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The Social Performance of Flood Warning Communications Technologies

Technical Report W5C-016

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Statement of use
This report provides us with recommendations for the future selection of flood warning dissemination channels based on their 'social performance'. It bases its recommendations on a review of our experience in the UK and also experience of organisations overseas working to understand how to improve social performance. The project suggests we use a matrix of social performance to help decisions on investment on new dissemination channels. The report will be of interest to people working in flood warning development.

Keywords
flood warning, social performance, communication technologies, flood warning dissemination, Floodline Warnings Direct, ICT, socio-demographics

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1 INTRODUCTION

1.1 Background to research

It is now increasingly accepted that flood risk cannot be eliminated. However, flood risk management activities can reduce the probability of flooding and can reduce the impacts of floods (Environment Agency, 2003a). Since 1996 the Environment Agency has accepted the role of delivering flood warnings in England and Wales where a service can be provided. The aim of flood warnings is to reduce the impacts of floods on people and to lessen property damage. This is achieved by providing a warning service that is accurate, timely and reliable, so that the benefits of flood detection and forecasting are captured as fully as possible. Timely flood warnings may also in some cases help protect environmental assets.

The Agency is seeking to improve both the communication of flood warnings, and the public response to them, in other words it seeks to improve the 'social performance' of flood warning communications technologies. The floods of winter 2000/01 and 2002/03 provided an opportunity for the Agency to introduce and communicate its new flood warning system, and the profile of flood warnings has been much enhanced both with the media and the public. However, the process of flood warning is constantly evolving.

New technologies are constantly emerging, particularly in the media, information, space and communication sectors. The world is currently passing through an information revolution and the pace of technological change – especially in information and communication technologies (ICT) - is fast with fresh innovations appearing in rapid succession. This potentially presents citizens with unrestricted access to information. Fast, inexpensive communication has enhanced people's opportunities to provide others with information and to obtain information themselves, not just from regional or national sources but from global ones.

Successful delivery of a flood forecasting and warning service in England and Wales depends to a very important extent on the way in which warnings are communicated to targeted individuals, organisations and flood-prone communities, and thus upon the types of technologies involved. Each of the eight regions of the Agency operates flood forecasting and warning systems, which are as diverse as the practices and technologies associated with them. Effective communications are essential to the success of these flood warning systems. A variety of technologies are currently being employed to enhance the rapidity and penetration of communications in targeted communities, and in September 2005 the new Floodline Warnings Direct service is due to replace the current Automatic Voice Messaging (AVM) and associated systems.

One social effect of this ICT revolution is to create a new community of 'haves' and 'have-nots' based on whether or not people have access to these new technologies at a time when the government is emphasising and introducing new policies and laws relating to inclusiveness (e.g. human rights legislation, new legislation covering the disabled). Another concern is related to what can be termed an increasingly 'two-speed Britain' regarding access to broadband technology. Uneven access to broadband now appears to be of serious concern to policy makers. There is currently insufficient knowledge about how these trends are interfacing with and affecting flood warning

communication, or how they are likely to in the near future (i.e. the next ten years), although there are already some indications within various R&D reports and survey data available to the Agency.

Currently not enough is known about the take-up and 'adoption' of flood warning communication technologies. Take-up includes whether or not people have 'access' to these new technologies. Those with access will fall into two categories: those who adopt the use of the technology, and those who choose (for one reason or another) not to adopt its use. The history of technological innovation indicates that the degree to which the population has access to and adopts technologies varies according to a range of factors. These include the nature of the technology; the manner in which the technology is introduced and promoted; the degree of perceived benefits and disbenefits to users; and other social and psychological factors such as fear of new technology or its perceived negative impacts. In addition, a variety of social, economic characteristics may act as barriers to access and adoption of technologies (e.g. age, educational attainment level and income).

How people respond to these technologies, how receptive they are to them, is also crucial to their 'social performance'. Not much is known about the receptiveness of flood prone communities to different communication technologies, although the Environment Agency has accumulated some recent experience. For example, the introduction of Automatic Voice Messaging (AVM) in flood warning communication has demonstrated that a significant proportion of some flood-prone communities will not accept the technology in their homes, and some of those who adopt the technology cease using it at a later date. This also raises the legal issue of opt-in vs opt-out flood warning systems, which will need further consideration in the future.

One of the priorities for change identified in the new *Flood Risk Management Strategy 2003-2008* (Environment Agency, 2003a) can be identified as being relevant to this warning process. This is 'the development of effective communications to support the development and delivery of flood risk management policy and services'. Therefore, the barriers to the receipt and effectiveness of flood warnings need to be explored further in order to find the best ways of maximising the social performance of communication and dissemination in flood warning technology, both now and in the future.

1.2 Aims and Objectives of the research

As outlined above, with greater knowledge about the various barriers, i.e. access to and adoption of warning technologies, it should be possible to target the deployment of these technologies more effectively to improve their 'social performance'. Therefore, the aims and specific objectives of the study were as follows:

- to review the flood warning technologies currently available, and likely to be available in the near future in relation to both fluvial and tidal flooding;
- to gather evidence on take-up, use of, and social performance of existing/recent and recent/future technologies;
- to analyse the information gathered in order to identify barriers to effective communication and lessons to be learned;

- to identify the best way to use the various warning technologies to improve their social performance in delivering the Agency's flood warning service.

The emphasis of the research is on warnings to households and not to businesses.

1.3 Conceptual approach to the research: defining Social Performance

A number of conceptual starting points were explored in the research. The first of these starting points was to have a clear understanding of what the term 'social performance' implied. The effectiveness of flood warning dissemination and communications technologies, the social performance, is dependent upon a number of factors and complex relationships between the technologies selected, the social characteristics of the warning recipients, and local barriers to warnings i.e. the local circumstances of the community/individual. It is also important to recognise that time is a fourth factor when assessing social performance, as the characteristics of any given community, individual, or agency may vary over time, thus affecting the social performance of communication technologies. With other things taken into account within the flood forecasting and warnings system (e.g. warning lead-time, warning accuracy and reliability), the social performance of flood warnings might, therefore, be hypothesised to depend upon the four principal factors as set out in the following formula:

$SocPerf = (Fwarn + Fwarn)\ x\ R + Bcomm + T$ (Formula 1.1).

Where:

SocPerf = social performance of warning communication technologies
Fwarn = flood warning technology(ies) selected
R = recipient characteristics
Bcomm = barriers to communication
T = time variables e.g learning; innovation; changes in populations, agencies, catchments etc.

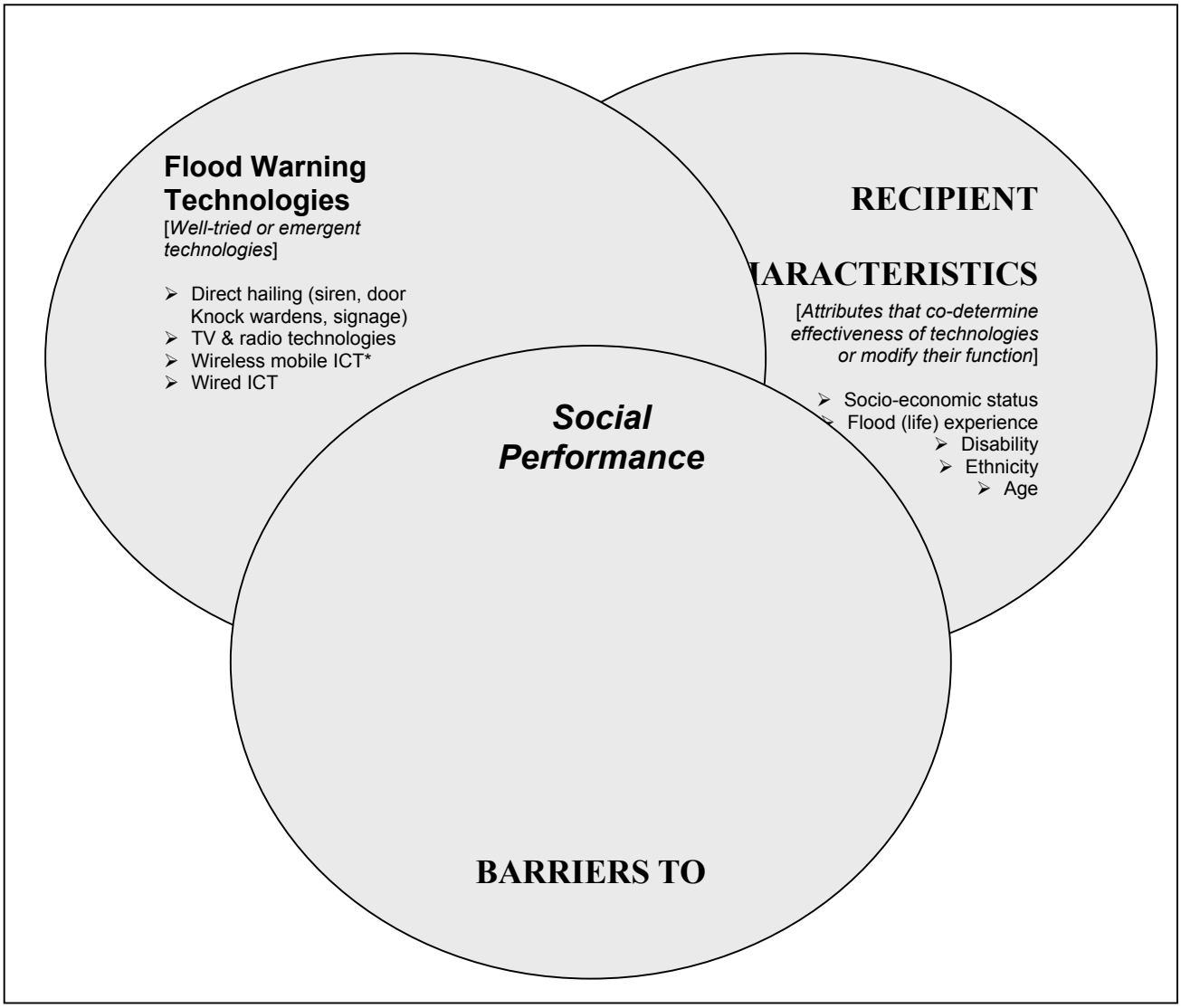
This complex inter-relationship is modelled in Figure 1.1 and discussed in further detail below.

1.3.1 Flood warning technologies

There are now a wide number of flood warning technologies available. These technologies range from currently in use well-tried and tested methods such as conventional telephone and sirens, to relatively new and recent technologies such as AVM and dial-up telephone systems. Finally, there are emerging possible and 'near-future' technologies still under development such as electronic mail and the internet, and possible advanced future technologies such as Radio Data Systems (RDS). Current classifications can also be made by whether the technology is an *individual* warning method, a *community* method, or a *broadcast* method (Quinetiq, 2003). Communication technologies may also be categorised in other ways which have direct relevance to recipients and their receptiveness to them, such as whether the message conveyed is received in audible or visual format or both. All of these technologies have strengths and weaknesses, including the well-tried and tested ones.

Different communication technologies may also be used in combination to provide reinforcement of the warning message (i.e. Fwarn + Fwarn). Environment Agency policy (Environment Agency, 2001) is for warnings to be targeted through at least one 'direct' route (e.g. AVM, flood wardens, sirens) and one 'indirect' (e.g. television, radio, Floodline) route. This opens up possible ways of countering weaknesses in one or another technology and increasing the effectiveness of the system.

Figure 1.1 Factors affecting the social performance of flood warning communication technologies



**ICT (information and communications technology)* is a term that comprises both hardware (PC, mobile telephone) and telecoms (broadband, ISDN, WAP, SMS)

1.3.2 Recipient characteristics

The characteristics of recipients (R) of warnings can be expected to vary in ways which impact upon the effectiveness of the warning service. For example, the social performance of flood warning communication technologies is likely to be dependent upon the *receptiveness* of various floodplain users to technologies, which in turn can depend upon their *access* to or ownership of the technology, and their *willingness to adopt* and use the technology (Box 1.1).

Box 1.1
Factors affecting receptiveness of warning technologies

Access to technologies

Access (A) to technologies is likely to depend upon a number of factors, such as the following: $A = Cost + Inc + Ed + Age + Soc$ (Formula 1.2)

Where:

A = access
Cost = cost of entry to technology
Inc = income class of SEG (socio-economic group)
Ed = educational attainment level
Age = age and ability/disability
Soc = access and use encouraged by social networks and social groups, including family members

Willingness to adopt and use a technology

Willingness (W) to adopt and use a technology may be a function of a number of factors, as follows: $W = Aw + Fp + Rec + Inf + Dd + Pi + Pb + Rep1 + Rep2 + Exp + C + Aa + SN + F$ (Formula 1.3)

Where:
Aw = awareness of the existence of the technology
Fp = flood risk perception (may be high or low)
Rec = recency and severity of flooding
Inf = access to good, well explained information and back up advice
Dd = degree of disruption involved in use (including the 'hassle factor')
Pi = perceived intrusiveness (the perceived 'big brother' factor and/or perceived intrusion by authorities)
Pb = perceived benefits in terms of increased personal/family safety and ability to reduce flood damage if flooded
Rep1 = reputation of the Agency
Rep2 = reputation of the technology and its reliability/effectiveness (i.e. what others say about it)
Exp = experience over time with the technology
C = annual costs of maintenance and use
Aa = access to and availability of an alternative warning communication means
SN = social networks e.g. wardens, community action groups, family, neighbours
F = fear of new technology and its possible effects (negative fear; positive fear e.g. of being left behind by technological advancement)

An important step forward in understanding how to increase the effectiveness of human response to flood warnings has been recognition that flood-prone communities are far from homogeneous in composition. Typically these communities comprise people of all ages, from different socio-economic and income groups, different gender groups and different (often non-English speaking) ethnic groups. They are also likely to include members who are infirm and disabled in a variety of ways, including members with sight and/or hearing difficulties. Warning communication technologies that rely upon delivering only audible or visual messages may be of limited use for those with visual or hearing impairments respectively. Therefore, access to and willingness to use different technologies which may be used in warnings is variable and is related to a number of complex factors, all of which need to be considered for effective social performance.

1.3.3 Barriers to communication

In addition to recipient characteristics, there are a number of additional factors or barriers that may help or hinder the social performance of warning communication technologies in particular local physical and institutional contexts. These 'barriers' may include the particular characteristics of the local catchment (i.e. where flood onset is rapid, thereby precluding certain warning methods), the composition and density of the resident population, local structures of governance, the existence of local agents of change or opinion leaders (e.g. community leaders), and the level of provision of ICTs within particular areas.

1.3.4 Time

The fourth principal factor in determining 'SocPerf' (Formula 1.1) is the variable of time (T). Over time, individuals, communities, and institutions are capable of increasing their knowledge of, and skill in, learning about and utilising communication technologies. Each of these groups may learn or adapt at varying rates which may be related to their characteristics and/or their awareness of, prior ownership of, or access to, a given communication technology. Some people will learn and adjust to new technologies quickly and painlessly, while others will never learn or adapt to their use. The diffusion of technological innovations over time in turn relates to the receptiveness and access to technology and willingness to adopt technology outlined above regarding recipient characteristics.

Learning about and uptake of technologies may be accelerated over time in various ways including through public demonstration or pilot projects. A community can be expected to learn at various accumulative rates that need further exploration. The Environment Agency has chosen to mount publicity campaigns to promote awareness and learning and take up in the area of flood warnings, for example the annual national flood awareness campaigns. Therefore, the process of time is clearly critical to the widespread adoption of new communication technologies.

1.3.5 The 'S-shaped Innovations Curve'

One way of exploring the social performance of warning communications is through the 'S-shaped Curve'. The S-shaped Curve was developed to explain the rate of adoption of technologies and refers to technology that is adopted in stages (see Figure 1.2). For a

given technology, the evolution is as follows: initial efforts result in little advancement and then the technology becomes successful. This success point, at the lower knee of the curve, is where the technology has finally demonstrated its utility. After this point significant progress and improvements are made as several embodiments are produced and the technology becomes widely available. Eventually, however, the physical limits of the technology are reached, and continued effort results in little additional advancement or in diminishing returns.

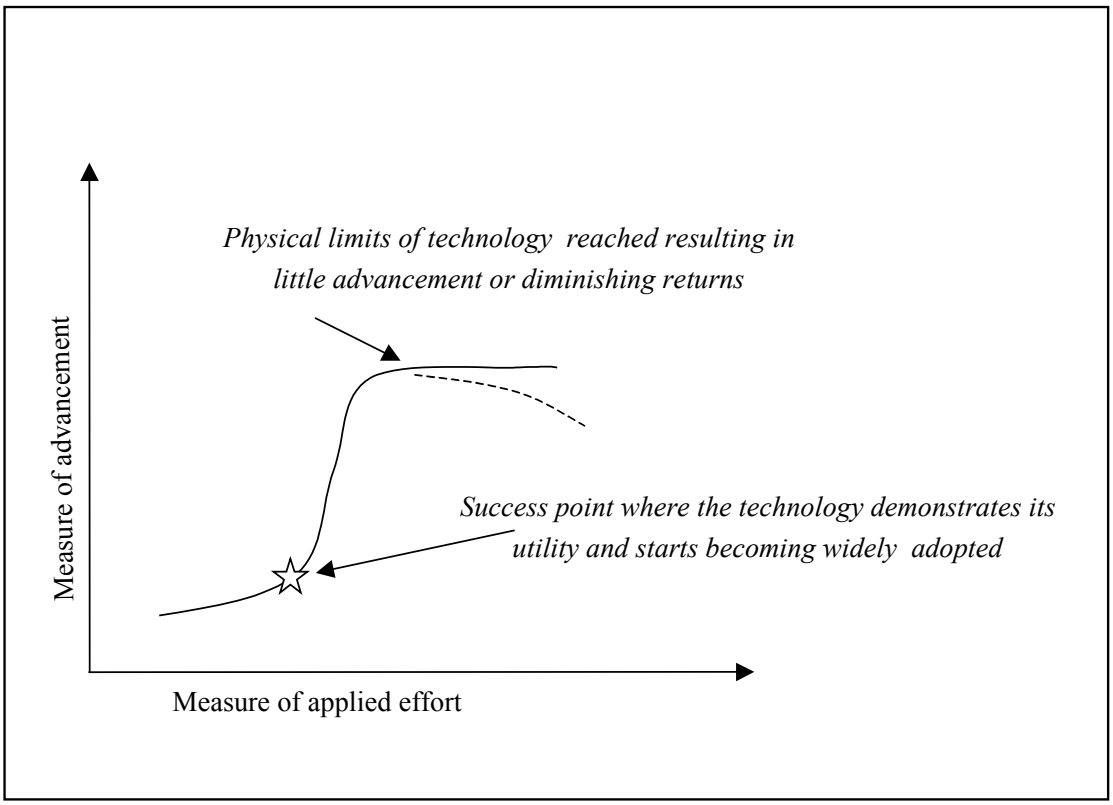


Figure 1.2 The 'S-shaped' innovations curve

As technology evolves, a given device or method will reach a point when it can no longer be improved. At this point it has reached the limits of its underlying physical principles. To go beyond the limits of the top of the S-Curve, a new alternative must be created. A breakthrough technology is when the performance limits for an existing device or method are exceeded by a new, different device or method – the key word is different. This new alternative will have its own S-Curve and will eventually require yet another new approach to surpass its performance limits. The *breakthrough event* is when the new method demonstrates its viability to exceed past the limits of its predecessor.

It can be hypothesised that with flood warning technologies a point will, therefore, be reached whereby different technologies will be at various stages along the 'S-shaped curve', or where new technologies supercede existing ones thus creating new S-Curves e.g. the utility of pagers as a warning method will be superceded by that of SMS text messaging. This concept might be relevant to understanding the adoption rate of specific flood warning technologies.

1.4 Data Collection Methods

A number of methods have been employed for the collection of data for this project. The general approach has been qualitative and has involved the following:

- discussion meetings with key Agency staff
- literature reviews
- direct contact with individuals and organisations in the UK and overseas by telephone or electronic mail
- searches of the internet

The proposed programme of work was structured into a number of work items and tasks as follows.

- Initial conceptual development and discussion meetings.
- Data and information gathering from a variety of sources, including British Market Research Bureau (BMRB) survey reports and other relevant reports and data available from the Agency.
- Collection of data from other sources on the following:
  - take up of new technology generally and the reasons affecting take-up e.g. the introduction of internet technologies into remoter rural areas and the receptiveness of local populations
  - ownership and adoption of communication technologies identified amongst flood-prone populations (e.g. AVM), by Region where possible
  - related socio-economic data (by Region and by flood prone community where available)
  - evidence on reasons for adoption or non-adoption of warning methods/communication technologies by individuals and communities
  - trends in these data over the past five years (where available)
  - trends in emergent ICT (recent, near future etc)
  - data on other non-warning innovations and the ways in which they have been promoted or hindered in their adoption
  - data from other countries (especially the USA and Australia) on the introduction and use of recent and new technologies for warning communication and the social performance of these systems, and possible barriers to their widespread use.

- Data collection on ‘similar areas’ involving the receipt and interpretation of warning messages. This involved data on: severe weather warnings other than floods e.g. cyclones; other natural hazard warnings e.g. earthquakes and bushfires; non-natural or human-induced hazards such as industrial, chemical or nuclear accidents.
- Data collection on ‘vulnerable’ groups and on ‘hard to reach’ groups such as those with visual or hearing impairments through telephone discussions with researchers and representatives of these groups.

1.5 Limitations on Data Collection and gaps in the literature

The main limitation on this research was the lack of available data on the social performance of the flood warning communication technologies included in this study. It appears that little research has been carried out into this specific area of flood warnings, and particularly into the emerging methods of warning communications such as the internet. The small number of studies from North America and Australia which were located also noted the failure to discover any existing literature on the subject. This does not mean that nothing has been done to examine the effectiveness of flood warning technologies, merely that the research has failed to discover any such studies, despite extensive searching. This could be due to the fact that any research has either not been published or is not publicly available.

A final limitation on the research was the slow response from both UK and overseas contacts, and in many cases contacts, especially in Europe, failed to respond at all.

1.6 Deliverables

The deliverables for this project comprise this Technical Report which contains recommendations for the most effective use of warning technologies in different at-risk 'receiver environments' in order to inform the Agency's flood warning dissemination strategy and supporting communications programmes.

2 RESULTS FROM LITERATURE REVIEW ON THE SOCIAL PERFORMANCE OF FLOOD WARNING COMMUNICATION TECHNOLOGIES

This section presents an overview and evaluation of the literature relevant to the social performance of flood warning communication technologies, along with material gathered from discussions or correspondence with key informants. We have sought only to include material that we believe is relevant to the research objectives. We have also sought to focus attention and evaluation upon those aspects that can, in some way, inform the development of a method of appropriately deploying warning technologies in order to ensure that their social performance is enhanced.

The chapter is structured around, and summarises, the most relevant research found with respect to each of the social performance variables outlined in Section 1.3 above (flood warning technologies, recipient characteristics, barriers to communication, and how they may vary over time). Inevitably, there is some overlap in the discussion of these variables, which serves to emphasise their interconnectedness and complexity.

2.1 Flood warning communication technologies

2.1.1 The historical development of flood forecasting, warning and response systems

Today's flood forecasting, warning and response systems (FFWRS) have evolved through both scientific progress and experience. A characteristic of more advanced and effective FFWRS is the quality of attention paid to warning dissemination, warning response and end-user performance (Parker and Fordham, 1996).

Unsophisticated, non-technical approaches usually involve simple, but potentially effective, observation of environmental processes such as rising river levels and subsequent reaction to perceived flood threat. Rising upstream water levels measured at a bridging point allows floods to be forecast and for warnings to be passed downstream. Devised by local people and communities these systems were amongst the earliest FFWRS; they are in use today in some communities where there is no formalised FFWRS (Haggett, 2000; Parker and Handmer, 1998). The systems are dependent upon local knowledge, expertise and resourcefulness, and reflect local social need. They are often very integrated systems closely linking forecasts to warning dissemination.

In Britain in the mid-1970s river and rain gauges began to be telemetered, enabling the central collection of data in preparing flood forecasts. The installation of a denser network of measurement locations, and the development of telemetric networks and weather radar led to vastly improved communication systems and longer warning lead times. Flood forecasting advanced through application of computer systems (Haggett, 2000). Although advances were made in integrating hydro-meteorological data to allow better and more timely flood forecasts, a critical weakness in formal FFWRS by the end of the 20th century was that the integration of flood forecast and warning dissemination, often achieved by non-technical approaches, was not matched in this phase of intense

technical development. The social performance of flood warning systems remained largely unaddressed.

A key shortcoming problem has been the weak integration of flood forecasting with flood warning dissemination and response. Between 1970 and 1996 most of the public investment into FFWRS went into flood detection and forecasting. Comparatively little attention was focused upon the process of disseminating flood warnings. The system relied upon a non-statutory, informal arrangement made with police services for them to disseminate flood warnings. During this period well-tried and in some cases, time-honoured, methods of disseminating flood warnings were in use (see Table 2.1).

The arrangements began to seriously unravel during the 1990s. Research evidence of the under-performance of flood warning systems began to accumulate and police services began to feel pressures on their budgets and statutory duties. Research revealed an uncomfortable gap between (a) the belief by flood forecasters that a timely and accurate flood forecast had been produced and a flood warning disseminated, and (b) the experience of those living in floodplains that no flood warning had been received by them. It became clearer that communicating risk and flood warnings was a complicated process and that the perceptions and needs of flood warning 'customers' required much greater consideration. Indirectness in disseminating warnings led to delay and sometimes to warnings not being passed to those for whom they were ultimately intended.

In 1996 the Government directed the Environment Agency to take lead responsibility for disseminating flood warnings. This coupled with the Easter 1998 floods in which the FFWRS under-performed, led to a new phase of development of FFWRS. It coincided with a period of innovation in digital communication technologies, including personal communication technologies (Table 2.1). Although AVM systems were introduced during the late 1990s they still only serve a small proportion of the at-risk population. One of the persistent problems faced by the Environment Agency - a problem also faced by many flood warning agencies in other countries - is that even when a timely and accurate flood warning is received by a member of the at-risk population, they may well not know how to respond effectively to the warning. A considerable amount of time and resource has therefore been directed at educating those at risk.

In the 1980s the effectiveness of a FFWRS would probably have been evaluated according to a measure such as the accuracy of the flood level predicted compared to the actual flood level achieved. By the late 1990s indicators such as the proportion of those at-risk who reported receiving a flood warning two or more hours before flood onset, were also in use reflecting an important shift towards a customer-oriented approach. Designing FFWRS from a customer perspective is now advocated by Emergency Management Australia (1999) which has promoted the 'total flood warning system', the hallmark of which is constant dialogue with community stakeholders about their needs and responsibilities.

Since the early 1990s, the potential of ICTs to greatly enhance flood warning has become quite apparent. Phenomenal rates of technological development have been maintained over recent decades, resulting in a range of new media, applications and devices such as mobile telephones, broadband internet and digital television. Miniaturisation and improved battery technologies have revolutionised mobile

telephony while the digital television market continues to expand. Over 50% of the UK's population now receive digital transmission either via satellite, cable or free-to-view.

In April 2000, the Environment Agency reviewed the systems that it uses for the dissemination of flood warnings (PB Kennedy & Donkin, 2000) and in particular, whether the current AVM system was the most appropriate system to meet future requirements. The review was the catalyst for the Agency's current *Flood Warning Dissemination Strategy* (2003) and investment proposals for the forthcoming Floodline Warnings Direct (FWD). The review focused on the technical aspects of flood warning dissemination however, (e.g. system capacity and functionality) and did not consider the social performance factors that affect the selection of an appropriate flood warning method.

Table 2.1 Information and communication technologies for flood warning dissemination. Adapted from Parker and Haggett (2001) and Quinetiq, (2003)

• **Well-tried and in use**	• **Comparatively new and in use**	• **Near future, potential and/or advanced**
• Standard analogue telephone	• Press-button digital telephone	• Mobile telephone SMS text messaging and SMS Cell Broadcast
• Door knocking	• Mobile telephone and voice mail	• Digital TV and Digital Audio Broadcast
• Mobile loudhailer	• Pagers	• Dedicated public address systems
• Written communication	• Automatic voice messaging (AVM) using telephone	• Wireless Application Protocol telephones
• Flood wardens	• Teletext	• Centrally activated local radio alerts
• Flood sirens	• Dial-and-listen services (e.g. Floodline)	• Centrally activated in-home alert systems
• Radio telephone/VHF	• Television/radio broadcast	• Integrated dial-and-listen and AVM services
• Radio	• Signage e.g. flashing signs	• Real time flood data on web; including livecams
• Facsimile	• Intranet and internet websites with real-time warnings	• Third and fourth generation mobile telephones
• Automatic water level alerts linked to telephone	• Electronic mail	• Others including: • Crawlers on standard TV • Power Line • The Grid • Mesh network • Bluetooth • ZigBee • Radio Data System • Light as a medium • Ultra wide band • Software Defined Radio • Ad hoc networks • Other Wireless Protocols

In 2004 we are currently in the midst of a new phase of the information and communication technology revolution in which new technologies are being marketed at what appears to be an increasingly rapid rate. 'Near future' technologies are on the immediate horizon or are already in use in sectors other than the flood forecasting and warning sector (Table 2.1), and some of them are now being applied to FFWRS. There is also a drive to reach parts of the at-risk community who are disadvantaged in one way or another and who may be excluded from effective FFWRS. The twin emphases upon improved performance and inclusiveness in Britain's multi-cultural society has led to this focus. The Floodline Warnings Direct service is potentially a further step in incorporating the detailed requirements of the flood warning customer, while also placing the responsibility on the customer to help themselves.

We are now seeing some of the fruits of this customer focus in improved rates of receipt of flood warnings, and in some cases, in improved warning response. Even so nothing should be taken for granted. Each 'improvement' in FFWRS needs to be evaluated to ensure that it really is an improvement. There remains a tendency to think of the introduction of new technologies as automatic improvements. However, a central, age-old issue with the introduction of new technologies - from the period of the Luddites to the present day - is their social acceptability and performance.

2.1.2 New digital data transmission mediums and wired network options for possible receipt of flood warnings

New digital and wired data transmission mediums hold potential for increasing dissemination of flood warnings. As telecoms have rapidly evolved to meet changing content demand (such as on-line gaming, text messaging, audio file-sharing and video-streaming) there are now a variety of means by which consumers can receive digital data transmissions. These mediums are outlined in Table 2.2, including any limitations that might influence the performance of each technology as a flood warning medium. In particular, attention is paid to whether the different transmission mediums are typically available as either un-metered (potentially ‘always-on’) or metered and/or battery-dependent services. The latter option seriously limits ability to communicate warnings in real-time.

Given that a warning lead time of eight hours can lead to a 50% reduction in damage levels for residential properties the more complex ‘digital divide’ between un-metered (always-on) technologies and metered or battery-dependent access (‘sometimes-on’) technologies and payment options must be considered in addition to the more fundamental conception of a divide between ‘haves’ and ‘have-nots’. However, receipt of broadband service does not guarantee that the user’s terminal will always be switched on nor that he/she constantly monitors incoming messages. Moreover, there appears to be an assumption that telephone lines will always remain connected during flood emergencies. In fact lines may be lost due to storms and power may be interrupted by floodwater damage. These caveats not withstanding, the potential for greatly improved dissemination *and rapid receipt* of warnings is still clear, as is the potential for greatly reduced running costs for the service provider.

Standard PSTN telephone lines

The standard telephone network (already used for AVM transmissions) is an always-on medium that doubles as a pay-as-you-go internet and email service. Modem connection

to the public switched telephone network (PSTN) remains the most common means of non-business internet access in the UK. It is the basic service used by 90% of the UK's on-line population to connect to the internet; a total of 11.7m households (47% of all private residences) now have internet access (ONS, 2003).

DSL broadband services

Newer broadband technologies (comprising a group of transmission mediums that offer data transferral rates of 10 to 100 times faster than the standard modem connection) are usually offered at a fixed rate as an 'always-on' un-metered service that also allows the household simultaneous use of a telephone. As a medium for public service delivery, broadband messages (which could be audio as well as text files) have a much higher potential to be seen and read immediately upon their despatch than those sent to 'traditional' internet users who may only turn on their PCs and modems intermittently to check their mail boxes. They also allow far more effective utilisation of the Agency's new Floodline and Floodwatch services.

In particular, Digital Subscriber Line (DSL) technology has revolutionised access to telecommunications services. Until recently, only analogue transmission was possible over the copper loops which comprise virtually the entire access network with data speeds typically limited to 33kbps. With DSL technology, speeds of at least 512 kbps are now achievable, and in theory speeds as high 52 mbps may be reached. This is already making it a very popular technology that is likely to make substantial market penetration in metropolitan areas. In April 2003, 22% of UK Internet users had broadband access. The raw figure is 1.1m broadband users in Oct 2002, rising by between 20,000 and 30,000 every week (DTI, 2002).

However, the implementation of DSL broadband services in remoter areas of the UK is dependent on BT fitting out its local exchanges to support the new services. Economics of scale suggest that DSL upgrades for many local exchanges in remoter areas will never be commercially viable, limiting the application of multimedia flood warning dissemination in such areas, and acting as a barrier to communications (see Section 2.3 below). Although BT have set the targets to be as low as 150-200 in some rural areas, threshold values of 500 still exist for some more remote exchanges. A variety of government initiatives are now underway to help bring broadband to such areas (see section 2.1.6). *It is therefore quite reasonable to assume that a majority of floodplain households will be utilising this 'always-on' technology within the next decade*[1].

Other fixed line options

In addition to broadband receipt of flood warnings, there are two other older wired mediums available that offer a notably superior level of service to PSTN:

- ISDN is not really a broadband technology but it is nevertheless adequate today for Internet applications with low to medium usage. It received an early roll-out into

1 DSL technology actually comprises a range of different transmission standards and the key standard is ADSL, an 'asymmetric' service offering up to 6mbps downstream to the customer but a much lower rate upstream from the customer. ADSL uses only one copper pair and can be run in parallel (without interference) with voice telephony services. It is the variant of DSL best suited for residential applications and is currently surrounded by a large degree of hype. ADSL Lite is a low-cost alternative to ADSL which offers 500kbps bandwidth, which is suitable for fast Internet access but not for high-quality real-time video.

much of Scotland during the 1990s and given the costs already incurred in doing so, it is likely to be regarded as best practise in remoter rural areas for some time to come (BT states that 97% of the population can potentially receive ISDN2 in the UK[2]).

- Cable modem services can provide a high speed service but coverage is uneven and unlikely to improve as the government is no longer actively encouraging the development of new franchise areas[3].

2 Some will never be able to receive it because there is a distance limitation on deployment of ISDN of around 10 kilometres. Others cannot receive it because of a variety of local loop problems, many, but not all of which, could be resolved if the will was there to do so. Whether this coincides with any serious flood risk areas cannot be ascertained – BT still do not produce comprehensive information relating to ISDN coverage in the UK. The extent to which vulnerable groups cannot gain access remains unknown.

3 Consolidation has taken place in the UK industry to such an extent that only two major players remain – NTL and Telewest. Both are repositioning themselves as telecommunications companies and are concentrating on increasing penetration in their existing franchise areas and developing new services.

Table 2.2 Digital data transmission mediums for possible receipt of flood warnings. *Source*: partially adapted from Rogerson *et al.* (2001)

	Speed	Limitations	Always-on*	Status in 2003-04
Data transmission via wired networks				
PSTN (public switched telephone network) Telephone & internet	Typically 5 kbps (up to 52 kbps)	*Telephone* use (including receipt of AVM messages) *Internet & email* use: Very slow download times. Most likely used as a pay-as-you-go and not an 'always-on' service	Yes No	Mature. Dominant.
DSL / ADSL broadband internet	128 kbps to 512 mbps and above	Technical and market limitations mean that there is uncertainty about what percentage of rural locations can be served.	Yes	Maturing. Prices falling (£20 / month). Found in many rural areas where threshold demand targets have been met.
ISDN/ ISDN2 high-speed internet	128 kbps	Costly compared to newer technologies but widely available in some remote regions such as the Highlands.	Varies	Mature. In decline as newer access methods provide higher speed at less cost.
Cable modem broadband internet	200 kbps up to several mbps	Security and quality of service. Bandwidth is shared, so speed depends on number of simultaneous users	Yes	Mature. Not available in some rural areas
Wireless transmission				
Fixed wireless internet access	64 kbps to 10 mbps, depending on spectrum	Line of sight is a problem in mountainous regions Weather causes signal to fade and limits distance.	No	Some use in the UK in for residential and business customers
Satellite transmission	Up to 2 mbps downstream	Cost and asymmetric bandwidth. Needs a telephone circuit for back channel for interactivity.	Yes	Maturing.
Mobile telephone networks	Up to 2 mbps with 3G; 10 kbps max	Cost of 3G still a disincentive although falling. Battery use and payment options may deter 'always-	No	Rapidly maturing, but uneven national coverage.

	with 2G	on' usage.		
Digital TV & radio broadcasts	Several mbps	Not suited for business applications. Limited potential for interaction. May often be switched off.	Yes	Maturing. Now received by more than 50% of homes.
Data transmission via electricity supply network				
Powerline	Up to 2 mbps	Pilot projects offer service for £25 month in Stonehaven and Winchester.	Yes	Pilot projects only.

* 'always-on' does not guarantee that receiver is actually switched on, merely that un-metered data transmission is possible.

2.1.3 Wireless network options for the receipt of flood warnings

Wireless internet options

Broadband wireless solutions[4] will not be technically suitable for all locations, depending on the local topography. The key requirement is for (near) line-of-sight access from the customer to the base station. This may be difficult in hilly localities. Even in relatively flat locations there is a reasonable likelihood that not all customers can be served. However, in urban areas, there is now growing provision of the shorter-range Wi-Fi technology.

Satellites can also be used to provide a broadband downstream path for data communications relying on a terrestrial technology, such as the PSTN or ISDN, to provide a lower speed return path. This is not an ideal situation, either in terms of quality or cost and is not widely deployed. However, for the receipt of flood warnings, where emphasis is clearly on the downstream path, then this is adequate.

Mobile services

The potential for the delivery of an effective public information service using this service is high given that 75% of the adult population (and 90% of young people) now possess a mobile telephone (Crabtree *et al.*, 2003). Additionally, all family members can be contacted individually via text messaging services. Even rural populations are now well served by mobile networks with all four UK operators providing coverage. However, many second generation (2G) users prefer pay-as-you-go options and cannot

4 Fixed wireless technologies are distinguished principally by the spectrum used. Low spectrum fixed wireless (at around 2.3–3.5 GHz) would have difficulty accommodating voice as well as data. The higher spectrums (principally 26–28 GHz and potentially 40 GHz in the UK) can easily package voice and data in its delivery. This is the main area of focus for wireless operators seeking an alternative to providing broadband access and The RadioComms Agency has recently auctioned spectrum in the 26–28 GHz spectrum band for broadband services. Coverage per base station at 28 GHz is around 13 square kilometres and bandwidth of up to 11 mbps can be provided.

be counted on to always carry their telephone or to have it switched on, seriously limiting ability to serve as an effective warning medium with sufficient lead time.

Third generation (3G) mobile licences were awarded to five companies in 2001 at hugely inflated prices. Data transmission rates in the region of 2 mbps are theoretically possible from third generation mobile systems but deployment costs are very high so operators have focused their attention on areas of high population to date. 3G telephone-users are likely to be following a payment-option that involves always-on connectivity. However the high costs of both telephones and payments will limit the numbers using this medium for a while to come.

Another possible drawback of relying on mobile telephones for the dissemination of warnings is that during large-scale events mobile networks may become overloaded, with the warnings not being able to get through.

Digital television and radio

The focus of digital television services is residential and they are certainly not a serious platform for SMEs to access the Internet. However, over 50% of households have now adopted digital television which they receive either:

- via a cable television network
- from a satellite receiver.
- from free-to-air broadcast (when only a single payment to purchase a receiver is required; services are then free).

Both satellite and free-to-air systems use the telephone network for the so-called 'back channel' needed to provide interactivity and *messaging* within the system. Because the data being transmitted on the back channel is low volume, comprising commands and information requests, the available bandwidth on a copper pair is perfectly acceptable[5]. This is a channel for Internet access and, potentially, for hazard information dissemination using 'TV crawlers'.

Digital radio has great potential to enhance regional flood warnings. In particular, The Radio Data System (RDS) allows digital sub-carriers to be used to interrupt normal programmes and even activate a device in stand-by mode in order to provide warnings.

2.1.4 Near-future technologies

In addition to the existing technologies outlined above, other mediums are currently being piloted or are close to development (see Table 2.1), examples of these include:

- *Powerline* Trials are currently underway to deliver broadband internet services over electricity power lines.
- *Software radios* These handheld devices will be able to adapt to future changes in digital transmission frequencies.

5 The Government has stated that it would like to turn off analogue television during the period 2006-2010 but has not set a specific date. It has set three criteria which must be met before the switch-off can occur. One of these is that 95% of all viewers must be able to receive the main free-to-air channels digitally. Thus, it is reasonable to assume that the vast majority of homes will be able to receive digital television by the end of the decade.

- *The Grid* This new system is allegedly set to supersede the Internet, and is driven by research at CERN [Project-gdmp.web.cern.ch].
- *Mesh network* This proposed system, based on Wi-Fi, turns any wireless device into a router, allowing a message to literally follow the user, jumping from telephone to PC to laptop or mobile until it finds its user. *This has great potential for the dissemination of flood warnings* but is likely to be constrained initially to high density urban environments where warnings are in any case easily communicated.

2.1.5 Preferences for warning communication technologies: international experiences

Advances in warning systems are being made in many countries following extreme events which have galvanised action to reduce future flood losses and through the spread and introduction of best practices, new thinking and new technologies. The Environment Agency's 'Flood Warning Dissemination Methods (T15)' (Quinetiq, 2003) usefully summarises warning dissemination systems used in various parts of the world to alert the public to various types of dangers including floods. Advances are being made in warnings for bush fires, tornados and industrial hazards. However, the Project and its reports focus almost entirely upon measures of 'technical performance' and almost completely ignore measures of 'social performance' which are the target of this report. The 'Flood Warning Dissemination Methods (T15)' research found that there is still a predominance of "traditional" warning systems, such as sirens and public address systems, although there are examples of more innovative warning systems in use or in development (Table 2.1).

Some of the international research the most relevant to the social performance of flood warnings highlights recipient preferences for specific types of warnings. Communities have been asked to rank their preferred methods of warning communication. The most common source of general information during the New South Wales bushfires was television and radio while specific information was most commonly received from neighbours (Odgers & Rhodes, 2002). Emergency services were also a common source of information, particularly for information relating to specific safety and instructional information. The media least commonly used by respondents were public meetings, information hotlines and the print media, while radio was identified as a good source of information pertaining to road closures.

For flood warnings, residents in France reported that every possible means of information must be used including sirens, loudhailers, telephone, fax, personal visits, television and radio, although they did not identify the relative priority given to each method identified (Blancher, 2001). Residents of Coode Island, Australia have no previous experience of warning technology and the majority of the sample reported that they would prefer to receive warning and information messages from a range of sources. The sources identified in priority order by the sample include (Betts, 2002):

1. A door knock from an official person
2. Telephone messages and access to further information
3. Radio message

4. Television reports
5. Hearing a siren

This preference for "traditional" warning technology is also apparent in the USA, where the population of Boulder Creek were asked (Gruntfest *et al.*, 2002) "What would be the best way to contact you at the following time (2:30 am, 11:00 am, 5:00 pm)" (Figure 2.1). The Boulder Creek study makes recommendations that may indicate residents' preferred methods of flash flood warning dissemination, these are:

- Consider **e-mail** as a viable warning dissemination device for Boulder residents.
- Determine if there may be a way to reach residents by **knocking on doors**, similar to the "Neighborhood Watch" program.
- Warning through **pagers** is not preferred. Even people with pagers did not want to be warned in this manner.

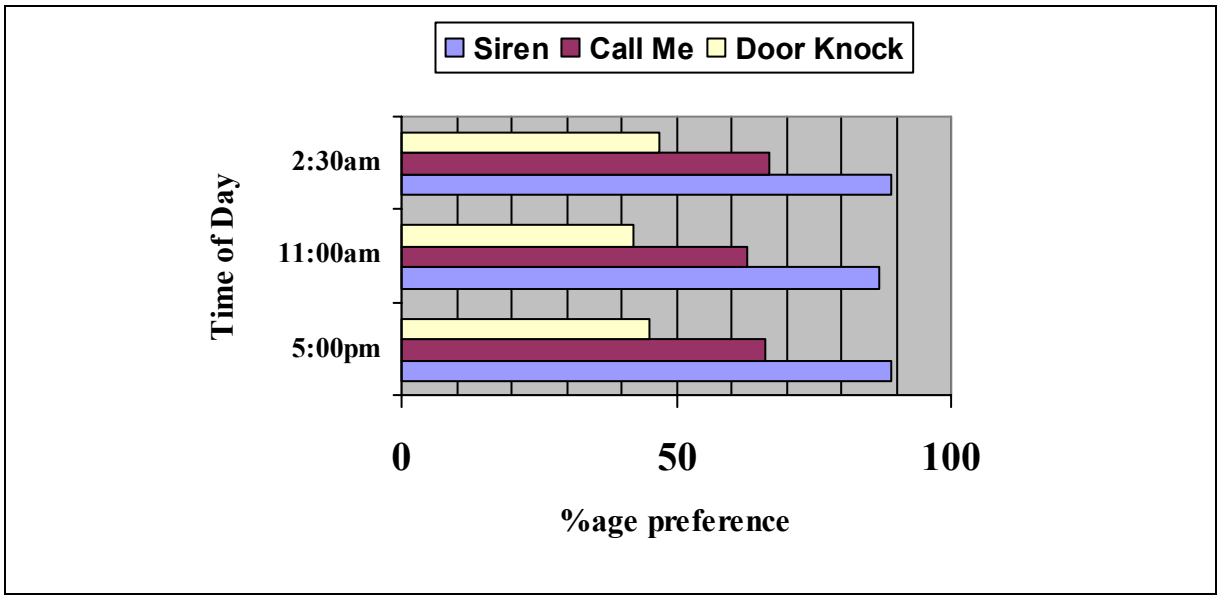


Figure 2.1 Boulder Creek warning preferences

Where innovative and relatively advanced warning technologies are used, there is evidence that if they are not operated effectively by the sender, then they will not be used effectively by the recipient (Gruntest *et al.*, 2002).

> *"Historically, the library had several NOAA weather radios. Most of these have been taken out of the library as they report conditions outside of Boulder. If the NWS issued alerts, watches, and warnings for Boulder County only, the library would reinvest in these radios. At least one NOAA weather radio remains at the library, with the alarm off."*

The preference for traditional warning methods can be largely due to the fact that they have been tried and test and actually work, as well as being due to the lack of awareness

of newer methods. Both of these factors have implications for the future promotion and development of warning technologies.

2.1.6 The effectiveness and performance of flood warning technologies in the UK BMRB reporting

Since its inception in 1996, the Environment Agency has relied upon the British Market Research Bureau (BMRB) to conduct a series of annual reports documenting awareness and performance of flood warning mediums in England and Wales. The series includes:

- *Flood Warning Dissemination National Awareness Surveys*
- *At Risk Surveys*
- *Flood Action Campaign Evaluation Reports*
- *Flood Warning Dissemination Post Event Surveys*

These surveys are able to tell us a great deal about recent improvements in the levels of social performance of different flood warning mediums.

Effectiveness and performance of existing mediums

An important measure of social performance is how successfully flood warnings are disseminated, received and acted upon. Campaign Evaluation Surveys (1999-present) focus upon this aspect of performance in greater detail than either the At Risk or National Awareness Surveys. Notable findings include:

- Amongst those whose address was at risk of flooding, nearly three-quarters of those questioned were aware of this in 2002. *In 2000 the figure stood at around two-fifths (41%), suggesting real progress has been made recently*.

- 86% of those questioned could think of preparations or precautions they could take in 2002 compared with only 57% in 2000. *This suggests that the net outcome of a multi-strand targeted approach has been high levels of public awareness*.

- Less encouragingly, all respondents who could think of any special precautions or preparations that could be made were asked if their household had actually implemented these special preparations in case of a flood event. Only 16% of those inhabiting 'at risk' addresses had actually done so! Performance can clearly be improved in this area (BMRB, 2002b, 46).

Post-event survey for autumn 2000

The severity of the autumn 2000 floods make the post-event survey (BMRB, 2001a) something of a benchmark report when examining the effectiveness of existing flood warning mediums. Notable findings that relate to social performance include:

- 60% of flooded respondents had received a prior warning. 12% of those that did not had received a warning too late.
- 66% of properties flooded *above floor level* had received a warning
- 91% of properties that were flooded above floor level and were warned by the Agency got at least two hours notice.
- The majority (74%) of those who received a warning felt they received it in the right way and 94% claimed to have understood it.

- Over four fifths (81%) were satisfied by the method used to deliver their warning.
- 91% of those warned took action in response to a warning.

When looking at the performance of individual technologies, of the 692 individuals included in the survey who received a flood warning, 30% first discovered their property was at risk via AVM. The AVM is by far the most commonly reported primary warning method cited by respondents, *no other single method comes close to this.* However, the AVM consistently under-performs in surveys documenting public perception of warning channels, particularly when surveys encompass non-serviced populations that have no knowledge of AVM. Other than AVM, 12% of respondents were contacted by neighbours and friends, 10% by the police, 10% by radio or TV and 5% by flood wardens. Of the remainder, only 3% had discovered that flooding was imminent via Floodline and the internet. However, a significant number (454) were advised to telephone Floodline during the flood period – of these 57% did so. Floodline appears to be performing well in a *supportive* role, with public awareness of this medium having risen rapidly over the last couple of years. Smaller numbers of people (67) had been advised to consult the Agency's website and only a third of these did so, perhaps reflecting access issues.

Response to the technologies employed during autumn 2000 was very positive overall. Targeted messaging clearly works, despite general lack of public awareness. Of those that received a flood warning, 61% could not think of a better method than the ones that had been used and suggestions from the remaining two fifths of the group were fragmented and suggest that there is no single technology that is widely perceived to be lacking. Existing technologies are seen to be performing well.

Regional variations in performance

Local opinions, local performance, local levels of access to new technologies are shown to vary considerably across the entire range of BMRB reporting. Certain locales and technologies, perhaps depending upon many factors such as settlement morphology and previous flood histories, are seen to perform very differently. This raises the question of whether the social performance of technologies can be usefully appraised at a national level or only in an appropriate local context. Subsequently multimedia projects and other initiatives might well strive to understand how flood warning technologies work *in an embedded regional context*. Unfortunately, information on regional differences is no longer included in BMRB post-event reporting.

Reported prospects for the popularity of new media (Multi-media warning dissemination survey project report, BMRB 2003b)

In this one-off study, 739 at-risk residents and businesses were targeted, focusing specifically upon the up-take of new technologies that might potentially serve as a flood warning medium[6]. The study also explores possible reasons for barriers to signing-up to warning dissemination systems, further noting the demographic and socio-economic make-up of the group. Key observations included:

- Of the 440 Internet users present in a survey group of 739, (weighted result), 178 (40%) use it on a daily basis. 31% go on-line as little as a few times per month or less.

6 A 63% response rate from eligible properties was achieved overall. Results could therefore be biased if prior knowledge of the survey content encouraged 'technophobes' to opt-out. In this case there may be even less public engagement with new technologies than the survey suggests.

- The overwhelming majority of current Internet users would be happy to receive flood warnings via e-mail (87%).

- 494 – around two-thirds of those questioned - have a mobile telephone, 333 (67%) of whom use text messaging. 69% of current users would be happy to receive flood warnings via this medium.

- Of the 73 individuals who are currently registered to receive warnings, 8 (10%) have requested a mobile connection while 62 (84%) may be contacted via a landline.

Of the survey group, 81% are 'fairly' or 'very' happy to register for contact via 'new technologies'. Those who are not commonly cite 'no need' (59%) irrespective of the fact that there clearly is a need given that they have all been designated as being 'at-risk'. Yet, when questioned in greater detail, only 27% actually express a real desire to receive text warnings via mobiles and only 27% would want email warnings. This may reflect the fact that many users are aware that their machines could be switched off at a critical time. In contrast, 58% see a landline telephone as a vital watch-warning medium. When asked to choose a *single* preferred method, telephone landline scores most highly once again at 41% while email falls to only 7% popularity in this instance (and mobile texting to 8%).

To sum up, although there are now a range of flood warning technologies available, with many new mediums being developed for the future, the social performance of these technologies is much less understood, being influenced by the factors outlined in Sections 1.3.2 to 1.3.4, and expanded upon below.

2.2 Recipient Characteristics

2.2.1 Perception of, and response to, risk

Perception of flood risk is seen to have a bearing on the take up of warning methods and the actions taken upon receipt of a flood warning. For example, those with previous flood experience are more likely to take disruptive action upon receiving a warning than those who had not been previously flooded (Fielding *et al.*, 2002).

Two similar models have proposed that the most important factor is how recipients' perceptions shape their response to risk (see Box 2.1). In both models, these factors when combined represent a measure of perceived risk. The propensity of an individual to become involved in safety initiatives is therefore likely to be closely linked to their perceptions in relation to their own susceptibility, vulnerability, resilience and recoverability. A practical implication of this theory is that if certain demographic groups do not perceive warning cues as evidence for personal susceptibility or severity, then different warning approaches for these groups would be warranted (Gruntfest, 2003).

The report on the New South Wales Bushfires (Odgers and Rhodes, 2002) concluded that the low level of perceived risk in relation to bushfire is likely to negatively impact on the current preparation levels of community members. This conclusion invites a

direct comparison with the low take up of the AVM service (where it is offered) because of the low level of perceived flood risk in the UK. In terms of social performance, it is therefore necessary to distinguish between individuals and communities of high and low perceived risk.

It follows that an individual's previous experience of flooding is likely to be a major factor in their perception of risk and consequently their involvement in preparation activities, such as a flood warning scheme. For example, community resident mobility has a direct impact on the perception of risk in the community. Australian research (Betts, date unknown) found that people moving in and out of the area alters some of the established connections and communications leading to reduced understanding of the threat.

Box 2.1

Risk Perception Models

Odgers & Rhodes (2002)	**Health Belief Model (Gruntfest, 2003)**
• Susceptibility: how often people feel that it is that an incident will occur. • Vulnerability: how likely people feel that they will be directly affected by an incident. • Resilience: how well people would cope during an incident. • Recoverability: how easily people feel that they would recover from an incident.	• Perceived susceptibility to the threat. • Perceived severity of the threat. • Perceived benefits of health enhancing behaviour (e.g., protective action) • Perceived barriers to enacting the behaviour • Perceived capability for performing the response. • Cues to action.

Very little research was found to consider the risk perception relative to educational attainment other than the special needs of those with learning difficulties. The Boulder Creek Survey found however (Betts *et al.*, 2001) that those with the least and those with the most education are the most concerned about flash flooding but concluded that "Perhaps this is not due to education as much as other factors."

2.2.2 Social characteristics

A recipient's social and personal characteristics may also directly affect their willingness and ability to use flood warning communication technologies, and therefore the technologies' social performance. There is a growing amount of research literature on disasters and hazards which suggests that certain groups within populations e.g. women, the elderly, ethnic minorities, those with physical disabilities, socio-economic groups C to E, and those new to an area, are more vulnerable to disasters such as flooding. These groups are vulnerable in being more exposed to disasters, to the impacts of such disasters, and in their ability to recover following a disaster (e.g. Ticehurst, 1996; Morrow and Enarson, 1996; Fordham, 1998; Morrow, 1999; Tapsell *et al.*, 1999;

Tapsell and Tunstall, 2001; Buckle *et al.*, 2001; Thrush, 2002; Few, 2003, Wisner *et al.*, 2003). Vulnerability can be defined as 'the exposure to a given risk and the ability to cope within a framework of various social, spatial and temporal contexts' (Dept. of Sociology and Centre for Environmental Strategy, 2002). This vulnerability has implications for the social performance of flood warning communication technologies.

In particular, the literature suggests that it is those people who are already socially disadvantaged in some way within societies who are particularly vulnerable in terms of being aware of flood warnings, in their ability to receive a flood warning, and in reacting appropriately to flood warnings. Evidence from recent research identifies some significant social factors affecting reception advice, levels of awareness of flood risk and propensity to take action to minimise the impact of flooding (Fielding *et al.*, 2002; Thrush, 2002). The following factors were seen as significant in affecting *levels of awareness of flood risk*:

- Previous experience of flooding (this caused the biggest increase in awareness).
- Being in socio-economic group A or B.
- Being in an Agency flood warning area
- Being an owner-occupier.
- Being in full-time or part-time work.
- Being aged 45-54
- Being in a pre-1970s property increased awareness.
- Where flood severity was worse, awareness was higher.
- Those resident for less than 1 year showed markedly less awareness than longer term residents.

Age is one factor in the adoption of certain ICTs. The Agency's MMWDS and annual At Risk surveys collect survey demographics in age bands of 16-34, 35-54 and 55 and over. The 2003 MMWDS survey indicates that there is a higher proportion of over 55's (45%) and 35-54(40%) age groups living in flood risk areas than in the population in general (33% and 35% respectively). Whilst this may be no more than a quirk of the survey methodology, this potential variation in age profile between the those living in flood risk areas and the population in general warrants particular attention when considering social performance.

Looking at results from the MMWDS survey (BMRB, 2003b), the exclusion rate of older cohorts from new technology access is striking: 76% of over 55s surveyed cannot currently access email and 65% have no plans to purchase a computer. These findings are similar to the results of a recent national online access survey (National Statistics Office, 2003) that concluded that only 17% of over-65s currently use the Internet. This obviously has short and medium term implications for the social performance of these mediums.

Age also appears to be an important factor in determining an individual's perception of flood risk with respect to both *resilience* and *recoverability*. For example, the elderly are often said to feel less able to cope with a flood and also find it more difficult to recover. However, research in the US (Norris *et al.*, 2001) and the UK (Tapsell and Tunstall, 2003) shows that middle-aged adults are often more adversely affected by natural disasters such as floods. This is possibly due to the fact that this age group are more at risk because they have greater stress and burdens before the disaster strikes and

they assume greater obligations afterwards. Moreover, the elderly may have greater experience in local issues or strategies, a wide network of friends and family, and personal strength drawn from many years of life. Research on flash flooding in Boulder Creek, Colorado, found that all in the 56+ age group selected "strongly agree" or "agree" to the statement "'my home is at risk from a flash flood'. This is compared with the results from the 18-25 age group, who perceived less risk to their home being at risk, and strongly disagreed that their lives were at risk.

Research in the UK suggests that gender may be an important factor affecting vulnerability and therefore social performance (Tapsell *et al.*, 1999; Tapsell and Tunstall, 2001). A survey in Boulder Creek also considered gender as a potentially significant recipient characteristic (Gruntfest *et al.*, 2002). The study found that more male respondents than female respondents strongly agreed that their homes are at risk from flash flooding, while more female respondents strongly agreed that their lives are at risk. More men however, chose "disagree" to home at risk and "strongly disagree" to life at risk than did women. These results are far from conclusive but suggest that females may feel more vulnerable than males and may therefore show greater access and/or willingness to use warning communication technology.

Further evidence from the UK (Tapsell *et al.*, 1999) and Australia (Betts, pers. comm. July 2003) suggests that ethnicity may be an important factor in the receptiveness to a warning and taking effective action, in addition to the language issues. Moreover, some cultures consider natural disasters to be an act of god and so are less likely to make advance preparations.

Research has also revealed possible regional differences in social vulnerability. In one study (Fielding *et al.*, 2002), two Environment Agency Regions, Thames and North East, were compared using Enumeration District data and data from Openshaw's (1994) GB Profile classifications. Results demonstrated a difference in population characteristics between the regions. For example, in Thames Region there are higher proportions of 'struggling multi-ethnic' populations, and 'aspiring academic' populations, while in the North East there are higher proportions of 'struggling less prosperous pensioner' areas and 'established rural farming communities'. These findings may have implications for the provision of, and social performance of, the type of flood warning technologies adopted in particular regions.

2.2.3 'Hard to reach' groups within 'at risk' populations

A key problem in the dissemination of flood warnings and their social performance is the diverse range of needs among at risk populations. Flood warning communications technologies need to be able to target different groups within populations that may have special needs and considerations e.g. the blind, deaf, physically disabled, ethnic minorities and elderly. According to the Agency's MMWDS survey, one in five (19%) of the UK's at risk population have physical, hearing, visual, learning or other difficulties. Therefore, many of these 'hard to reach' groups comprise large populations, as indicated in Box 2.2.

Research reviewing the effectiveness of disseminating warnings to these 'hard to reach' groups by the former National Flood Warning Centre raises some important communication issues (NFWC, 2002). Although there is diversity between different

groups within communities, diversity is also found *within* discrete groups which are themselves not homogenous. For example, for those with hearing loss, this can range from partial loss to being profoundly deaf, while for the visually impaired sight can vary from simply having to read larger print to total blindness. Older people are more likely to have additional problems which result in them being particularly vulnerable (e.g. restricted mobility and/or reduced vision and hearing).

Box 2.2 Indications of size of target 'hard to reach' groups in the UK
• *Visual impairment:* 2 million, with under 400,000 registered with Local Authorities, plus 20,000 Braille users. The majority with visual impairment are aged over 65, with conditions being age-related. Between 80-90% can read 14 point text and 77% can read some words in 10 point.
• *Hearing impairment:* 9 million, with 700,000 profoundly deaf. Many of these are elderly, with the condition being age-related. 60,000 people use sign language as their main form of communication.
• *Deaf/blind:* 23,000 – but may be major underestimate
• *Pensioners:* 8.3 million aged 65+, 450,000 living in sheltered housing

The development of integrated communications for 'hard to reach' groups will often ensure greater clarity for all user groups. For example, by using plain and clear language understanding will potentially be improved for all groups. A number of initiatives have been taken by the Agency in improving communications with certain 'hard to reach' groups, although the success of these is unknown. These initiatives include:

- the production of Braille credit card sized information cards for the blind, and Floodline information guides transcribed into Braille;
- consideration of providing deaf awareness and limited sign language training for frontline staff;
- an investigation of demand for translation of communications materials and arrangements of translation services where appropriate;
- all 2002 Flood Awareness Campaign materials printed to include the Minicom number and other information in languages other than English;
- details of deaf and hard of hearing, visually impaired, and older peoples community groups provided to Agency Area flood warning teams.

2.2.4 Discussions with RNID and RNIB

Telephone discussions were held with representatives from two groups working for people with special communication needs as part of the current social performance project: the Royal National Institute for the Blind and the Royal National Institute for the Deaf.

Representatives from both organisations recommended that any further research on people with visual or hearing impairments should be done *with the aid of these groups*. It was suggested that all of the various warning methods should be tested on groups of

people with special needs. For example, one suggestion was for testing the AVM with older people to see if they fully understand how it functions and how effective it can be. One of the issues raised by the RNIB was the problem of *getting information to people* with some form of visual impairment on the types of warning methods available to them. These discussions therefore highlighted a number of issues relating to the use of specific types of flood warning technology likely to affect social performance for these two recipient groups, the results of which are reported in Boxes 2.3 and 2.4 below.

2.3 Communication Barriers

As mentioned in Section 1.3.3 there are a number of additional barriers affecting adoption of flood warning technologies among recipient populations. Some key barriers relating to social performance are discussed in more detail below.

2.3.1 Social and regulatory issues concerning access

Access points

Demand for Internet and mobile services has grown exponentially over the last decade with a majority of UK users *now availing themselves of both.* Current statistics suggest that 90% of the populations' younger cohorts now possess a mobile telephone with a majority now able to access the internet from home (Crabtree *et al.*, 2003). However, despite encouraging aggregate statistics several points of general concern should initially be highlighted, the first of which is that there are still significant numbers that lack any access whatsoever to new technologies. For example, age is one access barrier already highlighted in Section 2.2.1 above.

There are also clearly marked regional and social-demographic inequalities of access. It is possible that there might be overlap between technically marginalized populations and vulnerable populations. Other questions to be considered concern the local access points for ICTs, what the access points are, and who is currently denied access. Finally there is the issue of how well these information 'gateways' perform as mediums for communicating flood watch / warning messages.

The issue of broadband access has also already been highlighted. Standard modems that utilise existing family telephone lines may not be used for days at a time. This suggests the possible scenario of a second tier of '2-speed Britain' where varying segments of the population – all of whom possess *some* form of data access - manifest a markedly different ability to be communicated with in real time. These abilities may be linked with income or age (i.e. being social characteristics of the recipients - see Section 2.2.1). Increasingly, concerns over *access* must do more than address the basic availability of a home or work-place PC. There is a typical 'migration path' for PC users from narrowband (standard modem) to broadband.

The effectiveness of different methods of dissemination also requires careful scrutiny of the user interface. Recent work in social science has stressed the unpredictability of 'socio-technical ensembles' – people and technology working in concert – and the ways in which they modify one another (see, for instance, Latour, 1993; Law, 1994; Jasanoff *et al.*., 1995, Morley & Robins, 1995). Ten years ago, few would have predicted, say,

that PCs would become family photograph albums. Indeed, debate must examine less access and more proficiency in using content as price barriers fall (Dutton *et al.*, 2003).

Box 2.3 Effectiveness of warning methods for people with visual impairments

Individual warning methods

- *Door knocking/wardens:* generally fine as involves human contact.
- *Telephone systems like AVM:* generally fine, and a good method for reaching blind people.
- *Mobile phones:* good method, especially among young.
- *SMS Texting:* this is now a very feasible method for reaching people with visual impairments. Software is now available for mobile phones that will allow any text messages to be spoken - the phone relays a voice message of the text. Again age is a factor and older people may be less inclined to use this method but younger people are very keen. RNIB is working with mobile phone companies on promoting this. They expect take up of this software to be rapid in the next few years, especially among younger people. This is seen as a potentially important method of warning blind people in the future.
- *Letters/pagers/fax:* low potential takeup/effectiveness.
- *Internet / e-mail:* although having less potential than texting, this is said to be an appropriate method for warning people if they have special speech output software on their computers, which a growing number of blind people do. Computers that have to print out messages in Braille are less effective as the Braille message is the last output in the chain. This method was thought to be a good medium for contacting people at work during working hours, but perhaps less so for receiving messages at home as some people will not always have their machine switched on – the same issue as with general population.
- *Centrally activated in home alert systems:* good potential if audio message/warning.

Broadcast warning methods

- *Dial and listen/Floodline:* good medium
- *TV broadcast:* surprisingly this is a *good* medium for reaching blind people as they 'watch' television as much, or almost as much, as people with vision. However, it would be important for any information to be given verbally and not by just flashing up a telephone information number (e.g. Floodline) on the screen, it needs to be read out. TV crawler messages would not be a good method for reaching blind people, presumably Cable TV would be the same as normal TV.
- *Radio:* good medium.

Community warning methods

- *Mobile loudhailers/Sirens/Public Address systems:* in theory these should be good systems but it was pointed out that if people did not catch what was being said, and could not see the passing vehicle or person giving the message to confirm the source (in the case of loudhailers), they might take no notice. In other words they would have no visual reinforcement of the warning and would not necessarily seek to verify it.
- *Signage:* signage such as flashing lights might be of some use. Many blind people would be able to see a flashing light and some might be able to read the message. However, if they could not read message there might be some misinterpretation of the warning and it would be hard for people to verify the warning.

Box 2.4 Effectiveness of warning methods for people with hearing impairments

Broadcast warning methods:

- *Dial and listen (Floodline)* most people would need to use Minicom for this and not all would have access to it.
- *TV broadcast and TV with crawlers* most deaf people watch TV, however, it would be particularly effective if broadcasts were subtitled. Not all programs currently are, though digital TV programmes all have subtitles available. If there was a major flood if might be useful to have a sign language interpreter on the TV to give a warning.
- *Cable TV Voice over ride* - few deaf people have cable TV.

Individual warning methods:

- *Door knocking and flood wardens* - these are problematic due to the very different levels of deafness within the deaf population. For those who are generally hard of hearing it might be a useful method but for the profoundly deaf these methods may be of little use unless people had flashing lights attached to their door bells (which some have), and also *so long as they could communicate with the person who knocked on their door if they opened it*. For sign language people this might be difficult unless there was some simple visual information that could be given to them.
- *AVM, Dial and listen, Digital telephones, Automatic water level alerts linked to telephone* – these are also dependent upon a persons level of deafness, and if people have phones with volume controls or hearing loops for their hearing aids, plus for the very deaf whether they have Minicom available. Floodline currently has a Minicom service for incoming calls only.
- *Pagers* - less people use these now, most people have switched to texting.
- *SMS texting* – this is very popular among the deaf community and is used by a high percentage of the deaf population, however any message sent would have to be in plain English and simple.
- *E-mail/internet* - this is very popular among many in the deaf community especially the profoundly deaf, but it can vary e.g. among older people who may not be used to new technology (as with the hearing). Guidance from computer ownership figures generally can be used, but if anything the ownership figure for the deaf might be slightly higher than for the general population.
- *In home alert systems* – these could be very good for warning dissemination so long as there was a visual message display (plain English and kept simple) or even better if there was a flashing light too.

Community warning methods

- *Mobile loudhailers/Sirens/Public Address system:* no, little or limited utility.
- *Signage:* generally fine.

2.3.2 Fostering access

Where access to new ICT media remains low (either socially or geographically) consideration is needed of how might greater uptake be fostered ahead of market forces. *Regulation* is one mechanism to fostering better access to ICTs. The UK telecoms regulator, Oftel, has launched many social initiatives that have sought to address the needs of low-income users. Oftel also places two requirements on BT which help to ensure the ubiquitous provision of telecommunications services across the country. These are:

Table 2.3 Key issues relation to inclusion and access points for ICTs

Access mode	Key issues
Mobile telephone Access	75% of the adult population now use a mobile telephone. However, the figure is much lower for the most elderly cohorts while studies show that many people limit usage to reduce costs by sticking to pre-pay options and often turning their telephones off. This may restrict usefulness as a warning medium.
Work access	Most SMEs are likely to have broadband soon and will, in effect, become 'always-on' organisations that are easily contactable by email during business hours. Broadband penetration of the smallest businesses (0-9 employees) is estimated to have only reached 11%. However, 70% of larger firms (1000+) have access. Businesses in remoter rural areas may be less likely to afford / have access to Broadband but they may in any case face a reduced flood risk if they are not situated on a major lowland floodplain.
Home access	Household penetration by the Internet now stands at 47% (ONS, 2003). However, as previously highlighted, this figure conceals more than it reveals. Bandwidth and frequency of use vary greatly between households and marginalized groups, especially those in low income brackets, are unlikely to score highly in either category. 86% of over-50s net-users are from middle and higher income brackets whereas amongst the lowest decile group in the UK only 12% are on-line (ONS 2003). There are marked regional differences - Home access varies from 52% in SE to 35% in N Ireland, 38% in Wales, 40% in NE. Age is also an issue: Only 17% of the over-65s use the Internet (and more than half the disabled are over-65). Dutton *et al.*. (2003) stress the vital role of young people in speeding up technical innovation at home, especially once they have been accustomed to broadband applications at school.
Community shared access	The prohibitively high cost of computing in the 1990s led to a 'kiosk' model of local access gaining popularity with local government and enterprise companies. Enthusiastic promotion of 'telecottages' in the Highlands and Islands was followed by the release of Millenial funds in 1999 to support village halls. School premises in Cumbria provide public access under the Cumbrian CREDITS scheme. Libraries now play a key role as local providers. School, health, academic, medical and library networks increasingly maintain 'always-on' links, often as part of wider local council and social service networks. The educational network in Argyll, Scotland has been linking all schools and FE institutions since the late-1980s. Little attention yet appears to have been paid to utilising existing systems aimed primarily at education, health and benefits to improve knowledge and understanding of flood risk, nor to disseminate warnings.
Proxy access (voluntary exclusion)	Dutton *et al.*. (2003) have attempted to profile those cohorts of the population that remain voluntarily excluded from the new media. According to their findings, a typical non-user is in his or her 50s and still in work. However, such individuals often ask others to act as a 'proxy user' if they have a good reason, perhaps asking their children to work the technology. The survey data shows that 6% of non-users have had someone make a purchase online on their behalf, 7% to send an email and 13% to find information. Of those who have made no such request, 54% know someone they could ask if the need arose.

- *The requirement for geographically averaged tariffs*. According to this requirement BT must make its commercial services available at the same tariff everywhere in the country.
- *The universal service obligation*. BT is obliged to offer basic voice telephone service to all customers at standard tariffs regardless of location. Oftel has considered, but so far rejected, the notion of extending the universal service remit to include broadband access.

Various other strategies are being employed by branches of central and local government and NGOs to drive ICT uptake and these include:

- Demand aggregation
- Taskforce campaigning
- Local champions

Demand aggregation
For flood warning technologies to reach the highest possible level of performance, they must approach near-universal levels of access. This is a given with television and radio, but not yet with the new ICT media. Communities stand to benefit from access to new ICT media in many ways, of course, notably in relation to health, education and employment. If different government agencies and NGOs identify low-level demand in certain locales, then it is often possible to introduce ICT media, notably broadband internet, ahead of market forces through demand aggregation.

> *The most important way for governments to boost broadband availability and deployment would be to get public-sector aggregation right, with sensitivity to local areas… a multiplicity of local broadband initiatives also offers a greater diversity of solutions (Devins et al., 2003, 27).*

For instance, national government is keen to roll-out broadband to rural areas because of the immense gains that are to be made by remote schools and GP surgeries. The Aggregation Scheme announced by the e-commerce minister Stephen Timms during 2003, encourages public bodies led by schools and the NHS to buy shared broadband networks jointly. The new networks will be procured by nine new Regional Aggregation Bodies, one for each of England's Regional Development Agencies. They are expected to begin procuring networks early in 2004.

The aim is to encourage as many public bodies as possible to combine forces, however Cross (2003) reports that Timms has found it hard to involve some actors, notably local authorities. As yet, he has no powers to compel councils to join what remains a voluntary scheme. Yet, there is no shortage of schemes currently underway to foster greater uptake of both internet and more specifically broadband technology, as Table 2.4 shows.

Local champions
The role of interpersonal networks and of specific individuals in these networks are important in access to and adoption of new technologies. Several groups of individuals who may influence these networks have been identified in the literature (Rogers, 1995): change agents, change aids, and opinion leaders.

Table 2.4 Initiatives campaigning for greater ICT uptake

- The **UK Broadband Taskforce** recently set up by the DTI and OGC (Office of Government Commerce) aims to help central government honour its commitment to deliver a much wider variety online services. Notably, weather forecasts are mentioned as an 'environmental' public service in the briefing documents but not flood warning. [www.citu.gov.uk/Resources/AnnualReport2002/fs/en]

- **The Office of the e-Envoy** unveiled a major campaign on 10 march 2003 to encourage greater internet use. Partners included Age Concern, Citizens Advice, RNID, BBC and BT. It aims to address the fact that ONS statistics show that only 10% of the lowest income social decile are online and that only 17% of over-65s are users (There is no mention in the briefing document of the EA, or any stated concerns of flood risk for vulnerable groups).

- **Wired-up Communities** (WuC) was launched in 2000 by the DfES with £10m funding to investigate how the digital divide could be bridged by enabling communities to use ICTs to access jobs, learning services, government and other services. Devins *et al.*. (2003) claim that the WuC initiative shows the importance of a 'joined up' approach to link the development of the widely varying strategic aims and objectives of different organisations with operational implementation at a local level.

- *Change agents:* these influence potential adopters' innovation decisions in a direction desired by a change agency, such as the Environment Agency. Change agents can therefore be employees of a change agency i.e. 'official' agents, or unofficial. For example, children and the younger generation in general can often be good agents of change relating to the adoption of new technology, often influencing their parents and older members of their family.

- *Change aids:* these are people who are closer to the respective target audience than the 'official' change agents. One example of change aids are flood wardens. These people live within the at risk population but are often able to influence their neighbours by passing on information and advice. Additionally, those people who have experienced flooding and the receipt of flood warnings can also act as change aids in passing on their knowledge and advice to others.

- *Opinion leaders:* are members of a social system who are able to influence others' attitudes towards an innovation. They usually have greater exposure to mass media, are more cosmopolitan, have more change agent contacts, have a higher socio-economic status, and participate more in their social system than their followers. Change agent success is also related to the extent to which they work through opinion leaders. Local community leaders and representatives can be one example of opinion leaders who may have influence on others within their communities.

In a similar vein, canvassing for broadband at a grassroots level advocates the use of *local champions* to foster access and adoption. This has begun to meet with success in some remoter/low population density regions. After 1,100 of BT's urban exchanges have been opened up to Broadband, demand targets were set for 1,450 more and so far 300 of these have had broadband rolled out in response to 'grass-roots' demand, many in rural areas (Todmorden was the first after 200 locals registered interest with their ISPs). BT will invest in upgrading *once local communities have demonstrated that there is sufficient demand* to justify the work. BT is currently actively helping 600

communities to drum up support for broadband in their area. Details of the 600 grass-roots campaigns underway, current registered levels of demand and contact details for a chairperson acting as a 'local champion' for each exchange are listed at BT's web-site.

These change agents and opinion leaders are likely to be crucial in future considerations of how to improve the take up and social performance of ICTs. Therefore, mechanisms to identify or create these agents, to engage them and enhance their effectiveness need to be considered.

2.3.3 ICT uptake in the UK

If 'social performance' marks the interface between technologies and their users then the success of any project utilising ICT rests not simply with ease and cost of access to new networks but the ability and willingness of individuals to optimise connectivity and there are many reasons why they might not do so, despite the efforts of local government, Oftel and various NGOs to tackle the issue of access mentioned above. Table 2.5 summarises the main causes of exclusion

2.3.4 Combinations of technologies to overcome barriers

The Australian Hawkesbury-Nepean Floodplain Management Strategy study (Molino Stewart, Undated) identified a number of possible barriers to warning communication within communities. A scientific approach to the identification of appropriate warning technology was employed for the study. Multi-criteria analysis (MCA) was used to evaluate 18 different technologies against 15 technical criteria (e.g. speed of dissemination) and 13 social criteria (e.g. users operating cost and whether the message delivered is easily understood). The Hawkesbury-Nepean conceptualisation considered not only the relative performance of the technologies but also considered how combinations of technologies could help overcome nine communication barriers. Similarly, the Environment Agency identified seven different scenarios under which warnings will be disseminated in England and Wales (Quinetiq, 2003), which may also be termed barriers to communication (Table 2.6).

Table 2.6 Communication Barriers

Hawkesbury-Nepean Communication Barriers	Environment Agency T15 Project Scenarios
1. Indoors	A: Catastrophic event/short lead time
2. Asleep	B: Travelling user on foot
3. Outside Flood Zone	C: Travelling user in vehicle
4. No Power	D: Travelling user remote location.
5. No Telephone	E: Static person in own dwelling.
6. No Road Access	F: Static person at place of work.
7. No Radio Reception	G: Inter-organisation warnings.
8. Language Other Than English	
9. Hearing Impaired	

Table 2.5 The causes of exclusion

Causes of exclusion	
Involuntary social exclusion	The elderly, the infirm and the blind may not be able to interface effectively with email and text messaging systems while there remain barriers to education in ICT such as lack of English reading skills and technophobia. Any additional costs incurred while fostering access will have to be borne either by the consumer or by central or local government (Crabtree *et al..*, 2003). Marginal groups that achieve access must also ensure that this is sustainable in the long-run. While it may be within the reach of most to 'buy into' the information age now, the continual demand to upgrade in order to receive optimum services is costly in the long-run. Corporate PC hardware upgrades occur approximately once every three years, allowing firms to migrate to superior operating systems and software and to take advantage of faster data transfers (Bisson, 2003). For low-income groups, three years seems an unrealistic refresh interval. As a consequence, newer technologies such as broadband may not be available for some time to those who are still running older PCs with very little processing power.
Voluntary social exclusion (opt-outs)	It does not automatically follow that new technologies will be willingly adopted by potential users as research in media and cultural studies has repeatedly stressed (Featherstone, 1991; Morley, 1992). Dutton *et al.*. (2003) report that around one-third of the British population are exercising digital choice not to use the internet, even though they have home, work or shared facility access. While 96% of the population have internet access (including library or other shared access facility), just 59.2% are current users of the internet, 34.7% have never used it and 6% are former users, having tried the net for, on average, between nine months and a year. This means that among the former users and the never-users are a significant number who have the time and means to go online but choose not to. Notably, only 17% of the over-65s use the Internet (Schofield, 2003)[7]. Recent research also shows that the uptake of 3G mobile telephones has been far less than expected, leaving the main providers surprised that customers do not wish to optimise performance and avail themselves of picture messaging and video services. Three quarters of mobile telephone users still remain on pay-as-you-go contracts to help them control cost and keep aware of how much money they are spending. This, in addition to limited battery life, may mean that mobiles are not switched on to receive warnings, especially amongst less youthful cohorts.
Additional social obstacles to the uptake of media-led flood warnings	
Spam Avoidance	Emails and text messages may frequently be disregarded by users, especially if they are unsolicited. 'Official' messages may also be deleted, unread, especially if sent too frequently. In a busy office environment, what will guarantee that an EA mail marked 'urgent' is actually read? Spam filters, if used, could easily target a mass mailing as a nuisance message and delete it. Particular problems also plague e-mail users that reduce the effectiveness of e-mail alerts, such as viruses.
Market fragmenation	With the advent of digital TV, the market share of BBC and ITV has fallen dramatically, potentially threatening the existing performance of radio and TV as proven mediums for the dissemination of flood warnings. While both organisations have proved effective at bringing breaking news to the UK audiences, what guarantees are there that minority interest channels can be relied upon to issue weather warnings? Additionally, while ITV and BBC provide regional services that can tailor their news output too the needs of regions, this is lost with a digital/cable system that consists of a greater number of channels but none of which offer any regional service.

7 Current users may also not wish to optimise the hardware, software and telecoms that they work with. PC users may not up-grade to the latest Mac or Windows operating system (currently XP) if they are happy with a previous version and this may affect future use of software. Older users who are less likely to demand high performance graphics for gaming may not replace older computers (perhaps lacking a modem) that remain perfectly adequate for basic word processing and accountancy.

The Hawkesbury-Nepean analysis resulted in a recommendation for an integrated flood warning dissemination system involving primary methods to all those affected by flooding, and secondary methods appropriate to each floodplain sector (see Box 2.5).

Box 2.5 **Hawkesbury-Nepean Flood Warning Dissemination Proposals**	
Primary Methods	*Secondary Methods*
• Dial-in only call centre. • Free to air electronic media broadcasts.	• Rural warden system. • Doorknocking in urban areas. • Fixed PA system with alert and notification capabilities.

A pilot study of an 'indoor' flood warning technology is also proposed for the Hawkesbury-Nepean and may be of interest to the Agency given their current proposals for the development of a similar prototype 'indoor' alerting system.

A common recommendation from both the Hawkesbury-Nepean and the Agency (Quinetiq, (2003) studies is that none of the technologies can address all of the identified communication barriers/scenarios and, therefore the adoption of a heterogeneous approach to warning dissemination is proposed which has a mix of technologies to provide as wide an audience as possible.

Other studies have shown that some communication methods suffer from their own unique communication barriers (Gruntfest *et al.*, 2002):

> *"The City of Fort Collins has many avenues for notifying the population-at-risk. Unlike Boulder, they have not installed warning sirens because they fear that people will associate the wailing sirens with tornado sirens and respond by going to their basements. Other drawbacks of siren notification are that siren systems are expensive and many times they cannot be heard by the population-at-risk during periods of heavy rainfall, when inside their homes, or out of the siren range."*

The idea of 'community connectivity' as a barrier or aid to communication is supported by Australian research. The proportion of the community undertaking their work, social and family activities in and around the community is thought to affect people's sense of safety and informal warning communication processes (Betts, 2002). The results of a survey of flood risk residents in the Maribyrnong Community, Australia (Betts, date unknown), found that the importance of neighbours and family was identified as a significant source of information, communication, assistance and shared understanding if there was a situation of the river flooding. Consideration should be given to how these sources can be best utilised to improve the social performance of warning mediums.

2.4 Time

2.4.1 Adoption of technologies

A useful starting point when considering the social performance of flood warning technologies over time is to consider the *diffusion of technological innovations* generally. There are correlations between the literature on diffusion of innovations and the conceptual starting points put forward for this research e.g. in the receptiveness and access to technology, in this case flood warning technologies, over time.

Probably the most well-known model or framework of the diffusion of innovations is that developed by Rogers (1983). According to Rogers (1995: 35), an innovation is 'an idea, practice or object perceived as new by an individual or other unit of adoption'. The diffusion process is largely *a communication process* by which an innovation is communicated through certain channels over time among the members of a social system. The innovation-decision process in which a person passes from first knowledge of an innovation to the decision to adopt or reject it plays a crucial role for the diffusion of that innovation. Some people will learn and adjust to new technologies quickly and painlessly, while others will never learn or adapt to their use (also see Sections 2.2 and 2.3 above).

An important concept in the diffusion of innovations framework is the *innovativeness* of individuals. This refers to the degree to which one person may adopt an innovation compared with another person. Five different groups of adopters (which also link with Section 2.3.2 above on fostering access to ICTs) have been identified for informing different diffusion strategies for each group, these are:

- *Innovators* who are gatekeepers in the flow of new ideas into a social system.
- *Early adopters* who decrease uncertainty about a new idea by adopting it and by then conveying a subjective evaluation to near-peers.
- An *early majority* who deliberately follow in adopting an innovation and who through their position between the early and the late adopters are important links for the further diffusion among the different groups within a social system.
- A *late majority* who often have scarce resources which means that almost all of the uncertainty about a new idea has to be removed before they adopt.
- *Laggards* who are behind concerning awareness knowledge and are most localised in their outlook; they are extremely cautious often owing to their precarious economic position.

The key in getting any idea adopted is to try to hasten the early adopters into adopting; from them (and the more of them the better) others will learn and adopt. The widened gap in the distribution of the fruits of new technology is, according to Jordan (2001), almost certainly a reflection of the fact that not everyone *is* equally prepared or willing to assimilate the technology. Those who assimilate most easily make the most gains and the others fall behind. The new communications technologies seem to be following a similar pattern.

The effect of time on social performance is also exemplified by Studies of Hurricanes Fran and Bertha (Dow *et al.*, 1998), which found that earlier findings on warning response behaviour do not account for current conditions of warning responses. They found that the perceptions of the public are affected by elements that did not exist 30

years ago, including private providers of information such as The Weather Channel and a reduced reliance on top-down information from emergency managers. Their study of "close calls" for Hurricanes Bertha and Fran in South Carolina found that official information is only one of many sources the public uses to make evacuation decisions. A public that once relied solely on the advice of emergency managers, now uses a variety of sources including The Weather Channel, the Internet, and sophisticated graphical images to make evacuation decisions (Baker, 1995).

Time can also affect social performance in both positive and negative ways when considering people's previous experiences. Findings from the BMRB surveys show that those with previous flood experience were more likely to take action upon receiving a warning than those who had not been previously flooded or were living in newer properties, increasing the social performance. Experience of previous floods is a recurring social factor in other studies, for example research in the Loire Valley of France for the OSIRIS project (Blancher, 2001). However, findings from this research showed that experience had a different effect on social performance of flood warnings.

> *"In sectors such as Bec de Vienne, the persons exposed have through time created their own "forecast system", to such an extent that certain persons say they ignore warning information if their observations in the field contradict it."*

> *"After a few years and two or three floods, the newcomers that we met, and those that had arrived several years previously and who told us of their past experience, had established their own conduct and had learned to interpret the levels, look at the river and find reference points."*

The acceptance of new warning communication technology is not always welcomed at first, as it can be insensitive to the basic human need for reassurance during a crisis, as exemplified by one finding of the OSIRIS project:

"Many people feel, that as the request for aid is for reassurance, certain modern techniques are inappropriate: "Very sophisticated communication tools should only be reserved for certain categories of the population, for to example, professionals, etc. More often, the population requires human contact to obtain little details, reassurance, etc. So, if the person is confronted by a pager or a computer screen, well, you know…."

There is however, evidence of increased community acceptance of 'new' warning technologies (in this case a bush fire siren) with time and experience of its operation, and underpinned by a community communication strategy and bushfire preparedness planning (Betts, 2002). Similar strategies need to be implemented for flood warnings.

2.4.2 Technological determinism vs the social shaping of technology

One final factor influencing the social performance of communication technologies over time, and a possible barrier to communications touched upon earlier, is that of the apparent lack of consideration of the socio-cultural contexts surrounding the application and take up of technologies. According to Brown and Damery (2002), UK government policy to date has reflected a highly technocratic approach to flood risk management, which can include flood warnings. The 'information-deficit' model currently used in the UK is said to neglect the socially embedded and contextualised manner in which people

make sense of the world, and onto which individual vulnerability is overlaid. The lay public are said to have a fundamentally different intellectual standpoint from that of the experts, which should be taken into account when technical information about flood risk is disseminated.

Similar criticism has been levelled at the adoption and diffusion approach to the dissemination of innovations. Allen (2000) suggests that the approach has a strong bias towards assuming that a technological innovation is positive, and will be adopted by a target population over time (technological determinism). This tends to blame poor adoption on adopting individuals rather than on systems of situations – the unpredictability of 'socio-technical' ensembles highlighted in Section 2.3.1. Moreover, there is said to be a lack of attention to community and population-level dynamics. The adoption and diffusion approach is poorly equipped to understand how different groups interact in the production and provision of innovation, including the influence of consumers on producers.

The popularity of the S-Curve mentioned in the introduction to this report is understandable when new communications technologies are under discussion. However, the reasons why people adopt or do not adopt new technologies need to be further examined. When a new technology, such as 3G phones, is slow to be adopted, perceived wisdom has it that it is only the lack of a 'killer application' that is preventing fuller uptake. In much of the literature, the designation of late adopters as 'laggards' (a highly pejorative term) suggests that technology is driving society. The benefits are clear, not adopting becomes an act of deviance. Barring overtake by a rival device, we expect these 'deviants' to eventually modify their behaviour, recognising the utility of the technology.

While this approach to modelling innovations is very useful in some contexts, caution is needed when dealing with communications technologies. While certain technologies undoubtedly hold universal utility, there is nothing to say that greater personal connectivity holds such utility. Discourse surrounding multimedia is driven by an industry and media that undoubtedly have a vested interest in fostering heightened connectivity. While the benefits in some areas are undoubtedly proven, choosing a more connected lifestyle is still a matter of personal choice, rather like car ownership, the benefits of which are viewed subjectively according to each individual's own cost-benefit analysis.

Many organisations setting up services for the internet have assumed that, like television in the Twentieth Century, virtually everyone will become a user. However, according to Dutton *et al.*. (2003), internet ownership has a pattern more like car ownership. The general household survey found that 72% of British households had a car or a van in 2001. As with the 28% of households without a vehicle, there are many people staying or turning off the information superhighway. In much of the literature, the designation of late adopters as 'laggards' (a highly pejorative term) suggests that technology is driving society. The benefits are clear, not adopting becomes an act of deviance. Barring overtake by a rival device, we expect these 'deviants' to eventually modify their behaviour, recognising the utility of the technology.

While this approach to modelling innovations is very useful in some contexts, caution is needed when dealing with communications technologies. Results from the Australian

research suggest that the tried and tested warning methods are still often the most preferred by communities, although some people are willing to try new methods if they are proven to be effective and are socially acceptable.

Parker and Handmer (1998), in an examination of flood warning systems which individuals and communities develop in the absence of a formal warning system, or in competition with a formal system that is not liked, advocate identifying the characteristics of warnings which individuals and communities regard as most useful to them. New technologies that are incapable of providing these features are less likely to be effective, for example, it is apparent that flood warning recipients much prefer and find most effective a warning message that permits a dialogue with the sender.

Heinrich (2001) highlights the importance of the socio-cultural context in producing the S-shaped curve and suggests that biased cultural transmission processes are much more important to understanding the diffusion of innovations and socio-cultural evolution than is often assumed. He concluded that individual learning about a technology never produces the S-shaped adoption dynamics typically observed in the spread of novel practices and technologies, but that biased cultural transmission always produces these dynamics. Moreover, he suggests that a combination of individual learning and biased cultural transmission can generate S-dynamics, but only when biased cultural transmission is the predominate force in the spread of new behaviours.

Other recent approaches to technological innovation developed in the social sciences (e.g. Allen, 2000; Kautz, 2000; and Valente, 1996) also highlight the social and cultural contexts of technological adoption. The diffusion of a new product usually takes place in a social setting or social system, either at a national or local level. A social system is a 'physical, social, or cultural environment to which people belong and within which they function' (Schiffman and Lazaaar Kanuk, 1994: 535). Each system has its own values and norms that are likely to influence the acceptance or rejection of new products. If a social system is more traditional (e.g. among ethnic minority groups), innovations that are perceived as infringements on established customs are likely to be avoided.

Allen's (2000) *'social shaping of technology'* approach investigates how organisational, political, economic and cultural issues shape the process of technological change. Social groups with particular visions, interests, and interpretations of reality form complex networks of practice that create and sustain socio-technical systems. This approach argues that technological success has to be explained rather than assumed and that the seemingly "best" technology does not always become the most widely accepted. Allen cites one study which found that adopter perceptions about their relationships with other groups in a factory played a larger role in adoption decisions than did the technology *per se*. The dynamic relationship between all stakeholders involved needs to be considered (Kautz, 2000); and the socio-cultural context of innovation should not be ignored. Nutley and Davies (2000) also suggest that innovations may be adopted without evidence of their effectiveness e.g. in order to seek legitimacy, or due to fads and fashions.

The apparent lack of research on the social performance of flood warning technologies raises the issue of whether a commitment should be made to adopting these technologies without true evidence of their effectiveness. There is a strong argument

that each and every innovation in communication technologies/methods should be properly evaluated for its social performance *before* the Environment Agency commits to it.

Finally, the importance of learning over time referred to in Section 1.3.4 also encompasses the concept of 'Social Learning'. Social learning is about people learning to deal with the interconnected issues of their environment e.g. flood risk within their community. Social learning requires that *the experts and the laypersons* recognise the potentials and limitations of both their own expertise and the expertise of the others, and learn from each other (Kalk and De Rynch, 2002). A key finding from the University of Surrey research, 'Flood Warning for Vulnerable Groups' (Thrush, 2002) was for the need to consider local issues and to use local information, and to retain (or reinstate) local action rather than adhere solely to a national initiative. The issue of local knowledge emerges in the literature as very important regarding the kinds of flood warnings issued, which should consider local populations, situations and conditions. Suggestions of building up local trust within communities and in giving local people a degree of control over their own warning systems appear to be the way forward for maximising the social performance of these systems.

3. RESULTS, ANALYSIS AND DISCUSSION

3.1 Social Performance Matrix

A key objective of this research project (Section 1.2) is to identify the best way to use various warning technologies to overcome barriers to communication and to improve their social performance. The BMRB survey results and other research data explored in Section 2, provide evidence on both access to and willingness to adopt particular warning dissemination technologies. A key outcome of this research project is the linking of this research evidence together to provide a measure of the likely social performance of different warning technologies. These measures then provide a means of guidance for flood warning managers in the selection, deployment and development of warning technologies to enhance social performance. The measures can also inform the recipient community about which warning methods and technologies might be best suited to them.

It is proposed to provide the guidance in the form of a 'Social Performance Matrix', which yields a social performance rating for each flood warning communication technology based upon the primary recipient characteristics, communication barriers and time variables identified by the research. The rating can then be used to rank the technologies by social performance for the at-risk population of England and Wales.

The Agency's Flood Warning Service Strategy identifies three types of warning dissemination method:

- **Individual Warnings:** methods that deliver a warning to an individual e.g. voice, pager, fax, flood warden, knock on door, SMS
- **Community Warnings:** methods that deliver a warning to a community or group of people e.g. sirens, loudhailers.
- **Broadcast Warnings:** warnings disseminated using broadcast methods and not delivered to an individual or community e.g. Floodline, internet, ceefax/teletext, TV, radio.

The Matrix is presented in three separate tables in Appendices A1, 2 and 3, one table for each of the three types of warning dissemination method identified by the Agency. Each technology is given a social performance rating against four primary social performance factors identified by the research, and described in further detail in Section 3.3:

- Socio Economic Group
- Age
- Previous Experience
- Special Needs

3.2 Social Performance Level Indicators

In order to ensure a clear and consistent assessment within the Matrix, social performance level indicators have been defined, which recognise the following factors:

- Access to communication technology
- Willingness to use communication technology
- Whether the evidence is based upon an established track record of use or an estimate of potential for future use.

The "level indicators" recognise that different technologies may have different areas of strength that must be accommodated within the scoring system. For example, a technology that scores highly for access but lowly for willingness is treated the same as another technology that scores lowly for access and highly for willingness.

Four Social Performance levels from 1 (low) to 4 (good) are proposed, as this degree of distinction between levels can be supported by the BMRB survey results and other research evidence. The evidence criterion for each social performance level indicator is defined in Table 3.1.

The BMRB Survey Results provide a good source of evidence with respect to *access* and *willingness* to use different communication technologies. It is therefore appropriate that some guidance is provided to relate the social performance level indicators to the results of the surveys. The indicators are defined by the percentage of respondents that have access to a communication technology (BMRB, 2003b), and in the case of the willingness indicator, either expressed as preference for, or interest in, a particular warning technology in the BMRB Multi Media report, Chart 6.4 (BMRB, 2003d). The percentages chosen to define each indicator recognise the natural grouping displayed in the results and are in keeping with the evidence criterion described in Table 3.1.

It is important to emphasise however, that *the social performance scores given in the Matrix are arrived at by reference to the full range of research evidence available, and not just the BMRB survey results.* The evidence criterion in Table 3.1 is, therefore the definitive measure of social performance and Table 3.2 is provided for guidance only, so that the results of the BMRB surveys, where used, are applied consistently.

Table 3.1 Social Performance Level Indicators

Social Performance Level	Evidence Criterion
Level 1 (Low)	Evidence of **either** little access **or** low willingness to use for receipt of flood warnings amongst the social group in question. Little potential demonstrated by examples of use for warning of other hazards or in other applications or in pilot studies and other countries.
Level 2 (Limited)	Evidence of some limited access **or** some willingness to use for receipt of flood warnings amongst the social group in question but not both. Use may be restricted to certain locales. Some limited potential demonstrated by examples of use for warning of other hazards or for other applications or in pilot studies and other countries.
Level 3 (Moderate)	Evidence of **both** moderate access **and** willingness to use for receipt of flood warnings amongst the social group in question but may still be notably stronger in one area than another. Use may be restricted to certain locales but with a very strong track record in these places. Moderate potential demonstrated by examples of use for warning of other hazards or in other applications or in pilot studies and other countries.
Level 4 (Good)	Evidence of **both** good access **and** high willingness to use for receipt of flood warnings amongst the social group in question, *although not necessarily excelling at both*. Widespread use in a range of circumstances and locales. Good potential demonstrated by examples of use for warning of other hazards or in other applications or in pilot studies and other countries.

Table 3.2 Social Performance Level Indicator Guidance from BMRB Research

Access Indicator	Willingness Indicator (Preference or interest)			
	<5%	<20%	<50%	<100%
<5%	1	2	2	2
<20%	2	2	3	3
<50%	2	3	3	4
<100%	2	3	4	4

NOTES: i. Access Evidence is taken from various BMRB Survey results.
ii. Willingness Evidence is taken from BMRB (2003b) Multi-Media Report, Chart 6.4.

3.3 Primary Social Performance Factors

The research has identified the following four primary social performance factors that affect an individual's access and willingness to use Flood Warning Communication Technology:

- Socio Economic Group
- Age
- Previous Experience
- Special Needs

In addition to the four primary social performance factors above, there are many other social characteristics that may influence social performance, including gender, ethnicity, educational attainment, tenure, and social contexts for instance. There is however, insufficient evidence to justify their inclusion in the Social Performance Matrix or from which to draw meaningful conclusions. Further research in these areas is therefore recommended.

3.3.1 Socio Economic Group

Socio Economic Group (SEG) is a good indicator of an individual's perception of flood risk, especially with respect to their *recoverability*. Recoverability is, in part, based on an individual's 'ability to pay' for the actual cost of recovery, repairing and replacing damaged property and possessions. Wealthy groups will be better able to pay for recovery and/or comprehensive home and contents insurance, and often be more aware of the different warning technologies available.

The Matrix scores against SEG reflect research findings that wealthy groups are better able to afford a wider range of individual and broadcast communication technologies through which to receive flood warnings and flood information. They are also better able to afford 'always-on' tariffs and hence enjoy access to more advanced communication technology.

3.3.2 Age

Age appears to be an important factor in determining an individual's perception of flood risk with respect to *resilience* and *recoverability* and may also indicate access to and willingness to use flood warning communication technology. The Matrix scoring reflects generally equal access to traditional warning methods for all three types of dissemination method. The scores for more advanced forms of communication technology are however, weighted towards the younger cohorts, as indicated in the literature.

3.3.3 Previous Experience

Several pieces of research have shown that previous experience of an emergency is very influential on an individual's perception of risk, especially with respect to their feelings of *susceptibility* and *vulnerability*. The research evidence shows that the response and preparedness for floods improves with experience, including *access* and *willingness* to use warning communication technology.

This is particularly relevant for individual flood warning methods where access by the inexperienced is dependent on whether an 'opt in' or 'opt out' scheme is operated. All the individual warning method scores assume that the current 'opt in' scheme approach is adopted, and this is reflected most strongly in the matrix scores for the inexperienced and experienced.

The Matrix scores reflect the tendency for traditional, individual and community warning methods to be preferred by those without previous experience. Whereas, the benefits of more advanced individual and broadcast communication methods are more likely to appeal to the experienced.

3.3.4 Special Needs

Disability can significantly affect an individual's *resilience* and *recoverability* to flooding and will therefore affect flood risk perception. Different disabilities affect *access* and *willingness* to use specific flood warning communication technologies that may not transmit the warning message in a way that can be received or understood by the recipient e.g. voice messages for the profoundly deaf and facsimile for the blind. It is therefore important to recognise the special needs of this large minority of the at risk population.

The Matrix scores for individual warning methods tend to favour traditional warning methods that involve personal contact, such as flood warden schemes and telephone messages via an operator. These forms of warning are likely to be preferred by those with special needs in order to reassure and provide additional advice and assistance. Certain advanced technologies are however popular with some special needs groups, such as text messaging for the deaf. Community warning methods generally score low because they are unable to overcome the communication barriers of several of the special needs groups. Broadcast warning scores tend to vary from one group to another depending on the relevance of the methods to the group in question.

The research confirms that people with learning difficulties tend to experience difficulties with warning methods that involve reading or using advanced technology. The scores for English speakers tend to be higher across the board for all warning methods except where it can be assumed that the warning method will also operate in the recipient's language of choice.

3.4 Relative Importance of Social Performance Factors

In order to use the Matrix scores to rank each flood warning method for the England and Wales at-risk population, we need an understanding of the relative importance of the social performance factors to each other (age, SEG, Special needs and experience), i.e. are some factors more important than others in determining an individuals *access* and *willingness* to use flood warning technology and hence social performance.

A simple plot of the scores of the options against the different criteria can be revealing (Appendix A4), however when applied to the Matrix scores the result is far too cluttered to be able to see what is going on. Looking at the mean and standard deviation of the scores of the different options for a single social performance factor (e.g. age or SEG group) indicates which factor is most powerful in distinguishing between the options. Figure 3.4.1 presents

the mean and standard deviation of the scores in a radar diagram for all warning methods for each social performance factor. If we look for areas of agreement and disagreement, then:

- No experience of flooding has the lowest mean score, and there is no significant difference in the standard deviation scores between those with or without flood experience. This indicates that lack of previous flood experience is a dominant social performance factor.
- Learning Difficulties and non-English speaking have the next two lowest mean scores. Standard Deviation scores are marginally higher for hearing, visual and learning difficulties relative to other factors. This also indicates that special needs are a significant social performance factor, although the higher standard deviations suggest that solutions tailored to the special need are available.
- Younger groups have higher mean scores than older groups, although the range of variation of the mean between age groups is not as great as that between special needs and previous flood experience groups. The over 55s have a relatively high standard deviation. Age is a significant social performance factor but not as dominant as special needs and previous flood experience. The relatively high standard deviation suggests that some methods have a good social performance score for the over 55s.

Those in higher Socio Economic Groups have higher mean scores than the lower SEGs. There are marginally higher standard deviations for SEG D & E. The range of variation of the mean between SEGs is similar to that of the Age groups and SEG is therefore a significant social factor but not as dominant as special needs and previous flood experience.

In summary, the percentage of at risk population who speak English, are between the ages of 16 and 34, are in SEG A or B, and who have been flooded in the past are more likely to have access to and be willing to use a wider range of flood warning communication technologies. In contrast, those with special needs, who are over 55, are in SEG D or E and have not been flooded before are far less likely to have access to or be willing to use the full range of flood warning communication technologies. Appropriate warning methods are available however, for specific special needs and the elderly, but previous experience of flooding may be the dominant social performance factor which reduces an individual's willingness to adopt flood warning technology altogether.

Given that the choice of warning method depends largely upon the special needs of the recipient and their previous flood experience, it is appropriate to evaluate the social performance of each technology for the general at risk population and then separately for the relatively small proportion of the at risk population that have special needs.

3.4.1 Social Performance Factor Weighting

Comparison of the social performance factors has shown that flood experience is a dominant factor. The mean social performance scores and variation of scores within the age and SEG are similar, which suggests that they are of roughly equal importance in terms of social performance. There is therefore justification for increasing the weighting of the flood experience scores in order to arrive at a true ranking of warning methods for the population at risk. The question however, is what additional weighting should be given to flood experience. If we compare the mean scores of those previously flooded (2.7) with the mean scores for those not previously flooded (1.6) we have a ratio of 1.7 i.e. the average social performance of warning technologies is 1.7 times greater amongst the previously flooded than amongst

those without previous flood experience. Given that the scores for age and SEG are irrespective of flood experience, then a weighting of 1.7 for the flood experience factor scores seems appropriate.

In addition, each social performance score has been weighted using the BMRB at-risk population statistics (BMRB, 2003a) for each of the social performance factors. For example, the social performance score for the door knocking method amongst the Not Previously Flooded group (4) has been multiplied by the percentage of the at risk population who have no previous of flooding (90%) and the flood experience weighting factor (1.7) to arrive at a weighted social performance score (4 x 90% x 1.7 = 6.12).

3.5 Social Performance Rankings

The social performance Matrix is, due to its size and complexity, difficult to interpret and understand. We have therefore, used a number of different methods to analyse the Matrix scores, present the results and draw meaningful conclusions. Green (2003) proposed a number of graphical techniques that do not assume that a ratio scale of measurement has been achieved and which allows us to explore the nature of the choice.

The first of the techniques is to plot the mean rank against the standard deviation of the rank of each option. A high standard deviation indicates that the option performs very differently against the different criteria; the mean rank how well on average it performs against those criteria. Hence, if one option has the highest mean rank and a standard deviation of zero then it is the best option in terms of all of the criteria.

The second technique is to plot the mean score against the product of the scores, weighted in each case if weights are used. This can show two things. Firstly, whether the weights matter. Secondly, it picks out the options that score badly upon one or more criteria. If the same options come out as best when additive (mean) and multiplicative (the product) approaches are adopted then these options are to be preferred to all others.

3.5.1 Ranking of Warning Technologies for the General At-risk Population

The fact that 90% of the at-risk population have no previous experience of flooding and that this factor attracts additional weighting means ‘no flooding’ heavily influences the social performance rankings of each technology when considering the general at-risk population of England and Wales. The following is a discussion of the results for each warning method type (Individual, Community and Broadcast)

3.5.2 Individual Warning Methods for the General At-risk Population

The results for Individual warning methods are presented in Appendix A5 and Figures 3.5.1 and 3.5.2. Letters have the highest mean rank and lowest standard deviation suggesting that they are the best performing across all groups, closely followed by telephone operators. Door knocking and flood wardens however, have the highest mean score because they perform well over all performance factors but especially with those who have no previous experience of flooding. The next highest ranking option is Mobile fixed tariff text messaging but its high standard deviation reflects that its performance is limited to the younger and more affluent cohorts. Amongst the remaining options, variants of automatic voice messaging and in-home

alerts have a high mean rank which is limited only because those who have no previous experience of flooding are unlikely to 'opt in' to such schemes in the first instance. Email (always on) and Mobile PAYG text and fixed tariff voice messaging have moderate potential because of high scores amongst young and affluent groups. Pagers and facsimile perform consistently poorly across all factors.

3.5.3 Community Warning Methods for the General At-risk Population

The results for Community warning methods are presented in Appendix A6 and Figures 3.5.3 and 3.5.4. Dedicated public address systems are the best community warning method with a very high performance rating amongst all groups. Mobile loudhailers also perform well but are likely to be less popular amongst those with previous flood experience who are aware of more effective individual warning methods. Sirens perform moderately well with all groups but signage performs poorly across the board.

3.5.4 Broadcast Warning Methods for the General At-risk Population

The results for Broadcast warning methods are presented in Appendix A 7 and Figures 3.5.5 and 3.5.6. Radio and its variants (RDS and radio alerts) are the best performing broadcast warning methods. SMS cell broadcasts have a high average score but also a relatively high standard deviation reflecting its potential amongst the younger and more affluent cohorts but poor performance amongst those that have not previously flooded. TV Broadcasts and crawlers, dial and listen and broadband always on services all perform moderately well, but broadband always on suffers from a high standard deviation, reflecting patchy performance amongst different groups.

TABLE 3.5.1: Social Performance rankings and mean scores of flood warning communication technologies for the general at-risk population of England and Wales								
Mean Rank	**Individual Warning Methods**	**Mean Score**	**Mean Rank**	**Community Warning Methods**	**Mean Score**	**Mean Rank**	**Broadcast Warning Methods**	**Mean Score**
1.3	Letters	1.17	1.00	PA systems	1.85	1.00	Radio	1.65
1.4	Telephone operator	1.02	1.13	Mobile loudhailer	1.82	1.50	Radio Data Systems (RDS)	1.34
3.9	Wardens	1.31	2.00	Flood sirens (No voice)	1.19	2.38	local radio alerts	1.06
4.3	Door-knocking	1.26	3.75	Signage e.g. flashing signs	0.71	2.88	SMS Cell Broadcast	0.96
4.4	Mobile Fixed Tariff Text	0.77				4.63	TV broadcast	0.85
4.6	AVM	0.80				4.63	TV Crawlers	0.85
4.6	Integrated dial-&-listen & AVM	0.80				5.13	Dial-and-listen services	0.74
4.6	Automatic alerts	0.80				5.38	Broadband "always on"	0.92
4.6	In-home alert	0.80				6.25	Dial-in Internet Services	0.68
5.3	Email - Always on	0.76				7.38	Cable TV Voice over ride	0.58
5.5	Mobile PAYG Text	0.75				8.63	Teletext	0.52
5.6	Mobile fixed tarrif Voice	0.69						
6.3	Email - Dial in	0.72						
9.0	Mobile PAYG Voice	0.64						
11.9	Facsimile	0.55						
14.0	Pagers	0.37						
17.0	Minicom	0.00						

3.5.5 Summary of Ranking for the General At-risk Population of England and Wales

Table 3.5.1 presents each warning technology in social performance rank order based on its mean rank across all factors.

The rankings in Table 3.5.1 confirm a preference for traditional tried and tested technologies such as telephone operators, letters and flood wardens. It is important to stress however, that the rankings are a pure measure of social performance and not technical performance. Warnings delivered by letter have the highest social performance ranking for an individual warning technology but are unlikely to be either technically or economically feasible for all of the properties at risk within England and Wales.

Furthermore, the rankings are provided as guidance for the strategic selection and development of flood warning technologies in England and Wales and are not intended to be used to discount any particular method as a flood warning method either now or in the future. Selection of an appropriate warning method for a specific site would need to be based upon the recipient characteristics and technical considerations of that site.

3.6 Warning Technologies for Special Needs Groups

When considering the social performance of warning technologies for special needs groups we are less interested in the average performance of the technology over the full range of special needs and more interested in which particular technology meets which special need. The evaluation has therefore been undertaken by a straight comparison of the social performance scores, without additional weighting given to any one special need over another. The mean and standard deviation of the scores has also been presented as an indicator of how different methods perform across the range of special needs. The results are presented in Appendices A8 to A10 and Figures 3.6.1, 3.6.2 and 3.6.3 for individual, community and broadcast warning methods respectively.

3.6.1 Individual Warning Methods for Special Needs Groups

Several methods are appropriate for Non-English speakers without there being a clear favourite. Flood Wardens is the most appropriate of the traditional methods assuming that the warden speaks the language of the recipient. Of the advanced technologies automatic voice messaging, text messaging and in-home alerts have a high potential for non-English speakers assuming the technology automatically translates the message into the recipient's language of choice.

Written warning methods perform well for those with hearing difficulties, although minicom also performs well. The scores reflect that text messaging is an increasingly popular form of communication amongst those with hearing difficulties.

Traditional methods such as door knocking, flood wardens and telephone operators perform well for those with visual difficulties because of the personal contact and support that is associated with these methods. Voice messaging also scores well but lacks the personal re-assurance offered by the more traditional methods.

Similarly, traditional methods involving personal contact and re-assurance perform well for those with mobility difficulties. All warning methods tend to perform better on average for this group as the nature of their disability does not generally preclude access to any of the methods.

Traditional methods involving personal contact also perform well for those with learning difficulties as these methods ensure that the message is received and understood and may also support the recipient in taking effective action. Written and advanced technology solutions perform particularly poorly for those with learning difficulties.

Overall traditional methods of door knocking, flood wardens and telephone operators have the highest average scores for all the special needs groups because of the re-assurance and support available to the recipient as a result of personal contact. Voice messaging, text messaging and in-home alerts also show potential across the range of special needs groups. Pagers have a very low rating.

3.6.2 Community Warning Methods for Special Needs Groups

Community warning methods perform particularly poorly for special needs groups because they are delivered in a way that does not overcome the special need of the recipient and, on their own, they provide no additional support or clarification to the recipient.

3.6.3 Broadcast Warning Methods for Special Needs Groups

Many broadcast warning methods perform poorly for non-English speakers as the broadcast is unlikely to be in the language of their choice. SMS cell broadcasts offer the greatest potential for this group assuming that the recipient has signed up to the service and the message is delivered in the language of their choice. Translation technology also means that services such as Floodline and internet based services also have potential with the non-English speaking population.

SMS cell broadcasts also have a high potential amongst the population with hearing difficulties. This group also favours visual warning methods such as TV broadcasts over radio broadcasts. The opposite is true of those with visual difficulties.

All broadcast warning methods tend to perform better on average for those with mobility difficulties as the nature of their disability does not generally preclude access to any of the methods. In addition, their immobility may mean that they are more likely to be at home tuned into broadcast methods, and in particular radio.

Advanced technology broadcast methods perform poorly for those with learning difficulties but more traditional TV and radio broadcasts perform better.

Overall, radio performs better on average than any other methods closely followed by TV broadcasts. SMS cell broadcasts shows great potential as a broadcast method for special needs groups.

4. THE APPLICATION OF SOCIAL PERFORMANCE INDICATORS

The question remains "how to use social performance to select, deploy and develop flood warning services in the future". The answer is twofold:

- firstly, social performance should be used to inform the strategic development and selection of warning dissemination methods and,
- secondly, social performance factors should be included with technical evaluation criteria when selecting a warning method at the local level.

4.1 Strategic Uses

It is apparent from the social performance rankings that the technologies with the best social performance do not necessarily provide the best technical solution, being either too costly (to the operator) and/or impractical for wide scale national use. The Agency has already made a strategic decision to invest in Floodline Warnings Direct, a highly technological solution to the warning dissemination problem. It is clear from the research that if the benefits of the Floodline Warnings Direct service are to be attained, then the social performance of its various dissemination methods must be explored and improved, especially if the sign up to the warning system remains voluntary.

A number of initiatives for improving social performance have been highlighted by the research:

- Demand aggregation – combining forces with other government agencies to offer a wide range of services, including flood warning, and therefore make take up of a particular technology more attractive or even essential. For example BT have set different targets for Broadband provision for different exchanges (from 150 to 500 customers are needed before provision). The Agency could correlate these exchanges with their own maps/databases and help canvass, maybe in exceptional cases aiming to lobby to lower the threshold demand for high-risk floodplains.

- Encourage the diffusion of warning technology innovations by targeting campaigns at the 'early adopters' and the 'early majority' so that the take up of the new technologies is as fast as possible. Such campaigns may include identifying and engaging 'Local Champions', 'Change Agents' and 'taskforce campaigning'.

- In relation to the above, harness the role of young people in speeding up technical innovation within households and communities, especially once they have been accustomed to broadband applications at school.

- Flood Awareness Campaigns should continue to aim to influence the individual's perception of flood risk by focusing on their susceptibility, vulnerability, resilience and recoverability. For example, the recent fire alarm campaign played on all four perceptions when urging people to check and change fire alarm batteries. A similar message could be utilised to encourage sign up to flood warning systems.

Separate evaluations of the various warning dissemination methods (Quinetiq, 2003 and Molino Stewart undated) have concluded that no single warning technology can overcome all the technical barriers to flood warning communication. This is also the case when considering the social barriers, and so the Agency's flood warning dissemination strategy will need to adopt a heterogeneous approach where layers of complimentary technologies are adopted to optimise dissemination effectiveness.

4.2 Local Selection Criteria

In Section 3 we present a number of social performance matrices, the measures in which may be used to guide the selection and deployment of flood warning technologies in communities in which recipient characteristics are known and understood. In theory modified forms of these matrices will also be of use to flood warning recipients considering which warning technology to select from the various options made available by the Floodline Warnings Direct, and could be accessible through the Agency's website.

The Agency's aim is to maximise the number of people receiving a timely and accurate flood warning. To achieve this, the warning method or combination of methods chosen must be both technically and socially appropriate. Local selection of warning methods has historically been based on technical criteria only, with little or no regard for social performance. Guidance with a step by step methodology for the selection of warning methods at the local level is needed that addresses both the technical and social issues. The methodology adopted for the Hawkesbury-Nepean Valley in Australia (Molino Stewart undated) may be adapted to reinforce social performance criteria and include the dissemination scenarios from the T15 Reports (Quinetiq, 2003).

The selection of a suite of warning technologies for a given community would start with gathering information on the recipient characteristics (age profiles, SEG, special needs, flood experience) and communication barriers (access to broadband, mobile phone coverage, flood warning lead time, language) relevant to the community in question. This could be achieved through (revised) existing BMRB surveys, Census data or social services data where available. This information is then used to perform a Multi-Criteria Analysis (MCA) to arrive at a short list of options. MCA is a mathematical technique for comparing a large number of options with diverse outcomes. It provides a systematic methodology for ranking options where performance criteria are measured quantitatively and qualitatively. MCA does not make decisions or give an answer but is a tool for decision making which allows large amounts of information to be analysed and sorted in a way that makes comparisons clearer.

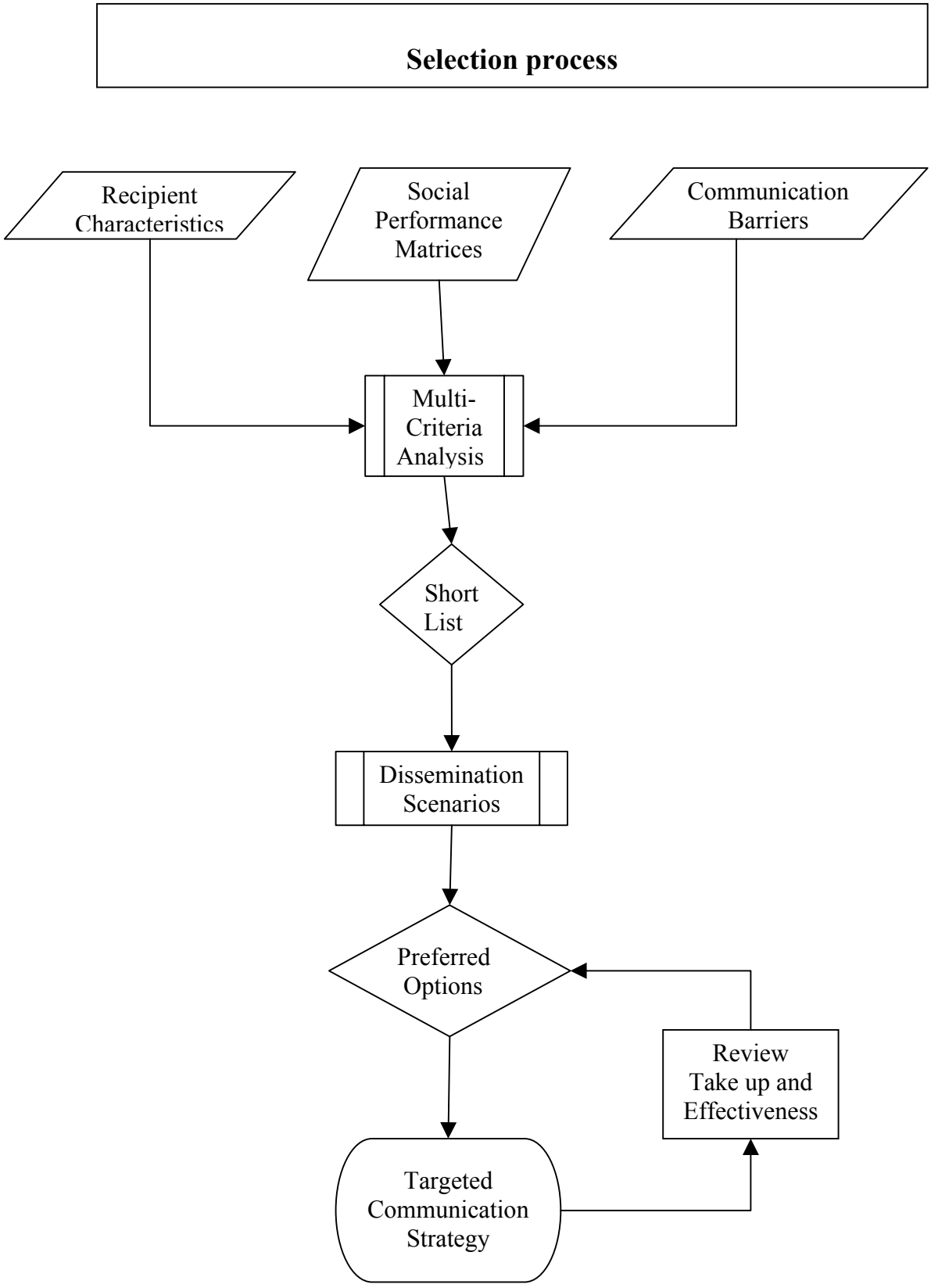


Figure 4.2 Flood warning communication technology selection process

The short list would then be tested against various dissemination scenarios, see Figure 4.2 to arrive at a list of preferred flood warning dissemination options for the community in question. The combination of methods that optimises both technical and social performance for any given dissemination scenario would be adopted and supported with a targeted communication programme to encourage take up and use. Reviews of take up and use of the selected methods would be essential to identify changes in the community and the need for improvements.

5. CONCLUSIONS

Although existing research into the social performance of flood warning communication technologies is limited, we have found evidence that social performance is a considerable factor in governing the effectiveness of warning technologies and is primarily determined by four factors: the flood warning technology itself; recipient characteristics; communication barriers and variation over time.

Considerable research has been found regarding the availability, technical performance and functionality of the various warning dissemination technologies. The new and emerging technologies offer significant benefits to the operator, from better speed of dissemination to improved cost effectiveness, yet take up of new warning technologies is poor and international surveys confirm UK experience that warning recipients prefer the tried and tested traditional methods. There is evidence of increased community acceptance of 'new' warning technologies with increased time and experience of operation, but this needs to be underpinned by a community communication strategy and preparedness planning.

An individual's perception of risk is a communication barrier that directly affects their access to and willingness to use flood warning dissemination technology. Various recipient characteristics may be used as indicators of an individual's perception of risk, the primary ones identified through the research being; age; SEG, experience and special needs. Previous experience of flooding appears to be a dominant factor, because of the associated increase in perception of risk to the individual. There are also a number of other locally specific physical and political barriers to communication including hydrology, ICT provision and the presence of change agents.

The complex interaction of all of the above factors results in what is defined here as Social Performance. We have found however that social performance is not a constant measure as it varies over time due to changes in technology, improvements/deterioration in infrastructure, and changes in risk perception, socio-cultural influences, and familiarity with technology due to experience and learning within the community.

The primary social performance factors have been used to create a simple model of social performance, the Social Performance Matrix. The Matrix confirms that the challenge for the Agency is to improve the social performance of the new and emerging technologies that are the spearhead of the proposed Floodline Warnings Direct. It further supports the concept that a heterogeneous approach to flood warning dissemination is required utilising a number of complimentary communication methods.

6. RECOMMENDATIONS

The following recommendations are made:

1. Future selection of flood warning methods should be based on achieving optimum technical *and* social performance across a range of dissemination scenarios, as described in Section 4.2. This will entail adoption of a heterogeneous approach to flood warning dissemination using a selection of complimentary methods based on the specific characteristics of each community.

2. In terms of social performance, it is necessary to distinguish between individuals and communities of high and low perceived flood risk. For example, there is low take up of the AVM service (where it is offered) because of the low level of perceived flood risk in many areas of the UK.

3. In light of the above, continue a public awareness programme that increases the public's perception of flood risk, and particularly target campaigns to those living in high risk areas.

4. More data on, and understanding of, warning recipient characteristics is needed. It is suggested that BMRB include more questions on these characteristics in future surveys.

5. The local socio-cultural context surrounding the application and take up of technologies within specific populations should be considered. Identify the characteristics of warnings which individuals and communities regard as most useful to them, to encourage take up and adoption. This could be achieved by the use of techniques such as focus groups or in-depth interviews with individuals, community representatives or those from groups with special needs. Every innovation in warning communications technology should thus be properly evaluated for its social performance *before* a commitment is made to it.

6. Seek to increase the social performance of new and emerging technologies available through the Floodline Warnings Direct by:
   - making access to flood warning technologies more desirable/essential by 'demand aggregation' initiatives with other agencies;
   - encouraging the diffusion of warning technology innovations by targeting campaigns at the 'early adopters' and the 'early majority' so that the take up of the new technologies is as fast as possible. Such campaigns may include identifying and engaging 'Local Champions', 'Change Agents', 'Change Aids' and 'taskforce campaigning'.
   - Creating more awareness of warning technologies among the later adoptees, perhaps by tailoring messages especially for these groups using appropriate communication channels.

7. Monitor the social performance of flood warning methods over time to input into future decision-making. This could be done by collecting relevant data in future at risk, post event and omnibus public opinion surveys e.g. access and willingness to

use different warning methods by age, SEG, special needs, experience, gender, ethnicity, educational attainment and at different times of the day.

8. In order to fine tune the Matrix it is suggested that a pilot selection process in three communities be carried out, each with its own distinct set of communication barriers and social characteristics, for example: an inner city community; a rural town and an isolated village. Revise the selection guidance in light of the results and publish step by step guidance for flood warning managers.

9. Develop web based self selection guidance for use by flood warning recipients, enabling them to select the method(s) that are most suitable for their own situation.

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GLOSSARY

2G mobile phone Second-generation digital wireless communication allowing SMS (text messaging).

2.5G mobile phone An extension to *2G* technology allowing *WAP* (mobile internet) and limited *MMS* (picture messaging) usage.

3G mobile phone Third-generation wireless communication with significantly greater *bandwidth* than its predecessors using *broadband*.

ADSL Asymmetric Digital Subscriber Line. Depending on how far a home is from the telephone exchange, this broadband service will typically provide up to 2 mbps speeds (15 times faster than *ISDN*) download. This is ideal for workers who need to move large files – including drawings or graphics - from home to office or vice versa. The upload speed (sending files) is not as fast, normally 512 kbps but this is still twice as fast as ISDN. The main advantage of the system is that no re-wiring is necessary, old telephone lines will do.

Analogue There are two main categories of voice telephone: analogue and digital. Analogue telephones operate with electrical signals that have a direct frequency and amplitude relationship to what is spoken and heard. In digital telephones speech is converted to binary patterns of digital pulses. The digital signals are converted back to audible speech at the handset receiver. So even though digital information is transmitted, the signals coming from, and going to, the handset remain analogue.

Bandwidth The rate at which information can be transmitted and received is determined by the computer's central processor, its modem speed and the network's bandwidth. Measured in kilobits per second (kbps) or megabits (mbps).

Bluetooth A way of connecting a range of electronic devices wirelessly over short distances (just a few metres).

Broadband A high capacity data stream such as *ADSL*. At least 512 kbps is usually associated with true broadband.

Dial up Otherwise knows as POTS (plain old telephone service). This is the basic service used by 90 per cent of the population in the UK (in 2001) to connect to the internet. All that is required is a PC and a *modem* which connects to a standard telephone line. The maximum speed is 53 kbps which is fast enough for using e-mail and browsing the occasional web-site.

Digital See *Analogue* entry.

E-commerce Doing business electronically using structured messages (electronic data interchange), unstructured messages (electronic mail) and databases.

E-mail The first electronic mail message was sent in 1972. Now, almost anything can be transmitted digitally, including word-processed documents, spreadsheets, graphics files, and digital sound (often in the MP3 format).

GPRS General Packet Radio Service. The high-speed technology that allows internet access through a mobile device (see *2.5G* and *WAP*).

GSM Global System for Mobile Communications. The International/Pan European operating standard for *2G* digital cellular mobile telecommunications. This enables mobile phones to 'roam' across country boundaries, accessing international mobile networks on the same number and being billed on one invoice.

IM Instant Messaging. Using the internet (usually at work) to maintain real-time contact with friends without using dedicated emailing software.

ISDN Integrated Services Digital Network. One step up from POFS in terms of speed, ISDN has long been the staple, if somewhat pricey, alternative to the standard dial-up service. Basic ISDN offers up to l28 kbps speed, with a super quality digital telephone service tacked on. This gives high speed connectivity between ISDN users, and a flexible phone service which will switch automatically from internet access to voice as needed.

Leased line Competitive pressures are driving down the cost of dedicated leased lines all the time, and have several advantages. With a separate leased line there is no competition with other household members or business partners for use of the existing telephone line. Top speeds are likely to be around the l28 kbps mark.

MINITEL Introduced into French homes in the 1980s, this provides a 'Yellow Pages' type service using a standard dial-up connection. Other low-tech networks that have subsequently been absorbed by the Internet include FidoNet and Bitnet.

MMS Multimedia Messaging Service. Allows picture-messaging and video-messaging using a *3G* mobile phone.

Modem (MOdulator/DEModulator) Hardware which converts digital data from a computer into a format that can be transmitted down traditional telephone lines to other computers. It also translates incoming data.

Moore's Law Describes how processor chip power doubles over successive short time intervals. Each leap forward in a specific field amplifies the effects of related information technologies, in a synergistic process. Mobile telephony relies on computing powers to route the messages but in term revolutionizes the computer/user interface.

MP3 A compressed audio format, typically requiring one tenth the data storage and transmission capacity of CD-quality sound but maintaining much of the original source sound's integrity**.**

PDA Personal Digital Assistant ('palm top'). Powerful mobile devices capable of running a dedicated version of Windows.

PSTN Public Switched Telephone Network, the fixed (i.e. wired telephone system as connected to homes and businesses throughout the UK.

SMS Short Messaging Service. An incredibly popular service that allows short text messages of between 140 an 160 characters to be sent to a *2G* or *3G* phone.

TCP/IP Transmission Control Protocol/Internet Protocol. The standard set of protocols used by the Internet for transferring information between computers. It divides data into packets that are then reassembled by the software when they are received. A kilobyte is a thousand bytes of information; a megabyte, a million; a gigabyte, a billion; a terabyte, a trillion.

WAP Wireless Application Protocol. The standard method of accessing the internet from a mobile device (see *2.5G*).

Wi-Fi Wireless Fidelity ('802.11b technology'). A standard for high-speed wireless networking, with access points now installed in many hotels, airports and coffee shops that allow laptop and mobile device users easy internet access.

WLAN Wireless Local Area Network. Access to an organization's internal network that is achieved through use of a mobile device.