Estimating the economic costs of the 2015 to 2016 winter floods

January 2018

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Executive summary

At a national scale, the winter floods of 2015 to 2016 were the most extreme on record according to the intensity of the rainfall, resulting in widespread flooding during December 2015 and January 2016 – primarily in the north of England. This report describes the methods used to produce a high-level economic estimate of the costs resulting from the winter floods in England following Storms Desmond, Eva and Frank in December 2015.

The approaches adopted in this study are based on the methods and extensive research used for 3 previous reports published by the Environment Agency: 'The costs of 2007 floods in England'; 'Assessing the economic costs of floods'; and 'The costs and impacts of the winter 2013 to 2014 floods'.

Applying these approaches, the best estimate of economic damages for the winter 2015 to 2016 floods is £1.6 billion, with a range of £1.3 billion to £1.9 billion to take account of uncertainty. These figures are the sum of the economic damages estimated for a set of different impact categories, taking care to avoid the risk of double counting where possible from the detail of the available data. The table below presents the best estimates for the different impact categories together with an indication of their uncertainty rating.

Best estimate of economic cost of winter floods 2015 to 2016 by impact category with uncertainty rating and estimate range (2015 prices)

Impact category	Best estimate (£ million)	Low (£ million)	High (£ million)	Uncertainty rating
Residential properties	£350	£308	£392	Medium to low
Businesses	£513	£410	£616	Medium to low
Temporary accommodation	£37	£31	£43	Medium to low
Vehicles, boats, caravans	£36	£31	£41	Medium to low
Local authorities (excluding roads)	£73	£55	£92	Medium to high
Emergency services	£3	£3	£3	Medium to low
Flood management asset and service	£71	£63	£78	Low
Utilities – energy	£83	£75	£91	Low
Utilities – water	£21	£16	£26	Medium to high
Transport – rail	£121	£103	£139	Low
Transport – roads	£220	£165	£275	Medium to high
Agriculture	£7	£6	£8	Medium to low
Health	£43	£32	£54	High
Education	£4	£3	£5	High
Other (wildlife, heritage and tourism)	£19	£13	£25	High
Total	**£1.6 billion**	**£1.3 billion**	**£1.9 billion**	

The nature of the economic costs follow a similar pattern to the damages associated with the 2007 and the 2013 to 2014 floods, with property and transport damages dominating. However, business property damages were significantly larger than household property damages in the 2015 to 2016 floods – a pattern not normally expected and not seen in the 2007 and the 2013 to 2014 floods. In terms of scale, the economic damages from the 2015 to 2016 winter floods are similar to the 2013 to 2014 winter floods. The 2007 floods, which took place in the summer, are by some margin the largest in terms of economic damages of these 3 flood events.

The assessment of uncertainty used to inform the range for the 2015 to 2016 floods is based largely on the availability and quality of the data on damages, and the number and type of assets affected. One of the most challenging aspects of the analysis affecting the certainty of estimates is the lack of primary data on flood damages, especially for major impact categories such as residential and business properties.

The report concludes by recommending 2 actions that could help to reduce uncertainty in the estimation of flood damages for future events, as well as supporting the appraisal of different options to reduce future flood risk.

- The availability of disaggregated information from the insurance industry would significantly improve confidence in future estimates of flood damages.
- The development of data sharing agreements with key partners is likely to be the most important step that can be taken to improve the basis on which the damage estimates are made.

Contents

1. Introduction

This report describes the methods used to produce a high-level economic estimate of the costs resulting from the winter floods in England following Storms Desmond, Eva and Frank in December 2015.

The approaches adopted in this study are based on the methods and extensive research used for 'The costs of 2007 floods in England' (Environment Agency 2010a), 'Assessing the economic costs of floods' (Environment Agency 2013) and 'The costs and impacts of the winter 2013 to 2014 floods' (Environment Agency 2015).

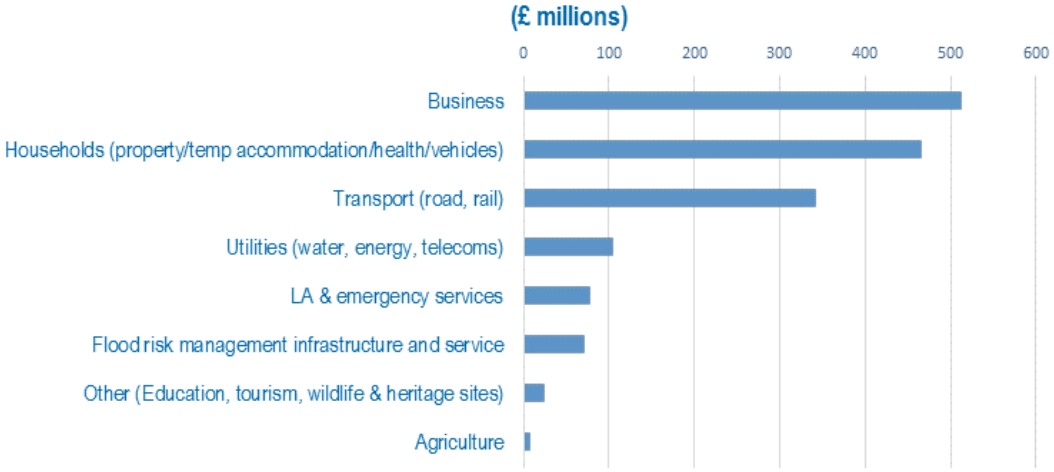
Applying these approaches, the best estimate of economic damages for the winter 2015 to 2016 floods is **£1.6 billion, with a range of £1.3 billion to £1.9 billion** to take account of uncertainty (Table 1 and Figure 1).

Table 1: Best estimate of economic cost of winter floods 2015 to 2016 by impact category with uncertainty rating and estimate range (2015 prices)

Impact category	2015 to 2016 winter floods (£ million)	Uncertainty rating	Range ± (%)	Low (£ million)	High (£ million)	Benefit from further research
Residential properties	£350	ML	Bespoke	£308	£392	H
Businesses	£513	ML	15%	£410	£616	M
Temporary accommodation	£37	ML	15%	£31	£43	L
Vehicles, boats, caravans	£36	ML	15%	£31	£41	L
Local authorities (excluding roads)	£73	MH	25%	£55	£92	H
Emergency services	£3	ML	15%	£3	£3	L
Flood risk management infrastructure and service	£71	L	10%	£63	£78	L
Utilities – energy	£83	L	10%	£75	£91	L
Utilities – water	£21	MH	25%	£16	£26	L
Transport – rail	£121	L	10%	£103	£139	L
Transport – roads	£220	MH	25%	£165	£275	H
Agriculture	£7	ML	15%	£6	£8	L
Health	£43	H	30%	£32	£54	M
Education	£4	H	30%	£3	£5	L
Other (wildlife, heritage and tourism)	£19	H	30%	£13	£25	M
Total	**£1.6 billion**			**£1.3 billion**	**£1.9 billion**	

Notes: H = high; MH = medium to high; M = medium; ML = medium to low; L = low

Figure 1: Best estimate by impact category of economic costs for winter floods 2015 to 2016 (2015 prices)



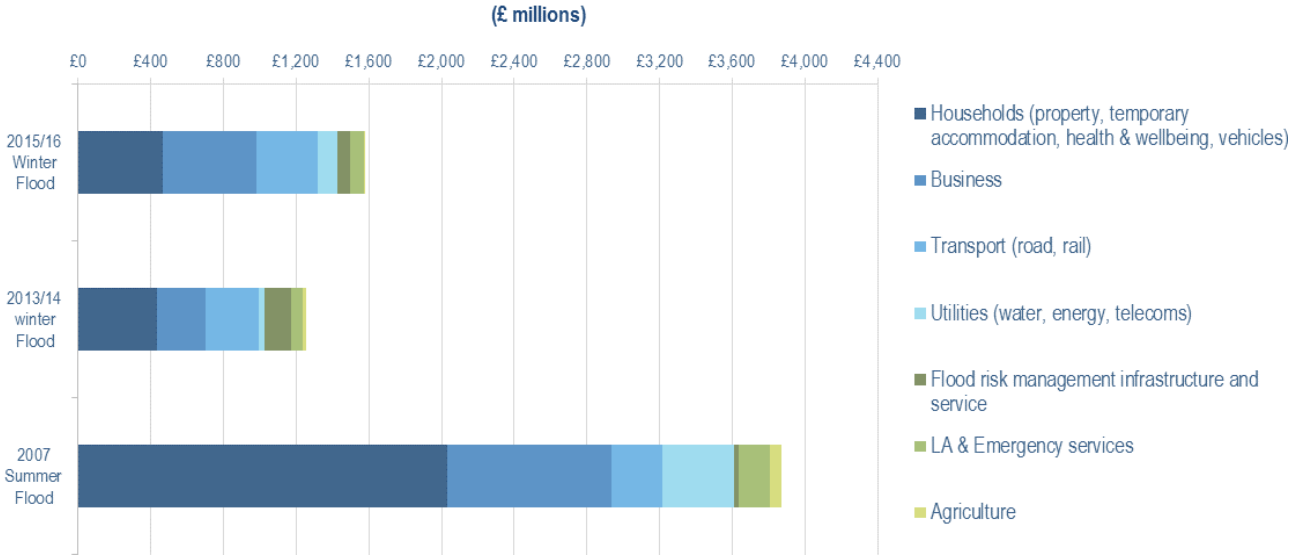
The characteristics of the economic costs of the 2015 to 2016 winter floods follow a similar pattern to those of the summer floods in 2007 and the winter flooding in 2013 to 2014, with property and transport damages dominating (Table 2). However, it is notable in the 2015 to 2016 floods that business property damages were significantly larger than household property damages – a pattern not normally expected.

In the overall scale of costs, the 2015 to 2016 floods at £1.6 billion are similar to the £1.3 billion of the 2013 to 2014 winter floods. The 2007 floods remain, by some margin, the largest economically with costs of £3.9 billion (all in 2015 prices) (Figure 2).

Table 2: Comparison of economic costs by flood event by impact category (2015 prices)

Impact category	2007 (summer floods) (£ million)	2013 to 2014 (winter floods) (£ million)	2015 to 2016 (winter floods) (£ million)
Residential properties	£1,500	£320	**£350**
Businesses	£910	£270	**£513**
Temporary accommodation	£120	£50	**£37**
Vehicles, boats, caravans	£98	£37	**£36**
Local authorities (excluding roads)	£170	£57	**£73**
Emergency services	£5	£3	**£3**
Flood risk management infrastructure and service	£24	£147	**£71**
Utilities (energy and water)	£398	£30	**£104**
Transport (roads, rail, air, ports)	£310	£295	**£341**
Agriculture	£59	£19	**£7**
Health	£340	£25	**£43**
Education	£14	£2	**£4**
Other (wildlife, heritage and tourism)	–	£13	**£19**
Totals	£3.9 billion	£1.3 billion	**£1.6 billion**

Figure 2: Comparison of economic costs by flood event by grouped impact categories (2015 prices)



2. Background

> At a national scale the winter floods of 2015 to 2016 were the most extreme on record. The November to January period was the wettest three-month sequence in the UK rainfall series. (Terry Marsh, Centre for Ecology and Hydrology)[1]

December was a record-breaking month for rainfall in some parts of the UK, with exceptional amounts of rain falling onto already saturated ground. Several of the major flood events were associated with named storms (Table 3). As a result of Storm Desmond over the weekend of 5 and 6 December, England experienced the highest levels of rainfall ever recorded in a 24-hour period. Parts of Cumbria were evacuated and around 7,000 properties were initially reported as flooded. During that time the Environment Agency estimates that flood defences successfully protected 10,900 properties against flooding.

On 24 December, following Storm Eva, a further 9,000 properties were reported as flooded over the Christmas period in Yorkshire, Lancashire, Greater Manchester and Merseyside. The Environment Agency estimates that 12,500 properties were protected by Environment Agency flood defences following Storm Eva.

Table 3: Named storms in winter of 2015 to 2016

Name	Date of impacts (UK/Ireland)
Abigail	**12–13 November**
Barney	17–18 November
Clodagh	29 November
Desmond	**5–6 December**
Eva	24 December
Frank	**29–30 December**
Gertrude	**29 January**
Henry	1–2 February
Imogen	8 February
Jake	2 March
Katie	27–28 March

Notes: The storms with the greatest hydrological impacts are marked in bold.
Source: Marsh et al. (2016, Table 1)

At the height of the flooding, 31 severe flood warnings were in place. Resources and personnel were deployed to where they were most needed; the multi-agency response to the flooding was organised rapidly, with the army and flood prevention assets deployed from day one and emergency funds paid out to local authorities in record time by central government. COBR met 14 times (including daily between Christmas Eve and New Year's Eve) to assess impacts and to co-

[1] Terry Marsh in the CEH press release about the report (http://www.ceh.ac.uk/news-and-media/news/uk-winter-20152016-floods-one-century%E2%80%99s-most-extreme-and-severe-flood-episodes)

ordinate where, and how, to most effectively deploy further resources from across government to support affected communities.

The Environment Agency, fire, police, other emergency response staff, military personnel, the voluntary sector and utility providers worked around the clock to help those affected. People evacuated from their homes were provided with assistance and shelter. Pumps were deployed in the affected areas and over 2.4km of temporary flood defences were erected. Emergency maintenance was carried out on permanent flood defences damaged by floodwater and debris. Throughout the event, Field Teams cleared blockages in watercourses to keep water flowing and Environment Agency incident rooms continued issuing messages warning and informing the public on local and national flood risks.

Over 1,700 military personnel were drafted in to support the rescue and recovery efforts, with around 700 deployed on the ground at any one time. The RAF played a vital role in delivering power generators to the Foss Barrier in York and repairing defences in Croston in Lancashire, using a Chinook helicopter.

The voluntary sector also played an important role: the British Red Cross, Salvation Army, Churches Together, RNLI, RSPCA and many other organisations – too many to mention – all supported those affected during the response and continue to do so in the recovery phase. The emergency services, the military, the Environment Agency, council staff and other responders were tireless in their response.

3. Methodology

3.1. Impact categories

Economic damages for flood events are estimated through a set of impact categories. These are then added together to give the total damages, taking care to avoid the risk of double counting where the detail of the available data allows.

Based on previous research for the 2007 and the 2013 to 2014 cost of floods reports and the development of the Environment Agency's Floods Cost Calculator in 2012, the impact categories included in this study are:

- **Residential property damages**: physical damage to residential properties and contents
- **Non-residential (including business property damages)**: physical damage to non-residential (including business) properties and contents
- **Temporary accommodation**: the costs of temporary accommodation
- **Vehicle damage**: physical damage to vehicles
- **Public health**: an estimate of additional psychological distress caused to households as a result of flooding
- **Emergency services**: additional costs (for example, overtime) incurred by the emergency services (fire, police and ambulance services)
- **Local authorities**: damages to public buildings, public spaces and additional costs faced by local authorities such as recovery grants (damages to local roads are considered in the transport section)
- **Education**: welfare costs of education days lost
- **Transport**: costs of repairs and induced losses from disrupted journeys for road and rail
- **Utilities**: costs for repairs and induced losses caused by loss and/or interrupted utility services for water and electricity
- **Flood risk management infrastructure and service**: cost of repairs to flood defence assets and additional service costs including staff and contractor overtime and materials
- **Agriculture**: damage to agricultural land, including losses of output and additional production costs
- **Other including tourism, heritage and wildlife sites**: damage to physical assets and, where possible to determine, indirect impacts on the wider economy

The estimates for these categories were calculated through a desk-based study using national level data obtained from a range of partner organisations including:

- Association of British Insurers (ABI)
- Department for Communities and Local Government (DCLG)
- Department for Energy and Climate Change (DECC) (now part of the Department for Business, Energy and Industrial Strategy)
- Highways Agency
- National Farmers' Union (NFU)
- Network Rail
- Rural Payments Agency
- water companies

3.2. Economic damages

It is important to note that the economic estimates for each of the impact categories described in this report cannot be compared directly to financial estimates such as the value of publically reported insurance claims.

Economic costs differ from financial costs as they estimate costs at a national level versus at an individual household, business or local area level. In practice this means adjusting financial costs to 'turn them into' economic costs. These adjustments include:

- taking account of transfers (such as taxes and subsidies)
- displacement of economic activity from one part of the economy to another[2]
- betterment[3]

In addition, economic assessments seek to account for welfare damages. These are typically things people care about (value), but are not necessarily easy to price. For example, economic welfare damages seek to estimate the stress and health impacts people suffer from being flooded, and the inconvenience incurred from delayed journeys by trains or roads, or losing access to their electricity and/or water services as a result of flooding.

The approaches used to make adjustments for each impact category are detailed in Section 4. Below is a summary of some of the main adjustments, which have been adopted from previous research for the 2007 and 2013 to 2014 cost of floods reports.

3.2.1. Insurance claims

Insurance claims data from ABI are adjusted to provide an economic cost estimate as follows.

- Value added tax (VAT) is removed at a rate of 20%.
- An inventory to non-inventory split of 75% to 25% is used for residential properties. This assumes that 75% of domestic insurance claims are for household contents ('inventory'), with the remaining 25% for building repairs.
- For non-residential (business) properties, the inventory to non-inventory split is assumed to be 45% to 55%.
- For the inventory items, adjustments for betterment are assumed at a rate of 50% for both residential and business.
- It is assumed only 75% of households and 95% of non-residential properties have insurance. Adjustments are made to compensate for the assumed underinsurance rates.

3.2.2. Costs not covered by insurance

Other repair and damage costs not thought to be covered by insurance are also considered to be financial costs and are adjusted for VAT and betterment to provide an economic estimate. It is recognised, however, that in certain cases the asset that was damaged and required repair or replacement was of equal quality or condition to a new asset (potentially the case for well-maintained flood defences), effectively resulting in a like-for-like replacement. Due to the lack of information on the condition of each asset damaged during a flood, a default betterment figure of 50% is considered a reasonable approach (as used in previous studies).

3.2.3. Grant money

In the absence of any better estimates, grant money is used as a proxy for the economic costs to the different stakeholders and is therefore unadjusted. These include different grants to different stakeholders such as the Severe Weather Recovery Schemes and Bellwin Scheme to help local authorities; but also flood support schemes to businesses such as the Repair and Renewal Grant Scheme and tax reliefs. However, this approach probably underestimates the total costs particularly as, in certain cases, the amount of grant funding received is capped such that the total private costs may not be covered by grants.

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[2] For example, flooding might temporarily reduce local tourism through lost visitors. These visitors may instead choose to visit a different location in England, or spend their income on other goods and services in the economy. So while the loss of visitors may be felt locally, nationally the economic value is retained as it has been displaced to alternatives within the economy or just delayed.

[3] Typically, something damaged by flooding will be replaced with an improved, more up-to-date version. So adjustments for betterment ensure that what is valued is the older item that was actually lost or damaged by the flooding (remaining value), rather than assuming the damage cost is equivalent to the cost of the replacement with the new/better/improved item.

3.2.4. Welfare impacts

Any data on welfare impacts that occurred as a result of the flooding events are considered to be an economic cost and are not adjusted.

Unless otherwise stated, all figures in this report are presented in 2015 prices.

4. Damage estimates by impact category

4.1. Damages to residential properties

The **best estimate for residential property damages is £350 million, with a range of £308 million to £392 million**, based on ABI claims information and DCLG estimates of the number of residential properties flooded.

Residential property damages consist of direct damages to building fabric, damage to inventory items and clean-up costs. Ideally, to assess property damages, it is necessary to know the number of properties affected and the average loss per property type. Both variables are difficult to determine accurately due to errors and inconsistencies in the data.

DCLG estimates that Storms Desmond and Eva led to 20,925 properties being damaged by flooding: 15,981 residential and 4,944 business (73% and 27% of the total respectively) (Table 4). ABI reported 9,700 residential insurance claims, from which a total of £480 million was paid out to households affected by the winter flooding. This gives an average financial residential insurance claim of approximately £50,000.[4]

Table 4: DCLG estimates of properties damaged by flooding from Storms Desmond and Eva, December 2015 and January 2016

	Total properties flooded		Residential properties	Business properties
	Number	Percentage		
West Yorkshire	8,198	39%	5,753	2,445
Cumbria	6,344	30%	5,316	1,028
Lancashire (and Blackburn)	2,567	12%	2,029	538
Greater Manchester	2,284	11%	1,760	524
North Yorkshire (and York)	1,142	5%	847	295
Northumberland	269	1%	185	84
Merseyside (Sefton, St Helens)	49	<1%	46	3
Warrington	36	<1%	17	19
County Durham	24	<1%	23	1
Herefordshire	12	<1%	5	7
Total number of properties	20,925		15,981	4,944

Source: DCLG

According to DCLG data, approximately 16,000 residential properties were damaged by flooding yet ABI reports that only approximately 10,000 insurance claims were made. While it is recognised ABI may not have complete coverage of the insurance market these figures do suggest a large number of households flooded made no insurance claim for damage. This is unusual, as typically

[4] Personal correspondence from ABI confirmed that these figures include temporary accommodation costs.

more insurance claims than properties damaged is expected as households often make more than one insurance claim.

This apparent discrepancy in the 2015 to 2016 data suggests that there is either a high rate of underinsurance for residential properties, or the number of residential properties actually damaged by the floods is currently an overestimate, or a mixture of both. There is some anecdotal evidence to suggest there was a high degree of underinsurance but as yet this has not been confirmed.

Given this apparent discrepancy between the number of flood damaged properties and the number of insurance claims made, a high and low estimate for residential property costs has been calculated and the midpoint between them taken as the best estimate.

The first method is the same used for the 2007 and 2013 to 2014 floods to estimate residential property damages and calculates economic damages of £308 million (Low estimate in Box 1). The second method, the high estimate, assumes every property thought to have been flooded has financial damages of £50,000 (that is, the average ABI household claim value). This method provides an estimate of £392 million (High estimate in see Box 1).

Since the evidence is not available to decide the extent to which the number of damaged properties is overestimated or true extent of underinsurance, taking the midpoint between these 2 estimates is recommended. This gives a best estimate of £350 million for damage to residential properties in the 2015 to 2016 winter floods. This makes residential properties the second largest impact category by value of damages for the 2015 to 2016 winter floods after businesses (Table 1).

Box 1: Best estimate of economic residential property damages for 2015 to 2016 winter floods

Best estimate of residential property damages (£350 million) = Low estimate (£308 million) + High estimate (£392 million)/2

Low estimate of residential property damages (£308 million) = ABI residential insurance costs – temporary accommodation costs + adjustment for underinsurance – economic adjustments

where:

- ABI value of residential property claims (£480 million) = ABI public data and personal correspondence
- adjustment for temporary accommodation costs (£443 million) = £480 million – £37 million (see Section 4.4)
- adjustment for underinsurance (£591 million) = £443 million/0.75
- adjustment for economic estimate (£308 million) = [(£591 million × 0.75 × 0.5) + (£591 million × 0.25)]/1.2
- economic adjustments = VAT 20%, inventory items75% of insured damages, remaining value 50%
- an average insurance penetration rate for domestic properties of 75% is assumed

High estimate of residential property damages (£392 million) = (DCLG estimated number of properties damaged by flooding × average economic cost property) – temporary accommodation costs

where:

- number of residential properties damaged by flooding (15,981) = DCLG reported numbers
- ABI financial cost per household (49,485) = from ABI data

- economic unit cost per residential property (£24,599) = [(ABI financial cost per household × 0.75 × 0.5) + (ABI financial cost per household × 0.25)]/1.2
- economic adjustments = VAT 20%, inventory items 75% of insured damages, remaining value 50%
- temporary accommodation costs = £37 million (see Section 4.4)

Key uncertainties

- Levels of underinsurance
- Average property claim per household (which may be skewed depending on the levels of underinsurance)
- Economic adjustments for VAT and betterment

4.2. Damages to non-residential properties (including businesses)

Many business properties were flooded during the winter 2015 to 2016 floods, resulting in damage to premises, equipment and fittings, and loss of stock. They also suffered disruption of business. The **best estimate for non-residential, business property damages is £513 million**, with a range of £410 million to £616 million, based on ABI claims information.

The method used to estimates business costs is the same as used in the 2007 and 2013 to 2014 cost of floods reports for business property damages (see Box 2). This method was chosen as the ABI data appear more consistent with the DCLG numbers for business properties flooded than is the case for residential properties, that is, there was a small difference between the number of insurance claims (5,600) than properties estimated to be damaged (4,944).

ABI states that 5,600 claims were made by businesses, from which £754 million was paid out by insurers, giving an average financial value of £134,696 per claim (though it is known from research in 2007 that the average business claim tends to be heavily skewed by a small number of businesses with very large flood damage costs).

Based on the insurance data, business property damages are estimated at £513 million. This makes business properties the largest category of economic damages for the 2015 to 2016 winter floods (Table 1).

Box 2: Best estimate of economic non-residential property damages for 2015 to 2016 winter floods

Best estimate of non-residential property damages (£513 million) = ABI non-residential insurance costs + adjustments for underinsurance – economic adjustments

where:

- ABI value of residential property claims (£7,540 million) = ABI public data and personal correspondence
- adjustment for underinsurance (£794 million) = £754 million/0.95
- adjustment for economic estimate (£513 million) = [(£794 million × 0.45 × 0.5) + (£794 million × 0.55)]/1.2
- economic adjustments = VAT 20%, inventory items 45% of insured damages, remaining value 50%
- an average insurance penetration rate for business properties of 95% is assumed

Key uncertainties

- Levels of underinsurance
- Average property claim per business (which may be skewed depending on the levels of underinsurance)
- Economic adjustments for VAT and betterment

4.2.1. Key uncertainties in property damage estimates (residential and non-residential)

ABI data provide a reliable national source of data on the financial costs of property damages after floods have occurred. However, uncertainties arise from the assumptions needed to take account of underinsurance and the assumptions used to make economic adjustments to financial data. The assumptions for underinsurance and economic adjustments used in this report are the same as those applied in the 2007 and 2013 to 2014 cost of floods reports. Data and anecdotal evidence suggest that the assumptions for underinsurance in particular would benefit from being reviewed. For example, there is anecdotal evidence from media reports of a high level of underinsurance in Carlisle. This supports a similar view from KMPG which, following the floods, estimated underinsurance might be as high as £1 billion (financial estimate) (KMPG 2015).

Given that property damages accrue the largest flood damages out of the impact categories, the more accurately property damages can be estimated the better. This means it is important to understand the levels of underinsurance when using ABI information as the basis of cost estimates. While the introduction of FloodRE[5] should act to reduce underinsurance in residential properties, the overall picture of underinsurance for both residential and business properties remains unclear and merits further investigation.

4.2.2. Comparison of property damages with previous floods (2007and 2013 to 2014)

Direct property damages dominate the total costs for all 3 flood events, with property damages accounting for 62%, 56% and 53% of total costs for the 2007, 2013 to 2014, 2015 to 2016 floods respectively. In absolute terms, the summer 2007 floods remain the largest, both in terms of the number of properties flooded and the associated economic costs (Table 5).

A comparison of costs between residential and business is also worth noting. In 2015 to 2016, business damages are significantly higher (an additional £163 million more) than residential damages. This is in contrast to the 2007 and the 2013 to 2014 floods where residential costs dominated (Table 5).

Looking at estimated costs per property, the average economic damages per property remain broadly similar across the 3 events. For business properties, however, the average costs appear to be increasing faster with each flood event – even with inflation taken into account. Further data and research would be needed to understand why this might be. Is this a genuine trend due, for example, to rising labour costs or is it due to uncertainties in the data, or a random effect?

The opportunity to analyse representative samples of property level ABI insurance data would greatly improve understanding of property flood damages for both residential and business properties. At present, only single aggregated national figures are available from ABI and these are something of a blunt instrument.

4.2.3. Understanding impact category costs as a percentage of total costs and property costs

Understanding the costs of floods on different impact categories as a percentage of total costs (sum of costs of all impact categories) and property damages (sum of both residential and

[5] FloodRE is a government and insurance industry re-insurance scheme that helps homeowners in need of insurance in flood risk areas

business damages to property) is useful for helping to predict the economic damages of future flooding (see Annex A).

This approach has been used to help develop the Environment Agency's Floods Cost Calculator (Environment Agency 2013) and to provide percentage values to support the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) for flood defence and coastal erosion investments (Environment Agency 2010b).

The Floods Cost Calculator is used by the Environment Agency to help estimate the national economic costs of flood events when data are limited (that is, there is only an estimate of the number of properties damaged by flooding). This makes the calculator particularly useful for estimating costs rapidly during a flood event before the more detailed data become available, which is usually sometime after the floodwater has receded.

The calculator makes the assumption that most (but not all) impact categories are related to the number of properties damaged by flooding, albeit to a greater or lesser extent, such as vehicles, temporary accommodation, public health, emergency services and roads. Thus understanding damages in relation to property damages can be a useful proxy for estimating other damages. In the remainder of this report, the assessment of each impact category includes both its percentage contribution to total damages and a percentage of property damages.

Table 5: Comparison of economic property damages for different flood events (2015 prices)

Flood event	Residential properties					Non-residential, business properties				
	Estimated property numbers damaged by flooding[1]	Best estimate of economic damages[2] (£ million)	Percentage of total economic damages	Average financial cost per property	Average economic cost per property	Estimated property numbers damaged by flooding[1]	Best estimate of economic damages[2] (£ million)	Percentage of total economic damages	Average financial cost per property	Average economic cost per property
2015 to 2016 (winter)	16,000	£350	22%	£46,000[3] £35,000[3] £24,000[3]	£24,000[6] £18,000[6] £12,000[6]	5,000	£513	32%	£153,000[7]	£99,000[9]
2013 to 2014 (winter)	10,500	£320	25%	£44,000[4]	£23,000[6]	3,100	£270	21%	£127,000[7]	£82,000[9]
2007 (summer)	48,000	£1,500	38%	£31,000[5]	£19,000[6]	7,000	£900	23%	£113,000[8]	£75,000[9]

Notes:
[1] Rounded to the nearest hundred for ease of comparison.
[2] Note that the 'best estimate of damages' does NOT equal the 'number of properties' multiplied by the 'average economic cost' due to assumptions regarding underinsurance for both residential (25%) and business properties (5%), a different methodology for the 2015 to 2016 residential estimate (see Section 4.1) and rounding.
[3] Value of ABI claims data divided by the number of ABI household claims made, with the costs of temporary accommodation removed (see Section 4.1).Note there is significant uncertainty in the average value of damages for the 2015 to 2016 floods given the apparent discrepancy between the number of residential properties damaged by flooding and the number of household insurance claims made. If the same method as for the 2013 to 2014 floods is used, the unit financial value would be £24,000 with an economic value of £12,000. The midpoint between the 2 methods puts the financial costs per property at £35,000 and £18,000 for economic costs. It is recommended the midpoint value is used as the best estimate.
[4] Value of ABI claims divided by DCLG estimate of properties damaged by flooding, with costs for temporary accommodation removed; see Section 4.1 and Environment Agency (2015).
[5] Based on ABI claims data; see Environment Agency (2010a).
[6] Based on the financial estimate with adjustments for VAT, inventory and betterment (see Section 4.1).
[7] Based on ABI claims data divided by the best estimate of properties flooded. For the economic average, the adjustments are VAT at 20% and assuming 55% of claims for inventory items with 45% betterment. ABI average claim value is £135,000.
[8] Based on ABI claims data; see Environment Agency (2010a). The average number is skewed by a few large claims and, in the 2007 report, it states the Pitt Review estimated business average damages at £92,000 while WeatherNet estimated them at £55,000 (both in 2007 prices).
[9] Based on the financial estimate, with adjustments for VAT, inventory and betterment (see Section 4.1).

4.3. Damage to vehicles

Many vehicles (motor vehicles, boats and caravans) are damaged during flood events, with the ABI recording these costs separately from property damages. Based on the ABI claims information, the **best estimate for damage to vehicles is £36 million with a range of £31 million to £41 million**.

In the 2015 to 2016 winter flood, ABI reported 6,700 claims for vehicle damages at a total cost of £36 million, giving an average cost of £5,388 per vehicle. It is recommended this figure of £36 million from the ABI is used as the best estimate of the economic cost without any adjustments. This is the same approach as used in the 2013 to 2014 cost of floods report. No economic adjustments are made as it is assumed that:

- most vehicles have insurance
- these policies tend to price vehicles at their residual value (that is, not on a 'new for old' basis)
- most replacement vehicles purchased will be second-hand and so not subject to VAT

Box 3: Best estimate of economic vehicle damages for 2015 to 2016 winter floods

Best estimate of vehicle damages (£36 million) = number of vehicles damaged × average cost per vehicle

where:

- number of vehicles damaged (6,700) = number of ABI vehicle insurance claims
- average cost per vehicles (5,388) = average cost per ABI vehicle insurance claim

Key uncertainties

- No adjustments have been made for underinsurance. It is assumed the majority of vehicles are insured.
- Adjustments for VAT and betterment have not been made as insurance policies for vehicles tend to price the residual value (and not a 'new for old' basis). Second-hand vehicles are VAT exempt.
- These are the same assumptions as made in the 2013 to 2014 cost of floods report.
- The split between residential and business vehicle damages is not known.

4.3.1. Comparison of vehicle damages with previous floods (2007 and 2013 to 2014)

Vehicle damages follow a very similar pattern across all 3 flood events, ranging from 2.3% to 2.8% of total damages, with unit costs of between £4,000 and £5,500 per insurance claim (Table 6).

Similar to property damages, in absolute terms, the 2007 flood event is by far the largest with more than double the number of vehicle claims being made as a result of the floods compared with the 2013 to 2014 and 2015 to 2016 floods.

Table 6: Comparison between flood events of number of vehicles damaged by flooding based on ABI insurance claims

Flood event	Number of insurance claims reported by the ABI	Average financial cost per claim[1]	Total economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	6,700	£5,400	£36	2.3%	4%
2013 to 2014 (winter)	9,000[2]	£4,100	£37	3%	6%
2007 (summer)	18,000	£5,000	£98[3]	2.5%	4%

Notes:
[1] This is a derived unit cost based on the total ABI value for vehicle damage divided by the number of claims. No data are available on the range around this average.
[2] Adjusted to include an estimate for the East Coast surge. Available ABI data for the winter floods did not include claims from the East Coast surge. ABI reported 5,400 claims at a cost of £22 million (an average cost of £4,100 per claim). In the 2013 to 2014 cost of floods report (Environment Agency 2015), it was estimated there were an additional 3,576 claims from coastal flooding, giving a total of 8,976 vehicle claims.
[3] Some adjustments were made for underinsurance in the 2007 report based on 5% underinsurance (Environment Agency 2010a).

4.4. Temporary accommodation

With major floods, many people and businesses require temporary accommodation whether in short-term local authority evacuation centres or longer term in temporary residences. Based on ABI data, the **best estimate for temporary accommodation costs is £37 million with a range of £31 million to £43 million**.

The estimate here relates to temporary residences rather than the costs of evacuation centres as the latter are covered by the local authority impact category. For 2015 to 2016, all that is known is the number of households that received temporary accommodation payments from ABI, which is reported to be 3,600. Although ABI did not provide any cost information relating to the 3,600 claims, it did confirm that these costs were included in its total property costs of £1.3 billion.

In the absence of specific cost data for the 2015 to 2016 floods, the average cost of temporary accommodation costs from 2013 to 2014 is used instead. The 2013 to 2014 report (Environment Agency 2015) states that ABI received 2,900 claims for temporary accommodation at a financial cost of £30 million,[6] giving an average of £10,345 per claim and total costs of £37 million (see Box 4).

Box 4: Best estimate of economic cost of temporary accommodation for 2015 to 2016 winter floods

Best estimate of temporary accommodation (£37 million) = number of households requiring temporary accommodation × average cost per stay in temporary accommodation

where:

- number of households requiring temporary accommodation (3,600) = number of ABI claims for temporary accommodation

[6] For the fluvial flooding during the winter floods of 2013 to 2014 it is assumed the ABI data excludes temporary accommodation resulting from floods from the East Coast surge.

- average cost per stay in temporary accommodation (£10,345) = estimated unit cost applied in the 2013 to 2014 floods report

Key uncertainties

- Unit cost per claim – ABI did not provide any data on the costs of temporary accommodation for the 2015 to 2016 floods. Hence the unit cost applied is from the 2013 to 2014 cost of floods report based on ABI data. Given the longer duration of flooding in winter 2013 to 2014, this value might be on the high side for the 2015 to 2016 winter floods.
- No adjustments have been made for underinsurance – there may have been households who paid for their own temporary accommodation but were not insured.
- No adjustments have been made for VAT as temporary rental properties are exempt from VAT. However, stays in hotels would have been subject to VAT.
- The split between temporary accommodations for residential households and businesses is not known.

4.4.1. Comparison of temporary accommodation costs with previous floods (2007 and 2013 to 2014)

Based on the limited data available on temporary accommodation, costs appear to be broadly similar to previous flood costs (Table 7). The costs range from 2% to 4% of total damages, with unit costs between £6,700 and £10,300 per insurance claim. The relationship to property costs is less consistent.

Also similar to other impact categories, in absolute terms, the 2007 flood event is by far the largest with almost triple the number of temporary accommodation claims being made compared with the 2013 to 2014 and 2015 to 2016 floods. This gives total temporary accommodation costs of £120 million and £50 million for the 2007 and the 2013 to 2014 floods respectively. It would be useful to be able to access ABI data to better understand the unit costs and the business versus residential split of temporary accommodation needs.

Table 7: Comparison between flood events of temporary accommodation costs based on ABI insurance claims

Flood event	Number of insurance claims for temporary accommodation	Average cost per temporary accommodation claim	% of total costs	% of property costs
2015 to 2016 (winter)	3,700	£10,300[2]	2%	4%
2013 to 2014 (winter)	4,800[1]	£10,300[3]	4%	8%
2007 (summer)	14,500	£8,200 (Res.) £6,700 (Bus.)	3%	5%

Notes:
[1] Includes estimates for the East Coast surge.
[2] No unit details are available for the 2015 to 2016 floods, so same unit value from the 2013 to 2014 floods (based on ABI data) has been applied.
[3] Average cost for business versus residential temporary accommodation is not known for the 2013 to 2014 floods.

4.5. Loss of life and health impacts

Floods pose a serious risk to people from fatalities to stress and other related health impacts. Estimating the cost of these impacts, however, is extremely difficult. Using the same methods applied in the 2007 and 2013 to 2014 reports the **best indicative estimate for the loss of life and health is £43 million, with a range of £32 million to £54 million**.

> The effects of the floods are personal. Thousands of Cumbrians, like people in other flood-affected parts of the country, have seen their lives upturned. Many have experienced life-changing financial losses and incredible stress. Speaking with flood victims, the words that come out are despair, fear and anxiety - fear of flooding again and the anxiety of an approaching winter. Floods don't just take your home, the place where you should feel safe, they often take your future as well.
> Cumbrian resident Dr Ed Henderson and a co-author of the National Hydrological Monitoring Programme review (Marsh et al. 2016)[7]

Fatalities due to flooding are linked to the type of flood event. Flash floods, which come with little or no warning, result in a higher casualty rate. For a different type of flooding caused by long periods of rainfall over large areas, which is typical for the UK, a lower mortality rate is expected.

The prevention of fatalities and injuries is an impact considered in a variety of public policies from road transport to air pollution reduction. HM Treasury's 'Green Book' recommends use of the Department of Transport (DfT) value of the reduction of risk of death in the context of road transport of about £1.145 million per fatal casualty prevented (2000 prices) (HM Treasury 2003); at 2014 prices, the value is £1.84 million per fatal casualty (DfT 2015, Table RAS60001). For injuries, the Climate Change Risk Assessment (CCRA) report suggests using a unit value of £72,000 (2010 prices) per injury (Defra 2012).

Flooding can also have a substantial impact on mental health causing fear, anxiety and depression. A study commissioned by Defra suggested households were, on average, willing to pay £200 per year (2004 prices) to avoid the negative health impacts of flooding (for events occurring less frequently than 1 in 75 years) (Defra 2004). Defra's CCRA report (2012) considers the costs of treating a case of mild depression following a flood event to be £970 (2010 prices), which can be used as an indicator of mental health impacts.

These monetary values are normally used in ex-ante[8] policy assessments to allocate resources to protect against an abstract individual losing their life or suffering harm. They were not designed with post-event analysis in mind. Without any official post-event values, however, these values were used as a surrogate in both the 2007 and 2013 to 2014 cost of floods reports to provide an indicative sum for loss of life and health impacts.

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[7] CEH Press release (http://www.ceh.ac.uk/news-and-media/news/uk-winter-20152016-floods-one-century%E2%80%99s-most-extreme-and-severe-flood-episodes)

[8] Based on forecasts rather than actual results.

Research by Public Health England since 2007 has sought to better understand the health impacts of flooding and this has resulted in some changes in the 2013 to 2014 cost of floods estimate methodology (Paranjothy et al. 2011). It is likely these methods will change again as the understanding of damages to health improves from the results from the ongoing research.

Box 5: Best estimate of loss of life and health impacts from 2015 to 2016 winter floods

Best estimate of loss of life and health impacts (£43 million) = surrogate cost of fatalities + surrogate cost of health impacts

where:

- surrogate cost of fatalities due to flooding (£5 million) = number of fatalities due to flooding × DfT 'average value of prevention of fatality'
  - number of fatalities (3) is taken from media reports
  - DfT 'average value of prevention of fatality' (£1,836,054 in 2014 prices) taken from 2015 edition of Table RAS60001 of DfT statistics RAS60
- surrogate cost for health impacts (£38 million) = cost per household × number of households affected
  - cost per household (£6,400 in 2015 prices) = household willingness to pay per year to avoid health impacts of extreme flood events (£261) × discount factor in year 49 (24.495)
  - number of properties affected (5,913) = number of residential properties flooded (15,981) × number of households likely to have health affects (37%)

Key uncertainties

- Given the importance of these impacts on individuals and households, these surrogate methods have been applied until further improvements can be identified as a result of ongoing research. The approach used in this report is the same as in the 2007 and 2013 to 2014 reports.
- The cost per household relies on research from 2004.
- It is assumed that health damages last 50 years, albeit discounted.

4.5.1. Comparison of casualty and health impacts with previous floods (2007 and 2013 to 2014)

There were 13 recorded fatalities resulting from the 2007 floods (Table 8). The 2007 flood report applied the ex-ante cost per fatality avoided of £1.15 million (2010 prices) and the £200 willingness to pay[9] per household to avoid extreme flood events, with a total estimate of loss of life and health damages of £350 million (Environment Agency 2010).

There were no recorded fatalities resulting from the 2013 to 2014 floods and the estimate for health damage was £25 million. While the approach to estimating health impacts for the 2013 to 2014 floods was similar to the 2007 method, amendments were made following research at Cardiff University (Paranjothy et al. 2011). As a result, only 37% of households were estimated to suffer from health impacts rather than all households and all businesses. In the 2007 floods report, health impacts were applied to all households and all businesses, and hence the large difference in estimated damages.

[9] The price someone is willing to pay to acquire an item or service.

Table 8: Comparison between flood events of loss of life and health impacts

Flood event	Number of fatalities	Surrogate value per fatality (£ million)	% properties estimated to have additional health impacts	Surrogate value for health impacts per household	Number of years affected	% of total costs	% of property costs
2015 to 2016 (winter)	3	£1.84[1]	37% (Res.) 0% (Bus.)	£261[4]	50	3%	5%
2013 to 2014 (winter)	0	n/a	37% (Res.) 0% (Bus.)	£261[4]	50	2%	4%
2007 (summer)	13	£1.15[2]	100% (Res.) 100% (Bus.)	£200[4]	50	9%	15%

Notes:
[1] DfT statistics – Average value of prevention per reported casualty (2014 prices) (DfT 2015, Table RAS60001)
[2] DfT value per fatal casualty prevented (2000 prices); given in The Green Book (HM Treasury 2003, p. 62) and quoted in Environment Agency (2010, p. 17).
[3] As a result of research following the 2007 floods, the method for estimating health impacts changed for the 2013 to 2014 and 2015 to 2016 flood events.
[4] Defra (2004) suggested households were, on average, willing to pay £200 per year to avoid the negative health impacts of flooding (for events occurring less frequently than 1 in 75 years). For the 2013 to 2014 and 2015 to 2016 floods, the value was uprated to 2014 and 2015 prices respectively. These are the same value as the Office for National Statistics reported zero Consumer Price Index inflation between 2014 and 2015.

4.6. Emergency services

Emergency services costs refer to the additional costs incurred by the police, fire and rescue, and ambulance services such as overtime and the purchase of materials and equipment. Based on data provided to DCLG, the **best estimate for emergency services is £3 million with a range of £2.6 million to £3.5 million**.

DCLG gathered information on public costs from the 2015 to 2016 floods and through personal communications. DCLG informed the Environment Agency that its estimate of the additional costs to emergency services is £3 million. This is consistent with previous floods (Table 9); it is assumed that these costs are economic costs and have not been adjusted.

In addition to costs incurred by emergency service organisations the EA

Table 9: Comparison between flood events of additional costs for emergency services

Flood event	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£3	0.2%	0.4%
2013 to 2014 (winter)	£3	0.3%	0.6%
2007 (summer)	£10	0.3%	0.4%

4.7. Local authorities (excluding road damages)

The **best estimate for local authority costs (excluding road damages) is £73 million with a range of £55 million to £92 million**. This is based on DCLG data and information from the 2007 and 2013 to 2014 cost of floods reports (Environment Agency 2010, 2015). Note that the estimate of £73 million does not include damages to local roads and bridges even where they fall under local government responsibility. These local authority costs are included within the estimate for road transport damages in Section 4.10.

Local government is in the front line when floods occur. Local authorities assist with warning and informing, deploying temporary defences, emergency evacuations and temporary accommodation. Local authorities also suffer damages to their own public assets such as flood defences, roads, public buildings, parks and other public spaces.

Following floods, local authorities are involved in the physical clean-up process. For example, the Local Government Association estimated that an average 1.66 tonnes of household goods and freezer waste was removed from each property flooded (LGA 2016a). In addition, local authorities support recovery through a number of schemes and grants including:

- Community Recovery Scheme
- Business Support Scheme
- Property Level Resilience Scheme
- Council Tax Discount Scheme
- Business Rate Relief Scheme

The excerpts below taken from the LGA illustrate the type of impacts faced by local authorities during the 2015 to 2016 winter floods.

Calderdale: A new chapter for flood-hit library

"Hebden Bridge Library is fully reopening on Thursday 29 September, after refurbishment following the flooding at the end of last year. The Boxing Day floods caused more than £100,000 of damage to books, equipment, fixtures and fittings. Around 5,000 books, DVDs and CDs were ruined. The shelving, other furniture, counter and self-service machine were also damaged beyond repair and the children's area was completely destroyed."

North Yorkshire County Council: Tadcaster Bridge

"The council created a £300,000 temporary footbridge within a month to connect the 2 sides of Tadcaster after the town's 18th century road bridge over the River Wharfe collapsed due to the force of flood water. The council secured planning permission to widen as well as restore the main bridge using £1.4 million of LEP (local enterprise partnership) money on top of £3 million provided by the government. The bridge is due to reopen early next year. The council employed geotechnical engineers to help stabilise the A59 over high ground between Harrogate and Skipton at Kex Gill after the road was closed for 6 weeks due to the hillside cracking following the heavy Christmas rains. In the event of an emergency such as severe weather, the council will update the list of road and bridge closures."

Leeds: Flood-hit print firm back in business

"Specialist print firm ERW Print Finishers is back in business after relocating to new premises. The business, which was severely affected by the Boxing Day floods, has relocated from Hunslet with support from Leeds City Council and Leeds City Region Enterprise Partnership."

Northumberland County Council: Highway flood damage repair programme

"Northumberland County Council has detailed the extensive repair programme, worth almost £15 million, that it is currently undertaking to repair the vast amount of damage inflicted on the county's highway network by record-breaking wet weather in winter 2015 to 2016. The Tyne Valley, which suffered its most catastrophic flooding since 1771, was worst affected. Almost 200 homes were flooded across the county and in Corbridge more than 50 homes were evacuated as the swollen River Tyne burst its banks with some still not able to return home."

Lancashire County Council: New scheme launched to help 'flood proof properties

"Householders and businesses affected by Storms Desmond and Eva can apply for grants of up to £5,000 to help make their homes more resilient to flooding in the future."

Source: LGA (2016b)

With such a wide variety of responsibilities and impacts, it is inevitable that floods place significant additional costs on local authorities. A survey conducted by the Local Government Association following the 2015 to 2016 floods reported the flooding would cost local authorities more than £250 million, with the worst hit authorities being Cumbria (£175 million), Calderdale (£33 million), Northumberland (£24 million) and Lancashire (£5 million) (LGA 2016a). However, the vast majority of these costs are due to road damages (see Section 4.10).

Identifying the exact nature of local authority costs in economic terms is complex. Some damages are insured against and some are covered by central government payments. However, many are not and there is currently no consistent method within DCLG for recording or reporting these flood damages or their associated costs.

Obtaining a high-level estimate of the winter floods of 2015 to 2016 by contacting each local authority affected by the floods is beyond the scope of this report. Nor are full details of central government compensation currently available, such as the funds provided under the Bellwin Scheme. For these reasons, the estimate is derived by assuming local authority damages are equivalent to 8.5% of total property damages. This percentage is based on the average percentage damages identified for local authorities in the 2007 and the 2013 to 2014 cost of floods reports for which where detailed studies of local authority damages were made (Environment Agency 2010, 2015).

Box 6: Best estimate of costs to local authorities (excluding road transport)

Best estimate of local authority costs (£73 million) = total property costs × average local authority costs as a percentage of total property damages

where:

- total property costs (£863 million) = residential property damages (£350 million) + business property damages (£513 million)
- local authority damages as a percentage of property damages (8.5%) = average of costs identified for the 2007 floods (7%) and 2013 to 2014 (10%)

Key uncertainties

- These figures would benefit from further research as details of the final applications made by local authorities under the Bellwin Scheme become available.

4.7.1. Comparison of local authority costs with previous floods (2007 and 2013 to 2014)

In 2007, estimated damage costs suffered by local authorities (excluding local road damages) were £164 million, that is, 7% of the total property damages. In 2013 to 2014, they were estimated at £60 million, that is, 10% of total property damages. Both these estimates were based on detailed and lengthy communications with local authorities, with economic adjustments made for insurance claims, VAT and betterment where appropriate and where the quality of data allowed.

The scale of damage costs as a percentage of total property damages for the 2007 and the 2013 to 2014 floods are similar (Table 10). The local authority damages in the 2015 to 2016 floods appear to follow the same pattern, with no significant differences identified. It is therefore considered reasonable to use the 8.5% of total property damages as a high-level method for estimating local authority damages (excluding road damages) fir the 2015 to 2016 floods.

Table 10: Comparison between flood events of costs incurred by local authorities

Flood event	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£73[1]	5%	9%
2013 to 2014 (winter)	£57	5%	10%
2007 (summer)	£170	4%	7%

Notes: [1] Based on the average percentage of property costs from 2007 and 2013 to 2014 floods.

4.8. Flood risk management infrastructure and service

The **best estimate for flood defence infrastructure and service is £71 million with a range of £63 million to £78 million**.

This estimate is based on Environment Agency internal data and reporting on the expected funding required to repair approximately 700 flood defence assets and the service costs associated with:

- preparing for the floods
- helping to prevent property flooding
- taking calls concerning floods
- distributing sandbags
- clearing debris

The infrastructure repair costs are estimated to be £65 million. These costs are economic costs as they take betterment into account.

Additional service costs incurred by the Environment Agency are recorded as £5.6 million. Including staff overtime costs and additional contractor and material costs.

4.8.1. Comparison of flood defence asset repairs with previous floods (2007 and 2013 to 2014)

Repair of flood defence assets represented 4% of the total costs for the 2015 to 2016 winter floods (Table 11). This compares with £147 million in 2013 to 2014 at 11% of total costs and £23 million and less than 1% in 2007. The higher costs in 2013 to 2014 are predominately due to damages to coastal defences from the East Coast tidal surge.

Table 11: Comparison between flood events of costs incurred from flood risk management infrastructure and service

Flood event	Estimated number of assets damaged	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	700	£71	4%	8%
2013 to 2014 (winter)	890	£147	12%	25%
Coastal surge	613	£100	8%	17%
Fluvial and other	277	£47	4%	8%
2007 (summer)	–	£24	1%	1%

4.9. Rail transport costs

Based on information from by Network Rail, the **best estimate for rail transport costs is £121 million with a range of £103 million to £139 million.**

Railways are prone to flooding due to the many sections of track running through cuttings and tunnels that are lower than the surrounding areas. Many other lines are on flat, low-lying land with limited drainage. Floodwater can wash away ballast (the bed of stones which supports sleepers), making lines unsafe until they are re-laid. When the water level rises above the rails, trains reduce their speed to prevent damage to the train. If the track has a live conductor rail, flooding can cause a short circuit. Points and signalling equipment can fail when water enters their housing and may need replacing before services can resume (Network Rail 2016).

To reduce these risks, Network Rail has a programme of investment to raise tracks and equipment and to install pumps. There is also an operational response programme to flood warnings issued by the Environment Agency, under which teams deploy temporary barriers and clear streams and culverts of debris. Network Rail also works with the local planners to ensure adequate drainage in new developments located near railway lines (Network Rail 2016).

The estimate of costs to rail transport for the winter 2015 to 2016 flooding was provided by Network Rail through private correspondence and includes costs for both physical rail infrastructure damages and business interruption costs. The latter are used as a surrogate for passenger welfare damages.

Network Rail reports £68 million for repairing capital damages and £93 million on disruption payments (see Box 7). The Network Rail data indicate that the main damages were associated with 3 events:

- welfare damages as a result of closure of the East Coast Line
- capital and welfare damages following the collapse of a sea wall in the Dover Folkestone area
- flooding in the north-east in the Prudhoe and Hexam area

Network Rail pointed out that:

- it is not always easy to determine what is storm damage and what is flood damage
- the estimate included some flood damages incurred in Scotland and Wales which had knock-on impacts for business disruption in England

The figures given here are intended to provide an understanding of the types and scale of rail transport costs. The capital costs have been removed from the total national cost estimate to reduce the likelihood of double counting; it is assumed that Network Rail's capital costs will be covered by insurance to a greater or lesser extent, and therefore included within ABI business insurance claims.

Box 7: Best estimate of costs for rail damages and disruption

Best estimate of rail damages (£121 million) = capital costs + operational costs + welfare damages

where:

- capital costs (£28 million) = infrastructure costs supplied by Network Rail (£68 million × 0.5)/1.2
- betterment is assumed to be 50%
- VAT is assumed to be 20%
- business disruption costs (£93 million) = Network Rail supplied data on payments
- operational costs (£0 million) = Network Rail did not include operational costs

Key uncertainties

- Business disruption costs – these payments are used as a surrogate for welfare damages for journey disruption. However, the Network Rail payments to operators are likely to be an underestimate of the true disruption costs to passengers.
- Assumption of betterment at 50%
- No costs have been reported for additional operational costs for rail operators or Network Rail.

4.9.1. Comparison of rail damages with previous floods (2007 and 2013 to 2014)

It is hard to draw comparisons for rail damages between different flood events. However, the costs for the 2013 to 2014 and the 2015 to 2016 floods are similar (Table 12) and, for both events, the highest damages for capital and business compensation costs resulted from failures in sea walls protecting railway lines – at Dawlish in the 2013 to 2014 floods and Dover–Folkestone in the 2015 to 2016 floods.

Table 12: Comparison between flood events of costs incurred by rail transport

Flood event	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£121	8%	14%
2013 to 2014 (winter)	£110	9%	19%
2007 (summer)	£44	1%	2%

4.10. Road transport costs

Based on local authority, DCLG and Highways Authority data, the **best estimate for road transport costs is £220 million with a range of £165 million to £275 million.**

Roads for the most part are publically owned by either local authorities for the local road network or the Highways Agency for the strategic road network. Both networks are susceptible to flood events, resulting in capital damages to the physical road infrastructure and welfare costs for users of the networks who face disrupted journeys.

During the winter floods of 2015 to 2016, there was considerable disruption to both local roads (and bridges) and the strategic road network. Local authorities reported more than £250 million in damages to roads bridges, public rights of way and drainage systems, and requested £220 million

from central government for repairs. DCLG has to date provided £179 million to local authorities in response to these requests (DCLG 2016). While the above provides estimates for physical damages, welfare damages are not known. Local authorities have not provided any estimate of the journeys disrupted due to floods on their local roads.

The strategic road network covers approximately 4,300 miles of road, with more than 4 million vehicle movements a day. This approximately 2% of the total road network accounts for about a third of all the traffic and it is estimated that 10% of this network is vulnerable to flooding (Environment Agency 2015). During the 2015 to 2016 floods, the Highways Agency tracked more than 850 road flood incidents on the strategic road network including lane and slip road closures on the M6. However, the Highways Agency has not reported any capital damages or estimated the welfare disruption costs of these 850 incidents.

Although unreported, it is assumed that welfare costs due to disruption across the local and strategic road network must have been considerable. This is particularly so where roads were closed for several weeks, such as at Tadcaster where the bridge was washed away and the closure of part of the A591 in Cumbria between Grasmere and Keswick. The A591 is one of the main roads through Cumbria and it is estimated that between 4,000 and 7,000 journeys a day were disrupted during the 6 months following the landslip. Indeed a year on from the floods, at least 5 routes remain subject to closure and diversions.

It is beyond the scope of this study to make an assessment of the welfare costs for the extensive road delays experienced during the flooding. It was therefore decided to use the value reported by local authorities (£220 million) without any economic adjustments as the best estimate of all road damages – both physical and welfare. This is the same approach taken in the 2013 to 2014 cost of floods report (Environment Agency 2015) and is informed by the 2007 cost of floods study (Environment Agency 2010). The approach is, however, recognised as being an uncertain estimate for welfare damages.

Box 8: Best estimate of costs incurred by road damages and delays

Best estimate of road damages (£220 million) = local authority estimate of cost of repairs to local road networks

where:

- 50% is assumed to be for economic damages for the local and strategic road networks
- 50% is assumed to be for welfare damages (delay and disruption) for the local and strategic road networks

Key uncertainties

- The assumptions on welfare damages

4.10.1. Comparison of road damages with previous floods (2007 and 2013 to 2014)

In 2007, road damages were estimated to account for £234 million (6% of total damages) (Table 13). Welfare damages were roughly estimated to account for more than half this figure, that is, they accounted for more than double the physical economic repair costs.

In 2013 to 2014, road damages were estimated at £179 million, 14% of total damages. This includes a Highways Agency estimate of disruption costs on the strategic road network of £1.3 million for the most severe incidents. However, the bulk of the £179 million is made up of the money paid to local authorities by central government for repairing physical damages to local roads. This figure was not adjusted for betterment or VAT, which would have reduced this number by approximately half. The economic adjustments were not made so as to take into account welfare damages from delays and disruption. Hence it is implicit that there was roughly a 50:50 split between capital and welfare damages, as informed by the analysis made in 2007.

Table 14 shows the number and severity of flood incidents on the strategic road network for the 2013 to 2014 winter floods and the 2015 to 2016 winter floods. The Highways Agency ranks and records flood incidents according to severity using its Flood Severity Index; 10 is the highest severity and 1 the least (Environment Agency 2015). This index takes account of both the duration of an incident and the classification of the road. While there were more incidents in the 2013 to 2014 winter floods in total, there were more severe incidents (types 7 to 10) in the 2015 to 2016 winter floods (109 compared with 71). There are no equivalent data for the 2007 floods, as it was only after the 2007 floods that this method was developed for mandatory reporting on the strategic road network.

Table 13: Comparison between flood events of costs incurred by road damages and delays

Flood event	Economic cost (capital and welfare) (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£220	14%	25%
2013 to 2014 (winter)	£179	14%	31%
2007 (summer)	£234	6%	10%

Table 14: Number of flood incidents recorded by the Highways Agency on the strategic road network during 2013 to 2014 and 2015 to 2016 flood events

Flood Severity Index	Number of flood traffic incidents	
	2013 to 2014 winter floods	2015 to 2016 winter floods
10	4	3
9	12	19
8	9	26
7	46	61
6	125	50
5	107	121
4	105	109
3	69	145
2	12	22
<1	502	297
Total recorded flood incidents	991	853

4.11. Utilities (water, electricity, telecoms)

The **best estimate for utilities is £104 million, with a range of £91 million to £117 million**. This is based on information provided by water companies, DECC and 'Living without electricity', a report from the Royal Academy of Engineering, Lancaster University and the Institution of Engineering and Technology about the experience of the city of Lancaster (Kemp 2016).

Utilities like transport are frequently disrupted by flood events. Utility costs relate to:

- physical damages to infrastructure
- additional operational costs
- welfare damages to consumers who suffer disruption or loss of services

While reported here to provide an understanding of the types and scale of utility costs, the capital costs for both water and energy utilities are removed from the total national cost estimate. This is to avoid double counting as it is assumed the capital costs will be covered by insurance to a greater or lesser extent and so included within the ABI business insurance claims.

Water

Through private correspondence, water companies reported operational and infrastructure costs of £97 million,[10] 5% of total costs. The majority of these costs arise from clearing sewers and pumping floodwater. No welfare damages were reported for loss of water services, although there is some anecdotal evidence to suggest some sewerage services to a few customers were disrupted for a short period of time.

Box 9: Best estimate of costs incurred by damages to water utilities

Best estimate of water utility damages (£83 million) = capital costs + operational costs + welfare damages

where:

- capital costs (£10 million) = reported water company costs [(£97 million) × 0.25 × 0.5]/1.2
- operational costs (£73 million) = reported costs by water companies (£97 million × 0.75)
- it is assumed that 75% of costs are operational and 25% are capital
- betterment (residual value) at 50% is assumed for capital costs
- VAT at 20% is assumed for capital costs
- welfare damages from loss of utility (£0 million) = there were no reports of extensive or prolonged loss of water services

Key uncertainties

- Split between capital and operational costs – this is based on correspondence with water companies, which reported similar total estimated costs and types of costs incurred. However, only one water company reported its operational to capital split and so it was assumed the same split applied to all companies.
- Assumption of betterment at 50% for capital costs

Electricity

For electricity, DECC estimated additional operational and infrastructure costs of £11million;[11] welfare damages from loss of power are estimated at £10 million using a £3 per hour compensation rate (as per the 2013 to 2014 report), which equates to approximately £70 per day.[12]

Some 61,000 households in Lancaster and 13,000 in Carlisle are estimated to have lost power as a result of the floods. The most serious incident being the Lancaster power cuts.

In Lancaster, a substation was inundated when its flood defences were overtopped and more than 100,000 people suffered from power cuts which lasted on and off for up to 3 days. The Lancaster University study provides a vivid account of the impact of these power cuts and found that the

[10] The water companies expected there to be some additional operational costs.
[11] As the operational versus capital damage split is unknown, the figure from DECC has not been adjusted.
[12] Electricity suppliers are required to compensate customers at a rate of £70 per day for a continuous loss service over 48 hours due to storms; source Citizens Advice Bureau and Ofgem.

welfare damages from loss of power affect a much wider set of day-to-day activities than maybe first thought (Kemp 2016).

As a result, the Lancaster University study suggests that traditional estimates of willingness to pay, to avoid or accept loss of power may underestimate the true welfare damages. The report provides a summary:

> Because electricity is always there, we have come to rely on it without question and have allowed it to infiltrate all aspects of our lives. The gas central heating in our houses relies on electrical controls and circulating pumps; our cordless phones, computers, Wi-Fi routers and some door locks all need a mains supply. And increasingly we have migrated the way we live from paper to electronic systems – we pay for a coffee with a contactless card, read our bank statement online, keep our address book in 'the cloud' and send emails rather than letters.
>
> In December 2015, life for more than 100,000 people in Lancaster reverted to a pre-electronics era. A flood at an electricity substation resulted in a blackout over the entire city that lasted for more than 24 hours. Suddenly people realised that, without electricity, there is no internet, no mobile phones, no contactless payment, no lifts and no petrol pumps. Although these dependencies were not difficult to see, few had thought through the implications of losing so many aspects of modern life at once.
> Foreword by Sir Mark Walport, Chief Scientific Adviser to HM Government

Box 10: Best estimate of costs incurred by damages to electricity utilities and loss of service

Best estimate of electricity utility damages (£21 million) = capital costs + operational costs + welfare damages

where:

- infrastructure and operational costs (£11 million) = DECC reported in personal communications that damages were in the region of £10 million to £11.2 million

- welfare damages from loss of utility (£10 million) = number of properties without power (60,987 in Lancaster) × cost per hour (£3) × number of hours without power (56 hours)
- number of properties and hours without power comes from the Lancaster University study (Kemp 2016)

Key uncertainties

- In the absence of information about the split between capital and operational costs for power companies, economic adjustments have not been made to the figure provided by DECC on the assumption that most of the costs would be operational.
- A welfare damage cost of £3 per hour per household is the value used in the 2013 to 2014 report. This is in line with willingness to pay and willingness to accept studies, and compensation payments of £70 per day for power cuts over 24 hours. However, as the Lancaster study suggests, this may be an underestimate.
- The assumption that all households lost power for the full 56 hours is an overestimate. It has been applied to allow for the likely underestimate in the £3 figure and to take some account of the other households who lost power as a result of the floods (for example, in Carlisle and other parts of Cumbria) for which details are not available to enable an informed estimate.

Telecoms

In addition to water and electricity, it is known that telecom services in Leeds and York were disrupted due to the floods. A BT exchange was inundated in York and a Vodafone data centre was all but submerged in Leeds. As with electricity networks, telecom networks have substantial capacity and are able to re-route services relatively quickly even in the face of severe flooding (assuming power networks are still available!).

No data have been provided by telecom companies and so the extent of the physical damages or the number of telecoms customers affected, or for what duration, is not known. It is therefore not possible to estimate either the physical or welfare damages for the telecoms impacts associated with York and Leeds.

4.11.1. Comparison of utility damages with previous floods (2007 and 2013 to 2014)

In the 2007 floods, the total utility losses were estimated at £397 million, 10% of total damages (Table 15). Loss of power affected 750,000 people and 350,000 people had their water supply interrupted for 17 days (Pitt 2008). Unit costs for welfare damages were estimated at £18 per household per day for water interruptions and at approximately £60 per household per day for power interruptions.

Following the 2007 summer floods, the Pitt Review recommended improving the protection and resilience of critical national infrastructure, anticipating that utility disruption costs would decrease in future. In the water industry in 2009, for example, Ofwat included approximately £400 million for network and asset resilience schemes to protect more than 150 critical, at-risk assets and to carry out 13 major network resilience schemes. Ofwat estimated that 9.6 million people would benefit from increased service resilience to external hazards such as flooding. Between 2010 and 2015, water companies invested approximately £800 million to reduce the risk of damage from sewer flooding to over 5,000 properties through improved sewer capacity, sustainable drainage systems and property protection (Ofwat 2009).

No doubt in part due to the flood protection investment programmes implemented by utility companies, utility damages from the 2013 to 2014 floods were estimated at only £30 million, 2% of total damages for both infrastructure and welfare damages. This was a fraction of the 2007 utility costs, and although utility damages did increase in 2015 to 2016 compared with 2013 to 2014, they are still approximately a quarter of the costs seen in 2007 (Table 15).

Table 15: Comparison between flood events of costs incurred by utilities and loss of utility services

Flood event	Economic cost (capital and welfare) (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£104	7%	12%
Water	£83	5%	10%
Electricity	£21	1%	2%
2013 to 2014 (winter)	£30	2%	5%
Water	£29	2%	5%
Electricity	£1	0.1%	0.1%
2007 (summer)	£397	10%	17%
Water	£227	6%	10%
Electricity	£169	4%	7%

4.12. Education

The **best estimate for the cost of education days lost and capital damages is £4 million, with a range of £3 million to £5 million**. This figure is based on the Lancaster University report, 'Living without electricity' (Kemp 2016) and information from the Department of Education (DfE) given in the 2007 and the 2013 to 2014 cost of floods reports (Environment Agency 2010, 2015).

Through private correspondence, DfE provided a figure of estimated capital damages in the region of £4 million to 16 schools covered under the government's Risk Protection Arrangements (economic adjustments would reduce this figure to £1.7 million). However, it is understood that these costs do not include damages to local authority managed schools for which no specific information was obtained.

An impact of the power failure in Lancaster in the 2015 to 2016 winter floods saw the closure of schools across Lancaster for 2 days in December and the closure of the University of Lancaster for 5 days. At a rough estimate this could have resulted in as many as 120,000 lost education days.

Lancaster University has over 12,000 students, giving a maximum of 60,000 education days over 5 days. There were also 61,000 homes without power in Lancaster and, if it is assumed half of these had a child in some kind of education, this would be another 60,000 days lost over 2 days. These assumptions give a high estimate of possible education days lost of 120,000. There may also be households that were not affected by power failures but which were affected by school closures. In addition, there are likely to have been some school closures or absences in other flooded areas due to flooding in Carlisle and other parts of Cumbria for which no data have been obtained.

In 2007, the value of an education day lost was priced at the average weighted cost of a school day per pupil (£30 per day per pupil in 2015 prices). In 2005, however, the National Audit Office estimated welfare damages of unauthorised absences as much higher as £275 per day per pupil (in 2005 prices) (NAO 2005).

Using the £30 value and the high estimate of 120,000 school days lost gives a high estimate of £3.7 million for lost education days from the 2015 to 2016 floods.

Due to uncertainties in the number of all schools damaged and the number of school days lost, it was decided to estimate the economic value of education costs using a percentage of total property costs, based on the average between the 2007 and 2013 to 2014 education cost estimates. This gives an estimate of £4 million (see Box 11), which is broadly in line with the costs provided by the DfE and the rough estimate for possible education days lost.

Box 11: Best estimate of welfare costs from lost education days

Best estimate of education days lost (£4 million) = total property damages × percentage of property costs

where:

- total property costs (£863 million) = residential property damages (£350 million) + business property damages (£513 million)
- percentage of property costs (0.4%) = average education costs from 2007 (0.59%) and 2015 to 2016 (0.27%) education as a percentage of total property costs

Key uncertainties

- Percentage value of 0.4%
- Number of schools suffering damages
- Number of pupil days lost

4.12.1. Comparison of education damages with previous floods (2007 and 2013 to 2014)

In 2007, the economic cost of lost education days was included, with more than 400,000 days estimated to have been lost. The cost was assumed to be equal to the average expenditure of £25 per pupil day (2007 prices), giving a total estimated cost of £14 million (2015 prices) and 0.4% of total costs (Table 16). However, it was noted in the 2007 report that the National Audit Office valued unauthorised absences from school at a very much higher rate of £275 per day (2005 prices) (Environment Agency 2010). Using this figure would have increased the welfare education damages from the 2007 floods to £110 million – an order of magnitude greater.

The 2013 to 2014 report did not estimate education days lost as there was little evidence of major or prolonged school closures, given that the worst of the flooding occurred during the school holidays. However, the report did estimate physical damages to educational buildings and assets at £2 million (Environment Agency 2015).

Table 16: Comparison between flood events of education costs

Flood event	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	£4[1]	0.2%	0.4%
2013 to 2014 (winter)	£2[2]	0.1%	0.3%
2007 (summer)	£14	0.4%	0.6%

Notes:
[1] Based on the average percentage of property costs from the 2007 and the 2013 to 2014 floods.
[2] In 2013, education costs were estimated for the physical damages to schools only. No estimate of education days lost was included as the worst of the flooding occurred during the school holidays.

4.13. Damages to agriculture

The **best estimate of agricultural costs is £7 million, with a range of £6 million to £8 million**. This estimate is based on Environment Agency LiDAR[13] and GIS[14] data, plus information from the NFU and ADAS.

The economic damages of a flood event on farmland depend mainly on the type of land use, the duration of the flooding and the seasonal timing of flooding. Agriculture is particularly vulnerable in the summer period when crops are nearing harvest and the use of grassland for livestock is most productive. Research and empirical evidence suggest that most crops can recover from floods of less than one week during their growing periods, although yields are likely to be reduced. Flooding of more than one week results in much higher yield penalties, possibly to the point where harvesting is uneconomic. Flooding that occurs 4–6 weeks before harvesting can lead to complete crop loss, especially if crops are completely inundated.

In the 2015 to 2016 winter floods, it is estimated from Environment Agency LiDAR and GIS data that some 16,556ha of agricultural land were flooded in the North of England. Defra estimates that 650 farms were affected by storm and flood damages.

An NFU survey of flood-hit farmers in Cumbria found that the main types of damages at 220 of these farms which responded were to property, machinery, livestock, fences and river boundaries (NFU 2016); an extract from the survey report is reproduced in Figure 3. From the survey responses, the NFU found that 144 of the farms suffered total damages estimated at £1.7 million, giving an average cost of £12,000 per farm. If this average is applied to all 650 farms this gives total damages of £7.8 million.

Following the floods, central government established an agricultural flood recovery fund of £10 million to support costs incurred by farmers; by early September 2016 approximately £1 million had been paid to flood-hit farmers to reimburse them for completed repairs (Rural Payment Agency and Defra 2016) while applications totalling over £9 million had been approved by the Rural Payments Agency (Table 17).

However, the extent to which the costs identified by the NFU would be covered by insurance and so already be included in the ABI residential and business property figures in Sections 4.1 and 4.2 is not known. Nor is it understood the extent to which the estimated repair costs covered by the Farming Recovery Fund include betterment.

Table 17: Applications approved by the Farming Recovery Fund

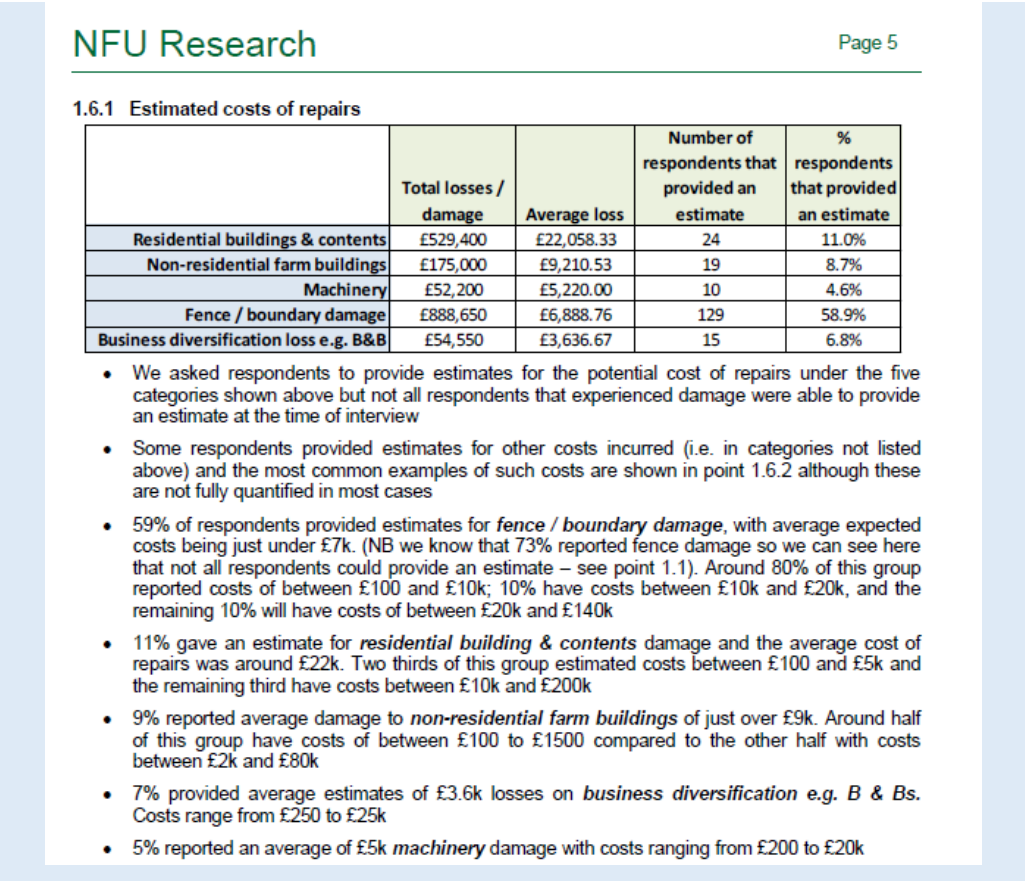
County	Number of applications approved	Value (£)
Cumbria	559	5,525,862
Yorkshire	244	1,764,468
Lancashire	149	1,158,675
Northumberland	61	479,607
County Durham	15	128,411
Greater Manchester	7	59,381
Total	1,035	9,116,604

Source: Rural Payments Agency and Defra (2016)

[13] LiDAR is an acronym for Light Detection And Ranging. LiDAR technology uses light sensors to measure the distance between the sensor and the target object. From an aircraft this includes objects such as the ground, buildings and vegetation.

[14] A geographical information system (GIS) is a computer systems for capturing, storing, checking, and displaying data related to the earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyse and understand patterns and relationships.

Figure 3: Extract from NFU report of its survey of flood-hit farmers in Cumbria



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1.6.1 Estimated costs of repairs

	Total losses / damage	Average loss	Number of respondents that provided an estimate	% respondents that provided an estimate
Residential buildings & contents	£529,400	£22,058.33	24	11.0%
Non-residential farm buildings	£175,000	£9,210.53	19	8.7%
Machinery	£52,200	£5,220.00	10	4.6%
Fence / boundary damage	£888,650	£6,888.76	129	58.9%
Business diversification loss e.g. B&B	£54,550	£3,636.67	15	6.8%

- We asked respondents to provide estimates for the potential cost of repairs under the five categories shown above but not all respondents that experienced damage were able to provide an estimate at the time of interview
- Some respondents provided estimates for other costs incurred (i.e. in categories not listed above) and the most common examples of such costs are shown in point 1.6.2 although these are not fully quantified in most cases
- 59% of respondents provided estimates for ***fence / boundary damage***, with average expected costs being just under £7k. (NB we know that 73% reported fence damage so we can see here that not all respondents could provide an estimate – see point 1.1). Around 80% of this group reported costs of between £100 and £10k; 10% have costs between £10k and £20k, and the remaining 10% will have costs of between £20k and £140k
- 11% gave an estimate for ***residential building & contents*** damage and the average cost of repairs was around £22k. Two thirds of this group estimated costs between £100 and £5k and the remaining third have costs between £10k and £200k
- 9% reported average damage to ***non-residential farm buildings*** of just over £9k. Around half of this group have costs of between £100 to £1500 compared to the other half with costs between £2k and £80k
- 7% provided average estimates of £3.6k losses on ***business diversification e.g. B & Bs.*** Costs range from £250 to £25k
- 5% reported an average of £5k ***machinery*** damage with costs ranging from £200 to £20k

Given uncertainties around the level of insurance, betterment and loss of production, the method used to estimate the economic damages from agriculture for 2015 to 2016 is the number of hectares of agricultural land flooded multiplied by an average cost per hectare for winter flooding of £425 as recommended by ADAS as part of research (ADAS 2014) for Defra carried out for the 2013 to 2014 cost of floods report (see Box 12).

Box 12: Best estimate of costs incurred by agriculture

Best estimate of agricultural costs (£7 million) = hectares of agricultural land flooded × average cost per hectare for winter flooding

where:

- area flooded (16,556ha) = estimate from Environment Agency LiDAR and GIS data
- cost per hectare (£425) = based on ADAS research carried out for Defra for the winter 2013 to 2014 floods and supplementary interviews

Key uncertainties

- Duration and hectares flooded: the LiDAR data were taken after the floods had peaked so may underestimate the area of agricultural land damaged by flooding.
- Cost per hectare: this is based on the 2013 to 2014 winter floods estimated from farms on low-lying flood plains and so may not be directly applicable to the upland farming areas of Cumbria where significant flooding occurred in the 2015 and 2016 event. The ADAS method focuses primarily on production and the costs of production.

- It is difficult to identify the level of damages for farms covered by insurance. It is assumed property damage and contents will be insured (residential properties and contents, and farm buildings contents including farm machinery).

4.13.1. Comparison of agricultural damages with previous floods (2007 and 2013 to 2014)

The 16,556ha of farmland flooded in the winter 2015 to 2016 floods is far less than the 42,000ha and 45,000ha flooded in the 2007 and the 2013 to 2014 flood events respectively (Table 18).

For the 2007 floods, a comprehensive assessment at field and farm level by ADAS (covering 5,800ha or 14% of the affected area) identified damages of £61 million, 1.5% of total costs (ADAS 2008). Over 80% of flood damage costs were associated with losses of output and additional production costs; the rest concerned damage to farm assets such as machinery, property and infrastructure. The ADAS study also derived average unit values according to crop and farm type. These ranged from £7,000 per hectare for horticultural and £1,000 per hectare for dairy farms and cereal farms to £600 per hectare for livestock grazing, with average flood costs at around £1,300 and £650 per hectare for arable land and grassland respectively (Environment Agency 2010a, Table 3.1). The overall average loss per hectare was £1,207 (2010 prices).

In 2013 to 2014, Defra commissioned ADAS to assess agricultural impacts supplemented with farm interviews. Although the area flooded was similar, the costs were substantially lower at £19 million – a difference primarily attributable to the season, with winter flooding instead of flooding in the peak summer months as seen in 2007.

Table 18: Comparison between flood events of agricultural damages

Flood event	Estimated area of agricultural land flooded	Average unit cost per hectare[1]	Economic cost (£ million)	% of total costs	% of property costs
2015 to 2016 (winter)	17,000ha	£425	£7	0.4%	1%
2013 to 2014 (winter)	45,000ha	£425	£19	1.5%	3%
2007 (summer)	42,000ha	£1,150	£61[2]	1.6%	3%

Notes:
[1] Based on ADAS reports for the summer 2007 floods and the winter 2013 to 2014 reports (ADAS 2008, 2014).
[2] Although similar areas of land were flooded in the 2007 and the 2013 to 2014 events, the 2007 floods were summer floods where damage costs are significantly higher.

4.14. Other (tourism, heritage and wildlife sites)

Based on the findings of the 2013 to 2014 cost of floods report, the **best estimate of damages to tourism, heritage and wildlife sites is £19 million, with a range of £13 million to £25 million**.

It is beyond the scope of this report to make a detailed national economic analysis of the impacts of the 2015 to 2016 floods on tourism, heritage and wildlife sites. In the absence of specific data on these categories, the percentage of property costs method has been used based on the 2013 to 2014 percentage of 2.3%. It is recognised there is a very large degree of uncertainty in this estimate.

4.14.1. Comparison of tourism, heritage and wildlife site damages with previous floods (2007 and 2013 to 2014)

The 2007 cost of floods report did not consider these categories in its economic assessment and they were considered for the first time in the 2013 to 2014 cost of floods report (Environment Agency 2015).

For tourism, it was found to be very difficult to estimate national damages as most of the impacts on tourism are likely to be either delayed or transferred to other goods and services in the economy. So while the local impacts on flooded areas can be severe, at the national level most of the income is not lost to the economy as it is likely to be spent elsewhere in the economy. As recommended in the 2013 to 2014 cost of floods report, further research is needed to better understand the impacts on tourism.

With respect to heritage and wildlife sites, the 2013 to 2014 study conducted detailed communications with site owners and managers of wildlife and heritage sites. This resulted in the gathering of extensive data on the types of physical damages incurred for example to paths, visitor buildings, car parks and historical assets. Economic repair costs were estimated in the 2013 to 2014 cost of floods report, but there was no attempt to value any welfare losses from damage to national heritage or biodiversity.

In 2013 to 2014, the total economic estimate for these other categories was £13 million (£2.4 million, £7.7 million and £3.5 million for wildlife, heritage and tourism respectively), 2.3% of total economic property damages and 1% of total economic costs.

5. Summary and recommendations

At a national scale, the winter floods of 2015 to 2016 were the most extreme on record according to the intensity of the rainfall, resulting in widespread flooding during December 2015 and January 2016.

This high-level assessment is based on the methods and extensive research carried out for:

- 'The costs of 2007 floods in England' (Environment Agency 2010a)
- 'Assessing the economic costs of floods' (Environment Agency 2013)
- 'The costs and impacts of the 2013 to 2014 winter floods' (Environment Agency 2015)

Applying these approaches, the best estimate for the economic damages in England from the winter 2015 to 2016 floods is £1.6 billion, with a range of £1.3 billion to £1.9 billion to take account of uncertainty.

The nature of the economic costs follow a similar pattern to the damages associated with the 2007 and the 2013 to 2014 floods, with property and transport damages dominating. However, it is notable that business property damages were significantly larger than household property damages in the 2015 to 2016 floods – a pattern not normally expected.

In terms of scale, the economic damages from the 2015 to 2016 winter floods are similar to the 2013 to 2014 winter floods. The 2007 floods are, by some margin, the largest in terms of economic damages of the 3 flood events.

The assessment of uncertainty used to inform the range for the 2015 to 2016 floods is based largely on:

- the availability and quality of the data on damages
- the number and type of assets affected

One of the most challenging aspects of the analysis affecting the certainty of estimates is the lack of primary data on flood damages, especially for major impact categories such as residential and business properties. The importance of having high quality primary data on the actual damages incurred on which to base the estimates of total damages is fundamental, yet remains an ongoing difficulty.

5.1. Recommendations

This is the fourth Environment Agency report to estimate the economic costs of a flood event. Starting with the detailed research into the 2007 summer floods (Environment Agency, 2010) the methods have been progressively improved, refined and peer reviewed (Environment Agency 2013, 2016). From these studies the broad pattern of damages caused by major flood incidents is now well understood. The balance broadly correlating with the nature of land use in the flooded areas, with some inevitable variations.

Nonetheless while the broad pattern of costs is well understood there remains a significant degree of uncertainty in exact estimates due to the inherent difficulties of data availability and gathering. Learning from this report and the previous three. The recommendations listed below are considered the most likely to help reduce uncertainty in the estimation of flood damages for future events, as well as supporting the appraisal of different options to reduce future flood risk.

5.1.1. Additional information on insurance claims

Nationally aggregated ABI data underpins estimates for residential and business property damages, temporary accommodation costs and vehicle damages. Impact categories which on average account for more than 60% of total flood damages for any given flood (Annex A).

ABI data is a reliable source of information as it is based on actual costs incurred. However, flood cost estimates could be improved if:

- ABI reported on a consistent set of national numbers for each flood event (for example ABI has reported on temporary accommodation costs for some flood events but not all).
- national insurance data could be disaggregated in order to better understand the component parts of household and business insurance claims. In particular this would help to review the assumptions used to make economic adjustments to the national insurance figures and is discussed below.

5.1.2. Review the assumptions on economic adjustments for properties

Damage to property, residential and business, is consistently the single biggest cost arising from floods (more than 50%, Annex A). Property damages are also used as the basis for estimating the damages to other impact categories in the Environment Agency's Floods Cost Calculator (Environment Agency, 2013). This means reducing uncertainty in property cost estimates has a significant impact on the overall robustness of flood cost estimates.

It is recommended property damage estimates can be improved by:

- improving further the methods for estimating the number of properties actually physically damaged by flood events. This is addressed in 5.1.3. below where improved working and data sharing with DCLG would be beneficial.
- reviewing the economic adjustments made to financial estimates of property damages (see section 3.2 for detail on these adjustments).

These economic adjustments were first applied in the report on the 2007 floods (Environment Agency 2010) and have been similarly used since in order to aid comparison between flood events. These adjustments include assumptions on:

- the level of underinsurance in both the residential property and business property markets
- the make-up of insurance claims with respect to the average percent of claims made for content damage versus building damage

Since 2007 both the economy and insurance markets have undergone significant change and it is therefore recommended these assumptions be reviewed. In particular the evidence on the level of under insurance with respect to flood damages.

5.1.3. Data sharing agreements

The development of data sharing agreements with key partners is an important step that can be taken to improve the basis on which the damage estimates are made. If agreements and data champions were in place, information could be improved in quality and provided in a more timely and efficient manner. This would improve the robustness of the results and enable better interrogation of data in terms of unit values for the type of flood, duration and differences between locations. These partners would include:

- DCLG
- Department for Business, Energy and Industrial Strategy (BEIS)
- DfT
- Highways Agency
- Lead Local Flood Authorities
- Local Government Association
- Network Rail

Furthermore, major flood damage costs arise in sectors providing critical infrastructure and services, notably transport and utilities. These involve a mix of corporate and quasi-government organisations that provide important public services in which disruption as well as asset damage is a major source of impact. Improved data sharing agreements with such organisations, whereby data on major flood impacts are assembled and made available to support public policy in flood risk management on the protection of critical services and infrastructure. This would be of mutual benefit, potentially helping those organisations to formulate flood risk reduction strategies.

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List of abbreviations

ABI	Association of British Insurers
CCRA	Climate Change Risk Assessment
DCLG	Department for Communities and Local Government
DECC	Department of Energy and Climate Change [now part of BEIS]
DfE	Department for Education
DfT	Department for Transport
GIS	Geographical Information System
NFU	National Farmers' Union
VAT	Value Added Tax

Annex A: Impact costs as a percentage of 'total costs' and 'property costs' by flood event (2015 prices)

	Costs by impact category			Impact category as a percentage of total costs				Impact category as a percentage of property costs			
	2007	2013 to 2014	2015 to 2016	2007	2013 to 2014	2015 to 2016	Average	2007	2013 to 2014	2015 to 2016	Average
Impact category	£ million			% of total costs				% of property costs			
Residential properties	£1,468	£320	£350	38%	25%	21.9%	28%	62%	54%	41%	52%
Businesses	£905	£270	£513	23%	21%	32.0%	26%	38%	46%	59%	48%
Temporary accommodation	£115	£50	£37	3%	4%	2.3%	3%	5%	8%	4%	6%
Vehicles, boats, caravans	£98	£37	£36	2.5%	3.0%	2.2%	3%	4%	6%	4%	5%
Local authorities (excluding roads)	£164	£60	£73	4%	5%	4.6%	5%	7%	10%	9%	9%
Emergency services	£10	£3	£3	0.3%	0.3%	0.2%	0.2%	0.4%	0.6%	0.3%	0.4%
Flood risk management infrastructure and service	£23	£147	£65	1%	12%	4.4%	5%	1%	25%	8%	11%
Utilities (energy and water)	£396	£30	£104	10%	2%	6.5%	6%	17%	5%	12%	11%
Transport (roads and rail)	£278	£295	£341	7%	23%	21.3%	17%	12%	50%	40%	34%
Agriculture	£61	£19	£7	1.6%	1.5%	0.4%	1%	3%	3%	1%	2%
Health	£351	£25	£43	9%	2%	2.7%	5%	15%	4%	5%	8%
Education	£14	£2	£4	0.4%	0.1%	0.2%	0.2%	0.6%	0.3%	0.4%	0.4%
Other (wildlife, heritage and tourism)	–	£13	£19	–	1%	1.2%	1%	–	2%	2%	2%
Total	**£3.9 billion**	**£1.3 billion**	**£1.6 billion**	100%	100%	100%	100%	n/a	n/a	n/a	n/a

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