RMS WHITE PAPER

THE 2012 U.K. FLOODS

Executive Summary

The year 2012 was the United Kingdom's second wettest on record—which was all the more remarkable considering the widespread drought that had persisted from the start of the year through spring. The rains began in April, and by the end of 2012 numerous on- and off-floodplain events had occurred. The relentless precipitation, in combination with cool summer temperatures that inhibited soil moisture evaporation, saturated the soil. The conditions were the catalyst for widespread pluvial (surface water) flooding, which became more prevalent as the year progressed. Although individual flooding events were small from a historical perspective, U.K. residents made a total of 486,000 flood claims in 2012—with roughly half of the reported damage from pluvial flooding occurring off the floodplain.

By year's end, accumulated insured flood losses had reached approximately £1.2 billion (US$1.8 billion)—the second highest since records began, surpassed only by the U.K. 2007 floods. Despite their significance, the annual exceedance probability of 2012's flood losses is just under 1 in 9, according to the RMS® U.K. Inland Flood Model, highlighting the potential for similar events in the future. Modeled estimates indicate that nearly half of the U.K.'s expected average annual flood loss can be attributed to pluvial flooding, in line with the losses observed in 2012.

According to the U.K. Centre for Ecology and Hydrology, the reversal of the drought situation from April to September was "without modern parallel," and the U.K. saw rainfall totals rise to 115 percent of the national average. To enable insurers and reinsurers to better manage flood risk from all sources under a variety of conditions, the U.K. Inland Flood Model simulates over 100,000 years of precipitation scenarios, which feed into the simulation of fluvial and pluvial flood conditions. The model captures on- and off-floodplain sources across over 1 million km (625,000 mi) of major and minor U.K. river networks, incorporating the complete Environment Agency (EA) National Flood Defense Database and simulating antecedent ground conditions; all of which are necessary to accurately assess flood hazard.

RMS climate change research indicates that the probability of flooding events like those in 2007 and 2012 could increase. Although the U.K. government has pledged additional funding for defenses, much of this is associated with coastal projects to protect against storm-surge related flooding, which will not protect against the type of inland flooding observed in 2012.

The U.K. government recently announced that the Statement of Principles—a commitment between the U.K. government and insurance industry to offer insurance to previously flooded or at-risk customers—will be replaced by Flood Re in the coming years. Flood Re is a not-for-profit pool providing coverage up to the 200-year return period level to properties with the highest flood risk. While this represents an enormous challenge for the insurance industry to execute, it will also be a tremendous opportunity to efficiently manage the financial implications of U.K. flood risk.

The RMS U.K. Inland Flood Model equips the insurance and reinsurance industry with comprehensive modeling capabilities to evaluate properties at risk from all sources of flood loss, which will aid in the identification of those properties most at risk, and in the effective management of the upcoming Flood Re pool.

Introduction

From a meteorological perspective, 2012 will be remembered by many as a year of extremes for the U.K. Almost every month broke some weather-related record, from extreme cold, snow, and ice to unseasonably warm weather; from extreme drought to widespread flooding (Figure 1). The cold, wet summer saw reports of rare "supercell" thunderstorms and large hailstones.

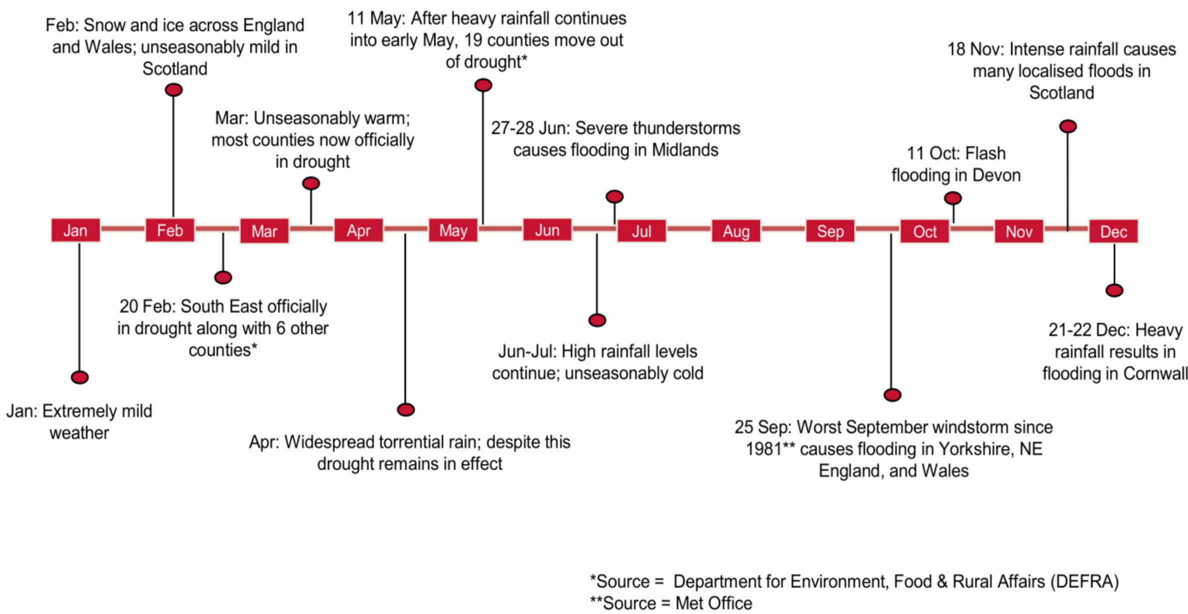

Figure 1: 2012 U.K. weather timeline.

The most significant meteorological event of 2012 was the extreme rainfall that occurred, almost without cessation, from April to December. This reversed a widespread drought that had existed across England and Wales owing to two consecutive years of below-average rainfall. Across large areas of the Midlands, total precipitation in the year preceding April 2012 was approximately 55 to 65 percent of the climatological[1] average (1971–2000). By the end of 2012, the situation had changed, with surplus rainfall totals experienced across England, Wales, and southern Scotland. In some areas, January–December precipitation was over 135 percent of the 1971–2000 average.

With the exception of May, each month from April to December 2012 saw widespread, intense rainfall. As the summer progressed, ground water levels rose and reservoirs were replenished, causing both flash flooding and regional flooding on multiple minor rivers including, but not limited to, the Caen, Calder, Ouse, Thames, and Yealm. In its end-of-year report, the Centre for Ecology and Hydrology (CEH, 2012) stated that the rapidity of the transition from drought at the beginning of April to the level of ground saturation by September was “without modern parallel.” The year 2012 was record-breaking in many respects, leaving few parts of the U.K. unaffected. This report summarizes the most significant inland flooding events in the U.K. in 2012, their implications for the insurance industry, and how we can use inland flood models as part of flood risk assessment.

[1] The climatological average is reported on a 30-year rolling basis every decade, as required by the World Meteorological Organization (WMO), as this period is deemed long enough to eliminate year-to-year variation.

Understanding U.K. Flood Risk

The U.K. is at high risk of flooding from multiple sources, including rivers, surface water, and coastal seawater or storm surge.[2] These flood types are all driven by stormy weather, but have different causes, impact different geographic locations, and are defended against in different ways. All types of flooding pose the highest risk in the winter, when storms are more frequent, although flooding is possible in all seasons. For example, heavy spring snowmelt was a major contributor to the devastating 1947 U.K. floods,[3] whereas summer thunderstorms contributed to the 2007 floods.[4]

Surface-water or "pluvial" flooding can result from intense precipitation in areas with saturated soil, high groundwater levels, and inadequate drainage. The risk that pluvial flooding poses to property is the most difficult to model and defend against—rather than using measurements such as river or tide gauge data to extrapolate river discharge conditions during extreme events, understanding this type of risk requires models that simulate both precipitation and antecedent conditions; for example, in soil moisture and groundwater levels.

Surface water can pool or create temporary streams in dips and hollows in topography regardless of location relative to the river network. Local surface cover and sewer design also impact the overall level of risk. For example, in 2007 the sewer systems of Kingston upon Hull became overwhelmed, resulting in the flooding of 6,500 buildings (RMS, 2007).

River flooding occurs when precipitation runoff drains into an existing river network, creating an anomalously high river discharge with the potential to overtop riverbanks or breach defenses. A flood wave can take several days to travel the length of a river, causing long-lasting, geographically widespread flood extents.

Currently, U.K. river defenses include both permanent structures and temporary demountable defenses erected when flood warnings occur. Defenses along main rivers and the sea are directly operated by the Environment Agency (EA), whereas defenses for smaller rivers, statutorily named "ordinary watercourses," are built and maintained by local authorities to standards overseen by the EA. Regular dredging to remove silt can be necessary to maintain channel volumes. Some analysts argue that recent budgetary cuts for dredging both nationally and locally may have exacerbated the impact of the 2012 events (Gray, L., 2012).

The hazard is further complicated by urbanization, floodplain development, and overuse of impervious surface coverings, which have aggravated the flood risk. The Committee on Climate Change's Adaptation Sub-Committee (CCC ASC) (2012) found that “the rate of development in the floodplain between 2011 and 2012 was higher (12 percent) than outside the floodplain (7 percent).”

Coastal seawater flooding, also known as storm surge, is caused when strong windstorms drive seawater onto land and funnel water upstream into tidal estuaries, rivers, and creeks. Flood maps from the EA typically include surge risk, although surge events are not driven by precipitation. The last time a national emergency was formally declared in the U.K., storm surge was responsible. In January 1953, a North Sea storm flooded over 600 square kilometers (232 square miles) in the U.K., killing 307 people; 1,800 people perished in the Netherlands during the same event (RMS, 2003).

[2]RMS flood models assess the risk from all types of flooding in the U.K. Surface water and river flooding are included in the RMS® U.K. Inland Flood Model, which simulates 100,000 years of precipitation and antecedent soil moisture conditions. Storm-driven coastal surge is included in the RMS® Europe Windstorm Model and is tied to simulated windstorm events.
[3]For more information, see https://support.rms.com/Publications/1947_UKRiverFloods.pdf
[4]For more information, see https://support.rms.com/Publications/UK_Summer_2007_Floods.pdf

2012 U.K. Floods: Event Characteristics

At the start of 2012, groundwater and river flow levels ranged from below normal to exceptionally low across England and parts of Wales (CEH, January 2012). Drought conditions were present in 40 counties from Cornwall to Yorkshire due to nearly two years of below-average rainfall. By mid-April, 20 million people were subject to drought restrictions (Harvey, 2012).

The histogram in Figure 2 illustrates the 2012 monthly rainfall as a percentage of the monthly climatological average (1971–2000). In all four of the member nations of the U.K., March was a particularly dry month, with rainfall less than half of the climatological average.

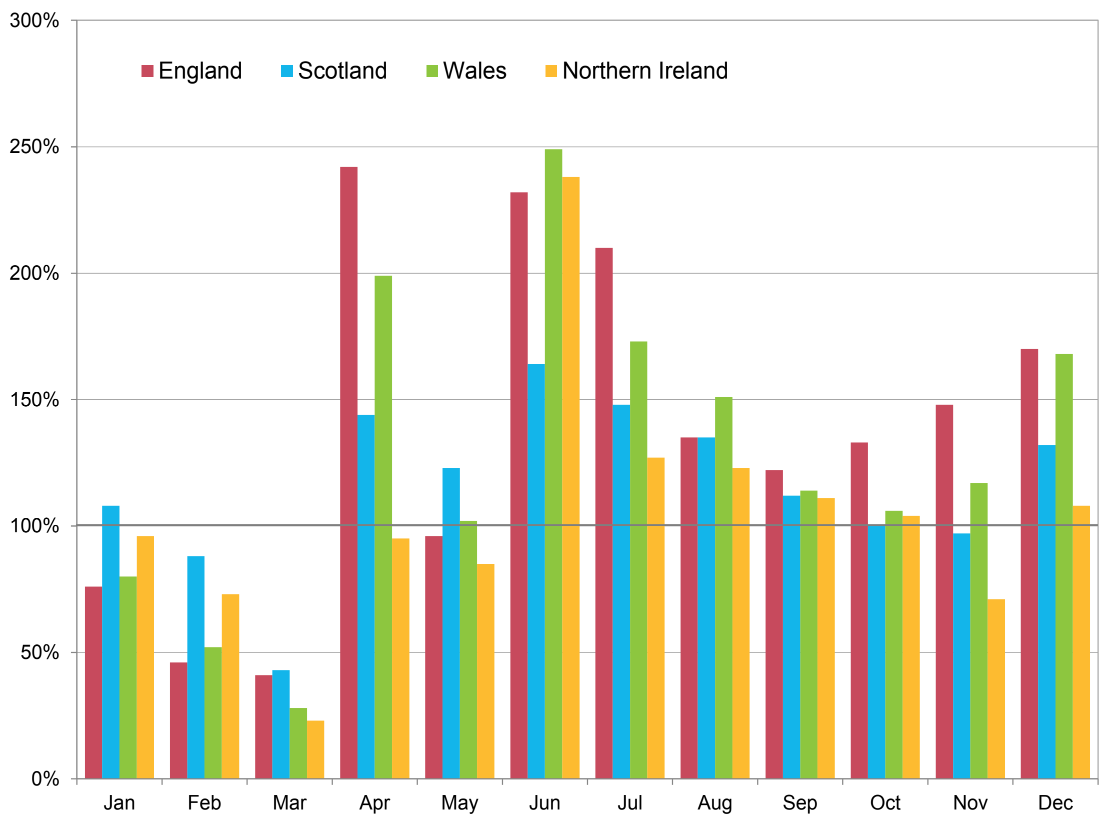

Figure 2: Monthly rainfall in 2012 as a percentage of the 1971–2000 monthly climatological average (data from the U.K. Met Office).

The succession of dry months ended in April when a near-continuous series of frontal systems traveled across the U.K. More than 121 mm (4.8 in) of rain fell over the country—173 percent of the climatological average—setting a new record for the wettest April since measurements began in 1910. The EA issued flood warnings for the southwest, Midlands, northeast, and east of England. Limited flash flooding occurred but did not cause significant damage, although power was disrupted to 5,000 homes in Wales. River flow levels rose to normal in April, but groundwater levels remained low because spring and summer rain is less effective at alleviating drought (more moisture is evaporated by warmer temperatures or is retained by vegetation, in contrast to the winter months).

The rainfall continued into the start of May but the end of the month saw drier conditions, as total rainfall returned to the average for the time of year. Due to the changeable weather, river levels remained high and the groundwater began to recover from the drought. June was another record-breaking wet month, beginning with heavy rain during Queen Elizabeth II's Diamond Jubilee Pageant. By month's end, England, Northern Ireland, and Wales had all received more than 200 percent of their average precipitation.

Table 1 summarizes a selection of 24-hour rain accumulations from Friday, June 22 across the northwest U.K. In some places this one-day total is in excess of the average rainfall for the entire month (the average rainfall across the northwest of England and North Wales for June is 83.6 mm or 3.3 in). The heavy rains led to record water levels in some rivers, with many bursting their banks. The peak flow of the River Calder at Hebden Bridge reached a record 3.2 m (10.5 ft) on June 22, causing flooding in Hebden Bridge, Mytholmroyd, and Todmorden. In Cumbria, the River Yarrow flooded Croston and the Rivers Caldew and Petteril in the north of the county also exceeded flood stage.

Table 1: 24-hour rain accumulations from 10:00 UTC on Friday, June 22, 2012 (Source: U.K. Met Office).

Location	24-Hour Rain Accumulation
Blencathra, Cumbria	93.8 mm (3.6 in)
Keswick, Cumbria	88.6 mm (3.4 in)
Stonyhurst, Lancashire	74.4 mm (2.9 in)
Levens Hall, Cumbria	58.2 mm (2.3 in)
Morecambe, Lancashire	57 mm (2.2 in)

The weather conditions in May and June were affected by the behavior of the jet stream, which had become locked into a position farther south than usual, similar to its position during the 2007 summer floods. The jet stream, which separates warmer air to the south from cooler air to the north, steered stormy, wet weather toward the U.K. Its southern position also led to cooler-than-average temperatures in May and June, which inhibited the evaporation of soil moisture, lessening soil water loss to the atmosphere.

Unsettled weather continued into July. From Friday, July 6, through Saturday, July 7, prolonged, heavy rainfall over parts of the U.K. triggered flash flooding in several regions, most notably in the southwest of England. Parts of East Devon and West Dorset received between 75–120 mm (3.0–4.7 in) of rainfall in this 24-hour period, more than the monthly July average of 60–100 mm (2.3–3.9 in) in these regions. Farther north, significant rainfall was observed across West Yorkshire and Lancashire. Table 2 summarizes a selection of 24-hour rain accumulations in the north and south of England from July 6 to July 7.

Table 2: 24-hour (*15-hour) rain accumulations on July 6 and July 7, 2012 (Source: U.K. Met Office).

Location	24-Hour Rain Accumulation
Dunkeswell Aerodrome, Devon	45 mm (1.8 in)*
Exeter Airport, Devon	41.8 mm (1.6 in)
Camborne, Cornwall	37.6 mm (1.5 in)
Mountbatten Plymouth, Devon	35.2 mm (1.4 in)
Emley Moor, West Yorkshire	56.6 mm (2.2 in)
Ryhill, West Yorkshire	52.6 mm (2.1 in)
Holbeach, Lincolnshire	44.8 mm (1.8 in)
Market Bosworth, Leicestershire	41.6 mm (1.6 in)

This rainfall led to another episode of flooding, with the worst-affected areas in the southwest of England, particularly in Devon, but also in parts of the northeast and the Midlands (Figure 3). The EA issued three severe flood warnings for Devon on July 7, while across the U.K., between July 6 and 7, the EA and the Scottish Environment Protection Agency (SEPA) issued a total of 76 flood warnings and 158 flood alerts. Several rivers overtopped their banks at record highs, including the River Yealm in Devon, which reached a record high of 2.3 m (7.5 ft), as well as the River Otter at Ottery St. Mary and the River Bride at Burton Bradstock.

In August, another low-pressure system—dubbed "extreme weather event Frida" by the Norwegian Meteorological Institute—brought more flooding to Devon, Tyne and Wear, West Yorkshire, and southern Scotland. By the end of the month, the rain had ceased and river levels began to fall, but groundwater levels remained exceptionally high in the Midlands and south of England. The ground water saturation at the end of summer set the stage for multiple pluvial flood events throughout the autumn. During this time, water pooled locally, causing areas distant from overtopped rivers or defense breaches to also experience damaging floods.

Severe flooding continued, particularly affecting Wales and the northeast of England, throughout the autumn and early winter (Figure 3). When low-pressure system Karin crossed the U.K. on September 24, bringing moisture absorbed from Hurricane Nadine in the Atlantic several days before, surface water flooding was significant.

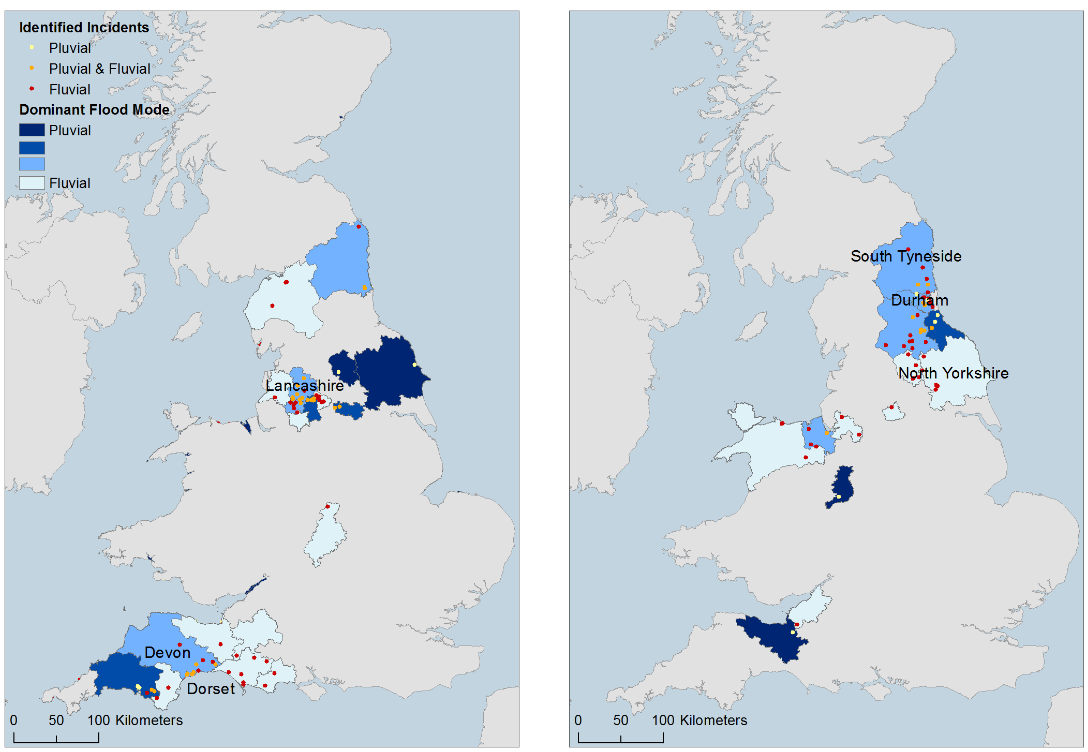

Figure 3: Reported flood incidents summarized by CRESTA zone for June and July (left) and September (right), and shaded in relation to dominant flood mode within that zone.

From November 21 to 27, flash flooding was observed in many parts of the U.K. (Figure 4). Buildings in the West Midlands were damaged by treefall and many road and rail services were shut down, including the two main railway lines that link the southwest of England to London. Several rivers (including the Thames, Ouse, Derwent, Cree, and Ruchill) overflowed their banks and in total, more than 1,000 properties were flooded.

Flooding continued through late December, when more wet weather caused transportation disruption during the busy holiday season (Figure 4). In North Devon, the River Caen burst its banks, and in Wales, landslides were reported. The Thames Barrier was raised on December 27 to prevent flooding of the Thames during high tide.

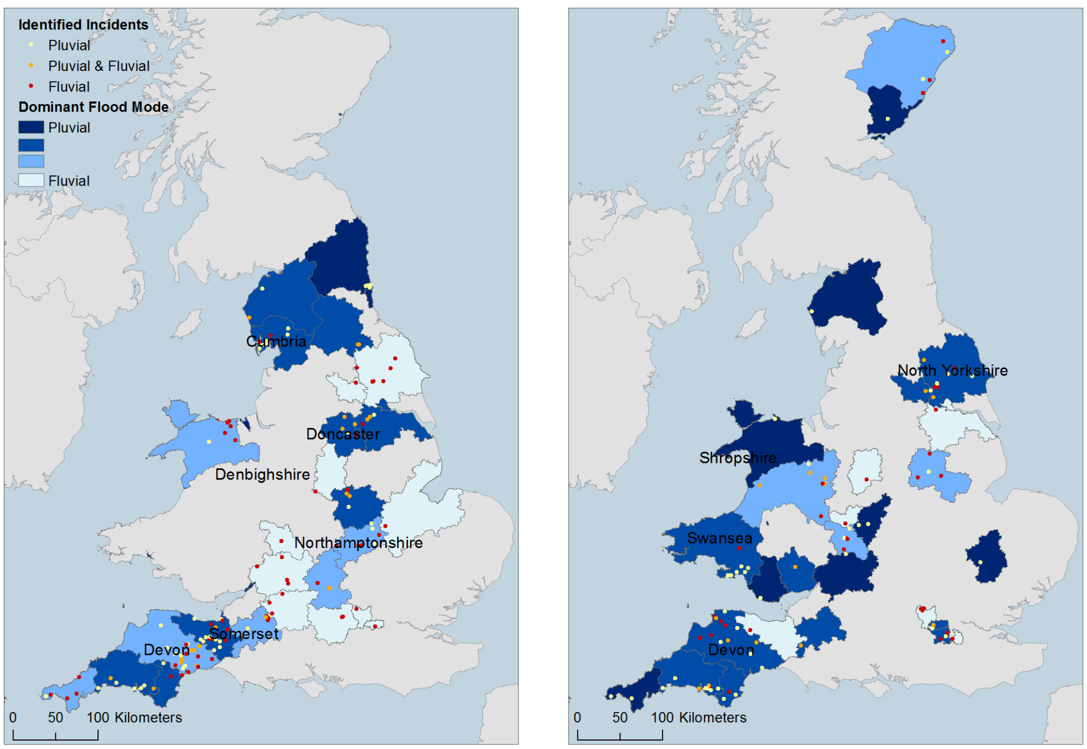

Figure 4: Reported flood incidents summarized by CRESTA zone for November and early December (left) and late December (right), and shaded in relation to dominant flood mode within that zone.

Despite the initial drought conditions, 2012 was by all accounts extremely wet. By the end of the year, 1,331 mm (52.4 in) had fallen across the U.K. ("Met Office: 2012 was UK's second wettest year on record," 2013) making it the second wettest year since 1910. Hundreds of distinct flood incidents had occurred, with the EA estimating that 8,000 properties had been flooded. The year was unique and record-breaking in many respects, but in particular will be remembered for the broad scale and duration of extreme weather and flooding.

RMS Flood Response

According to RMS catastrophe response accumulation footprints issued in June, July, September, November, and December 2012, as many as 300,000 properties in 161 unique postcode sectors in 30 counties across the U.K. were potentially exposed to flooding in 2012 (Figure 5, Table 3).[5] The widespread nature of the accumulated flooding is evident from the number and extent of counties affected, with Devon and Yorkshire counties having the largest number of affected postcode sectors.

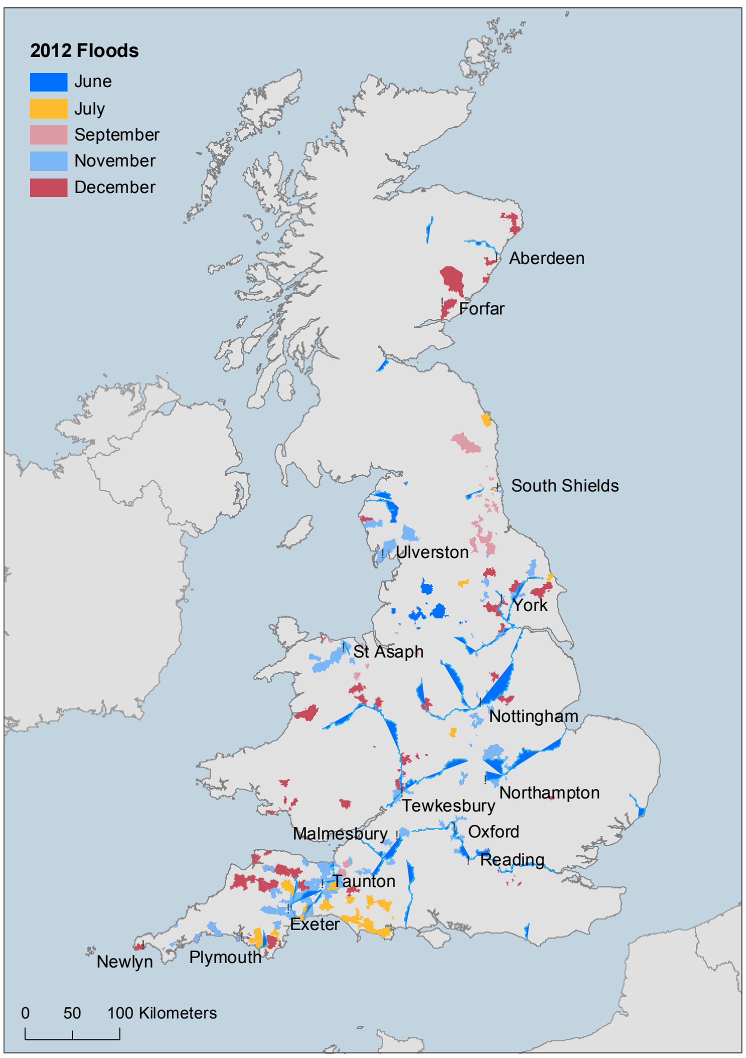

Figure 5: RMS accumulation footprints issued for the 2012 U.K. floods.

[5] RMS catastrophe response issues post-event accumulation footprints based on affected postcode sectors to inform clients of the potential properties affected by a flood event. The number of buildings in each affected postcode sector is calculated using the RMS® U.K. Industry Exposure Database (IED).

Table 3: Number of affected postcode sectors by county for RMS 2012 U.K. flood footprints

County	June	July	September	November / Early December	Late December	Total
Aberdeenshire					5	5
Angus					3	3
Bedfordshire				1		1
Berkshire				2	1	3
Buckinghamshire				1	2	3
Cambridgeshire					1	1
Cornwall				9	5	14
Cumbria	3			11	1	15
Devon		19		27	22	68
Dorset		8				8
Gloucestershire				2		2
Lancashire	17					17
Leicestershire		1		4		5
North Yorkshire		2	33			35
Northamptonshire				7		7
Northumberland		1				1
Nottinghamshire					4	4
Oxfordshire				3		3
Shropshire					9	9
Somerset		2		20	2	24
Staffordshire				1	1	2
Surrey				1	6	7
Tyne and Wear		2		4		6
Vale of Glamorgan					1	1
Wales				7	10	17
West Yorkshire	13		3			16
Wiltshire				8		8
Worcestershire				1	9	10
Yorkshire				19	13	32
Total	**33**	**35**	**36**	**128**	**95**	**327**

RMS engineers performed post-event reconnaissance to learn more about the damage mechanisms responsible for property loss. Complete structural damage from flooding is rare, but flood damage to moveable building contents is a common feature, and can cause a complete contents loss. Decontamination and drying is another large driver of loss, as these processes can be time-consuming and costly.

Two weeks after the September flooding began, RMS performed damage surveys in Morpeth, Newburn, and Chester-le-Street in northeastern England, regions that had been the hardest hit by this flooding event. The team found that extensive repair work was under way, including drywall replacement up to heights approximately three times the flood depth. RMS engineers found evidence of extensive damage to moveable contents such as furniture, and fixtures and fittings, and of electronics being thrown away (Figures 6 and 7).

Figure 6: Carpets being thrown out in Morpeth (Source: RMS).

Figure 7: Contents damage in Chester-le-Street (Source: RMS).

Loss Impacts and Implications for the Future

The 2012 U.K. floods led to the second highest annual insured flood losses in the U.K. since records began, surpassed only by the 2007 U.K. floods (RMS, 2007). As a result of the flooding, the ABI states that 486,000 residential, commercial, and motor flood claims were made in 2012, for a total insured damage amount of approximately £1.2 billion (US$1.8 billion). Pluvial flooding was a significant contributor to flood losses, especially as the year progressed and groundwater levels rose.

Although the individual flooding events were small, their high frequency led to significant accumulated losses through the year, having a marked impact on the primary insurance market. The countrywide spatial extent of the flooding diminished some of the advantages of geographic diversification in policy writing by insurers. Furthermore, due to the high frequency of events with low event losses, very little of the loss would be recoverable by insurers through reinsurance.

Especially hard hit by the pattern of continuous low-level flooding was the agricultural sector, particularly in the southwest and northwest of England. Although occasional flooding is a fact of life for farmers, the persistence of wet conditions from the spring through winter meant many fields did not have a chance to drain and the entirety of the growing season was impacted. Besides crop failure, the lack of pasture caused animal feed prices to rise. According to one newspaper article (Doward, 2012), "wheat yields were at their lowest level since the 1980s, the potato crop at its lowest since 1976," while livestock farmers have seen their income halved.

Climate models are forecasting increased episodes of flooding for the U.K. under climate change conditions (U.K. Meteorological Office, 2011). An upward trend in extreme rainfall events over the past years has already been identified (Harrabin, 2013). According to the U.K. Met Office, four of the wettest five years have occurred since 2000, a statistic made all the more remarkable given the drought between 2010 and 2012. Peer-reviewed scientific research, performed by academics in collaboration with RMS scientists, found that climate change increased the likelihood of the floods that impacted England and Wales in the year 2000 (Pall et al., 2011)—in which 10,000 homes and businesses were flooded due to heavy autumn precipitation.

The 2012 floods occurred a year prior to the July 31, 2013 expiration of the Statement of Principles, an agreement between the U.K. government and insurance industry that insurers would continue to provide flood insurance to previously flooded or at-risk properties (ABI: Flooding, 2013). At this stage, the agreement will not be renewed for another five-year term; instead a combined government- and industry-backed pool, called Flood Re, will replace it. Under Flood Re, the insurance industry, supported by the pool, must provide coverage for flood (and surge) losses up to the 200-year loss return period. The U.K. government will take primary responsibility for losses in excess of a 200-year return period event. Flood Re still requires negotiation between all involved stakeholders and is not expected to come into operation until the summer of 2015 at the earliest. While this represents an enormous challenge for the insurance industry to execute, it will also be a tremendous opportunity to efficiently manage the financial implications of U.K. flood risk. However, until the scheme is finalized, householders and businesses will not have certainty surrounding the availability of flood insurance in the future.

In November 2012, the U.K. government announced plans to spend £120 million (US$183 million) on flood defenses, split between new areas targeted for protection and speeding up protection already being built. The announcement came after a period of budget cutting, with government climate advisers in the summer of 2012 noting a 12 percent decrease in flood defense spending from the previous year ("Flood defense funding," 2012).

Construction began on 93 new flood defenses in February 2013 with a government pledge of an additional £2.3 billion (US$3.5 billion) until 2015 ("Construction to start," 2013). Despite this activity, some commentators have criticized the government for not doing enough (Carrington, 2012). Some of the largest projects, like the £80 million (US$122 million) coastal defense at Rossall, Lancashire, are to protect from storm surge rather than the pluvial flooding event that dominated 2012's losses.

Assessing Risk with the RMS U.K. Inland Flood Model

According to the RMS® U.K. Inland Flood Model, the annual exceedance probability of a flood loss of £1.2 billion (US$1.8 billion) in any given year in the U.K. is just under 1 in 9. Approximately 2.2 million homes are within the RMS 75-year return period flood extent map, including major river, minor river, and surface water (pluvial) flooding sources. Of those homes, 58,000 (2.6 percent) are in the major river floodplain, with many more at risk from minor rivers and surface flooding.

The RMS U.K. Inland Flood Model captures both on- and off- floodplain risk to assess flood risk from all sources. The model physically simulates rainfall events and runoff into over 1 million kilometers (625,000 miles) of river network, including a probabilistic view of flood defense failure and simulated antecedent soil conditions.

The RMS model estimates that only 50 percent of the U.K. average annual loss (AAL) for flood comes from major river flooding, with the remaining 50 percent from small river and stream flooding, flash flooding, pluvial flooding, and localized heavy precipitation.

RMS models pluvial flooding dynamically, based on a combined 100,000 simulated years of precipitation in order to capture crucial antecedent soil moisture conditions. This allows better modeling of event clustering and correlation between regions as well as a more realistic estimation of pluvial risk.

Information on flood defenses is critical for assessing flood risk and mitigating loss. However, this data is often incomplete and, as many flood defenses are temporary, difficult to factor in to the underwriting process. The increased development on floodplains in recent years makes up-to-date knowledge of defense locations and standard of protection even more important. Where this information does not exist or is incomplete, the U.K. Inland Flood Model algorithmically makes assumptions about defenses based on population and exposure, and validates these assumptions with EA databases and past loss experience.

Conclusions

As evidenced by the 2012 events, surface water or pluvial flooding is a major contributor to U.K. flood risk, but can be challenging for insurers to manage, as both precipitation and antecedent soil moisture conditions must be considered. Urbanization, floodplain development, and overuse of impervious surface coverings have aggravated this risk, as identified by the CCC's ASC 2012 report, citing that development in the floodplain between 2011 and 2012 exceeded that outside the floodplain. Furthermore, public works, such as the defenses and coastal barriers recently announced by the government, do not protect against pluvial flooding.

Many homes and businesses continue to face the ongoing risk of flooding. Understanding and managing accumulated flood risk from all sources is critical both for effective mitigation and flood response, as well as insurance solvency. As the Statement of Principles expires and we await the final structure and formalization of Flood Re, uncertainty surrounding the future availability of affordable flood insurance for at-risk properties will remain.

In the past, the “at risk” definition commonly referred to properties located in the floodplain or vulnerable coastal areas. However, 2012 demonstrated that high-frequency flood losses can accumulate to significant levels in other regions as well. While 2012 flooding was widespread, little of it occurred along major rivers; much of it occurred on the minor rivers or was pluvial in nature. The high groundwater levels and soil saturation were important antecedent conditions influencing the observed flooding. As the persistent, extreme weather exacerbated these conditions through the year, the reported incidents of pluvial floods increased to become the dominant mode of flooding by the end of 2012. From an insured loss perspective, no individual flood event was in and of itself a major source of concern to the insurance industry. However, taken together, the geographic extent and temporal concentration of flooding led to the second-highest total annual flood losses in the U.K. since records began; surpassed only by the annual losses from the U.K. floods of 2007.

Regardless of the development of Flood Re, the U.K. insurance industry will continue to face many challenges with respect to flood risk assessment and underwriting. According to the RMS® U.K. Inland Flood Model, an annual flood loss of £1.2 billion (US$1.8 billion) could be expected approximately once every decade. The RMS model also estimates that only 50 percent of the U.K. average annual loss (AAL) for flood comes from major river flooding, with the remaining 50 percent from small river and stream flooding, flash flooding, pluvial flooding, and localized heavy precipitation. To accurately and comprehensively assess the full scope of exposure at risk to floods both on and off the floodplain, insurers and reinsurers must look to solutions that capture the location, frequency, and severity of flood risk, from all potential sources.

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