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Standards for the repair of buildings following flooding

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Summary

Flooding is a major problem for many people in the United Kingdom, posing a risk to health, safety and wellbeing, and resulting in widespread damage to property. The scale of the problem can be gauged from the following quotation (OST, 2004):

> *Nearly 2 million properties in floodplains along rivers, estuaries and coasts in the UK are potentially at risk of flooding. 80,000 properties are at risk in towns and cities from flooding caused by heavy downpours that overwhelm urban drains – so-called 'intra-urban' flooding. In England and Wales alone, over 4 million people and properties valued at over £200 billion are at risk.*

In the autumn 2000 floods, 10 000 properties were flooded at more than 700 locations at a cost in the order of £1.0 billion.

With the effects of climate change and increased societal pressures on the country's infrastructure and services, the risks of flooding are predicted to increase considerably.

Flood damage to properties can range from minor effects on walls, floors, basements and services to serious structural damage to buildings. However, practical steps can be taken to reduce the cost of flood damage and to speed up recovery times should the flood return.

This guide sets out requirements for the repair of buildings following flooding and includes:

- a description of the causes of flooding and the impact that floods can have on buildings
- making safe, decontamination and drying activities that must be undertaken immediately after the floodwaters have receded, including recommendations on appropriate health and safety risk assessments
- conducting post-flood surveys and future flood risk assessments
- standards of repair for buildings following flooding.

The repair of buildings has to be appropriate to both the extent of damage and the risk of future flood. As the risk increases the proposed standard of repair is more rigorous, effectively increasing the resilience or resistance of the building to flooding. Three levels of standards of repair are included in the guidance. For each standard of repair, guidance is provided for external walls, internal walls, floors, fenestration, basements, services and fittings.

The guide contains illustrations of damage, surveys, drying and decontamination, and repair work to buildings. Appendices include guidance to homeowners, technical information, key organisations that can advise on flooding and information on the provision of insurance.

The guidance is aimed primarily at building professionals and insurers experienced in flood damage and repair. It may also be used by general builders, surveyors and building-owners, including householders, for advice in commissioning repair work.

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Glossary and acronyms

Cadw Welsh Historic Environment Agency, an organisation within the Welsh Assembly. The Welsh word *cadw* means "to keep".

Contamination Characteristic of matter that has an adverse effect on the quality of materials or surfaces, including solid or liquid deposits left after a flood. These may contain pollutants and hazardous substances, which should be removed as part of the remedial process.

Damp-proof course (DPC) Layer or coating of material covering the bedding surface of a masonry wall to resist the passage of moisture. It will prevent groundwater rising up into the building, commonly known as rising damp.

Damp-proof membrane (DPM) Layer or sheet of material within a floor or similar construction or vertically within a wall to prevent passage of moisture. A damp-proof membrane is similar to a DPC, but may be used in solid ground floors to prevent rising damp. To be fully effective, it should be connected to both the DPC in surrounding walls and any basement tanking.

Defra Department for the Environment, Food and Rural Affairs.

Dehumidification Removal of water from the air using an appropriate commercial device. This process can promote drying of the building, but must be controlled to avoid over-drying of the structure.

DoENI Department of the Environment, Northern Ireland.

Dry-proofing Applying measures to the outside of a building to prevent floodwater from penetrating into the structure. This may include a mixture of measures to improve the flood resistance of the floors and walls of the structure and can include flood barriers, drainage systems and flood protection products, or methods such as repointing masonry or raising floor levels.

Fenestration External elements of a building comprising windows, doors, glazing and hardware.

Flash flooding Rapid flooding caused by overland flows. This is generally caused by excessive rainfall running off impermeable surfaces at a rate that exceeds the capacity of the local drainage infrastructure.

Flood protection For the purposes of this guide this is the use of barriers and drainage infrastructure to reduce the risk of floodwater affecting a building. It can include the use of proprietary flood protection products, but also may include larger civil engineering works.

Flood risk assessment For the purposes of this guide, a distinction is made between the future flood risk assessment of a building and the health and safety risk assessment. The flood risk assessment considers the nature of the hazard, the type of floodwater, the likelihood of return and the duration and depth of the flood. The health and safety risk assessment considers requirements for the making safe, decontamination and drying of the building.

Flood skirt A flood protection system designed to wrap around a property to a maximum depth of 1 m above ground level. It provides temporary protection to the external faces of the building, preventing floodwater from seeping through the building fabric as well as through openings.

Groundwater flooding Flooding caused by water contained in the ground rising to the surface. This water can enter buildings through foundations, basements or low-level ducts.

Intermittent stream	In English geology, a river that is usually dry in the summer months. Also known as a winterbourne or ephemeral stream.
Permeability	Characteristic of a material that determines the rate at which liquids pass through it. For the purposes of this guide, this includes moisture passing through materials using cracks, capillaries and absorption processes.
Relative humidity	The ratio of water vapour pressure in the air at a given temperature to the saturation vapour pressure at the same temperature; commonly expressed as a percentage.
Resilience to flood	For the purposes of this guide, a characteristic of a building material, component or whole building that describes its ability to recover from flooding.
Resistance to flood	For the purposes of this guide, a characteristic of a building material, component or whole building that enables it to remain undamaged and unaffected by floodwater.
Risk assessment (health and safety)	For the purposes of this guide, the process of identifying and assessing the hazards to health and safety of those involved during the post-flood work (decontamination, drying, surveys and repairs). Hazards can include the structural safety of the building or risks from water-borne diseases.
Risk assessment (future building flood)	For the purposes of this guide, *risk* is equal to the product of the *likelihood* (the chance of a flood occurring) and *consequences* (the amount of damage to a building) of a future flood.
Standard of repair (SoR)	The extent to which repair work is carried out and the extent of measures undertaken so that damage from future flooding is minimised. Standards of repair are determined through risk assessment. The resilience and resistance measures in the standard of repair include dry-proofing and wet-proofing of the property.
Tanking	Impervious membrane used to prevent the infiltration of subsurface water; usually associated with basement walls and floor below, or close to, the water table.
Visqueen	A sticky, rubbery, waterproof material that is applied directly to a structure as a waterproofing measure.
Wet-proofing	For the purposes of this guide, the replacement of water-vulnerable elements in the building with water-resistant alternatives so that future flooding causes less damage.
Whole-life costing (WLC)	A methodology used to assess the cost performance of construction work, aimed at facilitating choices where there are alternative means of achieving the client's objectives and where those alternatives differ, not only in their initial costs but also in their durability and subsequent operational costs.

READER GUIDE – WHERE TO FIND INFORMATION IN THIS BOOK

For readers unfamiliar with flood problems												
For practitioners												
Chapter 1 **Introduction**	**Chapter 2** **Making safe, decontamination and drying**	**Chapter 3** **Post-flood survey and reducing the impacts of future floods**	**Chapter 4** **Standards of repair (SoR)**	**Appendix 1** **Organisations that can advise on flooding**	**Appendix 2** **Example risk assessment**	**Appendix 3** **Advice for building owners**	**Appendix 4** **Guidance on dehumidification**	**Appendix 5** **Floor finishes**	**Appendix 6** **ABI statement of principles**	**Appendix 7** **A simple example of whole-life costing**	**Appendix 8** **References**	**Appendix 9** **Further reading**
Problems posed by flooding to people living in the United Kingdom Flood sources and implications Scope of the guide How to use the guide Intended users Roles and responsibilities Related CIRIA guidance	Making safe a building including health and safety concerns Recommended procedures for decontaminating a building Advice for the process of drying a building Summary of both activities relevant to specific building elements	Advice on undertaking post-flood survey of damage to the building Guidance on assessing risk, including the likelihood of future folds and the potential consequences of a flood event Identifying appropriate standards of repair (SoR) required for a building	Specification for the SoR for • external masonry • external walls • wall cavities • rising damp in masonry walls • internal walls and partitions • fenestration • floors • services • fittings • basements Flood protection products available Purpose of a flood repair log	Contact details of relevant organisations that can help when flooding occurs	An example of a risk assessment approach to the future flood risk of a building. Flood risk assessment is essential in determining an appropriate standard of repair	Relevant advice for making an insurance claim and appointing surveyors and repair contractors	Important information on the process of dehumidifying a previously flooded building Frequently asked questions	Description of common construction forms Comment on flood resilience measures for each construction form	A description of the Association of British Insurers' (ABI) principles and policy on flood insurance and its availability	A comparison of the relative costs incurred for different standards of repair and how this can support decision-making	Key references and sources of information for flooding and associated issues	List of relevant British Standards and additional references

1 Introduction

Flooding is a major problem for many people in the United Kingdom, posing a risk to health, safety and wellbeing, resulting in widespread damage to property. The scale of the problem can be gauged from the following quotes (OST, 2004):

> *Nearly 2 million properties in floodplains along rivers, estuaries and coasts in the UK are potentially at risk of flooding.*
>
> *80,000 properties are at risk in towns and cities from flooding caused by heavy downpours that overwhelm urban drains – so-called "intra-urban" flooding.*
>
> *In England and Wales alone, over 4 million people and properties valued at over £200 billion are at risk.*
>
> Each year… *we experience an average of £1,400 million of damage.*

In the autumn 2000 floods, 10 000 properties were flooded at more than 700 locations at a cost of about £1.0 billion.

More than 5 per cent of the population of the UK live in areas that are less than 5 m above mean sea level, including parts of London and other major cities.

Thousands of people have suffered trauma and damage to homes and valuables.

Research commissioned by the insurance industry has shown that for a flood 1 m deep, the average cost of the loss of buildings is £22 000 and of contents £13 000, although they can be much higher (Black and Evans, 1999). The potential effects of climate change and societal pressures to increase development in "at risk" areas make it likely that the risks of flooding will increase considerably. However, practical steps can be taken to reduce the cost of flood damage and to speed up recovery times.

1.1 FLOODING – SOURCES AND IMPLICATIONS

1.1.1 Sources of flooding

Flooding can occur as a result of any of the following (ODPM, 2001; CIRIA and EA, 2003):

- flooding from watercourses such as rivers and streams, associated with extreme rainfall, snowmelt or hail, or overtopping of river defences
- surface water runoff
- the sea, through overtopping of sea defences
- groundwater rising into buildings
- infrastructure failure
- blocked or overloaded stormwater drainage systems and sewer flooding
- ducts used for service main inlets, particularly water mains
- accidental escape or leakage from household appliances such as radiators, dish washers etc.*

* Accidental escape or leakage from household appliances is outside the scope of this guide, although some of the principles of repair discussed herein may still apply.

1.1.2 Flood entry routes

Buildings will allow water to enter during a flood through (see Figure 1.1):

- masonry and mortar joints where the natural permeability of both these materials, particularly the mortar, can be high
- the brickwork/blockwork
- cracks in external walls
- vents, airbricks and flaws in the wall construction
- or around windows and doors at vulnerable points such as gaps and cracks in the connection of the frames and walls
- door thresholds especially where these have been lowered to the ground to allow level access
- gaps around wall outlets and voids for services such as pipes for water and gas, ventilation for heating systems, cables for electricity and telephone lines
- party walls of terraced or semi-detached buildings *in situ*ations where the property next door is flooded
- the damp-proof course, where the lap between the wall damp-proof course and floor membrane is inadequate
- sanitary appliances (particularly WCs, baths and showers) caused by back-flow from flooded drainage systems.

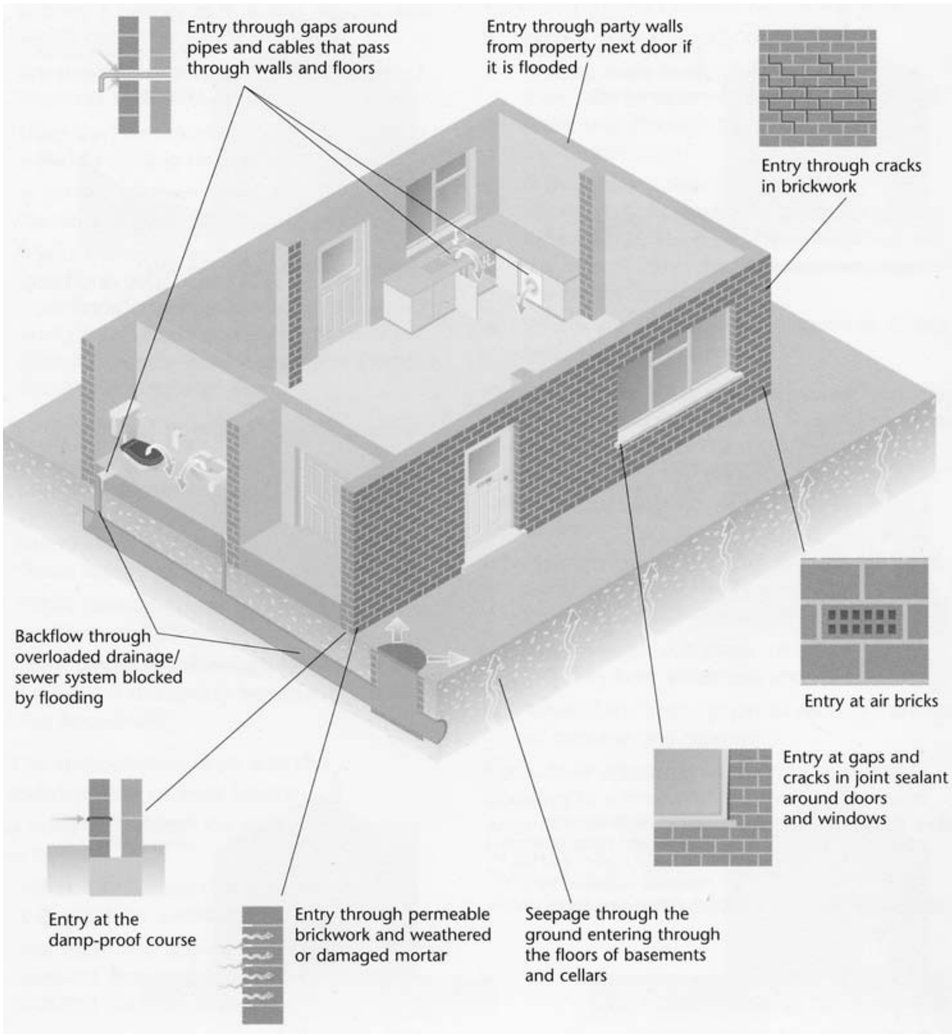

Figure 1.1 *Flood entry routes into a house (CIRIA, 2003)*

1.1.3 Implications of flood depth

The amount of damage caused to buildings will depend, among other factors, upon the water depth of exposure, as follows.

1 **Below ground floor.** Basement damage, plus damage to any below-ground electrical sockets or other services, carpets, fittings and possessions. Minimal damage to the main building. Deterioration of floors may result if the flood is of long duration, and/or where drying out is not effective.

2 **Above ground floor.** In addition to the above, damage to internal finishes, saturated floors and walls, damp problems, chipboard flooring destroyed, plaster and plasterboard. Services, carpets, kitchen appliances, furniture, electrical goods and belongings are all likely to be damaged to the point of destruction. Services such as water tanks and above ground electrical and gas services may be damaged.

NOTE: if a flood event of greater than 1 m depth above floor level has been experienced there may be additional factors that need to be considered before following the guidance in this publication (out of scope for this publication). Under no circumstances should flood protection products be used to a height of more than 1 m above ground floor level (see Section 1.4.3).

1.1.4 Implications of flood duration

The duration of the flood can make a significant difference to the extent of cleaning and repair that is required. Generally, short-duration flash flooding will be quickly remedied, and will be less costly to repair than a flood of longer duration. A flood lasting more than 24 hours can cause serious damage to the building elements (see Figure 1.2). The nature of the floodwater is also significant – for example, saltwater from coastal floods promotes corrosion to metal components, and water containing sewage requires extensive cleaning and decontamination.

Figure 1.2 *Structural flood damage*

1.2 STANDARDS OF REPAIR

This guide provides detailed specifications for the repair of buildings following flooding. The standard of repair is defined as follows:

> *The standard of repair is the extent to which repair work is carried out and the extent of measures undertaken so that damage from future flooding is minimised. The standards of repair are determined through risk assessment. The flood resilience or flood resistance measures in the standard of repair can include dry-proofing and wet-proofing of the property.*

Three standards of repair are defined in this book (see Chapter 4) and relate to the level of risk determined (see Chapter 3). They can be summarised as follows.

1 **Standard of Repair Level A**. The risk assessment shows that there is little or no risk of a future flood. It is recommended to repair the building to the original specification, although some minor upgrades may be incorporated to improve the flood resilience.

2 **Standard of Repair Level B**. The risk assessment shows that the likelihood of a future flood is low to medium, ie it is considered sufficiently high to recommend repairs to increase the resilience and/or resistance of the property above the original specification.

3 **Standard of Repair Level C**. The risk assessment shows that the risk of a future flood is high. It is recommended to instigate repairs that will increase the resilience and resistance of the property significantly. Such repairs involve dry-proofing and/or wet-proofing of the building.

1.3 FLOOD REPAIR ROLES AND RESPONSIBILITIES

Several parties have direct roles and responsibilities with regard to flooding in the United Kingdom, the main legislative and regulatory organisations involved being listed below.

1 **Government**. This includes the Department of Environment, Food and Rural Affairs (Defra) and the devolved administrations, which are responsible for national policy and providing strategic guidance on flood management. The Office of the Deputy Prime Minister (ODPM) and devolved administrations provide the policy and guidance on planning and flood risk relating to development.

2 **Regulators**. The Environment Agency manages flood risk in England and Wales, while the Scottish Environment Protection Agency (SEPA) has the same role in Scotland. Each provides a 24-hour flood warning service and an emergency response service. They maintain and improve main rivers for the efficient passage of flood flow and the effective management of flow. Along with other operating authorities, the Environment Agency also builds and maintains flood defence structures where appropriate to reduce the probability of a flood event occurring. It also issues licences for the abstraction of water, impounding of watercourses and discharges of effluent to controlled waters. In England and Wales local authorities are responsible for non-main rivers, although the Environment Agency has a supervisory role over them and can make recommendations to the local authorities.

3 **Local authorities**. Councils are the operating authorities for ordinary watercourses. They are the planning authorities responsible for implementing planning policy guidance from government. Through planning controls, councils seek to reduce flood risk by minimising development in flood risk areas.

4 **Water companies**. These companies are responsible for the supply of clean water and the treatment and disposal of sewage. They are responsible for public sewers and the maintenance and function of this infrastructure. (Private drains, pipes and sewers are the concern and responsibility of property-owners, local authorities and insurance companies. Public sewers are the sole responsibility of the sewerage undertaker – usually the local water company. All repairs to public sewers should therefore be referred to the water company.)

5 **Internal drainage boards**. In defined areas the drainage boards have operational and regulatory powers on specific watercourses. They operate and improve flood defences and provide emergency response.

6 **Ofwat**. The Office of Water Services (Ofwat) is the economic regulator for water and sewerage services in England and Wales. It is a non-ministerial government department led by the Director General of Water Services. Ofwat works with the Government, the Welsh Assembly Government and the quality regulators (the Environment Agency, the Drinking Water Inspectorate, English Nature and the Countryside Council for Wales) to monitor the way in which water companies provide a good-quality, efficient service at a fair price.

7 **WaterVoice**. This organisation operates through nine regional committees in England and a committee for Wales. It represents the interests of customers in respect of price, service and value for money; it also investigates complaints from customers about their water company.

During the repair process, the company providing insurance for the building will also have a key role to play.

1.4 ABOUT THIS GUIDE

1.4.1 How to get the best from this guide

This guide provides advice for each of the steps that make up the process of repairing and, where necessary, improving the flood resilience and resistance of buildings after a flood. The recommended process is summarised in Figure 1.3. More detailed flow charts are included in the chapters to illustrate specific steps.

When determining and undertaking repairs it is important to consider all the steps, in the right chronological order, regardless of the severity of the flooding.

Throughout the guide, readers are referred to specialists for advice where necessary. Appendix 1 provides contact details for organisations, while more advice on specific topics can be obtained from the sources listed in Appendix 8 References and Appendix 9 Further reading.

1.4.2 Intended users

The guide is intended for use by professionals within the construction industry who are directly involved in any of the stages of the repair work. General builders, surveyors and members of the public may also find the guide useful in the reinstatement of flood-damaged properties. For the public, the advice may serve as guidance when managing relationships with contractors undertaking work.

The guide may also be used by owners of properties that have been flooded, or that are at risk of flooding, to identify suitable options for reducing the risk of damage from future floods. The building-owner will have considerable input into standard of repair decisions (see Section 3.2), but they will seldom have the technical expertise to specify repairs in full. Therefore, it is essential that they consult with construction and insurance professionals.

Non-professionals using this guide need to remember that assessments should always be carried out by suitably qualified and experienced professionals.

1.4.3 Scope of guide

In scope

Guidance is provided for repair of the most common types of domestic building in existence in the UK and covers the main elements that are likely to be affected by floods, including basements, floors, walls, windows, doors and services. The recommended repairs are written for buildings that have suffered a flood event, although some of the advice may be applied in anticipation of a future flood event.

It is generally recognised that flood depths of greater than 1 m can result in damage to the structural integrity of a building. Such issues are not covered by this guide, which is intended for floods below 1 m height. The advice is applicable to flooding from a variety of sources (see Section 1.1).

The guide is structured to follow the chronological order of the repair process. It includes information on:

- making safe, decontamination and drying of buildings (Chapter 2), including ways to measure moisture content and how to assess whether or not a building has dried sufficiently for repairs to be undertaken
- post-flood surveys and risk assessments (Chapter 3), to determine the scope of the repair work required and guide the standard of repair to be implemented
- standards of repair (Chapter 4) including the use of flood protection products, although detailed guidance on different products is not within the scope.

Although some of the guidance may be applicable to historic buildings, it is strongly recommended that, before undertaking any work on such buildings, specialist advice be obtained from heritage organisations such as English Heritage, Cadw, Historic Scotland and the Society for the Preservation of Ancient Buildings; see Appendix 1 for contact details. Historic and older buildings are often particularly susceptible to the impact of floodwater, yet preservation of the original structure often means that there is limited potential for increasing its flood resistance. Consultation with the appropriate authorities may also be required where legal protection applies – for example, listed buildings or those in conservation areas.

Out of scope

The guide does not cover administrative arrangements in Northern Ireland, which differ from those in England, Scotland and Wales, although the technical principles contained within the guidance remain consistent and are applicable for buildings in Northern Ireland following flooding.

The guide does not cover the repair of major structural damage that can result from severe flood events. Nor does it consider damage to foundations, as this has structural implications for the building. Seek specialist advice on these issues.

The guide also excludes flooding caused by leaks from plumbing (water services, drainage systems or household appliances) and flood damage caused by rainwater leakage into buildings, eg through defective roofs and gutters. Some elements of the guide may be useful in these circumstances (for example decontamination and drying, which are directly applicable), but they are not written specifically for such incidents.

The advice does not include information on wet-proofing opportunities that can be incorporated within initial building design, eg designing kitchens to include moveable appliances (rather than permanently fixed units) so that they can be moved to safe locations if a flood warning is given.

Specific requirements for prefabricated buildings are not included. For these, the system supplier should provide advice on flood resilience, flood resistance and repair.

1.5 RELATED GUIDANCE

Provision of guidance on flooding, flood risk and flood repair is an important part of CIRIA's ongoing research. More information (including a series of downloadable advice sheets) can be found on CIRIA's flooding website at <www.ciria.org/flooding/>.

The following CIRIA documents are available:

- B14 *Design of flood storage reservoirs* (Hall *et al,* 1993)
- C506 *Low-cost options for prevention of flooding from sewers* (May *et al*, 1998)
- C521 *Sustainable urban drainage systems – design manual for Scotland and Northern Ireland* (P Martin *et al*, 2000)
- C522 *Sustainable urban drainage systems – design manual for England and Wales* (Martin *et al*, 2000)
- C523 *Sustainable urban drainage systems – best practice manual for England, Scotland, Wales and Northern Ireland* (Martin *et al,* 2001)
- C599CD *SUDS compilation CD* (Martin *et al*, 2004)
- C609 *Sustainable drainage systems. Hydraulic, structural and water quality advice* (Wilson *et al*, 2004)
- C624 *Development and flood risk – guidance for the construction industry* (Lancaster *et al*, 2004)
- C625 *Model agreements for sustainable water management systems. Model agreements for SUDS* (Shaffer *et al,* 2004)
- C630 *Sustainable water management in land use planning* (Samuels *et al*, 2005)
- C635 *Designing for exceedance in urban drainage systems – good practice* (Balmforth *et al*, 2005)
- C638 *Climate change risks in building – an introduction* (Vivian *et al*, 2005)
- FR/IP/45 *Reducing the impacts of flooding – extemporary measures* (Elliott and Leggett, 2002).

There is also a series of pamphlets jointly produced by the Environment Agency and CIRIA:

- *After a flood. How to restore your home* (CIRIA and EA, 2001a)
- *Damage limitation. How to make your home flood resistant* (CIRIA and EA, 2001b)
- *Flood products. Using flood protection produces – a guide for homeowners* (CIRIA and EA, 2003).

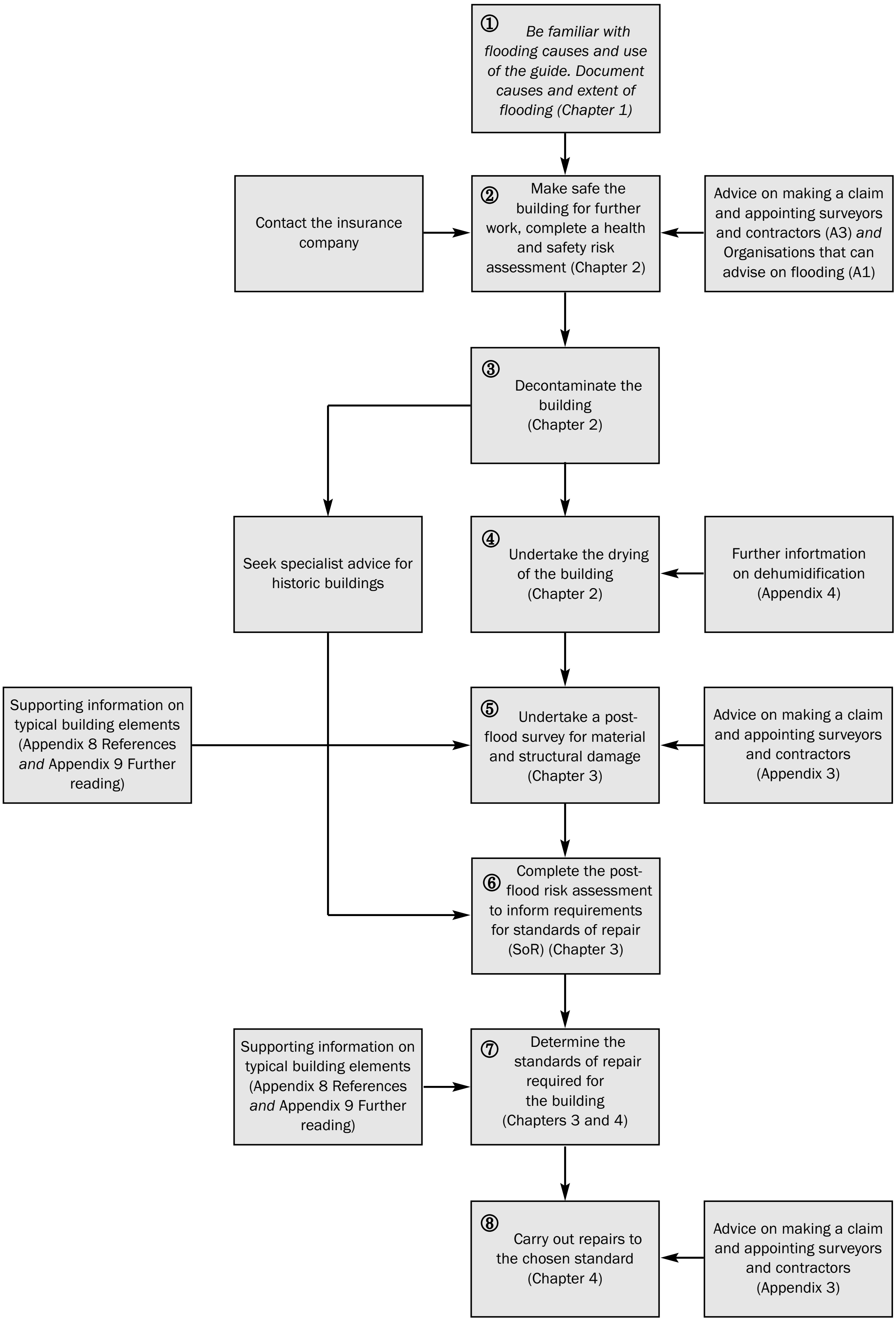

Figure 1.3 *Recommended repair process for a flooded building*

2 Making safe, decontamination and drying

Making safe, decontamination and drying should be undertaken as soon as possible after the floodwater recedes and before the post-flood survey (see Chapter 3). Floodwaters can bring both the structure and contents of a property into contact with silt, debris and other contaminants. It is likely that the building fabric will absorb moisture, the degree of saturation being dependent upon the duration of the flood. Although it is desirable to reduce the moisture content in all locations as quickly as possible, the process needs to be carefully controlled to avoid making the situation worse. Particular care should be taken to gain the necessary prior permissions and to employ appropriate techniques when working with listed or heritage properties.

Figure 2.1 shows the process of making safe, decontaminating and drying a structure that has been flooded. It is important to complete the decontamination before starting the drying process. The information provided in this section is not exhaustive and further guidance can be obtained from property damage restoration specialists (see Appendix 1).

The flood-related damage needs to be documented before decontamination and drying takes place. The documentation, which may include written records and digital photographs, can be used to determine the standards of repair required and is normally required by insurance companies as part of the loss adjustor and contractor relationship. Activities related to making safe, decontamination and drying, as well as the amount of damage involved, should all be documented.

2.1 MAKING SAFE

A competent person should carry out a full health and safety risk assessment for the making safe, decontamination and drying work before these activities are started. Failure to identify problems and make the building safe may endanger the health and safety of those involved in decontaminating and drying the property. The making safe process should be iterative with decontamination and drying, because, as decontamination progresses, it may become apparent that further elements need to be made safe before work can continue.

For any work to be undertaken during decontamination, drying, survey or repair, a method statement should be prepared. This should cover the methods to be employed and the means of protecting the personnel involved. The British Damage Management Association (BDMA) has developed a risk-based approach for this, which is provided in Appendix 2. Alternative means of assessing the health and safety risks may be used, but they should cover as a minimum requirement the issues in Appendix 2.

The making-safe process includes:

- checking that the flood has receded and there is no immediate danger of it recurring
- identifying the full range of potential contamination sources and types. Contaminants carried in floodwater may have been diluted but can still be hazardous. Washing and sanitisation can reduce the hazard. Potential local sources of contamination must be considered, eg industrial or agricultural sources, fuel tanks or sewerage systems. Use proper chemical analysis to determine the nature of the contamination where necessary

- identifying any building issues, such as structural stability (of both the building and its surrounds), gas and electrical safety, and slip and trip hazards. For help in assessing structural integrity, the Institution of Structural Engineers provides listings of qualified structural engineers. The Royal Institution of Chartered Surveyors and the Association of Building Engineers can also provide advice (see Appendices 1 and 3)
- **switching off all utilities and services that enter the building to reduce the risk they may pose until specialists can check their integrity.**

A booklet for building-owners, *After a flood. How to restore your home* (CIRIA and EA, 2001a), provides further information on making the building safe.

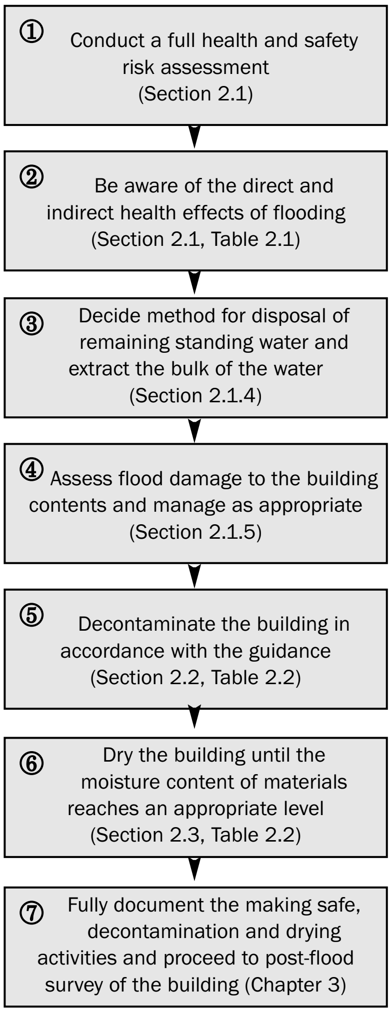

Figure 2.1 *Method for safe and effective decontamination and drying of a flooded building*

Individuals carrying out the making safe, decontamination or drying work should fully understand the health and safety requirements, in particular the importance of personal hygiene and use of appropriate personal protective equipment.

2.1.1 Health

Flood events can damage people's health and on occasions result in loss of life. This can result from direct or indirect effects, as follows:

- **direct** – those happening during or immediately after the flood;
- **indirect** – those developing in the days or weeks following the flood and longer-term effects, appearing after months or years.

Direct health effects include the following.

1 **Death** by drowning, heart attacks, strokes, hypothermia and accidents. The number of deaths associated with flooding is strongly related to the life-threatening characteristics of floods (rapidly rising water, deep floodwaters, objects carried by the fast-flowing water) and the behaviour of the victims.

2 **Injuries** (sprains, strains, lacerations, contusions etc). These are likely to occur in the aftermath of a flood as people return to their homes to begin cleaning up.

Indirect health effects include the following.

1 **Infectious diseases** (gastrointestinal diseases, dermatitis, conjunctivitis) and some rare cases of vector-borne diseases. Infectious diseases typically are confined to illnesses endemic to the flooded region. The risk of introducing new diseases, such as vector-borne, may be low, but there may be an increase in spread of any diseases that were present before flooding. Sanitation problems or overcrowding among temporarily displaced persons will increase the risk.

2 **Poisoning** caused by the rupture of underground pipelines, dislocation of storage tanks, wash-off from agricultural land, runoff from toxic waste sites, or release of chemicals stored at ground level.

3 **Stress** caused directly by the flood, the experience of a flood and dealing with its aftermath.

4 **Post-traumatic stress disorder**, including anxiety and depression, and psychological disturbances. Apart from the trauma caused by flooding itself, many mental health problems stem from geographical displacement, damage to the home or loss of familiar possessions. Lack of insurance adds to the stress levels and particularly affects low income families that may not be able to afford insurance. Such problems may continue for months or even years after the event itself. A link between psychological stress and physical illness after flooding has been determined in a study after a major flood in October 2000 (Reacher *et al*, 2004). Practical support to flood victims is of particular importance after a flood event. Organisations such as the Samaritans and the Red Cross provide support to individuals suffering as a result of a flood. Training in support of flood victims would allow loss adjusters and damage restoration specialists to understand the needs and vulnerability of victims. There is a high cost associated with stress and failed relationships that cannot be recovered through insurance. The support provided by families, authorities, professionals and voluntary services is essential to avoiding much of the stress and its consequences after a flood.

Table 2.1 summarises direct and indirect health effects of the flooding of buildings.

Anyone suffering (or who is concerned that they may be suffering) either direct or indirect health effects as a result of flooding should seek professional medical assistance at the earliest opportunity.

2.1.2 Moulds and dry rot

Moulds can grow and present hazards in the aftermath of a flood. In extreme situations they can appear within 48 hours, so it is essential to proceed rapidly with decontamination and drying (see also Section 2.3.4). Dry rot of timber is a risk if timbers are not properly dried out (see also Section 2.3).

2.1.3 Foundations

Fast-flowing floodwaters can affect foundations through scour action on the surrounding earth, thereby exposing or undermining the structure. Additionally, some soils can slump and settle following a flood, producing structural movements in the foundations. A visual inspection of the perimeter of the building will usually indicate whether the foundations have been affected. Where slumping or settlement is identified, specialist advice should be obtained to determine the need for remedial activity. Note that settlement can occur over long periods of time.

Sloping sites can be subject to slumping when they are affected by floodwater. This results in destabilisation or movement of the foundations of the building. Often, this causes major structural damage that can only be corrected with guidance from a structural engineer. Peat-covered slopes are particularly vulnerable in this respect.

This guidance does not specifically cover the repair of flood-damaged foundations, so further specialist advice should be sought, as it is important to know the condition of the foundations after a flood.

2.1.4 Pumping water from buildings and basements

Remove standing water first. Often this can be pumped into the local foul sewer, subject to serviceability and approval by the sewerage undertaker. Other specialist methods may have to be considered involving intermediate bulk containment or use of vehicle-mounted wastewater tankers. The chosen method of disposal must comply with the Control of Pollution Act 1989 and the Controlled Waste Regulations 1991.

The following issues need to be considered in pumping water.

- If it is safe to do so, start pumping water from the basement. There is no need to wait for insurance approval so long as guidance from a specialist has been given and is being followed. In practice there are rarely problems with removing water from basements, but care is always required; further guidance is available (CIRIA and EA, 2001a). Qualified and experienced professionals should be employed to undertake pumping work. Records should be maintained of the flood event, for example photographs of the flood damage and recorded heights of water, to aid future repair work and for insurance purposes.
- Before beginning detailed investigations or work in flooded basements it is essential to identify and deal with potential safety hazards.
- Water should be removed, in a controlled manner, over a period of several days until all of the floodwater has gone, as serious structural damage can result if the water is removed too quickly. It may take up to a week to remove the floodwater. **Remove no more than 1 m depth of floodwater in any one day.**
- Vigilance is needed during dewatering to identify signs of structural movement or damage while the pressure of the floodwater is being reduced. **NOTE**: removal of water may reduce the floodwater level in adjacent basements too.
- After drainage, water may continue to pond on the basement floor. This can be a sign that the tanking has been damaged in some way during the flood. The basements of older buildings may not have had tanking or waterproofing treatments, relying instead on the protection afforded by water-resistant building materials (eg slate). If the basement is no longer sufficiently water-resistant, tanking or waterproofing may have to be installed during repairs (see Section 4.17).

- Contamination in basements following floods may result in air quality problems. This is a serious safety issue that must be appropriately addressed before work starts. Air quality may be poor and require forced ventilation to dissipate fumes or pollutants. In areas where coal mining has been carried out, gas escaping from the mines can be driven to the surface following flooding and this can pose a health and safety risk.

Table 2.1 *Direct and indirect health effects*

Risk factors	Health effects
Direct health effects	
Stream flow velocity Topographical features Absence of warning Rapid speed of flood onset Deep floodwaters Rapidly flowing waters carrying debris Pre-existing health/mobility problems Failure of natural or artificial protective structures by overtopping or collapse Dam failure Standing water Contact with water Contact with polluted water Missing manhole covers	Risk of injury and drowning Risk of respiratory diseases, shock, hypothermia and cardiac arrest Risk of wound infections, conjunctivitis, dermatitis, gastrointestinal illness, and ear, nose and throat infections Falls leading to head injuries, broken limbs or cuts and bruises
Indirect health effects	
Damage to water supply systems Damage to sewerage and sewage disposal systems Damage to gas and electrical services Insufficient supply of water for water or washing Loss of wastewater services Disruption of underground piping Dislodgement of storage tanks Overflow of toxic waste sites Release of chemicals including general household chemicals Disruption of petrol storage tanks, including fire risk External pollution factors (eg oil tanks, petrol tanks, farm storage and land runoff) Heavy rainfall Rodent migration Clean-up activities following flooding and repair Cryptosporidium, in drinking water after a flood	Waterborne infections (eg enteropathogenic *E coli*, shigellosis, hepatitis A, leptospirosis, giardiasis, campylobacteriosis) Vector-borne diseases Rodent-borne diseases Dermatitis and conjunctivitis Electrocution, injuries, lacerations and puncture wounds Acute or chronic effects of chemical pollution Vapour inhalation Stress and trauma, from work required to clean up housing and damage caused to property and belongings, removal from house or loss of pets or property Bites and scratches from animals

2.1.5 Building contents

Where possible, damaged building contents should be removed to ensure that decontamination and drying activities can take place unhindered (see also Section 2.2.1). Undamaged contents should be salvaged and moved to an unaffected area for storage.

2.2 DECONTAMINATION

Decontamination should begin as soon as possible after the flood recedes and preferably within 24 hours. It is important that anyone involved in decontaminating the building wears appropriate personal protective equipment (PPE); requirements for this should be determined in a health and safety risk assessment. Gloves, overalls, safety boots and eye protection will usually be needed. Further specialist equipment, such as breathing apparatus, should also be available where required.

Contamination may either be physical (sediment), biological or chemical, and the cleaning regime should reflect the type of contamination that is present. It should be assumed that floodwaters are contaminated with a mixture of pollutants, probably including sewage. Some pollutants – eg petrol or oil – may be readily identifiable visually or by the presence of an odour, but other contaminants may be less easy to identify without chemical analysis. The existence of industrial, agricultural or commercial processes upstream of the flooding will help to determine the risk of other pollutant hazards being found in the floodwater. The source of the floodwater should be identified, as this will help to indicate which contaminants may be present. Where chemical or other industrial pollutants are suspected, floodwater samples should be collected using a clean specimen bottle for chemical analysis.

Care should be taken to consider the possibility of trapped or adsorbed contaminants in the building and to identify how they may be safely removed. Where necessary, building components, eg kitchen units, fixed cupboards, appliances or skirting boards, should be removed to expose areas for cleaning. Alternatively, access points can be opened up to allow cleaning; for example, small areas of floorboards could be lifted to allow access to the void space below (see Figure 2.2). See Table 2.2 for further advice on decontamination.

Figure 2.2 *Floor boards damaged and removed to allow for surveying*

2.2.1 The decontamination process

For full decontamination of a building the following process is recommended.

1 Use a shovel or scoop to clear debris and silt. The disposal of debris, silt and other materials must be carried out in compliance with the Control of Pollution Act 1989 and the Controlled Waste Regulations 1991. Dispose of contaminated materials in an appropriate fashion, possibly as hazardous waste. Advice can be obtained from

specialist waste disposal companies, the local authority or regulators, such as the Environment Agency, SEPA and DoE NI. Remove sandbags, which frequently are contaminated with sewage.

2 Determine and document the contaminated areas within the building and identify the affected materials. Include materials visible on the outside and inside surfaces of the building and within building cavities and floor voids. Identify contamination through visual inspection, the presence of odours or analysis. Identify the source of the floodwater to assist in making these determinations (see Section 1.1).

3 Remove building contents from affected areas to enable the restoration of the building structure to proceed. Use the following approach:

- store undamaged contents in an unaffected area
- identify salvageable contents and take appropriate action to prevent further damage before restoration
- remove unsalvageable contents for disposal once agreed with all interested parties (owners and insurers).

4 Wash down and clean affected walls, floors and basement areas using appropriate amounts of detergent. Use power washing or mechanical scrubbing, if possible without causing further damage. For minor floods, scrubbing by hand may be sufficient. Check the water supply is clean before beginning this work. (Detergents are wetting agents and may react with some paints and adhesives. Consequently, care should be taken to avoid excessive wetting during this process where possible.)

5 Detergents can be used to clean chemical or oil contamination. Where mould, bacteria or fungi are present, use detergents and sanitising disinfectants to remove them effectively.

6 Always rinse down the whole area thoroughly with clean water after detergents have been applied.

7 If necessary, take swabs from surfaces for analysis to determine the effectiveness of the decontamination.

8 Apply further detergents or sanitising disinfectants to minimise the potential for mould and bacterial growth. Normally each area will have to be cleaned at least twice.

9 Document the activities undertaken for future reference in determining standards of repair.

If done properly, decontamination of a flooded building can be fully effective, especially where the contamination is restricted to accessible areas internally. However, there are some special circumstances in which it will be necessary to undertake further action, which are summarised below.

◆ External walls may be contaminated, and it is important to decontaminate them (see Figure 2.3). The same type of cleaning process described above can remove contamination to these walls. For brick walls, refer to advice from the Brick Development Association (Harding and Smith, 2002).

◆ Cavity walls, voids and floor voids need to be cleaned properly. They can be flooded with detergents and fogged with sanitising agents. If irrecoverably damaged, insulation in cavities and voids may need to be removed for decontamination.

◆ Floating floors, with insulation installed under a screed layer or surface, can present particular difficulties. If the insulation is wetted by floodwater then it is difficult to decontaminate and dry, although special methods exist to dry *in situ*. If necessary remove the screed layer for decontamination.

- Odours may be present after a flood. In general, they can be vented off, but if they originate from decaying materials then those materials will need to be decontaminated or removed.
- Oil contamination, especially from storage tanks, can present a specific risk to building materials, since fuel oil released from the tanks can be absorbed into walls and floors. Once absorbed, it is difficult to remove and may necessitate plaster, plasterboard or render being stripped from walls to effect complete decontamination (see Figure 2.4). New enzyme-based products can be extremely effective on this type of contamination, but the use of specialist contractors is recommended.
- Basements and cellars are vulnerable in flood conditions, so decontamination is often problematic. (Not only is there a risk of drowning in such confined spaces, but they may also contain toxic gases or vapours produced from floodwater-borne chemicals. The latter hazard is typically met with in cellars, but can pose a risk in any enclosed space where there is little or no ventilation. Gases and vapours may be toxic in their own right or may have displaced the air required for normal respiration.)

  During a flood, water will generally flow fastest into the basement, carrying silt that then settles out. Extensive cleaning is often necessary to remove the silt. In particular, it is important to check that any ventilation ducts into the basement are properly cleaned and reinstated, and to clear silt from drainage forming part of the tanking system. **NOTE**: materials removed must be disposed of in accordance with the Control of Pollution Act 1989 and the Controlled Waste Regulations 1991.

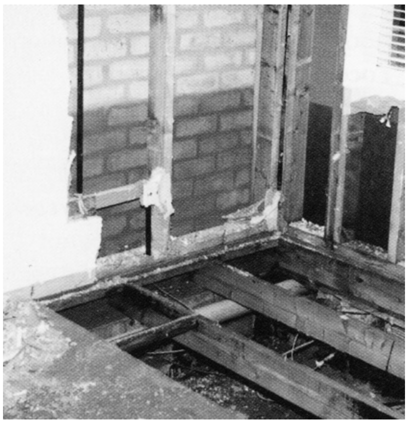

Figure 2.3 *Flood damage to walls*

Figure 2.4 *Removed plasterboard*

2.3 DRYING

The drying process should start as soon as decontamination has been completed. This may be on a room by room basis. There are many ways to achieve a dry structure, ranging from entirely natural drying to entirely assisted drying. By artificially controlling the internal environment to achieve optimum conditions, assisted drying normally reduces the drying period to weeks instead of months for natural drying. Careful control and monitoring is required throughout the process for all methods of drying. Do not use flueless appliances in areas such as basements, as exhaust gases may build up. Always monitor the use of these appliances.

The stripping out of building elements can be minimised by carrying out a moisture survey. To do this, identify the affected areas and the levels of moisture present in the materials (see Section 2.3.1) and the ambient conditions. Drying equipment can then be used to promote drying. By assessing unaffected areas of the building, or unaffected neighbouring properties, it should be possible to determine the likely moisture levels before the flood. The drying process should aim to return the building fabric to these moisture levels, at which point they can be considered sufficiently dry.

Drying efficiency depends on the following (see also Table 2.2 on page 36).

1. **Material properties**. Some materials dry more quickly than others; for example softwood timber will dry faster than dense concrete.
2. **Relative humidity**. Optimum drying conditions for the structure require a relative humidity of 40–50 per cent in the air. Buildings can dry out well in winter when the vapour pressure is low, but the opposite may be the case in summer when vapour pressures are often high. A high relative humidity (greater than 60 per cent) indicates a high vapour pressure.
3. **Temperature of the drying process**. Heating the building can increase the rate of drying because it puts heat into the building materials, promoting the evaporation of moisture and reducing the relative humidity of the air. However, as outlined above, the use of higher temperatures to promote drying will only be effective if the relative humidity within the building is properly controlled. Heating will almost certainly be needed for effective drying of a building flooded in winter. If the building's heating has been checked by an appropriate engineer, and certified safe, the thermostat should be set to 22°C. In the summer the air temperature may be sufficient such that the only requirement is for effective ventilation, to allow moist air to escape from the building.

   NOTE: avoid the use of gas or oil-burning heaters that create moisture in the air as a by-product of the combustion process.
4. **Ventilation**. Removal of moist air is important to the drying process. It may be possible simply to open windows and doors if the vapour pressure of the outside air is such that it will help the drying process. If the electricity system has been certified safe, fans may be used to promote air movement. If not, dehumidification is the best option (see below).
5. **Dehumidification**. This can be used to remove moisture from the air when it is not appropriate to ventilate moist air out of the building (see Appendix 4). If a dehumidifier is used, all doors and windows should be closed.

Dry rot will occur to timber if the moisture content remains above 20 per cent by weight for any length of time. Materials should be dried to levels at which there is no risk of dry rot or other forms of deterioration occurring.

NOTE: see Section 2.3.4 for prevention of secondary damage during drying.

2.3.1 The wetting process

The processes of wetting and drying of building materials are driven by different forces. The wetting process for porous materials is driven predominantly by capillary suction forces. The rate of wetting and the advance of a wet front into the materials are therefore dictated by the number and types of capillary pores in the material and the duration of exposure. Surface cover treatments on walls tend to reduce the rate of water movement through the structure.

In general, the longer the exposure of building materials to floodwater the greater the degree of wetting that occurs.

2.3.2 The drying process

The following factors should be taken into consideration when establishing a drying programme.

1 **Materials and structure**:

- the types of material to be dried
- the presence of cavities or void spaces that need to be dried
- the overall condition of the materials and structure of the property and the existence of pre-existing faults likely to affect the drying process
- the presence of trapped moisture (for example in insulated floors, wall cavities, under impermeable covers and in insulation)
- the building structure and materials surrounding the affected materials and the equilibrium moisture content around the material *in situ*.

2 **Flood duration**:

- the duration that the materials were under water
- the depth of water saturation.

3 **Building services**:

- the working condition of the building's heating and/or air conditioning system
- the serviceability of the electrical system
- the type of equipment used to assist the drying process
- the ability to control the environment within the building or affected areas.

4 **Climatic and external factors**:

- the outside weather condition and its likely variability during the drying period
- the attitude and level of co-operation of the building-owner/occupants with construction and insurance professionals
- the responsiveness of other parties such as the insurance company, loss adjuster and property manager
- the risk of the property flooding again both in the short term and long term.

After considering these factors there are several ways by which a property can be dried. Specialist advice should be sought where necessary.

The importance of monitoring during drying

If the drying process is to be as efficient as possible it is important to check and adjust the relationship between moisture removal and air movement as necessary. The critical factor is to maintain the optimum evaporation rate from the material and to make sure that the installed equipment is producing the required conditions. It is often necessary to adjust the combination of equipment used as drying progresses. Drying rates may need to be increased or reduced in response to the changing circumstances, using more or less drying equipment as appropriate.

Care must be taken to prevent avoidable damage such as the shrinkage or warping that occurs when materials dry too quickly. Even after most of the absorbed water has been removed, the drying processes will continue for many months as the structure reaches equilibrium with its surrounding environment. Additional repairs to the walls, due to shrinkage from drying, may be necessary for a year or more.

Where evaporation of excess moisture is restricted the occurrence of trapped moisture within the structure needs to be carefully monitored. The most likely areas where this will happen are within insulated floors and cavities in walls. Surface coatings or covers can inhibit the release of moisture and slow the drying process considerably. Remove them where necessary to allow drying.

Drying is a continuous process and there will be levels of dryness reached that will allow some repairs to proceed. For example, once the wall has dried to a certain extent it may be possible to decorate it with a moisture-permeable paint to enable the building to be reoccupied. In this way the condition of the building is restored, but the drying process is not halted. There may be some deterioration as the wall continues to dry but this type of approach is a practical solution that can reduce stress to occupiers and owners of flooded properties. Seek the advice of a specialist in making these decisions.

Key factors to monitor and control in the drying process are:

- air movement, sufficient ventilation to remove moist air
- air temperature to be maintained at 18–23°C
- air moisture content, monitor relative humidity and maintain at 40–50 per cent.

Determining the end of the drying process

Drying is achieved when the following have been achieved:

- the internal conditions are at or better than the normal room conditions for that individual property
- the remaining moisture, resulting from the water damage that has most recently occurred either on or in the building materials, will not support active growth of mould and mildew
- the building materials and contents will finish returning to equilibrium with normal room conditions by themselves without further damage.

When the three criteria have been achieved, no further drying equipment or services should be required.

Drying of walls

The following points should be noted for drying walls.

1. Walls constructed of traditional brick or concrete blocks with mortar joints will generally dry well, but it may take several months. A solid brick wall (100 mm thick) can absorb up to 55 litres of water per square metre in a flood. Drying by natural evaporation is usually the best method if the weather is dry, but standard brick dries at a rate of approximately 25 mm per month, so it may take some months for a wall to dry to equilibrium.

2 Some types of lightweight block may gradually lose strength after a period of standing in floodwater.

3 As walls dry white salts may appear on the surface. This is usually a good sign, as these salts exist naturally within the wall. In some cases, however, salts may have been introduced into the walls by seawater and may themselves attract moisture, producing symptoms similar to those of rising damp.

4 Stone walls are likely to dry out more rapidly than those of brick, since they are often less porous. But if the walls have thick rubble cores these may need to be drained in a similar manner to cavity walls.

5 Close inspection should be made for signs of buckling of the wall such as horizontal cracking and areas that have moved out of alignment. When buckling has seriously weakened the wall, damaged parts should be supported and rebuilt immediately.

6 Settled walls and footings are indicated by vertical or stepped cracks either in small areas or throughout the structure.

7 After the flood, brickwork will be wet and may be susceptible to frost damage if there is freezing weather. Bricks can also shrink and crack as they dry, and such such cracking should be monitored.

Drying of floors

Remove floor finishes that could impede drying of the floor. The floor structure itself may be able to absorb significant volumes of water during flooding. Identify the moisture content of the floor and begin appropriate monitoring.

Methods and materials of damp-proofing solid concrete floors are described in BS 8102:1990. These are described in detail in the standards of repair of buildings (see Chapter 4). It is important that moisture is eliminated from the floor to a sufficient extent to allow the relaying of floor coverings. The approach in BS 8203:2001 can be used as a method of measuring the relative humidity of the floor after a flood. It involves the measurement of the relative humidity of a sealed air space above the floor. Floor coverings should not be laid until the relative humidity of the screed has reduced to 75 per cent or less.

If the damp-proof membrane is laid below the main slab of the floor then the whole slab should be dried before finishes are laid. If the damp-proof course is between the screed and the main slab then drying times will be less, but must still be completed before relaying finishes.

Drying of services

Address the following issues for services.

1 **Electrical**. Water may be trapped in ducts or conduits containing cables. These should be opened to allow inspection and assist drainage. Replace rubber-sheathed wires whether obviously damaged or not. Inspect all terminations and unsealed connections. These should be cleaned and dried, especially if the supply was switched on while the equipment was wet.

2 **Gas**. Check and restore heating installations as quickly as possible to assist drying of the building. Check copper pipes. Copper is generally considered to be durable and corrosion-resistant and is unlikely to be affected by short-term contact with floodwater. Replace damaged copper pipe after a saltwater flood.

3 **Drainage**. Check drainage pathways are clear and free from any silt deposited by the floodwater.

4 **Plumbing and central heating, including hot air systems**. Check and clear pipes and equipment of debris. For plumbing ensure that it is thoroughly flushed out before reconnecting or reusing. Copper pipes are used for water in central heating and plumbing (see advice given for gas above).

5 **Chimneys**. Gradually dry out chimneys through natural drying for at least two weeks before lighting a fire. Use controlled fires for short periods of time. Lighting a fire too quickly can cause problems when the absorbed moisture within the brickwork changes to steam, which may damage the structure further. Alternatively, dehumidifiers can be used to dry out a chimney more rapidly and with less risk of structural damage.

Drying of fixtures and fittings

Address the following issues.

1 **Domestic appliances (or white goods)**. These contain insulation materials that can be contaminated and wetted by the flood. If possible, remove covers for cleaning and drying. It may not be possible to clean the goods to eliminate all health risks, however, as the insulation may have become contaminated, for example. Agreement should be obtained from the insurer before instigating repairs, because it may specify replacement rather than repair work.

2 **Baths, showers, sinks, toilets and bathroom cabinets**. It is important to expose the floor finishes and wall finishes under and around these fittings, in particular to establish whether debris has accumulated from the flood and to allow drying. Remove side panels to enable drying under the bath.

2.3.3 Monitoring equipment

Many types of equipment are available, and numerous methods used, to measure both air conditions and the material equilibrium moisture levels. The appropriateness of each technique depends on the circumstances and the material being assessed. The most common techniques are described below.

Digital hygrometers

These instruments measure ambient air conditions of temperature and relative humidity. They can also be used to obtain the equilibrium relative humidity level within a material and are not affected by the quality and type of material.

Resistance or conductance meters

Electrical resistance meters are the most widely used technique for surveying moisture content, particularly for timber elements.

When they are dry many building materials – wood, brickwork and concrete, for example – are effective insulators. They do not conduct electricity and have a high electrical resistance. When moisture is introduced into the material during a flood the conductivity increases. This low level of conductivity allows a small current of electricity to pass through the material. The greater the moisture content the more conductive it becomes. Resistance or conductance meters are able to measure these small amounts of electricity and are calibrated to measure this as moisture content.

Many types of resistance or conductance meters are available. It is important that the person taking the readings be suitably trained and able to understand the measurements and to interpret them in the correct way. Electrical resistance methods need to be treated with caution, as they can be misleading where metallic components are embedded in the timber, salts (eg from seawater) are, or have been, in contact with the surface or where certain preservative treatments have been applied. Floodwater contaminants and also some building products conduct electricity well and can produce misleading results. These meters are usually calibrated for timber, hence great care is required in their use on other material types. For timber elements, the handheld device is lightly pressed into contact with the timber element and gives a direct moisture content reading.

Capacitance meters

Capacitance meters are non-destructive and provide an instant measurement of the sub-surface moisture levels in a variety of materials. These meters create an electrical field in the material, directly beneath the transmitter in the instrument. The meter measures the response: the wetter the material the greater the response. The measurements obtained provide an indication of moisture in the material to a depth of approximately 10–15 mm below the surface. They provide an alternative to the electrical resistance or conductance meter but still require personnel trained in the interpretation of the results.

Drilling techniques

Material is drilled from the surface layers of masonry or plaster and assessed for its moisture content. This can be either by weighing, then drying in an oven and reweighing, or by using a commercial device such as a calcium carbide meter. These techniques require the removal of a small sample of the material for testing, so appropriate filling and repair will be required afterwards. See Digest 245 for further information on the procedure (BRE, 1989).

Measuring the moisture content of a material by drilling is a longer process than using the direct moisture content measurement techniques identified above. It has, however, the advantage of providing results from within the material in question (depending on the depth of sampling) rather than at, or near, the surface.

Karsten tube

This method uses a graded glass tube bent at a 90° angle to measure the rate of water absorption by porous masonry materials such as brick, blocks and stone. Both ends of the tube are open, one of which is sealed to the masonry wall. The other end is filled with water to the first level. The time for a quantity of water to move from the tube into the wall is recorded and a rate of absorption can be calculated. The test needs to be carried out on unsaturated brickwork, as the degree of saturation affects the absorption rate.

Borescope

A borescope can be used to investigate the presence of water in sealed and hidden cavities in a building. It is not a method of measuring moisture content or humidity, but incorporates a camera that can be used for remote viewing of the water lying in cavities. The borescope, complete with its miniature camera, is inserted into a hole drilled in the wall or floor and the resulting images recorded.

Further information is available from CIRIA and BRE on different methods for testing both air and material moisture levels (Dill, 2000; BRE, 2004).

2.3.4 Prevention of secondary damage

Condensation and humidity

Excessive evaporation of flooded water from the ground floor may produce condensation problems in upstairs rooms. Install temporary vapour barriers to prevent condensation reaching unaffected rooms during this process. It may be advisable to heat the building's upper floors to reduce the potential for condensation occurring. Failure to take these precautions may lead to condensation damage and mould problems.

High humidity damages food, paper, consumables and electronic equipment. In non-domestic buildings stocks of materials can be damaged by high humidity after a flood.

Mould

A normal well-maintained building has a low level of moisture held in the building structure. Moulds do not grow in such conditions, where the low moisture levels are in equilibrium throughout the property. After a flood incident the balance is disturbed. When water soaks into a building and its contents the materials become wet enough to support mould growth and drying becomes essential to prevent ongoing damage. Relative humidity in the air in excess of 70 per cent could promote mould growth; below this level it is in a safe state for finishes to be applied, provided the wall or floor itself has dried sufficiently.

As water evaporates from wet materials it can travel through the air and be absorbed by other materials remote from the affected area, which in turn become wet enough to support mould growth. This secondary damage from mould growth is avoidable if moisture levels are reduced promptly.

Water movement through capillary action

Capillary rise of water through materials can result in damage, dampness and mould growth problems. It can move water away from the directly affected area to higher levels in the building, where secondary damage may occur.

2.3.5 Activities relevant to decontamination and drying

Table 2.2 summarises decontamination and drying activities relevant to different building elements. Further specialist advice on making safe, decontamination and drying can be obtained by contacting organisations such as the corporate members of the British Damage Management Association (see Appendix 1 for contact details).

Table 2.2 *Decontamination and drying for different building elements*

Component	Decontamination	Drying
	External walls	
Masonry walls	Power-wash or mechanically scrub walls. For minor floods scrub wall by hand. Apply and rinse down wall with detergents and, where required, disinfectants. Rinse after using detergents; normally multiple cleaning operations will be required. Remove contaminated insulation from cavity walls.	Remove impermeable finishes (eg gloss paint or vinyl wallpaper). Dry-brush off efflorescence and salts that appear during drying using a bristle brush.
Timber frame	Remove contaminated surface finishes, eg plasterboard. Remove debris deposited in the frame. Remove contaminated insulation from cavity.	Achieve timber moisture content of less than 20 per cent (to avoid dry rot) before replacing wall finishing; ensure readings are taken from depth not the surface.
Steel frame	Remove contaminated surface finishes, eg plasterboard. Remove debris deposited on the structural frame. Remove contaminated insulation from cavity.	Remove surface cover if necessary to dry moisture from structure.
Door leafs and door frames	Clean door leafs, frames and associated hardware.	Ensure moisture content of timber door leafs and frames is below 20 per cent. Apply paint finish to all accessible surfaces of the door. Replace damaged hollow-core doors with solid doors or those of more resilient materials. Replace damaged timber doors with PVC or hardwood timber.
Double glazing units	Remove units from drained and ventilated window frames and clean debris from frame before reinstatement.	Replace failed units with quality-assured insulated glass units.
	Internal walls	
Internal masonry partition	Remove contaminated plasterboard. Apply and rinse down wall with detergents or disinfectants. Rinse off, and repeat operation if required.	Remove impermeable coverings (eg gloss paint or vinyl wallpaper).
Party walls	Remove contaminated plasterboard.	Remove impermeable coverings (eg gloss paint or vinyl wallpaper).
Stud partition walls	Remove contaminated plasterboard to gain access to and remove contamination.	After short flood durations, allow natural drying. After prolonged flooding, remove plasterboard if necessary for drying.
Cellular plasterboard partition	Remove contaminated plasterboard.	Remove impermeable coverings. Replace if partitions are not sufficiently robust.
Solid and panelled doors	Remove contaminated hollow-cored doors.	Remove excess water to avoid distortion and swelling.
Skirting boards	Remove or clean contaminated skirting boards.	Remove skirting and cut or drill holes through plasterboard or dry lining.

Table 2.2 *Decontamination and drying for different building elements (contd)*

Component	Decontamination	Drying
	Floors	
Floor finishes	Remove contaminated finishes (eg carpets, vinyl coverings).	Remove finishes to allow drying to start. Strip timber floorboards or chipboard (eg carpets, vinyl coverings).
Solid floors	Power-wash or mechanically scrub floors. For minor floods scrub by hand. Apply and rinse down with detergents and disinfectants where appropriate. Rinse off, and repeat operation if required.	Lift any floating floor structure to expose concrete slab. Achieve humidity levels of no more than 75 per cent (at depth in the floor) before reinstating floor finishes. Heaved floors that do not return to original position should be removed.
Timber suspended floors	Stagnant water should be removed either through air-bricks, using a pump and drilled holes in external walls. Inspection and access for work can be achieved by forming an access trap.	Floorboards may need to be lifted to aid under-floor ventilation and drying. Reinstate sub-floor ventilation. Achieve timber moisture content of less than 20 per cent (at depth) before reinstating floor finishes. Replace floor covering as necessary (eg damaged chipboard) Inspect under-floor timbers six months afterwards and then again after 12 months.
Chipboard	Remove swollen and damp-penetrated chipboard.	Where chipboard cannot be removed additional support should be provided.
Timber joists	Remove badly contaminated and rotting joists.*	Remove rotting joists and treat surrounding joists to prevent spread.
Suspended concrete floors	Flood ventilated void with detergents or disinfec-tants and leave to dry.	Clear debris from air-breaks or drainage holes to allow natural drainage and drying.
	Basements	
Walls and floors	Power-wash or mechanically scrub walls and floors. After minor floods, scrub surfaces by hand. Apply and rinse down surfaces with detergents and, where required, disinfectants. Rinse off, and repeat operation if required.	Drain and dry through appropriate heating (in winter), ventilation and dehumidification. **NOTE**: do not use gas or oil burners for heating Flueless appliances should not be used and flued appliances should be monitored. Ventilate vertically through upper stories of the building.

Note

* It is unlikely that joists will become rotten after a single flood event. More often, rotten joists are symptomatic of long-term dampness, which may be the result of progressive flooding or a lack of appropriate damp-proofing.

3 Post-flood survey and reducing the impacts of future floods

This chapter provides guidance on reducing the impacts of flooding by assessing damage to the existing building and the potential impacts of a future flood. The guidance is relevant mainly to buildings for which no previous measures have been taken to increase flood resilience or resistance. It is designed to help those responsible:

- undertake a post-flood survey of damage to the building. This will be required for the specification of the repairs and determining the extent of repairs needed
- assess the risks of a future flood by undertaking a building flood risk assessment. This will guide the standards of repair required for the building.

Post-flood surveys need to be undertaken by competent specialists (see Section 3.2). However, the information contained in this chapter may be used by a homeowner as a guide when liaising with tradesmen and other professionals (see also Appendix 3). Nevertheless, it is not a practice guide for the layman and professional advice should be sought throughout the process (see Appendix 1). Good Repair Guide 11 (Parts 1 to 4) provides further advice (BRE, 1997c).

A post-flood survey should be conducted to identify damage as soon as the floodwaters have receded and decontamination and initial drying have been completed. A health and safety risk assessment should be made before undertaking the post-flood survey (see Section 2.1). Note that the nature of the hazard is likely to have changed as a result of decontamination and drying work. A specialist should prepare a method statement that clearly sets out how the survey will be undertaken and the means of controlling risks to all personnel involved.

It is essential to identify and check parts of the building fabric that could potentially retain significant volumes of water and so potentially promote corrosion or the growth of moulds. Figure 3.1 summarises a recommended process for post-flood survey. It is recommended that, first, the type of building be identified – particularly important if the building is of non-traditional construction. In such cases, specialist advice may be required.

3.1 POST-FLOOD SURVEY

3.1.1 External wall elements

The first step in assessing the impact that flooding has had on a structure is to identify the exact form of construction of the building. Table 3.1 identifies the survey activities needed after a flood for the most common wall constructions currently used in the UK.

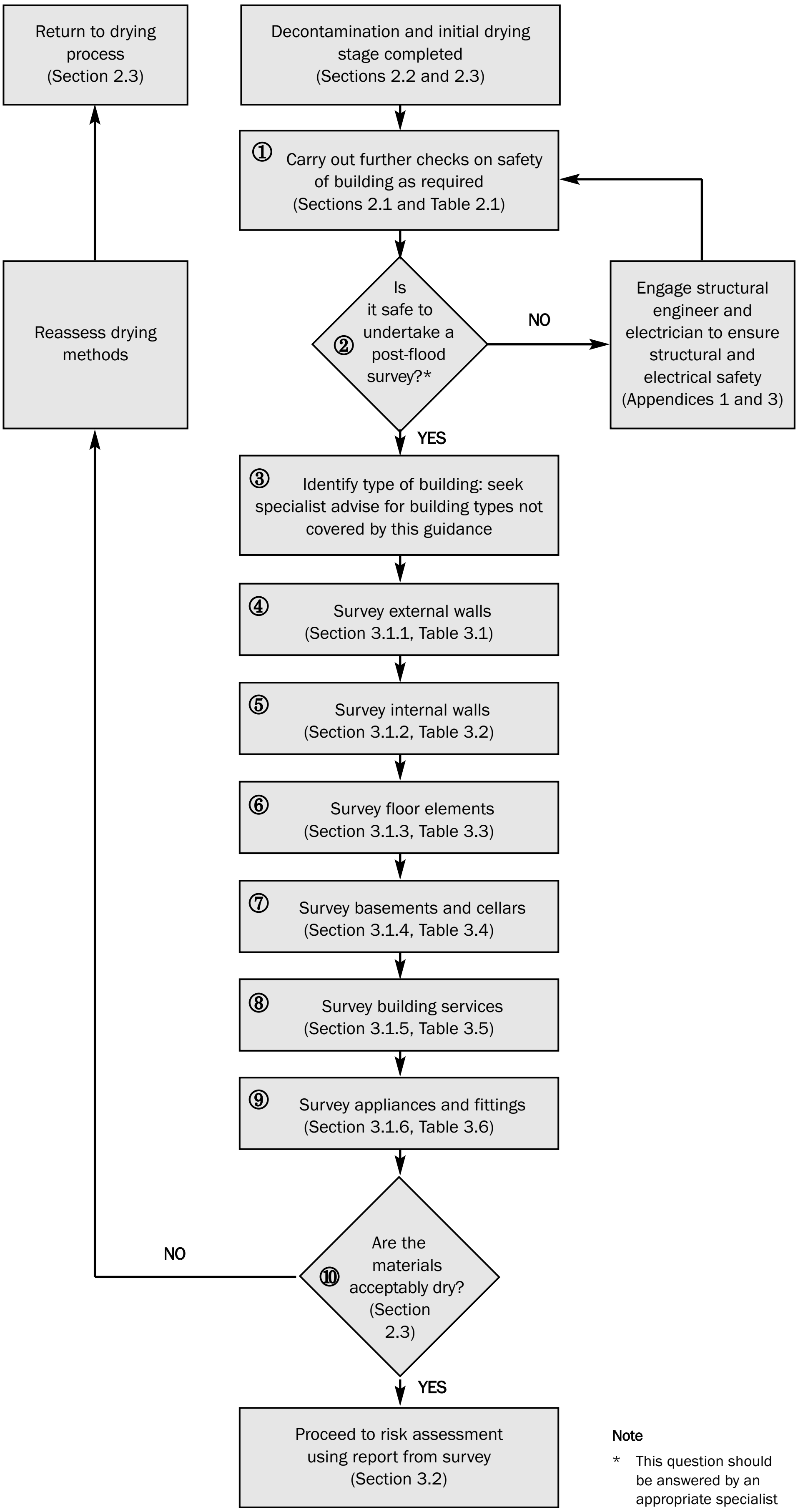

Figure 3.1 *Post-flood survey and reducing the impacts of future floods process*

The following list describes the survey activities in more detail.

1 **Assess for structural damage**. Damage may include bulging or dislodged sections of the building fabric, or cracks above openings such as windows and doors (see Figure 1.2). Close inspection should be made for signs of buckling such as horizontal cracking and areas that have moved out of alignment. When buckling has seriously weakened the wall, damaged parts should be rebuilt immediately. After remedial works have taken place, subsequent cracking of the structure may occur as the structure dries back to equilibrium conditions and final repairs may be necessary more than a year after the flood. Guidance on the structural requirements of the Building Regulations is not provided here, but should be checked with the local building control authority.

2 **Assess for settlement damage**. Settled walls and footings are usually indicated by vertical or stepped cracks either in small areas or throughout the structure.

3 **Assess the surface material condition of the wall (internal and external)**. Fast-flowing floodwaters can remove some types of mortar from joints or facings. Prolonged exposure of masonry materials to floodwater will saturate the brickwork and leave it vulnerable to frost damage if external temperatures fall below freezing. This can leave both the mortar and the brickwork damaged and in need of repair. Exposure of some render systems to flooding can lead to detachment. Plaster and plasterboard may become damaged and need repair or replacement.

4 **Assess for material damage**. This will include assessment of brick, concrete block, plaster, renders, mortar joints, ancillary components, skirting boards and finishes.

5 **Assess the internal condition of the wall**. Floodwaters can cause deterioration of insulation materials in cavities. Establish whether there has been shrinkage, slumping or disintegration of insulation materials. Surface coverings such as plasterboard or cladding will have to be removed so that the insulation can be inspected. In masonry walls, remove bricks or blocks for inspection, or, if possible, use a borescope for a less destructive investigation.

6 **Assess for staining**. Floodwaters can deposit silt and other materials against the external surfaces of walls, which can in turn lead to surface staining. Record the extent and progression of potential staining problems following flood, to inform the repair specification. Use photographs as a record as well as making a written description.

7 **Measure moisture content**. Timber will rot if it retains a moisture content exceeding 20 per cent for prolonged periods (see Figure 3.2). Assess the degree of saturation remaining in the wall components after drying to minimise the risk of deterioration. Assess any warping or deterioration of timber components from both wetting or drying.

8 **Assess for corrosion**. Prolonged exposure to floodwaters, especially if salt-laden, can cause corrosion to metal components such as steel frames, wall ties and fixings. If this type of flood has occurred, potentially affected components need to be surveyed. Metals should be cleaned and dried after the flood to prevent future corrosion problems.

9 **Assess for blocked ventilators**. Floodwater can deposit silt and debris into the wall structure. Clearing ventilation pathways will help to speed the drying process. Glazing exposed to floodwaters may accumulate debris within "drained and ventilated" types of frames.

Figure 3.2 *Flood-damaged floors*

Table 3.1 *Post-flood survey checklist for external wall elements*

Checks required	Masonry walls	Timber-frame walls	Steel-frame walls	Glazing	Cladding systems	Render and external insulation systems	Cavities
Structural damage	✓	✓	✓	✓	✓*		
Settlement damage	✓	✓	✓	✓			
Surface condition of the wall	✓	✓	✓		✓	✓	✓
Material damage	✓	✓	✓	✓	✓	✓	✓
Internal condition of the wall	✓	✓	✓		✓	✓	
Staining	✓	✓	✓		✓	✓	
Moisture content	✓	✓	✓		✓		✓
Corrosion	✓		✓	✓	✓	✓	✓
Blocked ventilators	✓	✓	✓	✓	✓	✓	✓

* Refers to fixing failure as a result of flooding.

3.1.2 Internal wall elements

Table 3.2 identifies the required survey activities for internal wall elements. It reviews the main internal wall features typically found in buildings and that need to be assessed. More detail is given below.

1 **Assess for structural damage**. Many internal wall elements have some load-bearing capacity (except for cellular plasterboard partitions and doors). Load-bearing internal walls should be assessed in the same way as external walls (see Section 3.1.1).

2 **Assess the internal condition of the wall**. Party walls in housing can be of masonry and cavity construction. As with external cavity walls, floodwater may penetrate into the cavity and deposit debris within the wall. Pockets of water may remain in party walls after a flood. These need to be identified, and the cavities drained and dried before repair and redecoration, otherwise they will cause continued dampness.

3 **Assess the surface and material condition of the wall**. As with external walls, plaster and plasterboard may become damaged and have to be repaired or replaced (see Figure 3.3). Gypsum-containing materials and components can absorb large amounts of water and distort. Plasterboard dry-linings or insulated plasterboard fixed to a wall with adhesive may need to be replaced up to at least the high water mark if they have debonded. Where plaster is dry on the surface, in good condition and has been cleaned thoroughly, it may be possible to redecorate, but ensure that the substrate beneath is not still damp before doing so. Refer to Chapter 2 on making safe, decontamination and drying. Replace detached and damaged plaster when it is clearly apparent that any crack, movement or salt deposition has stopped.

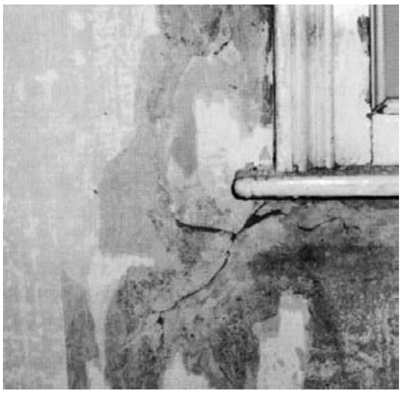

Figure 3.3 *Flood damage to plaster*

4 **Assess for staining**. Floodwaters can deposit silt and other materials against the internal surfaces of walls, which may lead to surface staining. For internal walls exposed to short periods of flood, staining may add to the water damage to surfaces, and may make the difference between the need to repair and the need to replace.

5 **Measure moisture content**. Measure the moisture content in timber, concrete and porous masonry materials as for external walls.

6 **Assess for corrosion**. Survey steel stud partitions to check for evidence of corrosion. Galvanising or other coatings on steel may be damaged. Corrosion effects may be delayed and may start after the flood has occurred and after the survey. Clean and dry the steel properly to avoid future corrosion problems and repair damaged galvanising.

Table 3.2 *Post-flood survey checklist for internal wall elements*

Checks required	Party walls	Masonry partition walls	Stud partitions (boarded)	Stud partitions (applied finish)	Cellular plasterboard partitions	Doors
Structural damage	✓	✓	✓	✓		
Internal condition of the wall	✓	✓	✓	✓		
Surface and material condition of the wall	✓	✓	✓	✓	✓	✓
Staining	✓	✓	✓	✓	✓	✓
Moisture content	✓	✓	✓	✓	✓	✓
Corrosion	✓		✓	✓		✓

3.1.3 Floor elements

The required survey activities for floor elements are detailed in Table 3.3 and described below.

1 **Assess the flooring surface finish** (see Appendix 5 for information on flood damage to floor finishes).

2 **Assess the condition of the floor structure and materials**. Moisture swelling and ground heave can result in cracking of the screed and the concrete slab of solid floors. The underlying cause can be hydrostatic pressure or expansion of fill under a solid floor. Suspended concrete and beam and block floors can also move as a result of floods. Timber suspended floors can be damaged from moisture swelling and subsequent warping of timbers. The affected timbers need to be identified and replaced. Timber floors can rot if they are allowed to remain wet for a period of time, so it is imperative that appropriate drying conditions are established quickly and that the timbers are dried as soon as practicable without causing additional damage.

3 **Assess for moisture, ventilation and debris in sub-floor space**. Survey the sub-floor space to determine whether it needs to be cleaned, drained and dried. Check ventilation pathways for blockages. For suspended timber floors gain access through the floor itself; for suspended concrete floors gain access through the ventilators around the perimeter. Check the condition of all sub-floor ventilators and clean out as appropriate.

4 **Assess for corrosion risk**. Suspended concrete and beam and block floors contain steel reinforcement elements, which may corrode after a tidal, salt-laden flood. If this is the case, a chloride check should be carried out on any reinforced concrete to determine the corrosion risk.

5 **Assess for structural robustness under load-bearing elements**. Wet timber elements and chipboard finishing may distort or sag after a flood and cause problems where they support load-bearing elements or partition walls. Identify any need for remedial under-floor strengthening.

6 **Measure moisture content**. Identify the moisture content of the floor and monitor how this changes as drying takes place.

Table 3.3 *Post-flood checklist for floor elements (see Section 4.10 for standards of repair)*

Checks required	Solid floors – concrete	Suspended floors – concrete	Beam and block floors (suspended)*	Suspended timber floors	Floating floors
Flooring surface finish	✓	✓	✓	✓	✓
Condition of floor structure	✓	✓	✓	✓	✓
Moisture, ventilation and debris in sub-floor space		✓	✓	✓	
Corrosion risk	✓		✓	✓	
Structural robustness under load-bearing elements				✓	
Moisture content	✓		✓	✓	✓

* Refers to a type of suspended concrete floor

3.1.4 Basements and cellars

Table 3.4 highlights particular issues associated with basements and cellars. Many issues also apply to a retaining wall structure following a flood.

1 **Assess for structural damage**. Floodwaters may lead to structural damage of basement walls, with partial collapse being possible in extreme cases (see Figure 1.2). Signs of damage may include the dislodgement or movement of internal door frames and the bulging of load-bearing and external walls. If there is any evidence of structural damage having occurred, consult a structural engineer before continuing. As noted in Chapter 2, the process of draining a basement of floodwaters can lead to structural problems, so throughout the repair work the building's structural integrity should be checked regularly to ensure safe practice.

2 **Assess for staining and damage to the internal surfaces**. Floodwaters may leave a range of debris and contaminants in basements following a flood.

3 **Assess for damage to tanking, waterproofing or drainage**. Damage to tanking, damp-proofing or drainage of the basement may cause water to pond in the basement. Identify the pathway taken by the water through the floor or walls. Refer to Report BR466 for damp-proofing faults and repair (BRE, 2004). Refer to Report 140 for information on water-resistant basement construction (Johnson, 1995). Often the inaccessibility of tanking and damp-proofing makes further surveying without excavation difficult.

Table 3.4 *Post-flood checklist for basements and cellars*

Checks required	Basement	Cellar
Structural damage	✓	✓
Internal surfaces	✓	✓
Tanking, waterproofing or drainage	✓	✓

3.1.5 Building services

Table 3.5 summarises the checks to be made on services. These include main building services such as electricity, gas, oil, solid-fuel fires, water, drainage and private sewers. Any of these services may be affected by floodwater, including supply pipes, wiring or the installations themselves.

1 **Assess damage to electrical services**. It is essential that a qualified electrician checks all affected circuits and appliances before they are reused. In many cases extensive repair and replacement will be required.

2 **Assess damage to gas and oil services**. Gas meters may be affected by floodwater and may need to be replaced. Floodwater can sometimes infiltrate gas pipes, causing problems for subsequent use. Ventilation systems must be thoroughly checked; if they are blocked the carbon monoxide build-up can kill (see Section 3.1.6). Oil tanks may be directly damaged or subject to corrosion from saltwater and should also be inspected. Check all pipework and ensure that the bund associated with the tank has been pumped dry. Do not knock a hole in the bund to allow floodwater out. Check that the bund and tank has not been damaged and will not leak in the event of an oil spill.

3 **Assess damage to solid-fuel fires**. Chimneys are often a significant structural element in housing construction and it is important to check that they have not

become unstable. Check the structural integrity of chimneys and consider damage to materials and saturation of brickwork.

4 **Assess ventilation ducts and air conditioning units**. These may have suffered damage or been contaminated.

5 **Assess water services**. Water services are unlikely to be directly damaged by flooding. Check and replace pipe insulation if it is wet or defective. Check that pipework has not been damaged or allowed contaminated floodwater to penetrate the system. Ensure that the water supply is flushed through.

6 **Assess drainage, private wastewater systems (including septic tanks) and wastewater treatment services**. Sewers and pipes may become blocked and cause the system to back up. Septic tanks may be affected by flooding, disrupting normal biological activity, and silt may have been deposited into the system. Silt deposits should be cleared from any drainage pathways. Sewage may escape from a septic tank, presenting a hazard to health. Also the septic tank may have moved under hydrostatic pressure (a part-full tank will tend to float). It is advisable to have a professional inspect an affected septic tank, which should be appropriately maintained after a flood. Flooding of a private sewage treatment system may cause sewage to back up into the home and make it impossible to use the sanitary system. Sewage tanks should not be used until water in the drainage field is lower than the water level around the house, otherwise further contamination may result. Signs of damage may be settling or an inability to accept water, or in some cases the tank may have floated.

7 **Contact the water utilities directly for a survey of the sewer system (non-private) where necessary.**

If further flooding is highly likely, it is important that the septic tanks be kept as full as possible or be weighted down. If empty, or not firmly anchored, there is a risk that they may become detached from the ground under hydrostatic pressure and may even float away.

Table 3.5 *Post-flood checklist for services*

Checks required	Electrical	Gas and oil	Solid-fuel fires	Ventilation	Water	Drainage	Private wastewater systems
Condition of structure		✓	✓			✓	✓
Moisture, silt and debris in services	✓	✓	✓	✓	✓	✓	✓
Corrosion risk	✓	✓		✓	✓	✓	✓
Damage to materials	✓	✓	✓	✓	✓	✓	✓
Leaks		✓			✓	✓	✓

3.1.6 Appliances and fittings

Table 3.6 sets out the survey requirements for fixtures and fittings. Most fixtures and fittings can be categorised as detailed below.

1 **Assess domestic appliances for damage**. These include cookers, fridges, freezers, microwave ovens, washing machines, dryers and dish-washers. Do not reuse kitchen equipment that has been affected by contaminated floodwater until it has

been cleaned, checked and repaired or replaced. It may not be possible to clean the goods to eliminate all health risks; for example insulation may have become contaminated. Goods may become corroded, especially where the floodwater contained salts. When reinstated, electrical devices may develop intermittent faults, or even short circuits, due to silt left from the flood, so it is important to check and clean them thoroughly. A professional should ascertain whether all flood-affected white goods are safe for reuse. Discuss the repair or replacement of white goods with the insurance company. Other appropriate remedial action includes the installation of a new consumer unit with circuit-breakers.

2. **Assess damage to utility appliances**. All gas appliances affected by floodwaters should be inspected by an installer registered with CORGI (Council of Registered Gas Installers). The appliances may light and appear to be in working order, but the flue and ventilation systems, which are essential for normal working operation, may have been adversely affected by the floodwater and may not be operating correctly.

3. **Assess baths, showers, sinks, toilets**. These are unlikely to be damaged, but floodwater may have impaired their function. Contamination and saltwater can lead to corrosion. Check under the bath and sink pedestals for damage to timber bath frames, chipboard or flooring. Some baths have integral chipboard supports to provide additional strength to the glass fibre and plastic structure. Check that these are still sound. Sanitary ware will not generally be affected when it is supported on rigid flooring.

Table 3.6 *Post-flood checklist for fixtures and fittings*

Checks required	White goods	Sanitary ware
Contamination trapped in appliances and fittings	✓	✓
Corrosion	✓	✓
Damage to materials	✓	✓

3.1.7 Sources of professional advice and services

Reputable organisations will be able to offer further detailed advice, guidance and services to deal with the consequences of flooding and undertake remedial activity. The insurance company and insurance surveyors will also provide advice and should be contacted. Appendix 1 lists organisations that can provide flood services.

3.2 REDUCING THE IMPACTS OF FUTURE FLOODING

This section introduces the Environment Agency's approach to protecting a building from flooding. It gives guidance on undertaking a building flood risk assessment to:

- determine the standards of repair required for flooded buildings
- assess the opportunities to reduce the potential future flood risk by improving the resilience or resistance of a building to flooding.

The flood risk assessment considers the nature of the hazard (the flood), the type of floodwater (seawater, mains water, river, sewer, rainfall etc), the likelihood of return and the duration and depth of the flood. Specialist advice will be required to conduct the future flood risk assessment.

The future flood risk assessment of a building is not the same as the health and safety risk assessment that should be carried out before starting work on a building that has been flooded (see Glossary and Section 2.1). It is designed to help identify the appropriate standard of repair and so increase the building's resilience or resistance to reduce the impacts of any future flooding. Building-owners will need to determine the costs and value of increasing the building's flood resilience or resistance for their personal circumstance and preferences.

The information in this section is given as guidance only and focuses on existing buildings. Note that professionals determining the specification (such as those appointed by insurance companies) may use alternative means to define the required standards of repair for a building.

Building-owners should be aware that it may be possible to reduce the risk of flooding to their building through the use of extemporary and flood protection products (see Section 4.18). Where there is a high risk of flooding the preferred option is to improve both flood resilience, through the use of materials that recover from flooding, and flood resistance, through the use of unaffected materials or flood protection products.

3.2.1 Environment Agency approach to flood management for buildings

The Environment Agency sets out an approach to flood management for buildings, particularly homes (CIRIA and EA, 2003), as follows:

> *Where a property is at risk, the preferred solution is for protection by permanent river or coastal flood defences.*
>
> *When permanent defences are not available, temporary free-standing barriers that typically hold floodwater back from a group of houses or an individual detached house are the next best option. Traditionally these have been formed from piles of sandbags, however a variety of portable dams and barriers are now available.*
>
> *Where permanent or temporary barriers protecting a group of houses are not viable, removable household flood products fitted to an individual property to help stop water coming through walls, doors, windows, air-bricks and vent covers are the third choice. These will generally need to be used with other measures to improve the flood resistance of the building.*

If none of the above options is present, or if they are unable to guarantee that water will not enter the building, then wet-proofing of the building can offer a fourth option for protection.

3.2.2 Assessing the risk of future flooding

A future flooding risk assessment should be undertaken for each individual building affected by a flood (see Figure 3.4) and should be supported by good information and reliable data. Record relevant information and details of survey work for future use. Specialist advice will be required to conduct a full risk assessment. Advice for home-owners can be found in the booklet *Flood products. Using flood protection products – a guide for homeowners* (CIRIA and EA, 2003).

There is no single construction profession that is qualified to carry out the full risk assessment, but they are likely to be carried out by surveyors or building and civil engineers. The essential requirement for these professionals is that they are experienced in dealing with the aftermath of a flood. They will require experience of assessing flood-damaged buildings and also the factors that either increase or decrease the risk of future floods. Professionals carrying out risk assessments should use the guidance in this section. Homeowners can use the information given here to help to commission a post-flood survey and risk assessment. Refer to Appendix 3 for advice to building-owners.

Risk is defined as the likelihood of being flooded again multiplied by the consequence to the building if it is flooded. Therefore, in determining risk both aspects need to be considered:

Risk = likelihood × consequence

Likelihood

When considering the likelihood of a flood recurring, it is important to take into account the impacts of climate change, which are likely to increase the probability (Phillipson and Graves, 2001; Vivian *et al*, 2005; see also Section 3.2.3). It may be possible to define the likelihood using data that is already available, such as that provided by local authorities and the Environment Agency, eg indicative flood maps. Where data is not available, or for more complex assessments, specialist assessment may be required. CIRIA C624 *Development and flood risk – guidance for the construction industry* (Lancaster *et al*, 2004), provides full guidance on assessing the flood risk of potential sites for new buildings. The approach recommended applies equally well to assessing potential future flood risk of existing properties already at risk. The book also provides a list of sources of information to help in assessing flood risk. Planning policy guidance from the ODPM (ODPM, 2001) and devolved administrations also provides guidance in this area. Further details on assessing the likelihood are outside the scope of this guide.

Consequence

Determining the consequences of a flood event is dependent on factors that include the depth and duration of the flood event and the specific aspects/uses of the building. The following factors are all important in determining the consequences associated with a future flood event (ODPM, 2001):

- the source of flooding, whether fresh water or saltwater and any potential substances it may contain, such as contaminants (including sewage) and floating debris
- the likely depth and duration of flooding
- the likely rates of flow of the floodwater
- the extent to which a building and its environs are currently designed and built to deal with flood risk.

3.2.3 Assessing the likelihood of future flooding

The first step toward defining risk is to identify whether or not there are factors that indicate the likelihood of a future flood. Desk studies and site surveys are used to assess the risk of future flooding and are briefly described here.

Desk study

Box 3.1 lists some factors that may help to determine whether a flood is likely to occur in the future. The factors can mostly be assessed as a desk exercise and should help to identify the potential flood hazards. The list is not exhaustive, but is indicative of the factors that should be considered. These hazards will be relevant later when determining the level of risk and the corresponding standard of repair required. There may be specific circumstances that are not covered by this generic list and that will need to be considered by the assessor.

When considering Box 3.1, the ground type and its permeability can be determined by:

- obtaining soil condition records for the site from the builder (assuming the builder can be traced)
- consulting a geological map, soil map or borehole records (available from the local authority, the British Geological Survey or the National Soil Research Institute)
- commissioning a survey by specialist surveyors, who can advise on the soil type.

Information on the flood history of a building may also be available through discussion with building-owners, neighbours, the fire service, wastewater undertaker, Environment Agency and/or local authority, which may all be able to provide valid information. It is also recommended to check newspaper articles, local history societies or library records for information on previous flood incidents.

Box 3.1 ***Factors to be considered to help determine the likelihood of a future flood***

Risk likelihood factors

Historic factors

- Previous flood history of the building. Information will be held by insurers, householders, building-owners, the local authority, fire brigade or local flood groups. *These organisations may have previous survey reports; alternatively, information may be available in newspaper reports and/or from local societies*
- Flood warnings have been issued for the area
- Previous floods have caused closure of buildings, movement of people from their homes or disruption to business
- Previous floods have been of greater than 24 hours duration
- Sewer flooding has occurred previously. *Note: could be a result of overloaded or blocked sewers. The responsible authority may have subsequently solved the problem*

Exposure

- The building is located within a flood risk zone, as indicated on flood maps. *Maps are available from the environmental agencies, Ordnance Survey or insurers*
- The building is located within a flood risk zone, as indicated on flood maps, and is unprotected by a flood or coastal defence, or is unprotected by a flood control structure (eg flap valve, sluice gate, tidal barrier)
- The building is protected by existing flood defences. In this case it is important to understand the extent and standard of the existing protection and its anticipated effectiveness over time
- The building is protected by current flood defences, or there are plans to construct or repair flood defences
- The building is protected by temporary defences. *Emergency deployment plans are essential*
- The development is unprotected by a flood control structure (flap valve, sluice gate, tidal barrier)
- The building is covered by the Environment Agency AFW system
- The site of the building has characteristics that indicate it may be prone to flooding. *For example, a building situated in a natural or artificial hollow, at the base of a valley or at the bottom of a hillside*
- The building is underlain by a chalk aquifer
- The building is close to an intermittent stream
- There are prolonged periods of wet weather in winter and a propensity for intense rainfall events. *Climate change is likely to increase winter rainfall across the UK and increase annual rainfall in the north of the country*

Adjacent installations and facilities

- The building could impede natural or artificial land drainage flow paths
- The building is located upstream of a culvert. *Note: culverts can be prone to blockage*
- Water levels in watercourses near to the building are controlled by a pumping station
- The building is downstream or downslope of a reservoir or other significant water body

Local ground conditions

- There is a relatively high proportion of hardstanding to soft ground
- The soil is impermeable or often near saturation point
- There are signs of soil erosion upslope of the site
- There are artificial drainage systems on, adjacent to or upslope of the site

Site survey

Any information that is required but cannot be obtained from the desk study should be gained through a site survey that will establish the land topography and likely routes of surface water runoff. Site surveys can also serve to determine what happened during previous flood events (eg the consequences). Relevant information should be collected during the post-flood survey (see Section 3.1) and a record kept with all the other relevant information.

3.2.4 Assessing the consequences of future flooding

Consequences of flood events relate not only to the built environment but also to people and the natural environment. However, for the purposes of this guide, only the consequences to the building are considered.

Box 3.2 lists factors that need to be considered in order to assess the consequences should a flood occur in future.

Box 3.2 *Factors to be considered to help determine the consequences of a future flood*

Risk consequence factors

- The value of the property
- The type of property, eg detached, terraced, basement, prefabricated
- Building design, eg timber, modern brick, suspended floor etc
- The costs of repair from previous floods
- The availability and cost of insurance
- The depth of the flood relative to the building and any differences between the external depth and internal depth of the flood
- The duration of the flood
- The type of flood that occurred (or is likely to occur)
- The elements of the building affected and the amount of damage caused with differentiation made between material and structural damage (gather as part of the post-flood survey; see Section 3.1)
- The sources of flooding, eg tidal, rising groundwater, sewer backflow, riverine etc

An assessment of the consequences of future flooding is essential, as it enables the building-owner (or other interested party such as an insurance company) to decide on the best way to manage their exposure to flood risk using appropriate standards of repair.

3.2.5 Different levels of risk

Within this guide, three categories of flood risk are described. For each flood risk there is a corresponding standard of repair:

Level of risk ➔ Standard of repair

These levels of risk and standards of repair are used throughout the remainder of the book (see Section 4.1).

This guide is not prescriptive about ways to determine the level of risk. Each post-flood risk assessment should be considered on the basis of the available evidence and the particular situation. The criteria provided are for guidance only and assessors are required to arrive at the best solution that does not entail excessive cost or disruption to the building, while meeting the needs and preferences of the specific building-owner or occupiers. Note that failure to repair to the correct level of risk and standard of repair may result in additional damage during future floods.

There is no single level of risk for a building. More frequent flooding may cause small amounts of damage, whereas less frequent flooding to higher depths may result in much larger, longer-term damage and greater disruption.

To assess the level of risk, first consider the factors in Boxes 3.1 and 3.2. Collate any information that is available for the area from, for example, local authorities or the Environment Agency or local knowledge. Compile as much information as possible from the flood event that has occurred and assess the damage caused to the building using the information in the post-flood survey (see Section 3.1). The building-owner's personal choices and attitude towards the levels of risk that are acceptable to them in the future will play an important role in decision-making. For example, an owner may prefer to implement a higher standard of repair than that recommended to reduce the trauma associated with a future flood event. Using all the information available (on the likelihood of a future flood and the potential consequences of a flood event) it should be possible to make an assessment of the level of risk for the building. The following definitions may help to guide the assessment.

Little or no risk

Even where a flood has occurred, there may be an insignificant risk of the event being repeated, and this should be recognised. This may apply where the source of flooding has been reduced or removed – for example, a sewer unblocked or a flood defence installed. In such cases it is unlikely that any of the risk factors in Boxes 3.1 and 3.2 would be relevant. If little or no risk is determined, the risk assessment may be limited to a particular timeframe, such as the lifetime of a flood protection measure.

Low to medium risk

Most previously flooded buildings will have some level of risk of future flooding. If there are some identified risk factors from the lists in Boxes 3.1 and 3.2 then low to medium risk is likely. This level of risk should also take into account the depth and duration of exposure and the damage caused to the building. Although not prescriptive, the following may apply:

- the depth of previous floods was above floor level
- the duration was up to 12 hours.

High risk

If a significant number of the risk factors in Boxes 3.1 and 3.2 applies, then the building should probably be assessed as high risk, as it should if previous floods caused significant damage. The following points may be useful in determining high risk:

- the depth of previous floods was above floor level
- the duration was more than 12 hours
- significant work was required to dry and decontaminate the building.

3.2.6 Identifying the standard of repair required

There will always be a degree of uncertainty involved in assessing the risk of future flooding. Where there is significant uncertainty then assessors are advised to follow the precautionary principle and exercise additional caution. Uncertainty is caused by lack of good data and information from which to identify hazards. If the degree of uncertainty is such that the assessor cannot be certain of the correct level of risk then there are two potential courses of action.

1 Assign a level of risk that reflects the uncertainty. For example, if a low to medium risk is assessed but there is uncertainty then assign a high risk to the building.

2 Undertake further desk study or site surveys to gather more, or better, information from which to assess the level of risk more accurately.

Impacts of potentially changing attitudes of planning authorities may be a source of uncertainty in assessing risk to existing buildings and determining the standard of repair required.

It is recommended that the standards of repair (see Chapter 4) be determined as follows:

- **little or no risk = use Level A standard of repair**
- **low to medium risk = use Level B standard of repair**
- **high risk = use Level C standard of repair.**

Additional factors to consider

Building type and use. The type and use of a building may affect the level of repair required. A building that has been found to have little or no risk of the flooding returning, but is supplying an essential service (eg hospital, electrical substation) should have its level of risk increased so that potential future disruption is reduced.

In the domestic building sector it is essential to take the housing type into account. For example, where the building provides sheltered accommodation for elderly or disabled people, it may be necessary to change its use to avoid future risk to life.

In some instances, particularly for terraced or semi-detached housing, joint action is required to prevent water entering a dwelling from the neighbouring property.

Flood warning. Flood warning schemes for main rivers exist in much of England, Wales and Scotland (Environment Agency Floodline, <www.environment-agency.gov.uk>, and SEPA, <www.sepa.org.uk/flooding/>. Appendix 1 provides contact details for these organisations). Flood wardens are present in many flood-prone areas and will provide warnings to building occupiers. In some areas residents' associations provide a local service. If sufficient time and support exists after the warning to take action, it may be possible to reduce the risk of damage, for example through the use of flood protection products. Advice is given in Section 4.18 on the types of flood protection products available and their potential benefits. The existence of a flood warning scheme does not necessarily reduce the risk of flooding to a property, but it may provide sufficient time in which to move belongings and at-risk items to safety.

Climate change. The Foresight Future Flooding study, commissioned by the Office of Science and Technology (OST, 2004), reviewed the potential changes to future flood risk over the next 100 years and the impact that could occur, under four contrasting socio-economic scenarios. Its findings suggest that the flood hazard in Britain will increase significantly as a result of climate change.

The Foresight project indicated that, if current levels of expenditure and approaches to flood management remain unchanged, over the next 100 years:

- river and coastal flood risk could increase between two and 20 times
- risk of flooding from rainfall could increase between three and six times
- annual economic damage could increase from £1 billion to between £1.5 billion and £21 billion by the 2080s, dependent on the scenario. This compares with growth of GDP of between two and 14 times over the same period
- the number of people at high risk of river and coastal flooding could increase from 1.6 million today, to between 2.3 and 3.6 million by the 2080s.

The report also found that the effectiveness of drains and sewers in towns and cities could be particularly affected by climate change effects, such as more severe short-duration rainfall events, and could cause increased flooding, but this is an area that needs more research.

The risk assessment process should consider the likely effects of climate change for the local area and consider whether or not the standard of repair should be raised a level to accommodate the effects.

3.2.7 Maintaining information on the risk assessment

All information associated with the risk assessment should be kept for future reference, including details of the activities undertaken and the decisions made. Information may be maintained within a formal risk assessment report or by the homeowner through personal notes. The following should be included:

- list of factors from Tables 3.7 and 3.8 that are relevant to the building, plus any additional information that has emerged during the assessment
- all potential sources and causes of flooding to the building
- the depths and durations of the recent and any previous historical flood
- the assessed level of risk of a future flood
- any additional relevant factors.

It is recommended to keep a flood repair log containing all the information in a single place (see Section 4.19).

3.3 INSURANCE

The Association of British Insurers (ABI) has indicated that,

> *For properties at very high risk of flooding (greater than 1.3 per cent annual probability) insurers cannot guarantee to maintain cover, but will use their best efforts to look at ways that the property's resilience or resistance to flooding can be improved.*

For further information from the ABI refer to its statement of principles on provision of flood cover in Appendix 6. This will be regularly updated and the latest version can be viewed on the ABI website, <www.abi.org.uk>.

For owners of buildings where this applies, conducting a full risk assessment followed by implementation of suitable standards of repair may help them to obtain cover. A flood repair log can be used to record the risk assessment and the repair work (see Section 4.19).

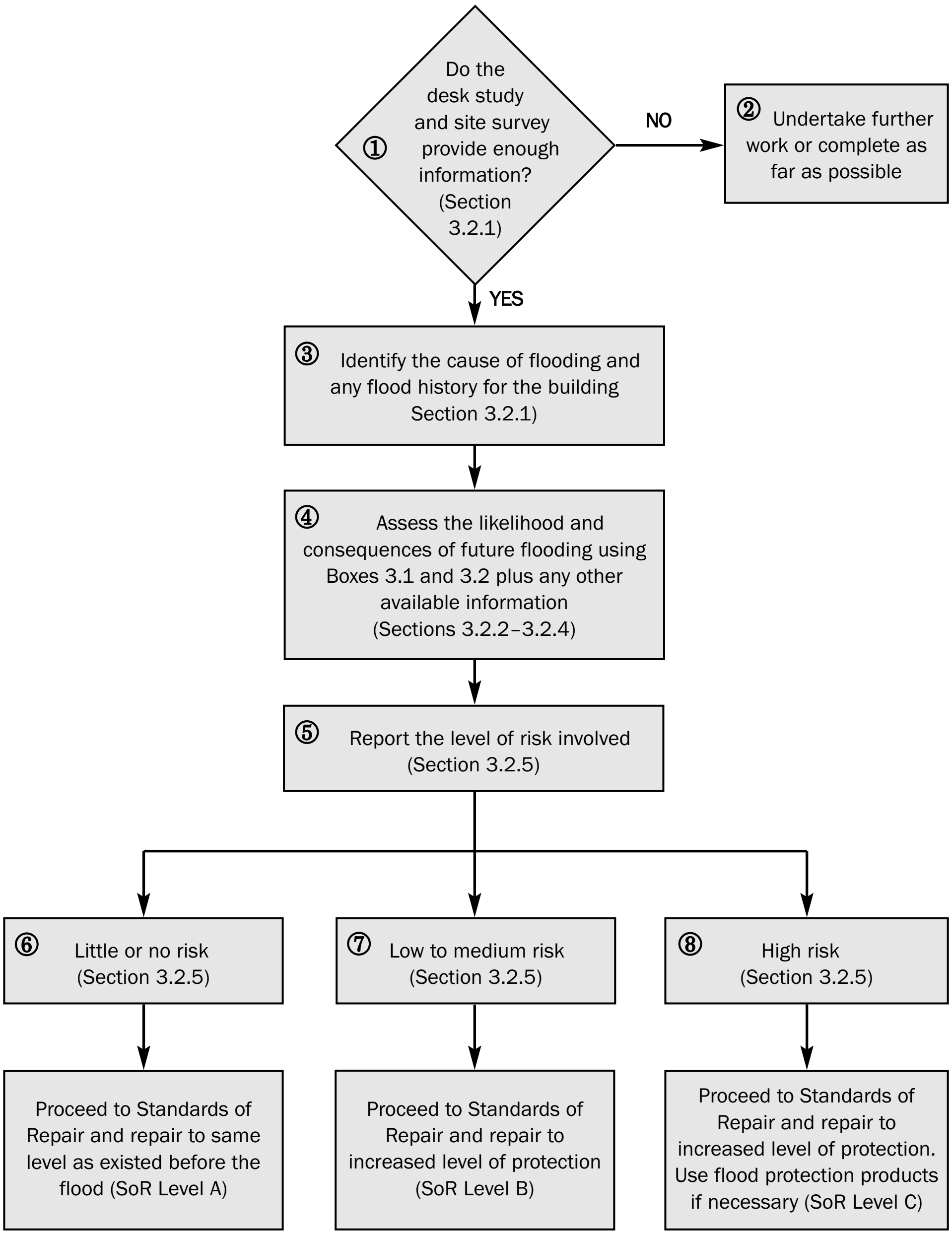

Figure 3.4 *Risk assessment procedure to determine level of repair required for the flooded building*

4 Standards of repair

This chapter provides specifications for the standards of repair of buildings following flooding. Section 4.1 introduces the standards of repair and how they should be used. Please read this section before proceeding to the subsequent sections, which provide guidance on flood protection measures (wet-proofing and dry-proofing) and standards of repair for external walls, internal walls, floors, services, fittings and basements. For each of these areas, the guidance covers aspects of the building element. For external walls, for example, standards of repair are given for the external face of walls, internal face of walls, cavities, fenestration and finishes. Standards of repair of Levels A, B or C are provided for assessed levels of risk as defined in Section 3.2. Figure 4.1 summarises the recommended repair process.

Information on basements, flood protection products and the role of a flood repair log is also provided (see Sections 4.17 to 4.19).

Box 4.1 *Contents of Chapter 4*

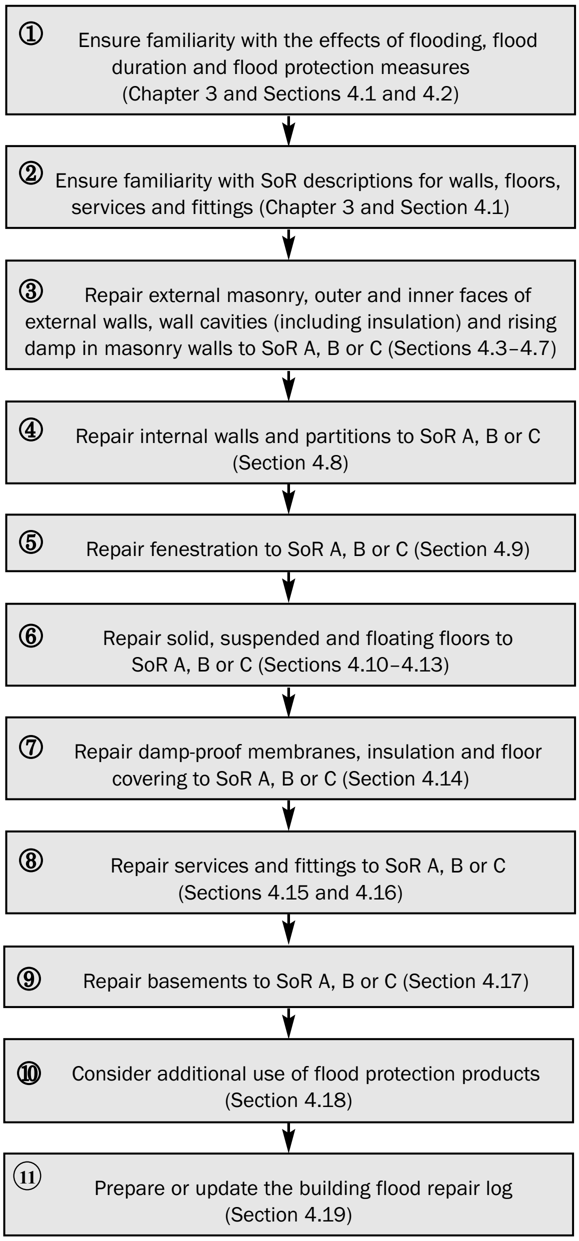

Figure 4.1 *Specification for the standard of repair (SoR) for building elements of flooded buildings (following thorough decontamination and drying)*

4.1 STANDARDS OF REPAIR: OVERVIEW

A post-flood survey (see Section 3.1) should be undertaken before specifying and carrying out repair work. The required standard of repair will have been determined through the post-flood risk assessment detailed in Section 3.2. Clearly, the building-owner will have considerable input into the decisions. They will rarely have the technical expertise to specify repairs, however, so it is essential they consult fully with other professionals.

Where there is a risk of future flooding, then the standards of repair will suggest improving the resilience or resistance of the building:

- **improved resilience** means improving the ability of the materials to recover from flooding
- **improved resistance** involves the use of building materials, components and elements that are undamaged or unaffected by floodwater.

There may be increased cost involved in increasing the flood resilience and/or flood resistance of a building. However, it is important to balance the extra initial investment with potentially reduced whole-life costs of the repair measure (see definition of whole-life costing below), including the reduced impacts on the property occupiers or users.

The standard of repair is defined in this guide as follows:

> *The standard of repair is the extent to which repair work is carried out and the extent of measures undertaken so that damage from future flooding is minimised. The standards of repair are determined through risk assessment. The resilience or resistance measures in the standard of repair can include dry-proofing and wet-proofing of the property.*

This guide defines three standards of repair, which relate to the level of risk determined (see Section 3.2) and are summarised below.

1 **Level A standard of repair**. The risk assessment shows that there is little or no risk of future flooding. The repairs to the building are to the original specification, or may involve some improvements.

2 **Level B standard of repair**. The risk assessment shows that the likelihood of a future flood is sufficient (ie low to medium) to justify increasing the resilience and/or resistance of the property to flood damage, above the original specification.

3 **Level C standard of repair**. The risk assessment shows that the risk of future flooding is high or that a flood event would result in significant damage to the fabric of the building. Consequently, increasing the resilience and resistance of the property is essential. The repairs recommended involve both dry-proofing and wet-proofing of the building.

NOTE: for refurbishment of a previously undamaged property where a risk assessment shows there is a flood risk, use Level B or Level C standards of repair in any remedial work.

Table 4.1 *Particular flood damage vulnerability of typical construction elements*

Construction	Vulnerability to flood damage
Masonry walls	Damage to plasterboard Damage to gypsum plasters Damage to applied plaster
Timber-frame walls	Water damage to frame structure (including rot and warping) Damage to plasterboard Damage to lath and plaster
Steel- or concrete-frame walls	Corrosion to steel frame, or reinforcement and fixings Damage to plasterboard
Timber suspended floors	Damage to floor cover and structure (including rot and warping) Damage to timber boarding and decking
Ground-supported or suspended concrete floors	Damage to sand/cement screeds Damage to insulation, particularly in floating floors
Fenestration	Glass breakage Sealed insulating glass unit failure Timber frame warping Leakage through window frames and door leafs Corrosion of metal frames or steel reinforcement in PVC-U frames

The particular vulnerabilities to flood damage associated with common forms of construction are illustrated in Table 4.1. By adopting the preferred standards of repair for these forms of construction, subsequent flooding should be easier and less costly to repair. This may also reduce the whole-life cost of repairing the building when subject to repeat flooding.

BS ISO 15686:2000 defines whole-life costing as follows:

> *Whole life costing (WLC) is a tool to assist in assessing the cost performance of construction work, aimed at facilitating choices where there are alternative means of achieving the client's objectives and where those alternatives differ, not only in their initial costs but also in their subsequent operational costs.*

Whole-life costs are made up from the initial capital costs of the repair work or product, plus the through-life costs. For flood repairs these will be the maintenance of the building materials, components or products.

A simplified example of whole-life costing to illustrate the potential benefits of increasing resilience and resistance during repair is provided in Appendix 7. Whole-life costs and performance should be reviewed when identifying standards of repair as opposed to simply the initial costs.

NOTE: if the work needs to be done in any case as part of the repair work, and additional cost of implementing the highest specification is low, then it is advisable to go for the higher specification.

Users of this guide should refer to construction details provided in Report BR262 (BRE, 2002b), *Design guidance on flood damage to dwellings* (Scottish Office, 1996) and various of the British Standards cited in the following sections. The National House-Building Council may also be able to advise on house types and construction (see Appendix 1).

4.2 FLOOD PROTECTION MEASURES

When a flood warning has been issued, it is prudent for occupants at risk to move furniture and valuable items to upper floors or alternative locations. This may not be possible for occupiers of ground-floor flats and bungalows, although they may be able to raise vulnerable items off the ground (CIRIA and EA, 2001a). Improving flood resilience and resistance is likely to include either dry-proofing or wet-proofing existing buildings (see also Glossary). These terms are defined as follows.

1 **Dry-proofing** involves the use of flood protection barriers to prevent water entering the building through walls, floors, doors, windows, air-bricks, ventilation holes and other openings, thereby preventing wetting and damage to internal building materials (see Figures 4.2 and 4.3). **Dry-proofing measures can be used for floods of up to 1 m depth but should not be used above this depth of water**.* Where floodwaters rise above 1 m depth of the wall, dry-proofing measures become undesirable as the pressure of floodwater can cause structural damage to the building (see Section 4.18). Above 1 m depth, therefore, water should be allowed to enter the building. Dry-proofing can also involve repairs such as repointing damaged brickwork walls that prevent water from entering the building through the brickwork, and raising floor levels to above a predicted flood level.

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* Where dry-proofing measures are likely to cause differential hydrostatic pressure on a wall, a structural engineer should advise on the work necessary to strengthen the structure to resist them.

2 **Wet-proofing** is based on the acceptance that some water will enter the building, so the intention is to design and/or use materials in the construction or repair of the building that will help to prevent damage to the building when this occurs. It should make it easier and quicker to reinstate the building once the flood has passed. A range of wet-proofing measures may be employed, including flood-resilient or flood-resistant building materials and the raising of electrical wiring above flood levels.*

Often a combination of dry-proofing and wet-proofing measures offers the most effective solution, especially where the risk is high.

(a)

(b)

Figure 4.2 *Air brick cover: (a) holding plate in position but cover removed to allow ventilation under normal conditions; (b) cover in place when flood risk is high*

Figure 4.3 *Flood door board*

* The definition given above is for the purposes of this guide. In a wider context, wet-proofing can also include measures affecting the type and layout of building contents, such as the adoption of lightweight, portable fittings that can easily be moved to higher levels, or low-cost fittings that are inexpensive to replace.

4.3 STANDARDS OF REPAIR FOR EXTERNAL MASONRY

Brickwork and other forms of external masonry are designed to allow some moisture penetration and movement, so they are unlikely to remain waterproof if exposed to floodwaters for long periods. Because water always finds the route of least resistance, attention to detail when applying flood protection measures can slow the rate of moisture ingress and protect against shorter-duration flood events. Table 4.2 details weaknesses in external masonry, including brickwork, against moisture penetration and outlines waterproofing options relating to both new-build and repairs.

Table 4.2 *Moisture penetration and waterproofing of external masonry*

Issue	Moisture pathway	Waterproofing options
Weep holes in the brickwork	Through the weep hole to the cavity	Where available, use proprietary covers when flood warning is given
Air-bricks and ventilators	Through the ventilation holes	Use proprietary covers when flood warning is given
Service penetrations and openings, including pipes, flues and tumble-dryer vents	Through the junction between pipework and brickwork, and through the pipes/vents themselves	Clean and renew sealant materials and maintain effective seal at these junctions Consider moving to higher level in the wall For services below ground level consider using additional protection measures
Cracks in brickwork	Through the crack	Repair excessive cracks by: • applying a water repellent, which can cover and protect fine cracks for short periods; has little resistance to water pressure, however • applying render or external insulation system, which may be appropriate for dealing with extensive cracking
Cracks in brick/ mortar interface and in the mortar	Between the brick and mortar joint interface	Inspect the mortar joints for cracking, remove and repoint the mortar where evident
Through the mortar	Mortar is generally much more permeable than brick. Water can quickly saturate a mortar joint and, through the pressure of a flood, form a moisture pathway	Can be stopped only by applying external waterproofing, such as a render coating or a rendered external insulation system Consider the mortar mix and the benefits of increased lime content
Through the brick	Bricks will absorb water and under the pressure of floodwater may saturate and allow water to pass through them. This will normally take longer than through mortar	Low-permeability bricks, such as engineering bricks, will reduce the speed of water penetration. However, to reduce the risk of the problem in existing brickwork, barrier techniques will be necessary (eg including render and external insulation systems)
Through movement joints in external masonry	Through the joint, especially where external sealant is in poor condition	Apply good-quality sealant (two-part gun grade) to the joint. Joints should be backed with suitable filler

NOTE: the permeability of a brick can be assessed using a Karsten tube apparatus, which attaches to the surface of the wall and can be used to measure the rate of moisture absorption (see Section 2.3.3). If the device is being used to assess the permeability of a flood-affected wall, it should be attached to brickwork above the flood level, as the water already absorbed from the flood will temporarily affect the permeability measurement. The assessor should be experienced in the use of Karsten tube apparatus and similar equipment, otherwise errors may be made.

4.4 STANDARDS OF REPAIR FOR THE OUTER FACE OF EXTERNAL WALLS

4.4.1 Level A standards of repair

Water repellents

Resilience and resistance. Water repellents are used to treat masonry walls to resist water penetration from driving rain conditions. As a flood-resilience measure they may reduce water penetration into the brickwork in floods of short duration, but are unlikely to work effectively on prolonged exposure to floodwater.

Specification. Water-repellent treatments are commonly available, although there is no current British Standard for their use. Most are proprietary products formulated from silicones, siloxanes and aluminium stearates. Water repellents can be applied by brush or spray, depending on the type of product used. They should be applied to thoroughly cleaned, dry brickwork, fully covering the area likely to be affected by floodwater. The water repellence of the finished brickwork should be checked by wetting sections of the wall and assessing the repellent properties. Water should not be readily absorbed by a water-repellent surface, but should run off rapidly.

Water repellents will reduce the amount of water the bricks will absorb. However, some products reduce moisture loss by evaporation, causing water to accumulate within the brick and leaving it susceptible to frost damage. The manufacturer should be asked for advice before using a product on the particular type of masonry and mortar. Note that water repellents will not work where damage, cracking, gaps or openings affect the wall.

Floodwater may cause contamination of the brickwork, while flooding of the building will encourage efflorescence. Cleaning of the masonry surface to take the water repellent can be carried out to the recommendations given in BS 8221-1:2000 and BDA Building Note no 2 (Harding and Smith, 2001). Scrubbing with a bristle brush can remove a lot of the salt, dirt and stains. Where dirt is difficult to remove, chemical treatments can be used on some types of brickwork. The user should obtain detailed guidance from the supplier of the cleaner to avoid any risk of eroding the masonry.

All products for cleaning, preparation and application of the repellents must be applied and used in accordance with the manufacturers' instructions, taking account of the stated hazards associated with their use.

Initial costs and whole-life issues. The initial capital cost of water repellents is low, but they need to be reapplied every five to 10 years. The water repellence of the wall should be checked regularly.

Heritage bodies discourage the use of water repellents on stone-built properties in conservation areas as they may cause deterioration of the stone. In these cases, repointing the stonework is the preferred repair method.

Repointing

Brickwork mortar in poor condition should be repointed. This will provide increased resilience and resistance not only to flood but also to driving rain. Standard of repair Level B provides a detailed repointing specification (see Section 4.4.2).

Render

Repair or replace damaged render on existing masonry on the outer face of walls. Level B below gives render specifications (see Figure 4.4).

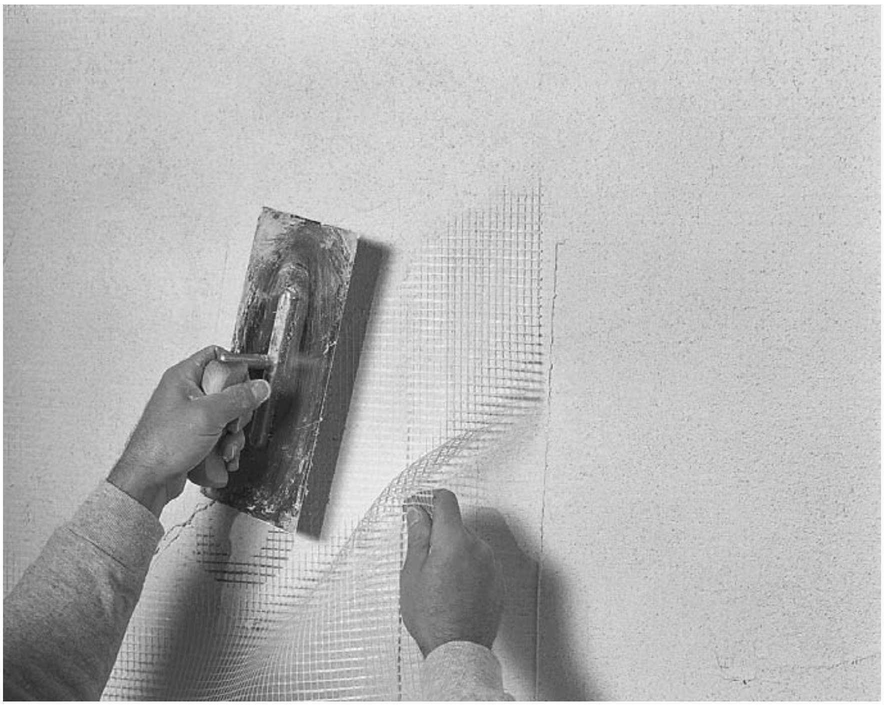

Figure 4.4 *Render application*

4.4.2 Level B standards of repair

Repointing

Resilience and resistance. Repoint masonry where the mortar is damaged and in poor condition. Repointing will reduce cracks and water penetration pathways. The repointing should be carried out to at least 1 m above the damp-proof course, without bridging the damp-proof course.

Specification. Repointing is generally one of the few maintenance activities undertaken to the outer face of a brickwork wall, so it requires due care by skilled workers. Wherever possible, the mortar joints should be raked out using hand tools, because considerable damage can be caused when power-driven disc cutters are employed. Use BS 8221-1:2000 and -2:2000 and Good Building Guide 24 (BRE, 1997b) for good practice guidance on the cleaning and repointing of masonry units. The main steps are as follows:

- rake out mortar joints to at least 20 mm depth into the wall and not less than twice the thickness of the joint. Any wide joints should be raked out to at least 38–50 mm, while preserving the stability of the masonry units above
- clear dust and loose material from joints by air or clean water
- thoroughly clean and wet joints before placing new mortar
- achieve maximum penetration of repair mortar to bond to the original bed
- the finish to the pointing should match the original and the mortar should not extend beyond the face of the masonry, unless this occurs in the original, as, for example, in Scottish slaisters or pear pointing.

When repointing is well applied the cracks between the bricks and the mortar do not reappear. Suitable mortar mixes include the following:

- cement:sand-based (with additives such as plasticisers and retarders)
- polymer-modified cement
- hydrated lime:cement:sand-based
- hydraulic lime:sand-based.

Initial costs and whole-life issues. The initial capital costs of repointing work are relatively low. In buildings at risk of flooding the concern relates to the first 1 m of the wall, so extensive scaffolding is not required. Repointing will normally be required only every 40 years, although more exposed locations may require earlier repointing. The whole-life costs of repointing are low, therefore.

Renders

If the mortar joints are in good condition (ie they have not deteriorated), but still leak then apply a suitable external finish to the outer face of the walls. This generally means a render system.

Existing external renders on walls may need to be repaired or replaced if they are damaged. Render can be applied directly to the masonry (or concrete) wall or to the insulation.

Any significant damage (including cracking, spalled areas or hollowness) to an existing render finish needs to be repaired. Remove damaged render by hacking off to the masonry background. A masonry paint finish can achieve a consistent appearance between original and repaired areas.

Resilience and resistance. Renders can present a significant barrier to the passage of water through the outer masonry wall. They can either be site-mixed, where the constituents (lime, cement, sand, admixtures and additives) are entirely mixed on site, or proprietary products, where only water is added on site to a dry, bagged product. Although renders are not designed to withstand floodwater (they are generally used to prevent rain penetration and/or for aesthetic purposes), they can provide a barrier for a period of time. Renders act by sealing the outer wall and preventing water being transported into the building through:

- cracks and gaps in the masonry, which become a minimal risk as floodwater cannot readily reach them through the render
- absorption of water by the masonry, which is reduced as direct contact with flood-water is prevented.

Renders can form effective barriers to water ingress from floods for up to 24 hours.

Specification. There is a wealth of information available on rendering practice. Use the following standards and guidance in repairing buildings with renders.

1. **BS 5262:1991** ***Code of practice for external renderings***. The requirements of this standard for rendering work should always be followed. Although it does not cover flood issues specifically, it describes the achievement of good rendering, which is essential to flood resilience and resistance. Rendering should be carried out by competent tradespersons. The standard covers both site-mixed and proprietary products.

Poor-quality masonry surfaces require some pre-treatment, either a dubbing-out render to repair holes or bonding assistance, which may require mesh reinforcement. A waterproofing agent can be added to site-mixed renders to reduce water uptake in the event of a flood. Traditional cement:hydrated lime:sand renders are applied in two or three coats. Each successive layer should not be stronger than the one preceding it (use the specification guidance in this standard or in Digest 410 (BRE, 1995) to determine suitable mixes for each coat). Site-mixed renders are generally applied by hand trowel. Allow the preceding coats of render to set before applying the finishing coats. Protect the fresh render from strong sunlight, high winds, frost or direct rain during construction. Polymer-modified proprietary renders are generally thinner than cementitious renders and must be applied in accordance with the manufacturer's instructions.

For historic buildings reference should be made to the guidance on rendering provided by heritage bodies.

2 **GBG18** ***Choosing external rendering*** **(BRE, 1994)**. This Good Building Guide offers guidance on the appropriate selection of renders for a range of masonry types and exposure conditions. Although, it does not cover flood issues, resilient render specifications can be selected from this document to suit the masonry wall.

3 **Digest 410** ***Cementitious renders for external walls*** **(BRE, 1995)**. This provides good practice in application of renders. It does not mention flooding, but the specification issues are relevant.

4 **GBG23** ***Assessing external renders for repair or replacement*** **(BRE, 1997a)** and **GBG24** ***Repairing external render*** **(BRE, 1997b)**. Both guides are relevant to identifying damage and deterioration of existing render finishes. They can be referred to for repair of cracks, crazing and hollowed areas of render.

5 ***External rendering appearance matters*** **(BCA, 1999)**. This British Cement Association report is similar to the British Standard in its coverage. It does not discuss flood issues, but the good practice identified should be followed.

The use of a render to repair a building where there was previously no render will significantly affect its appearance. Before progressing with rendering, consult the local planning authority.

There are also some practical difficulties associated with the use of a render. Before undertaking render work, assess:

- the position of down-pipes on the wall, as they may need to be removed, repositioned and/or replaced
- alterations to sill projections from windows and reveal details. The use of the render should not compromise the performance of the windows. Preserve oversail and throating designs for weathertightness
- the extent of the render. It would not normally extend below the damp-proof course (dpc), as it is likely to be damaged by frost and cause a potential bridge to the dpc. If the brickwork is well sealed by the render above the dpc the area below will therefore form a weak point in a flood. Alternative means of sealing the brickwork below the dpc are required, which might include repointing or the use of an adhesive bituminous coating.

Initial costs and whole-life issues. Applying a render is expensive, but, if properly applied, it is likely to last for at least 30 years, so the associated whole-life costs may be more justifiable. Apart from painting, maintenance levels are generally low.

4.4.3 Level C standards of repair

Repointing

At this level of risk the external masonry walls should be repointed as described for Level B, even when the incidence and amount of water leakage in a previous flood has not been significant.

Proprietary renders

Resilience and resistance. As an alternative to repointing masonry, where it is possible, a proprietary render finish (eg polymer-modified system) can be applied. This will reduce the water penetration as described for Level B. Proprietary systems only, as opposed to site mixes, are recommended because there is greater quality control over the product and its application.

This option can be considered where it is technically feasible and there are no aesthetic objections.

Specification. For proprietary renders the manufacturer's instructions for application should be followed. Methods of application include hand trowel and machine (spray appliances).

Rendered external wall insulation systems are also available, which may serve to upgrade the building's thermal performance as well as improving its flood resilience and resistance. Care is required in the selection of insulation materials: rigid closed-cell materials that do not absorb water should be used in preference to mineral wools that take up water and are liable to damage or loss of form. Systems that incorporate insulation should be fixed securely – by mechanical fixings, for example – to prevent movement of the insulation in a flood. For proprietary renders and those intended for external wall insulation the manufacturers should have third-party certification of their products (check with the British Board of Agrément or BRE Certification that certificates are valid and up to date).

Site-mixed hydraulic lime:sand mixes can be used for render on historic buildings. Use the requirements set out above and consult historic building agencies.

Initial costs and whole-life issues. The initial costs of proprietary render systems are high. If well applied, however, proprietary renders require minimal maintenance and have lifetimes in excess of 30 years. The through-life and whole-life costs are therefore relatively low.

Flood protection products

Use proprietary flood protection products (to BSI kitemark standard) where a render system cannot be used, for example for aesthetic reasons or on a listed historic building. Types of products and requirements are set out in Section 4.18. Flood protection products hold back floodwater to prevent it entering a building and can reduce the damage caused.

Warning. Flood protection products should only be used to hold back floodwater to a maximum depth on the wall of 1 m. The pressure exerted by water deeper than 1 m can cause damage to the structural integrity of a building. If the flood depth exceeds this height, water should be allowed to enter the property.

Resilience and resistance. Flood protection products can reduce the risk of water leakage through the outer wall. Use flood protection where there is difficulty in achieving structural watertightness using standard construction techniques.

Specification. Descriptions of products and advice on specification are given in Section 4.18. The types of products that can be used to protect the outer face of the walls are as follows:

- permanent flood defences such as impermeable perimeter walls around the property
- temporary free-standing barriers, which hold back floodwater locally from a detached building or group of buildings. There may be some restrictions on their ability to withstand flowing water
- removable household products, such as flood boards or air-brick covers, are fitted as a temporary measure to stop water leaking into the building through doors, windows and air-bricks
- flood skirts are products that are designed to wrap around a property to a maximum depth of 1 m above ground level. They provide temporary protection of external faces of buildings, so preventing floodwater from seeping through the building fabric as well as through openings
- specify products that meet the BSI kitemark scheme in preference to those with no certification or history of use.

Initial costs and whole-life issues. The costs of flood protection products are highly variable. Some household products cost little and usually removed after each flood event. Permanent flood defences are expensive to construct but have minimum maintenance requirements and lifetimes of 25 years or more. These should not be constructed without liaison with the appropriate regulator (eg Environment Agency, SEPA).

Tanking

Walls can be "tanked" externally both underground and normally up to a height of 1 m above ground level. Tanking seals them and should be used in conjunction with proprietary flood defence products to door openings and air vents etc.

Resilience and resistance. Tanking is resistant to the effects of floodwater. It normally provides effective sealing between the horizontal and vertical members of the basement.

Specification. Apply tanking to the requirements of BS 8102:1990 and BS 8000-4:1989. The type of building will determine the tanking specification required. Some buildings such as car parks can tolerate a certain amount of moisture ingress from the surrounding ground. Occupied buildings should resist all forms of moisture. The jointing between the horizontal and vertical damp-proof membranes is particularly important to maintaining moisture resistance. A high standard of workmanship is required for tanking work, as repairs are difficult and expensive to carry out.

Initial costs and whole-life issues. Tanking will be expensive to use in repair. However, if properly applied it will require no maintenance over the life of the building, thus the through-life costs will be low (see Figure 4.5).

Figure 4.5 *Basement tanking – internal membrane application*

4.4.4 Structural collapse issues

Masonry walls

If structural collapse or damage has occurred to walls, repairs should be undertaken so that they will be resistant to any future flood. The nature of the repairs required will depend on the type of wall and level of damage; advice should be sought from a suitably qualified structural engineer.

Where structural damage has occurred, use the same level of repair regardless of the level of risk assessed. General principles on the repair requirements are given below.

For any type of wall with structural damage the extent of damage should be assessed and the building must be appropriately supported before repair work.

Resilience and resistance. The reconstruction of a wall that has been structurally damaged by flood should include improvements in the flood resilience and resistance commensurate with the level of risk. Careful attention should be paid to the filling of mortar joints and detailing around windows and doors. The use of renders or water repellents will improve the ability of masonry to resist water ingress.

Specification. Reconstruction of the masonry will minimise the potential for water leakage through the mortar beds and the masonry units. Increase the hydrated lime content in the mortar to reduce drying shrinkage and cracking. In general, use a mortar of no stronger than designation (iii) according to BS 5628-3:2001, but check this against the strength required to maintain the structural integrity of the building. Fill the mortar joints (both horizontal and vertical) in accordance with the good practice guidelines set out in Report BR352 (BRE, 1998).

Concrete blocks with a minimum strength of 7 N/mm^2 should be used for repair of blockwork.

The number of wall ties used per square metre area of wall should be increased to enhance the strength of the composite action of the two leafs in a cavity wall.

Where a cavity exists, cavity insulation should be water-tolerant (closed-cell insulation boards). The rigid cavity insulation boards must be properly attached to the inner masonry leaf.

Timber and steel frames

Use good-quality treated timber to replace damaged structural timber components. As the strength of timber frame depends to a considerable extent on the composite action of the frame and cladding, the connection to the sheathing, or other component providing lateral resistance, will be vital for good performance. For advice, use BS 5268-2:2002 on the structural use of timber.

Replace any damaged steel-frame components. Once again the composite action of the frame and wall cladding dictates the strength of the wall. New members must be fully integrated into the structural system.

Repair damaged cladding to prevent water ingress from driving rain. For brickwork cladding, adopt the approach described above (ie repointing or rendering).

4.5 STANDARDS OF REPAIR FOR THE INTERNAL FACE OF EXTERNAL WALLS

4.5.1 Level A standards of repair

If internal plasterboard, plasterwork or finishes are damaged they should be repaired to the original specification. However, there are some cost-effective changes that can be made to prevent future flood damage.

Gypsum plaster

Gypsum plaster is commonly used in construction work and is applied directly to internal masonry surfaces.

Resilience and resistance. Gypsum plaster can be damaged in floods of significant duration; short-duration floods are unlikely to cause significant damage. Gypsum plasters may be selected for replastering work so long as there is little or no risk of future flooding. Wet-applied plaster works in a similar manner to external render in sealing the masonry surface and slowing water contact with the masonry, thereby preventing water from saturating or passing through the wall. Hydraulic lime:sand-based plasters and cement:hydrated lime:sand-based plasters are more resilient to floods of significant duration than are gypsum plasters.

Specification. The following standards apply to plasterwork.

1 **BS 5492:1990** is the code of practice for internal plastering. It sets out requirements for wet plastering using a variety of materials.

2 **Report BR352** (BRE, 1998) can be used for general advice for internal walls. Bonding coats or stipple-coats may be required on dense concrete or concrete blocks. Some suction (by the masonry units on the fresh plaster) is required to achieve a good bond, but this should not be excessive otherwise too much water will be lost from the mix. High-suction surfaces can be wetted with care before plastering to reduce the degree of suction. For lightweight aerated concrete blocks a bonding agent can aid the plastering process.

3 **BS 8000-10:1995** is the code of practice for workmanship on building sites for plastering and rendering. It sets out good practice in the application of plasters that should be followed. If the masonry surface is likely to remain damp or salts appear from drying then plastering work may need to be delayed until the masonry is dry and/or efflorescence has stopped. A cement:sand mix of 1:5, with water-proofing additives, can be used quite successfully on poor masonry backgrounds.

4 **BS EN 998-1:2003** provides the specification for mortar for masonry including both rendering and plastering mortars. It gives a further choice of materials for mortar mixes.

Lime-based plasters were traditionally based on slaked lime:sand mixes. They are still widely available, but have largely been replaced in general building work by the quick-drying gypsum plasters referred to above. However, lime-based plasters have excellent durability and offer good resistance to water and moisture in internal environments (see *Hydraulic lime mortars for stone, brick and block masonry* – Donhead, 2003). For repairs, lime-based plasters should be used in preference to gypsum-based plaster.

Initial costs and whole-life issues. There is little variation in the cost of different wet-applied plasters, so always use the most flood-resistant approach. The lifetime of well-applied plasterwork is in excess of 30 years in normal use and can reach a building's lifetime of 60 years. Whole-life costs are low, therefore, as little maintenance is required.

4.5.2 Level B standards of repair

Plasters and finishes

Resilience and resistance. The approach to plastering work has been described in Level A above. At this level of risk, gypsum plasters are to be avoided for repair.

Specification. Plasters based on lime:sand or cement:lime:sand mixes represent the preferred options for flood resilience.

Initial costs and whole-life issues. As described above for Level A.

Tiling

Resilience and resistance. An alternative to a plaster finish is to change to a tiled finish. The tiles will normally be applied to a plaster on the masonry wall. Ceramic tiles or similar can be resilient to flood and, provided they are well applied, they will reduce water damage or the passage of water through the wall. Waterproof adhesive should be used to prevent failure of the fixings after a flood event.

Specification. A good coverage of tile adhesive should be applied to the tile and/or the plaster on the wall. Newly applied plaster should be at least 28 days old before this is carried out. Grouting should proceed between 24 and 72 hours after fixing. Tiles should not be butt-jointed without spacer lugs and nor should thin-bed adhesives be used if the wall substrate level varies.

Initial costs and whole-life issues. Tiles are durable materials that do not need maintenance and the main costs will be from installation. Costs to carry out tiling work are medium, but take into account the cost of repairing underlying plasterwork. Tiles require minimum maintenance over their lifetime. Re-grouting at intervals of 10 years or so after a flood may be required. The whole-life costs are therefore low to medium.

Plasterboard

Often plasterboard will be removed to allow inspection of the wall, decontamination and drying (see Figure 2.4), so it may be necessary to repair the plasterboard even when it has not been directly damaged by the flood. This provides an opportunity to improve the flood resilience. Do not reuse damaged plasterboard.

Resilience and resistance. Plasterboard will not necessarily be damaged by short-duration floods, but it can delaminate in longer-duration events. The amount of damage depends on the condition of the plasterboard before the flood. In good condition it has higher resilience.

Cement-based wall boards are more resilient to the effects of floodwater. They are often used in bathrooms and similar locations where the humid environment would cause gypsum-based plasterboard to deteriorate.

Specification. Plasterboard is normally either mounted on timber or steel battens or on plaster dabs. Insulated plasterboards are also commonly available.

Where whole plasterboards are damaged they should be replaced with whole new boards. For smaller areas of damage, support should be provided around the area of repairs and the new pieces fixed securely to the new supports. The replacement piece of board needs to be fixed into place before the joints are filled and lightly sanded smooth or a skim plaster applied.

Plasterboard can be mounted horizontally as opposed to vertically. This can be useful if floodwater has affected only the bottom half of the boards, and this will reduce the quantity of replacement boards required in a future flood. The methods of application, such as attachment to timber battens, are substantially the same for horizontally as for vertically hung plasterboard.

Initial costs and whole-life issues. The use of new plasterboard to replace damaged plasterboard does not imply a substantial initial capital cost. However, plasterboard will be at risk of damage in flood, leading to high repair costs. The whole-life costs are likely to be high in comparison with fully resilient wet-applied plasters. Using cement-based board in place of gypsum plasterboard will not significantly alter the initial costs, but may reduce whole-life costs.

Cement-based boards

Resilience and resistance. An alternative to using plasterboard is to use cement-based boards. These have greater flood resistance and resilience than plasterboard. There is a risk that they will deteriorate in longer-duration floods.

Specification. Cement boards should be hung vertically in a similar manner to traditional plasterboard. For additional resilience, the board can be hung in the horizontal plane.

Initial costs and whole-life issues. The use of cement-based boards is slightly higher than plasterboard, but the through-life costs are low.

4.5.3 Level C Standards of repair

At this level of risk it will be necessary to replace damaged gypsum plaster with a more resilient finish, to reduce the cost of future floods. The potential approaches are the same as for Level B risk, including resilient wet-applied plaster, tiles, cement-based boards and horizontally hung plasterboard. Avoid the latter two options in preference to wet-applied plaster or tiles.

Flood protection products

Use proprietary flood protection products where there is a high risk of flood occurring. The product types and requirements are set out in Section 4.18. These products are intended for external use on the building, and if they can prevent floodwater entering the building they will protect the inner walls.

4.6 STANDARDS OF REPAIR FOR WALL CAVITIES

The main impact on wall cavities from a flood is to the insulation that is often contained within them. This could include closed-cell rigid board types, soft batt-type boards or loose blown-in insulation.

Other materials that could be affected are cavity wall ties and cavity trays.

4.6.1 Level A standards of repair

Insulation

Resilience and resistance. Different insulation materials vary in their flood resilience and resistance.

Closed-cell insulation boards have good resistance to floodwater. There is a risk of closed-cell partial-fill insulation boards becoming dislodged from the inner leaf, resulting in poor thermal performance and susceptibility to penetrating damp from driving rain following the flood. If the boards are well fixed then they are less likely to move in a flood.

Soft batt-type insulation, such as mineral wool, may slump within the cavity during a flood and can slow down subsequent cavity drying. This insulation has some resilience to flooding and if it does not slump it can dry out.

Blown-in types of insulation can dry out after a flood, but certain types may slump when saturated by a flood.

Specification. At such a low level of risk, consideration need not be given to changing the specification of the materials. Improvements can be made where it is necessary to replace damaged insulation. Repair can be effected with partial-fill cavity insulation fixed firmly to the inner leaf of masonry to obviate movement in the event of flood. This repair would require access to the internal leaf via the outer leaf, which would need to be in part of fully removed. At this level of risk undertake this action only if the outer wall needs to be rebuilt.

An alternative is to use blown-in plastic bead or mineral wool insulation. This can be injected into the cavity wall after the existing insulation has been removed.

Initial costs and whole-life issues. The initial costs are low if the original insulation and other cavity components can be left in place. Where extensive work is required to replace cavity insulation then initial costs will be high. Little maintenance is required to wall cavities, so through-life costs will be low.

Wall ties

Specification. Replace any corroded wall ties. Use stainless steel ties to ensure that they are resistant to moisture.

Initial costs and whole-life issues. *The component life manual* (HAPM, 1997) provides guidance on the various lifetimes of wall ties. A lifetime of at least 30 years can be expected from stainless steel internally in buildings.

4.6.2 Level B standards of repair

Resilience and resistance. Wall cavities are present in both masonry cavity walls and framed walls of timber or steel. The most vulnerable element is likely to be insulation that has been added to the wall cavity. It is preferable to maintain a clear wall cavity, ie between the outer leaf and the insulation, in order to drain any water that enters the cavity during a flood.

For walls with insulation in a cavity, the resistance and resilience of the outer wall should be improved through repointing or applying an external render. This reduces the risk of floodwater damaging the insulation in the cavity.

Specification. The difficulty of replacing existing full cavity fill without removing masonry or internal surface finishes means that other means of protecting the cavity are preferred, unless it is necessary to repair or rebuild the outer wall. Protect the cavity by increasing the resistance of the wall to the passage of floodwater.

The cavity, and the insulation contained within it, should be protected from the ingress of floodwater. Address the potential entry of floodwater through the following:

- for the outer wall of the building, use the guidance above (see Section 4.4)
- for the inner wall the use of hard, moisture-resistant plaster on masonry inner leafs could prevent water ingress to the cavity
- the wall-to-floor junction and the skirting boards should be well sealed. Use good-quality sealants that are resistant to moisture and sunlight and have excellent long-term adhesion to masonry and/or timber surfaces
- for framed walls, plasterboard has to be used, so good sealing of junctions between boards and at the floor junction is essential to prevent water ingress. Moisture-resistant wall finishes will also help to resist moisture ingress through the inner leaf with plasterboard
- use stainless steel cavity wall ties to replace corroded or damaged existing ties.

Initial costs and whole-life issues. The issues have been discussed earlier and are substantially the same with respect to wall cavities.

4.6.3 Level C standards of repair

At this level of risk, protection of the wall cavity is essential. The approach is the same as described for Level B. In addition, flood protection products should be used to protect the outer wall.

4.7 STANDARDS OF REPAIR FOR RISING DAMP IN MASONRY WALLS

4.7.1 Level A standards of repair

No Level A repair is appropriate, as a failed damp-proof course will always require repair to a higher specification (see Level B and Level C repairs below).

4.7.2 Level B standards of repair

Resilience and resistance. Capillary rise of moisture through brick, concrete block or other porous materials is a real risk if the floodwater reaches above the damp-proof course (DPC). All porous materials are subject to some level of capillary transfer of water. Dense concrete and engineering clay brick are not subject to significant capillary rise. However, porous clay bricks can allow capillary rise to a height of at least 1 m above the level of the floodwater.

Specification. Several options are available to reduce rising damp in outer and inner walls of masonry.

1. **Secondary chemical DPCs**. The installation of a secondary chemical DPC into a masonry wall can control capillary rise through the wall. Only consider the use of a chemical injection DPC if there is a risk that rising damp will damage parts of the structure that are not affected to the flood depth.

   Chemical injection systems require careful installation and they cannot be applied effectively in some types of wall. Older walls with irregular masonry units and rubble fill are particularly difficult to treat, as are wider, solid-masonry walls. It may be necessary to treat both leafs of a cavity wall. Use BS 6576:1985 for advice on the installation of chemical injection DPCs.

2. **Physical DPC membrane**. Use a plastic DPC at a depth just above that where flood will reach (1 m). This would involve cutting a masonry unit course and mortar joint out of the wall in order to install the DPC. The DPC would prevent the capillary rise of water above the flood level, thereby limiting the potential for frost damage, efflorescence and water penetration to the inside of the building. Use the guidance in BS 8215:1991 and BS 8000-4:1989 for installation of membrane DPCs.

3. **Physical DPC masonry**. Use engineering bricks or natural slate in the wall. These materials would need to be cut into the wall to replace existing masonry courses to a height just above the point where the flood will reach (1 m). The practicalities of carrying out this work and the aesthetic impact need to be carefully considered.

Initial costs and whole-life issues. A well-applied chemical injection system can last at least 20 years, so the whole-life costs could be high, especially where the first treatment is unsuccessful. The installation of secondary physical DPCs might involve high installation costs. The through-life costs would be low, as no maintenance would be required for the 25-year lifetime and the protection afforded to the walls would result in cost savings.

4.7.3 Level C standards of repair

Resilience and resistance. Follow the requirements for Level B risk. The main difference is where structural damage has been caused to the wall in a flood and extensive repairs are required. Consider rebuilding with strong engineering brick.

Specification. The construction of walls in clay engineering brick with a BS 5628-3:1992 designation (i) mortar will effectively form a damp-proof course. There will be little capillary rise of moisture through this form of brickwork. Since the pressure from the water is lateral, however, a designation (iii) mortar may be more effective, as the potential for cracking will be reduced.

Initial costs and whole-life issues. The high initial costs of these works will be returned through the low maintenance costs involved and the protection from damage afforded to other parts of the wall and building.

4.8 STANDARDS OF REPAIR FOR INTERNAL WALLS AND PARTITIONS

This section details the standards of repairs for internal walls and partitions, including masonry partitions, timber frame with plasterboard, steel frame with plasterboard and framed party walls. Floodwater can damage timber, metals and plasterboard. For clarity, internal walls are those that are only internal to a building, ie not the internal leaf of a cavity wall or the internal side of a timber-frame wall.

4.8.1 Level A standards of repair

Masonry walls and partitions, and timber and steel frames

At this level of risk the approach to repairing masonry and framed partitions and walls is similar and they are treated as the same for these purposes. The standard of repair is effectively to the original installation standard. However, some repair measures can be taken to improve resilience and resistance at this level of risk.

Resilience and resistance. Internal walls and partitions generally have little ability to resist the passage of floodwater or damage to surface finishes, but improvements can be made.

Specification. Practical measures can be taken to ensure the building will have sufficient resilience and resistance if a flood returns.

Sealing

Seal the junctions between walls and partitions and floors using good-quality sealants. Remove skirting board before the seals are applied and then replace. Use sealants appropriate for the purpose and of proven quality (specified to the requirements of BS 6213:2000). A good backing system is required for the joint to perform well. Sealants have a limited lifetime in comparison with the building. Check their condition regularly and carry out repair work as necessary. This approach will not work for all combinations of floors and partitions and should only be applied where the joint can be designed for durability.

Insulation in partitions

Replace any damaged mineral wool sound insulation in internal partitions with a tight-fitting, impermeable, closed-cell-type insulation. This is a low-cost refurbishment option that will limit the cost of damage from a similar repeat flood. Remove plasterboard from the partition wall to carry out this work.

Corroded fixings

Replace any corroded fixings with non-corroding types. Use stainless steel masonry fixings where they are load-bearing. Otherwise use galvanised or stainless steel screws and nails.

Initial costs and whole-life issues. The costs of repairs described are minimal. Sealing is a low-cost repair but may offer large savings. Replacement of fixings with more resilient types also costs little and does not generate much additional capital cost. In return the whole-life costs are reduced due to the higher durability of these fixings. *The component life manual* (HAPM, 1997) provides guidance on the various lifetimes of fixings in wall and cladding environments. A lifetime of at least 30 years could be expected from stainless steel or galvanised fixings internally in buildings.

4.8.2 Level B standards of repair

At this level of risk it will be necessary to take measures to improve the flood resilience and resistance of internal walls. Different types of internal partitions and walls will be involved.

Masonry walls and partitions

Resilience and resistance. Internal masonry walls and partitions have good resilience to floodwater, but the plaster and plasterboard finishes may deteriorate. Gypsum-based plaster and plasterboard is vulnerable to deterioration in a flood. Cement and/or lime-based plasters and plasterboard have greater resistance to floodwater.

Specification – plaster and plasterboard. Replace gypsum plaster with hydrated cement:lime:sand or hydraulic lime:sand-based equivalents. The methods of application will be the same as outlined previously for the internal leaf of external walls. The use of cement- or lime-based plasters in place of gypsum has no impact on the positioning of electrical services, conduits, skirting boards and floor finishes.

Gypsum plasterboard could be replaced on masonry partitions with resilient plasters. Suitable types of plaster and methods of application are as described for external masonry walls. It is possible that electrical services have been hidden in the void behind plasterboard and these will need to be accommodated in conduits or chased into the wall if plaster is used instead of plasterboard. Ideally, electrical installations should be moved during this repair work. The position of skirting boards may also require adjustment to accommodate this change.

Alternative means of improving resilience are as follows:

- use cement-based boards as opposed to gypsum-based plasterboard. These products have greater resistance to floodwater
- use horizontally mounted gypsum plasterboard as an alternative for flood depths to 1 m. The plasterboard differs from the original specification only in being horizontally hung rather than vertically hung. This reduces the costs of replacement in the event of a flood. This is a cost-effective option where a change to plaster could necessitate major works to accommodate electrical services, skirting boards and conduits.

Initial costs and whole-life issues. The use of wet-applied plaster or replacement plasterboard will have high initial costs. However, when well applied there will be little maintenance required for wet plaster over a 30-year lifetime.

Cement-based boards will be more expensive than gypsum boards, but will have lower cost over time. Hanging plasterboard horizontally rather than vertically is cost-effective initially and over time, although in subsequent floods there will still be repair costs.

Timber and steel-framed partitions

Resilience and resistance. Timber and steel-frame partitions are generally clad with plasterboard, although early examples may be fibreboard. There is a risk of water leakage into the partitions and rot or corrosion can follow. The resilience of the timber partitions can be improved, but this will involve using plasterboard, in the manner described above, as wet-applied plaster is not an option for frame construction.

Specification. Options to improve the flood resilience and resistance of timber and steel-frame partitions include the following:

- seal the junctions between walls and partitions and floors using good-quality sealants. Two-part polyurethane and polysulfides are available as well as one-part silicones. Protect sealants using cover strips or decoration in order to avoid deterioration from UV light
- replace mineral wool insulation in internal partitions with closed-cell type insulation. This is a low-cost refurbishment option that will limit the cost of damage from a similar repeat flood. To replace the insulation first remove plasterboard from the partition wall. Where appropriate, the replacement plasterboard can be hung horizontally
- replace damaged or deteriorated timbers with treated timber
- replace corroded steel frame members with galvanised steel equivalents.

Initial costs and whole-life performance. A lifetime in excess of 20 years can be achieved from some sealants, but occasional maintenance will be required.

Internal doors

Resilience and resistance. In domestic properties internal doors are typically timber. These can be solid, especially in older properties. Provided that the doors are in good condition, they will generally be resilient to short-duration flooding. Good maintenance is the key to ensuring they do not become affected by floodwater. Hardwood doors are particularly resistant to floodwater. Softwood doors are common and, provided they are in good condition and not subject to water absorption, permanent damage is unlikely to occur.

Hollow-core doors are common, especially in buildings constructed since 1945. Water that penetrates these doors can destroy them and replacement will be necessary.

Specification. Replace internal doors in domestic buildings with resistant types such as solid timber doors. Finish the door properly with a high-build paint system. Paint the doors before hanging so that the sides and bottom are fully covered.

Doors can be hung on hinges that allow their easy removal, so that the doors can be lifted during floods and damage prevented.

In non-domestic buildings the range of internal doors will be greater and includes glazed doors, steel doors and fire-resistant doors. These types of doors are typically resistant to floodwater, but their condition needs to be checked.

When replacing fire-resistant doors particular care should be taken that the correct rating is obtained. Fire-resisting doors should have appropriate third-party certification and be tested accordingly.

4.8.3 Level C standards of repair

At this level of flood risk the standards of repair will be substantially the same as for Level B. The main difference is that structural damage is a high probability. If hydrostatic pressure in the flood has caused structural damage to internal walls and partitions then particular care should be taken in the process of repair. Flood protection products should also be used to improve the resistance of the building.

Specification – masonry walls and partitions. These will be formed from concrete blocks, brick, mortar and ancillary components. They should be replaced with a type of high strength, especially high flexural strength. The preferred option would be for high-strength concrete blocks (at least 7 N/mm^2) or brick, with an appropriate mortar, no stronger than designation (iii) according to BS 5628-1:1992 and BS 5628-3:2001. Where the walls are subject to high vertical stresses, stronger mortar may be necessary.

A cement:hydrated lime:sand mix can supply strength as well as flexibility and is less likely to have cracks than a cement:sand mix. Joints in the masonry should be fully filled with mortar to prevent water entry through gaps. Position wall ties as advised in BS 5628 and only use corrosion-resistant types.

The use of brick or high-strength concrete blocks may affect the thermal and acoustic performance of the building. Where a cavity exists this could be filled with rigid insulation boards that are not affected in any way by contact with water.

Provide a seal between the walls and partitions and floors after completing the main structural repair.

Use flood protection products on the outside of the building to protect it in the event of future floods. Preventing water, fully or partially, from entering the building will avoid or reduce the damage caused to internal partitions.

Timber and steel frames

Damaged timber-frame components should be replaced using timber of suitable quality. As the strength of timber frame depends to a considerable extent on the composite action of the frame and cladding, the key to good performance will be the connection to the sheathing or other component designed to resist lateral forces. A double layer of plasterboard, installed horizontally, will provide some additional strength. An alternative is to add bracing to the frames.

For steel frames, any damaged elements should also be replaced. Once again, the composite action of the frame and wall cladding dictates the strength of the wall. In this case, a double plasterboard layer could be used or additional steel framing added.

Provide a seal between the walls and partitions and floors after completing the main structural repair.

Flood protection products should be used on the outside of the building to protect it in the event of future floods. Preventing water from entering the building will avoid or reduce the damage caused to timber and steel frame partitions, including the insulation and finishes.

Initial costs and whole-life performance. The initial costs of rebuilding masonry walls and framed walls to a higher specification will be significant. However, when well constructed there are few maintenance requirements over time. Whole-life costs are therefore low to medium.

The initial costs of flood protection products can be high, but through-life costs typically are low.

4.9 STANDARDS OF REPAIR FOR FENESTRATION

Various repair options are available for fenestration, dependent on the assessed risk. Short-duration flooding is unlikely to cause damage to particular types of door or window, except that low-level glass panels may be broken by the pressure exerted upon them. However, floodwater can breach the seals of the doors and windows and additional protection will be required. This section discusses the options available for Levels B and C standards of repair. At Level A the repairs required will be no more than to replace the original specification of the doors, windows, glass and hardware.

The rest of this section provides details on repairs to improve both the sealing of the windows and doors into the wall, and frame and glass issues for windows and door leafs. For resilience and resistance of internal doors, see Section 4.8.2.

4.9.1 Level A standards of repair

Replace doors, windows, glass and hardware to the original specification where repairs are required. If there were problems with rain penetration around doors and windows then repair will be required in any case.

4.9.2 Level B standards of repair

Sealing of door and window frames into buildings

The sealing of the window or door frame into the building is as important to restricting the passage of water to the inside of the building as sealing the brickwork effectively. In general, silicone, polyurethane or similar sealants are used for both door and window frames to bridge the gap between the frame and the surrounding wall.

Resilience and resistance. Good-quality sealants that are well adhered to the masonry or window frames restrict the passage of water in the short term. Longer-duration floods may still result in leakage into the building.

As well as the outer sealant, windows and doors normally have a vertical damp-proof course attached to the frame. This diverts any penetrating water down the cavity and to the outside.

Specification. Carefully cut out the sealant if it is in poor condition or has been damaged by the floodwater. Clean and allow the area to dry before applying the new sealant. Fill the joint with a sufficient amount of sealant. For certain sealants a primer may be required on the window frame and wall; check with the supplier. BS EN ISO 11600:2003 provides a classification for the requirements for sealants. BRE IP25/81 (BRE, 1981b) provides further information on the selection and performance of sealants.

Joints wider than 10 mm can be difficult to fill properly. Use backing strips and fillers so that the joint is properly sealed.

Check the condition of the damp-proof course visually as far as possible when a joint is opened up. Make sure it has not become dislodged or damaged by the floodwater entering the wall.

Advice on the sealing of windows and doors is provided in BS 8213:1990, although this is mainly concerned with general installation issues.

For replacement of windows in some areas, approval may be required from the conservation office of the local planning authority.

Initial costs and whole-life issues. The initial cost of sealant repairs is low and provides substantial benefits for resilience and resistance if effected correctly. Although the sealant will have a lifetime perhaps as short as 10 years, the low cost of replacement work at ground-floor level means the whole-life costs are also low.

Sealing of windows and doors into their frames

Resilience and resistance. Water can enter the seals between the opening leaf of the door and the surrounding frame, and between the opening and fixed parts of window frames. If water has entered these areas then the weatherproofing seals may not be present, may be damaged or be in need of replacement.

Specification. Although various weatherproofing materials are available, they are intended for driving rain and are not designed to withstand standing water. The type of weatherproofing that can be fitted is partly limited by the existing windows and doors. Fitting the wrong type of weatherproofing may cause distortion of window frames or door surrounds.

Further general advice on weather-stripping of doors and windows is provided in Report BR352 (BRE, 1998) and BRE IP16/81 (BRE, 1981a). Avoid painting over weather-strips and gaskets, as this will impair performance.

Initial costs and whole-life issues. The installation or replacement of weather-stripping has low initial capital costs. The work can be carried out quickly and with minimal disruption to the building occupants or other works. The weather-strips when well installed have limited maintenance requirements. Weather-strips and gaskets have lifetimes of up to 20 years, depending on the exposure conditions, so whole-life costs are low.

Glass in doors and windows

Fully bedded frames use sealants and glazing compounds to prevent moisture from making contact with the edge seal of the insulating glass units and penetrating through the frame to the building. Drained and ventilated frames rely on gaskets or glazing strips to resist water, but any water that breaches these barriers is drained and vented away from the frame.

Resilience and resistance. Glass can break under a sufficient hydrostatic force of water, the risks being higher for single-glazed than for double-glazed windows or doors.

Sealed insulating glass units (IGUs) in doors or windows that have failed (identified by condensation on the inside surface of the glass) need to be replaced. A good-quality edge seal of an IGU is unlikely to fail where there is short-term contact with floodwater. However, the frame needs to be drained and dried out quickly after the flood.

Specification. If glass or frames have broken or cracked during a flood it is obviously necessary to replace the glass or whole door or window. In the case of glass replacement, care is required as unsuitable glass can damage the window or door frame (BS 6262:1982). Normal annealed glass may be replaced with toughened glass, which is four times stronger and may be heavier. In areas near to ground level, safety glass should always be used. Relevant standards for safety glass are BS 6206:1981 and BS EN 12600:2002; specify heat-soaked toughened safety glass.

Install glass to the requirements of BS 6262:1982), BS 8000-7:1990 and Digest 453 (BRE, 2000). Although flooding is not considered within these standards, the requirements for setting blocks, location blocks and distance pieces are to be followed. The glazing sealants and gaskets will be resistant to floodwater. Use sealant capping for the external glazing seals to increase flood resistance.

Failed insulating glass units should be removed from the window or door frame and replaced with a good-quality unit specified to BS EN 1279:2002. Unit suppliers will also be able to provide advice.

Initial costs and whole-life issues. The initial capital cost of replacement glass is high. There is an additional cost of specifying toughened as opposed to annealed glass. Good-quality insulating glass units to BS EN 1279 may require a higher initial capital investment, but their increased durability will reduce the through-life costs.

The cost involved in supplying a sealant capping to the glazing system is minimal even if it needs to be replaced at 10-year intervals.

Frame repair

Cleaning door and window frames and glass replacement is important. Dirt and contamination may have entered the rebates between the opening and fixed parts, or penetrated glazing rebates. Open and clean the rebates of doors or windows. If any hardware has been damaged or corroded then it should be replaced with suitable non-corrosive components. If water has entered the glazing rebate between the frame and the glass, which is possible where the frames are a drained and ventilated type, then it may be necessary to remove the glass and clean the frame.

Replacement fenestration

Resilience and resistance. Timber door and window frames in poor condition could give rise to damage and deterioration. A good surface finish to a timber door will help avoid moisture absorption by the timber during a flood. PVC-U doors and windows are resistant to moisture. Steel and aluminium frames will not be directly affected by moisture in the short term, but in the longer term corrosion can occur and poor condition will enhance corrosion.

Specification. Use PVC-U doors, which are not subject to absorption of moisture. Because they do not contain reinforcement, fillers and insulation in door panels, they must be sealed to avoid water penetration into these areas. Replacement windows and doors need to comply with the requirements for thermal performance as described within the Building Regulations (Part L1/L2). In conservation areas and in historic buildings the use of PVC-U windows is typically restricted and advice should be obtained from the local planning authority on suitable replacement windows.

Standards for different types of doors are available. However, these have not been written from the perspective of flood resilience and resistance. The standards are BS 4787-1:1980 for timber door sets, BS 6510:2005 for steel door sets, BS 5286:1978 for aluminium door sets and BS 7412:2002 and BS 7413:2002 for PVC-U door sets. Specifying to these standards is preferred, although it does not imply flood resilience or resistance properties.

Where doors do not need to be replaced but the finishes are in poor condition, repainting should be undertaken. Good-quality water-borne paints and stains may be applied to external timber doors. High-build systems that include primer, undercoat and topcoat can be applied to form a high-build finish. Maintain the external finish on a regular basis and repair any cracking or deterioration. Report BR352 (BRE, 1998) provides general advice on external paintwork. Follow the British Standards on painting, BS 7664:2000 (undercoats and topcoats) and BS 7956:2000 (primers). Use microporous paint systems to allow timbers to dry without warping.

It is preferable to remove doors from their hinges to carry out the painting. This will allow access to the bottom and sides of the door, which is otherwise restricted when the door is hung.

4.9.3 Level C standards of repair

Flood resilience and resistance options for doors, windows and glazing have been described for Level B, and these methods may also be applicable where there is a Level C risk. In addition, proprietary flood protection methods may be used to increase the flood resistance for Level C risk.

Flood products

Resilience and resistance. Several products are available for use with doors and windows. These are demountable and require the property-owner to use them when there is the risk of a flood. The products are referred to as flood boards (see Section 4.18). They can withstand floodwater for up to 24 hours.

Specification. Flood boards slot into a frame that is attached to the surrounding wall.

Flood products that carry the BSI kitemark should be used in preference to those without quality assurance.

4.10 STANDARDS OF REPAIR FOR SOLID FLOORS

Ground-floor construction usually falls into one of two categories: solid or suspended. This section, through to Section 4.14, describes the standards of repair for solid, suspended concrete, floating and suspended timber ground floors. Guidance on floor construction and the provision of damp-proof membranes, including the materials used, is given in BR332 (BRE, 1997d).

Solid floors are likely to consist of concrete, insulation, damp-proof membranes, screeds and finishes. Suspended floors can be formed from timber or concrete (usually beams infilled with concrete or concrete blocks). Floating floors have become more common in recent years, and involve a timber decking or screed being placed on insulation and then a concrete base. They are used for both solid concrete and suspended concrete floors. Water ingress into such floating floors can be difficult to repair.

Steps should be taken to prevent dampness from entering the building. Damage to damp-proof membranes should always be repaired.

Upper-storey floors are generally not at risk from flooding, but can be affected by secondary effects (eg arising from condensation and mould).

4.10.1 Level A standards of repair

At this level of risk follow the original specification, although some additional measures can be included.

Resilience and resistance. Solid concrete floors are the most resilient to flooding. They are not normally affected by short-term water exposure. Floods resulting from rising groundwater may cause greater damage.

Specification – floor screeds. If the floor screed is found to be damaged then it either needs to be replaced or repaired. The following options are possible.

1. Any crack through which liquid water can readily transfer under a small hydraulic head needs to be filled or repaired. Use good-quality sealant or proprietary repair materials. Where deterioration of the surface has also occurred, cut out the affected area and repair with a proprietary material.
2. In instances where there is damage or deterioration over one area (as a guide, less than 20 per cent of the total floor area) of the screed, cut out the affected area and repair with a proprietary system.
3. Where there is damage to the screed in more than one area or over more than 20 per cent of the floor area in any room, the damaged screed should be changed for a proprietary dense cement:sand screed (see Section 4.10.2).

Installing new screeds will delay the time in which the floor can be covered, as it needs to set and then dry. Guidance on drying times for new screeds is provided in BS 8203:2001, BR332 (BRE, 1997d), Digest 163 (BRE, 1974) and Digest 364 (BRE, 1991). Drying times vary between eight weeks for a 50 mm screed to 12 weeks for a 75 mm screed. Note that concrete ground-floor slabs require several months of drying.

Initial costs and whole-life issues. The initial costs are low for repairs with sealant. Even though sealants need to be checked and replaced at intervals, the whole-life costs are low. The cost of repairing screeds is high initially, but through-life costs are low.

4.10.2 Level B standards of repair

At this level of risk the resilience and resistance of the floors must be improved.

Screeds

Specification. Replace damaged screeds using the following options.

1. Dense cement:sand of proportions between 1:3 and 1:4.5 (by weight). A thicker screed may be laid to increase resilience and resistance to floodwater, but longer drying times will be required and careful consideration of aggregate size needs to be made. This can also affect door openings and stairs. Use cement-rich screeds for flood resilience, as water will be less able to transfer through the dense concrete.
2. Lightweight screeds are based upon either aerated concrete or lightweight aggregates. They are used for light or medium-trafficked areas, but not generally heavily trafficked areas. Lightweight screeds have resistance to moisture, but not necessarily to the same extent as dense screeds. Only select them for this level of flood risk with care.
3. Screeds based on calcium sulphate, anhydrite binders can be laid in much thinner layers and are useful for thermal insulation (BRE, 1997d). They can be laid with a thin layer of insulation to the same thickness as a cement:sand screed. However,

calcium sulphate screeds have little useful resistance to water contact and will lose strength if flooded for a significant duration. Use only in conjunction with damp-proof membranes to prevent water contact. Their use at this level of flood risk is likely to be severely limited.

Proprietary screeds should be used, as better control over the quality can be exercised and mixing problems and blending are reduced. In all cases the installation must be carefully supervised and be carried out to a high standard.

A sump with pump can be installed at the floor level of the property, which can remove water from the building where natural drainage in the area is still operating. In certain circumstances, forming a sump in the lowest level of the structure and providing a water pump to clear floodwaters will prevent the levels rising in the rest of the building. This could be applied to solid floor or to under-floor spaces where the water is collected at the lowest point. It will be effective only where the cause is flash flooding passing the property and not a general rise in levels.

Hydrostatic pressure of floodwater externally can cause upward pressure and cracking of solid floor slabs. To prevent this, provide pressure release valves within the floor, which can be connected to sump pumps. The sump pump should also be located within a chamber below floor level.

Initial costs and whole-life issues. Repair costs are initially high. However, little maintenance is required, so through-life costs are low and little damage will result from a future flood.

4.10.3 Level C standards of repair

At this level of risk the options to be considered are based on raising the floor level and using flood protection products.

Raising the floor height to above the predicted future flood level will be effective in keeping the internal environment dry during shallow floods. This option is generally only suitable for limited types of property such as large industrial buildings; it is not normally appropriate for housing or smaller buildings.

For the floor level to be increased, the structural floor beams will need to be repositioned. The wall must be capable of maintaining the load applied by changing the level of the floor.

This strategy may involve or require a change of use of the building. For example, garages or amenity spaces may need to be located at ground-floor level and living spaces moved to the first floor and above. The ground floor could then be made resilient through wet-proofing measures.

The structural implications of changing floor levels or changing the use of the building must be taken fully into account. The need to reposition doors and windows can be particularly problematic.

As an alternative to raising the floor level, or as an additional means of protecting the building where only a limited floor level rise is possible, buildings can be dry-proofed with flood protection products.

Initial costs and whole-life issues. The change-of-use costs are initially high. Little maintenance is required, however, so through-life costs are low. The damage from future floods will be significantly less.

The costs involved in raising floor levels are high. Whole-life costs need not be greater than for other levels of risk, but this will depend on the design and construction used.

Pump and sump should be installed at the lowest level of the property, where natural drainage in the area is still operating, to remove water from the building. The costs of pump and sump are moderate for the initial installation; long-term maintenance costs are low.

4.11 STANDARDS OF REPAIR FOR SUSPENDED CONCRETE FLOORS

4.11.1 Level A standards of repair

At this level of risk follow the original specification, although some additional measures are suggested here.

Resilience and resistance. Suspended concrete floors have resilience to flooding and are not normally affected by short-term water exposure. However, damage to under-floor elements, insulation and/or screed may occur (see Section 4.14).

Specification – floor screeds. If the floor screed is found to be damaged then follow the requirements for solid concrete floors (see Section 4.10).

Initial costs and whole-life issues. The initial costs are high for screed repairs. The costs of repair in future floods will be less, reducing through-life costs.

4.11.2 Level B standards of repair

Specification. At this level of risk the resilience and resistance of the floors needs to be improved. The main approach will be to use different screed finishes and seal the floor-to-wall junctions. The guidance for solid concrete floors can be followed as appropriate. Sealing sections of the floor is particularly important with respect to the floor's ability to resist water penetration to the under-floor void.

A pump and sump should be installed below the floor of the property in the same way as for solid concrete floors.

Initial costs and whole-life issues. Repair costs are initially high, but little maintenance is required so through-life costs are low. Little damage will result from a future flood.

4.11.3 Level C standards of repair

Specification. Raise the floor height to above predicted flood level, which will be effective in keeping the internal environment dry during shallow floods. This option is generally only suitable for limited types of property, such as large industrial buildings and is not generally appropriate for housing or smaller buildings.

Raising the floor level will require the structural floor beams to be repositioned. The wall must be capable of maintaining the load applied when the level of the floor is altered.

This strategy could involve, and may require, a change of use of the building. For example, it may be necessary to locate garages or amenity spaces at ground-floor level, moving the living spaces to the first floor and above. The ground floor could then be made resilient through wet-proofing measures.

The structural implications of changing floor levels or changing the use of the building must be taken fully into account. The need to reposition doors and windows can be particularly problematic.

Initial costs and whole-life issues. The change-of-use costs are initially high. However, little maintenance is required, so through-life costs are low. The damage from future floods will be significantly less.

The costs involved in raising floor levels are high. Whole-life costs need not be greater than for other levels of risk, although this will depend on the design and construction used.

Install a pump and sump at the lowest level of the property, where natural drainage in the area is still operating, to remove water from the building. The measures used to dry-proof buildings include the types of measures intended to protect walls and the building as a whole, as described previously.

4.12 STANDARDS OF REPAIR FOR FLOATING FLOORS

Floating floors comprise a timber decking or screed placed on insulation and then a concrete base. They are used for both solid concrete and suspended concrete floors.

4.12.1 Level A standards of repair

At this level of risk follow the original specification, although some additional measures are suggested here, particularly sealing the floor screed to the wall and sealing between sections of the floor.

Resilience and resistance. Floating floors can be badly affected by flooding, allowing water into the insulation layer. Damage to under-floor elements or to the screed may occur (see Section 4.14).

Specification – floor screeds. Undertake minor repairs to the screed and seal the periphery with the walls.

Should the whole screed need to be replaced, remove any damaged insulation and install a flood-resistant (eg closed-cell) type.

Floating screeds, laid directly on to insulation, are based upon cement:sand mixes. The screeds should be 65–75 mm thick. Do not install floating screeds up to other hard surfaces, such as the masonry wall. Leave a slight gap and fill it with either a good-quality sealant (two-part polysulfide or polyurethane or one-part silicone, for example) or sand mastic to resist water.

Initial costs and whole-life issues. If only minor repairs are required, the initial costs are low. Even although sealants will need to be checked and replaced at intervals the whole-life costs are also low.

4.12.2 Level B standards of repair

Specification. At this level of risk the resilience and resistance of the floors needs to be improved. The main approach will be to use different screed finishes and seal the floor-to-wall junctions. The guidance for solid concrete floors can be followed as appropriate (see Section 4.10). The sealing of sections of the floor is particularly important for the ability to resist floodwater penetration to the under-floor void.

The main difference from Level A flood risk is that the floor should be repaired with a new screed and new insulation whatever level of damage has been caused. The repair should use a closed-cell-type insulation that is resistant to water exposure.

Install a pump and sump at the lowest level of the property, as described above.

Initial costs and whole-life issues. Repair costs are initially high. However, little maintenance is required, so through-life costs are low. Little damage will result from a future flood.

4.12.3 Level C standards of repair

The options to be considered are to:

- raise the floor height to above predicted future flood level; follow the advice given for solid or suspended concrete floors (see Sections 4.10 and 4.11)
- consider removal of the floating floor and the use of insulation in different locations, including in the floor void. Alternatively, consider increasing the insulation in other elements of the building to compensate for its removal from the floor. Consideration should be given to the implication for Building Regulations approvals on the amendment of the amount and relocation of insulation
- use flood protection products to prevent water entry into the building, as described for solid concrete floors.

Initial costs and whole-life issues. The costs involved in raising floor levels are high. Whole-life costs need not be greater than other levels of risk, although this will depend on the design and construction used. The change-of-use costs are initially high. However, little maintenance is required, so through-life costs are low. The damage from future floods will be significantly less. A pump and sump should be installed at the lowest level of the property.

The measures used to dry-proof buildings include the types of measures intended to protect walls and the building as a whole (see Sections 4.4.3 and 4.18).

4.13 STANDARDS OF REPAIR FOR SUSPENDED TIMBER FLOORS

4.13.1 Level A standards of repair

Resilience and resistance. Different timbers have varying levels of natural resistance to decay fungi, but softwood species used in building all have low natural resistance. Occasional periods of surface wetting are acceptable, but long-term water contact or high moisture content are not.

Specification. Repairs to timber components that are potentially affected by floodwater are as follows.

1 **Structural components**. Structural timber includes wall plates, joists, beams, strutting and trimmers. If the timber is already correctly specified and constructed there are unlikely to be problems at this level of risk. Check these components, but normally they should not need to be replaced. Preservative-treated timber is required where wetting in service is anticipated. For existing floors there is unlikely to be a requirement for any improvement in the structural performance.

2 **Floor cover components**. These include traditional floorboards (tongue and grooved), chipboard, plywood and oriented strand board (OSB). These materials can all be affected by moisture from floods. Replace damaged timber with similar materials. Exceptions include materials such as chipboard that have no flood resilience. The requirements of BS 6399-1:1996 and BS 5268-2:2002 should be followed in this regard. Floors that have suffered from long-term high moisture content and decay will not be able to sustain the same level of load and collapse can occur. The condition and moisture contents of timber flooring materials must therefore be carefully considered.

Check fixings for timber floors and replace corroded fixings with corrosion-resistant types.

Ventilation of the belowground-floor void is essential to ensuring that the moisture content remains below 20 per cent. Ventilation to the requirements of BS 5250:2002 or BS 8102:1990 is required. Check the ventilation of the void that it has not become blocked over time.

Initial costs and whole-life issues. The additional costs involved are low, as are the whole-life costs.

4.13.2 Level B standards of repair

Resilience and resistance. At this level of risk it is essential to replace damaged timbers with treated timber, which will reduce the level of damage to timber suspended floors from subsequent floods.

Specification. Check fixings for timber floors and replace corroded fixings with corrosion-resistant types.

Specifications for timber floor components are as follows.

1 **Structural components**. As previously, replace damaged components to the requirements of BS 5268-2:2002 and BS 6399-1:1996. Replace timber wall plates with corrosion-resistant steel alternatives, which will reduce the level of damage to timber suspended floors from subsequent floods.

2 **Flooring components**. Follow the same advice as for a Level A. Check to determine whether or not additional strutting needs to be used where the floor is supporting an internal partition. Replacement of the existing flooring component must be considered. Vulnerable materials such as chipboard could be replaced with treated softwood tongue and grooved boards.

Initial costs and whole-life issues. The costs involved are medium for these floor components. The through-life costs are low.

4.13.3 Level C standards of repair

Resilience and resistance. Additional protection will be required beyond that for Level B. Structural changes may be required to timber suspended floors if structural damage has resulted from the flood.

The options to be considered are as follows.

1 Replace suspended floors with solid floors, which are easily reinstated following a flood event. Changing to a solid floor construction will reduce the cost and time of reinstatement. This option will require considerable levels of work and may not be practical. The solid floor may require the under-floor void to be built up. The floor should meet the requirements of Building Regulations. Insulation may be required to ensure that the correct standards of energy efficiency are maintained.

2 Install a sump and pump system to remove water from the under-floor void, as described for suspended concrete and solid floors (Sections 4.10 and 4.11).

3 The measures used to dry-proof buildings include the types of measures intended to protect walls and the building as a whole (see Sections 4.4.3 and 4.18). For floors there are some particular measures that are required, as follows:
   - **protection of under-floor ventilators**. These will be positioned under the damp-proof course through external brickwork or blockwork. Proprietary systems are available to block floodwater from entering the ventilators and flooding the under-floor void of suspended floors
   - **protection of brickwork around floor level**. This can be achieved using proprietary skirting products.

Initial costs and whole-life issues. The costs involved are high. Whole-life costs need not be greater than other levels of risk, although this will depend on the design and construction used.

4.14 STANDARDS OF REPAIR: OTHER FLOOR ISSUES

4.14.1 Damp-proof courses and membranes

Floors at ground level normally have the timber joists supported on masonry or concrete and protected from rising damp by impervious damp-proof courses. If materials have been bridged or punctured by rising groundwater then water may reach timber components. Additionally, timber floors may become damp after a flood if joists have been built in contact with solid external walls. The dpc needs to be checked, damage identified and repaired.

A membrane beneath the screed and insulation may be punctured by rising groundwater. If the area of damage is extensive then considerable work will be required, especially where the damp-proof membrane is positioned under a screed and ground-floor slab. This may be extremely difficult to identify in the short term since water penetrating the screed or slab from below needs to be differentiated from absorbed floodwaters that are drying out. Refer to Report BR466 for further advice on damp-proofing (BRE, 2004).

4.14.2 Insulation

Insulation is laid in a variety of ways within a floor. Water will affect some types of insulation: for example, mineral wool insulation can sag or become distorted and may hold water for a while. Where insulation has obviously been damaged or contaminated, replace it with a closed-cell rigid-board type. If the insulation is wet but not damaged or contaminated then consider whether it should be removed or retained. If retained, allow it to dry out thoroughly.

4.14.3 Floor finishes

The range of floor finishes, or coverings, available is considerable. The advice given in Appendix 5 refers to the resilience to flood as well as the ability to seal the floor against floodwater. The risks and potential of each floor covering are considered. Practical issues must also be taken into account, such as the suitability of certain finishes for the type of building.

4.15 STANDARDS OF REPAIR FOR SERVICES

The protection of services is particularly important, as provision of water, fuel and power are essential to the use of the building after a flood has occurred. This section and Section 4.16 describe the standards of repair for services and fittings.

4.15.1 Level A standards of repair

At this level of risk the standards of repair will not involve repairs to improve the flood resilience.

Resilience and resistance. Electrical services have little resilience to floodwater and are easily damaged. These services may need to be replaced, or thoroughly dried and checked for electrical safety before reuse. Other services will have greater resilience. Water and drains may only require measures to make sure they continue to work in the event of a minor flood without backing up.

Specification. The following points provide general guidance on reinstating services:

- fully dry out electrical services before reusing them. Check the electrical safety before reuse
- electrical sockets will typically be located above skirting boards in all floors. Drain water from ducts and chases before reuse
- check gas fittings for leaks. If there is a leak the gas supply should be switched off at the mains, the building should be ventilated by opening windows and doors, and specialist advice should be sought (see Appendix 1)
- check water services for contamination when the mains water is reconnected (if it was cut off). Run water until it is clear before reuse. Ask the local authority environmental health department for advice on its suitability for drinking. Check connections between pipes and repair any defects
- check drainage and sewers and allow them to clear before reuse. Check the connections of pipes and repair them as necessary. Floodwaters may have deposited silt in the drains, so they should be checked and, where necessary, cleaned.

Initial costs and whole-life issues. The costs will vary from quite minor to relatively high. The flood repairs will minimise costs resulting from any repeat flooding.

4.15.2 Level B standards of repair

At this level of risk further measures will need to be taken to reduce the risk of a future flood affecting the services and fittings.

Resilience and resistance. Electrical services have little useful resilience to floodwater and are easily damaged. They will probably need to be replaced or at least thoroughly dried.

Specification

Electrical services

Typically, electrical services are brought into a building through consumer units close to ground level, which makes them vulnerable to interruption from flood damage. If replaced, electrical services should be placed within easily accessible conduits and voids so that they can be drained, checked and fully dried in the event of a future flood. Such conduits could include replacement skirting boards in PVC-U that are sealed to the walls and floors.

Alternatively, move electrics to a higher level in the structure so that power cables drop from first-floor level down to the sockets. This will enable electrics to be reinstated quickly after a flood and will make sure that consumer units are above the flood level. Position at least 1 m above floor level, depending upon the predicted flood depth.

The electrical cables will normally be accommodated in channels or voids in the wall. Where different wall finishes abut, such as a change from plasterboard to plaster, the accommodation of electrical cables and sockets must be taken into account.

For advice on electrical safety, refer to BS 8434-1:2003, BS EN 60335-1:2002, BS EN 60898-1:2003 and BS EN 61140:2002.

From January 2005 people carrying out electrical work in housing and other buildings have been subject to the new requirements of Part P of the Building Regulations (England & Wales). This does not apply to general repairs or maintenance work, but significant repair, as defined by Level B or above, is likely to be covered by the regulation. Consult the local authority building control department for assistance in this matter. Work under Part P should be carried out by a tradesman registered with a competent person scheme (see <www.odpm.gov.uk> for guidance).

Gas

Gas fittings should be checked for leaks and, if found to be leaking, should be subject to the same procedure as described for Level A.

Replace damaged copper pipes with similar ones, and wrap them in protective sleeving.

For advice on gas safety, refer to BS 5258-1:1986, BS 5258-9:1989, BS 5258-15:1990, BS 5386-4:1991, BS 5440-1:2000, BS 5440-2:2000, BS EN 30-1-1:1998, BS EN 30-1-2:1999, BS EN 30-1-3:2003 and BS EN 30-1-4:2002.

Oil

Raise the oil tank above the ground-floor level to avoid the risk of water entering the tank, which may result in leakage. If possible, raise the tank above the likely flood level. If the tank cannot be moved, secure it so that it does not float in floodwater.

Remove boilers from the ground floor to avoid damage from floodwater. Mount boilers on to the wall 1 m above floor level or on a plinth above the level of a flood. This will lessen the impact and cost of a flood on the heating system, which in turn will reduce the cost and time needed for repair, enabling heating to be restored quickly after the flood has receded to facilitate effective drying.

Water

Water services are generally under pressure, which helps resist floodwater ingress, although water pressure can be lost during a flood event. Wrap water services in polyethylene sheeting to seal them fully. This will prevent contaminated floodwater entering the service pipes through junctions and joints in the pipes or by diffusion through the pipe wall. Place water service pipes in conduits or voids through floors or walls to make them easily accessible for inspection. Protect taps using non-return valves.

Drainage

Rubber test plugs can be fitted into the ends of exposed pipes, or alternatively in the first inspection chamber. Fit them when a flood warning has been issued. Inflatable plugs are also available and can be easier to use. One-way valves can also be used (see Section 4.18.2).

Meters

Move service meters to at least 1 m above floor level, to reduce the replacement costs and disruption associated with remedial flood works.

Initial costs and whole-life issues. These will vary from fairly minor to relatively high, depending on the amount of repair required or the need to move services. The costs resulting from any repeat flooding will be reduced, so the through-life costs are low.

4.15.3 Level C standards of repair

At this level of risk similar requirements will exist to those of Level B. The depth of the flood is the key differential, so consideration should be given to increasing the flood resilience of the whole building by either moving certain rooms or facilities, or using flood protection products such as dry-proofing measures to protect any services that cannot be practically moved to a higher level.

Move the electrics higher up in the structure so that power cables drop from first-floor level down to sockets.

For other services the same provisions as Level B can be considered.

4.16 STANDARDS OF REPAIR FOR FITTINGS

4.16.1 Level A standards of repair

Resilience and resistance. Fittings include domestic appliances (white goods), furniture, units and similar items. Their flood resilience varies greatly depending on the product type and the materials involved. White goods are electrical and are at risk of electrical damage as well as contamination. Kitchen and bathroom units and furniture based on chipboard can be significantly damaged by exposure to floodwater. Solid timber or plastic units are less likely to be seriously affected.

Specification. Replace damaged white goods with raised built-under types. This may put them above the flood level for this level of risk and eliminate the need for replacement. It may be necessary to adjust the levels of work surfaces where the goods are located under a surface. Damage is likely to occur if the floodwater reaches above the legs of the goods, so they may need to be removed if there is sufficient time between the flood warning and the flood occurring. Pressed-steel kitchen units are available and will resist floodwater.

Replace damaged chipboard fitted units with proprietary plastic or water-resistant alternatives. This will reduce the cost of reinstatement and replacement of fitted units after a flood.

Initial costs and whole-life issues. The costs involved are typically low to medium. The use of pressed-steel kitchen units does raise initial costs. Whole-life costs need not be greater than other levels of risk, although this will depend on the range and quality of goods in the property.

4.16.2 Level B standards of repair

Specification. Damaged fittings, cupboards or white goods will need to be replaced after a flood. At this level of flood risk simply raising the level of the white goods from the ground may not be sufficient. An alternative is to incorporate a means of lifting such goods to a higher level in the building. As the most difficult appliance to move is generally the washing machine, it is recommended that this be installed at a higher elevation or placed on a raised concrete plinth in the garage. Cut-off devices should be fitted to electrical services for safety.

Replace chipboard fitted units with proprietary plastic or water-resistant alternatives. This will reduce the cost of reinstatement and replacement of fitted units after a flood.

Initial costs and whole-life issues. The initial costs involved are low to medium. Whole-life costs need not be greater than other levels of risk, although this will depend on the range and quality of goods in the property.

4.16.3 Level C standards of repair

Specification. Consider moving kitchens to first-floor level. This will make sure that the kitchen is not directly affected by future flooding and so will avoid future costly replacements of units, white goods and other fitments.

Ground-floor bathrooms are less likely to be damaged by floodwater than kitchens, as items such as toilets, sinks and baths are resistant to floodwater. Measures to make bathrooms easier to clean and dry after a flood include readily removable frames and fascia covers that will allow removal of floodwater from under baths.

Flood protection products should be used to prevent floodwater entering the building at this level of risk.

Initial costs and whole-life issues. The costs involved are medium. Whole-life costs will be unaffected if the white goods and units are located above flood levels.

4.17 STANDARDS OF REPAIR FOR BASEMENTS

Basements are usually designed to resist the ingress of groundwater through the use of tanking to waterproof the structure. Where the flood level rises above the top of the tanking, water will still flow into the basement. The standards of repair concentrate on the removal of water through pumps. Measures for ensuring damage does not occur to walls and floors are given in the previous sections on masonry walls and concrete floors (see Sections 4.3–4.6 and 4.10–4.13).

Resilience and resistance. Basements resist the passage of groundwater by a designed water-resisting structure or through tanking (see Figure 4.4). It may be necessary to improve the waterproofing of an existing basement and to enhance drainage provision to keep it dry. For basements affected by surface runoff there is little that can be done with the basement design itself to prevent water ingress.

Specification. Specific options exist for improving the drainage of a basement, or even ground floors, to reduce the risk of groundwater flooding occurring should this type of flooding be a risk to the property. In particular, sump and pump techniques for maintaining a watertight space are increasingly popular and could be usefully incorporated into an existing building to achieve greater resilience to a flood problem. The system is designed so that, as the groundwater level rises, it is diverted into the sump hole. When the water reaches what is called “the critical level” the sump pump removes the footing drain water from around the basement wall through a pipe and discharges it to the surface of the ground, a ditch, foul sewer or a storm sewer, dependent on the surface grading around the house. This is only applicable where the extent of the flooding has not overwhelmed the existing sewers and removed the possibility of natural drainage in the area.

Three types of sump pumps are commonly used.

1 **Pedestal**. This type of electric pump stands upright, with a motor a few feet above the pump, which is designed to get wet. It has a float-activated switch that turns the pump on when the water reaches a certain level. It is intended for basements that need frequent water drainage. It is usually the least expensive of the three, but is noisier than the submersible type.

2 **Submersible**. A submersible electric pump is installed underground and is designed to work underwater. It has the same float-activated switch as the pedestal pump. While more expensive than the pedestal type, it is quieter and tends to have a longer life because its sealed, oil-cooled motor is protected from moisture and dust.

3 **Water-powered**. This type of pump runs off the water pressure from the home plumbing system and also has the same float-activated switch as the two types above. It handles water at a much slower rate than the electric types, but requires no electricity to operate. A water-powered pump can be installed alongside an electric pump and is generally used as a back-up system during a power failure.

Each sump pump will have a check valve on the water outlet pipe so water does not flow back into the sump when the pump shuts off. Water flowing back and forth can cause the pump to turn on and off more than necessary and shorten the life of the pump.

Finishes and fittings

Further measures will include:

- replastering walls in accordance with earlier sections; do not use gypsum plasters
- repairing floor screeds using dense cement:sand materials
- positioning services in protected conduits, preferably at high level
- replacing all damaged white goods and fittings.

Initial costs and whole-life issues. The costs involved are medium, but the maintenance costs are low. It is necessary to check operation and replace any malfunctioning pumps.

4.18 FLOOD PROTECTION PRODUCTS

Repairing a flood-damaged property with more robust building solutions is a major step towards reducing the risk of future flood damage. Another important option is the use of flood protection products, which may be required for Level C risk. There is a variety of commercially available products that can be installed to resist floodwaters entering a building. Some of these products have been awarded a BSI kitemark under a specific flood protection products scheme and these are recommended when making a selection (see PAS 1188-1:2003, -2:2003 and -3:2003). The products may have a maintenance requirement and many of the barrier techniques are temporary, as they have to be installed manually before the flood. It is important to check the suitability of the products for a particular building. Often one product on its own is not sufficient, as a holistic approach to protection is required.

There is a limit to the depth of floodwater that a building can be protected against because of the pressure exerted by that water. A flood depth of 1 m exerts half a tonne of force to each metre length of wall. It is therefore important that the flood barrier and the existing structure is strong enough to withstand this loading, otherwise structural failure may occur. It is recommended that the existing structure be inspected by a qualified structural engineer before any barrier system is installed. Further information on temporary flood protection is given by Defra/EA R&D Publication 130 (Ogunyoye *et al*, 2002) and by Crichton (2004).

4.18.1 Product types

Commercially available products generally fall into one of three main categories.

1 **Temporary free-standing barriers**. These are erected at a distance from a property or group of properties to hold back, or in some cases redirect, floodwater. There are various types of barrier on the market, some of which are rigid and some flexible. Figure 4.6 shows a pallet barrier system in operation.

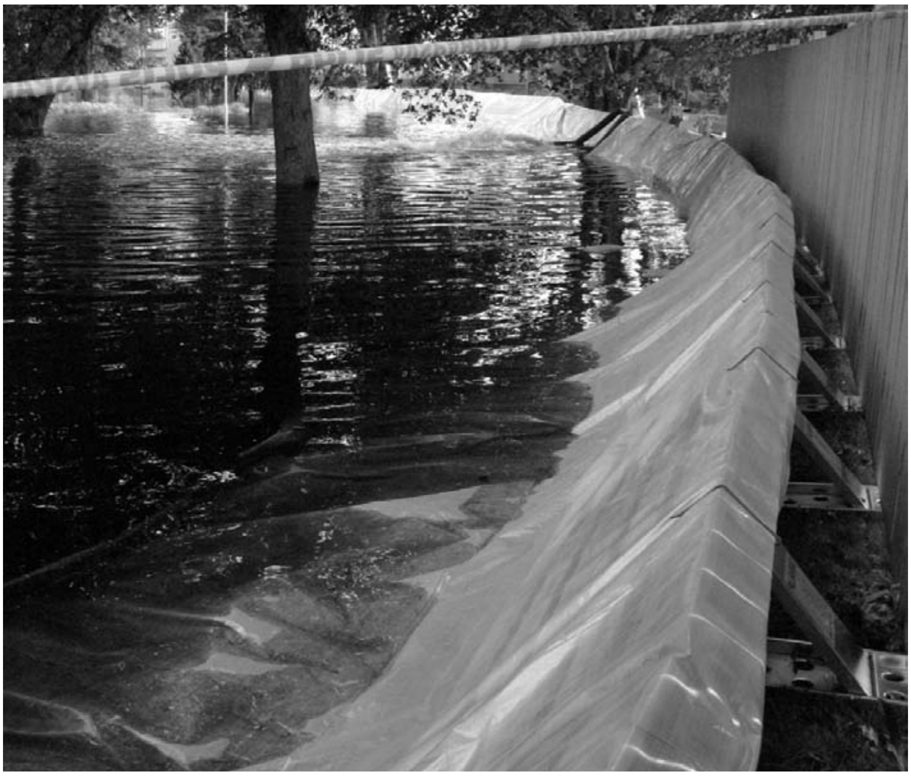

Figure 4.6 *Pallet barrier*

2 **Flood skirts**. Some products wrap a house in plastic or visqueen sheeting. These products rely on the structure of the building for support. Flood skirts have drains at the base of the plastic and bricks to hold the plastic in place; installation should be in accordance with the manufacturer's instructions. The suitability for any particular building needs to be considered, but a skirt should reduce at least some of the walls' exposure to floodwater. The plastic barrier will typically extend to 1 m above the damp-proof course.

3 **Removable household products**. Sandbags, flood boards, airbrick covers and similar items are temporarily applied to or around the building. These types of products are discussed in detail in a CIRIA report on flood-proofing of buildings (CIRIA and EA, 2003). Some types of household products are summarised below.

- **Panels and sheeting**. The approach is to reduce floodwater entry, particularly in entrances that open into the building, by sandbagging or placing previously prepared plywood or metal sheeting on the outside of the door frame. The pressure of the floodwater will increase the sealing capability. The effectiveness of such measures can be enhanced by placing a gasket of suitable material such as a blanket or a silicone-type sealant compound between the door frame and the barrier. A similar approach can be used for windows, patio doors and French windows. American designs of door barriers have an attached, inflatable seal and therefore do not need to have permanent anchors installed (see Figure 4.7). Custom-made covers or floor boards are available from kitemarked manufacturers.

Figure 4.7 *Flood door board*

- **Air-brick covers**. Air-bricks can be blocked in a similar way to door frames by placing a suitable material on the outside of the air-brick or by using a sandbag. Covers may not provide a complete seal but the amount of water entering will be reduced. Covers should be removed as soon as the flood has receded to ventilate the under-floor area (see Figures 4.2 and 4.3).
- **Water-filled barriers**. These are recent innovations that are placed across building entrances. Plastic sealed tubes are filled with water before being placed across the entrance and then weighed down. Sandbags can be placed on top of the barrier to increase the protection height.

4.18.2 Drains, pipes and sewers

Private drains and sewers can be protected during a flood to reduce the risk of contaminated floodwater flowing back up these pipes and entering the building and to help prevent damage to the pipes. Various products and methods are available, including one-way valves and penstocks. For example, the end of a pipe can be sealed with a flexible ball or inflated inner tube, or sandbags, clothes or polythene can be used.

Custom-built seals are available, but sandbags can be used to fill a WC during a flood to prevent back-flow. The bottom of the WC should be plugged before the sandbags are inserted. Plugs can be placed in sinks and baths and weighed down with sandbags. The force of back-flow in a flood can be considerable, however, and these measures may have a limited effect. Sandbags can also be used to weigh down drain covers and pipes to prevent them from being damaged or swept away in a flood.

Anti-flood devices can be installed on private drainage systems to prevent back-flow from the main sewer, which may become overloaded by surface water runoff or from flooding watercourses. These devices, such as flap gates, gate valves or ball valves, are best placed within specially constructed inspection chambers, which will facilitate their maintenance.

Flooding from deficient public sewers is a concern for homeowners, but it is not their responsibility. Where problems with public sewers are known or suspected, the sewerage undertaker – usually the local water and sewerage company – should be contacted. Under the Water Industry Act 1991, the sewerage undertaker has a duty to (a) prevent unreasonable occurrence of flooding, (b) provide, improve and maintain the public sewerage system and (c) cleanse and maintain those sewers. It may be able to adjust the sewerage system to reduce the risk of flooding, subject to an assessment of the severity of the flood risk problem against other concerns. Where problems relate to flooding from the public sewerage system, householders should contact the sewerage undertaker in the first instance. A householder with a complaint about a sewerage undertaker's failure to comply with its duties should write to WaterVoice and Ofwat or the Secretary of State for the Environment, as identified in the House of Lords judgement in Marcic *v* Thames Water Utilities Limited (House of Lords, 2003).

4.19 FLOOD REPAIR LOG

All the information relating to a building, from the flood event to the completion of any repairs, should be filed in one place. Such information may include photographs, receipts, notes on advice given, formal surveys and risk assessment reports, and all should be dated. Where flood-resilient repairs have been carried out, their nature and maintenance requirements should be recorded.

Where repairs are concerned, the flood repair log should serve to:

- record accurately the design for future owners and occupants, thereby assisting new owners should conditions change and the design no longer meet requirements
- ensure a proper understanding of maintenance requirements, including the frequency of maintenance, and that maintenance activities are logged
- provide guidance to enable appropriate remedial action in the event of a flood.

A flood repair log may be one way to demonstrate a continued and positive interest in reducing the risk of future flood damage. The log may be of use to insurance companies when they are determining flood insurance premiums, as it should indicate that repairs were carried out properly. In the future, homeowners are likely to be required to compile and keep a "home information pack", or "seller's pack". It is envisaged that this would record building design information together with details of any alterations or repairs carried out to the dwelling. The flood repair log could be incorporated in the pack.

After a flood the proprietor of a property may be asked to enquire personally and obtain competitive quotes for work required and seek approval from their insurance company before repair work can start. The British Damage Management Association (see Appendix 1), is the only UK-based certifying authority for practitioners in flood recovery and restoration. The BDMA advises property-owners to be aware of incompetent "cowboy" restoration work, which can lead to health risks and serious damage to the property structure. Historically, floods have been known to attract attention from unqualified building contractors, who have used people's desperation after the traumatic experience of a flood to gain work, which often fails to meet the required standards.

Good practice and high standards of workmanship are essential elements for achieving appropriate standards of repair of flood-damaged properties. The flood repair log should contain any completion certificates or workmanship records.

APPENDICES

A1 Organisations that can advise on flooding

Details were correct at time of going to press.

Association of British Insurers (ABI)
51 Gresham Street
London EC2V 7HQ
Tel: 020 7600 3333
Email: info@abi.org.uk
Web: <www.abi.org.uk>

Association of Building Engineers (ABE)
Lutyens House
Billing Brook Road
Weston Favell
Northampton NN3 8NW
Tel: 01604 404 121
Fax: 01604 784 220
Email: building.engineers@abe.org.uk

Association of Drainage Authorities
The Mews
Royal Oak Passage
Huntingdon
Cambridgeshire PE29 3EA
Tel: 01480 411123
Web: <www.ada.org.uk>

British Board of Agrément
PO Box 195
Bucknalls Lane
Garston
Watford
Hertfordshire WD25 9BA
Tel: 01923 665300
Web: <www.bbacerts.co.uk>

British Damage Management Association
Willow Business Centre
Mitcham
Surrey CR4 4NA
Tel: 020 8274 3337
Email: info@bdma.org.uk
Web: <www.bdma.org.uk>

British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham NG12 5GG
Tel: 0115 936 3100
Fax: 0115 936 3200
Web: <www.bgs.ac.uk>

Building Research Establishment
Bucknalls Lane
Garston
Watford
Tel: 01923 664000 (England and Wales)
Web: <www.bre.co.uk>

BRE Scotland
Scottish Enterprise Technology Park
East Kilbride G75 0RZ
Tel: 01355 576200 (Scotland)
Email: EastKilbride@bre.co.uk

CADW
Plas Carew
Unit 5/7 Cefn Coed
Parc Natngarw
Cardiff CF15 7QQ
Tel: 01443 33 6000
Fax: 01443 33 6001
Web: <www.cadw.wales.gov.uk>

Chartered Institute of Building (CIOB)
Englemere
Kings Ride
Ascot
Berkshire SL5 7TB
Tel: 01344 630 700
Fax: 01344 630 706
Web: <www.ciob.org.uk>

CIRIA
Classic House
174–180 Old Street
London EC1V 9BP
Tel: 020 7549 3300
Fax: 020 7253 0523
Email: enquiries@ciria.org
Web: <www.ciria.org>

The Civic Trust
Winchester House
259–269 Old Marylebone Road
London NW1 5RA
Tel: 020 7170 4299
Fax: 020 7170 4298
Web: <www.civictrust.org.uk>

Chartered Institute of Loss Adjusters (CILA)
Peninsular House
36 Monument Street
London EC3R 8LJ
Tel: 020 7337 9960
Web: <www.cila.co.uk>
Web: <www.corgi-gas.com>

Council for Registered Gas Installers (CORGI)
1 Elmwood
Chineham Park
Crockford Lane
Basingstoke
Hampshire RG24 8WG
Tel: 0870 401 2300

Department for Regional Development for Northern Ireland
Water Service
Tel: 08457 440088
Web: <www.drdni.gov.uk>
Web: <www.waterni.gov.uk>

Department of Environment (DOE) Northern Ireland
Headquarters
Clarence Court
10–18 Adelaide Street
Belfast BT2 8GB

Environment and Heritage Service
Built Heritage General Enquiries
Tel: 028 9054 3034
Fax: 028 9054 3111
Email: bh@doeni.gov.uk
Web: <www.doeni.gov.uk>

Historic buildings general enquiries
Tel: 028 9054 3058
Fax: 028 9054 3150
Email: hb@doeni.gov.uk
Web: <www.doeni.gov.uk>

English Heritage
Customer Services Department
PO Box 569
Swindon
Wiltshire SN2 2YP
Tel: 0870 333 1181
Fax: 01793 414786
Web: <www.english-heritage.org.uk>

Environment Agency
Head office
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD
General enquiry: 0845 9333 111
Emergency hotline: 0800 807 060
Floodline: 0845 988 1188
Web: <www.environment-agency.gov.uk>

Federation of Master Builders
Gordon Fisher House
14–15 Great James Street
London WC1N 3DP
Tel: 020 7242 7583
Fax: 020 7404 0296
Web: <www.fmb.org.uk>

Floodline
Tel: 0845 988 1188 (throughout the UK)
A 24-hour telephone information service operated by the Environment Agency in England and Wales and by the Scottish Environment Protection Agency (SEPA) in Scotland.

Flood Protection Association
66 Paxton Road
Fareham
Hampshire PO14 1AD
Web: <www.floodprotectionassociation.org>

Health Protection Agency
Floor 11
The Adelphi Building
John Adam Street
The Strand
London WC2N 6HT
Tel: 020 7339 1300
Fax: 020 7339 1302
Web: <www.hpa.org.uk>

Historic Scotland
Head office
Longmore House
Salisbury Place
Edinburgh EH9 1SH
Tel: 0131 668 8600
Fax: 0131 668 8669
Web: <www.historic-scotland.gov.uk>

Institution of Civil Engineers
One Great George Street
Westminster
London SW1P 3AA
Tel: 020 7222 7722.
Web: <www.ice.org.uk>

Institution of Occupational Safety & Health
The Grange
Highfield Drive
Wigston
Leicestershire LE18 1NN
Tel: 0116 257 3100
Fax: 0116 257 3101
Web: <www.iosh.co.uk>

Institution of Structural Engineers
11 Upper Belgrave Street
London SW1X 8BH
Tel: 020 7235 4535
Web: <www.istructe.org.uk> and
Web: <www.findanengineer.com>

National Federation of Builders
55 Tuftom Street
London SW1P 3QL
Tel: 0870 8989 091
Fax: 0870 8989 096
Web: <www.builders.org.uk>

National Flood Forum
5 Beale's Corner
Bewdley
Worcestershire DY12 1AF
Tel: 01299 403 055
Fax: 01299 403 101
Web: <www.floodforum.org.uk>

National House Building Council
Buildmack House
Chiltern Avenue
Amersham
Buckinghamshire H86 5TB
Tel: 01494 735 363
Web: <www.nhbc.co.uk>

National Inspection Council for Electrical Installation Contracting (NICEIC)
Vintage House
37 Albert Embankment
London SE1 7UJ
Tel: 020 7564 2323
Web: <www.niceic.org.uk>

National Soil Research Institute
Cranfield University
Cranfield Campus
Bedfordshire MK43 0AL
Tel: 01525 863 242
Fax: 01525 863 253
Email: nsri@cranfield.ac.uk

OFWAT
Office of the Water Service
Centre City Tower
Hill Street
Birmingham B5 4UE
Tel: 0121 625 1300
Fax: 0121 625 1400
Web: <www.ofwat.gov.uk>

Royal Institution of Chartered Surveyors:
RICS Contact Centre
Surveyor Court
Westwood Way
Coventry CV4 8JE
Tel: 0870 333 1600
Web: <www.rics.org>

Scottish Environment Protection Agency (SEPA)
Corporate Office
Erskine Court
Castle Business Park
Stirling FK9 4TR
Tel: 01786 457700
Fax: 01786 446885
Web: <www.sepa.org.uk/flooding/index.htm>

Society for the Protection of Ancient Buildings
37 Spital Square
London E1 6DY
Tel: 020 7377 1644
Fax: 020 7247 5296
Web: <www.spab.org.uk>

Water UK
1 Queen Anne's Gate
London SW1H 9BT
Tel: 020 7344 1844
Web: <www.water.org.uk>

WaterVoice
(part of Ofwat)
1st Floor, Charles House
86 New Street
Birmingham B2 4BA
Tel: 0121 644 5252
Fax: 0121 644 5265

A2 Example risk assessment

Courtesy of British Damage Management Association

This appendix provides an example risk assessment for a building following flooding. Hazards are identified and the risk associated with the hazard is calculated by assigning a value of 1 to 5 (low to high) for both the likelihood of the hazard occurring and the severity of the consequences should the hazard occur. By multiplying the two values together a “risk level” is assigned.

In the table below, “severity” refers to the severity of the consequence of flooding. The risk level is calculated by:

RISK = LIKELIHOOD × SEVERITY OF CONSEQUENCE

The risk level may be reduced as a result of existing control measures in place or additional control measures that could be implemented.

The text given within the boxes is indicative only.

Number	Hazard identified	Severity	Likelihood	Risk level	Existing controls	Revised risk (severity × likelihood)	Additional controls required	Final risk (severity × likelihood)
Slips, trips and falls								
1	Falls into voids hidden below floodwater, eg open manholes, trenches	5	3	15			Avoid entering floodwater unless the ground or route details can be verified with certainty	(5;2) 10
2	Falls through wooden floors made structurally unsound by water damage	4	3	12	None	(4;3) 12	None	(4;3) 12
3	Contact by falling buildings or building fabric such as ceilings made structurally unsound by water damage	4	3	12	None	(4;3) 12	None	(4;3) 12
4	Slips on wet or slippery surfaces whether hidden by floodwater or not	3	3	9	Identify as part of general risk assessment process. Avoid areas as far as practicable, otherwise wear Wellingtons or safety boots with slip-resistant soles	(3;1) 3	None	(3;1) 3
5	Trips over ground or building features hidden by floodwater	3	3	9	None	(3;3) 9	None	(3;3) 9
Drowning								
6	Drowning, brought about by floodwater factors: excessive depth of water, fast-flowing or rising water, entrapment, unconsciousness; failure to identify watercourse location in general floodwater etc	5	3	15	None	(5;3) 15	Stop and carefully consider location with regards to this hazard. Do not enter floodwater where these potential hazards exist	(5;2) 10

Number	Hazard identified	Severity	Likelihood	Risk level	Existing controls	Revised risk (severity × likelihood)	Additional controls required	Final risk (severity × likelihood)
Electrocution								
7	Electrocution caused by earthing of live electrical apparatus via floodwater or wet surfaces	5	3	15	None	(5;3) 15	Pre-visit enquiries to establish if electricity supply isolated or not. Do not enter building containing floodwater or touch appliances until isolation of electricity supply is confirmed	(5;2) 10
Hazardous substances – chemical								
8	Potential contamination of floodwater with unidentified hazardous chemicals such as fertilisers, petroleum and diesel fuels, DIY chemicals kept in homes etc	4	3	12	Risk assessment process may result in detection of some chemicals identifiable by smell or observance of slicks etc on water surface. It may not be possible to detect contaminants in all cases, however. Wear Wellingtons and coveralls to protect from minor splashes and wear disposable nitrile gloves	(4;2) 8	For large-scale flooding refer to the Environment Agency, local authority or fire services for any information. In general, do not allow floodwater to come into contact with skin either directly or through wetting of clothing	(4;1) 4
9	Additional hazardous substances created by mixing of chemicals in floodwater	4	3	12	As 8 above	(4;3) 12	As 8 above	(4;1) 4
Hazardous substances – biological								
10	General contamination of floodwater with unidentified hazardous biological (viral, bacterial etc) agents. Typical sources are sewage or contaminants normally found in watercourses, eg bacteria that cause Weil's disease. Contamination also arises when floodwater (even localised) is in contact with other sources of waste, including material on the ground surface such as dog and animal fouling. The following health hazards may arise	4	3	12	The risk assessment process may lead to identification of obvious visible evidence or odours of sewage in floodwater	(4;3) 12	It must always be assumed that floodwater from external sources (eg other than internal leakage from the building's clean water supply) will contain such contamination. Avoid direct contact with floodwater	(4;1) 4
10a	**Weil's disease** is a serious and potentially fatal, though less common, form of leptospirosis infection that causes organ damage and jaundice. Many leptospirosis infections do not become so serious, though all require prompt treatment. The *Leptospira* bacterium is transmitted to fresh water (saltwater kills it) from animal urine, especially that of rats. It is common in watercourses of all kinds, not just those carrying sewage. Infection is usually through cuts, or when the nose or mouth comes into direct contact with infected water	4	3	12	As above	(4;3) 12	Follow additional controls as above, avoiding contact with water or wet surfaces as a priority	(4;1) 4
10b	**Hepatitis**. Floodwater risks appear to be limited to the hepatitis A and E (the latter is not common in the UK) viruses, which are spread by contact and ingestion of water contaminated with infected faeces. Hepatitis B, C and D are spread by contact with infected blood or body fluids only	4	3	12	As above	(3;2) 6	Additional controls as above	(3;1) 3
10c	**Gastroenteritis** is caused by various forms of bacteria in floodwater	3	3	9	As above	(3;3) 9	Additional controls as above	(3;1) 3

Number	Hazard identified	Severity	Likelihood	Risk level	Existing controls	Revised risk (severity × likelihood)	Additional controls required	Final risk (severity × likelihood)
10d	**Tetanus** is caused by a bacterium entering the body via a wound. Although rare in UK because of immunisation, tetanus can be fatal	5	3	15	As above plus common programme of existing immunisations against the infection	(5;2) 10	Additional controls generally as above but focus on disinfecting and protecting cuts or wounds. Also ensure tetanus immunisation is up to date as preventative measure	(5;1) 5
11	**Moulds** are a type of fungus that can develop on wet building materials in specific conditions. Spores from the mould can cause allergic reactions, respiratory irritation and skin or eye irritation. People with pre-existing conditions of this type are particularly vulnerable. Certain, more toxic, strains of mould can cause more significant health problems	4	3	12	Mould will not usually have developed by the time early initial visits are made, although it may be present where wet conditions have been left untreated for some time (usually more than three days). The risk assessment process should lead to visual identification of mould	(4;2) 8	Avoid areas of mould. In particular, do not disturb spores that could be inhaled or come into contact with skin. Disturbance or cleaning of mould must be carried out only by trained personnel complying with a specific risk assessment and guidance note such that unprotected individuals are not exposed	(4;1) 4
Confined spaces and asphyxiation								
12	In addition to drowning risks, toxic gases or vapours produced from floodwater-borne chemicals may be present in confined spaces. Typically, these would be cellars, but can include any poorly ventilated enclosed space. Gases and vapours may be toxic in their own right or may have displaced the air required for normal respiration	5	3	15	Use risk assessment process to identify potential hazard areas	(5;2) 10	Do not enter suspect areas unless certain the atmosphere is free from toxic gases and vapours. There may be no odour to act as a warning. Be particularly cautious of areas that appear to have no ventilation for some time	(5;1) 5
Fire and explosion								
13	Flammable gases or vapours may be present from floodwater-borne chemicals such as petrol or solvents. These may collect in enclosed spaces in sufficient concentrations to be ignited by naked flames or sparks. Fire or explosion could result	5	3	15	Many flammable vapours will have an identifiable odour – use risk assessment process to identify potential hazard	(5;2) 10	Keep well clear of suspect areas unless certain the atmosphere is free from flammable gases or vapours. Be particularly cautious of areas which appear to have no ventilation for some time	(5;1) 5
14	If flooding has caused structural damage it is possible that gas supply pipes may have been damaged, causing gas leakage and presenting the risk of explosion	5	2	10	Be vigilant for smell of gas during existing risk assessment process	(5;2) 10	Keep well clear of suspect areas. To prevent fire or explosion ensure no smoking, no naked lights and do not activate electrical equipment (including mobile phone), which may cause sparks. Contact gas supply company urgently	(5;1) 5
15	Short-circuiting electrical apparatus may also cause fires	4	2	8	See controls for 7 above	(4;1) 4	See controls for 7 above	(4;1) 4
Asbestos								
16	Asbestos fibre from asbestos-containing building products may be liberated when such products are damaged by floodwater	3	3	9	Existing specific asbestos procedures	(3;1) 3	Damaged asbestos-containing materials (ACM) will usually be wet, minimising the risk of airborne fibres, although waterborne spread may occur. Do not attempt mechanical drying or ventilation of contaminated area until competent operatives have identified and removed to disposal the damaged ACM	(3;1) 3

A3 Advice for building-owners

This section briefly reviews advice for homeowners. Homeowners and householders can use it directly for guidance, while construction professionals can use it as the basis of advice for their clients. The advice is relevant to making a claim and appointing surveyors and contractors.

A3.1 MAKING AN INSURANCE CLAIM

The following items are relevant to insurance claims.

1. Contact the insurance company as soon as possible – most have a 24-hour emergency helpline. If you do not already know, find out exactly the level of cover the company provides and what this includes. The insurance company may provide support such as temporary accommodation, drying equipment and electrical and gas inspections.
2. If the insurance company does not supply alternative accommodation and it is necessary to vacate the building, provide the insurer with details of temporary addresses and contact information.
3. Once the insurance company has been informed and has approved the proposed work, begin initial repairs. Any emergency pumping should be started immediately, even if insurance approval has not been obtained (see Section 2.1.4). Retain receipts for all work that is undertaken. Generally, the longer it takes to start the drying out process, the greater the damage will be as water soaks into the fabric of the building and capillary action plus evaporation spreads the dampness to upper floors. For homes with basements and cellars, water extraction may be more problematic (see Section 4.17).
4. The insurance company may appoint a repair contractor or request quotations from several firms. Some insurance companies or loss adjusters may give advice on reputable contractors to contact from an "approved list". As the standard of work from such a builder will be known and will have been monitored, it will be acceptable to the insurer. Using an approved builder means that, if any problems arise, it will be easier to raise the matter with the insurer.
5. To assist the insurance company in managing a claim, both parties should make notes, including:
   - the time the flood warning was announced
   - the time the floodwaters entered the dwelling
   - marking where the water level reached on the walls
   - photographs or video footage of damage, both to property (walls, floors etc) and contents (carpets, suites, electrical appliances etc).

A3.2 APPOINTING A SURVEYOR

The following points apply to the appointment of a surveyor to undertake a post-flood survey.

1 The surveyors should be a member of the Royal Institution of Chartered Surveyors (RICS). Chartered surveyors are experienced professionals who provide independent, impartial and specialist advice and whose academic qualifications and training have been approved by RICS.

2 A chartered surveyor can be identified by the letters MRICS and FRICS, meaning they are either a member or a fellow of RICS.

3 A technical surveyor will use the letters TechRICS, indicating that they are a qualified technical member of RICS.

4 If you are in doubt as to whether or not someone is a genuine RICS member, call the RICS contact centre (see Appendix 1) with the person's details and they will carry out a check on your behalf.

5 Surveyors should comment on all parts of a property that are readily accessible, but they are not obliged to inspect areas that are dangerous to access.

6 Discuss and clarify the scope of the survey with the surveyor and check that it meets the needs of the insurers.

7 RICS members who offer surveying services to the public must have professional indemnity insurance.

A3.3 APPOINTING REPAIR CONTRACTORS

The following items are relevant to appointing repair contractors.

1 Immediately after a flood it is important to obtain several quotations from recommended repair contractors. Before allowing any work to start, you should obtain confirmation from the insurance company that it has agreed the estimate. Any increases in costs caused by problems arising during the repair work should be referred to the insurer and its agreement should be obtained before any such additional work goes ahead. The insurer will not deal with any complaints arising from work undertaken by a non-approved builder.

2 Contractors should be members of a recognised trade association and should provide evidence of this in their quotations. For example, membership of the Federation of Master Builders (FMB) or Federation of Builders can be checked with the FMB (see Appendix 1).

3 Payments should be made only at the end of the work or at specified milestones on completion of the work. Signed and/or stamped receipts, or printed company receipts, should be provided for all work carried out.

4 A Quality Mark scheme arranged by the Department for Trade and Industry (DTI) covers mainly small builders and attempts to drive out the cowboys. The scheme is backed by an insurance guarantee, which provides protection for the public.

The detrimental effects on physical and psychological health caused by flooding leaves homeowners vulnerable to exploitation by inappropriately trained or even unqualified repair contractors. By following the advice above you will be at less risk of losing money to a "cowboy" builder.

A4 Guidance on dehumidification

A4.1 TYPES OF DEHUMIDIFIER

There are essentially two ways of dehumidifying atmospheric air.

1. Chilling air below its dew point causes moisture to condense on cool surfaces.
2. Air is passed over substances called desiccants that have an affinity for moisture. These substances – eg silica gel – are capable of extracting moisture directly from the atmosphere.

A4.2 DEHUMIDIFICATION USING THE REFRIGERATION PRINCIPLE

Air at its initial temperature and moisture content is drawn into the dehumidifier and chilled by refrigeration. When the air has been cooled sufficiently it reaches saturation condition. Further cooling causes the moisture to condense out. In a typical refrigeration unit this condensation occurs directly on to a finned cooling tube and the liquid water is collected and drained away.

At its final dehumidified condition the air is considerably cooler than on entry and contains less moisture, but it is still nearly saturated, with a relative humidity of close to 100 per cent. This air is then reheated as it passes through and out of the dehumidifier, reducing the relative humidity.

Dependent on the prevailing temperature and relative humidity, the use of mechanical refrigeration for drying can be quite efficient. The actual cooling effect or energy extracted can be several times greater than the energy input required to operate the system (the coefficient of performance). The best operating range of a refrigeration dehumidifier is between 15°C and 28°C and 60–98 per cent relative humidity.

A4.3 DEHUMIDIFICATION USING THE DESICCANT PRINCIPLE

Desiccants are substances with a high affinity for moisture, allowing them to draw in moisture from the surrounding air. The desiccant dehumidifier uses a drying wheel that is impregnated with an adsorbent substance such as silica gel. The wheel, which has a honeycomb structure, is sectioned off into two zones. The first is a working zone, in which air is drawn through the honeycomb structure to enable the silica gel to absorb the moisture in the air stream. In the second section, usually called the reactivation zone, pre-heated air is drawn through in the opposite direction. The moisture held by the desiccant wheel is absorbed by the air and driven off as a warm, wet vapour. The wheel rotates within the unit at 8–10 revolutions an hour, so that as the wheel moves from the reactivation zone it is warmed and dried ready to accept more moisture. The optimum operating range of the desiccant dehumidifier is 0–25°C and 40–90 per cent relative humidity.

Irrespective of the system used, dehumidification must be combined with a suitable number of air-movers and a temperature control. All three factors are critical to the effectiveness of the evaporation process. It is also important that each one is monitored and adjusted as necessary during the drying period. There are different ways of deciding the type, combination and quantity of equipment to be used.

A start can be made by identifying the moisture load within the property. This information will inform the decision about the type and number of dehumidifiers that need to be used, based on the different models' moisture removal rate (usually quoted in kilogrammes or litres per hour).

A more approximate method is based on a subjective assessment of the degree of damage. A property that has had light water damage may require one air change per hour, whereas a more severely damaged building may need up to 10 hourly air changes. The number of air-movers can be calculated from the volume of air to be changed, based on the device's rating in cubic metres of air moved per minute or per hour.

A4.4 FREQUENTLY ASKED QUESTIONS

Can heat alone dry a property?

No. The effect of a heater is to raise the temperature, which in turn lowers the relative humidity. However, heating the air merely increases its capacity to hold moisture; once the heat source is removed and the air temperature drops, the capacity to hold moisture falls again. The moisture then returns to the walls, floors etc, with condensation occurring on the windows and other cold surfaces. Increasing the ventilation may help, dependent upon the relative humidity of the new air being introduced. Gas-powered heaters should not be employed, since they produce a kilogramme of water for every kilogramme of gas burnt. Flueless gas or paraffin heaters are dangerous if used in a humid environment.

Should radiators be used to dry the property?

While it is generally agreed that a suitable temperature is required to dry materials, uncontrolled heating can cause far more damage than the incident itself. To avoid secondary damage, it is essential to remove the moisture being evaporated.

Is the property dry if the screed floor looks white?

Within the first few hours of drying a certain amount of evaporation takes place from the surface whatever the degree of saturation within the material. This gives the appearance of the material being dry. It may be deceptive, however, and a decision made too hastily regarding reinstatement (such as installing a new floor covering), without checking that the material has dried completely, could result in failure of the new floor after only a short period.

Will the flood affect the insulation in a cavity?

This depends on the depth of floodwater and the type of construction and cavity insulation. The cavity should be inspected as part of the moisture survey. If the insulation has degraded it may have to be removed. Some types of insulation can withstand wetting and can be dried *in situ*.

How long will it take for mould to start to grow in a house after a flood?

Mould spores will be found in all homes, usually with no harmful effect. Mould becomes a problem only when conditions within the property are out of balance – when a flood occurs, for example. After a flood, the time taken for mould to start developing is variable and is dependent upon a range of factors, but moisture is the major stimulus for growth. If the moisture can be removed quickly, mould will not grow. It is recommended that cleaning, decontamination and drying be started within 48 hours of the incident or immediately after the floodwaters have subsided and access for extraction of standing water can be gained. Starting the drying programme immediately after damage has occurred will limit the risk of mould growth.

Is under-floor heating affected by floodwater?

As soon as the water has subsided an investigation will be made to identify the level of damage within the floor. A decision can then be made regarding the best remedial method. In some cases, dependent upon the level of damage, the under-floor heating system can be dried *in situ* successfully.

Is the gypsum plaster on the walls automatically ruined by flooding?

It is possible to decontaminate and dry walls without removing plaster finishes. Specialists are able to monitor the drying process and will only remove finishes when absolutely necessary.

A5 Floor finishes

This appendix provides advice on the resistance and resilience of floor surfaces and finishes to flooding. As floors will almost inevitably be wetted, often for a long period of time, it is important to consider the floor finishes. Where there is a significant risk of a future flood it is clearly inappropriate to use easily damaged floor finishes.

A5.1 JOINTLESS FLOOR FINISHES

Concrete wearing surfaces. Used in industrial buildings, these surfaces are normally formed from plain concrete with either a power float, power trowel or hand trowel finish. When in good condition they have good resistance to the passage of water. Concrete wearing surfaces are durable under water contact and they have resistance to many chemicals apart from acids. BS 8000-9:2003 and BS 8000-2:1990 are relevant to their use.

Polymer-modified cementitious screeds. These finishes are achieved by using modifying agents such as natural latex and synthetic rubbers (PVA, SBR) and bituminous emulsions in cement mixes. They have good durability, resilience and resistance to water passage in a flood. They are typically used for industrial buildings. BS 8000-9 and BS 8204-5:2004 are relevant to their use.

Granolithic and cementitious wearing screeds. A hard granite or crushed hard rock aggregate is incorporated in these concrete surfaces. They are used where good abrasion resistance is required and are typically used for industrial buildings. They have good durability, resilience and resistance to water passage in a flood. BS 8000-9:2003 and BS 8204-1:2003 are relevant to their use.

***In-situ* terrazzo**. Chiefly used in prestigious buildings, terrazzo finishes are hard-wearing and aesthetically pleasing, but demand high standards of workmanship for installation and should be used where building movements are minimal. They incorporate coloured cements with marble or other decorative aggregates and should only be laid on concrete bases, not timber. These surfaces have excellent resistance to floodwater contact, although they are vulnerable to attack by acids and alkalis. In good condition, the terrazzo finish will not allow transport of water through the floor.

Synthetic resins. Resin floorings were developed in the 1960s and provide the designer with a variety of materials that can be modified to achieve different performance characteristics. They are suitable for chemically aggressive environments and for sterile buildings used for food preparation or pharmaceuticals. There are two basic types of synthetic resin floors: polymer-modified cementitious and resin-bound aggregate. The former is likely to contain cement, but not the latter. Synthetic resins are generally resistant to floodwater, but if the substrate cracks they will also crack and repairs will be necessary. Moisture in the concrete slab can affect the resins, so repair work involving the use of a resin finish must include proper drying of the underlying concrete.

Paints and seals. Paints are generally applied over large areas of surface to improve appearance. Seals are applied for surface hardening to prevent dusting of the floor. Several types are suitable for floors, such as polymer-based emulsions, bitumen-based emulsions, resin-based solvent mixes, oleoresinous paints, one- or two-pack polyurethane, two-pack epoxies and chlorinated rubber. Polyurethanes are the most frequently applied floor paints. Painted and sealed surfaces typically have little resistance to abrasion and therefore are often worn and need maintenance. While they will not be affected by short-term water contact they are unlikely to add flood resilience to the building.

Mastic asphalt and pitchmastic. The waterproofing qualities of these materials have been used for more than 5000 years. Mastic asphalt is prepared from bituminous binders and inert materials (aggregates). The thickness should be between 15 mm and 50 mm. Mastic asphalts have good resistance to water, but less so to some chemicals. They supply an excellent means of sealing a floor. They should be selected with care, as there are many types with varying properties; not all are suited to heavily trafficked areas with high abrasion. Relevant standards are BS 8204-5:2004, BS 6925:1988 and BS 1447:1988. Pitchmastic is the same as mastic asphalt except coal tars are used instead of bitumen.

Magnesium oxychloride (magnesite). This is a mixture of calcined magnesite and magnesium chloride solution, with various fillers such as wood flour, sawdust, sand and pigments. Single coats of 10–25 mm are used, or two coats up to 50 mm. Magnesite floors resist water contact well, but are less tolerant of chemicals. They are generally suitable for public areas of buildings, but not for industrial use.

A5.2 JOINTED FINISHES

These types of finishes are thin sheet or tile flooring, as described in BS 8203:2001. The most common type of failure is where the flooring has been applied before a concrete slab or screed has dried sufficiently; a relative humidity of 75 per cent should first be achieved in the structural floor. They should be used only where a damp-proof membrane provides protection from ground moisture. Rather than putting down whole-floor coverings, rugs could be used over parts of the floor. These are readily removable when a flood warning is given.

Textiles. The range of textiles found in floor coverings is enormous: wool, cellulose, and synthetic fibres such as acrylics and polypropylene, even glass fibre, are just some of the materials used. An effective damp-proof membrane is essential for most kinds of textile flooring, particularly those made with natural fibres. Natural fibres will have moisture contents of 15–18 per cent and synthetics a few per cent only. Floodwater will damage most textile floor coverings, including carpet tiles, and it is normal to replace them after a flood event as they have no useful resistance to the passage of floodwater. If carpets are used in high flood risk locations, it must be assumed that they will have to be sacrificed in a flood. It is suggested that rugs be used as an alternative, as they can be moved in advance of a flood event for which have warnings have been given.

Linoleum. This is a mixture of linseed oil, resins, cork and wood floor. Thickness can vary from 2 mm to 6.7 mm. Linoleum can be placed on to most substrates, but a damp-proof course is required. Moisture from the substrate or from floodwater can affect the bond to the substrate. Linoleum has limited resistance to floodwater and its transport into the floor. It is likely to need to be replaced after a flood.

Cork. These finishes are available in sheets and tiles. They have little useful resistance to floodwater and are likely to need replacing after a flood.

PVC flexible. The tiles and sheets consist of PVC resins, plasticisers, stabilisers and extenders to form a rubber-like material. They are flexible so long as not too much filler is used. With good workmanship, the material can be used on most substrates.

PVC is generally water-resistant, but the substrate should be dry before the covering is applied, otherwise loss of adhesion and rising of the cover will occur.

Rubber. This is available in either sheet or tile format. Normally it is stuck to the substrate with a proprietary adhesive. The substrate should be dry or failure will occur. Floodwater could also cause failure of the rubber bonding to the substrate. The material itself will survive, but it may be difficult to reuse if it has been affected by water contact. The requirements of BS 8203:2001 should be followed.

A5.3 JOINTED HARD FINISHES

These types of finishes are both hard and durable. They are commonly used in public access areas but can be used in some domestic buildings.

Ceramic tiles and brick paviors. Ceramic flooring, in the form of tile and brick, has been used for thousands of years. Hard tiles are resistant to the effects of floodwater and for short periods will prevent the passage of water through to the floor. They can be applied to concrete, screeds or timber (the latter only with care). The tiles can be bonded to the floor in a variety of ways, based on cement-based tile adhesives and mortars. At Level B or C standards of repair a full bedding of tile adhesive or mortar should be used to fix the tiles to the substrate. Good workmanship is essential and the requirements of BS 8000-11.1:1989, BS 5385-3:1989 and BS 5385-4:1992 should be followed.

Concrete flags. These are normally used for external paving, but some have been used in public buildings. They are resistant to floodwater.

Stone flags. A wide variety of natural stone can be used for flooring. The flags are normally cut to a thickness of 12–20 mm and laid in bedding mortar. It is important to keep the substrate dry. Floodwater may cause brown staining of certain marbles, as pyrites in the marble are drawn to the surface. Natural stone should therefore be selected with care, for although the stone does not deteriorate in a flood these stains are difficult to remove.

Terrazzo tiles. As with *in-situ* terrazzo, the tiles comprise crushed marble in a cementitious matrix. They should be laid on to clean concrete substrates. While inherently durable, the adequacy of jointing is critical and good workmanship is essential during installation, which should be to the requirements of BS 5385-5:1994 and BS 8000-11.1:1989. After floods, the edges of tiles have sometimes been affected by staining, which is difficult to clean.

Composition blocks. These are made from sawdust, sand, pigment and cement. The screed needs to be fully dried before the blocks are laid and full bedding of the blocks with mortar is required. Moisture that comes up from the substrate can cause softening and reduction in strength, which could be a problem in floods where there is an inadequate damp-proof membrane. Water lying on the surface will have little effect, however.

Metals. Various kinds of metal flooring are used in industrial buildings, either as plates or meshes. They are generally resistant to floodwater, but may suffer corrosion if the water has a chloride content.

A5.4 TIMBER AND TIMBER PRODUCTS

This section details the different types of exposed finishes are available in timber. As stated previously, timbers are hygroscopic in nature and will move in sympathy with ambient conditions. When laid on a solid base, a damp-proof membrane should be used. Wood floorings should be kept at a moisture content of less than 22 per cent, but preferably 20 per cent. Timbers should be laid at moisture contents similar to those likely to be achieved in service. After a flood, timber flooring should be laid only after the building has been thoroughly dried.

Typical timber floor finishes include:

- board and strip
- block
- parquet and mosaic
- laminated flooring.

These types of finishes are normally decorated with varnish or other surface finish and are generally long-lasting. Both hardwoods and softwoods may be used. The timber sections are not normally sealed together and therefore will not restrict significantly the passage of floodwater. Provided they have not suffered deterioration, warping or cracking after a flood, the materials should be retained. Replacement with more resilient materials may need to be considered, although there may be restrictions in historic buildings.

Panel products. Chipboard, plywood and other wood-based panel products are not normally used as finishes, although they are used in unprotected states in some circumstances. They are not normally resistant to flooding. Advice on panel products for different situations is given in Report BR332 (BRE, 1997d).

A6 ABI statement of principles on the provision of flooding insurance

The Association of British Insurers' (ABI) website (<www.abi.org.uk>) provides an information sheet on the household and property insurance aspects of flooding. The website also gives its "Statement of principles on the provision of flooding insurance", which sets the framework within which flood cover can be delivered. The quoted principles below are the latest available at the time of going to print. Refer to the ABI website for the latest information.

Box A6.1 *Statement of principles on the provision of flooding insurance*

General policy

It is the intention of ABI members that flood insurance for domestic properties and small businesses should continue to be available for as many customers as possible. The premiums charged and other terms – such as excesses – will reflect the risk of flooding but will be offered in a competitive market.

This statement of principles will apply from 1 January 2003 but is subject to review in the event of significant external shocks such as withdrawal of flood reinsurance. Successful operation of the principles is dependent on planned information on risk levels and investment being available from the relevant flood defence authorities.

Areas currently defended to Defra standards

The majority of properties in flood risk areas are already protected to the Department of Environment, Food and Rural Affairs' indicative minimum standard of 1 in 75 years for urban areas, or better. The level to which properties are defended above this will vary considerably and premiums will reflect different degrees of risk; but flood cover will be available as a standard feature of household and small business policies.

High risk areas where improved defences are planned by 2007

In a number of locations the risk of flooding is unacceptably high. Existing flood defences provide less protection than the Department of Environment, Food and Rural Affairs' indicative minimum standard of 1 in 75 years for urban areas. Where improvements in flood defences sufficient to meet these standards are scheduled for completion within the next 5 years, insurers will maintain flood cover for domestic properties and small businesses which they already insure. The premiums charged and other policy terms – such as excesses – will reflect the risk.

If a domestic property in this category is sold the current insurer will continue to provide cover, subject to satisfactory information about the new owners of the property, especially their previous claims record.

Where a small business is sold the current insurer will consider whether to continue to provide cover; this will depend heavily on the proposed new use of the premises and the previous claims record of the new owner.

High risk areas where no improvements in defences are planned

There are other locations where the risk of flooding is unacceptably high – and in some cases they have been shown to flood frequently – and no improvements in flood defences are planned. Here insurers cannot guarantee to maintain cover, but will examine the risks on a case by case basis, use their best efforts to continue to provide cover and will work with the owners of domestic properties and small businesses which they currently insure to see what action could be taken by the property owner, the Environment Agency and the local authority, which might make the property insurable in some form. This action might include the use of accredited products, flood resilient materials and temporary defences to defend the property.

Action from government

The implementation of these principles will depend on action from Government as detailed below with an annual review of progress:

- actual expenditure on flood defences to meet or exceed that set out in the 2002 Spending Review;
- implementation of the improvements in the system of flood defence planning set out in Defra's consultation "Flood and coastal defence funding review";
- full implementation of PPG25 (Planning Policy Guidance on Development Planning and Flood Risk), with full reporting of the level of compliance by local authorities and consideration of administrative processes in the planned review of PPG25 in 2004;
- the Environment Agency's flood asset database to be available to insurers by the beginning of 2003, and publicly available as soon as possible;
- early improvements in the flood warning system, and implementation of the Cabinet Office's recent emergency planning review;
- full and detailed consideration, including a benefit/cost analysis, to be given to integrated drainage management for England and Wales, similar to that in operation in Scotland;
- implementation of realistic solutions to sewer flooding including increased investment in improvement programmes and adoption of water companies and sewerage undertakers as statutory consultees in the development planning process.

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A7 A simple example of whole-life costing

Following the flooding of a property, the occupiers are provided accommodation while the property is dried and repaired. There are two repair standards that can be applied:

- A – which has minimal resilience
- B – which has a high standard of resilience.

The cost of A is made up as follows:

• accommodation during drying and initial repairs	£12 000
• drying	£4800
• repairs	£4000
• **total**	**£20 800**

The cost for B includes:

• accommodation	£15 000
• drying	£4800
• repairs	£9000
• **total**	**£28 800**

Thus Option B costs £8000 more than A.

If flooding occurs again, the cost of making good in accordance with repair standard A remains the same, whereas for standard B, the costs are as follows:

• accommodation	£6000
• drying	£2400
• repairs	£1500
• **total**	**£9900**

In this case the cost of B is £10 900 less than that of A. This means that the total current cost of Option B is £2900 less than A.

The property has a life expectancy of 60 years, which means that if the flood frequency is greater than this, Option B should be chosen. However, if the frequency is less than this then A should be chosen.

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LANCASTER, J W, PREENE, M and MARSHALL, C T (2004). *Development and flood risk – guidance for the construction industry*. C624, CIRIA, London

MARTIN, P *et al* (2000a). *Sustainable urban drainage systems – design manual for Scotland and Northern Ireland*. C521, CIRIA, London

MARTIN, P *et al* (2000b). *Sustainable urban drainage systems – design manual for England and Wales*. C522, CIRIA, London

MARTIN, P *et al* (2001). *Sustainable urban drainage systems – best practice manual for England, Scotland, Wales and Northern Ireland*. C523, CIRIA, London

MARTIN, P *et al* (2004). *SUDS compilation*. C599CD, CIRIA, London

MAY, R W P, MARTIN, P and PRICE, N J (1998). *Low-cost options for prevention of flooding from sewers*. C506, CIRIA, London

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OGUNYOYE, F and VAN HEEREVELD, M (2002). *Temporary and demountable flood protection. Interim guidance on use*. R&D Publication 130, Defra and Environment Agency, London

PHILLIPSON, M and GRAVES, H (eds) (2001). *Climate change and buildings*. Foundation for the Built Environment, Watford

REACHER, M *et al* (2004). "Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households". *Communicable disease and public health*, vol 7, no 1, pp 1–8

SAMUELS, P, WOODS-BALLARD, B, HUTCHINGS, C, FELGATE, J and MOBS, P (2005). *Sustainable water management in land use planning* C630, CIRIA, London

SCOTTISH OFFICE (1996). *Design guidance on flood damage to dwellings*, Scottish Office, Edinburgh

SHAFFER, P, ELLIOTT, C, REED, J, HOLMES, J and WARD, M (2004). *Model agreements for sustainable water management systems. Model agreements for SUDS*. C625, CIRIA, London

VIVIAN, S, WILLIAMS, N and ROGERS, W (2005). *Climate change risks in building – an introduction*. C638, CIRIA, London

WILSON, S, BRAY, R and COOPER, P (2004). *Sustainable drainage systems. Hydraulic, structural and water quality advice*. C609, CIRIA, London

A8.2 BRITISH STANDARDS

All published by British Standards Institution, London.

BS 1447:1988 *Specification for mastic asphalt (limestone fine aggregate) for roads, footways and pavings in buildings*

BS 4787-1:1980 *Internal and external wood doorsets, door leaves and frames. Specification for dimensional requirements*

BS 5250:2002 *Code of practice for control of condensation in buildings*

BS 5258-1:1986 *Safety of domestic gas appliances. Specification for central heating boilers and circulators*

BS 5258-9:1989 *Safety of domestic gas appliances. Specification for combined appliances: fanned-circulation ducted-air heaters/circulators*

BS 5258-15:1990 *Safety of domestic gas appliances. Specification for combination boilers*

BS 5262:1991 *Code of practice for external renderings*

BS 5268-2:2002 *Structural use of timber. Code of practice for permissible stress design, materials and workmanship*

BS 5286:1978 *Specification for aluminium framed sliding glass doors*

BS 5385-3:1989 *Wall and floor tiling. Code of practice for the design and installation of ceramic floor tiles and mosaics*

BS 5385-4:1992 *Wall and floor tiling. Code of practice for tiling and mosaics in specific conditions*

BS 5385-5:1994 *Wall and floor tiling. Code of practice for the design and installation of terrazzo tile and slab, natural stone and composition block floorings*

BS 5386-4:1991 *Specification for gas burning appliances. Built-in domestic cooking appliances*

BS 5440-1:2000 *Installation and maintenance of flues and ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases). Specification for installation and maintenance of flues*

BS 5440-2:2000 *Installation and maintenance of flues and ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases). Specification for installation and maintenance of ventilation for gas appliances*

BS 5492:1990 *Code of practice for internal plastering*

BS 5628-1:2001 *Code of practice for use of masonry. Structural use of unreinforced masonry*

BS 5628-3:2001 *Code of practice for use of masonry. Materials and components, design and workmanship*

BS 6206:1981 *Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings*

BS 6213:2000 *Selection of construction sealants. Guide*

BS 6262:1982 *Code of practice for glazing for buildings*

BS 6399-1:1996 *Loading for buildings. Code of practice for dead and imposed loads*

BS 6510:2005 *Steel-framed windows and glazed doors*

BS 6576:1985 *Code of practice for installation of chemical damp-proof courses*

BS 6925:1988 *Specification for mastic asphalt for building and civil engineering (limestone aggregate)*

BS 7412:2002 *Plastics windows made from unplasticized polyvinyl chloride (PVC-U) extruded hollow profiles. Specification*

BS 7413:2002 *Unplasticized polyvinyl chloride (PVC-U) profiles for windows and doors. Specification*

BS 7664:2000 *Specification for undercoat and finishing paints*

BS 7956:2000 *Specification for primers for woodwork*

BS 8000-2.1 and 2.2:1990 *Workmanship on building sites. Code of practice for concrete work*

BS 8000-4:1989 *Workmanship on building sites. Code of practice for waterproofing*

BS 8000-7:1990 *Workmanship on building sites. Code of practice for glazing*

BS 8000-9:2003 *Workmanship on building sites. Cementitious levelling, screeds and wearing screeds. Code of practice*

BS 8000-10:1995 *Workmanship on building sites. Code of practice for plastering and rendering*

BS 8000-11.1:1989 *Workmanship on building sites. Code of practice for wall and flooring tiling. Ceramic tiles, terrazzo and mosaics*

BS 8102:1990 *Code of practice for protection of structures against water from the ground*

BS 8203:2001 *Code of practice for installation of resilient floor coverings*

BS 8204-1:2003 *Screeds, bases and in-situ floorings. Concrete bases and cement sand levelling screeds to receive floorings. Code of practice*

BS 8204-5:2004 *Screeds, bases and in-situ floorings. Mastic asphalt underlays and wearing surfaces. Code of practice*

BS 8213-4:1990 *Windows, doors and rooflights. Code of practice for the installation of replacement windows and doorsets in dwellings*

BS 8215:1991 *Code of practice for design and installation of damp-proof courses in masonry construction*

BS 8221-1:2000 *Code of practice for cleaning and surface repair of buildings. Cleaning of natural stones, brick, terracotta and concrete*

BS 8221-2:2000 *Code of practice for cleaning and surface repair of buildings. Surface repair of natural stones, brick, terracotta and concrete*

BS 8434-1:2003 *Methods of test for assessment of the fire integrity of electric cables. Test for unprotected small cables for use in emergency circuits. BS EN 50200 with addition of water spray*

BS EN 30-1-1:1998 *Domestic cooking appliances burning gas. Safety. General*

BS EN 30-1-2:1999 *Domestic cooking appliances burning gas. Safety. Appliances having forced-convection ovens and/or grills*

BS EN 30-1-3:2003 *Domestic cooking appliances burning gas. Safety. Appliances having a glass ceramic hotplate*

BS EN 30-1-4:2002 *Domestic cooking appliances burning gas. Safety. Appliances having one or more burners with an automatic burner control system*

BS EN 998-1:2003 *Specification for mortar for masonry. Rendering and plastering mortar*

BS EN 1279-2:2002 *Glass in building. Insulating glass units. Long term test method and requirements for moisture penetration*

BS EN 1279-3:2002 *Glass in building. Insulating glass units. Long term test method and requirements for gas leakage rate and for gas concentration tolerances*

BS EN 1279-4:2002 *Glass in building. Insulating glass units. Methods of test for the physical attributes of edge seals*

BS EN 1279-6:2002 *Glass in building. Insulating glass units. Factory production control and periodic tests*

BS EN 12600:2002 *Glass in building. Pendulum test. Impact test method and classification for flat glass*

BS EN 60335-1:2002 *Specification for safety of household and similar electrical appliances. General requirements*

BS EN 60898-1:2003 *Circuit-breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c. operation*

BS EN 61140:2002, IEC 61140:2001 *Protection against electric shock. Common aspects for installation and equipment*

BS EN ISO 11600:20032 *Building construction. Jointing products. Classification and requirements for sealants*

BS ISO 15686-1:2000 *Buildings and constructed assets. Service life planning. General principles*

PAS 1188-1:2003 *Flood protection products. Specification. Building apertures*

PAS 1188-2:2003 *Flood protection products. Specification. Temporary and demountable products*

PAS 1188-3:2003 *Flood protection products. Specification. Building skirt system*

A8.3 BRE PUBLICATIONS BY SERIES

All published by Building Research Establishment, Garston, Watford.

Digests

163 *Drying out buildings* (1974)

245 *Rising damp in walls* (1989)

364 *Design of timber floors to prevent decay* (1991)

410 *Cementitious renders for external walls* (1995)

453 *Insulating glazing units* (2000)

Good Building Guides

2 *Repairing external rendering* (2002)

18 *Choosing external rendering* (1994)

23 *Assessing external renders for repair or replacement* (1997)

24 *Repairing external render* (1997)

Good Repair Guide

11 *Repairing flood damage* Parts 1–4 (1997)

Reports

BR262 *Thermal insulation: avoiding risks* (2002)

BR332 *Floors and flooring* (1997)

BR352 *Walls, windows and doors* (1998)

BR466 *Understanding dampness* (2004)

Information Papers

IP16/81 *The weather stripping of windows and doors* (1981)

IP25/81 *The selection and performance of sealants* (1981)

A8.4 CIRIA PUBLICATIONS BY SERIES

All published by CIRIA (formerly Construction Industry Research and Information Association), London.

CIRIA/Environment Agency booklets

After a flood. How to restore your home (2001)

Damage limitation. How to make your home flood resistant (2001)

Flood products. Using flood protection products – a guide for homeowners (2003)

Book

B14 *Design of flood storage reservoirs* (1993)

Publications

C506 *Low-cost options for prevention of flooding from sewers* (1998)

C521 *Sustainable urban drainage systems – design manual for Scotland and Northern Ireland* (2000)

C522 *Sustainable urban drainage systems – design manual for England and Wales* (2000)

C523 *Sustainable urban drainage systems. Best practice manual for England, Scotland, Wales and Northern Ireland* (2001)

C538 *A review of testing for moisture in building elements* (2000)

C599CD *SUDS compilation* (2004)

C609 *Sustainable drainage systems. Hydraulic, structural and water quality advice* (2004)

C624 *Development and flood risk – guidance for the construction industry* (2004)

C625 *Model agreements for sustainable water management systems. Model agreements for SUDS* (2004)

C635 *Designing for exceedance in urban drainage systems – good practice* (2005)

C638 *Climate change risks in building – an introduction* (2005)

Independent funders report

FR/IP/45 *Reducing the impacts of flooding – extemporary measures* (2002)

Report

R140 *Water-resisting basement construction – a guide. Safeguarding new and existing basements against water and dampness. Summary report – guide to the full report (factors which most influence preliminary appraisal)* (1995)

A9 Further reading

This chapter lists publications and standards broken down by topic. These can be referenced for further good practice guidance during the restoration of a flood-damaged building.

A9.1 GENERAL

Flooding

ASSOCIATION OF BRITISH INSURERS (2003). *Assessment of the cost and effect on future claims of installing flood damage resistant measures*. ABI, London

BOWKER, P (2002). "Making properties more resistant to floods" *Municipal engineer*, vol 151, pp 197–205

CIRIA and ENVIRONMENT AGENCY (2001). *Damage limitation. How to make your home flood resistant*. CIRIA, London, and Environment Agency, Bristol

FLEMING, G (2002). "Learning to live with rivers – the ICE's report to government". *Civil engineering*, vol 150, no 5, pp 15–21

KELMAN, I and SPENCE, R (2003). "A limit analysis of unreinforced masonry failing under floodwater pressures." *Masonry international, J Brit Masonry Soc*, vol 16, no 2, pp 51–61

MILNE, J (2002). "Better flood management: the insurance perspective". *Municipal engineer*, vol 151, pp 283–286

OFFICE OF THE DEPUTY PRIME MINISTER (2003). *Preparing for floods*, 2nd edn. ODPM, London

PROVERBS, D and SOETANTO, R (2004). *Flood damaged property*, 1st edn. Blackwell Publishing, Oxford

PURNELL, R (2002). "Flood risk – a government perspective". *Civil engineering*, vol 150, no 5, pp 10–14

ROYAL INSTITUTION OF CHARTERED SURVEYORS (2001). "Flooding: issues of concern to chartered surveyors". RICS, London

SAYERS, P (2002). "Towards risk-based flood hazard management in the UK". *Civil engineering*, vol 150, no 5, pp 36–42

Climate change

HULME, M *et al* (2002). *Climate change scenarios for the United Kingdom. The UKCIP02 scientific report.* Tyndale Centre for Climate Change Research, University of East Anglia, Norwich

RICHARDSON, D (2002). "Flood risk – the impact of climate change". *Civil engineering*, vol 150, no 5, pp 22–24

SANDERS, C and PHILLIPSON, M (2003). "Adaptation strategy and technical measures in the UK, the impacts of climate change on buildings in the UK". *Building research and information*, vol 12, pp 210–212

VIVIAN, S, WILLIAMS, N and ROGERS, W (2005). *Climate change risks in building – an introduction.* C638, CIRIA, London

WERRITY, A *et al* (1998). *Climate change, flood occurrences review*. Environment Group Research Programme Research Findings no 19, Scottish Executive, Edinburgh

Insurance issues

ASSOCIATION OF BRITISH INSURERS (2001). *Flooding: a partnership approach to protecting people*. ABI, London

ASSOCIATION OF BRITISH INSURERS (2002). *Renewing the partnership – how the insurance industry will work with others to improve protection against floods*. ABI, London

CLARK, M *et al* (2002). *Insurance and UK floods: a strategic reassessment. A research report for TSUNAMI.* University of Southampton, Southampton

CRICHTON, D (2001). *The implications of climate change for the insurance industry.* Building Research Establishment, Watford, ISBN 1-903852-00-5

CRICHTON, D (2003). *Flood risk & insurance in England & Wales – are there lessons to be learned from Scotland?* Benfield Grieg Hazard Research Centre, London

MUNICH RE (1997). *Flooding and insurance*. Munich Re, Munich

Planning policy

DEPARTMENT OF TRANSPORT, LOCAL GOVERNMENT AND THE REGIONS (2001). *Development and flood risk*. Planning Policy Guidance Note 25, DTLR, London

SAMUELS, P, WOODS-BALLARD, B, HUTCHINGS, C, FELGATE, J and MOBS, P (2005). *Sustainable water management in land use planning* C630, CIRIA, London

SCOTTISH EXECUTIVE (2004). *Scottish planning guidelines for flood*. SPP 7, Scottish Executive, Edinburgh. Available at <www.scotland.gov.uk>

WELSH ASSEMBLY (1998). *Development and flood risk, planning guidance (Wales).* Technical Advice Note (Wales) 15, TSO, Cardiff

Damage and repair after flooding

BOWKER, P (1997). "Making properties more resistant to floods". *Municipal engineer*, vol 151, pp 197–205

BUILDING RESEARCH ESTABLISHMENT (1991). *Dealing with flood damage*. Information leaflet, BRE, Watford

BUILDING RESEARCH ESTABLISHMENT (2000). *Foundations, basements and external works*. BR440, BRE, Watford

BUILDING RESEARCH ESTABLISHMENT (2002). *Non traditional housing: a collection of BRE publications on CD*. AP149, BRE, Watford

BUILDING RESEARCH ESTABLISHMENT (2001). *Recognising wood rot*. BR453, BRE, Watford

CIRIA (nd). *Improving the flood resistance of your home – advice sheets*. Available online at <http://www.ciria.org/flooding/advice_sheets.html>

ENVIRONMENT AGENCY (2001). *Flood-line flood pack*. Environment Agency, Bristol

MAY, R W P, MARTIN, P and PRICE, N J (1998). *Low-cost options for prevention of flooding from sewers*. Publication C506, CIRIA, London

Health

WATER RESEARCH CENTRE (2005). *WRc utilities – sewerage case studies*. WRc, <www.wrcplc.co.uk>

Moisture content and drying of materials

BUILDING RESEARCH ESTABLISHMENT (2002). *Thermal insulation: avoiding risks*. BR262, BRE, Watford

BUILDING RESEARCH ESTABLISHMENT (2002). *Assessing moisture in building materials, Parts 1 to 3*. Good Repair Guide 33, BRE, Watford

OFFICE OF THE DEPUTY PRIME MINISTER (2004). *Approved Document C, Site preparation and resistance to contaminants and moisture*. ODPM, London

HARRISON, H W and TROTMAN, P M (2002). *Foundations, basements and external works*. BRE Elements, BRE, Watford

DEPARTMENT OF THE ENVIRONMENT, TRANSPORT AND THE REGIONS (1999). *Accessible thresholds in new housing*. DETR, London

A9.2 STANDARDS

The standards referenced here are relevant to the construction of buildings. They do not generally refer to flooding, except those for proprietary flood protection. Use them for good practice and detail specification.

Plastering and plasterboard

BS 1191-1:1973. *Specification for gypsum building plasters. Excluding premixed lightweight plasters*. BSI, London

BS 1191-2:1973. *Specification for gypsum building plasters. Premixed lightweight plasters*. BSI, London

BS 1230-1:1985. *Gypsum plasterboard. Specification for plasterboard excluding materials submitted to secondary operations*. BSI, London

BS 8000-8:1994. *Workmanship on building sites. Code of practice for plasterboard partitions and dry linings*. BSI, London

BS 8212:1995. *Code of practice for dry lining and partitioning using gypsum plasterboard*. BSI, London

Repointing

BS EN 998-2:2003. S*pecification for mortar for masonry. Masonry mortar*. BSI, London

Renders

BS EN 13914-1:2005. *Design, preparation and application of external rendering and internal plastering. External rendering*. BSI, London

02/103010 DC prEN 13914-2. *Design, preparation and application of external rendering and internal plastering. Part 2: Internal plastering*. Draft for comment, BSI, London

Doors and windows

BS 1245:1975. *Specification for metal door frames (steel)*. BSI, London

BS 1567:1953. *Specification for wood door frames and linings*. BSI, London

BS 6375-2:1987. *Performance of windows. Specification for operation and strength characteristics*. BSI, London

Flooring

BS 8000-2.1:1990. *Workmanship on building sites. Code of practice for concrete work. Mixing and transporting concrete*. BSI, London

BS 8000-2.2:1990. *Workmanship on building sites. Code of practice for concrete work. Site work with in situ and precast concrete*. BSI, London

BS 8103-4:1995. *Structural design of low-rise buildings. Code of practice for suspended concrete floors for housing*. BSI, London

BS 8201:1987. *Code of practice for flooring of timber, timber products and wood based panel products*. BSI, London

BS 8204-5:2004. *Screeds, bases and in-situ floorings. Mastic asphalt underlays and wearing surfaces. Code of practice*. BSI, London

Water and sewers

BS 8000-13:1989. *Workmanship on building sites. Code of practice for above ground drainage and sanitary appliances*. BSI, London

BS 8000-14:1989. *Workmanship on building sites. Code of practice for below ground drainage*. BSI, London

BS EN 752-1:1996. *Drain and sewer systems outside buildings. Generalities and definitions*. BSI, London

BS EN 752-2:1997. *Drain and sewer systems outside buildings. Performance requirements*. BSI, London

BS EN 752-3:1997. *Drain and sewer systems outside buildings. Planning*. BSI, London.

BS EN 752-4:1998. *Drain and sewer systems outside buildings. Hydraulic design and environmental considerations*. BSI, London

BS EN 752-5:1998. *Drain and sewer systems outside buildings. Rehabilitation*. BSI, London

BS EN 752-6:1998. *Drain and sewer systems outside buildings. Pumping installations*. BSI, London

BS EN 752-7:1998. *Drain and sewer systems outside buildings. Maintenance and operations*. BSI, London

BS EN 13380:2001. *General requirements for components used for renovation and repair of drain and sewer systems outside buildings*. BSI, London

Proprietary flood protection

BS EN 13564-1:2002. *Anti-flooding devices for buildings. Requirements*. BSI, London