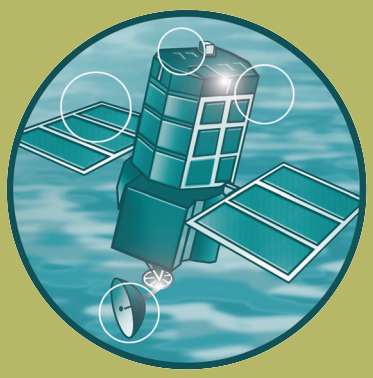
Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Development of economic appraisal methods for flood management and coastal erosion protection

Objective 13: The damage reducing effects of flood warnings: results from new data collection

R&D Technical Report FD2014/TR1



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Development of economic appraisal methods for flood management and coastal erosion protection

Objective 13: The damage reducing effects of flood warnings: results from new data collection

R&D Technical Report FD2014/TR 1

Produced: July 2006

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Statement of use

Dissemination status: released to public domain

Keywords: ***Floods; flood damage; warnings; performance***

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www.defra.gov.uk/environ/fcd

PB No. 12146

ACKNOWLEDGEMENTS

We are grateful to Defra, the Environment Agency and to the Project Advisory Group for their comments and for the support given to this research under Project FD2014. Thanks are due to the residents affected by flooding who participated in the surveys and focus groups, to Ed Griffiths and others at the Environment Agency for their assistance with the research, in particular arranging for collaboration on the Phase 1 survey, and to Environment Agency officers in the areas who assisted in drawing up the sample for the Phase 2 survey. The contribution of the staff at the two survey organisations that managed and carried out the surveys, BMRB and MORI, is also much appreciated. At FHRC, help and advice were received from Dennis Parker, Clare Johnson and Theresa Wilson.

EXECUTIVE SUMMARY

Objectives of this research

This report presents the results from research carried out to meet objective 13 of Defra/EA project FD 2014 'Development of economic appraisal methods for flood management and coastal erosion protection'.

This objective required us:

- To examine, and further develop as necessary, the model of the economic benefits of flood warnings set out by Flood Hazard Research Centre (FHRC) researchers (CNS Scientific and Engineering Services, 1991; Parker, 1991) in the light of recent research.
- To review and refine methods for collecting data on damage reducing actions taken by households associated with flood events and warnings.
- To carry out research to produce a new data set to be used to calibrate the model.

The model of economic benefits of flood warnings

FDA = PFA x R x PRA x PHR x PHE
Where:

FDA =	**Actual flood damage avoided**
PFA =	**Potential flood damage avoided** (property plus road vehicle damage avoided was specified in 1991 but vehicles have not been included in this analysis)
R =	**Reliability** of the flood warning process (i.e. the proportion of the population at risk which is warned with sufficient lead time to take action)
PRA =	**Availability:** the proportion of residents/households available to respond to a warning
PHR =	**Ability: t**he proportion of households able to respond to a warning
PHE =	**Effective response:** the proportion of households who respond effectively.

Research methods

The following research was undertaken to meet the objectives.

- A review of national and international literature on the economic benefits of flood warnings and on public responses to flooding and flood warnings.
- Five focus group discussions with flood affected residents to develop survey methods and test survey materials, in particular a checklist of household contents damaged and saved by residents actions.
- Surveys in two phases with flood affected residents. The first phase was conducted in collaboration with the Environment Agency's post event survey of flooding in 2003/4. The second phase focused on residents affected by flooding since September 2000 in 19 areas in England. A total of 446 affected properties were included in the combined survey data set (168 in Phase 1 and 278 in Phase 2). The data from the two surveys

were combined for the analysis and the analysis focuses on 341 residential properties whose built property was affected by flooding and thus whose household content could have been damaged or saved from damage in the recent event.

Review of survey research methods to collect data on the damage reducing effects of flood warnings

- The research was innovative but not entirely successful in attempting to estimate the £ value of the potential flood damage avoided (PFA) and the £ savings of residents with built property affected by flooding (FDA). Survey respondent were asked to tick items on a checklist that were damaged and saved and £ values were attached to these items. The surveys produced £ values for the potential flood damage avoided that were about half the values that were found in the latest Manual data (Penning-Rowsell, *et al*, 2005) probably due to the simplified methods used for estimating the monetary values in order to ensure that the interviews were not too long and burdensome for the respondents and too costly for the project.
- The £ value of reported property saved and the proportion of property at risk saved provide the measures of Flood Damage Avoided (FDA) used in the survey tests of the model. Although the £ values of savings and of property at risk derived through the surveys may understate the real £ value, the information on the proportion of property saved and the comparisons across groups remain valid, because the same methods were used to obtain damage and savings data and across all the groups in the surveys.
- The surveys indicate that it would be preferable to use a checklist of sources of warning to define this key warning variable in the surveys since there is evidence in this study that some residents will not mention warnings received, particularly unofficial ones but also AVM messages, without being prompted. Without a checklist, respondents interpret what is meant by a warning differently.
- It is useful to differentiate in the survey questions between being registered on the AVM at the time of the interview and at the time of the recent flood, in order to be able to evaluate the contribution of AVM registration to the success of flood warning dissemination.
- The focus group discussions were a significant source of insights to aid in understanding the complexities of resident's responses to flooding and flood warnings.

Receipt of a flood warnings (R, PRA) and damage reducing action (FDA)

- Only 38% of residents received what they regarded as a flood warning of any kind (from official or informal sources) in the events surveyed. The research confirms that warning dissemination is currently unlikely to reach more than 40% of properties affected.
- The research supports the assumption of the economic benefits model that warnings are important for damage saving. Those warned tend to be, but are not always, more likely to take action and to save more. However, many residents take action without a warning on the basis of their own judgement, prior experience and common sense.
- The average £ value of savings reported were:

£2,373 for the warned,
£1,552 for those not receipt of any kind of warning
£1,860 overall on average.

Thus the £ savings of those not in receipt of a warning of some kind were only about two-thirds of the value of those of the warned. It could be argued that the benefit of a warning should be taken to be the difference between savings with and without a warning rather than the total savings with a warning.

- The source of the warning, whether the warning comes directly from an official source or from informal contacts does not appear to be of significance.
- Receiving an event specific warning, rather than merely being in a serviced area appears to be a factor in damage reducing action.
- A longer warning lead time was both in the regression analyses and in the residents' views a crucial factor. Those with a prior warning of less than eight hours saved on average only two thirds of the £ value of savings achieved by those with a longer warning.
- The content of warning messages is important. Survey respondents cited more specific and informative warnings as a feature that would enable them to save more and warnings regarded as 'very informative' were associated with greater savings. Information on the timing of the peak flows and more detailed location specific warnings were requested in the focus groups discussions.

Ability to take action (PHR) and damage reducing action (FDA)

- The research does not support the assumption of the economic benefits model that those in vulnerable households including those with disabilities and health problems or living alone will be unable to take damage reducing action. However, household vulnerability did emerge as a factor exerting some negative influence on damage saving achieved in the regression analyses.

Some other factors affecting damage reducing action (FDA)

- **Outside help:** help from outside the household played a part in reducing damages. Vulnerable households were no more likely to attract such help than other households. Help came largely from informal sources: from neighbours, friends and family. This is an area in which community groups, voluntary organisation or local authorities could provide support that could contribute to reducing the damages incurred.
- **Flood experience:** the research demonstrated again the importance of flood experience as a factor in response to flooding and to flood warnings. Those who had had past experience of flood waters in their home made greater savings than those without that experience. Indeed, as the focus group discussions showed, in some cases they had well rehearsed routines for moving and raising property.

The data illustrate the paradox that warnings are most beneficial and most needed in areas where there is little experience of flooding, which are the areas and events for which it is most difficult and least common to provide warnings. Enhancing warning

capacity for these areas and events, however, will yield greater benefits than will be achieved in areas where flooding is frequent and residents experienced.

- **Complexity of residents' responses:** the regression analyses and focus groups indicate how complex are the influences upon residents' damage reducing action in the event of flooding. The influence of a large number of independent variables hypothesised as potentially significant in our theoretical model was examined. However, the regression models were only able to explain a small amount of the variance in flood damage savings (12-13% adjusted R^2).

The damage reducing effects of flood warnings: a new approach

A new approach to establishing the damage reducing effects of flood warnings is presented in the 'Multi-coloured Manual' (Penning-Rowsell *et al.* 2005). The approach is summarised in Executive Summary Table 1. This shows that Potential Flood Damage Avoided (PFA) has been calculated in a different way: Potential Inventory Damage Items have been estimated as representing 52% of Total Potential Damage on average. It has also been estimated that, on average, only 41% of Potential Inventory Items are moveable. Thus, only 21% of Total Potential Damage could be avoided even with 100% success in warning and 100% effective action by property owners.

The new approach, in estimating the damage reducing effects of flood warnings, takes into account two additional factors:

- Receipt of a warning (R and PRA in the economic benefits model) (38%).
- The proportion of property at risk saved with a less than 8 hour warning (55%) and with a warning of 8 hours or more (71%).

These percentages were derived from the survey data.

Executive Summary Table 1 Flood warning damage reduction

Item	Description	% (Y)	£ (X) Example	Calculation
A	Total Potential damage (TPD)	100	30,000	
B	Potential Inventory damage (as a % of TPD)	52	15,600	BY*AX
C	Moveable Inventory damage (as a % of Potential Inventory damage)	41	6,396	CY*BX
D	Households in receipt of a warning	38		
	Effectiveness of :			
E	< 8 hour warning	55		
F	> 8 hour warning	71		
	Total Potential damage saved by:			
	< 8 hour warning	4.46	1,337	AY*BY*CY*DY*EY
	> 8 hour warning	5.75	1,726	AY*BY*CY*DY*FY
	Potential Inventory damage saved by:			
	< 8 hour warning	8.57	1,337	CX*DY*EY
	> 8 hour warning	11.06	1,726	CX*DY*FY

How these figures are applied will depend on the scale of the analysis being conducted and the level and detail of the data available as described in full in the ‘Multicoloured Manual’ (Penning-Rowsell *et al.* 2005).

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This objective in Defra/EA Project 2014 required us:

- To examine, and further develop as necessary, the model of the economic benefits of flood warnings set out by Flood Hazard Research Centre (FHRC) researchers (CNS Scientific and Engineering Services, 1991; Parker, 1991) in the light of recent research.

- To review and refine methods for collecting data on damage reducing actions taken by households associated with flood events and warnings.

- To carry out research to produce a new data set to be used to calibrate the model.

2. METHODS

2.1 Literature Review

FHRC undertook a review of recent literature on the benefits of flood warnings in the following ways:

- Internet searches using the International Bibliography of the Social Sciences (BIDS), Google and Ingenta and various special sites such as NOAA, FEMA, USACE, EMA, BTE.
- A custom search conducted for FHRC by the National Hazards Research Centre, University of Colorado. This produced over 3000 abstracts of recent research.
- Mailbase information request and personal and e mail contacts with researchers and practitioners in UK, Europe, Australia and the USA.

The information derived from these sources was compiled in note form rather than a formal literature review report.

In June 2004, it was agreed that this project should co-operate in various ways with an Environment Agency (EA) Project on ‘Public Response to Flood Warnings’ being undertaken by the University of Surrey. In particular, it was agreed that there should be collaboration over a literature review and a sharing of data on the recent relevant literature. We passed on our information and notes on recent literature to the University of Surrey. We received the University of Surrey’s draft ‘A Summary Review of the Literature’ which generally provided a useful confirmation of our conclusions drawn on the basis of our literature searches.

2.2 Focus group research

Five focus groups were held to test and time the survey questions. In particular, the focus groups allowed the researchers to observe and examine the use of the household inventory checklists by residents with different characteristics and flood experiences. We were

interested to establish how easy or difficult participants found remembering what property they managed to move and what they lost in the flood. The focus groups were held in the following locations and covered the following specific events.

- Wraysbury, Thames Region, 15 June 2004, 9 participants, flooded January 2003
- Sunbury, Thames Region, , 12 July 2004, 2 participants, flooded January 2003
- Worcester, Midlands Region, 9 June, 8 participants, flooded November/December 2000
- Halstead, Anglian Region, 15 July 2004, 4 participants, flooded October 2001
- Redbridge, Thames Region, 29 July 2004, 6 participants, flooded October 2000

A total of 29 people took part.

2.3 Survey research

2.3.1 First phase survey

In August 2004, it was agreed that this project should seek to collaborate with the Environment Agency's post-event survey of those flooded in 2003/4 to be carried out by the British Market Research Bureau (BMRM) to avoid respondent fatigue. The Agency and BMRB were very helpful in accommodating the needs of the FHRC research team for this Defra/EA project. It proved possible to combine the two survey instruments into a common interview schedule. The Agency's post event survey drew on all the addresses in the three main areas where flooding happened in 2003 and 2004. Thus, this collaboration provided the only opportunity for the Defra research to obtain information from these key recently flooded areas.

The Agency post event survey was based on 220 usable addresses and in the end yielded 168 survey responses (including responses from businesses as well as residents) and some 33 responses from properties where no property flooding, even of gardens or driveways, had occurred. Full details of the methods and results of this first phase survey are available in a separate report (BMRB International 2005), it was felt that the responses from this survey would be insufficient in number to calibrate the model and therefore a second phase survey was mounted.

2.3.2 Second phase survey

Three survey organisations had been approached initially about the survey and two had provided tenders for the survey work, MORI and Continental Research. BMRB was too busy to undertake additional work. As the costs of the two tenderers were broadly comparable, MORI were chosen because they appeared more confident of their ability to undertake the fieldwork within the specified time period and countrywide and because their work for the 'Human Intangible Impacts of Flooding' had been satisfactory and gave them experience of surveys of flood victims. In the event, their work on this project has been good. They completed the work just about to the time table and achieved a total of 278 interviews out of the 300 aimed for.

Initially, it had been the intention to restrict the interviewing to households flooded since January 2001. However in order to identify a sufficient number of areas where flooding had occurred which had not been included in either BMRB post event surveys or in the 'Intangibles Project' survey, it was decided to extend the basis of the sampling to include those flooded in areas affected since September 2000 i.e. including the autumn 2000 floods. Focus groups research with those flooded in autumn 2000 suggested that these victims had a reasonably good recall of the events at that time. They were asked to fill in detailed checklists of the household inventory items that they saved from damage and the items damaged, and this task did not appear to be too taxing for participants.

In order to develop the second phase sample, area staff in all 19 English Environment Agency areas (Wales was excluded from the second phase sample but included in the first) were contacted by telephone or e-mail, and asked about flood events in their area since September 2000. Six areas were excluded from the sample either because staff were unable to provide information or because they reported very little flooding in their area. Overall, Agency area officers were extremely helpful in extracting the information required for undertaking the interviewing (information on the names of streets affected by events and maps of the areas flooded) although the process took some time to complete. Interviews were targeted for 13 of the 19 Environment Agency areas in England, thus covering a variety of flood events, warning scenarios and social settings.

The basis on which respondents were selected for interview differed in the two phases of the research and therefore the two samples differ in their composition:

- The Phase 1 survey included businesses as well as local residents and those who were only minimally affected by flooding with water in their gardens, drives or roads as well as those with flood waters inside their properties and some with no property flooding of any kind.
- Phase 2 of the research included only those with residential accommodation affected and was confined to those with flood waters inside their property, underfloor or in garages or outbuildings. A quota of one in five was set for the inclusion of residents with only garages or outhouses affected to ensure that a large enough number of households had experienced more serious flooding and thus opportunities to save property from damage.
- In Phase 2, households in which all household members were staying away from home over night on holiday or on business at the time of the flood were excluded in order to include as many people as possible who were available to take action to prevent damage. This means that the data on receipt of flood warnings in the two phases are not entirely comparable and the Phase 2 results should be higher because those away from home who were less likely to have received a warning have been excluded.
- However, Phase 2 of the research included some residents affected by flooding from minor watercourses not covered by flood warning systems.
- In Phase 1, an attempt was made to interview all 220 eligible properties. In Phase 2 interviewers were given a target number of interviews to achieve from lists of addresses provided and they were not expected to interview all the eligible respondents.

In both surveys, interviews were taken with those aged 18 and over.

The areas and flood events covered in the two phases are shown in Table 2.1 and the timetables for the two phases of the survey are presented in Table 2.2. Differences in the type of property affected: residential or business and in the extent of property flooding in the two phases of the survey are shown in Table 2.3.

2.3.3 Survey questionnaires

The Questionnaire used in the first phase was slightly modified for the second phase survey. Questions that were only relevant to the Environment Agency were cut out and a few additional questions were included that were of interest to the Defra/EA research project. A few questions were modified at the suggestion of the survey company for the second phase. However, the two survey instruments were comparable with a large core of common questions. The Phase 2 survey questionnaire is presented in Appendix 1.

2.3.4 Quantification of flood damages and savings

The surveys carried out for this project were innovative in that they sought to derive estimates in monetary terms of the actual damages incurred and saving achieved by households through moving or raising property.

Respondents in both surveys were asked whether they raised or moved any items in certain rooms or parts of their property and as a result saved them from flood damage. They were also asked whether anything in any of the rooms or parts of the property were damaged by the flood. They were then presented with a checklist of standard inventory items and asked to think about the rooms and to indicate by ticking which of the listed items were saved and which were damaged for each of the rooms and parts of the property affected.

The checklist was derived from the standard inventory items as presented in FLAIR (1990) in Tables 3.1 and 3.2 and in updated versions (2001). In the surveys, 100 items including an 'other' category for each room or part of the property were listed. The lists of items in each room were guided by the room assembly data presented in FLAIR (1990) in Table 3.2. The checklist used in Phase 2 was amended very slightly with a few items combined so that the list could be laid out over two pages (Appendix 2).

In order to attach values to the items saved or damaged, the following steps were taken:

- FLAIR data updated for inclusion in the draft ' Multi-coloured Manual (Penning-Rowsell *et al.* 2003) were used. These provide prices without VAT.
- The data on prices were updated to March 2005 using the Consumer Price Index rise from March 2001 – March 2005
- Prices were all calculated at 50% as representing half way through their lives.
- Items were priced for expensive, medium and cheap items.
- Prices for saved and damaged items were attributed to the respondents according to their social class The items of those in Social Classes A and B were given 'expensive'

prices, social classes C1 and C2, medium prices and social classes D and E, cheap prices.

- Many of the item categories were composites covering a number of individual items, for example, sofas/armchairs. It was not possible to differentiate between these items.
- Also, in order not to overburden the respondents, they were not asked to indicate the number of objects in the item category moved, for example, tables. Therefore, judgements had to be made as to what average value to attach to these composite categories. All the decisions taken in determining the prices to attach to categories are recorded in the analysis files and can be accessed.
- Where an item category was ticked both for damage and items saved, the full value was used in each case rather than dividing the value between damages and saved.

The values attached to the items saved and items damaged were summed for each of the five main rooms or parts of the property, and then an overall value of total savings and of damage was calculated for each respondent.

The method used has limitations:

- The method depends upon the respondent's memory and this may be faulty, although respondents observed in the focus groups appeared to have good recall of their actions at the time of the flood. The checklists helped respondents to remember.
- Respondent fatigue could have affected the responses: the task of going through the items listed for each room took time and concentration.
- The list shown in the surveys had only 100 main items compared with over 200 items in the inventory although this was to a considerable degree due to the amalgamation of items into combined categories rather than their complete omission.
- The survey checklist excluded certain items that are included in the household inventory because they were deemed to be unmovable. These were items such as fitted kitchens and built in ovens, heaters and bedroom furniture. Many of these are valuable items. Clean-up costs which are part of the household inventory were also not included in the survey checklist.
- The pricing of the composite items involved judgement. Usually composite items were priced conservatively so as not to overestimate the savings efforts of respondents. This may have lead to underestimating of the value of savings and damage.
- As the number of items such as chairs moved or damaged has not been recorded the values are necessarily very approximate.
- As the same value has been attached to those saving/or having damage to one table or chair or three, the £ savings/damage measure is necessarily rather insensitive to variations in saving or damage effects due to more examples of a category being affected.
- Some of the items in the inventory are alternatives e.g. gas and electric cooker; also some items were duplicated and appeared more than once in the checklist because households might have more than one of an item located in different parts of the property e.g. TVs. Thus, the £ value of all the items on the list may over represent the potential savings available to households.

2.3.5 Survey data analysis

The data were received as separate data sets and a lengthy process of checking each of the variables in the two surveys for comparability of coding was undertaken. Variables were recoded where necessary and then combined into one data set. Most of the analysis was undertaken on, and unless it is indicated otherwise, tables are presented for, the combined data set. SPSS was used for the analysis.

The data on household inventory items saved or damaged were processed initially as a separate Excel file in which £ values were attached to items as described in detail in section 2.3.3 above.

3. MODEL OF THE ECONOMIC BENEFITS OF FLOOD WARNINGS

3.1 Background

Since the 1970s data on flood damages in England and Wales has been accumulated and published (Penning-Rowsell and Chatterton, 1977, Parker *et al*, 1987, Penning Rowsell *et al*., 1992, and the recent Multi-coloured Manual consultation draft (2003) and its final version (Penning-Rowsell 2005). The depth damage data in the manuals represent the maximum potential, ignoring any damage reducing effects of action taken by property owners or authorities after a flood warning. Since the late 1970s research has been undertaken into the benefits of flood warnings. Initially, this took the form of an examination of the issue of the potential maximum amount of damage that might be avoided with different lengths of flood warning (Chatterton and Farrell, 1977; Penning-Rowsell, and Chatterton 1977; Penning-Rowsell, Chatterton and Parker, 1977). A substantial amount of survey research was carried out with property owners affected by flooding in the 1980s to determine what actions property owners were able to take and the factors affecting damage reducing actions. A total of over 1,200 interviews were conducted by FHRC (Parker and Tunstall, 1991). Based on this body of research, a model of the damage reducing effects of flood warnings was developed by Green and Newsome (CNS Scientific and Engineering Service, 1991). The research was summarised and the model calibrated by Parker (1991). The suggested site specific methodology for benefit assessment was based on a simple linear model:

FDA = PFA x R x PRA x PHR x PHE

Where:

FDA = **Actual flood damage avoided**
PFA = **Potential flood damage avoided** (property plus road vehicle damage avoided was specified in 1991 but vehicles have not been included in this analysis)
R = **Reliability** of the flood warning process (i.e. the proportion of the population at risk which is warned with sufficient lead time to take action)
PRA = **Availability:** the proportion of residents/households available to respond to a warning
PHR = **Ability: t**he proportion of households able to respond to a warning
PHE = **Effective response:** the proportion of households who respond effectively.

Although the original formulation of the model above included cars and motor bikes, these are not included in the household inventory items and have in this analysis been assumed not to form part of the model. The model has subsequently had a life independent of FHRC. It was included in/formed the basis of a 1995 report entitled 'An Assessment of the Costs and Benefits of Fluvial Flood Forecasting' which is an R&D Note (463) of the EA produced by WS Atkins Water and published by the WRC (Heijne, I S, Robinson, C J and Chatterton, J B). It has been further developed and refined in research to estimate the benefits of enhancing flood warnings in estuaries (Chatterton 2001). The model has been employed in adapted form in assessing flood forecasting and warning benefits the Environment Agency's national investment strategies for flood forecasting and warning (National Flood Warning Centre 2001;

Environment Agency 2003). Met Office research has employed the model in a different context, namely Severe Weather Warnings of pluvial flooding to local authorities. Thus, the range of applications of the model has widened and detailed changes in the way the model is applied have been made. However, the fundamental principles and assumptions of the model have remained the same.

The model was developed mainly on the basis of research with private households and the assumptions of the model reflect that. Parker (1991) noted that there was much less research evidence then available on non-residential property on which to base a calibration of the model. Data on non-residential property responses to flood warnings have remained sparse. Despite this, the model has been employed to assess the benefits of flood warnings to all types of property although the benefits to non residential and residential property have usually been calculated separately and different values have been attached to the factors of the model for the different types of property.

3.2 Some applications of the model

Table 3.1 presents the original calibration of the model (Parker 1991) and some recent applications showing the values that have been attached to the factors in the model. The Environment Agency in adapting the model to cover its performance factors and targets has introduced an additional factor, the coverage of the warning service (the proportion of properties within the indicative flood plain that have been offered an appropriate warning service).

3.3 Limitations of the model

The model is focused on only certain aspects of the damage saving potential of flood warnings. First, it addresses damage saving achieved by the efforts of individual property owners. Within that category, it is focused on damage reduction achieved through moving and raising property out of the reach of flood waters since PFA is based on consideration of what standard household inventory items can be moved within a given warning period.The model does not explicitly cover damage reduction that may be achieved in response to a warning through property owners taking effective action to prevent water entering the property by effective sandbagging or pumping or through putting flood boards and other protective devices in place.

There is increasing interest in flood risk management in property owners taking greater responsibility for managing their own risk particularly where provision of flood alleviation is difficult and in promoting the incorporation of flood resistance and/ or resilience into existing properties as well as new ones (Defra 2005). The measures may involve permanent adaptations to buildings or temporary devices. This potential element in damage reduction in response to flood warnings is likely to be of increasing importance.

Traditionally, householders and businesses have sought to keep flood waters out of their property through sandbagging and other preventative measures. The responsibility for, and the efficiency of the supply of sandbags has remained an unresolved issue for those affected

by flooding. There is also a question as to whether sandbagging is an appropriate or effective response to a flood threat and as to whether property owners time would not be better spent in moving items rather than trying to keep flood waters out. There is also evidence that sandbagging to keep waters out may be undesirable where flood waters are likely to reach over a metre in depth, because the pressure of the water at such high depths may give rise to costly structural damages to property.

There is growing market interest and marketing through Flood Fairs of flood protection devices such as flood gates, air brick covers and pumps. The post-event surveys provide evidence of property owners taking action to prevent waters entering their property when floods threaten, mainly through sandbagging but also for a very small minority through the installation of flood gates. However, data has not been collected to demonstrate whether or not these efforts were successful. It is understood that this issue is to be covered by response surveys in the future. The model could be expanded to include damage savings achieved through keeping flood waters out of properties altogether. The damage saving in these instances would be greater than those covered by the existing model since the potential saving would be to *a substantial proportion of* the contents inside the protected parts of the property and would also include some structural and fixture damages avoided, for example, to plasterwork, fitted kitchens and floor boards. Flood warning response surveys, in the future, could include questions to establish the number of properties where property damage was avoided through the use of individual property measures such as flood gates or sandbagging.

Second, the model deals with damage reduction by individual property owners only. It does not cover the potential for community or agency action in response to a flood warning to reduce damages. This might take the traditional form, for example, of sandbagging by troops or others to shore up defences. Alternatively, it might involve the use of demountable or temporary flood barriers erected in response to a warning by the flood risk management agency. The number of such temporary flood barrier systems has grown in recent years and they have been successfully deployed in Europe. Some systems were successfully trialled in flood events in February 2004 in three locations along the River Severn at Ironbridge, Shrewsbury and Worcester which have timely and accurate flood warnings essential for this approach to flood risk management. It was concluded that ‘They provide a valuable new option in the hierarchy of flood management’. It was also noted that they provide a more efficient and cost beneficial response than sandbagging (Stokes and May, 2004). Clearly, the benefits of these approaches are potentially greater than those that can be realised by individual householders moving property. Potentially, most structural and contents damages together with many of the intangible impacts of flooding may be avoided by the deployment of such temporary and demountable defences.

4. TESTING AND CALIBRATING THE ECONOMIC BENEFITS MODEL

4.1 Economic benefits model: a simplification

The economic benefits model is necessarily a simplification of the complex social processes involved in responses to flood warnings and flooding. There are many factors that may influence the damage reductions achieved by property holders in addition to those included in the economic benefit model. The factors in that model were chosen in part as those where data could be readily obtained from warning service providers or from census or other publicly available information. For the purposes of the survey, a broader theoretical model (Figure 1) which included other factors that might affect response was developed to guide the design of the questionnaire and the analysis. The discussion and analysis in this report focuses on residential property. The evidence on the potential for damage saving as a result of warning by non-residential property holders of various kinds is considered in chapter 5 of the Manual of Benefit Assessment Techniques (Penning Rowsell *et al*. 2005).

The theoretical model hypothesises that the response to flooding by residents is influenced by four sets of factors:

- The characteristics of the flood event and its catchment
- The social characteristics of those affected
- The type of housing in which residents live
- The characteristics and functioning of the flood warning system available in the area affected.

Every flood event presents a unique combination of these factors, which is one of the reasons why it is difficult to generalise about the response to flooding and to develop simple models to describe response.

In the following sections, the components of the economic benefits model are examined and the assumptions underlying the model are reviewed and tested in the context of the broader theoretical model.

In order to test and calibrate the economic benefits model, as well as examining the results from all 408 residents in the project surveys, a sub-group of 370 within the residents in the survey have been examined: those households that experienced flooding of their built property – above floor level, under floor, in basements, garages or out buildings but excluding those with flooding to gardens or drives only. This is because the household inventory items and thus the potential for damage and savings cover items found in built property including garages and outbuildings but not damage to gardens and drives. Cars and motorcycles are excluded from the £ values of savings and damages as these are not included in the standard inventory. In addition, respondents (29) who reported that they experienced built property flooding but reported neither damages nor savings i.e. their built property was unaffected by the flooding, were excluded. Thus, much of the analysis is based on a sub-sample of 341 households described as having ‘built property affected by flooding’.

This sub-sample of 341 households whose built property was affected by flooding do not appear to be significantly different from the sample as a whole in their social characteristics (Table 4.1) and housing (Table 4.2). The households included also appear similar in terms of their vulnerability and household composition to the residents as a whole (Table 4.3). Those with built property affected by flooding are polarised in terms of their flood awareness and experience: more of them have prior experience of flooding above floor level but more also were unaware that their property was in a flood risk area prior to the recent flooding.

4.2 Limitations on testing the economic benefits model

The project surveys had some limitations as a means for testing the model:

- Although the sample achieved in the surveys of 446 interviews was close to the target number of up to 500 interviews set for the project, the number of households that could be used in testing the model was smaller and this somewhat reduced number of cases limited the analysis to some extent.
- There were fewer households than anticipated that had received a warning, and this again restricted the analyses using this key variable.
- There were too few cases in some sub groups to permit their use in the analysis.
- Although the surveys drew on varied flood events and locations, they covered a limited number of locations and specific events that had occurred recently. The results may reflect specific aspects of the locations and events.
- Some variables were not measured in the ideal way as continuous variables because of the EA's and BMRB's requirements of the Phase 1 survey. This has also, to an extent, constrained the analysis of the data.
- The measures of the £ value of savings and damages also had limitations (section 2.3.4)

5. POTENTIAL FLOOD DAMAGES AVOIDED (PFA)

5.1 Assumptions

This factor, the foundation of the benefit assessment methodology, was formulated by Chatterton and others in the late 1970s. It is a measure of the maximum damage with a given warning lead time (i.e. time between the dissemination of a warning to the public and the onset of flooding) that could be avoided if all other factors in the model were 100% (Reliability 100%, Availability 100%, Ability 100%, Effective response 100%). It assumes that:

- the amount of possessions at risk and needing to be saved will depend on the depth of flooding
- The amount of property that **can** be saved will depend on the amount of time available for raising or moving items.
- Some standard inventory items could not be moved however long the warning lead time, so the PFA will always be lower than the total standard inventory value at risk at a particular flood depth. Items of this kind have been removed from the checklists used in the surveys.

The PFA is expressed as a percentage of Total Potential Flood Damages (Damages to building structure and damages to household inventory items) for:

- Five levels of flooding: 1.2m, 0.9m, 0.6m, 0.3m, 0.1m.
- Four warning lead times: up to 2 hours, 2-4 hours, 6 hours and 8 hours.

It is important to note that the PFA percentages were derived partly on the basis of expert judgement rather than on extensive empirical evidence of the maximum amount that can be moved in a given time. Furthermore, the PFA percentages have not been re-evaluated or subject to any empirical research since they were first introduced and presented (Parker 1991). Thus the assumptions on the maximum that could be moved have not been reconsidered, for example, in the light of changes in household possessions over the period of nearly 30 years, although the content of the standard inventory data has been updated (FLAIR 2001). It is possible that changes in the contents of dwellings, for example, an increase in built-in fitted kitchen and bedroom furniture as compared with moveable furnishings, may have changed the potential value of the PFA

It was not possible within the scope of the present project to undertake empirical research to re-evaluate PFA because a different research approach would have been required to do this. Furthermore, it is questionable as to whether PFA could be empirically determined through research.

5.2 Testing and calibrating PFA

5.2.1 Project survey measure of PFA

The current survey research provides evidence on the £ value of items that householders reported that they saved by moving or raising and on the £ value of the items that were damaged by the flood event. These, when added together, can be taken as a surrogate for PFA.

Overall, for those with built property affected by flooding, the average for PFA across all flood depths was £3,457 with a reported minimum damage potential of £8 and a maximum of £14,161

The survey also provides evidence on the rooms in which items were saved or damaged by the flooding (Table 5.1) and thus where in the property there was the greatest potential for avoiding flood damages according to the residents' reports. This is shown below for those with built property flooding in descending order (means calculated to include zero values):

- Living room - 83% with damage or savings there; mean £ value of damage plus savings £2,068
- Kitchen - 74% affected, mean £ value of damage plus savings £904
- Outbuildings, garage - 68% affected, mean value of damages plus savings £327
- Bedroom - 14% affected, mean £ value of damage plus savings £121
- Bathroom, cloakroom – 30%, a mere mean £ value of £36.

Most of the residents surveyed overall lived in detached, semi-detached or terraced housing and the same was true of the residents with built property affected by flooding (Table 4.2). Therefore, it was to be expected that the rooms usually found on the ground floor were most affected.

5.2.2 PFA and depth and duration of flooding

According to the model, PFA would be expected to vary according to the depth of flooding.

In the project surveys, because of the way in which the Phase 2 respondents were selected most of the residents (70 % or 287 out of 408) had experience flooding above floor level. The same was true of those with built property affected by flooding, 83% (284 out of 341) of whom were flooded above floor level. When all those with some built property affected, both those in receipt of a warning and those unwarned, were examined, total £ savings plus damages did vary according to the extent of flooding with those not flooded above floor having less potential damage than those with flooding above that level. Also, as expected, households with flooding above floor level were able to save a significantly smaller proportion of the potential flood damages than those with lesser built property flooding. The two groups did not differ significantly in the £ value of savings achieved nor in the proportion making at least some savings (Table 5.2).

However, among those both warned and unwarned who experienced flooding above floor level in their property, it did not appear to make a significant difference as to whether the flooding was under 30cms or above that level (Table 5.3). Those with depths of 60cms or more likewise did not appear to be significantly different from those less affected in their potential savings and response.

The duration of flooding is another factor that might be expected to have a limited effect on potential flood damages. In the surveys, nearly two thirds of residents with above floor level flooding (64%) had flood waters in their homes for 12 hours or more. There were differences in the proportion experiencing long flood events between the two phases. In the Thames areas surveyed in Phase 1, two fifths (42%) reported flood waters staying in their homes for seven days or more. However, in bi-variate analyses of the project survey data, there were no differences in the £ saving and damages combined of those affected by above floor level flooding lasting less than 12 hours compared with flooding of 12 hours or more. The 12 hour or more duration of flooding was associated with a significantly higher proportion of savings but not greater £ savings than the shorter duration events. Those flooded for 12 hours or more reported saving 54% of property at risk compared with 44% for those flooded for a shorter time. This could possibly be because the shorter duration floods occurred in 'flashy' catchments where there was less chance of receiving a warning or a shorter warning lead time.

5.2.3 PFA and social class

Household inventory items listed in the survey were priced according to the respondents' social class. The expensive, moderate and cheap items varied quite markedly in price. The total £ value of all the items included in the survey checklist was £20,233 for the expensive items, medium £12,664 and cheap £4,315.

Reflecting the character of the areas surveyed, the residents included a substantial proportion of people in the AB social group (33%), nearly half in the C1 and C2, and a relatively small proportion in the DE category (18%). The pattern was similar for those with built property affected by the flooding (Table 4.1).

The potential flood damages avoided and the actual savings achieved varied significantly according to the social class of the residents with those in the AB groups reporting significantly higher potential flood damages avoided and higher saving than the C1,C2 group and this group reporting higher values than the DE group. However, the proportion attempting to make some savings and the proportion of potential damage actually avoided by the efforts of the residents did not vary by social class, indicating that it was the £ values attached to the household items by social class rather than the level of response by the residents in the different social class groups that made the difference (Table 5.4).

The implication of this for economic benefit assessments is that the social class composition of the area at risk or affected will be a significant factor in the potential damages and savings that may be found. Treasury weighting (H.M. Treasury 2003) may be a counteracting factor.

5.3 Conclusions on the survey measure of PFA

The lack of variation in bi-variate analysis of the survey measure of PFA, the sum of the £ value of reported damages and savings, with depth of flooding raises questions as to the validity of the survey measure. The limitations of the methods for ascertaining the £ values listed in section 2.2.4 may go some way to explain the insensitivity of the survey measure of PFA to flood depth. In particular, the fact that the number of items damaged or saved could not be taken into account may reduce the variation observed. The limited number of cases and the possibility of extreme values distorting the data may also be factors.

An attempt was made to compare the survey data on the sum of the reported £ value of savings and damages with data on moveable household inventory items that would potentially be at risk with a given level of above ground floor flooding taken from the latest Manual (Penning-Rowsell *et al*, 2005). However, it must be recognised that the two data sets were obtained using very different methods that may mean that it is inappropriate to attempt the comparison. The household inventory data on contents used to establish the moveable contents damage likely to occur with a given depth of flooding is built up for different house types and on the basis of synthetic data on individual room assemblages. These take into account the number of items of a given type and price that can be expected to be found according to property type and social class. The approach that was adopted in the survey was necessarily much simpler and cruder: it would have been too time consuming to go through each room in the detail that would have been required to reflect the approach used to build up the data available in the Manual.

Table 5.5 shows data from the Manual (Penning-Rowsell *et al*, 2005) on the moveable contents damage that would be expected at certain depths of flooding. In the project Phase 2 survey, the average depth of above floor level flooding was 0.38 metres and yet the average reported £ value of savings and damages combined was £3,434. This is about half the potential damages we would expect from the Manual data shown in Table 5.5. Thus, it has to be recognised that the survey surrogate measure of PFA is very different from the Manual measure: under reporting of damages and savings and limitations in the way these were recorded and priced in the surveys may account for the difference.

As there is no reason to expect that these factors have had a differential effect on the reporting of damages and of savings, the data on the proportion of potential flood damages saved remains valid. Comparisons across groups can also usefully be made although it is possible that the recording methods mean that the data is not as sensitive to differences between groups as might have been the case with more elaborate recording methods.

5.4 PFA: a new approach in the 'Multicoloured Manual'

A new approach to estimating PFA is suggested and used in the new Manual. For all house types, building periods and social classes, the inventory items value as a percentage of total damages averages 52%. Of the household inventory items, it was calculated that only 41% has the potential to be moved. This proportion was calculated by examining the inventory and adding up the £ value of items that were judged to be unmoveable

E.g. fitted kitchens, built in ovens, hobs, and heaters and also fitted bedroom furniture. Clean up costs were also included as an item that could not be avoided through a flood warning. These were mostly high value items. Thus, it was concluded that only 21% of the total potential damages could be influenced by the provision of a flood warning. Table 5.5 shows the kind of values that this represents for different depths of flooding. This approach is simple and more transparent than the estimates of PFA that it replaces.

6. EFFECTIVE RESPONSE - PROPORTION OF HOUSEHOLDS WHO RESPOND EFFECTIVELY (PHE) AND FDA FLOOD DAMAGES AVOIDED (FDA)

6.1 Assumptions

Here, the assumption is that 'an effective response' is action to reduce damages to property. It is also assumed that those who take 'effective action' will be 100% effective and save 100% of potential flood damages. In some events such as life-threatening floods and for some vulnerable households a more appropriate response than action to reduce property damage might be evacuation in advance of the flooding. Thus, an important matter to explore is whether or not saving property and indeed maximising the £ value of property saved is a priority for action in most households. People may have other actions that they consider more important.

6.2 Testing and calibrating 'effective response' (PHE) and FDA

6.2.1 Priorities of becoming aware of the possibility of flooding

In the Phases 1 and 2 project surveys, respondents were asked an open question as to what their priorities were on becoming aware of the possibility of flooding before they were asked specifically about whether or not they had taken any specific actions (Table 6.1).

Broadly, the responses to this open question suggest that householders did accord high priority to property saving activities. Moving carpets and rugs, first in line for damage, was a priority for a majority of respondents in Phase 2. The other main priority was to try to stop the water entering the property through a variety of actions. Only small minorities gave high priority to other things such as saving items of personal value, important things and documents. Some of these were items of sentimental value. Others were concerned to save items that would reduce the disruption to their working and domestic lives. In the focus groups, one woman gave priority to saving her computer and work documents so that her work would not be interrupted. The only other key priority mentioned was saving pets.

6.2.2 Actions taken in response to a flood threat

Damage reducing action is only one form of activity of the many that residents may engage in on becoming aware of a threat of flooding. Research on natural hazards has shown that a common response on receipt of a warning or on becoming aware of a hazard is disbelief and denial. A second common response is to seek confirmation of the warning from other sources (Drabek, 1986; 2000). Respondents in the project surveys were asked whether they had taken any of a list of 19 actions to prepare for flooding and to protect their property. The results show confirmation seeking as a very common behaviour in which those whose built property was in the end affected by the flood event were somewhat more active than those not affected. They were significantly more likely to have called Floodline or the EA and to have sought information from friends, family or neighbours (Table 6.2).

Warning others is also a common activity. Drabek (2000) points out that the response to warnings involves social processes since warnings are usually received and acted on by groups, households, businesses or other organisations rather than by individuals. These social communication and interaction processes take up time and often precede the damage reducing action as residents decide through their consultation with others on the seriousness of the threat and on what action it is necessary to take.

Those threatened by flooding also commonly try to prevent the flood waters entering their property. As can be seen in Table 6.2, these efforts often meet with limited success: many of those whose built property was affected in some way by flooding had made attempts to keep the flood waters out. These activities, particularly trying to get hold of sandbags can serve to delay other damage reducing activities such as raising or moving property.

However, of all the listed activities that residents were asked about, moving valuable or personal belongings was the most commonly undertaken action for both those whose built property was affected by the flood and those not affected. Those affected by built property flooding were more active than others suggesting that residents wait to be fairly sure that their property is going to be flooded before taking action.

6.2.3 Project survey measures of PHE and FDA

In the surveys, 'effective action' was measured as:

- The proportion that actually moved or raised items and thus saved them from damage by the flood waters.

Actual flood damages avoided (FDA in the economic benefits model) is the key dependent variable that the model seeks to explain. It was measured in the survey in two ways as:

- £ value of savings including those with no savings reported
- £ value of savings as a proportion of total potential damage reported i.e. £ value of savings plus £ value of damages incurred.

In this group with built property affected by flooding, overall, including both those warned and those who received no warning:

- 78 percent took some effective action and saved at least some items of property from damage.
- Mean £ savings of £ 1,860 were reported with those with no savings included in the calculation of the means as zero. The standard deviations were very large reflecting enormous variation in the £ value of savings. These ranged from £ 25 to £ 10,776.
- £ Savings as a percentage of potential flood damages (£ savings plus £ damage incurred) were on average 52%: just over half the property damage was avoided on average by those with built property affected according to residents reports. The proportions ranged widely with some 22% saving nothing to a small proportion, 15 percent, who reported saving everything.

- Thus, the assumption that ‘effective response’ will mean 100% savings is not born out by the survey results: most of those who took action, according to their reports, were only able to save some of their property at risk.
- However the proportion taking effective action (with and without a warning) is higher than has usually been assumed to be the case in applications of the model (Table 3.1)

In the following sections, the relationships between the dependent variables PHE and FDA and the explanatory variables, R Reliability of warning, PRA Availability to respond and PHR Ability to respond presented in the model are examined through bi-variate analyses.

7. RELIABILITY OF THE FLOOD WARNING PROCESS (R)

7.1 Assumptions

Reliability combines the probability that a flood is accurately detected and forecast and the probability that a flood warning is effectively disseminated. Thus, it can be derived from records of the proportion of past observed flooding events that have been accurately forecast and a warning issued by the agency responsible prior to flooding. Generally, the reliability of a flood warning will decline the longer the warning lead time since there will be greater uncertainty in forecasting many hours ahead of an event. However, the reliability of warnings in relation to lead time will vary according to the type of event and source of flooding and according to the characteristics of rivers and their catchments.

Warning lead time is defined in the Environmetn Agency's Agency Management System Document as the time period between when the last warning is issued and the first onset of property flooding flooding in an area (Environment Agency 2003). This definition is imprecise since it is not clear whether property flooding means any form of property such as gardens or outhouses, or flooding above floor level affecting residential or business property. Warnings can, of course, be issued after property flooding has commenced, but for the model the assumption is that a warning must be issued prior to the start of flooding.

Warning lead time from issue of warning to onset may be different from the time between the **receipt** of a warning message by individual property owners and flood waters entering their property since warnings if the warning is disseminated via third parties such as flood wardens or local authorities rather than directly by the issuing agency. Furthermore, properties in an area may be affected at different times because of the levels of their properties and the way flood waters flow. The surveys provide evidence of the warning lead time reported by individual property owners rather than that defined by the issuing authority.

8. RELIABILITY (R) AND AVAILABILITY – PROPORTION OF RESIDENTS AVAILABLE TO RESPOND (PRA).

8.1 Assumptions

In the original specification of the model, PRA or availability referred to the proportion of households in which at least one adult was at home and awake to receive a warning. Clearly, the warning dissemination mechanisms used to deliver warning messages have implications for this factor. The assumption at the time the formula was developed was that the warning would need to be delivered to a particular location or the threatened property, through a siren, loud hailer or policeman or other agent calling in person or by telephone to the threatened home and that a household member would need to be available there to receive it. The proportion of people spending time out at work or pursuing household or leisure activities outside the home was therefore highly relevant.

With the development of new warning technologies, the presence of household members at home is becoming less salient. In England and Wales, the Environment Agency's AVM telephone warnings are now the main form of direct warning and the Agency is now able to issue AVM warnings to work and mobile phone numbers. Furthermore, AVM systems provide evidence of whether or not the message was delivered successfully. However, persuading those at risk to register on the AVM system is difficult and at present nationally, the AVM is only taken up by about 35% of at risk property owners despite promotional efforts (Environment Agency 2005).

The Agency's new Floodline Warnings Direct Service will have a greater capacity to reach recipients outside the home, at work or on the move by utilising a range of current and emerging technologies such as SMS text messaging and e mail. However, if a warning is issued to work numbers or to someone on the move and no one is at home, there will be a delay in the householder's taking action due to the time needed to reach home.

More serious are those who are absent on holiday or overnight on visits, a factor which may have more impact in flood events occurring at holiday times. Changes in the number of holidays and the length of holiday time taken, and the increasing trend to holiday away from home may affect this factor. The night time effectiveness of different warning methods and thence the level of availability varies. Radio and TV, internet and e mail and indeed mobile phones are likely to be switched off at night. Sirens or loud hailers may not be heard by those asleep. Telephone and door knocking may be effective at waking people.

The reliability and availability factors and the model appear to assume either that:

- only those in receipt of a 'warning' will take damage reducing action
- or that only where a warning has been received can the damage reducing action taken be *attributed* to the provision of a flood warning service
- or that only where a warning is directly from an official source will it stimulate damage action or action that can be attributed to the flood warning service.

Whether or not damage reducing actions that do not follow on directly from the receipt of some kind of warning, including both official and unofficial warnings, should be attributed to the provision of a flood warning service is open to question. Those who act without receiving a specific warning message in a particular event may do so on the basis of information and advice and awareness raising activity that is part of the flood warning service broadly defined. However, they may also do so through personal experience, observation and commonsense independent of any information and advice from the warning agency. It can be argued, however, that the model ignores the benefits that may accrue from the flood warning service broadly defined in raising awareness and preparedness in the at risk population, which may have greater benefits in the long term than specific warnings in specific events.

Furthermore, it is open to question as to whether benefits should be judged to arise only from a warning directly from an official source. Flood warning involves a complex social process in which households, groups and local communities take part. In this process, there is likely to be interaction between formal and informal systems. Official flood warnings may be passed on through informal networks and informal warnings may stimulate recipients to check with official sources. The research evidence shows those at risk are active in seeking further information from official and unofficial sources and in passing on information: they warn neighbours and friends and seek confirmation in many different ways (Table 6.2). Thus, there is a rationale for not making a distinction here between formal and informal warnings since there is so often interaction between the two systems so that the distinction between them becomes blurred.

The availability factor has been calculated on the basis of census or other statistics on the proportion of the households or of the population, employed full time, part time or retired etc and thus likely to be at home and from statistics on holidays (Haskoning/Met Office 2004).

Alternatively, survey data on the proportion of householders who **receive** a warning message (either official or from any source) can be taken as reflecting both, R, the agencies' success in issuing and disseminating a warning and PRA, the availability of householders to receive the warning, and thence the success in delivering a warning message.

The proportion of households away overnight at the time of flooding will continue to be important. However, whether or not household members resident at the time are actually at home to receive flood warnings is perhaps no longer such a salient component in the equation as it was when the model was originated in 1991. At that time, more warnings were disseminated by the police and flood wardens knocking on doors and with loud hailers than is now the case. In the interim, the Environment Agency have assumed responsibility for warning dissemination and the main warning mechanism is the AVM system of automatic telephone calls direct from the Environment Agency. Such messages can be sent to work and mobile numbers making the presence of household members at home less significant. Furthermore, warning information is also available on the internet, radio and from Floodline which can be accessed while away from home. Not all regions and areas rely upon the AVM system and where it is used there is variable success in recruiting people to the system.

8.2 Testing and calibrating Reliability (R) and Availability (PHA)

8.2.1 How many receive a warning?

The data on warnings here cover both official and unofficial warning sources including personal observation. 'Warned' here refers to those who responded positively when asked whether their household received a warning that their property might flood. The wording of the question differed slightly between the two project survey phases but in both cases it was broadly left to the respondent to define what constituted a warning.
In the first phase respondents were asked:

> 'So, during the events of February 04/January 03, did you receive any warning that your property might flood?

In the second phase, the question was:

> 'So, before or during that flood, did your household receive any kind of warning, whether official or unofficial that your property might flood?'

This open question approach to eliciting information on flood warnings has been used in the earlier BMRM post event surveys although the exact wording of the question has varied slightly. In the phase 2 project survey, those who responded negatively to the open question on receipt of a flood warning were then asked:

> 'Can I just check, did you receive a warning in any of these ways?'

And were shown a checklist of possible sources of warning both official and unofficial.

In the phase 2 survey, 40 % overall reported receiving a warning in response to the open question. When asked the check question, an additional 11% (31 respondents) reported receiving a warning. Most of these recalled an informal warning from a neighbour, friend or relative (13 respondents) or from personal observation (18 respondents). However, when prompted, two respondents recalled receiving an AVM and three cited their calling Floodline. This finding indicates that the open question approach will result in an understating of warnings received particularly unofficial warnings and that different respondents may interpret what constitutes a 'warning' in different ways. Presenting respondents with a checklist of possible warning sources would overcome both problems. For consistency and comparability, the response to the open question used in both phases of the survey has been used in the analysis and the results from the checklist questioning have not been included as warned.

Among all the residents in the project surveys, only 37% received a warning of any kind prior to flooding. The proportion warned amongst those with built property affected by flooding was similar, 38%.

Table 8.1 shows the proportion of flooded properties where a prior warning of flooding was received found in BMRM post event surveys since 1997 and in Phase 1 and Phase 2 project

surveys. The Phase 2 survey excluded households where all household members were away overnight, for example, on holiday, at the time of the flood and that were therefore in a poor position to respond but also includes 54 respondents in areas with no flood warning service. An improved performance in flood warning dissemination was evident in the autumn 2000 floods which, it can be argued, is partly explained by the fact that the flooding affected rivers for which it is easier to issue warnings. However, the improvement does not appear to have been maintained. On the basis of the data in Table 8.1, it appears that the percentage in receipt of a warning is currently unlikely to be more than 40% although the Environment Agency aims to improve forecasting and dissemination through its Investment Strategy (Environment Agency 2003).

8.2.2 Sources of warning

The project surveys (Table 8.2) demonstrate that the AVM is becoming the dominant source of flood warnings with 42% of those warned receiving the message in this way. Other important official warning sources were flood wardens mentioned by 14% of residents and personal telephone contacts with the EA cited by 11% of residents in receipt of a warning.

Unofficial warnings from neighbours, relatives or friends remained an important source of warning information reported by 24% of warned residents as was personal observation mentioned by 18%. However these informal warnings were often drawn on in conjunction with official warning sources. Nevertheless over a quarter of all warned residents (28%, 41 households) relied solely upon such informal warning sources. The proportion was similar for those with built property affected by flooding (27%, 35 households).

The pattern of warning sources was very similar across the events and locations included in the two phases of the research in all but one respect: flood wardens were mentioned much more frequently as a warning source in Phase 2 compared with Phase 1. This was because Phase 2 covered particular locations in Thames Region and along the Severn where warden schemes were promoted.

8.2.3 Who receives a warning?

Within the surveys, there were very marked variations in the receipt of warnings at different locations with different warning systems facing different events. This is illustrated in Table 8.3 although the data must be interpreted with some caution because the numbers in particular locations are small. The BMRM post event surveys including the Phase 1 project survey cover only areas of known risk where a warning service can be expected to be provided. The Phase 2 survey included some areas, and at least 54 residents, that were identified as affected by flooding from non main rivers for which warnings could not be expected to be issued. The inclusion of these non-serviced areas partly accounts for the poor level of receipt of warning in some areas.

Only 13% of the residents in the non-serviced areas received any kind of warning. At least in the non-serviced areas surveyed in this study, informal systems did not operate to compensate for the lack of an official warning service: no warnings were received from informal sources

there. Indeed, the only warnings that were received in the one main non-serviced area reporting any warnings, came from an official source, a flood warden responsible for a nearby area. The informal warnings operated in combination with official ones in serviced areas.

Being registered on the AVM system was the main factor associated with receiving a warning. Residents in both phases of the project were asked whether they were registered on the AVM system at the time of the interview. Overall, 51% of those who answered the question were registered on the system. The proportion was very similar for those whose built property was affected by the flood (52% overall). Those residents currently registered on the AVM were twice as likely to have received a warning compared with those not registered (48% on the AVM compared with 24% not registered). There was a similar picture for those with built property affected (47% compared with 27%).

The Phase 2 survey respondents were also asked whether they were registered on the AVM at the time of the flood. This demonstrates even more clearly the impact of being on the AVM system on actually receiving a warning: three quarters (76%) of all residents registered at the time of the flood reported being warned compared with 27% of those not on the system. Those who had prior experience of flooding (above floor level) were more likely to have been registered at the time of the flood than those lacking that experience. The Phase 2 survey also demonstrates the importance of experience of flooding and shows how the flood served to encourage residents to register. At the time of the flood, only 28% of all residents in the Phase 2 survey reported being on the system; an additional 24% joined after the flood so that altogether 52% were on the system at the time when the survey took place.

No other variables apart from flood experience were identified as accounting for residents being registered on the AVM system. Current registration did not vary according to social class, length of residence, living alone, household vulnerability in terms of age or health or the presence of children in the home or even awareness of flooding prior to the recent event.

Bi-variate analyses on the project survey data indicate some other factors that are associated with receipt of a warning. More long terms residents (those resident 20 years or more) had received some kind of warning than more recent residents. This did not appear to be due to the longer term residents being more likely to be signed up on the AVM system: the AVM system is a fairly recent phenomenon. It may be because long term residents have greater experience and awareness of the flood risk or because they are better linked into local social networks that amplify warnings. Certainly all those residents who reported that they were aware of the flood risk prior to the recent flooding were significantly more likely to have received a warning (47% compared with 23%) and again this did not appear to be simply due to a higher proportion being registered on the AVM. Not surprisingly, those with prior experience of flooding inside their homes (above floor level) were not only more likely to have been registered on the AVM at the time of the recent flood but also to have received a warning.

There were no differences in receipt of warnings according to social characteristics of residents such as social class, living alone, household vulnerability in terms of age or ill health or the presence of young children. Warnings are not, as yet, targeted at particular groups and it remains the responsibility of households to sign up to the AVM warning system, although it is

the responsibility of the EA to ensure that they are aware of and are offered the opportunity to join the system where it is available.

8.2.4 Reliability (R) and Availability (PRA) and Effective action (PHE) and Flood Damages Avoided (FDA)

Receipt of a warning and actions taken

According to the model, we would expect those in receipt of a warning to be more active in preparing for a flood and in protecting their property than those who reported receiving no warning. However, Table 8.4 which presents results from the BMRM post event survey on the autumn 2000 floods and from the project surveys shows that this is not always the case. When the extent of property flooding was taken into account, there was little difference between those with and without a warning in autumn 2000. In the recent surveys, the picture was somewhat different. In Phase 1 again those warned behaved in most respects in a similar way to those who received no warning. In Phase 2, however, the two groups did differ significantly in what they did with many more of those who were warned engaging in actions to protect their property (Check as to whether this was because of serviced /unserviced areas rather than warning as such. Perhaps it is not the receipt of an event specific warning that is the spur to action but awareness of the flood risk and experience of flooding? Check)

Receipt of a warning and PHE and FDA

Table 8.5 shows the proportion of those with and without warning who succeeded in making some household inventory damage savings among residents with built property affected by flooding. The differences between the two groups are significant but not very large. There were significant differences in the flood damages avoided (FDA) according to the receipt of a warning both in terms of the £ value of savings achieved and in terms of the percentage of damage avoided.

In monetary terms, on average for those with built property affected, the unwarned reported saving £ 821 less than those with a warnings (those with zero savings included in the calculation of the means) and the households without warnings only saved two thirds of the amount that warned households saved. As the actual £ value of savings is likely to be substantially understated because of the way in which the savings and damage data were collected, the proportion is perhaps the more useful figure. It could be argued that it is this difference between the savings of those in receipt of a warning and the unwarned rather than the total value of the savings of those in receipt of a warning that should be taken as the benefit of a flood warning.

Furthermore, given that a relatively low proportion of flood affected residents actually received a warning, the total reported £ savings of all those warned (£ 303,744) were slightly less than the total reported saving of those who took action without the benefit of what they understood to be a warning (£ 330,576).

The data indicate that it is mainly the receipt of an event specific warning rather than the fact of being in a serviced area, that makes a difference to the £ value and proportion of savings achieved. Although residents in the areas without a flood warning service saved less than other residents, when their savings were compared with those of residents in serviced areas who received no warning, there were no significant differences. Significant differences, however, remained between the warned and the unwarned in the proportion saved when those in non-services areas were excluded (Table 8.6). The small number (54) in the non-serviced areas must be noted.

Official v unofficial warnings and PHE and FDA

Although those who received at least one warning from an official source were more likely to make some damage saving efforts than those who relied on an unofficial warning (relatives, neighbours or personal judgement), (87% compared with 77% respectively), the differences were not statistically significant. There were also no significant differences between the two groups in the flood damages avoided both in terms of the £ value of damage savings and in terms of the proportion of savings achieved among those with built property affected by flooding (Table 8.7). This suggests that a warning of some sort does make a difference to damage reduction but it need not be an official one. This finding supports the argument against making a distinction between official and unofficial warnings. However, as there were only 35 cases where residents with built property affected relied upon an unofficial warning only; this finding must be interpreted with caution.

Warning lead time and PHE and FDA

The economic benefits model assumes that warning lead time is a significant factor in flood damages avoided. The research tested the assumption that a longer warning lead time will lead to greater savings. Residents reported on how long before flooding they received a first warning. This interval is the warning lead time used in the analysis rather than the time from warning issue to flooding. As some of the main locations in the surveys were on long, slow rising rivers, many people had long warning lead times. The warning lead time in hours is shown in Table 8.8 for all warned residents, and for warned residents whose built property was affected by flooding. The numbers who had very short warning lead times were small and therefore the analysis of the impact of warning time on effective action and savings is for those with less than eight hours warning and eight hours or more warning.

Warning lead time categorised in this way does appear to have an effect on savings achieved (Table 8.9). Those with eight hours or more warning of flooding saved significantly more in terms of the £ value of the savings and also in terms of the proportion of property saved. Those with a warning lead time of less than eight hours saved on average £990 less than those with a longer warning lead time and what those with the shorter warning lead time were able to save represented only 66% of the £ value of savings of those with eight hours or more notice. However, here it is particularly important to be aware of the small numbers of cases and the very large standard deviations involved. The fact that the method used to obtain the £ valuations of savings means that £ savings are understated must also be born in mind: the £ savings reported are likely to be minimum values.

Beliefs about the warning

Research indicates that it is not simply the receipt but also the content of a warning message that has an influence on the response of recipients (Drabek, 2000). The type and level of information in the warning message and how believable recipients find the message to be are important. Handmer (2000) stresses that warnings must be meaningful to recipients if they are to be acted upon. Bye and Horner (1998: p.5) commenting on the Easter Floods of 1998 recognised the importance of message content and called on the Agency to give:

> '*greater attention to the human and social aspects of warning message construction, dissemination and encouraging effective response*'.

The Agency responded by producing new warning codes and message texts.

To test this, the research included a question asking those who had received a warning how informative the warnings were. Generally, residents were pleased with the information they received with 40% of all warned residents and 42% of those with built property affected finding the warning or warnings 'very informative'. 'Fairly informative' was the next most common response given by 30% of all those warned, followed by 'not very informative' by 19%, and with only 9% regarding the message as 'not at all informative'. Percentages were similar for those with built property affected by flooding.

From the data, there is little to indicate that any sources stood out as particularly informative, whether official or unofficial, although the handful of residents (22) receiving a warning from a flood warden were significantly more likely to regard the warning as 'very informative' than residents warned in other ways (72% compared with 34%) perhaps because this method involved personal interaction.

The majority of residents (74%) also, on the basis of the warning received before the flooding, believed that their property was at risk from flooding and indeed, as many, believed (73 %) that it was going to flood. For those with built property flooded the percentages were (77% and 79% respectively). This suggests that the denial and disbelief, often identified in hazards research, were not major impediments to action for those who received a warning in the areas and events studied for the project. However, there may be an element of post-hoc rationalisation in the answers given. Certainly, the small number of warned residents (21) whose built property was not affected by the flooding were significantly less likely to report that they believed the warning on risk (57%) and flooding (38%) than those affected more seriously.

Residents with built property affected by flooding who received a warning message that they regarded as 'very informative' were no more likely to take some action to save property than others with less informative messages. However, they did report making significantly greater £ savings and saving a significantly greater proportion of their property than others (Table 8.10). Residents in the focus groups complained that warnings were too general and covered too wide an area to assist them in making a decision as to whether to move or raise property. In some instances, those issuing warnings were viewed as too distant and out of touch with the

local situation to be useful. Some reported that it would have helped them to know when rives would peak at a point up stream so that they could then calculate when the flood would be at its height in their location, and thus judge whether they would need to take action to protect their property. The research indicates that the more detailed and site specific a warning message is, the more likely it is to be believed and acted upon (Drabek 2000). Evidence from this research tends to support that view. Changes to the flood forecasting and warning system and planned investment in the service may result in a service that is better able to meet these needs (Andryszewski *et al*. 2005; Environment Agency 2003). What residents believed from their warning might happen to their property generally did not appear to influence their damage reducing actions.

9. ABILITY-PROPORTION OF HOUSEHOLDS ABLE TO RESPOND (PHR)

9.1 Assumptions

This component makes the assumption that a proportion of households will be totally unable to take any damage reducing action by reason of age, infirmity or due to other factors such as pregnancy. Households with small children or with English as a second language, in which people might have difficulty in understanding warnings, have also been suggested as households that might not be able to respond to a warning. The proportion of the households reporting in post event surveys that they contained someone with 'any long term illness, health problems or disability which limit your/their daily activities or the work you/they could do (including problems which are due to old age)' has been taken as a guide to this proportion. In the BMRM post event surveys, the proportion responding positively to this question has ranged from 17% (BMRM 2000) to 23% (BMRB 1998b). In these surveys, with the exception of 17% of Welsh speakers mentioned in the 1997 post event survey report, those with English as a second language have included just a handful of respondents or about 1% of the sample.

In the various applications of the model proportions of 15 – 25% of households in residential properties have been assumed to be incapable of moving furniture and thus saving damages (Table 3.1).

9.2 Testing and calibrating Ability (PHR)

9.2.1 The proportion of 'vulnerable households' (PHR)

The surveys provide evidence on the characteristics and number of all households and of households with built property affected by the flooding that might be expected to be unable to make savings (Table 4.3). These include households containing an ill or disabled member, a member aged 75 and over and single person households. A composite category of 'vulnerable household' has been derived for households falling into at least one of the three vulnerable categories above.

Table 4.3 indicates that if the ill, disabled or over 75s only are included in the category of those unlikely to be able to take damage reducing action, a proportion of 27% is a likely estimate. 'Vulnerable households' (ill, disabled, over 75 or living alone) constitute a substantial minority of those in the project surveys (35%).

There were only 4 households where English was a second language in the project surveys and there were few household which contained very young children under 5 years of age and even of households with one or more children under ten (Table 4.3). This suggests that these categories are unlikely to add significantly to the proportion unable to take action in many flood events. However, there could be specific events where more minority ethnic group residents and households with very young children were affected. The small numbers have limited the opportunity to examine the impact of the presence of very young children on the household's ability to make savings.

9.2.2 Vulnerable households and the receipt of a warning.

Research has been undertaken for the Environment Agency to investigate the special issues involved in disseminating flood warnings to vulnerable groups (Thrush *et al*, 2005) and also to examine any particular problems that new and emerging flood warning technologies might pose for those with special needs (Tapsell *et al*., 2004). However, in this survey, these vulnerable groups were found to be no more or less likely to have received a warning in the recent flood event than other households. As yet, it is not possible in most areas to target warnings first to those who might need extra time to summon help or to take action themselves to save property.

9.2.3 Ability (PHR) and Effective Action (PHE) and Flood Damages Avoided (FDA)

Vulnerable households whose built property was affected by flooding, both those in receipt of a warning and those unwarned, were considered. It emerged that households containing an ill or disabled person were as likely as other households to engage in some damage saving activity and there were no significant differences in the £ value of savings, the proportion of savings achieved and the total £ value of savings and damages taken together (Table 9.1). These households, on the basis of this research, were very similar in their response to flooding to other households.

For the households including someone aged 75 and over, although there were differences in the proportion making some savings, they were not statistically significant. There were significant differences in the £ value of savings but not in the proportion of property saved. This appears to reflect the fact that these elderly households had less property to save as the £ value of their damaged plus saved property was also significantly lower.

A similar picture emerged when the households containing someone aged 75 and over and/or those with an ill member were combined. These households containing elderly or ill people were less likely to make some savings but differences were not statistically significant. The same was true of the proportion of savings made. These households, therefore, made as much effort to save property and appeared to be as effective in their actions as other households. There were significant differences in the £ value of savings and in the overall £ value of their savings and damages: these households saved less but had less to save according to their reports.

The findings were broadly similar when those living alone were compared with households with two or more residents (Table 9.2). As many residents in single person households as in other households made some effort to move or raise items and they were as effective in their actions as other households. However, the £ value of their savings was significantly less reflecting the lower value of their threatened property.

When all three categories of household that might be expected to be unable to take action on flooding (those living alone, the ill or disabled, and 75+ households) were combined to create a ‘vulnerable households’ category, the picture was the same. The vulnerable households saved significantly less property in terms of £ value but also had less £ value of property to

save. The proportion that they managed to save was not significantly less than that saved by less vulnerable households.

When the small number of households containing children under ten whose built property was affected by the flooding was compared with households without young children, no significant differences in actions taken and savings achieved were found in the bi-variate analysis.

9.2.4 Help from outside the household and PHR

In the economic benefits model, the vulnerable are assumed to receive no help from outside the household and to be unable to take effective action to save property partly for that reason. The analyses above do not take the factor of outside help into account.

About 40% of all residents reported that their household had received help other than that of household members in protecting their property. The proportion was similar for those whose built property was affected by flooding (44%). However, outside help was significantly and understandably less forthcoming for the small number of households whose built property was not in the event affected. Only 21% of these households received such help.

Neighbours and friends were the most commonly cited source of outside help in protecting property, mentioned by more than half of all the residents helped (55%), followed by family outside the household (25%). The focus group discussions provide many examples of neighbours on the spot helping each other save property. The other main sources mentioned were local authorities (24%), emergency services (12%) and others unspecified (17%). From these responses, it appears likely that residents defined help 'protecting property' quite widely and did not confine their replies to help with moving or raising items.

The households that might be considered to have greater need of help from outside: households with an ill or disabled member, with a member aged 75 and over, single person households individually and in combination, and those containing children under ten, generally and where their built property was affected by flooding, were no more likely to attract help than other less vulnerable households.

When all residents with built property affected by flooding, were considered without taking the receipt of a warning into account, help from outside the home appeared in bi-variate analysis to be a significant factor (Table 9.3). It was found to have a significant effect on the proportion attempting to save property, and the £ value and proportion of savings achieved. The findings for the vulnerable households were in the same direction but the only statistically significant difference between those receiving outside help and those with no help among vulnerable households was in the £ value of savings.

These bi-variate analyses provide little support for excluding a proportion of households from the calculation of benefits on the grounds of disability or ill health: these households may be able to achieve less but they do take some action.

10. OTHER FACTORS AND EFFECTIVE RESPONSE (PHE) AND FLOOD DAMAGES AVOIDED (FDA)

10.1 Flood experience

Past experience of flooding has consistently been found to be a significant factor in flood risk perception and response. However, as Drabek has pointed out past experience of a flood where the property was not affected can mislead residents into believing that their property will not be flooded in subsequent events (Drabek, 2000). The focus groups discussions provide instances in which residents had believed that they would not be affected because their property had not been flooded in past events.

Partly for that reason, residents were asked how many times altogether their address had been flooded above floor level since they had been living there. There were very few residents with some built property flooded in the recent flood who had never experienced above floor level flooding (7%), for two thirds the recent flood was their only experience of above floor level flooding in their home and small proportions (16%) flooded inside on two or three occasions in total and another minority (15%) who had been flooded inside four or more times.

Not surprisingly, the number of times residents had experienced above floor level flooding was a significant factor in taking some damage reducing action in the recent flood event. Almost all (96%) of those flooded four or more times inside their homes, reported responding in this way compared with 76% of those for whom the recent event was their first experience of above floor level flooding at their address. Those with substantial experience (flooded four or more times inside their property) also saved more in £ value terms and in the proportion of their property they saved compared with those flooded inside just once.

Table 10.1 compares the damage reducing actions of those never flooded or flooded just once above floor level with those with experience of two or more flood events that affected the inside of their homes. Flood experience categorised in this way does appear to make a significant contribution to £ value of property saved and the proportion of property saved. However, among those with built property of some kind affected by flooding in the recent event, those with experience of above ground floor level flooding predating the recent flood event were more likely to have received a warning than those without experience (55% compared with 30%). This was hardly surprising since they were more likely to be located in an area where the risk was known and a service provided, and to have signed up for the AVM system or to be able to rely on their own judgement about the flood risk.

The question then arises as to whether flood experience is a factor in damage reducing action over and above the receipt of a warning? Table 10.1 shows that those in receipt of a warning who also had flood experience made the greatest savings and saved more of their property than others in the surveys. However, differences between those warned and not warned among the small category with flood experience, although in the expected direction, were not statistically significant. For the larger group with no flood experience, the receipt of a warning did appear to make a significant difference to £ savings and to the proportion of property

saved. Ironically, therefore, warnings are less likely to be received by those who would benefit most from them: those without prior experience of flood waters in their homes.

10.2 Prior awareness of flood risk in the area

A majority of residents (56%) and a similar proportion of those with built property affected by flooding (52%) were aware that their address was in a flood risk area before the recent flooding. Awareness did not differ significantly according to the gender, age, or social class. It did not differ according to length of residence categorised as less than 10 years, 10-20 years, or 20 years or more although it is possible that very recent residents might have been different. Not surprisingly, those with previous experience of above ground level flooding were more aware than those who had only experienced such flooding in the recent event or never before. Those who had received a warning were also more likely to claim prior awareness of the flood risk in the area.

In bi-variate analyses, those who had prior awareness of the flood risk did not differ significantly from those unaware in the proportion making some attempt to save property and in the £ value of property saved. They did report saving a significantly higher proportion of their property at risk than those unaware. This may simply reflect the fact that more of them received a warning and had prior experience of flooding.

10.3 Contents insurance

It has been argued that as residents with 'new for old' contents insurance will be compensated through insurance for their losses, having such insurance cover may act as a disincentive to residents to take action to protect their property. Nearly two fifths of all the residents (78%) and a similar proportion, 81% of those with built property affected had such insurance.

There was no evidence in the surveys to support the argument that having such insurance has any influence on damage reducing action overall. Those with new for old insurance were as likely to take some action to save their property and were as successful in their efforts as those without such policies. The only significant difference lay in the amount of property the two groups had at risk (£ value of property saved plus property damage incurred). Those with new for old insurance had more property to save compared with the uninsured. This may simply reflect the fact that the DE social class groups, whose items were accorded a lower value, were markedly less likely to have such insurance (57% compared with 85% of other social class groups with built property affected).

10.4 Number of people in the household

Larger households might be expected to be able to save a higher percentage of property at risk simply by virtue of having more hands available to move and raise items. However, the households included in the surveys were small. Nearly a fifth (18%) were single person households; over two fifths contained two persons (44%). A further 30% comprised three or four people and a mere 8% were larger households with five or more members. There were significant positive correlations between the number of people in the households with built

property affected by flooding and the £ value of savings achieved and the £ value of property at risk. However, there were no associations between household numbers and the proportions attempting to save property or in the proportion of property saved. It appears that larger households may save more in terms of £ value because they have more to save.

10.5 The type of housing

Some housing such as bungalows, ground floor flats and caravans is particularly vulnerable since these properties do not have an upstairs to which residents can move items. In these vulnerable properties, the content at risk might be expected to be greater and the savings achieved smaller than in other properties. Focus group discussions provide evidence that narrow staircases and restricted space upstairs may also limit the amount of damage reduction that can be achieved. However, there were too few properties in the surveys (30 overall and 19 where built property was affected by flooding) in the 'vulnerable housing' category to allow this variable to be analysed separately although it was included in the multivariate analysis.

11. RESIDENTS' VIEWS ON PROPERTY SAVING ACTION

11.1 Beliefs about effectiveness of actions

All residents who took action of some kind to prepare for a flood (not just raising or moving property) were asked how effective they thought their actions were in reducing the damage caused by flooding. Those who received a prior warning were significantly more likely to believe that their actions were effective than those who did not (Table 11.1). A fifth of those without a warning regarded their actions as 'not at all effective'.

Furthermore, the resident's subjective judgements on their damage reducing actions appeared to be reflected in the numerical measures of the £ value of property saved and the proportion of property at risk saved. Residents with built property affected by flooding, who rated their actions as 'very' or 'fairly effective' saved significantly more than those who regarded their efforts as 'not very' or 'not at all effective'. There were no significant differences in the total value of property potentially at risk (£ value of damaged plus £ value of saved property) (Table 11.2).

11.2 Saving more

Towards the end of the interview, after reporting on items saved and damaged, residents were asked what if anything would have enabled them to save more property (Table 11.3). Most commonly, residents saw a longer warning time as the thing that would have helped them. This was true both of those who received a warning prior to flooding and those who did not. Not surprisingly, unwarned residents were much more likely to cite this. A more specific, more informative warning was also mentioned by residents, who had no prior warning. Among those who were warned, those who had a warning of under two hours were much more likely to mention the warning time as a factor in their saving. However, even among those who had a warning of eight hours or more there were some who felt that they could have done more with a longer warning.

12. MULTIVARIATE ANALYSES OF PREDICTORS OF FLOOD DAMAGES AVOIDED (FDA)

The bi-variate analyses identified some of the factors that appear to affect residents' behaviour in response to flooding and flood warnings and the £ value and proportion of their property that residents are able to save (FDA). These bi-variate analyses can be misleading. Therefore, multivariate regression analyses were undertaken in order to identify the contribution of the many different factors that may have some influence on the savings achieved.

12.1 Variables for inclusion in regression analyses

A backwards regression analysis was undertaken for residents with built property affected. All the selected predictor variables were entered into the regression and were removed one at a time according to the criterion for exclusion: a significance of $p>0.05$ for that variable indicating it is not reliable as a predictor. The two dependent variables: £ value of savings and the proportion of property at risk saved, were log transformed to create the two new variables LNSVTOT (log normal [£ savings +1]) and LNSVPROP (log normal [proportion of property saved +1]). The factors listed below were entered as predictor variables and various models were examined.

Factors relating to the flood event:

- Extent of flooding – above floor level or not
- Depth of above floor level flooding in centimetres
- Duration of flooding (12 hours or more: 0,1)
- Day or night time flooding? (1,0)

Factors relating to the Warning: R Reliability and PRA Availability

- Serviced area or not (1,0)
- Receipt of a warning (1,0)
- Official or not (1,0)
- Warning lead time (8 hours or more:1,0)

Beliefs about warning

- Warning very informative (1,0)
- Believed at risk
- Believed would be flooded

Ability of households to respond: PHR Ability

- Long term illness or disability (1,0)
- Aged 75 and over (1,0)
- Living alone (1,0)
- Vulnerable households (1,0)
- Vulnerability scale (0-3)
- Children under ten in the household (1,0)

Other social factors

- Social class: AB (1,0), DE (1,0)
- Length of residence (20 years or less: 1,0)
- Experience of above floor level flooding (0,1,2,3,4 times)
- Number in household (1-8)
- Prior awareness of flooding (1,0)
- Tenure/home owner (1,0)
- Help from outside the home (1,0)
- New for old insurance

Type of dwelling

- Vulnerable housing (1,0)

12.2 Models to predict £ savings and the proportion of property saved (FDA)

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Despite careful examination of various models, the initial best-fit models that emerged explained only a small proportion of the variance in the dependent variables (Tables 12.1 and 12.2). The predictor variables were consistent with our theoretical model (Figure 1) and the predictions were in the direction we would expect. However, behaviour in response to flooding and, in particular the £ value and the proportion of savings made, are complex matters and the variability in individual responses remains difficult to explain.

For the £ value of savings (Table 12.1), prior experience of above floor level flooding was a key predictor; the more of such floods households had experienced at the address in the past the greater the savings. This is, of course, what the research literature from Kates onwards would lead us to expect. Help from outside the home also contributed positively to the savings achieved. In other studies of the wider impacts of flooding, we have been unable to discern any effects of social support of this kind on the impacts of flooding. For example, in a study of the overall subjective severity of the overall impacts of flooding and of individual impacts, this was the case (Ketteridge and Green, 1994). Help received was not a significant factor in the health effects experienced as a result of flooding in our recent study (Tunstall *et al*, in press). The number of people in the household was also a predictor: it may be that the more hands available to move or raise items the greater the £ value of items saved. Alternatively it may reflect the higher value of property at risk in larger households and the fact that larger households had more property to save. Household size was not a predictor of the proportion of property saved.

Being in social class AB had a positive effect on the £ value saved probably reflecting the much higher values attaching to individual items in the household inventory as social class was not a factor in the proportion saved. Households containing someone sick or disabled, or aged 75 and over had a negative effect on the £ value of savings. A warning time of more than eight hours was a predictor of higher £ savings. A flood duration of more than twelve hours was associated with greater £ savings. These could be because events in which flood waters were slow to recede were slow onset events allowing residents more time to protect their property,

or it could be that long duration of flooding characterised certain events and the localities they affected.

The proportion of property at risk saved is perhaps a better measure of household's success in saving property since it does not reflect the £ value of property at risk in the way that the £ value of property saved does (Table 12.2). Many of the predictors, however, were the same for the two dependent variables. Experience of above ground floor flooding was again a key predictor of damage reducing action. For this dependent variable, a characteristic of the flood, the depth in centimetres of flooding above floor level was a significant factor with the proportion of property saved declining with increasing depth of flooding. Warnings, too, were important with a warning of eight hours or more again a significant factor associated with a higher proportion of savings. For this dependent variable, it was not only the length of warning time but also another feature of the warning, the reported level of information conveyed that was significant. A warning described as 'very informative' was a predictor of saving a greater proportion of property at risk. This is consistent with the research that indicates that a more detailed and specific warning will stimulate a greater response (Drabek, 2000). Finally, vulnerable households containing people aged 75 and over, or ill or disabled members were again a factor contributing to saving a smaller proportion of property.

13. INSIGHTS FROM THE FOCUS GROUP DISCUSSIONS

At the beginning of this project, five focus groups discussions were carried out with residents who had experienced flooding since September 2000. Details are given in section 2.2 above. The following are edited extracts from the transcriptions of the discussions. Names and details have been changed to protect the anonymity of participants These quotations illustrate the complexity of the social processes that take place on receipt of a flood warning. They also indicate the very wide range of factors: individual circumstances, personal histories, priorities, beliefs and attitudes that come into play in an individual's responses to flooding and flood warning.

13.1 Receiving a flood warning

The following extract from a focus group held in Worcester with a group of residents who had considerable experience of flooding shows the complex processes involved in receiving a warning, and the denial, debate and personal judgement involved in acting on it. It also indicates the type of information that warning recipients are looking for in a warning.

> *"My husband received a call at work because they didn't get our houses on the phone but since we've had an answer machine, it comes on there but because nobody has activated the switch, they get the message but they still ring him at work on the mobile as well."*
>
> *"It was me, phoning from Amsterdam to tell my partner who was in the house but she didn't realise that the water was downstairs. That sounds remarkable but that's what it was. It was myself. The water was already in."*
>
> *"I had a call on my mobile and the answer machine at home and the phone at work. This was all from the EA, but we already knew we were going to flood from watching it, because I've lived there for so long, you know when it's going to come over."*
>
> *"Having said I was the first one, it wasn't because I was at home. I was at work and I knew it was coming pretty close but I was at work and I work with my neighbour Lynn and Billie, down at the end of the road, we both work for a catering company and Billie rang me at work to say Lynn's just rung, we've had a flood warning and it's coming up pretty quick, what do you want to do ... you know, this was in the afternoon, so I said well I'll hang on until I finish.*
>
> *"You also know from further upstream. Other people get it before us and you know when it's peaking there and when you're going to get it. You can tell by watching."*
>
> *"I think we all look somewhere across the river don't we?"*
>
> *"You look every hour, every couple of hours ...".*

“Again, my mobile at work, but I knew it was coming anyway, but you tend to persuade yourself that you’re wrong, that it’s not going to come in, that it will only come up a couple of inches and go back down.”

“I think everyone’s circumstances are different. You know, we know the river so well, if it’s up in the gardens, and there’s an Atlantic squall coming in, I don’t care what the warning system says, I start to get ready even if it’s just tidying up. Yes, I’ve often had warnings after it’s been in.”.

“Yes, so in fact we all just make a judgement between us, and warnings and news reports we just kind of disregard really. Our houses are in a row, single terraced, one unit, we know pretty quickly how it’s going to affect our property.”

“I will say that the main thing we want to know, in a warning, is when the peak is going to be at Bewdley, if we knew when they expected their peak, we know ours is 24 hours later”.
This was particularly when we were very very close to being flooded, we just could not get anything definite”.

Comments from a Wraysbury resident exemplify how denial and disbelief lead to delays in taking action to protect property.

“*There were no flood warnings that crossed my line of living, any telephone numbers I dialed, they didn’t really seem to know except to say that there is a red flood warning. It was quite a shock, completely unexpected”,*

“Well time is relative, I did not think it was going to get higher, I kept on thinking that must be it. So anything in my outbuildings was completely ruined, I did nothing about that at all because I kept on thinking it must be going to stop. When I became aware it was still rising, as I said, the lowest room in my house is one of the bedrooms, and I took absolutely everything off the bedroom floor and piled it onto the bed because I thought that would give me at least another six inches, eight inches and I would just lose the bed but keep everything that was on the floor, it would be safe and that was as much as I did”.

“I didn’t have much time, that’s why I decided that I needed to do that. I did it in the time, altogether it takes some two to three hours, I was on my own. I was a question of emptying wardrobes, the bottom of the wardrobes”.

“I think a lot of people didn’t do things in time because of sheer disbelief that it was actually getting higher”.

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13.2 Not receiving a flood warning

The following quotations are from residents flooded at night time in Halstead, Essex. They indicate the high expectations of residents regarding the flood warning system and how attempts to obtain sand bags can take priority over moving property.

> *"Myself and my husband have been there 27 years and it's the first time it had ever happened and hopefully it's the last and I recall that night, I hadn't been sleeping very well, and I remember getting up and looking out of the window and thinking, this river's rising really quickly, and I went downstairs and told my husband and he came out and looked and said we'll have to keep an eye on it. About half an hour later I said we're going to have a problem here, so I got in touch with the EA, told them what was happening, and I said can you bring us some sandbags and they said no, what we've got has to go to Colchester, and I said well that's not going to help us, so I remember coming down the stairs, dressing gown, slippers, knocking all the neighbours up, they all thought I'd gone mad, what the hell are you doing knocking on my door at 1 o'clock in the morning sort of, you know, and I said well look out of the window, of course, everybody started to come out and in the end I phoned up the Council and some man, I remember he was very polite, and I explained what had happened, the sandbags did arrive but too late"*.

> *"I didn't actually know we were being flooded until my neighbour woke me up and said have you seen outside and I thought she'd gone bonkers. I think that was about half past twelve. Yes, it was at night and like I said I have an answer phone and I am on the flood warning list with the EA but I don't remember getting a call for a start. That's why I said maybe with answer phones, I mean, it could be that it clicked in while I was upstairs or something, you know, but I didn't receive a call and I'm actually on the list and have been since I moved in".*

> *"I live by the river front, so if there is going to be high water, there's an obvious chance that it might come into the garden at least, but I would point out that that night I never actually had a flood warning, but even if I had of done it wouldn't have made any difference as the other people have said, but I do think one thing's important, the flood warning is something that's very important, I mean, we should know if there's a risk of flooding, but I also think there ought to be some kind of degree of risk, if it is possible, in other words, are we going to be flooded or is the river going to be full of water, they are two very different things, and if there is a way of assessing at least the degree of flooding, there should be properties that are prioritised, that are obviously more likely to be flooded than others".*

The remarks of Sunbury residents also show the high expectations residents have of the flood warning service. They provide indications of disillusionment with official warning systems and reliance on informal systems on the basis of their experience.

> *"I remember the first time (we were flooded) we were ringing up the EA all the time and just trying to get through to a person to speak to rather than a recorded message, and saying can you give any indication as to how many more inches there are likely to be and*

they sort of would say anything between sort of 1 and 12 inches and you'd say well, 1 is the difference between us no longer having a house to live in and that was all they were able to say, and I don't know, I just don't really have much faith in these Government agencies".

"Use our own judgement and rely on other people to tell you what is going on, and this is really what was so good about everybody helping each other out".

"*Yes, it was useful down our street because certain people obviously knew about different high tides and low tides and what times they were going to come, so they would actually tell you all we're going to have another high tide tonight, so you could actually monitor it more."*

"*Yes, sharing information".*

"And it was local information from people in that immediate area".

"*Yes, because if you phone the Floodline it just tells you that from the river down from Windsor to sort of Headington, you're on a sort of low flood warning, but it doesn't actually specify which little section, so of course it can vary quite considerably in that long stretch of the river, and depending on how they're monitoring it.".*

13.3 Priorities and actions to save property from damage

Comments from Worcester residents show how those with experience of flooding swing into action when they decide that their property is going to flood. The following are their varied responses when asked what were their priorities on becoming aware that they were going to flood and when asked if they knew what to do.

"*Yes, just move what you could. And what you wanted to, what you could, whatever you could lift, you moved it. And that was it. Having three bedrooms spare you just managed and that was it. You came downstairs in your Wellington".*

"You had to think how high, I left the TV, the video, the stereo, everything, in the front room because it was that far up, and that stayed there for quite a while. And everything survived, but you can't really move a great big three piece suite up the stairs of an old house, you can't get it round the top, so that was lifted on a coffee table and stood in the water. The dining room, the stuff went out into the conservatory and was turned upside down on top of the other table and everything was piled onto that. You just moved what you could, boxed the rest and take it upstairs".

"Empty your kitchen cupboards. All your small items go upstairs".

"If I tell you what my first priority was you would never believe me. What would my first priority be? Move the motorbikes. And that was the main priority ... get the bikes!

We'd already moved our car but it was ..... yes, the most expensive things that you've got ... you move them".

"Yes, the car and the kids".

"I'd just move anything from the lower parts, move to the top so that you can still use it. I took the kettle upstairs and whatever we could take up we took upstairs".

"I did the front room first, raised the furniture, raised the bikes, took all the drawers out, like you say, out of the bottom of the units, raise the furniture, then started on the living room. Televisions, upstairs."

"All my newspaper cuttings and notes from work and that, books and paintings as well. That was what was downstairs".

: *"We've got a lot of books and so even when there's a possibility, even long before it's imminent, when there's a possibility, we like to take the books upstairs, the bookcases aren't a heavy item and they can be carried, they don't even have to be, (can be) left on blocks but the books do need to be moved out and so well before, when there is a possibility, we always move the books upstairs and that is the longest job, taking the books up and from then on it's fairly easy, apart from if we have to get up the carpets and then that is quite a nasty job, but then we start in the kitchen".*

"My house is quite interesting because it is so minimalist now, there's nothing in there. I've got bare boards, I've got a rug, I've got a big table that everything is piled on and then the sofa. I can literally do it in under 2 hours. The kitchen is a hassle and that's the bit ... I don't like to have to lift unnecessarily so I always leave it until the very last minute before I judge because it's just pulling out washers and then they go on top of a top that's been built, like a table, and you can put them on and it's strong enough to hold their weight, so my priority would be to do things like ... it's the garden, get the composting secure and empty and it's just disgusting when it floods, the whole place is like being in a swamp and make sure there's no ash around anywhere or anything dangerous that might float up and hurt you when you're trying to walk around at night, so it's that and the garden that's the most important. You have to do that whether it comes in the house or not".

"I think I've learnt from the last flood now, if I think it's going to flood in the kitchen, unplug the washing machine and move that into the living room on something. I take it out, because you can't do without your washing machine can you?"

The following descriptions from resourceful Sunbury residents illustrate how much even those without flood experience could achieve in terms of saving items without the benefit of a flood warning particularly with the help of neighbours. It also highlights that property was saved not just for its money value but because of associations and sentimental value.

“Well we moved the plinths off the kitchen units because we thought well that ... the worst that was going to happen was that the bottom was going to blow. We put tables and chairs up on bricks or crates, we have a little collection of crates, and we raised the bed up on crates and things. We took doors off and put them up into the attic and laid them flat so they would not actually all blow. …..but even by raising stuff up on crates and things we lost the dining room table and things, because that came up beyond (it).
It came up about 6 inches. It’s like my husband’s father’s bureau thing, which is a family heirloom, which fortunately we managed to get right up and out and that just sort of missed by a few millimetres from actually touching that, but it’s those sort of things that can’t be replaced that are the hardest things to lose.”

“There was me, my husband and a neighbour across the road. The builder who was working across the road did help and the girl next door helped us raise everything up, you know, and a woman down the street came and sort of moved stuff up onto garden furniture, they brought in the plastic garden furniture and put those things up on that, so if you could get as much up off the floor as you possibly could then you were fine.

“Most of the things, we put them up on bricks and things and tables. But in our living room where there’s antique furniture we were able to sort of raise that up on bricks because we had four inches of water, but the piano unfortunately we just could not move it so it was just ruined”.

14. SUMMARY AND CONCLUSIONS

14.1 Survey research methods

- The research was innovative in attempting to estimate the £ value of the potential flood damages to be avoided and the £ savings of residents with built property affected by flooding. However, the research was not entirely successful in this. The surveys produced £ values for the potential flood damages avoided that were about half the values that were found in the latest Manual data (Penning-Rowsell, *et al*, 2005). It appears that the method of collecting data on potential flood damages and on the £ value of flood damages avoided may have lead to an understatement of these valued. The simplified methods used for deriving the monetary values were necessary in order to ensure that the interviews were not too time consuming and burdensome for the respondents and too costly for the project.
- Although the £ values of savings and of property at risk may understate the real £ value, the information on the proportion of property saved and the comparisons across groups remain valid, because the same methods were used to obtain damage and savings data across all the groups in the surveys.
- The surveys indicate that it would be preferable to use a checklist of sources of warning to define the key warning variable in the surveys since there is evidence in this study that some residents will not mention warnings received, particularly unofficial ones but even AVM messages without being prompted. Without a checklist, respondents can and do interpret what is meant by a warning differently.
- It is useful to differentiate in the survey questions between being registered on the AVM at the time of the interview and at the time of the recent flood, in order to be able to evaluate the contribution of AVM registration to the success of flood warning dissemination.
- The focus group discussions were valuable in the development of the survey research but are also a significant source of insights to aid in understanding the complexities of resident's responses to flooding and flood warnings.

14.2 The importance of flood warnings to damage reducing action

- Flood warnings are, the research shows, important for damage saving. Those warned tend to be, but are not always, more likely to take action and to save more. However, many residents take action without a warning on the basis of their own judgement, prior experience and common sense. The £ savings of those not in receipt of a warning of some kind were only about two-thirds of the value of those of the warned.
- The source of the warning, whether the warning comes directly from an official source or from informal contacts does not appear to be of significance.
- Receiving an event specific warning, rather than merely being in a serviced area where residents may have experienced awareness raising campaigns and may have been supplied with information on the flood risk, appears to be an important factor in damage reducing action.
- A longer warning lead time emerged both in the regression analyses and in the residents' views on what would enable them to save more as a crucial factor. Those

with a prior warning of less than eight hours saved on average only two thirds of the £ value of savings achieved by those with a longer warning.

- The content of warning messages has been identified in hazards research and in this project as important in stimulating a response. Residents in the surveys cited more specific and informative warnings as a feature that would enable them to save more and warnings regarded as 'very informative' were associated with greater savings. Information on the timing of the peak flows and more detailed location specific warnings were requested in the focus groups discussions. The Environment Agency is moving towards providing warnings for more specific areas and the research suggests that this may yield benefits through increased damage reducing action.

14.3 Ability to take damage reducing action

- The research does not support the assumption that those in vulnerable households including those with disabilities and health problems including those due to old age or living alone will be unable to take damage reducing action. However, household vulnerability did emerge as a factor exerting some negative influence on damage saving achieved in the regression analyses.
- Help from outside the household played a part in reducing damages. Vulnerable households were no more likely to attract such help than other households. Help came largely from informal sources: from neighbours and friends who spontaneously helped each other and from family who rushed in to provide assistance. This is an area in which community, voluntary groups or local authorities could provide support that could contribute to reducing the damages incurred.
- The research demonstrated again what is very well established in the research literature: the importance of flood experience as a factor in response to flooding and to flood warnings. Those who had had past experience of flood waters in their home made greater savings than those without that experience, perhaps because they were more likely to believe that their home could flood and because they knew what to do to protect their property. Indeed, as the focus group discussions showed, in some cases they had well rehearsed routines for moving and raising property.
- The data illustrate the paradox that warnings are most beneficial and most needed in areas where there is little experience of flooding, which are the areas and events for which it is most difficult and least common to provide warnings. Enhancing warning capacity for these areas and events, however, will yield greater benefits than will be achieved in areas where flooding is frequent and residents experienced.

14.4 The complexity of the residents' responses to flooding and flood warnings

- The regression analyses indicate how complex are the influences upon residents' damage reducing action in the event of flooding. The influence of a large number of independent variables hypothesised as potentially significant in our theoretical model were examined. However, the regression models were only able to explain a small amount of the variance in flood damage savings.
- The focus groups illustrate this complexity further showing that a wide range of interactions between individual circumstances, personal histories and priorities,

experiences, beliefs and attitudes, as well as event and warning characteristics have an influence on actions taken to save property from flood waters.

15. THE DAMAGE REDUCING EFFECTS OF FLOOD WARNINGS: A NEW APPROACH

A new approach to establishing the Potential Flood Damages Avoided (PFA) is recommended (Section 5.4 of this report) and presented in the 'Multicoloured Manual' (Penning-Rowsell, *et al,* 2005). This new approach is simpler and more transparent than the data on PFA presented in the earlier Manuals.

In addition, while the survey research has provided some evidence for the inclusion of some of the factors in the economic benefits model, the research has shown that some of the assumptions made in the model are only partially supported by the empirical results from the surveys. In particular, the economic benefits model included 'Ability' as a key factor explaining the level of damage reduction achieved as a result of warnings. The research indicates that it is not justifiable to single out ability or disability as a factor determining response as there are other factors that are as important. These include flood experience and flood warning message content that are significant. Furthermore, the models (Table 12.1 and 12.2) including the variables in the economic benefits model explain only a small proportion of the variance in residents' damage reducing actions in response to flood warnings as measured by the £ value of savings and the proportion of potential damages avoided. The research demonstrates that flood warning response by residents is a complex matter that cannot easily be explained in terms of the economic benefits model or even when a wider range of variables are considered.

On the basis of this research, therefore a new simpler approach is proposed and included in the 'Multicoloured Manual' (Penning-Rowsell, *et al,* 2005). The details and a worked example of this approach are included in Table 15.1.

For each house type, building age and social classes, the inventory value as a percentage of Total Potential Damages (TPD) is on average 52%. Of the household inventory items, it was calculated that only 41% have the potential to be moved. This proportion was calculated by examining the inventory and adding up the £ value of items that were judged clearly to be unmoveable. These included items such as fitted kitchens, built in ovens, hobs, and heaters and also fitted bedroom furniture. Clean up costs were also judged to be an item that could not be avoided through a flood warning. These items that could not be saved through a warning were mostly high value items. Thus, it was concluded that only 21% of the Total Potential Damages (TPD) could be influenced by the provision of a flood warning.

The recent survey research indicates that only 38% of households receive a warning and this is broadly in line with past performance (Table 8.1). The Environment Agency's Investment Strategy (2003) aims to increase service effectiveness and receipt of warnings and this may yield improvements over time. Households then respond in varying degrees with efforts to save the 21% of total potential damages that can potentially be moved.

The survey research results showed that the length of warning lead time had an effect on the proportion of moveable property at risk that residents were able to save. Due to the combination of factors shown in Table 12.2, those in receipt of a long warning of eight hours or more, on average managed to save 71% of moveable inventory value; for those with a shorter

warning, the average was only 55%. This results in the total potential damage reduction percentages shown in Table 15.1 which is derived from Table 4.15 in the Manual (Penning-Rowsell *et al*., 2005).

How these figures are applied will depend on the scale of the analysis being conducted.

- For **strategic level studies** using weighted Annual Average Damages, the damages saved by warning lead time should be applied as a percentage of total damages (e.g. 4.5% or 5.8%) as shown in Table 15.1
- For **all other appraisals**, the data available on the Manual's CD is aggregated by inventory items, building fabric items and total damage figures. Thus, where the appraiser knows the depth of flooding, the average inventory value as a percentage of total potential damages should be ascertained from the data (in Appendix 4.1 of the 'Multicoloured Manual'). This new inventory figure should then be substituted for the figure of 52% (BY in the Table) resulting in a re-evaluation of the potential value of inventory items saved by a warning lead time. For example, were this figure to rise to 55%, the total potential damage saved value by a warning of more than 8 hours would be 6.1%.

  Where the depth of flooding is unknown, the average inventory value (52%) should be applied across all depths depending on the level of analysis.

  - At strategy level, this would be the average inventory value from the 'residential sector average' tables in the Manual (Appendix 4.1)
  - For all other studies it would be averaged across all types of houses and ages, with the most detailed investigation inclusive of social class.

Thus, it important to recognise that on average only 21% of the total potential damages could be saved even if warning dissemination were 100% successful and if all warning recipients were 100% effective in saving moveable items. Since 100% success in both areas remains unlikely and even 80% success in both remains very difficult to achieve, this places a low ceiling on the economic benefits to be obtained from flood warnings.

In addition, the research shows that even without an event specific warning, the majority of residents will save some property although they will achieve less than those warned, on the basis of common sense, past experience and their own judgement. There will be damage reduction greater than the savings that can be attributed to flood warnings. Furthermore the benefits of schemes may be overstated if only the damage reducing actions of those in receipt of a warning are taken into account.

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FIGURE 1 MODEL OF FLOOD WARNING RESPONSE AND DAMAGES AVOIDED

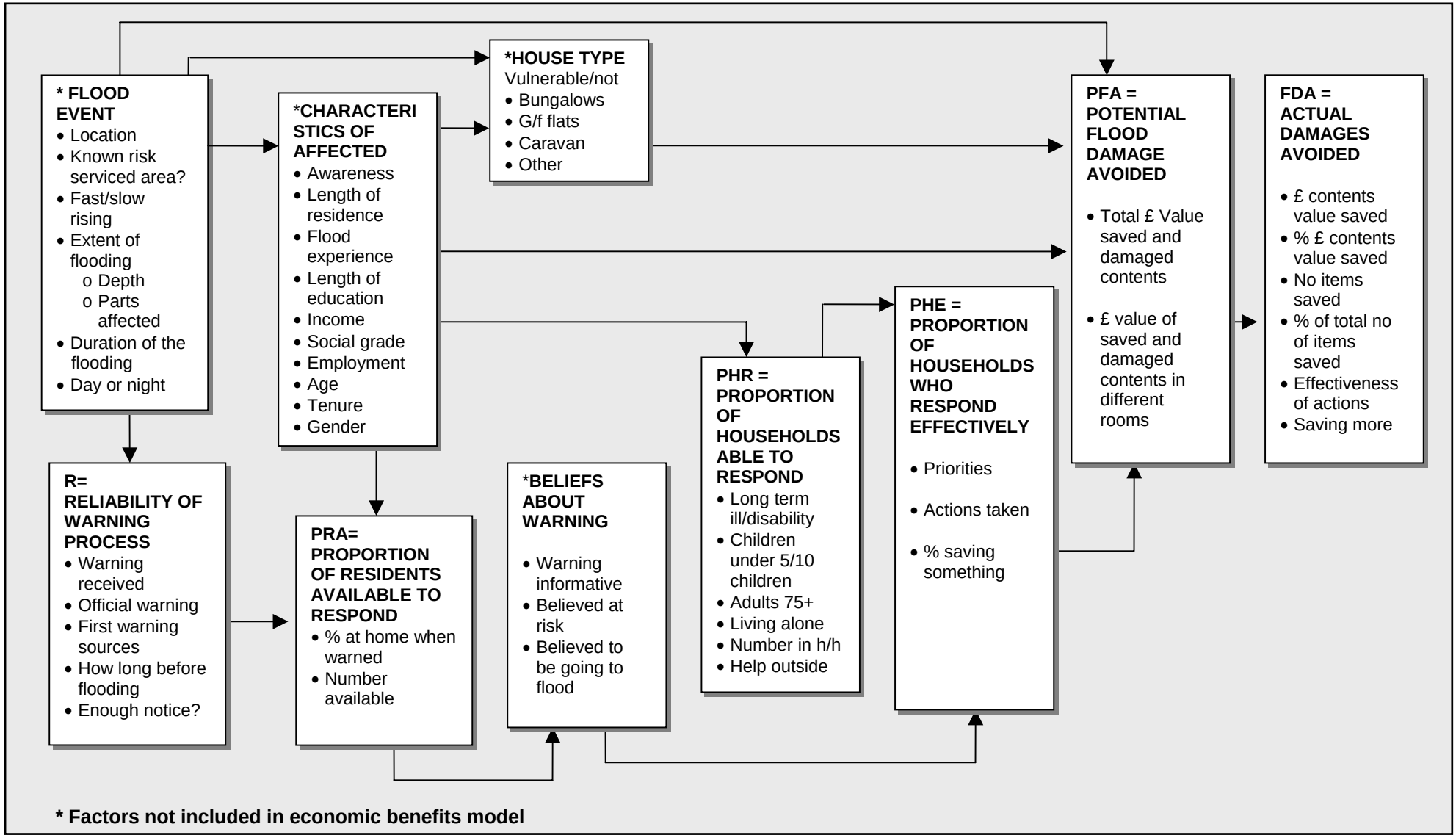

Table 2.1 Sample areas for phase 1 and 2 of the survey

Region Area	Areas and river	Date of events	No affected Properties	Targeted interviews	Completed interviews
PHASE 1					
NORTH WEST					
(1) North	Kendal, Burnside				**43**
THAMES					
(2) West	Marlow, Bisham, Wraysbury, Egham, Staines, Chertsey - Thames	Jan 03			**103**
WALES					**22**
(3)	Trefriw, Llanrwst				
TOTAL PHASE 1				220	**168**
PHASE 2					
ANGLIAN					
(1) Eastern (a)	Braintree/Bocking Halstead, Witham	Oct 01	126	25	**56**
(2) Eastern (b)	Kelveden	Oct 01	101	25	
(3) Central	Linton, Girton Oakington, Cambs – non-main river St Ives/ Hemingford	Oct 01 Jan 03	147 38	25	**25**
MIDLANDS					
(4)Upper Severn (a)	Shrewsbury, Montford Ironbridge, Bridgenorth - Severn	Feb 04 Feb 02 Oct 00	99** - 314	25	**43**
(5) Upper Severn (b)	Bewdley Worcester - Severn	Feb 04 Feb 02 Oct 00	68** - 220	25	
NORTH EAST					
(6) Dales	Pickering Ilkley And other locations	Aug 02 Feb 02 Autumn 2000	28 164	20	**18**
(7) Ridings	Glusburn and other non-main river locations	Aug 04	100	25	**25**
NORTH WEST					
(8) North	Flooding along the Cumbrian Coast	Feb 2002	80	15	**15**
SOUTH WEST					
(9) Cornwall	Flushing, Penryn, Fowey, and other locations	Various dates 2002-4	90***	20	**14**
(10) S.Wessex	Fordingbridge,Downton Longham, Ringwood, Shipton Bellinger	End 02/ Jan 03	132	25	**21**
SOUTHERN					
(11) Kent	Various location	02/03 0ct/Nov 00	75*** 236	25	**24**
THAMES					
(12) North East	Ilford, Woodford,	Oct 00	230	20	**19**
(13) West	Oxford, Reading area Wargrave, Shiplake, Henley - Thames	Jan 03	144	25	**18**
TOTAL PHASE 2					**278**

NOTES ON TABLE 2.1

*For Phase 2, the data on numbers were not pre-screened and the approximate numbers include residential and non-residential property and different definitions of affected and flooded property. The numbers for events other than autumn 2000 are derived from information supplied by Agency area officers in lists and maps of varying degrees of detail. Numbers for autumn 2000 floods are derived from information in the Environment Agency's Autumn 2000 Floods Review Regional Reports.
** Numbers are for the Feb 04 event only, not the earlier Feb 2002 event. The same properties may have been included in the autumn 2000 flood figures.
*** Numbers are very approximate.

Table 2.2 Timetable and details of the fieldwork and data processing for Phases 1 and 2 of the survey

TIME TABLE AND DETAILS	PHASE 1	PHASE 2
Start date of fieldwork	25 October 2004	22 January 2005
Completion date for fieldwork	23 December 2004	24 February 2005
Coding, (tabulations, SPSS disk to Environment Agency by):	14 January 2005	28 February 2005
Tabulations to FHRC by:	2 February 2005	8 March 2005
SPSS data disk to FHRC by:	1 February 2005	11 March 2005
Interviewing	Computer-assisted personal interviews	Non computer-assisted personal interviews
Duration of interview	45 minutes	35 minutes

Table 2.3 Extent of flooding in Phase 1 and Phase 2

Flooding extent	Phase 1			Phase 2	Phase 1 and 2 combined		
	Resid -ential	Business	All	Resid -ential only	Resid -ential	Business	All
Flooded above floor level	(49) 38%	(20) 53%	(69) 41%	(238) 86%	(287) 70%	(20) 53%	(307) 69%
Other property flooding inc drives/garden	(55) 42%	(11) 29%	(66) 39%	(40) 14%	(95) 23%	(11) 29%	(106) 24%
No property flooding	(26) 20%	(7) 18%	(33) 20%	-	(26) 6%	(7) 18%	(33) 7%
Number of cases	130	38	168	278	408	38	446
Total %	100%	100%	100%	100%	100%	100%	100%

Number of cases shown in brackets

Table 3.1 Examples of applications of the model

Factor	Parker 1991	Parker 1991	EA Investment Strategy (2003)	Haskoning/ Met Office Pluvial study (2004)	Haskoning /Met Office Pluvial study (2004)
	Residential %	Non-Residential %	All properties %	Residential %	Non-Residential %
Coverage	-	-	70		
R Reliability Service Effectiveness	NA	NA	65	90	90
PRA Availability	55	45-80	64	47	65
PHR Ability to respond	75	95	80	85	100
PHE Effective Action	70	95	50	60	60
Damage reduction conversion factor	NA	NA	30	22	35

Table 4.1 Characteristics of respondents according to whether built property was affected by flooding

Residents	Built property		
Respondent characteristics	Not affected %	Affected %	All residents %
Gender			
Male	57 (38)	49 (168)	51 (206)
Female	43 (29)	51 (173)	49 (202)
Age			
18-34	5 (3)	7 (22)	6 (25)
35-44	17 (11)	17 (57)	17 (68)
45-54	32 (21)	19 (63)	21 (84)
55-59	8 (5)	14 (47)	13 (52)
60-64	11 (7)	11 (36)	11 (43)
65-74	11 (7)	22 (75)	20 (82)
75 and over	18 (12)	12 (41)	13 (53)
Number of cases	66/67	341	407/8
Social class	Not affected	Affected	All residents
AB	29 (19)	34 (115)	33 (134)
C1 C2	42 (28)	50 (170)	49 (198)
DE	29 (19)	16 (56)	18 (75)
Number of cases	66	341	407

Number of cases shown in brackets

Table 4.2 Type, age and tenure of property according to whether or not built property was affected by flooding

	Built property		
Property type %	Not affected %	Affected %	All residents %
Detached	37 (25)	41 (138)	40 (163)
Semi	22 (15)	26 (87)	25 (102)
Terraced	24 (16)	25 (85)	25 (101)
Bungalow	10 (7)	4 (15)	5 (22)
G/f basement flat	2 (1)	0 (0)	* (1)
Mobile home	5 (3)	1 (4)	2 (7)
Other	0 (0)	3 (9)	2 (9)
Number of cases	67	338	405
Property age %	Not affected %	Affected %	All residents %
Before 1919	30 (20)	44 (150)	42 (170)
1919-1944	8 (5)	10 (35)	10 (40)
1945-59	16 *(11)	9 (31)	10 (42)
1960s, 1970s	25 (17)	16 (54)	17 (71)
1980s	6 (4)	12 (43)	12 (47)
1990s, since 2000	12 (8)	6 (20)	7 (28)
Not known	3 (2)	2 (8)	2 (10)
Number of cases			408
Tenure			
Own/mortgage	90 (60)	91 (309)	91 (369)
Other	10 (7)	9 (31)	9 (38)
Number of cases	67	340	407

Number of cases shown in brackets

Table 4.3 Household characteristics according to whether or not built property was affected by flooding

Household composition	Built property		
% of households with:	Not affected %	Affected %	All residents %
Children under 5	6 (4)	8 (29)	8 (33)
Children 5-9	7 (5)	9 (31)	9 (36)
Children under 10	10 []	14	14
Young people 10-17	19 (13)	19 (66)	19 (79)
Adults 18-64	76 (51)	69 (336)	70 (387)
Adults 65-74	18 (12)	28 (95)	26 (107)
Adults 75 and over	18 (12)	16 (56)	17 (68)
Number of cases	66/7	341	407/8
Vulnerable households			
Living alone	21 (14)	17 (58)	18 72)
Ill or disabled member	21 (14)	16 (55)	17 (69)
Ill/disabled or aged 75+	28 (19)	26 (90)	27 (109)
Ill/disabled, 75+ or living alone	42 (28)	34 (116)	35 (144)
Length of residence			
< 10 years	43 (29)	49 (161)	48 (190)
10< 19	25 (17)	27 (89)	27 (106)
20 years and over	31 (21)	24 (77)	25 (98)
Number of cases	67	327	394
Property flooded above floor level			
Never	76 (31)	6 (20)	14 (51)
Once	20 (8)	63 (214)	59 (222)
Two to three times	2 (1)	16 (54)	15 (55)
Four or more times	2 (1)	15 (50)	14 (51)
Number of cases	41	338	379
Aware of address being in flood risk area before recent flood			
Aware	73 (49)	52 (176)	56 (225)
Not aware	27 (18)	48 (160)	44 (178)
Number of cases	67	336	403

Number of cases shown in brackets

Table 5.1 PFA (Total of £ savings plus £ damages incurred) and savings in different part of the built property

Residents with built property affected:	Living room	Kitchen	Out-side	Bed-room	Bath-room	All parts
PFA: Total of £ savings plus £ damages incurred						
Mean	£2,068	£904	£327	£121	£36	£3,457
Standard deviation	1,968	921	426	485	73	2,921
Number of cases	341	341	341	341	341	341
£ savings including those with zero saving						
Mean	£1,405	£268	£109	£71	£8	£1,860
Standard deviation	1,6805	555	264	404	33	2,145
Number of cases	341	341	341	341	341	341
Percent saving items						
Items saved	69	37	37	7	9	78
Nothing saved	31	63	63	93	91	22
Total	100	100	100	100	100	100
Number of cases	341	341	341	341	341	341

Table 5.2 PFA (Total of £ savings plus £ damages incurred) and savings according to the extent of flooding

Residents with built property affected	Not flooded above floor level	Flooded above floor level	All with built property flooding
Total of £ savings plus £ damages incurred			
Mean	£1,772	£3,795	£3,457
Standard deviation	1,790	2,988	2,921
Number of cases	57	284	341 (a)
£ savings including those with zero savings			
Mean	£1,524	£1,928	£1,860
Standard deviation	1,798	2,204	2,145
Number of cases	57	284	341
£ savings as a percentage of total of £ savings plus £ damages incurred (b)			
Mean	65	49	51
Standard deviation	43	37	38
Number of cases	57	284	341(b)
Percentage saving items			
Items saved	74	79	78
Nothing saved	44	41	41
Number of cases	57	284	341

(a) t test: t = 6.832; df = 128.224; p = 0.000
(b) t test: t =- 2.711; df = 73.359; p = 0.008

Table 5.3 PFA (Total of £ savings plus £ damages incurred) and savings according to the depth of above ground floor flooding

Flooded above floor level Depth above floor level	< 10 cms	10< 30 cms	30 <60 cms	60 cms or more	All with above floor level flooding
Total of £ savings plus £ damages incurred					
Mean	£3,414	£4,034	£3,257	£3,648	£3,699
Standard deviation	2,900	3,019	2945	3,220	3,024
Number of cases	52	106	59	57	274
£ savings including those with zero savings					
Mean	£1,832	£2,127	£1,673	£1,696	£1,833
Standard deviation	2,231	2,257	2,225	2,079	2,206
Number of cases	52	106	59	57	274
£ savings as a percentage of total of £ savings plus £ damages incurred					
Mean	52	49	50	45	49
Standard deviation	41	36	39	36	37
Number of cases	52	106	59	57	274
Percentage saving items					
Items saved	77	79	78	79	78
Nothing saved	23	21	22	21	22
Number of cases	52	106	59	57	274
Percent of cases At the depth	19%	39%	21%	21%	100%

Table 5.4 PFA (Total of £ savings plus £ damages incurred) and savings according to social class

Residents with built property affected	AB	C1, C2	DE	All residents with built property affected
Total of £ savings plus £ damages incurred				
Mean	£4,998	£3,197	£1,080	£3,457
Standard deviation	3,548	2180	1,046	2,921
Number of cases	115	170 (a)	56 (c)	341
£ savings including those with zero savings				
Mean	£2,551	£1,790	£654	£1,860
Standard deviation	2,616	1,856	1,081	2,145
Number of cases	115	170 (b)	56 (d)	341
£ savings as a percentage of total of £ savings plus £ damages incurred				
Mean	52	51	50	52
Standard deviation	37	39	41	38
Number of cases	115	170	56	341
Percentage saving items				
Items saved	83	77	73	78
Nothing saved	17	23	27	22
Number of cases	115	170	56	341
Percent of cases in the social class	34%	50%	16%	100%

(a) t test, social class AB and C1, C2 : t = 4.858; df = 172.1; p = 0.000
(b) t test, social class AB and C1, C2 : t = 2.693; df = 190; p = 0.008
(c) t test, social class C1, C2 and DE : t = 9.715; df = 195; p = 0.000
(d) t test, social class C1, C2 and DE : t = 5.604; df = 163.6; p = 0.000

Table 5.5 Household Inventory Damage and Moveable Item Damage by depth and duration of above ground floor level flooding (Source: Penning-Rowsell et al 2005)

Depth of above ground floor level flooding in metres	0.05	0.1	0.2	0.3	0.6	0.9	1.2
£ Household inventory damage <12 hours sector average	9,175	9,977	17,009	18.046	19,051	20,237	20,423
£ Household inventory damage >12 hours sector average	9,247	10,238	17.176	18,288	19,456	20,594	20,800
£ Moveable items (41% of household inventory <12 hours sector average	3,762	4,090	6,974	7,399	7,811	8,297	8,373
£ Moveable items (41% of household inventory >12 hours sector average	3,791	4,198	7,042	7,498	7,977	8,444	8,528

Table 6.1 Open responses on priorities on becoming aware of the possibility of flooding: All residents in Phase 1 and 2 surveys

Priority actions Phase 1	% of all residents	Priority actions Phase 2	% of all residents
Action to prevent damage to property		**Actions to prevent damage to property**	
		Remove carpets and rugs	54
Prevent damage to property	9	Protect/move furniture	26
		Move things/moved what I could (unspecified)	
		To move valuables	7
Move or raise valuables, personal belongings, stock	52	Raised furniture /appliances, put them on blocks	7
		Move car onto higher ground	7
Action to prevent water entering property		**Actions to prevent water entering property**	
Prevent water entering property	9	Stop water getting into house	26
Sandbags, any mention	2	Sandbagged property	9
		Put up flood gates	7
		Went to get sandbags	4
		Put towels against doors	3
Actions for safety		**Actions for safety**	
		Turned off gas	8
Turned off electricity	1	Switched off electricity and electrical appliances	8
Other actions		**Other actions**	
Other unspecified	9	Save pets	10
		Move important/ personal things/documents	9
		Received food from the Salvation Army	10
Other responses			
Monitor water levels	6		
Finding out more about the flood	2		
Not necessary to take any action	14		
Unable to take action/not sure what to do	2		
None of these/don't know	2	**None /no answer**	4
Number of cases	**130**	**Number of cases**	**278**

Table 6.2 Actions taken by residents according to built property flooding

Actions taken by residents	Built property not affected %	Built property affected %	All residents %
Seeking information			
Telephoned floodline	18	32	30*
Listened out for warnings	19	31	29
Listened to local radio	25	24	24
Sought information from EA	15	26	24 *
Sought information from friend/family or neighbour	13	29	27 **
Sought information from LA	13	18	17
Sought information from emergency services	9	13	12
Passing on information			
Warned neighbours	18	23	22
Phoned other h/h members to warn them	9	18	16
Preventing water getting in			
Blocked doorways /airbricks	13	45	40 ***
Put up flood boards/gates	8	11	10
Saving property from damage			
Moved valuables	33	65	60 ***
Moved cars	33	45	43
Safety measures			
Moved h/h members to safety	8	38	33***
Switched off electricity/gas	13	30	26 **
Checked gas/electricity before reuse	8	28	25 ***
Moved stock for businesses/animals/pets to safety	10	27	24 **
Took supplies to safe place	8	18	16 *
Boiled water until declared safe	6	10	10
None of above	30	13	16 ***
Number of cases	67	341	408

* Chi square p =< 0.05
** Chi square p= <0.01
*** Chi square p=<0.001

Table 8.1 Proportion of those with flooded property (including gardens and drives) in receipt of flood warnings

Event date	Jan-April 1997	January 1998	Easter 1998	Oct-Nov 1998 March 1999?	December 1999	Autumn 2000	Phase 1 Jan 2003/ Feb 2004	Phase 2 September 2000-Feb 2002/4
	%	%	%	%	%	%	%	%
Prior/any warning	57	62	32	54	35	61	32**	40***
No prior/ no warning	-	-	67	42	62	37	65	54
Warning too late/during flood	2	3	15	6	9	5	NA	4
No information	37	32	50	34	53	32	NA	
Don't know	2	3	2	6	-	-	3	1
Flooded N=	89	188	320	224	66	608	135	278
Total N=	159	376	349	357	122	1,395	168	278
Report date	Oct. 1997	June 1998	Nov. 1998	July 1999	May 2000	Aug. 2001	Jan 2005	Dec 2005

*The question asked in earlier BMRB surveys was 'On the most recent occasion, did you have any warning that your property might flood before it actually did?'
** A slightly different question was asked in Phase 1: 'During the events of Feb 04/Jan 03, did you receive any warning that your property might flood?'
*** The question asked in the Phase 2 of the research was 'So, before or during the flood did your household receive any kind of warning, whether official or unofficial, that your property might flood?'
Data include business properties as well as residential ones for all surveys except Phase 2.
Phase 2 surveys exclude those with garden or driveway flooding only.

Table 8.2 Source of warning for residents by phase

Sources of warning: all residents warned	Phase 1	Phase 2	All residents
Official sources	**%**	**%**	**%**
AVM Recorded telephone message from EA	49	40	42
Personal telephone call from EA	8	12	11
You telephoned floodline	3	4	3
Flood warden	3	18*	14
Police	3	4	3
Fire brigade	-	1	1
Local authority	5	3	3
Radio announcement/broadcast	-	7	5
TV announcement/broadcast	3	2	2
Siren/loudspeaker	-	-	-
BBC Ceefax	-	-	-
ITV teletext	-	-	-
EA Fax	-	-	-
Unofficial sources			
Neighbour, friend, relative	30	21	24
Personal observation	18	16	17
Other			14
Don't know/not stated			2
Number of cases	37	112	149

Percentages add up to more than 100% because respondents were able to cite more than one source.

* Chi square p =< 0.05

Table 8.3 Residents in receipt of a warning by survey area

	Phase 1			Phase 2										
Receipt of warning*	Thames West %	North West %	Wales %	Anglian Eastern %	Anglian Central %	Midlands U.Severn %	N.E Dales %	N.E Ridings %	N.W Cumbria %	S.W Cornwall %	S.W Wessex %	Southern Kent %	Thames N.E %	Thames West %
Not warned	74 (72)	55(11)	83 (10)	71 (40)	80 (20)	14 (6)	61 (11)	100 (25)	53 (8)	57 (8)	52 (11)	75 (18)	58 (11)	44 (8)
Warned	27 (26)	45(9)	17 (2)	29 (16)	20 (5)	86 (37)	39 (7)	0 (0)	47 (7)	43 (6)	48 (10)	25 (6)	42 (8)	56 (10)
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Number of cases	98	20	12	56	25	43	17	25	15	14	21	24	19	18

* Those who did not know whether they had received a warning or did not answer are included in the not warned category.

Table 8.4 Actions taken to prepare for a flood and to protect property according to extent of flooding and receipt of a warning

Actions taken by those with property flooding	BMRM Autumn 2000 (a)				Phase 1 (b)		Phase 2 (c)	
	Flooded above floor level (d)		Other property flooding (e)		Property flooded (f)		Property flooded (g)	
	Warned	Not	Warned	Not	Warned	Not	Warned	Not (h)
Seeking / passing on information	%	%	%	%	%	%	%	%
Telephoned floodline	16	18	7	7	31	24	49	17 ***
Listened out for warnings	24	45*	21	20	42	27*	44	15***
Listened to local radio	25	40	19	33	19	22	42	15***
Sought information from EA	-	-	-	-	21	18	41	16***
Sought information from friend/family or neighbour	-	-	-	-	31	23	37	19 **
Warned neighbours	23	13	16	16	31	8***	38	14***
Phoned other h/h members to warn them	-	-	-	-	15	12	22	15
Sought information from LA	-	-	-	-	12	21	21	13
Sought information from emergency services	-	-	-	-	15	11	9	13
Preventing water getting in								
Blocked doorways /airbricks	32	56**	19	17	39	35	62	30 ***
Put up flood boards/gates	5	3	4	2	4	2	25	6 ***
Saving property from damage								
Moved valuables	34	50	16	20	56	49	82	52 ***
Moved cars	34	42	25	13	62	52	58	28 ***
Safety measures								
Moved h/h members to safety	23	53 ***	7	12	25	26	52	25 ***
Switched off electricity/gas	24	48	7	9	37	28	38	20 **
Checked gas/electricity before reuse	24	32	5	4	21	22	38	18 **
Moved stock for businesses/animals/pets to safety	-	-	-	-	33	28	32	22
Took supplies to safe place	15	30	7	7	14	13	24	11 **
Boiled water until declared safe	5	13	4	3	6	7	13	7
None of above							3	21***
Total	122	60	247	165	52	110	112	166

(a) Residential property only (b) Residential and business property (c) Residential or both residential and business
(d) Flooded above floor level (e) Flooding to property including gardens and drives (f) Property flooded including inside house and gardens and drivers only (g) Property flooded but excluding gardens and drive only flooding (h) Includes some residents outside warning service areas.

* Chi square p =< 0.05
** Chi square p= <0.01
*** Chi square p=<0.001

Table 8.5 Household inventory damage saving of those with built property affected by flooding according to the receipt of a warning

Residents with built property flooding:	**Warned**	**Not warned ***	**All**
Percent saving items	**%**	**%**	**%**
Items saved	84	75	78
Nothing saved	16	25	22
Total	10 0	100	100
Number of cases	128	213	341 (a)
£ savings including those with zero saving			
Mean	£2,373	£1,552	£1,860
Standard deviation	2,334	1,964	2,145
Number of cases	128	213	341 (b)
Total of £ savings plus £ damages incurred			
Mean	£3,710	£3,305	£3,457
Standard deviation	2,904	2,927	2,901
Number of cases	128	213	341 (c)
£ savings as a percent age of total of £ savings plus £ damages incurred			
Mean	62%	45%	52%
Standard deviation	38	38	38
Number of cases	128	213	341 (d)

(a)Chi-square= 4.452; df= 1; p=0.035
(b) t test: t = 3.331; df =232.917; p = 0.001.
(c) t test not significant
(d) t test: t = 3.917; df= 266.147; p = 0.000.
* Not warned includes don't know and no response

Table 8.6 Household inventory damage saving of those with built property affected by flooding according to the receipt of a warning and serviced area

Residents with built property flooding:	Warning received in a serviced area*	No warning received in a serviced area	Non-serviced area*
Mean percent saving items			
Items saved	84	77	71
Nothing saved	17	23	29
Number of cases	121	172	48
£ savings including those with zero saving			
Mean	£2,153	£1,683	£1,755
Standard deviation	2,124	2,020	2,564
Number of cases	121	172	48
Total of £ savings plus £ damages incurred			
Mean	£3,507	£3,384	£3,591
Standard deviation	2.777	2.855	3,509
Number of cases	121	172	48
£ savings as a percent age of total of £ savings plus £ damages incurred			
Mean	60	48	42
Standard deviation	38	38	38
Number of cases	121	172 (a)	48

*7 residents in non-serviced area who received a warning are included in the non-serviced.
(a) Serviced area warned/not warned: t = 2.743;df = 291; p=0.006

Table 8.7 Household inventory damage saving of those with built property affected by flooding by receipt of an official or unofficial warning

Residents with built property flooding:	Official warning	Unofficial Warning only	All
Mean percent saving items			
Items saved	87	77	84
Nothing saved	23	33	16
Total	100	100	100
Number of cases	93	35	128 (a)
£ savings including those with zero saving			
Mean	£2,501	£2,032	£2,373
Standard deviation	2,370	2,232	2,334
Number of cases	93	35	128 (b)
Total of £ savings plus £ damages incurred			
Mean	£3,767	£3,558	£3,710
Standard deviation	2,943	2,834	2,904
Number of cases	93	35	128 (c)
£ savings as a percent age of total of £ savings plus £ damages incurred			
Mean	65	53	62
Standard deviation	37	40	38
Number of cases	93	35	128 (d)

(a)(b)(c) (d) not significant

Table 8.8 Length of warning lead time for all residents and those with built property affected by flooding

Length of warning	Residents with built property affected who received a warning %	All residents who received a warning %
Less than an hour *	13 *	14 *
1-2 hours	6	6
2-4 hours	6	7
4-6 hours	9	8
6-8 hours	6	7
8 hours or more	59	58
Number of cases	110**	124**
Number warned	128	149

* includes two cases of warning received after flooding
** There were a significant number of respondents who did not know or did not answer on length of warning time

Table 8.9 Household inventory damage saving of those with built property affected by flooding according to the warning lead time

Residents with built property flooding:	<8 hours	8 hours or more	All with a known warning lead time
Percent saving items	**%**	**%**	**%**
Items saved	84	89	87
Nothing saved	16	11	13
Total	100	100	100
Number of cases	45	65	110 (a)
£ savings including those with zero saving			
Mean	£1,968	£2,958	£2,553
Standard deviation	1,877	2,609	2,378
Number of cases	45	65	110 (b)
Total of £ savings plus £ damages incurred			
Mean	£3,469	£4,031	£3,801
Standard deviation	2,488	3,019	2,816
Number of cases	45	65	110 (c)
£ savings as a percent (age of total of £ savings plus £ damages incurred			
Mean	55%	71%	64%
Standard deviation	40	36	37
Number of cases	45	65	110 (d)

(a) Not significant
(b) t test: t = -2.315; df 107.8; p = 0.023.
(c) t test not significant
(d) t test: t = -2.157; df 108; p = 0.033.

Table 8.10 Household inventory damage saving of those with built property affected by flooding according to how 'informative' the warning was

Residents with built property flooding:	'Very informative' warning	Other responses on warning (fairly, not very, not at all informative)	All warned
Percent saving items (a)	**%**	**%**	**%**
Items	89	82	85
Standard Deviation	11	18	15
Number of cases	54	71	125
£ savings including those with zero saving (b)			
Mean	£2,906	£1,967	£2,373
Standard deviation	2,593	2,012	2,334
Number of cases	54	71	128
Total of £ savings plus £ damages incurred (c)			
Mean	£3,701	£3,608	£3,710
Standard deviation	2,938	2,791	2,904
Number of cases	54	71	128
£ savings as a percent (age of total of £ savings plus £ damages incurred(d)			
Mean	75	54	62%
Standard deviation	35	37	38
Number of cases	54	71	128

(a) t test not significant
(b) t test: t = 2.203; df = 97.216; p = 0.030
(c) t test not significant
(d) t test: t = 3.269; df = 123; p = 0.001

Table 9.1 Household inventory damage saving of those with built property affected by flooding according to household age and illness/disability

Residents with built property flooding:	Ill, disabled	Not ill or disabled	Aged 75+	Not aged 75 +	Aged 75+ or ill, disabled	Neither
Mean percent saving items						
Mean percent saving items	76	79	68	80 (a)	71	81
Standard deviation	24	21	32	20	29	19
Number of cases	55	286	56	285	90	251
£ savings including those with zero saving						
Mean	£1,533	£1,923	£1,168	£1,996 (b)	£1,198	£2,098 (d)
Standard deviation	1,977	2,173	1,796	2,184	1,746	2,226
Number of cases	55	286	56	285	90	251
Total of £ savings plus £ damages incurred						
Mean	£3,218	£3,503	£2,352	£3,674 (c)	£2,561	£3,778 (e)
Standard deviation	2,887	2,929	2,630	2,930	2,570	2,976
Number of cases	55	286	56	285	90	251
£ savings as a percent age of total of £ savings plus £ damages incurred						
Mean	49	52	45	53	45	54
Standard deviation	41	38	40	38	41	38
Number of cases	55	286	56	285	90	251

(a) Aged 75+/Not aged 75+: Chi-square = 4.300;df = 1; p = 0.38
(b) Aged 75+/Not aged 75+: t = -3.040; df = 90.131; p = 0.003
(c) Aged 75+/Not aged 75+: t = -3.373; df = 84.119; p = 0.001
(d) Ill or 75+/Neither: +: t = -3.888; df = 180.344; p = 0.000
(e) Ill or 75+/Neither: +: t = -3.690; df = 198.931; p = 0.000

Table 9.2 Household inventory damage saving of those with built property affected by flooding according to living alone and vulnerability

Residents with built property affected by flooding:	Alone	With others	Vulnerable: Aged 75+ or ill, or alone	Not vulnerable
Mean percent saving items				
Mean percent saving items	79	78	74	80
Standard deviation	21	22	26	20
Number of cases	58	282	116	225
£ savings including those with zero saving				
Mean	£1.210	£1,989 (a)	£1,248	£2,176(c)
Standard deviation	1,587	2,223	1,708	2,279
Number of cases	58	282	116	225
Total of £ savings plus £ damages incurred				
Mean	£2,338	£3,686 (b)	£2,525	£3,937(d)
Standard deviation	2,108	3,018	2,470	3,022
Number of cases	58	282	116	225
£ savings as a percent age of total of £ savings plus £ damages incurred				
Mean	48	52	48	53
Standard deviation	41	38	40	37
Number of cases	58	51	116	225

(a) Alone/not alone: t = -3.152; df 108.684; p= 0.002
(b) Alone/not alone: t = -4.086; df 111.178; p = 0.000
(c) Vulnerable/not vulnerable: t = -4.226; df 295.228; p = 0.000
(d) Vulnerable/not vulnerable: t = -4.625; df 276.371; p = 0.000

Table 9.3 Household inventory damage saving of those with built Property affected by flooding according to help from outside the household

	All residents		Vulnerable households: Ill/disabled, 75+ or alone	
Residents with built property affected by flooding:	**Outside help**	**None**	**Outside help**	**None**
Mean percent saving items				
Items saved	86	73 (a)	79	71
Nothing saved	36	44	21	29
Number of cases	149	192	48	67
£ savings including those with zero saving				
Mean	£2,419	£1,427 (b)	£1,700	£900
Standard deviation	24	1,852	2,074	1,307
Number of cases	149	192	48	67
Total of £ savings plus £ damages incurred				
Mean	£3,850	£3,151 (c)	£2,832	£2,210
Standard deviation	3,041	2,793	2,702	2,155
Number of cases	149	192	48	67
£ savings as a percent age of total of £ savings plus £ damages incurred				
Mean	59	45 (d)	56	42 (e)
Standard deviation	37	39	41	40
Number of cases	149	192	48	67

(a) Chi square = 6.112; df = 1; p=0.013
(b) t = 4,211; df 276.42; p = 0.000
(c) t = 2.512; df 336; p = 0.012
(d) t = 3.275; df 336; p = 0.001
(e) t= 2.358; df 73.331; p = 0.021

Table 10.1 Household inventory damage saving of those with built property affected by flooding according to above ground level flood experience and receipt of a warning

Residents with built property flooding:	With flood experience		No flood experience		All	
Percent saving items	**Warned**	**Not warned**	**Warned**	**Not warned**	**With flood experience**	**No flood experience**
Items saved	90	79	80	74	85	76
Nothing saved	10	21	20	26	15	24
Number of cases	57	47	71	166	104	237
£ savings including those with zero saving						
Mean	£2,551	£2,198	£2,230	£1,369	£2,392	£1,627
Standard deviation	2,526	2,402	2,176	1,789	2,465	1,948
Number of cases	57	47	71	166 (a)	104	237 (c)
Total of £ savings plus £ damages incurred						
Mean	£3,284	£3,381	£4,051	£3,283	£3,328	£3,513
Standard deviation	2,681	3.426	3,046	2,780	3,026	2,878
Number of cases	57	47	71	166	104	237
£ savings as a percent age of total of £ savings plus £ damages incurred						
Mean	70	57	55	42	64	46
Standard deviation	435	37	39	37	37	38
Number of cases	57	47	71	166 (b)	104	237(d)

(a) No flood experience, warned /not warned: t =2.935; df = 112.347; p=0.004
(b) No flood experience, warned /not warned: t =2.448; df = 235; p=0.015
(c) With flood experience/No flood experience: t =2.802; df = 161.920; p=0.006
(d) With flood experience/No flood experience: t =4.219; df = 339; p=0.000

Table 11.1 Effectiveness of actions to prepare for a flood: all residents who took action

Effectiveness of action for those who took action	Warned	Not warned	All
	%	%	%
Very effective	38	25	31
Fairly effective	32	27	29
Not very effective	18	25	22
Not at all effective	12	22	18
Don't know	0	1	1
Number of cases	135	192	327

Chi-square = 13.287; df= 4; p=0.000

Table 11.2 Household inventory damage saving according to beliefs about effectiveness of actions

	All residents		Residents with built property affected by flooding	
	Not very, Not at all effective	Very, fairly effective	Not very, Not at all Effective	Very, fairly effective
Percent saving items				
Items saved	62	85	66	93
Nothing saved	38	15	34	7
Number of cases	130	194 (a)	119	174 (d)
£ savings including those with zero saving				
Mean	£1,163	£2,358	£1,253	£2,552
Standard deviation	1,678	£2,390	1,718	2,352
Number of cases	130	194 (b)	119	174 (e)
Total of £ savings plus £ damages incurred				
Mean	£3,000	£3,232	£3,260	£3,525
Standard deviation	2,824	2,926	2,807	2,868
Number of cases	130	194	119	174
£ savings as a percent age of total of £ savings plus £ damages incurred				
Mean	34	70	34	69
Standard deviation	35	32	35	32
Number of cases	120	176 (c)	119	174 (f)

(a) Chi square = 22.729; df = 2; p = 0.000
(b) t = 5.285; df= 321.273; p = 0.000
(c) t = 9.052; df =294; p = 0.000
(d) Chi square =34.555; df = 1; p=0.000
(e)) t = 5.458; df = 289.723; p = 0.000
(f) t= 9.104; df =291; p = 0.000

Table 11.3 What would have enabled residents to save more: all residents?

Length of warning	Residents with no prior warning %	Residents with prior warning %	All residents %
Longer warning time	44	18	34***
More specific, more informative warning	21	10	16 **
More people to help move things	15	12	14
More space	12	8	11
Being stronger, more physically able	5	7	6 (a)
More equipment to raise items	5	6	5
Other	18	22	20
Nothing	22	47	31*** (b)
Number of cases	239	142	382

(a) This response category was only included in Phase 2
(b) there was a high level of non response on this category: number of cases were 239, 138, and 377

Table 12.1 Regression analysis for £ value of savings: residents with built property affected.

R^2 0.14; Adjusted R^2 0.12; N=339

Explanatory variables	Unstandardised coefficient B	Standardised coefficient Beta	T	Sig.
Constant	3.032		5.342	0.000
Experience of above floor level flooding	.661	.169	3.225	0.001
Help outside the household	.858	.134	2.554	0.011
Number in household	.293	.123	2.315	0.021
Warning or 8 hours or more	.951	.118	2.241	0.026
Social class A or B	.771	.115	2.190	0.029
Ill/disabled or aged 75+ household	-.767	-.107	-1.994	0.047
Duration of flooding of 12 hours or more	.548	.086	1.662	0.097

Table 12.2 Regression analysis for £ value of savings as a percentage of total £ savings plus damages incurred: residents with built property affected.

R^2 0.14; Adjusted R^2 0.13; N=339

Explanatory variables	Unstandardised coefficient B	Standardised coefficient Beta	T	Sig.
Constant	.290		9.393	0.000
Experience of above floor level flooding	.055	.166	3.114	0.002
Flood depth in cm above floor level	-.001	-.123	-2.404	0.017
Ill/disabled or aged 75+ household	-.073	-.121	-2.375	0.018
Warning or 8 hours or more	.087	.128	2.234	0.026
Help outside the home	.063	.117	2.228	0.027
Very informative warning	.084	.119	2.018	0.044

Table 15.1 Flood warning damage reduction

Item	Description	% (Y)	£ (X) Example	Calculation
A	Total Potential damages (TPD)	100	30,000	
B	Potential Inventory damage (as a % of TPD)	52	15,600	BY*AX
C	Moveable Inventory damage (as a % of Potential Inventory damage)	41	6,396	CY*BX
D	Households in receipt of a warning	38		
	Effectiveness of :			
E	< 8 hour warning	55		
F	> 8 hour warning	71		
	Total Potential damage saved by:			
	< 8 hour warning	4.46	1,337	AY*BY*CY*DY*EY
	> 8 hour warning	5.75	1,726	AY*BY*CY*DY*FY
	Potential Inventory damage saved by:			
	< 8 hour warning	8.57	1,337	CX*DY*EY
	> 8 hour warning	11.06	1,726	CX*DY*FY

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