INFORMATION AND COMMUNICATION TECHNOLOGIES FOR FLOOD WARNING IN ENGLAND AND WALES

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Abstract

It is essential to be able to communicate information and warnings about rapid-onset hazards in an effective, reliable and timely manner. However, the theory is easier than the practice. Evidence from England and Wales reveals that flood warning communications have often performed less well than required. The information and communication technology revolution is generating innovations and new products in rapid succession. Application of these to flood warning dissemination opens up new possibilities for being more effective.

New impetus to improving flood warning dissemination was given in England and Wales in 1996 when the Government gave the Environment Agency (i.e. the flood forecasting and defence agency) the responsibility for communicating flood warnings to organisations and the public. Since then the Agency has experimented with and deployed a range of new ICTs for communicating flood warnings. This was given further impetus by severe flooding in Easter 1998, and by unprecedented, serious and prolonged flooding during the autumn and winter of 2000/2001. During 2000 the Agency launched a new flood warning system and a major public awareness campaign, the effect of which was enhanced by the media attention given to the floods.

This paper discusses recent experience with the use of ICTs for flood warning dissemination in England and Wales. A range of ICTs are being applied successfully to flood warning dissemination. We focus upon Automatic Voice Messaging; a dial-up telephone system (called Floodline); national television and local radio; and the internet.

Introduction

How to make warning systems for rapid-onset hazards work effectively is one of the recurrent questions of hazard management. This problem has exercised the minds of

researchers and practitioners for decades, and continues to do so (Williams, 1964; McLuckie, 1973; Drabek, 1986; Emergency Management Australia, 1999; Haggett, 2000; Parker, 2000a, 337). It became a focus of the International Decade for Natural Disaster Reduction (United Nations, 1999). It is a problem relevant to different types of hazards, including tropical cyclones (World Meteorological Organisation, 1989), volcanoes (UK, NCC for the IDNDR, 1998); earthquakes and tsunamis (Adams, 1999); and technological, transport and crowd disaster events (Parker and Handmer, 1992). The problem also presents one of the key challenges facing England and Wales' flood defence agency – the Environment Agency - over the past five years.

This paper discusses the recent experience with ICTs for flood warning dissemination in England and Wales, where recent, severe floods have generated a requirement for solutions to pressing problems and the establishment of a National Flood Warning Centre. We focus upon Automatic Voice Messaging; a dial-up telephone system with recorded messages (called Floodline); national television and local radio; and the internet. Until comparatively recently, application of ICTs in the flood forecasting and warning process was limited mainly to the flood detection and forecasting phases where applications are relatively well-developed for frequently flooded areas. They include the use of radar and telemetered hydrometric systems and relatively sophisticated forecasting models. By comparison the application of ICTs to the warning communication phase was neglected. This paper focuses only upon ICTs for flood warning communication. In England and Wales up to 2 million homes and buildings are located in floodplains which cover approximately 8 per cent of the country.

The ICT revolution and its implications for flood warning dissemination

We are currently experiencing an information and communication technology revolution. The pace of change is fast with fresh innovations and products (e.g. in the mobile telephone sector) appearing in rapid succession. This revolution potentially presents citizens with almost unrestricted access to information at times and places when it is required. Where they need to disseminate information, Government and other agencies have available a range of new and emerging technologies. Fast, inexpensive communication is liberating people's opportunities to provide others with information and to access information themselves, not just from regional or national sources but from global ones. One social side-effect of this revolution is to create a new community of 'haves' and 'have-nots' based on whether or not people have access to these new technologies. Adoption of new ICTs for disseminating flood warnings lags behind their introduction to the market-place, and reducing this time lag is desirable.

Currently insufficient is known about how new/emerging technologies are interfacing with hazard warning communications, including flood warning dissemination, or how they are likely to in the future. The ICT revolution opens up the prospect of a major enhancement in people's access to warnings and related information (e.g. advice on how most appropriately to respond), and in the rapidity and timeliness of the communication of warnings. This is very significant since recent experience in England and Wales with flood warnings indicates that warnings are not always communicated effectively, rapidly or in a timely manner. There appears, therefore, to be great scope for further application of ICTs to the problem of flood warning communication.

The application of ICTs to flood warning dissemination has developed in England and Wales, especially since the severe floods of 1998 (Table 1). The primary aim of deploying these technologies is to provide the individual citizen and relevant organisations with a basis for their own risk management decisions. Ultimately, the aim is to reduce the impacts of floods on humans, by saving lives and injuries, lessening property and infrastructure damage, and protecting environmental assets. Table 1 sets out well-tried, new and 'near future' (emerging) flood warning communication technologies. The well-tried technologies and methods are those that have been in use for flood warning dissemination in England and Wales for several decades, with the use of 'fax' being the most recent. Flood wardens are local volunteers who agree to advise those in their neighbourhood about flood precautions and who help disseminate flood warnings within the local community.

Table 1 Flood Warning Communication Technologies

Well-Tried	New	Near Future
Standard analogue telephone	Press-button digital telephone	Electronic mail
Radio telephone/VHF	Mobile telephone	Internet and website with real time warnings
Radio	Pagers	WAP telephones
Facsimile	Automatic voice messaging (AVM)	Activation of local radio - electronic signal alerts
Flood siren	Illuminated flashing signs	
Door to door	Teletext	
Loudspeaker	Dial up telephone with recorded messaging	Integrated AVM/Floodline service
Written letter	(FLOODLINE)	Computer links in wardens homes
Printed press		
Leaflets	Television	Real time hydrologic data on website
Flood warden	Radio (local/national)	
Automatic water level alert linked to telephone	Electronic file transfer via AVM	

The policy background

Improving flood forecasting and warning systems is one of the main policies in England and Wales for defending against floods, although £400 million is spent annually on structural flood defences. Although flood forecasting sometimes works well and has improved in accuracy and reliability, the communication of flood warnings has often been neglected and flawed. Investments focused on the technological improvement of rainfall and runoff detection and prediction, rather than upon the problem of communicating warnings. Research, largely undertaken by the Flood Hazard Research Centre at Middlesex University revealed that often less then half of those who should have received flood warnings, actually received them. In one case 29% of the flood

warnings received by those in the path of a flood, were received after the flood had occurred (Parker, 2000b).

In 1996 the Government directed the Environment Agency to use its permissive powers for disseminating flood warnings. Communication of warnings can now be more direct than previously. Under old informal arrangements, intermediaries including the police and local authorities passed on warnings creating a chain of communications. Flood warnings were often slow to be communicated, and indirect flood warning communication proved to be inefficient and ineffective. The police and local authorities must still be warned of flooding, but in most regions they do not now provide the main channel of communication between the forecasting agency and the flood-prone public.

In September 2000, the Agency launched a new graduated flood warning system (Table 2) to replace a previously colour-coded system (yellow, amber, red) which was poorly understood by the public and organisations. The new definitions use more vivid language, are more action oriented and convey more of a sense of urgency.

Table 2 Flood Warning Codes for England and Wales post-September 2000

Flood watch	Flooding is possible. Be aware! Be prepared! Watch out!
Flood warning	Flooding of homes, business and main roads is expected. Act now!
Severe flood warning	Severe flooding is expected. Imminent danger to life and property. Act now!
All clear	There are no Flood Watches of Warnings currently in force in the area

The launch of this new system was followed in a matter of days by the longest period of severe, prolonged flooding in England and Wales in living memory, and allowed the publicity campaign associated with the launch to gain additional, regular public exposure.

The floods of 1998, 2000 and 2001

The April 1998 floods came two years after the Agency had been directed to disseminate flood warnings. The Agency had not been able by then to fully implement its warning strategy. These severe and widespread riverine floods were often caused by flood defences being overwhelmed. The severity of floods was not forecast by the Agency which was caught off guard by events. Many thousands of people were severely affected; 4,500 families lost their homes and possessions; and there were five flood-related deaths and many narrow escapes. In the most affected catchments the Agency issued 22 red, 20 amber and 16 yellow flood warnings during these floods which lasted for 4-5 days. The flood warning system performed poorly leading to severe criticisms. Flood warnings were often not received as intended and flood victims had to be evacuated after rather than prior to flooding. Losses are estimated at more than £350 million and the health effects were extensive. A special independent review was set up to report on the problems and shortcomings and to make recommendations for concerted action (Independent Review Team, 1998).

The floods of 2000-01 differed significantly and in ways which proved to be significant for the future use of particular ICTs (see below). Whereas the 1998 floods were severe and comparatively short-lived, the floods of 2000 and 2001 were prolonged and repetitive – and unusually so for the British Isles. Rainfall in the Autumn of 2000 was the greatest since records began in 1776, and in the city of York river levels were higher than the previous record of 1625. The floods across England led to 150,000 properties being directly at risk. 10,000 properties were flooded at 700 locations, and 11,000 people were requested to evacuate their property. During the Autumn of 2000, 1,437 flood warnings were delivered of which 190 were Severe Flood Warnings. Total loss is estimated as circa £1 billion (Environment Agency, 2001).

The Environment Agency's response to flood warning deficiencies

In November 1998 the Environment Agency published its Action Plan in response to the Independent Review Team (1998) Report on the Easter 1998 floods. In September 1999 the Agency published a Flood Warning Strategy for England and Wales (Environment Agency, 1999) setting out plans for the next five years. Over £100 million is to be spent over 5 years on this strategy. The Action Plan has involved replacing the colour-coded warnings; checking all flood warning dissemination plans for errors and omissions; reviewing internal management structures (creating 8 forecasting and 27 warning centres) and taking action to address skill shortages; publishing flood risk maps; undertaking more detailed preparation of warning dissemination arrangements and reviewing the content of flood warning messages; introducing improvements to telemetered river flow monitoring networks and equipment; and completing surveys of the condition of flood defences. Review and improvement of flood warning arrangements has involved applying ICTs to the problem of securing efficient, effective and timely dissemination of flood warnings. The Agency reports that it has increased the percentage of people who receive at least two hours notice of flooding from 13 per cent in the early 1990s to 65 per cent in 1998, and has targets to increased this further to 80 per cent over the next ten years.

ICTs within the national flood warning strategy

Experience with hazard warnings strongly indicates that warning recipients should receive warnings via more than one communication channel, and preferably via three or more. Human response to warnings requires confirmation that the warning is genuine; communication systems are sometimes unreliable and should have 'back-up'; and not all recipients will have access to each warning communication channel.

The Environment Agency's current strategy incorporates a minimum standard which is to try to provide most warning recipients with one direct and one indirect method of warning (Table 3).

Table 3 Direct and indirect methods of flood warning in England and Wales

Direct (alert) warning	Indirect (broadcast) warning
AVM	Floodline
Flood sirens	Flood wardens

Loudspeakers	Media (e.g. local radio, TV, teletext)
Door-to-door	Via Local authorities & emergency services
Other (e.g. personal telephone call)	Internet

The target standard for receipt of flood warnings is two hours before flooding occurs. In slow-response catchments and for coastal warnings this two hour target may be increased; and in flashy catchments (e.g. London) it may be reduced. The mix of dissemination methods and technologies will vary from location to location according to what is feasible and appropriate. For 'All Clear' and 'Flood Watch' the minimum standard will be selected direct dissemination into communities, including farmers, gatekeepers, flood wardens and others who are required to take early actions. For 'Flood Warning' and 'Severe Flood Warning' direct dissemination to all nominated recipients in the relevant flood warning areas is required. For operational organisations the minimum requirement is that they should receive all messages direct from the Agency by attended fax machine. The Agency has established a nationally consistent message format and style, and is seeking to agree a target standard with all radio stations broadcasting flood warnings. Warning performance is being monitored according to a national specification.

The Agency has concluded that **AVM technology and developments of that technology**, which was introduced in1996 to rapidly disseminate flood warnings by telephone more or less simultaneously to a large number of recipients, is likely to be the principal system for warning the public in the foreseeable future. The number of properties connected to the system has increased from 23,000 in 1996 to 60,457 in 2000 (4% of those at risk) (Table 4). Properties are only connected to AVM at the owner's prior consent i.e. an 'opt-in' approach, but in future an 'opt-out' approach may be adopted. The use of AVM varies enormously by region (Table 4) with the southern region having by far the most connections. The current system is less practical in densely populated urban areas such as the Thames basin because of limitations on the number of messages which can be sent simultaneously.

Table 4 Properties at risk from flooding in England (fluvial, tidal and coastal) and proportion for which automatic voice messaging (AVM) is provided

Environment Agency Region	Number of properties at risk from flooding	Automatic voice messaging recipients	
	Number	Number	Per cent of those at risk
Anglian	330, 029	3, 630	1.1
North East	246, 829	3, 277	1.3
Thames	203, 508[1]	5,080	2.5
Southern	198, 069	32, 530	16.4
North West	162, 293	9, 090	5.6
Midlands	98, 615	4, 630	4.7

South West	43, 050	2, 220	5.2
Total	**1, 503, 309**	**60,457**	**4.0**

Note: 1. Fluvial only. A further 220,961 properties are at risk from tidal flooding.
Source: National Audit Office analysis of E. Agency data with Thames updated

A hall-mark of good hazard warning practice is direct communications between forecaster and warning recipient. AVM permits this. By global standards, most flooding in England and Wales develops rapidly and the capacity, which AVM possesses, to contact a large number of customers simultaneously is an advantage. Experience reveals that a principal disadvantage is that prior consent to connect from the owner is often not forthcoming, and the task of constructing and maintaining the telephone number database is labour intensive. In addition, although the warning message is a voice one, it is still 'disembodied' and to that extent impersonal (and not permitting dialogue),whereas research indicates that personal verbalised messages are preferred and likely to be more effective (Drabek, 1986). To date, the 'social performance' and acceptability of this technology is largely unknown in the context of flood warnings in England and Wales. AVM technology also requires regular checking and occasional breakdowns have been experienced. Telephone lines may be lost in severe storms, and customers are increasingly using the internet without possessing a second telephone line: this may block receipt of a message (but alternate work, mobile or pager details can also be programmed in). The Thames region has adopted other direct warning methods in addition to AVM. In addition to selective deployment of AVM, the Thames region has been experimenting with more personalised, community-based communication systems in which good two-way communication with flood wardens, local contact and good public relations are emphasised. This emphasis recognises the importance of community ownership of flood warning systems, and the value of using existing community communication networks (Parker and Handmer, 1998).

Members of the public are encouraged by the Environment Agency to obtain detailed information on flood warnings in their locality by contacting '**Floodline**' – which incorporates a dial-and- listen telephone service (Tel: 00 44 845 988 1188) which is updated during flood events, and which was introduced in 1999 during a major public information campaign designed to raise public awareness of flooding and flood warning services. Floodline allows a caller to link to an advice centre (to allow dialogue) which includes recorded summaries of flood warnings in force, 24 hours per day, and is a hotline to access information and advice from flood staff (printed information is in nine languages). An advantage of Floodline is that it allows people to confirm warnings received; permits them to keep up to date on warnings; and provides a range of information which can be used to select appropriate actions. With the growing use of mobile telephone technology it provides a flexible information resource. The main disadvantages with the system are

that it can get overloaded and it only covers riverine flooding whereas England and Wales also experience coastal and other flood types.

The use of **national television and local radio** to carry flood warning messages has been developed in the past five years in England and Wales. National television is a major means of accessing large audiences, and recently the Agency, the Meteorological Office (which provides meteorologists trained in weather forecast presentation) and the British Broadcasting Corporation, have combined to integrate flood warnings with regular televised weather forecasts. If flood warnings are in force weather presenters refer to the Agency's Floodline telephone number. During the recent 2000/2001 flood season, public awareness of flooding and the new flood warning system was raised enormously in this way, especially because flooding was severe and prolonged. The number of local radio stations in Britain has increased greatly recently and is becoming a front-line means of disseminating flood warnings to specific communities and keeping the general public aware of flood risks. In the 2000/01 floods, the Agency's Thames Region increased its engagement with local radio stations and gave 150 interviews in the October/November 2000 floods. Feedback from the radio stations indicates that listening figures rose by up to 40% during the floods and these figures have been maintained since. The Agency has installed improved technology (ISDN lines and transmission equipment) to achieve broadcast studio quality. The tensions which exist between journalistic objectives and approaches and those of flood managers needs to be carefully managed, and the Agency is placing emphasis upon this requirement.

The **internet** is no longer 'near future' in general, but it is an emerging 'near future' technology in terms of public flood warning dissemination in England and Wales. Domestic web access and use of Email has grown rapidly, and recently the Agency launched a website (www.environment-agency.gov.uk) which provides generalised maps for every part of the country of known flood risk areas plus advice on how to respond to warnings. The next step is to make real-time flood warnings available. Dialogue with weather forecasters over the internet is now possible, and the potential for both rapidly gaining flood information, including warnings, is large. The internet is bound to grow as a warning communication channel, although its greatest use will probably be for flooding situations which do not onset very rapidly. Like Floodline, domestic web technology currently depends partly on the integrity of telephone lines which may be damaged in storm conditions accompanying floods.

Experience with new and emerging ICTs for flood warning dissemination in the recent floods

The AVM systems delivered messages to 85,715 locations with between a 75-85% success rate between 9/00 and 11/00. This is a 5-fold increase from the 15% success rate in 1996. However, in some regions the proportion of floodplain occupiers on the AVM is

low: in some cases just over 1% (Table 4). Therefore in many instances those flooded did not receive a direct flood warning. The converse was that in other localities the targeting of warnings was poor with a significant number of AVM warning message recipients not being subsequently flooded. Improving floodplain zoning and more effective flood forecasting is required to overcome this problem.

Floodline experienced a dramatic increase in public calls in the autumn 2000 floods. 781,000 calls were received between 1/10/00 and 31/12/00 compared to 100,000 during the first 11 months of operation. The peak daily rate was 58,000 on 7 November. The downside was that the call centre was under severe pressure, at peak times as few as 30% of calls were answered and handled successfully. Working practices and call capacity have been reviewed: over 90% of calls were handled successfully during December 2000.

Take-up of ICTs used in flood warning dissemination

Currently insufficient is known about the public take-up of flood warning communication technologies. Take-up includes whether or not people have 'access' to these new technologies (e.g. only a proportion of the population have direct access to push button telephones and the internet), and access is affected by social and economic factors such as age, educational attainment level and income. Take-up also includes 'adoption'. This will fall into two categories – those who adopt the use of the technology and those who choose not to adopt its use. Barriers to access and adoption exist and these need to be explored further in order to find the best ways of using various technologies. Britain's floodplains contain a larger proportion of elderly, infirm and disabled than the national average, and many who are flood-prone are from low-income groups. Available evidence suggests that these sectors of the population are the slowest to gain access and to adopt new ICTs, and this may prove to be a significant barrier to improved flood warning dissemination.

Transferable lessons

Many countries are experiencing an increased frequency of flooding at the beginning of the 21st century, and the steps taken in England and Wales to introduce new and complementary ICTs for flood warnings is almost certainly of relevance elsewhere. Other countries may be ahead or behind England and Wales in this respect. Our previous work has demonstrated the need for transfer of experience from the Britain to other countries and vice-versa, and this is welcomed (Parker and Fordham, 1996). Evaluation of the strategies deployed is also relevant beyond flooding, and is relevant to general strategies for effectively managing the emergencies created by rapid-onset natural hazards.

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