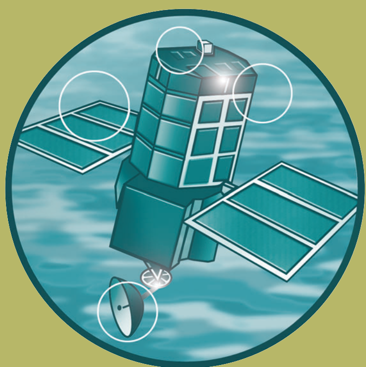
Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

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

Objective 14: Strategies for the future updating of flood damage tables and related indices

R&D Technical Report FD2014/TR2



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R&D Technical Report FD2014/TR 2

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Introduction and summary

The Scientific Objectives (from CSG7): develop strategies for future updating of damage tables and indices

> "To ensure that decision-makers are provided with the most comprehensive and up-to-date figures and indices in their project appraisals it is critical that a strategy is developed (in conjunction with Defra) for the future updating of flood damage tables. This will include the investigation of potential indices that might better reflect the real change in damages between future revisions. This strategy will form the basis of a one-off trial update, which will culminate in a report to Defra of the strategy feasibility and recommendations for future updates. Subject to the outcome of this work, appropriate methods for interim updating by users may be included in the Handbook and Manual."

Approaches and research plan (also from CSG7)

> "A strategy for future updating of damage tables and indices will be developed in discussion with Defra. This strategy, once developed, will be implemented on a one-off trial basis which will culminate in a report to Defra on the strategy's feasibility and recommendations for future updates and their resourcing. Where potential indices or other approaches for interim updating by users are identified, these will be included in the Handbook."

Task completion and modification of work objectives and plan

This paper is not restricted to just discussing up-dating data sets and techniques, because these methods have a context. That context includes the changing policy context, and also the role of databases in promoting more consistent decision-making. Hence the two major sections of this report, below, to elucidate that context. **Table 1** shows progress on this Objective since the start of the FD2014.

Table 1. Task and completion status

Task	Completion status
The investigation of potential indices that might better reflect the real change in damages between future revisions.	This is completed. The principal index is the *Consumer Price Index*, which has replaced the *Retail Price Index* as the 'official' measure of inflation
This strategy will form the basis of a one-off trial update	This has been done to produce the 2005 MCM CD.
A report to Defra of the strategy feasibility and recommendations for future updates.	This is that report.
Appropriate methods for interim updating by users may be included in the Handbook and Manual	This has been done and is covered in each MCM chapter.

Summary

The ***Multi-Coloured Manual*** flood damage and loss database at FHRC needs to be kept up to date so that decision making with its use is consistent through time.

The recommended strategy for future updating of damage tables and indices is to update most of the data on an annual basis, and have this available to users, on a subscription basis, via an updated CD Rom.

In addition, and every 5 or so years, a much more comprehensive update needs to be undertaken, so as to prevent the situation that occurred in 2002 when a major shift in damage/loss values occurred in single update after 10 years.

The annual update is not likely to be costly, and could be funded from the annual CD sales (if that CD data can be restricted to purchasers, and not put on the web). We believe that the 5+ years update should be funded by the Environment Agency.

Rationale: why flood damage data is important

Residential and non-residential flood damage is highly significant in almost all cases of serious flooding in the UK. It has been estimated, for example, that of the £1.4 billion of financial losses attributed to the floods of Autumn 2000, 63 per cent of which (£946 million) was a direct result of flooding to commercial and residential properties (Penning-Rowsell *et al.*, 2002).

Given this magnitude, it is paramount that those empowered to make decisions in the appraisal of flood and coastal risk management projects are provided with the best available data and techniques such that the decision-making process is just, fair and equitable. It is also paramount that the outcomes of these decisions distribute scarce national resources to areas of risk for which there is greatest benefit to the nation. This requires an approach to decision-making that is participative and transparent, ensuring decision-maker accountability. It also requires a multi-functional and multi-strategy approach which recognises the full range of flood risk management options. Flood risk management is also just one objective in the complex process of integrated water management which includes, for example, the management of water supply, wastewater, pollution and navigation. These multiple objectives are inherent to the implementation of the EU Water Framework Directive, which must be the context of flood risk management (FRM) in the future.

Over the last decade or so, the flood damage potential of residential and non-residential properties has significantly increased in real terms (Penning-Rowsell *et al.*, 2003: see also below). As key economic benefits in the project appraisal process, this has important implications for the prioritisation of flood and coastal defence capital expenditure in England and Wales.

The purpose of this paper is to examine (a) the relationship between the changing policy context towards flood risk management, (b) the implications of this for the flood risk appraisal process, (c) the role that any increase in the economic benefits of residential and non-residential properties may have in this process, and (d) the need therefore to keep our flood damage data up to date.

The altered policy context: more complex data needs

The approach to managing flood risk in England and Wales has undergone significant change in the past 10-15 years. In 1993, when MAFF and the Welsh office issued their strategy for flood and coastal defence, the focus for project appraisal was urban, scheme-specific and dominated by tangible economic costs and benefits that were easily quantifiable (MAFF, 1993).

Whilst this approach has been developed and updated over the subsequent years, there is now an explicit recognition of the need to embody the principles of sustainable development into, first, flood risk management decision-making and hence, secondly, appraisal methods. The former has resulted in the development of a new strategy for flood and coastal erosion risk management (Defra, 2004, 2005), which is underpinned by a number of legislative elements (e.g. the Water Framework Directive, the Habitats Directive, and the Aarhus Convention) and strategic priorities (Sustainable Development, Sustainable Communities, Natural Resource Protection) each of which have significant implications for the flood risk management appraisal process.

This new strategy (Defra, 2004, 2005) differs from those that have preceded it in a number of important ways. By applying a more holistic approach to flood risk management, where risk is defined as a function of the probability and consequences of flooding, the new strategy adopts a much more integrated approach to risk management, which recognises in particular:

- The need to manage risk from all sources of flooding which, in addition to coastal and fluvial flooding, also includes pluvial, groundwater and sewer flooding. This is in accordance with the suggestions made in the Foresight programme (Foresight, 2004), will require significant developments in our understanding and mapping of these risks and a clarification of the roles and responsibilities of the various stakeholders involved;
- The need to adopt a risk-driven, rather than project-driven, approach to managing floods which will require better and more reliable information at the catchment scale as well as a greater understanding of the main drivers for increasing risk, as highlighted by the Foresight project (2004);
- The need to seek multi-functional benefits from flood and coastal risk management interventions, particularly with respect to water quality and water resources, which is again consistent with the requirements of the Water Framework directive;
- The need to consider a wide range of risk management options, and a wide range of techniques and decision-making processes, to better account for the social and environmental consequences of flooding;
- The need to emphasise the social pillar of sustainable development by extending the risk management tools such that flood risk management decision-processes take account of social justice and equity issues as required under the Government's Sustainable Development and Sustainable Communities strategies (HM Government, 2005).

- The need to better define and reflect the social and environmental consequences of flood and coastal erosion in the decision-making process.

This new Government strategy also provides the first formalisation of the changing understanding of, attitudes towards, and actions concerning, the management of flood risk throughout England which have been developing since the inception of the Environment Agency in 1996 and the widespread floods of Easter 1998 (Johnson *et al*., 2004). It is also illustrative of the influence of European legislative requirements such as the Water Framework Directive (2000) and the Habitats and Bird's Directives (1994) on national and local approaches to flood and coastal risk management. Likewise, as illustrated in the strategy itself, it is illustrative of the importance and influence of cross-Governmental policy, such as the Government's Sustainable Development Strategy (2005) and Sustainable Communities strategy on the direction and application of approaches to managing this risk.

Of particular note, however, are the significant improvements that will be required in our knowledge base, institutional structures and appraisal techniques if a risk-based approach is to be applied at the catchment level. For as recognised in the findings of the Foresight (2004) project, under all scenarios considered, there are expected to be significantly increased flood and coastal erosion risks in the next 100 years, driven mainly by factors such as climate change, urbanisation, environmental regulation, rural land management, increasing national wealth and social factors (Evans *et al.*, 2004).

Without a change in policy the economic impact alone is likely to be significant with figures ranging from less than £1 billion to £27 billion, depending on the scenario. In addition, it is expected that the flood risks from inadequate sewers and urban drainage will significantly increase.

Thus, as the new government strategy recognises, there is an urgent need to improve our understanding of, and examine our institutional arrangements towards the management of pluvial, sewer and groundwater flooding. All of this has significant implications for the increased economic damage potential of floodplain properties. There is also an urgent need to examine the catchment level processes through which risks are evaluated and managed, which at present are still generally evaluated and managed on a project-by-project basis, notwithstanding the developments in Catchment Flood Management Plans (with their flood damage dimension), Shoreline Management Plans and Water Level Management Plans.

Ultimately, whilst the higher level strategy is to be applauded for its catchment-wide, holistic, participatory, multi-functional and multi-strategy approach, the techniques, information and science upon which decisions are made at the catchment and local level requires significant investment and improvement if they are to develop from their current project and river/coastal length focus - dominated by economic damages - to one focused on managing risks across the catchment in accordance with the three pillars of sustainable development; economic, social and environmental. Here, the relationship between the new strategy – *Making Space for Water* (MSFW) – and the current appraisal and funding structure, and the knowledge base upon which it is founded becomes important. That is for the future.

The needs for an evolving appraisal system and datasets

This changing policy context has significant implications for flood risk project appraisal in general, and the role of the economic benefits of protecting floodplain assets in particular. As it currently stands, the flood and coastal defence project appraisal guidance notes (PAGN) are provided for the assessment of benefits from fluvial and coastal flooding only, with Ofwat and the water utilities responsible for managing the risks associated with sewer flooding. This is not in keeping with the MSFW need to manage the risks from all sources of flooding, particularly the risks associated with groundwater and pluvial flooding.

In addition, the current appraisal system is structured around an appraisal led design philosophy that is project specific. Thus, it tends to be project-driven rather than risk driven - the former being specific to a particular length of river or coastline and the latter being catchment focused. Here again the appraisal system will – with time - have to be altered to fit with the new strategy.

Furthermore, the strategic intentions are to develop a more ‘balanced’ approach to project appraisal between the three pillars of social, economic and environmental development. This is rightly ambitious but will require significant improvements in the techniques used for assessing social and environmental risks. At present, environmental and social costs remain extremely difficult to quantify, and the tools and techniques for integrating intangible benefits into the appraisal process remain poorly developed.

Thus, in the context of the new *Making Space for Water* strategy being put forward for flood and coastal risk management, the manner in which risks are appraised at present means that not only are the values of losses associated with flood risks dominated by damage to residential and non-residential properties and their contents, current risk assessment methods remain dominated by economic damages, a factor recognised by the Government in its *Making Space for Water* document (Defra, 2004:131). As a result, the increased potential economic damages highlighted in the section that follows become increasingly more important under the current system of project appraisal.

This changing funding structure has implications for the process through which projects are appraised by Defra and the Agency; although the appraisal process for all other operating authorities remains unaltered. Under the Grant in Aid system, the Agency no longer has to seek Defra approval for projects that are part of approved strategies and less than £5 million, although Defra can ‘call-in’ projects of more than £2 million where they are not part of an approved strategy, or in excess of £5 million where they are.

In addition, Defra approval is sought for projects where an assessment is required under the Conservation (Natural Habitats &c.) Regulations, 1994 (Habitats Directive), regardless of cost (Defra, 2005). In all other cases of ‘traditional’ Grant Aid, Defra approval is required. However, for the Agency, by adding Critical Ordinary Watercourses to their ‘main river’ responsibility, with the increased flexibility inherent in the new Grant in Aid funding arrangements, this provides significant improvements for the delivery of the new strategic direction for flood risk management.

Importantly, however, irrespective of the nature of the funding, all projects must continue to meet the technical, economic, social and environmental criteria as set out in the series of Project Appraisal Guidance Notes (PAGN), and they must meet the priority threshold score to be considered for funding (dominated as this is by Benefit:Cost ratios) . Here, therefore, we can once again illustrate the importance of economic damages in the current appraisal system, and in turn the importance of the increased potential damages through time for the decision process.

Leaving aside the legal requirements under the Conservation (Natural Habitats &c.) Regulations, 1994, for which special exception must be made for projects considered in internationally recognised Special Protection Areas (SPA), Ramsar sites or Special Areas of Conservation (SAC), all proposed projects must achieve a priority threshold score to be considered for funding which for 2005-6 is set at 19, with an indicative figure of 19 and 15 set for the following two years.

Through the appraisal process, the priority scoring system attaches values to the appraised benefits for each of the three pillars of sustainability – environment, people and economics. As it currently stands, out of the total potential score of 44 (although in reality most do not exceed 32), 20 are allocated to economics (benefit-cost ratio) and 12 each to people (No. of people at risk, vulnerability and public safety) and the environment (combined habitat and heritage score) respectively (Defra 2005).

This effectively means that, theoretically, the current 19 threshold could be met by economics alone. Thus, the potential benefits from residential and non-residential properties remains the most critical factor in flood risk management, with the appraisal process remaining dominated by economic considerations. Where the resulting decisions are not regarded as socially equitable, the Treasury Green Book (HM Treasury, 2004) recommends that potential benefits should incorporate distributional impacts, with the potential damages weighted accordingly (Defra, 2004b). However, whilst this is an important first step in accounting for social issues in the economic appraisal process, it does not reduce the importance of economic benefits, which as the following section illustrates have increased significantly in the past 15 years.

Principles for developing flood damage databases

Introduction

One of the principal purposes of developing flood damage databases is to ensure policy consistency. If flood risk management (or flood defence) projects are assessed using the same sort of data, then there will be fair comparison between flood warning systems, flood defence arrangements, land use planning and other non-structural measures (Defra, 2004, 2005).

This has occurred in the UK over the last 28 years, following the production of the Middlesex University FHRC “Blue Manual” (Penning-Rowsell and Chatterton, 1977). Such a move was supported by the UK government, which had to reassure the HM

Treasury that the basis of investment appraisal was consistent across the country, and through time, hence the need for a consistent set of flood damage data (or more accurately, potential flood damage data).

In essence, therefore, one of the fundamental pre-requisites of a flood damage data base is a consensus as to the appropriateness of its data for prescribed purposes. If there is no such consensus, then the database will not be widely adopted, and the measure of consistency outlined above will be lost.

This in turn means that the flood damage database needs to be rigorously researched, preferably by an organisation which has no inherent interest in the outcome (unlike an insurance company, which may well wish to see damage totals at the lowest possible), and with full knowledge of the consequences of flooding derived from a number of typical or important flood events.

Why we need to develop flood damage databases

As indicated above, there are a number of different reasons why we should develop flood damage databases, and therefore a number of different uses to which these databases may be put. To a certain extent these different purposes require different sorts of data, or a different structure to the database, and this is something that needs consideration when designing systems to produce such a damage database.

Flood damage data for investment appraisal (economic values)

Flood defence and other flood risk management measures tend to be public goods: this is something provided by government, because in its provision it is impossible to prevent people benefiting from it, when it is provided, even if they are unwilling to contribute to its cost.

This tends to mean that flood defence or flood risk management is provided by governments or similar state organisations. Economies of scale are also important, and therefore the large capital resources available to government and state agencies encourages them to act to provide this public service.

For the appraisal of public sector investment in this respect (HM Treasury, 2003, 2005) national economic values are needed. This is because they need to match the locus of payment for these public services, which in the case of the UK comes from general taxation, even if it is routed through the Environment Agency, from Defra.

Such economic values, with a national base, ignore transfers within the economy (such as taxation), and seek to determine the gains and losses to the nation as a whole from floods or from flood defence investment. Therefore, for example, the loss from one particular retail establishment of sales during a flood is likely to be compensated by gains elsewhere in the retail environment. One baker's shop loses, whereas another one gains (people do not generally consume less bread overall as a result of a flood).

Similarly, in the assessment of damage to domestic properties, the assumption is made that the loss during flooding is a function of a diminution of the pre-flood value of household contents. Therefore, for example, floor coverings may be damaged during a flood but the loss of value of those floor coverings in that flood is from the depreciated value of the floor coverings prior to the flood event.

Therefore in the UK we have coined the term “Average Remaining Value” to represent the depreciated value of the floor coverings and other house hold goods prior to a flood. In the UK, with some notable exceptions, the Average Remaining Value of these goods is 50% of their new value (excluding any taxation element). For certain good such as DVD recorders or laptop computers the Average Remaining Value may be more than 50%, reflecting the fact that these good are in general on average less than half way through their lives.

Baring these points in mind, it is important in the construction of flood damage databases which are to be used for national economic investment appraisal of flood defence works undertaken by government or within the public sector that care is taken to exclude taxation and allow for the depreciation of values to pre-flood conditions. This is not a difficult process but has to be borne in mind right throughout the assembly of flood damage data and the construction of the necessary flood damage databases.

Investment appraisal for individuals or companies (financial values)

A comprehensive flood damage database should contain information for use by individuals or companies seeking to assess their exposure to a range of flood events. They may need to do that so they can take action themselves, or purchase insurance, or lobby governments to seek public sector investment in flood risk management measures. They may need this information, also, in order to see whether insurance is necessary at all, or whether they can take the risk of flooding and whether that risk can be accommodated within their business planning processes.

In this case, flood damage data should be collected which excludes the depreciation of values to pre-flood conditions, because the loss of assets or other fittings and fixtures may have to be compensated for by the purchase of new equipment and new furnishings and fittings, there by costing the company or individual concerns 100% of the replacement costs (including any purchase taxation such as VAT).

Similarly, if a flood damage database is to be used by individuals (perhaps to assess the worthwhileness of them taking action themselves), then the damage data values will have to include all taxation elements to be incurred in the repair and recovery operations following a flood. Financial values will need to be set at repurchase or replacement cost, and the full costs of repair and renovation of the fabric of the building itself.

Such a set of data, including all financial values, will make the flood damage database quite complex, because each individual property will have a range of different flood damage values, depending on the purpose to which the data is put.

In the case of retail or commercial organisations, financial values within the flood damage database will need to include all effects to the property and business concerned, irrespective of national economic values. These full effects, again, will include the replacement of equipment, fittings and furnishings at full replacement cost values, rather than values depreciated by use or by taxation. It will also include loss of trade at its full (financial) value.

Insurance rate settings (financial values)
Many insurance companies, and their associated data gathering organisations, collect flood damage data in order to assess premium levels and levels of risks to particular properties.

As with the investment appraisals for individuals/companies, above, financial values are needed here, because the insured will require or demand full replacement of assets damaged or destroyed during a flood. Naturally, loss adjusters will assess these damages, but increasingly with new-for-old insurance policies, householders and companies will demand full replacement with new fittings, fixtures and equipment, rather than the salvaging and repair or renovation of old assets harmed during a flood, as in the past.

For insurance purposes, it often the case that damage data is needed for extreme events, including the demolition of property as a result of fast-moving flood waters. This is not common in the UK, but in continental Europe such flash flood conditions are not uncommon.

A re-insurance company, being the insurer of last resort, will need to know the maximum exposure of their portfolio of insurance contracts, so as to determine the viability of their total portfolio. What this means, in effect, is that any flood damage database to be used by insurance or re-insurance companies must include the full effects of extreme flood events which by any standard are rare. Re-insurance is usually not triggered until such a rare event occurs, and therefore its assessment of viability needs to be based on extreme flood damage data, rather than typical averages.

Flood damage data for warning prioritisation (financial values)
Many flood warning schemes, within comprehensive flood risk management measures, are assessed on the basis of damage saving. These schemes may be either private sector initiatives, but are more commonly public sector systems.

Therefore, for these purposes, a flood damage database needs to include data on the damage-reducing effects of flood warnings (Parker, 1996; Tunstall, Tapsell and Fernandez-Bilboa, 2005). Such data is sparse, because there is relatively little research undertaken on this matter which looks at precisely what effects warnings have on damage reduction for particular types of household or company.

Recent research (Penning-Rowsell et al., 2005) has sought to quantify the damage reducing effects of warnings and, to generalise, we have found that these have declined over the three decades over which FHRC has been operating.

In 1977 (Penning Rowsell and Chatterton, 1997) we judged that about 70% of total potential damage could be avoided as a result of flood warnings being delivered to individual householders or businesses. More recently (FHRC, 2005) we find that this value is much lower than hitherto we had appreciated. This may be because people are now not responding as well as they might do to flood warnings as issued, but perhaps it is more likely that it is a result of new-for-old insurance policies now being available, which discourage householders somewhat from taking action to reduce potential flood damage.

Be that as it may, any comprehensive flood damage database needs to contain data on realistic potential damage, assuming that warnings are given. In the UK, our experience is that flood damage reduction is not made much more efficient with many hours or even days of warnings; residents and other property owners tend to wait until flood waters are near to occupying their property before talking action, for fear that this action is unnecessary.

Land use planning
Any sensible approach to planning the use of flood plain areas should take on board the damage potential of land uses allocated to such areas.

It is clearly sensible not to locate in flood risk areas properties which have high damage potential, but at the same time it might be sensible to allocate land uses such as warehousing, recreational areas, car parks, nature conservation facilities to such areas, owing to the low damage potential and the benefits that come from locating these facilities in terms of opportunity costs.

Therefore some indication is necessary of the damage potential of these land uses in flood plain areas, so that sensible decisions can be made about land use and spatial planning allocations. This indicates that any flood damage database used for these purposes needs to have land use and property categories that are relevant to spatial planning processes and decisions.

Other purposes
It often cannot be anticipated what a flood damage database will be used for, and the sub-sections above give insight into many possible uses.

What has to be borne in mind, quite simply, is that whenever a flood damage database is constructed, the eventual purposes of that data are reviewed and the database organised and structured accordingly.

In this away the maximum potential use of the database is guaranteed, whereas it is often difficult to alter a database subsequent to its construction to fit a new use as it becomes appreciated.

Philosophy

There are different approaches to flood damage collection and the presentation of these data in databases. The following include some of the different approaches adopted, reflecting different purposes and the availability of source data.

Real flood damage data
It is usually tempting to try to incorporate as much real flood damage data as possible from recently floods into a database.

The difficulty that we have experienced in the UK is that this often biases the results, by over-emphasising damage to building contents (which appear to be devastated following a flood), and underestimating long term effects on the building fabric. This is partly because the assessments of real flood damage data are usually done in the immediate aftermath of a flood, when salvage and other recovery values cannot realistically be known. Or it is done some time later, when damaged items may be missed but damage to the building becomes more easily identified. There is therefore no ideal time to do such an assessment of real flood damage to individual properties, and often the appraisal falls between two stools.

Having said this, it is obviously important to use insight and information obtained from real floods to populate any flood damaged database.

Synthetic approaches
These approaches are sometimes misunderstood. By the term "synthetic" we do not mean arbitrary or artificial. What we mean is that the approach involves a synthesis of all available data, from both secondary sources and from the real experience of floods.

This is the approach which had been adopted in the UK. Flood damage data is built up from an accumulation of knowledge about the effect of floodwaters on household or building contents and the effect on the fabric of the building and its repair and renovation. Many thousands of items of data are looked at in this respect, based on typical properties flooded to a range of depths from floods with different severities. In this way we can obtain data on the range of experiences that are likely in flood risk areas, rather than the one-off situations represented by individual actual (historical) floods.

This synthetic approach has the limitation that it is not necessarily applicable for measuring the effect of *particular* floods (all of which are likely to be different), and therefore experience of damage by *particular* owners in *particular* properties may not fit the average synthetic set of data. On the other hand there are advantages in that the synthetic data set can be more comprehensive than otherwise would be the case.

The unit area approach
This approach looks at individual properties and assesses damage per square metre of the floor space. We have found in the UK that this is appropriate for commercial, retail and industrial premises, where size is an important variable affecting flood damage potential.

This approach can be adopted by those constructing real flood damage databases or using the "synthetic" approach above, and is simply designed to allow for one particular variable (size) in assessing flood damage potential.

The percentage of property value approach
This is a completely different approach used commonly in several continental European countries.

It uses the market value of the property concerned, preferably just for the building rather than the land the building occupies, and expresses flood damage potential as percentages of that value. Therefore, for example, a particularly serious flood might cause damage to the extent of 65% of the total value of the property concerned, if substantial rebuilding was necessary and majority of the contents were destroyed. A minor flood might result in just 10% of the property's value being representative of flood damages.

The advantage of this approach is simplicity, because many data sources are available on the value of property in flood risk areas. Thus in the UK we could use data from the Land Registry or from commercial databases to determine the value of both residential and industrial/commercial properties.

On the other hand, the market value of a property is related to the demand for that property (and, in the commercial sphere, goodwill values), and it is not necessarily correlated with flood damage potential. Thus some property might have substantial value because of the value of the land it occupies. In another case, the flood damage potential of a warehouse will be related more to the value of the contents of that warehouse rather than the value of the building itself. But property databases containing information on property value tend not to include the contents of the property, quite naturally, but only record the value of the land and buildings.

Nevertheless, and notwithstanding those limitations, this approach could well be one that is most applicable across Europe, rather than the unit area "synthetic" approach developed in the UK.

Weighted annual average damage approaches
One limitation of all the above approaches to flood damage potential is that it only records the damage from one particular flood event. Yet in many applications what we need to know is the total exposure of a property or land use item to the full range of floods that might cause it damage, thus recording its total hazard exposure.

To do this, it is necessary to incorporate flood probability into the assessment of flood damages. Ideally, the full range of flood probabilities need to be deployed, and the annual average damage calculated weighted by the appropriate flood exposure. This can be a complex operation, incorporating data from a range of floods, and in the UK has only been attempted on a regional basis.

An example of such data set for the UK, developed by John Chatterton and incorporating the results from several dozen individual project appraisals (see Penning-Rowsell *et al.* 2005). What this does is to weight damage potential by the probability of flooding of particular depths, taken from a range of project appraisals, resulting in the weighted average. This approach has the great advantage in producing data which calculates or records total exposure to a range of floods, but is a complex operation to achieve and requires considerable data to be successfully accomplished.

Building a flood damage database

A simplified structure for the construction of a flood damage database is contained in **Figure1**.

The essential ingredients and decisions involved here are as follows:

- Values of the assets at risk.
- The susceptibility of those assets to flood damage.
- Key variables affecting the extent of damage, which are likely to vary in different flooding circumstances.
- The level of aggregation of the data required.
- Some information as to flood probability, in order to convert event damages into annual average damages.

A key difference here across countries experiencing different types of floods will be item 3 above (the key variables affecting the extent of damage). In the UK experience, where floods are generally characterised as slow moving, slowly accumulating, shallow and short-lived, it is generally considered that flood depth is the most important variable affecting flood damage (other than flood extent, which brings properties into the flood risk area).

In other circumstances it will be other variables that dominate this calculus, such that, for example, in mountainous areas the flood water velocity might be the dominant characteristic, such that extra damage is caused where flood velocities are particularly high. This point emphasises that appraisers will have to be aware of local circumstances when populating their flood damage database with appropriate data suitable for their circumstances.

Assembling the components of a flood damage database

As indicated in **Figure 1**, a flood damage database is composed of a number of components. Each of these has to be considered when the database construction is evaluated, so as to facilitate easy incorporation of the data into the total system.

Asset values

An important starting point for any flood damage database is the assets at risks and their value. These can be characterised from field surveys, secondary sources, or synthetically (see above).

What is needed here, is the market value of the assets at risk, including buildings, land and the contents of buildings. Other assets at risk could be infrastructure components, such as telecom facilities, water utilities and gas and electricity systems. These contribute to an assessment of the indirect affects of flooding, and it is not therefore the asset at risk that is important here but the value of that asset to maintaining the system provided by the infrastructure.

In terms of building contents, the asset value determines the maximum potential damage suffered by the facility or property at risk. In the UK, we have determined values by summing the total value of each component within the building (building repair operations and inventory values). An alternative approach (see above) is to assess the total value of the whole property, using market values or information from rateable or taxation databases.

The treatment of land here is problematic. Obviously, in a flood the land is not lost, but it could be damaged in some way. Contamination from sediments could occur or erosion might reduce soil depths or land stability. Notwithstanding this, the total value of land is likely to over-estimate considerably the potential flood damage, and therefore this item needs to be treated with caution.

Similarly, most floods do not damage buildings totally, although exceptions do occur. This means that the total asset value will over-estimate the flood damage potential, unless susceptibility values are appropriately determined (see below). In the same way, building contents represent maximum flood damage potential, and allowance needs to be made in the database construction for the damage reducing effects of flood warnings, because building contents damage will be thereby reduced.

As with all flood damage assessments, the treatment of taxation elements within values must also be approached cautiously. The implied value of inventory items in properties will be inflated by taxes such as Value Added Tax, yet the loss of these values are transfer payments rather than an opportunity cost. For financial damage evaluations, however, taxation has to be included, because this is the loss to the organisation or individual concerned. In almost all other circumstances, taxation has to be deducted from values.

Some values may be intangible. Thus historic buildings may have a value far greater than their repair and replacement cost, in the same way that the value of contents of buildings will include items of sentimental or nostalgic value for which market values inappropriately measure their true worth. Finally, it must be remembered that some assets are movable, and therefore not necessarily potentially all at risk. Mobile homes and other facilities may be moved away from flood risk areas, given sufficient warning, and household and building contents may also be treated similarly.

Asset susceptibility

It is generally easy to obtain information on the value of property at risk from flooding. Secondary source or even field surveys backed up by estate agent sources provide the appropriate access to that data.

Much more problematic is the susceptibility of property to flood damage. By “susceptibility” we mean the percentage loss or reduction in value with immersion by flood water. Thus, for example, a television may be completely destroyed and lose all of its value by immersion in flooding (susceptibility 100%), whereas a ceramic tile floor may suffer virtually no damage, or only require inspection to determine that no damage has occurred (susceptibility in this case might be measured as 5% of total value).

The concept of susceptibility should not be confused with Average Remaining Value measures of the depreciation in value of some items of property contents or fabric as a result of age; a five year old television might only be worth 20% of its purchase price as new. The Average Remaining Value of a DVD player might be 80% of its purchase price as new, because most DVD players are still less than 5 years old.

Susceptibility is assessed in many different ways. After a flood it is possible to assess the value of damage as the price new less the re-sale value of the flood damaged contents of that property, as determined by quantity surveyors or loss adjusters. Simple inspection may review items that are completely valueless after a flood (the television example), as above, or free from damage (the ceramic floor, above). In some cases considerable technical knowledge is required to assess susceptibility, such as the damage to a central heating boiler or antique furniture.

Therefore to assemble a database incorporating accurate or appropriate susceptibility values takes time, and the incorporation of specialist knowledge into the assessment of flood effects. Notwithstanding this, this is an essential stage, and has to be approached by assembling experts or specialists in the field or those with knowledge of valuation techniques (e.g. quantity surveyors) or insurance claims (loss adjusters). Often a "common sense" approach is necessary, for many items, leaving the residual difficulties to these specialists.

Flood damage potential is assessed as susceptibility times Average Remaining Value, since the damage potential is at pre-flood conditions, where items such as DVD players or televisions are part way through their lives. In the UK, an Average Remaining Value of 50% has generally been assumed but susceptibility values vary widely.

An additional dimension of the construction of a flood damage database is incorporating other key variables thus, for example, in the UK flood depth is considered to be an important variable, and therefore different susceptibilities for different depths of flooding have to be determined. In the case of flood warnings, a similar approach would apply, varying susceptibility levels by duration of warning, or flood water velocities in the case of that being the determining variable.

Key determining variables

As indicated above, certain key variables will determine overall flood damage potential in different circumstances, such as flood water velocity being the crucial variable in certain areas (e.g. mountainous regions), whereas in the UK the natural flood characteristics mean that flood depth is the one variable seen as critical in determining flood damage potential.

This means that the construction of a truly useful flood damage database will therefore depend on local circumstances. What is important is identifying the effects of these key variables on susceptibility values, or repair and renovation costs for building fabric operations, and assembling the appropriate information or expertise accordingly.

For example, in the UK, as indicated above, flood depth is seen to be the key variable. Therefore in the construction of the FHRC database considerable effort was expended in determining different susceptibility and asset values by height/depth within properties liable to flooding. This was done partly by field survey (in the early years of database construction), but also by consulting appropriate specialists (quantity surveyors; engineering surveyors; loss adjusters). The result was a suite of depth/susceptibility/asset curves, from which flood damage potential was calculated. The full details of this process cannot be covered here, but are to be found in the initial Manual produced by FHRC in 1977 (Penning-Rowsell and Chatterton, 1977).

It has to be recognised, however, that few floods in the UK exceed 1.0 metres in depth. Therefore while damage data and depth data is provided up to 3.0 meters of flooding in the FHRC database, the data items for depths of flooding greater than1.0 meters are rarely used. The situation may be very different to different countries, and in different circumstances. Therefore, for example, if flood warning lead time is the key determining variable, warning lead time may vary from a few minutes to many days or even weeks. Such a consideration will affect the way that data is collected and stored in a flood damage database.

Levels of aggregation

The fourth step in **Figure 1** indicates that different levels of aggregation are possible and desirable within a flood damage database. Thus some data may be obtained on individual buildings, whereas others sum those values for localities, regions or indeed the whole nation.

The level of aggregation within the database is an important consideration determining the character of that database. The FHRC database at Middlesex University is highly detailed, and contains data at many different levels. However many project appraisal exercises require only data for a particular region (e.g. in MDSF), or even the nation as a whole (as in the Foresight project). Nevertheless this aggregated data usually has to be built up from more detailed assemblages of information, containing individual properties from which higher level averages are derived. Again, much of it will depend upon the use to which the data is to be put.

In the context of the above, any high level averages need to be based on weighted data. Thus, for example, if one is assembling a database on residential flood data, from information obtained in specific localities perhaps concerning individual properties, then it is important to know the weights of those individual properties within the national total before calculating the weighted averages.

This is not a process that can be accomplished by field surveys. It will be important to have knowledge of the numbers of each type of properties within the region or the nation concerned, in order to derive the appropriate weights. Thus, for example, the number of detached, terraced and semi-detached houses is known to the whole of the UK, and these have been used as weights within the FHRC database. We also know the numbers of different types of non-residential properties in the indicative flood plain within England and Wales, based on postal information sources, and therefore that information can be used both as a sampling frame work for field surveys and as a basis for averaging data collected from particular localities or regions.

The process of aggregation would need to be pre-determined for the particular database being constructed. In general it is necessary to use information collected at as high a level of aggregation as possible, because this is likely to be more generally applicable than locally-based individual survey results. This assumes that some secondary source data is available on property types and numbers at a regional or national level, and this needs to be pursued vigorously in order to make the database as generally applicable as possible.

5.5 Incorporating flood probability data

All the above guidance has been designed to collect and aggregate flood damage data for damage from an individual flood event. This can be used in a number of ways, as indicated above.

However, increasingly it is necessary to assess the full exposure of property or land to a range of flood events likely to be experienced at that particular location. Thus a property exposed to a flood with a return period of 1 in 10 years will also be exposed to the flood that occurs once in 100 years. Many uses of flood damage data need to know the full range of risks and consequences, in the form of an annual average damage value. This is the potential flood damage from the full range of floods likely to be experienced at that location, including both the 20 year flood and the 100 year flood in the example above.

Incorporating flood probability data in this way is not easy. What one needs to know is the depth or duration or velocity of the individual floods from which the property is at risk (depending on the key variables: see above), and the consequences of those different events. In effect, a loss-probability curve has to be established for the individual property, from which the area under the curve is the value of the annual average damage. In addition, that annual average damage needs to be weighted by the appropriate property concerned, in the same way as described in the section on Aggregation, above.

Aggregation of weighted annual average damages

In the same way that the flood event damage is aggregated for application at regional or national levels, so the weighted annual average damage values need aggregation.

This again depends upon exactly the same principles as discussed above, by knowing the proportions of properties within different classes in the appropriate regions or areas involved. The result is a database of flood benefit values and different levels of aggregation for different types of application, mainly regional projects or national evaluations.

Quality assurance procedures

Flood damage data can be manipulated to achieve certain aims (such as furthering levels of government investment for local communities). The data that therefore is used to ensure policy consistency needs to be quality-assured.

How this is best done will depend on local circumstances. The following are important:

- An audit trail back from the data to its sources
- Broad stakeholder acceptance of the data and the assumptions that have been used in its derivation
- Some form of peer review of the resulting data and its database
- An acceptance of the data by government (because much of its use will be related to government activities)

In addition, use over time brings confidence that the data is valid and dependable.

The changing FHRC data and its context

Introduction

Within England and Wales, the Government recommends that the assessment of potential economic damages to residential and non-residential properties utilise the data sets developed by the Flood Hazard Research Centre at Middlesex University. These are generally regarded as accurately gauging potential economic losses across a range of flood severities (Penning-Rowsell and Green, 2000). Initiated in the 1970s by Penning-Rowsell and Chatterton (1977), these have been updated in subsequent years, with the latest figures reflecting values at 2005 prices.

Since the last comprehensive assessment (Suleman *et al.*, 1988), the flood-damage potential has significantly increased in real terms (Penning-Rowsell *et al.*, 2003, 2005). There have also been changes in project appraisal guidance, public attitudes (e.g. on health and safety), technological developments, institutional structures, building regulations, ownership of household goods, and alterations to building fabrics. Moreover, the UK economy (as represented by increases in GDP) has more than doubled in size (Clegg, 2002) resulting in a more affluent society with increased investment by homeowners and businesses in their properties and contents (Penning-Rowsell and Green, 2000).

By contrast, the underlying philosophy for assessing the flood-damage potential of properties has remained unaltered. In essence, this method involves costing the likely direct damage from flood events with a range of magnitudes and durations but assuming normal velocities, effluent and silt content. Thus, depth of flooding remains the primary determinant of flood loss, the duration is assumed to be of lesser importance and the part played by flood water velocities is assumed to be small except in cases of structural failure.

Residential properties

A comparison between the data published in 1990 (N'Jai et al, 1990), and the more recently calculated 2005 figures (Penning-Rowsell et al., 2005) illustrates the above-inflation increases in the potential economic damages to residential properties. **Figure 2** shows the increases observed to the sector average potential-damages, household inventory and building fabric items between 1990 and 2005, with the 1990 prices adjusted to 2005 values using the CPI.

In both short (<12 hours) and long (>12 hours) duration floods there has been a significant increase in potential-damages at all depths of flooding. For short duration flooding, the 2005 values represent a 7-fold increase in sector average damages for floods of shallow depth (0.1m), a 5.2-fold increase for medium depths (0.3m) and a 3.5-fold increase for deeper floods (1.2m). For long duration flooding the comparative figures are 3.9, 3.3 and 2.2 respectively. This suggests that although long duration floods still produce greater total damages (£32,754 and £26,105 at 0.3m for long and short, respectively), the duration is no longer as significant as once assumed. These figures are also indicative of the increased damage potential of floods of shallow depths with the greatest increase observed at 0.1m and 0.05m depths. At 0.05m, for example, the damages have risen 9.2-fold for a short duration flood and 5-fold for a long duration flood.

These increases are, however, differentially influenced by the potential damage to household goods and building fabric items. For household goods, the potential damage for short duration flooding represents a 15.4-fold increase at 0.05m, a 10-fold increase at 0.1m, a 6.2-fold increase at 0.3m and a 4.1-fold increase at 1.2m. For long duration flooding the comparative figures are 7.8, 6.2, 5.2 and 3.7 respectively.

These figures are a direct result of the increase in the unit cost, quality, quantity and susceptibility of household goods at significantly lower depths of flooding than previously assumed and the increased cost of domestic clean-up. They are also indicative of the 'throw-away' society in which we now reside where household goods are now ‘written off’ at lower depths of flooding; a factor that is particularly significant during short duration floods which were previously assumed to operate within a more repair-orientated culture. Furthermore, as many of the household inventory items are now deemed to be damaged on contact with water, irrespective of the length of contact, this has significantly influenced the increased damage percentage observed at lower depths.

The increased potential damage to building fabric items, whilst less substantial than for household goods, remains significant (**Table 2a**). For short duration flooding there has been a 3-fold increase at 0.05m, a 3.8-fold increase at 0.1m, a 3.7-fold increase at 0.3m and a 2.9-fold increase at 1.2m.   For long duration flooding the comparative figures are 3.0, 2.7, 2.3 and 1.5. These increases are a result of the changing unit cost of building fabric items, materials, increased labour costs and building construction changes both in terms of house types and materials. Here again, as with household goods, flood duration now appears to be less significant than previously assumed.

From the above analysis it is clear that the depth of flooding remains the key determinant in the assessment of the flood-damage potential of residential properties. This is particularly significant considering the altered susceptibility assumptions for both household goods and building fabric items.

Using a simple RPI update factor, Penning-Rowsell and Green (2000) analysed the changing flood-damage values between 1977 and 1996, concluding that increased flood damage is most marked at low depths, high depths and in houses occupied by the higher socio-economic groups. This finding was based on an up-date of the 1990 data without any methodological developments (N’gai, 1990). Hence, although a comparable analysis between the 1990 and 2005 data furthers the argument that flood damage is most marked at low depths of flooding, a similar conclusion cannot be made for floods at high depths or floods in houses occupied by the higher socio-economic groups (**Table 2b**). Rather, as flood depth increases, the comparative increase in values decreases proportionally; a finding which holds true irrespective of social class. This latter observation suggests that although the total damage in lower socio-economic groups remains less, the damage increases are proportionally similar to those of higher socio-economic groupings.

This variation is as expected because the damage values at lower depths of flooding have increased disproportionately when compared with those of higher depths, thus reducing the differential previously observed. In addition, where higher socio-economic groups were deemed to have greater rates of economic advancement in the 1970's and 1980's, this no longer appears to hold true.

An evaluation of these changes across the four social class categories occupying post war (1945-1964) terraced housing further clarifies this argument. Here, the real percentage increases are significantly greater for those in lower socio-economic groups than higher (**Table 2b**). This is indicative of an increase in the ability of lower socio-economic groups to invest more in their property and contents than previously assumed. This is an argument illustrated by the change in ownership of various household goods by social class between 1990 and 2000 (**Figure 3**) (OPCS, 1992; ONS, 2002).

Developments related to non-residential properties

As with the residential data, the last modification of data on non-residential properties (NRPs) was carried out in 1988 (Suleman *et al.* 1988), with the data merely updated to 1990 prices for the FLAIR (1990) report. Since then there have been a number of trends and developments in the non-residential property sector that have implications for current and future flood damage potential.

Like residential properties, flood damage for non-residential properties varies depending upon the type of property and its size; however, for non-residential properties the function of the premises is obviously also important. The current data on non-residential properties results from new research in this sector, and is an attempt to simplify the previous approaches to determining direct flood losses for retail, commercial, industrial and manufacturing properties, as advocated by Penning-Rowsell and Chatterton, and Parker in the 'Blue' and 'Red' Manuals(Penning-Rowsell and Chatterton, 1977; Parker *et al.* 1987). The new data also promotes an increased transparency in user data selection. This section will outline the key changes in the sector which have influenced the potential for increased flood damages for non-residential properties, and report on the recent methodological and data developments in assessing these damages.

Factors influencing increased susceptibility to flood damage

A number of changes have taken place in the non-residential property sector over recent years that have implications for increasing flood damage potential. Various studies by leading UK surveyors and property valuers were consulted which indicated the extent and direction of these trends and developments. These changes and trends largely relate to the development of new technology, and to changes in land use such as the location, size, and type of non-residential properties and new construction schemes; the main changes are highlighted in **Table 3**.

There are a number of key factors, or characteristics of properties and their function, which may affect susceptibility to flood damage and indicate why some properties have higher susceptibility than others. Susceptibility of the five components of flood damage (building structure/fabric; services; fixtures and fittings; moveable equipment; and stock (or raw materials/work in progress/finished goods, as appropriate)) can vary enormously, both from component to component within the same property categories, and between categories.

Across the range of non-residential properties it is stock which tends to be the most variable component of damage. The level of susceptibility may be related to whether or not the company's goods and equipment are technologically sophisticated, whether the company sells or stores food or non-food items, and whether the food is ambient or refrigerated. For example, fresh food produce is highly susceptible, and would now always be 'written off' on the grounds of public health risk, even if untouched by floodwaters.

Health and safety issues are also paramount for laboratories or other environments where extensive hygiene conditions are needed. Paper goods (e.g. books or stationery) and electrical goods are particularly susceptible to damage from damp conditions and air moisture content, even if untouched by floodwaters. Some of these items may also be 'written off' due to possible public health or safety fears, and because items such as these need to ‘look good’ in order to sell: public confidence is paramount for a successful business.

For properties such as multi-screen cinemas or theatres, which have extensive seating, fixtures and fittings are likely to constitute the largest component of flood damage, while for plant hire companies, or printers relying on high precision electronic machinery, moveable equipment would constitute the largest flood damages. Serious damage to building structure is unlikely to occur except in very deep flood events, or from damage resulting from high-impact coastal or river flooding.

However, damage to services can result in significant losses. Many companies now rely heavily on computing, information technology equipment and telecommunications that require extensive use of cabling and electrical services. Large companies, such as national supermarket chains and banks, are increasingly reliant on computing equipment, with tills or computers from each store or branch being linked to the head office or support centre computer. If these tills or computers were affected by flooding then the businesses would not be able to operate and would lose trade, and more importantly, customer confidence.

Finally, in today's competitive commercial world, many companies will not take mitigating actions upon receiving a flood warning unless they believe that flooding is certain and imminent. This is because any interruption of business from 'false alarms' can lead to lost revenue and, often more importantly, to loss of customer confidence and eventually loss of custom. Subsequently, when evasive actions are taken, it may often be too late to mitigate significant losses and damages.

The updated the flood loss/damage database for non-residential properties

It has long been recognised by flood damage researchers and users in the UK that the ‘FLAIR 1990’ non-residential property data employed over the last decade was problematic in a number of ways (N’Jai *et al.*, 1990). To address these problems, and to raise the quality of the non-residential property flood damage data in line with the residential data, a radical approach to the revision of the databases on retail, commercial and industrial flood damages was required. This necessitated a revised methodology to create a new database.

Several key principles have influenced the research leading to this revised methodology. Firstly, the number of non-residential land-use categories and sub-categories, for which flood damage data is presented, has been radically reduced in order to limit confusion and misclassification. More guidance was needed on criteria to enable the user to make an objective selection of appropriate non-residential property depth-damage data. The new approach also recognises that scheme appraisal for flood defence involves appraising flood damages over a long time perspective (typically 50 years), and that one particular type of premises in the floodplain today (e.g. a bookshop), could be quite different in 50 or even 10 years time (i.e. by then it could be a café, or a clothes shop).

An important development is that the new data is more relevant to flood-prone situations than data presented in previous Manuals, in that it relates to the distribution of non-residential premises located in the floodplains of England and Wales. Consideration has also been made of new technological developments that may markedly affect changes to flood damage potential. Moreover, the damage data provided has been disaggregated for the five components of flood damage, namely: building structure/fabric; services; moveable equipment; fixtures and fittings; stock (raw materials/work in progress). This new ‘mix and match’ philosophy enables the user (where appropriate and with guidance), to build their own depth-damage curves from data on the four constituent damage components.

The new non-residential land-use categorisations comprise 10 categories and 61 sub-categories. A sector, category, sub-category hierarchy (with mean values weighted by frequency) enables different levels of data collection to be applied to damage assessments (as with the residential depth-damage data). Just six sub-categories (retail shops and stores, public houses, offices, warehouses, and workshops) account for 70% of all non-residential floodplain properties. This frequency distribution of properties helped determine where collection of the new depth-damage data should be concentrated. The new database facilitates the derivation of depth-damage data for any non-residential property represented in the Environment Agency's Indicative Floodplains and, therefore, represents a more effective sampling frame.

Rather than surveying properties liable to flooding, the main approach has been to contact head offices of companies to obtain data about a range of property types, and their flood susceptibility. In certain circumstances discussions have also been held with organisations with experience of flood damage in the recent past (primarily the Autumn 2000 floods). Totally new depth-damage data sets have been derived based on the data collections and discussion meetings. The sample of companies and property types selected for the meetings was specifically chosen to reflect many of the new trends in the development and expansion of the non-residential property sector. Although the sample sizes were small it is planned to add to the database in the future.

The above principles have been followed in order to provide data that is simpler in structure, more relevant to floodplain situations, and accompanied by a breakdown of damage components. Thus, the approach is largely generic rather than taking specific scheme-related examples as in the earlier Manuals. The approach is also intended to be pre-emptive about future land uses and flood damage potential, moving away from the concentration on the 'core' more traditional non-residential properties (e.g. butchers' shops), many of which are in such decline that they are likely to be increasingly less significant in the future.

Sets of depth-damage curves have been produced which can be applied to any non-residential property with a simple knowledge of its size (ground floor area). The data from the curves have been used to produce (for each sub-category of non-residential property where data was available) a table of their equivalent percentage loss values (including clean-up and repair costs) for flood depths of 0.25m intervals, broken down by the four damage components. From this information, high and low susceptibility bands and indicative susceptibility data for the respective sub-categories have been extracted, and guidance given on choosing the appropriate susceptibility level. The susceptibility curves form a banding outside which damage should not be expected. **Figure 4** illustrates these for sub-category 211 (High Street Shops) for the basic flood scenario of a river flood of less than 12 hours duration with no flood warning being issued.

The resulting increased flood-damage potential for non-residential properties

Comparisons have been made between the flood-damage potential of non-residential properties reported in FLAIR 1990 (N'Jai *et al.,* 1990) and data from the recent update. However, a number of factors made comparison between the 1990 and 2005 figures difficult. The flood depths for the new data have been amended to be more logical, e.g. 0.25m, 0.5m rather than 0.3m, 0.6m as in 'Flair 1990'. Therefore, the depths for the 2005 data have had to be adjusted to those of 1990 for comparative purposes. Moreover, the 1990 data does not include any damage figures for depths above 1.0 metre. As the land use categories have been changed, the ones illustrated here are comparisons for the nearest type of land-use data, and for many categories direct comparisons have not been possible. Sample sizes also vary between the 1990 and 2005 examples, therefore, the figures illustrated here can only serve as broad comparisons, but are useful for indicating the recent trends and future flood damage potential.

Figure 5 illustrates the increases in the sector average potential damages for selected non-residential property types between 1990 and 2005, with the 1990 prices adjusted to 2005 values using the appropriate RPI or PPI. These increases are significant across all sub-categories of non-residential properties. The largest increases illustrated here are those for retail supermarkets and hyper-markets, with an increase of 287% for damages at one metre depth and significant increases at the lower depths. This can be partly explained by the changes that have taken place within this type of retail outlet over the last decade or two. Current stores now sell electrical and white goods, clothing and soft furnishings alongside food items, all of which are highly susceptible to flood damage. Figures for offices and workshops also reflect the changes in the non-residential property sector outlined above, however, it should be noted that the new data refer to state-of-the art premises.

The concept of a ‘throw-away’ society is as true for businesses today as it is for residential properties, if not more so, as customer confidence and the earliest resumption of trading/operating is paramount. Many businesses do not feel that there would be substantial differences in damage from increased duration of flooding. Flood depth is now seen as being more significant than duration in affecting damages, largely due to the fact that less would tend to be repaired or salvaged than in the past. Possible greater damage to building structure might result from longer duration flooding, and certainly greater loss of profit from being unable to trade for a longer period, and even possible loss of custom to rival companies.

The main conclusions for non-residential property are therefore as below:

- There is increased damage potential across all categories of non-residential properties;
- Higher damages are largely the result of new technologies and of developments and changes within the non-residential land use and property sector;
- Potential increases in losses can depend upon the function of the property and the levels of susceptibility of the five components of damage;
- Increased damages reflect both higher quality of goods and services, and in some cases higher quantities;
- Flood duration is less important than depth in affecting potential damages; and,
- Customer confidence and public health risks are key to influencing the increased levels of goods and equipment deemed to be 'written off' during floods, which has increased susceptibility and the damage potential from flooding. Getting back to business as soon as possible is paramount.

Updating strategy

All data bases get out of date. Given that they are developed to ensure policy consistency over space and time, the updating of the data is important. What is needed is:

- Advice on price updating indices to use over a 1-5 year period
- Regular more systematic updates of the data sources on a 3-7 year cycle
- More fundamental updates and revisions to reflect new uses of the data on a 5-10 year cycle.

The first of these will depend on the nature of the database (i.e. its sources data) and the availability of relevant census bases updating indices on a regional or a national basis. The second and third items above depend upon a continuing research capability in the organisations responsible for the database and its maintenance.

The Multi-Coloured Manual flood damage and loss database at FHRC needs to be kept up to date so that decision making with its use is consistent through time. The recommended strategy for future updating of damage tables and indices is to update most of the data on an annual basis, and have this available to users, on a subscription basis, via an updated CD Rom.

In addition, and every 5 or so years, a much more comprehensive update needs to be undertaken, so as to prevent the situation that occurred in 2002 when a major shift in damage/loss values occurred in single update after 10 years.

The annual update is not likely to be costly, and could be funded from the annual CD sales (if that CD data can be restricted to purchasers, and not put on the web). We believe that the 5+ years update should be funded by the Environment Agency.

As far as the FD2014 recommendations are concerned, these are summarised in **Table 4**. On the basis of the above analysis of need, and related only in this first instance to the requirement for economic (national level) data, the FHRC database needs to be regularly updated using the relevant Prices Indices (general the Consumer Price Index). But the analysis above shows that over a longer time period (5-10 years) there are major shifts in damage values that need to be identified and measured. Hence the recommendations in **Table 4** about the 5-10 year strategy.

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Table 2a:
Changing residential flood-damage values 1990-2005

	All residential				Detached, pre-1919, AB social class				1919-1944, Semi, C2 social class				Pre-1919 terrace, DE social class			
Depth (m)	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase
3	14300	20163	44,115	118.8	34520	48673	107,076	120.0	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
2.7	13180	18584	42,594	129.2	30320	42751	101,683	137.8	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
2.4	11790	16624	39,301	136.4	26000	36660	93,320	154.6	10320	14551	38,092	161.8	7900	11139	28,605	156.8
2.1	10480	14777	37,852	156.2	22840	32204	89,660	178.4	8850	12479	36,329	191.1	6690	9433	27,126	187.6
1.8	9000	12690	36,399	186.8	20000	28200	85,923	204.7	7800	10998	34,843	216.8	5170	7290	25,952	256.0
1.5	7720	10885	34,622	218.1	17530	24717	80,988	227.7	6730	9489	33,143	249.3	4070	5739	24,501	326.9
1.2	6700	9447	33,040	249.7	15670	22095	76,206	244.9	5880	8291	31,698	282.3	3600	5076	23,265	358.3
0.9	5820	8206	31,265	281.0	13290	18739	72,049	284.5	5290	7459	30,163	304.4	3220	4540	21,987	384.3
0.6	4820	6796	29,268	330.6	11030	15552	66,144	325.3	4440	6260	28,412	353.8	2780	3920	21,060	437.3
0.3	3590	5062	26,105	415.7	8620	12154	58,773	383.6	3490	4921	25,240	412.9	2170	3060	19,004	521.1
0.2	2580	3638	23,290	540.2	5750	8108	49,938	515.9	2570	3624	22,531	521.8	1620	2284	17,473	665.0
0.1	1370	1932	13,507	599.2	2600	3666	28,191	669.0	1540	2171	13,008	499.1	1090	1537	10,285	569.2
0.05	850	1199	10,973	815.6	1980	2792	19,917	613.4	958	1351	10,655	688.8	803	1132	8,942	689.8
0	339	478	611	27.9	525	740	929	25.5	512	722	871	20.7	490	691	821	18.8
-0.3	254	358	611	70.7	488	688	929	35.0	497	701	871	24.3	453	639	821	28.5
Mean				**208.4**				**212.9**				**268.4**				**307.0**

Table 2b
Changing residential flood-damage values by social class 1990-2005

	1945-64 Terrace AB				1945-64 Terrace C1				1945-64 Terrace C2				1945-64 Terrace DE			
Depth (m)	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data (£)	1990 data updated by CPI (£)	April 2005 Update (£)	Real % increase	1990 data (£)	1990 data updated by CPI (£)	April 2005 Update (£)	Real % increase	1990 data (£)	1990 data updated by CPI (£)	April 2005 Update (£)	Real % increase
2.1	8190	11548	32937	185.2	6590	9292	25949	179.3	5550	7826	24719	215.9	4680	6599	20196	206.1
1.8	7130	10053	32228	220.6	5530	7797	25244	223.8	4880	6881	24107	250.4	4010	5654	19588	246.4
1.5	5730	8079	31001	283.7	4190	5908	24154	308.8	4000	5640	23106	309.7	3150	4442	18679	320.6
1.2	5220	7360	29994	307.5	3770	5316	23294	338.2	3630	5118	22312	335.9	2800	3948	18036	356.8
0.9	4420	6232	28284	353.8	3150	4442	21819	391.3	3330	4695	21149	350.4	2530	3567	16971	375.7
0.6	3770	5316	26298	394.7	2750	3878	20703	433.9	2910	4103	20086	389.5	2230	3144	16383	421.0
0.3	2850	4019	23742	490.8	2090	2947	19025	545.6	2230	3144	18366	484.1	1770	2496	15256	511.3
0.2	1900	2679	21949	719.3	1570	2214	17876	707.5	1640	2312	17293	647.8	1310	1847	14731	697.5
0.1	1040	1466	13261	804.3	890	1255	10660	749.4	948	1337	10406	678.5	813	1146	8778	665.8
0.05	634	894	11164	1148.8	568	801	9162	1043.9	623	878	9046	929.8	552	778	7857	909.5
0	251	354	544	53.8	251	354	544	53.8	251	354	544	53.8	251	354	544	53.8
-0.3	22	31	544	1654.2	22	31	544	1654.2	22	31	544	1654.2	22	31	544	1654.2
Mean				**334.2**				**349.8**				**352.9**				**363.3**

* flood duration < 12hours
** CPI April 1990 to April 2005 = 1.41

Table 3

New developments in NRP sector/land use affecting flood-damage potential

Commercial/office sector:
Growth in demand for out-of-town business park space - possibly located in floodplains. Key factors driving this demand include the constraints of insufficient space (e.g. for car parking) within city centres, emergence of new industry structures between technology, media and telecom companies (brought about by the internet).
In-town retail sector:
High Street shops constitute the largest proportion of NRPs in the floodplains of England and Wales (28%), both tidal and fluvial. Retail shop and services premises have, on average, the highest flood damage potential per unit area of all properties owing to the combination of high stock value and intense use of space. Changes taking place within town centres with regard to the type of retail and service premises, and their numbers include: the departure of 'traditional' shops such as green grocers, as goods are now purchased in super markets. Significant expansion by companies such as mobile telephone and sports operators, and demand from coffee shop operators. Predictions for the future of town centres are more ‘lifestyle’ and leisure focused: e.g. more mixed leisure, retail and residential uses; re-establishment in town centres of cinemas, restaurants, and bars; more requirements for cafés, pubs, health and fitness centres.
Out-of-town retail sector:
Growth in out-of-town retail parks, particularly along main arterial roads. 'Big box' retailing predicted to be the catalyst for many development schemes in the future. Retail services such as fast-food restaurants expanding in out-of-town locations, often located within, or adjacent to, retail parks. Growth of the retail warehouse market, particularly in retail parks, with the DIY sector dominating recent changes. Demand from the technology, media and telecom sector has led to expansion of the logistics industry, with retailers offering on-line shopping from dedicated warehousing.
Industrial sector:
Expansion of the industrial and industrial warehouse sector. One of the driving forces predicted to be the demand from Internet Service Providers for tele-hotels, which provide an outsourcing service to major clients. Growth of self-storage warehouses within the service industry. Corporate activity and rapid growth in the technology, media and telecom sector has created demand for hi-tech and specialised storage space.

Table 4

Proposals for updating strategy for damage tables and indices in the Multicoloured Manual

Chapter/Sector	Annual strategy and likely costs	5-10 year strategy and possible costs	Issues and comments
4. Residential: tangible damages	▪ Update the value of inventory items by Consumer Prices Index (CPI). ▪ Update building and Fabric costs by an index of construction costs. ▪ Re-issue CDs on an annual basis to make this updating easier for users. **Say 7 person days per annum (£2,100 at 2005 prices)**	▪ Need to update ownership of household goods; value of household goods; susceptibility of household goods; depth relations for the above. ▪ This is a task that takes 3-4 person months of collecting and evaluating a wide range of data items from a number of different source **Costs: £12,000 to £15,000**	This is a fairly mechanical exercise but does take time.
4. Residential: intangible damages	CPI adjustment. **Costs included in the above**	Re-do the health effects research? **Costs: Not known**	Re-doing the basic research is likely to be very expensive. Is there a suitable health cost index?
5. Non-Residential Property (NRP) direct flood damages	1. CPI indices (see above) And/or: 2. Commission some industrial market research firm to collect data on an annual basis on the value of: ▪ Stocks; ▪ Moveable equipment; ▪ Fixtures and fittings; ▪ Building Structure and Fabric ▪ Services **Cost: Low £000s**	1. EITHER: Repeat the research of up to 85 “head office” surveys **(£60,000 at 2005 prices)** OR: 2. Commission some industrial market research firm to undertake surveys and collect data on an annual or 2-yearly basis on the value of: ▪ Stocks; ▪ Moveable equipment; ▪ Fixtures and fittings; ▪ Building Structure and Fabric ▪ Services **Costs: Not known**	Some form of secondary source data updating system is badly needed. The Sector in parts is very fast moving as regards cost changes.
5. Non-Residential	Not yet known. There is very little data in the	Not yet known.	

Chapter/Sector	Annual strategy and likely costs	5-10 year strategy and possible costs	Issues and comments
Property (NRP) indirect flood damages	new MCM on indirect flood losses. If "Sugden" approaches are developed, this needs attention		
6. Other flood losses (roads; railways; emergency costs)	Update by the CPI. Rail disruption needs more attention post-Railtrack Costs:	Repeat the research on emergency costs when a major flood occurs.	Traffic cost indices need to be reviewed and applied.
7. Values of property at risk from erosion	Obtain up to date house prices from the standard data sources used in Chapter. Re-issue CD on an annual basis to make this easier for users. **Say 1.00 person day (£300 at 2005 prices)**	Not needed; changes would be picked up by the annual monitoring.	None
8. Recreational values	Update by CPI index/indices. **Costs included in the above.**		
9. Agricultural values	Update by CPI index/indices. **Costs included in the above.**		
10. Environmental values	Update by CPI index/indices. **Costs included in the above.**		
Possible/likely TOTAL costs	Annual costs (except the years when the 5-10 year update is undertaken): **Say c. £5,000 - £7,500**	Once every 5-10 years costs: **Probably £25,000 - £75,000**	This really should be a routine item paid for by the EA

Figure 1
Simplified structure:
flood damage database construction
(synthetic approach)

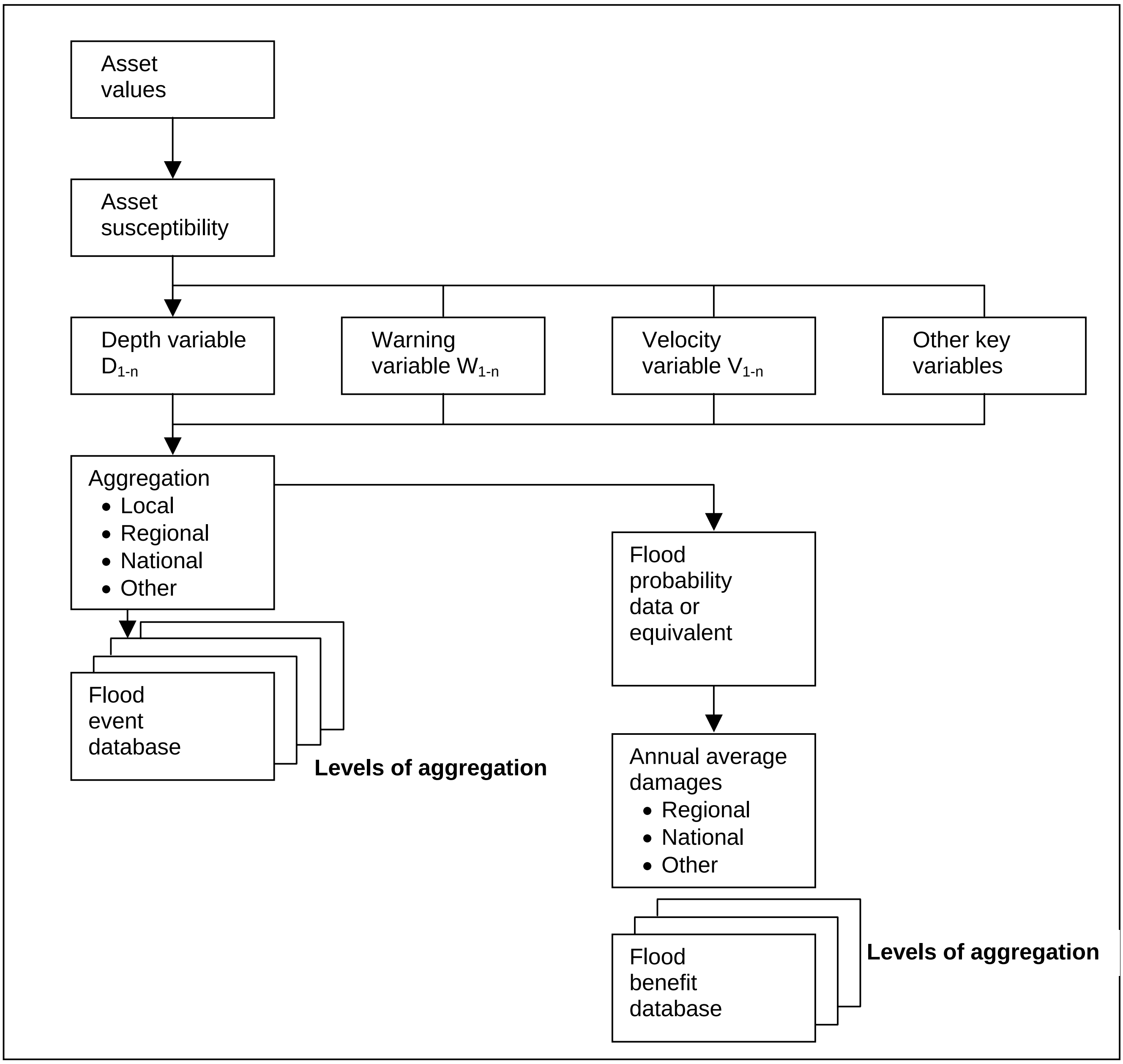
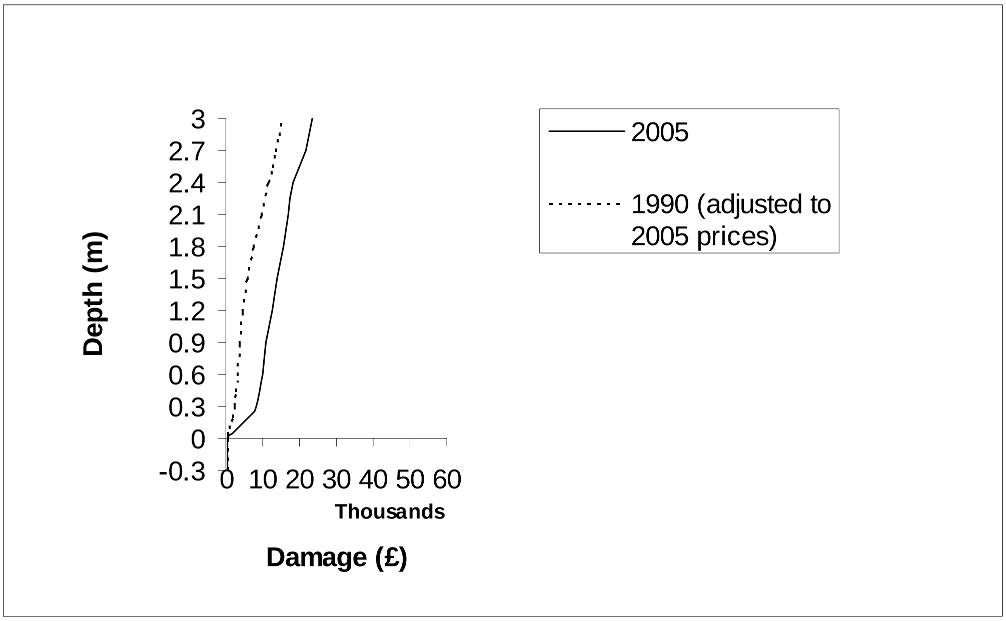


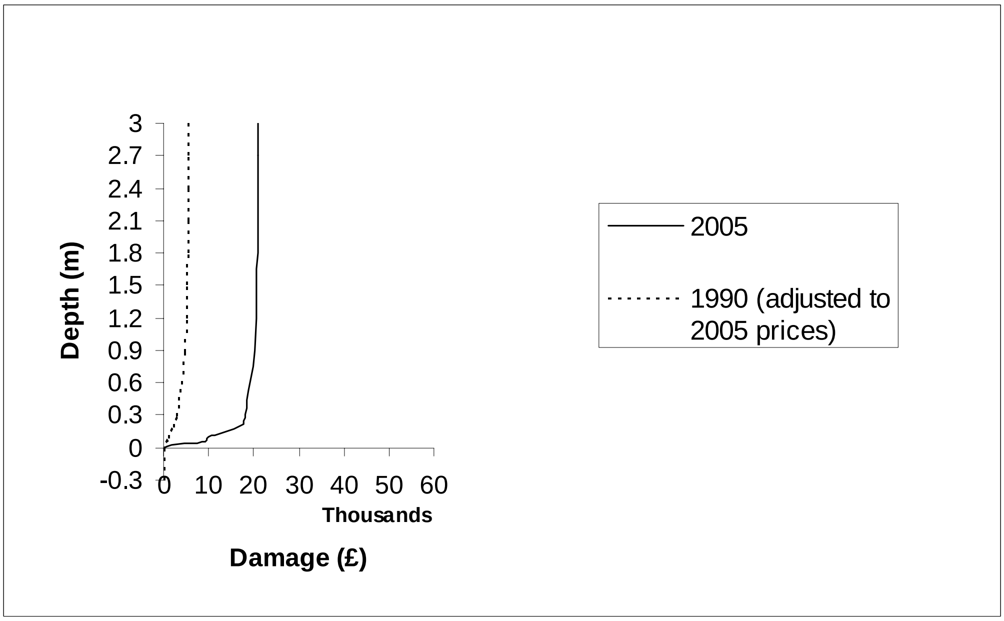
Figure 2 (a to f):

Increased average flood-damage potential of residential properties

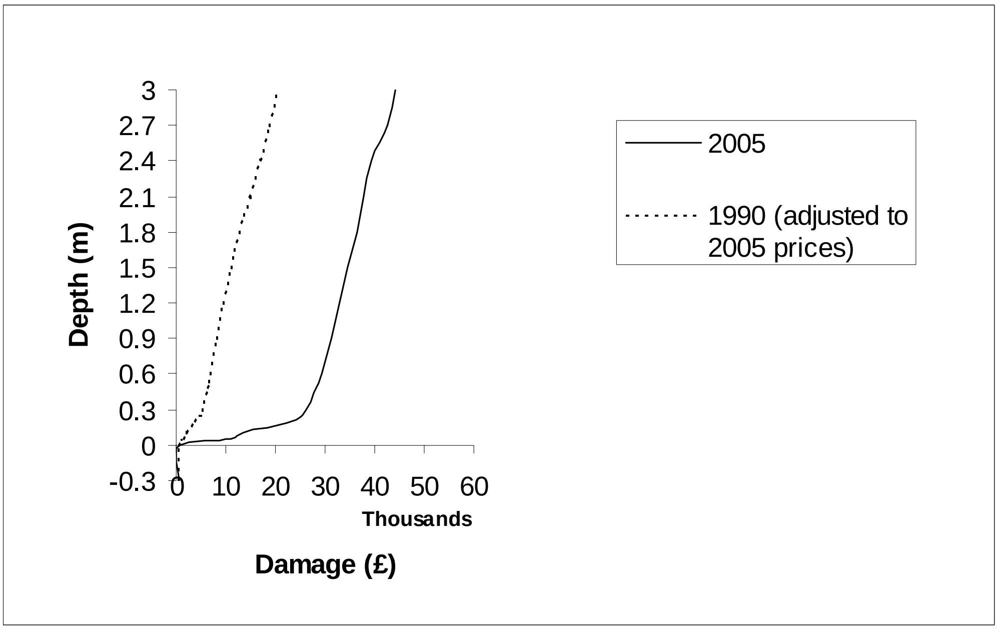
(a) Building Fabric (<12 hours)



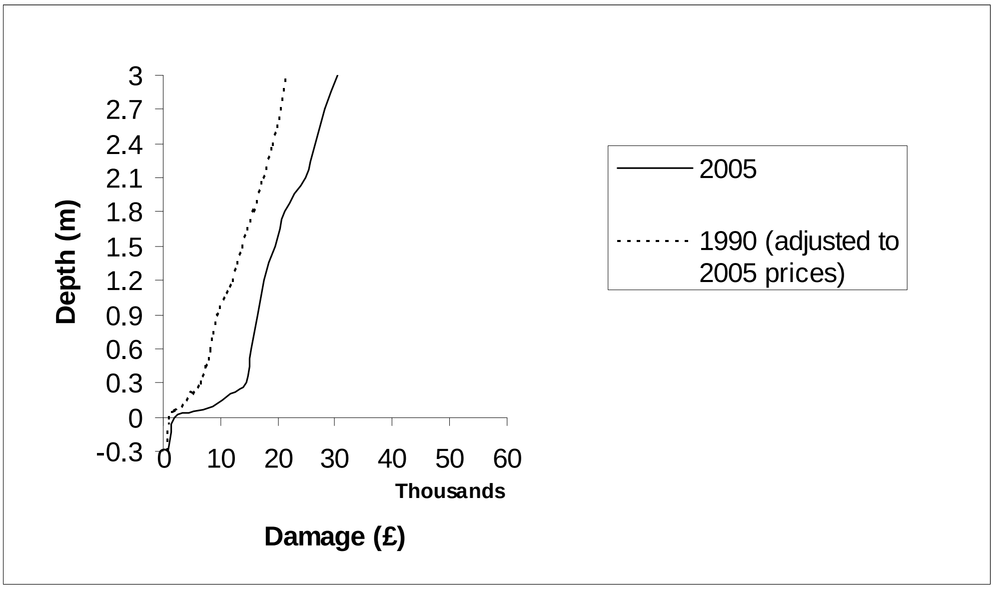
(b) Household Inventory (<12 hours)



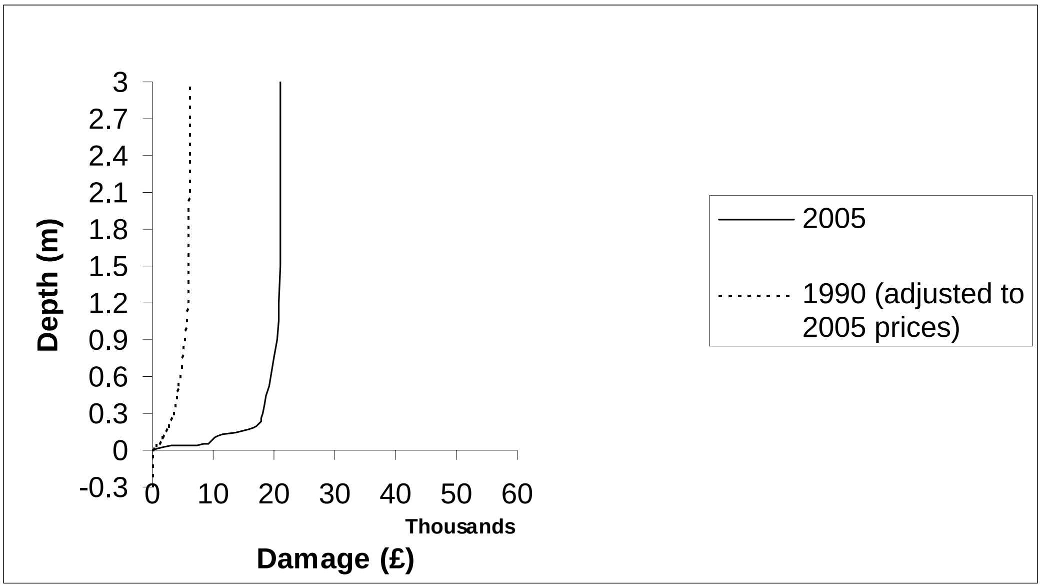
(c) Total (<12 hours)



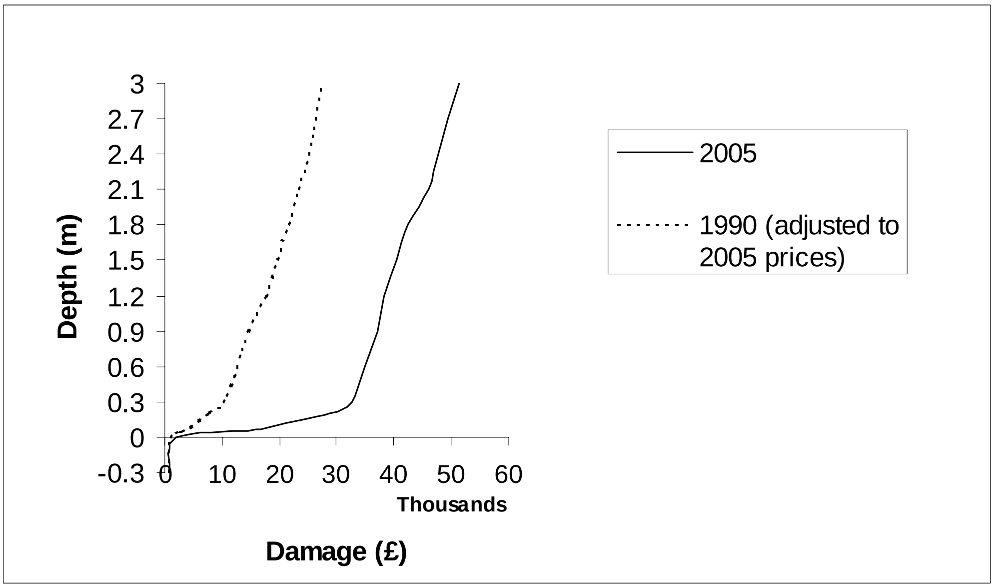
(d) Building fabric (>12 hours)



(e) Household inventory (>12 hours)



(f) Total (>12 hours)



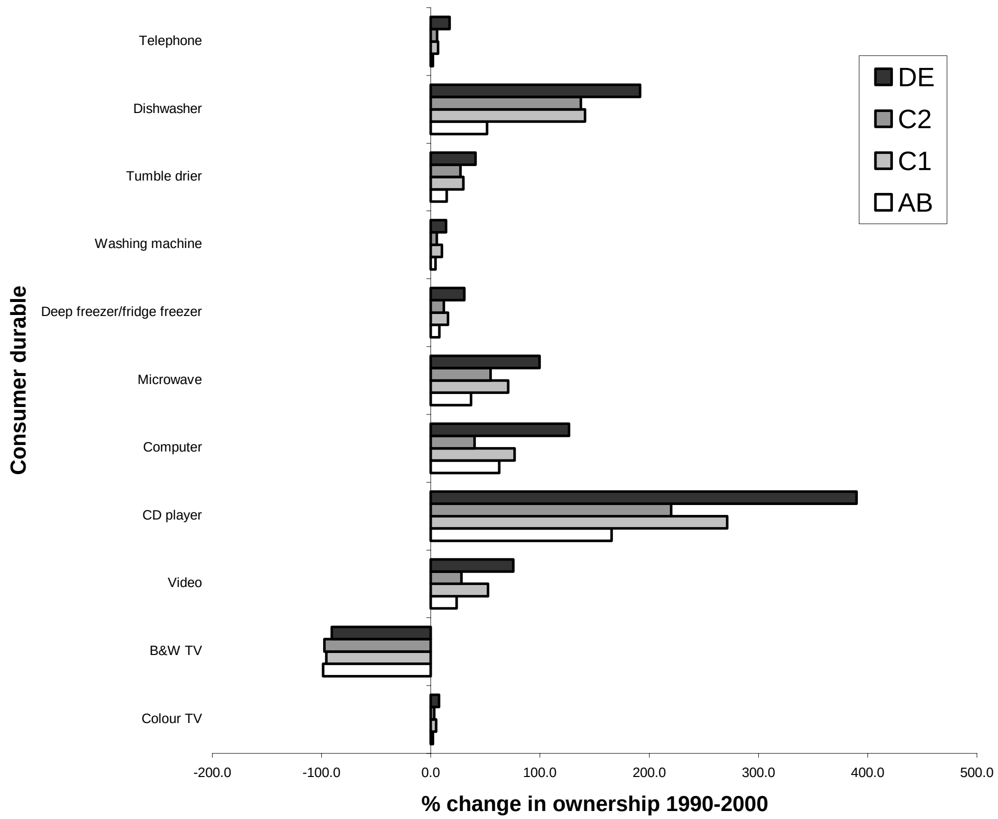


Figure 3

Changing ownership of consumer durables by social class, 1990-2000
(Source: General Household Survey 1990 and 2000/1) (OPCS, 1992; ONS, 2002).

Figure 4.

The MCM structure of the NRP data processing (and updating) system

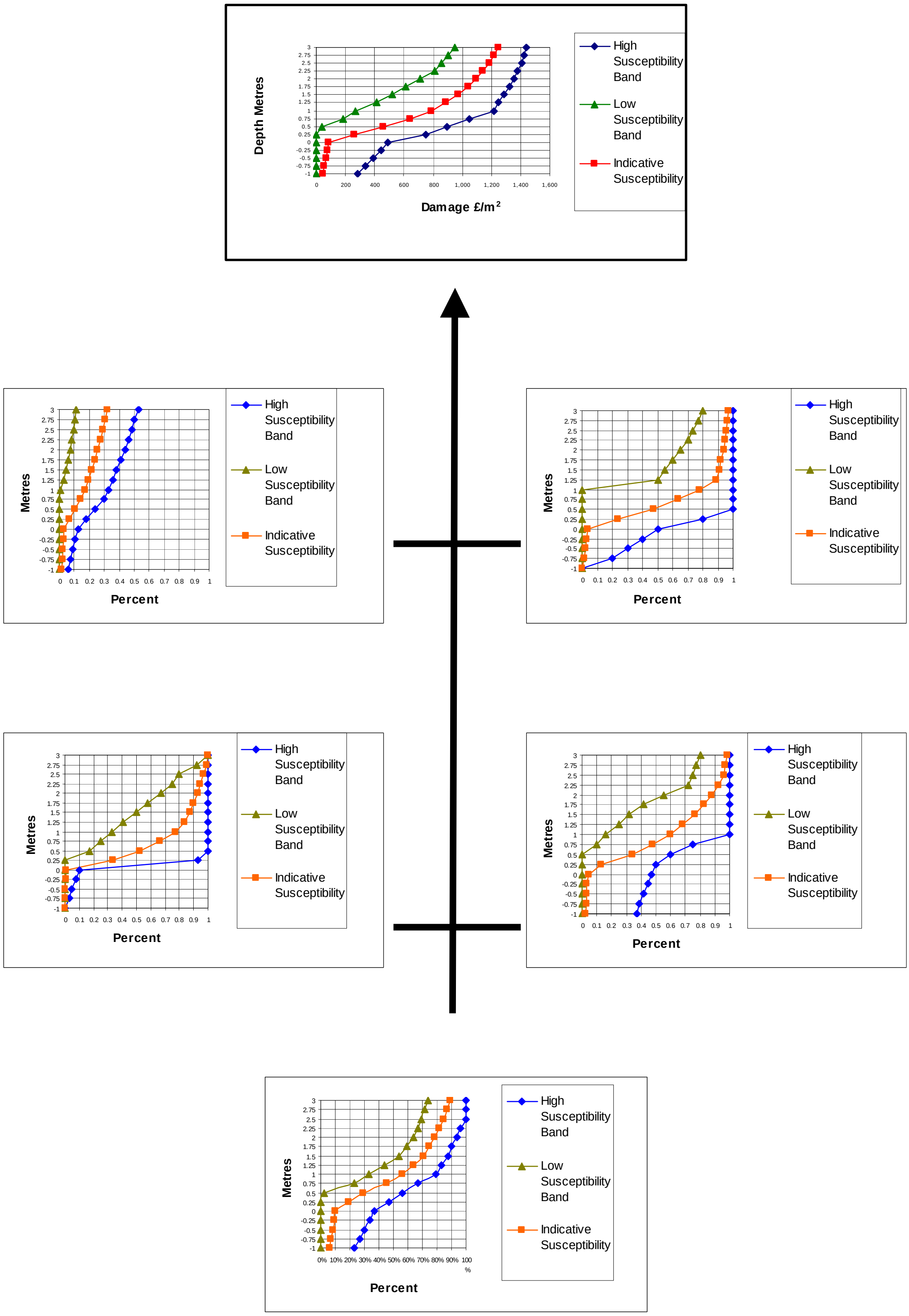
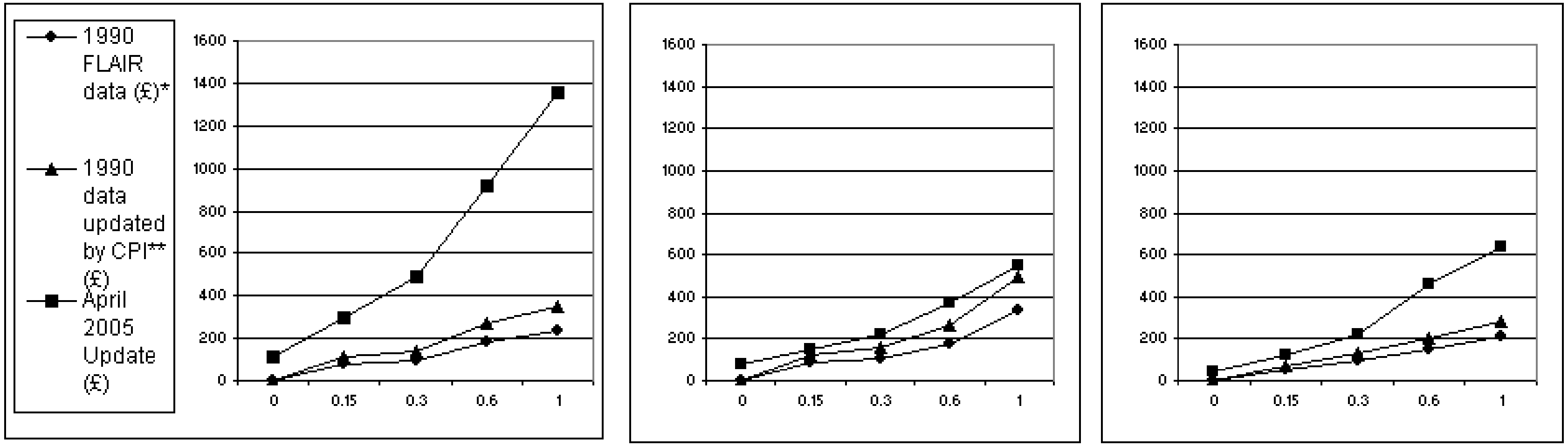


Figure 5

Data and diagrams illustrating the changes in NRP potential flood damage between 1990 and 2005

	Retail supermarkets/ hypermarkets code 213				Offices (financial) Code 320				Manufacturing/workshop Code 810			
Depth (m)	1990 FLAIR data (£)* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase	1990 data* (£)	1990 data updated by CPI** (£)	April 2005 Update (£)	Real % increase
0	0	0	110		0	0	80	N/A	0.5	1	41	4000
0.15	77	113	293	159	87	128	151	18	55	74	125	69
0.3	94	138	491	256	110	161	221	37	97	131	225	72
0.6	185	272	915	236	178	262	369	41	150	202	457	126
1	237	349	1352	287	334	491	548	12	209	283	635	124



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