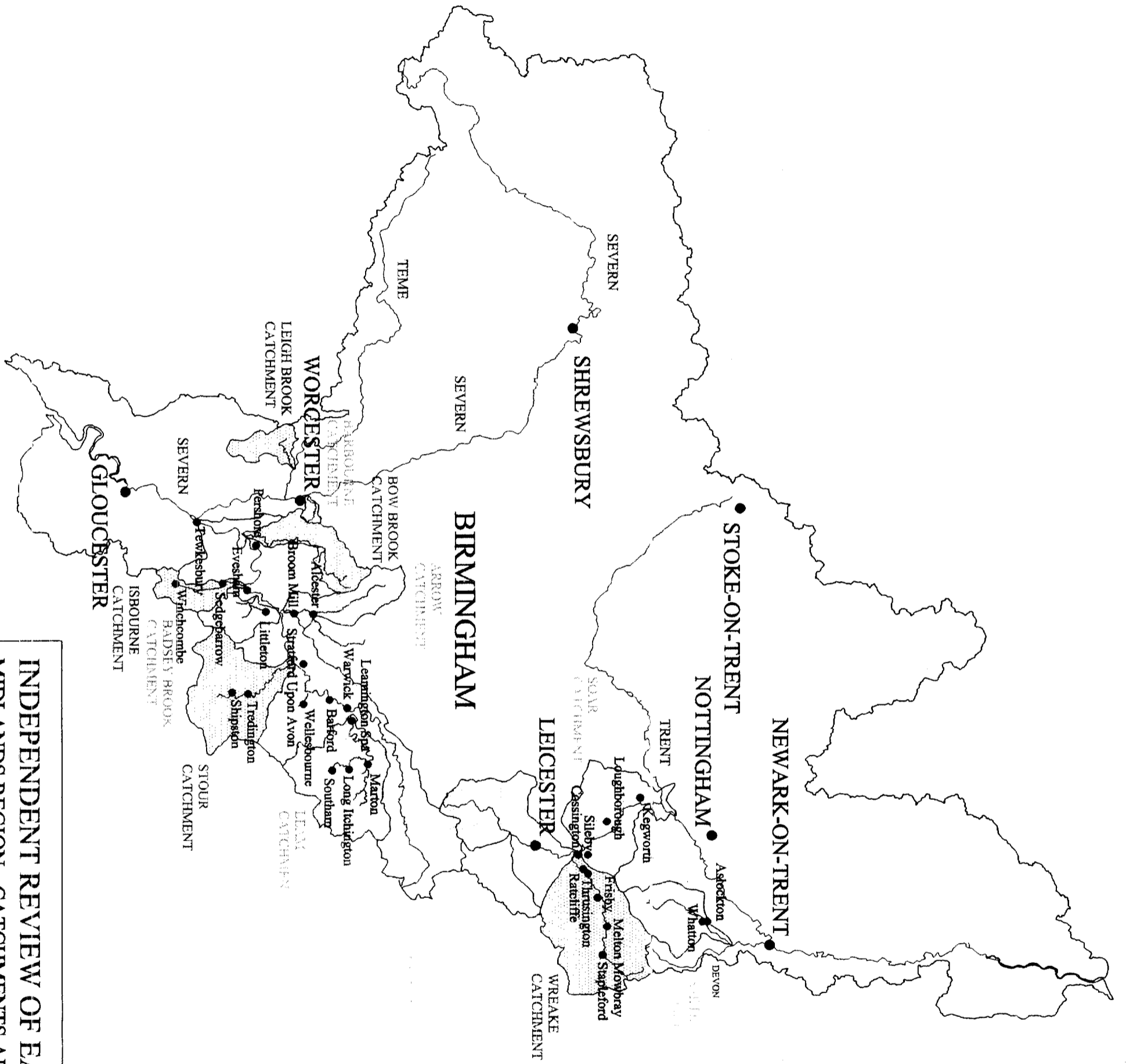
Area and Catchment Control Rooms were opened on a 24 hour basis from noon on 9th/10th April in order to:-

- a) Monitor rainfall and river flows, via the Anglian Region Telemetry System (ARTS), during the course of the event.
- b) Pass relevant flood information to the Emergency Services and Local Authorities, i.e. flood maps, properties at risk and the current and predicted river situation.
- c) In accordance with procedures, continuous patrols were established in the area with DSG staff. The purpose of the patrols is to ensure that bridges, weirs and sluices are, as far as is reasonably possible, kept clear of debris which may otherwise affect their ability to effectively discharge the flow of water.
- d) Sandbags were deployed and issued at reported vulnerable locations and where stocks allowed, made available to Local Authorities, if requested. Some private residents No formal flood defences exist in this location.

Possible Courses of Action

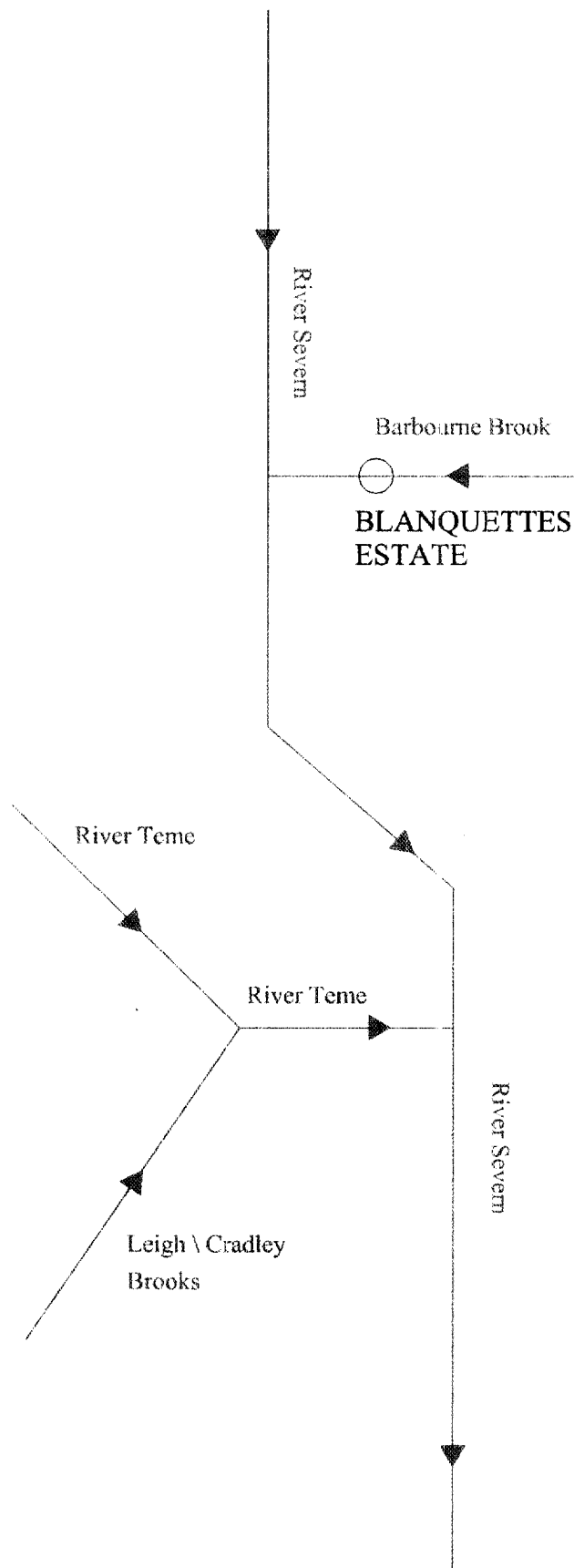
1. Undertake level surveys of flood affected properties. (Completed).
 2. Prepare flood maps for Easter floods. (In hand).
 3. Analyse flood data to determine return period of flood event and compare flood event with indicative and existing standards. (In hand).
 4. Update plans used in consultations for development in the flood plain.
 5. Existing flood warning arrangements will be investigated to identify improvements to river gauging and warning dissemination. (In hand).
-
1. Review existing standards to identify the possibility of justifying any flood defence improvement works.

3.2 MIDLANDS REGION



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
MIDLANDS REGION - CATCHMENTS AFFECTED**

Upper Severn Area



ANNUAL OCCURRENCE PROBABILITY
 (Estimate - based on available data
 of variable quality)

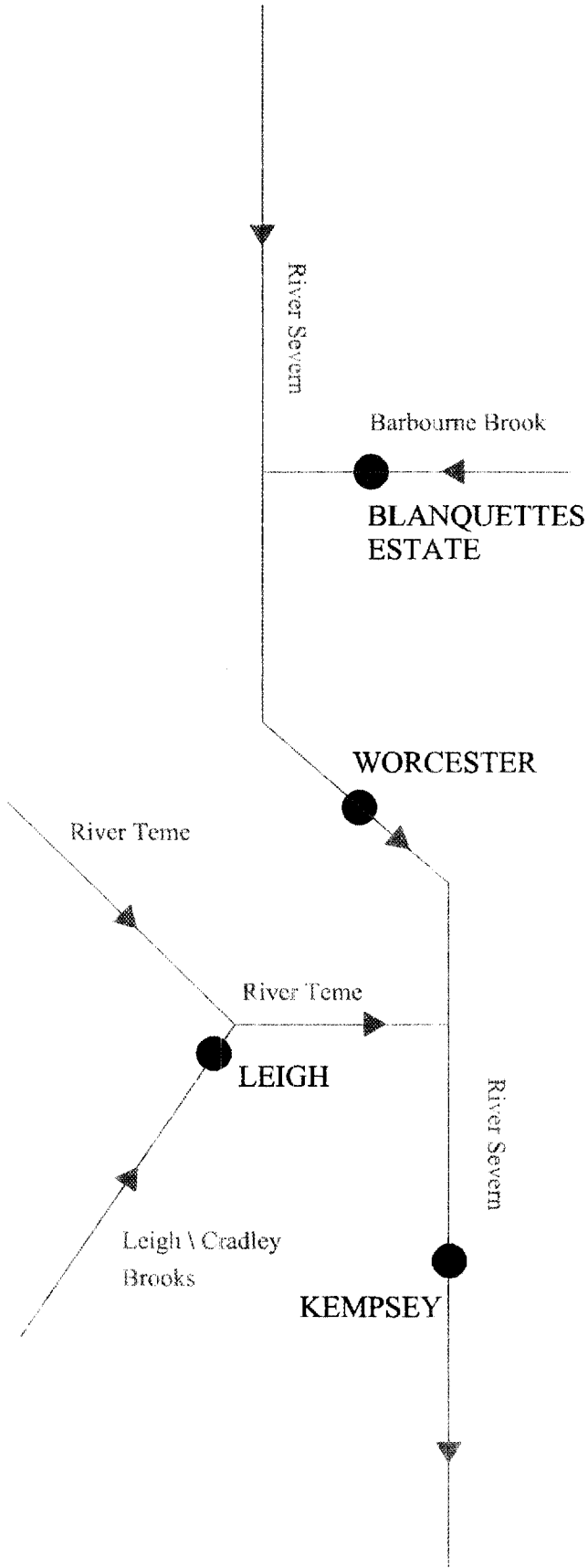
- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

* Time first property reported flooded

AMBER

RED

NO FLOOD WARNINGS ISSUED



INDEPENDENT REVIEW OF EASTER FLOODS 1998
BARBOURNE BROOK \ LEIGH BROOK CATCHMENTS
FLOOD WARNINGS

SEPTEMBER 1998

BLANQUETTES ESTATE, WORCESTER, BARBOURNE BROOK

Background

The Barbourne Brook drains a catchment of 16km² to the North and East of Worcester. The downstream part of the catchment, about one third of the total area, includes development contained within the City boundary, the rest being rural. More recent development in the Blackpole /Warndon part of the catchment has incorporated flood flow balancing facilities.

Significant development adjacent to Barbourne Brook upstream of Gregory's Mill commenced during the 1950s and 60s, accompanied by the culverting of the watercourse under Sections 262 - 266 of the Public Health Act 1936 as required by the City of Worcester Council. Culvert sizes and type vary, but were generally of the order of 1.2 m diameter. A short length of the watercourse between Shelley Close and Bilford Road remains unculverted.

Development of the Blanquettes Estate took place between about 1965 and 1972 with the first completions in 1967. Flooding occurred twice in 1968 affecting ten and twelve houses on the two occasions in Longfellow Road. Upstream of the development the watercourse had already been culverted under a waste disposal tip during and after the Second World War, in a similar sized culvert.

Following the 1968 flooding, the City Council installed a penstock control and overspill structure at the upstream end of the Perdiswell culvert. The purpose of this work was to control flows passing downstream and alleviate the flooding by effectively creating a flood storage area upstream.

In 1993, the then National Rivers Authority (predecessors to the Environment Agency) recognised that the Barbourne Brook had been subject to substantial urbanisation, which was growing. It was therefore considered appropriate that the watercourse should be designated as a Main River.

In March 1994, Worcester City indicated to the NRA that they were agreeable in principle to the watercourse becoming a Main River. Prior to submission of the proposal to the Ministry of Agriculture, Fisheries and Food, the NRA requested from Worcester City details on the existing culverting. The NRA was informed that the works that had taken place provided a standard of protection to development of 1 in 50 years. The watercourse was confirmed as Main River in July 1995.

In January 1998, the Environment Agency commenced work on site to refurbish the grids on the watercourse and the work was still ongoing at Easter 1998.

Flood Warning

No flood warning service is currently available for the Barbourne Brook, which has no gauging stations or river level recorders on it. The catchment size and the extent of urbanisation render the watercourse most prone to summer storm floods with rapid rises in flows. Conventional methods of flood warning using detection of river state and dissemination to those at risk via voice messaging or local radio are unlikely to be appropriate.

Description of Flooding

Information on the rainfall which gave rise to the flooding has been obtained from the nearest Environment Agency raingauge which is situated at Crowle about 3 km to the East of the catchment. Information has also been obtained from a manually read Met Office registered raingauge situated at Barbourne at the downstream end of the catchment.

The rainfall data is summarised below:-

<u>RAINFALL</u>	<u>DAILY(mm)</u>		<u>TOTALS (mm)</u>
	8 th	9 th	
CROWLE	13.0	52.0	65.0
BARBOURNE	13.2	46.3	59.5

At Crowle, rainfall intensities of greater than 5mm per hour were recorded from 11.00 - 17.00 hrs with 9.5mm between 15.00-1600 hrs. It rained continuously from 05.00 hrs to 20.00 hrs during which 60.0mm was recorded. The remaining 5mm fell before 05.00hrs (2.5mm) and after 20.00(2.5 mm), and was not continuous. Intermediate readings at 3 hrs intervals through the day are also available for the Barbourne Gauge.

Flows in the Barbourne Brook rose throughout the morning and afternoon of Thursday 9th April. By approximately 16.00 hrs, water was about to overflow from the open watercourse section adjacent to Shelley Close and was backing up drains into Longfellow Road. At the same time the storage of floodwater upstream of the Perdiswell control reached about 0.5m below spillway level, where it would commence by passing the penstock by flowing over the spillway. By the time the penstock was closed at about 16:45 hrs, water was overflowing in the vicinity of Shelley Close and the lowest properties were starting to flood. Operation of the penstock resulted in the cessation of the overflow into Shelley Close.

Although the main rainfall had stopped by 20.00 hours, inflows to storage upstream of Perdiswell must have continued at high levels because it was between 10.00 hrs & 11.00 hrs on the 10th before levels at Perdiswell stabilised. The storage level at Perdiswell took 6 - 7 hours to build up to the level at which flows going over the spillway were sufficient, in combination with downstream inflows, to once again exceed the capacity of the channel and culvert at Shelley Close, adding to the flooding of the estate. There were no blockages of the screen at the Shelley Close culvert entrance nor did corrugated iron sheets in one of the open inspection chambers in the Carmichael site cause any blockages.

Between 80 and 90 houses were flooded to depths of up to 1.2m.

Emergency Response

The first phone calls from residents on the Blanquettes Estate were received by the Agency between 15.30 and 16.00 hrs on the 9th April.

The Agency had a key to the penstock and operators in the area. These were diverted from a previously reported flooding incident and the penstock was closed at approximately 16:45 hrs.

By that time Longfellow Road and possibly some houses were flooded by water backing up the road drainage system and overflow from the brook down Shelley Close. The flooding then started to recede but, with the penstock closed, levels in the storage area continued to increase visibly.

Phone calls from residents about renewed flooding were received at approximately 01.00 hrs on the 10th. Three Agency operatives, the same that had attended the previous evening, were dispatched to the site to see whether anything could be done. On arrival it was apparent that the storage level had built up such that flows, in accordance with the design of the system, were bypassing the closed penstock, by flowing over the spillway to a depth of 0.3m. Downstream flows could not therefore be reduced by any operation of the penstock. Screens on culverts were checked for blockages but none were found. There was little further that could be done except keep a check on levels at Perdiswell, Blanquettes Estate and other culverts and screens downstream.

Levels in the Perdiswell storage peaked at about mid-day on Friday 10th and at the Blanquettes Estate an hour or so later. The flood water cleared from the estate in the early hours of the morning of Saturday 11th. The re-opening of the Perdiswell penstock was commenced on the Saturday morning, ensuring that flows downstream did not cause flooding. The Perdiswell storage was evacuated by Monday 13th.

The decision to close the penstock was taken in order to try to prevent the flooding of houses that were in imminent danger of being flooded. This action was effective initially and for a less severe event would have prevented serious escalation of damage. Unfortunately, the severity of this event was such that the property still flooded once the design capacity of the storage area was exceeded.

Possible Courses of Action

A CCTV survey of the culvert between Shelley Close and Gregory's Mill was carried out shortly after the flood showing it to be free of obstruction, but deformed over a short length.

Since the Easter event, the Environment Agency has instigated a feasibility study to investigate the possibility of alleviating this flooding problem. The adequacy of the existing culverting and control arrangements will be questioned, together with investigation into the possibility of the reinstatement of overland flood flow routes, which have been obstructed by development. Given the topography of the site, which is a shallow bowl shape with some properties located in the lowest parts with floor levels below road levels, it is unlikely that the flood risk can be completely alleviated.

The investigation will quantify the risk of recurrence of similar events of lesser or greater magnitude in order to determine what expenditure would be justified and by what means it could be alleviated. In the interim, procedures for operating the penstock have been documented by the Environment Agency.

The investigation will also identify interim measures needed to warn the residents, if a similar situation should arise again, before measures can be taken to alleviate the risk. The feasibility of remote monitoring of levels in the brook with alarms will be investigated. In the particular circumstances, loud hailer warnings combined with house to house calling will probably be the most appropriate method to use. Lists of properties to be warned will be compiled, with the lowest lying property being first to be warned.

A survey of the threshold/floor levels of all the properties flooded or nearly flooded has been undertaken. This will be used in the feasibility investigation and for the warning measures referred to above.

CRADLEY/LEIGH BROOK, WORCESTERSHIRE, ARROW

Background

The Cradley/Leigh Brook drains a catchment of some 51 km², lying on the west flank of the Malvern Hills. It flows in a generally northerly direction to the River Teme at Leigh. The Brook is designated as an ordinary watercourse throughout, and flows through parts of the areas of Malvern Hills District Council and Herefordshire Unitary Authority. It is a hilly catchment with rainfall enhanced by the effects of the Malvern Hills. The catchment is wholly rural but the brook has been used extensively by water driven mills in the past leaving a legacy of conversion of mill buildings to residential use with inherent flood risks.

Flood Warning

The Cradley/Leigh Brook is an ungauged catchment not currently covered by the Environment Agency's flood warning service.

Brief Description of Flooding

The Agency received phone calls indicating that the brook was flooding during the afternoon of Thursday the 9th April, but without either a level/flow gauge or interrogable rain gauge in the catchment it was not apparent how serious the flood was. Information on the event was obtained afterwards from on the ground enquiries and visible evidence.

Flooding of 19 isolated properties took place at 14 locations throughout the length of the watercourse, approximately 17km. A small number of other properties (less than five) just escaped being flooded. Minor roads were flooded at 17 locations associated with culvert capacity being exceeded or blockage at one location.

Levels rose rapidly giving flooding depths in property of up to 1.5m with flooding lasting for up to two days. Most durations of flooding were 12 hours or less. Various opinions were obtained on the severity of the event compared with previous floods from the few longer-term residents, ranging from similar to the 1968 event to considerably worse.

Emergency Response

Being a minor non-Main River watercourse those affected dealt with the situation as best they could and it is known that one or two evacuated to friends or relatives. The Agency did not receive any requests from the local authorities for assistance in responding to this ordinary watercourse flooding incident.

Possible Courses of Action

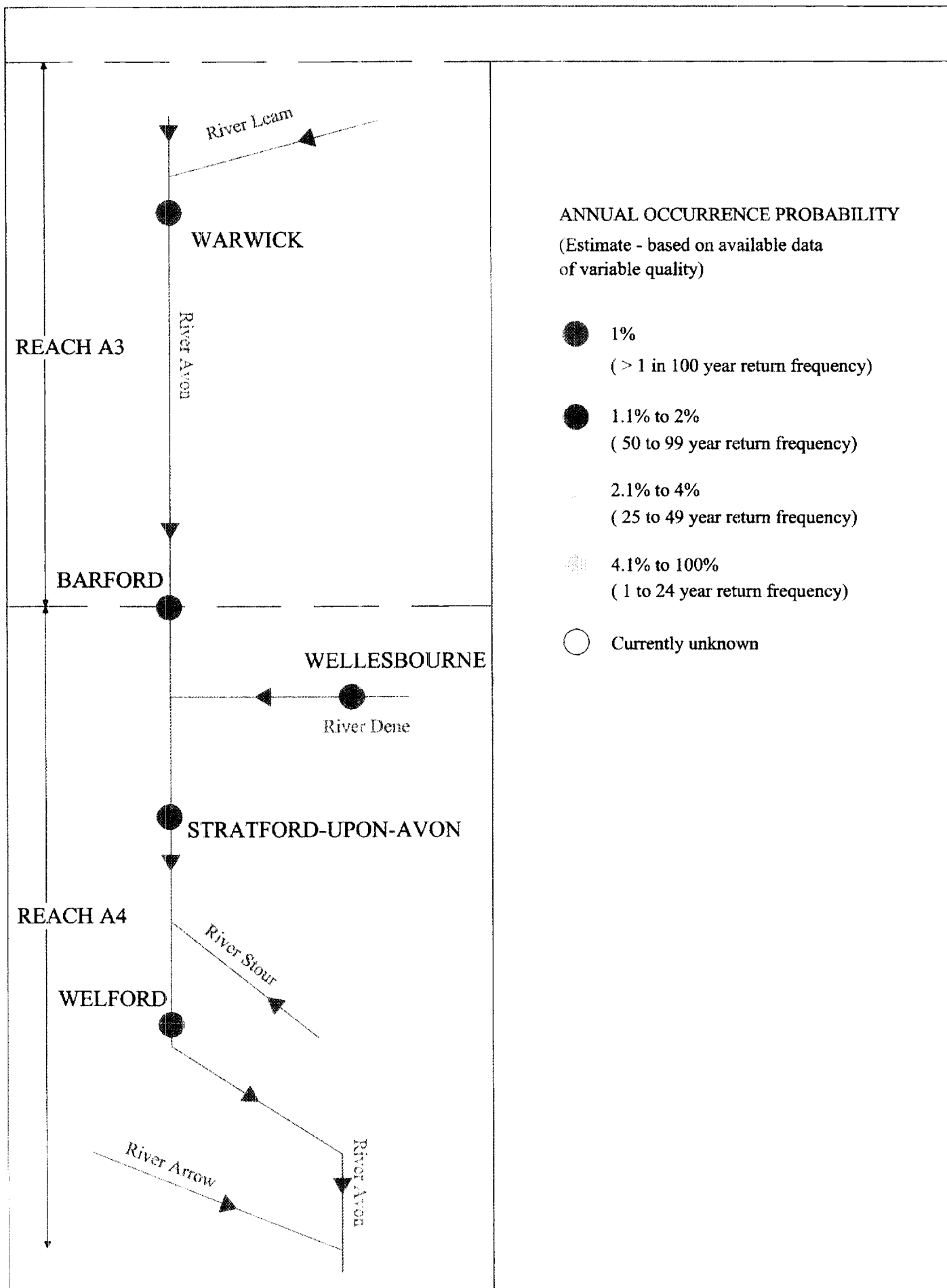
The possibility of extending the Environment Agency's flood warning service to this catchment will be investigated.

Details of the flooding that took place will be incorporated in the Environment Agency's Section 105 survey of flood risks and used to advise prospective purchasers of the risks, as well as in advising the planning authorities of the risks when considering development proposals. The inadequacies of road culverts and bridges will be raised by the Agency with the

local authorities where appropriate.

The possibility of a flood alleviation scheme will be investigated. It is considered unlikely that publicly funded flood alleviation measures will be justifiable, given the small number of properties at each location. Nevertheless, the information obtained on the risks may be used to advise property owners of any alleviation work they may wish to undertake themselves.

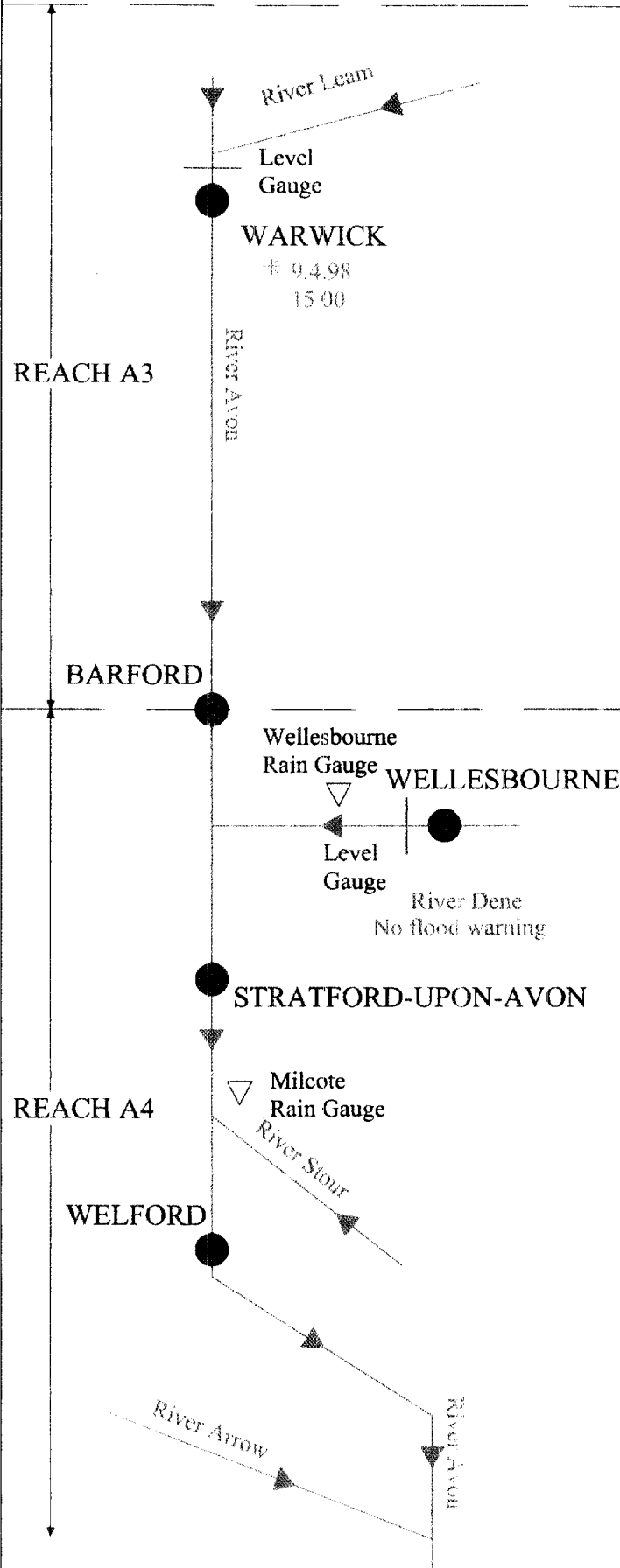
Lower Severn Area



INDEPENDENT REVIEW OF EASTER FLOODS 1998
AVON (MIDDLE) CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded



	AMBER	RED
9.4.98	9.4.98	10.4.98
18.18	22.34	07.40

Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and Phone to BBC Coventry and Warwickshire

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, BBC Northampton, Midlands Electricity

A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

In addition, detailed information on both the current and future flood situations on this reach of river will be periodically faxed to the media and emergency services.

	AMBER	RED
9.4.98		10.4.98
18.13		01.56

Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and phone to West Mercia Police who contact Hereford and Worcester Fire Brigade, and Hereford and Worcester Ambulance Service NHS Trust

Fax and Phone to BBC Coventry and Warwickshire, Hereford and Worcester County Council, Wychavon District Council, BBC Hereford and Worcester, and Radio Wyvern

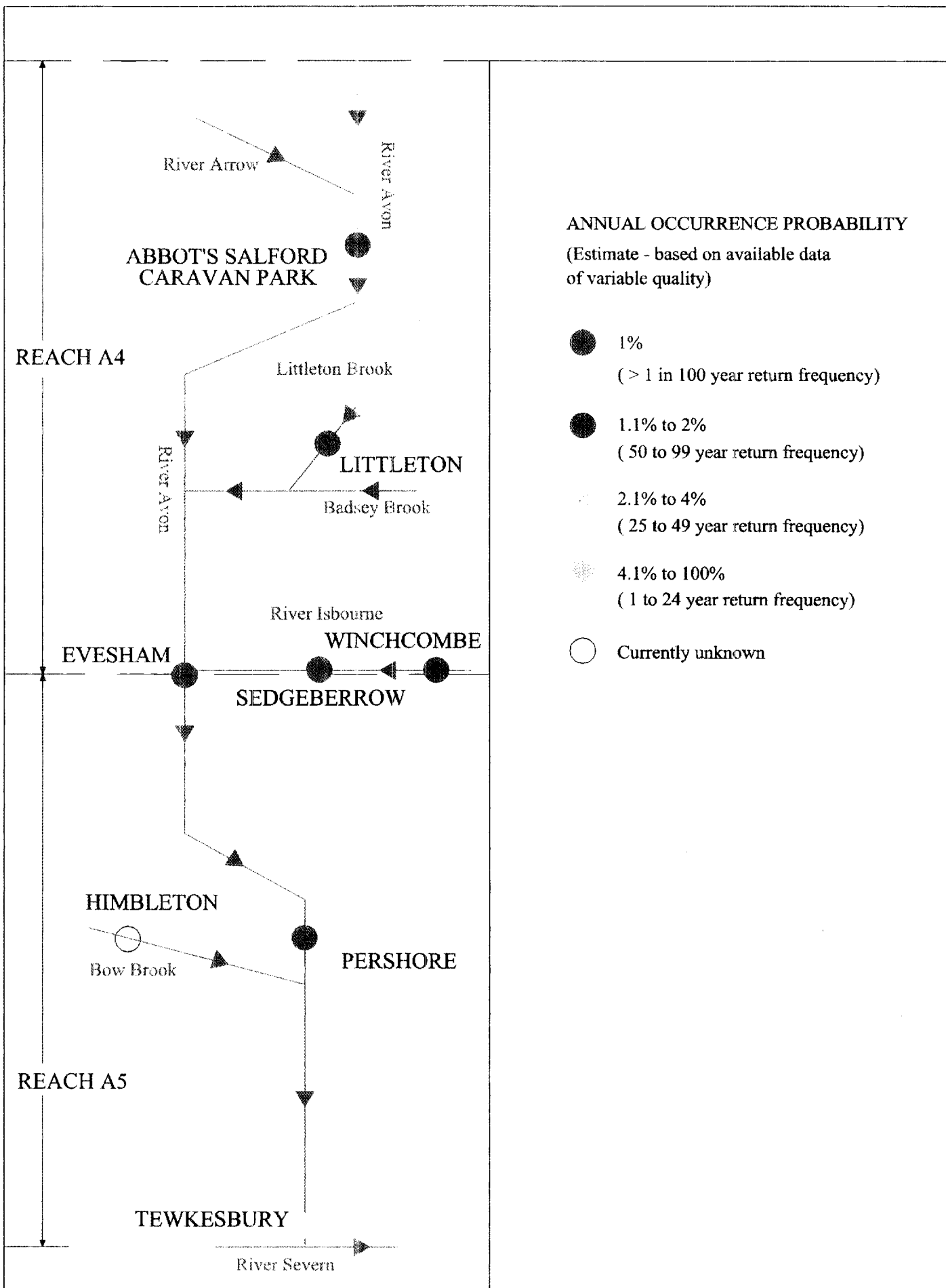
Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, Midlands Electricity

In addition, detailed information on both the current and future flood situations on this reach of river will be faxed to AA Roadwatch.

A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

INDEPENDENT REVIEW OF EASTER FLOODS 1998 AVON (MIDDLE) CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

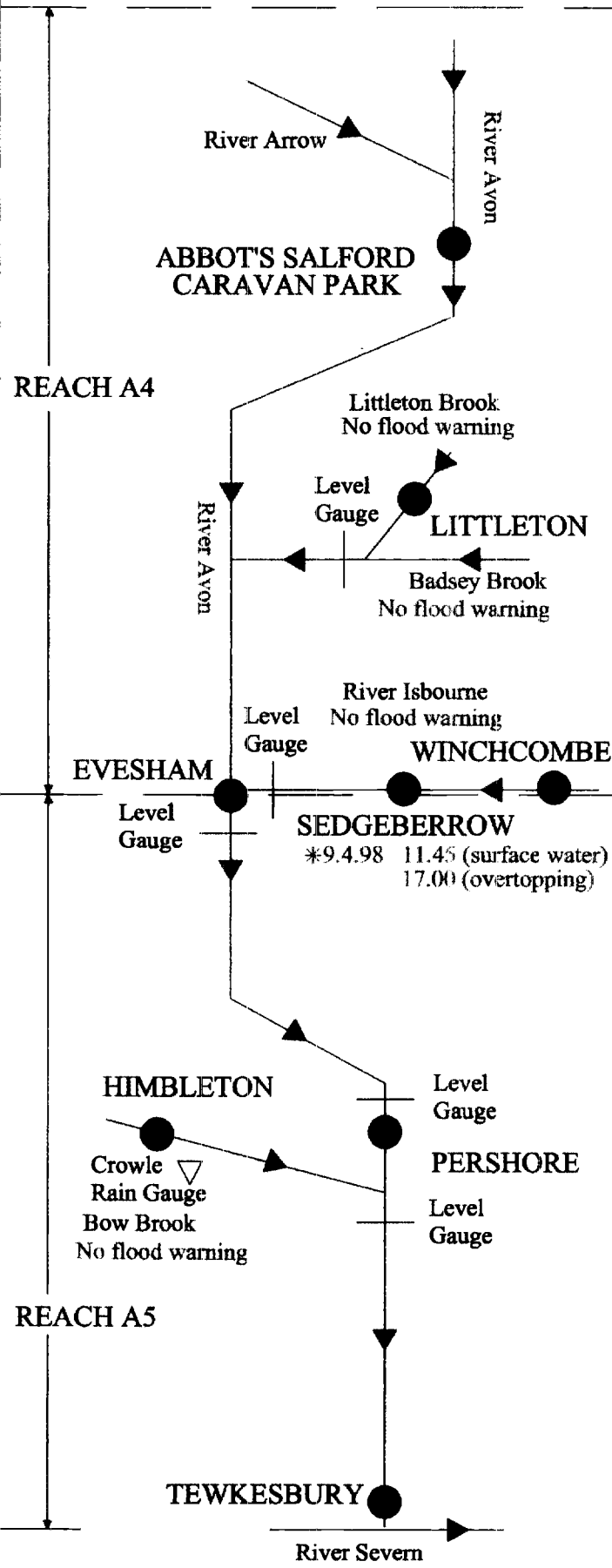


INDEPENDENT REVIEW OF EASTER FLOODS 1998

AVON (LOWER) CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded



	AMBER	RED
9.4.98		10.4.98
18.13		01.56

Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and phone to West Mercia Police who contact Hereford and Worcester Fire Brigade, and Hereford and Worcester Ambulance Service NHS Trust

Fax and Phone to BBC Coventry and Warwickshire, Hereford and Worcester County Council, Wychavon District Council, BBC Hereford and Worcester, and Radio Wyvern

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, BBC Northampton, Midlands Electricity

In addition, detailed information on both the current future flood situations on this reach of river will be periodically faxed to the media and emergency services.

A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

	AMBER	RED
9.4.98	9.4.98	9.4.98
13.53	15.26	18.24

Fax and phone to West Mercia Police who contact Hereford and Worcester Fire Brigade, and Hereford and Worcester Ambulance Service NHS Trust

Fax and phone to Gloucestershire Police who contact Gloucestershire Fire and Rescue Service, and Gloucestershire Ambulance Service NHS Trust

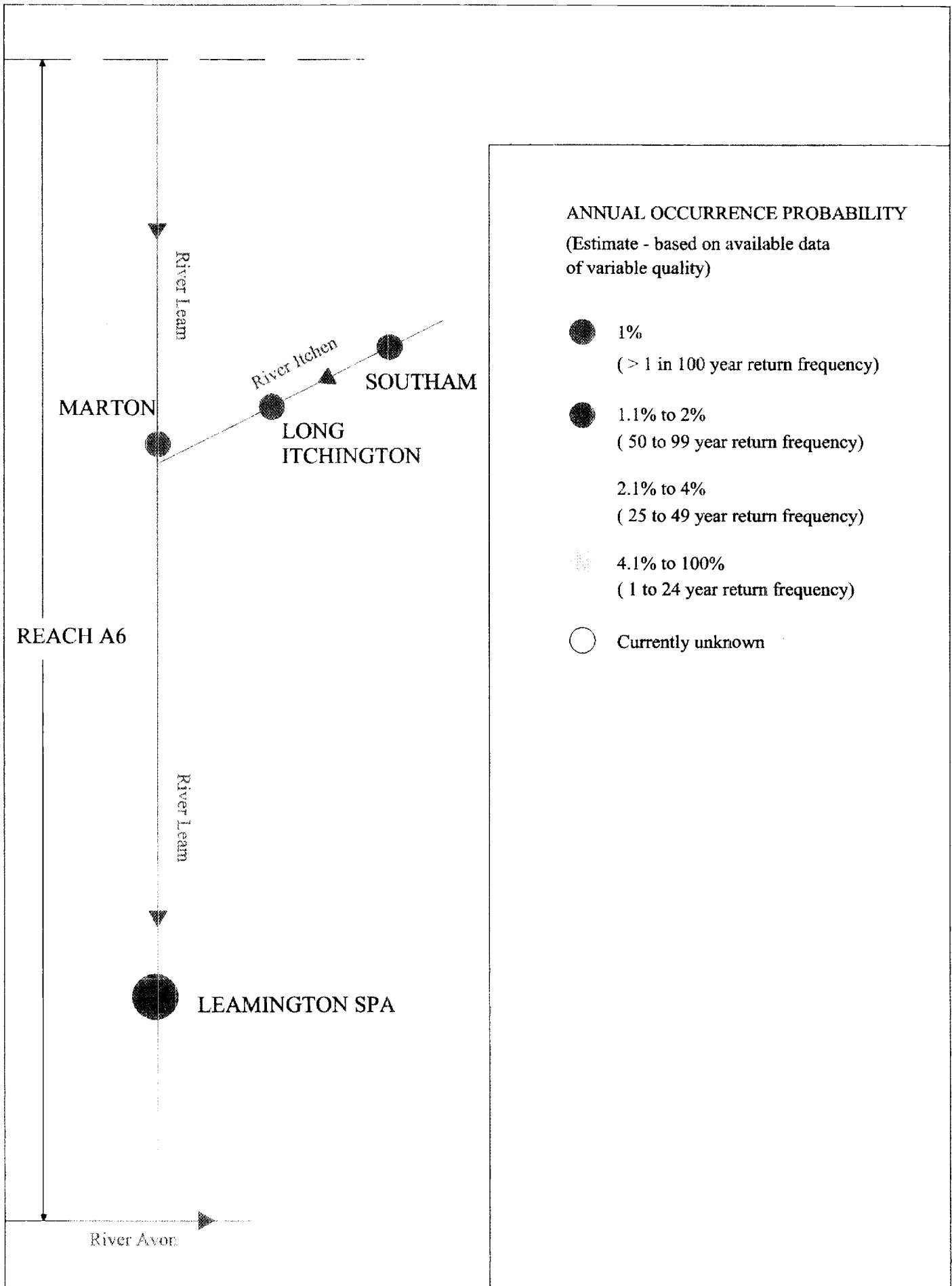
Fax and Phone to Hereford and Worcester County Council, Wychavon District Council, BBC Hereford and Worcester, Radio Wyvern, Gloucestershire County Council, Tewkesbury Borough Council, Radio Gloucestershire, and Severn Sound.

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, Midlands Electricity

In addition, detailed information on both the current and future flood situations on this reach of river will be periodically faxed to the media and emergency services.

A flood warden scheme, administered by Wychavon District Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

INDEPENDENT REVIEW OF EASTER FLOODS 1998 AVON (LOWER) CATCHMENT - FLOOD WARNINGS



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
LEAM CATCHMENT - FLOOD EVENTS**

* Time first property reported flooded

	AMBER	RED
9.4.98	9.4.98	9.4.98
15.54	17.02	23.19

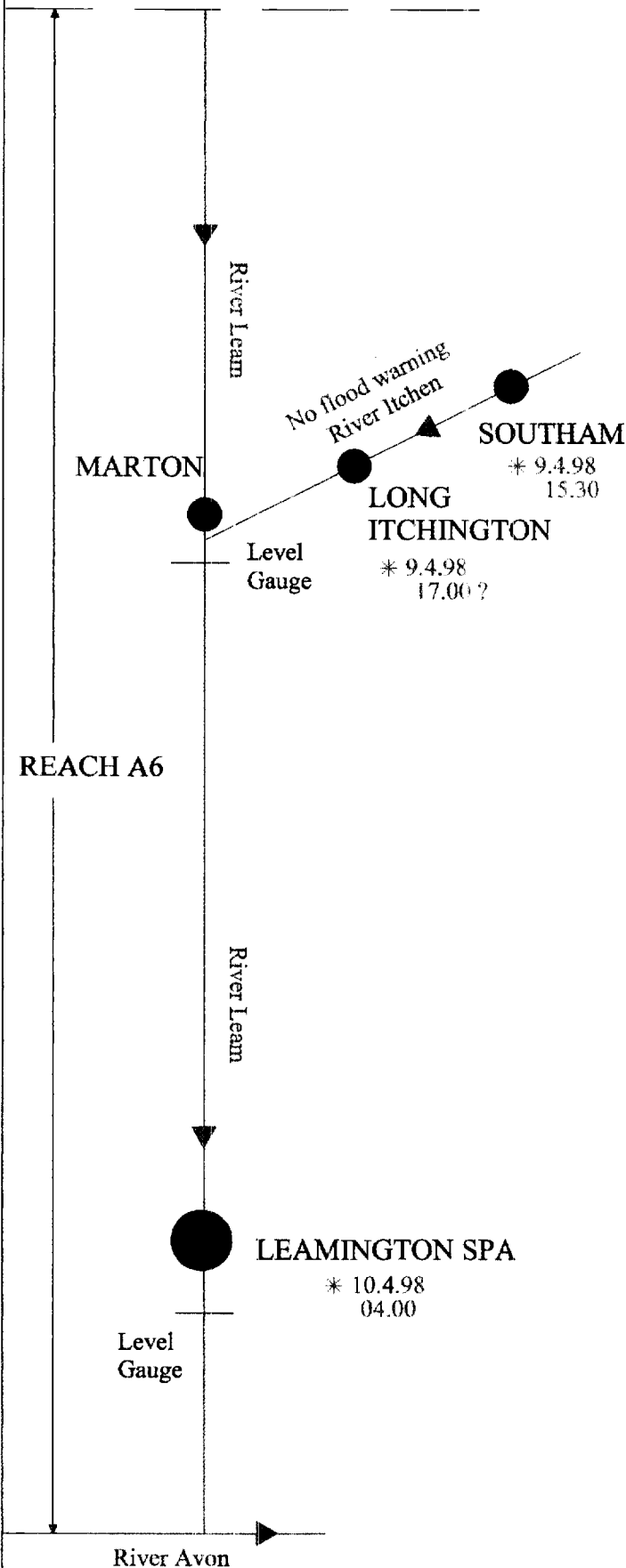
Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and Phone to BBC Coventry and Warwickshire

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, BBC Northampton, Midlands Electricity

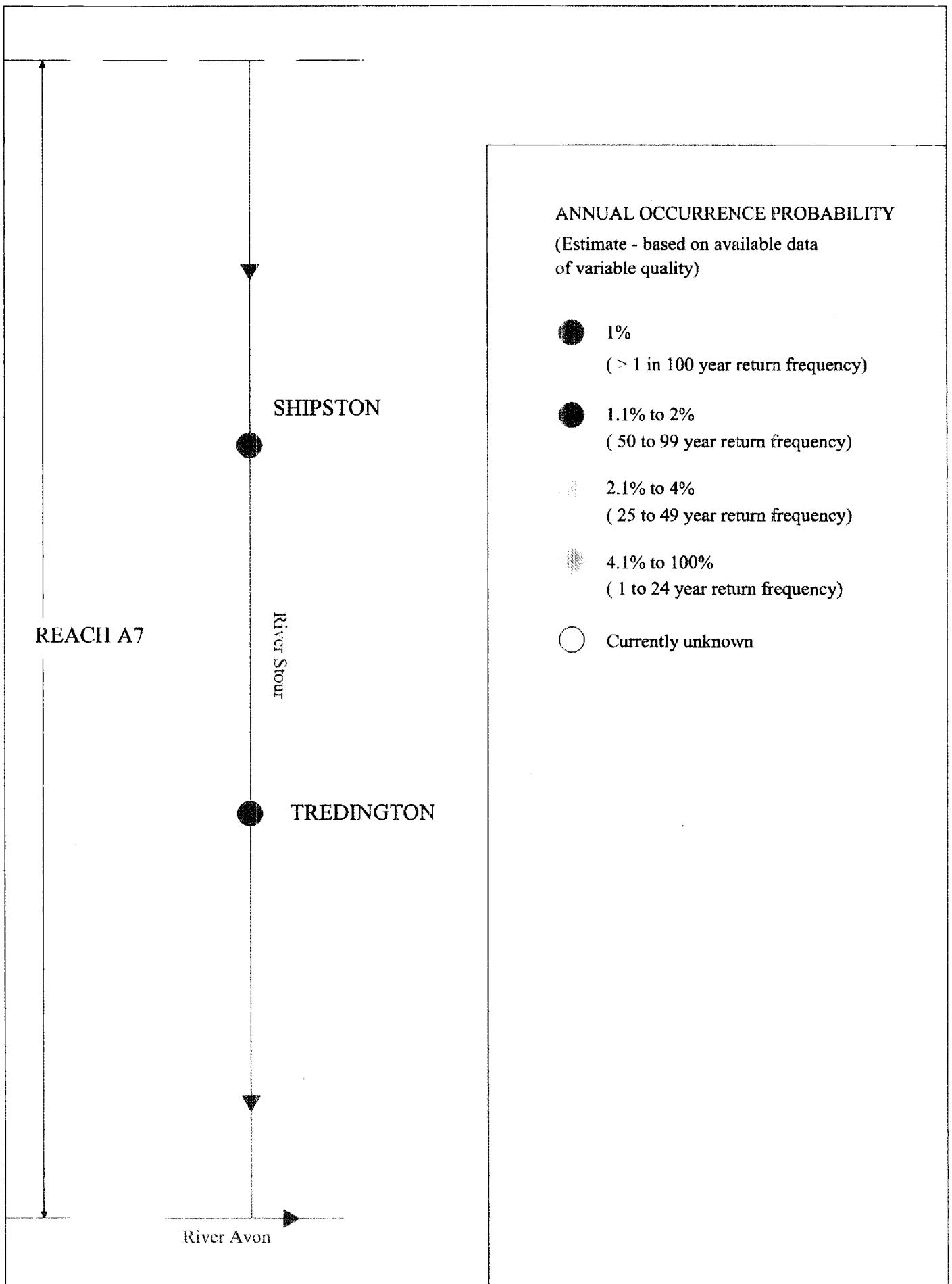
A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

In addition, detailed information on both the current future flood situations on this reach of river will be periodically faxed to the media and emergency services.



INDEPENDENT REVIEW OF EASTER FLOODS 1998 LEAM CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998



INDEPENDENT REVIEW OF EASTER FLOODS 1998
STOUR CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded

	AMBER	RED
9.4.98	9.4.98	9.4.98
10.13	11.40	14.05

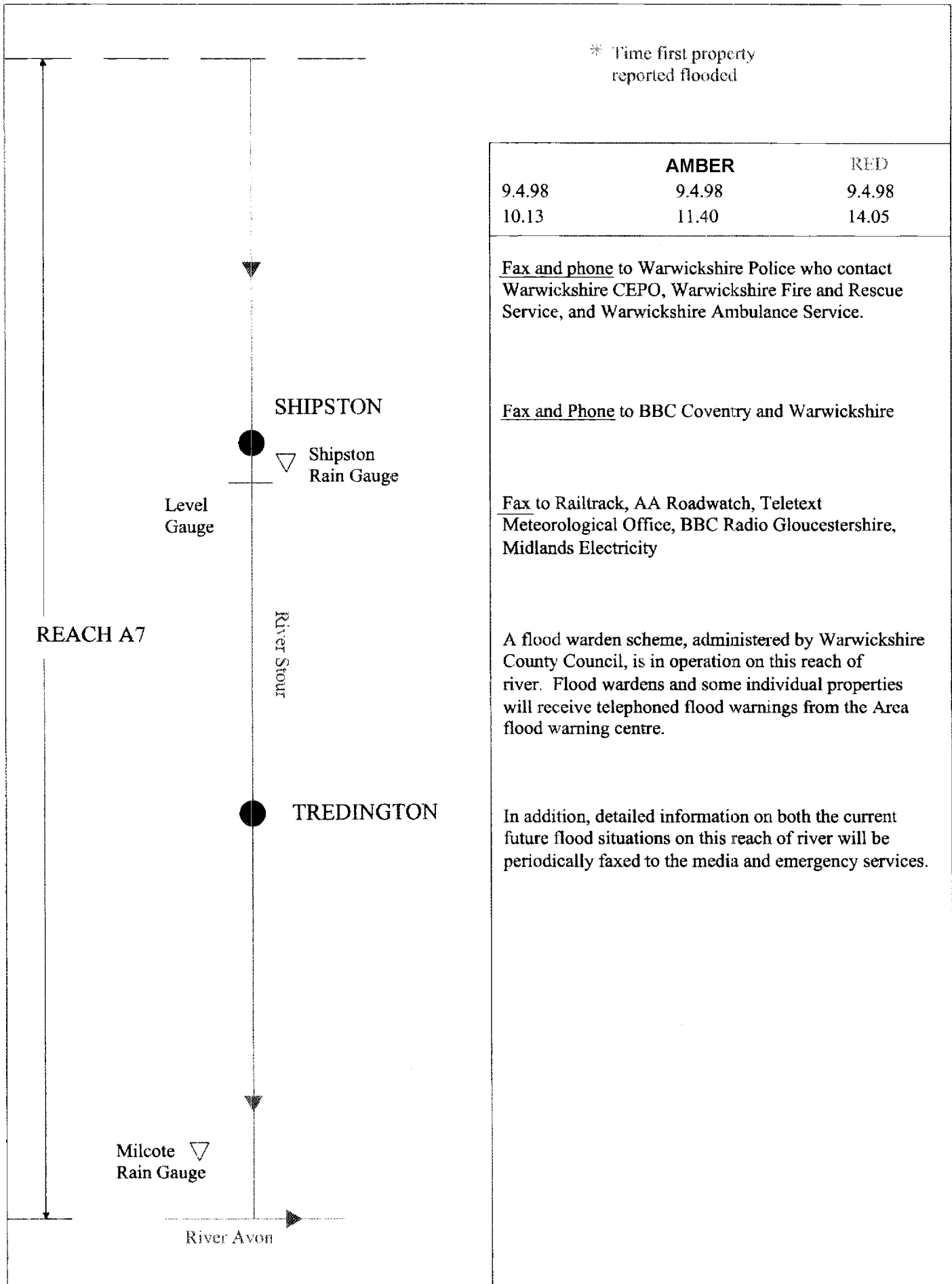
Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and Phone to BBC Coventry and Warwickshire

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, Midlands Electricity

A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

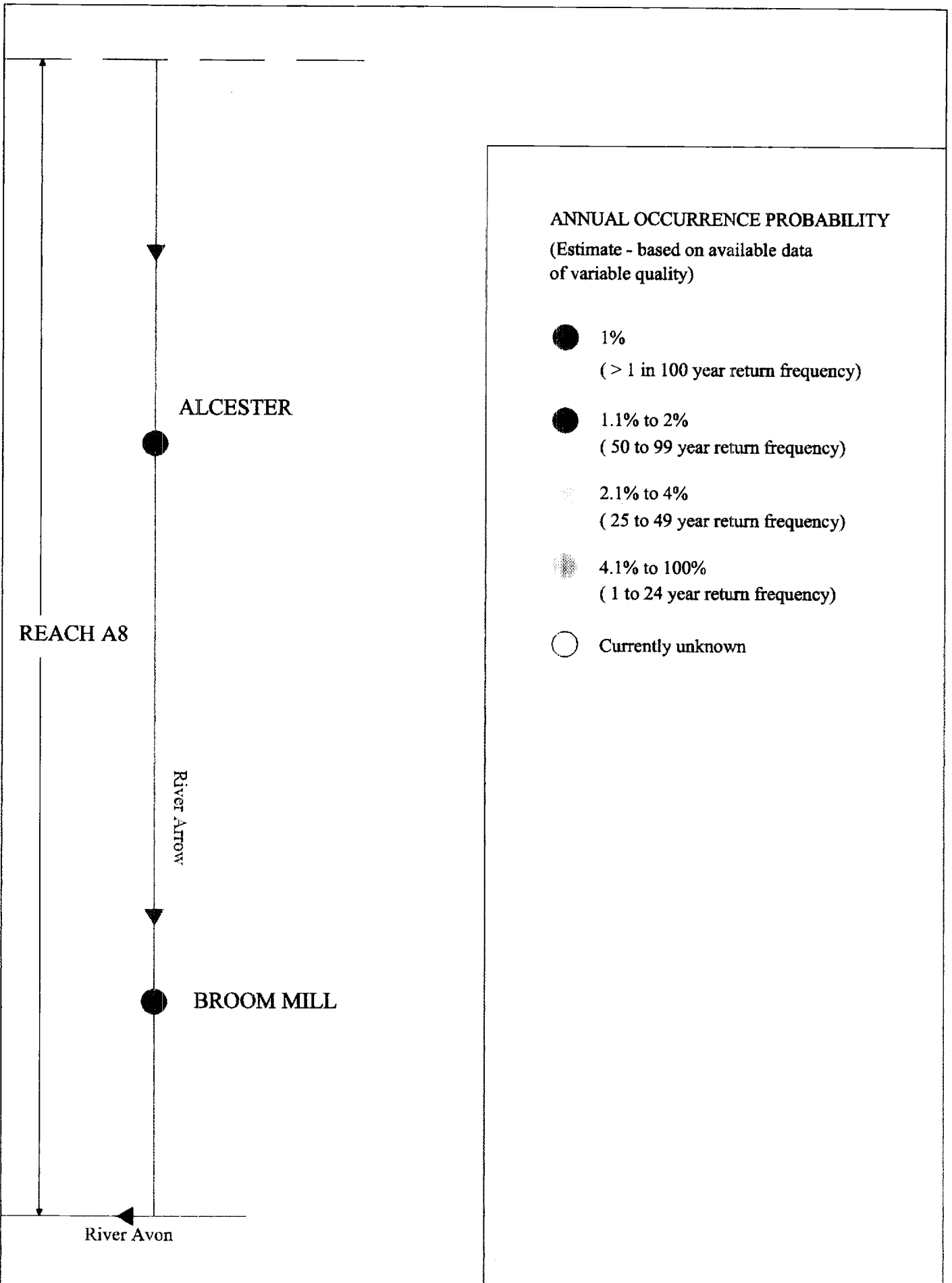
In addition, detailed information on both the current future flood situations on this reach of river will be periodically faxed to the media and emergency services.



INDEPENDENT REVIEW OF EASTER FLOODS 1998

STOUR CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
 ARROW CATCHMENT - FLOOD EVENTS**

* Time first property reported flooded

AMBER

RED

9.4.98
19.02

Fax and phone to Warwickshire Police who contact Warwickshire CEPO, Warwickshire Fire and Rescue Service, and Warwickshire Ambulance Service.

Fax and Phone to BBC Coventry and Warwickshire

Fax to Railtrack, AA Roadwatch, Teletext Meteorological Office, BBC Radio Gloucestershire, Midlands Electricity

A flood warden scheme, administered by Warwickshire County Council, is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Area flood warning centre.

In addition, detailed information on both the current future flood situations on this reach of river will be periodically faxed to the media and emergency services.

ALCESTER
* 9.4.98
15.00

River Arrow

BROOM MILL

Level
Gauge

River Avon

REACH A8

INDEPENDENT REVIEW OF EASTER FLOODS 1998 ARROW CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

ALCESTER, WARWICKSHIRE, RIVER AVON

Background

Alcester is a small town some 10km west of Stratford-upon-Avon, Warwickshire, in the area of Stratford-on-Avon District Council.

The town is situated on the River Arrow at its confluence with the River Alne. Both are designated Main River at this point. Alcester is approximately 7km upstream from the confluence of the River Arrow with the River Avon. There are six bridge crossings of the Arrow within the town. Working upstream these are the A435(T) Alcester Bypass, a minor road, the former A422, a footbridge, the B4089, and the abandoned Alcester-Stratford railway. There are no crossings of the River Alne in the town.

The River Arrow has a catchment area of 300km² underlain by Keuper Marl and Sandstone.

Alcester has suffered severe flooding in the past and following the floods of 1960, the then Severn River Authority constructed floodbanks to protect the town from floods up to a 1 in 50 year return period. In the early 1970s a further improvement scheme was carried out from the Avon confluence to Redditch raising some of the defences to a 75 year standard. The scheme incorporated pumping for surface water drainage behind the defences. The defences were inspected in 1994 as part of the Stage I Asset Survey and found to be in a good condition. The results of the more detailed Stage II investigations are still awaited.

Between 1996 and 1998 the Agency was consulted on 27 planning applications in the town of Alcester.

Flood Warning

Alcester is covered by the flood warning service provided by Lower Severn Area, being on Reach A8 - River Arrow.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, also go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. The catchment was almost

saturated with a soil moisture of at most 5mm, and river levels were above normal. A low pressure area moved along the south coast on Thursday April 9th April bringing heavy rainfall. The rainfall continued throughout Thursday and into Friday with some prolonged periods of extremely heavy rainfall.

On April 9th at 13.05 hrs the Arrow was reported as being very high. A check was carried out of the sluice gate at 14.34 hrs which confirmed that the Arrow Mill sluice was working properly.

The flooding of the town was severe with 25 properties affected. It is believed that the defences at Gas House Lane were outflanked and other defences were overtopped by the floodwater. The return period of the flood is estimated at 40-90 years.

Emergency Response

A Yellow warning was issued on 9th April at 19.02 hrs based on the Studley gauge but the threshold was not crossed.

Possible Courses of Action

One of the issues raised by the flooding was the number of properties flooded when only a Yellow flood warning had been issued for the River Arrow. Flood warnings for the River Arrow use a river level gauge located 7km upstream of Alcester at Studley. A previous river level gauge on the Alne was taken out in the latter days of Severn Trent Water Authority. It is therefore currently not possible to issue flood warnings for the River Alne even though it can have a considerable effect on levels at Alcester and further downstream on the Arrow.

At Easter, the storm passed over the lower reaches of both the Arrow and Alne, such that the gauge at Studley upstream did not even reach the Yellow threshold level. The return period at Studley was only 7 - 11 years. It was the combination of flows from these lower reaches which caused levels to reach flooding proportions at Alcester. Consideration is being given to re-installing the gauge on the Alne to enable the warning service to be extended (possibly to include Henley-in-Arden) and to facilitate more accurate and timely warnings for Alcester.

A re-examination of the Flood Alleviation Scheme will be undertaken. This will look at the existing defences, identify the level of service being provided and consider options.

BARFORD, WARWICKSHIRE, RIVER AVON

Background

Barford is a small village 5km south of Warwick in the area of Warwick District Council. The village is on the left bank of the River Avon which is designated Main River at this point.

The Avon is 191km long, draining an area of around 2,850km². It is the main arterial drain for Warwickshire and SE Worcestershire. It is also widely used for water supply and is navigable between Tewkesbury and Stratford upon Avon. The catchment is mainly impermeable Keuper Marl and Lias Clays with small areas of triassic mudstone. This results in rapid river flow response to rainfall.

In Barford village the Avon is crossed by the A429 trunk road and 2km upstream of the village the M40 motorway crosses it. There are no other crossings in the area.

Since 1981 the Agency and its predecessors have been consulted on eleven planning applications including six in the last three years.

The village has been affected by flooding a number of times in the past, most recently in 1977, 1979 and 1981.

Flood Warning

Barford is covered by the flood warning service provided by Lower Severn Area, being on Reach A3 - River Avon from Warwick to upstream of Stratford.

A flood warden scheme is in operation on all this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, also go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

During the flood event ten properties were affected at Barford and the return period has been estimated at 40 – 90 years.

Emergency Response

As water levels rose, routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back to staff in the office to give them an accurate picture of what was actually happening on the ground.

Flood warnings were issued on reach A3 at the following times:

Yellow on 9th April at 18.24 hrs;
Amber on 9th April at 22.34 hrs and
Red on 10th April at 07.40 hrs.

Possible Courses of Action

At present there are no defences at Barford. An investigation of the feasibility of a flood alleviation scheme will be undertaken, whereby the costs will be weighed against the benefits and the various options considered.

Currently Reach A3 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive warnings direct. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review has been instigated, in order to devise a system that maximises reliability and flexibility.

BROOM , WARWICKSHIRE, RIVER ARROW

Background

Broom is a small village in Warwickshire, 4km south of Alcester, in the area of Stratford-on-Avon District Council. The village is on the left bank of the River Arrow which is designated Main River at this point. In the village there is a mill stream with a weir and sluice gate. An unclassified road crosses both channels in the centre of the village.

The River Arrow is a tributary of the River Avon with a catchment area of over 300km² (around 10% of which is urban). It is underlain by Keuper Marl with a small area of sandstone.

Broom has been affected by flooding a number of times in the past, the worst events in recent years being in 1985 and 1993.

Of the thirty six planning applications the Agency and its predecessors have been consulted on since 1981, thirteen have been in the last three years. For any development which has taken place, the Agency has recommended that ground floor levels be set 600mm above the highest flood level recorded.

Flood Warning

Broom is covered by the flood warning service provided by Lower Severn Area, being on Reach A8 - River Arrow.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. The catchment was almost saturated with a soil moisture deficit of at most 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the area. The rain was held over the area by this low pressure system throughout Thursday and into Friday producing prolonged periods of extremely heavy rainfall.

In the flooding which followed, 15 properties were affected. The highest level reached was 32.51mAOD on April 10th at 23.15 hrs. This is the highest level on record for this location (levels

date back to 1947). The return period of the flood was estimated at around 100 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, at appropriate locations, and check at-risk areas.

The only flood warning that was issued was Yellow, based on the Studley gauge, at 19.02 hrs on 9th April. The threshold for the Studley gauge (2.0m) was not crossed and the level reached here was only 1.871mALD. This was the appropriate warning for the River Arrow at Studley.

Possible Courses of Action

One of the major difficulties with providing warnings for this location is that the warning for the reach is based on the gauge on the watercourse at Studley, 10km upstream. In between the Studley gauge and Broom, the River Arrow is joined by the River Alne at Alcester. The Alne can have a significant effect on flows from Alcester downstream. The system could be adapted to allow warnings to be issued for the Broom area only. This would necessitate defining some new thresholds and possibly splitting the reach up, but it is a possible consideration. Options for improving the warning arrangements are being investigated

Currently Reach A8 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive warnings direct. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility. The Agency will also carefully examine the recipient lists for wardens to ensure that the residents of Broom are being properly catered for by the service.

Finally, the possibility of a Flood Alleviation Scheme will be investigated. This will mean a feasibility study being carried out to weigh up the costs and benefits of any scheme, and consideration of all the available options.

CARAVAN SITES WITHIN THE WARWICKSHIRE AVON CATCHMENT

Background

Since the beginning of the 1980s the Agency, together with its predecessors, (the National Rivers Authority and Severn Trent Water Authority), has been consulted by the appropriate planning authorities with regard to the development of caravan sites at the following locations. All are within the Warwickshire Avon catchment

<i>Location</i>	<i>Name</i>
Stratford	Avon Caravans
Stratford	Rayford Caravan Park
Stratford	Green Willows & Elms Riverside Caravan Park
Stratford	Stratford Racecourse
Binton Bridges	Binton Bridges Caravan Park
Binton Bridges	Avonside Caravan Park
Bidford	The Paddock Caravan Park
Abbot's Salford	Abbot's Salford Caravan Park
Offenham	Offenham Caravan Park
Harvington	Anchor Meadow
Harvington	Moors Caravan Park
Evesham	Weir Meadow Holiday & Touring Park
Evesham	Pippins Green Parks Ltd
Evesham	Avon Riverside Caravan Park
Wyre Piddle	Anchor Meadow
Wyre Piddle	Rivermead Holiday Home Park
Wyre Piddle	Wyre Mill
Eckington	Anglesey Caravan Park
Bredon	
Twynning	The Fleet Inn
Twynning	Fleet Farm
Salford	
Oversley	Essex Park Homes
Wixford	

Invariably when consulted the Agency, and its predecessors, has objected to the siting of the caravans in the floodplain. The Agency's objections have been based upon matters of public safety, including the risk of caravans being washed away and the difficulties of advising those at risk, as well as the general issues of loss of flood storage capacity and obstruction to overland flood flows.

Flood Warning – Reach A4 (Stratford to upstream of Evesham)

On Reach A4 a flood warden scheme is in operation. Flood wardens and some individual properties receive telephoned flood warnings, Yellow and Red as appropriate, from the Environment Agency's Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Below is a list of the caravan parks on Reach A4 and whether or not they currently receive direct flood warnings from the Agency.

<u>Location</u>	<u>Name</u>	<u>FW</u>
Stratford	Avon Caravans	Yes
Stratford	Rayford Caravan Park	Yes
Stratford	Green Willows & Elms Riverside Caravan Park	Yes
Stratford	Stratford Racecourse	Yes
Binton Bridges	Binton Bridges Caravan Park	Yes
Binton Bridges	Avonside Caravan Park	Yes
Bidford	The Paddock Caravan Park	Yes
Abbot's Salford	Abbot's Salford Caravan Park	Yes
Offenham	Offenham Caravan Park	No
Harvington	Anchor Meadow	No
Harvington	Moors Caravan Park	No

Flood Warning – Reach A5 (Evesham to upstream of Tewkesbury)

On Reach A5 a flood warden scheme, administered by Wychavon District Council, is in operation. Flood wardens and some individual properties receive telephoned flood warnings, Yellow, Amber and Red as appropriate, from the Environment Agency's Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to the following emergency services:

- i) Worcestershire County Council
- ii) Wychavon District Council
- iii) West Mercia police, who then pass them on to the following:
 - a) Hereford and Worcester Fire Brigade
 - b) Hereford and Worcester Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to the following radio stations, which then broadcast them:

- i) BBC Hereford and Worcester

ii) Radio Wyvern

Below is a list of the caravan parks on Reach A5 and whether or not they currently receive direct flood warnings from the Agency.

<i>Location</i>	<i>Name</i>	<i>FW</i>
Evesham	Weir Meadow Holiday & Touring Park	Yes
Evesham	Pippins Green Parks Ltd	No
Evesham	Avon Riverside Caravan Park	Yes
Wyre Piddle	Anchor Meadow	No
Wyre Piddle	Rivermead Holiday Home Park	No
Wyre Piddle	Wyre Mill	No
Eckington	Anglesey Caravan Park	No
Bredon		No
Twyning	The Fleet Inn	No
Twyning	Fleet Farm	No

Flood Warning – Reach A8 (River Arrow)

On Reach A8 a flood warden scheme is in operation. Flood wardens and some individual properties receive telephoned flood warnings, Yellow and Red as appropriate, from the Environment Agency's Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Below is a list of the caravan parks on Reach A8 and whether or not they currently receive flood warnings from the Agency.

<i>Location</i>	<i>Name</i>	<i>FW</i>
Salford		No
Oversley	Essex Park Homes	Yes
Wixford		No

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th causing rain to

circulate from east to west across the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall. In general, recorded rainfall totals for the month of April for the whole of the Avon catchment were between two and three times the normal totals for April.

Most of the caravan sites were clearly very vulnerable when overtopping occurred because of their very close proximity to the watercourses. The extent of flooding varied from a few caravans being flooded to a major disaster situation at Abbot's Salford where a large number of caravans were washed away and the emergency services had to rescue people from being swept away.

In total during the event 1300 caravans were flooded in the Avon valley, a number of these being washed away, causing problems downstream. Of these, 905 were on the Avon (Reach A4), 330 on the Avon (Reach A5) and 65 on the River Arrow (Reach A3).

In addition to the caravan flooding here, the high levels in the Avon combined with a minor flood on the Severn caused flooding between Tewkesbury and Gloucester. This affected the Lower Lode Caravan Park where a number of vans were flooded.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

A request for a boat was received from Warwickshire Police in the early hours of Friday 10th April to assist in a rescue at Abbot's Salford. The boat and required men were mobilised but the police later advised the Agency that the assistance was not required in this instance. (This rescue later featured in BBC1's '999' programme).

Men and equipment were available during the event to be called upon at short notice, if required.

Possible Courses of Action

Caravan parks in the floodplain represent some of the most vulnerable areas from a flood risk point of view. They are also the most challenging in terms of the provision of a reliable flood warning service. The majority of those people using the sites will, in all probability, only visit on an infrequent basis and will not have an appreciation of the potential dangers, only the delights of their location in the summer.

Currently, some but not all caravan sites receive flood warnings direct from the Environment Agency. This is a situation inherited by the Agency which is subject to review and change as the warning service is progressively expanded in terms of coverage. The Agency must first of all ensure that it has identified all caravan parks and camping sites within the floodplain, including any not covered by the planning process, and then make arrangements with the owners/operators for them to receive all appropriate flood warnings direct from the Agency. In addition, site owners/operators will be encouraged to have an agreed evacuation procedure in place. It is not considered practical for the Agency to endeavour to warn the owners/occupiers of individual caravans

The Agency will continue to advise against the siting of any caravans within floodplain areas, including the expansion of existing sites. Nevertheless, it is recognised that it is unlikely that existing

well established sites will be closed. Consequently the Environment Agency supports the views expressed in the 10 Minute Rule Bill introduced by Sally Keeble MP, in July 1998. This recommended that there should be a legal obligation on property owners, which includes caravan parks and camping sites, to ascertain from the Agency what the risk of flooding is for the property and then pass this information on to prospective purchasers or tenants. It also recommended that the proprietors of sites should have a legal obligation to draw up a plan of action in case of flooding.

EVESHAM, WORCESTERSHIRE, RIVER AVON

Background

Evesham is a large town in the Vale of Evesham, Worcestershire, in the area of Wychavon District Council. The town is situated on the River Avon, which is designated Main River at this point. There are five bridge crossings of the Avon within the town of Evesham. Working upstream, they are the Oxford-Worcester railway, the A4184 at New Bridge, an unclassified road the former A44 at Workman Bridge, the Oxford-Worcester railway and the A435(T) Evesham Bypass at Simon de Montfort Bridge.

The River Avon is 191km long and drains an area of 2,850km². It is mainly rural in character and is the main arterial drain for Warwickshire and SE Worcestershire. It is also widely used for water supply and is navigable from Stratford to Tewkesbury. The catchment is mainly impermeable Keuper Marl and Lias Clays, which result in rapid river flow response to rainfall

Three other lengths of Main River have confluences with the Avon on its left bank at Evesham. These are the River Isbourne and Battleton Brook within the town, and Badsey Brook immediately upstream of the Evesham Bypass. Because of this, flood events at Evesham tend to have either a double or even triple peak. The Badsey Brook and Isbourne systems can cause flooding downstream of Evesham before the main Avon peak arrives, or simply hold the Avon levels up.

In the last 50 years there have been three major floods on the Lower Avon. There were 50-year events in March 1947 and July 1968 and a 10-year event in January 1959. A feasibility study was undertaken in 1985 on the Lower Avon between Evesham and Tewkesbury, with a view to undertaking major improvement works. Unfortunately this coincided with a change in government priority away from land drainage works primarily for agricultural benefit. There were also some conservation concerns and consequently the improvement scheme was abandoned

Between 1981 and April 1998 the Agency and its predecessors were consulted on planning applications on 155 occasions for Evesham. No development in the town centre floodplain has been allowed that went against Agency advice. The Agency is involved in a focus group for the development of Port Street, Bengeworth in the town.

Flood Warning

Evesham is covered by the flood warning service provided by Lower Severn Area, being on Reach A5 - River Avon from Evesham to upstream of Tewkesbury. Yellow, Amber and Red flood warnings are issued.

A flood warden scheme, administered by Wychavon District Council, is in operation on reach A5 of the River Avon. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to the following emergency services:

- i) Hereford and Worcester County Council
- ii) Wychavon District Council (Reach A5 only)

- iii) West Mercia police, who then pass them on to the following:
 - a) Hereford and Worcester Fire Service
 - b) Hereford and Worcester Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, also go to the following radio stations for broadcasting:

- i) BBC Hereford and Worcester
- ii) Radio Wyvern

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the Avon catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The flooding affected 100 properties of which 25 were commercial premises. The return period has been estimated at between 70 and 200 years, in the main around 1:150. The peak flood level was 24.73mAOD reached at 10.30 on April 10th. This was the highest level since records began, beating the previous highest in 1900 of 24.63mAOD.

Emergency Response

The Agency issued Yellow, Amber and Red warnings for Reach A5 of the Avon on 9th April. The Yellow was issued at 13.53 hrs, the Amber at 15.26 hrs and the Red at 18.24 hrs.

As water levels rose routine patrols were instigated on 9th April, by the Environment Agency's Emergency Workforce. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

Possible Courses of Action

The question of a possible flood alleviation scheme has been investigated previously but for a number of reasons did not go ahead. Following the Easter flooding a further feasibility study into a possible scheme for the town, which will compare the costs/benefits and also take into account the amenity aspects of the river, has been initiated.

Currently Reach A5 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive warnings direct. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review has been instigated, in order to devise a system that maximises reliability and flexibility.

Since Easter Wychavon District Council has been in contact with everyone known to have flooded and reworked their flood warden scheme to include all those people wishing to receive flood warnings. In addition the dissemination chain of senior flood wardens, flood wardens and deputies has been consolidated.

A full study of the tributary watercourse systems around Evesham will also be undertaken in order to establish more precisely the extent of their influence on River Avon levels during an event. There are interrogable river level recorders on the Isbourne at Hinton and on the Badsey Brook at Offenham.

HIMBLETON, WORCESTERSHIRE, BOW BROOK

Background

Himbleton is a small village in Worcestershire around 10km north-east of Worcester, in the area of Wychavon District Council. It is situated on both banks of the Bow Brook which is designated Main River at this point. In the village an unclassified road crosses the brook. The watercourse also runs alongside an unclassified road for 1km on its left bank.

The brook is subject to 'flash' flooding which regularly overtops the principal road running through the village, cutting off the two sides of the valley. The worst events in recent years occurred in 1981 and 1993.

In 1994 engineering consultants, Scott Wilson Kirkpatrick, were engaged by the National Rivers Authority to investigate the feasibility of flood alleviation works for the village. A model was constructed with Micro-FSR used to carry out the flow calculations and Micro Flucomp the backwater analysis. Little flow information was available to calibrate the model. The report concluded that ten houses and three barns were at risk from a 1 in 50 year event rising to eleven houses and four barns in a 100 year event. The study concluded that flood defences could not be economically justified

Flood Warning

No flood warnings are currently issued for Himbleton or the Bow Brook. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the lower reaches of the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The rainfall gauge at Crowle, 3km downstream of Himbleton, recorded 52.0mm on April 9th.

During the flood event 14 properties were affected. The return period has been estimated at between 25 and 50 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

Possible Courses of Action

At the time of the previous model study, there was only limited data available to calibrate the model

but following recent events there is justification in re-visiting the study. The Environment Agency has initiated a further feasibility study using data gathered from this event to assess the viability of a possible flood alleviation scheme. It is worth noting that there is desire from landowners and householders to enter a partnership for funding with the Agency.

The Agency is also investigating the possibility of introducing of a flood warning service for Himbleton. The Bow Brook is not currently part of the warning system and there is no gauging station on the Bow Brook at present. The only relevant instrumentation is a rainfall recorder at Crowle. Further work will be necessary before a decision on the type of service possible can be made. Threshold levels will need to be devised, local residents will need to be contacted about receiving warnings and liaison will be necessary with the local authority regarding the feasibility of setting up a warden scheme.

LITTLETON, WORCESTERSHIRE, LITTLETON BROOK

Background

Littleton in the Vale of Evesham, Worcestershire, is made up of three separate villages, North, Middle and South. They are situated some 5km to the north-east of Evesham, in the area of Wychavon District Council.

The villages are on the Littleton Brook, which is designated Main River. The brook is a tributary of the Badsey Brook which in turn flows into the Avon just north of Evesham. There are four minor road crossings in the area.

Flooding has occurred on the Littleton Brook on a number of occasions in the recent past, with 1968 being the worst event.

The Agency, and its predecessors, have been consulted on planning applications on 45 occasions since 1981, including 15 in the last three years.

Flood Warning

No flood warnings are issued for Littleton or the Littleton Brook. The flood warning service provided by Lower Severn Area of the Environment Agency is currently limited to the main trunk of the Avon, together with the lower reaches of the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing periods of extremely heavy rainfall.

The first property flooding, on Thursday 9th April was caused by surface runoff from adjacent fields and roads. This was made worse by the brook overtopping and inundating houses. In all, 31 properties were affected by flooding in the village of North Littleton.

Emergency Response

As water levels rose, routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

Possible Courses of Action

The Environment Agency has initiated an investigation into the feasibility of a possible flood alleviation scheme for Littleton. This will involve a full survey of not only the brook but also the many tributary drains and ditches. The Parish Council feels that many of these tributary watercourses are poorly maintained and that Littleton Brook itself needs to be cleaned out. The feasibility study will examine the drainage network, and consider various scheme options. The Agency's current programme of watercourse maintenance will also be examined to see if any

changes would be beneficial.

The possible introduction of a flood warning service is also being investigated. However the nearest gauging station to Littleton is currently at Offenham on the Badsey Brook, around 4km downstream. A gauge on the Littleton Brook would be the first logical step if it were found that a service was at all feasible. Littleton is very near the top of the catchment of a watercourse which may be too 'flashy' for anything other than an alarm type service.

LONG ITCHINGTON, WARWICKSHIRE, RIVER ITCHEN

Background

Long Itchington is a large village around 10km east of Leamington Spa in the area of Warwick District Council. The village is on the right bank of the River Itchen, which is designated Main River at this point. Just upstream of the village the Itchen is crossed by the Grand Union Canal. In the village two unclassified roads, Bascote Road and Stonebridge Lane cross the river, and there is a caravan site on the right bank. The Itchen is a major tributary of the River Leam, with a catchment area of 130km².

During the major flood of 1968 there was extensive flooding in Long Itchington. As a result of this a Flood Alleviation Scheme was carried out between 1969 and 1972. This included channel resectioning, construction of floodbanks and reconstruction of bridges. The scheme was carried out to a return period of 100 years. In 1994, the defences were inspected as part of the Stage I Asset Survey and were found to be in a good or fair condition although there were some signs of settlement and low spots. The full results of the more detailed Stage II Survey are still awaited. In the meantime the then NRA commissioned a study in 1995 by Scott, Wilson, Kirkpatrick, Consulting Engineers (SWK). As part of the study a hydraulic model of the river reach was constructed using the HEC-2 river modelling program. It showed that the defences met the requirement for a level of service of a 100 year event, but with low levels of freeboard. However the model used relies for calibration on a single flood event, 1968. For the model to be used with confidence further level and flow information is required.

A new development of 55 houses was built in the north-west of the village in 1996. During consultation the then NRA had no objection to the proposals in principle as the development was not in the floodplain. However it asked for provision of adequate surface water drainage to be installed as part of the scheme and foul water to be directed to the main sewerage system. A surface water drain was built from the development to the Itchen. There were two 90° bends in the drain with a manhole above each of them. It is still awaiting adoption by Severn Trent Water plc, due to some concern over its course.

Flood Warning

No flood warnings are currently issued for Long Itchington or the River Itchen. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the lower reaches of the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th causing rain to circulate from east to west across the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The first property flooding occurred in Long Itchington during the afternoon of April 9th. Water was reported to be bubbling up from a manhole in the centre of the village which caused some flooding problems. At 16.55 hrs during one of the Environment Agency's flood patrols, water was

reported to be at the top of the defences and only 100mm from the electrics of the pumping station. Shortly after the defences overtopped and at 19.20 hrs the floodwater caused a mains failure at the pumping station.

During the flooding a total of 40 properties were affected. These included thirty five behind the defences (two of them commercial premises) and five to the west of the village that were outside the scope of the hydraulic model and were therefore not defended. These five were flooded due to surcharges from the storm drain from the 1996 development. This may have been due to inadequate capacity or because it had become blocked.

Levels taken following the event were between 68.75 and 69.22 mAOD. It is difficult to make a direct comparison with the 1968 event as the levels were not taken at the same locations, but generally the levels seem to be fairly similar. The return period of the flood event has been estimated at around 1:100 years.

Emergency Response

As water levels rose on April 9th routine patrols were instigated. Gangs were sent out to inspect structures and check the integrity of defences.

As soon as the high level alarm went off a man was sent to check levels on site etc. At around 17.00 hrs the defences were observed to overtop. Following the failure of the mains at the pumping station arrangements were made to bring in 4 x 6" pumps (two from Gloucester, two from Upper Trent). Unfortunately due to road conditions in and around Long Itchington, although the pumps arrived in the area before midnight it was not until 04.00 hrs that the pumps arrived in the village and 05.00 hrs on Friday 10th that they were up and running. Pumping continued until the afternoon of the 11th when the pumps were stood down.

Possible Courses of Action

The flooding at Long Itchington raised a number of issues. At the pumping station, surface water gathered behind the pumps, which could not cope and were overwhelmed causing failure of power and necessitating mobile pumps being brought in. The Environment Agency is looking at the design and capacity of the station with a view to upgrading, if appropriate.

There is also the issue of the flood alleviation scheme. The Agency has completed checks on the defences physically to establish their integrity following the pressure they were put under. In addition, the model created by SWK in 1995 will be re-visited and calibrated using the levels from this event. This will then produce a more accurate picture of the level of protection currently offered by the defences.

An investigation will be completed into how the flooding developed during the course of the event, particularly with respect to the role played by the surface water drain from the recent development. It is clear that the flooding was the result of a combination of water from this source and overtopping of the banks, but the relative proportions are not clear.

An assessment of the viability of introducing a flood warning service for Long Itchington has also been instigated.

MARTON, WARWICKSHIRE, RIVER LEAM

Background

Marton is a small village in Warwickshire 10km north-east of Leamington Spa, in the area of Rugby Borough Council. It is situated on the left bank of the River Leam at the point where the River Itchen has its confluence with the former on the left bank. Both are designated Main River at this point. The A423 trunk road crosses the River Leam here, together with a minor road crossing of the River Itchen.

The River Leam has a total Main River length of 39km. The catchment of 364km² is mainly agricultural. The river flows in a generally westerly direction through layers of Keuper Marl and Lower Lias with a small amount of triassic mudstone. This results in a rapid river flow response to rainfall.

The village of Marton has been affected by flooding on a number of occasions most recently in 1979, 1981 and 1985.

Flood Warning

At Marton some farmers, but not the village, are not covered by the flood warning service provided by Lower Severn Area, being on Reach A6 - River Leam.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties will receive telephoned flood warnings from the Environment Agency's Area flood warning centre at Tewkesbury.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th causing rain to circulate from east to west across the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

During the course of the flooding 10 properties were affected on A423 Coventry-Oxford Road, Church Street and Birdingbury Road. The return period of the flood has been estimated as a 100 year event.

Emergency Response

All three flood warnings for the Leam were issued during Thursday 9 April based on the Eathorpe gauge as follows:

Yellow at 15.54 hrs Amber at 17.02 hrs and Red at 23.18 hrs

As water levels rose routine patrols were instigated on 9th April, by the Environment Agency's Emergency Workforce. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

Possible Courses of Action

At present there are no defences at Marton. An investigation into the feasibility of a flood alleviation scheme will be carried out whereby the costs will be weighed against the benefits and the various options considered.

Currently on Reach A6 there is one flood warden in Marton who receives a voice message direct from the Environment Agency's AVM machine and contacts a number of people at risk. If the warden is unavailable then currently these people will not receive a direct warning. The Agency's AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

PERSHORE, WORCESTERSHIRE, RIVER AVON

Background

Pershore is a small town in the Vale of Evesham, Worcestershire, 10km west of Evesham, in the area of Wychavon District Council. It is situated on the right bank of the River Avon which is designated Main River at this point. At Pershore there is one bridge crossing of the Avon, namely the A44 trunk road at the downstream end of the town. In addition, there is a navigation lock and associated sluices.

The Avon is 191km long, draining an area of around 2,850km². It is the main arterial drain for Warwickshire and SE Worcestershire. It is also widely used for water supply and is navigable between Tewkesbury and Stratford. The interests of navigation in the Pershore area are taken care of by the Lower Avon Navigation Trust. The catchment is mainly impermeable Keuper Marl and Lias Clays. This results in rapid river flow response to rainfall.

Pershore has been affected by flooding on a number of occasions, most recently 1982, 1983, 1984 and 1993.

The Agency and its predecessors have been consulted on planning applications on 71 occasions for Pershore since 1981.

Flood Warning

Evesham is covered by the flood warning service provided by Lower Severn Area, being on Reach A5 - River Avon from Evesham to upstream of Tewkesbury. Yellow, Amber and Red flood warnings are issued.

A flood warden scheme, administered by Wychavon District Council, is in operation on reach A5 of the River Avon. Flood wardens and some individual properties receive telephoned flood warnings from the Environment Agency's Area flood warning centre at Tewkesbury.

Telephoned flood warnings, backed up by fax, go to the following emergency services:

- i) Worcestershire County Council
- ii) Wychavon District Council
- iii) West Mercia police, who pass them on to the following:
 - a) Hereford and Worcester Fire Brigade
 - b) Hereford and Worcester Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to the following radio stations, which then broadcast them:

- i) BBC Hereford and Worcester
- ii) Radio Wyvern

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the area. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The level recorded at the gauge at Pershore peaked at 17.56mAOD on April 10th. This was the highest level on record, although records only date back to 1978. The return period of the flood has been estimated at between 50 and 70 years. During the event a total of 10 properties were affected by flooding.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

The Agency issued Yellow, Amber and Red warnings for Reach A5 of the Avon on 9th April. The Yellow was issued at 13.53 hrs, the Amber at 15.26 hrs and the Red at 18.24 hrs.

Possible Courses of Action

At present there are no flood defences at Pershore. An investigation into the feasibility of a scheme has been initiated, whereby the costs will be weighed against the benefits and the various options will be considered.

Currently Reach A5 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive direct warnings. The Agency's AVM equipment is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

Since the Easter floods, Wychavon District Council has been in contact with everyone known to have flooded and re-worked their flood warden scheme to include all those people wishing to receive flood warnings. In addition, the dissemination chain of senior flood warden/deputy and flood wardens/deputies has been consolidated.

SEDGEBERROW, WORCESTERSHIRE, RIVER ISBOURNE

Background

Sedgeberrow is a small village in the Vale of Evesham lying some 5km south of Evesham, Worcestershire, in the area of Wychavon District Council. It is on the left bank of the River Isbourne, which is a tributary of the River Avon. Both are designated Main River at this point. Downstream of the village the River Isbourne is crossed by the A436 Sedgeberrow Bypass, while in the village the B4078, the former main road, crosses the river. There are no other river crossings in the village.

The Isbourne rises near Cleeve Hill to the north-east of Cheltenham and flows in a generally northerly direction for 22km where it joins the Avon at Evesham. The soils are predominantly derived from impermeable Keuper Marl and Lias Clays, ensuring the catchment has a rapid response to rainfall.

There is a history of flooding in the village. Serious flooding in 1968 and 1979 led to a major flood alleviation scheme in the early 1980s. This comprised extensive channel works, embankments, flood walls and a pumping station to evacuate water from behind the defences. However, during a relatively moderate flood event in 1993 the defences were very close to overtopping. A preliminary investigation and survey suggested the scheme was not performing to the original design.

Consultants, Scott Wilson Kirkpatrick, were commissioned to assess the scheme in detail in 1995. As part of the study the existing HEC-2 model was moved onto ONDA to tie in to an existing model of the Isbourne further downstream. However, calibration of the model was limited as there was very little recorded historical flood data. The results indicated that the existing flood defences probably do not provide a 100 year standard of service. Several improvement options were initially considered but discounted because of cost / benefit or environmental reasons. A further option of a flood relief culvert has since been suggested but has not yet been fully investigated or modelled.

Flood Warning

No flood warnings are issued for Sedgeberrow or the River Isbourne. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the lower reaches of the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The first indication of the severity of the situation came at 10.25 hrs on April 9th with a high level alarm (u/s) at Sedgeberrow Pumping Station. The first report of property flooding was received at 11.45 hrs when surface water runoff was affecting seven properties. By 13.35 hrs the floodwater was overtopping the embankments and flooding houses. During the event a total of forty properties were affected, the return period being estimated at 100 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April by the Agency's Emergency Workforce. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas.

In the initial stages of the flooding the pumping station was dealing with the surface water, but it was decided that if pumps were hired in then it could be dealt with more efficiently. Sykes Pumps were called at 07.45 hrs on 10th April and 2 x 6" pumps were sent to Sedgeberrow. These were working during daylight hours for the whole of the 10th and on the 11th until 18.05 hrs when they were finally stood down.

Possible Courses of Action

Following on from the investigations already carried out into the Sedgeberrow defences, a full feasibility study will take place. The study will include further detailed modelling. Since the original model was devised further flow and level data have been gathered and can now be used to improve the model. The feasibility study will also need to include a survey of the route for a possible relief culvert, incorporating service enquiries and land ownership investigations.

Another consideration will be the possible introduction of a flood warning service on the watercourse. At present there is a gauging station on the Isbourne at Hinton 2km downstream of Sedgeberrow but no warning service exists for the watercourse. Further work will be required to determine the practicalities of introducing a scheme here. Threshold levels would need to be devised, local residents contacted about receiving warnings and liaison with the local authority regarding the feasibility of setting up a warden scheme.

Following the flooding, condition surveys of the defences have been carried out. The preliminary report indicates that some defences have been damaged. The full report is awaited which will provide a better indication of what needs to be done.

SHIPSTON-ON-STOUR, WARWICKSHIRE, RIVER STOUR

Background

Shipston-on-Stour is a large village 15km south-east of Stratford-on-Avon, Warwickshire in the area of Stratford-on-Avon District Council. The village is on the left bank of the River Stour which is designated Main River at this point. Upstream of the village the Stour is crossed by the A34 trunk road (the main road between Stratford and Oxford) and adjacent to the village by the B4035 road.

The Stour is a major tributary of the River Avon draining a catchment of 349km². It flows in a generally northerly direction and is characterised by a relatively narrow floodplain and a steep gradient. The soil is generally Keuper Marl in origin.

There have been a number of flood events affecting the village in previous years, the worst of them being in 1947 and 1968.

Since 1981 the Agency and its predecessors have been consulted on 92 planning applications for Shipston.

Flood Warning

Shipston-on-Stour is covered by the flood warning service provided by Lower Severn Area, being on Reach A7 - River Stour.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The 15 hour period from 04.00 hrs to 19.00 hrs on 9th April saw 66mm of rain fall at the gauge at Shipston. During the event a total of 20 properties were flooded. The highest level achieved was 63.21mAOD at 16.45 hrs on April 9th. This was higher than the previous record of 62.85mAOD,

reached during the event of 1968. The return period is estimated at 40 - 80 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, at appropriate locations, and check at-risk areas.

In the course of the event, warnings for all three colours were issued on 9th April. The Yellow was issued at 10.13 hrs, the Amber at 11.40 hrs and the red at 14.05hrs.

Possible Courses of Action

A feasibility study into a possible flood alleviation scheme for the town has been initiated which will compare the costs and benefits of any possible scheme, and take into account the public amenity aspects of the river.

Currently Reach A7 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive direct warnings. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

SOUTHAM, WARWICKSHIRE, RIVER STOWE

Background

Southam is a small town in Warwickshire some 10km east of Leamington, in the area of Stratford-on-Avon District Council. It is situated on both banks of the River Stowe, which is designated Main River at this point. There are seven crossings of the Stowe within the town. Working upstream they are as follows: Warwick Road the former A425, current Banbury Road the former A423(T), original Banbury Road, an unclassified road, the A423(T) Southam Bypass, an unclassified road and Daventry Road the A425. The latter is the current upstream limit of Main River. In addition, there are a number of footbridges across the Stowe within the town.

The River Stowe is a tributary of the River Itchen, the Main River length being 2.5km long, flowing in a generally westerly direction. The underlying soils are derived from Keuper Marl with some Blue Lias, resulting in a rapid river flow response to rainfall.

There have been a number of flood events affecting the town in the past, the worst occurring in 1968. However, no historic level information is available.

The Southam bypass was completed in 1991. Since then a large amount of infill development has taken place between the existing town and the bypass. There have been 70 planning consultations with the Agency and its predecessors since 1981. These have been for a mixture of residential and industrial development. Due to the lack of data the Agency did not object outright on flooding grounds but generally the developer would be asked to undertake an appropriate flood study.

Flood Warning

No flood warnings are currently issued for Southam or the River Stowe. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the lower reaches of the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th causing rain to circulate from east to west across the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The River Stowe was unable to contain the flood flows and water came out of bank. The first property was reported to be flooding at 15.30 hrs in Tattle Bank, Southam on April 9th. During the resulting flooding 10 properties were affected, including some new houses. The return period has been estimated at up to 100 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding information back to staff in the office to give them

an accurate picture of what was actually happening on the ground.

Possible Courses of Action

At present there are no defences at Southam. An investigation into the feasibility of a flood alleviation scheme will be undertaken, whereby the costs will be weighed against the benefits and the various options considered.

The question of the possible introduction of a flood warning service for Southam is being investigated, although the River Itchen and River Stowe are not currently part of the system. At present there is only a gauging station on the River Leam at Eathorpe 8km downstream, which will not provide sufficient information to enable the issue of warnings for Southam. If the provision of a service is feasible, further work and the installation of equipment will be necessary. Appropriate warning threshold levels will need to be devised. In addition, local residents will need to be contacted about receiving warnings, and liaison with the local authority regarding the feasibility of setting up a warden scheme will be necessary.

The Agency is also considering whether it is appropriate to recommend that the Main River be extended further. This would allow a larger area to be considered under a feasibility assessment and would also give the Agency more influence in terms of development control, as there are still a number of areas around the town where development could take place.

STRATFORD-UPON-AVON, WARWICKSHIRE, RIVER AVON

Background

Stratford-upon-Avon is a large town in Warwickshire, in the area of Stratford-on-Avon District Council. The town is situated on the River Avon, which is designated Main River at this point. There are four bridge crossings of the Avon within the town. Working upstream they are the former Stratford-Honeybourne railway now a long distance footpath, the A4390 Stratford Southern Relief Road, the former Stratford-Moreton tramway at Tramway Bridge and the A422.

The River Avon is 191km long. It drains an area of 2,850km², which is mainly rural in character. It is the main arterial drain for Warwickshire and South East Worcestershire. It is used for water supply and is navigable from upstream of Stratford at Alveston, to Tewkesbury, a distance of 74km. The catchment is mainly Keuper Marl and Lias Clays which result in rapid river flow response to rainfall.

Two other lengths of Main River have confluences with the Avon on its right bank within the town, the Racecourse Brook and Shottery Brook.

On several occasions in the past property flooding has occurred during an extreme flood event. The most notable events occurred in 1947 and 1968. Following the report on "Significant Flood Problems in the Section 136(1) Survey" undertaken in June 1990, it was decided to undertake a feasibility study. In the 1994 study four options were considered - i) do nothing, ii) channel improvements, iii) upstream storage and iv) embankments/walls.

Options ii) and iii) were rejected because there is no area of land available for storage. In addition, channel works would be either ineffective or too excessive for the location involved, because water levels in Stratford are largely controlled by the two weirs and a sluice gate downstream of the recreation ground. A cost-benefit analysis was undertaken to assess option iv). This found that the costs far outweighed the benefits on a 100 year event. The recommendation of the report was therefore the 'do nothing' option.

There have been a number of minor developments in the floodplain in recent years, eg. A bandstand, a new house on Tiddington Road and a new marina (approved but not yet built). Discussions are currently going on with Stratford-on-Avon District Council on "planning policy and practice" in order to establish best practice with them.

Flood Warning

Stratford is covered by the flood warning service provided by Lower Severn Area, being on Reach A4 - River Avon from Stratford to upstream of Evesham.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service

iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the Avon catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The flooding affected 40 properties including some on the Shipston Road and Warwick Road (near the canal) which were not identified in previous assessments. Some commercial properties were affected including the Leisure Centre and the Royal Shakespeare Theatre. The return period is estimated at between 1 in 40 and 1 in 90 years although levels reached were not as high as in 1947. The peak level was 36.71 mAOD.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

The Agency issued Yellow and Red flood warnings for Stratford. A Yellow warning was issued on 9th April at 18.13 hrs. This was followed by a Red warning on April 10th at 01.56 hrs.

Possible Courses of Action

The Environment Agency has undertaken to revisit the earlier feasibility study in the light of the Easter flood event. The Easter 1998 event affected 40 properties at a level of 36.71mAOD with an estimated return period of 40 to 90 years. The model created during the feasibility study will be re-calibrated using this information. In addition, the floodplain mapping project for the middle Avon which includes Stratford was completed last year. This information will also be fed into the feasibility study. The flood alleviation scheme that was proposed will then be re-assessed.

Currently Reach A4 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive direct warnings. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

TEWKESBURY, GLOUCESTERSHIRE, RIVER SEVERN

Background

Tewkesbury is a large town in Gloucestershire, in the area of Tewkesbury Borough Council. It is situated at the point where the River Avon has its confluence with the River Severn, either directly at Upper Lode or via the Mill Avon at Lower Lode. All are designated as Main River at this point. The town generally lies along the left bank of the Avon and Mill Avon. There are no flood defences in Tewkesbury. There are, however, a number of structures which control water levels, namely Upper Lode weir on the Severn, Stanchard Pit weir and sluice on the Avon and Abbey Mill sluice on the Mill Avon.

Other lengths of Main River in Tewkesbury are the Carrant Brook, which joins the River Avon just to the north of Tewkesbury and the River Swilgate which flows into the Mill Avon just to the south.

The catchment is mainly impermeable Keuper Marl and Lias Clays resulting in a rapid river flow response to rainfall.

The town has been affected by flooding on a number of occasions, most significantly in 1947 from the Severn and 1998 from the Avon. A feasibility study was undertaken in 1985 on the Lower Avon between Evesham and Tewkesbury, with a view to undertaking major improvement works. Unfortunately this coincided with a change in government priority away from land drainage works primarily for agricultural benefit. There were also some conservation concerns and consequently the improvement scheme was abandoned.

Flood Warning

Tewkesbury is covered by the flood warning service provided by Lower Severn Area, being on Reach S11 - River Severn from Tewkesbury to upstream of Gloucester. It is also at the downstream end of Reach A5 - River Avon from Evesham to upstream of Tewkesbury. Flooding at Tewkesbury can occur as a consequence of high flows in either the River Severn, the River Avon, other tributary watercourses or a combination of these.

A flood warden scheme, administered by Tewkesbury Borough Council, is in operation on this reach. Flood wardens and some individual properties receive telephoned flood warnings from the Environment Agency's Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to the following emergency services:

- i) Gloucestershire County Council
- ii) Tewkesbury Borough Council
- iii) Gloucestershire Police, who then to pass them on to the following:
 - a) Gloucestershire Fire & Rescue Service
 - b) Gloucestershire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to the following radio stations, who then

broadcast them:

- i) Radio Gloucestershire
- ii) Severn Sound

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to both the Severn and Avon catchments. In particular, the rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The peak level achieved at Mythe Bridge on the River Severn was 11.96mAOD, which is slightly less than the peak of 1990 of 11.98mAOD. During the event 20 properties were flooded. The return period has been estimated at between 25 and 75 years.

Emergency Response

The following flood warnings were issued:

Reach	Colour	Date	Time
A5	Yellow	9/4/98	13.53 hrs
	Amber	9/4/98	15.26 hrs
	Red	9/4/98	18.24 hrs
S11	Yellow	9/4/98	20.14 hrs
	Amber	10/4/98	03.44 hrs
	Red	10/4/98	16.14 hrs

Possible Courses of Action

The Environment Agency will carry out a feasibility study into the possibility of further flood alleviation works for Tewkesbury. This will compare the costs and benefits of any scheme, taking into account the public amenity aspects of the river.

Currently reaches A5 and S11 are served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive direct warnings. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

TREDINGTON, WARWICKSHIRE, RIVER STOUR

Background

Tredington is a large village in Warwickshire 15km south-east of Stratford-on-Avon, in the area of Stratford-on-Avon District Council. It is situated on the left bank of the River Stour which is designated Main River at this point. There are no river crossings in Tredington but the A34 trunk road runs very close to the river upstream and downstream of the village.

The Stour is a major tributary of the River Avon with a catchment area of 349km². It flows in a generally northerly direction. The floodplain is very narrow and the watercourse has a steep gradient. The underlying soils are derived from Keuper Marl and Lower Lias, resulting in a rapid river flow response to rainfall.

There have been a number of flood events affecting the village in previous years, the worst of them being in 1947 and 1968.

Since 1981 the Agency and its predecessors have dealt with 22 planning applications for the village.

Flood Warning

Tredington is covered by the flood warning service provided by Lower Severn Area, being on Reach A7 - River Stour.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Environment Agency's Area flood warning centre at Tewkesbury.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th causing rain to circulate from east to west across the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

During the flooding a total of ten properties were affected. The return period has been estimated at

around 40 – 80 years.

The 15 hour period from 04.00 hrs to 19.00 hrs on 9th April saw 66mm of rain fall at the gauge at Shipston, 3km upstream of Tredington.

At the Shipston gauge the highest level achieved was 63.21mAOD at 16.45 hrs on April 9th. This was higher than the previous record of 62.85mAOD, reached during the event of 1968.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding back information to staff in the office to give them an accurate picture of what was actually happening on the ground.

In the course of the event warnings for all three colours were issued on April 9th. The Yellow was issued at 10.13 hrs, the Amber at 11.40 hrs and the Red at 14.05 hrs.

Possible Courses of Action

A feasibility study into a possible flood alleviation scheme for the village will be incorporated into the investigations undertaken for Shipston, just upstream. This study will compare the costs/benefits and also take into account the public amenity aspects of the river.

Currently Reach A7 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive direct warnings. The Agency's AVM equipment is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

WARWICK, WARWICKSHIRE, RIVER AVON

Background

Warwick is a large town in Warwickshire lying immediately to the west of Leamington Spa, in the area of Warwick District Council. The town is situated predominately on the right bank of the River Avon at the point where the River Leam has its confluence with the former on its left bank. Both are designated as Main River at this point. There are four crossings of the Avon within the town, working upstream they are the A425, the Birmingham-Leamington railway, the Grand Union Canal and the A445. There are also two weirs - downstream of the A425 and upstream of the A445.

The River Avon is 191km long, draining an area of 2,850km². It is the main arterial drain for Warwickshire and south east Worcestershire. It is used for water supply and is navigable from Stratford to Tewkesbury. The River Leam is 39km long, the catchment is mainly agricultural and drains an area of 364km². The underlying soils are mainly impermeable Keuper Marl and Lias Clays, resulting in rapid river flow response to rainfall.

On several occasions in the past, most notably in 1947 and 1968, a number of properties in Warwick have been affected by flooding. The majority of these are located in Bridge End along the left bank of the river. Following the Section 136(1) Survey in 1990 it was agreed that a feasibility study would be undertaken. A mathematical model was commissioned to produce flood outlines for various flood event return periods using the ONDA modelling software. There were four possible options considered: i) do nothing; ii) channel improvements; iii) flood walls at river edge; iv) flood walls at patios of property together with a reconstructed boundary wall.

Option ii) was rejected because water levels in the area are controlled by the large weirs downstream. Channel works would either be ineffective or too excessive. Option iii) was not considered viable because of restrictions to river access for the residents. To consider option iv) further discussions with property owners were undertaken and environmental considerations looked at. A scheme to protect the houses would require a 600mm flood wall to connect between each property, which would cause a lot of disturbance. The cost / benefit analysis that was undertaken using the ESTDAM program found a ratio of benefits to costs of 0.85. The conclusion of the report was that flooding would not start until a 50 year event and that a scheme to protect property against 100 year flooding was not feasible. The do nothing option was therefore chosen.

Since 1996, the Agency has been consulted on 11 planning applications for Warwick, but all of the proposals have been of a minor nature.

Flood Warning

Warwick is covered by the flood warning service provided by Lower Severn Area, being on Reach A3 - River Avon from Warwick to upstream of Stratford.

A flood warden scheme is in operation on this reach of river. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council

- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the Avon catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The flooding affected 39 properties in two areas of the town – Bridgend and the area near to the confluence with the Leam. The return period of the flood has been estimated as between 1 in 40 and 1 in 90 years. The peak flood level was 47.95mAOD at 10.45 hrs on April 10th. This was just below the highest level on record of 48.0mAOD in March 1947.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding information back to staff in the office to give them an accurate picture of what was actually happening on the ground.

Flood warnings for Reach A3 were issued as follows: Yellow on 9th April at 18.24 hrs, Amber on 9th April at 22.34 hrs and Red at 07.40 hrs on the 10th of April.

Possible Courses of Action

A re-examination of the feasibility scheme is being undertaken. This will allow the model to be re-calibrated using information from this event, which will produce a more accurate set of flood outlines. The floodplain mapping of the middle Avon, which includes Warwick, was completed last year and the information that was generated will be fed into the feasibility study.

Currently Reach A3 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive a direct warning. The AVM is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits however with the warden system, so a full review is being undertaken, in order to devise a system that maximises reliability and flexibility.

WELFORD-ON-AVON, WARWICKSHIRE, RIVER AVON

Background

Welford-on-Avon is a large village in Warwickshire, 6km south-west of Stratford-on-Avon in the area of Stratford-on-Avon District Council.

The village is situated within a loop of the River Avon (left bank) which is designated Main River. There is one crossing of the river at Binton Bridge by a minor road.

The River Avon is 191km long, draining an area of around 2,850km². It is the main arterial drain for Warwickshire and SE Worcestershire. It is also widely used for water supply and is navigable between Tewkesbury and Stratford. The catchment is mainly impermeable Keuper Marl and Lias Clays. This results in rapid river flow response to rainfall.

Flooding has affected the village on a number of occasions, most notably in recent years in 1977 and 1981, although larger events occurred in 1947 and 1968.

Since 1981 the Agency and its predecessors have been consulted on 21 planning applications in the village.

Flood Warning

Stratford is covered by the flood warning service provided by Lower Severn Area, being on Reach A4 - River Avon from Stratford to upstream of Evesham.

A flood warden scheme is in operation on this reach. Flood wardens and some individual properties receive telephoned flood warnings from the Area flood warning centre.

Telephoned flood warnings, backed up by fax, go to Warwickshire police, who then pass them on to the following:

- i) Warwickshire County Council
- ii) Warwickshire Fire & Rescue Service
- iii) Warwickshire Ambulance Service NHS Trust

Telephoned flood warnings, backed up by fax, go to BBC Coventry and Warwickshire, who then broadcast them.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

The rainfall gauge at Milcote around 3km upstream of Welford recorded a total of 60mm of rain on

April 9th. A total of ten properties were affected by flooding during this event in the village. The return period has been estimated at around 40 – 90 years.

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, as appropriate, and check at-risk areas. They were also tasked with clearing any blockages and feeding information back to staff in the office to give them an accurate picture of what was actually happening on the ground.

The Agency issued Yellow and red flood warnings for reach A4. A Yellow warning was issued on 9th April at 18.13 hrs. This was followed by a red warning on April 10th at 01.56 hrs.

Possible Courses of Action

At present there are no defences at Welford. An investigation into the feasibility of a scheme will be carried out, whereby the costs will be weighed against the benefits and the various options considered.

Currently Reach A4 is served by a Flood Warden scheme whereby each of the wardens contacts a number of people at risk. If the warden is unavailable then currently these people will not receive warnings direct. The Agency's AVM equipment is capable of warning all those at risk, via a cascade system, whereby if the warden is not reached those at risk receive a call instead. There are merits, however, with the warden system, so a full review is being undertaken in order to devise a system that maximises reliability and flexibility.

WELLESBOURNE, WARWICKSHIRE, RIVER DENE

Background

Wellesbourne is a large village in Warwickshire, some 8km east of Stratford-upon-Avon, in the area of Stratford-on-Avon District Council. The village is on both banks of the River Dene, which is designated Main River at this point. Downstream of the village the River Dene is crossed by the A429 Wellesbourne Bypass, while in the village, the former main road, crosses the river. There are no other crossings in the village

The River Dene has a catchment area of 97.3km² (4.2% being urban). The soil is generally heavy, being derived from Lias Clay, with some Keuper Marl in the lower part of the catchment. Wellesbourne is approximately 3km above the Dene's confluence with the Avon.

In the last two years the Agency has been consulted on 36 planning applications in Wellesbourne. Generally speaking it has not objected, providing ground levels in the floodplain are not raised, which would increase the risk of flooding.

The areas liable to flood are protected by a flood alleviation scheme constructed by the then Severn Trent Water Authority in 1975, up to a level of approximately 75 years protection (protecting over 100 properties). The scheme consisted of a realigned channel, increased capacity at the major road bridge by installation of box culverts, replacement of a footbridge, construction of flood embankments and floodwalls (300mm above the 1968 flood levels) and the lowering of a weir 500m downstream of the village. Also incorporated into the scheme was pumping for surface water drainage behind the defences.

There was a survey of the defences in 1993/94. The crest levels were found to be at or above design levels, but with some settlement at field boundaries. The condition was found to be generally good. The results of the more detailed Stage II surveys are still awaited. An assessment of the scheme was undertaken in 1996 by Carl Bro Group, Consulting Engineers. As part of this study a hydraulic model of the river reach was constructed. The model created was based on 1968 conditions (the last major flood event). This was then calibrated using flood levels recorded at various locations during the 1968 event, and the existing situation model adjusted accordingly. From this, design flood levels were predicted. The results indicated that the defences gave a level of protection of 1:100. However, the model has known limitations because of a shortage of calibration data.

Flood Warning

No flood warnings are currently issued for Wellesbourne or the River Dene. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels were above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the area. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall. The 18 hour period from

05.00 hrs to 20.00 hrs on 9th April saw 64.5mm of rain fall at the gauge at Wellesbourne.

The flood defences at Wellesbourne were overtopped by the rising floodwater on Thursday 9th April. In the ensuing flooding approximately 50 properties were flooded, including 5 commercial premises. The highest level achieved was 43.29m above Ordnance Datum, at 20.45 hrs on 9th April, the return period estimated at between 50 and 100 years. This was the highest level on record (records commenced here in 1976).

Emergency Response

As water levels rose routine patrols were instigated on 9th April. Gangs were sent out to inspect structures and check the integrity of defences. During one of these patrols the defences at Wellesbourne were found to be about to be overtopped. At 07.45 hrs on Friday 10th Sykes pumps were called and they confirmed that 2 x 6" pumps could be sent to Wellesbourne. A gang was deployed to meet them on site. At 10.15 hrs the pumps arrived and were set up. At 11.45 hrs Sykes confirmed that as requested a further 2 pumps (4" this time) could be dispatched. Pumping of the floodwater over the defences continued until 22.00 hrs on the 10th (the road was clear by 19.01 hrs that evening) and commenced again the next morning. Pumping continued until 15.30 hrs on the 11th, when the pumps were stood down.

Possible Courses of Action

Following the flooding the Environment Agency is re-examining of the flood alleviation scheme for Wellesbourne. A full survey of the defences has been carried out and a Consultant's report is awaited. This will establish the condition of the defences following the inevitable pressure they were under during the floods and also establish whether their current level equates to the design level. The hydraulic model created by Carl Bro in 1996 will be re-calibrated using flood levels from this event which will give a more accurate picture of the level of protection currently offered by the defences. Following these studies there may be work required to bring the defences to the required standard.

A second matter being investigated is the question of the lack of evacuation facilities for floodwater. During this event pumps had to be brought in from outside to deal with the water. An assessment of the need for a pumping station for minor overtopping and disposal of surface water will be undertaken.

The other major consideration will be the possible introduction of a Flood Warning Service to Wellesbourne. The River Dene is not currently part of the system. There are however interrogable river level and rainfall recorders at Wellesbourne and therefore historical data are available. If a service is feasible, work will be required to set thresholds at appropriate levels based on the existing data. The residents who flooded will also need to be contacted to establish whether they want to receive a warning.

WINCHCOMBE, GLOUCESTERSHIRE, RIVER ISBOURNE

Background

Winchcombe is a large village in Gloucestershire, 10km south-east of Tewkesbury in the area of Tewkesbury Borough Council. The village is on both banks of the River Isbourne (mainly the left) which is designated an ordinary watercourse at this point. In the village 3 unclassified roads and the B4632 cross the Isbourne. Downstream of the village another unclassified road and the Gloucestershire and Warwickshire railway line cross the watercourse.

The River Isbourne rises near Cleeve Hill to the north-east of Cheltenham and flows in a generally northerly direction for 22km where it joins the River Avon at Evesham. Currently the downstream 9km is designated Main River between Wormington and Evesham. The soils are predominantly derived from impermeable Keuper Marl and Lias Clays, ensuring the catchment has a rapid response to rainfall.

Flood Warning

No flood warnings are currently issued for Winchcombe or the River Isbourne. The flood warning service provided by Lower Severn Area is limited to the main trunk of the Avon, together with the Leam, Stour and Arrow valleys.

Brief Description of Flooding

In the weeks leading up to the event there was above average rainfall. This meant that the catchment was almost saturated with a soil moisture deficit of only 5mm and river levels above normal. A low pressure area moved along the south coast on Thursday April 9th bringing rain to the catchment. The rain was held over the Avon catchment by this low pressure system throughout Thursday and into Friday, producing prolonged periods of extremely heavy rainfall.

During the resulting flooding 20 properties were flooded with a return period of up to 1 in 100 years.

Emergency Response

As water levels rose the Environment Agency's Emergency Workforce instigated routine patrols on 9th April. Gangs were sent out to inspect structures, check the integrity of defences, where applicable, and check at-risk areas.

Possible Courses of Action

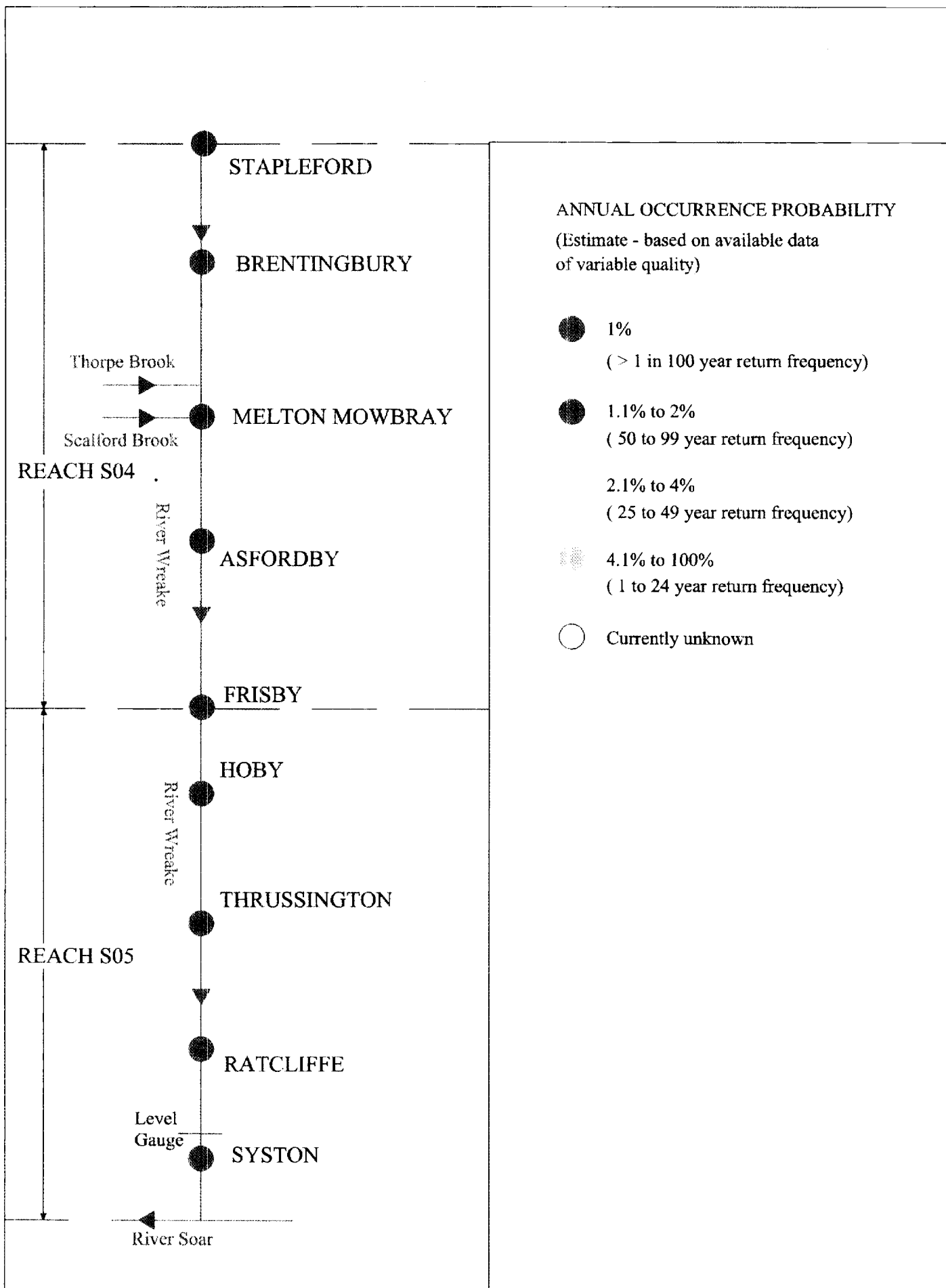
As part of the Agency's programme for extending the flood warning service, consideration will be given to the feasibility of the establishment of a flood warning service on this watercourse. This would require the installation of necessary gauges and telemetry. Currently there is only a gauging station on the Isbourne at Hinton, 13km downstream, which is not suitable for the issue of warnings for Winchcombe.

A restricting factor on further action at present by the Environment Agency is that the part of the Isbourne in question is an ordinary watercourse. The possibility of the Main River being extended to Winchcombe, a distance of around 10km, will be considered. Change of status would require

approval of the Regional Flood Defence Committee and the Ministry of Agriculture Fisheries and Food. The process can take many months to complete.

With regard to the possibility of a flood alleviation scheme, it may be possible that a limited feasibility scheme could take place prior to a change of status of the watercourse, in order to assess the viability of any scheme. This could also help with the maining process. Alternatively a full feasibility study could take place following maining.

Lower Trent Area



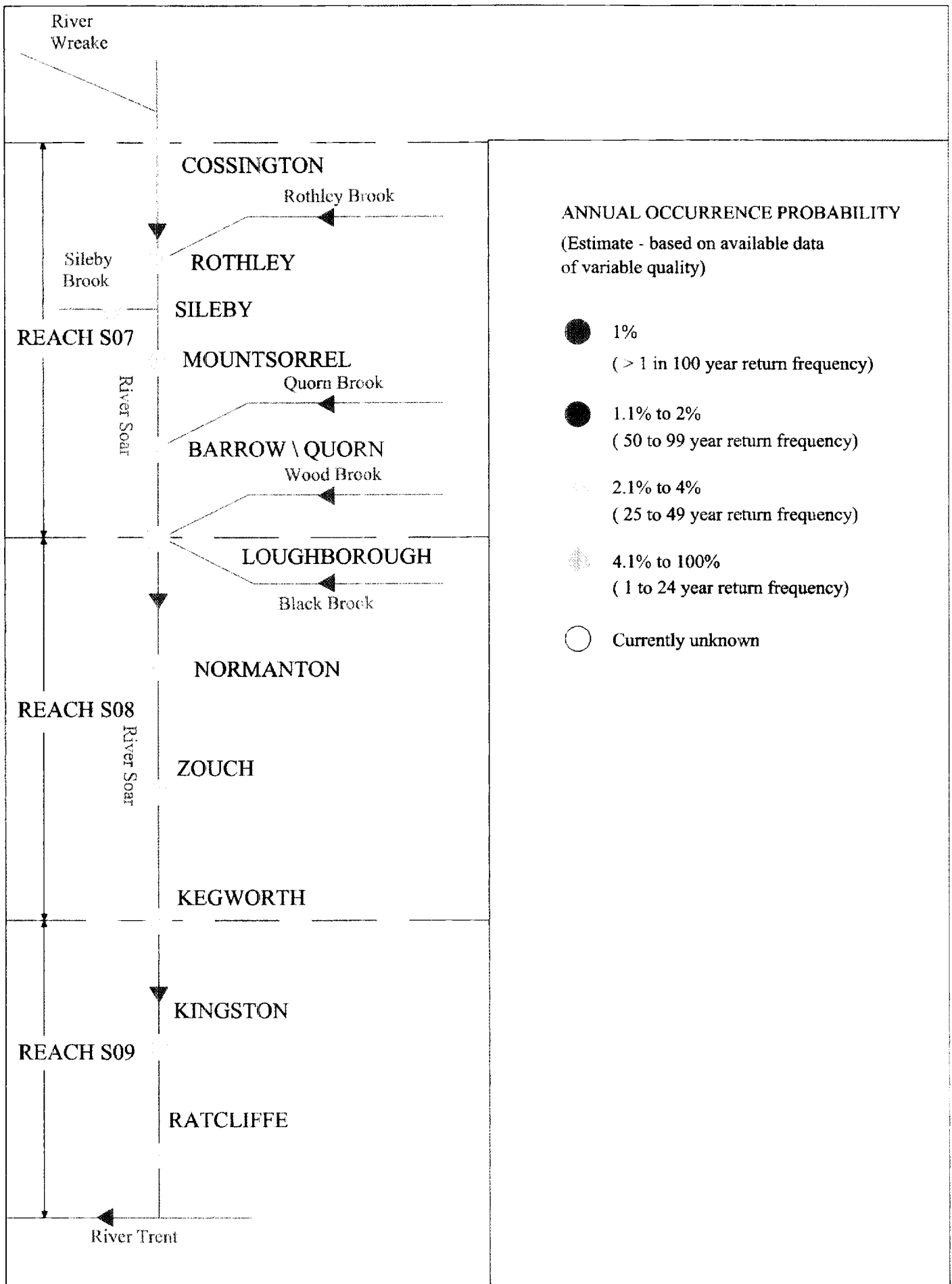
INDEPENDENT REVIEW OF EASTER FLOODS 1998
EYE \ WREAKE CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded

<p>STAPLEFORD</p> <p>BRENTINGBURY</p> <p>Thorpe Brook</p> <p>Scalford Brook</p> <p>MELTON MOWBRAY</p> <p>REACH S04</p> <p>River Wreake</p> <p>ASFORDBY</p> <p>FRISBY</p>	<table border="1"> <tr> <td style="text-align: center;">AMBER</td> <td style="text-align: center;">RED</td> </tr> <tr> <td colspan="2" style="text-align: center;">NO FLOOD WARNINGS ISSUED</td> </tr> </table>	AMBER	RED	NO FLOOD WARNINGS ISSUED			
AMBER	RED						
NO FLOOD WARNINGS ISSUED							
<p>FRISBY</p> <p>HOBY</p> <p>River Wreake</p> <p>THRUSSINGTON</p> <p>REACH S05</p> <p>RATCLIFFE</p> <p>Level Gauge</p> <p>SYSTON</p> <p>River Soar</p> <p>LEICESTER</p>	<table border="1"> <tr> <td style="text-align: center;">AMBER</td> <td style="text-align: center;">RED</td> </tr> <tr> <td style="text-align: center;">10.4.98 05.39</td> <td style="text-align: center;">10.4.98 23.13</td> </tr> <tr> <td colspan="2"> <p>Yellow Warning:</p> <p><u>Fax, phone and pager</u> to Leicestershire County Council</p> <p><u>Fax and phone</u> to Leicestershire Police, Leicestershire Ambulance, Leicestershire Fire and Rescue, Radio Leicester</p> <p><u>Fax</u> to Railtrack, AA Roadwatch, Teletext Midlands Electricity</p> <p>Red Warning: - as yellow plus</p> <p><u>Fax and phone</u> to Charnwood Borough Council</p> <p><u>Phone</u> to Melton Borough Council</p> <p><u>Fax</u> to Meteorological Office</p> </td> </tr> </table>	AMBER	RED	10.4.98 05.39	10.4.98 23.13	<p>Yellow Warning:</p> <p><u>Fax, phone and pager</u> to Leicestershire County Council</p> <p><u>Fax and phone</u> to Leicestershire Police, Leicestershire Ambulance, Leicestershire Fire and Rescue, Radio Leicester</p> <p><u>Fax</u> to Railtrack, AA Roadwatch, Teletext Midlands Electricity</p> <p>Red Warning: - as yellow plus</p> <p><u>Fax and phone</u> to Charnwood Borough Council</p> <p><u>Phone</u> to Melton Borough Council</p> <p><u>Fax</u> to Meteorological Office</p>	
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INDEPENDENT REVIEW OF EASTER FLOODS 1998
EYE \ WREAKE CATCHMENT - FLOOD WARNINGS



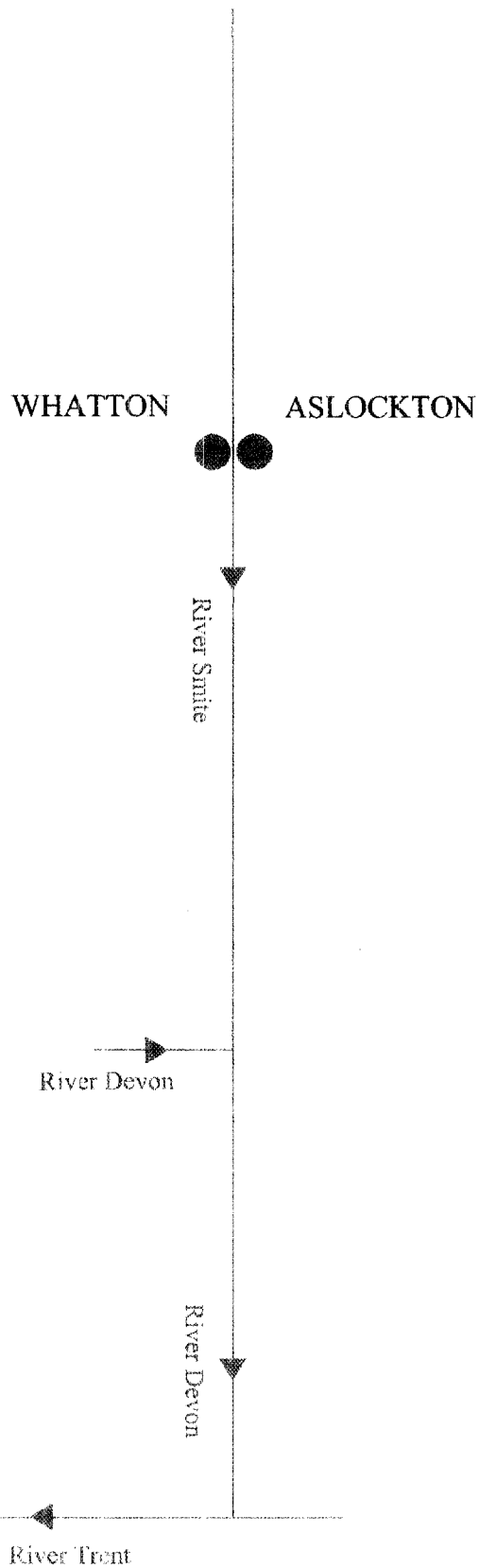
**INDEPENDENT REVIEW OF EASTER FLOODS 1998
SOAR CATCHMENT - FLOOD EVENTS**

		* Time first property reported flooded		
River Wreake	● LEICESTER			
	● COSSINGTON	9.4.98	AMBER 10.4.98	RED 11.4.98
	▼ Rothley Brook	15.42	08.34	06.55
Sileby Brook	● ROTHLEY	Yellow Warning: Fax, phone and pager to Leicestershire County Council Fax and phone to Leicestershire Police, Leicestershire Ambulance, Leicestershire Fire and Rescue, Radio Leicester Fax to Railtrack, AA Roadwatch, Teletext Midlands Electricity, British Waterways Amber Warning: - as yellow plus Fax and phone to Charnwood Borough Council Red Warning: - as amber		
	● SILEBY			
	● MOUNTSORREL			
REACH S07	● BARROW \ QUORN			
River Soar	▼ Quorn Brook			
	▼ Wood Brook			
	● LOUGHBOROUGH	10.4.98	AMBER 10.4.98	RED 11.4.98
	▼ Black Brook	08.34	17.39	22.59
	● NORMANTON	Yellow Warning: Fax, phone and pager to Leicestershire County Council Fax and phone to Leicestershire Police, Leicestershire Ambulance, Leicestershire Fire and Rescue, Nottinghamshire CEPO, Nottinghamshire Police, Nottinghamshire Fire Service, Radio Nottingham, Radio Leicester Fax to Railtrack, AA Roadwatch, Teletext Midlands Electricity, Radio Trent Amber Warning: - as yellow plus Phone to flood wardens Fax to Meteorological Office Red Warning: - as amber plus Fax and phone to Charnwood Borough Council Phone to North West Leicestershire District Council Fax to Meteorological Office		
REACH S08	● ZOUCH			
River Soar	▼			
Level Gauge	● KEGWORTH			
	● KINGSTON	10.4.98	AMBER	RED
	▼	15.07		
REACH S09	● RATCLIFFE	Yellow Warning: Fax, phone and pager to Leicestershire County Council Fax and phone to Leicestershire Police, Leicestershire Ambulance, Leicestershire Fire and Rescue, Nottinghamshire CEPO, Nottinghamshire Police, Nottinghamshire Fire Service, Radio Nottingham, Radio Leicester Fax to Railtrack, AA Roadwatch, Teletext Midlands Electricity, Radio Trent		
	●			
	▼ River Trent			

INDEPENDENT REVIEW OF EASTER FLOODS 1998

SOAR CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998



ANNUAL OCCURRENCE PROBABILITY
 (Estimate - based on available data
 of variable quality)

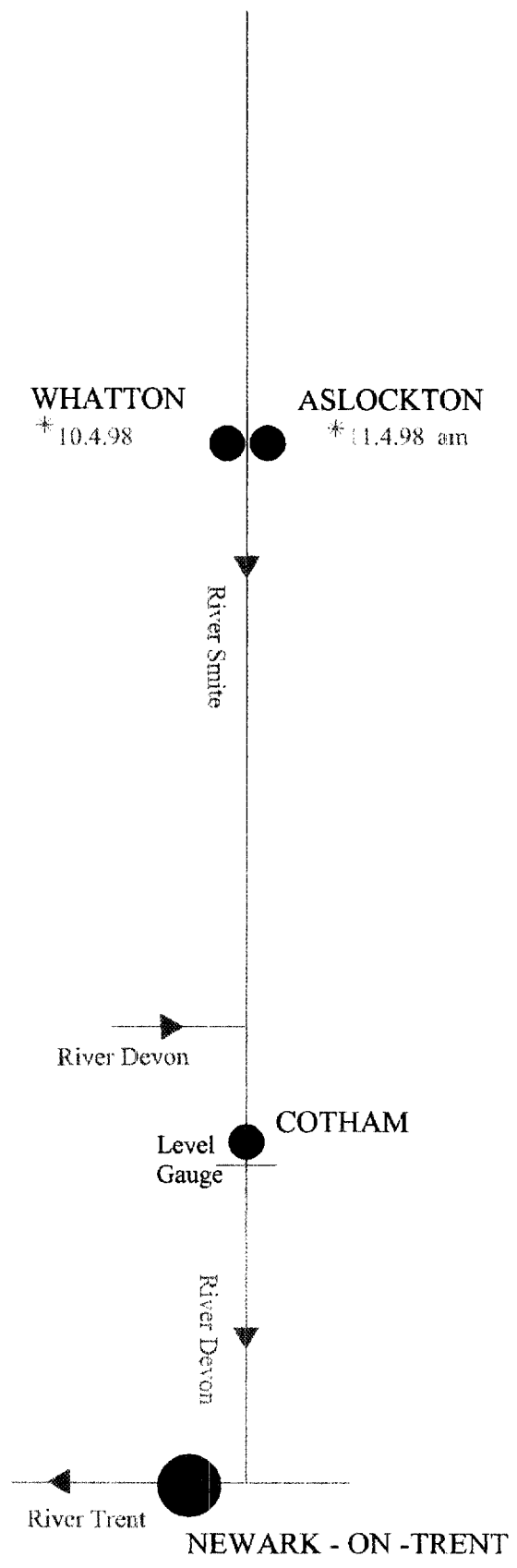
- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

INDEPENDENT REVIEW OF EASTER FLOODS 1998
SMITE CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded

AMBER	RED
NO FLOOD WARNINGS ISSUED	



INDEPENDENT REVIEW OF EASTER FLOODS 1998

SMITE CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

ASFORDBY, LEICESTERSHIRE, RIVER WREAKE

Background

The village of Asfordby is located due west of Melton Mowbray on the north bank of the River Wreake, approximately two miles downstream of Melton. The catchment of the River Wreake is rural and characterised by the open rolling hills of the Leicestershire Wolds. The Wreake valley at Asfordby has been subject to gravel extraction and a number of lakes have been formed as a result.

The River Wreake comes out of bank several times a year and floods large areas of agricultural land. The main cross valley road in Asfordby (Station Lane) is normally affected by flooding once or twice a year.

There are no flood defences at this location but a flood storage / flow balancing area is located approximately one mile downstream at Frisby on the Wreake.

Flood Warning

This section of the River Wreake lies within Reach So4 of the Flood Warning Scheme for the Midlands Region of the Environment Agency. However, flood warnings for this reach are issued on the basis of a forecast flow from a gauging station located at Syston, some eight miles downstream. As such no Amber or Red warning thresholds have been established due to the difficulty in relating a forecast flow at Syston to a level at Asfordby. A Yellow warning threshold does exist for this reach and is designed to give prior warning of flooding at Station Lane.

In this instance the flood warning for the River Wreake at Asfordby was not issued. The Asfordby area was already subject to flooding from overland water flows before the Yellow warning threshold on the Main River had been forecast and the potential recipients of that warning were already aware of the situation.

Brief Description of Flooding

The Agency's rain gauge at Whissendine, in the headwaters of the River Wreake, recorded 56mm of rainfall mainly in the 24 hours preceding the flooding (approximately 1 in 4 year return period / 25% chance of occurring in any year). This rainfall was not exceptional but the antecedent conditions, with zero soil moisture deficit and river flows at 150% of monthly long term average, had a significant influence on the severity of the event. It has been estimated that the event was in the order of 1 in 75 to 1 in 100 year return period (1.33% to 1.00% chance of occurring in any year). The flooding was at its most severe on the afternoon of Friday 10th April 1998.

Development in Asfordby is generally elevated above the floodplain of the River Wreake and there have been no reports of properties being subject to flooding from the Main River watercourse (although gardens were affected). The saturated ground conditions, resulted in large volumes of water flowing directly off the higher land to the north of Asfordby. This water was collected and channelled through natural routes as well as the established watercourses. The volume of water present in these flood routes resulted in problems of ponding at constrictions.

Flows were so great that in one incident, where an un-named watercourse passes under the Asfordby bypass (constructed 1989), backing up continued until the flood water rose to a level where it weired over the top of the bypass and continued, over land, into the Wreake floodplain.

There were several flood flow routes in Asfordby, one of which inundated approximately 20 properties, including an elderly persons residential home and commercial premises. The main problem areas being Prince Charles Street, Bradgate flats and Main Street. A large commercial property (Asfordby Storage & Haulage) was particularly badly affected. Once the water had established this route the speed at which property became affected was reported to be extremely rapid. In addition, some property flooding at Main Street has been attributed to the surcharge of storm water sewers.

Extensive flooding on each side and in the centre of the village resulted in main roads becoming impassable for several hours and, in one case, for a number of days.

Similarly, at Asfordby Valley another un-named ordinary watercourse had insufficient capacity to cope with the volume of water present. This resulted in the watercourse overtopping its banks and a commercial garage and about ten residential properties were flooded.

Emergency Response

The Environment Agency did not receive any requests for assistance from residents in Asfordby. However, the Fire Service and Melton Borough Council provided assistance, placing sandbags and pumping out flooded property. Unfortunately, due to intense activity at nearby Melton Mowbray, assistance did not arrive until after the majority of properties were flooded. Since the event Melton Mowbray Borough Council has established a supply of sandbags within the village.

Possible Courses of Action

Prior to this flood event, improvements to the flood forecasting system for this area had been identified with the planned introduction of a river gauging station, upstream of Melton Mowbray at Brentingby in the 1999-2000 financial year. Since the Easter event a telemetered level measurement is planned for the 1998-99 financial year, as an interim measure. The introduction of this station will, in the longer term, improve the accuracy of information which is used in the flow forecasting model and enable Amber and Red flood warning thresholds to be established. In the short term, the inclusion of an alarm on the interim level monitoring station should allow an improvement in warning lead times to be achieved.

It is also clear that with regard to flooded areas, particularly for those that are not Main River or identified as high flood risk zones, the public have a poor understanding of the relative roles of the Environment Agency, local authorities and the emergency services. As such the Agency will be working closely with these authorities to address the problem.

Information from the flood will be used by the Agency to continue to strongly advise against any proposed development on the floodplain and overland flood routes.

BARROW-UPON-SOAR, LEICESTERSHIRE, RIVER SOAR

Background

Barrow Upon Soar is a small village lying at the edge of the River Soar floodplain to the south east of Loughborough. The village is generally well elevated above the Soar floodplain with most of the development to the east of the Grand Union Canal navigation, which is partly formed by the navigable river and partly formed in a separate canal cut.

The Soar Valley has an extensive floodplain and has suffered frequent flooding since the late 18th Century. The frequency of flooding and the poor drainage are due in part to the shallow natural gradient of the river and the general clay nature of the catchment, and also due to the structures constructed to facilitate navigation.

Where development has encroached into the floodplain it is vulnerable to flooding and three isolated properties are known to be at risk. In addition a fairly large caravan site (Proctors), situated between the canal and river channels is also liable to flood.

Flood Warning

This section of the River Soar lies within Reach S07 of the Flood Warning scheme for the Midlands Region of the Agency. During the Easter floods Yellow, Amber and Red warnings were issued for this reach and the three isolated properties received both Amber and Red flood warnings. The owner of the caravan site did not wish to be included in the flood warning arrangements when they were originally set up prior to September 1996, preferring to insist that his site should be protected from flooding instead.

The Agency has not received any complaints from the three residents warned and it is assumed that the warnings were acted on successfully.

Brief Description of Flooding

The flood on the River Soar has been assessed as a 1 in 25 year flood event (probability 4%) and since the properties lie at the edge of the floodplain they were only marginally flooded. The flood outline experienced was in accordance with what would have been expected from such an event both from flood records and from the ISIS computer model that exists for the River Soar on this reach. Proctor's caravan site was flooded and approximately 200 caravans were affected. The site is vulnerable to less severe flooding than that which occurred at Easter, and was also extensively flooded during the flood events of February 1977 and February 1990. Parts of the site are subject to more regular flooding.

Emergency Response

The Environment Agency is not aware that any requests were made for assistance from either the owners of the isolated properties affected or the owner of the caravan site. In discussions since the flood event it has been stated that some caravans were moved out of the flooding by the site owner although no further details exist.

Possible Courses of Action

Since the Easter flooding the Agency has met the owner of the caravan site (Mr Proctor) and also wrote to him on 2 June again offering to include him in the Agency's Flood Warning Scheme. To date we have not received a reply. The caravan site is well within the floodplain of the River Soar and it is understood from Charnwood Borough Council that only part of the site has planning permission.

The Environment Agency and its predecessors have consistently objected to the use of this floodplain for a caravan site due to the high flood risk and resultant danger to lives. The site itself takes up a large proportion of the floodplain width at this location and a flood protection scheme would be likely to raise flood levels upstream and put other properties at increased risk. It is therefore unlikely that the Agency can justify a flood alleviation scheme for the site.

It is recommended that the site should not be used for residential caravans and that strict conditions are enforced if it is used for touring caravans.

COSSINGTON, LEICESTERSHIRE, RIVER SOAR CATCHMENT,

Background

Cossington is a village in the River Soar catchment area, in the Borough of Charnwood, Leicestershire. The village is sited on the edge of both the River Soar and the River Wreake floodplain boundary.

Cossington Brook is an ordinary watercourse and is approximately 5km in length from source to its confluence with the Soar. It descends some 50m over its course. The brook borders the village to the north west before meeting the River Soar approximately 1km downstream of Cossington. The catchment to Cossington is rural and is characterised by both pastoral and arable agriculture.

The 1997 Section 105 flooding survey report states that flooding occurs to the "B" class road between Sileby and Cossington where it crosses the Cossington Brook. During the 1998 Easter flooding event flooding occurred here and in some additional locations.

Flood Warning

The Agency currently offers no warning service for the Cossington Brook. Although a flood warning service operates for the nearby River Soar, there is not a significant relationship between the flooding in the two catchments. At this point the River Soar has a flooding lead in time of between 12 and 24 hours, whereas that for the Cossington Brook is considerably less. It is therefore unlikely that the peaks will coincide, as was demonstrated by the timings of the peaks in the Easter event.

Brief Description of Flooding

The flooding in Cossington was typical of that experienced by other settlements on the northern side of the Soar catchment during this event. From the evidence obtained, it would appear that the storm centre was somewhere to the north east.

The flooding in Cossington was exacerbated by a number of factors. These include saturated ground conditions, high river base flow, snow melt and heavy rainfall over a short space of time. There are no direct measurement devices within the catchment but results from nearby raingauges suggest that the rainfall return period was approximately 1 in 4 years. The flood flow return period in the nearby River Wreake was approximately 1 in 75 to 1 in 100 years and, it is not unreasonable to assume that the return flow for the Cossington Brook was of a similar order.

Flooding was experienced in other parts of the village from overland flow and insufficient surface water drainage. Some of the older residents reported that flooding had previously occurred on a similar scale approximately 50 years ago.

Flooding from the surface water drains is enhanced by additional water that runs off the fields to the north of the village. The problem of run-off from these fields was partly addressed by the farmer prior to the Easter flooding following liaisons with the Agency's own Development Control section and Charnwood Borough Council. This work involved the creation of an earth embankment to prevent run-off through properties and the construction of a concrete holding tank. This work appears to have prevented flooding of properties in Middlefield Road. However, over ground flow inundated properties on the corner of Platts Lane.

It has been reported that the flooding experienced from the overtopping of Cossington Brook was exacerbated by highway works that prevent water from weiring over the top of the road bridge and instead, deflect the water onto the road into the village. It is also thought that poor maintenance of the non-Main River channel contributed to this effect.

From Parish Council accounts and post event investigations it was discovered that approximately ten properties were flooded and several roads were rendered impassable.

Emergency Response

The flooding was attended by Leicestershire Fire and Rescue Service who aided the residents with sandbagging and pumping. The pumping was made difficult as there were no areas to release water without aggravating the problem further. The Environment Agency was not called to the scene during the flooding.

Possible Courses of Action

The Agency has liaised closely with Charnwood Borough Council with issues surrounding the Easter Flooding Event. Charnwood Borough Council are currently working closely with Leicestershire County Council to try and resolve some of the problems that exist. These may involve the redesigning of the Cossington Brook road bridge and investigation into the surface water drainage problem.

The provision of a warning service for the village of Cossington would be difficult due to the lack of lead in time and because there is currently no monitoring within the catchment on which to base these warnings. Nevertheless, the possibility of a warning service will be investigated.

FRISBY ON THE WREAKE TO RATCLIFFE ON THE WREAKE, LEICESTERSHIRE, RIVER WREAKE

Background

This report covers the villages of Frisby on the Wreake, Thrussington and Ratcliffe on the Wreake.

The River Wreake comes out of bank several times a year and floods large areas of agricultural land and several roads along the valley. In the 1980s, Severn Trent Water Authority, predecessors to the Environment Agency, undertook extensive channel maintenance dredging and re-sectioning works on the watercourse. This provided additional freeboard under normal flow conditions and reduced the frequency of flooding, particularly of the cross valley road network. The works also allowed farmers to install/improve their land drainage systems. However it did little to alleviate the larger, less frequent floods. Nevertheless, a small number of properties are at risk even during such rare events.

Development in these areas is generally above flood level but, since the cessation of their use, old mills along the watercourse have been converted to domestic properties. It has always been known that these properties were at risk, as they have been throughout history.

There are no flood defences at these locations but a flood storage/ balancing area is located at Frisby on the Wreake.

Flood Warning

This section of the River Wreake lies within Reach So5 of the Flood Warning scheme for the Midlands Region of the Environment Agency.

Yellow flood warnings, based on flows occurring at Syston gauging station downstream, are and were issued in April 1998 to the emergency services, Leicestershire County Council and the media when Station Road Thrussington and Broome Lane Ratcliffe on the Wreake were likely to be affected. They also receive Yellow flood warnings, based upon the gate level at Frisby Lake, when flooding is anticipated at Mill Lane and Water Lane, Frisby on the Wreake.

One resident at a property known as "Mill Deeping" Frisby on the Wreake receives a personal warning via the Agency's AVM system. "Mill Deeping" can be affected by flooding during relatively minor events when high levels of groundwater are present. Water enters the property from below the floor boards and it is therefore difficult for the Agency to always offer a timely warning.

The occupier of "The Mill House" Frisby on the Wreake has, on two occasions, declined to receive any flood warning.

The Melton Mowbray Sailing Club, located adjacent to the Frisby Lake, receives a warning when the lake commences filling and when the lake is full.

Brief Description of Flooding

The Agency's raingauge at Whissendine, upstream of Melton Mowbray, recorded 56mm of rainfall mainly in the 24 hours preceding the flooding (approximately 1 in 4 year return period). This is not exceptional, but the antecedent conditions (zero soil moisture deficit and river flows at 150% of

normal) had a significant influence on the severity of the event. It has been estimated that the event was in the order of 1 in 75 to 1 in 100 year return period.

It is known that two properties were affected at Frisby on the Wreake, four at Thrussington and four at Ratcliffe on the Wreake.

The Agency's Frisby Lake operated as designed and was full by 14.00 hrs on the 10th April. The River Wreake continued to rise exceeding the design capacity of the system. Although water continued to enter the lake, it was effectively immediately released back to the river by the overtopping of the emergency spillways. Once Frisby Lake is full there are no other flood defence / retardation systems in place to offer any protection to the properties downstream. It is suspected that over-land flow off the steep hillsides may have added to the flooding problems. The Agency is not aware of any appreciable blockages at bridges having occurred.

Emergency Response

In this severe event there was little that could have been done to lessen the impact on these very vulnerable properties. However, the Agency was aware that these properties were "high risk". As soon as it was evident that the magnitude of this event was escalating beyond anything previously experienced, the Agency's Emergency Workforce delivered sandbags to all of the properties, reaching them prior to them being affected by floodwater.

The emergency services and the local authority, as far as the Agency is aware, responded to the residents needs and there was no loss of life.

Possible Courses for Action

The vulnerability to flooding of former mill premises has been clearly demonstrated. Through the Agency's Development Control input to the planning system objections to all barn/mill conversions which lie within the floodplain must be made even if the footprint of the building remains unchanged. These locations are often across fields on unadopted roads and residents could be surrounded by water for some days. Local authorities should be aware that significant flood alleviation schemes are unlikely to be provided in the short term.

Prior to this event the level at the gauging station at which some properties would be affected had not been known and they had not been included in the Agency's Flood Warning Service. The provision of a service in the future is now being investigated and, should the occupiers wish to become part of the warning group, they will be added to the list of existing recipients at the relevant level i.e. Yellow, Amber or Red.

MELTON MOWBRAY, LEICESTERSHIRE, RIVER WREAKE

Background

Melton Mowbray is a market town situated in the Leicestershire Wolds which has developed around the confluence of the River Eye, Salford Brook and Thorpe Brook which join together in the town to form the River Wreake. The catchment to Melton Mowbray is rural with rolling open exposed ridges and valleys with sparse tree cover. A flood storage reservoir is located on the Salford Brook (to the north of the town) which controls the rate of discharge from this watercourse into Melton town centre.

The confluence of the Eye, Thorpe Brook and Salford Brook occurs at the eastern edge of Melton Mowbray and the River Wreake then flows from east to west through the centre of the town. The river is crossed by a number of road and rail bridges and adjacent to the confluence is located a large pet food factory (Pedigree Masterfoods) with associated historical river control structures (weirs and sluices) inherited from the site's previous use as a woollen mill.

Melton Mowbray has been affected by serious flooding previously, with the worst recorded instances occurring in 1974 and 1924. There are no flood defences located within the town.

Flood Warning

This section of the River Wreake lies within Reach So4 of the Flood Warning Scheme for the Midlands Region of the Agency. However flood warnings for this reach are issued on the basis of a forecast flow from a gauging station located at Syston, some 10 miles downstream, and consequently only a very limited service can currently be provided for Melton. As such no Amber or warning thresholds have been established due to the difficulty in relating a forecast flow at Syston to a level at Melton Mowbray. A Yellow warning threshold does exist for this reach but the warning was not issued in this instance as by the time the Yellow threshold had been forecast, Melton was already subject to serious flooding and the recipients of that warning were already aware of the situation.

A Red warning was issued at 23.12 hrs on 10 April for the downstream reach So5.

Brief Description of Flooding

The Agency's rain gauge at Whissendine, upstream of Melton Mowbray, recorded 56mm of rainfall mainly in the 24 hours preceding the flooding (approximately 1 in 4 year return period / 25% chance of occurring in any year). This rainfall was not exceptional but the antecedent conditions (zero soil moisture deficit and river flows at 150% of normal) had a significant influence on the severity of the event. It has been estimated that the event was in the order of 1 in 75 to 1 in 100 year return period (1.33% to 1.00% chance of occurring in any year). The flooding was at its most severe on the afternoon of Friday 10 April 1998.

Flooding in the Melton area was attributable to a combination of the overtopping of watercourses together with some flooding attributed to the inundation of sewerage systems. The water level in the River Eye rose rapidly and the available floodplain storage capacity was quickly filled. Flood water from the Eye backed up the Salford Brook and its banks were overtopped in the confluence area. Similarly, the Thorpe Brook was unable to discharge its waters into the River Eye due to its already high level which resulted in the Thorpe Brook overtopping its banks. The combined

overtopping of the River Eye, Scalford Brook and Thorpe Brook resulted in the excess water taking an alternative course along residential streets, at depths of up to 1.0m, damaging property and vehicles.

In addition to the extreme flows, a major blockage occurred at the railway bridge on the River Eye / Scalford Brook confluence which completely closed off one of the arches of the bridge. At this moment the precise consequences of this partial blockage are still being investigated.

Melton Borough Council reports that 164 properties were affected at Melton Mowbray including the Pedigree Masterfoods site, which was inundated to an approximate depth of 300mm throughout the factory. It is fortunate that the factory was not fully operating over the Easter holiday or the damage would have been even more serious. The town's major indoor leisure centre was also flooded to a depth of 500mm.

Emergency Response

Leicestershire Constabulary quickly established a "Silver Level" command centre at County Headquarters in collaboration with the County Council's Emergency Planning Team so as to coordinate the response of the various agencies involved. The Borough Council opened an Emergency Response Centre within the Council's main offices, when it was evident that the emergency call-out arrangements required multi-agency support. The constabulary, fire brigade, local authority, Severn Trent Water plc, local voluntary agencies, military and local businesses were actively involved in responding to the emergency and the associated welfare and safety issues. It is estimated at its peak, there were in excess of 100 people actively involved in the emergency response.

Melton Borough Council reported that, as day moved into evening it became increasingly difficult to respond to the emergency, principally due to traffic congestion caused by people sightseeing.

Possible Courses of Action

Prior to this flood event, improvements to the flood forecasting system for this area had been identified with the planned introduction of a river gauging station at Brentingby in the 1999-2000 financial year. Since the Easter event a temporary telemetered level monitoring station is planned for the 1998-99 financial year. Brentingby is situated 2 km to the east and upstream of Melton Mowbray, and the introduction of this facility will improve the accuracy of information used in the flow forecasting model. The introduction of a river level alarm facility should also allow an improvement in warning lead times to be achieved as well as Amber and Red flood warning thresholds to be established. Nevertheless, the nature of the catchment and the location of Melton within this catchment mean that warning lead times will be relatively short.

A large number of the properties that flooded were located outside the modelled 1 in 100 year flood outline. The addresses of those properties are being collected as part of a regional initiative so that the offer of a warning service can be considered when the flow forecasting improvements are in place. In the interim, discussions have taken place with Pedigree Masterfoods with a view to establishing an improved warning system using existing systems but incorporating data and lessons learnt from the Easter event. In order for this to take place, and to assess the effect that the bridge blockage had on flood levels, it is proposed to rerun the computational model for this area using the estimated flows from Easter and simulating the effect of the closing of the bridge arch.

A feasibility study for part of this area is to be extended to cover Melton town centre but presently

no plans have been formulated to establish a flood defence scheme for Melton Mowbray. Until all the relevant information has been interpreted it is too early to discuss the merits or practicalities of any suggested scheme. It is proposed to involve both Melton Borough Council and Pedigree Masterfoods in the above process.

The blockage at the railway bridge was caused by an accumulation of waterborne debris from upstream, including a large number of wooden pallets. Since the event the Environment Agency has contacted upstream riparian owners regarding the storage of materials in locations where they may be at risk of being washed away. Through the Agency's development control procedures, continued efforts will be made to enforce the Agency's Land Drainage Byelaws to prohibit permanent storage of materials in the floodplain.

SILEBY, LEICESTERSHIRE, SILEBY BROOK

Background

Sileby is a village in the River Soar catchment area, in the Borough of Charnwood, Leicestershire. The village borders the north-east limit of the River Soar floodplain and has developed around the Sileby Brook which flows into the River Soar. The Brook is classified as Main River from the upstream side of the High Street road bridge to the confluence with the River Soar, a length of just 1km.

The catchment to Sileby is rural and is characterised by both pastoral and arable agriculture. The brook is approximately 9km in length from source to its confluence with the Soar and descends some 80m. The brook borders the small village of Seagrave about halfway down its length.

The section of brook through Sileby Village was heavily engineered in 1957. This work is believed to have been carried out by the Barrow Upon Soar Rural District Council (now succeeded by Charnwood Borough Council). This involved the creation of a concrete channel and flood berms. It is stated in the 1997 Section 105 flooding survey report that this channel has an estimated flow capacity return period of 1 in 3 years. The village reach is crossed by a number of road and footbridges.

Serious flooding has occurred in Sileby on a number of previous occasions, notably, in 1977 when three shops, two houses and roads were flooded. Flooding also occurred in 1981 and photographic evidence exists of flooding that occurred in 1915. Some of the older residents have also reported that flooding was a regular occurrence in the 1920's upstream of the High Street road bridge.

Flood Warning

The Agency's flood warning service does not currently extend to the Sileby Brook although a flood warning service operates for the nearby River Soar (Main River). There is not, however, a significant relationship between the flooding in the two catchments. At this point flooding on the River Soar has a lead in time of between 12 and 24 hours, whereas the Sileby Brook responds much more quickly. It is therefore unlikely that the flood peaks will coincide, as was demonstrated by the timings of the peaks in the Easter event.

A warning service specifically for Sileby Brook would need to address the difficulties of a very short lead time and the fact that there is currently no monitoring equipment within the catchment on which to base warnings.

Brief Description of Flooding

The flooding on Sileby Brook was typical of that experienced by other settlements on the northern side of the nearby River Wreake catchment during this event. From the evidence obtained, it would appear that the storm centre was somewhere to the north east.

The flooding in Sileby was probably due to a number of factors. These include saturated ground conditions, high river base flow, snow melt and heavy rainfall over a short space of time. There are no direct measurement devices within the catchment. However, results from nearby raingauges suggest that the rainfall return period was approximately 1 in 4 years. The antecedent conditions resulted in a flow return period in the nearby River Wreake of approximately 1 in 75 to 1 in 100

years. It is not unreasonable to assume that the return period for the Sileby Brook was of a similar order.

Eye witness accounts report that the brook level rose and went down again very quickly. This is consistent with flooding on a small steep catchment. However, some local people felt that an opening of a sluice or other similar structure must have caused the sudden drop in water level. There are no sluices or control gates on the Sileby Brook and those on the River Soar do not effect the water level at the confluence. The Fire Service, who actually maintained the bridge clear of obstructions, has also discounted claims that there was a blockage at the High Street road bridge.

Sileby Parish Council has given details of at least eight properties that were flooded. Several roads were also rendered impassable. Charnwood Borough Council has instigated a postal flooding survey which is expected to highlight more properties that were affected.

There are several bridges along the watercourse which may have acted as a constriction to the flow. However this cannot be assessed until a full investigation has been undertaken.

Emergency Response

The flooding was attended by Leicestershire Fire and Rescue Service who aided the residents with sandbagging and pumping. The pumping was made difficult, as there were no areas to release water without aggravating the problem further. The Environment Agency was not called to the scene during the flooding.

Possible Courses of Action

Since the event the Agency has liaised closely with Charnwood Borough Council who have instigated an in depth study of the flooding. Representatives from the Agency and Charnwood Borough Council attended a Parish Council meeting in Sileby. The event, and actions taken during, after and possibly in the future were discussed. Questions from members of the public were also answered.

The Charnwood Borough Council study will determine if further remedial works are feasible. The Agency is assisting Charnwood Borough Council with its investigations and the possibility of a joint flood alleviation scheme, encompassing both the Main River and ordinary watercourse sections of the brook, will be investigated.

Consideration of the viability of providing a warning service for this watercourse will be undertaken as part of the Agency's improvement programme for the flood warning service.

WHATTON AND ASLOCKTON, NOTTINGHAMSHIRE, RIVER SMITE

Background

The villages of Whatton and Aslockton are located approximately 16 km due east of Nottingham on the west and east banks of the River Smite respectively. The catchment of the River Smite is rural and its upper reaches are very similar to that of the adjacent River Wreake catchment, characterised by the open rolling hills of the Nottinghamshire and Leicestershire Wolds. The River Smite joins the River Devon and the lower reaches are flat and open, as is typical of the Trent lowlands.

Whatton and Aslockton are situated on a section of the River Smite which is classified as an ordinary watercourse which is administered by Newark Area Internal Drainage Board. Although no formal flood defences exist in this location a system of levees has developed as a result of past dredging operations. Prior to this event the last record of properties being flooded was in February 1977, although that was not to the same extent as at Easter 1998.

Flood Warning

The Agency's flood warning service does not currently extend to the River Smite. A gauging station is located approximately 13 km downstream of the River Smite on the River Devon at Cotham but this station is not incorporated into the Agency's flood forecasting model.

Brief Description of Flooding

The River Smite overtopped its banks on Friday 10th April and flooding affected approximately 30 properties in Whatton. The Upper Smite catchment had received approximately 50mm of rainfall in the preceding 24 hours. Water levels continued to rise and by Saturday morning, flood water had passed through a series of culverts running beneath the Nottingham to Grantham railway line and 50 properties at Aslockton were flooded. Water levels finally started to recede on the afternoon of Saturday 11th April.

Sandbags were delivered to the villages, but the scale of flooding was such as to render sandbags ineffective in most instances. Many people were evacuated from their homes and the local village pub opened its doors to provide shelter for those residents.

The return period of this flood event has been estimated at between 1 in 50 to 1 in 100 years (a chance of occurring in any one year of between 1% and 2%). However, due to problems associated with water overtopping banks and bypassing the gauging station at Cotham, the accurate determination of flood return periods is difficult. The fact that the River Smite shares the same headwaters as the River Wreake makes the assumption of a similar return period (1 in 75 to 1 in 100 years) reasonable.

Emergency Response

This flood event was attended by Nottinghamshire County Council Emergency Planning Unit, Nottinghamshire Fire and Rescue Service, Nottinghamshire Constabulary, Newark Area Internal Drainage Board, Rushcliffe Borough Council and the Environment Agency. Evacuation of property was undertaken by the Fire Service who were reported to have a large presence at the scene. Rescues were hindered by a lack of available boats, although some were reported to have been borrowed from the National Watersports Centre.

Rushcliffe Borough Council and Nottinghamshire Constabulary established an Incident Room in the village from which they co-ordinated actions and prepared contingency plans in case the situation escalated. Newark Area IDB which is able to draw on limited resources provided sandbags and information on the likely places of flooding. The IDB also assisted in the filling and placing of sandbags delivered by Rushcliffe B.C. and the Agency. In addition, the IDB removed a culvert located downstream of the villages which was reported to have been holding up flood flows. However, in the opinion of the IDB the effects of this action were negligible.

Since the flooding, a Whatton Parish Council meeting was attended by officers from the Environment Agency and Newark Area IDB at which residents did criticise the lack of response and co-ordination of the rescue attempts.

Possible Courses of Action

Since the event there has been close liaison between Newark Area Internal Drainage Board, the Environment Agency and Rushcliffe Borough Council. The Clerk and Engineer of Newark Area IDB has recommended to his Board that a feasibility study for a flood defence scheme at Whatton and Aslockton is carried out. The Agency has offered help and advice where required. Quotations for the above scheme have been returned to Newark Area IDB and the feasibility study will go ahead next year subject to Board approval in September. Solutions will have to be evaluated and promoted by the IDB.

In order to improve emergency response to any future flood events in this area, meetings have been held between the organisations involved and problem areas discussed. As a result, issues relating to internal communications, inter-organisational communications and the responsibilities and methods used for the provision of sandbags have been addressed.

As with many instances of flooding over the Easter period, reinforcement of controls for development of the floodplain would be beneficial and will be actively pursued by the Agency. A number of properties which were flooded at Whatton had been built despite objections on flooding grounds from the Internal Drainage Board and the Parish Council.

It is also clear that with regard to flooded areas not previously identified as flood risk zones, the public have little understanding of the relative roles and responsibilities of the Environment Agency, Internal Drainage Board, Local Authority and the Emergency Services. As such a campaign for greater public awareness is required to address the problem of diverse responsibilities.

At present there is no data collection or telemetered data available within the Smite catchment on which to base flood warnings and there would be considerable difficulties to be overcome to provide adequate lead time. The possibility of a warning service will nevertheless be investigated, if protection to the flooded properties is not feasible.

ZOUCH, NEAR KEGWORTH, LEICESTERSHIRE, RIVER SOAR

Background

Zouch is a small village situated within the River Soar floodplain to the north-west of Loughborough. The majority of the village is situated on an island with the River to the south and the Grand Union Canal to the north.

The River Soar was canalised some 200 years ago linking the Grand Union Canal to the River Trent. Navigation requires a constant relatively high water level which conflicts with the needs of agriculture for good drainage and hinders the escape of floodwater. This has resulted in both frequent flooding and an extensive floodplain in the Soar Valley.

The river system at this location is complicated. River control works upstream of the A6006 road bridge maintain river levels for both navigational purposes and Zouch Mill, albeit that the mill no longer uses water power.

In the late 1980s Severn Trent Water Authority, predecessors to the Environment Agency, designed an improvement scheme for the Soar Valley which was constructed in stages. The improvements for Zouch consisted of 1 in 10 year defences to protect the permanent residential properties at Zouch. However, weekend/holiday chalets situated on the island are not protected. Over the past ten to twenty years the chalets have progressively become more residential than weekend/holiday chalets.

Flood Warning

This section of the River Soar lies within Reach So8 of the Flood Warning scheme for the Midlands Region of the Environment Agency. During the Easter floods Yellow, Amber and Red warnings based on forecast flows at Kegworth gauging station were issued for this reach. The warnings were issued to the emergency services, Leicestershire and Nottinghamshire County Councils and the media. An Amber warning was issued to Charnwood Borough Council and Red warnings were issued to Charnwood Borough Council and North West Leicestershire District Council and twenty-eight defended residential properties.

Prior to this event the Agency had set a provisional Red warning threshold for this location. As the event developed it became clear that this provisional threshold was too high. The Agency's duty officer issued the Red warning in expectation of property flooding at a lower level. Recipients of the Red warning were subsequently flooded.

A Flood Warden scheme at Zouch exists to forward warnings to twenty two owner/occupiers of weekend/holiday chalets. The flood warden permanently lives in one of the chalets.

The Flood Warning Duty Officer tried to contact the Flood Warden at Zouch several times on the morning of the 10th April but without success - the telephone appeared to be out of order. Although the Flood Warden was not personally warned by the Automatic Voice messaging system, later, contact between the Flood Warning Duty Officer and the Flood Warden and his wife occurred on several occasions before and after the warnings being issued. The Flood Warden was made fully aware of the situation ahead of the flow thresholds being reached with sufficient advance warning to alert the other residents.

Brief Description of Flooding

The flood on the River Soar has been assessed as a 1 in 25 year flood event (probability 4%) and since the weekend/holiday chalets are not protected and the residential properties are only protected to a 1 in 10 year event, considerable flood damage occurred. Although such a flood does not rank as extreme, it is rare. The flood outline experienced was in accordance with that expected from such an event both from flood records and from an ISIS computer model. The weekend/holiday chalets some of which are constructed on piers are vulnerable to less severe flooding and were flooded during the flood events of February 1977, February 1990 and possibly less significantly on other occasions.

Emergency Response

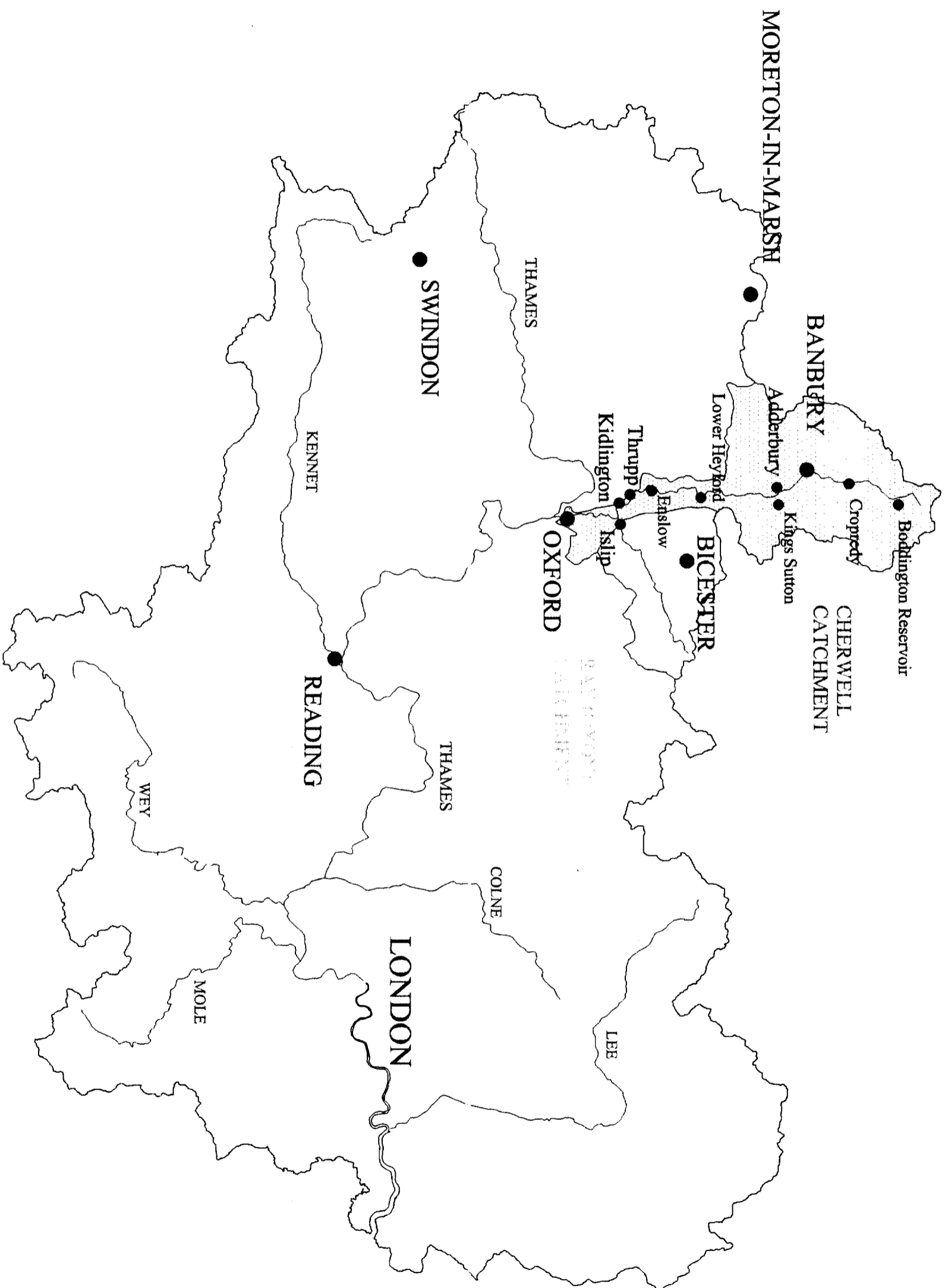
Environment Agency operatives were able to provide assistance with sand bagging properties on the main road. The Agency operatives also assisted the Police and the Fire & Rescue Service in the evacuation of residents from the chalets.

Possible Courses of Action

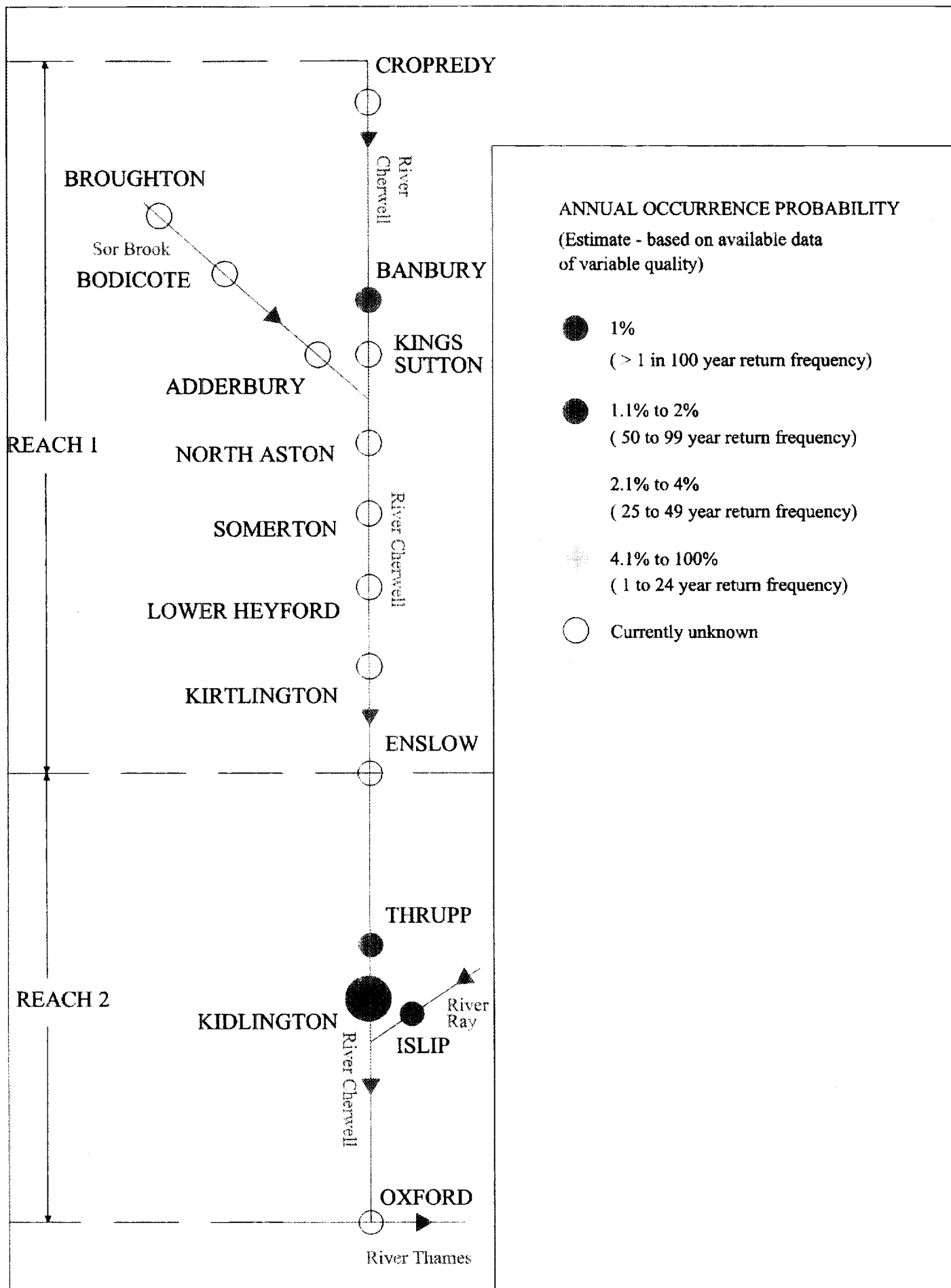
Since the Easter flood the Agency has revised the Red warning threshold level for this reach and has reviewed the flood warning arrangements generally for this location.

The Environment Agency will continue to object to any future development proposals for Zouch including building extensions and chalet replacements.

3.3 THAMES REGION

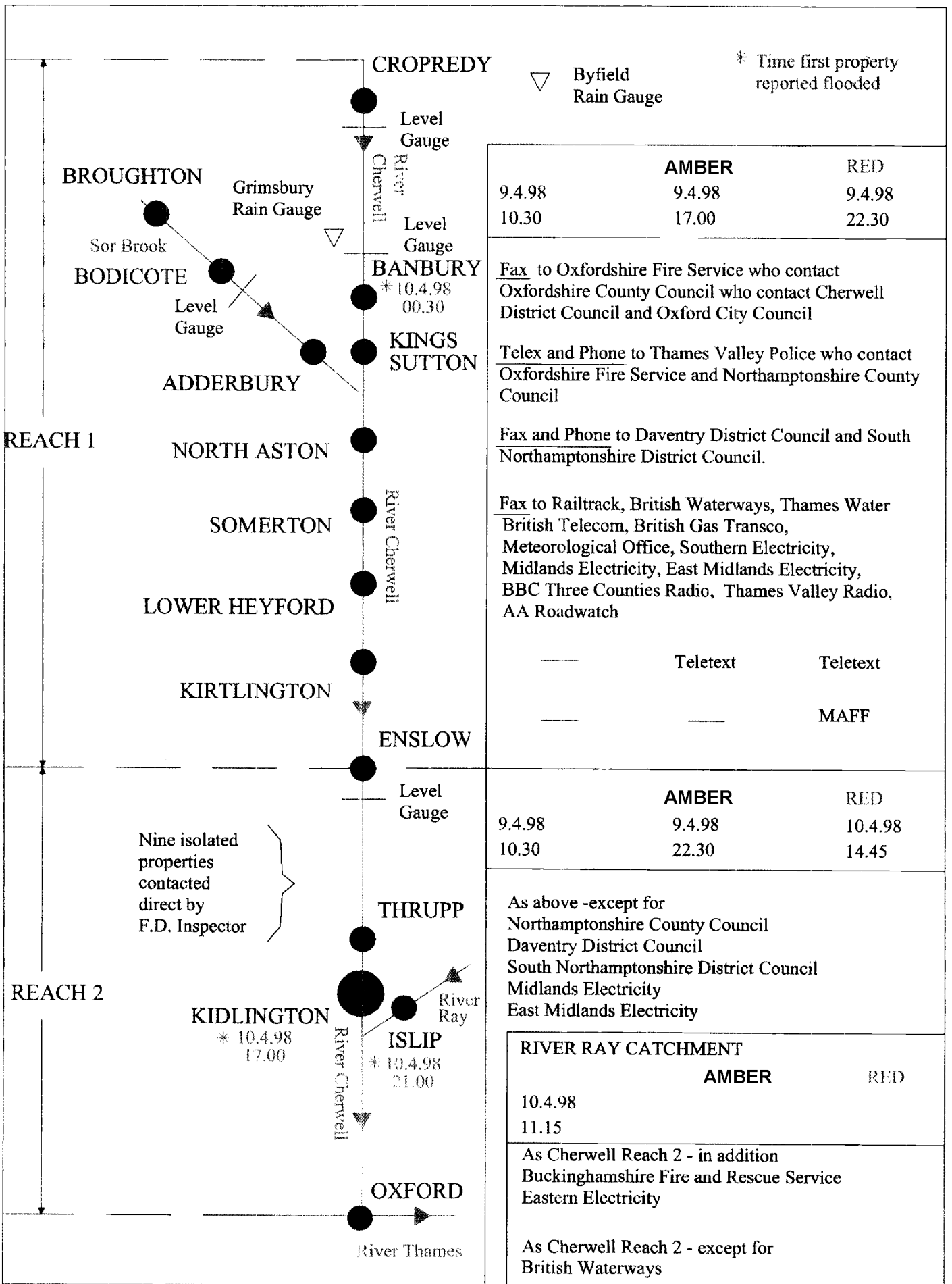


INDEPENDENT REVIEW OF EASTER FLOODS 1998
THAMES REGION - CATCHMENTS AFFECTED



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
CHERWELL \ RAY CATCHMENTS - FLOOD EVENTS**

SEPTEMBER 1998



INDEPENDENT REVIEW OF EASTER FLOODS 1998 CHERWELL \ RAY CATCHMENTS - FLOOD WARNINGS

ADDERBURY, OXFORDSHIRE, SOR BROOK

Background

Adderbury is a town of 2,417 inhabitants (1981 census) bisected by the A4260 5km south of Banbury. It is built on both sides of the Sor Brook valley, a Main River watercourse.

The Sor Brook's major tributary the Bloxham Brook joins together less than 1km west of the village and the Sor flows into the Cherwell 3km to the east, as is indicated on the map appended.

Upstream of a disused mill, the Sor is in two channels over a length of 1/2km, with some property between the two channels.

Changes recorded in the Sor catchment since 1949 include at least 50ha of residential and 17ha of industrial development in the town itself and another 50ha in Bloxham - both towns more than doubling in area; a net loss of woodland and closure of ironstone quarries and their associated railway networks.

Predominantly a clay catchment with a flashy response; flooding of fields occurs in most years.

Previous property flooding in Adderbury has been recorded within the Operations, Development Control and Flood Warning groups - five properties around Dog Close, upstream of the mill, were recorded flooding in 1992 in the Flood Warning Reach System.

The property flooded is shown on the Agency's Section 24 flood plain maps as within a 'dotted' envelope (*this is from a 'low area flood map' or 'LAFM' produced from a survey of limited scope in the 1930s. LAFM details are of a lesser significance as they have never been confirmed as true*).

Following a feasibility study for a flood alleviation scheme, the NRA, in 1992/3, carried out bank erosion protection work. A comprehensive scheme was not considered viable, but it is unclear at present what standard of protection was being evaluated at the time.

There are no raised flood defences at this location.

Flood warning

The Region's policy is to provide a direct flood warning service for 'high risk' properties, based the Section 24 flood plain and on records, trawled from within and outside the organisation and including Local Authorities and the Police. Properties not at high risk are informed via information leaflets, and advised to check 'Teletext', the media, or to use the Agency's 'Floodcall' telephone service.

The five properties mentioned above are not deemed at a 'high risk' from flooding, and would have received flood warning leaflets.

A 'Yellow' flood warning was issued for the whole Cherwell catchment at 10.30hrs on April 9th, escalating on this reach to 'Amber' at 17.00hrs then 'Red' at 22.30hrs.

Brief description of flooding

Residents in Dog Close, Adderbury, contacted the Agency during the evening of April 9th and Agency operatives were sent to attend to sandbagging at six properties and a motor factor's premises, and assisted in moving vehicles to safety.

Sandbagging appeared to be ineffective, as the floodwaters overtopped these temporary defences.

It is apparent that the volume of water exceeded the carrying capacity of the river system and spilled into the flood plain. The properties flooded all appear to be post war construction within the LAFM area.

The impact of changes in the catchment would have been minimal.

The damage to property was four dwellings and a garage business.

The gauging weir at Adderbury on the Sor Brook was commissioned only recently and as such long term records are not available. Estimates have not yet been made of return periods for this location, but are expected with the results of the feasibility studies for Capital works. A more definitive probability of recurrence will be calculated from 20 years of gauging station records at Adderbury.

Emergency response

The fire service was not contacted, residents being aware of the Agency's responsibilities from frequent liaison in the past.

Possible courses of action

Reconsider the feasibility work carried out in the early 1990's. *Problems have been experienced at this location in previous years, but insufficient evidence of flooding may have made it difficult to justify works.*

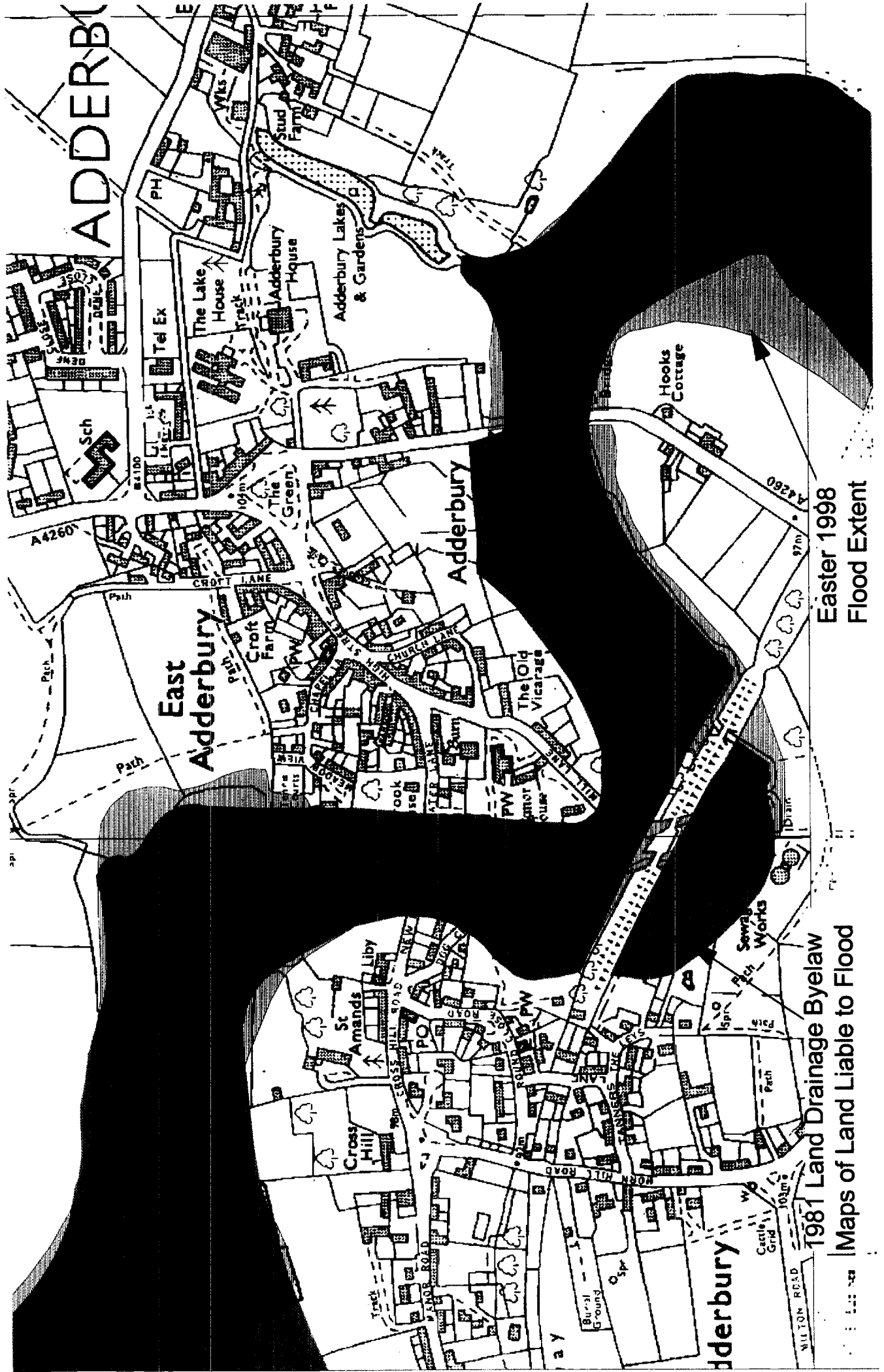
Investigate a locally situated flood warning alarm. *This could be the most cost effective short - term solution for mitigating flood damage.*

Investigate improving the rainfall radar to allow better coverage for the whole of the Upper Cherwell. *This area is not well served by a 2km resolution radar and this could afford better and earlier prediction of floods.*

Apart from the enhancement of telemetry systems to provide improved presentation of real time information for operations, which are not specific to Adderbury, there are no capital programme proposals.

Consulting engineers have now been commissioned to investigate the feasibility of improvement works at Adderbury and are in the initial stages of flood damage assessment in conjunction with insurance companies.

Note: General 'lessons learned' – as opposed to the site specific "Possible courses of action" listed above – appear within the Special Study Report for Kidlington.



1981 Land Drainage Byelaw
 Maps of Land Liable to Flood

Easter 1998
 Flood Extent

BANBURY, OXFORDSHIRE, RIVER CHERWELL

Background

Banbury is the major town in the upper Cherwell catchment and had a population, in 1981, of 36,000.

The Cherwell is a predominantly clay-based catchment, the headwaters of which are found on the Lower Lias clay to the north of Banbury. The flow in the River Cherwell in this upper part of the catchment is derived mainly from drainage of the clays and from springs.

Within the catchment, there are a number of small reservoirs at Wormleighton, Boddington and Clattercote, which provide water for the Oxford Canal, which shares the valley with the Cherwell and its tributaries. In addition there is a raw water storage reservoir at Grimsbury, owned by Thames Water Utilities Limited (TWUL) and used for public water supply.

In Banbury, a major tributary of the Cherwell – the Hanwell Brook – joins at Spiceball Park via the Oxford Canal. The Hanwell flows in a south-easterly direction and drains into the canal east of Southam Road. It then flows along the canal for 300 metres and spills out of the east bank of the canal, via a weir, into a channel across to the Cherwell.

Both the River Cherwell and Hanwell Brook are Main River watercourses, except for the 300 metre section of the canal which takes flow from the Hanwell.

A flood alleviation scheme was carried out in the 1960s, with an estimated protection (then) against a 35 year return period flood. Subsequent evaluation following serious floods in 1979 suggested that the degree of flood relief was less than anticipated. It was not until 1992 that the full computer modelling study of Banbury gave an accurate indication of the 100 year flood plain.

The opening of the M40 motorway has increased development pressure in the catchment by making the area more accessible from London and Birmingham.

Flooding in Banbury is well documented in the Agency, the following records are from the Development Control team's archive:

1947	Major flooding in Banbury, including the railway station area.
1959	Ditto
1969	Flood alleviation works completed.
1974	Flood affects Spiceball Leisure Centre amongst other sites
1979	Floods in February and December affect properties and Spiceball Leisure Centre. Discussions held over effectiveness of 1967 works, and possible future flood relief works
1989	Formation of NRA and beginning of pro-active role in planning policies; Initial Consultation on Banbury Local Plan review
1990	Town & Country Planning Act places emphasis on formation of comprehensive district wide local plan, containing detailed policies.
1990-1992	Liaison over Banbury Local Plan review and Central Oxfordshire Local Plan (Cherwell), and detailed study of flooding by NRA to produce computer model and flood maps for 100 year return period event.

1992 Flooding in September, including Spiceball Leisure Centre
1996 Cherwell Local Plan published. NRA becomes part of Environment Agency
1998 Easter floods. Worst on record, exceeding previous recorded levels by over 1 metre in some locations.

The Flood Warning Reach System identifies only Spiceball Leisure Centre and Spiceball Mill Arts Centre as at risk.

There are no flood defences in Banbury, other than the 1960's channel improvement works.

Flood warning

The Region's policy is to provide a direct flood warning service for 'high risk' properties, based the Section 24 flood plain and on records, trawled from within and outside the organisation and including Local Authorities and the Police. Properties not at high risk are informed via information leaflets, and advised to check 'Teletext', the media, or to use the Agency's 'Floodcall' telephone service.

There are no properties identified as 'high risk' but Spiceball Park Leisure Centre, and Spiceball Mill Arts Centre are identified as 'at risk' and would have received leaflets.

The railway station is known to have flooded in 1947 from newspaper photographs, but is not shown on the Agency's Section 24 maps, nor is recorded in the Flood Warning system.

A 'Yellow' flood warning was issued for the whole Cherwell catchment at 10.30hrs on April 9th, escalating to 'Amber' at 17.00hrs then 'Red' at 22.30hrs.

The manager of the leisure centre was telephoned direct with a warning by the Agency's Operations Duty Co-ordinator at 22.40hrs, on the 9th April.

Brief description of flooding

Oxfordshire County Council Emergency Planners were in close contact with Agency Operations Duty staff throughout the event and minimal assistance was required of the Agency as the local authorities, the Police and Oxfordshire Fire Service took the situation under control, including evacuation measures. The Fire Service were in attendance at Spiceball when the Red Flood alert was issued.

Most of the flooding was due to flood plain inundation from the Cherwell or Hanwell Brook.

The Cherwell's capacity downstream of Spiceball Park is limited and was unable to take the river flow which in turn led to the bank full situation and subsequent flooding in the Spiceball area and the railway station.

The Hanwell Brook was responsible for floodplain inundation in the Southam Road area and the Alcan premises.

Ferguson Road and Victoria Place were flooded from the Cherwell, backing up an ordinary watercourse.

The impact of the change in the catchment appears to have been significant. Experience and liaison

with the District Council has shown that responses made on individual planning applications by Thames Water Authority and in early NRA days may not have been forceful enough over flooding issues to influence their decision making, and some development had been allowed in the flood plain.

The Middleton Meadows estate, in particular, had been raised out of the flood plain and this may have had effects downstream due to the loss of flood plain storage capacity. Its proximity to Ferguson Road and Victoria Place has led to concerns that it may also have contributed to their flooding, however the flood mechanism and levels suggest this is not so.

The last ten years have seen a significant advance in the consideration of flooding as a significant planning issue. Despite this, sites may have been approved from the early part of this period, which have only been built in recent years, giving the impression that development control is not as strict as it could be.

The property damage consisted of 32 dwellings, 12 business and leisure premises and the railway station are confirmed as having flooded, as at August 20th, based on observation and responses to Agency questionnaires. Detailed surveys are in progress - early reports of 100 or more flooded properties are being investigated.

Estimates as at August 10th show a return period in excess of 1 in 100 years, based on 30 years of Banbury gauging station records. This is the biggest flood recorded at this site. However a similar extent of flooding occurred in 1947 according to local records. More survey data emanating from capital scheme feasibility work may allow a more accurate figure to be determined.

Emergency response

BW staff attended to their control structures, along the canal, as floodwaters progressed along the canal/ river system during the 9th April.

Sandbagging appeared to be ineffective where floodwaters overtopped these temporary defences, but were effective around the periphery of the flood.

Possible courses of action

Continue effective liaison between the Agency and Cherwell District Council over development in the floodplain. *Both organisations have been working together to reduce flood risks through planning policies which protect the flood plain and encourage measures to cater for rainfall runoff at source;*

Investigate improving the rainfall radar to allow better coverage for the whole of the Upper Cherwell. *This area is not well served by 2km resolution radar and this could afford better and earlier prediction of floods;*

Update the Flood Warning Reach System using the best available information. *The Spiceball area should be on the 'high risk' list, and the 1 in 100 year model, as developed to assist in development control, may help to indicate vulnerability elsewhere in the town.*

Apart from the enhancement of telemetry systems to provide improved presentation of real time information for operations, which includes information from Banbury, there are no capital programme proposals.

Consulting engineers have now been commissioned to investigate the feasibility of improvement works at Banbury and are in the initial stages of flood damage assessment in conjunction with insurance companies.

Note: General 'lessons learned' – as opposed to the site specific "Possible courses of action" listed above – appear within the Special Study Report for Kidlington.



Easter 1998
Flood Extent

1981 Land Drainage Byelaw
Maps of Land Liable to Flood

ISLIP, OXFORDSHIRE, RIVER RAY

Background

Islip is a village of 670 people (1981 census), 8km north of Oxford and is north of the 'tee' shaped confluence of the rivers Cherwell and Ray, the former being the stem and top left of the tee. Mainly on high ground, part of the village runs adjacent the Ray at a lower level.

The Ray discharges immediately downstream of Islip into the Cherwell via an Agency operated automatic weir. This serves to regulate water levels within the engineered river system immediately upstream around Otmoor. Otmoor is a flat area of some 12 km², which acts as a natural storage area for floodwater from the River Ray.

The most significant change in the Ray catchment since 1949 was the building of the M40 motorway. The Cherwell has had at least a 2% increase by area in urban development; a net loss of woodland; expansion of a quarry at Shipton and also the building of the M40. The direct effect of the latter is considered to be insignificant during major floods, although its construction has led to increased development pressure along its corridor.

Predominantly a clay catchment with a flashy response, flooding of fields occurs in most years around Islip and most notably on Otmoor, although this is related to the Ray. The Cherwell is thought to affect Islip on occasion – although this has not been expressly recorded.

Previous flooding in Islip has been recorded within the Operations, Development Control and Flood Warning groups – the Flood Warning Reach System show Collice Street and Lower Street as flooding in 1973 and 1972 respectively, and it is thought that this was related to a Cherwell flood.

Some of the properties flooded are evident within the flood plain shown on the Agency's s.24 maps, recent history relates this to garden flooding only, however flooding of this nature is relatively common.

There are no flood defences at this location.

Flood warning

The Region's policy is to provide a direct flood warning service for 'high risk' properties, based the Section 24 flood plain and on records, trawled from within and outside the organisation and including Local Authorities and the Police. Properties not at high risk are informed via information leaflets, and advised to check 'Teletext', the media, or to use the Agency's 'Floodcall' telephone service.

The Flood Warning Reach System does not refer to any property flood risk, although shows Collice Street and Lower Street as at risk. As such, flood warning leaflets would not have been issued.

There are no properties identified as at 'high risk' from flooding.

A 'Yellow' flood warning was issued for the Ray catchment at 11.15hrs on April 10th; no 'Amber' or 'Red' warnings were issued, nor was a correlation made between the high levels in the Cherwell and possible effects on the Ray at Islip.

Brief description of flooding

Oxfordshire County Council Emergency Planners were in close contact with Agency Operations Duty staff throughout Good Friday, April 10th, 1998, and the Fire Service were in attendance in Islip during that evening.

Agency staff on flood patrols ensured Islip Weir was operating satisfactorily throughout the flood event, although the high water levels damaged equipment at the site.

Floodwaters entered low - lying properties adjacent the River Ray. It is evident from the records of Islip gauging weir that the main cause of Islip property flooding was water backing up the Ray from the Cherwell, spilling out into the floodplain as levels rose.

The impact of changes in the Ray catchment would appear to have been minimal, despite river channel enlargement since 1944 and work to the drainage around Otmoor. However, as the Cherwell was the main cause of flooding, the changes within that catchment would be more relevant, but would appear to have had an insignificant effect on the magnitude of this flood.

The property damage was eight dwellings and one public house.

The gauging weir at Islip was commissioned only recently and as such long - term records are not available for comparison.

As the flood appeared to be a combination of both Cherwell and Ray runoff, with the rainfall on the Ray catchment not being exceptional, estimates of the Cherwell return period may be more relevant. These show a return period of up to 1 in 100 years.

As more survey data becomes available from capital scheme feasibility work, a more accurate figure may be determined.

Emergency response

Agency staff on flood patrols ensured Islip Weir was operating satisfactorily throughout the flood event, although the high water levels damaged equipment at the site.

Agency staff assisted Cherwell District Council staff with pumps, sandbags and labour.

Extra sandbags were requisitioned from the Army, although the effectiveness of the sandbags is questionable.

Possible courses of action

Investigate a locally situated flood warning alarm. *This could be the most cost effective short - term solution for mitigating flood damage.*

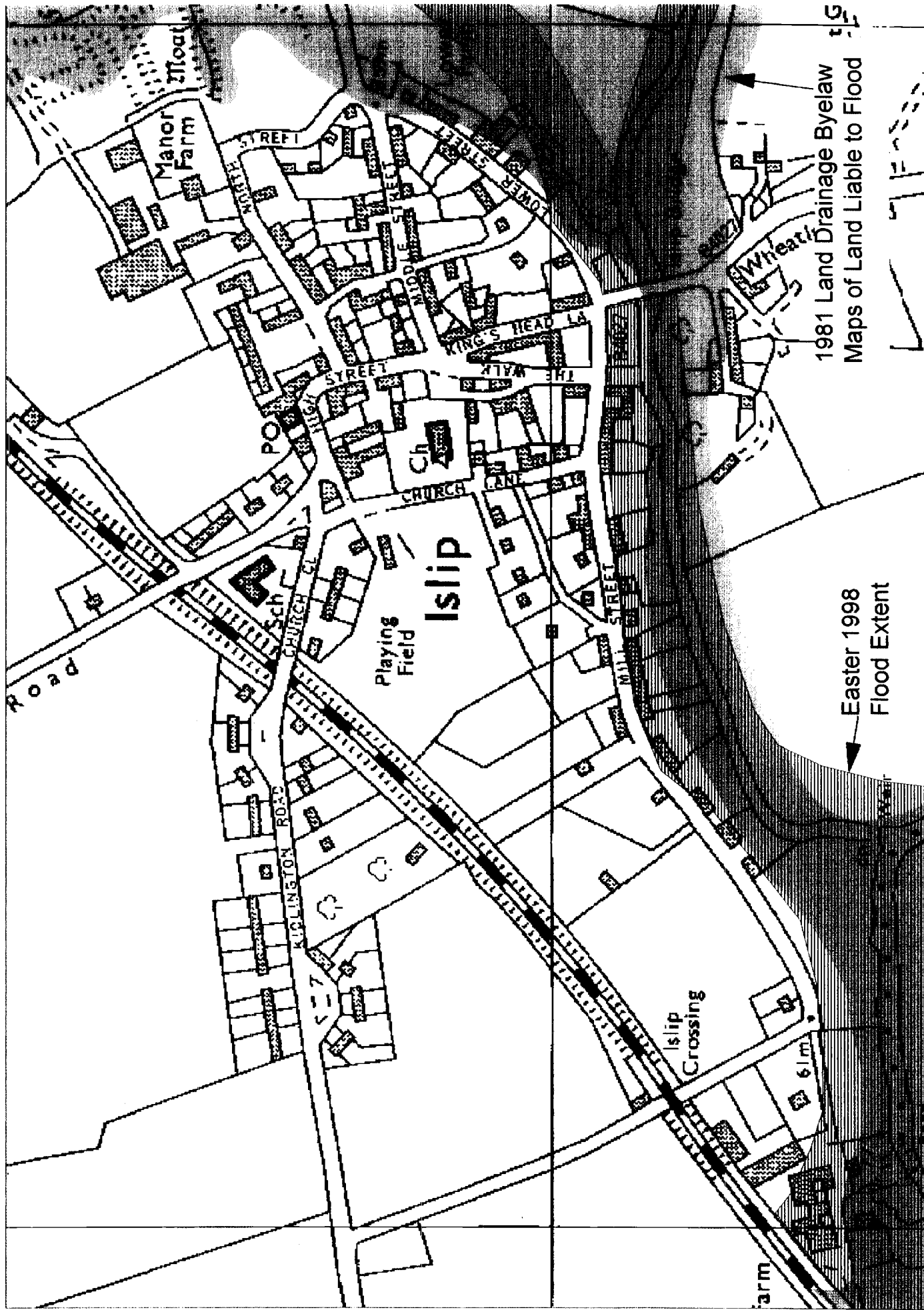
Include that part of the Ray affected by the Cherwell in the appropriate Flood Warning documents. *To ensure that Islip is warned in the event of another Cherwell flood.*

A reassessment of the vulnerability of equipment to flooding at the Agency operated weir. *This equipment was damaged by the high water levels.*

Apart from the enhancement of telemetry systems to provide improved presentation of real time information for operations, which includes information from Islip, there are no capital programme proposals.

Consulting engineers have now been commissioned to investigate the feasibility of improvement works at Islip and are in the initial stages of flood damage assessment in conjunction with insurance companies.

Note: General 'lessons learned' – as opposed to the site specific "Possible courses of action" listed above – appear within the Special Study Report for Kidlington.



THRUPP, OXFORDSHIRE, RIVER CHERWELL

Background

Thrupp is a hamlet in the Parish of Shipton on Cherwell and Thrupp (population 362, 1981 census), 10 km north of Oxford. Reference to the map in the appendix shows how it is east of the A4260 and bounded to the east and south by the Oxford Canal as the canal describes a near right angle in plan. Levels in the village are flat.

The canal, which separates Thrupp from the River Cherwell, is raised above the river flood plain at Thrupp and shares the same valley as this river for most of its length. Normally separate, both canal and river occupy the same channel upstream of Thrupp from Shipton to Enslow, some 15 km. This can cause river levels to affect the canal.

The Cherwell is a Main River watercourse.

At Shipton, there is a timber gate, which can be closed across the canal, to divert high flows back into the river system and so prevent the canal from overtopping below the gate. The water above the gate would flow across the towpath to the River Cherwell. The other control structures are sluices and sidespill weirs, which perform the function of controlling water levels in the canal.

Changes recorded in the catchment since 1949 include at least a 2% increase by area in urban development; a net loss of woodland; expansion of a quarry at Shipton and the building of the M40 motorway. The direct effect of the latter is considered to be insignificant during major floods, although its construction has led to increased development pressure along its corridor.

Predominantly a clay catchment with comparatively flashy response, flooding of fields occurs in most years but there is no documentary evidence of previous property flooding in Thrupp within the Agency's Operations, Flood Warning or Development Control groups.

There are no flood defences at this location, although the canal - being raised above the floodplain - affords a degree of flood protection in low order floods - and the area flooded has not been recorded on the Agency's 'byelaw flood maps' (also known as 'Section.24' or 'statutory flood plain' maps).

Flood warning

The Region's policy is to provide a direct flood warning service for 'high risk' properties, based the Section 24 flood plain and on records, trawled from within and outside the organisation and including Local Authorities and the Police. Properties not at high risk are informed via information leaflets, and advised to check 'Teletext', the media, or to use the Agency's 'Floodcall' telephone service.

The local Flood Warning Information leaflet does not show Thrupp as at risk, so no leaflets or warnings would have been issued directly to the village.

A 'Yellow' flood warning was issued for the whole Cherwell catchment at 10.00hrs on April 9th, escalating on this reach to 'Amber' at 22.30hrs then 'Red' at 14.45 on the 10th. As Thrupp lay outside the assumed risk area, the recipients, who included the Local Authorities and Emergency Services, may not have considered these warnings relevant.

Brief description of flooding

Oxfordshire County Council Emergency Planners were in close contact with Agency Operations Duty staff throughout Good Friday, April 10th, 1998 and Oxfordshire Fire Service advised the Agency of flooding at Thrupp at 16.24hrs.

There was no contact between the Agency and British Waterways and the Agency was not involved in any response at Thrupp, as its resources were already committed elsewhere on flood patrol and sandbagging duties and it had not been required to assist.

It is evident that the inability to close off the canal via the Shipton floodgate allowed water to pass down the canal and flood the village. Levels in the canal at Thrupp fell by around 125 mm, between 14.30 hrs and 15.00 hrs, which was when the gate was finally shut.

It is believed that the gate did not affect the levels, to the extent of causing flooding, as it is apparent that the flooding in the BW yard and house came up from the river. The flooding in the houses near the Boat Inn may have been exacerbated, by the excavation of the canal bank, on the towpath. This was carried out in the hope that the water would go straight into the ditches and alleviate flooding to the adjacent properties.

The impact of changes in the catchment would have been minimal, if at all measurable.

The property damage was four terraced cottages, a car park cars and BW's depot.

Estimates as at August 10th showed a return period of up to 1 in 100 years, however more survey data emanating from capital scheme feasibility work elsewhere in the catchment may allow a more accurate figure to be determined.

Emergency Response

British Waterways (BW) staff attended to their control structures along the canal and where sent to close the Shipton floodgate at 17.00 hrs on April 10th. BW reported the gate closed at that time, probably from the effects of hydrostatic pressure. Eye witnesses reported that locals had tried to close the gate earlier in the day but found it obstructed, the most likely cause being gravel or silt accumulations in the canal bed. Levels in Thrupp fell by around 125mm after the gate had properly been shut.

Possible courses of action

Liaison between the Agency and BW needs improvement, particularly in respect of the operation of the Shipton floodgate. *The Environment Agency was unaware of the existence of this gate, its significance in times of flooding, and the need to ensure its ability to operate.*

BW recognise the need regularly to maintain and exercise the Shipton flood gate among other elements of its infrastructure. *Although a key element in flood management at Thrupp, the gate is a British Waterways owned structure, and as such BW have the responsibility to ensure its effectiveness.*

The provision of flood alleviation measures is considered not to be feasible. *The value of flood damage avoided, by providing specific flood alleviation measures over and above the Shipton flood gate would be far less than the cost of providing alleviation measures, and would therefore be precluded under current Government rules.*

Specific flood warning arrangements for Thrupp should be evaluated. *As with other areas determined to be at 'low risk', appropriate measures for Thrupp should be examined.*

The Agency gauging station at Enslow, upstream of Thrupp, is characteristically unreliable for use in frequency analysis. *Local records of past events – 1947, 1903, 1809, 1643 etc. could be examined to determine a more accurate likelihood of recurrence.*

Apart from the enhancement of telemetry systems to provide improved presentation of real time information for operations, which are not specific to Thrupp, there are no capital programme proposals.

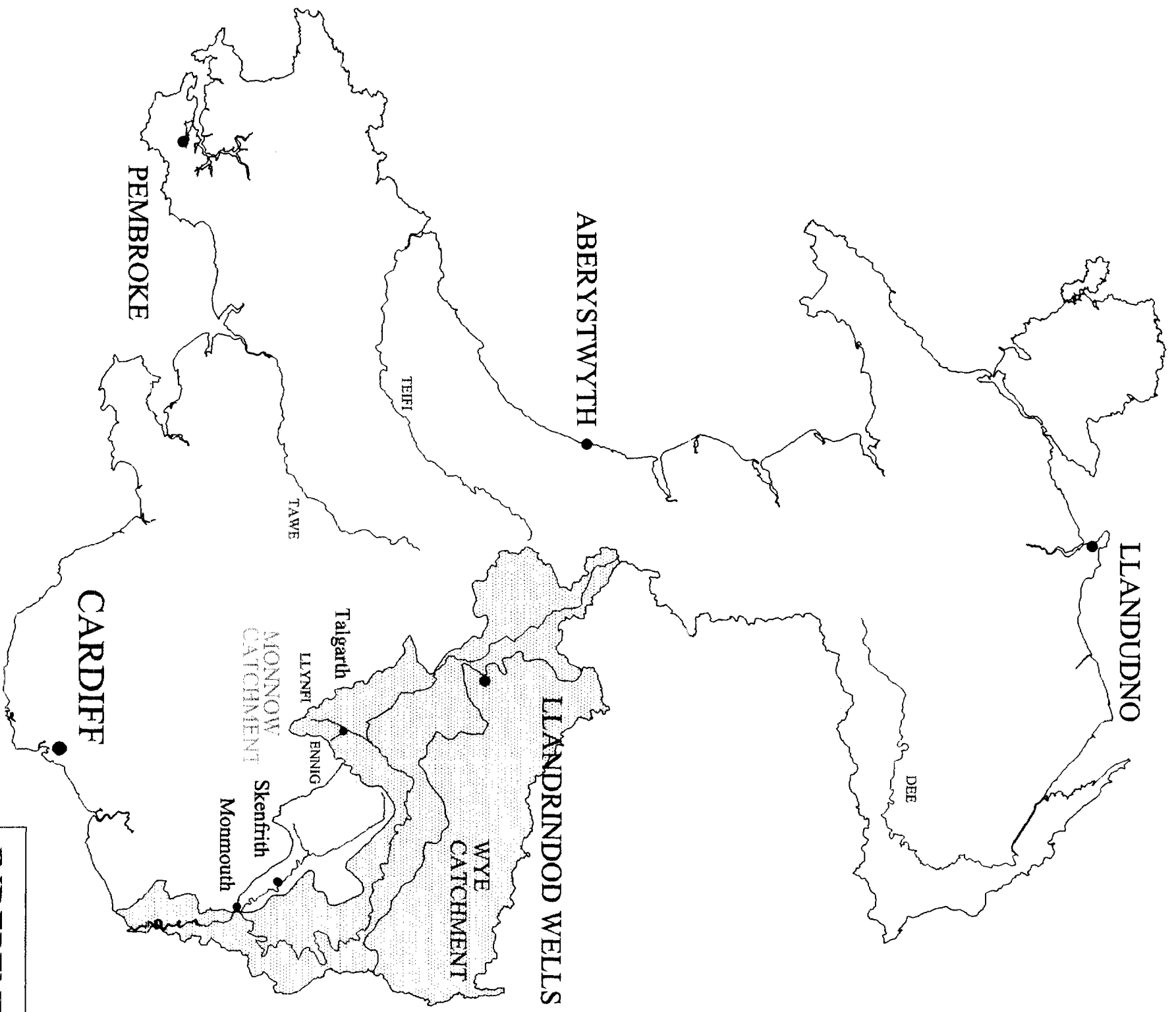
Flood Warning enhancements are being progressed in other areas where higher priorities have existed.

This situation may be reviewed as more information becomes available, but flood alleviation measures are not, at this stage, considered viable.

Note: General 'lessons learned' – as opposed to the site specific "Possible courses of action" listed above – appear within the Special Study Report for Kidlington.

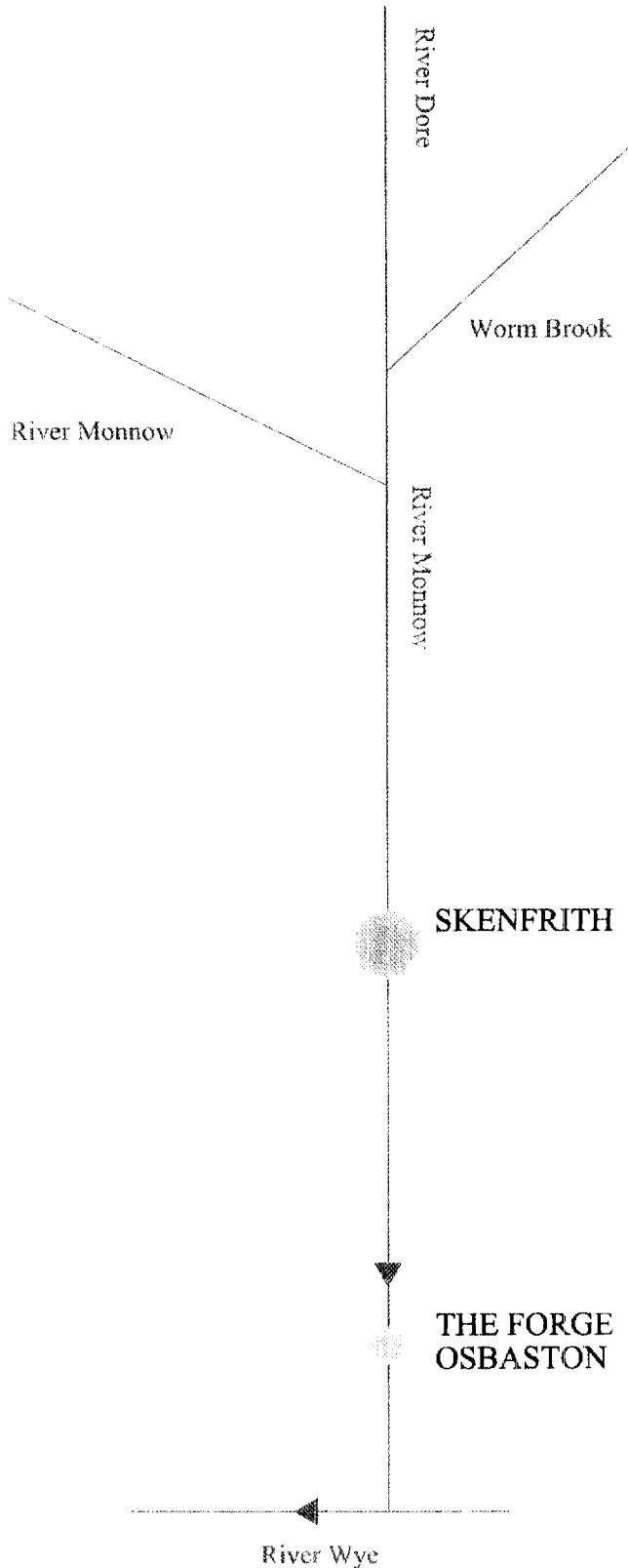


3.4 ENVIRONMENT AGENCY WALES



**INDEPENDENT REVIEW OF EASTER FLOODS 1998
ENVIRONMENT AGENCY WALES - CATCHMENTS AFFECTED**

SEPTEMBER 1998



ANNUAL OCCURRENCE PROBABILITY
 (Estimate - based on available data
 of variable quality)

- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- ▨ 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

INDEPENDENT REVIEW OF EASTER FLOODS 1998
MONNOW CATCHMENT - FLOOD EVENTS

SEPTEMBER 1998

* Time first property reported flooded

AMBER

RED

9.4.98

9.4.98

9.4.98

14.06

18.28

19.12

Fax and phone to Monmouthshire County Council, Welsh Ambulance Services NHS Trust

Phone to Monmouth Chamber of Commerce, Monmouth Town Council, Wardens.

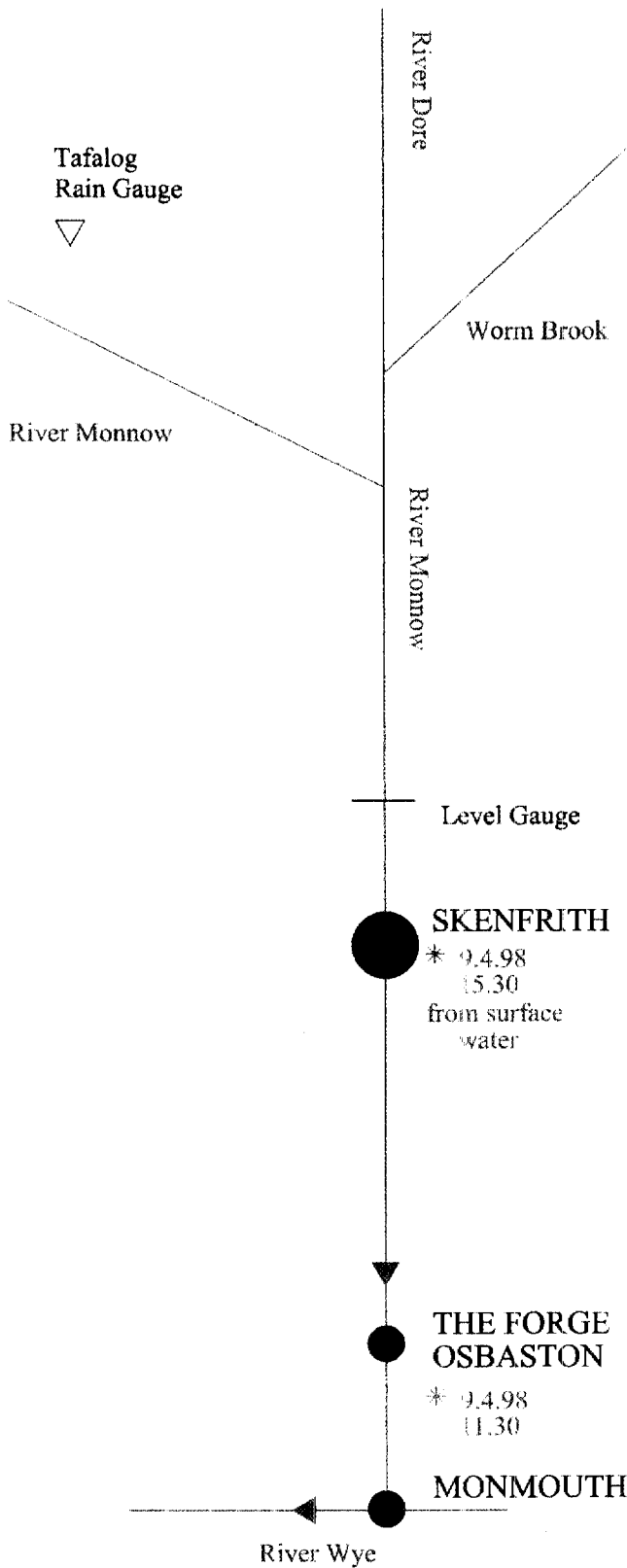
Fax to Army HQ 160 (Wales) Brigade, British Telecom, Heddlu Gwent Police, Railtrack, South Wales Fire service.

Teletext

Teletext

Media

Media



INDEPENDENT REVIEW OF EASTER FLOODS 1998

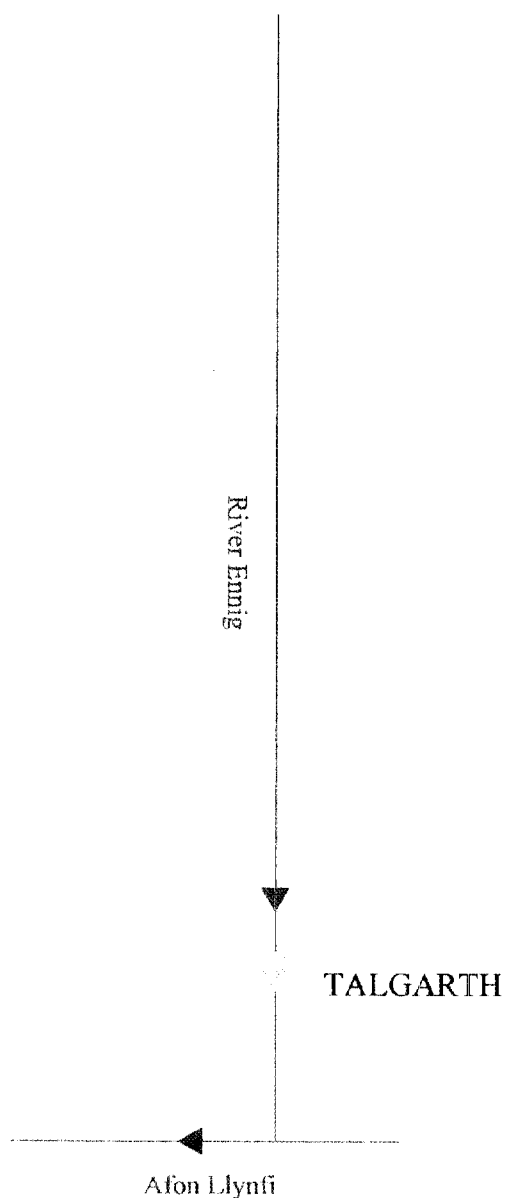
MONNOW CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

ANNUAL OCCURRENCE PROBABILITY

(Estimate - based on available data
of variable quality)

- 1%
(> 1 in 100 year return frequency)
- 1.1% to 2%
(50 to 99 year return frequency)
- 2.1% to 4%
(25 to 49 year return frequency)
- 4.1% to 100%
(1 to 24 year return frequency)
- Currently unknown

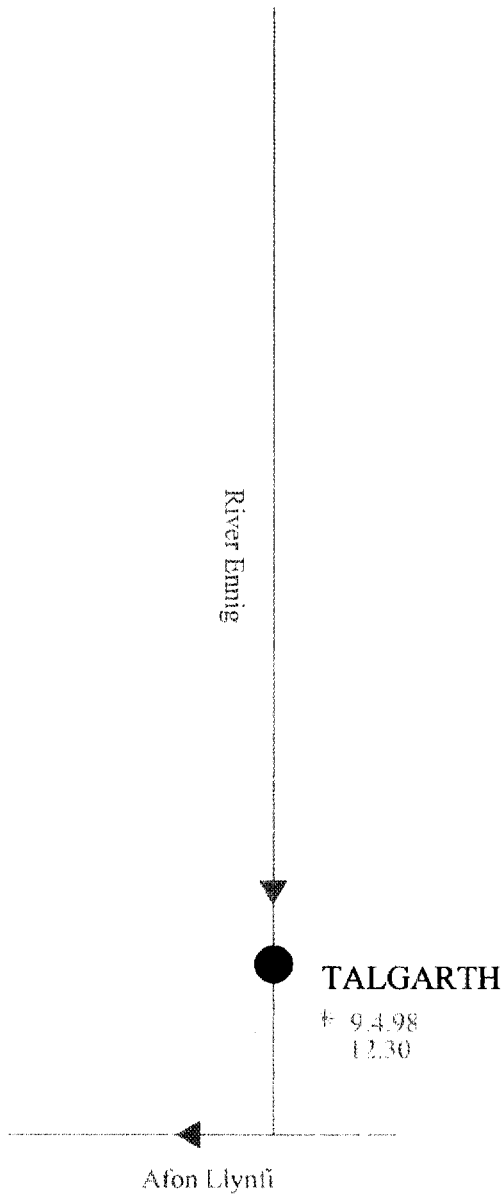


* Time first property reported flooded

AMBER

RED

NO FLOOD WARNINGS ISSUED



INDEPENDENT REVIEW OF EASTER FLOODS 1998

ENNIG CATCHMENT - FLOOD WARNINGS

SEPTEMBER 1998

THE FORGE, MONMOUTH, RIVER MONNOW

Background

The Forge area which comprises twelve private residences and three commercial buildings is located at the northern boundary of the town of Monmouth and is situated on the eastern bank of the River Monnow, which is a Main River, some 1.5 km upstream of its confluence with the River Wye. Much of the property dates from the nineteenth century, but one property has been built with a raised threshold within the last twenty years and conversion of an outbuilding into a residential dwelling has been undertaken more recently. The area originally formed part of an iron forging and industrial centre for which power was provided from the Forge Weir situated some 100 metres upstream of the community.

Approximately 450m downstream of the main Forge Area, there are two other properties situated adjacent to the River Monnow, namely Monnow Mill and Monnow Mill House. The whole of the area is cut off when downstream flooding of the access road adjacent to Monnow Mill occurs in the early stages of a flood event.

Proposals to defend the Forge Area were incorporated within the Monmouth Flood Alleviation Scheme which was undertaken between 1990 and 1992. However the inclusion of such works which were estimated to cost £365,000 in 1985, resulted in the overall scheme becoming financially unviable. As a result only fairly minor works comprising the construction of an embankment adjacent to Forge Weir to prevent flood water overspilling during low return period events were undertaken.

As part of the planning consultation process, the National Rivers Authority objected to a proposed development on the site of the Works buildings. This was subject to a Planning Appeal in 1991 and the objection was subsequently overruled. Outline planning permission has since been granted for development of the site for housing.

The hydrology of the area is determined by reference to Grosmont Gauging Station, for which flow records have been analysed in relation to the flooding at Skenfrith.

Flood Warnings

The Flood Warning Service for the area has been in operation for many years and provides reliable warnings with good lead times of about 6 hours.

The issue of warnings is based upon forecast levels for Monmouth. The forecast is made from the Agency's river level recording station at Grosmont, which is located approximately 25km upstream of the recorder at Monnow Gate, Monmouth. Average travel time for peak flows between the two stations is 6 hours but on this occasion it was 8 hours.

The following flood warnings were issued on 9 April 1998

Yellow - 14:06 hrs
Amber - 18:28 hrs
Red - 19:12 hrs

Stand-down was issued at 11:25 hours on 11 April. Issue of the stand-down is delayed because high levels in the River Wye have a backing up effect on the River Monnow thus maintaining flood alert levels in Monmouth.

	<u>Properties Affected</u>	<u>Depth of Flooding (m)</u>
1.	Monnow Mill House	0.07
2.	Monnow Mill	0.23
3.	1 Forge Cottage	0.30
4.	2 Forge Cottage	0.30
5.	3 Forge Cottage	0.30
6.	4 Forge Cottage	0.30
7.	5 Forge Cottage	0.30
8.	6 Forge Cottage	0.30
9.	7 Forge Cottage	0.20
10.	Forge House	0.20

Brief Description of Flooding

As identified above, as part of the Monmouth Flood Alleviation Scheme a flood bank was constructed adjacent to Forge Weir and successfully prevented floodwater from prematurely breaking out from the side stream which is situated opposite the Weir. This flood bank terminates just downstream of the weir and was not designed to prevent flooding from the River Monnow downstream. The Forge area remains subject to flooding, as it historically has been from floodwater overflowing the river bank and inundating the adjacent properties. Overtopping of the river bank at the Forge area commences during a flood on the River Monnow when the level at Monnow Bridge Monmouth reaches 16.75 metres AOD. These circumstances were observed to occur at 11.00 hrs on 28 January, 1990, when floodwater overtopped the river bank and flowed down the flood plain, behind Forge Cottages, before returning to the River Monnow downstream of the Cottages.

The largest known flood which occurred at the Forge Area was in 1947 and the second largest occurred in 1960. Observations have also been made during the flood of 29 December 1979, when the area flooded to a depth of between 0.75 and 0.9 m. During a 100 year flood the area upstream of Forge Cottages is liable to flood to a depth of between 1.25 m and 1.5 m. Depths of flooding for various flooding events are listed below.

On 10 and 11 April, the access road at Monnow Mill began to flood from the river at about 17.00 hrs and became impassable during the early evening. As river levels continued to rise the ditch system which runs to the landward side of Forge Cottages gradually filled and the flood plain upstream became waterlogged. River levels increased throughout the evening until Monnow Mill began to flood at 23.00hrs. Thirty minutes later, when flood waters overtopped the river bank causing more general flooding of the area, flooding of Forge Cottages commenced and in total, ten residential properties were flooded to depths of up to 300mm. Flood depths at the lower end of Forge Road reached a maximum of 1.3m deep.

The peak was recorded at Monnow Gate Bridge at 03.00 hrs on 10 April. It is reasonable to assume that the return period established at Grosmont Gauging station will give an indication of the likely return period of the flood, 1 in 20 years.

Depth of Flooding of Forge Area

<u>YEAR OF FLOOD</u>	<u>DEPTH OF FLOODING</u>
1947	1.25
1960	0.90
1979	0.75
1998	0.25
1990	River Starts to Overtop its Banks

Emergency Response

The Agency Emergency Response Plan details duties primarily to ensure the integrity and operation of Flood Defences but the Emergency Work Force is also active in clearing Main River bridges and culverts where it is safe and practicable during a flood event together with the operation of sluice gates. In addition, if resources allow, assistance will be given in an emergency to resolving non Main River problems.

Monmouthshire County Council staff are familiar with problems that are likely to arise in the Forge Area and are well prepared for such events, Council staff were providing assistance to residents with effect from 18.00 hrs.

Agency staff were not called upon for assistance but there was liaison between the Assistant Director of Environmental Services (David Harris) and the Flood Warning Duty Officer at regular intervals throughout the event.

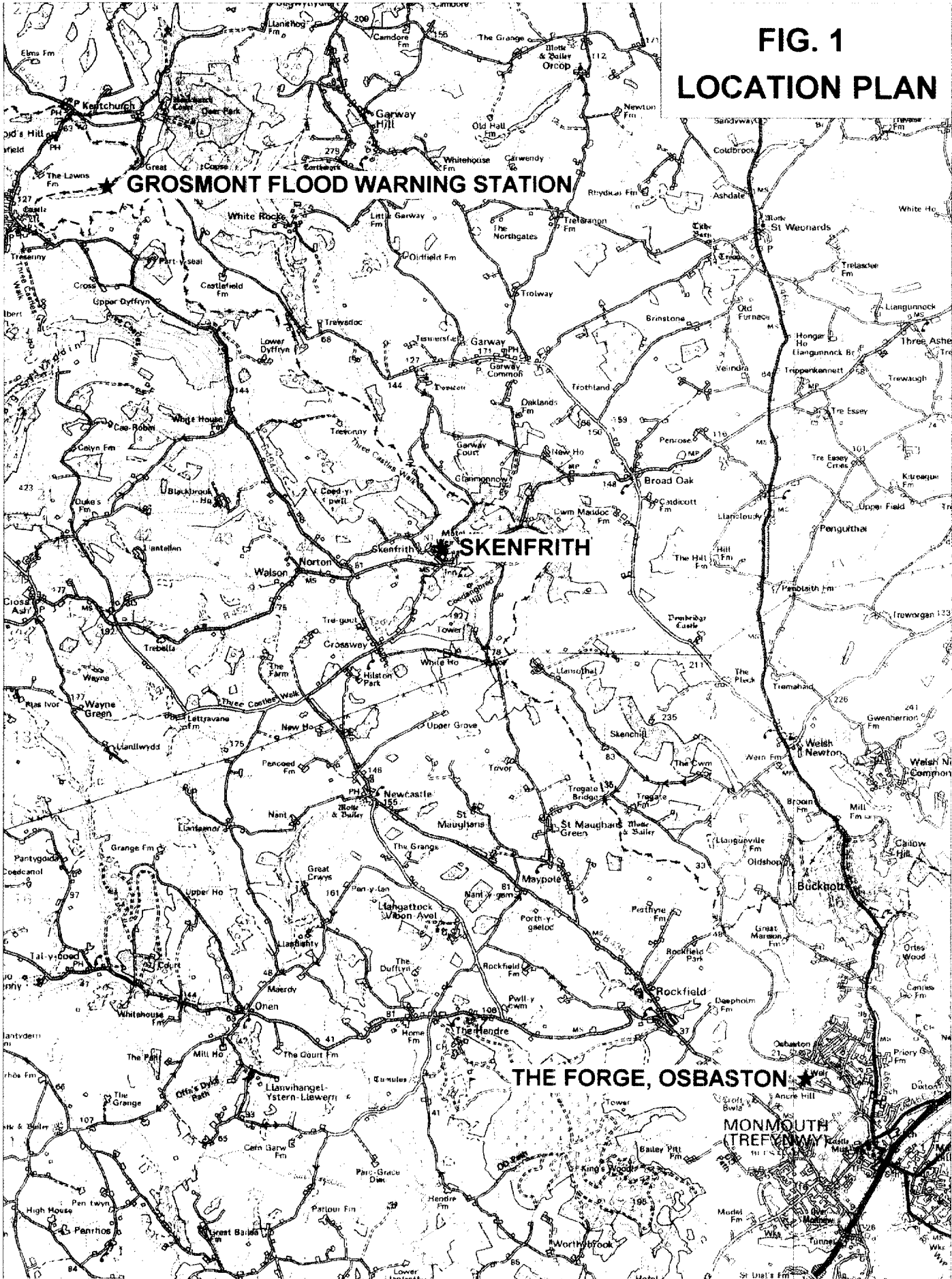
High discharges from the River Monnow cause a backing up effect in the River Wye and Agency staff were on duty in Monmouth to close the flood gates at the Monmouth Rowing Club and monitor levels continuously from the early hours of 10 April until midday on 12 April.

Possible Courses of Action

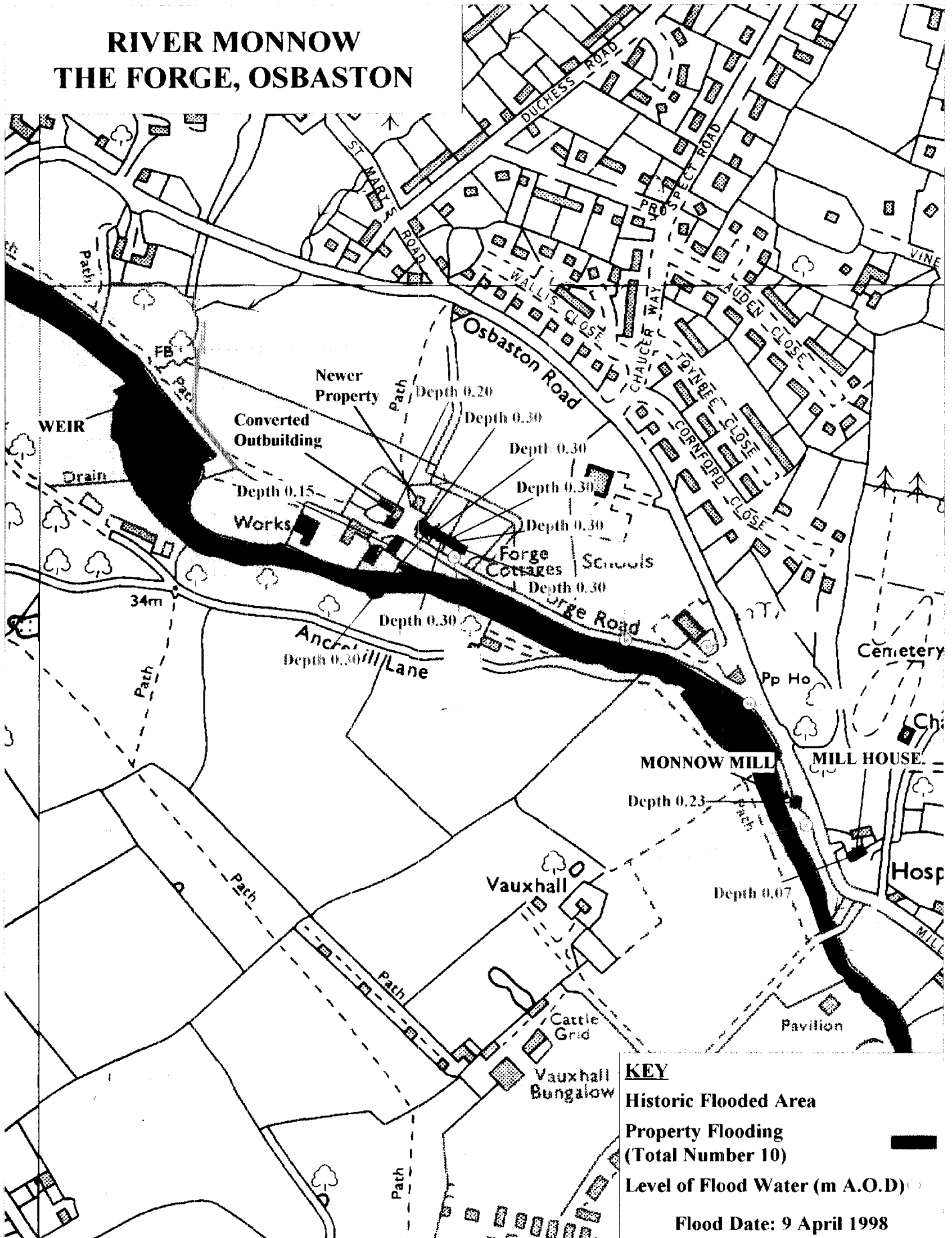
The Police Plan for the dissemination of warnings specified a warden system and this system was adopted by the Agency in 1996. However, the Forge area will receive priority in the 5 year flood warning programme so that affected residents will be given the opportunity of receiving warnings directly via AVM before the onset of the next flood season.

The question of providing comprehensive defences for the area has been thoroughly investigated in the past and is not thought to be financially viable at the present time.

FIG. 1
LOCATION PLAN



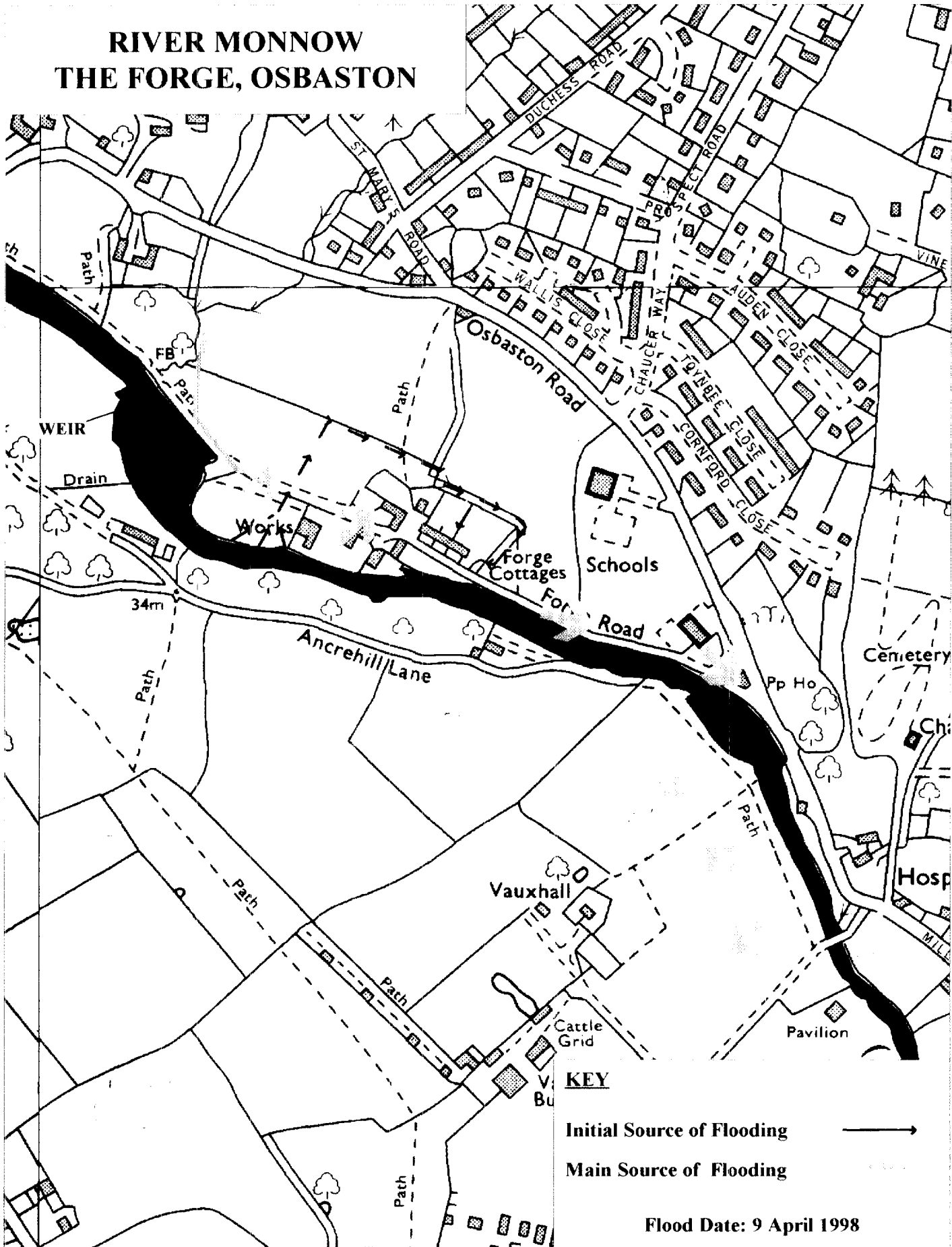
RIVER MONNOW THE FORGE, OSBASTON



KEY
 Historic Flooded Area
 Property Flooding
 (Total Number 10)
 Level of Flood Water (m A.O.D.)

Flood Date: 9 April 1998

RIVER MONNOW THE FORGE, OSBASTON



Flood Date: 9 April 1998

TALGARTH, NEAR BRECON, POWYS, RIVER ENNIG

Background

Talgarth is a village in the north western foothills of the Black Mountains in the County of Powys. The village has developed around the Afon Ennig and an unnamed tributary, refer to location plan Fig. 1.

The catchment to Talgarth is rocky in nature rural and hilly. The village reaches of the Ennig and its tributary have steep overall gradients with boulder strewn pool and riffle features and a series of waterfalls. The catchment which is 18.9km² in area rises to a level of 730m A.O.D. and falls to about 130m A.O.D. at Talgarth, an average gradient of 1 in 11. The valley sides above and through the village slope steeply to the watercourses. The absence of extensive flood plain areas is typical of the upper reaches of a river system. No reservoirs or other water systems which could influence flood hydrology are evident in the catchment.

Development, mainly housing appears to have occurred over decades if not centuries and there is little modern construction. Some properties are close to or hard against the watercourses.

The village reaches are crossed by nine bridges, four of which were blocked during the flood.

There are no flood defences at Talgarth. Only limited records of flooding of the village exists however recently a report of a severe flood which occurred in 1880 has been found.

Flood Warning

The Agency's policy to date has been to confine its warning service to locations known to be at risk of Main River flooding.

The Afon Ennig is not designated as Main River and Talgarth was not thought to be of risk of frequently flooding. The village has not been considered for coverage by the Agency's flood warning service.

Main River and risk considerations apart, effective warning is precluded by the rapid response of the Ennig to rainfall on the small and steep catchment to Talgarth. As a consequence, this community must rely on general forecasts of severe weather in the locality, intense convective storms in particular, for their awareness of possible flooding.

Brief Description of Flooding

From the evidence gained by site inspection and discussion with County Council officials and by reference to the Hydrological Report, heavy rain over the northern slopes of the Black Mountains on 8 and 9 April resulted in flood flows in the upper reaches of this part of the Wye system. There are no hydrometric records specific to the Afon Ennig and, therefore probability cannot be directly assessed. However, consideration of data relating to the downstream system suggests that probability is in the order of 3.3% (return period of 30 years) for the Easter flood discharge being equalled or exceeded in any one year.

Such a flood does not rank as particularly extreme and the explanation for the flooding experienced would appear to be that a moderately large flow rate combined with substantial blockages at several of the bridges.

From eyewitness descriptions it appears that fallen trees and other flood washed debris carried down by the flood partially blocked the waterway at the road bridge on the upstream side of the village. The resulting water level caused flooding to properties alongside the bridge and flow down the road running into the village, inundating buildings, mainly houses. Further blockages at another three footbridges within the village, resulted in more overspill into the streets and buildings, refer to Flood Plan Fig.2. Overland flow off the steep hillsides added to the discharge down the roads and the flooding in the village

The event was particularly dangerous, and no doubt frightening for the community, because of the high velocities of flows down the steep village roads and the high flows in the watercourse channels. Also, some properties were flooded to depths in excess of one metre.

First reports that flooding of property was at risk was received by the Environment Agency at 11.30 hrs from Powys county Council Emergency Planning Office and the first of two flood peaks occurred at about 14.30 hrs closely followed by another at about 15.00 hrs. The flood water had subsided about 1 m from its maximum by 16.30hrs

A total of fifteen properties and four cellars were flooded with many severely damaged. In addition seven properties were prevented from flooding by sandbagging.

Emergency Response

In the difficult and dangerous circumstances of this event, little could have been done to lessen the impact of the flooding. However, it is evident that Powys County Council's emergency planning and highways and direct services departments, which have a depot in the village, responded quickly and deployed a total of some 30 men with the support of a gang from the Environment Agency who were deployed at 11.30hrs. The actions taken after the flood to clear obstructions from blocked bridges and otherwise restore the watercourse channels were important for reducing the risk of flooding in the event of further storms. Sand bagging of flood prone properties was also undertaken and seven properties were protected from flooding as a result close liaison was undertaken between the Environment Agency and the Emergency Services both during and following the flood event.

Possible Courses of Action

The vulnerability to flooding demonstrated on 9 April at Talgarth is common to many towns and villages on the upper reaches of the river systems in Wales and England.

Flood alleviation schemes for such situations may involve construction to provide singly or in combination:

- channel diversion
- trap, deflector or screen devices for intercepting boulders, gravel, timber and trash swept down by the flood flows;
- channel works to alter flow characteristics so that flood levels are reduced,

- flood walls or embankments.

With or without flood alleviation works, flood risk is lessened by regular maintenance to control tree and bush growth on watercourse banks and to remove gravel accumulations and boulders from critical sections.

HYDROLOGICAL SUMMARY

The first week of April saw persistent heavy rainfall across much of South East Wales. Many locations received more than the average rainfall for April in just the first seven days. Therefore, by the start of the second week of April the catchments were saturated.

During Wednesday 8th April a low pressure area moved south across the UK. Associated with this were two fronts, one to the north of the low's centre moving southwards and an occluded cold front wrapped around the centre moving northwards. By Thursday this had become an intense, slow moving frontal zone. As it moved northwards, widespread thunderstorms broke out ahead of it from the Welsh borders eastwards. Continuous heavy rain was reported further west.

Locally, the rain fell predominantly in an east-west band across the Wye catchment with the heaviest falls occurring over the Black Mountains (134 mm at Blaen-Bwch over the 48 hour period 8th to 9th April). The bulk of the rainfall occurred over a 10 to 12 hour period, starting about 6 am on Thursday morning. Peak rates of 8 to 9 mm per hour showed the rainfall to be "heavy" not "torrential" but that there was a longer period of moderate rainfall. To the north and south the rainfall was considerably less.

Estimates of the return period of the rainfall were made using the method recommended in the Flood Studies Report. The critical storm duration was found to be around 24 hours and had a return period of about 25 years. Totals recorded over shorter durations were not found to be exceptional, for example the peak 5 hour rainfall had a return period of only 6 years. This storm event was classified as "noteworthy" by the Met. Office, rather than exceptional.

The combination of wet antecedent conditions and prolonged heavy rainfall resulted in a marked and rapid response from the Ennig (a tributary of the River Llynfi), which drains the western edge of the Black Mountains. A peak flow of 125.5 cumec was recorded downstream on the Llynfi at Three Cocks gauging station at 12:45 hrs on the 9th. This was the second highest flood in a record dating back to 1970. Therefore, in terms of recent history this was a significant flood.

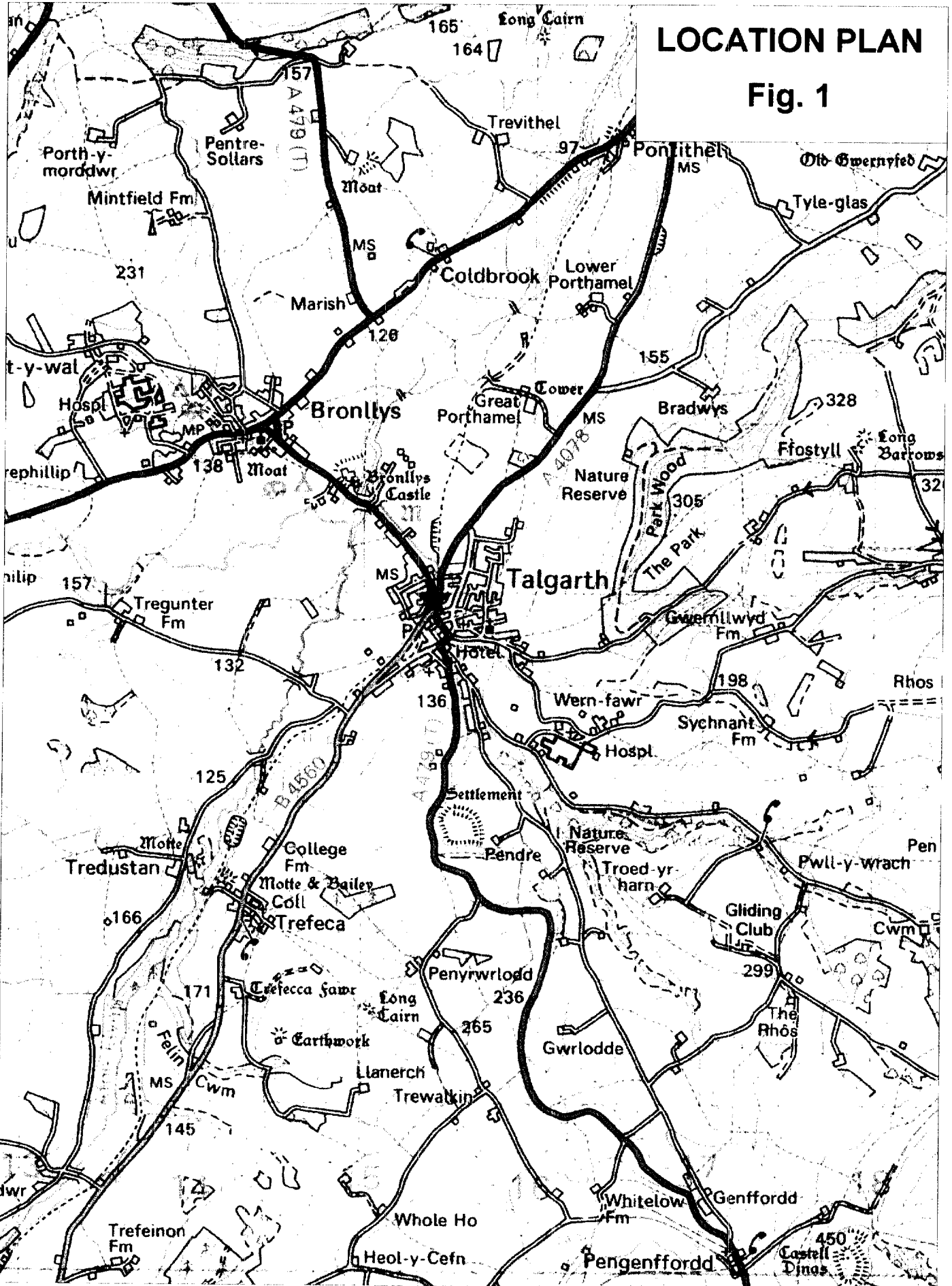
Because there is no flow record for the Ennig, the peak flow at Talgarth was estimated using methods recommended in the Flood Studies Report combined with the estimate of rainfall return period. Together these suggest that the Ennig at Talgarth had a peak discharge of at least 22 cumec. This estimate should be treated with caution.

Flood frequency analysis on the Llynfi at Three Cocks (return period 30 to 60 years) coupled with the rainfall return period (25 years) enables a bandwidth to be set for the flood return period at Talgarth. As the Ennig is a smaller catchment and drains higher, steeper ground (greater runoff) the return period at Talgarth would probably exceed that at Three Cocks. **Therefore it is estimated that the Easter 1998 flood at Talgarth had a return period of at least 30 years, possibly in the range 40 to 70 years. Limited historical information supports this.**

The time to peak of the Ennig to Talgarth is estimated to be around 5 hours with 80% of the rise in the hydrograph in the last 2.5 hours. This has implications on the ability to issue timely flood warnings to residents, should a scheme be considered.

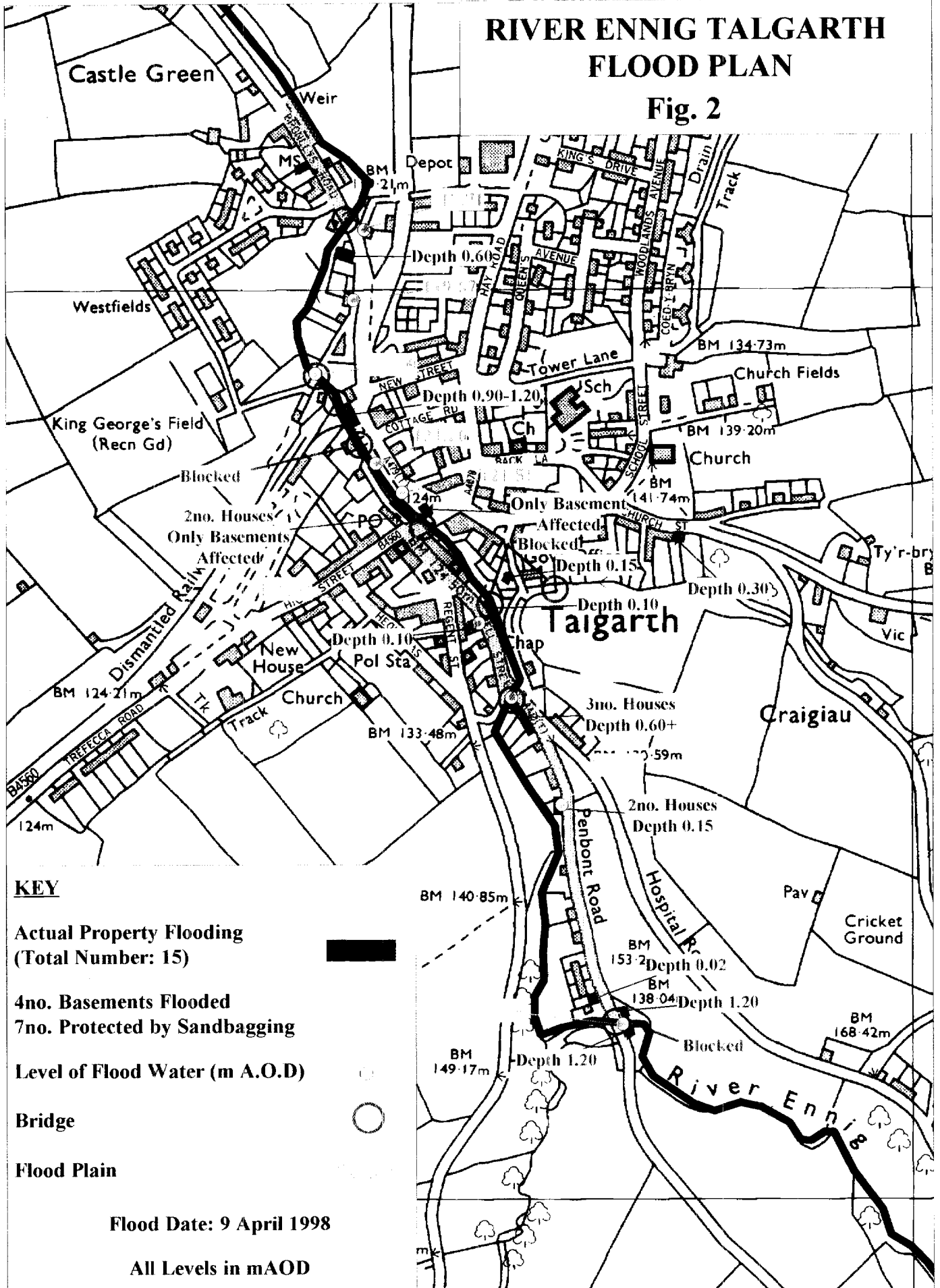
LOCATION PLAN

Fig. 1



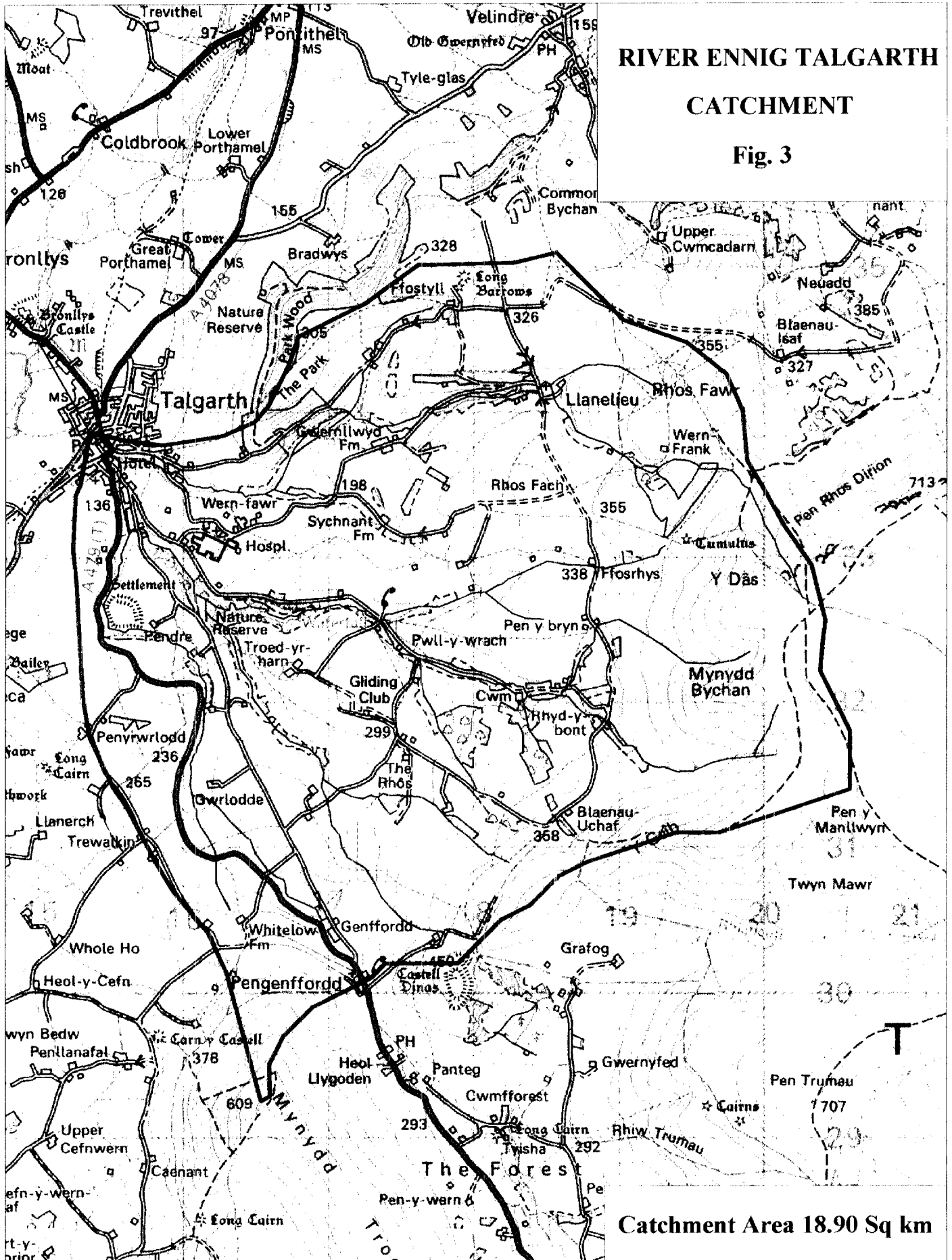
RIVER ENNIG TALGARTH FLOOD PLAN

Fig. 2



RIVER ENNIG TALGARTH CATCHMENT

Fig. 3



Catchment Area 18.90 Sq km

4. SUMMARY TABLES

4.1 ANGLIAN REGION

FLOODING AND FOLLOW UP ACTION

Sheet 1 of 4

Region: Anglian
River: Nene

Main/Non Main : Main

Location	No of Properties Flooded			Return		Protection		Flood Warning		Agency Actions	Date	Defences *2	Date
	Res	Com	Cat	Years	Period	Standard	Issue	Method	Comment				
Long Buckby	1			N/K	N/K	N*				Warning System *1 Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Newnham	1			N/K	N/K	N*				Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Everdon	1			N/K	N/K	N*				Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Weedon	45	1		>150	5	Y		M. S. F. A		Warning thresholds reviewed AVM system extended	Aug. '98	Defences to be reviewed	Mar. '99
Bugbrooke	9	1		>6	6	Y		M. S. F	Owner of Mill did not wish to be on AVM	Warning thresholds reviewed Properties to go onto AVM	Sept. '98		
Kislingbury	43	1		100-150	10	Y		M. S. F. A		Warning thresholds reviewed AVM system extended	Aug. '98	Review of defence	Oct. '98
Northampton	2200	300		150-200	100	N*			Number of flooded properties under review	Warning thresholds reviewed Consultation on new flood warning system complete. Properties going onto AVM. Siren system trial. Local Authority developing warden system.	Oct. '98	Interim improvements completed at six sites Further three planned. Overall review ongoing - Completion improvement scheme approved in Capital Plan	Jan. '99

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A; Surefax - Media Police Release - M; Flood Wardens - W;
Others: Floodcall - F; Police knocking on doors - P; Agency staff knocking on doors - EA; Army knocking on doors - AR; County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

* **NO WARNING ISSUED SPECIFIC TO THIS SITE BUT GENERAL WARNING FOR ALL SITES INCLUDED IN FIRST SITE SPECIFIC WARNING**

*1 **Warning System :** The following actions are being taken at all locations affected by flooding (1) review of flood warning thresholds trigger levels, extension of flood warning dissemination system, update of Flood Warning Plans including flood risk area maps, warning system for boats on Nene navigation, reissue of flood warning leaflets, review of 5 year plans for Telemetry System and Dissemination Plans, clarification of responsibilities with other Emergency Service review of flood warning statements to improve clarity awareness, PR campaign to improve awareness resource reviews.

*2 **Defences :** The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principal flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Anglian
River: Nene
Main/Non Main : Main

Sheet 2 of 4

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions			
	Resid	Com	Period years	Caravan years	Standard years	Issued?	Method	Comment	Warning System *1	Date	Defences *2	Date
Billing Aquadrome	1	10	150-200	250+	8	Y	M. S. F. A		Warning thresholds reviewed	Aug. '98		
Cogenhoe Mill	1		>50	55	>50	Y	M. S. F. A		Warning thresholds reviewed	Aug. '98		
Earls Barton	1		>50		>50	Y	M. S. F. A		Warning thresholds reviewed	Aug. '98		
Hardwater Mill	3		>50		>50	Y	M. S. F. A		Warning thresholds reviewed	Aug. '98		
Wellingboro	1	3	100-150		100	N*			Warning thresholds reviewed Properties to go onto AVM	Sept. '98		
Ditchford		1	>50		>50	N*			Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Irthingboro	1		>50		>50	N*			Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Woodford Mill	2		>50		>50	N*			Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Denford	6		>50		>50	N*			Warning thresholds reviewed AVM system extended	Aug. '98		
Thrapston & Islip	23	19	>150	5	50-100	Y	M. S. F. A. E.A. P. AR		Warning thresholds reviewed AVM system extended	Aug. '98	Defences to be reviewed	Mar. '99
Thorpe Waterville		1	>50		>50	N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind/Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A: Surefax - S: Media Police Release - M: Flood Wardens - W:
Others: Floodcall - F: Police knocking on doors - P: Agency staff knocking on doors - E.A: Army knocking on doors - AR: County Emergency Planning Officer - CEPO: Civil Protection Unit - CPU

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*2 Defences: The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Anglian
River: Nene

Main/Non Main : Main

Sheet 3 of 4

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions		Date	Defences *2	Date
	Resid	Com	Period	Caravan	Standard	years	Issued?	Method	Comment	Warning System *1			
Wadthoe	1		>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Barnwell Mill	1	1	>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Oundle Marina / Fairline	1	2	>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Oundle	1 (12)		>50		>50		N*		() - flooding from riparian source	Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Ashton		1	>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Cotterstock	1		>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Tansor	1		>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Peto - Bluebell Lakes		1	>50		>50		N*			Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Elton	6	1	>50		>50		N*	Police knocked on doors		Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Yarwell - Marina			>50	30 approx.	<50		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98		

Key: Protection Standard - Level of protection at Easter Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR. County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Anglian
River: Nene

Main/Non Main : Main

Sheet 4 of 4

Location	No of Properties Flooded		Return Period	Protection Standard	Flood Warning Issued?	Method	Comment	Agency Actions				
	Resid	Com						Date	Date			
Wansford	14	4	>150	100	N*	EA/Police knocked on doors		Warning System *1 Warning thresholds reviewed Properties to go onto AVM	Aug. '98	Defences to be reviewed	Mar. '99	
Stibington	1		>50	>50	N*	EA/Police knocked on doors		Warning thresholds reviewed Properties to go onto AVM	Aug. '98			
Water Newton	1		>50	>50	N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98			
Alwalton	3		>100	100	N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98			
Peterborough	9 (100)	9	>100	100	Y	M. S. F. CPU, P	() - flooding from riparian source	Warning thresholds reviewed	Aug. '98	Defences to be reviewed	Mar. '99	
Total (from Main River only)	2,379	356										

Key: Protection Standard - Level of protection at Easter
 AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
 Others Floodcall - E. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR. County Emergency Planning Officer - CEPO. Civil Protection Unit - CPU
 Residential - including garages outbuildings Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Slade Brook

Main/Non Main : Main Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions			
	Resid	Com	Caravan	Period	Standard	years	Issued?	Method	Comment	Date	Defences *2	Date
Kettering	2	6		>100	100		N*		Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Total (Main River only)	2	6										

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
Others: Floodcall - F; Police knocking on doors - P; Agency staff knocking on doors - E.A. Army knocking on doors - AR; County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Welland

Main/Non Main : Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (years)	Flood Warning		Agency Actions	Date	Defences *2	Date
	Resid	Com			Issued?	Methods				
Stamford	6	2	>50	50	Y	M, S, F. CEPO	No properties on AVM. Surface water / seepage	Sept. '98		
Deeping St	3	0	>50	50	Y	M, S, F. CEPO	Surface water / seepage through defences	Oct. '98		
Total (Main River only)	9	2								

Key: Protection Standard - I: level of protection at Easter; Residential - including garages/outbuildings; Ind Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A: Surefax; S: Media Police Release; M: Flood Wardens - W;
Others: Floodcall - F: Police knocking on doors; P: Agency staff knocking on doors; EA: Army knocking on doors; AR: County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

* NO WARNING ISSUED SPECIFIC TO THIS SITE, BUT GENERAL WARNING FOR ALL SITES INCLUDED IN FIRST SITE SPECIFIC WARNING
*1 Warming System: The following actions are being taken at all locations affected by flooding (1) review of flood warning thresholds / trigger levels, extension of flood warning dissemination system, update of Flood Warning Plans including flood risk area maps, warning system for boats on Nene navigation, re-issue of flood warning leaflets, review of 5 year plans for Telemetry System and Dissemination Plans, clarification of responsibilities with other Emergency Services, review of flood warning statements to improve clarity / awareness, PR campaign to improve awareness, resource reviews.
*2 Defences: The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Southwick Brook
Main/Non Main : Main
Sheet 1 of 1

Location	No. of Properties Flooded		Return Period	Protection		Flood Warning		Agency Actions				
	Resid	Com		Caravan	Standard	years	issued?	Methods	Comment	Date	Defences *2	Date
Southwick	10			>25	25	N*			Warning System *1 System Warning thresholds reviewed Properties to go onto AVM	Oct. '98	Review of defences commenced complete	Oct. '98
Total (Main River only)	10											

Key:
 Protection Standard - Level of protection at Easter
 Residential - including garages outbuildings
 Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
 AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
 Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR, County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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 *2 Defences : The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
 River : Willow Brook
 Main/Non Main : Main & Non Main River
 Sheet 1 of 1

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions			
	Resid	Com	Caravan	Period	Standard	Issued?	Methods	Comment	Warning System *1	Date	Defences *2	Date
Weldon	1			K/N	K/N	N*		Main River	Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Corby	Extensive							Non Main River				
Total (Main River only)	1											

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind. Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
 AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
 Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR; County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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 *2 Defences : The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Great Easton Brook

Main/Non Main : Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions		Date	Defences *2	Date	
	Res	Com	Caravan	Period	Standard	years	issued?	Methods	Comment	Warning System *1				
Great Easton	2			K/N	K/N		N*			Warning thresholds reviewed Properties to go onto AVM	Oct. '98			
Total (Main River only)	2													

Key: Protection Standard - Level of protection at Easter Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A: Surefax - S: Media Police Release - M: Flood Wardens - W:
Others: Floodcall - F: Police knocking on doors - P: Agency knocking on doors - EA: Army knocking on doors - AR: County Emergency Planning Officer - CEPO: Civil Protection Unit - CPU

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 *2 Defences : The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Sheet 1 of 1

Region : Anglian
River : Harpers Brook

Main/Non Main : Main

Location	No. of Properties Flooded		Return Period	Flood Warning		Agency Actions	Date
	Resid	Com		Issued?	Methods		
Little Oakley	1		K/N	N*		Warming System	
Brigstock	10	2	>25	N*	Surface water.	Warming thresholds reviewed Properties to go onto AVM	Sept. '98 Review of defences commenced
Sudborough	4		>25	N*		Warming thresholds reviewed Properties to go onto AVM	Oct. '98 Review of defences commenced
							Complete
							Review of defences commenced
							Complete
							Review of defences commenced
							Complete
							Review of defences commenced
							Complete
Total (Main River only)	15	2					

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A: Surefax - S: Media/Police Release - M: Flood Wardens - W:
Others: Floodcall - F: Police knocking on doors - P: Agency staff knocking on doors - E:A: Army knocking on doors - AR: County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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*2 Defences: The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION Region : Anglian**

Sheet 1 of 1

River : **Glen** Main/Non Main : **Main**

Location	No. of Properties Flooded		Return Period	Protection		Flood Warning		Agency Actions		Date	Defences #2	Date
	Resid	Com		Caravan	Standard	years	Issued?	Methods	Comment			
Kates Bridge	1			K/N	K/N	N*			Warming thresholds reviewed Properties to go onto AVM	Oct. '98		
Surfleet		41	>3	3	Tidelock	Y	M. S. CEPO, F. A		Warming thresholds reviewed	Aug. '98		
Greatford	1		>5	5		Y	M. S. CEPO, F. A		Warming thresholds reviewed	Aug. '98		
Edenham	1		>3	3		Y	M. S. CEPO, F. A		Warming thresholds reviewed	Aug. '98	Defences to reviewed	Mar. '99
Corby Glen	2		>3	3		Y	M. S. CEPO, F. A	No properties on AVM	Warming thresholds reviewed Properties to go onto AVM	Oct. '98	Defences to reviewed	Mar. '99
Little Bytham	5		>3	3		Y	M. S. CEPO, F. A		Warming thresholds reviewed Properties to go onto AVM	Sept. '98	Defences to reviewed	Mar. '99
Manthorpe	1		>3	3		Y	M. S. CEPO, F. A		Warming thresholds reviewed	Aug. '98	Defences to reviewed	Mar. '99
Essendine	1		>3	3		Y	M. S. CEPO, F. A		Warming thresholds reviewed	Aug. '98	Defences to reviewed	Mar. '99
Total (Main River only)	10	2	41									

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A. Surefax - S. Media, Police Release - M. Flood Wardens - W.

Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR; County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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*2 Defences : The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Wootton Brook
Main/Non Main : Main
Sheet 1 of 1

Location	No. of Properties Flooded		Return Period	Protection Standard	Flood Warning		Agency Actions	Date	Defences *2	Date
	Resid	Com			Issued?	Methods				
Collingtree	12*		>50	50		N*	Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Hackleton	2	1	K/N	K/N		N*	Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Horton	4	0	K/N	K/N		N*	Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Total (Main River only)	6	1								

Key: Protection Standard - Level of protection at Easter
 Residential - including garages outbuildings. Ind Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres.
 AVM - A, Sureflax - S, Medha Police Release - M, Flood Wardens - W,
 Others: Floodcall - F, Police knocking on doors - P, Agency staff knocking on doors - EA, Army knocking on doors - AR, County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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 *2 Defences : The following actions are being taken at all locations affected by flooding (1) review of flood defence standards, remind local authorities of non-main river maintenance responsibilities, development of operational response plans for principle flood risk areas

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Ise

Main/Non Main : Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return Protection		Flood Warning		Agency Actions					
	Resid	Com	Caravan	Period	Standard	Issued?	Methods	Comment	Warning System *1	Date	Defences *2	Date
Clipston	3			>12	12	N*	M, S, F		Warning thresholds reviewed Properties to go onto AVM	Sept. '98	Review of standards complete. Works programme planned	
Geddington	17	2		>100	50	Y	M, S, F, A		Warning thresholds reviewed	Aug. '98	Defence to be reviewed	Mar. '99
Warkton		1		>50	50	N*	M, S, F		Warning thresholds reviewed Properties to go onto AVM	Oct. '98		
Finedon Mill	1			>50	50	N*	M, S, F		Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Wellingboro		5		100-150	100	N*	M, S, F		Warning thresholds reviewed	Aug. '98		
Total (Main River only)	21	6										

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
Others: Floodcell - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR; County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian **Main/Non Main :** Main **Sheet 1 of 1**
River : Alldege Brook

Location	No. of Properties Flooded		Return/Protection		Flood Warning		Agency Actions				
	Resid	Com	Period years	Standard years	issued?	Methods	Comment	Warming System *1	Date	Defences *2	Date
Grafton	1		>50	>50	N*		Surface water.	Warming thresholds reviewed Properties to go onto AVM	Oct. '98		
Woodwell	6		K/N	K/N	N*			Warming thresholds reviewed	Aug. '98		
Total (Main River only)	7										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
 AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
 Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - F.A. Army knocking on doors - AR; County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian **Main/Non Main :** Main **Sheet 1 of 1**
River : Barnwell Brook

Location	No. of Properties Flooded		Return Period	Flood Warning		Agency Actions	Date	Defences #2	Date
	Resid	Com		Issued?	Methods				
Barnwell	1		>100	100	N*	Warning System *1 System Warning thresholds reviewed Properties to go onto AVM	Aug. '98		
Total (Main River only)	1								

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
 AVM - A. Surefax - S. Media Police Release - M. Flood Wardens - W.
 Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR. County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Eye Brook

Main/Non Main : Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return		Protection		Flood Warning		Agency Actions				
	Resid	Com	Period	Years	Standard	Years	Issued?	Methods	Comment	Warning System *1	Date	Defences *2	Date
Caldecott	1		Syphons	Y	Syphons			M, S, CEPO, F, AVM		Warning thresholds reviewed	Aug '98		
Total (Main River only)	1												

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A: Surefax - S: Media, Police Release - M: Flood Wardens - W:
Others: Floodcall - F: Police knocking on doors - P: Agency staff knocking on doors - E.A: Army knocking on doors - AR: County Emergency Planning Officer - CEPO; Civil Protection Unit - CPU

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**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region : Anglian
River : Heyford Brook

Main/Non Main : Main

Sheet 1 of 1

Location	No. of Properties Flooded		Return Period	Protection		Flood Warning		Agency Actions	Date	Defences #2	Date
	Resid	Com		Caravan	Standard	years	Issued?				
Nether Hayford	5		>50	<50		N*		Warming System *1 Warming thresholds reviewed Properties to go onto AVM	Sept. '98		
Total (Main River only)	5										

Key: Protection Standard - Level of protection at Easter. Residential - including garages outbuildings. Ind Comm. - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A, Surefax - S, Media Police Release - M, Flood Wardens - W. Others: Floodcall - F. Police knocking on doors - P. Agency staff knocking on doors - E.A. Army knocking on doors - AR. County Emergency Planning Officer - CEPO, Civil Protection Unit - CPU

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EASTER FLOODS 1998

SUMMARY TABLE - FLOODING AND FOLLOW UP ACTION

REGION: ANGLIAN
RIVER: Ouse

Main/Non Main: Main River

Sheet 1 of 2

Location	No of Properties Flooded		Return Period (Yrs)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions			
	Resid	Com			Caravan	Issued?		Method	Warming System	Date	Defences
Buckingham	25	5	125	20	N	M	Threshold Level not reached.	Review Arrangements	2001	Review on existing level of protection	
Stony Stratford	9	4	125	10-40	Y	M		Review Arrangements	2001	Review for flood defence improvements	4/99
Newport Pagnell	78	1	125	10-20				Self Help Group	9/98	Minor works	12/98
Clapham	13	4	125	10-50	Y	M		Review Arrangements	2001	Review on priority flood defence improvements	
Kempston	13	12	125	10-50	Y	M		Review Arrangements	2001		
Total	138	26									

Key: Protection standard - Level of protection at Easter: Res - Residential including garages/outbuildings: Com - Commercial includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A, Surefax - S, Media Release - M, Flood Wardens - W, Others (?)

SUMMARY TABLE - FLOODING AND FOLLOW UP ACTION

**REGION: ANGLIAN
RIVER: Ouse**

Main/Non Main: Main River

Sheet 2 of 2

Location	No of Properties Flooded		Return Period (Yrs)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions				
	Resid	Com			Issued?	Method		Warning System	Date	Defences	Date	
Bedford	45	9	125	50-100	Y	M		Review Arrangements Works to WL gauge	2001			
St Neots	20	6	75	20-50	Y	M		Review Arrangements	2000		4/99	
Hemingfords	56		75	20-50	Y	M		Self help group	9/98	Flood defence appraisal Minor works	12/98	
St. Ives	6		75	20-50	Y	M		Review Arrangements	2001	Included with Hemingfords	4/99	
Total	127	15										35

Key: Protection standard - Level of protection at Easter. Res - Residential including garages/outbuildings: Com - Commercial includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surefax - S; Media Release - M; Flood Warden - W; Others (?)

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Sheet: 1 of 1

Main/Non Main: Main River

RIVER: Tove

Location	No of Properties Flooded		Return period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions			
	Resid	Com			Issued?	Methods		Warming System	Date	Defences	Date
Towcester	16	5	125	35	N		Not on warming arrangement	Review Arrangements	2001		
Total	16	5									

Key: Protection standard - Level of protection at Easter: Res - Residential including garages/outbuildings: Com - Commercial includes Industrial, Commercial, Retail, public buildings, schools, recreation centres. AVM - A. Surefax - S. Media Release - M; Flood Wardens - W; Others (?)

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Sheet 1 of 1

Main/Non Main: Main River

RIVER: Alconbury Brook

Location	No of Properties Flooded		Return period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions			
	Resid	Com			Issued?	Methods		Warming System	Date	Defences	Date
The Alconburys	91		12.5	10-15	Y	M	Warden system insufficient for scale of event	Self help group Review warning arrangements	9/98 2001	Review defences	4/99
Total	91										

Key: Protection standard - Level of protection at Easter: Res - Residential including garages/outbuildings: Com - Commercial includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surefax - S; Media Release - M; Flood Wardens - W; Others (?)

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Sheet 1 of 1

Main/Non Main: Main River Awarded Drain

RIVER: Parsons Drove
Houghton Field Drain

Location	No of Properties Flooded		Return period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions			
	Resid	Com			Issued?	Methods		Warning System	Date	Defences	Date
St. Ives		5	20	10	Y	M		Review arrangements	2001	Review standards on Main River (Agency) on main drain (H.D.C)	
Total		5									

Key: Protection standard - Level of protection at Easter: Res - Residential including garages/outbuildings: Com - Commercial includes industrial, commercial, retail, public buildings, schools, recreation centres. A VM - A; Surefax - S; Media Release - M; Flood Wardens - W; Others (?)

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Sheet 1 of 1

Region: Anglian,
River: Waveney

Main/Non Main: Main

Location	No. of Properties Flooded			Return Period (years)	Protection Standard (years)	Flood Warning		Comment	Agency Actions			
	Resid	Com	Cara-van			Issued?	Methods		Warning System	Date	Defences	Date
Brockdish	1			1:12	None	Yes	A, M	Low lying older isolated property	None		None	
Total:	1											

Key: Protection Standard - Level of protection at Easter: Residential - Including garages/outbuildings: Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres.
AVM - A. Sureflax - S. Media Release - M. Flood Wardens - W. Others (?)

Independent Review Team Comments:

4.2 MIDLANDS REGION

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Leam

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com vans						Warning System	Date	Defences	Date
Leamington Spa	360	40	120-175		Y	A. W	Not on system	Review flood warden system Audit AVM system.		Investigate feasibility of FAS	
Marton	10				N			Review flood warden system		Investigate feasibility of FAS	
TOTAL	370	40									

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Avon

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions		Date	Date
	Residential	Ind/Com vans			Issued?	Meth		Warning System	Defences		
Evesham	75	25	70-200		Y	A	Carry out full study of tributary systems around Evesham as well.	} }	} }		
Stratford	40		40-90		Y	A		}Carry out }review of }flood warden }system	}Investigate }feasibility of }FAS		
Warwick	39		40-90		Y	A		}	}		
Tewkesbury	20		25-75		Y	A		}	}		
Welford	10		40-90		Y	A		}	}		
Barford	10		40-90		Y	A		}	}		
Pershore	10		50-70		Y	A		}	}		
TOTAL	204	25									

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Itchen

Main

Sheet: 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions		Date
	Residential	Ind/Com vans			Issued?	Meth		Warning System	Defences	
Long Itchington	38	2	100	100	N		Not on system	Viability of warning service to be investigated	Investigate design and capacity of pumping station and upgrade if required Check level of protection provided by defences.	
TOTAL	38	2								

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S; Media Release – M; Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Isbourne

Main

Sheet: 1 of 1

Location	No of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions					
	Residential	Ind/Com	Cara vans			Issued?	Meth		Warning System	Date	Defences	Date		
Sedgeberrow	40			100	20		N		Not on system	Feasibility of warning service to be investigated		Feasibility study of defences to be carried out as well as condition survey.		
Winchcombe	20			100			N		Not on system	Feasibility of warning service to be investigated		Consider extending Main River to Winchcombe.		
TOTAL	60													

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S; Media Release – M; Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

**Region: Midlands/Lower Severn
River: Dene**

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com			Caravans	Meth		Warning System	Date	Defences	Date
Wellesbourne	45	5	50-100	100*	N		Not on system * Poor calibration	Feasibility of warning service to be investigated		Re-examine FAS. Carry out survey of defences. Assess need for pumping station.	
TOTAL	45	5									

Key: Protection Standard Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Arrow

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com vans						Warning System	Date	Defences	Date
Alcester	25		40-90	50-75	Y	A, W		Consider re-installing gauge on R Alne		Re-examine FAS	
Broom	15		100		Y	A, W		Review thresholds and flood warden scheme		Investigate FAS	
TOTAL	40										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S: Media Release - M: Flood Wardens - W: Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Stour

Main

Sheet: 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions				
	Residential	Ind/Com			Issued?	Meth		Warning System	Date	Defences	Date	
Shipston	20		40-80		Y	A		} Review flood warden system				
Tredington	10		40-80		Y	A						Feasibility study into FAS for both villages
TOTAL		30										

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools recreation centres. AVM – A: Surfex – S: Media Release – M: Flood Wardens – W: Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Stowe

Main

Sheet: 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com vans						Warning System	Date	Defences	Date
Southam	10		100		N		Not on system	Feasibility of warning service to be investigated		Investigate feasibility of FAS. Consider extending Main River.	
TOTAL	10										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Badsey Brook

Main

Sheet: 1 of 1

Location	No of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions						
	Residential	Ind/Com	Cara vans			Issued?	Meth		Warning System	Date	Defences	Date			
Littleton	31						N		Not on system	Consider installation of gauge on Littleton Brook. Investigate feasibility of warning service.			Feasibility study into FAS		
TOTAL	31														

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S: Media Release – M: Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn

River: All

Main/Non Main:

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Agency Actions	Date	Defences	Date
	Residential	Ind/Com			Issued?	Meth				
Various locations							Identify all sites at risk and include in warning system if appropriate. Encourage owners to devise evacuation procedures.			
TOTAL										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S: Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Severn
River: Bow Brook

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com			Caravan	Meth		Warning System	Date	Defences	Date
Himbleton	14		25-50		Y		Not on system	Investigate possibility of introducing a flood warning service.		Investigate feasibility of FAS	
TOTAL	14										

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S: Media Release – M; Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Severn Area
River: Leigh/Cradley Brook

Non Main

Sheet: 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions		Date
	Residential	Ind/Com vans						Warning System	Defences	
Mathon - Leigh	19		Not known	Not known	None*	None*	Properties affected at 14 locations	None	Include in Section 105 Survey. Feasibility of FAS to be investigated.	
TOTAL	19									

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM A: Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

* Not included in flood warning system

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Severn Area
River: Barbourne Brook

Main

Sheet: 1 of 1

Location	No of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com	Cara vans			Issued?	Meth		Warning System	Date	Defences	Date
Blanquettes Estate	8(0-90)			Not known	Not known	*	*	Capacity of upstream balancing exceeded and culvert capacity exceeded	Investigation to identify interim measures to warn residents. No data on which warning could be based.		Feasibility of alleviation to be initiated	
TOTAL	8(0-90)											

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**not included in flood warning system*

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands
River: Sibley Brook

Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com			Cara vans	Issued?		Meth	Warning System	Date	Defences
Sibley	8*		75-100			N	No warning service available at present	Consider viability of providing warning service		Investigating possible joint FAS with Charmwood BC	
TOTAL	8*										

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recre centres. AVM – A: Surfex – S: Media Release – M; Flood Wardens – W; Others (?).

* Full investigation currently being carried out by Charmwood BC

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Trent Area
River: Smite

Non-Main

Sheet: 1 of 1

Location	No of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com	Cara vans			Issued?	Meth		Warning System	Date	Defences	Date
Aslockton	50					N		No warning service present	Consider possibility of warning service if FAS not feasible		Provide assistance to Newark Area IDB if requested.	
Whatton	30					N		No warning service present. The Smite is maintained by Newark Area internal Drainage Board			Provide assistance to Newark Area IDB if requested.	
TOTAL	80											

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfax - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Trent
River: Eye/Wreake/Soar

Main

Sheet: 1 of 2

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions		Date	Defences	Date
	Residential	Ind/Comm			Cars/vans	Meth		Warming System				
Stapleford	3		75-100	100	Y		Rainfall alarm issued by RCC (telephone)	Consider new gauging station at Brentingby				
Melton Mowbray	154	10	75-100	-	Y	A	Yellow warnings only	Consider new gauging station at Brentingby. Establish Amber and Red Warning thresholds			Feasibility study to be carried out	
Asfordby	28	3	75-100		N		No warning threshold established	Establish warning threshold. Offer inclusion in AVM database				
Frisby	2		75-100		Y	A						
TOTAL	187	13										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM A: Surfax - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Trent
River: Eye/Wreake

Main

Sheet: 2 of 2

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com						Warning System	Date	Defences	Date
Thrussington	4		75-100	-	N		No warning threshold established	Establish warning threshold. Offer inclusion on AVM			
Ratcliffe on the Wreake	4		75-100	-	N		No warning threshold established	Establish warning threshold. Offer inclusion on AVM			
TOTAL	8										

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Lower Trent
River: Soar

Main

Sheet: 1 of 1

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions Warning System	Date	Defences	Date
	Residential	Ind/Commercial			Issued?	Meth					
System	2	3	25		Y	A					
Cossington	10		75-100	10	Y	A	Mainly flooding from minor watercourses	Possibility of warning service to be investigated			
Barrow upon Soar			25	10	N		Previously declined offer of warning	Offer to include on AVM database			
Zouch	30		25	10	Y	A	Flood warnings issued however one warden omitted from database	Flood warning database repaired Warning threshold reduced (Red)	14/4/98 01/8/98		
TOTAL	42	3									

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S; Media Release – M; Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Trent

Main

Sheet: 1 of 1

Location	No of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com	Cara vans						Warning System	Date	Defences	Date
Grt. Haywood to Yoxall	0	0	0	3		Yes	A M	Yellow warnings only				
TOTAL												

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S: Media Release – M: Flood Wardens – W: Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Tame **Main**

Sheet: 1 of 1

Location	No. of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com	Cara vans			Issued?	Meth		Warning System	Date	Defences	Date
Drayton Manor to Hopwas	0	0	0	3		Yes	A M	Yellow warnings only				
TOTAL												

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfax - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Blythe Main

Sheet: 1 of 1

Location	No. of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com	Cars/vans			Issued?	Meth		Warning System	Date	Defences	Date
Cheswick Green to Coleshill	0	0	0	3		Yes	A M	Yellow warnings only				
TOTAL	0	0	0									

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Anker

Main

Sheet: 1 of 1

<u>Location</u>	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?	Meth	Comment	Agency Actions			
	Residential	Ind/Com vans						Warning System	Date	Defences	Date
Nuneaton to Tamworth	0	0	3		Yes	A M	Yellow warnings only				
TOTAL	0	0									

Key: Protection Standard – Level of protection at Easter. Residential – including garages/outbuildings. Ind/Comm – includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A: Surfex – S: Media Release – M: Flood Wardens – W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Mease

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions				
	Residential	Ind/Commercial			Meth	Warning System		Date	Defences	Date		
Clifton Campvill to Edingale	0	0	3		Yes	A M	Yellow warnings only					
TOTAL												

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Sow

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning Issued?		Comment	Agency Actions			
	Residential	Ind/Com			Cars	vans		Warning System	Date	Defences	Date
Grt Bridgeford to Grt Haywood	0	0	0	3	Yes	A M	Yellow warnings only				
TOTAL	0	0	0								

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A; Surfex - S; Media Release - M; Flood Wardens - W; Others (?).

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Midlands/Upper Trent Area
River: Penk Main

Sheet: 1 of 1

Location	No of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions				
	Residential	Ind/Com vans			Issued?	Meth		Warning System	Date	Defences	Date	
Penkridge to Stafford	0	0	3		Yes	A M	Yellow warnings only					
TOTAL												

Key: Protection Standard - Level of protection at Easter. Residential - including garages/outbuildings. Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM A: Surfex S; Media Release - M; Flood Wardens - W; Others (?).

4.3 THAMES REGION

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: THAMES
River: Cherwell

Main/Non Main: MAIN

Sheet 1 of 3

Location	No. of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions				
	Residential	Ind/Comm	Caravan			Issued?	Method		Warning System	Date	Defences	Date	
West Farndon	1			>100	50	Y	M	Undefended			2001	REVIEW OF SOS	9/99
Wardington	1			>100	25	Y	M	Undefended					
Croprey	2	5		>100	10 - 50	Y	M	Undefended					
Banbury	Up to 168	8		>100	5 - 50	Y	M	Undefended				Post flood appraisal Damage cost appraisal Review of SOS	10/98 10/98 ongoing
Bloxham	5			>100	2 - 20	Y	M	Undefended				Review of SOS	4/99
B-dicote	1			>100	50	Y	M	Undefended				Review of SOS	9/99
Kings Sutton	1			>100	25	Y	M	Undefended				Minor Works Post Flood Appraisal	9/99 10/98
Adderbury	4	1		>100	5 - 50	Y	M	Undefended				Review of SOS	9/99
Clifton	1			>100	30	Y	M	Undefended				Review of SOS	9/99
Nth Aston	1			>100	30	Y	M	Undefended				Review of SOS	9/99
Somerton	1			>100	20	Y	M	Undefended				Review of SOS	9/99
Lwr Heyford	6			>100	10 - 50	Y	M	Undefended				Review of SOS	4/99
Flights Mill	2			>100	5 - 50	Y	D	Undefended					
Kirtlington													
Enslow	3	1		>100	10 - 50	Y	M	Undefended				Review of SOS	9/99
Total	197	15											

Key: Protection Standard - Level of protection at Easter all ESTIMATED; Residential - Including garages and outbuildings; Ind/Comm - Including industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A.Surefax - S; Media Release - M; Flood Wardens - W; Others - (?); Direct Warning from E.A - D; Standards of Service - SOS = Standards of Service provided through river maintenance activities

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Thames
River: Cherwell

Main/Non Main: Main

Sheet 2 of 3

Location	No. of Properties Flooded		Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions					
	Residential	Ind/Comm			Caravan	Issued?		Meth	Warming System	Date	Defences	Date	
Thrupp	4	1	*	10 - 50	Y	M	Undefended	Review Arrangements	2001	Review of operational protocol with BW Develop integrated FD management for canal & river network	4/99	9/99	
Kidlington	Up to 280		100	10 - 50	Y	M/D	Undefended				Post flood appraisal. Appraisal of actual damage costs Review of standards of service	30/9/98	Ongoing
Cuttleslowe		1	100	10 - 50	Y	M	Undefended			Review of SOS	9/99		
Islip	8	1	100	10 - 50	Y	M	Undefended	Flood Warden	8/98	Review of SOS Post flood appraisal	9/99	10/98	
Oxford	5	1	100	20 - 50	Y	M	Undefended	Review Arrangements		Review of SOS Review of the operation of 3 rd party structures	9/99	9/99	
Total	330	4											

Key: Protection Standard - Level of protection at Easter all ESTIMATED; Residential - Including garages and outbuildings; Ind/Comm - Including industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A.Surefax - S; Media Release - M; Flood Wardens - W; Others - (?); Direct Warning from EA - D; Standards of Service - SOS = Standards of Service provided through river maintenance activities.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: THAMES

River: Cherwell Catchment

Main/Non Main: NMR

Sheet 3 of 3

Location	No. of Properties Flooded			Return Period (Years)	Protection Standard (Years) Recommended for Main River (Assumed)	Flood Warning		Comment	Agency Actions				
	Residential	Ind/Comm	Cara-van			Issued?	Meth		Warning System	Date	Defences	Date	
Hornton	2							Undefended					
Horley	1							Undefended					
Woodford Halse	1							Undefended Not From Cherwell					
Byfield	3							Undefended					
Balscote	1							Undefended					
Hook Norton	1							Undefended					
Tadmarton	1							Undefended					
Shutford		1						Undefended					
Milcombe	1							Undefended					
Caulcott	3							Undefended					
Total	14	1											

Key: Protection Standard – Level of protection at Easter all ESTIMATED; Residential – Including garages and outbuildings, Ind/Comm – Including industrial, commercial, retail, public buildings, schools, recreation centres. AVM – A, Surefax – S; Media Release – M; Flood Wardens – W; Others – (?); Direct Warning from EA – D; Standards of Service – SOS = Standards of Service provided through river maintenance activities.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

**Region: Thames
River: Eventlode**

Main/Non Main: Main

Sheet 1 of 1

Location	No. of Properties Flooded			Return Period (Years)	Protection Standard (Years)	Flood Warning		Comment	Agency Actions			
	Residential	Ind/Comm	Caravan			Issued?	Method		Warning System	Date	Defences	Date
Ascot - Under Wychwood	2			25	20	Y	M	Undefended	Review Arrangements	2001	Review of SOS	9/99
Ashford Mill	1			25	20	Y	D	Undefended				
Total	3											

Key: Protection Standard - Level of protection at Easter all ESTIMATED; Residential - Including garages and outbuildings; Ind/Comm - Including industrial, commercial, retail, public buildings, schools, recreation centres
 AVM - A, Surefax - S, Media Release - M, Flood Wardens - W, Others - (?); Direct Warning from EA - D; Standards of Service - SOS = Standards of Service provided through river maintenance activities.

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Environment Agency Wales
River: ENNIG

Non Main:

Location	No. of Properties Flooded			Return Period (years)	Protection Standard (years)	Flood Warning		Comment	Agency Actions			
	Residential	Ind/Comm	Caravans			Issued?	Methods		Warning System	Date	Defences	Date
Talgarth	15	0	0	30	Undefended	no	n/a	No flood warning system in force.	Introduction of flood warning system impracticable with current technology, because it is a small steep catchment.	n/a	None Main River FAS not currently under consideration.	n/a
Total	15	0	0									

Key: Protection Standard - Level of protection at Easter: Residential - Including garages/outbuildings: Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres
AVM - A: Sturefax - S: Media Release - M: Flood Wardens - W: Others (?)

**EASTER FLOODS 1998
FLOODING AND FOLLOW UP ACTION**

Region: Environment Agency Wales
River: Monnow

Sheet 2 of 2

Main

Location	No of Properties Flooded			Return Period (years)	Protection Standard (years)	Flood Warning		Comment	Agency Actions				
	Residential	Ind/Comm	Caravans			Issued?	Methods		Warning System	Date	Defences	Date	
Skenfrith	19	2	0	20	Undefended	Yes	Warden	n/a	Warning trigger levels to be lowered and all properties in the flood risk area to be incorporated onto AVM system.	31.8.98	Feasibility study in progress.	30.9.98	
The Forge	10	0	0	20	Undefended	Yes	Wardens	n/a	Warning trigger levels to be lowered and all properties in the flood risk area to be incorporated onto the AVM system.	31.8.98	Scheme not financially viable.	n/a	
Total	29	2	0										

Key: Protection Standard - Level of protection at Easter Residential - Including garages/outbuildings: Ind/Comm - includes industrial, commercial, retail, public buildings, schools, recreation centres. AVM - A: Surefax - S: Media Release - M: Flood Wardens - W: Others (?)

5. GLOSSARY OF TERMS

Glossary of Terms Used in This Report

Alert Schemes

A generic term for schemes that alert the public to probable flooding.

Asset Survey

See Section 105(2) Survey below.

AVM

Automatic Voice Messaging equipment used by the Environment Agency to disseminate pre-recorded flood warning messages by the telephone system, by voice, fax or pager.

Balancing

Balancing is the process by which devices are used to regulate and limit the quantities of surface water runoff to watercourses in order to minimise flood risk.

Breach

Major structural failure of a raised earth or concrete river or sea defence. A rare occurrence, not normally associated with a Yellow or Amber warning.

Caravan

The term caravan has been used to describe all types of mobile or semi-permanent domestic dwellings.

Cascade System

A process for disseminating flood warnings from one group of people to another group eg. flood wardens to those at risk.

Catchment

Area bound by high ground containing rivers which flow towards a common point downstream.

Culvert

A covered channel or large pipe, usually underground, to carry water under roads, railways or urban areas.

Dissemination Plans

A public document produced by the Environment Agency, in consultation with other relevant organisations, which sets out the arrangements made to issue flood warnings for locations at risk of flooding where a warning service is provided.

Feasibility Study

A study to investigate options for alleviation works. The study will look at the choices available and the levels of protection offered, (see return period), along with the associated costs of construction and benefits accruing from the avoidance of flooding, (eg. damage to property). It will also take into account environmental impacts. Under the rules that the Agency has to follow, the value of the benefits has to be greater than the costs. This is determined using an approach common to most public sector projects.

Flood Alleviation Scheme

An engineering solution to reduce the risk of flooding. This may take the form of embankments and walls, widening and deepening the channel to increase carrying capacity, the installation of sluices, gates and pumps, the construction of flood relief channels etc. Flood alleviation schemes will reduce the frequency of floods but cannot eliminate the risk entirely.

Floodbank

Embankment, usually made of earth, to prevent or control the extent of flooding.

Floodcall

A "dial and listen" national telephone service that the public can call to get information about flood warnings.

Flood Defence

Flood Defence means the drainage of land including defence against flood water and the provision of flood warning systems.

Flood Meadow

Low lying pasture land next to a river used for temporary storage of flood water.

Floodplain

Area of land bordering a river which is partly or wholly covered with water during floods.

Flood Risk Area

The maximum known flooding extent or area protected by a flood defence scheme.

Flood Warden

An individual or organisation that has volunteered to convey flood warning information received from the Environment Agency to a number of other individuals or organisations. Local authorities sometimes carry out this role.

Flood Warnings

The Environment Agency issues colour coded warnings which indicate the likely severity of flooding:

Yellow Warning: A warning of flooding to some low-lying farmland and roads near rivers or the sea.

Amber Warning: A warning of flooding to isolated properties, roads and large areas of farm land near rivers or the sea.

Red Warning: A warning of serious flooding affecting many properties, roads and

large areas of farm land.

Flood Warning Service

The Environment Agency's Flood Warning Service includes the monitoring of climatic conditions, the monitoring and forecasting of river and sea conditions, and the dissemination of warnings to the public.

Flow Forecasting System

A system, mostly computerised, that collects information about rainfall, river levels and flow and uses it to forecast trends for the immediate future. Its use is triggered by heavy rainfall or rapid or significant rises in river levels. These are monitored continuously and when trigger points are passed, automatic alarms are sent to a central control point.

Frontiers

A rainfall forecasting system which uses radar and covers all of England and Wales.

Gauge

A site where rainfall or river levels and/or flows are monitored. There is a network of these which are operating continuously and, when trigger levels are exceeded, raise alarms.

HYRAD

A rainfall forecasting display and calibration system which uses radar.

I.D.B.

Internal Drainage Board.

ISIS

A commercially available computer software package which includes a full hydrodynamic flow and level simulator that models any open channel system including river systems and floodplains.

Main River

Larger rivers and streams or stretches of rivers where the Environment Agency has powers to carry out works, as shown on maps approved by the Ministry of Agriculture, Fisheries and Food.

mALD

Metres above local datum. Refers to height above a local reference point such as a weir.

mAOD

Metres above Ordnance Datum. Levels of land, water etc. are referenced to Ordnance Datum. This is a point used by the Ordnance Survey whereby all maps and surveys are related to height above average sea level at Newlyn.

Master Terminal Unit

A device used by Thames Region of the Environment Agency to direct alarms to appropriate staff.

Micro-FSR / Micro Flucomp

Commercially available computer packages used to analyse the effects of surface water runoff on watercourses.

Model

A mathematical model used to predict future water flows or levels based on a series of formulae which take account of the topography and shape of the river bed, obstructions etc. Models are calibrated using known events.

NIMROD

A rainfall forecasting system which uses radar and covers all of England and Wales. The system is the successor to the Frontiers system.

Non-Main River

See Ordinary watercourse.

Ordinary Watercourse

A watercourse which does not form part of a Main River. Generally, the Environment Agency does not have powers to carry out works on ordinary watercourses.

PAGN

Project Appraisal Guidance Notes produced by the Ministry of Agriculture Fisheries and Food and which set out best practice in relation to the economic investment appraisal of Flood Defence proposals.

Penstock

A sluice or control apparatus to regulate the flow in a watercourse.

Property

In the context of these reports, property usually means buildings.

Reach

A length of watercourse between two defined points not necessarily a standard length.

Return Period

The risk of flooding to property is often described in terms of a return period. Return periods relate to the long term average time interval between events of a particular magnitude. The 1 in 100 year return period flood has a 1% chance of occurring in any one year. It should not be assumed that it will be 100 years before the next event of a similar magnitude. In fact it is statistically possible for such events to occur in successive years.

Runoff

Overland flow caused by rainfall or snow melt.

Section 24(5) Survey

Predecessor to Section 105(2) surveys – see below.

Section 105(2) Surveys

Section 105(2) of the Water Resources Act 1991 requires the Environment Agency for the purposes of carrying out its flood defence functions, to carry out from time to time, surveys of the areas in relation to which it carries out those functions.

Such surveys include:

1. **Asset Surveys** which look at the condition and remaining life of Agency owned and maintained structures such as flood defences, pumping stations, embankments, walls, sluices etc. The Agency carries out these surveys which are used to plan maintenance and replacement through capital schemes.
2. **Floodplain Mapping Surveys** which delineate the extent of the floodplains of watercourses.
3. **Flooding Problems Surveys** which identify locations where there have been watercourse flooding incidents.

Soil Moisture Deficit

A measure of the rainfall which would theoretically be necessary to saturate the soil.

Threshold

A physical feature beyond which a particular condition occurs. In a flood warning context it may be the level above which the onset of flooding occurs.

Trigger

A condition set to initiate action in advance of a threshold being crossed. The trigger may relate to a specific site or to a broader set of locations or areas depending upon the actions it serves to initiate. The trigger might be based on observed and/or forecast values. In a flood warning context, the values would typically relate to river level or flow, or rainfall.

Washland

See Flood Meadow.

Watercourse

Route along which water flows by gravity.

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