



# Estimating the Potential Impact of Climate Change driven weather-events on GB Property

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By Richard Cantwell

The British climate is changing. Warmer oceans are leading to increased rainfall, storms are becoming stronger and more frequent, heatwaves in summer months hotter and more prevalent while winter months are becoming significantly wetter [ref 1]. As a result of global climate change flooding is expected to become more severe across Europe, with Britain and Ireland particularly affected [ref 2]. Drier and hotter summers are already having a major impact on soil moisture levels, leading to shrinkage and subsidence [ref 3]. But how can we start to quantify the potential cost of future property damage that these changes may bring, based on our current projected scenarios?

This paper aims to calculate an estimate of the potential damage impact on residential and commercial property from increasing flood and subsidence related events under current climate change scenarios.





In carrying out this research Gamma has worked closely with Ambiental Risk and Terrafirma to assess the future impact of climate change on properties in Great Britain.

We have established that over 1.3 million residential and commercial addresses in Great Britain will newly be at risk of flooding by 2050, at current levels of payout for flood related insurance claims this represents a potential additional liability of over £122 Billion. Increased risk of subsidence will be even more widespread, with an additional 1.9 million properties potentially impacted in some scenarios. And while typical subsidence claims are lower than flood related claims this still represents a potential liability of over £52 billion.

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## Climate Change Scenarios

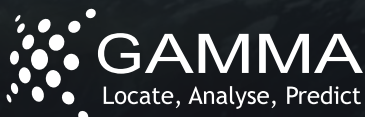
There are 4 main Representative Concentration Pathways (RCPs) used in the literature [ref 4]. These correspond to different concentrations of greenhouse gas in the atmosphere, leading to differing amounts of temperature rise and thus different flood outcomes. The RCPs are based on different assumptions about population and economic growth, sources and consumption of energy, and changes in land use in the 21st century. The RCPs are labelled with their radiative forcing by the year 2100, and range from 2.6W/m<sup>2</sup> to 8.5W/m<sup>2</sup>. RCP 2.6 is the most ambitious target, involving extreme and immediate cuts to carbon emissions. Even if that target is achieved temperatures will continue to rise as the elevated levels of carbon dioxide currently in the atmosphere will take hundreds of years to dissipate [ref 5].

RCP	Scenario	Description	Temperature Rise 2050	Temperature Rise 2100
2.6	Extreme Carbon Cuts	Emissions peak in 2020 and reduce to zero in 2080	1.0c	1.1c
4.5	Moderate Carbon Cuts	Emissions peak in 2050 and decline to 2000 levels	1.4c	1.8c
6.0	Minor Carbon Cuts	Emissions double by 2060 and decline but only to 2030 levels	1.3c	2.2c
8.5	Business as Usual	Emissions continue to increase at the present rate	2.0c	3.7c

*Figures are global and are relative to the 1986-2005 period. Source: IPCC [ref 6].*







## Components of Flooding

As global temperatures increase areas are becoming newly prone to flooding, and areas that are currently flood prone are seeing increased frequency and severity of flood events. This is due to a number of factors. Warmer air can hold greater volumes of moisture than colder air, leading directly to increased rainfall. Warmer seas provide more energy for storm events, making them larger and more frequent. Large scale melting of polar ice and thermal expansion is causing sea levels to rise. As the carrying capacity of rivers, soils, drainage and coastal systems are fixed, these increases in rainfall lead directly to flooding as system capacities are exceeded. The increased severity of storms can also cause higher storm surges in coastal areas along with flash floods, where intense rainfall causes sudden overload of drainage systems.

## Sea Level Rise and Storm Surge

These rising temperatures will directly lead to increased sea levels, due to polar ice cap melting in Greenland and Antarctica, glacier melting and thermal expansion.

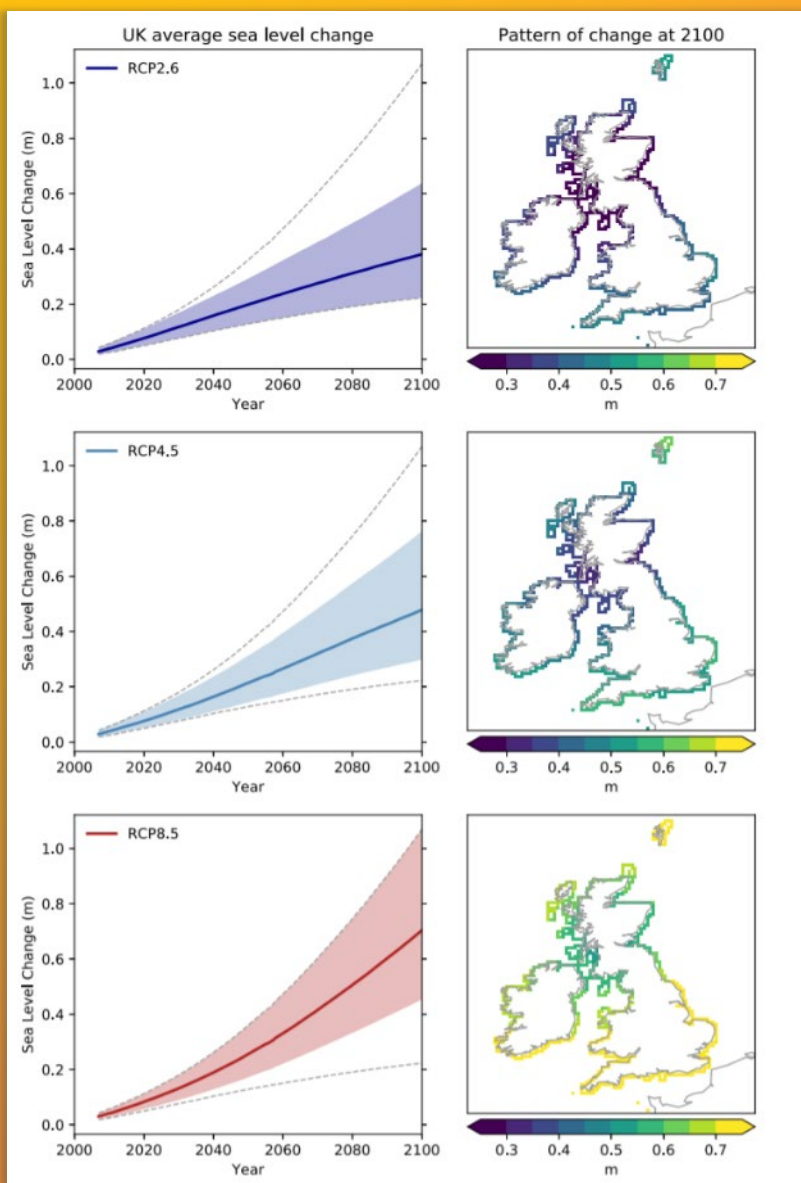


Figure 1: Time series of time-mean sea level change based on the average of the UK ports listed in table 3.2.1. The solid line and shaded regions represent the central estimate and ranges for each RCP scenario as indicated in the legend. The dashed lines indicate the overall range across RCP scenarios. (right) the spatial pattern of change at 2100 associated with the central estimate of each RCP scenario. All projections are presented relative to a baseline period of 1981-2000. Source [ref 7].



Recent research [ref 8] on storm surge projections for Europe suggests that climate change will lead to increased extreme sea levels over and above sea level rise alone. The magnitude of these increases depends on location and RCP, but in the North Atlantic a 100 year event is expected to consist of between 64 and 88cm of additional water level by 2100.

According to an IPCC 2019 report [ref 9] "Extreme sea level events that are historically rare (once per century in the recent past) are projected to occur frequently (at least once per year) at many locations by 2050 in all RCP scenarios".



## Components of Extreme Sea Levels

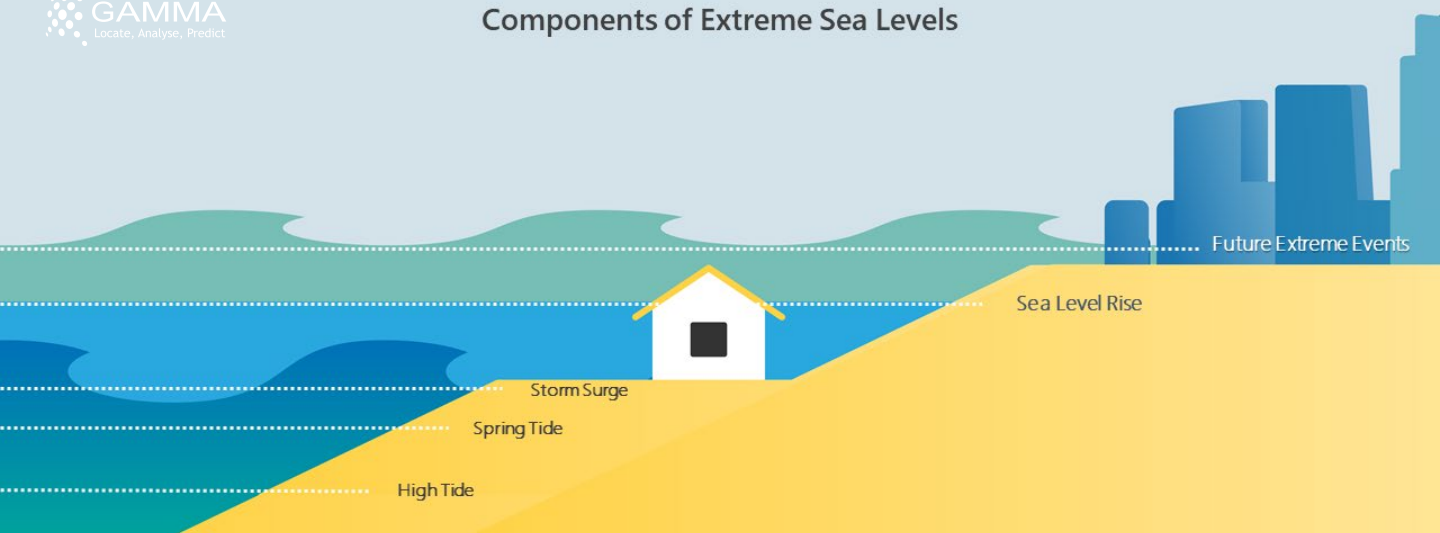


Figure 2: Components of Extreme Sea Levels.



## Rainfall

As warmer air has a larger carrying capacity for water, higher temperatures also lead to more rainfall. The effects of climate change are already being seen, with the highest rainfall totals in a five day period in the decade 2008-17 being 4% higher than 1961-1990 [ref 10] in the UK. February 2020 was the wettest February in Britain since records began, primarily due to the arrival of 3 named storms during the month, Ciara, Dennis and Jorge.

Winter precipitation is expected to increase significantly [ref 11] across the UK, and while rainfall in summer is expected to decrease significantly, storms may become more intense. Despite the expected summer decrease, UK Summers between 2010-19 have been on average 11% wetter than 1981-2010 [ref 12].

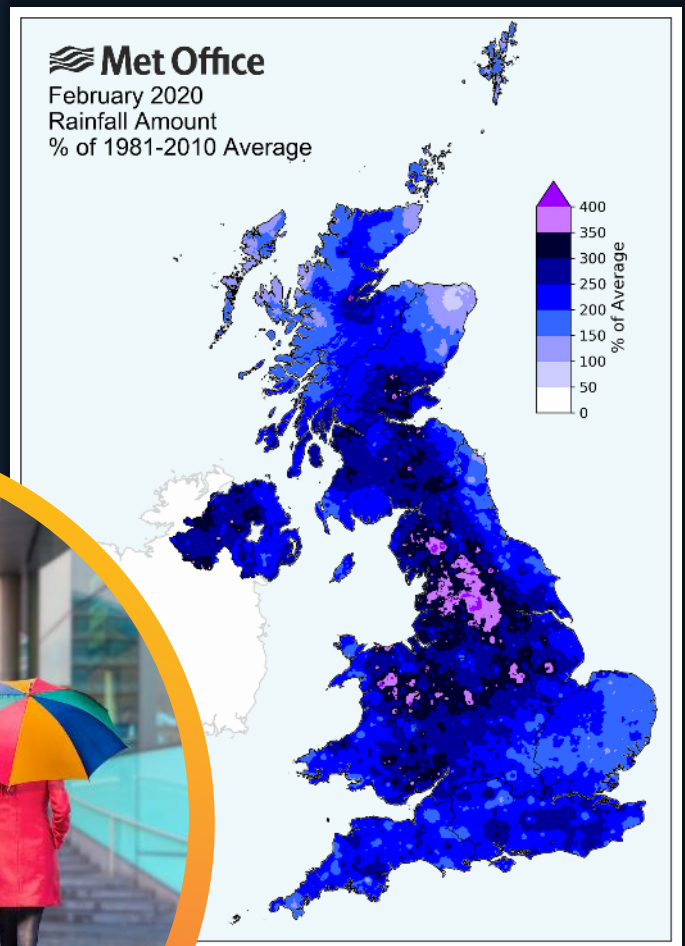


Figure 3: February 2020 [ref 13].



Figure 4:  
Increased extreme winter rainfall [ref 14].





## Ambiental Models

Gamma have used the [FloodFutures™](#) model from [Ambiental Risk](#) to assess the impact of Climate Change on properties in the UK. FloodFutures™ examines a range of climate change scenarios over a set of timescales from 2020 to 2080. The model includes data layers on fluvial (river), pluvial (rain), sea level rise, sea level inundation, river bank and river bed erosion potential, impact on transport infrastructure and bridge flooding heights. For this analysis Gamma worked with the high emissions scenario (90th percentile) data for the year 2050. We included model layers for fluvial, pluvial, sea level rise and tidal inundation.

FloodFutures™ is developed from a broad range of data including UK Climate Projections, currently UKCP09 with UKCP18 expected to be complete in the near future. Digital terrain (DTM) and digital surface (DSM) data is a key component and is derived from Environment Agency (EA) LiDAR mapping augmented with NEXTMap. Land Use and buildings data is sourced from the Ordnance Survey. The inputs are completed with hydrological and river flow data from the Centre for Ecology and Hydrology (CEH). The models have a resolution of 5 metres (horizontal) while the vertical accuracy is +/- 0.15m in areas with LiDAR coverage and +/- 0.6m elsewhere. The model is regularly validated against actual flood events in the UK.



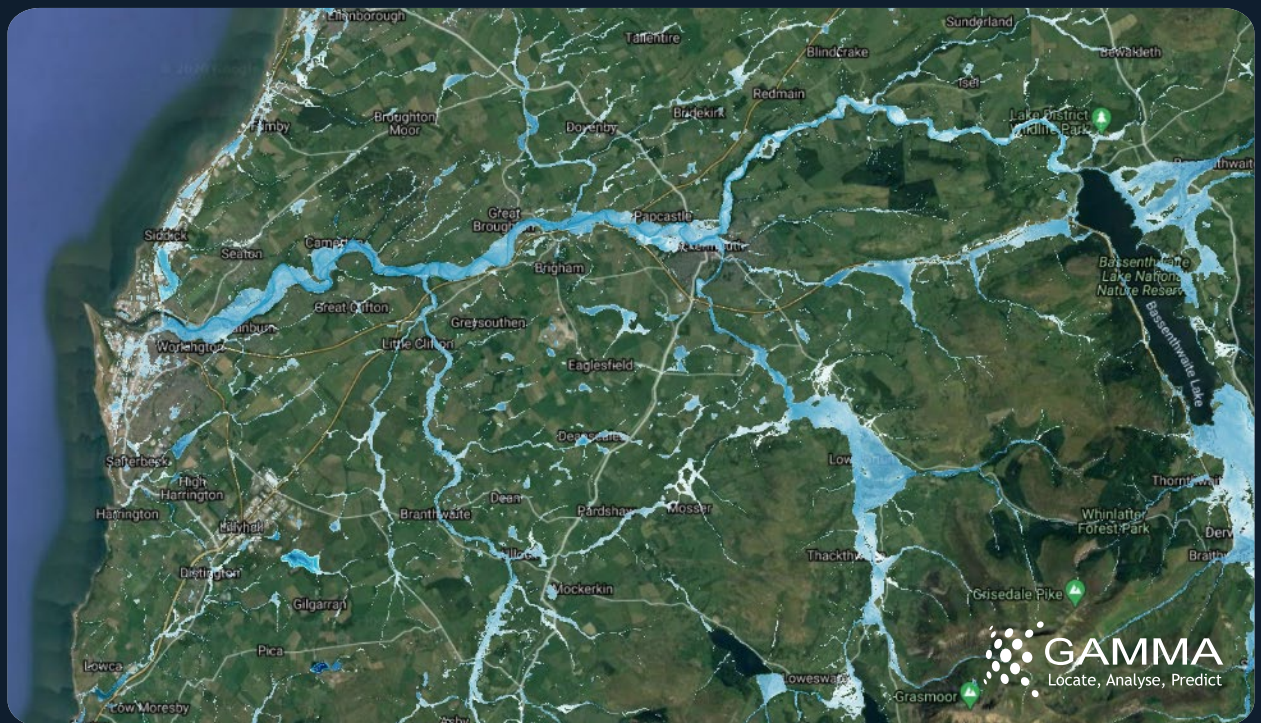


Figure 5: FloodFutures™ Fluvial & Pluvial Layers, 2050 High Emissions Scenario, Cumbria.



Figure 6: FloodFutures™ Fluvial & Pluvial Layers, 2050 High Emissions Scenario, Richmond-upon-Thames.





## Predicting future financial impact on properties from flooding

Combining FloodFutures™ model data with OSGB AddressBase, MasterMap and other datasets allows for the estimation of the number of properties impacted by flooding across the different flood types, climate change scenarios and timeframes.

Consideration needs to be taken that flooding impacts properties on the ground floor of buildings much more severely than properties on higher stories in a multi-unit building. For this analysis we have conducted an outline analysis of buildings which contain more than one address and have worked on the assumption that as the number of addresses in a building increases the proportion of those which are on the ground floor decreases. For this research our model allocates 50% of properties to the ground floor level in a building with 2-4 addresses, this reduces steadily to 20% in buildings which have 50 or more addresses.



The increasing severity and frequency of flood events will have severe implications for flood defences across the UK. Events that currently have a return rate of once per hundred years will become much more common as temperatures continue to rise. Much of the current flood defence infrastructure is designed to withstand these 1 in 100 year events. For this analysis we have worked on the assumption that flood defences other than the Thames Tidal Barrier will have no impact on fluvial, coastal and tidal flood severity and extent.

Looking at the base scenario, set to 2017, we estimate that there are a total of 1,799,271 residential and commercial properties in areas currently at risk from flooding in Great Britain, which is 5.6% of the total number of these properties. In the case of the high emissions scenario from UKCP09, by 2050 we estimate that an additional 4.0% of residential and commercial properties will be newly at risk, giving a total of 3,066,318, or almost 1 in 10 of such properties. This assumes that there are no new interventions in the form of flood defences or other infrastructural works in at risk areas.

This increase in risk is not evenly distributed across Great Britain. Some districts face much larger impacts than others. The 10 with the largest increase in proportion of impacted residential and commercial properties are listed below. As can be seen the South coast from Portsmouth to Worthing, including Arun and Chichester sees the largest proportional rise, areas along the East coast also see significant rises and Conwy is the only one of the top ten not in England.

District	At Risk Base	Additional by 2050	Total Stock	Base %	Additional %	Total %
Portsmouth	4,630	16,504	101,324	5%	16%	21%
East Riding of Yorkshire	31,149	28,403	188,396	17%	15%	32%
Arun (West Sussex)	4,689	9,885	81,346	6%	12%	18%
Merton (London)	6,539	10,210	91,555	7%	11%	18%
Chichester (West Sussex)	6,559	7,567	68,891	10%	11%	21%
Kensington and Chelsea	3,579	10,092	101,802	4%	10%	13%
Conwy (Wales)	9,527	6,002	61,273	16%	10%	25%
Great Yarmouth (Norfolk)	13,120	4,813	53,778	24%	9%	33%
West Berkshire	6,704	6,679	76,022	9%	9%	18%
Worthing	3,035	4,906	55,873	5%	9%	14%



The most heavily impacted districts are Bolton and South Holland in Lincolnshire, however there is only a marginal difference in these areas between the current baseline and the 2050 scenario as they are already at very high risk currently. Nonetheless, flood events in these areas and other currently impacted areas can be expected to become more extreme and frequent as the climate changes.

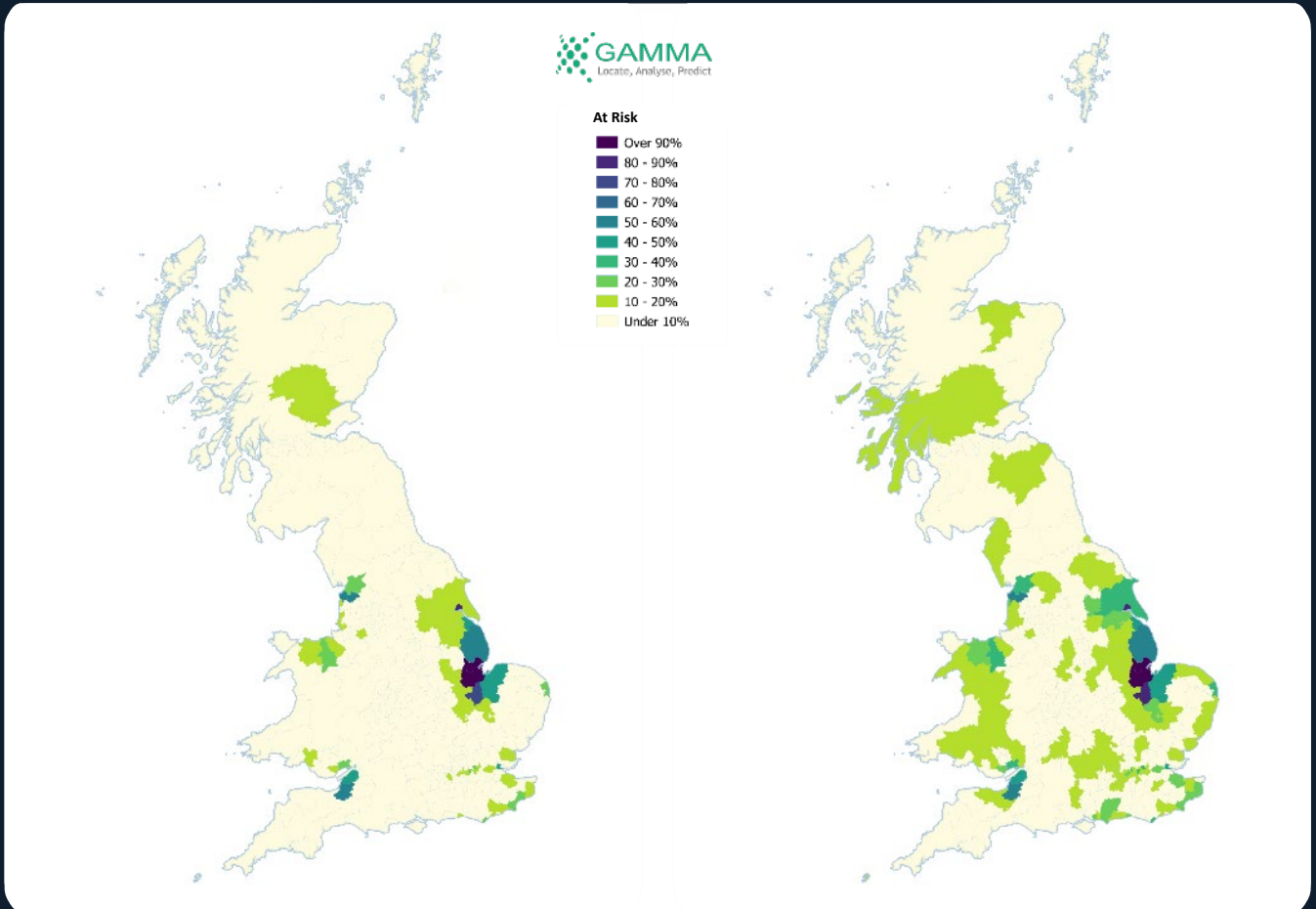


Figure 7: Proportion of Residential and Commercial Addresses impacted by flooding, 2017 Baseline.

Figure 8: Proportion of Residential and Commercial Addresses impacted by flooding, 2050 High Emissions scenario.





## Insurance Impact

According to the Association of British Insurers (ABI) the average payout for a domestic insurance flood claim in February 2020, following storms Ciara and Dennis, was £32,000 while commercial flood claims averaged at £57,000 [ref 15]. Applying these average claim amounts to addresses impacted by 2050 gives a potential insurance liability of £122 Billion, an increase of £50 Billion over the current baseline figure of £72 Billion. There are a number of basic assumptions used to arrive at this figure, including that all properties within the flood zone are impacted, while in reality some may have reduced or negligible claims, while others may have significantly larger claims. However as remediation costs rise and floods become more severe, payouts can be expected to rise. Similarly micro site factors can have unexpected effects beyond the resolution of current models, but the figures above provide useful guidance. Ambiantal can provide more detail on risk variance.

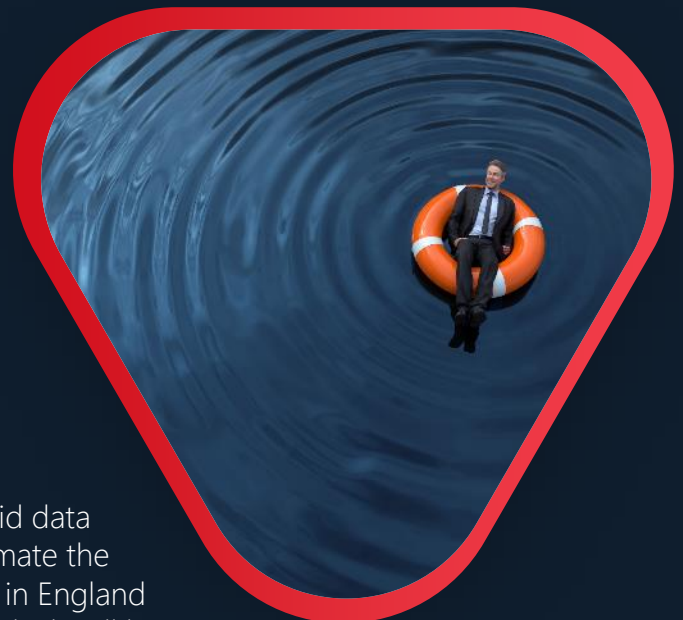


## Property Sales in impacted areas

By combining FloodFutures™ with Price Paid data from the Land Registry [ref 16] we can estimate the volume and value of property transactions in England and Wales since 1995 which were in areas which will be impacted by flooding by 2050 in some scenarios.

Looking at the 10 years from 2010 – 2019 it can be seen that the total value of transactions in newly impacted areas steadily increased from 2010-17 and has since dropped slightly, however the average transaction value has increased every year since 2011.

New builds as a proportion of all transaction value in impacted areas were as low as 10% in the early 2010's, however this has risen to 20% by the end of the decade, meaning that one fifth of all recorded residential property transaction value in areas that will newly be impacted by flooding by 2050 was of newly built property.





Year	Residential Transactions (£M)		Average Value
	Total	Of Which New Build	
2010	£ 7,588	£ 764	£ 260,000
2011	£ 7,483	£ 772	£ 259,000
2012	£ 7,794	£ 931	£ 263,000
2013	£ 10,195	£ 1,360	£ 278,000
2014	£ 12,738	£ 1,746	£ 287,000
2015	£ 13,067	£ 1,768	£ 295,000
2016	£ 14,096	£ 2,353	£ 310,000
2017	£ 15,677	£ 3,324	£ 335,000
2018	£ 14,929	£ 3,131	£ 340,000
2019	£ 13,730	£ 2,639	£ 347,000

Given that over 60% of first time buyers in the UK take out mortgages with terms over 25 years [ref 17] it is likely that there will be a large volume of mortgages taken out in the next few years that will not be fully paid off before much of the predicted impact of climate change driven flooding will come into play. It remains to be seen how exposed the GB mortgage market is to these perils.







## Climate Change and Subsidence

Hotter, drier summers with erratic rainfall and increased solar radiation and warmer, wetter winters have already altered soil moisture conditions across Britain. Long intense dry spells can lower ground levels severely enough to cause fissures which undermine the foundations of buildings and other structures. Fluctuations in soil moisture lead directly to shrinking and swelling in soils, particularly in clay based soils which are common across much of Great Britain. As the soil changes it causes potentially damaging vertical movement. When soils do not dry out evenly this can lead to even more damaging differential ground movement. [\[ref 18\]](#).

Unlike flooding, impacts from clay related shrinkage and swelling are chronic processes, developing over many months or seasons [\[ref 19\]](#). This has been observed in parts of France where drought induced soil subsidence has caused as much property damage as flooding since 1989 [\[ref 20\]](#). As the climate continues to change these severe droughts in summer can be expected to move northwards into Britain. By combining climate change models with soil data the Potential Soil Moisture Deficit (PMSD) can be forecast across Britain for a range of climate scenarios.



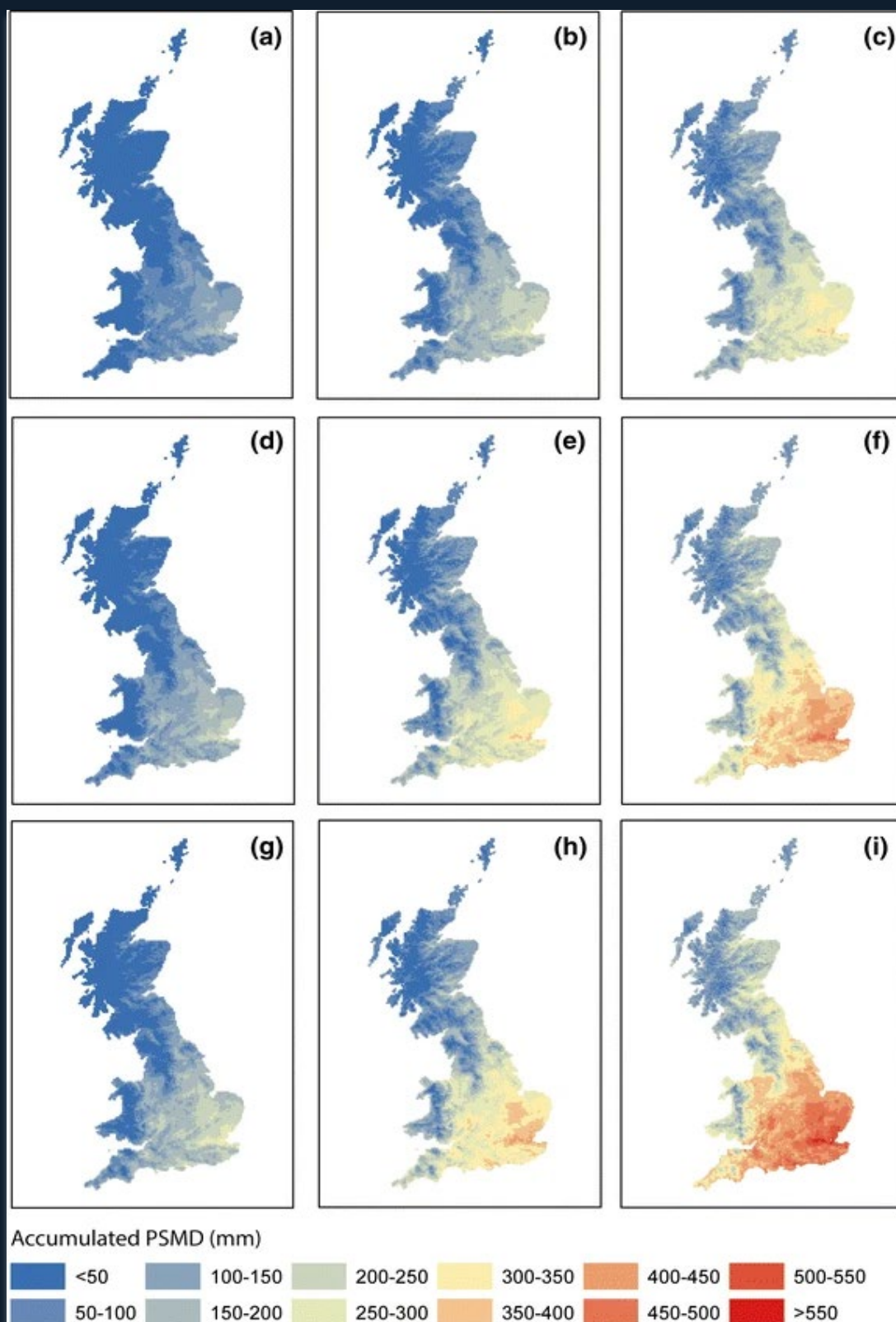


Figure 9: UKCP09-derived projections of accumulated annual Potential Soil Moisture Deficit (PSMD) for GB Baseline (1961–1990) **a** 10th, **b** 50th and **c** 90th percentiles; 2030 (2020–2049) **d** 10th, **e** 50th and **f** 90th percentiles; 2050 (2040–2069) **g** 10th, **h** 50th and **i** 90th percentiles. Source: Prichard, Hallett & Farewell, *Climate Change* 133, 635–650 (2015).



## Terrafirma Models

Terrafirma's National Ground Risk Model<sup>tm</sup> (NGRM) uses high resolution data from a wide range of sources covering land use, soils, local geology, terrain, vegetation, weather historical mining and complex erosional processes. By combining soils data with climate change models, currently UKCP09 with UKCP18 under development, the spatial variation of soil subsidence hazards can be mapped across Great Britain. To this additional surface and subsurface ground instability hazards are added, giving a full understanding of how ground risk may impact the built environment now and into the future.



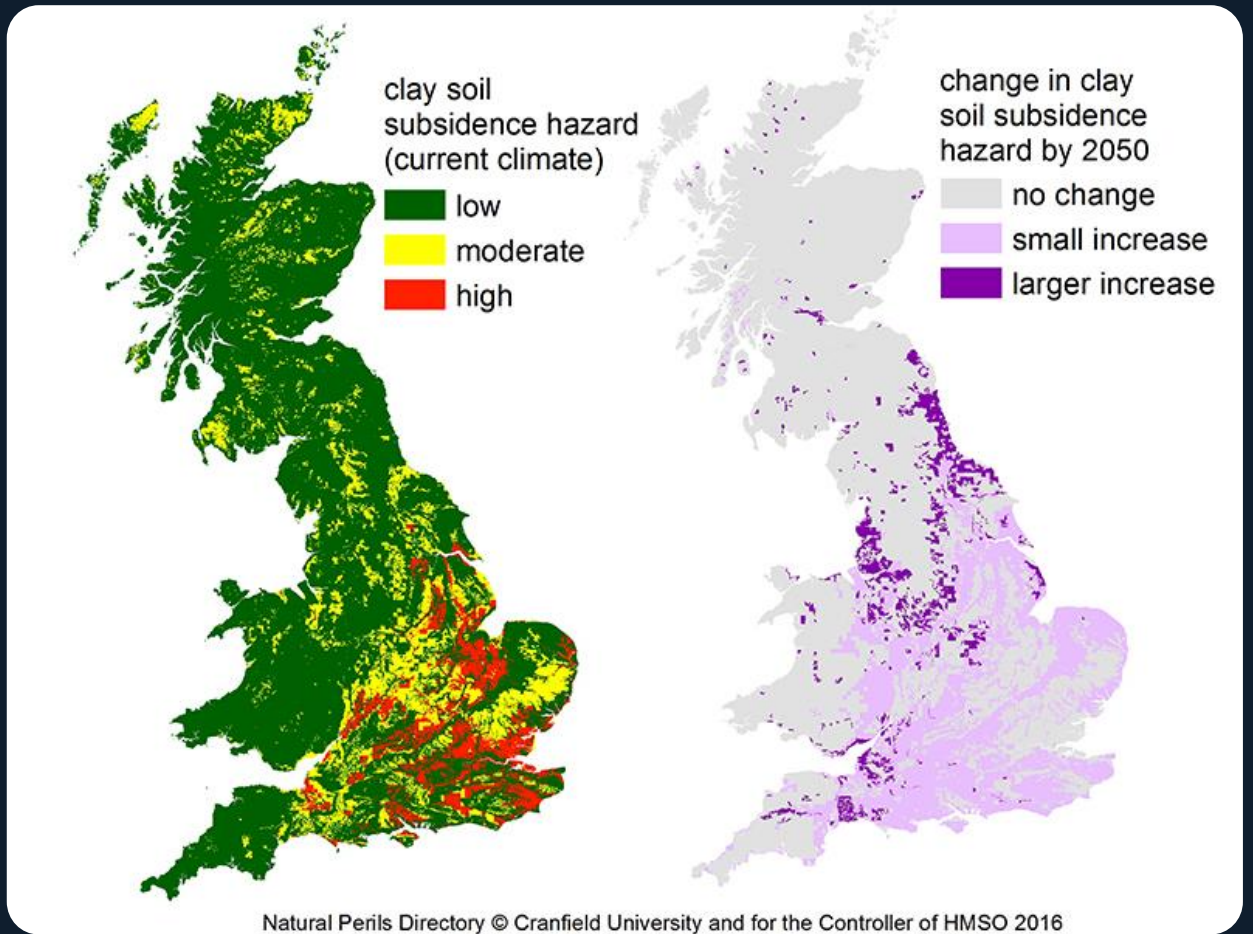


Figure 10: Current and future clay soil subsidence hazard.

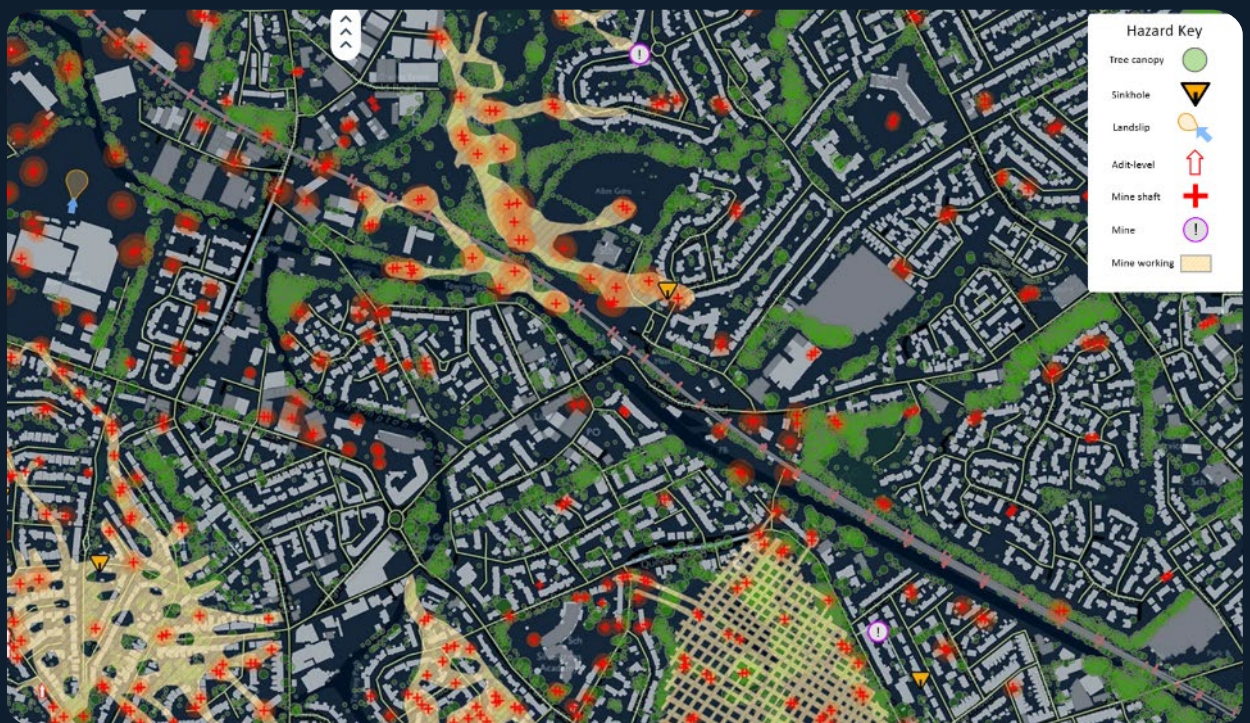


Figure 11: Additional ground hazards from the Terrafirma National Ground Risk Model (NGRM).





## Predicting future financial impact on properties from subsidence

Currently 70% of subsidence cases are due to soil shrinkage [ref 21]. Given the widespread but uneven distribution of clay soils across Great Britain the impact of climate change driven subsidence and other ground hazards on properties will be highly variable. Terraforma have assessed the potential impacts on 44 million buildings, including 29 million dwellings, sourced from Ordnance Survey data. The districts which will see the largest change are listed below.

District	At Risk Base	Additional by 2050	Total Stock	Base %	Additional %	Total %
Swindon	1,339	85,102	107,019	1%	80%	81%
South Tyneside	11,375	58,607	76,395	15%	77%	92%
Stockton-on-Tees	1,621	54,748	94,546	2%	58%	60%
Cheltenham	1,998	32,003	63,061	3%	51%	54%
Crawley	910	24,098	49,849	2%	48%	50%
Mendip	3,254	27,848	58,405	6%	48%	53%
Cotswolds	2,937	22,520	50,075	6%	45%	51%
York	2,629	43,780	102,512	3%	43%	45%
Daventry	977	16,978	40,800	2%	42%	44%
Wellingborough	8,281	15,592	38,791	21%	40%	62%





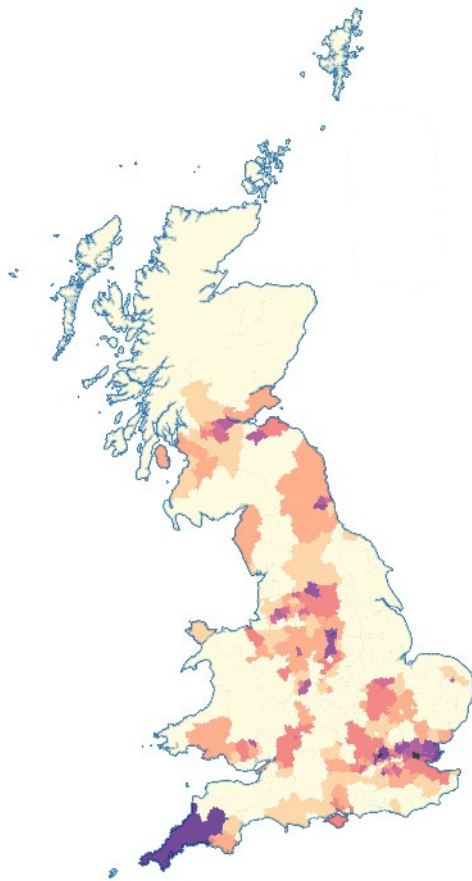


Figure 12: Subsidence Risk, baseline.

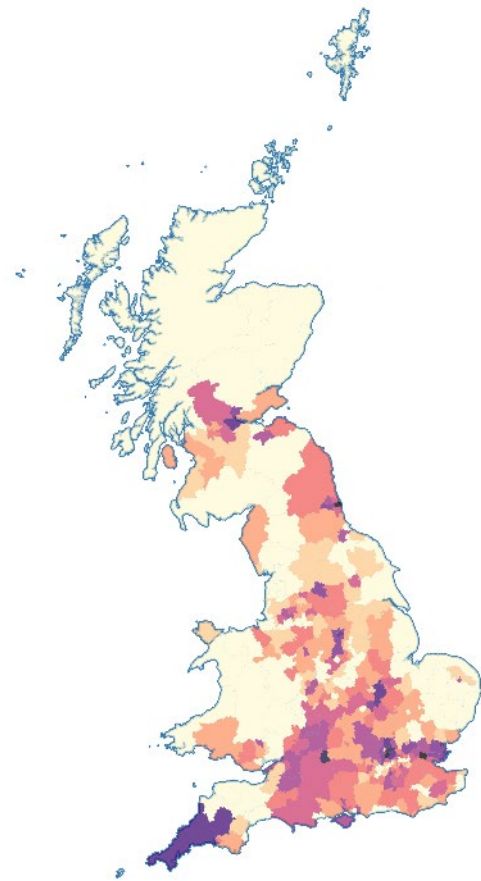


Figure 13: Subsidence Risk, 2050.

It is important to note that in areas where subsidence is currently prevalent, local practitioners may have expertise in adaptation and mitigation of the risk. However such experience is not likely to be widespread in areas that are not currently at risk but will become so in future.

As with flooding, the cost of subsidence related insurance claims are highly variable. Remediation costs have been falling in recent years as methods improve, but particularly complex claims can exceed £100,000. Based on Terraforma industry experience and data from The Association of British Insurers (ABI) the average claim appears to be in the range £6,000 - £12,000. If we take the lower bound of this, £6,000 and apply it to properties at risk we can estimate the current total claim potential to be £40.9 Billion. By 2050 this will increase by £11.8 Billion to £52.7 Billion. There is an assumption that all properties in the impacted areas are equally at risk, whether they are single or multi-storey and are on the ground floor or not. More detailed analysis of the risk variance is available from Terraforma.

In recent years the number of subsidence claims in the UK has averaged at around 10,000 annually, which equates to an average annual loss of approximately £60 Million per annum, according to the Association of British Insurers. However this increases sharply in drier years such as 2018, when the number of claims in a single quarter approached annual levels and the value of claims almost doubled [ref 22]. Given that drier years will be much more common in future and that almost 30% more properties are expected to be at risk of subsidence by 2050 the average annual loss could exceed £155 Million in 30 years time, with particularly dry years significantly exceeding that figure.

Year	Residential Transactions (£M)		
	Total	Of Which New Build	Average Value
2010	£ 11,439	£ 902	£ 239,000
2011	£ 11,025	£ 977	£ 233,000
2012	£ 11,618	£ 1,273	£ 238,000
2013	£ 14,326	£ 1,638	£ 242,000
2014	£ 18,350	£ 2,044	£ 260,000
2015	£ 19,775	£ 2,472	£ 276,000
2016	£ 21,734	£ 3,080	£ 296,000
2017	£ 24,688	£ 3,432	£ 334,000
2018	£ 23,762	£ 3,873	£ 329,000
2019	£ 21,742	£ 3,511	£ 324,000

Combining TerraFirma's National Ground Risk Model with Price Paid data from the Land Registry for England and Wales we can see the volume and value of residential property transactions in areas that will be newly at risk of subsidence by 2050.

In 2019 alone almost £22 Billion of transactions occurred in these areas, almost double the aggregate value of transactions in the same areas 10 years earlier. The average transaction value in the impacted areas over that time period rose by only 35%, so the number of transactions in impacted areas is rising.

Newly built properties represented 8% of all transactions by value in impacted areas in 2010. This has risen steadily to 16% by 2019. Thus newly built residential property now represents one sixth of all residential property transactions in England and Wales that occurred in areas that have been projected to be at risk of climate change driven subsidence by 2050.







## Key Findings

In writing this report Gamma have worked closely with Ambiental and their FloodFutures™ Model along with Terrafirma and their National Ground Risk Model™. We utilised the UKCP09 High Emissions scenario for this analysis. UKCP18 models will be available from both Ambiental and Terrafirma in the near future.

From analysing the geocoded property data and the risk models in our Perilfinder™ location intelligence platform, we can conclude that:

- ▶ Britain's changing climate is already having a major impact on properties across the country. As more energy is added to the atmosphere these impacts will become more severe.
- ▶ There is wide spatial variation in the above ground (flooding) and below ground (subsidence) impacts.
- ▶ Using lower bound claim estimates, the current exposure from flooding (£79 Billion) and subsidence (£41 Billion) is £120 Billion
- ▶ Using lower bound claim estimates the total additional exposure by 2050 from flooding (£52 Billion) and subsidence (£12 Billion) is £64 Billion. Giving a total exposure by 2050 of £184 Billion.
- ▶ Given the long term nature of mortgage borrowing and the more widespread and severe impacts of climate change, mortgage lenders need to evaluate their exposure.
- ▶ Average annual subsidence claims are expected to rise from £60 Million to over £150 Million by 2050.







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