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Cost estimation for household flood resistance and resilience measures – summary of evidence

Report – SC080039/R11

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Miranda Kavanagh

Director of Evidence

Executive summary

This detailed summary of evidence provides indicative costs and guidance on household flood resistance measures (those that attempt to prevent floodwaters from penetrating a property) and resilience measures (those put in place inside a property to minimise the damage caused by floodwaters that enter into a property).

Household flood resistance and resilience		
Key cost components	Key cost components for temporary and demountable barriers will include: <ul style="list-style-type: none"> • administration and survey costs • capital costs • operation, maintenance and replacement costs • associated flood warning costs 	
Key asset types	Flood resistance measures Flood resilience measures	
Data reviewed in specific guidance	Key datasets include: <ul style="list-style-type: none"> • Defra resilience grant documentation • Defra report on flood resistance and resilience solutions • Defra research report on flood resilience • ABI report on flood resilience measures and costs 	
Other relevant data	Local or proxy records such as data from Environment Agency SAMPs and local authority information Manufacturers and suppliers	
Relative cost importance	Enabling costs	Relatively low costs but will include initial administration costs, survey costs and planning
	Capital costs	Variable depending on type and range of measures required, size and type of property and flood depth/duration. Higher costs for resilience measures particularly if retrofitting.
	Maintenance costs	Low costs implemented by homeowners
	Other cost considerations	Asset replacement and post installation surveys may be required. Additional flood warning may also be required if not available.
Cost estimation methodology	Initial concept/national appraisal	Example capital cost unit rates for different barrier types available. Some estimated costs for resilience options provided to build up a cost estimate.

	Strategic, regional, or conceptual design	Example capital cost unit rates for different barrier types available. Some estimated costs for resilience options provided to build up a cost estimate.
	Preliminary feasibility/design	No specific cost information provided. Guidance on data availability and procedures provided.
Design life information	<p>No applicable for most resilience measures</p> <p>For resistance measures, the design life is variable and little examples available to date based on experience, although manufacturer information is available. Typical values of 20–30 years.</p>	
Quality of data	<p>A range of data sources and case studies have been collated. Historical reference case studies and reference projects are provided that are suitable for initial option appraisals or strategic studies.</p> <p>Methodologies and examples are provided to assist appraisers with cost estimation for survey and installation costs and checklists for all items that need to be considered. Costs per property can be determined based on the available information.</p> <p>Guidance and availability of information for manufacturers is to available and referenced provide sufficient detail for more detailed analysis.</p>	
Additional guidance	<p>Checklist of factors likely to influence capital and maintenance costs, and key factors to consider for detailed costs estimation</p> <p>List of R&D and general design guidance</p> <p>Case studies of recent schemes</p>	

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1 Flood mitigation measure – household flood resistance and resilience

Construction techniques that increase the flood resistance and resilience of a building may be the most appropriate way of managing flood risk for developments located in areas prone to flooding.

Flood resistance, or dry proofing, techniques prevent floodwater from entering a building. This approach includes, for example, using flood barriers across doorways, airbricks and raised floor levels. Household flood resistance measures aim to prevent floodwaters from entering a building structure. These measures may be deployed or constructed within the immediate curtilage of a property or become a component of the building's fabric. Property resistance measures may be appropriate in areas that frequently flood to shallow depths, and where community-scale defences are unlikely to be a viable option.

Resilience measures are those that are undertaken inside a property to reduce damage caused by floodwaters. Flood resilience, or wet proofing, accepts that floodwater will enter the building and allows for this situation through careful internal design such as raising electrical sockets and fitting tiled floors so that the building can quickly be returned to use after the flood. Resilience measure may be suitable for properties vulnerable to repeated flooding where the depth of flooding exceeds 600 mm (CIRIA 2007). When floodwater exceeds this level it may be more appropriate to allow water into a property, preventing possible structural damage to walls in a way that limits the potential damage, cost, disruption and ultimately the time that a property is uninhabitable.

1.1 Broad level cost estimation

A number of standard costs need to be considered when estimating the value of household flood resistance and resilience measures. These are:

- administration and survey costs
- capital costs
- operation, maintenance and replacement costs
- any associated flood warning requirements

1.1.1 Administration and survey costs

Administration costs are likely for organisations using household flood mitigation measures to manage communities at risk. Administration costs may include those costs associated with:

- community engagement (for example, holding flood awareness exhibitions)
- procuring surveys and products

- planning
- building control and heritage issues
- preparation of agreements with beneficiaries of the scheme

These costs may already be provided for through existing funding. However, the staff costs of those wholly employed to undertake these tasks and external providers of administrative services would also be eligible.

Threshold surveys require specialist personnel with the appropriate skill level and experience required to understand both the scale and nature of flood risks to a particular building and to understand the measures required to mitigate that risk. Key aspects for consideration include:

- an assessment of the depth, frequency, type and duration of flooding
- an assessment of the elevation of the buildings
- an assessment of the possible points of entry of floodwater into a building
- an evaluation of the measures needed to prevent the entry of water
- an assessment of the balance between flood protection and flood resilience appropriate for the building
- post-implementation quality assurance inspections at each building to confirm that measures have been implemented in full

Survey costs will vary depending on scale and location of property. Eligible costs for administration used for the Flood Defence Grant in Aid (FDGiA) scheme for household level flood mitigation are £500 per property. There is no limit for the survey element, other than it has to come out of the overall limit of funding per property (currently £4,250).

The findings of the Resilience Grant Pilot Projects for Defra (Defra 2008a) suggests that threshold surveys can add an additional £250 per property where needed. This report also suggests survey costs represent 15% of the total costs for residential property. The cost of survey if paid for individually is more likely to be £1,000 (Defra 2008a).

Based on two studies undertaken by JBA Consulting for 80 and 40 mostly residential properties the following survey costs are considered appropriate:

- Threshold survey: £25–50 per property
- Building survey: £200–400 per property (£450+ for a commercial property)
- Post-construction survey: £55–75 per property (£180+ for a commercial property)

The use of these values is suitable for an early assessment of the likely costs associated with flood resistance measures, although survey costs will vary depending on the number and type of properties involved. More detailed cost estimates would need to involve professionals with the appropriate skills and experience to provide a cost for the community being appraised.

Work undertaken for the Defra pilot scheme indicated that the costs to an organisation (including scheme administration, overheads, survey procurement and contract supervision) represent a significant cost in terms of implementation of a scheme. Allowances for these aspects should be at least 16% of the total costs, but 40% may be a more realistic value (Defra 2008a).

Table 1.1 summaries the main factors influencing administration and survey costs.

Table 1.1 Key factors influencing administration and survey costs

Factor influencing administration and survey costs	Impact on cost estimation
Size of community to be assessed	Individual properties would be more expensive to manage and survey (on a site-by-site basis) than groups of properties.
Type/size of property	Larger residential and commercial properties would increase survey cost.
Experience and training of staff undertaking and delivering measures	New techniques required to manage property level approach. Administration costs could be higher where this is undertaken for the first time.

Survey costs for resilience measures may be much higher than those for resistance measures. Flood resilience is often a reactive measure with specialist surveys required by surveyors to assess the extent of damage, building construction, drying out works and the assessment of repairs, reinstatement works and resilient alternatives. Even if resilience is undertaken proactively, specialist advice and surveys will be required to build up a schedule of works.

Household protection – resistance measure costs

The capital cost of household flood protection products represent the majority of the whole life costs as maintenance costs are minimal and longer term replacement costs will be discounted.

For an initial assessment, the costs associated with a range of measures are readily available in the literature and reports collated as part of wider research reports and studies. Defra undertook an industry consultation exercise in 2008 that provided estimated average costs for a semi-detached house. Indicative costs for temporary and permanent property-level protection were £4,000 and £8,000 respectively. These values were based on the report by Entec and Greenstreet Berman (Defra and Environment Agency 2008).

The same report also provides a model for estimated installation costs based on the costs of 'Kitemark' approved products. This information was gathered during discussions with product manufacturers. The costs were estimated for both a standard resistance option (using demountable door guards) and a premium option (using flood proof doors and additional external wall render/bricks). A range of costs are provided in Table 1.2 for the three important property types.

This analysis is generic and costs for resistance measures will be highly variable depending on the type and size of property and the type, depth and duration of flooding. The requirements for each property are likely to require bespoke solutions specific to the property. So while very simple solutions that can prevent short duration floodwaters from entering a property can be provided for relatively low costs (£1,500 (Defra 2008b), the costs may be substantially greater than those presented in Table 1.2.

Table 1.2 Indicative costs for flood protection (2008 prices)

Property type	Option	Description	Low cost	Medium cost	High cost
Residential	Standard resistance	Two demountable door guards and two airbrick covers	£1,500	£1,960	£2,380
	Premium resistance	Two flood-proof doors, two airbrick covers and external wall render/bricks (20 m)	£2,210	£3,320	£4,430
High street shop	Standard resistance	Two demountable door guards and multiple airbrick covers	£1,530	£1,960	£2,380
	Premium resistance	Two flood-proof doors, multiple airbrick covers and external wall render/bricks (28 m)	£3,750	£5,190	£6,640
Office	Standard resistance	Three demountable door guards and multiple airbrick covers	£2,300	£2,940	£3,570
	Premium resistance	Two flood-proof doors, multiple airbrick covers and external wall render/bricks (35 m)	£4,040	£5,640	£7,230

Notes: Costs are based on indicative costs associated with door guards, airbrick covers and wall rendering.
No allowance for anti-flood valves or sump and pump installation.
From Defra and Environment Agency (2008)

For initial estimates it is suggested that a complete house solution consisting of door gates and air bricks to protect against flood levels up to 900 mm could cost in the region of £2,000 to £4,000. A more secure approach involving the former options with the addition of anti-flood valves and external wall treatments would be in the region of £10,000 to £14,000 (ABI 2009).

Household protection – resilience measure costs

For an initial assessment, costs for many measures are available in literature and reports collated as part of wider research reports and studies. Defra undertook a study and industry consultation exercise in 2008 that provided estimated average costs for a semi-detached house. Indicative costs to provide flood resilience to a residential property were £10,000 to £15,000 (Defra and Environment Agency 2008).

The same study also provided a model for estimated installation costs for resilience measures. The costs were estimated for both a standard resilience option and a premium option (that included resilient flooring). A range of costs are provided in Table 1.3 for three important property types.

Table 1.3 Indicative costs for flood resilience measures

Property type	Option	Description	Low cost	Medium cost	High cost
Residential	Standard resilience	Resilient plaster, removable doors, internal wall rendering, resilient kitchen, raised electrics and appliances	£6,210	£7,830	£9,450
	Premium resilience	Concrete/sealed floors, resilient plaster, removable doors, internal wall rendering, resilient kitchen, raised electrics and appliances	£9,620	£11,870	£14,130
High street shop	Standard resilience	As above	£8,510	£10,210	£11,920
	Premium resilience	As above	£10,210	£11,920	£13,620
Office	Standard resilience	As above	£11,490	£14,040	£16,600
	Premium resilience	As above	£14,040	£16,600	£19,150

Notes: 2008 prices
 Costs are based on indicative costs provided by suppliers for each resilience measure.
 No allowance for anti-flood valves or sump and pump installation.
 From Defra and Environment Agency (2008)

Again, the analysis is generic. The costs of resilience measures will be highly variable and will depend on the type and size of property, and the type, depth and duration of flooding. The requirements for each property are likely to require bespoke solutions specific to the property and as a result the costs may be substantially greater than those presented above.

Further assessment by the Association of British Insurers (ABI) suggests that resilience repair costs are indeed greater. An ABI research paper (ABI 2009) reviewed a large number of flood repair costs and calculated the uplift costs for resilient reinstatement. While the costs relate to post flood repair and therefore incorporate costs associated with drying out and additional supervision and surveyor/insurance involvement, the costs associated with the strip out and reinstatement should be useful as a proxy for flood resilience costs. The costs are provided for a range of property types.

The costs for resilient reinstatement are provided in Table 1.4. These relate to actual repair costs with an uplift for resilient reinstatement.

Table 1.4 Costs of resilient reinstatement up to 900 mm

Date of construction	Floor	Wall	Cost (£)
Pre 1919	Suspended timber	Brick – solid	40,100
	Concrete	Brick – cavity	39,500
1919–1939	Suspended timber	Brick – solid	34,500
	Concrete	Brick – cavity	38,400
1939 to date	Suspended timber	Brick – cavity	39,000
	Concrete	Brick – cavity	32,400
	Concrete	Brick – cavity	43,700

Source: ABI (2009)

1.2 Detailed assessment

For site-specific studies it is recommended that that options for resistance and resilience measures are obtained directly from professionally qualified flood risk consultants and manufacturers for the specific products of interest. Each site will have its own site-specific requirements that relate to the length, height and type of defence system. Most manufacturers will provide unit costs and will be able to advise on installation costs of permanent fixtures and fittings, training costs and any bespoke storage that may also be supplied.

There are a large number of manufacturers. Useful sources of details of suppliers of flood resistance and resilience products include:

- National Flood Forum Blue Pages Directory <http://www.bluepages.org.uk>
- Flood Protection Association <http://thefpa.org.uk/>
- Kitemark website <http://www.kitemark.com/products-and-services/building/flood-protection.php>

Where more detailed cost assessments of household flood mitigation measures are required, it is recommended that further analysis is made following completion of the initial survey. This survey will enable informed decisions, in terms of the extent and type of any work, to be made.

Costs can be obtained from a number of suppliers to determine an estimated cost for the works required and built up from each of the separate elements required (for example, an appropriate group of measures may consist of airbrick covers, door guards and anti-flood drainage valves).

Details of costs for individual elements were collated as part of a scoping study for Defra and the Environment Agency (Bowker 2007). This report provides a comprehensive list of all available flood resistance (and resilience) measures available at that time, along with indicative costs, benefits of the measure and associated risks. A summary of the costs is provided in .

Table 1.5 Indicative costs of flood protection measures

Type of temporary flood protection system	Cost (£)	Comment
Periphery wall (based on a 40 m length)	£3,500–4,500	May require ancillary pumps (maintenance costs required) Depends on size of curtilage
Periphery wall residential gate (1.2 m)	£2,500–4,500	
Raise threshold	£1,200–1,500	
Storm porch (per door)	£5,800–8,800	Includes additional cost of locking mechanism
Additional external layer (render, bricks, facing) (per m)	£50–100	£2,500–4,000 per property assuming a 100 m ² detached house
Flood resistant door (per door)	£875–2,500	
Periscope airbricks (assumes 12 per property)	£2,500–3,000	
Automatic airbrick (assumes 12 per property)	£1,550	Includes installation costs
Flood resistant door	£750–2,500+	
Automatic door guards (domestic 2 m opening)	£8,000	Costs exclusive of ground work and construction
Anti-flood valves	£50–500	Costs exclusive of labour to fit an construct an inspection chamber
Free standing barriers (for detached house)	£5,000–12,000	Ancillary pumps may also be required
Aperture guards (per guard)	£250–750	May require additional costs to prepare and fit fixtures and fittings
Airbrick covers (assumes 12 per property)	£180–1,680	
Flood skirt (per house)	£10,000–35,000	Costs include construction, fitting and training
Sump and pump	£50–2,500	Costs depend on pump capacity and sump size

Source: Bowker (2007)

These costs can be used to build up a cost per property if a particular set of measures is known for a property. In reality, property types will vary significantly in an area at risk and will require specialist on-site surveys to build up a cost per property.

1.2.1 Factors affecting costs

Beyond the low depth, short duration flooding, the ability of the typical measures used in the Defra schemes to protect against direct entry of floodwater into a property may not provide adequate protection. Other flood mechanisms may be applicable that are much more costly to protect against. Other mechanisms include:

- hydrostatic backsurge – for properties with combined drainage and sewerage systems, water can enter surface water drainage systems and backup through downstairs washing machines, toilets and showers/baths
- water ingress through walls – typically occurs via mortar joints and therefore depends on the type of construction and depth and duration of flooding
- water ingress via hydrostatic pressure from beneath a property – depends on the ground and rock type beneath a property

Where such aspects are an issue, the costs of providing a suitable level of protection may be significantly higher than the standard approaches used more widely. The factors that influence the costs of property level flood protection measures are given in Table 1.6.

Table 1.6 Factors influencing capital costs

Factor influencing capital costs	Impact on cost estimation
Points of entry of floodwater	Combination and number of measures will vary from property to property.
Type of property	Commercial properties are generally larger than residential and will require additional components in some circumstances.
Flood depth	Standard door guards >1 m high are not recommended as high water pressure causes serious structural concerns above 1 m.
Flood duration	Brick walls will usually only keep the floodwater at bay for a short period of between 20 and 60 minutes.
Construction of property	Property construction can limit water ingress via walls and floor.

Total Flood Solutions Ltd¹ have particular experience of providing solutions where the type of flooding or type of property is not suitable for standard barrier options. Examples of costs for properties where standard approaches are not applicable are provided in Table 1.7.

The greatest cost for a residential property of £68,000 provided a system to protect a detached listed 16th century property that involved strengthening the building, veneer walling, non-return valves to the WC and sink waste, sumps with automatic pumps and lift off door barriers to doors and windows.

These examples provide an indication of the types of works required and the indicative costs per property. These costs may help to assist those undertaking detailed

¹ Personal communication, Martin McDermid

assessments of the upper limit of potential costs where a more robust solution to flood mitigation is required.

Table 1.7 Example case studies of complex flood protection

Location	Type of property	Type of flooding	Resistant measures	Cost
Thames Valley	Substantial detached house	Fluvial	New system was installed including underpinning part of the building/veneer walling, NRVs to the WC and sink waste, lift-off/swinging door barriers to doors.	£24,000
Kempsey, Worcestershire	Detached cottage	Fluvial	New system was installed including strengthening the building/underpinning, veneer walling, NRVs to the WC and sink waste, sump with automatic pump, lift-off door barriers to doors.	£26,000
	Detached listed 16th century cottage	Fluvial	New system was installed which included strengthening/underpinning the building, veneer walling, NRVs to the WC and sink waste, sumps with automatic pumps, lift-off door barriers to doors and windows.	£68,000
	Detached listed 16th century cottage	Fluvial	New system included strengthening the building, veneer walling, NRVs to the WC and sink waste, new permeable sumps with automatic pumps, lift-off door barriers to doors and windows.	£29,000
Bicester	Detached	Pluvial	System was installed which included NRVs to the WC and sink waste, sump with automatic pump, lift-off door barriers to doors.	£12,000
Stockton-on-Tees	Detached	Fluvial/pluvial	Veneer walling to the walls a retractable flood barrier to be installed across the back door of the property and a sump and pump installed to deal with rising ground water.	£18,500
Pitlochry	Detached	Fluvial	System was installed which included NRVs to the WC, sumps with automatic pumps, door barriers to doors and swinging door barrier to main river wall.	£16,000

Location	Type of property	Type of flooding	Resistant measures	Cost
Elgin	Detached medical centre	Fluvial	Veneer walling to the walls, retractable flood barriers to all door openings, NRVs to all WCs of the property.	£107,000
Unknown	Detached commercial property	Fluvial	Door barriers, NRVs, flood-proof manhole covers and frames	£16,000

Household mitigation – resilience measure costs

For site-specific studies, it is recommended that options for resilience measures are obtained directly from manufacturers for the specific options of interest. Each site will have its own requirements and needs that relate to the type, duration and depth of flooding.

There are a large number and variety of elements that can be undertaken to provide flood resilience. Typical options may include:

- move services (electrics, boilers and service meters) above a likely flood level
- install new electrical circuitry, fuse boxes and heaters at a higher level, ensuring that embedded or power cables in trunking are carried down from the ceiling and not up from floor level
- install a sump with submersible emergency power supply to help drain areas quickly after the flooding subsides
- fit backflow valves to prevent water or sewage entry from drains and sewers
- replace timber suspended floors with treated timber, concrete or lime concrete floors
- raise floor levels
- tile floors
- re-position appliances above flood levels
- raise air vents above floodwater levels
- replace mineral insulation within internal partition walls with closed cell insulation
- replace gypsum plaster with a more water resistant material, such as lime plaster or cement render on walls.
- replace doors, windows, skirting boards, architraves, doorframes and window frames with fibreglass (GRP), plastic, PVC-U or other similar water-resistant alternatives
- move kitchens and appliances to first floor rooms

Should a cost assessment of household resilience measures be required, it is suggested that this is carried out following an initial survey that informs the type of

measures required. Cost can be built up from each of the separate elements required (for example, an appropriate group of measures may consist of concrete sealed floors, resilient plaster, removable doors, raised electrics and appliances).

Details of costs for selected resilience elements were collated as part of the 2007 scoping study for Defra and the Environment Agency (Bowker 2007). The report provides a comprehensive list of all available flood resilience measures available, along with indicative costs, benefits of the measure and associated risks. A 2003 ABI report provided more detailed cost estimates (ABI 2003), with estimated costs for 34 measures for five different property types and three floodwater levels (below the damp proof course (DPC), 5 cm above the DPC and up to 1 m above the DPC). A summary of the resilience costs from the ABI report is given in Table 1.8.

Table 1.8 Cost of replacement with flood resilience alternatives assuming flooding up to 1 m in depth

	Measure	Estimated cost
1	Move service meters	£1,500
2	Move electrics	£700–1,100
3	Install one-way valves	£1,500
4	Mount boilers onto wall	£1,000
5	Replace sand–cement screeds	£500–1,000
6	Replace floor with treated timber	£3,200–5,100
7	Replace flood timbers and joists with treated timber	£3,500–6,200
8	Replace timber with wall plates with steel alternatives	£8,400–14,900
9	Install damp-proof material around floor joists	£5,200–8,400
10	Replace oak floorboards	£700–1,300
11	Remove ash bedding	£500–900
12	Replace chipboard flooring with treated timber	£800–1,400
13	Raise floor levels (includes measures 2, 7, 20, 23, 24)	£28,200–44,700
14	Replace timber floor with concrete	£7,600–12,500
15	Clean and repair airbricks	£200–300
16	Install airbricks above flood level	£300–400
17	Install a damp proof course	£5,100–9,300
18	Replace mineral insulation within internal partition walls	£600–900
19	Replace gypsum plaster	£6,300–8,200
20	Fix plasterboards horizontally	£7,200–9,300
21	Coat exterior walls	£2,400–8,000
22	Re-point brickwork	£3,900–12,800
23	Replace doors, windows, skirting boards and frames	£8,100–15,000
24	Replace door hinges	£50–80

	Measure	Estimated cost
25	Fit kitchen units with extendable feet	£1,800–2,700
26	Replace ovens with raised built under type	£700–800
27	Move kitchen to first floor	£6,000
28	Move washing machine to first floor	£600
29	Replace chipboard kitchen/bathroom units with plastic	£3,000–4,100
30	Specify least expensive kitchen	£2,000–2,800
31	Replace chipboard stiffened baths	£500

Notes: Costs based on 2003 prices.
Costs also available for alternative flood depths, property types and costs associated with replacement after a flood.

Flood resilience measures are likely to be very site-specific and dependant on a number of factors as presented in Table 1.9. At the time of writing, Defra guidance was that resilience measures are outside the scope of the grant-in-aid schemes where they form the only or main mitigation measure (that is, resistance only).

Table 1.9 Factors influencing capital costs of flood resilience

Factor influencing capital costs	Impact on cost estimation
Size of property	The greater the floor area of the property, the greater the cost is likely to be.
Type of property	Different types of property will require different options
Property wall types	Different approaches are applicable to different construction methods (for example, solid, cavity, timber framed).
Property floor types	Different approaches are applicable to different construction methods (for example, suspended timber, concrete, suspended concrete).
Depth of flooding	Depth of flooding will determine the type and number of resilience measures required.
Post flood or pre flood	Cost of works may be less if performed after a flood and as part of restoration works. However, this will not be applicable for a proactive approach to flood risk mitigation and inclusion within economic appraisal studies.
Frequency of flooding	For shallow flooding below the DPC some measures are worthwhile and cost-effective. Other measures may not be justified and cost-effective for low depth, low frequency flooding. Where flood depths are greater and flood frequencies higher, many more measures can be justified in that the investment is repaid during repeat floods.
Consent for historic or cultural buildings	Some flood protection works may require Listed Building Consent from the local planning authority for listed buildings or scheduled monuments.

1.3 Ongoing operation and maintenance costs

1.3.1 Inspection and maintenance

Operation costs for installation of measures will be negligible as implementation will be by homeowners. Household property measures will require a degree of maintenance costs to minimise the risk of operational failure during a flood. The degree of maintenance required will depend on the type of measure implemented, but may require intermittent or annual inspections and maintenance by qualified personnel to ensure that all elements are in good working order.

Costs for this work should be defined through discussions with the manufacturer. Typical costs for maintenance work used for past studies have assumed a value between 1%² and 5%³ of the purchase cost of the measures.

Inspection and maintenance costs for resilience measures are effectively zero.

1.3.2 Asset replacement costs

To be able to compare options as part of an appraisal, the long-term costs need to be determined over the entire appraisal period. In the cases where the appraisal period is greater than the asset design life the replacement costs may need to be considered.

Replacement costs for household measures should be similar to the purchase costs, although costs for survey and permanent elements such as additional rendered/wall external layers would not be required. Design lives for household flood measures used in previous studies have been between 20 and 30 years. This assumes that all elements of the system or package remain effective and continue to provide the homeowner with the benefits.

While manufacturers may indicate that individual elements may have a design life longer than 20–30 years, poor maintenance, neglect or residential mobility will reduce their effectiveness and design life.

A decision by the appraising authority is required to decide whether these costs should be incurred by the owner or the organisation undertaking the works.

1.3.3 Associated new or upgraded flood warning and forecasting systems

Unless systems are designed to be closed automatically or do not require closure (for example, automatic door guards and flood resistant doors), the provision of household resistance measures requires a reliable flood forecasting and warning system to inform homeowners.

Should a community-based approach to flood resistance measures be the preferred option, it is important to consider whether there is a reliable flood forecasting and warning system in place, and if not, whether an existing system be upgraded or an alternative provided.

² 1% was used for Defra and Environment Agency (2008)

³ 3% was used within the Defra (2008) consultation on policy options for promoting property-level flood protection and resilience, though some responders suggested that a value of 5% was more appropriate.

The costs of providing this will depend on the site in question and availability of flood warning. Costs should be determined if necessary and particularly if a new system is required. Whether the costs for this should be offset against other benefits to the wider community should be reviewed by the appraising organisation. Example costs for these systems are provided in flood warning and forecasting section evidence summary.

1.4 Cost estimation methodology

The flow diagram in Figure 1.1 summarises the key aspects required to generate a whole life cost for property level flood resistance measures.

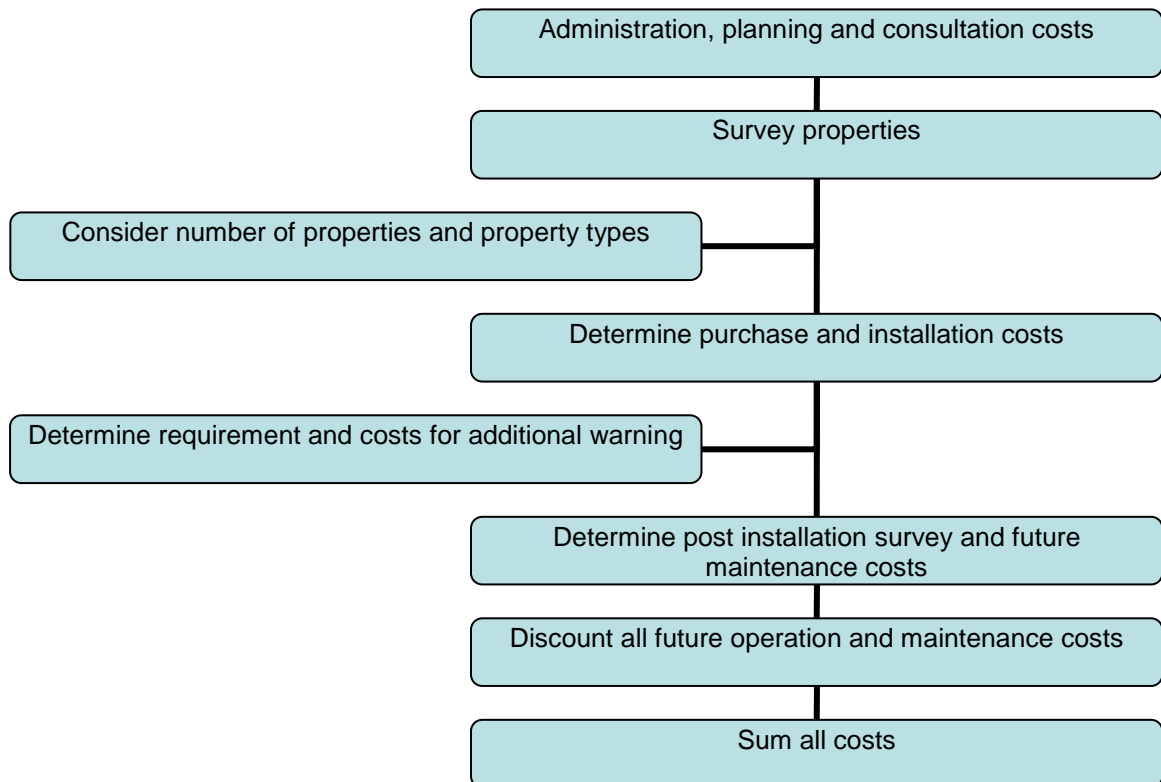


Figure 1.1 Flow diagram for channel whole life costs

1.5 Case studies

1.5.1 Alconbury scheme

The villages of Alconbury and Alconbury Weston in Huntingdonshire have a long history of flooding, with a number of significant flood events over the past 40 years which have affected many properties in both villages. Most notable were the floods of July 1968 and Easter 1998.

Huntingdonshire District Council was awarded funding from both Defra and the Environment Agency's Regional Flood Defence Committee totalling £428,000 to mitigate flooding to approximately 82 homes in Alconbury and Alconbury Weston using a variety of measures including flood boards, airbrick covers and non-return valves. The majority of the properties are individual with 15 being listed, mostly grade II.

JBA Consulting won a tendering process to carry out the property threshold surveys; building surveys, make recommendations for flood mitigation measures to each property, and following the construction phase, undertake a post-construction inspection. Contractors Breheny were appointed by Huntingdonshire District Council to undertake the construction phase.

A total of 75 properties including detached, semi-detached and terraced properties were included in the scheme. The average and maximum cost per property is shown in Table 1.10. Average unit costs supplied by Huntingdon District Council for particular measures are included in Table 1.11.

Table 1.10 Mean and maximum cost per property by property type for Alconbury case study

Property type	Mean cost per property (£)	Maximum cost per property (£)	Number of properties
Detached	3,770	9,820	39
Semi-detached	3,760	6,560	12
Terraced	2,600	7,560	15

Table 1.11 Mean and maximum cost per protection measure for Alconbury case study

Measure	Mean unit cost (£)	Maximum cost (£)	Minimum cost (£)
Door protection 700–1,000 mm wide	300	350	290
Door protection 1,000–1,500 mm wide	660	1,150	350
Door protection 1,500–2,000 mm wide	1,220	1,750	290
Door protection 2,000–4,500 mm wide (garage)	1,900	5,450	770
Window protection	620	–	–
Airbrick (up to 33 required)	70	–	–
Vent cover (up to four required)	70	–	–
Toilet back flow valve (up to seven required per property)	130	180	50
Back water valve (up to six required per property)	50	–	–
U-bend toilet bung	50	–	–
Repointing of brickwork and masonry (£380 per day)	960	1,900	190
Provisional sum for materials and so on	200	500	200

Notes: Data provided by Chris Allen, Huntingdonshire District Council

1.5.2 Carlisle case study

Following flooding in January 2005, a recovery programme was put in place, utilising part of funding provided by central government in April 2005 to assist with the flood recovery. One of the areas of spend was on a pilot project for flood mitigation work to properties in the rural areas, which were not to be protected by the engineered flood resilience programme to be provided by the Environment Agency.

A tendering process was entered into with approved companies that could provide BS kitemarked products and which had appropriate experience in the marketplace. The successful tenderer was Floodguards Systems Ltd, Wokingham. The scheme incorporated flood protection measures to 79 residential properties.

As part of the scheme a multi-partnership approach was utilised to provide appropriate expertise to deal with all eventualities and to make the correct decisions at the right time. Partners included the Environment Agency, Communities Re-united, Cumbria Community Foundation, Carlisle Housing Association, Private Landlords Association, St Martin's College, Cumbria Constabulary, Government Office North West, Citizens Advice Bureau and Voluntary Services.

In terms of costs per property, there was a considerable difference between the cheapest and the most expensive property to provide the flood-guard protective shells to. These ranged from approximately £1,700 at the lower end to £11,000 at the upper end. The total cost was approximately £300,000, and the 79 properties were protected at an average cost of approximately £3,800. Average unit costs for specific door/window guards and other aspects are provided in Table 1.12.

Table 1.12 Mean and unit costs per property measure for Carlisle case study

Measure	Mean unit cost (£) (2006 costs)
Standard door guards	750
Patio doors/garage door guards	950
Garage doors that had an internal door to the house	950
Low sill windows	750–900
Standard airbrick covers	120
Door channels (where the wall-fixed back frame could not be fixed, without digging out the step)	300–400

Notes: Supplied by Allan Dickson, Carlisle Council

An important finding from the Carlisle scheme was that the costs for the works were not particularly dependent on the size of the property but were directly linked to the number of openings it had. For example, the lowest cost was for a one-bedroom bungalow, which had two external doors and two airbricks. The most expensive was a detached six-bedroom farmhouse with two patio doors, three external doors, two low window sills and numerous airbrick covers. Conversely a large stone-built house had a relatively low cost as a result of no air bricks, a concrete floor and only two door openings.

This finding has important implications for any detailed assessment and the requirements for site inspection and investigation necessary before household protection measures are implemented.

1.5.3 Flood resilience measures

A Norfolk Council/Norwich Union research project fitted resilience measures to a housing association house to promote and demonstrate this option. The measures took 12 weeks to fit and at a total cost of £24,000 (Bowker 2007). Measures included:

- ceramic tiled floors, walls and skirting
- walls re-plastered up to 1 m above floor with Limelite Renovating Plaster
- new internal doors, frames and linings for ease of removal
- concrete bottom stair
- main appliances and base kitchen units raised on plinths
- stainless steel kitchen
- new sockets for freezer and oven, raised electric sockets, phone and TV points
- new waste system and double check valves to prevent sewer back flows
- dishwasher and washing machine with double check valves to stop back flow
- toilet bung to be fitted by resident when required

1.6 Checklist

Use the checklist to:

- identify the key cost elements required for watercourses
- ensure all relevant whole life costs are incorporated into the cost estimate

Whole life cost estimate checklist for household flood resistance and resilience measures

Item	Description	Frequency	Comment
Capital			
Administration	All costs associated with management liaison and planning aspects	One-off	May also be recurring costs
Survey	All costs associated with property surveys	One-off	
Measures	Combination of a range of measures necessary for each property	One-off	
Warning system	Costs for any specific warning or telemetry system	One-off	Will require maintenance
Operation and maintenance			
Inspection and maintenance	Costs associated with inspection and maintenance	Annual or intermittent	Only relevant to resistance

1.7 R&D and general information

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