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Guidance on the code of practice for property flood resilience

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Guidance on the code of practice for property flood resilience

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	Status	Committee-guided
	User	Owners, occupiers, property managers, flood risk managers, engineers, property surveyors, loss adjusters, builders, architects, building control officers and local authority planners. Risk management authorities, insurers, community flood resilience groups, suppliers and contractors involved in the installation of PFR measures, local authorities and local planning authorities.

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Front image courtesy: Flood Ark/Mary Dhonau

Summary

Property flood resilience (PFR) is an important part of the response to flood risk. PFR includes measures that provide a way to reduce the risks to people and property enabling households and businesses to reduce flood damage, speed up recovery and reoccupation of flooded buildings. PFR measures should reduce the amount of water entering buildings (known as resistance measures), or limit the damage caused if water does enter a building (known as recoverability measures).

A code of practice (CoP) has been developed covering the inclusion of PFR measures that can be introduced to buildings at risk from flooding. Often these measures can be installed as part of the repair of buildings after they have been flooded. However, some property owners may wish to be proactive and fit measures in anticipation of a flood.

The CoP includes six standards that specify what should be achieved. This guidance supports the CoP's six standards and provides comprehensive guidance on how the standards should be met by following Stages within a PFR delivery process. There are also complementary guidance on using the CoP for households and businesses and local authority planners.

Readers should note that the website links included in this guide were correct at the time of writing (November 2020).

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Peter May	JBA Consulting
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Contents

Boxes

Case studies

Figures

Tables

PART A

ABOUT PROPERTY FLOOD RESLIENCE

Manually deployed flood barriers

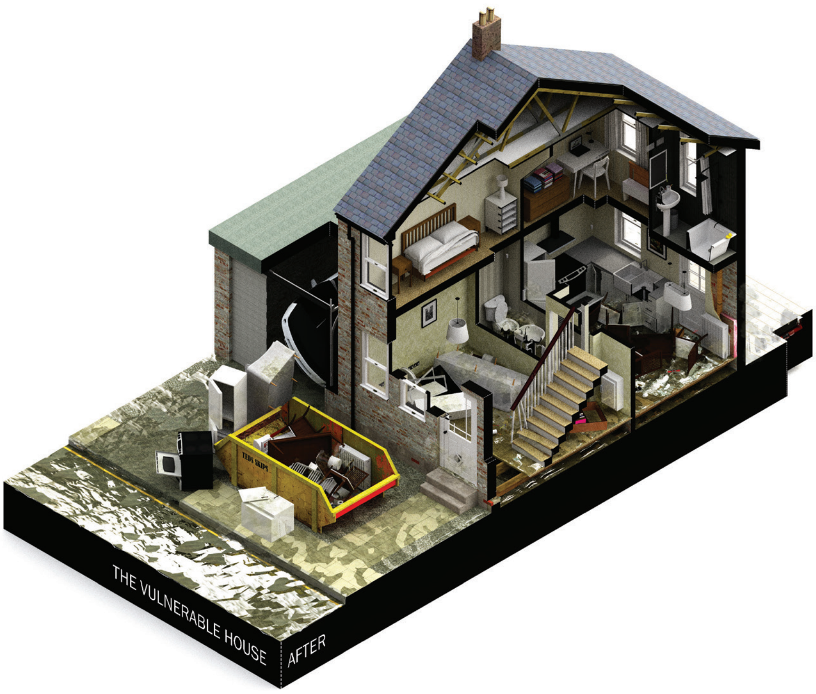
1 What is property flood resilience?

PFR is an important part of managing flood risk. PFR measures should reduce the amount of water entering buildings (known as resistance), or limit the damage caused if water does enter a building (known as recoverability). Some of the terminology used in the guidance is presented in **Box 1.1**. An illustration of a vulnerable (non-resilient) home after a flood (**Figure 1.1**) and of a flood-resilient home after a flood is presented in **Figure 1.2** that demonstrates the difference that PFR can make by managing and reducing the damage caused by flooding.

PFR is particularly useful in areas where it is not practical to protect communities by structural flood defences or where it is necessary to manage residual flood risk (where existing defences may be overtopped or breached). PFR can reduce the risks to people and property, enabling households and businesses to reduce flood damage, speed up recovery, and reoccupy flooded buildings sooner.

PFR can give peace of mind to the occupants or owners of buildings at risk of flooding, particularly if the property has been flooded in the past. The impact on the long-term health and wellbeing of occupiers and on business continuity are important factors and should inform approaches to PFR.

The range of measures and approaches that can be used to make properties more flood resilient is covered in **Chapters 24 and 25**.



Note

In the vulnerable home floodwater has entered the building damaging floors, walls, furniture, fixtures and fittings and appliances. The recovery process will require flooded areas to be cleaned and dried with any damaged materials possibly needing to be discarded and replaced.

Figure 1.1 A vulnerable (non-resilient) house following a flood (courtesy The Environmental Design Studio)

Note

In the flood resilient home resistant measures like door and window barriers reduce the amount of floodwater entering the building. A sump and pump removes any floodwater that does make it into the property. The end users are prepared for the flooding and move furniture and belongings to reduce damage. Recoverable materials used for floors and walls enable them to be easily cleaned and dried.

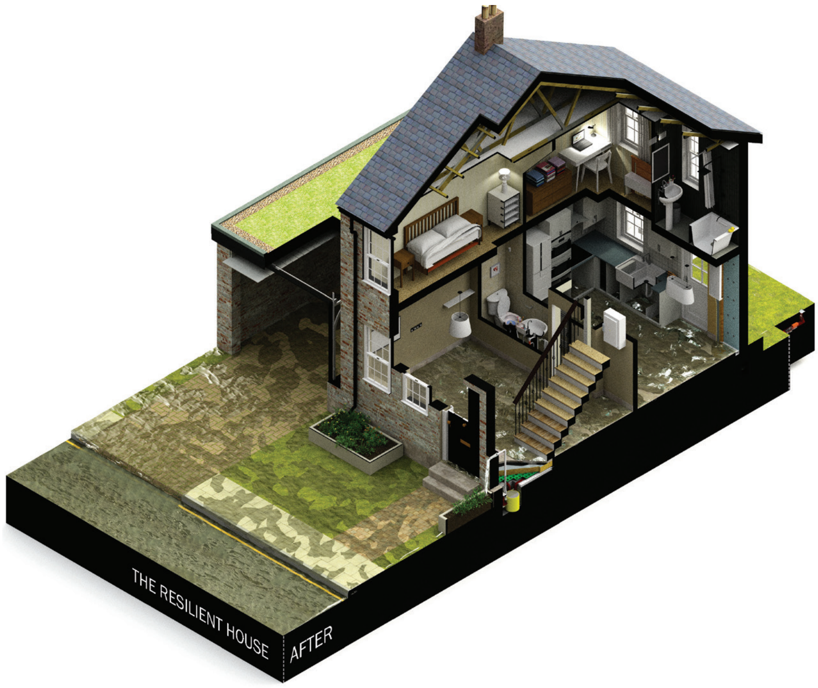


Figure 1.2 A resilient house following a flood (courtesy The Environmental Design Studio)

Box 1.1 Key terminology

Flood resilience	The capacity that people, groups or structures may possess to withstand or recover from a flood.
Flood resistance	The use of materials and approaches to manage water entry into the property. This relates to water exclusion, ie keeping water out.
Flood recoverability	The use of materials, products and construction methods that prevent the internal fabric of the property from being unduly damaged by floodwater and allow it to recover quickly after a flooding.
End user	The occupier of the property, or owners – the primary user of PFR measures who is likely to deploy, operate and maintain any PFR measures.

2 Background to the code of practice

2.1 WHY IS A COP NEEDED?

When PFR is used well it delivers many benefits, most importantly giving peace of mind to those who own or occupy buildings that are at risk of flooding, limiting damage and speeding up recovery. However, on occasions, it is also evident that PFR has not been delivered well, resulting in other issues such as investment in measures that are not needed or too expensive, measures not performing as expected, and users not being able to operate or maintain the measures. This inconsistency in how PFR measures are specified and installed can lead to a lack of confidence in PFR.

The purpose of the CoP is to provide standards that ensure PFR is consistently well implemented. It has been developed by referencing existing knowledge (see **Table 3.1**) and providing new guidance, with input from a broad group of industry stakeholders and specialists.

The CoP applies to individual properties and does not cover the use of community flood schemes or sustainable drainage systems (SuDS). However, reference is made to the inclusion of boundary and curtilage protection for properties (**Section 24.6.6**).

The CoP and guidance are designed to be used by a variety of individuals involved in delivery of PFR, including:

- property owners, occupiers, and managers (residential and non-residential)
- engineers, property surveyors, and architects
- manufacturers and suppliers of PFR measures
- construction contractors and installation companies (involved in installing PFR measures)
- local authority planners, developers and regulators specifying PFR for new build and retrofit situations (planners, building control, risk management authorities)
- insurers, loss adjusters and insurance brokers
- sewerage companies.

The CoP is intended to be applied in several different circumstances, including retrofit of measures as a precaution before flooding and during the repair of flood damaged buildings. It should also be considered when planning the repair or refurbishment of existing buildings at risk from flooding for any reason, eg extension works, or new-build construction.

This publication is relevant for both domestic and non-domestic properties (including public buildings, and commercial and industrial properties). Two complementary guides have been developed, one for property owners, occupiers and managers of households and businesses, and one for planners working in local authorities. These guides summarise key information presented in the CoP and guidance, with signposts provided to this publication where appropriate.

2.2 STRUCTURE OF THE COP

PFR delivery follows the three key phases that are generally associated with construction projects, ie design, construction, and operation, but within each of these there are aspects that are unique to PFR. For this reason, the delivery process has been divided into six stages that better reflect the needs of PFR (**Figure 2.1**). The CoP is based on this six-stage process, with standards defined for each stage.

Design phase

Stage 1: hazard assessment

Deliver a property level flood hazard assessment that clearly summarises the available hazard information to determine the likelihood and consequences of flooding from different sources. These details will be use to inform the suitability of potential PFR measures.

Stage 2: property survey

Carry out an appropriate flood risk survey of the property and assessment of end user requirements. The purpose of the survey is to assess the current level of flood resilience and provide information for the detailed design and implementation of PFR.

Stage 3: options development and design

Based on the outputs from the hazard assessment and the property survey, produce a detailed PFR options appraisal and design which is agreed by all parties, and will inform the installation of appropriate PFR measures. This considers the current and future needs of the occupant(s) and building.

Construction phase

Stage 4: construction

Construction in accordance with regulations, instructions and good practice is undertaken to enable the PFR products and their installation to deliver the levels of resistance and recoverability required.

Stage 5: commissioning and handover

Carry out checks and a post-installation audit (PIA) to assess whether the relevant PFR construction work operates effectively as designed. Also, check users have all relevant information and are informed on the operation and maintenance needs of the PFR measures installed.

Operation phase

Stage 6: operation and maintenance

Clearly define and assign responsibilities for operation and maintenance so that the completed PFR construction works are properly operated and maintained throughout their planned lifetimes.

Figure 2.1 Process showing PFR stages

The CoP is supported by guidance on delivering PFR, contained in **Part C** of this publication. This part also includes a hypothetical illustrative example for each stage that explains how the CoP may be used in a 'real' situation. In addition, **Appendix A5** contains case studies that demonstrate the benefit of following the good practice included in the CoP. References are also given to existing guidance and related documents with more information. These are signposted in the text and a complete list presented at the end of this publication. Recommendations for further reading are included in each chapter.

3 Background to the guidance

3.1 WHY IS THE GUIDANCE NEEDED?

The CoP is available as a standalone document (C790A) and is also included in **Part B** of this guidance. It provides the standards that should be met in delivering PFR. The focus is on the required output from PFR. This guidance describes how the standards can be met in different circumstances. The number of guidance documents and research reports on PFR has grown substantially over recent years, resulting in fragmented information on the options for and the delivery of various elements of PFR. This guidance provides a consolidated resource and a framework for the selection of appropriate measures and management of those measures over the complete life cycle of PFR. The guidance does not describe in detail every aspect of delivery but does set out particular aspects of PFR that differ from conventional small building works. For example, the full requirements of meeting the Construction (Design and Management) Regulations 2015 (CDM 2015) are not covered here (see **Appendix A2**), only those specific to PFR.

Research and development work undertaken across the UK and beyond have been used in the development of this CoP and guide. It does not seek to re-invent evidenced-based knowledge on PFR, but instead uses this to develop a concise CoP and guide as a useful resource to everyone involved in PFR. **Table 3.1** identifies some key research projects which informed its development.

Table 3.1 Key projects which have informed the development of this guidance

Project title	Funder(s) of project
SMARTeST (Within Cordis) *Smart technology, systems and implementation tools*	EU FP7 = major funder, plus contributions from none other participating organisations
FD 2668 *Post installation effectiveness of property level flood risk management measures*	Department for Environment, Food and Rural Affairs
FD 2681 *Surveying for flood resilience in individual properties*	Funded by the joint Flood and Coastal Erosion Risk Management Research and Development Programme (FCERM R&D). The joint FCERM R&D programme comprises Defra, Environment Agency, Natural Resources Wales and Welsh Government
FD 2682 *Supporting the uptake of low-cost resilience*	
FD2706 *Supporting the uptake of resilient reinstatement during the recovery process*	
FloodProBE *Cost-effective means for flood risk reduction in urban areas*	European Commission, 7th Framework programme

Sections of the guidance contain public sector information published by the Health and Safety Executive and licensed under the Open Government Licence.

3.2 STRUCTURE OF THE GUIDANCE

Part C provides details on the guidance and has a stage for each of the standards in the CoP (**Figure 2.1**). Each stage is divided into several steps which contains details of how the required outputs can be delivered to meet the associated standard. An illustrative example is also provided in **Part C** to show the PFR process aligned to the relevant stages and steps.

This guidance is designed to help users specify and provide PFR solutions that meet the needs of the property, its owners and occupiers, as well as being suited to the assessed flood risk. It covers the life cycle of the PFR project from initial scoping to final operation and is based upon the stages involved in delivering PFR. It applies to the delivery of PFR schemes to single or multiple buildings.

Elements of both resistance and recoverability can be used for any property. The type and severity of flooding and the level of risk involved, as well as the type of property and its occupants, are central to selecting the approach to PFR. Obtaining information relating to the flood hazard and the features of the property will help to determine whether resistance, recoverability or a combination of both approaches should be used.

This guidance supports the use of the CoP for PFR (Gabalda *et al*, 2013). It has four main parts as set out in **Table 3.2**. **Parts A, B and C** can be read as standalone documents, or together as a comprehensive guidance. See **Chapter 4** for further information on how to use the CoP and guidance.

Table 3.2 Description of all parts in this guidance

Section of document	Description
Part A	This part provides introductory background information on flooding and PFR. This includes information on definitions and overriding principles that are relevant for the document. **Part A** also includes information on roles and responsibilities, liabilities and contracting approaches that may be relevant for those procuring PFR.
Part B	This part introduces the six standards that describe specific elements of PFR which should be achieved to improve the resilience of a property. The six standards constitute the CoP and have requirements that should be fulfilled.
Part C	This part describes the PFR process in six stages, which relate to the six standards of PFR. Each of the stages has a number of steps that guide the user to successfully implementing PFR and deliver the requirements of the CoP.
Part D	This part provides further information to support the user when implementing PFR. It is linked to the guidance in **Part C** and provides detailed support to those who require more information.
Appendices	This includes a glossary, detail of CDM 2015, checklists, and additional information to support the PFR process. Case studies on the implementation of PFR are also given.

3.3 APPLYING THE GUIDANCE

3.3.1 Interpretation

When interpreting the guidance, the following key principles shall apply:

- **Clarity and confidence.** The CoP and guidance provide clarity on how to improve the resilience of a property by the introduction of PFR measures. Care should be taken to ensure the CoP delivery process does not lead to false or exaggerated expectations about the improved resilience performance of the property. Care should also be taken to ensure measures specified do not result in unintended consequences that could adversely affect the property, occupants, or surrounding buildings and infrastructure. This will give confidence to the property owner and occupier about the resilience of the property during and after a flood event.
- **Proportionality.** The PFR approach should be proportionate to the identified risk, costs, and expected levels of resilience. There should be a balance of the need for a structured and accountable process for delivering PFR, while not over-specifying the level of resilience required or the need for costly fees and assessments where they may not be required.
- **Appropriate solutions for the end user.** The needs and preferences of the end user and of the building occupants should be key to the PFR delivery process. Assessments of user needs should cover impacts arising from current and future daily needs of occupants of the building. For example, redecoration and the effects of normal activities, including operation and maintenance (O&M), should be considered. PFR measures should account for the circumstances of those who will operate and maintain the recommended measures.
- **Effective communication and engagement.** At every stage of the PFR process, clear and effective communication is vital. This is important to establish a shared understanding of the process and what can be achieved. It should include dialogue between appropriate persons and end users and supporting agencies and advisors, such as insurance representatives and community groups. Written communication should be in language that is easy to understand and appropriate for the intended purpose.

3.3.2 Existing buildings – before and during a flood

Often resilience measures (eg removable flood gates) require active deployment before a flood. Consequently, adequate advance warning is required for the measures to be deployed and checked. Occupants may choose to deploy manual measures if they are away from the building for a period of time.

Deploying manual resilience measures can be part of a wider flood plan such as removing items to safety and evacuating the premises if appropriate.

Further information on the best approach to take in the event of a flood, and how to prepare for a flood, can be found through the sources presented in **Box 3.1**:

Box 3.1 *Further information on preparing and managing floods*

- National Flood Forum: **www.nationalfloodforum.org.uk**
- Scottish Flood Forum: **www.scottishfloodforum.org**
- Know Your Flood Risk: **www.knowyourfloodrisk.co.uk**
- FloodGuidance.co.uk: **www.floodguidance.co.uk**

There is also value in engaging with any present local community action groups in an area.

3.3.3 Existing buildings – after a flood

Following a flood property owners should:

- liaise with the emergency services to confirm it is safe to return to and/or stay in the property
- contact the insurer and agree the process for damage assessment
- when it is deemed appropriate to do so, commence cleaning/decontamination of affected areas
- seek professional advice on drying and reinstatement/repair (**Section 15.4.2**).

The extent to which property owners needs to undertake these activities will depend on the level of flood resilience. If PFR measures have been properly implemented, then the impact of most floods on a property will be minimal. Recovery may be a case of appropriately drying and decontaminating surfaces that have been exposed to floodwater. Where fittings and fixtures have been moved in preparation for the flood, they can now be returned to their original place. Manual resistance measures can be removed, cleaned and inspected, and stored for future use. Only in exceptional circumstances should more need to be done. For example, in an extreme flood event it may be that resistance measures are overtopped. In such case there may be flood damage to the property that requires more attention. A flood event is often the catalyst for improvements to be made to incorporate PFR measures as shown in many of the case studies in **Appendix A5**.

3.3.4 New development

PFR may be an important consideration when planning new development, particularly when that development may have a significant residual risk of flooding. However, note that each government administration in the UK has policy and legislation, such as the National Planning Policy Framework (NPPF) (MHCLG, 2019) in England, which sets out that new development should avoid areas that are at risk of flooding where possible. PFR measures should not be used to justify inappropriate development. An assessment of flood hazards against plans, drawings and specification of the development should be undertaken early in the development process, and opportunities to embed PFR in the design and construction of the building should be explored and exploited.

An adaptation strategy for future flood resilience incorporated early in the design process is likely to make any future resilience improvements much simpler, less disruptive and more cost effective. Some recoverability measures can readily be applied for new construction with a minimal impact on overall cost.

3.4 DELIVERING PFR

There are many ways in which PFR can be delivered. For example, an end user may wish to improve the resilience of a property to flooding for better peace of mind. In this case the client (**Section 22.2** [domestic] and **Section 22.3** [non-domestic]) and the end user are the same. The end user may act in expectation of a future flood or because of past flooding.

Many PFR initiatives have been delivered in recent years by central and local government, water companies, estate managers and businesses. In these cases, PFR measures are often implemented on a group of properties. Most government-funded schemes use grant-in-aid to fund PFR measures. Following severe flooding incidents the government makes support packages available to help people whose homes and businesses have suffered from flooding. In these circumstances, the funder, client and end user may all be different, and the end user may be asked to make a financial contribution to the measures delivered.

Regardless of whether the end users are clients or not, engaging fully with the end users of PFR to understand and meet their requirements (individually, or as a group where multiple properties are involved) is as important as understanding both the building(s) and the characteristics of the flood hazard.

There are two reasons for this:

1 Where flooding has already affected a building, the occupants may possess additional information on, for example, previous attempts to protect the property, as well as details regarding any building extensions and/or alterations. This can help the surveyor to achieve a comprehensive understanding of the flood hazard(s) and the additional and/or replacement measures needed.

2 If PFR measures are to be effectively deployed and maintained, it is important that users fully understand and agree to both the measures and how they should be used and maintained.

Engagement with users will depend on the scheme delivery method and number of properties involved. Users should be included from the property survey through to the options development and outline design. If necessary, a community group may be formed to ensure that engagement involves all the affected occupiers.

When engaging with homeowners or business owners who have already experienced flooding, it should be noted that long-term mental health issues can result from their experiences, including depression, anxiety and post-traumatic stress disorder (PTSD). It is important to be aware that any discussion of a previous flood event may provoke strong emotional responses, which should be handled with a high level of tact and understanding.

Finally, it should be remembered that for each home or business concerned, the PFR process is a new and unfamiliar situation. Avoiding the use of acronyms and technical jargon (except where this is accompanied by a clear explanation) when discussing their needs and requirements will make it a less daunting experience for the owners and occupiers concerned.

3.4.1 Procurement of PFR

The procurement of PFR may vary depending on the size of the property, the needs of the client, the scale and source(s) of funding, the scope of the required works and the use of the buildings concerned. This CoP and guidance does not prescribe procurement routes. It does offer some examples, but these are not exclusive, and the potential advantages and disadvantages of these approaches are presented in **Table 3.3**. In all cases, the procurement approach should reflect the scale of the PFR measures and the status of those funding the measures, ie whether homeowner or local authority. The procurement route should also follow the overriding principles of this guidance, ie proportionality, and ensuring those delivering services have the appropriate skills, expertise, and insurances to carry out the tasks in-line with the requirements of this guidance.

A key decision in procuring PFR is whether to use a 'one-stop shop' approach in which the survey, specification of measures (design) and installation and/or construction is undertaken by one organisation, or whether different parts of the process are delivered by different organisations (**Table 3.3**).

Table 3.3 Example pros and cons of three procurement types

Procurement type	Pros	Cons
One-stop shop. Survey, selection of measures, design, and specification of measures, and installation and/or construction combined	• Easier for less experienced clients to manage, single point of responsibility, single most cost-effective contract price. • May be more cost effective if the proposed works are modest.	• May unduly favour particular products.
Two-stage process. Survey and selection of measures separate from design and specification of measures, and installation and/or construction	• Most likely to give impartial advice so that the most appropriate measures are installed. Independent check on installation can assure quality.	• May not be cost effective for small-scale projects. • May be difficult to assign responsibility if something goes wrong.
Three-stage process. Survey, followed by independent selection, design and specification of measures, then separate installation/construction	• May be an advantage on particularly complex projects where significant design input is required and/or where independent supervision of the installer is required.	• May be more difficult to assign responsibility if something goes wrong. • May be more expensive to manage and deliver.

As with any construction work, PFR should be procured using an agreed form of contract. There are several versions already in existence for building projects that are suitable for this purpose, and it is the responsibility of the client to choose the appropriate form. The form of contract sets out the 'rules' which each party to the contract shall abide, and these will differ from one form of contract to another. Some examples of the type of contracts that may be relevant to PFR projects are presented in **Table 3.4** (this is not an exhaustive list).

Table 3.4 Types of potential contract for PFR delivery

Type	Explanation
Standard building contract	Used for large or complex construction projects using a three-stage procurement process where detailed provisions are needed. Suitable for projects procured via the traditional or conventional method, eg Joint Contracts Tribunal (JCT, 2019a and b).
Minor works building contract	Used for smaller, basic construction projects where the work is simple. Suitable for projects procured via the traditional or conventional method and often one stop shop.
Design and build contract	Suitable for construction projects where the contractor carries out both the design and the construction work a two-stage procurement process. Projects can vary in scale, but contract is generally suitable where detailed provisions are needed.
Repair and maintenance contract	Suitable for use on individual projects that involve a defined programme of repair and maintenance works to specified buildings or sites. This contract is primarily for use by local authorities and other employers who regularly place small and medium-size contracts with subcontractors and are sufficiently experienced that an independent contract administrator is not required.
Householder contract	Used specifically for private individuals looking for the benefits and protection of a contract when appointing consultants or contractors to carry out their building work.

Irrespective of the contract used, contractors (**Section 22.5**) or installers should have documented processes to assure the competency of their operatives. These quality control processes should extend to the installation of products to the requirements of manufacturers and the PFR design and specification.

The liabilities relating to PFR should not differ from those commonly identified in construction activity. The products, materials and installations may be different, however the development of the PFR design, construction activity, handover and operation are consistent with most forms of construction activities.

All appropriate persons engaged in PFR should possess insurance for an appropriate amount, eg professional indemnity for those involved in survey/design, and contractors all risks for those involved in installation plus public liability. Appropriate persons should be members of trade associations and/or professional institutions that provide support through continued professional development (CPD). For more information about the requirements to undertake PFR, see **Chapter 5** and for more information on contract management see **Chapter 22**.

3.5 PROFESSIONAL STANDARDS, CERTIFICATION AND SKILLS

CDM 2015 guides users in relation to various roles and responsibilities in construction (see **Appendix A2**). While CDM 2015 primarily determines the duties of the different parties in terms of health and safety, they can also place duties on those parties for other matters, eg overall design responsibility for a PFR scheme and/or solution. To accommodate this variation, this guidance often refers to the 'appropriate person' (see **Box 3.2**) for particular stages of the PFR delivery process.

Box 3.2 Appropriate person

One of the duty-holders described under CDM 2015 they should act in accordance with a relevant set of professional standards, carry appropriate professional indemnity insurance and can demonstrate the required levels of skills, knowledge and experience and, as defined in the regulations, have a construction-related or a flood and water management background.

This individual should have the necessary capabilities and resources, with right blend of skills, knowledge and experience, who understands their roles and responsibilities when carrying out work. They shall always act impartially and without favouring any supplier of equipment, materials or services.

Appropriate persons, construction professionals and trades people working together or independently within the PFR sector should deliver services in an efficient and effective manner. The CoP should be used to underpin training and certification of qualified people at all stages of PFR delivery.

There is limited use of professional certification within the PFR sector, which is largely due to it being a relatively new sector within construction. This is expected to improve as the PFR sector becomes more mature and regulated. Qualified individuals may have certification from engineering, surveying, or building organisations, such as Institution of Civil Engineers (ICE), Chartered Institution of Water and Environmental Management (CIWEM), Royal Institution of Chartered Surveyors (RICS), Chartered Institute of Building (CIOB), Federation of Master Builders (FMB), Residential Property Surveyors Association (RPSA), and Chartered Association of Building Engineers (CABE).

3.6 LIMITATIONS FOR THE USE OF THE COP AND GUIDANCE

The CoP and guidance does not cover the use of strategic flood defences, community barriers or sustainable drainage systems (SuDS). The guidance 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 guidance may be useful in these circumstances (eg decontamination and drying, which are directly applicable), but they are not written specifically for such incidents.

There are many factors that will influence the impact of flooding on a property, including the flood hazard, the construction form, and condition of the property. End user needs will also differ. For this reason, the range of appropriate measures are likely to be unique to a particular property.

Also, there is currently no accepted measure of resilience. This relates to both products and properties (or buildings). The lack of an industry measure for resilience, and the significant variability in relevant parameters (as previously discussed) does not allow generic 'guarantees' to be provided in relation to performance of PFR. However, performance guarantees may be available for specific products. Note that some products may comply with BSI kitemark, in accordance with the testing and certification of a resistance measure which conforms with the requirements of BS 851188-1:2019 and BS 851188-2:2019.

Any guarantees, warranties, certification or gradation of resilience performance will be specific to the agreed contract and design for each individual case.

Further reading

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HSE (2015d) *Summary of duties under Construction (Design and Management) Regulations 2015 (CDM 2015)*, Health and Safety Executive, London, UK
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https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-concise-building-contract

RIBA (2018b) *RIBA Domestic Building Contract 2018*, Royal Institute of British Architects, London, UK
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4 How to use the CoP and guidance

4.1 SCOPE AND STRUCTURE

The scope and structure of the CoP and guidance cover the three phases of, design, construction and operational. Implementing PFR is a six-stage process, as set out in **Table 4.1**.

Table 4.1 The PFR process stages

Stage	Action and predicted outcome	Outputs
Design phase	***The design phase includes identifying the flood hazard to the property. Using this information PFR options will be selected and a design solution developed for the property***	
PFR Stage 1: hazard assessment	A flood hazard assessment for the local area of the property will be undertaken. This will identify the flood hazard at the property based on information sources such as: • flood maps and climate prediction information • historical information of flooding in the area • nature of flood hazard in that specific location (eg source, depth, frequency) and ground conditions • personal experiences of tenants, community etc.	A report outlining the findings of the hazard assessment given to the end user in a suitable format.
PFR Stage 2: property survey	Detailed survey of the property in its current form, and potential areas for 'improvement' when affected by the potential hazard(s) identified in Stage 1, will be completed. The surveyor will prepare a written report to discuss with the end user. Entry points for floodwater should be identified and considered in case a resistance approach is suitable.	A report outlining the findings of the property survey given to the end user in a suitable format.
PFR Stage 3: options development and design	This stage is in two parts to identify different responsibilities and potentially accommodate different forms of procurement. The first part is based on the hazard assessment and property survey, and a range of PFR options will be developed and presented to the end user for consideration. Each option will consist of one or more generic measures. Selection of the appropriate option of PFR measures will consider: • operational performance • cost and benefit • operation and ability of the property owners/tenants • maintenance costs. • degree of resilience that each option delivers (relative to other options) In some cases, only one option may be practical. Options will only be described in outline terms at this stage and specific products would not normally be identified. In the second part, the measures in the selected option are designed and specified, and drawings are normally produced ready for construction. As part of this, particular products may be specified.	Report(s) that include an options development summary report and the final PFR design and specification provided to the end user in a format suitable for installation/construction. Depending on procurement this can be two separate reports or combined.
Construction phase	***The construction phase includes the installation of PFR measures for the property, as identified in the design phase. Once installed, the PFR measures should be checked/tested to ensure they are operating effectively***	
PFR Stage 4: construction	Installation of the selected PFR solution at the property in a safe, efficient, and cost-effective manner and in accordance with the design and specification developed in Stage 3. The appointed contractor will provide details of the scope of works to the end user and identify any deviation from the original design.	Completion of the PFR works installation on the property.

Stage	Action and predicted outcome	Outputs
PFR Stage 5: commissioning and handover	On completion of the construction work, the contractor will demonstrate the operation of the PFR measures and conduct *in situ* testing of components (where relevant). The contractor will show the end user the PFR adaptations and discuss their function and operation. The contractor will provide the end user with a document summarising the works undertaken, and any operational/maintenance information that may be relevant. It is the responsibility of the contractor to ensure that the end user is confident and competent in deploying the measures, and that they have a point of contact for further information. Depending on the form of procurement, this stage may include an independent inspection and certification of the installation.	O&M handover pack – information on the operation and maintenance of the installed PFR measures. Completed works sign off and agreement of all parties that the works have been undertaken to a suitable standard, where relevant, a final certificate.
Operational phase	***The operational phase gives guidance on the use of PFR measures and their deployment and maintenance***	
PFR Stage 6: operation and maintenance	The end user should regularly check the integrity and operation of the PFR measures installed and any storage facilities for them. This should include checks after a flood incident and at regular intervals – following product manufacturer's guidance where relevant. Ongoing maintenance is important to ensure the integrity and operation of the PFR measures to achieve their design life. This responsibility lies with the property owner who should keep an accurate record of routine and unplanned maintenance.	Continued operation and ongoing maintenance of all PFR measures installed on the property in accordance with manufacturer's recommendations.

Part B contains the PFR CoP. It specifies the outputs expected from each stage in the form of standards and can be used as a free-standing tool by any party engaged in PFR. If PFR works are to be delivered in accordance with the CoP, all the outputs specified here shall be delivered. Any client or end user not experienced in PFR may wish to use an independent assessor to certify the works have been completed to the standards. A checklist for each stage is included to help ensure that the standards are met (see **Appendix A3**).

Part C contains guidance on how to meet the standards. This has been written for construction professionals with experience of general construction work to explain how the requirements of the CoP can be met. Supporting information is given in **Part D** and the **appendices**, which should be read with **Part C**. Within this CoP and guidance examples are given to highlight the PFR process and products that could be used to improve property resilience. These are not exhaustive but are included to show how the guidance could be applied in practice. Further advice, information and support is signposted throughout the guidance.

Chapter 18 provides examples of typical end user questions and how the CoP and guidance helps to answer them.

The CoP and guidance gives the best available representation of good practice at the time of writing. However, this is a relatively new and rapidly developing field and there is a need to keep up to date on key developments.

PART B

CODE OF PRACTICE FOR PROPERTY FLOOD RESILIENCE

River Severn flooding at Shrewsbury

5 Overriding principles

The PFR CoP is made up of six standards. To achieve each of these there are specific requirements which should be met. The standards cover the range of activities that should be undertaken to successfully deliver PFR. This CoP is under-pinned by three overriding principles for PFR as set out in **Table 5.1**. Competence of individuals is important and all aspects of the PFR process should be undertaken by an appropriate person. There may be different people for each stage, but it is important to recognise the experience and limitations of those involved.

Table 5.1 Overriding principles to meet the PFR Standards

Requirement	Aspects relevant to all stages of PFR delivery
Competence of individuals	All aspects of the PFR process should be undertaken by an appropriate person acting in accordance with a relevant set of professional standards. They should carry appropriate professional indemnity insurance and be able to demonstrate the required levels of skills, knowledge and experience through previous work experience, membership of a professional body and/or certified training. An appropriate person should always act impartially, without favouring a particular supplier of equipment, materials or services.
Proportionality	It is important the specification and deployment of PFR is proportionate to the risk to the property and the resources available. For example, if the perceived risk to the property is low, then a less detailed property survey may be sufficient. Similarly, if the risk is perceived to be high, a more detailed survey of the property would be appropriate and more costly PFR measures may be justified. This common-sense approach should allow a degree of flexibility in relation to the scale of activities undertaken as described within this PFR CoP.
Information and reports provided to the end user	All communications and reports should be provided in easy to understand, clear and concise language appropriate to the purposes for which it is to be used. It should be sufficiently detailed and comprehensive to fully inform any stage within the PFR process. Any uncertainties in the information given should be made clear in these reports. Information should also be provided at an appropriate time to assist the end user.

The six standards within the PFR CoP consists of the following:

- A brief description that sets out the context.
- The aim and purpose of the standard.
- The requirements which should be delivered during the specific stage of the PFR process. If any requirement is not met, the work will not meet the standard set out in the PFR CoP.

6 PFR Standard 1: hazard assessment

INTRODUCTION

To comply with PFR Standard 1 a flood hazard assessment shall be undertaken to understand how flooding might threaten a property. This assessment shall include the following:

- likelihood of flooding in the property location (and surrounding areas)
- nature of the flooding that could potentially occur
- likely frequency of flood events for the location – including the potential for increased frequency due to climatic change and/or urban development
- susceptibility of the property and its building(s) to flooding, given its surroundings, design, structure, materials used, condition, and adaptations.

Identifying the flood hazard to a property is a critical element in the development of PFR measures. Conducting a flood hazard assessment can be a detailed and intricate process, often requiring specialised skills to interpret information presented within flood maps or other relevant sources.

AIM

PFR Standard 1 shall deliver a property level flood risk assessment, which clearly summarises the available hazard information to determine the likelihood and severity of flooding from different sources. This information will be used to inform the selection and design of PFR measures.

REQUIREMENTS

1. A survey of the flood risk to the property shall be carried out. The scale and detail of the survey shall be proportionate to the perceived level of risk and the potential size of the project. Surveys shall be extended should a greater complexity of flood risk become apparent during the survey.
2. The site of the property shall be assessed for the likelihood of flooding based on a 'source–pathway–receptor' approach for all potential sources and range of probabilities of flooding.
3. The potential source(s) of flooding shall be determined using appropriate methods of hazard identification. This shall be accompanied by an assessment of flood frequency, as well as depth and duration for all sources at a range of return periods.
4. The property flood risk assessment shall take account of relevant flood risk information from local authorities, utilities and other environment agencies. It shall take account of additional flood risk information from other relevant sources (including property owners).
5. The potential routes of floodwater (pathways) to the buildings/structures within the property from the sources shall be identified.
6. The pathways for flooding from each source to the property and likely speed of onset shall be identified, including measures that currently exist, or are planned, for controlling that pathway at the property, community or catchment scale (including flood defence works). This analysis shall include all relevant structures near to the property.

7 PFR Standard 2: property survey

INTRODUCTION

The identification and delivery of PFR relies upon information provided by a suitably detailed survey of the building(s) at the property. The design, materials, condition, orientation, and exposure of buildings will vary greatly and a survey, unique to each building, is a critical element to identifying suitable resilience measures.

AIM

PFR Standard 2 requires that an appropriate survey of the property and end user requirements is carried out. The purpose of the survey is to assess the current level of flood resilience of the property to provide the necessary information for the identification of the PFR options suitable for the property. Each building and structure at the property shall be surveyed.

REQUIREMENTS

1. The scale and detail of the survey shall be proportionate to the level of risk and the size of the project. The survey shall also identify appropriate approaches to increase resilience and minimise damage, with reference to the end user needs.
2. The survey shall establish the building type, age, construction, condition, operation and contents.
3. The current level of PFR shall be established, including estimating the water leakage resistance capacity of the walls and floors, the recoverability of the materials and components, and end user capacity to implement measures.
4. The method of drying and decontamination of the building after a flood shall be assessed, including the impact of wetting of building materials and that of voids and cavities in walls and floors.
5. The ground conditions on the site shall be established, and in particular, the potential for water to transfer through the ground or from an adjacent building into the building shall be assessed.

8 PFR Standard 3: options development and design

INTRODUCTION

Following achievement of PFR Standards 1 and 2, the options for implementing PFR are set out. The possibilities are discussed with the end user and the most appropriate options are selected. Each option is then designed and specified as a series of measures for implementation.

AIM

PFR Standard 3 allows options for PFR to be identified and considered. These options shall reflect the outcomes from Standards 1 and 2, and PFR measures suitable for the property and specify the most suitable PFR measures for the property. The options for PFR will consider the use of:

- measures that restrict water entry to the building under defined conditions
- materials that are recoverable after water contact
- services, fixtures and fittings that are recoverable by their location and/or ability to resist water damage.

The design and specification will be based on the information provided by Standard 1 and 2, and the measures specified shall be selected impartially.

REQUIREMENTS

1 An options appraisal of flood resilience measures shall be undertaken based on the information generated within Standards 1 and 2. These appraisals shall also evaluate costs and benefits of suitable approaches, end user needs, operation and performance.

2 The appraisal shall evaluate the lifetime maintenance and operation requirements of the measures considered.

3 Where possible, and where relevant, specified PFR measures shall make use of products and processes that are compliant with a recognised industry standard and/or are subject to a warranty.

4 The preferred options shall be agreed and documented.

5 This specification shall be set out in drawings and/or written text and shall adequately describe the measures to be taken and their method of installation.

6 The output is the identification and specification of the most suitable PFR measures for the property. This information shall then be developed into a construction/installation plan, undertaken by the appropriate person before any works or installation begins.

9 PFR Standard 4: construction

INTRODUCTION

The achievement of the specification outcomes depends on the construction activity and installation of PFR measures. Ultimately, the quality of construction will help to ensure that the PFR measures installed will deliver the levels of resistance and recoverability required to meet the needs of both the building(s) and end users. This will then provide confidence to the end user and those providing insurance and/or maintenance to the building(s).

AIM

PFR Standard 4 ensures that the construction works deliver the specified PFR measures to the required standard and with the desired outcomes.

REQUIREMENTS

1. The appropriate person shall deliver all the necessary works associated with the construction and installation of PFR measures.
2. Where subcontractors are used, the appropriate person shall retain overall responsibility for the works.
3. All necessary preliminary work, including drying out and decontamination where appropriate, shall be carried out prior to implementation of PFR measures. These works shall be carried out in accordance with the design and specification described in PFR Standard 3, and shall take due note of the flood risk assessment (PFR Standard 1) and the survey (PFR Standard 2).
4. The construction work shall be undertaken in accordance with good practice, including relevant standards, guidance and legislation, and shall comply with CDM 2015.
5. All PFR measures shall be inspected during construction by an appropriate person..

10 PFR Standard 5: commissioning and handover

INTRODUCTION

An important element of any construction project is commissioning and handover. These elements demonstrate that the construction activity undertaken, and the measures installed within the property deliver the PFR required by the end user. They also set out all operational and maintenance requirements of the PFR measures installed and are often contained within a 'handover pack'.

AIM

PFR Standard 5 ensures that the completed PFR construction work will operate effectively as designed, and that the end user has all relevant information and has been instructed in any deployment, operation and maintenance requirements.

REQUIREMENTS

1 PFR measures shall be inspected during construction (PFR Standard 4) and on completion by an appropriate person to ensure that the work meets the design and specification requirements of PFR Standard 3. The inspection shall be conducted in an objective and impartial manner.

2 Any products used which have an agreed *in situ* flood resistant test procedure shall be tested after their installation within the building(s) at the request of the end user. These tests shall be supervised by an appropriate person.

3 The appropriate person shall provide all relevant information on the PFR works, design, specification, and operation and maintenance requirements in a project file (ie a handover pack) to the end user.

4 Where PFR measures need to be deployed for flood events, a person shall be nominated and agreed to take responsibility for deploying the measures in the event of a flood warning. This person shall be referred to as the 'nominated person'.

5 The appropriate person shall demonstrate the method of deployment of measures (where appropriate) to the nominated person and shall ensure that this person understands how to prepare for a flood.

11 PFR Standard 6: operation and maintenance

INTRODUCTION

Properties with a defined flood risk are likely to remain at risk over time. It is possible for the level of risk to the property to increase due to factors such as climate change and urbanisation. To ensure a level of protection to a property, the PFR measures installed should be operated and maintained following the guidance provided in the handover pack.

AIM

PFR Standard 6 ensures that the completed PFR construction works are properly operated and maintained, and that any demountable equipment is stored correctly. Note that the responsibilities and duties for operation and maintenance are defined as part of meeting the requirements of Standard 5.

REQUIREMENTS

1. The appropriate person, in accordance with CDM 2015, shall provide an operation and maintenance plan to the end user at the point of handover.
2. The nominated person shall ensure that the PFR measures remain operative by following the guidance provided in the handover pack.
3. In the event of a flood warning, the nominated person shall deploy any measures following guidance provided in the handover pack.
4. Any operation of the PFR measures shall be recorded and the information retained and kept securely as an appendage to the handover pack.
5. All maintenance work shall be recorded and kept securely as an appendage to the handover pack.
6. The PFR measures shall be reviewed periodically to ensure that they continue to meet the needs of the end user and that the nominated person can continue with their obligations.
7. After a flood event, the PFR measures shall be fully checked and inspected by an appropriate person taking account of the information in the handover pack. Any necessary maintenance shall be commissioned and delivered by an appopriate person.

PART C

CODE OF PRACTICE GUIDANCE

Manual flood barrier

The PFR process

The PFR process is defined by six stages and this forms the structure of the guidance. These stages form a logical sequence of activity from hazard assessment and property survey, through options development, design, construction, handover, and maintenance. The elements of this process will be recognised by construction professionals and should ensure users have the greatest opportunity to define and implement effective PFR measures. All reports should be written in plain and non-technical language, by individuals with the appropriate skills, knowledge, and experience.

PFR Stage 1: hazard assessment

Deliver a property level flood hazard assessment that clearly summarises the available hazard information to determine the likelihood and consequences of flooding from different sources. Information will be used to support the suitability of potential PFR measures.

PFR Stage 2: property survey

Carry out an appropriate flood risk survey of the property and assessment of end user requirements. The purpose of this survey is to assess the current level of flood resilience and to provide information for the selection of measures and the detailed design and implementation of PFR.

PFR Stage 3: options development and design

Based on the outputs from the hazard assessment and property survey, select the most appropriate PFR option that is agreed by all parties. Complete the detailed design and specification of selected PFR measures which will enable the PFR products and installation to deliver the levels of resistance and recoverability required.

PFR Stage 4: construction

Undertake installation and construction in accordance with the design and specification, and good practice.

PFR Stage 5: commissioning and handover

Carry out checks and a post-installation audit (PiA) to assess whether the PFR construction work operates effectively as designed. Also check users have all the relevant information and are informed on any O&M needs.

PFR Stage 6: operation and maintenance

Clearly define and assign responsibilities for O&M so the completed PFR construction works are properly operated and maintained.

PFR Phase 1: design phase

12 PFR Stage 1: hazard assessment

Introduction

To comply with PFR Standard 1, a flood hazard assessment shall be undertaken to understand how flooding might threaten a property. This assessment shall include the following:

- likelihood of flooding in the property location (and surrounding areas)
- nature of the flooding that could potentially occur
- likely frequency of flood events for the location – including the potential for increased frequency due to climate change and/or urban development.

Identifying the flood hazard to a property is a critical element in the development of PFR measures. Conducting a flood hazard assessment can be a detailed and intricate process, often requiring specialised skills to interpret information presented within flood maps or other relevant information sources.

PFR Stage 1: assessment of flooding likelihood and severity
Deliver a property level flood risk assessment which clearly summarises the available hazard information to determine the likelihood and consequences of flooding from different sources. This information will be used to inform the suitability of potential PFR measures.

Determine if the property is at risk of flooding

Step 1
Source identification and analysis

- Identify all potential flood sources that may affect the property (**Section 12.2**)
- Identify risk from all flood sources (**Section 12.5**)
- Review all local, site, historical, and online sources of information and knowledge for the area (including local organisations if appropriate) (**Section 12.6**)
- Understand likely frequency, depth, velocity, and duration for each flood source (**Section 12.7**)

Outcome: knowledge of flood sources posing a threat to the site with predicted frequency, depth, velocity, duration, and speed of onset.

Step 2
Pathway identification and analysis

- Identify all potential flood pathways which may affect the property (**Section 12.3**)
- Review all flood pathways for identified sources of flooding (**Section 12.6**)
- Review any information on potential future changes or adaptation to pathways (**Section 12.6**)
- Identify influencing factors and assess the impact of the surrounding environment on flood risk at the property (**Section 12.6.2**)

Outcome: knowledge of all potential pathways outlining how flood sources may impact the property, with appreciation of whether existing (or planned) flood risk management infrastructure or other flood management measures may be present.

Step 3
Understanding the flooding likelihood at the property location

- Understand all potential routes of floodwater to the property location (**Section 12.6**)
- Understand the potential impact of all flood sources on the property location (**Section 12.7**)
- Understand the likelihood of flooding at the property location (**Section 12.7**)

Outcome: assessment of all flood hazard information relevant to the property, and an understanding of all flood sources and pathways to the site to inform the property survey.

Is the information collected sufficient to appropriately assess flood hazard(s)?

No → More detailed assessment may be required

Yes → Property flood hazard assessed

Figure 12.1 Flowchart for PFR Stage 1: hazard assessment

12.1 UNDERSTANDING SOURCE-PATHWAY-RECEPTOR

When a site is assessed, all potential sources of flooding should be considered. This should include sources along with the pathways the water will take, including low probability events and events that exceed the design level for community defences. Understanding all possible sources and the nature of flooding is important when assessing the flood hazard at a location.

Using the 'source-pathway-receptor' model (**Figure 12.2**), the following actions should be undertaken:

- identify the 'source' of flooding, ie if it is likely to come from a nearby watercourse, groundwater, sewer, water management asset, such as a reservoir, or coastal area
- identify the 'pathway', ie how does the flood reach the 'receptor'
- identify the 'receptor', eg the property, business and or people that will be affected by the flood.

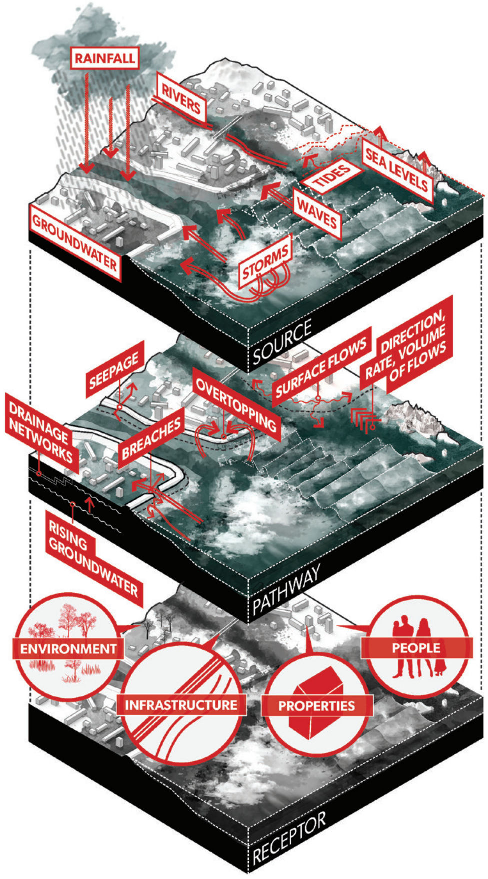


Figure 12.2 The 'source–pathway–receptor' model (courtesy The Environmental Design Studio)

12.2 SOURCES OF FLOODING

The source of flooding is where the flooding comes from. A property can be at risk of flooding from the:

- coast
- tides
- rivers
- surface water
- sewers
- groundwater
- asset (eg dam) failure.

Further details of flood sources are given in **Chapter 20**. A property may be susceptible to flooding from more than one source, even though previously it may only have flooded from one. Escaped water (eg a pipe burst) within a building, or a water main outside, may also be considered as a source of flooding by some stakeholders, however this is not within the scope of the CoP and this guidance.

The source of flooding will influence its pathways, impacts and characteristics. This may include:

- routes of entry into the property
- speed of onset of flooding
- depth of floodwater
- velocity of floodwater
- level of debris and contaminants in floodwater
- duration of flooding inundation.

12.3 FLOOD PATHWAYS

A flood pathway is the route that the floodwater will travel. The route(s) water takes from flooding sources to a property can vary. For example, when a river overflows its banks the water will initially run across the surrounding land, always taking the lowest-lying available path. Sometimes this can mean water flows around behind a property and enters first from the side opposite the nearest river or stream. Similarly, surface water may flow across car parking areas and along roads, flooding low-lying buildings some distance away. With groundwater flooding, this pathway could include penetration of a property basement.

Some areas benefit from measures such as flood defence walls, gates, pumps, or demountable defences which reduce flood risk. In other places, temporary barriers can be used to delay or minimise water ingress and damage, such as groups of properties where building a permanent scheme would be impractical, or not cost effective. There are also ways to design and construct flood pathways that enable drainage 'exceedance' (ie water that cannot be conveyed in the underground drainage system) to be managed and directed away from people and property. CIRIA has produced information on approaches to design for exceedance (Balmforth *et al*, 2006, and Digman *et al*, 2014).

There is always a risk of the river or sea rising high enough overtop flood defences or exceeding pump capacity. In considering sources and pathways of flooding for PFR purposes, it is important to consider this residual risk, which will be increasing with the growing impact of climate change. There will always be a residual risk for properties located behind defences.

12.4 FLOOD RECEPTORS

The receptor is defined as the people within the property, the property to be assessed for PFR, and the contents. An understanding of the receptor is needed to evaluate how the consequences can be mitigated and the appropriateness of any PFR measures. Identification of buildings or parts of buildings at risk and an initial assessment of potential ingress routes to a property or building is an important part of the flood hazard assessment and this is further refined during the property survey.

12.5 FLOOD HAZARD IDENTIFICATION

Identifying hazards in relation to potential sources of flooding requires an understanding of risk and consequence. When identifying potential sources of flooding, users should make use of flood hazard information from all relevant parties.

UK sources of information on flood hazards provided by national and regional government are described in **Chapter 19**, and examples of using historical information provided in **Boxes 19.1 and 19.2**. This may be supplemented by details from news articles, reports and talking to residents. Other sources of information relevant to a flood hazard assessment may be held by organisations such as:

- flood risk management authority, sometimes termed risk management authority (RMA) for that area of the UK. These can include environmental regulators, lead local flood authorities, district and borough councils, coast protection authorities, water, and sewerage companies, internal drainage boards (IDBs) and highway authorities
- other government agencies (eg Historic England [formerly English Heritage], Historic Environment Scotland [formerly Historic Scotland])
- infrastructure providers
- local community groups
- property owners and occupiers.

12.6 IDENTIFYING FLOOD PATHWAYS

The next step is to determine how the floodwater might pass from the source to the property. This is done by assessing potential pathways.

- Identify the pathway and other measures, existing or proposed, which could affect the PFR plan for the property.
- Look at structures along the pathway that may increase the likelihood of flooding and how these may inform or affect the PFR plan.
- Identify areas of concern within the pathway that could reduce or increase the risk to the property.

12.6.1 Identifying pathways and influencing factors

During flood events, existing infrastructure often provides the pathway for flood water, eg existing roads, pathways, and passages between buildings. When surveying the pathway for a property in relation to the flood source(s), it is important to identify all possible routes, and potential impacts on the flow routes (eg existing or proposed flood management measures), and local development plans.

An initial assessment of the flood pathways should be conducted as part of the hazard assessment in Stage 1. This can be amended during the on-site property survey and site walkover in Stage 2 of the PFR process if required. Pathways may be determined by using topographical maps to determine the local surface geography between the flood source(s) and the property. This may also be done using online resources showing the layout of the local area (eg Google Earth, Lidar records or similar).

The flood pathway may have a profound effect on the speed of the onset of different types of flooding. For example, an environment where there are several obstructing factors between the receptor and the flood source, may allow more time for warnings of flooding than a pathway where there are no obstructions. The flood pathway will be specific to any given property and its assessment should be carried out in sufficient detail to identify the hazard and risk to the building.

12.6.2 Assessing the surrounding environment

An assessment should also be made of the environment surrounding the property which may identify alternative flood management approaches in nearby areas (eg local SuDS or flood barriers). This may influence the pathways of floodwater to the receptor, and the overall potential impact on the property. The level of development in the area should be assessed, as the increased risk of surface water flooding due to urbanisation may need to be considered. Identifying existing infrastructure and services is important, as it could affect how floodwater approaches the property. For example, if a sewage outlet, or treatment facility is located between the predicted flood source and the property location.

Consideration should be given to any proposed or potential works in the surrounding area. This may include development of new buildings, which could increase surface water flooding risk. Additionally, new flood risk management and drainage features may be being considered, which could in turn reduce this likelihood. Finally, consideration should be given to the introduction or removal of obstacles in the pathway between sources of flooding and the building. For example, if the assessment identifies a group of properties at risk it may be more cost effective to provide a local bund around all the properties to manage that risk rather than tackling each property individually with PFR measures.

Chapter 19 provides further information on the flood hazard assessment.

12.7 QUANTIFYING THE LIKELIHOOD OF FLOODING AT THE PROPERTY

Following completion of the hazard assessment it is important to understand the likelihood of flooding at the property location. This will require an assessment and understanding of the probability of flood events of differing severity for the potential sources of flooding and the likelihood of those sources reaching the property location. This should also include a consideration of the impact of climate change.

Consideration should also be given to the effects that potential pathways from each source has on the property. This may introduce new issues not previously recognised in the existing flood map or hazard assessment data. For example, in the event of new buildings being proposed, or if there may be more impermeable surfaces along this pathway, the likelihood of future surface water flooding at the property could increase.

This should be used to help identify and understand the potential impact of each flood source for the property being assessed. This would include determining how each of the types of flooding may be influenced by parameters such as topography and site layout. For example, surface water flood hazards may result in higher velocity rapid-onset flooding, but at a shallower depth, than a river flood. This may be factored into the options development in PFR Stage 3.

In some circumstances, flood modelling may be required to fully understand the implications of the flood sources on the property. This could be appropriate for complex developments, or if there is significant underground development around the property. This should be proportional to the flood risk, the needs of the project and the end user.

Once this information is obtained and assessed, the likelihood of flooding from each flood source and potential pathway to the property should be known and understood, along with the potential severity of each flood source. Where more than one flood source is identified, the probability of flooding from both sources simultaneously should be considered. These should be included in the property flood hazard assessment report for the client.

Box 12.1 provides further detail on the information needed in a property flood hazard assessment.

Box 12.1 Assessment of flood hazard to the property

Provide information on:

- sources of flooding, identifying each type of risk, their relative importance and likelihood of occurring concurrently. These include:
  - rivers
  - the sea
  - surface water runoff and ponding
  - groundwater
  - surrounding drainage system, including sewers.
  - infrastructure failure
  - compound flooding
- history of flooding at the property
- likely contamination of floodwater, eg muddy river water, water contaminated with sewage
- assessment of the frequency and duration of a range of depths of flooding
- future changes to risk such as from climate change and identified developments
- flow routes and likely hazard (velocity of flow at different depths)
- evidence used to make the assessment, eg Environment Agency risk maps and modelling, flooding records from newspapers and official sources.

Box 12.2 An example of PFR Stage 1: hazard assessment

What is needed at this stage

To comply with PFR Standard 1, a flood hazard assessment shall be undertaken to understand how flooding might threaten a property. This assessment shall include the following:

- likelihood of flooding in the property location (and surrounding areas)
- nature of the flooding that could occur
- likely frequency of flood events to the location – including the potential for increased frequency due to climate change and/or development
- susceptibility of the property and its building(s) to flooding, given its surroundings, design, structure, materials used, condition, and adaptations.

Mr and Mrs Green own and live in an end of terrace house in a village. They were flooded in October 2017 and are concerned about this re-occurring. They have been doing some online research on PFR measures and have decided to invest in some PFR measures to better protect their home.

The property was built in the 1950s. It is a traditional masonry-built house with cavity fill insulation. The road is on a slope and there is a step up to the main door threshold and air bricks to ventilate the sub-floor area. The entrance is off a common path, which follows an access road to the end of the cul-de-sac where they live. When they were flooded, water came into the property through the front door and from underneath the floor. The depth of floodwater in the property reach about 400 mm above the internal floor level. They evacuated their property overnight and returned the next day after the worst of the flood had ceased. Water remained in the property for five days, with significant damage to floor coverings, furniture, electrical and plumbing connections, white goods, and kitchen units.

Step 1: source identification and analysis

Following advice from their insurer, Mr and Mrs Green obtained quotes from several organisations who provided a flood hazard assessment for their property. Having received quotes from each of these organisations and after reviewing examples of previous reports from each of these, they selected a flood hazard assessor they feel is suitable (Mrs Jones).

Mrs Jones uses the 'source-pathway-receptor' approach to assess the flood risk for the property. This starts with an assessment of flood sources, followed by a review of pathways. The assessor reviews all potential sources of flood risk. This includes reviewing many sources of information for each of these sources such as flood maps for the local area, as well as geological maps to understand the subsurface bedrock and drift geology. Mrs Jones consults the EA flood maps for river flooding and surface water flooding and determines whether the property was sufficiently close to the coast or to a reservoir to determine if the hazard of flooding from these sources should be accounted for. She also consults the local sewerage authority to see if the property was on any of their at risk registers for sewer flooding. This assessment uses a wide range of information, both qualitative and quantitative, and captures information from local sources as well as national datasets. The analysis identifies river (fluvial) flooding as the most significant source of flooding affecting the Green's property. Following identification of these flood-risk sources, potential pathways are assessed.

The previous flood event was caused by high intensity and prolonged rainfall events that led to the local watercourses and culverts to flood. The local watercourse nearest the property is 80 m away and has had some barrier defences installed since the event in 2017.

Step 2: pathway identification and analysis

Topographic maps are reviewed by the assessor to understand the layout of the area surrounding the property and distance from this property to each identified source. These show the local watercourse is likely to flow down the road leading into the cul-de-sac, highlighting this as the main pathway for floodwater to arrive at the property. It was found that there were no ongoing works or proposed developments between the river and the property that could affect these flood pathways. Using the information collected relating to flood-risk sources and pathways, and supplemented by a site visit, the hazard assessor finds that the only significant high risk source of flooding to the Green's property is from fluvial sources. The pathway assessment found that water is likely to flow down the road and into the property.

Step 3: understanding flooding likelihood at the property location

The overall findings of the assessment was that floodwater could exceed 300 mm and up to 500 mm within the Green's home for a 1 in 50, a 1 in 100 or a 1 in 200 year event. The 2017 flooding was in this range, which presents a significant hazard to the property. Further to this, estimates of duration were found to be in the range 12 to 24 hours from this source of flooding and velocity estimates were found to be about 0.15 m/s. No detailed modelling is required. The assessor compiles a summary report which she gives to Mr and Mrs Green, via email and post.

Further reading

ENVIRONMENT AGENCY and LOCAL GOVERNMENT ASSOCIATION (2011) *Flooding from groundwater. Practical advice to help you reduce the impact of flooding from groundwater*, Environment Agency, Bristol, UK
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297421/flho0911bugi-e-e.pdf

GARVIN, S (2012a) *Flood resilient building: Part 1 – Legislation, planning, flood risk assessment and performance of buildings*, DG 523-1, Building Research Establishment, Watford, UK (ISBN: 978-1-84806-242-9)
https://www.brebookshop.com/details.jsp?id=326887

GARVIN, S (2012b) *Flood resilient building: Part 2 – Building in flood-risk areas and designing flood-resilient buildings*, DG 523-2, Building Research Establishment, Watford, UK (ISBN: 978-1-84806-243-6)
https://www.brebookshop.com/details.jsp?id=326888

13 PFR Stage 2: property survey

Introduction

The identification and delivery of PFR is reliant upon information provided from a suitably detailed property survey. The design, materials, condition, orientation and location of properties will vary, and a survey is a critical element to identifying suitable resilience measures that could be considered.

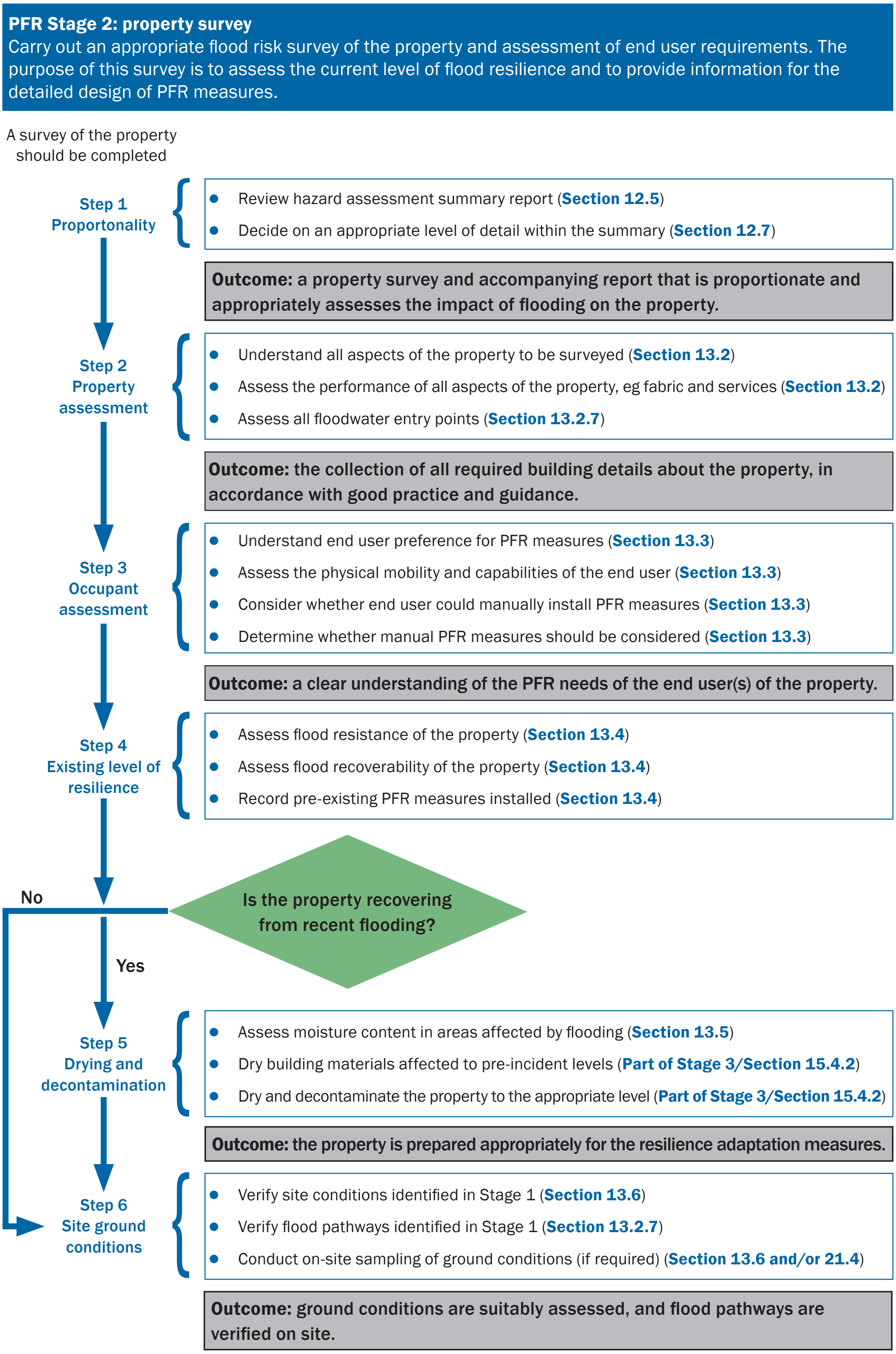


Figure 13.1 Flowchart for PFR Stage 2: property survey

13.1 STEP 1: PROPORTIONALITY

The proportionality of the survey is an important consideration and should be discussed. This means the cost of the survey should not be excessive when compared to the identified hazard presented in the hazard assessment (output of Stage 1) and the needs of the client. This is to ensure that there is sufficient funding available to cover the cost of the specification and installation of PFR measures.

The property survey report should be provided to the client with an appropriate level of detail, using suitable language and information for the client to understand. This report should highlight any major risks or vulnerabilities identified during the site survey and should also flag up any uncertainties recorded in this process. **Section 14.10** provides information on unintended consequences. It is good practice for the survey to identify appropriate approaches to increase resilience and minimise damage, taking account of end user needs.

13.2 STEP 2: PROPERTY ASSESSMENT, SURVEYING APPROACH AND PROPERTY CHARACTERISTICS

If possible, have a site plan and develop or use layout plans for every level of a property. This would include a ground floor, upper floor, and a basement, where relevant.

13.2.1 Health and safety of survey

Before starting a site survey at the property, the surveyor should conduct and complete a full risk assessment of the areas where work will be undertaken. All risks identified as part of this risk assessment process should be addressed and managed in accordance with good practice. Also, those undertaking this work should be supplied with appropriate personal protective equipment (PPE).

13.2.2 Survey approach

The survey should be undertaken using a systematic approach. However, surveyors should be prepared to investigate all areas of the property to determine relevant construction details. Further information is available from the Royal Institution of Chartered Surveyors (RICS, 2011, 2012, 2016).

The survey should include (but not be limited to):

- basic property information
  - construction type – wall (eg solid masonry wall)
  - construction type – floor (eg solid concrete floor)
  - age of property
  - property attachment type (eg terraced)
  - size of property footprint (m^2)
  - number of building storeys (presence or absence of below ground space, basements etc)
  - external windows, doors and glazing (type and height)
  - identification of damp problems or evidence of previous flooding
  - identification of any building faults/defects relevant to resilience proposals
- building use and contents
  - use class (eg residential, industrial)
  - occupation type (eg storage, living accommodation)
- building services
  - level of electrical sockets

  - heating, cooling, and ventilations systems (HVAC) including the potential for water ingress through the system
  - drainage and plumbing systems, including the potential for water ingress through the system
  - information and communications technology (ICT) systems
  - utility/fuel supply systems
  - lifts and escalators (if present)
  - security and alarm systems
  - gas safe assessment of combustible heat sources
- building fabric
  - condition of walls
  - condition of ground floor
  - identification and assessment of potential points of water ingress (these could include the following building elements)
    - air bricks
    - service entries (eg utility connections) including waterproof seals
    - window apertures
    - door apertures
    - weep holes
    - wall-to-window or wall-to-door seals
  - identification of wall/floor membrane(s)
- internal building fixtures and fittings
  - insulation type (flooring and wall)
  - internal floor finish
  - internal walls
  - internal doors
  - kitchen fittings and appliances.

The recommended contents of the property survey report including additional reporting items is presented in **Box 13.1**.

Box 13.1 Contents of a property survey

Provide information on:

- flood risk information
- building construction information:
  - building construction type
    - wall and floor types (eg solid, cavity, glazed)
    - floor types (eg suspended, solid concrete)
    - any underfloor voids
  - building footprint (m^2)
  - description of building layout (including orientation)
  - number of floors (including presence of basement)
  - age and condition of the property (eg including listed status if applicable)
  - any other relevant considerations (eg split-level property if applicable)
- external assessment of the building:
  - assessment of the condition of external wall finishes
  - an evaluation of the potential floodwater entry routes up to the maximum expected flood level
- a detailed internal room-by-room analysis of the vulnerability of all building elements
  - floor and wall finish and resilience properties of these
  - height and details of items that may be damaged by floodwater (below maximum predicted depth of flooding)
  - height and details of electrical sockets and location within room (below maximum predicted depth of flooding)
- date of site visit and contact details of surveyor
- site photographs to support the findings of the survey
- use, detailed contents for items difficult to move, occupation patterns and access considerations
- assessment of the needs and/or preferences of the property owner and/or occupants.

During this process, it is important to ensure that the building does not contain any existing resilience measure that may contravene safety or building performance considerations. For example, this could include ensuring that air bricks have not been sealed to prevent floodwater entry, but also preventing ventilation into an underfloor void. Similarly, existing measures that are captured during this survey should be assessed for potential risks of unintended consequences (**Section 14.10**). Any flood resilience measures that may be appropriate for continued use should be identified.

Chapter 21 provides information on how to complete the survey, including the use of site notes and sketches and taking a sufficient number of high-quality photographs. The main aspects of the building that should be assessed should follow the survey process outlined in Environment Agency (2017) and should consider the elements given in BRE's flood-resilient building guides (Garvin, 2012a and b).

To plan for Stage 3 it is necessary for the survey to establish the following:

- type of construction – for example, traditional construction including solid wall masonry and stone and cavity wall construction, non-traditional frame and concrete types, and non-domestic frame and cladding
- age of the construction – this assists in determining the type of walls, floors, and materials. For older properties, the building may have been extended or adapted, with different types of construction added. Newer properties may also have been adapted, but information is more likely to be available.
- external wall types – solid, cavity, framed with cladding or glazed. External wall finishes, and their condition should be assessed
- ground floor types – suspended (timber or concrete) or solid concrete and, where possible, establish the water proofing of the floor, presence of insulation and ventilation provision (air bricks and ventilation gap), and the type of screed used
- presence of large underfloor voids, including any basement, its construction and use
- types of external doors, windows and other types of glazing
- party wall (also known as common wall) that divides adjoining buildings
- internal wall types and finishes – including masonry or stud partitions, or partitions with wallboard covers, the finishes to the inner side of the external wall and to the internal walls
- internal finishes above screed or floorboards.

13.2.3 Surveying equipment and measurement

Digital devices can make measuring quicker and easier, but it is important that they are calibrated if they are used. A tape measure is appropriate for the building for determining the overall lengths, ceiling heights, location and height of service entries and widths of doors.

The surveyor should have a ladder, either fixed segmented or telescopic, which is suitable for the property to be surveyed. They should have a digital camera capable of recording the building details and the resistance and recoverability measures installed. A calibrated moisture or damp meter should be used if the surveyor notes any aspect of the property that appears to be wet, damp, or with mould or condensation. If this is the case, these issues need to be addresses before resilience measures are undertaken.

For measurements taken during the property survey, guidance is available from both the International Property Measurement Standards Coalition (IPMSC), and through the RICS (2018). Taking measurements and assessing the area(s) is important in the planning, design and construction of the flood resilience and resistance measures.

Section 21.1 provides further information on measurements of the property.

13.2.4 Property characteristics

The types of property and their construction found in the UK varies substantially. At the most basic level property is categorised as domestic or non-domestic and construction types between traditional and non-traditional. Construction type varies within both domestic and non-domestic property.

13.2.5 Condition of construction

Condition and age of a property is an important element to consider when assessing options for PFR. This, and the 'ageing' of a property, will inform the key aspects of durability and resilience performance. The owner or occupier of the property may be aware of the age and of any alterations or extensions, which may indicate the presence of different types of construction. The title deeds and conveyance records of the property and its plans are a good source of these details.

Some of the external features that can help to determine the age of a property include the appearance and the style of construction, the number and size of windows and doors, the construction materials used, the roof coverings, presence and type of chimneys and the external wall finishes.

13.2.6 Building fabric

Knowledge of the building fabric is a critical element of the building survey (BS 85500:2015). The information available will depend on a wide variety of factors but needs to be verified by an on-site visit.

There could be many variations in the building fabric, particularly related to traditional and non-traditional construction methods. Examples of these elements and guidance on how they should be surveyed is given **Chapter 26**, including further information related to traditional and historic building fabric.

13.2.7 Routes of water entry

The route of water entry will depend on the location of the property, its orientation, design, materials used, condition, and adaptations. These parameters will vary from property to property so an individual property-specific survey should be carried out to identify all possible water entry points. An illustration of all possible routes into buildings and/or structures is given in **Figure 13.2**.

The following points provide guidance on how to carry out this aspect of the property survey:

- the perimeter of the property should be surveyed to identify all possible water entry routes
- information on the building fabric, floors, walls, foundations, cavities and voids, windows and doors should be collated and assessed in relation to their ability to resist and recover from flooding
- all visible service connections and penetrations through the building foundations and envelope should be identified.

This information may be collected from design drawings if available. However, the property should also be subject to a non-intrusive survey to identify elements that may differ from the original design.

Surveyors need to be aware that during floods of longer duration water can penetrate through the building fabric as well as through openings, for example if the floodwater does not recede for many hours, water can penetrate the walls.

For flood entry points that are external to the building, an above-ground visual inspection should be possible. In other cases, where it is reported that water may enter through the floor, access to underfloor voids may need to be considered.

Floodwater can also enter through adjoining properties, meaning issues may arise for attached properties (eg semi-detached and terraced properties, flats, shared offices and warehouses). It is important to consider common walls, adjoining voids, cellars, underground car parks and shared services.

Initially, it is important to identify the potential methods to seal or partially seal all points of entry.

Where it is not possible to identify a practical and safe method to limit water entry to an acceptable rate for a resistant approach, the survey should consider water entry rates during a flood (eg by recording size and elevation of all water entry points and estimating leakage of fabric) as an important factor in designing recoverable approaches. It is also useful to note how water entry points may be used to evacuate water safely after a flood.

13.2.8 Building services

The property survey should include a detailed review of the building services. **Chapter 21** provides a detailed summary of relevant information.

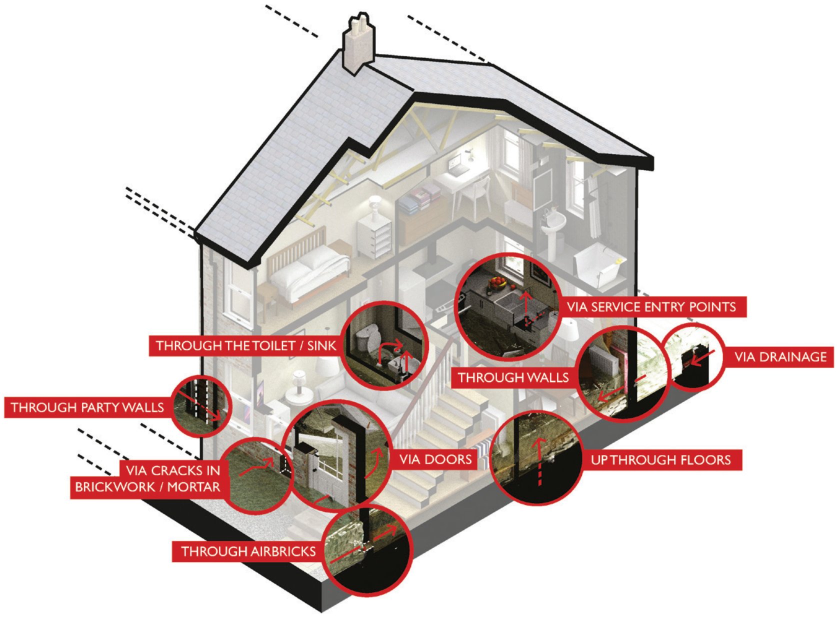


Figure 13.2 Possible routes of floodwater entry to a property (courtesy The Environmental Design Studio)

13.2.9 Site sketches and plans

A sketched plan is required for each storey that could be potentially affected by floodwater (as determined from the hazard assessment report) and should have dimensions marked on it. Take either internal or external measurements but not a combination of both. Any difference in floor levels should be clearly marked and the ceiling height distinguished between buildings with high and low ceilings.

The surveyor should use their site notes to create sketch plans to scale and mark on measurements where appropriate.

13.2.10 Non-habitable buildings

If a garage, sub-station, or out-building is situated in the property grounds the resilience and risk aspects of these buildings will be relevant. The surveyor should consider if a resistance approach is to be taken, the conveyance of water in and around the non-habitable building, and into the property itself if these are connected.

13.3 STEP 3: OCCUPANT ASSESSMENT

To understand the needs of the client and occupant, it is important to ensure that the PFR solution provided for the property is suitable for the occupants.

Communication and engagement with the end users of PFR to understand and meet their requirements (individually, or as a group where multiple properties are involved) is as important as understanding both the building(s) and the characteristics of the flood hazard.

There are two reasons for this:

1 Where flooding has already affected a building, the occupants may possess additional information on, for example, previous attempts to protect the property, as well as details regarding any building extensions and alterations. These can help the surveyor to achieve a comprehensive understanding of the property resilience and the additional or replacement measures needed.
2 If PFR measures are to be effectively deployed and maintained, it is essential that users understand and agree to both the measures and the plan. End users may have information related to the normal use and access requirements for all occupants and visitors to the property.

The form of engagement will depend on the scheme delivery method and number of properties involved. Users should be involved from this stage of conducting the property survey through to the options development (Stage 3). If necessary, a community group may be formed to ensure that engagement involves all the affected occupiers. Records of the discussions, including an assessment of the owners' and occupiers' needs and preferences, should form part of the options development.

For scenarios where the individuals may be required to deploy active PFR measures or move contents, information about the physical mobility and capabilities of the end user(s) to prepare for flooding is considered as a part of the survey to determine the suitability of PFR measures for these individuals. The assessment should identify whether the client or end user(s) would be able to install the potential types of PFR measures, such as manual aperture barriers and then subsequently evacuate the building safely.

Information should also include the occupation patterns of the property and whether clients or the end user(s) can easily return to the property after receiving a flood warning.

Any alterations to accessibility during normal building operations also needs careful consideration particularly in situations where occupants or potential occupants may have specific access requirements.

Once an assessment has been made, consider the suitability of manual PFR measures for the property and whether these would be applicable for the client and end users. Following this, establish whether manual measures should be factored into the options development phase for the end user(s). This information should be clearly presented in the summary report provided at the end of PFR Stage 2.

It is also important to capture the preferences of the end user(s), which will help to inform the most suitable measures presented. Clients and end users may have preferences related to aesthetics or priorities for areas within the property or fixtures or contents needing higher levels of resilience (for example critical machinery, cooking areas or items with high sentimental value that are difficult to replace). Collecting this knowledge during the survey will help inform options development.

Chapter 17 gives further information.

13.4 STEP 4: EXISTING LEVEL OF RESILIENCE

The surveyor should consider the flood resilience of existing buildings. There may be substantial resilience, either resistance or recoverability, already built into the construction, eg the primary materials used in construction. The materials from which the building is constructed should be identified during the survey and the impact of those materials on the amount of strip out and drying required in the event of a flood should be considered. There may also be pre-existing PFR measures installed that need to be recorded and assessed in terms of their condition and functionality.

The resilience of building materials can be considered from different perspectives. Resilience of materials could mean that they are:

- structurally capable of taking load, in particular the loading applied from flooding without deterioration, collapse, change of form or shape
- durable in the event of a flood, without damage, risk of corrosion or rot occurring at a later stage
- capable of recovering their shape and form after wetting and go back to their original state

- able to dry without damage or that damage could be limited and capable of restoration and ultimately there cannot be a significant loss of performance
- capable of being decontaminated without damage or loss of form and their appearance should recover. The materials affected by flooding are primarily those in walls, windows, doors, and floors.

Building materials can be classified into either porous and permeable materials, which include masonry materials such as bricks and blocks, concrete and timber, or non-porous and impermeable materials such as plastics and metals. Porous and permeable materials can be manufactured materials, or natural materials. There are also other materials to consider such as sealants, paints, and coatings and these can contain properties that may assist with the resistance and resilience of other materials.

It is important that both the resistance properties of the building and the recoverability of the building, if floodwater enters, are considered. The resistance properties should also consider how well the building would resist water entry in the event of a flood.

For flood recoverability properties of the building, similar considerations should be provided for the performance aspects of the property, as well as an assessment of how each material is likely to perform if it encounters floodwater.

The following sections will explain in further detail the considerations that should be made for this process and what information should be captured in the summary report.

Section 23.2 gives information on the resilience of construction materials.

Structural integrity in relation to flood damage action is an important consideration when surveying, and information can be found in **Section 21.4.5**.

13.4.1 Consideration of vulnerabilities

During the survey, an assessment of potential vulnerabilities of the building should be undertaken. This should include:

- assessing the potential for PFR measures to resist floodwater entering the property given the physical and operational information gathered in the survey
- identifying the most likely failure routes for a resistant approach
- assessing the condition of all aspects of the property's external boundary including the pathways that floodwater may take to reach the property
- identifying the internal and external materials likely to be damaged through contact with floodwater or flood action
- noting any potential structural concerns needing further investigation by qualified personnel
- recording any occupant or client needs or sensitivities that may increase the vulnerability.

Any restrictions on adapting the property should be noted, such as listed building status (see **Chapter 26**). The local authority can be contacted to establish what development restrictions exist on the property being assessed.

Consideration should be given to the suitability of adopting a mainly resistant approach and the extent to which recoverability measures should be the primary approach based on the findings of both the hazard assessment and the property survey. The suitability of a combination of resistance and recoverability measures should also be noted. The summary report for the survey should identify any challenges in adopting either approach. This should include consideration of deployment and a recommendation regarding the suitability of manually deployed measures, based on the occupant assessment, the expected type of flooding and the availability of timely flood warnings.

Potential PFR options will reference the requirements of Stage 2 and identify areas of vulnerability within the property.

13.5 DRYING, DECONTAMINATION AND MOISTURE TESTING

If a property has previously been affected by water damage, it is essential that the property is properly dried and decontaminated at an appropriate level before any further work is undertaken. Any areas that have been affected by water damage or generally appear to be damp should be assessed using a suitable measuring method (for example a moisture meter). If the test indicates that there is a high moisture level, then the area should be appropriately dried and decontaminated in accordance with good practice guidance.

Regardless of whether previously flooded a calibrated moisture meter should be used if the surveyor notes any aspect of the property that appears to be wet, damp, or with mould or condensation (**Section 13.2.3**).

Section 15.4.2 and **Appendix A4** provide further information on drying and decontamination.

13.6 SITE GROUND CONDITIONS

While on site, the assumptions about flood pathways identified as part of the hazard assessment in Stage 1, outlining routes from identified flood sources to the receptor should be confirmed as far as possible. If there are any irregularities from the predicted pathways, or any aspects that may influence these pathways (eg construction of new developments) that had not been previously anticipated, then this should be captured and detailed within the survey report.

If further information is required to verify the site ground conditions, site sampling may be required. This could be conducted using, for example, a trial pit to determine the exact ground conditions at the site.

See **Section 21.4** for further information.

13.7 USE OF PFR IN NEW CONSTRUCTION

For new builds (or similar scenarios such as change of use) and extensions of existing properties PFR should be part of the early considerations at planning stage. Planning regulations throughout the UK require that PFR should be included where permission is given to build in a flood risk area. According to the NPPF (MHCLG, 2019), this could include consideration that buildings are *"adequately flood resilient and resistant"*.

Early consideration of flood hazard and flood risk mitigation at the design stage of the process, by the developer, will give the opportunity to design in PFR. The detailed design of a new building can more readily incorporate PFR than for an existing building. It is the responsibility of all those involved to ensure that those measures required at planning stage are delivered. Inclusion of PFR within the new development will work for various types of construction contract, including traditional, design and build, management contract or private finance initiative (PFI).

Box 13.2 An example of PFR Stage 2: property survey

What is needed at this stage

The identification and delivery of PFR depends on information provided from a suitably detailed property survey. The design, materials, condition, orientation, and location of properties will vary, and a survey is a critical element to identifying suitable resilience measures that could be considered.

Step 1: proportionality

In accordance with PFR Standard 1, a hazard assessment of Mr and Mrs Green's end-terraced house has been carried out. To determine the affect of any previous damage and to assess the building's suitability for PFR measures, a property survey is required. The hazard assessment set out the requirements for an appropriate survey. The purpose of the survey is to assess the likely impact of flooding on the property based on the identified risk from PFR Stage 1.

Consistent with the principle of proportionality Mr and Mrs Green employed the surveyor who completed the flood hazard assessment, Mrs Jones, as she was also qualified to do this.

Step 2: property assessment

The property is a traditional build (masonry) with cavity fill insulation. There is a step up to the main door threshold and air bricks providing ventilation beneath the suspended timber floor. The entrance is off a common path, which follows an access road to the end of the cul-de-sac where it is situated. The external surfaces are made up of brickwork and roughcast. These are in good condition with no obvious signs of cracking or delamination within the external masonry.

The entrance doorway is a standard PVC-U composite door with draught-proof strips around its perimeter. The large lounge window is about 400 mm above the external pathway and is a standard double-glazed unit.

Service entry points for utility supplies (ie gas, electricity, water, sewerage and telecoms) to the property have been identified.

The property has a small garden to the rear and there is a back door which is at a similar level to that serving the front of the property.

Mrs Jones assesses the resistance properties of the building and determines that there are several apertures at varying heights around the exterior of the building that remain unprotected including the party wall, doors, service entry points and unprotected air bricks around the exterior of the building.

Internally, the property has a lounge and kitchen on the ground floor and two bedrooms and bathroom upstairs. The entrance hallway has laminate flooring, the lounge has a carpet, and the kitchen is covered with plastic flooring tiles. Kitchen appliances and white goods are positioned at finished floor level and electrical sockets are positioned at the standard height of 300 mm. The property has a gas-fired central heating system with the boiler positioned at worktop height in the kitchen. The materials used for the kitchen worktops and doors are noted in the survey, as well as the ease of removal in the event of a flood. Skirting boards material is also noted.

Step 3: occupant assessment

Mrs Jones asks Mr and Mrs Green about their needs, whether they have any mobility impairments and whether they could deploy manual PFR measures. She determines that manual measures may be suitable for the property but after reviewing the preferences of the Green's, that passive measures would be preferable as these do not require manual activation.

Step 4: existing level of resilience

Mrs Jones then conducts an assessment of the recoverability properties of the building and finds that many of the outer surfaces of the lower external walls in the property have been coated in a sand-cement render and while a tiled floor has been used in kitchen areas, the hallway is laminate and the lounge area includes a carpet finish. These and other resistance and recoverability aspects are recorded by the surveyor.

Step 5: drying and decontamination

The property has previously been flooded, but the surveyor determines that previously affected areas are suitably dried and decontaminated by taking moisture measurements in all the affected areas. The cavity wall fill insulation is confirmed as a flood -resilient material.

Step 6: site ground conditions

Mrs Jones conducts a site walkover and verifies the site conditions, as well as the pathways for water ingress recorded in the desktop study. Those identified in the flood hazard assessment match with a river flooding source that still has a clear pathway to the property down the road in the cul-de-sac. No on-site sampling is required at the property.

A property survey report in line with the content presented in **Box 14.2** is provided to Mr and Mrs Green and Mrs Jones offers to provide any further clarifications if necessary.

Further reading

COMMITTEE ON CLIMATE CHANGE (2017) *Progress in preparing for climate change 2017 report to Parliament*, Committee on Climate Change, London, UK
https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2017/06/2017-Report-to-Parliament-Progress-in-preparing-for-climate-change.pdf

DFI (2014) *Revised Planning Policy Statement 15 'planning and flood risk'*, Department for Infrastructure, Belfast, Northern Ireland
https://www.infrastructure-ni.gov.uk/sites/default/files/publications/infrastructure/PPS15%20Planning%20and%20Flood%20Risk.pdf

WELSH GOVERNMENT (2004) *Planning policy wales. Technical advice note (TAN) 15: Development and flood risk*, Welsh Government, Cardiff, Wales (ISBN: 0-75043-501-1)
https://gov.wales/sites/default/files/publications/2018-09/tan15-development-flood-risk.pdf

14 PFR Stage 3: options development and design

Introduction

Following achievement of PFR Standards 1 and 2, the options for implementing PFR are set out to meet Standard 3. Note that this standard has two parts, Stage 3 options and Stage 3 design. In Stage 3 options, the possibilities are discussed with the end user and the most appropriate PFR measures* determined. In Stage 3 design, they are designed and specified for implementation.

The options for PFR development will consider the use of:

- measures that restrict water entry to the building under defined conditions
- materials that are recoverable after water contact
- services, fixtures and fittings that are recoverable by their location and/or ability to resist water damage.

* note that at this point measures are described generically. Specific products and materials are specified as part of the design process that follows.

The selection and design of PFR measures should address the expected flood characteristics (depth, duration etc) and detail the expected severity of event for which the measures would be effective. For example, high depths of floodwater may exceed the height of raised services, fixtures and fittings, and some materials normally considered resistant or recoverable may lose their integrity after prolonged flooding.

The selection and design should also take account of the needs and preferences of the property owner and occupier. An aesthetically acceptable design is particularly important in the internal living space of a domestic dwelling, so aesthetics should always be considered. The end user should be consulted about the use of the building and the elements most critical to preserve and keep operational, and the design should take due account of these priorities.

The capability of the occupants is also a key feature of selection and design (eg physical ability to lift barriers into place when needed). Access to the building when not occupied, for example during working hours for domestic buildings and outside working hours for non-domestic buildings, could also affect the choice of options. Measures for historic or listed buildings should be designed to be compliant with relevant permissions and guidelines (**Chapter 26**).

The selection process in Stage 3 options should provide a series of appropriate design proposals for the occupant, owner, or client. these should highlight a range of alternative approaches where possible and the advantages and limitations associated with each approach. This allows the client to consider their options and to understand there may be several approaches to managing the effects of flooding with different costs and benefits.

Once the preferred option has been agreed, the specific measures within that option are designed and specified. Products and materials selected should meet the full performance requirement of the agreed option. Appropriate plans, details and specifications should be drawn up in sufficient detail for the construction contractor to complete the installation.

During detailed design additional information is occasionally obtained that indicates that improvements can be made to the preferred option. In such cases modifications to the option should be suggested to the client, together with details of its impact on cost and performance. Any changes to the preferred option should then be agreed with the client and end user.

PFR Stage 3: options development and design
Based on the outputs from the hazard assessment and property survey, produce a detailed PFR options development and design agreed by all parties which will inform the installation of appropriate PFR measures

Determine if the property is at risk of flooding

Step 1
Propose options (existing properties) (options)

- Identify suitable generic resistance measures if deemed appropriate (**Section 14.3**)
- Identify suitable generic recoverability measures if deemed appropriate (**Section 14.3**)
- Develop packages of generic measures (options) from those deemed to be appropriate (**Section 14.3**)

Outcome: a series of suitable approaches to managing flood risk at the property that are suitable for both the property and the occupants.

Step 2
Lifetime requirements (options)

- Consider ease of construction and ease of maintenance (**Section 14.4.1**)
- Consider lifetime operational cost requirements of PFR options (**Section 14.4.1**)
- Consider maintenance and storage requirements of PFR (**Section 14.4.2**)
- Assess suitability of requirements against end user needs (**Section 14.4.6**)

Outcome: proposed PFR measures that are suitable for the end users given long-term O&M requirements.

Step 3
Calculate indicative costs (options)

- Identify sources of impartial costings for the generic measures identified as suitable (**Section 14.5**)
- Calculate indicative costs of generic measures proposed using sources of independent cost information (**Section 14.5**)
- Ensure costing are suitable for the end user (**Section 14.6**)

Outcome: a series of PFR options with indicative costings and known limitations.

Step 4
End user preference (design)

- Present suitable approaches and generic measures to the end user for discussion (**Section 14.6**)
- Determine the suitability of generic measures based on cost, operation, and maintenance (**Section 14.6**)
- Ensure costing are suitable for the end user (**Section 14.6**)

Outcome: the preferred option selection expressed as a series of generic measures. This completes Stage 3 options.

Step 5
PFR design and specification (design)

- Undertake detailed design of measures and select appropriate products (**Section 14.7**)
- End user to accept and approve the proposed approach (**Section 14.7**)
- Compile drawings and specifications suitable for installation and construction (**Section 14.7**)
- Incorporate mechanisms for the installer to discuss this with the designer (**Section 14.7**)

Outcome: a final design and specification of PFR measures that meets the needs of both the building and the end user(s).

Step 6
Assign responsibilities (design)

- Identify and assign installation and operational responsibilities for the PFR measures (**Section 14.11**)
- Identify appropriate drying and decontamination approaches that may be required after flooding (**Section 15.4.2**)
- Identify and assign responsibility for maintenance requirements of PFR (**Section 14.11**)

Outcome: identification and documentation of all O&M responsibilities for the client, owner, and end user(s). This completes Stage 3 design.

Figure 14.1 Flowchart for PFR Stage 3: options development and design

14.1 PFR APPROACH

Suitable PFR measures should be identified following the hazard assessment (Stage 1) and the property survey (Stage 2) and discussed with the end users. Approaches may include either resistant or recoverable measures or both.

14.2 STEP 1: PROPOSE OPTIONS

By referring to the findings of PFR Stages 1 and 2 (if an existing property), options for appropriate PFR measures should be identified.

These measures should consider the following criteria:

- flood hazard(s) affecting the property
- construction form and its condition
- suitability of options based on the ability of end users to operate and maintain them
- cost of PFR options and proportionality in relation to the identified risk.

14.2.1 Existing properties

For existing properties, based on the findings of PFR Stage 2 about the suitability of resistant and recoverable approaches, appropriate measures should be identified in accordance with the needs of both the property and the end users.

The property survey should be used to identify suitable measures that can limit:

- ingress at each identified point of entry
- damage if floodwater does enter
- floodwater levels inside the building.

These should meet the requirements of the end user, as well as the building itself where possible. Selection should, where necessary and appropriate, minimise the lifetime cost and requirements while satisfying client and end user goals.

Areas that should be reviewed will include all rooms that are at ground level or have an exit at ground level. For split-level properties (ie those that have two exits at different levels which both open onto the external ground level – set into a slope) all levels should be assessed for both resistance (if applicable) and recoverability measures.

14.2.2 New-build properties

If the building has not yet been constructed or is being substantially altered, the flood hazard assessment and design plans should be reviewed to see where it may be suitable to adopt PFR measures, and to suggest where good adjustments could be made to the design to manage flood risk.

Following this review of the design plans, an assessment should be made as to the suitability of both resistance and recoverability measures for the property. If either resistance or recoverability measures are considered suitable, a separate list of appropriate types for each measure should be devised. From these lists, suitable packages of resistance and recoverability measures should be developed that would meet the needs of the property, and the client.

14.3 SELECTING PREFERRED OPTION

When alternative PFR options have been determined for the property owner and end user needs that are within or close to the available budget, these should be presented to the client. This should include all relevant information about the different measures within each option so that an informed judgement can be made about which option would be most suitable. However, at this stage, options should only be described as a series of generic measures. Selection of specific products and materials comes later during detailed design.

Once the information has been presented to the client, it is recommended that the appropriate person discusses the key advantages and disadvantages of each option proposed. This will also help the client to understand if there are any additional factors to consider that they had not previously thought about (eg storage/maintenance of PFR). The appropriate person should then work with the end user to understand which approach would be most suitable, in terms of cost, performance, O&M.

After all options have been discussed including expert opinions from the appropriate person, the end user should determine which approach they feel would be most suitable for their needs. Once the selected option has been identified, the end user should confirm that they are happy with the proposed approach. This may include a sign-off process for the appropriate person to summarise what was discussed with a signature of agreement from the end user.

Where the PFR work is being carried out as part of other work or adaptation to the property, for example after a destructive flood, escape of water or fire, PFR should be presented within the framework of that repair and not as a discrete element.

This information should be provided to the property owner at the end of Step 4, before detailed design and specification is undertaken.

14.3.1 Resistance measures

Resistance measures can be an effective means of protecting a property from flooding up to a specified height (usually set at the expected maximum flood depth) or to limit the possibility of structural damage.

When considering the suitability of resistance measures and the choice between passive or active measures (**Box 14.1**), it is important to take into account the following identified in Stage 2:

- flood hazard to the property
- likelihood of flood depth exceeding a 'safe' height for resistance measures
- availability of adequate advance warning to deploy active measures
- availability of personnel to deploy and maintain active measures
- availability of personnel to maintain passive measures
- suitability of external wall finishes in resisting water for prolonged flood durations
- assess whether a property should adopt a resistance approach or if it would be more suitable to consider adjacent or joined properties as a single unit.

Box 14.1 Key terminology

Active resistance measures	These are measures which are not permanently installed into the property and will require deployment before a flood event (eg door guard).
Passive resistance measures	These are measures which are installed into the property and do not require further deployment or activation before a flood event (eg a full height flood door or automatic air brick cover).

14.3.2 Recoverability measures

The cost effectiveness of recoverability measures may depend on the circumstances of their installation. The marginal additional cost in new construction (new build or extensions) or during renovation after a flood can make them more attractive than as a pre-emptive measure on an existing building in anticipation of a possible flood. For example, if a kitchen is to be renovated after a flood, then the use of flood-resilient cabinets at low level might be an option.

14.4 STEP 2: LIFETIME REQUIREMENTS OF PFR

14.4.1 Operation and maintenance

The lifetime requirements of any proposed measures and the condition of any PFR measures already installed on the property should be included as a part of the PFR plan.

Requirements for maintenance of PFR measures installed on the property, or that have been proposed for installation, should be included in a PFR maintenance plan, which should meet the conditions of PFR Stage 6. The ease of construction and O&M of measures proposed should be considered carefully as a part of the options development process. The suitability of these requirements to the property and the occupants, may depend on the needs of both the building and the end user.

14.4.2 Storage

In addition to considering the suitability of PFR packages for all flood receptors (including the property and the end user), any storage requirements for equipment while they are not in use, should be identified. Further detail on storage is included in **Section 17.2**.

14.4.3 Longer-term impacts

Consideration should also be made for any implications of the long-term impacts on the receptor due to the measures in place. While this may be negligible, it is important that the client is fully aware of any and all potential risks or considerations about the use of PFR measures. This will allow them to make an informed decision about the most suitable approach for their needs.

14.5 STEP 3: CALCULATE INDICATIVE COSTS

Indicative costs for the packages of PFR measures should be prepared and presented to the client. Resources such as guidance produced by the Environment Agency (2015) can help to identify these costs.

When a suitable costing source has been identified and indicative costs have been determined for the selected approaches, it is important that the appropriate person (eg designer) assesses the suitability of the measures against the client's budget. If these costings are not suitable for the client, alternative options should be identified, and indicative costs should be determined for these. It may be advisable to discuss options that are close to the client's budget if these are expected to be more suitable than alternative approaches. Indicative costs will be dependent on measures identified for an option and the performance of the package of PFR measures being considered.

This will help the client to understand the financial costs of each approach and will allow them to make an informed judgement on which approach they wish to proceed with. This may also help with the procurement of a contractor.

14.6 STEP 4: END USER PREFERENCES

Depending on who the client is for the property (ie owner, occupier, or other end user), consideration should be given to their preferences to ensure that these are delivered as a part of the design.

All the options that are considered suitable for the needs of the owner should be presented along with their pros and cons for review and agreement on the most suitable approach; reference to end user shall include the client and any third parties involved with the PFR works (eg insurer). If third parties are involved, it is important that they are consulted to determine what measures may be deemed suitable.

Chapter 13 provides further information on the consideration of the requirements of end user.

14.7 STEP 5: PFR DESIGN

The series of generic measures that constitute the agreed option should be summarised in an 'options development summary'. This should be given to the party responsible for the design and specification of measures and the selection of products and materials, which takes place during the detailed design process. Ideally the contractor/installer should be engaged at this stage to allow for discussion on the practical installation of the PFR measures. There may need to be an opportunity for the contractor/installer to make suggestions or propose adjustments to the design/specification because of the products involved. The PFR measures should be specified and designed for ease of construction and maintenance.

When the final PFR design is complete, costs should be created to support this.

In summary, the PFR design and specification should include the following elements:

- rationale behind the identified PFR measures as contained in the options development summary
- suitability of the measures to mitigate the identified flood hazard for the property (including substrate materials, accessibility), end user capability etc
- suitability of building products for the property (eg sand-cement render). This specification should detail the materials that should be used, location, and any detailed product information
- list of products including the detailed specification, drawings, measurements, and any preparatory works associated with their installation
- method of installation and commissioning
- method of operation
- accessibility for routine operation, maintenance, repair etc
- cost estimates for product supply, installation and associated works.

14.7.1 The design of resistance measures

The design of resistance measures should be consistent with the definition of resistance as presented in **Box 1.1** and the glossary (ie the use of materials and approaches to safely limit water entry to the property).

Resistance measures should be designed to resist floodwater up to an appropriate depth and include a mechanism to allow the measure to fail or overtop safely so that it does not present additional risk to the property or the inhabitants (ie structural damage). This could be a letterbox in a passive flood-resistant door for example, which will allow water to enter the building above the maximum threshold height of the measures. The whole PFR design for the property should present a robust approach to the protection of areas of water entry and report likely levels of performance related to the identified risk.

The design approach should consider the sources and characteristics of the flooding summary report from Stage 1 and the following:

- aperture or building element that requires protection
- points of water ingress
- surrounding materials and substrates
- installation, maintenance, and operational requirements
- removal of floodwater that enters the building
- user installation, removal, cleaning, and storage of active resistance measures
- provision for evacuation in the event of a flood.

Chapter 25 gives examples of resistance products and **Chapter 24** provides discussion on their O&M.

If a resistance approach is being adopted, ensure that all points of water ingress into the property are considered (not just the obvious) as shown in **Figure 13.2**.

14.7.2 Design of recoverability measures

The design of recoverability measures refers to the use of materials, products, and construction methods that can enable a building to recover from flooding quicker.

The design approach should consider the following:

- area or element that requires protection
- approaches to the recoverability of elements
- recovery processes after a flood occurs
- surrounding materials and/or substrates
- installation, maintenance, and operational requirements.

Recoverable measures (also known as flood repairable approaches, resilient reinstatement, resilient repair or wet proofing) are defined as measures that are designed to limit loss, damage and disruption if water enters the building envelope during a flood. For more information see **Chapter 23**.

Chapter 25 gives examples of recoverability products and **Chapter 24** provides discussion on their O&M.

14.7.3 Managing recoverability

Any design that includes recoverable measures should also incorporate a flood recovery plan for the building. This plan should include:

- likely routes of water entry and any measures suitable to limit or control internal flows
- actions required before a flood (such as removal of doors, contents)
- actions of the end users during a flood
- actions required after a flood (ie safe removal of water from the property)
- drying and reinstatement plans to ensure that the measures are not compromised during reinstatement or other building works.

It is important to recognise that a flooded property incorporating recoverable measures will still require cleaning and possibly redecoration and repair after a flood. This is because water, which is often contaminated, has been allowed inside. The measures may only limit damage up to the depth for which they were designed.

Recoverable measures can also be applied piecemeal to a selected number of building elements. In this case failure of one measure may be independent of other building elements (unlike resistant schemes). Where recoverable measures are interconnected (or if they interact with any resistance measures) this should be made clear in the design.

14.8 SPECIFICATION OF PFR MEASURES

The requirements of the property should be reflected in the PFR measures specification. The designer should provide evidence to ensure that the required levels of resilience can be achieved, and that the measures proposed can be practically constructed and installed as well as ensuring they are operational, maintainable and suitable for the occupiers and users of the property. Providing a clear and consistent specification of PFR measures will help to ensure that the contractor completely understands the proposals.

The specification describes the materials and workmanship required for the PFR work. It should also be accompanied by other documents such as reference to manufacturer's instructions, bills of quantities and construction drawings. For recoverable measures (unlike resistance measures) a bespoke detailed specification will be required because the products used are not necessarily designed for use in PFR and will not always come with instructions for use within a PFR design. Due to the specific technical requirements (and current lack of familiarity among contractors with PFR works) a prescriptive specification is advisable to guide contractors in the use of materials to achieve the required performance. For example, the exact type of tile adhesive or the thickness of membranes needs to be precisely specified for a recoverable design to perform as expected.

The specification should also identify where specialist skills may be needed to achieve the desired workmanship standard (eg the wiring of electrical sockets down from the ceiling) as opposed to those where any competent building contractor will be sufficient. The construction drawings should be of standard format, detailing the arrangement and dimensions of elements in the design and, where necessary, include plans, elevations, and trade drawings. The level of detail should be appropriate to the scale of the PFR works and sufficient for a competent contractor to produce a cost estimate for the job and to undertake the work.

The specification will also be a key document within the PFR plan, as it will enable a damage management (or drying and decontamination) professional, or other contractor subsequently carrying out work on the property, to understand the measures in place and ensure proper treatment of recoverable features. Failure to record the detailed specification could easily result in unnecessary 'strip out' after a flood, or inappropriate finishes being applied (such as waterproof wallpaper on a lime plaster wall) during any redecoration or refurbishment works.

In cases where there are no existing standards that are specifically proven or recognised as appropriate for flood recoverable designs (as is often the case), the specification should provide precise material performance standards that are deemed adequate to achieve the required performance. For example, 'tile adhesive warranted for use in swimming pools' or including a specific product name, along with a rationale for the choice of a product, so that future contractors can source the same materials if required, and can repeat the process or use similar products.

Section 23.2 gives more information on specification of recoverable measures.

14.9 CERTIFICATION OF PFR PRODUCTS

Independently tested and certified products are strongly advised as part of the CoP (**Part B**). The final choice of the product specification should lie with the end user.

14.10 UNINTENDED CONSEQUENCES

Consideration should also be given to the risk of unintended consequences. Depending on the specific measures proposed for the property, these may vary, however the risks of installing PFR given the construction of the property should be reviewed. An example of an unintended consequence that may occur though the installation of PFR measures could be the increased risk of mould or a rise in ground gas levels in the event that manual air brick covers are not removed once floodwater has receded.

Also, there should be appropriate consideration given to the requirement for ventilation in construction to ensure that under normal practice, buildings will still be appropriately ventilated. It is important that if the PFR solution seals any ventilation apertures (such as air bricks), end users understand that these measures should not prevent airflow once the floodwater has receded. BS 851188-1:2019 and BS 851188-2:2019 provide further guidance.

There should also be consideration of gas safety, for example, so that no vents vital to the safe operation of gas appliances remain inadvertently covered. This could be through legislation or good practice guidance such as the Gas Safety (Installation and Use) Regulations 1998 and approved code of practice (HSE, 2018), but should also consider manufacturer's guidance regarding the free circulation of air both in and out of the building. In such instances special care is to be taken.

Always ensure that good practice guidance and/or manufacturer's instructions for use are followed.

14.11 STEP 6: ASSIGN RESPONSIBILITIES

The design details and specification should be handed over to the installation contractor. This should identify responsibilities for installing the PFR measures proposed. Identification of responsibilities and process for the operation of any measures (passive or active approaches) should also be established. This could be several individuals, who will be physically able to do this. Any drying and decontamination responsibilities should be identified. This may include the involvement of third parties, however an understanding of who is generally responsible for managing and operating measures should be incorporated into the construction/installation plan.

Finally, any expected maintenance requirements of the PFR measures should also be assigned to named individuals or roles. This will be confirmed at a later stage once construction/installation has been completed.

In the event of a leased property, it should be clear whether it is the responsibility of the tenant to deploy these PFR measures, or if this rests with other individuals. The tenants should have all information provided to them by their landlord. If this process will be managed through an aftercare agreement, full documentation should be provided to the end user, outlining services proposed and all contract terms.

Once all these responsibilities have been assigned, the options development summary report should be provided to the end user(s). This should incorporate the information outlined in **Box 14.2**. Copies of this report and the construction/installation plan should be retained by the end user at the commissioning and handover stage.

Box 14.2 Options development summary report

The following is a list of the final specification selected for the property, and why this has been selected as the most suitable approach.

- the different types of resistance measures that are to be installed on the property (eg flood barrier) for all areas of the house
- the different types of recoverability measures that are to be installed on the property (eg recoverable floor finish)
- detail proposed materials or fittings that would meet this requirement (eg sealed porcelain floor tiles with waterproof adhesive grouting or passive full height door meeting BSI requirements)
- outline where each of the measures would be installed on the property
- if building elements (eg service meters) are to be relocated, outline where exactly these will be relocated
- outline if any additional measures need to be installed with this measure (eg back-up battery system with sump pump installation)
- outline whether each measure will be manual (active) or automatic (passive)
- outline whether site testing will be required for these measures
- specify any operational, maintenance, cleaning, or recovery plans for the proposed measures
- outline who will be responsible for operating, maintaining and cleaning all measures within a property (as appropriate).

Box 14.3 An example of PFR Stage 3: options development and design

What is needed at this stage

Following achievement of PFR Standards 1 and 2, the options for adopting PFR are set out. The possibilities are discussed with the end user and the most appropriate PFR option is selected. A detailed design of the proposed measures is then undertaken, and a specification prepared for implementation.

The options for PFR developpment will consider the use of:

- measures that restrict water entry to the building under defined conditions
- materials that are recoverable after water contact
- services, fixtures, and fittings that are recoverable by their location and/or ability to resist water damage.

Mr and Mrs Green appoint their building surveyor, Mrs Jones, to undertake the options development for their property, and the detailed design and specification of the measures in the preferred option. Mrs Jones primarily reviews the findings of the flood hazard assessment (PFR Stage 1) and the property survey (PFR Stage 2).

Step 1: propose options (existing properties)

After determining that both resistance and recoverability measures would be suitable for the property, Mrs Jones identifies suitable measures for both resistance and recoverability, and develops these into four packages of generic measures that are suitable for the property. While the overall packages do differ, some measures are used in multiple packages.

Step 2: lifetime requirements

Mrs Jones also considers the longer-term implications of ongoing construction and maintenance of these measures. All packages are found to be easily constructed and maintained. Some measures were found to require storage when not in use, but there is space in the garden shed. Mr and Mrs Green are both physically able to install manual measures and both work in the local area, so would be able to return to their property in the event of a flood warning. Mrs Jones also understands the budgets of Mr and Mrs Green, so she knows which packages and approaches would be suitable for them.

Step 3: calculate indicative costs

Mrs Jones provides an outline cost estimation for each package of suitable measures. Two packages are deemed to be outside of the scope due to being too costly. The other two packages are presented to Mr and Mrs Green.

Step 4: end user preference

Mrs Jones outlines some of the pros and cons of each of these two packages. It is decided that one package is the most suitable for the property, and the needs of Mr and Mrs Green. They are provided with the options development summary report that outlines the measures, predicted levels of performance and limitations.

The PFR measures proposed are:

Resistance measures:

- automatic air brick covers (passive measure requiring no human intervention to function)
- flood door for front and rear entrance doorways, (passive measure requiring no human intervention to function)
- window guard for lounge window (active measure requiring installation before a flood event).
- Recoverability measures:
- tiled floors throughout the ground floor area with drainage points
- sump and pump installed in sub-floor space
- kitchen electrical and white goods to be elevated off floor level
- quick release fitted kitchen unit doors for removal before flood event (active measure requiring action before a flood event).

Mr and Mrs Green confirm they are happy with the proposed approach and they accept and approve package C.

Step 5: (design) PFR design and specification

Mrs Jones then undertakes the detailed design of the measures in the package, selects suitable products and materials and prepares a design specification and drawings for Mr and Mrs Green to give to their contractor as part of a two-stage process. She includes her contact details for the contractor and details of liability and insurance for the detailed design and specification.

Step 6: (design) assign responsibilities

Mr and Mrs Green determine the responsibilities for the installation, operation, drying and decontamination for all measures proposed.

PFR Phase 2: construction phase

15 PFR Stage 4: construction

Introduction

The quality of the installation of PFR products and the construction of measures will have a major influence on their performance. Ensuring high-quality installations will give the property owner, and those providing finance, insurance, and maintenance to the building(s), confidence. Precise adherence to specifications should give the greatest opportunity for PFR to deliver the levels of resistance and recoverability required. This will ensure that the intended level of resilience is achieved and give confidence that the associated benefits will be realised.

This chapter describes the stages for the PFR installation and construction element of the PFR process. It is not anticipated that the construction of PFR will differ greatly from other adaptation retrofit or construction activity except in the attention to ensuring all required gaps and defects are sealed as necessary for limiting water ingress.

Users of the guidance are reminded of the different methods of procuring the installation and construction of PFR measures and of using an appropriate form of contract, as explained in **Section 3.4.1**. Should any changes to the design or specification be needed during construction, for example, if conditions appear to be different once elements of the building are stripped out, then these should be discussed with the designer and any changes agreed in advance with the end user.

PFR Stage 4: construction
Construction in accordance with regulations, instructions and good practice is undertaken to enable the PFR products and installation to deliver the levels of resistance and recoverability required.

Complete PFR installation

Step 1
Contractor to review design and specification

- Review design and specification developed in Stage 3 (**Section 15.1**)
- Discuss any issues with the designer (**Section 15.1.1**)
- Identify any additional costs or requirements to complete the work (**Section 15.2**)

Outcome: the contractor is familiar with the proposed approach to improving the resilience of the building.

Step 2
All parties to agree design proposal

- Agreement of design between designer and contractor (**Section 15.1.1**)
- Agree final PFR design and cost with end user (if required) (**Section 15.1.1**)
- Agreement of PFR design with any third parties (if required) (**Section 15.1.1**)

Outcome: both the designer and the contractor are happy with the approach proposed, and this has also been agreed by the client.

Step 3
Contract scope agreement

- Discuss contract scope with the end user (**Section 15.2**)
- Develop contract scope with the end user (if required) (**Section 15.2.1**)
- Create schedule of works (if required) (**Section 15.2.2**)

Outcome: clear understanding of all parties of what is and is not included as part of the project contract.

Step 4
Installation of PFR

- Complete the works in accordance with the design and specification, and with good practice (**Section 15.3**)
- Meet all health and safety requirements when undertaking installation works (**Section 15.3.1**)

Outcome: all PFR measures are correctly constructed and installed to the right standard and quality

Figure 15.1 Flowchart for PFR Stage 4: construction

15.1 STEP 1: REVIEW OF DESIGN PROPOSAL

The appointed contractor should have a chance to review the options development summary report and the final design of PFR specified in Stage 3. Once the contractor has reviewed the design and specification produced by the designer in Stage 3, there may be aspects the contractor would like to discuss, including any proposed departures from the design and specification. A suitable approach should then be agreed.

If additional costs are involved in delivering the final agreed approach, then new costings should be calculated by the contractor and a revised proposal should be presented to the client and any third parties involved with the PFR process.

15.2 STEP 2: AGREEMENT OF ALL PARTIES

Written agreement and acceptance of the design proposal (whether original or revised) should be obtained from all parties. If adjustments have been made to the final PFR approach in Stage 3, there should be written agreement of amendments to the original design specification previously agreed by all parties. This includes the designer, installer, and the client, as well as any other third parties involved with the process for the property (eg insurer, end user).

15.3 STEP 3: DEVELOPING AND AGREEING CONTRACT SCOPE

To ensure the completed works meet the expectations and requirements of the client, the contract scope should be agreed before works begin.

15.3.1 Develop contract scope

The scope of the contract for the works should be discussed by the contractor with the client and end user so they understand exactly what the scope of the works will cover. This should also include a schedule of works where appropriate. When the client and contractor are satisfied with this, the contractor should prepare a written summary of this information and present it to the client and end user. This will outline and detail the specific constraints of the project and will allow the client and end user to have a written document of the exact scope of these works.

15.3.2 Schedule of works

The schedule of works should be developed by an appropriate person.

The schedule should reflect the agreed scope of the project. It should outline the expected duration of the project, key tasks within these works and specific dates that each task is expected to be completed by. There should also be a final completion date. The schedule should be discussed with all parties involved with the installation of PFR measures, and all parties should agree to the schedule of works proposed by the contractor or surveyor.

15.4 STEP 4: INSTALLATION OF PFR

Sections 15.4.1 to 15.4.4 outline the key requirements and considerations for undertaking the installation of PFR measures on a property. All works should follow manufacturer's instructions. No products should be installed without the necessary preparatory work set out in the design and specification

There should also be ongoing monitoring of the works throughout their completion in case additional issues arise which means that the scope of works may change. If this occurs, the client should be informed immediately, and a solution should be developed and agreed by all relevant parties.

15.4.1 Health and safety of works

Before works begin on the property, the contractor should conduct and complete a full risk assessment of the areas where work will be undertaken. Risks identified as part of this risk assessment process should be addressed and managed in accordance with good practice. Also, any PPE which is required for the work completion should be identified, obtained, and provided to the individual(s) carrying out this work.

15.4.2 Drying and decontamination

If drying and decontamination was identified as required through the property survey in Step 5 of PFR Stage 2 but not carried out, then it should be undertaken before starting any installation of PFR measures.

Appendix A4 provides more information on drying and decontamination.

15.4.3 Small-scale construction activity

Although relevant regulations and guidance (eg CDM 2015) may seem more appropriate to contractors involved in large-scale construction work, they also apply to small-scale construction activity, such as that which may be carried out during PFR work. In this case, the end user may be acting as the 'client' and the contractor may assume multiple roles, including designer, contractor etc.

It is important to ensure that the appointed contractor has the correct skills, experience, insurance etc.

15.4.4 Installing measures

PFR products may be factory tested before they are delivered to site. However, they are only as good as the quality of the installation. It is important that the contractor is competent and sufficiently experienced in installation, understands the need for proper preparatory work, and can complete installation in accordance with the design and specification.

15.5 GENERAL CONSTRUCTION PRINCIPLES

General principles include the following.

- Construction and installation should be undertaken with good workmanship and knowledge of bespoke measures and approaches. As with other construction projects delivery of PFR should be delivered in accordance with BS 8000-0:2014, HM Government (2018) and in Section 8 of Scottish Government (2017).
- Ensure installation of PFR measures are in accordance with the PFR design and following the manufacturer's instructions and guidance.

The installation of products and materials should be accompanied by the manufacturer's warranty (where relevant). **Table 15.1** provides a non-exhaustive list of some important factors to consider during construction and installation of PFR. **Chapter 24** gives more information on O&M.

Table 15.1 Considerations for installing PFR

PFR measure	Consideration at Stage 4: construction
Resistance PFR measures	
Aperture barriers (both manual and passive, Sections 24.6.1 and 24.6.2)	• Preparatory building modifications works should be undertaken to ensure sound surface, a watertight seal and barriers fit within the frame or aperture. • Consider shape of the aperture to ensure a good seal. • Do not fit the wrong way around.
Non-return valves (NRV) (Section 24.6.4)	• If a larger NRV is connected to a foul sewer, construction of a new manhole may be required.
Service entries, weep holes (Section 24.6.3)	• Alternative ventilation should be provided in place of weep holes where they are required to maintain good indoor air quality. • Purpose of the weep holes should be determined.
Air brick protection (both manual and passive, Section 24.6.3)	• The cover of the air brick should be free to come away from the unit and sealed with mastic or mortar. • With passive air brick protection ensure mastic or mortar seals do not affect activation.
Vent protection (Section 24.6.3)	• Advice from a Gas Safe engineer or HETAS engineer should be taken for vents associated with a combustible fuel source.
Membranes (Section 24.6.5)	• Ensure the installations of membranes, and the service penetrations through them, are adequately detailed and sealed.
Wall finishes (Section 24.6.2)	• Ensure preparatory work can be carried out to ensure good quality of wall finish in line with the levels of performance required. • Ensure detailing and finish is of good standard and maintains the integrity of the finish and operational performance.
Sump and pump or puddle pump (Section 24.7.3)	• Sump pump installation requires electrical safety certificate. • Consider need for alternative power source. • If using a generator provide safe ventilation of fumes.
Recoverable PFR measures	
Floor finishes (Section 24.8.1)	• Ensure existing, remaining, or original sub-floor structures are adequate to support the proposed floor covering. • Ensure preparatory work is undertaken to allow the floor to be installed effectively and in line with its anticipated performance. • Ensure detailing is adequately designed/installed to lessen the probability of leakage. • Ensure fixings do not penetrate through or damage any resistant membranes/coatings. • Consider short and medium-term cleaning and maintenance issues.
Wall finishes (Section 24.8.2)	• Ensure preparatory work can be carried out to ensure good quality of wall finish in line with the levels of performance required. • Ensure access for drying of building fabric if non-permeable finishes are applied. • Ensure fixings do not penetrate through any resistant membranes/coatings.
Resilient kitchens and other fitted units (Section 24.9)	• Ensure adequate access for drying of building fabric behind fitted units. • Ensure fixings do not penetrate through any resistant membranes/coatings.
Services (Section 24.6.3)	• Ensure gas, electrical, water and communications services are suitably positioned, installed, sealed and accessible for future maintenance. • Ensure fixings do not penetrate through any resistant membranes/coatings.

Box 15.1 An example of PFR Stage 4: construction

What is needed at this stage

The quality of the installation of PFR products and the construction of measures will have a major influence on their performance against design and specification outcomes. Precise adherence to specifications should enable PFR to deliver the levels of resistance and recoverability required. High-quality installations will give confidence to the property owner and those providing insurance and/or maintenance to the building(s). This will ensure that the intended level of resilience is achieved and confidence that the associated benefits will be realised.

Step 1: contractor to review design and specification

Mr and Mrs Green employ a local builder, Mr Smith, to undertake the installation of the PFR measures. Mr Smith has installed PFR measures at a couple of other houses in the area and the Greens have been able to visit one of these to see the works, and meet the householders who appear to be satisfied with the workmanship. The Greens also get a quotation from another builder in the area who also has PFR installation experience, but this would not result in any significant cost saving.

Mr Smith reviews the PFR design and specification provided and identifies some additional construction work that may be required to install the sump pump. Mr Smith contacts the designer (Mrs Jones), who confirms that these changes are necessary. This decision is agreed by Mr and Mrs Green. There are no third parties to consider, so no other approvals are required.

Step 2: all parties to agree design proposal

Mr Smith discusses details of the work with Mr and Mrs Green. He estimates how long the works will take, discusses the exact process that will be undertaken as part of this work, and highlights what will and will not be included in this work. This includes an agreement that the supplier of the flood door will arrange for a different contractor to install the full height flood doors.

Step 3: contract scope agreement

When Mr and Mrs Green confirm they are satisfied with the arrangement, Mr Smith writes up the information and receives a sign off from the Greens. This also confirms the schedule of works to undertake these tasks.

Mr Smith ensures all health and safety requirements are met to undertake this project, and when he is satisfied, he begins work on the Green's house. All work is undertaken in accordance with good construction practice.

Step 4: installation of PFR

Installation of the flood doors are carried out by the door supplier and a subcontractor appointed by Mr Smith. The subcontractor ensures that the installation satisfies the product warranty and provides a copy of the warranty to Mr and Mrs Green. The air brick cover and sump and pump have been installed by Mr Smith as per the manufacturer's specifications and installation guidance.

Work associated with tiling, repositioning, or electrical/white goods, and quick release kitchen doors have been undertaken by Mr Smith.

Overall, the PFR measures specified are delivered within the estimated timescale and approved costs.

16 PFR Stage 5: commissioning and handover

Introduction

An important element of any construction project is commissioning and handover. These elements demonstrate that the construction activity undertaken, and the measures installed within the property, deliver the PFR required by the end user. They also set out all O&M requirements of the PFR measures installed and are often contained within a 'O&M handover pack'.

PFR Stage 5: commissioning and handover
Carry out checks and a PiA to assess whether the PFR construction work operates effectively as designed. Also check users have all relevant information and know any operation and maintenance needs.

Commission PFR and handover to end user

Step 1
Quality check and demonstration of PFR measures

- Complete the work with a quality check of installation and address any issues arising (**Section 16.1**)
- Discuss the operation of PFR measures with the end user (**Section 16.1**)
- Demonstrate operation of PFR measures to the end user (**Section 16.1**)
- Confirm operation, storage and maintenance responsibilities for all parties involved – from Stage 3 (**Section 16.1**)

Outcome: the contractor demonstrates the PFR measures installed are 'fit for purpose' and demonstrates operation to the client and end user(s).

In situ testing available for PFR measures?

No

Yes

Step 2
***In situ* testing of PFR (optional)**

- Present *in situ* testing options for PFR measures to the end user (**Section 16.2**)
- Complete an independently witnessed *in situ* test at the request of the end user (**Section 16.2**)
- Independent witness to provide a verification document or statement (**Section 16.2**)

Outcome: the client and end user(s) are familiar with the proposed approach to improving the flood resilience of the building.

Step 3
PiA

- Arrange an independent inspection of installation following the completion of the work (**Section 16.3**)
- Independent expert to assess and provide a brief report on the PFR installation (**Section 16.3**)
- Provide this confirmation report to the end user (**Section 16.3**)

Outcome: successfully installed PFR measures that have been audited by an external and independent professional, and a summary report provided for the end user to present to insurers and other parties.

Step 4
Snagging and correction

- Identify and highlight any issues raised in testing and inspection (**Section 16.4**)
- Identify a suitable solution for these issues for the property (**Section 16.4**)
- Complete any corrections or facilitate any additional work required (**Section 16.4**)

Outcome: a successful and suitable installation of PFR that has been checked and issues corrected

Step 5
Information handover (O&M) pack

- Provide handover pack to the end user in a suitable format (**Section 16.5**)
- Ensure end user have demonstrated an understanding of PFR operation, maintenance and storage (**Section 16.5**)
- Ensure end user have shown an understanding of lifetime requirements (**Section 16.5**)

Outcome: a well informed end user who understands how to deploy and operate their installed PFR measures, and how to maintain them.

Step 6
Worts sign-off

- Confirm all parties are happy with the completed works (**Section 16.6**)
- Obtain final sign-off to confirm works have been completed to the standard required (**Section 16.6**)

Outcome: signed documentation showing all parties have accepted the completed works.

Figure 16.1 Flowchart for PFR Stage 5: commissioning and handover

16.1 STEP 1: QUALITY CHECK AND DEMONSTRATION OF PFR

Following completion of the works by the contractor, a quality check should be conducted. This is an assessment process by those who installed the measures on the property, to ensure the measures are operating effectively and are fit for purpose. It will allow the installer to review all works for functionality and suitability and should identify if there are any faults with the product(s) installed on the property. If there are any deployment or storage requirements for the installed measures, an assessment of these aspects should form part of the quality check. Defects with any aspect of the PFR measures should be rectified to the satisfaction of the client and end user. The individual conducting this process may vary, depending on the procurement route of the PFR measures. See **Section 3.4.1**.

Once the quality check has been conducted, the contractor should discuss the operational requirements of the PFR measures with the end user. This can be done either separately or as part of a demonstration of the operational, deployment or storage requirements of the PFR measures to the end user. It is the responsibility of the contractor to ensure that the measures are demonstrated to the end user as far as reasonably possible (**Section 22.4.1**). The end user should be able to ask any questions or discuss any concerns with the contractor about the operation, storage or deployment of any of the products. Signed confirmation from the end user should be retained by the contractor to confirm this was done.

To ensure the expected performance of the PFR measures is achieved, a post-installation inspection can be commissioned by a client, albeit at additional cost. A record of all inspections and quality checks should be retained. The inspections should be carried out by an appropriate person, and with reference to the relevant building regulations, CDM 2015 and the accompanying summary (HSE, 2015) and/or a certified installers scheme.

An inspection should assess the following:

- Do the PFR measures deliver the performance requirements specified in PFR Stage 3?
- Have the measures been installed effectively and with reference to the design and/or the manufacturer's guidelines?
- Have the measures been installed with a good level of workmanship?
- Do the measures require any reconfiguration/alteration after a flood event? Have these requirements been accounted for during the installation process?
- Are the roles and responsibilities about commissioning and handover for the property clear?

A checklist for site inspection should be used during the inspection. This can be signed, dated, and passed to the property owner at the handover stage.

In the event of a leased property, it should be clear whether it is the responsibility of the tenant to deploy these PFR measures, or if this rests with other individuals. The tenants should have all information provided to them by their landlord.

16.2 STEP 2: *IN SITU* TESTING OF PFR MEASURES

For some resistance and recoverability measures, product manufacturers may specify test procedures related to resilience performance over and above standards required for normal health and safety. Testing should be carried out in accordance with recommended manufacturer test standards, where available, and by a qualified and independent individual.

In the absence of a comprehensive set of accepted standards covering the *in situ* testing of PFR measures, it will be for each end user to decide on competency of installation teams. This will be based upon recommendations, experience, testimonials and perhaps visits to recently completed works – similar to when engaging a domestic builder.

If post-installation testing is recommended for the products by the manufacturer, this should be presented and offered as an additional service which the end user can request. Such testing should be witnessed by an independent flood professional, where possible, who should provide a statement of verification.

All testing should also be proportional to the budget of the client and risk associated with failure of the product.

It is worth noting that standard construction products and materials can be used within properties to increase the levels or resistance and recoverability. These products and materials may not have resilience specifications that can be tested.

16.3 STEP 3: POST-INSTALLATION AUDIT

An independent inspection of the installed and completed PFR measures may be carried out by a qualified flood professional. This may incur an additional charge to the client, but it will provide a robust impartial verification of the completion of the works to a suitable standard. They should assess and record all relevant information about the work completed and provide a summary report detailing their findings to the client, in a suitable format.

16.4 STEP 4: SNAGGING AND CORRECTION

Following the completion of the contractor's quality check any *in situ* testing of PFR measures and an independent PIA, plus any snags with the installation of the PFR measures, should be identified and raised with the contractor. An appropriate solution to these should be determined and the corrections should be carried out by the relevant party. The audit may then be repeated, at the request of the client, following the completion of corrections.

16.5 STEP 5: INFORMATION HANDOVER

All appropriate information should be provided to the end user.

16.5.1 Handover pack

A handover pack provides information relating to the performance of the installed PFR measures, and detailed operational instructions of how to operate each measure (if applicable). It may also cover the maintenance schedule (if required) for each measure, which will help to ensure their continued successful O&M. (**Section 24.9** provides further information on maintenance of products.) The handover pack may include storage instructions if the measures are not fixed in situ. This should include requirements for the lifetime of the products.

The information contained in the handover pack could also include:

- details of the property survey and identified risks
- the flood hazard assessment
- design of the PFR measures
- product details of the PFR measures installed
- details of operation and maintenance
- results of any post-construction audits, testing, copies of warranties and manufacturer's guidelines.

This O&M handover pack should also include all contact details for the suppliers of all PFR measures installed on the property. The contractor should ensure that this information has been provided in its entirety to the end user, and in a format that is suitable for them to use.

This information should be as detailed as possible, signed by the contractor, and should remain with the end user.

16.5.2 Understanding the operation and storage of PFR measures

The contractor should ensure that the end user fully understand the operational, deployment and storage requirements of new PFR measures installed. This could be done through the end user doing a practice demonstration of any deployment and operational requirement(s) of PFR measures before returning them to storage (if required).

16.5.3 Understanding maintenance requirements of PFR measures

The client and end user should also demonstrate to the contractor they fully understand the maintenance requirements of the PFR measures installed, in accordance with the information provided as a part of the O&M handover pack. The client and end user should also be fully aware of any drying and decontamination requirements for these PFR measures following use. Finally, the end user should demonstrate an understanding of the lifespan of the measures.

16.6 STEP 6: WORKS SIGN OFF

All parties involved with the completed works, should be contacted to attain verbal confirmation that they have accepted the completion of the PFR works. This should include the client (domestic see **Section 22.2** or non-domestic see **Section 22.3**), the end user, the principal contractor (**Section 22.4.1**) and any third parties.

If this has been completed, written confirmation should be obtained from all parties.

Box 16.1 An example of PFR Stage 5: commissioning and handover

What is needed at this stage

Commissioning and handover is the final stage of any construction project. For a PFR project it is the point at which the end user is assured the installed measures meet their expectations. O&M requirements are outlined, and a detailed handover pack provided.

Step 1: quality check and demonstration of PFR measures

The PFR measures installed within Mr and Mrs Green's property at Stage 4 have been checked by the contractor (Mr Smith) to ensure he is satisfied the works have completed to a good standard and are fully operational. Mr Smith explains how each PFR measure works to Mr and Mrs Green, and concludes with a physical demonstration of how to use each of them. This includes showing how to install the window guard before a flood event, and how the flood doors work.

Step 2: *in situ* testing of PFR (optional)

Mr Smith has checked the pump and sump works and discussed this with the Green's, who now feel comfortable with how the PFR measures should operate and how the resilience of their property has been improved.

Mr Smith offers 'post-installation testing' of the appropriate PFR measures installed such as the door which could be tested by the subcontractor who installed the product. Mr and Mrs Green request that this is conducted for the tiled floor and sump and pump. This is witnessed by the Green's, who sign a verification statement, provided by Mr Smith, of successful functioning of this test. Copies of this document is retained by Mr Smith and Mr and Mrs Green.

Step 3: PiA

Mr Smith requests the independent surveyor (Mrs Jones) inspect the PFR installation. Mrs Jones assesses the works carried out by Mr Smith and prepares a summary which she provides to both Mr Smith and Mr and Mrs Green.

Step 4: snagging and correction

The report states all works have been carried out to a satisfactory standard, but one unprotected air brick had not been changed to a passive flood air brick. This additional work was undertaken by Mr Smith immediately. This concluded the snagging and correction phase of these works.

Step 5: information O&M handover pack

Mr Smith gives the O&M handover pack to Mr and Mrs Green, which contains the relevant information for the PFR measures installed. They have practiced installing the window guard a few times to understand the time and effort involved. They also practiced removing the kitchen cabinet doors and decide the best place to store them during a flood is on top of the kitchen table. They also discuss the maintenance requirements for the flood doors and the sump and pump and confirm a schedule is included in the pack. Following this, Mr Smith confirmed that he was happy the Green's understood the requirements of managing the PFR measures installed, both in use and over their operational lifetime.

Step 6: works sign off

Mr and Mrs Green confirm that they will be responsible for the operation, storage, and maintenance of the installed measures. This has given them some comfort that even if their property is flooded, the damage should be minimised, and the time for their property to recover should be reduced.

Mr and Mrs Green confirmed they were happy with the completed works to Mr Smith. Both parties have completed the final works sign-off process to verify the works had been carried out to a satisfactory standard.

PFR Phase 3: operational phase

17 PFR Stage 6: operation and maintenance

Introduction

Properties with a defined flood risk are likely to remain at risk over time. Indeed, it is possible that the risk to the property may increase due to factors such as urbanisation and climate change. To maintain a level of protection to a property, the PFR measures installed should be operated and maintained following the guidance provided in the O&M handover pack.

PFR Stage 6: operation and maintenance
Completed PFR construction works are properly operated and maintained. All responsibilities and duties for operation and maintenance should be clearly defined and agreed.

Operation and maintenance of PFR

Step 1
Use of O&M handover pack by end user

- Safely store O&M handover pack documents (**Section 17.1.1**)
- Make O&M handover pack documents available to new end user and those with responsibility for maintenance as outlined in Stage 3 (**Section 17.1.1**)
- Read and meet all O&M requirements (**Section 17.1.1**)

Outcome: maintenance and operational requirements for the PFR measures are met in accordance with the handover pack

Step 2
Storage and accessibility

- Store PFR measures in a suitable and robust location (**Section 17.2**)
- Keep any tools that are required for operation in storage alongside the PFR measures (**Section 17.2**)
- Maintain access to PFR measures (**Section 17.2**)

Outcome: easily accessible PFR measures that are stored in a suitable location when not in use

Step 3
PFR maintenance

- Conduct maintenance work in accordance with the schedule (**Section 17.3**)
- Maintenance to be completed in line with manufacturers guidance (**Section 17.3**)
- Record maintenance activity and retain maintenance documentation for future reference (**Section 17.3)**

Outcome: functional PFR measures with a complete record of any maintenance work conducted on them and periodic assessment of their condition and effectiveness

Step 4
Operation of PFR measures

- In the event of a flood, deploy all active measures (**Section 17.5.1)**
- In the event of a flood, seal all passive measures fully (**Section 17.5.2)**
- After a flood, dry and decontaminate all measures as required (**Section 17.5.3)**
- Repair damaged measures and return all measures to storage, and record any maintenance carried out (**Section 17.5.3)**

Outcome: an effective system that can continue to remain functional following use, ready for future events.

Figure 17.1 Flowchart for PFR Stage 6: operation and maintenance

17.1 STEP 1: USE OF HANDOVER PACK

17.1.1 Safely storing information

It is important that upon presentation of the handover pack to the end user, that they retain this information indefinitely in a location that is accessible in the event of a flood and to all parties responsible for O&M.

This information should be passed to any new owners or occupants if the property changes ownership or occupancy.

The persons responsible should undertake the O&M requirements of the PFR measures installed. These responsibilities will have been broadly outlined during the options development in Stage 3 Step 6. Once the sign-off process of works is done, these responsibilities should be defined, agreed and confirmed for the specific measures installed at the property.

17.2 STEP 2: STORAGE AND ACCESSIBILITY

The operation of the PFR measures should be understood and those responsible for deploying or operating them should also be agreed. Any preparatory work or actions in anticipation of a flood event should be defined and understood.

The storage arrangements of any measures that require deployment should have been determined as part of the design process. The storage should be safe and secure but accessible to those responsible for adopting the PFR measures in the event of a flood. This storage should also contain any tools, or fittings that are required to implement the PFR measures, to ensure quick and simple deployment.

Storage requirements for PFR measures may also include space to accommodate items removed from a property before a flood. Stored items between events may include removal aids, plastic containers, and sheeting required to protect and store contents of a property. These requirements should be detailed in the plan and handover pack, but need to be regularly reviewed, as the contents may change over time.

17.3 STEP 3: MAINTENANCE OF PFR MEASURES

Depending on the measures recommended in Stage 3, there may be a mixture of both flood resistance and flood recoverability measures installed at a property.

It is recommended that regular test installation of all manual PFR measures is undertaken as a minimum requirement. This will ensure that the nominated person will be able to install all manually deployed measures, and that they can meet the physical requirements to do so. If deployment cannot be done (perhaps because the circumstances or responsible persons have changed), the PFR design should be re-evaluated and a new options development process should be undertaken.

In addition, a regular test procedure will enable practice of the installation process of the measures to be assessed and highlight anything that the responsible person is unsure about. Any co-ordination issues, training needs or access difficulties will also be identified. It provides an opportunity to contact the product manufacturer or installer to request more information.

The maintenance schedule prepared by the contractor in accordance with manufacturer recommendations and provided to the client and end user in the handover pack, should be followed. Any maintenance work undertaken should be recorded as part of a maintenance log, and as a method of demonstrating ongoing assessment of the installed PFR measures.

The design and specification, as well as installation and testing of PFR, should include details on maintenance and recovery. A maintenance and recovery schedule associated with the range of measures installed within a property should be included in the O&M plan. This information should be provided to the property owner at the handover stage.

- Any documentation or maintenance guidance received with PFR measures should be stored in a safe location for reference or information purposes. This could be stored alongside the flood plan for PFR measures.
- To ensure these devices continue to operate to design specification, they should be regularly inspected so that they remain fit for purpose.
- Maintenance should at least conform to the relevant manufacturer's instructions and normal expectations for building maintenance schedules.

Where specified by the manufacturer any maintenance work undertaken should be conducted by competent individuals, and in accordance with manufacturer's recommendations. In many cases the end user will be able to undertake simple maintenance. All maintenance activities should be recorded, noting the date, maintenance required and outcomes. **Chapter 24** provides more information on O&M of PFR measures.

17.3.1 Flood resistance measures

With the wide variety of flood resistance measures available, there are many maintenance procedures that should be followed to ensure that all products function as designed. In most cases, upon purchase of flood resistance measures, manufacturer's instructions will be supplied along with the product which will explain the normal maintenance process and service requirements. These are often applied directly on the product. If the appropriate maintenance requirements of any PFR measures are unclear, the product documentation should be reviewed, and the manufacturer or supplier contacted if required. Many products will also come with a warranty, which may require servicing to be carried out by an approved company or competent person. Any documentation or maintenance guidance received with PFR measures should be stored somewhere safe for reference.

Property flood resistance measures are designed to resist water entry to a specified standard. To ensure that these devices continue to operate to design specification, they will need to be regularly inspected (following manufacturer's guidelines). By applying manufacturer's recommendations for maintenance, aftercare and storage requirements, any issues or defects that occur in the products over time can be recognised and addressed.

Additional considerations around the O&M of flood resistance measures are given in BS 851188-1:2019 and BS 85188-2:2019.

17.3.2 Flood recoverability measures

As with flood resistance measures, recoverable measures need ongoing maintenance to ensure that they function correctly (ie that they can help speed up the process of recovery following a flood). Maintenance requirements for recoverable measures will depend on the approach and materials employed. Some of these measures will require consideration as to their integrity (eg recoverable floor finishes), due to ongoing wear, whereas others will require an on-site inspection by an appropriate person (eg sump and pump systems).

In general, maintenance should at least conform to the relevant manufacturer's instructions and normal expectations for building maintenance schedules. However, at the design stage the appropriate person should make clear any additional requirements (ie those that are specific to the use of the materials or products in the context of flood recoverability) and provide a maintenance and replacement schedule. This schedule should highlight whether any specialised knowledge, parts or materials are required to maintain the measures, where these can be sourced, and make recommendations for any monitoring needed.

If recoverable measures require active intervention in the event of a flood, then they should be accompanied by a plan of operation provided as part of the O&M handover pack. This plan should be regularly reviewed to ensure that the responsible persons are informed, and that it is still practical following any changes to the property or to the capability its occupants. In some cases, regular drills may be advisable, and these should be recommended in the maintenance plan.

17.3.3 Responsibility for operation and maintenance

The O&M of any PFR measures installed by a contractor, followed by the inspection and sign off by an independent appropriate person, are the responsibility of the client and end user. This will be the case unless additional maintenance contracts have been commissioned involving a periodic inspection of the quality and condition of the PFR measures by an appropriate person.

17.4 OPERATING INSTRUCTIONS FOR PFR

Operation instructions should also be available to the person(s) responsible for any deployment. Operation should have been explained or demonstrated to them. The O&M plan should also be available to the occupiers of the premises (where they differ from the owner) so that they are aware of the plan and can take the necessary actions themselves, or ensure other responsible persons do so.

Chapter 24 gives more information on O&M of PFR measures.

17.5 STEP 4: OPERATION OF PFR MEASURES

Being prepared to use PFR measures in the event of a flood can be beneficial to a property and its occupants. This will normally form part of a wider preparedness strategy and should be incorporated into the PFR plan and any wider flood management plans and strategies (Environment Agency, 2012).

17.5.1 Deployment of PFR

Flood warnings are available across the UK. On receipt of a warning, manual measures should be deployed in accordance with the demonstration provided by the contractor as part of Stage 5 Step 1. The handover pack will provide an alternative source of information for the end user responsible for implementing these measures. End users should ensure passive measures are fully sealed in line with manufacturer's recommendations to ensure correct and successful operation.

17.5.2 Preparing for a flood

Being prepared in an emergency can help to reduce stress, panic, and avoid loss of life. It is important households and business owners do not wait until flooding happens.

End users should sign up to receive flood warnings where available.

Flood plans (**Section 24.1**) form an important part of emergency plans for individuals, communities, and businesses. By planning in advance, people will not only be better prepared to respond in an emergency but will be better equipped to recover in the long term (Environment Agency, 2012).

A flood plan explains how households (**Section 24.2**), communities (**Section 24.3**) and businesses (**Section 24.4**) will respond in the event of a flood. This can help quick responses when flooding happens and with decisions on practical actions to be taken before and during a flood. Ultimately, the plans can help reduce the damage flooding can cause. The use and O&M of PFR measures should be included in any household, community, or business flood plan.

The operation of PFR should be reviewed after any of the following events occur:

- modifications, renovations, adaptations, repairs to the property
- change in use, tenants, ownership, or status of the property
- after a flood event
- annually, or in accordance with PFR products guidance.

Further guidance around preparing for a flood is available in **Chapter 24**.

17.5.3 Drying, decontaminating and returning PFR measures to storage

Following a flood, all measures should be dried and decontaminated in accordance with the responsibilities and requirements identified within Stage 5. **Section 15.4.2** and **Appendix A4** give further information around drying and decontaminating PFR measures.

Upon completion of the drying and decontamination process, the measures should be reviewed for evidence of damage or stress. To meet the requirements of PFR Standard 6 Requirement 7, the nominated person should ensure the individual conducting the checks has relevant knowledge and experience to carry the checks out to a good standard and undertakes correct procedures and to ensure that all products function as designed. The checks should be fully recorded with a high level of detail for the end user, and need to be carried out after every flooding event. If visible damage is present on these measures, they should be reviewed for robustness and operability by an appropriate person and repaired or replaced as recommended.

Any undamaged measures, or measures deemed suitable following inspection, should be returned to storage ready for redeployment in the event of future floods.

17.5.4 Periodic audit of PFR

A periodic audit of PFR measures is an important part of the O&M. For PFR measures to remain fully functional and suitable for the property they are installed on, they should be checked by an appropriate person. This audit will require an on-site inspection to consider the condition of each device and to ensure that these measures have been installed correctly and will remain fully functional in the event of a flood.

Many PFR measures will come with a warranty. For this warranty to remain valid, there may be requirements for periodic audits to be conducted. This will be dependent on the product and supplier, and may also require a specific organisation or appropriate person to conduct this inspection. This involves an on-site visit to the property, to review the device *in situ*. Audits should be completed by an appropriate person. This person should have a prior knowledge of the measures they are inspecting and should also be a competent person who can review the measures on site. General wear and tear inspections should also be conducted periodically by the property owner. If a measure is found not to be functioning as expected, then a competent person should be contacted to perform a full on-site inspection.

The time between these audits of PFR measures will depend on the specific measures that have been installed. This audit timescale should be based on manufacturer's recommended guidance for proper and appropriate maintenance.

17.5.5 Outcomes of PFR periodic audit

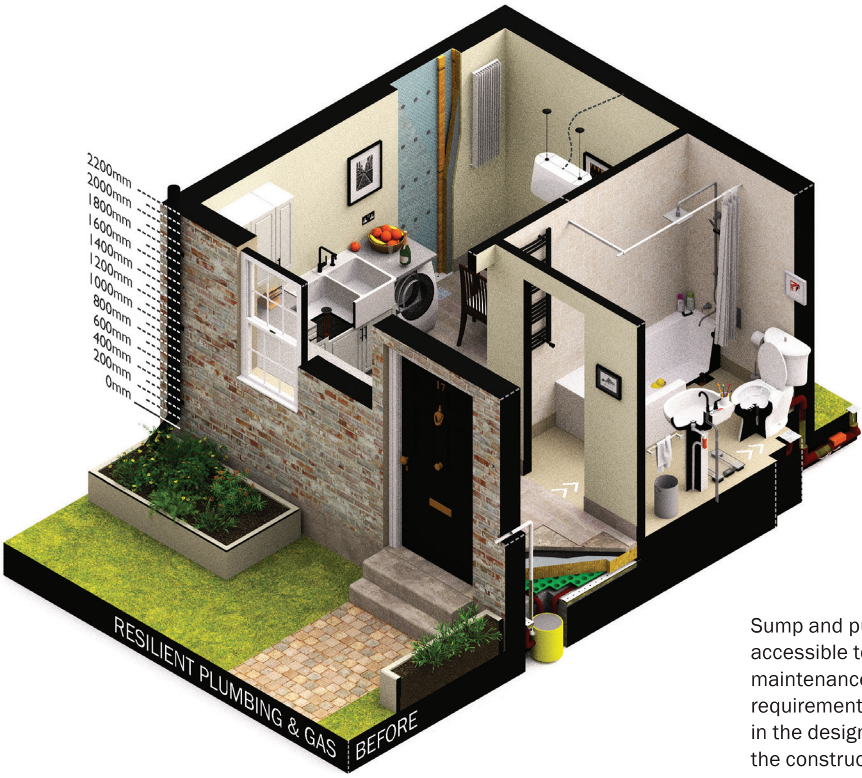
There are clear benefits of completing a regular audit of PFR measures. Primarily, the reassurance that these measures are functioning correctly. An on-site audit will inspect these measures and will ensure that not only the end user(s) remember how to install any manual protection measures, but that they are checking that these measures are still in a condition where they can continue to function. For products that will act as resistance measures, failure of any single measure will mean the benefit that the remaining resistance measures can provide is now limited, as floodwater will have found an entry point through the failed measure.

A periodic audit will allow the identification of flaws or potential defects with each of the PFR measures inspected. This will ensure that properties remain protected up to the design level of the measures installed. Regular audits should provide reassurance to end user(s), and any relevant third parties, that an appropriate person has inspected the measures on site.

17.5.6 Example of routine checking of PFR

Manual flood barriers require regular checks. The seals on such products, and the joints where barriers are installed onto stanchions or external walls, should all be assessed as a part of a periodic audit. If the seals are not deemed to be watertight on visual inspection, they should be tested and, if they fail, replaced. A periodic audit may recognise a weakness due to the impact of debris on a manual flood barrier. Debris damage could result in product warping, inability to deploy the product, poor sealing, or complete failure. Seals could also degrade more quickly than expected if the product is not correctly stored. Annual testing of the mounting and demounting of the barrier will ensure any mechanical parts are still operational and that the responsible person can still deploy the barrier.

A similar process may be required for some recoverability measures. For example, sump and pump systems will require a periodic inspection in accordance with manufacturer's recommendations. Without an annual inspection and audit of these systems, an end user will not know if the device will work successfully in a flood scenario. Drainage pipes linked to sump and pump systems may also become blocked, and blockages need to be removed to allow rapid removal of floodwater from the premises (see **Figure 17.2**).



Sump and pump should be accessible to allow for routine maintenance and inspection. This requirement should be considered in the design stage (Stage 3) and in the construction phase (Stage 4)

Figure 17.2 Sump and pump installed in a property (courtesy The Environmental Design Studio)

Box 17.1 An example of PFR Stage 6: operation and maintenance

What is needed at this stage

Properties with a defined flood risk are likely to remain at risk over time. It is possible for the level of risk to the property to increase due to factors such as climate change and urbanisation. To maintain a level of protection to a property, the PFR measures installed should be operated and maintained following the guidance provided in the O&M handover pack.

Step 1: use of handover (O&M) pack by end user

The contractor, Mr Smith, provided a full handover pack to Mr and Mrs Green for their property at the point of handover. They have stored this safely both in digital and paper forms. They keep track of when PFR measures require routine maintenance and have set reminders to make sure these dates are not missed.

Step 2: storage and accessibility

Mr and Mrs Green have stored their manual (active) measures in secure storage facilities in the rear garden of their property. All tools required to deploy the measures are kept in the same storage container for easy access and there is a clear access path to this at all times. In the event of a flood, the water will reach the house before it reaches the access path and the storage facility.

Step 3: PFR maintenance

They are aware of specific maintenance activities as follows:

- regular checks of flood doors perimeter and seals (as per manufacturer's recommendations)
- regular checking of automatic air brick covers to ensure they are free from obstruction/debris
- routine cleaning of window guard housing to ensure it remains free of any obstructions
- six-monthly electrical check of sump and pump system (as per manufacturer's recommendations).

All professional maintenance work undertaken on these PFR measures is carried out in accordance with the manufacturer's recommendations by an appropriate person. Mr and Mrs Green retain receipts of this maintenance work as proof it has been carried out. They check the air bricks and housings themselves on a regular basis.

Step 4: operation of PFR measures

Having carried out some 'test runs', Mr and Mrs Green are confident they can install the window guard in less than 30 minutes. They have signed up to the Environment Agency and local community flood warning groups, which circulates information on flood warnings for the area. They have also developed a quick method of removing kitchen unit doors and can remove all the doors within a 20-minute period and store these, and their contents, safely. They have chosen to deploy manual measures if they are to be away from the property for a period of time.

Mr and Mrs Green know that their flood doors and window guard have been designed to resist water up to 500 mm, thereafter water will enter their property. They are comfortable in the operation of their sump and pump system and know that damage will be limited due to the tiled floor they now have throughout the ground floor.

A full check of all measures will be undertaken after a flood event to ensure they remain fully functional. If Mr and Mrs Green decide to move to a new house, they will provide all of the information about the PFR measures installed on the property to the new owners They would also demonstrate the O&M and storage of all PFR measures to the new owners to ensure that these measures are still suitable.

PART D
SUPPORTING INFORMATION

Flood-resilient home

18 End user questions

Table 18.1 provides a series of questions that may be asked at key stages of the PFR delivery process. This helps to highlight where PFR may be useful, and what aspects of this guidance may assist the user(s) in following this process.

Table 18.1 Some typical end user questions

I am concerned about the flood risk to my property. We have been flooded before and I want to protect my property from further damage.
Part A (Chapters 1 to 4) introduces PFR and gives useful background information on its use.
I am considering installing PFR measures into my property. What is the first thing I need to do?
Action: follow PFR Stage 1 (Chapter 12), to understand the flood hazard to the property, ie where flood is likely to originate from (Section 12.2), how floodwater approaches the building (Section 12.6), and how likely it is to affect the building (Section 12.7).
I now know the flood hazard related to my property. What is the likely impact on the property itself?
Action: follow PFR Standard 2 (Chapter 13), to understand what the flood risk is to the property, based on its location, construction, condition, materials, etc. and end user requirements (Section 13.3).
I know the types of flood, chances of flooding and potential impacts on my property, but how do I find out which PFR measures are right for me?
Action: follow PFR Standard 3 (Chapter 14), so both flood resistance (Section 14.3.1) and recoverability (Section 14.3.2) measures are considered. These options should be assessed against the identified flood risk, before a design solution is prepared (Section 14.7).
Now that I have got my PFR design, how do I get it installed in my property?
Action: follow PFR Standard 4 (Chapter 15). This guidance will inform the installation of PFR measures (Section 15.4) to an agreed contract and scope (Section 15.3) to ensure operation and performance in line with the design solution identified.
I now have my PFR measures installed, but how do I operate them? Is there anything I need to do before or during a flood?
Action: follow PFR Standard 5 (Chapter 16). All PFR measures installed in the property should function effectively and to the level of performance required. Your installer should explain to you (Section 16.1) everything you need to know and leave you with a handover pack (Section 16.5.1).
Is there anything I need to do to make sure my PFR measures operate effectively in the future?
Action: follow PFR Standard 6 (Chapter 17). Your handover pack should have information on how to deploy the measures (Section 17.5.1), and on how the PFR measures should be maintained (Section 17.3) to allow effective operation through their lifetime. This should include regular testing (Section 16.2) in line with manufacturer's recommendations. You should also regularly review your emergency plan (Section 17.5.2).

19 Flood hazard assessment

Available information relating to flood hazard varies across the devolved nations of the UK. Consequently, relevant guidance relating to the PFR process depends on the location of the property. **Table 19.1** highlights where guidance can be found.

Table 19.1 Summary of information available across the UK nations

England – Environment Agency
For properties in England, gov.uk shows how long-term local flood risk can be established via an address and postcode search function available. At the time of writing this facility was in a beta testing phase, so there could still be some changes. The map interface allows you to switch between extents of coastal and river flooding, surface water flooding and reservoir flooding risk. The impact of flood hazards is classified as either high, medium, low, or very low. Gov.uk: **https://flood-warning-information.service.gov.uk/long-term-flood-risk** Environment Agency: **https://www.gov.uk/government/organisations/environment-agency**
Wales – Natural Resources Wales (NRW)
For properties in Wales, NRW provides long-term local flood risk through a similar mapping viewer. Surface water flooding is shown a little differently as 'high', 'low', and 'medium' flood extents. River and coastal flooding follow the same approach as that presented for England, and the same probability classification is used. More detailed information of flood depth and velocities is also available via the map interface. NRW (English): **https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en** NRW (Welsh): **https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=cy**
Scotland – Scottish Environment Protection Agency (SEPA)
For properties in Scotland, SEPA provides a flood hazard mapping viewer. Areas prone to flooding are shaded differently according to the source of flooding: river (blue), surface water (purple), coastal (green), and it is possible to display all three simultaneously. However, as previously mentioned these maps do not represent the interaction of two types of flooding happening at the same time. There is also some limited information about where groundwater flooding might be an additional consideration although it not comprehensively mapped. More details on depth and velocities is also accessible via the mapping interface. SEPA: **https://www.sepa.org.uk/environment/water/flooding/flood-maps/** SEPA: **http://www.sepa.org.uk/flooding/** Scottish Fire and Rescue Service (SFRS): **http://www.firescotland.gov.uk/**
Northern Ireland – Department of Infrastructure Rivers (DfI Rivers)
A similar interactive flood hazard map viewer is available for Northern Ireland. These maps show flooding from the sea, rivers and surface water separately, and also highlights 'significant flood risk areas' and areas of historic flooding. An additional feature of the NI approach is that alongside risk maps for the present day, risk maps including predicted climate changes are also provided. General flood management (including some alleviation schemes) is the responsibility of the DfI Rivers. Some flood warning information is available via local news, weather, and traffic bulletins. Traffic Watch NI: **http://trafficwatchni.com/home** DfI Rivers: **https://www.infrastructure-ni.gov.uk/articles/rivers-maintenance-and-flood-management** DfI Rivers: **https://dfi-ni.maps.arcgis.com/apps/webappviewer/index.html?id=fd6c0a01b07840269a50a2f596b3daf6** NI Direct: **https://www.nidirect.gov.uk/articles/flooding** Northern Ireland Water: **https://www.niwater.com/i-have-been-flooded-by-sewage/**

When assessing the flood hazard, there are other sources of information that can be referenced to fully appreciate the hazard to the property. **Table 19.2** identifies potential supplementary information sources.

Table 19.2 Supplementary flood hazard information across the UK nations

Organisation	What do they do?	How can they help?
Local authorities	Each local authority will have its own local and historical information relating to flooding and flood risk which may be presented in local development plans.	Local authorities will have access to the local flood management strategy and how this informs development activity in the area. This information may contain greater detail on 'local' flood hazards and will also recognise future plans for flood defences and resilience measures.
Combined authorities	Combined authorities are created voluntarily. They allow a group of local authorities to pool appropriate responsibility and receive certain delegated functions from central government to deliver transport and economic policy more effectively over a wider area. Examples of combined authorities include Manchester Combined Authority, Liverpool City Region Combined Authority, Tayside etc.	Combined authorities may hold strategic information relating to flood hazards. Strategic flood risk assessments can also be used as a tool to inform the identification of areas most suitable for development and the safeguarding of areas suitable for sustainable flood management. This can support an integrated and holistic approach to the multiple functions of green infrastructure such as open space, flood management, coastal zones, climate change adaptability, river basin, the marine environment and outdoor access.
Water and sewerage companies	Some of the main companies looking after water and sewerage are as follows: • Anglian Water (East of England) • Castle Water (Thames Valley) • Northumbrian Water (North East) • Severn Trent Water (West Midlands and East Midlands) • Southern Water (South East England) • South West Water (South West England) • Thames Water (Greater London and Thames Valley) • United Utilities (North West England) • Wessex Water (South West England) • Yorkshire Water (Yorkshire and the Humber) • Scottish Water • Welsh Water • Northern Ireland Water.	Across the UK utility and water companies are responsible under DG5 'at risk registers' to record the number of properties that have flooded from sewers and are at risk of flooding again. Although this is confidential information, they may be willing to consider sharing it with others such as local authorities.
Historic built environment agencies	Historic England are a public body which manages the historic built environment of England. This includes buildings, infrastructure, and sites of national interest and historic value. Historic England have provided guidance on protecting and repairing historic buildings in relation to flooding. Historic Environment Scotland is the lead public body set up to investigate, care for and promote Scotland's historic environment. Cadw is Wales' historical environment service.	Historic Scotland (2014), Historic England (2015), and Cadw (2019) provide information when identifying flood hazards in older properties, or in areas where older properties are situated.
Infrastructure providers	Organisations such as Highways England, Transport Scotland, Network Rail and the Canals and River Trust could be a source of potentially useful information in relation to flood hazards.	Infrastructure providers may hold detailed risk assessments based on bespoke modelling under their responsibility to assess the risk to critical infrastructure. Other agencies within the Department for Transport include: **https://www.gov.uk/government/organisations/department-for-transport**
Community groups	Community groups exist in many areas across the UK. These groups specifically deal with flooding issues, but equally may have a broader remit in addressing many issues affecting communities and homeowners.	Flood action groups have strong local knowledge of the potential for property level flooding and the history, for example: National Flood Forum (NFF): **https://nationalfloodforum.org.uk/** Scottish Flood Forum (SFF): **https://scottishfloodforum.org/**

Organisation	What do they do?	How can they help?
Media organisations	Provide coverage of local and national flood issues through printed text and online media as well as promotion through social media.	Produce and distribute information through newspapers and/or news articles (local and national). Social media (eg Facebook, twitter) and local community portals.
Property occupiers	Property owners and occupants will have valuable knowledge relating to building operation and condition.	Owners and occupiers of the property can give detailed accounts of any recent flood incidents. Possible additional sources could include newspapers and/or news articles (local and national).

Boxes 19.1 and 19.2 give examples of flood risk assessments using historical information.

Box 19.1 Example of flood risk assessment using historical information from a local authority (from Environment Agency, 2012)

To the best of the owners' knowledge the property has not flooded during their five-year occupancy. Local authority records indicate the surrounding area has flooded once from the beck in December 2008, flooding three local properties. No records of the property flooding were held by the Environment Agency or the local authority.

No previous risk mitigation works have been undertaken by the Environment Agency or local authority for the property or surrounding area.

Box 19.2 Example of flood risk assessment using historical information from Otley, River Wharf, Yorkshire, UK (from JBA, 2016)

Information on the property-specific flood history has been collected through flood questionnaires and discussions with the owners of the property and neighbouring properties.

There have been several flood events in the area, notably in 1883 and 1935, December 1965, January 1975, January 1982, February 1991, January 1995, October 2000, November 2002, and November and December 2015. Flooding in Otley is influenced by a few factors, including the River Wharfe, Kell Beck, Carr Banks Gill, surface water and groundwater. The River Wharfe is known for rising rapidly after heavy rainfall on the moors.

Except for the December 2015 flood event, there have been no reports of internal flooding above floor level in recent times.

During the November 2015 flood event, floodwater from the River Wharfe entered the Cattle Market Field, before flowing across Billams Lane, along Farnley Lane and Back Bridge Avenue before re-joining the River Wharfe downstream of the lido building and the Otley weir. The River Wharfe rose suddenly again in the early hours of 26 December 2015 following heavy rainfall from Storm Eva. River levels in the Wharfe and the Kell Beck began to rise, before exceeding their capacity of their respective channels and flooding the Cattle Market Field. It is reported that the Cattle Market Field flooded by 02.00 am, when the Wharfe had risen to a level of 52.720 mAOD on the River Wharfe's gauging station, immediately downstream of the Otley bridge. Several residents have reported receiving flood warnings from the Environment Agency at this time.

The moat along Bridge Avenue was able to convey floodwater from the Cattle Market Field back into River Wharfe, downstream of the Otley Weir. However, as the level of the Wharfe continued to rise through the morning, the moat was unable to drain sufficient floodwater from the Cattle Market Field, resulting in water flowing out through the four openings in the Billams Hill wall and down Farnley Lane and Back Bridge Avenue. It has been reported that by 09.00 am, properties along both Farnley Lane and Bridge Avenue were surrounded by Floodwater. By 11.45 am, the entire Wharfmeadows Park, between Otley Bridge and the lido building was submerged by the River Wharfe flowing over the landing stage. Homeowners have reported that the level of flooding remained relatively stable between 11.30 am and 1.30 pm, before a second surge saw water levels rise by about 300 mm between 01.00 pm and 01.45 pm.

A peak level of 2.016 m (equivalent to 53.246 mAOD) was recorded on the Wharfe's gauging station, immediately downstream of Otley Bridge, at 3.15 pm. Flood levels then began to recede from about 5.30 pm.

In addition to floodwater from the River Wharfe and the Kell Beck, many residents confirmed that groundwater also contributed to the flooding, with water rising between the floors.

Further reading

ENVIRONMENT AGENCY and LOCAL GOVERNMENT ASSOCIATION (2011) *Flooding from groundwater. Practical advice to help you reduce the impact of flooding from groundwater,* Environment Agency, Bristol, UK
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297421/flho0911bugi-e-e.pdf

MAY, P, EMONSON, P, O'HARE, P, COBBING, P, CONNELLY, A, LAWSON, N and BURCHARD, H (2015) *Surveying individual properties for flood resilience – technical guidance for local authorities and other scheme promoters,* FD 2681, Department for the Environment, Food and Rural Affairs, London, UK

THURSTON, N, FINLINSON, B, BREAKSPEAR, R, KIDD, B, GLERUM, J, LAMOND, J, PROVERBS, D and DHONAU, M (2010) *Defra/EA Flood and Coastal Erosion Policy. Availability and uses of property level flood risk data and information, Technical Report FD2637/TR. Final report,* Department for the Environment and Rural Affairs, London, UK

20 Sources of flooding

Sources of flooding can be described as follows.

Coastal flooding

In coastal regions, flooding can happen from both the sea up to, and even further, upstream of the tidal limit of the rivers that empty into it. This typically happens during storms, and tidal levels increase to above average and/or normal levels. Storms are characterised by low atmospheric pressure, which means that around the storm the air pressure is lower, causing sea level to rise much higher than normal. Storms can also generate higher than usual waves due to strong winds acting over a long distance across a body of water like the sea. The combination can lead to 'storm surges', meaning waves and water levels which are much higher than usual. If this happens on top of already high tides, an extreme event can occur which overtops coastal defences.

River flooding

When there is more water coming into the river channel than can be carried within its banks, it is known as 'fluvial' flooding. This can occur due to high intensity rainfall events, seasonal weather effects, urbanisation, and changes within the river system.

Areas near to rivers are often designated as floodplains and have requirements within the planning system to address potential flooding. Where floodplains have become completely transformed into urban environments, it can be difficult to recognise a location is in a floodplain.

Surface water flooding

In recent years, surface water flooding has had an increasing impact. This has little to do with either rivers or the sea. Storms can be very intense, meaning a very high volume of rain falls within a short period of time. While very intense storms have always occurred, many studies show that they are becoming more frequent and intense because of climate change.

During these storms water will naturally flow over the surface to the lowest point, entering the underground network via gullies and other drainage infrastructure. The UK's drainage network, especially underground pipes, has limited capacity which is exceeded in very intense storms.

In addition, gullies, culverts, and drains can be blocked by vegetation and other matter, meaning they fill quickly, and water starts to back-up.

Buildings in flatter urban areas or those in slight depressions can be rapidly flooded as a result. This is termed 'pluvial' flooding, where the ground cannot take excessive volumes or rainwater, or surface water and/or the urban drainage systems are overwhelmed (see Sewer flooding).

Sewer flooding

This type of flooding often happens at the same time as surface water flooding. In more recently developed areas surface water drainage and foul (sewer) drainage are usually carried in separate pipes. In older areas, there is often a single pipe system which conveys water to the local water treatment works. During flood events, these sewers can rapidly fill and start spilling ('surcharging'). This may be onto the street through a manhole or rising through toilets and plug holes in homes and businesses. This form of flooding can be particularly hazardous to health, as the bacterial contamination in sewerage can combine with floodwater contaminated with fuels or chemicals.

Areas that could be affected by sewer flooding may not be anywhere near a river or the coast. Consequently, the ability to assess surface drainage, and what might happen during an intense storm, or if there are blockages in the drainage system, is important in understanding the overall flood risk to a site. Surface water flood risk maps can be extremely helpful in initially identifying areas at potential risks.

Groundwater flooding

In most areas, at some distance below the surface (ranging from a few metres to over a hundred), there is a 'water table' below which the soil or rock is completely saturated. As rain passes into the soil it percolates downward to enter this saturated zone. In areas where the water table is close to the surface, it does not take much rain for the groundwater level to rise upwards and come out at the surface, leading to flooding. When very wet conditions occur for an extended period (such as during the winter of 2013–2014) groundwater flooding can appear in unusual areas with water rising directly upwards from the ground. Typically, the first thing that might be noticed in these cases is a flooded basement.

In some parts of the country there are permeable rock formations known as aquifers. When there is prolonged rainfall on these, the water can escape and feed streams, most commonly in areas where the bedrock is chalk or limestone. Flooding can then occur if these streams overflow – both sometime after and some distance from where the rainfall originally fell. Groundwater flooding is a particular challenge because it can last for prolonged periods. It can also happen in locations with sand and gravel in the river valleys.

The British Geological Survey (BGS, 2020) has developed maps of susceptibility to groundwater flooding for the whole of the UK on a 50 m x 50 m grid. These maps indicate three classes of groundwater flooding:

- Class A: limited potential for groundwater flooding to occur.
- Class B: potential for groundwater flooding of property situated below ground level.
- Class C: potential for groundwater flooding to occur at the surface.

There is a charge for obtaining this data, and it can also be obtained via home buyers reports.

Go to: **http://www.bgs.ac.uk/research/groundwater/datainfo/GFSD.html**

Compound flooding

Flooding can be a combination of one or more of all these types of floods. For example, it is not unusual for surface water flooding and sewer flooding to occur together. Because sewer flooding may have occurred anywhere upslope of an area of surface water flooding, it is always safest to assume that the floodwater has been contaminated with sewage.

It is possible for some locations near a river to be affected by river, surface water and groundwater flooding all at the same time. Being able to assess risk from all of these sources is vital.

Infrastructure failure flooding

Flooding can also happen for many other reasons. For example, accidental damage to a mains water pipe could lead to localised flooding. While this can still cause major damage and disruption, it is usually contained to a limited area. Water companies will respond quickly, so it can be stopped more easily than other types of flooding.

Flooding might also occur if an upstream dam burst. This is known as reservoir flooding. This is relatively rare in the UK and there is extensive legislation to ensure inspection and maintenance of significant dams. Knowing whether a location is at risk from reservoir failure should still be a part of the overall risk assessment for a site.

21 Property survey

21.1 MEASUREMENTS DURING THE PROPERTY SURVEY

The measurements the surveyor will take are intended to allow PFR to be designed and specified. It is important to note that these are not installation measurements, which should be undertaken by an installer through a works inspection.

The surveyor should consider any flood resistance and recoverability measures that are already included within the building.

The PFR survey should consider all structures on the property and the whole of each building, all floors, and rooms. The exterior of the building, and each relevant element of the building should be measured individually. The interior layout and elements should be assessed, the position of service entries into the building and the location of electrical services, boilers, heating, and water services should be established.

The measurements help a surveyor determine the perimeter of the building likely to be exposed to floodwater. This informs an understanding of the potential for floodwater to enter through the building fabric, elements, services, and the damage that may be caused to those elements. It would also allow an estimate of flood-resilient repair costs to be made, which will require the areas of flooring and ceiling heights to be determined. The length of boundary walls around the property, retaining walls, presence of drainage and permeable paving should also be considered.

The surveyor should carry out the survey on every level of the property, floor by floor, around the external wall, the outer surface. If it is a semi-detached property, then consider half the party wall thickness. Including voids and cavities.

The full length of the perimeter is the gross measurement, and the internal areas would be measured wall to wall and above the skirting board so the full area within the property is known and understood.

Service entries should also be noted and the service entry height above the ground and the location on the wall should be recorded on sketches and drawings. Where the property has a split-level storey or building height difference this should be noted. Split-level properties will often be located where the ground is sloping.

The surveyor should consider and record the surrounding area within the community, particularly where community measures or barriers would be suitable or are already installed. This may include SuDS within a community, temporary or demountable flood barriers, and the presence of organised flood groups who would help individual property owners to manage in a flood.

21.2 BUILDING SERVICES

21.2.1 Electrical

The surveyor should note the location of appliances services, meters, fuse boxes and sockets. If the meters have been left at low level, they could be submerged by the floodwaters causing damage and the need for repair. It may be necessary to cut off the power supply during and after a flood. Services located at higher level will inevitably provide more resilience, reducing the damage and repair needs.

Electrical services typically involve the wiring as well as fittings such as electrical switches, sockets, meters, and light fittings. The location of the electrical fittings determines, to a large extent, the resilience of these services, as they are often easily damaged by water. Understanding the location, type, and condition of the wiring, by survey or if the owner has an electrical wiring diagram for the property, is important. The location and height on the ground floor walls of switches and sockets needs to be established. The wiring location and any runs in floor voids, basements, behind plasterboard, back-up power supplies, generators, below-ground services and meter locations needs to be established.

A resilient approach to electrical wiring would be to run electrical cabling from the ceiling and locate the electrical sockets at a higher level. This can be done in kitchens above worktops but may have more of a visual impact in sitting rooms than in kitchens or offices. Electrical sockets for wall mounted TVs and other electrical items may be placed at a higher level without an unacceptable visual impact.

21.2.2 Gas

Part of the property survey should include an inspection of gas appliances and services. All gas appliances in a property need to be safety checked by a Gas Safe registered engineer annually and serviced according to manufacturer's instructions. Checks on gas appliances should be made after flooding. The gas pipework should be inspected at the same time as having a gas safety check after a flood. This is particularly important when changes to the gas services are proposed as part of a resilient/resistant strategy and/or repair.

Gas services and other fuels will normally be supplied at ground floor level and then distributed throughout the property. The condition and location of service pipes should be established, as well as the sealing of entry points.

Flues, chimneys, and air vents play an important role in the safe operation of gas appliances, allowing products of combustion to escape and ensuring a high level of ventilation. Presence and location of existing vents should be noted. These items should never be permanently blocked up, as it could result in a build-up of carbon monoxide inside the home. If there are any vents at low level (less than 600 mm height in a wall) then particular attention needs to be given to how resistance could work in this case and to the need to properly vent during and following flooding before appliances and systems are used.

Property owners with a shared flue or chimney will need to share responsibility with others to ensure they are checked annually. This is because it is possible for carbon monoxide to enter properties through shared vents.

21.2.3 Water and drainage

Water services typically involve both freshwater supply and removal of wastewater to the sewage system. The service entry points in existing buildings will be at ground floor level, with the services running throughout the property. The condition of service pipes and the sealing of entry points needs to be established during the survey.

To prevent floodwater flowing back into a property a suitable mechanism, for example a non-return valve (NRV) or an appropriate pump on any pipework that removes wastewater from the property, should be used. The pipework should be fitted with a non-return value at each outlet to a drainage system.

If the property uses non-standard drainage (eg septic tanks) then an appropriate approach to establishing the features of the system should be undertaken by the surveyor.

21.3 ENGAGEMENT WITH END USER

During the PFR survey it is important to engage with end users of the products and systems being surveyed. For example, some flood resistance equipment can require physical strength and/or manual dexterity to deploy correctly, so the residents'/occupiers' abilities in these respects need to be taken into consideration. Other equipment may require storage between flooding which may not be available.

The end user should also be invited to view and approve samples of materials and fittings before a flood event (sometimes through a community surgery or flood fair) and given the chance to understand their available choices and the limitations of measures. Users will also have an individual perspective on their toleration of residual risk and willingness to pay to reduce future flood damage or to use the opportunity of recoverable measures to upgrade their fixtures and fittings. The requirements of the scheme with regards to insurability and understanding of roles and responsibilities may also involve wider engagement.

When engaging with homeowners or business owners who have already experienced flooding, it should be noted that, in some cases, long-term health issues can result from their experiences, including depression, anxiety and PTSD (formerly termed 'shell-shock') (Waite *et al*, 2017). It is important to be aware that any discussion of a previous flood event may arouse strong emotional responses, which should be handled with a high level of tact and understanding.

Finally, it should be remembered that for each home or business concerned, the PFR process is a new and unfamiliar situation. Avoid acronyms (including the term PFR) and technical jargon (except where this is accompanied by a clear explanation) when discussing their needs and requirements to make it a less daunting experience for them.

21.4 SITE GROUND CONDITIONS

It is essential surveyors and end users understand the risks from water moving through the soil in flood conditions and rising from under the property. The ground conditions at existing properties are difficult to determine in the absence of existing good records. The existing building and other structures such as walls and hard standing may make it difficult to assess the ground if they restrict the potential to do site investigations.

Trial pits can also be used for the infiltration tests described in Garvin (2016). The method of determination should give representative results for the site and should be proportionate to reflect the scale of PFR works being considered. This is achieved by:

- excavating a trial pit of sufficient size
- filling the pit several times with water in quick succession while monitoring the rate of seepage
- examining site data to ensure that variations in soil conditions, areas of filled land, preferential underground seepage routes, variations in the level of groundwater, and any geotechnical and geological factors likely to affect the long-term percolation and stability of the area have been assessed
- local building control and/or planning authorities may be able to advise where fluctuations in groundwater level may be an issue.

21.4.1 Hydrostatic actions

The main flood action that is likely to cause damage to properties is from hydrostatic forces acting on the external fabric of a building. Hydrostatic pressure does not include flowing water or wave actions (**Section 21.4.2**) but the load from the water without waves can still be significant.

Two forms of hydrostatic action exist, lateral pressure and capillary rise. Lateral pressure is the pressure that water exerts in a horizontal direction. Capillary rise occurs when water is forced up above the water table and is commonly seen in porous materials. However, the damage caused by other factors often outweighs this issue.

The amount of lateral pressure exerted depends on the specific flood situation and the building component being considered. Issues can arise when the forces are unequal either side of a component, such as a window or wall, whether the water level is greater on the outside or inside, the same pressure difference is imparted to the building component.

In most flood situations water levels are higher outside the wall, with either no water, or a much lower water level inside the property. This is most likely to occur after the fitting of resistance measures. The opposite occurs in groundwater flooding, where water may rise within the property, exerting pressure from inside to outside. After any flood recedes, there is also the possibility of water being retained inside a building, also exerting internal pressure. As walls are not typically designed to withstand hydrostatic pressure, resistance approaches to PFR (ie keeping water out) should be restricted to depths suitable to the particular form of construction. Subject to review by a qualified building surveyor, a resistance approach may be appropriate above this depth. Where there is concern over the performance of the walls to that depth, a structural engineer should be engaged.

21.4.2 Hydrodynamic actions

Different forms of hydrodynamic actions exist, including those from water flow velocity (including turbulence) and from breaking waves.

Hydrodynamic actions can be significant, eg fast flowing water from rivers, runoff or water running downhill, or sudden failure or overtopping of man-made structures. In such cases, resistance measures should be restricted to no more than 300 mm depth of flooding. The property should be assessed by a structural engineer if its ability to withstand pressures from a greater height of resistance is to be estimated. Hydrodynamic actions are also likely to result in erosion, debris impact and other structurally compromising impacts.

21.4.3 Impact of voids and cavities

Voids and cavities could have an impact on the property's ability to withstand the effects of floodwater. They also need careful consideration during drying after any flooding. Cavities and voids are often used to provide ventilation to the building envelope and are not often sealed. Consequently, cavities and voids could act as a route of water entry and affect the structural stability of the property.

As part of the property survey, the presence of cavities and voids within the property should be identified and potential associated risks assessed. Any filling or partial filling by insulation or other materials should be recorded including the resilience of the filling material, remaining air gaps and presence or absence and height of ties across cavities should be noted.

Voids can form a link between attached properties and underfloor voids may extend some way beyond the perimeter of a building and have entry vents outside the perimeter. Careful measurement of voids and tracing of external access points is required to understand their role in flood resilience.

21.4.4 Flood factors to consider

Some of the flood factors that should be considered when surveying the property are described in **Table 21.1**. These may impact the existing resilience of construction and proposed PFR measures.

Table 21.1 Flood factors (from Kelman and Spence, 2004)

Flood action	Description
Erosion	Moving water may cause erosion by scouring away soil along the flow path, undercutting the building's sides, or undermining foundations or floor slabs. Water moving through soil may physically move the soil particles, due to seepage action during infiltration.
Buoyancy	The buoyancy force is linked to the submerged volume of the building. The resulting uplift can result in the building, or parts of it, floating. This can then cause damage, destabilisation, or complete destruction. Buoyancy can cause lighter structures such as timber sheds or fallen trees to move. This adds to other waterborne debris, pipes, or water storage tanks, and contaminants such as fuel.
Debris	There are three types of debris action: • static action includes additional forces on walls exerted by sediment deposited by floodwater • dynamic action occurs when debris moved by water, such as trees or cars, collide with the outside of a building. Internal impacts can also occur if floating furniture hits ceilings, internal walls, or windows • erosion caused by debris if objects carried by the flow gouge out soil from around a building.
Non-physical	Non-physical flood actions would include chemical actions (eg corrosion), or biological actions, such as damage arising from moulds or fungi. Some overlap exists between physical flood actions and non-physical flood actions.

21.4.5 Structural integrity and resilience

Full structural assessment by an appropriate person in relation to flood damage actions should be undertaken if the potential hazard severity includes high hydrostatic or hydrodynamic pressures, erosion, or buoyancy risk. As the flood actions in the third category would have highly localised effects, prediction of their impact on overall flood damage would be extremely challenging.

To assess the potential risks to the structure from flooding it is necessary to consider flood actions which could cause damage or failure of a building or its components (Kelman and Spence, 2004). This goes further than the traditional approach of analysing flood damage to buildings from 'slow-rise' flood depth alone (large hydrostatic pressure differentials between the inside and outside of a building do not occur in this type of flooding).

Flood actions can take the form of energy transfers, forces, pressures, or the consequences of contact with the water itself or contaminants within it. The construction materials used, and their condition, will also affect the structural performance of the property.

For flood damage assessment purposes, flood action types fall into the following three categories:

1 **Highly relevant and relatively predictable:** hydrostatic pressure from different water depths either side of walls, hydrodynamic pressure, which depends on the velocity of the flood flow, and water contact due to slow-rise depth.
2 **Variable relevance and relatively predictable:** buoyancy issues.
3 **Variable relevance and low predictability:** capillary rise, erosion, debris impacts, and velocity actions and non-physical issues such as corrosion.

21.4.6 Long-term impacts of floodwater

Consideration should be made for the long-term effects of floodwater on the receptor(s). The long-term durability of both the property, its materials, fixtures and fittings, and the ability of the building occupant(s) to withstand longer periods of disruption, should also be considered at this stage. This information may need to be considered when selecting suitable PFR approaches in Stage 3.

If the duration of flooding is likely to be extended, it is important to use this information to support the design of suitable PFR measures as a part of Stage 3 options development. By understanding the effect of long-term flooding, the designer will be able to determine the suitability of the proposed materials and measures. This will also be relevant if there is frequent occurrence of flooding, as it may affect the long-term damage to building fabric and the options development, and the choice of materials used in Stage 3.

21.4.7 Record pre-existing PFR measures

When conducting the survey of the property, existing PFR measures should be recorded by the surveyor and incorporated in the summary report. This should include the condition of the PFR measures, particularly if they appear damaged or function improperly. This will help to inform the options development and design (PFR Stage 3) later in the process.

21.4.8 Drying and decontamination

If a property has previously been affected by water damage, it is important it is dried and decontaminated at an appropriate level before any further work is undertaken. Any areas that appear to have been affected by water damage should be assessed using a moisture meter. If this test indicates a high moisture level, then the area should be dried and decontaminated in accordance with good practice guidance.

Appendix A4 provides detailed information.

21.4.9 Site investigation and sampling

If further information is required to verify the site ground conditions, site sampling may be an option. This could be conducted using a trial pit to determine the exact ground conditions at the site.

In new developments, site investigation and testing of the ground should be carried out before design or construction work taking place. For most new developments ground condition reports will need to be produced for planning and building control purposes. Assessment should be made of the ground conditions to determine if there is a risk of groundwater flooding (see also the flood hazard assessment in PFR Stage 1, **Chapter 12**). In addition, the potential for water to transfer from the surface to the ground and then into the property via under floor voids and flooring should be considered.

The ground conditions at existing properties could be more difficult to determine in the absence of existing good records. The existing building and other structures such as walls and hard standing will make it more difficult to assess the ground as it will restrict the potential to do site investigations.

There is no accepted standard for assessing ground conditions around a property in relation to flood risk and resilience. It is important to consider the assessment of the ground conditions in relation to PFR and the desired outcome of the site assessment.

21.5 POINTS OF WATER INGRESS INTO A PROPERTY

The potential points of water ingress into a property are described in **Table 21.2**.

Table 21.2 Points of water entry into a building

From the outside of the building to the inside		
Water ingress point	***Description***	***Risk factors***
Masonry walls – units (bricks, blocks, and stone) and mortar	Water will transfer slowly through a well-built masonry wall, whether solid or cavity construction. External renders and coatings that are in good condition can slow the passage of moisture transport. The water transport mechanism depends on the extent of saturation, with suction/capillary attraction dominating for drier walls. The interface between the masonry unit and the mortar joint can contain micro-cracks that water can leak through and be in contact with insulation materials. Materials within cavities can then form either a bridge or a barrier to water penetration to the other leaf.	• High absorption masonry units. • Cracks and flaws in external walls. • Cracked, poorly adhered or missing render. • Poorly constructed masonry with unfilled perpend and bed joints. • Gaps between the mortar and masonry. • Older properties without adequate maintenance and repointing.

From the outside of the building to the inside		
Water ingress point	***Description***	***Risk factors***
Timber frame walls	Water is likely to transfer through the external skin of a timber frame wall (assuming it is masonry or render) Well-detailed render and coatings can slow the transfer of water into the cavity Once water enters the cavity it can penetrate the external membrane, sheathing and meet the insulation and plasterboard.	• Cracks and flaws in external walls. • Cracked, poorly adhered or missing render.
Vents and air bricks in the wall	These are vents that open into either living spaces or underfloor voids.	• Low-level vents may need to be addressed for resistance approaches. • Modern buildings generally have higher numbers of air bricks than older properties.
Through or around windows and doors, including the lower threshold	Through window gaskets and sealants around glazing units, and through opening window sashes. Through door gaskets between the leaf and the frame. Gaps and cracks in the junction of the frames and walls. Any entry points within the door (eg cat flaps, keyholes, letterboxes).	• Older windows and doors. • Poor quality hardware. • Single glazing. • Deteriorated or damaged frames. • Worn seals and gaskets. • Level access doors (thresholds and windows at low level), non-habitable spaces and shutter doors.
Service entries through walls (including weepholes)	Wall outlets and voids for services such as pipes for water and gas, ventilation for heating systems, dryer vents, cables for electricity and ICT lines if left unsealed will allow leakage into occupied space	• Address any relevant service entry if a resistance approach is being used. • Unsealed or poorly sealed service entries. • Use of the wrong sealing material.
High water table penetration	Water entering underfloor void spaces from outside then rising through the ground floor. Groundwater flooding may rise under floor and could enter through basements, at joints or along service penetrations.	• Entry via masonry and mortar walls, especially if in poor condition and vents and air bricks allowing water to enter voids. • Through a damp-proof course, where the lap between the wall damp-proof course and floor membrane is inadequate. • Closed-cell insulation in floors can be affected by buoyancy and floors can lift causing structural damage. • For solid floors groundwater pressure can cause failure of the concrete slab and screed.
Backflow through flooded drainage systems	Any water drainage service that removes foul water from the building has the potential to back up during flood events. Water will enter through sanitary appliances (particularly WCs, baths, and showers).	• Most drainage services in basements, ground floors and first floors potentially at risk. • Drainage systems without NRVs fitted.
Via adjoining buildings		
Party walls of attached properties	In situations where the property next door is flooded water can enter via the party wall.	• High absorption masonry units. • Cracks and flaws in party walls. • Poorly constructed masonry with unfilled perpend and bed joints. • Non-habitable attached spaces less likely to be sealed
Underfloor voids	Where the ground floor is suspended and has an underfloor void, water can transfer between voids.	• Ventilation holes in adjoining walls. • Cracks and flaws in adjoining walls. • Poorly constructed masonry with unfilled perpend and bed joints. • Gaps between the mortar and masonry.

21.6 COST FACTORS IN PFR

Where a building has been flooded and needs extensive repair, the additional costs of some measures can be considerably lower than retrofitting if the element is being replaced as part of the repair. In this situation, the cost of the measure is the difference between a resilient repair and a like-for-like replacement. This can also be the case when other repair or maintenance work is being carried out on a property. For example, in instances where electrical wiring and sockets are being replaced, the additional cost in locating sockets higher above the finished floor level is likely to be small. Including PFR in new developments has minimal impact on the overall cost (**Section 3.3.4**).

For some low-cost recoverability measures this can make the measures cost neutral. These measures typically involve the application of widely available construction materials applied in a different way or in a different place to their normal situation. These include, for example:

- standard wallboards applied horizontally
- water-resistant bathroom wallboards applied everywhere
- stone or ceramic tiles
- membranes typically used for basement tanking
- waterproofing technology designed to prevent rain penetration.

Bespoke materials and approaches, such as acrylic kitchen units, stainless steel, or waterproof wallboards, would not generally fall within the definition of low cost but would still be cheaper during repair.

The cost–benefit appraisal of suitable PFR approaches should include maintenance costs (**Sections 14.3** and **14.5**) and consideration of both intangible benefits and drawbacks. For example, insurers have generally expressed a preference for automatic or passive resistance measures rather than those requiring human intervention. Automatic measures should operate even when there is nobody present to deploy measures. They will be more useful when flood warnings are not available for a specific area, or for surface water flooding.

The cost effectiveness of PFR should not be the only consideration in determining the approach but proportionality (**Section 13.1**) of the identified risk, costs, and expected levels of resilience is important. In some cases, the availability of funding might limit choice. In preparing the PFR plan the appropriate person should always take account of the needs and choice of the user (**Section 13.3**). Issues such as a lack of willingness to accept floodwater into a property might favour a resistance approach (**Section 14.3.1**). However, if the likely depth of floodwater is such that resistance would not work, then the inclusion of recoverability measures (**Section 14.3.2**) becomes more critical.

Further reading

KELMAN, I (2002) *Physical flood vulnerability of residential properties in coastal, eastern England,* PhD thesis, University of Cambridge, Cambridge, UK

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22 Contract management

22.1 ROLES AND RESPONSIBILITIES

There are specific roles and responsibilities associated with the options development and design process which may vary depending on, for example, whether the property is a domestic, or a non-domestic property. Further information on the factors are described in the following sections and guidance in HSE (2015a). Approaches to procurement of PFR and forms of contract are presented in **Section 3.4.1**.

22.2 DOMESTIC CLIENTS

A domestic client is any individual who has construction work carried out on their home, or the home of a family member, which is not as part of any business. While CDM 2015 places client duties on commercial clients in full, such duties for domestic clients normally pass to:

- **The contractor.** If it is a single contractor project, who shall take on the legal duties of the client in addition to their own as contractor. In practice, this should involve little more than what they normally do in managing health and safety risks.
- **The principal contractor.** For projects with more than one contractor, who shall take on the legal duties of the client in addition to their own as principal contractor. If the domestic client has not appointed a principal contractor, the client duties should be carried out by the contractor in control of the construction work.

If a domestic client has appointed an appropriate person (eg architect, surveyor or other designer) on a project involving more than one contractor, they can ask them to manage the project and take on the client duties instead of the principal contractor. The designer then assumes the responsibilities of principal designer and should have a written agreement with the domestic client, confirming they have agreed (as principal designer) to take on the client duties as well as their own responsibilities.

Any designer in charge of co-ordinating and managing a project is assumed to be the principal designer. However, if they do not have a written agreement with the domestic client to confirm they are taking on the client duties, those duties automatically pass to the principal contractor.

Appendix A2 provides a summary of duties under CDM 2015.

22.3 NON-DOMESTIC CLIENTS

A non-domestic (or commercial) client is any individual or organisation that carries out a construction project as part of a business or other non-domestic activity (eg a school).

These clients have a crucial influence on how projects are run, including the management of health and safety risks. Whatever the project size, the commercial client has contractual control, appoints designers and contractors, and determines the money, time, and other resources for the project.

For all projects, commercial clients should:

- Make suitable arrangements for managing their project, enabling those carrying it out to manage health and safety risks in a proportionate way. These arrangements include:
  - making sure that any principal designer and principal contractor appointed carry out their duties in managing the project
  - appointing the contractors and designers to the project (including the principal designer and principal contractor on projects involving more than one contractor) while making sure they have the skills, knowledge, experience, and organisational capability

   - allowing sufficient time and resources for each stage of the project
   - making sure suitable welfare facilities are provided for the duration of the construction work.
- Maintain and review the management arrangements for the duration of the project.
- Provide pre-construction information to every designer and contractor either bidding for the work or already appointed to the project.
- Ensure that the principal contractor or contractor (for single contractor projects) prepares a construction phase plan before that phase begins.
- Ensure that the principal designer prepares a health and safety file for the project which is revised as necessary and made available to anyone who needs it for subsequent work at the site.

For notifiable projects (where planned construction work will last longer than 30 working days and involves more than 20 workers at any one time, or where the work exceeds 500 individual worker days), commercial clients shall:

- notify the HSE in writing with details of the project
- ensure a copy of the notification is displayed in the construction site office.

22.4 SELECTING AN APPROPRIATE CONTRACTOR

Following the CDM 2015, a principal contractor is appointed by the client to control the construction phase of any project involving more than one contractor. The following sections draws on the guidance provided by HSE (2015c).

22.4.1 Principal contractor

Principal contractors have an important role in managing health and safety risks during the construction phase. They should have the skills, knowledge, experience, insurance cover and, where relevant, organisational capability to carry out this work.

The principal contractor should:

- plan, manage, monitor and co-ordinate the entire construction phase
- take account of the health and safety risks to everyone affected by the work (including members of the public), in planning and managing the measures needed to control them
- liaise with the client and principal designer for the duration of the project to ensure that all risks are effectively managed
- prepare a written construction phase plan before the construction phase begins, implement the plan, and then regularly review and revise it to make sure it remains fit for purpose
- have arrangements in place for managing health and safety throughout the construction phase
- consult and engage with workers about their health, safety, and welfare
- ensure suitable welfare facilities are provided from the start and maintained throughout the construction phase
- check that anyone they appoint has the skills, knowledge, experience and, where relevant, the organisational capability to carry out their work safely and without risk to health
- ensure all workers have site-specific inductions, and any further information and training they need
- take steps to prevent unauthorised access to the site
- liaise with the principal designer to share any information relevant to the planning, management, monitoring and co-ordination of the pre-construction phase.

When working for a domestic client, the principal contractor will normally take on the client duties as well as their own as principal contractor. If a domestic client does not appoint a principal contractor, the role of the principal contractor shall be carried out by the contractor in control of the construction phase. Alternatively, the domestic client can ask the principal designer to take on the client duties (although this should be confirmed in a written agreement) and the principal contractor should work to them as ‘client’ under CDM 2015.

22.5 CONTRACTORS

A contractor is anyone who directly employs or engages construction workers or manages construction work. Contractors include subcontractors, any individual self-employed worker or business that carries out, manages, or controls construction work. They shall have the skills, knowledge, experience, insurance cover and, where relevant, the organisational capability to carry out the work safely and without risk to health.

Contractors and the workers under their control are most at risk of injury and ill health from construction work. Contractors have an important role in planning, managing, and monitoring their work to ensure any risks are controlled.

Contractors on all projects should:

- make sure the client is aware of the client duties under CDM 2015 before any work starts
- plan, manage and monitor all work carried out by themselves and their workers, considering the risks to anyone who might be affected by it (including members of the public) and the measures needed to protect them
- check that all workers they employ or appoint have the skills, knowledge, training, and experience to carry out the work, or are in the process of obtaining them
- make sure that all workers under their control have a suitable, site-specific induction, unless this has already been provided by the principal contractor
- provide appropriate supervision, information, and instructions to workers under their control
- ensure they do not start work on site unless reasonable steps have been taken to prevent unauthorised access
- ensure suitable welfare facilities are provided from the start for workers under their control and maintain them throughout the work.

In addition to these responsibilities, if a project involves more than one contractor, they should:

- co-ordinate their work with all others in project team
- comply with directions given by the principal designer or principal contractor
- comply with parts of the construction phase plan relevant to their work.

Where there is only one contractor working on a project, they should ensure a construction phase plan is drawn up before setting up the site.

When working as the only contractor for a domestic client, the contractor takes on the client duties, as well as their own, and should comply to standard health and safety law.

23 Design and specification of measures

23.1 RECOVERABLE MEASURES

Recoverable measures may be used when it is clear that water entry cannot be reliably prevented. This is sometimes called a water entry strategy. At the extreme, water entry can be necessary due to structural considerations, and defined in Bowker *et al* (2007) as: *"allow water through property to avoid risk of structural damage"*. There are important structural considerations (particularly regarding the effects of depth and velocity of flood flows on the integrity of the building) that will be highlighted by the flood hazard assessment and the property survey which can render it inadvisable to attempt to exclude water.

A water entry strategy may include any or all the following:

- measures to allow easy routes of water ingress and/or to control or limit flow and depth within a property
- recoverable materials and designs
- design to drain water away after flooding (Escarameia *et al*, 2012)
- sacrificial approaches
- consideration of hydrostatic pressures/impact loads on structures (Gabalda *et al*, 2013)
- access to all spaces to allow drying and decontamination.

However, water entry strategy may also be appropriate for other reasons. These include, for example:

- long duration floods where many resistant methods may fail
- flash floods where there may be inadequate time to install barriers and other resistance measures
- historic properties where resistance methods may be unsuitable.

The reason for adopting the strategy, and the associated depth of flooding and duration that is expected, will influence the suitability of some of the recommended measures.

Recoverable measures can also be suitable as part of an 'integrated scheme' which includes some attempts to exclude water, but recognises the limitations of resistance under certain circumstances. In this case, the routes of safe water entry need to be carefully planned once a flood has reached a given depth. The methods for allowing water out of the property once the flood has subsided are also critical, such as pumps.

Finally, if recoverable measures are included as a 'failsafe' it is important to explore the ways in which measures are most likely to fail (eg non-deployment when occupants absent) to establish the most appropriate measures to take and their cost effectiveness.

As in all PFR design solutions, it is also important to consider the points at which water will be allowed to enter a property and what means of escape will remain available to the building's occupants as a result of these choices. The impacts upon the security of building contents during and after a flood should be assessed (for example, leaving doors open to permit through-flow during the flood event and windows ajar to aid the drying-out process could lead to unauthorised persons accessing the contents). The assessment of the potential for such 'secondary damages', together with security and safety concerns, are considered to be part of the normal professional reinstatement process as outlined in the relevant standard (PAS 64-2013).

The specification of PFR measures is covered in Stage 3 (**Section 14.8**).

23.2 SPECIFICATION OF RECOVERABLE ELEMENTS AND MATERIALS

23.2.1 Specification of plaster

The specification for a plaster finish should include recommendations for a base layer and a finishing layer. Any special additives (eg water-resistant additives or salt resistant additives) should be clearly identified. If an airgap is required (eg where plaster is to be laid over a metal mesh) then the depth and height of the gap and any required jointing needs to be detailed.

Plastering should conform to the CoP for plasterwork (currently BS EN 13914-2:2005) and further advice is available in Harrison and de Vekey (1998) bonding coats and agents. The CoP for workmanship is BS 8000-0:2014. and for rendering mortar is BS EN 998-1:2016. Information on lime mortars is available in Allen (2003).

BS 8102:2009 provides guidance for plastering over membranes and drainage of membranes and the manufacturer's instructions for such products should be adhered to. For metal laths the relevant standards are BS EN 13658-1:2005 and BS EN 13658-2:2005. For external render, the standard is BS EN 13914-1:2016.

23.2.2 Specification of wallboard/plasterboard

There are many alternative boards that can be applied to internal walls, or on internal surfaces of external walls. These range from standard gypsum, through 'moisture resistant' and 'water resistant' to fully waterproof boards. The specification should state a minimum requirement that meets the performance criteria set out in the design. Water-resistant plasterboard can generally withstand short-term exposure (up to three days) but gypsum products (even if strengthened) are not recommended for areas subject to prolonged flooding. They may also be unsuitable for areas expected to be exposed to contamination.

Alternative waterproof boards are available, including cement based and magnesium oxide fully waterproof boards. These are designed for use in wet areas, such as shower backing or fire prevention. It is generally accepted (but not tested) they will perform well in longer floods. When using water-resistant or waterproof boards, the specification should be clear whether they are to be bonded to adjacent materials or require an air gap to prevent trapped moisture. Attention should also be paid to the joints at edges of the walls. Wall mounting should be undertaken using manufacturer's recommendations for preserving the water tightness and no fixtures should be attached through the wallboards.

23.2.3 Specification of insulation materials

Where closed-cell insulation is used, care will be needed to select the appropriate grade of insulation. Some have been shown to be waterproof under flood conditions (ie usually of a grade designed for basement tanking). Caution needs to be taken regarding 'closed-cell' floor insulation materials, as not all of these are suitable for use in a permanently wet environment (such as below the membrane layer in a groundwater flood-risk location). The manufacturer's specifications should be examined carefully to ensure the material under consideration is suitable. Stainless steel wall ties should be specified, as advised by HAPM (1997).

The presence of insulation can, however, slow the drying speed of walls and floors, which may lead to longer repair times and secondary damage including mould growth (Perkes, 2011, Escarameia *et al*, 2007). Some specified insulation material, such as rigid fibre boards, will absorb water and so will often need to be removed for drying in the aftermath of a flood.

Consideration should be given to methods of removing and drying insulation in cavities and in floors, where necessary, without undue damage to the surrounding construction. External mounting may be preferred. For more water-resistant types, consideration can be given to provision of appropriate air gaps and air flow (for blown-in closed-cell insulation) or ease of removal. In replacing insulation, or when large sections of uninsulated wall need to be disturbed, an upgrade to comply with current building regulations is likely to be needed.

The end user may prefer to have improved insulation (and even to self-fund or seek grants for a further upgrade) to enjoy the improved thermal and sound insulation benefits.

Manufacturer's recommendations and local building regulations should be complied with and normal condensation and drainage considerations apply.

23.2.4 Specification of timber

Solid timber can be highly resilient to flooding (even quite prolonged flooding) with quick and careful drying and slight restoration. This is highly dependent on the type, quality, and treatment of timber components. In general, slow-grown timber with greater structural density (historic timber) is more recoverable than more modern standard timber products.

Note

Where new timber components are to be used, they should be primed on all surfaces before installation (not just on the faces to be painted) to inhibit mould/rot after subsequent flooding. Any fixings should be stainless steel (rather than ferric), as most timbers are acidic (oak in particular) and corrosion will result (O'Leary, 2014). Recoverable plywood should be compliant with BS 1088:2018.

Hardwood is preferred to softwood and is suitable for locations where swelling and distortion will not be an issue. Special housings (eg for floorboards) can be used to allow for swelling. Engineered wood can be used where hardwood is not suitable. The type of preservative, varnish, or paint treatment to be applied should be made clear and the requirement for vapour permeability in case of wetting should also be set out.

23.2.5 Specification for services

Raising water sensitive services above the likely flood level is a commonly recommended 'avoidance' approach. The specification should take full account of the anticipated flood level and connections should be routed from above where possible. Where plinths or supports are required they should be specified not only to be adequate to support the services but also to survive the flooding. Following the electrical regulations for new builds will achieve a more recoverable system than older wiring.

23.2.6 Other specifications: windows and doors

PVC-U doors should comply with local building regulations for thermal performance and should be sealed to avoid water penetration to the interior. Timber types should have good quality oil-based paints and stains applied in multiple layers and microporous paint systems can be used to allow drying without warping. For further guidance see BS 7956:2000, BS 7664:2000 and Harrison and de Vekey (1998).

23.2.7 Floor screeds

Use cement rich screeds of thicker depth for recoverability. Avoid screeds based on calcium sulphate and use proprietary screeds. Resin (epoxy) based and waterproof screeds for structural waterproofing are increasingly available and should comply with BS EN 1504-2:2004.

24 PFR operation and maintenance

24.1 FLOOD PLANS

In preparation for a flood, it is the responsibility of the property owner to ensure all PFR measures are fully operational and ready for deployment. It is important to identify individual(s) who will lead the preparatory actions and ensure relevant documentation and resources are available to allow for easy deployment of manual products and activities.

The contractor should ensure that all relevant documentation and operational information is provided to the property owner and there are no identified issues relating to the PFR design and construction.

24.2 HOME FLOOD PLANS

An individual flood plan should include a list of items that householders should do before, during and after a flood and should provide space to note down important contact details such as utility companies and insurance details.

Being prepared will make things easier if a home is flooded. Putting together a flood kit grab bag can minimise risks and help in the time following any flooding. The National Flood Forum have a list of suggestions of items to keep in a grab bags:

https://nationalfloodforum.org.uk/about-flooding/preparing/emergency-flood-kit

Personal flood plans should consider:

- moving furniture and electrical items to safety
- putting PFR measures in place
- turning off electricity, water, and gas supplies
- rolling up carpets and rugs
- move sentimental and high-value items to safety
- putting important documents in polythene bags and moving them to safety
- moving cars away from flood risk and to higher ground.

Further details of what personal flood plans should consider, and a checklist template can be found in HM Government (2017) or Flood Guidance (2019).

It is also important to ensure appropriate consideration is given to all the building occupants, and their needs in these plans. The Emergency Planning Society can provide additional guidance and support:

www.the-eps.org/

24.3 COMMUNITY FLOOD PLANS

A community flood plan can form an important part of community emergency plans. Guidance is available from the Environment Agency to help support communities or groups to improve their ability to plan for a flood. Community flood plans may be vital in ensuring that groups of connected properties have their measures deployed appropriately and in collaborative efforts to deploy measures for those in need of help for any reason, including physical absence, different abilities and measures stored separately from the affected property.

https://www.gov.uk/government/publications/community-flood-plan-template

24.4 BUSINESS FLOOD PLANS

By taking actions in advance of flooding, most businesses can save between 20 and 90 per cent on the cost of lost stock and movable equipment, as well as some of the personal issues (eg stress) that goes with such an event.

Taking steps to protect businesses from flooding could:

- significantly reduce financial losses, damage to property and business interruption.
- help compliance with regulatory requirements
- reduce exposure to civil or criminal liability
- enhance a company's image and credibility with employees, customers, suppliers, and the community
- demonstrate moral responsibilities to employees, the community, and the environment
- help to obtain insurance cover.

Key areas to consider in business flood plans are:

- human resources
- maintenance/facilities
- finance and purchasing
- post-event action planning
- post-flood operations
- business continuity.

It is important that flood plans are reviewed regularly. A business should make sure their flood plans are up to date and in the event of a flood that they can be used. The Environment Agency (2015) provides useful information for businesses.

Building tenants and their needs should be considered as appropriate in these plans. The Emergency Planning Society may be able to provide additional guidance and support on this through their website: **www.the-eps.org/**

24.5 OPERATION INSTRUCTIONS FOR PFR MEASURES

Operation instructions should also be available to the person(s) responsible for any deployment. Operation should have been explained or demonstrated to them. The O&M plan should also be available to the occupiers of the premises (where they differ from the owner) so that they are aware of the plan and can take the necessary actions themselves or ensure other responsible persons do so.

If the PFR measures require actions in advance of a flood, the O&M plan should contain an estimate of the time needed and the minimum 'lead time' (ie the gap between receipt of a warning and floodwater entering the building) in which the plan can be effectively put into operation. Any specialised knowledge or skills required for deployment should be made clear and an appropriate individual identified to deploy the measures.

The O&M plan should also consider the health and safety of these responsible persons and ensure there is sufficient time to put measures into operation without risk, as well as safely evacuating the building either in advance of flooding or during a flood (if unavoidable). Routes for exiting the building(s) should be planned. Occupiers should also take reasonable precautions to make the premises safe, such as switching off utilities in accordance with emergency plans and evacuation procedures.

It is also important to consider whether routes of water entry should be cleared. For example, which (if any) doors, windows or other openings should be opened, and how they should be secured.

- Avoidance measures may be passive, ie permanently raised above the expected flood depth and require no operation. Alternatively, there may be a need to move some contents, fixtures, or fittings. A suitable storage space should be determined in advance and appropriate steps taken to avoid secondary damage through their removal, transport, and storage (eg protective sheets in storage areas).

- Measures designed to resist water penetration may also be permanent and require no operation. However, some temporary protective coatings or containers may require deployment after a warning is received. The location of such temporary materials should be detailed in the plan.
- Measures designed to retain integrity and be easily recoverable should require no deployment.
- Sacrificial measures should require no deployment.

After a flood event, the PFR plan should specify immediate actions required to limit secondary damage once it is safe to re-enter the property. Such steps may include the speedy removal of water-logged sacrificial elements and speed drying – provided this does not contravene any contract with any third parties (eg insurer). A plan for cleaning and drying of the building, replacement of removed articles, remedial decoration or repairs should also be provided and the responsibility for carrying out such works should be clear.

- Passive avoidance measures may require little/no post-flood actions (outside from routine maintenance). Items removed in advance of flooding may be replaced as soon as any cleaning and drying has taken place and the humidity has been reduced to a level that will not cause secondary damage.
- Resistant measures may require cleaning, and this can involve the use of chemical or biological decontaminants, depending on the nature of the floodwaters (eg where foul sewage, or spilled fuel is suspected). The source of cleaning materials may be indicated in the plan. Temporary coverings and bags should be left in place until the humidity is reduced to avoid secondary damage.
- Recoverable measures will require cleaning and drying but may also require redecoration. Surfaces and voids should be tested for contaminants after drying is complete. Chemical and biological decontaminants or heat treatment may be used. If materials cannot be satisfactorily cleaned due to excess contaminants, they should be removed and disposed in accordance with health and safety guidelines.
- Fast removal of sacrificial elements after a flood will speed up drying and help to avoid any secondary damage, providing this has been approved by any relevant third parties (eg insurer).

The plan for PFR should also include information on how to remove or reinstate any recoverable measure that may be overtopped or become ineffective, such as in a prolonged or highly contaminated flood. It is expected that recoverable measures should not cause extra loss or damage in these events, but there may be special conditions for their removal or repair that should be observed.

24.6 OPERATION OF FLOOD RESISTANCE MEASURES

24.6.1 Aperture flood barrier products

Passive flood barriers (eg certified flood doors) will not require any additional manual intervention if installed correctly. If certified flood doors have been properly maintained, the automatic sealing of this device when closed will ensure it functions correctly. As this is often a normal everyday activity upon leaving or re-entering a property, no further intervention or operation will be required from building occupants or managers. However, where doors may be left open during normal building occupation these will need to be closed as part of the flood plan. Similarly, passive flood-resistant windows will not require any additional manual intervention.

Table 24.1 provides details of a passive flood-resistant door.

Passive measures have benefits over manual barriers as they do not require any deployment in the event of a flood and reduce the requirements for physical strength in their operation. These products may be the preferred option for end users who suffer from physical or cognitive restrictions or disabilities. In addition, individuals who are away from the property regularly or who would not be able to return to the property quickly in the case of an emergency may prefer passive measures.

Manual PFR barriers (eg manual door barriers) will require an individual(s) to ensure they are in place. This should include the placement of any stanchions separating individual barrier panels. The deployment of manual measures will depend on which types of products have been installed on a building.

Some manual barriers will slot in between grooves and fittings on a door aperture. These fittings are often always installed on the door and, in the event of a flood, it is only the barriers that need to be slotted into place to prevent floodwater entering a property.

Other barriers may fit over the top of pre-drilled bolts or fittings that have been embedded in the wall. Additional fitments and bracing of these manual barriers may be available, and guidance should be provided by the manufacturer or supplier on the exact requirements for deploying these products.

Table 24.1 gives examples of these measures.

For the installation and operation of flood barriers, it is important to follow the manufacturer's good practice guidance. Window barriers will function in the same way as door barriers and the exact fitment of these *in situ* will be product dependent. Follow manufacturer's recommendations for product-specific operation requirements.

Aperture barriers will also be needed for any patio doors that are below the designed maximum threshold of flood resistance. These will work in the same way as front and rear flood door protection on the property, whether this is manual or passive.

Aperture barrier protection should also be considered if there is a garage that has been designed to be made resistant to floodwater. The use of stanchions may be required to ensure that the integral strength of any manual flood barriers is not surpassed by the weight of floodwater against them. Stanchions should be installed first, followed by the barriers. Some manual barriers for garage protection can be installed on the inside of garage doors. This increases security as these can be installed discretely, so they are not visible from the outside. They can be a useful method of protecting a garage when leaving a property for a given period of time.

Automatic or passive flood barriers may be available for garage doors. While a passive flood gate will be watertight when occupants close the gate upon entering or leaving the house, automatic systems will close using a power source – often electricity. Any automatic flood gate systems that use electricity, should be supported by a back-up battery system to ensure that the device can function correctly if the local electricity connection is lost.

Depending on the weight and size of the barrier(s) being deployed, several people may be needed to deploy them. If this is the case, but there is often only a single person available, the property owner, occupier or manager is strongly recommended to consider the use of passive measures rather than manual protection.

24.6.2 Other flood barrier products

Temporary flood barriers may also be installed. While these will function in a similar way to manual barriers installed on property apertures, there may be some differences with regards to the exact deployment and operation requirements of these barriers. Temporary flood barriers are often larger scale barriers and consequently can be more difficult to deploy in the event of a flood, due to the requirements for more individuals to be available and physically able to deploy them in the event of a flood.

Building skirt systems can also be deployed to protect a property in the event of a flood. Skirt systems will consist of a rising waterproof material and supporting framework which are, in most cases, manually operated. The operator will be required to lift the building skirt system to the designed flood level, to ensure that all apertures and potential entry points for floodwater have been appropriately protected from flooding.

24.6.3 Air bricks, air vents, weeps, and service entries

In buildings with suspended flooring, air bricks are a potential entry point for floodwater. These should be protected in the event of a flood if resistance is to be used as a part of the property flood protection strategy for the building. Air brick protection may include passive flood air bricks, there several devices available that meet this need. The use of certified and site-tested products is recommended. Passive flood air bricks use a self-closing mechanism to help prevent floodwater entering the building by ensuring a watertight seal on this entry point. All air bricks on the building, up to the designed threshold of resistance, should be fully protected.

An alternative to passive flood air bricks, would be the use of manual air brick covers that can be installed in the event of a flood. These products may be difficult for some property owners or managers, and the process could take a lot of time if there are many of these covers. The individual responsible would need to have quick and easy access to the property and to be physically able to install all these devices quickly and safely.

Building service entries (eg utilities and pipework entry points) should have a watertight seal around the edge of them to fix them to the building. Under normal operation, and in the event of a flood, these seals should not allow any water to enter. Following initial installation there should be no additional requirement for any operation, providing the seal is properly maintained.

Weep holes should also be sealed before a flood, using manual or passive products. Passive weep hole flood protection will not require any operational intervention. If these products are properly maintained and regularly inspected, they should function as designed. If these devices fail an inspection, they should be replaced immediately. Passive weep hole protection will allow moisture to drain out of a wall cavity, however they will not allow floodwater to enter through these holes. Manual weep hole protection can also be installed to help prevent floodwater entering the cavity though these drainage holes. Before a flood, these measures should be inserted into all weep holes in a building, up to the maximum design threshold for resistance. This may be a time-consuming process immediately before a flood, and requires a building occupant or manager to be able to return to the property in the event of a flood and install these. Installation of these products should simply involve the fitting of these devices into the holes left in the weep holes within the building wall. Manufacturer instructions for fitting should always be consulted before installation.

At the end of life of any of these aperture protection products, they should be fully replaced to manufacturer's recommended standards, and by an appropriate person.

24.6.4 Backflow protection

To reduce the risk of floodwater flowing the wrong way through the buildings water-connected appliances (eg sink basins), non-return valves (NRVs) can be fitted. These devices act in a similar way to a one-way cat flap allowing water to leave the devices but preventing flow into a building during a flood. Most NRVs will be passive and should not require any intervention by occupants of a building in the event of a flood. The design of these means in normal and flood conditions the device will continue to work if properly maintained. All NRVs should be installed by an appropriate person, to ensure it has been installed correctly, all seals are watertight, and the device will function correctly in the event of a flood.

Manual devices are also available to fit to most water-connected appliances to limit backflow. These will require deployment according to the manufacturer's specifications for each individual entry point and will need to be stored securely between events. Passive measures are often recommended over manual measures, as they will not require an occupant or responsible individual to be able to enter the property and fit the backflow devices.

24.6.5 Membranes and tanking systems

Floor and wall membranes, as well as entire basement tanking, will not require any additional operational intervention from the building occupants or managers. They should be considered as passive devices. If they are installed and maintained according to the installer's and manufacturer's instructions, they will perform as designed throughout their design life. Sump and pump systems may be included with membrane and tanking and these may need to be activated (**Section 24.7.3**). For further advice on these systems, consultation with the independent flood surveyor should be sought.

24.6.6 Boundary protection

Boundary flood protection will usually be a passive or automatic PFR measure and stops floodwater before it reaches the property. The perimeter of the property may be protected with a combination of a flood-resilient wall, fence, or barrier. Apertures, such as a gateway entrance, would need to be blocked using removable barriers or flood gate. Flood-resistant walls should be fully resistant to flooding, up to their designed maximum threshold, as should any flood barriers which have been installed to close entrances. Flood barriers could be passive, automatic, or manual and they may also require stanchions to strengthen them across wide entrances. Full instructions for the operation of specific boundary protection products should be provided by the manufacturer.

24.7 FLOOD RECOVERABLE MEASURES

24.7.1 Floor coverings

Floor coverings that offer recoverability include a range of waterproof floorings. These could include (but are not limited to) finishes such as tiles, some linoleum floorings, or impermeable stone flooring slabs. These finishes will be able to be wiped or hosed clean very quickly following the receding of floodwaters from a property. Once these measures have been recommended and installed by an appropriate person(s) there should be no additional operational requirements. Any maintenance instructions from the manufacturer should be followed to ensure the continued service of the flooring.

Appendix A4 gives further guidance on the drying and decontamination of a building following a flood.

Internal floor fittings may also be incorporated with the recoverability design of a property. Depending on the product installed, these may remain in place or could have detachable mechanisms from the fixtures and fittings. If measures are passive, then no manual intervention will be required to ensure that these devices operate correctly. However, if these measures are manually operated and require human intervention to be effective, manufacturers, installers or designers should provide detailed guidance notes on their operation.

Exposed floor finishes may also be used as a passive recoverability measure and will require no deployment. Concrete (coated or uncoated) may be a chosen internal finish, as this provides a suitable recoverable approach given the characteristics of concrete. Concrete floorings demonstrate good durability and cost effectiveness and can offer good performance and recoverability in a flood situation.

Insulation may be installed in a floor as a recoverability measure, such as closed-cell resilient floor insulation. Unless these measures are expected to fail or appear to have been damaged, they should operate as designed if installed correctly. If damage is suspected to this insulation, it should be inspected by an independent surveyor or appropriate person.

When considering the use and operation of recoverable floor finishes, BS 85500:2015 outlines the performance expectations of various wall and floor finishes. This includes evaluation of the appropriate 'water-entry strategy' and how this will differ depending on the floor construction of the property (eg timber suspended). The standard also considers the addition of damp-proof floor membranes and the potential impact on flood recoverability.

24.7.2 Internal wall systems

Internal wall systems can be finished in a range of different materials which are considered recoverable measures. The correct installation and operation of these is important in limiting the damage to the property in the event of a flood, and in reducing the cost of a claim. For recoverable finishes on walls (eg internal rendering), there should not be any additional intervention required. These finishes should be installed by an appropriate person and should function correctly if maintained properly. Alternatively, if a non-resilient plasterboard has been installed on an internal wall as a sacrificial element, they should be installed horizontally. This will limit the number of wall panels that need to be replaced if damaged by floodwater, however no action is required before flooding.

In the same way as recoverable floor insulation, wall insulation which is recoverable should be considered a passive measure. This will be the case providing it is an appropriate material, recommended by an independent surveyor and installed by an appropriate person. No additional operation requirements will be necessary for these measures to function correctly.

24.7.3 Drainage systems

The operation of sump and pump systems (see **Figures 24.1** and **24.2**) will depend on the design, other linked measures and other systems linked to them. If the device is wired into the property's electrical system, and has an automatic engagement function, no additional operation will be needed to allow this device to remove floodwater from a property. However, if this is not the case, the device may need to be manually operated by a building occupant or manager, both to start and finish pumping. Back-up battery systems (if installed in line with sump and pump systems) will not require additional operational intervention. These should operate automatically if floodwater collects in the sump.

Figure 24.1 Example of a sump and pump system (courtesy Peter White, BRE)

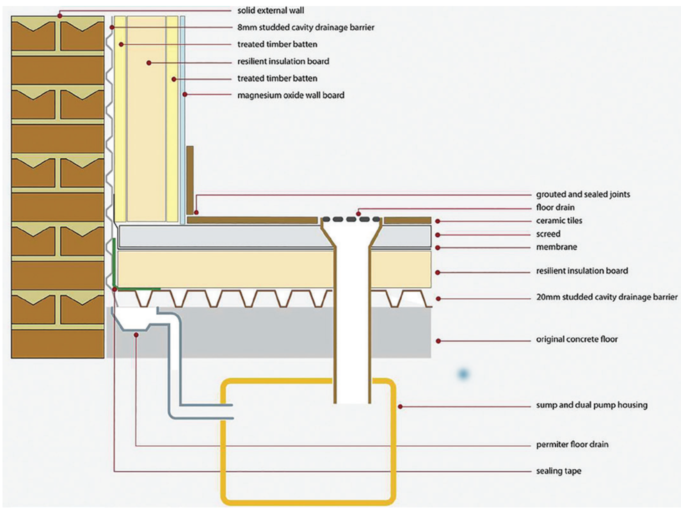


Figure 24.2 Example of drainage systems (courtesy Peter White, BRE)

Smaller systems, such as flood vacuums or puddle suckers, require manual operation. These devices are often linked or plugged into the electrical mains sockets of a property. This should be done in the event of floodwater entering a property if the volume of water is suitable. The manufacturer will provide guidance with the devices that will outline the maximum amount of water they can remove from a property. They should be used in accordance with manufacturer's recommendations and a back-up energy supply should be deployed if required.

Additional drainage systems (including cavity drainage systems, perimeter floor drains and central floor drains) help to remove water entering specific elements of the building fabric. These may incorporate additional PFR measures such as sump and pump systems. The drainage systems will be built into the design of the property and should not require any additional action to be taken by a property owner or manager to function correctly in a flood scenario. If any aspect of the operation of these systems fails during a flood, these systems should be inspected by an appropriate person. All these systems should undergo required annual maintenance.

24.8 FIXTURES AND FITTINGS

Flood recoverable kitchens (**Figure 24.3**), such as those described by Lamond *et al* (2016) are designed so floodwater will have a limited impact on kitchen appliances, such as fridges and ovens, through elevation or relocation. Kitchen cupboards and worktops likely to be affected by the flooding will be designed from materials that do not degrade when they encounter floodwater or they will be removable.

Figure 24.3 Flood recoverable kitchen. This kitchen, installed as part of the BRE flood-resilient repair house, showcases raised electrical appliances and sockets, as well as composite materials for cupboard doors and a stonework finish on the worktops (courtesy BRE)

Some designs require the fixtures and contents of lower levels of cupboards to be removed in the event of a flood (contents below the threshold design height of resistance within the property – usually 600 mm). These elements will be designed for quick and easy removal and they can often be placed on the worktops out of the reach of floodwater. This may be done using detachable hinges, click-on kickboards, removable baskets or drawers but could use additional similar mechanisms. The kitchen should be designed to be resilient to floodwater and, other than the removal of any low-level items, with most recoverable kitchens, there will be no other action required from end users. Any additional operational requirements for these flood recoverable kitchens will be outlined in the manufacturer's guidance, including careful drying and decontamination of the kitchen which will be required after flooding. Manufacturer's guidance should be strictly adhered to.

Flood recoverable furniture may also be part of the property design. It should not require any interaction from end users before a flood. However, the furniture may require a drying and decontamination process to be conducted if they encounter water.

Appendix A4 provides more information about the appropriate process for drying and decontamination.

24.9 MAINTENANCE OF RESISTANCE MEASURES

For flood resistance measures to remain in good working order, regular maintenance should be carried out. Information on likely maintenance requirements for specific products is given in **Table 24.1**.

Table 24.1 Maintenance of flood resistance measures

Passive and automatic flood barriers
Passive and automatic flood doors and barriers are typically highly engineered products. Manufacturer's maintenance guidance should be followed to ensure the product works as designed. Seals should be checked regularly by an appropriate person to ensure they remain sufficiently watertight. Mechanisms should be regularly tested (deployed where possible) and inspected (particularly electrical deployment systems). Inspection and maintenance should be carried out according to the required schedule, as a minimum, as well as after any major flooding event where this measure needed to be used. Additional inspections may be required if any deterioration or damage to any aspect of a resistance measure is observed. Any required repairs or replacements should be completed in line with manufacturer's guidance.
Manual barriers
For manual barriers, maintenance requirements will be similar to passive barriers and manufacturer's guidance should be followed. Depending on the type of material that they are manufactured from, barriers may be affected by damp and the watertight seals could become ineffective if exposed to low temperatures. They should be stored in a secure, dry place, away from damp and rain to prevent such deterioration. Any equipment required to install these barriers should be stored with them. This would be the case for manual flood barriers on both doors and windows. With manual barriers, stanchions may be required to support them across larger doorways. Stanchions should be regularly inspected, as well any fixings around apertures of the building (eg wall brackets). This should include any bolts or hinges connected to the property. Corroded or damaged fixings, frames and fastenings should be replaced immediately, as these may cause failure of the measure. Annual or bi-annual deployment tests are recommended for manual PFR measures, to ensure occupiers or managers of a property are able to fit the barriers.

Air brick covers
Air brick flood protection will often be required for buildings with a suspended floor. These could be passive flood air bricks, in which case they should be inspected annually or following major weather events that could potentially cause them damage. For example, extreme cold could cause damage to the joints and hinges within these measures which could prevent them from creating a watertight barrier. It is also important to check they do not become stuck in a permanently closed position thereby compromising air flow during normal buildings operation. Manual air brick covers can also be used that rely on a watertight seal against the wall of the building. These covers should be stored (with any equipment required to install these) in an easily accessible location, for quick installation before a flood. As with other barriers, seals should be regularly checked, and deployment tested. They should be maintained in line with manufacturer's guidance and should be replaced if damaged or poorly maintained.
Weep holes
Weep hole protection measures are usually manual barriers that can be fitted into the weep holes in cavity walls which allow the removal of moisture from the cavity. These cover types should be maintained in accordance with manufacturer's instructions and should be stored in an easily accessible location so that they can be fitted quickly before a flood. Regular inspections should be conducted of these measures as a minimum to ensure that this will continue to be effective, as well as inspections following major flood events, or if these measures deteriorate or become damaged.
Service entry points
Service entries into properties should be appropriately sealed using a waterproof sealant if these fall below the expected flood threshold of a building. These seals should be inspected regularly, if these seals begin to deteriorate or become damaged then they should be replaced. A biennial inspection of these seals should demonstrate whether these seals will be watertight. If deterioration is observed by the building occupant, owner or manager, an earlier inspection should be conducted.
Domestic appliances
Any domestic appliances that remove wastewater from the property, or supply clean water to the property, and are located on the ground floor level will require the installation of a NRV. Most NRVs are passive measures, however, some manual versions are available. The devices will require continued maintenance during their working lifetime, to ensure that they continue to work in the event of a flood as well as during normal building operations. Manufacturer's instructions for this should be followed, and inspection should be conducted by a qualified individual to ensure the device will function properly. A lack of servicing of NRVs could result in them seizing at the flap hinge, resulting in failure in the event of a flood. Manual alternatives to NRVs would require similar inspections, however, they will also have a manual lever (or similar closing mechanism) which should be tested.
Bungs
Similar to NRVs, bungs can help to prevent the backflow of water through pipework and operate in a similar manner. These bungs are manually operated by building owners or occupiers. Depending on the type of device used, the installation of these may be slightly different, but all are designed to create a watertight seal around the edge of the appliance to reduce water from being able to flow through the system. This usually is done through of the *in situ* inflation of a device. Inspections of these systems should be conducted by a qualified individual to ensure they are functioning correctly. These devices should be stored in a place that is easily accessible to building occupants and will protect the device from damage.
Floor membranes
Floor membranes are additional impermeable barriers that can help prevent water ingress from rising water (eg through groundwater flooding). These membranes are installed on the lowest level floor of a property (ie ground floor or basement), beneath the finished floor level. Once installed they are usually covered by a warranty for a given period depending on the product and supplier. As these devices are covered by the floor they will usually only need inspecting if they fail (or are expected to have failed) and water is found to be percolating through the membrane. Similarly, wall membranes will also only need inspecting if they are expected to have failed, and water is found to be penetrating through the wall membrane. The studs in these membranes may need to be replaced in line with manufacturer's recommended timescales and guidelines. A similar approach will be required for basement tanking systems (basement waterproofing systems). Any impermeable surfacing applied to a wall should be inspected if found to have structural failures (eg cracks or fractures) within the system. If this is the case, an on-site inspection by a qualified building surveyor should be conducted.
Building skirt
Building skirts are typically highly engineered installations which require appropriate maintenance to ensure they continue to provide the designed protection. They should be tested regularly to ensure the end users is able to install them in the event of a flood. In addition, maintenance procedures and information should be provided upon purchase of any building skirt system, with specific roles and responsibilities identified in this guidance.
Perimeter protection
Boundary walls and flood gates are perimeter protection measures that can help prevent floodwater reaching the walls of a property. A flood-resistant wall coating on a perimeter or boundary wall will need maintenance to ensure that its watertight characteristics are not compromised. Annual or bi-annual checks for cracks and weather damage should be undertaken. If these are observed, a qualified person should assess the integrity of the wall coating, to ensure that this will remain resistant to floodwater.

24.10 MAINTENANCE OF RECOVERABLE MEASURES

For flood recoverable measures to remain in good working order, regular maintenance should be carried out. Information on likely maintenance requirements for specific products is given in **Table 24.2**.

Table 24.2 Maintenance of specific recoverable measures

Floor coverings
Recoverable floor materials (eg tiled flooring) with gaps in the surface should be sealed using a watertight sealant or grouting. This should be regularly checked for any cracks and signs of degradation and any weaknesses should be inspected by a qualified surveyor or other competent person. Flood recoverable fixtures and fittings may be applicable alongside a resilient floor finish. These fittings should be appropriately maintained throughout the life of the product in line with the manufacturer's maintenance instructions.
Internal wall systems
Building occupants should conduct annual inspections of any flood recoverable internal walls, including those which are hard plastered or rendered. Any damage or cracking should be inspected and repaired by a competent person. Providing damage is inspected by a competent person, there should not be any additional requirements for continued ongoing maintenance of the internal wall finishes beyond general wear and tear. Both wall and floor insulation materials can be applied in a resilient manner, which will ensure where floodwater does enter a wall cavity, there will be little or no damage to the insulation. As these measures will be inaccessible when installed within a wall cavity, they should not require any continued or ongoing maintenance in normal conditions. However, if floodwater is suspected to have entered a wall cavity, or the insulation has been externally applied to a property, this insulation should be inspected by a qualified surveyor or a competent person.
Drainage systems
Where sump and pump systems are installed, these should be maintained regularly. These systems are usually installed in underfloor voids or are set into solid concrete flooring. They should be inspected in line with the manufacturer's guidelines. To ensure that the pump will continue to operate, an appropriate person should check the system is in full working order. Failure to do so may result in the system failing in the event of a flood. Smaller independent systems, often called puddle suckers, are also available and may form part of a recovery plan where small depths of water need to be removed quickly. These are usually portable systems which come in a range of sizes. Depending on the manufacturer's recommendations, systems may require servicing and maintenance work to be carried out by approved contractors. The maintenance process should also include the assessment of a back-up battery system if this is installed as a part of this inspection. Flood alerts or alarms may also be linked to these devices and some of these have the ability to contact (via text message) the owner or occupier of the property if a specific PFR measure has been activated. Other alert systems are available which will warn the owner or occupier of the property if floodwater reaches a certain threshold height. These should also be tested periodically. Perimeter and central floor drains within a room may be linked to these sump pump systems. These systems will ensure any water that does enter a property will flow to this sump for removal. To ensure that these drains do not get blocked by dirt and sediment, they should be cleaned, in accordance with the servicing guidance requirements and they should undergo a thorough cleaning process after every flood event. There should be no additional requirements for ongoing maintenance of these perimeter drains over their lifespan.
Fitted elements
The maintenance of resilient kitchens will be similar to the maintenance requirements of a non-resilient kitchen. Unless stated in the maintenance requirements from the kitchen supplier or fitter, a flood-resilient kitchen should only require ongoing maintenance due to general wear and tear.

25 Examples of resistance and recoverable products

The measures described in **Table 25.1** (resistance) and **Table 25.2** (recoverable) outline some of the different PFR products that are available on the market. This includes a wide range of both resistance and recoverability measures that can be installed independently or as part of a wider package design. Each of these products have different O&M requirements, and specific products installed on buildings, even within the same products type, may also have different O&M requirements. It is important the property owner and/or occupier(s) fully understand their responsibilities for the O&M of the measures installed on their property.

Table 25.1 Examples of flood resistance products and approaches

Product	Description	Example
Manual aperture barrier (doors and windows)	Manually installed barriers to seal doorways and windows on a property.	
Passive flood door	Flood-resistant door that should resist floodwater entry up to the designed flood depth. When closed and locked in place, this measure will form a barrier to help prevent water from entering.	
Passive flood window	Flood-resistant window that should help resist floodwater entry up to the designed flood depth. When closed and locked in place, this measure will form a barrier to help prevent water from entering.	

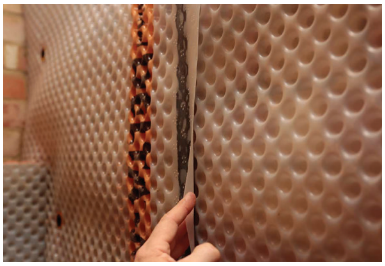
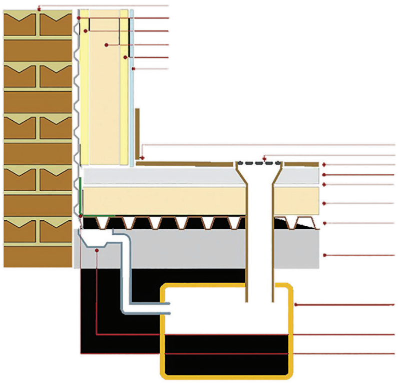
Product	Description	Example
NRV	Acting like a one-way cat flap, this measure reduces the risk of wastewater flowing the wrong way through pipework and into a property, even when drainage systems are overloaded. These products can only be fitted where the normal flow direction opposes flood direction. Traditionally passive measures, however, there are also a range of manual alternatives (such as penstock valves) which a property occupant/designated individual can manually close the flap over the connected pipework to prevent water (and any suspended material) from flowing in either direction through the pipework. These measures will need to be manually re-opened when floodwater has receded.	
Wall and wall membranes	Impermeable layer that is installed on walls or floorings to minimise the risk of water from penetrating the building fabric. This can be linked to drainage and pumping systems.	
Sealed service entries and weep holes	Waterproof sealant can be applied to all entry points below the designed threshold of flood resistance on a property. Weep holes on properties should be temporarily sealed before a flood if used as a resistance measure.	
Passive air bricks	Automatically closing alternative to traditional air bricks that allow airflow into sub-floor voids under normal practice but can seal watertight in the event of a flood.	
Manual air brick/ vent covers	Manually applied covers that can be applied to seal air bricks as well as additional vents (eg tumble dryer vent).	
External wall finish	The use of waterproof external wall finishes can influence the permeability of a building's fabric. External rendering and high-quality repointed masonry construction perform well in the event of a flood.	

Table 25.2 Examples of flood recoverable products and approaches

Product	Description	Example
Recoverable floor finish (eg ceramic tiles)	Waterproof internal flooring finish that should be sealed into a waterproof wall finish at the perimeter junctions.	
Recoverable wall finish (eg magnesium oxide board)	Waterproof wall finish should help prevent damage from floodwater and should not warp or deteriorate in performance in the event of a flood.	
Closed-cell insulation (batts)	A closed-cell insulation should not allow water to permeate through. If used in a floor, buoyancy uplift should be considered – particularly with the risk of ground water flooding.	
Closed-cell insulation (injected)	A closed-cell insulation should maintain its thermal performance, even if it encounters floodwater.	
Closed-cell insulation (spray-on)	A spray-applied insulation that will not be damaged by floodwater, this is a closed-cell material. If used in a floor, buoyancy uplift should be considered – particularly with the risk of ground water flooding.	

Product	Description	Example
Raised services (electrical sockets) and electrical appliances	By raising electrical sockets and appliances in a property, the risk of these appliances and electrical sockets from being damaged by floodwater is reduced.	
Electrical wiring installed from ceiling down to electrical sockets and appliances.	Electrical wiring installed at ceiling level and dropped down inside walls prevents damage to wiring, avoids the need to rewire and the risk of moisture being trapped in conduits.	
Sump pump system	A pump that can be installed in an underfloor void or set into a concrete floor. This will remove water from a property in the event of a flood. The pump will be connected to an independent outflow pipe that removes water at a level above the designed flood depth threshold.	
Cavity drainage system	Often connected to a pump, this system will ensure that any water that does enter a drainage cavity is channelled into a collection point from which it can be removed. This is usually comprised of both wall and floor membranes.	
Central floor drains	In-floor drains that can be connected to a pumping system, these ensure that any water entering the property can be quickly removed.	

Product	Description	Example
Perimeter floor drains	Additional drains connected around the edge of the room, these can be connected to the membrane systems on walls and floors and can be linked to a sump pump.	
Back-up battery system	A back-up battery system for sump pumps, this will ensure that the pump can continue to operate in the event of a loss of electrical power to the property. This should also be sited at a high level, above the maximum predicted flood level	
Alert meter	An alert system that lets the property occupant know when the sump pump is activated, needs routine maintenance, or fails.	
Resilient kitchen	Kitchen designed so that it limits the potential damage of floodwater. This will require electrical appliances and sockets to be installed at a height above the designed depth of flooding in the property. In addition, kitchen cabinets and fittings should not be severely damaged by floodwater and should use materials that can be dried and decontaminated easily (eg resin, resilient timber, aluminium, stainless steel).	

26 Guidance for historic and traditional buildings

For traditional or historic buildings, there may be additional considerations when assessing both the vulnerability of the building and its fabric, and a suitable options development to manage flood risk. Key considerations include the need to retain historic fabric and heritage value and avoids inappropriate adaptations that comprise fabric and value, including the requirements for air movement to avoid deterioration of historic fabric.

When assessing such buildings that are at risk of flooding, additional good practice guidance documents and information should be consulted. As part of the survey process, it is necessary to determine whether it is a Listed Building (ie it is included in a statutory list as being of special architectural or historic interest) or is situated in a conservation area, both of which could affect the considerations as a part of PFR Standard 3. More information can be found in Historic England (2015), Historic Scotland (2014), Cadw (2019) and from the Department for Communities Northern Ireland.

26.1 FLOOD-SPECIFIC GUIDANCE

The heritage organisations in each of the nations of the UK publish useful guidance relating to historic buildings, for example Historic England (2015), Cadw (2019) and Historic Scotland (2014).

Historic England has also produced a series on threats and emergencies, with specific examples on how flooding and moisture can be managed in historic properties. For more information go to:
https://historicengland.org.uk/research/current/conservation-research/threats-and-emergencies/

26.2 GENERAL PRACTICE GUIDANCE DOCUMENTS

Some additional sources of guidance on the management of traditional and historic buildings in the context of PFR and its suitability are outlined as follows.

Historic England's practical building conservation series provides different aspects on the sensitives of historic and traditional buildings (**Box 26.1**). This is a vital factor when considering the potential effects of flooding on properties. Moisture issues may be a significant risk to older properties and these documents may help to address this. For information about the process of claiming after a flood, and some of the considerations on insurance for historic buildings, see Historic England (2018).

Box 26.1 Additional sources of information

Further information on how to manage the impact of flooding on historic buildings is available through the technical guidance pages available on the following websites:

Historic England

Practical building conservation:
http://research.historicengland.org.uk/redirect.aspx?id=7480%7CDoes%20Wall%20Plaster%20Retard%20the%20Drying%20of%20Walls%20After%20Flooding

Technical guidance: **https://historicengland.org.uk/advice/technical-advice/**

Flooding and historic buildings:
https://historicengland.org.uk/images-books/publications/flooding-and-historic-buildings-2ednrev/heag017-flooding-and-historic-buildings/

Threats and emergencies – flood resilience and recovery:
https://historicengland.org.uk/research/current/conservation-research/threats-and-emergencies/

Does plaster retard the drying of walls after flooding?:
http://research.historicengland.org.uk/redirect.aspx?id=7480%7CDoes%20Wall%20Plaster%20Retard%20the%20Drying%20of%20Walls%20After%20Flooding

Scotland, Northern Ireland, Wales

Historic Environment Scotland: **https://www.historicenvironment.scot/**

Department for Communities Northern Ireland: **https://www.communities-ni.gov.uk/**

Cadw: **https://cadw.gov.wales/advice-support/climate-change**

A1 Glossary

Active resistance measures	These are measures which are not permanently installed into the property and will require deployment before a flood event (eg door guard).
Appropriate person	One of the duty-holders described under CDM 2015 They should act in accordance with a relevant set of professional standards, carry appropriate professional indemnity insurance and can demonstrate the required levels of skills, knowledge and experience and, as defined in the regulations, have a construction-related or a flood and water management background. This individual should have the necessary capabilities and resources, with right blend of skills, knowledge and experience, who understands their roles and responsibilities when carrying out work. They shall always act impartially and without favouring any particular supplier of equipment, materials or services.
Attenuation	The process of water retention on site and slowly releasing it in a controlled discharge to a surface water or combined drainage system, sewers or watercourse.
Avoidance of risk	Removing buildings or equipment to an area with lower flood risk, or to raise thresholds above predicted flood levels.
Awareness of risk	The awareness of risk means an individual knows and accepts their (property's) vulnerability to a hazard.
Barriers	A manually operated or passive measure that can be fitted either across an aperture, or free-standing. This helps to prevent water ingress and resists floodwater.
British Standards	Quality standards for goods and services produced by the British Standards Institution (BSI) Group.
Building regulations	Minimum standards for design, construction, and alterations to most buildings. Building Regulation is a devolved matter in the UK, with each nation taking responsibility for their own Regulations.
CDM 2015	UK health and safety policy covering all aspects of construction activity and designating specific actions to stakeholders.
Certification	Confirmation of certain characteristics and quality of a product or its installation. This confirmation is often, but not always, provided by some form of external review or assessment.
Client	Person(s) or organisation who wants professional support/services from a company. Often the same as the end user for households but may be different for rented properties and business schemes.
Consequences	The potential impact of a flood source of a specific location, highlighting how vulnerable the property or location is to a flood.
Cost benefit analysis	The process of assessing the relationship between the cost of an undertaking and value of the resulting benefits.
Damp-proof course	A damp-proof course is a horizontal barrier (or cavity system) that is designed to stop water from seeping into a structure through capillary action (colloquially known as rising damp when on the inside of the building). Older buildings (eg Georgian and Victorian buildings) do not always have a damp-proof course.
Decontamination	The removal or neutralisation of potentially harmful substances from an object or area.
Design standard	A performance indicator specific to the engineering of a defence to meet a particular objective. The performance requirements of a design standard will vary under different loading conditions. This could include seepage rates such as those in BS 851188-1:2019 and BS 85118-2:32019.
Domestic	Includes any type of housing irrespective of occupancy
Drying	The removal of moisture from a building or building materials.
End user	The occupier of the property or owners – the primary user of PFR measures who is likely to deploy, operate and maintain any PFR measures. The end user might also be the client.
Event (flood)	The occurrence (at source) of a flood hazard (such as surface water, river flooding). This is often used in accordance with a probability of a flood occurring (eg 1 in 100 flood event – or one per cent annual chance of meeting or exceeding this level).
Exceedance	The water that cannot be conveyed in the underground drainage system

Flash flood	Rapid flooding of an area of land because of intense or extreme rainfall events or failure of infrastructure designed to store or carry water or protect against flooding (distinguished from general flooding by the sudden onset).
Flood forecasting system	A system designed to forecast flood levels, frequency, and locations before they occur.
Flood defence	Infrastructure used to protect an area against floods such as floodwalls and embankments. Normally these are designed to a specific standard of protection.
Flood defence grant-in-aid (FDGiA)	Funding available to risk management authorities in England from central government for flood defence schemes. The amount available depends on the benefits provided by a scheme and it is likely that any scheme will require other sources of funding such as from local levy or other external organisations.
Flood map for planning	A map for land-use planning and development purposes, showing what flood zone under NPPF (MHCLG, 2019) definitions a proposed development is in.
FloodRe	A UK-wide 'reinsurance' scheme launched in 2016 and lasting until 2039. This enables insurance companies to be insured against losses because of flooding. This will then permit home insurance to be widely available and affordable in areas at risk of flooding for the duration of the scheme.
Flood recoverability	The use of materials, products and construction methods can be recovered after flooding, ie managing water entry.
Flood resilience	The combination of flood resistance and flood recoverability.
Flood resistance	The use of materials and approaches to safely keep water out of the property. This relates to water exclusion.
Flood resilience technologies	Practical devices and techniques which improve the resilience of buildings to flooding.
Flood risk	An expression of the combination of the flood probability (or likelihood) and the consequences of that flood event. The higher the likelihood and the greater the impact of flooding, the higher the level of flood risk. Risk = probability (or hazard) x consequences (or impact)
Flood risk management	Means of mitigating flood risk
Flood source	Where the floodwater is coming from. This may be one or a combination of the following types of flooding: • flooding from rivers (fluvial flooding) • flooding from the sea (coastal flooding) • groundwater flooding • surface water flooding • sewer flooding • infrastructure failure flooding (eg dam failure) • compound flooding.
Flood warning system	A way of detecting threatening events in advance which enables the public to be warned so that actions can be taken to reduce the adverse effects of the event.
Floodplain	Any low-lying area of land next to a river, coastline, or stream, which is susceptible to partial or complete inundation by water during a flood event.
Fluvial flooding	Flooding from a river or other watercourse.
Form of contract	The set of rules which all parties subject to the contract must abide.
Frequency	The average rate of occurrence of an event (eg a flood).
Future proofing	Ensuring a given product, policy, or document is designed to be flexible and adaptable enough to be changed easily given uncertain future conditions or to anticipate future failure.
Groundwater	Water that collects or flows beneath the earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. The upper surface of groundwater is the water table.
Hazard	The potential to produce harm.
Kitemark	The kitemark is a registered certification mark owned and operated by the BSI Group. BS 851188:2019 covers flood resistance products and systems.
Likelihood	The probability of a given thing (eg a flood) occurring
Maintenance	The process of preserving the condition of products and measures on a regular basis (normally in line with the defined schedule).
Nominated person	Identified individual who has specific responsibilities for related tasks.
Mitigation	The action of reducing the severity, seriousness, or consequences of a risk.
New build	The construction of new houses or other buildings.

Non-domestic	Properties such as public buildings, schools, hospitals, shops, offices, warehouses, factories not classed as domestic property.
Operation	The use or deployment of PFR measures during a flood event.
Overtopping (of defence measures)	When floodwater reaches levels that are higher than the flood defence level and flows over the top of the barrier or similar.
Passive resistance measures	These are measures which are installed into the property and do not require further deployment or activation before a flood event (eg a full height flood door or automatic air brick cover).
Pathway	The route that floodwater takes to reach a property.
Performance criteria/ indicator	The well-articulated and measurable objectives of a particular project or policy. These may be detailed engineering performance indicators, such as acceptable wave overtopping rates, rock stability, or conveyance capacity or more generic indicators such as public satisfaction.
Plain English	Clear and unambiguous language, without the use of technical or difficult terms.
Preparedness	The ability to ensure effective response to the impact of hazards, including the issue of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.
Probability	The average chance that something could happen. Normally expressed as an annual probability.
PFR	Flood resilience related to buildings within the curtilage of a property.
Receptor	The entity that may be harmed by a particular hazard (eg a person, property, habitat). For example, in the event of heavy rainfall (source) floodwater may propagate across the flood plain (pathway) and inundate a building (receptor) that may suffer material damage (the harm or consequence).
Recoverability	The use of materials, products and construction methods that prevent the internal fabric of the property from being unduly damaged by floodwater and allow it to recover quickly after a flood.
Requirement	A step to meeting specified aspects of PFR.
Residual risk	Risks remaining after actions have been taken to mitigate flood risk.
Resilience	The capacity that people, groups, or structures may possess to withstand or recover from emergencies.
Resistance	The use of materials and approaches to manage water entry to the property. This relates to water exclusion.
Resilient adaptation	Implementation/retrofit of property level resilient measures (including but not limited to resilient reinstatement).
Resilient reinstatement (resilient repair)	Implementation of resilient measures during the process of flood damage recovery sometimes known as 'build back better'.
Retrofitting	Retrofitting describes the installation or alteration of a component, product or material within a building.
Return period	The average period of occurrence of an event. When applied to flooding it is normally expressed in years. Return period is the inverse of frequency.
Risk	See *Flood risk*.
Risk management	The systematic process of risk assessment, options development and implementation of any risk management measures to control or mitigate risk.
Risk mapping	The process of establishing the spatial extent of risk (combining information on probability and consequences). Risk mapping requires combining maps of hazards and vulnerabilities. The results of these analyses are usually presented in the form of maps that show the magnitude and nature of the risk as well.
Risk perception	Risk perception is the view of risk held by a person or group and reflects cultural and personal values, as well as experience.
Runoff	The draining away of water (or substances carried in it) from the surface of an area of land (a field), a building or structure (a road).
Sealing	Sealing is a dry proofing technique where the floodwater does not reach the interior of the building as the external walls, floors and openings are sealed and used to hold back the floodwater.
Severity (of flood hazard)	The potential maximum impact level of a source (or combination of sources) of flooding at a specific location.
Smart technologies	Technology that responds to and reacts to flood incidents with minimal human intervention. Smart technology has defined uses and performance measures and should be assessed through recognised testing methods and quality assurance.
Source (flooding)	See *Flood source*.

Stage	The individual parts of the process of delivering PFR.
Subcontractor	The person or organisation responsible for delivery of part of the construction or installation works normally employed by the principal contractor as defined in CDM 2015.
Survey	The inspection and assessment of a building, land or water body, including other information sources as part of the PFR process.
Sustainable drainage systems	An approach to surface water management which aims to address water quantity, quality and amenity/biodiversity impacts from new and existing developments.
Telemetry	Automated communications process by which data are collected from instruments located at remote or inaccessible points and transmitted to receiving equipment for measurement, monitoring, display, and recording. In relation to floods, this helps with forecasting when water levels are reaching critical points.
Water ingress	The seepage or entry of water into an area it should not be in.

A2 CDM 2015

Table A2.1 Guidance on CDM 2015 duties (from HSE, 2015)

CDM duty-holders – who are they?	Main duties – what do they need to do?
Commercial clients – organisations or individuals for whom a construction project is carried out that is done as part of a business.	Make suitable arrangements for managing a project, including making sure: • other duty-holders are appointed as appropriate • sufficient time and resources are allocated. Make sure: • relevant information is prepared and provided to other duty-holders • the principal designer and principal contractor carry out their duties • welfare facilities are provided.
Domestic clients – people who have construction work carried out on their own home (or the home of a family member) that is not done as part of a business.	Although in scope of CDM 2015, their client duties are normally transferred to: • the contractor for single contractor projects • the principal contractor for projects with more than one contractor. However, the domestic client can instead choose to have a written agreement with the principal designer to carry out the client duties.
Designers – organisations or individuals who, as part of a business, prepare or modify designs for a building, product or system relating to construction work.	When preparing or modifying designs, eliminate, reduce, or control foreseeable risks that may arise during: • construction • the maintenance and use of a building once it is built. Provide information to other members of the project team to help them fulfil their duties.
Principal designers – designers appointed by the client in projects involving more than one contractor. They can be an organisation or an individual with sufficient knowledge, experience and ability to carry out the role.	Plan, manage, monitor and co-ordinate health and safety in the pre-construction phase of a project. This includes: • identifying, eliminating, or controlling foreseeable risks • ensuring designers carry out their duties • prepare and provide relevant information to other duty-holders. • liaise with the principal contractor to help in the planning, management, monitoring and co-ordination of the construction phase.
Principal contractors – contractors appointed by the client to co-ordinate the construction phase of a project where it involves more than one contractor.	Plan, manage, monitor and co-ordinate health and safety in the construction phase of a project. This includes: • liaising with the client and principal designer • preparing the construction phase plan • organising cooperation between contractors and co-ordinating their work. Make sure: • suitable site inductions are provided • reasonable steps are taken to prevent unauthorised access • workers are consulted and engaged in securing their health and safety • welfare facilities are provided.
Contractors – those who carry out the actual construction work, contractors can be an individual or a company.	Plan, manage and monitor construction work under their control so it is carried out without risks to health and safety. For projects involving more than one contractor, co-ordinate their activities with others in the project team – in particular, comply with directions given to them by the principal designer or principal contractor. For single contractor projects, prepare a construction phase plan.
Workers – *those* working for or under the control of contractors on a construction site.	*Workers* shall: • be consulted about matters which affect their health, safety and welfare • take care of their own health and safety, and of others who might be affected by their actions • report anything, they see which is likely to endanger either their own or others' health and safety • co-operate with their employer, fellow workers, contractors, and other duty-holders.

A3 PFR stages and checklists

A3.1 PFR STAGE 1: HAZARD ASSESSMENT

This checklist shows all tasks for each step of the PFR Stage 1 flowchart.

Step in process	Task	Completed?
Step 1	All sources of flood risk understood (Section 12.2)	
	All potential flood risk sources reviewed (Section 12.5)	
	Relevant local, site and historical information sources reviewed (Section 12.6)	
	Frequency, depth, velocity, and duration of each source calculated (Section 12.7)	
Step 2	All pathways of flooding understood (Section 12.3)	
	All pathways of each source identified reviewed (Section 12.6)	
	Site information assessed for potential future changes or adaptation to pathways (Section 12.6)	
	Any influencing factors have been identified (Section 12.6.2)	
	Impact of the surrounding environment on flood risk at the property has assessed (Section 12.6.2)	
Step 3	All potential flood pathways are understood and fully evaluated (Section 12.6)	
	Impact of all potential sources understood and fully evaluated (Section 12.7)	
	Likelihood of flooding at the property understood (Section 12.7)	
Decision point	Additional flood modelling is not required or has been successfully completed if required. Property flood hazard assessment provided to end user	

A3.2 PFR STAGE 2: PROPERTY SURVEY

This checklist shows all tasks for each step of the PFR Stage 2 flowchart.

Step in process	Task	Completed?
Step 1	Hazard assessment summary report reviewed (Section 12.5)	
	Property survey is proportional to needs and budget of client (Section 12.7)	
Step 2	All aspects of building to be surveyed understood (Section 13.2)	
	All performance aspects of building assessed (Section 13.2)	
	All floodwater entry points assessed (Section 13.2.7)	
Step 3	End user preferences for PFR measures understood (Section 13.3)	
	Mobility and capability of the end user assessed (Section 13.3)	
	Suitability of manual PFR measures considered (Section 13.3)	
	Suitability of manual PFR measures determined (Section 13.3)	
Step 4	Flood resistance of the property assessed (Section 13.4)	
	Flood recoverability of the property assessed (Section 13.4)	
	Existing PFR measures recorded (Section 13.4)	
Decision point	**The property is determined to be recovering from recent flooding (go to Step 5) or not (go to Step 6)**	
Step 5	Moisture content in impacted areas assessed (Section 13.5)	
	Building materials affected dried (Section 15.4.2)	
	Property dried and decontaminated to appropriate level (Section 15.4.2)	
Step 6	Site ground conditions verified/determined (Section 13.6)	
	Flood pathways verified/determined (Section 13.2.7)	
	On-site sampling (if required) conducted (Section 13.6 and/or 21.4)	

A3.3 PFR STAGE 3: OPTIONS DEVELOPMENT AND DESIGN

This checklist shows all tasks for each step of the PFR Stage 3 flowchart.

Step in process	Task	Completed?
Step 1	Suitable generic resistance measures (if deemed appropriate) identified (**Section 14.3**)	
	Suitable recoverability measures (if deemed appropriate) identified (**Section 14.3**)	
	Package of suitable measures developed (**Section 14.3**)	
Step 2	Ease of construction and maintenance considered (**Section 14.4.1**)	
	Lifetime operational cost requirements of PFR options identified (**Section 14.4.1**)	
	Maintenance and storage of proposed packages considered (**Section 14.4.2**)	
	Suitability of requirements considered against end user needs (**Section 14.6**)	
Step 3	Sources of impartial costings identified (**Section 14.5**)	
	Indicative costs for generic measures proposed determined (**Section 14.5**)	
	Suitability of costings for the client determined (**Section 14.6**)	
Step 4	Suitable approaches presented to the end user (**Section 14.6**)	
	Advantages and disadvantages discussed with end user (**Section 14.6**)	
	Suitability of generic measures based on cost, O&M determined (**Section 14.6**)	
Step 5	Detailed design of measures and selected appropriate products completed (**Section 14.7**)	
	The proposed approach is accepted and approved by the end user (**Section 14.7**)	
	Drawings and specifications suitable for installation and construction compiled (**Section 14.7**)	
	Mechanism for installer/contractor to discuss solution with designer incorporated (**Section 14.7**)	
Step 6	Installation and operational responsibilities for PFR measures identified and assigned (**Section 14.11**)	
	Appropriate drying and decontamination approaches that may be required after flooding identified (**Section 15.4.2**)	
	Responsibility for maintenance requirements of PFR measures identified and assigned (**Section 14.11**)	

A3.4 PFR STAGE 4: CONSTRUCTION

This checklist shows all tasks for each step of the PFR Stage 4 flowchart.

Step in process	Task	Completed?
Step 1	Contractor reviewed design proposal (**Section 15.1**)	
	Any issues discussed with designer (**Section 15.1**)	
	Additional costs or requirements identified (**Section 15.2**)	
Step 2	PFR design agreed between designer and contractor (**Section 15.1**)	
	PFR design and cost agreed with end user (if required) (**Section 15.1**)	
	PFR design agreed with third parties (if required) (**Section 15.1**)	
Step 3	Contract scope of works discussed with end user (**Section 15.3**)	
	Contract scope of works developed (if required) (**Section 15.3.1**)	
	Schedule of works created (if required) (**Section 15.3.2**)	
Step 4	Installation of PFR completed in accordance with good practice (**Section 15.4**)	
	All health and safety requirements of works are met by contractor (**Section 15.4.1**)	

A3.5 PFR STAGE 5: COMMISSIONING AND HANDOVER

This checklist shows all tasks for each step of the PFR Stage 5 flowchart.

Step in process	Task	Completed?
Step 1	Quality check of the installation work completed. The contractor addresses any issues and is satisfied that it meets requirements (**Section 16.1**)	
	Operation of the PFR measures has been discussed with the end user (**Section 16.1**)	
	Operation of the PFR measures has been demonstrated to the end user (**Section 16.1**)	
	Responsibilities for operation, storage, and maintenance confirmed for all parties (**Section 16.1**)	
Decision point	*In situ* testing of PFR measures is available (go to Step 2) or is not available (go to Step 3)	
Step 2*	*In situ* testing options presented to end user (if required) (**Section 16.2**)	
	Impartially witnessed in situ test is conducted (**Section 16.2**)	
	Witness provides statement/verification document of test results (**Section 16.2**)	
Step 3	Independent inspection of works as part of PiA completed (**Section 16.3**)	
	Provision of report outlining findings and results to the end user (**Section 16.3**)	
Step 4	Snagging issues raised in the audit highlighted (**Section 16.4**)	
	Solutions to snagging issues identified (**Section 16.4**)	
	Correction of snagging issues completed (**Section 16.4**)	
Step 5	Handover pack provided to the end user (**Section 16.5**)	
	End user demonstrate understanding of PFR operation, maintenance, and storage (**Section 16.5**)	
	End user show understanding of lifetime requirements (**Section 16.5**)	
Step 6	All parties are happy with the completed works is confirmed (**Section 16.6**)	
	Final sign off from all parties obtained (**Section 16.6**)	

Note

* if applicable

A3.6 PFR STAGE 6: OPERATION AND MAINTENANCE

This checklist shows all tasks for each step of the PFR Stage 6 flowchart.

Step in process	Task	Completed?
Step 1	End user have safely stored the O&M documents (**Section 17.1.1**)	
	The end user can make these documents available to future owners of the property (**Section 17.1.1**)	
	All O&M requirements outlined in Stage 3 read and met (**Section 17.1.1**)	
Step 2	PFR measures are suitably stored (**Section 17.2**)	
	Any tools required to operate PFR measures are kept with measures in storage area (**Section 17.2**)	
	Access pathway is clear in order for quick access to PFR measures (**Section 17.2**)	
Step 3	Maintenance work conducted in accordance with maintenance schedule (**Section 17.3**)	
	Maintenance carried out in accordance with manufacturer recommendations (**Section 17.3**)	
	Maintenance activities recorded and documentation retained by end user (**Section 17.3**)	
Step 4	In the event of a flood, manual measures are deployed (**Section 17.5.1**)	
	In the event of a flood, all passive measures are fully sealed (**Section 17.5.2**)	
	After a flood, all PFR measures dried and decontaminated (**Section 17.5.3**)	
	Any damaged measures are replaced, and undamaged measures returned to storage (**Section 17.5.3**)	

A4 Drying and decontamination of buildings

Resilient buildings are expected to be returned to their pre-flood condition much quicker than buildings that have not been designed in this way. This will allow property owners to return to their homes and businesses and continue with minimal interruption. Industry guidance is available on the general principles and process of designing buildings to be resilient (eg Garvin, 2012a and b, BRE, 1997, Bowker *et al*, 2007).

A4.1 DECONTAMINATION

Pryke (2000) and BRE (2000a, 2000b) provide guidance for professional services on the appropriate method for cleaning and decontaminating buildings following a flood. This guidance reviews relevant legislation, procedures, and industry good practice.

The Flood Repairs Forum (2006) also assesses the key health and safety implications with the repair of properties following flooding. It refers to applicable legal standards (the Health and Safety at Work etc. Act 1974, The Workplace (Health, Safety and Welfare) Regulations 1992, The Management of Health and Safety at Work Regulations 1999, and HSE, 2003) and outlines the requirement to use PPE during this process. The document is based on generic risk assessments and evaluates appropriate considerations of this within the guidance.

A4.2 DRYING

There are several publications on post-flood drying of a building which describe the appropriate steps to take and to do so safely. The Property Care Association (PCA, 2013) defines drying with respect to flood recovery as *"the process of removing floodwater from the fabric of the building"* (Clause 11.1). It highlights the impact of removing moisture from buildings, specifically if it existed before a flood event, which is also removed during this drying phase. It defines the responsibility of a surveyor to identify when the drying phase of a building has been completed, and when the building is suitable to be reoccupied or repaired. This is an alternative to applying a given percentage moisture content for materials in a building, which will depend on several social, economic and environmental factors highlighted within PCA (2013) regarding the building (eg when drying is no longer economically viable). This guidance also provides more information on the key issues related to the drying of properties.

Kidd *et al* (2010) provides recommendations for the appropriate equipment to dry flooded buildings, as well as key processes for doing this (and as recommended by Garvin *et al*, 2005). Information is also provided in Bowker *et al*, 2007 of the methods of determining target drying times for a property, including a range of different considerations with regards to this. This DCLG guidance also discusses drying processes highlighted by BRE (1974).

The British Damage Management Association (BDMA) provides guidance on considerations for energy (Spencer, 2011a), permeance (Spencer, 2011b) and humidity (Spencer, 2011c).

A4.3 SUMMARY

The drying and decontamination process is a complex and challenging procedure that should be undertaken in accordance with industry good practice, and the guidance documents outlined in **Section A4.2**. It is important that any site inspections are done safely, and buildings are only entered after the structural integrity of the building has been checked by a qualified surveyor, using appropriate PPE. The cleaning and decontamination process should be carried out as soon as possible after the floodwater recedes from the building.

Upon completion of the decontamination process, the drying phase of the flood recovery process can begin and should continue until the surveyor confirms that it is complete. A final inspection process should then be carried out to ensure that the work has been completed successfully by the surveyor, before re-occupation of the property.

A5 Case studies

These case studies do not provide examples of the best practice application of the CoP as they were recorded before the PFR standards and CoP were published. They show elements of the approach that form the CoP. It is essential to follow all six standards in the code of practice for property resilience.

CASE STUDY A5.1
A LOCAL AUTHORITY-LED INITIATIVE, WIGAN, LANCASHIRE

The importance of engaging with the whole community and understanding the building structure was clear in a council-led PFR scheme that included a housing terrace set on a slope (**Figure A5.1**). This terrace was supplied with flood doors as part of a resistant/water exclusion strategy. However, the measures failed to keep water out due to the reluctance of one resident, at the top of the slope, to accept the doors.

Figure A5.1 The terrace of houses in Wigan set on a slope (courtesy Whitehouse Construction)

Standard 1. A property survey was included as part of the flood risk assessment, many of the properties were of non-standard or historic construction and required 'heritage' measures.

Standard 3. During the design and specification, the benefits of the flood doors and the need for all residents to accept and operate the doors was not sufficiently explored with the end users.

Standard 4. The contractor co-ordinated the measurement survey and installation by specialist product installers on all the properties that accepted the measures. During a subsequent flood these operated as expected and prevented water from entering through the property doors and air bricks.

> *"The learning workshop proved most insightful, helping raise the bar of PFR nationwide"*
>
> Wigan Council

As the measures were passive, at the end of the installation customers were given maintenance instructions but no arrangements were put in place to check the measures would work. Subsequently, a flood occurred, and water entered all the properties through a common wall cavity – bypassing the door guards and other PFR measures.

The issues experienced here might have been prevented by a better property survey, end user engagement and construction as well as a thorough commissioning and handover process (Standards 2 and 4). If an understanding of the common cavity had been factored into the design from the outset the adoption of measures might have been successful. It is also possible better engagement could have ensured that the entire terrace had adopted the measures (Standards 5 and 6). If neither of these options were possible then recoverability could have been considered.

CASE STUDY A5.2
A LOCAL AUTHORITY-LED INITIATIVE, ESSEX COUNTY COUNCIL

Essex County Council used £245 000 funding from the Environment Agency to improve the resilience of some homes in Essex to surface water flooding. They used a co-ordinated approach which demonstrates good practice included in many of the CoP standards.

Standard 1. The Council appointed a main scheme contractor, and they were involved throughout planning and delivery, taking responsibility for the plan. Engagement with the community to encourage take up included branding the scheme and creating a logo and publicity materials (**Figure A5.2**). The branding continued through to installation, providing continuity, and presenting a considered approach that involves all parties in measures to manage risk to attached properties.

An independent flood risk assessment was carried out for all properties. This resulted in some properties being recommended for small community schemes rather than property-specific measures.

Umbrella logo | A-Board Advert | A5 leaflet posted to homes

Figure A5.2 Community engagement information (courtesy Aquobex and Essex County Council)

Standard 2. A property survey was included as part of the flood risk assessment, many of the properties were of non-standard or historic construction and required measures to accommodate 'heritage' features.

Standard 3. During design and specification the contractors and council worked together to present appropriate options based on end user needs through community flood fairs. An independent community engagement consultant was employed to help with this. Although products were recommended based on the flood type and building design, the contractor provided opportunities for end user preferences, including a wide range of solutions from both their own product range, and those offered by other companies.

Standard 4. The main contractor co-ordinated measurement survey and installation by specialist product installers.

Standards 5 and 6. At the end of the installation customers were trained in how to use and maintain the PFR products before signing off the job completion sheets. A customer survey established that this was carried out satisfactorily (95 per cent satisfaction).

CASE STUDY A5.3
JOHN O'GAUNT ROWING CLUB, LANCASTER, LANCASHIRE

Figure A5.3 PFR measures being put to the test in October 2017 (courtesy Adler & Allen)

In December 2015, the rowing club which was a block-built building was affected by Storm Desmond. The club was flooded primarily because of the heavy rainfall and the subsequent overwhelmed river. The water ingress to the ground floor and first floor was up to four metres deep. Due to the location of the river and the subsequent flooding damage it was necessary to install PFR measures to help protect against future flooding.

Standard 2. A contractor was appointed to undertake a property survey and an assessment of the site and damage as well as provide necessary PFR measures.

> *"...we were given clear instructions on how to deploy the barriers, which we have since deployed successfully in two recent floods. The barriers ensured no water came through and the club remained dry."*
>
> **Michael Pugh, chairman, Lancaster John O'Gaunt Rowing Club**

Standards 3 and 4. After the survey had been completed, the contractor compiled a full report and made recommendations on the types of PFR measures that should be installed. Three x 1 m high demountable aluminium flood barriers were installed across the doors to help minimise water ingress into the rowing club. These can easily be deployed before a flood. A further large aluminium flood barrier was also fitted on the main (single) door to the building. A polyurea coating system was applied on to the external walls up to 1.5 m in height. The polyurea coating is waterproof and creates a seal ensuring water cannot penetrate through the brickwork outside. The contractor also advised that a sump pump should be installed to help pump out water more quickly in the event of a flood. The customer provided their own pump, and the contractor fitted the pipework.

Standard 5. The barriers were tested after initial installation to check for any leaks or potential areas for concern. More recently the barriers have been tested in a real flood and withstood any water getting into the rowing club.

Standard 6. In October 2017, the River Lune breached its banks, and the flood barriers were put to the test (**Figure A5.3**). No water passed through the barriers ensuring the rowing club remained dry and was able to continue to operate business as usual.

CASE STUDY A5.4
FLOOD PROTECTION MEASURES, CEMEX, SOUTH FERRIBY

An initial site survey was conducted in December 2016 with the PFR installation completed in March 2017. The work was carried out at the CEMEX site at South Ferriby. CEMEX is a global construction product supplier.

Standard 1. There was a tidal surge which inundated the local area and resulted in flooding at the site in 2015. The flood overtopped the existing protection which was set at 1.5 m. The flooding affected the server and switch control room for the entire site.

Figure A5.4 Waterproof coating to 1.5 m height applied to external control room walls (courtesy Adler & Allen)

Standard 2. A contractor conducted an initial survey which was carried out before supplying the client with recommendations and a quote for the work. The same contractor was requested to visit the site following the flood event.

Standard 3. The contractor worked closely with the client to understanding how they operate and make appropriate recommendations that were eventually implemented. The height of the existing flood protection at 1.5 m was above BSI recommendations (**Figure A5.4**). The contractor made the client aware that it was their responsibility to assess the structural stability of the building following flooding to ensure it was safe to enter/work.

A range of PFR recommendations were made. These included:

- sealing of incoming ducts
- installation of a sump and pump
- installation of a flood/security door and the outer fabric of the building received a waterproof coating. This was sprayed 1.5m in height around the building

Standard 6. Since the installation of the PFR measures there have been other floods but not as extreme as the flooding in 2015. The switch control room has not been flooded again.

CASE STUDY A5.5
PFR MEASURES AT BURBERRY MILLS, YORKSHIRE

Figure A5.5 Deployment of a floodgate defence system to prevent water entering the site (courtesy Adler & Allen)

The Burberry factory in Keighley, Yorkshire located on the bank of the river Worth, was flooded after the river overflowed in December 2015. This led to PFR being explored as an option to reduce damage and disruption.

Standard 2. A contractor was engaged by Burberry to carry out a site survey in August 2017. The survey was based on a flood risk assessment and took into account client requirements and the need to provide PFR to mitigate against flooding.

Standard 3. After conducting the site survey, the contractor recommended several different PFR measures. These included the installation of the following.

- A modular flood barrier system to stop water flooding and damaging critical assets. Its length and height can be easily modified on site. The contractor proposed to deepen the existing drainage channel by 600 mm to reduce the chance of it being overwhelmed.
- Spray lining using waterproof polyurea coating to prevent water penetrating through the walls. This provided a waterproof barrier up to 1.8 m in height.
- Demountable barriers were fitted across the existing doors, as the seals were beginning to degrade, reducing the level of protection. The barriers will help prevent water entering the property via doorways and windows.
- Flap valves on pipework.
- Sump and pumps were installed to assist in removing water from the drainage channel to avoid the channel becoming overwhelmed during flooding.
- Flood gate to allow access and to stop the ingress of floodwater.

Standard 6. As the installation has been completed recently, it has not yet been tested in a flood.

CASE STUDY A5.6
RECOVERABLE AND RESILIENT MEASURES, EDEN BRIDGE HOUSE, CARLISLE

Eden Bridge House in Carlisle is a 1960s office block that suffered significant flood damage to the lower ground floor in December 2015, the second time in five years (**Figure A5.6**). Extensive repair work was required before it could be returned to use.

Recoverable PFR measures and resilient repair were used for offices sited next to the River Eden. It was recognised that the building would probably flood again despite existing flood defences and that the building did not permit the use of barriers.

Figure A5.6 Flooding at Eden Bridge House, December 2015 (courtesy Defra and Interserve)

Standard 3. The decision to repair the building using recoverable PFR measure was informed by several consultants assessing future flooding risks. Cost effectiveness and quicker re-occupation (weeks rather than months/years) were the main drivers for the PFR approach.

The consultants reviewed numerous resilience measures and met with suppliers to discuss different products. They employed the principle that if a building material, or product could be re-ordered and delivered in a similar timescale to that required to dry out the flooded building, it would not be worth paying over three times as much for a more specialist resilient option. The resilient design employed several strategies:

- Reorganisation and relocation of facilities where possible to avoid sensitive materials being at risk of flooding.
- Raising of services where possible to avoid damage.
- Investment in building fabric where this will speed up re-occupation after future flooding and can be justified on a cost basis.
- Sacrificial elements where they can be replaced quickly, and more specialist resilient alternatives are significantly more expensive.
- Robust contingency plans were improved through better understanding of flooding mechanisms and mitigation developed by the project.

"As part of this study we worked with the design team to review numerous resilience measures and met with suppliers to discuss different products. We looked at the lead times for products being proposed and review cost effectiveness with a principle that if a product could be re-ordered and delivered in a similar timescale to that required to dry out the flooded building, it would not be worth paying over three times as much for a resilient option.

Ongoing annual maintenance and refurbishment repair budget was reviewed as part of the options into materials and methods used as was the estimated lifetime of the materials used which informed the decision on cost effectiveness of resilient solutions. It was important that there would not be an unjustified increase in annual maintenance as a result of the works. I do not believe any of the method or materials used caused an increase to the maintenance budget. If fact, as a result of the incumbent FM contractor being involved in the total redesign of the floor, we were able to relocate systems to ensure future maintenance would be easier."

FM consultant to Defra

Figure A5.7 Recovered interior (courtesy Defra and Interserve)

Standards 5 and 6. The recovery was managed by the clients existing building and facility managers, good working relationships and understanding between the parties enabled a swift re-occupation of most of the building.

The ongoing annual maintenance/ refurbishment repair budget was reviewed as PFR options were explored and information on lifetime considerations of materials/methods used were known. The review informed the decision on cost effectiveness of resilient solutions. It was important that the materials used would not cause an increase in the maintenance budget.

CASE STUDY A5.7
PROPERTY PROTECTION SCHEME, SOUTH ZEAL, DEVON

A property level protection scheme was delivered to better protect properties from a stream flooding at South Zeal in Devon. The residents enrolled on the Environment Agency's flood warning alert scheme, but as the stream is prone to flash flooding there was a risk the flood warnings would be too late. Property level protection, along with robust emergency planning, had been used to great effect in the community. It is unlikely the community would have benefitted from any other scheme.

Figure A5.8 The community in South Zeal, Devon are a vital part of the property protection scheme (courtesy Peter Kilgannon)

Standard 3. All the properties installed the same (active) measures, so that everyone would know how to install each other's measures if anyone gets into difficulty.

Standard 6. Maintenance requirements influence the selection of PFR measures. The pumps provided were locally sourced so that if there was an issue, the residents could get them fixed locally. A proactive flood group and annual dry-run tests meant that the scheme was successful. Before purchasing residents were trained in deploying their PFR measures. This meant that residents knew how to deploy and fit their barriers and ensured that suitable measures were provided. The Parish Council organises a dry-run test to be conducted once a year. This enables residents to check their equipment and practice installation. The practice sessions help new tenants in the village understand and install the PFR measures.

Emergency planning

The village has recently installed a water-level monitoring and warning device, which has helped reduce the time required by flood wardens (who used to stay up all night in case of a flood) to monitor the gauge. Once a pre-set level is reached, a warning is sent to local flood wardens who 'cascade' the alert out to other residents.

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PAS

PAS 64-2013 *Mitigation and recovery of water damaged buildings – code of practice*

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Property flood resilience (PFR) is an important part of the response to flood risk. PFR includes measures that provide a way to reduce the risks to people and property enabling households and businesses to reduce flood damage, speed up recovery and reoccupation of flooded buildings. PFR measures should reduce the amount of water entering buildings (known as resistance measures), or limit the damage caused if water does enter a building (known as recoverability measures).

A code of practice (CoP) has been developed covering the inclusion of PFR measures that can be introduced to buildings at risk from flooding. Often these measures can be installed as part of the repair of buildings after they have been flooded. However, some property owners may wish to be proactive and fit measures in anticipation of a flood.

The CoP includes six standards that specify what should be achieved. This guidance supports the CoP's six standards and provides comprehensive guidance on how the standards should be met by following stages within a PFR delivery process. There are also complementary guidance on using the CoP for households and businesses and local authority planners.

AVIVA

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BUILDING SCOTLAND'S RESILIENCE TO NATURAL HAZARDS

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