FLOOD MODELING

UNIT 4

RMS® CCRA® Training Program

Certified Catastrophe Risk Analyst

AGENDA

- Unit 1: Peril Anatomy
- Unit 2: Modeling River and Surge Floods
- Unit 3: Flood Vulnerability
- **Unit 4: Interpreting Flood Analysis Results**
- Unit 5: Flood Catastrophe Response

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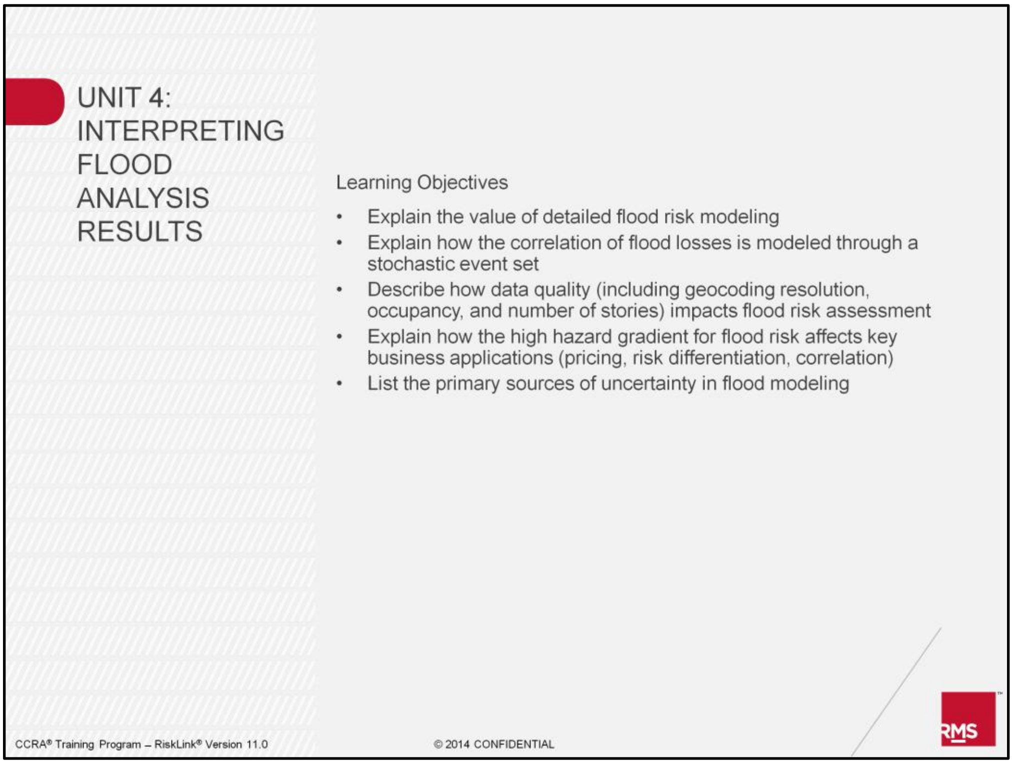
RMS

This unit discusses the vulnerability module of the Europe windstorm model.



At the end of this unit you should have a good understanding of each of the five learning objectives listed on this slide.

THE VALUE OF FLOOD RISK MODELING

- Key applications
  - The ability to price risk
  - How it can be aggregated
  - How risk can be differentiated
- Among all standard perils flood risk shows the greatest degree of concentration and localization
- Ability to differentiate flood risk at the highest resolution is a major competitive advantage
- Distinguish and differentiate through ability to model frequency and severity. Most government agencies provide only frequency maps (e.g. 100-year return period flood zone maps).

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Flood risk modeling enables you to price individual policies to see how risk can be differentiated as well as to understand how risk can be aggregated, how we can build up a portfolio, and how we can look at potential diversification across that portfolio.

Among all the perils we model, flood risk shows by far the highest degree of concentration and localization. High-resolution information is more critical in flood than in any other peril. Given that fact, a company that is able to differentiate flood risk at the highest resolution has a major competitive advantage if it is able to use that information effectively.

FLOOD LOSSES ARE HIGHLY LOCALIZED

- In most situations flood loss tends to be highly localized
  - Localization depends on topography
  - Most regionalized in coastal floodplains, most localized in mountains
- Individual property losses from even one to two feet of inundation can be 10-20% of insured value (and higher for contents)
- However, for longer return periods (e.g. 1,000-year RP), flood extents may cover a large area and be highly correlated, and therefore lead to large losses.

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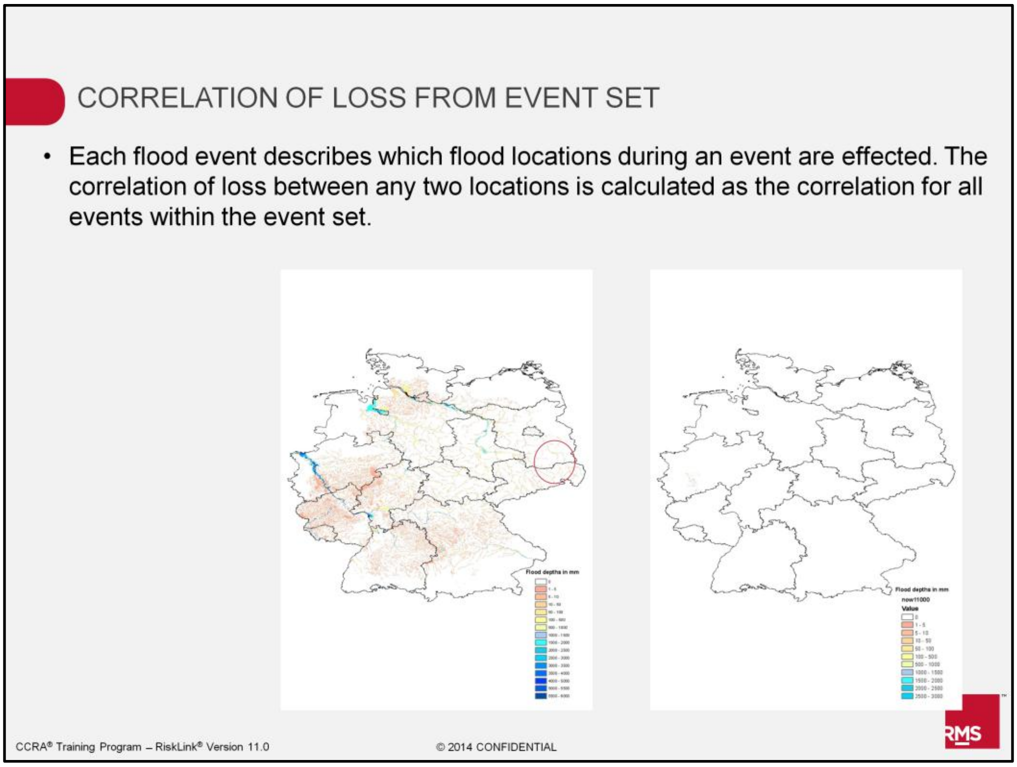
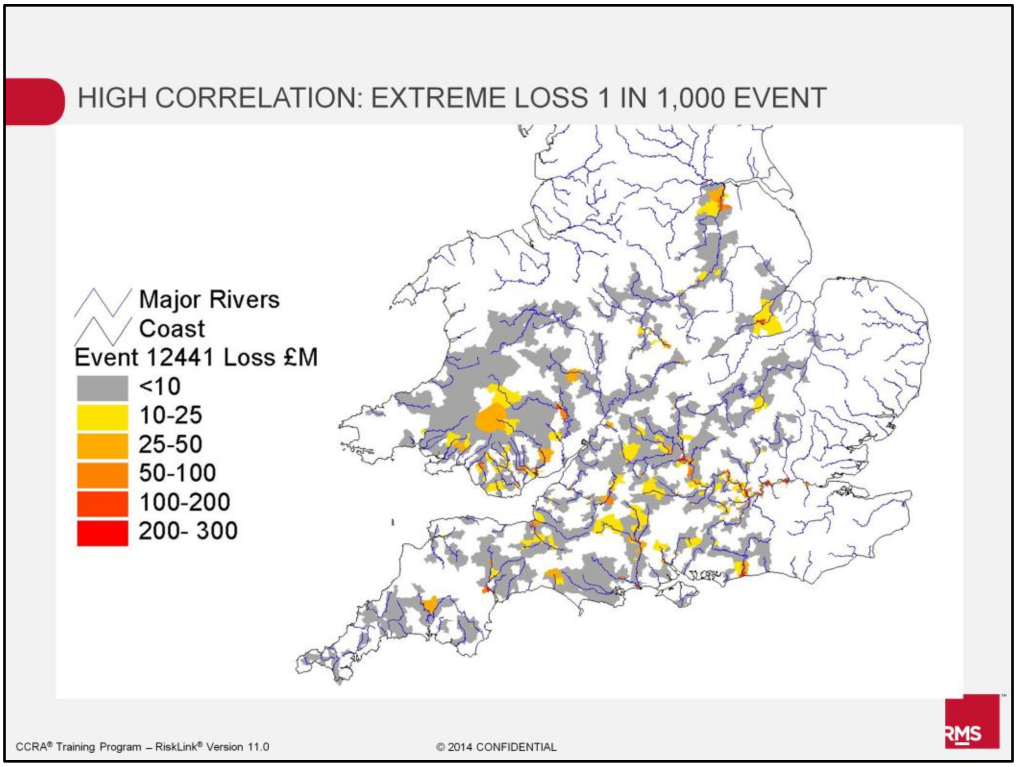
The principal driver of localization is topography, the elevation of the property with respect to the floodplain. Localization is much higher in areas of high topography, for example, in mountainous regions where the floodplains may be very small and very localized. In coastal floodplains, the floodplain is often very broad and the elevation range may be quite low, so there may be less opportunity to be able to differentiate risk at the higher resolution. However, even the quite small variations in the elevation of properties and ultimately the inundation depths can be significant in affecting losses.

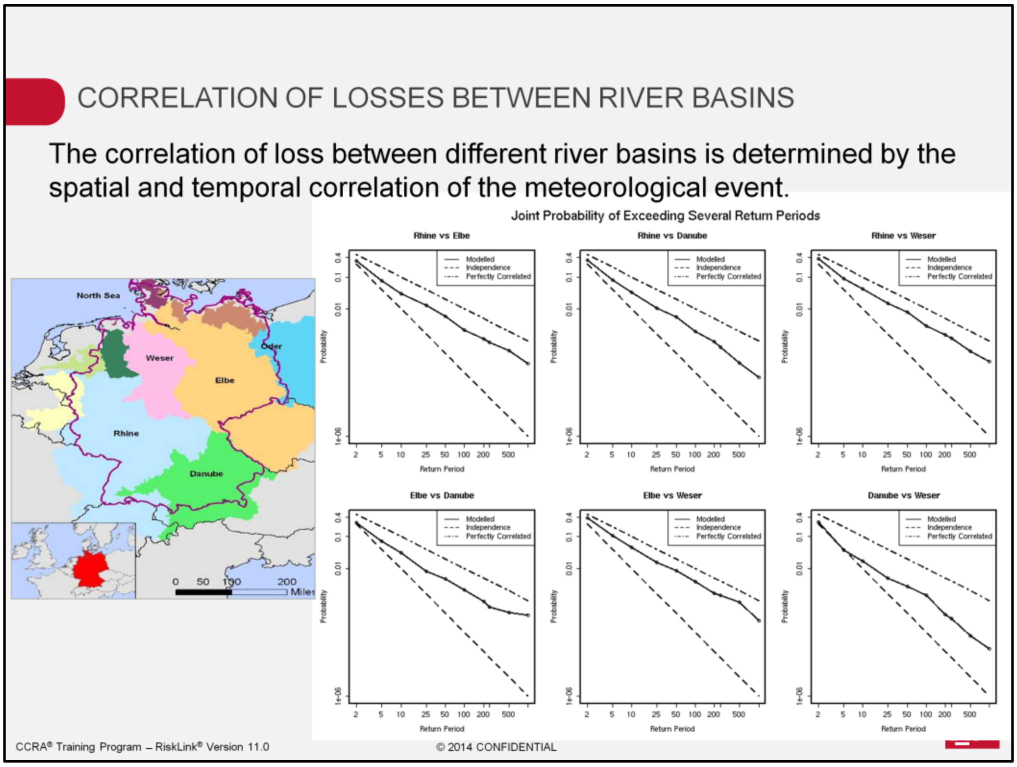


The flood events contained in the RiskLink event set represent all possible scenarios. Some flood events cover a broad area (shown on the left) and flood many properties at the same time. Other flood events cover only a small local area (shown on the right) and therefore only flood a few properties. Given that we can look at the flood depth of two or more properties for all events, we can establish the correlation of flooding between these locations.



This is an example of an event from the inland river flood model in the U.K. This event is a 1,000-year return period event. This highlights the degree to which a very catastrophic loss event can be expected to have a distribution across multiple catchments and river systems as a result of several weather systems arriving across the region.

The reason why this event is so extreme is because it has impacted the three river systems that have the highest concentrations of exposure in their floodplain. The principal one is the River Thames, in addition to the River Trent in the midlands of England and the River Severn on the borders with Wales. If all three of these rivers are affected by an extreme flood event at the same time, then the losses can rise to a very high level.



When we look at different river basins we can describe the correlation of flooding in these basins as the joint probability of exceeding the loss for all return periods. This estimate is bound by the uncorrelated case, where the chance of two 100-year events happening at the same time is 1/10,000, or 1/(100 x 100), and by the correlated case where this is 1/100. Not surprisingly the two rivers in Germany with the largest degree of spatial separation, the Weser and Danube, are uncorrelated for low return periods where the patterns are more local.

HOURS CLAUSES

How are losses aggregated in case of prolonged periods of heavy rainfall / snowmelt?

The market standard wording for physical damage excess of loss policies (LPO98a / NMA 2244) defines loss occurrence as all individual losses arising out of and directly occasioned to one catastrophe. In the case of flooding each event is limited to 168 to 504 hours (seven to 21 days), making each event definition dependent on exposure and the specific contract.

Precipitation systems are complex. The overlapping space – time structure of river flow makes an event definition that is independent from the exposure distribution a complicated task. Using the RMS derived IED produces events that must be longer than 168/504 hours.

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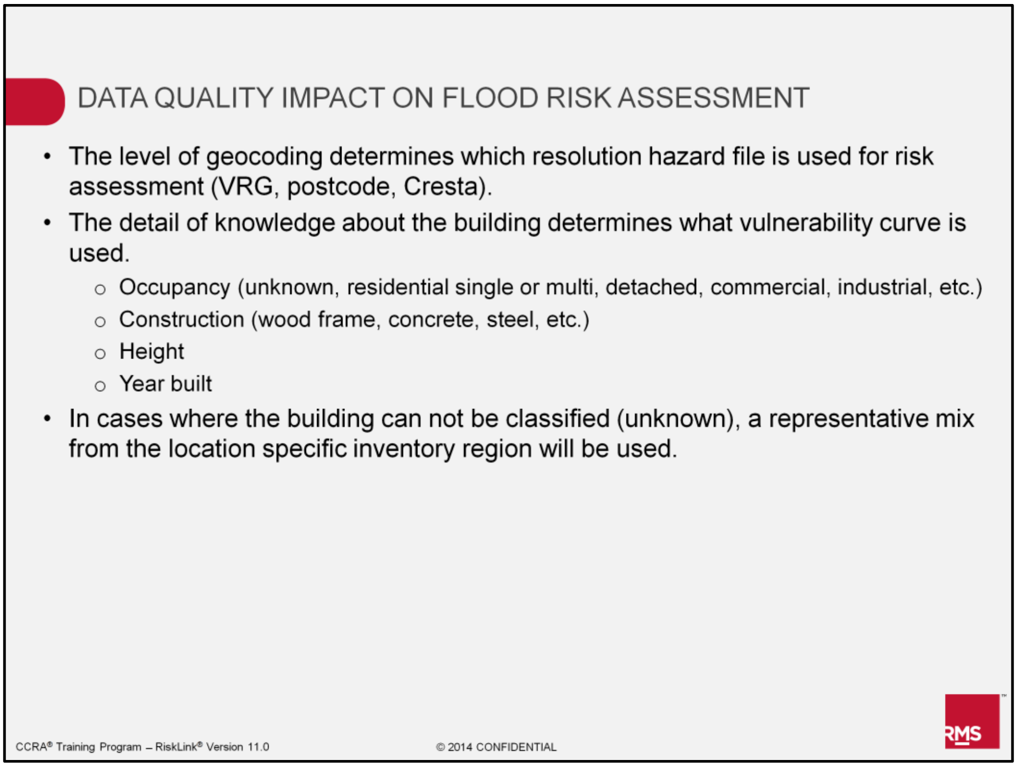
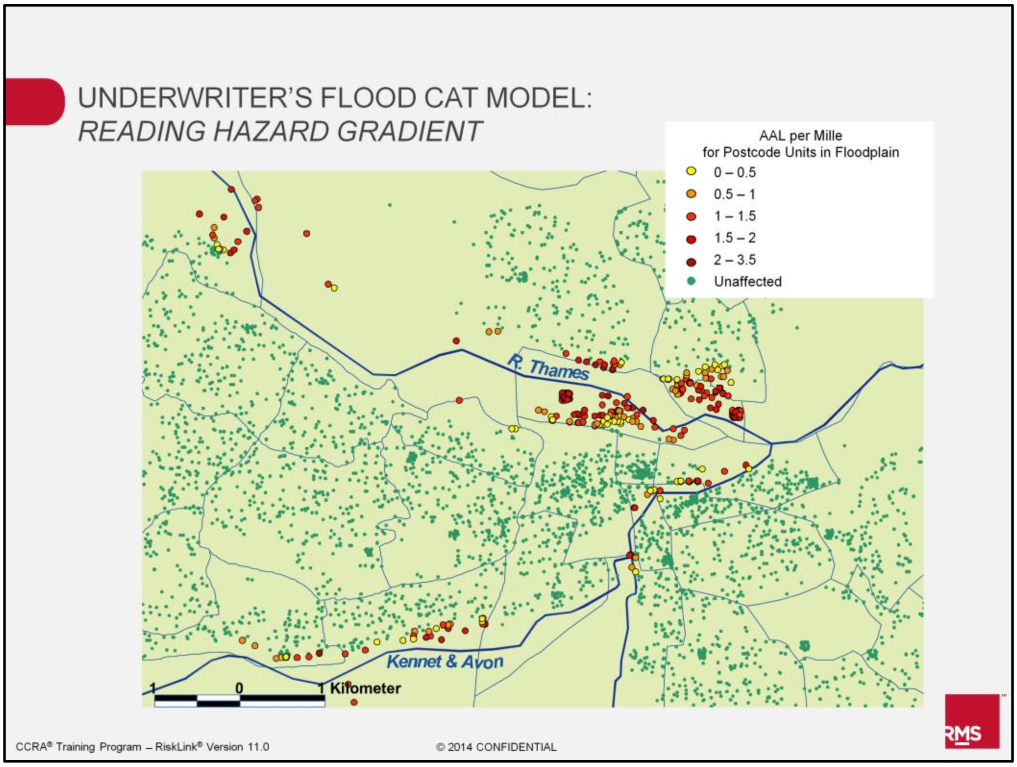
This slide explains hours clauses, which defines how losses are aggregated during prolonged periods of heavy rainfall or snowmelt.



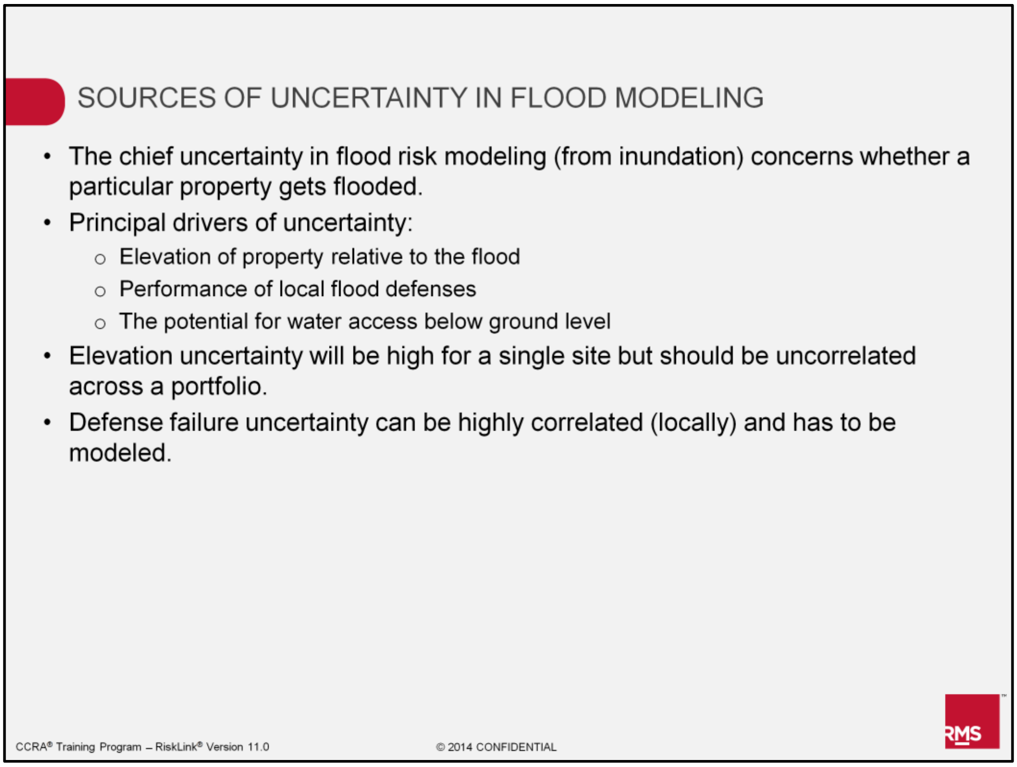
The importance of accurate geocoding cannot be overestimated when it comes to flood modeling. While other perils, such as windstorms, have footprints that are significantly larger than postcode areas, flooding is very localized and major losses occur close to major rivers. The difference of losses based on postcode or VRG files can be quite significant, sometimes up to a factor 100 and more.



This is an example from our U.K. river flood model looking at what we represent the average annualized loss to be in parts per thousand. On the edges of the principle floodplains the cost may be up to 0.5 per mille. In the center of the floodplain it may be up to two to three-and-a-half per mille.

The green dots are not areas that have no risk but are areas effectively outside the floodplains, so they are only going to be impacted by off-floodplain sources of loss.

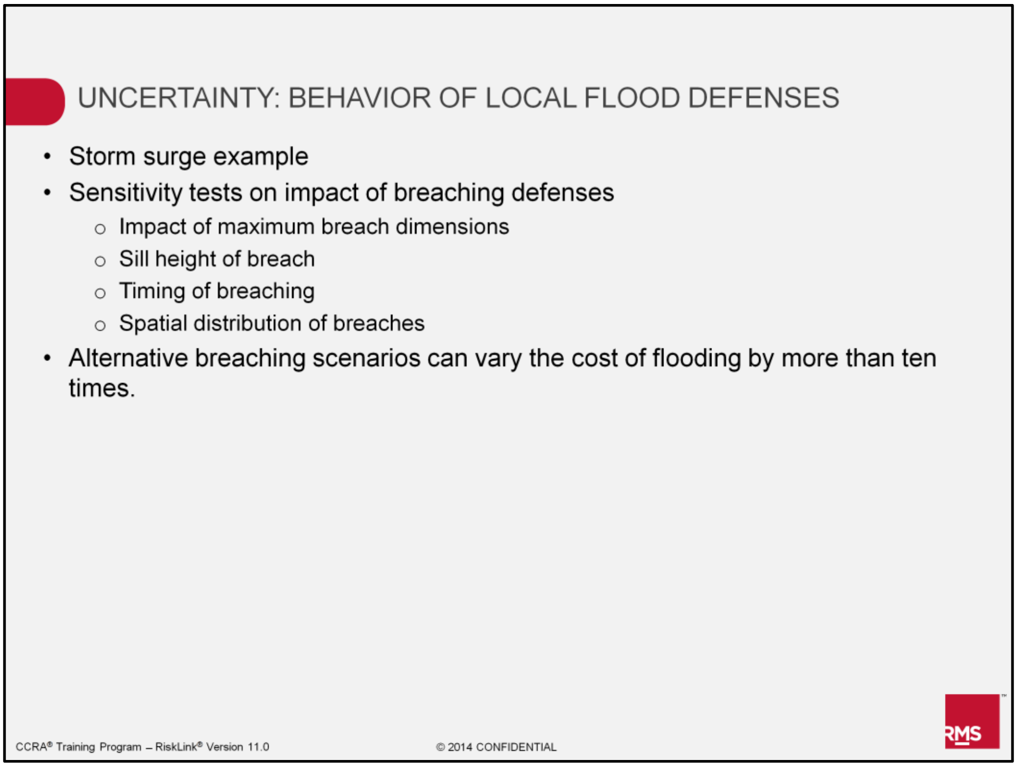
This illustrates that in a short distance around the River Thames, through the town of Reading, the flood risk measured as loss costs varies significantly from very low up to two to three-and-a-half parts per thousand.



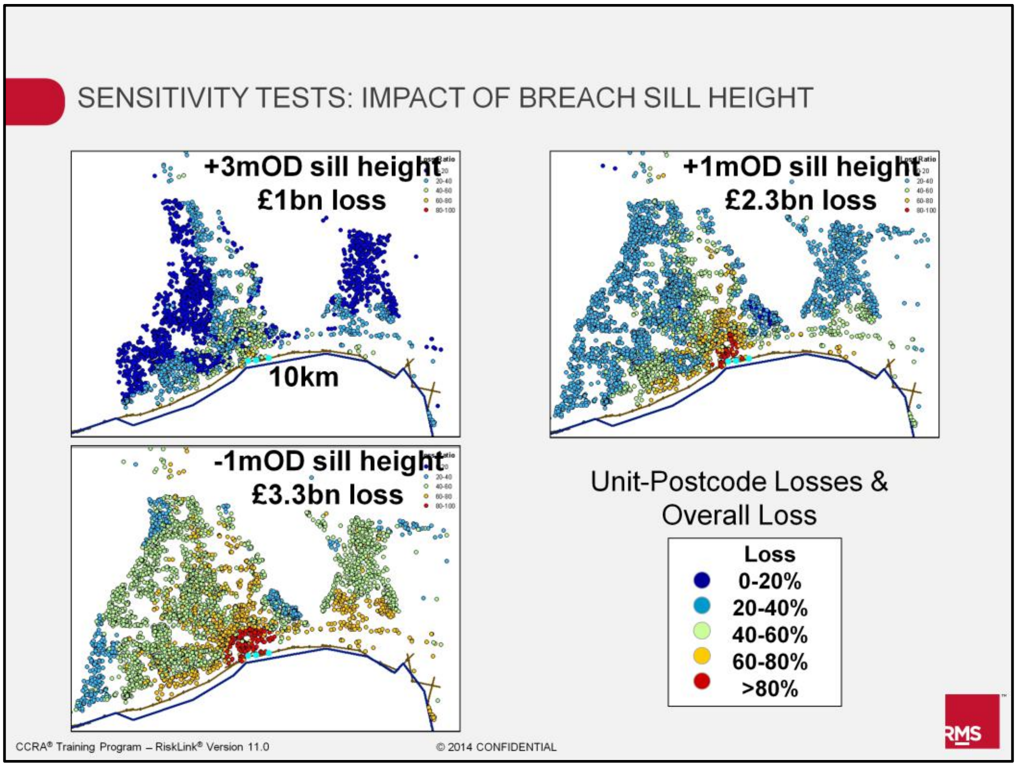
Localization is critical in understanding flood risk, and is one of the principal drivers of the uncertainty in flood risk modeling. The exact location of a property determines whether it gets flooded in any particular event. This can be driven by the elevation of the property relative to the flood, which can be both a function of the elevation of the ground as well as whether the building is stepped up in some way. It can also be very critically affected by the performance of the local flood defenses, whether they fail or whether they hold. And it can be affected by whether there is a potential for water to access basements below the ground level in the property. The water may come up through the sewerage system, for example, and flood the property from the inside.

The elevation uncertainty for a single location flood risk analysis can be high if there is some variation in the height of that property relative to the average in that situation. But we find in general it is uncorrelated across a portfolio. That is why when using a flood risk model for underwriting one property there will be significant uncertainty but when we look across a portfolio, we expect these variations to average out.

In particular, for urban areas it can make a major difference to the correlation of losses across a portfolio of properties whether flood defenses hold or fail. There can be situations where all the properties in the town are either flooded or all of them are protected. We include this in the modeling by representing the potential probabilistically for the defense to fail or hold. We have found that the shorter the return period of the flow and the greater the amount of value at risk, the greater the level of protection on average. If the defense fails, then we will model the impacts of the floodwater on all affected properties in the associated floodplain.

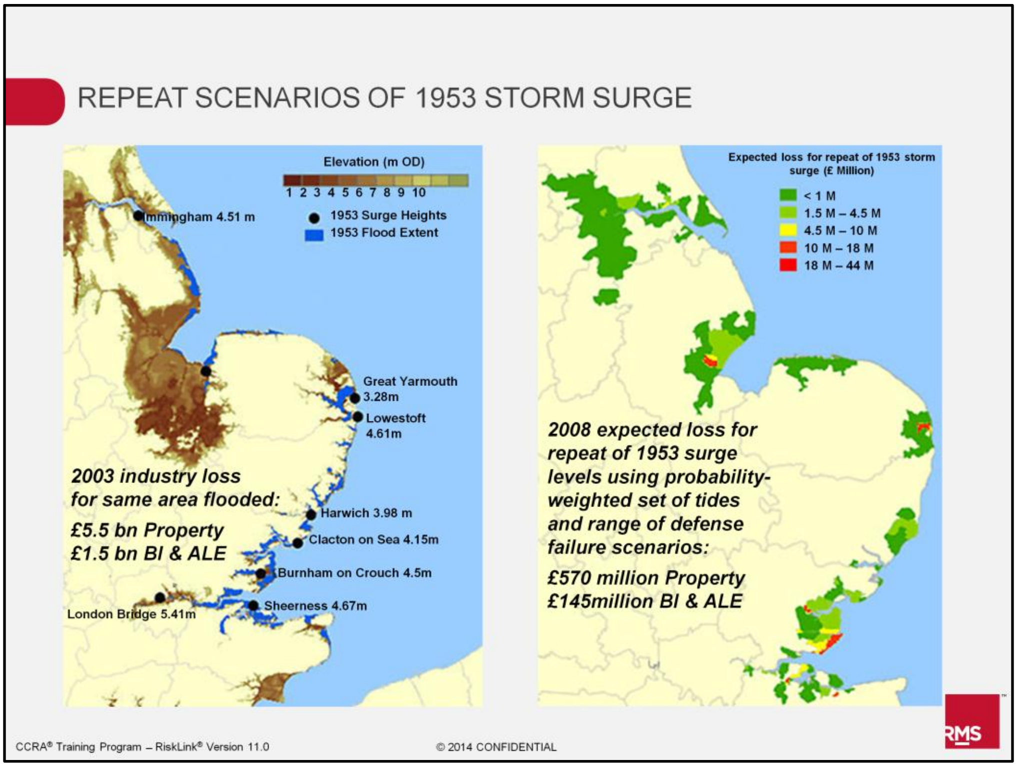


In many situations, in particular for coastal locations, it is what happens to the local flood defenses that is the principal driver in terms of the outcome of flood loss. We deal with this probabilistically because different breaching scenarios, different combinations of failure, and the population of breaches, can vary the cost of flooding by more than a factor of ten.



These are some sensitivity tests for one location on the east coast of England at the town of Hull. RMS performed a range of tests on different sized breaches in the defense. This is a well-protected town, and a very extreme event was modeled. We looked at what would happen if we changed the height of the lowest point to which the water eroded the defense after it had failed. This determines how much water can flow through the defense, and how far inland the water travels during the tidal cycle.

Small changes in the height of the sill at the lowest point of the breach can have a dramatic impact on the overall modeled loss. In this example, if the sill height is at three meters above sea level, then the total industry loss in this very extreme case was about £1 billion. If the sill height had been eroded down to one meter below sea level, then the loss had risen to more than £3 billion.

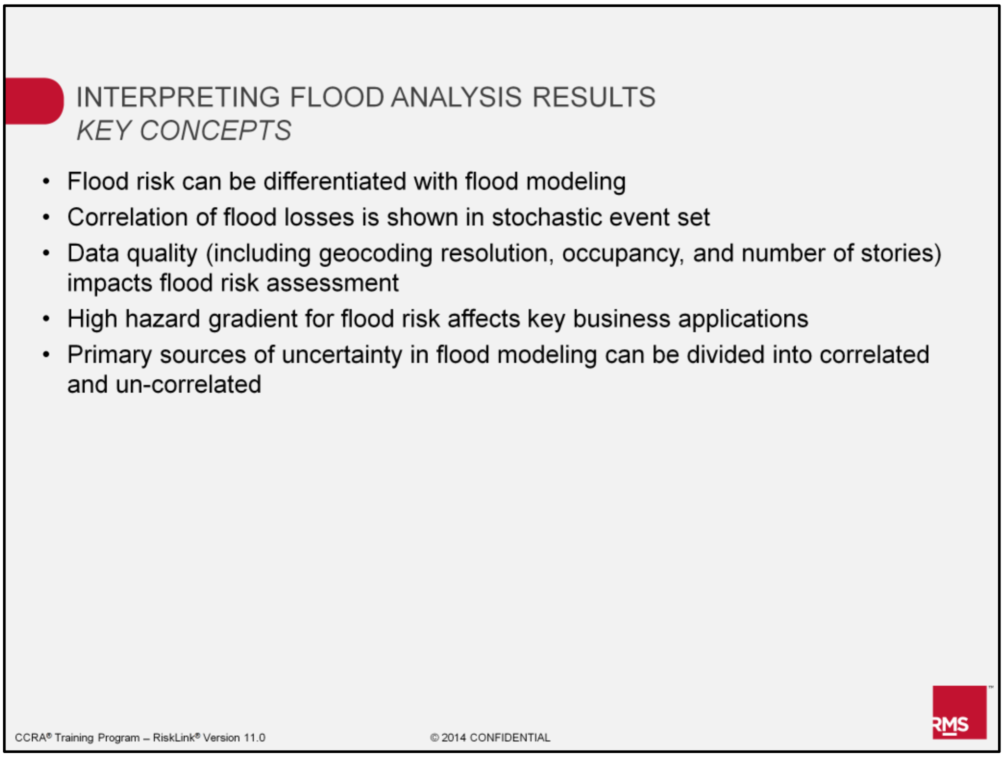


As part of the exercise for exploring the impact of the sea defenses, the key benchmark event for the U.K. for storm surge modeling is the 1953 storm surge and coastal flood. As part of the anniversary in 2003, we explored this event in some detail, looking at two alternative situations.

In the first of them, shown on the left, we looked at what the loss would be to today's portfolio of properties. The area that was flooded in the 1953 event is marked in blue. The result was a property loss of about £5.5 billion and business interruption and alternative living expenses loss of around £1.5 billion, making a total of about £7 billion in 2003 values.

Along this coastline the defenses have been significantly improved since 1953, but they have not been improved to the extent that there would be no flooding if this event occurred today. We explored a range of alternative possibilities in which we modeled the 1953 surge occurring on a range of alternative tidal states. In some of these tidal states, the water levels at the coast were even higher than those in 1953. In others they were lower. We then weighted these at different states of the tide according to the probability they would occur. For each alternative, we computed what the ultimate loss would be.

We found that having the 1953 storm surge occurring on a random set of tidal states, the expected loss would be about £470 million to the property and £120 million for the business interruption and alternative living expenses. These losses were about an order magnitude smaller than those experienced if the sea defenses had not been improved. They show the value of the investment that has been made into the coastal flood defenses.



This slide summarizes the key concepts from Unit 4. Review the summary to make sure all key concepts are clear to you before continuing on to Unit 5.