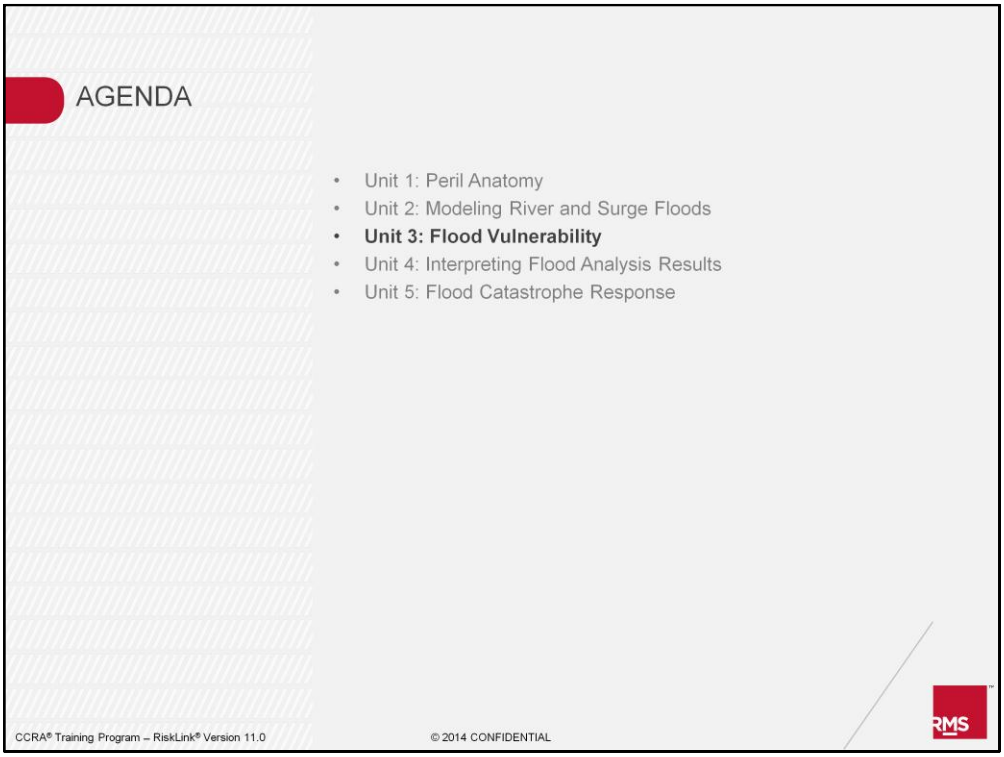
FLOOD MODELING

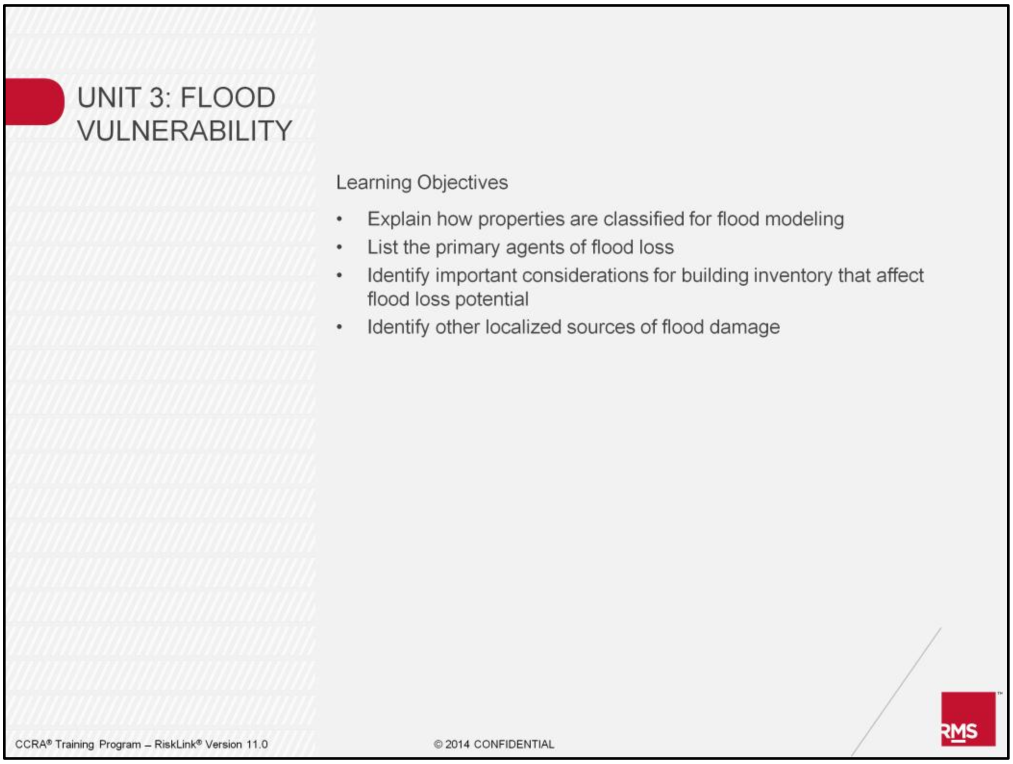
UNIT 3

RMS® CCRA® Training Program

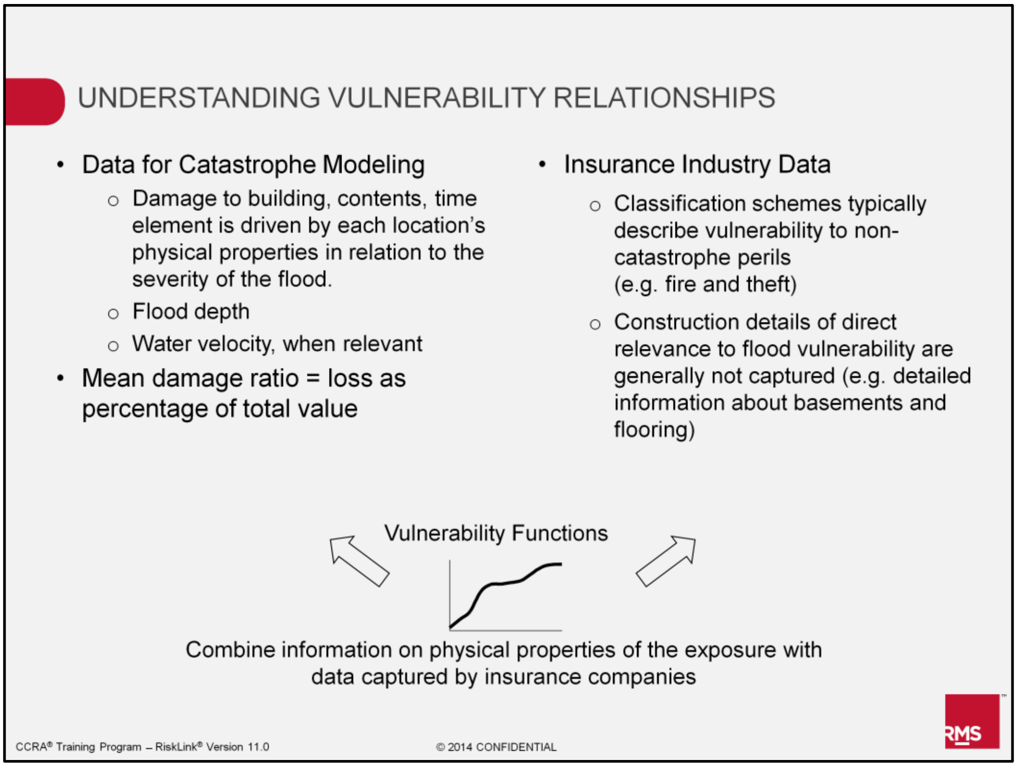
Certified Catastrophe Risk Analyst



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 concept of a vulnerability relationship in all modeling is based on the idea that given some measurement of the hazard, it is possible to predict the level of loss to a particular property.

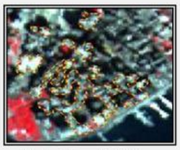
For catastrophe modeling, we typically use flood depth as a principal determinant of the hazard when we are defining vulnerability. This is good enough in most situations where the water is not moving very fast. However, as soon as water velocity rises above some threshold, it is the speed at which the water is moving (rather than the inundation depth) that can become a greater driver of flood damage.

Unfortunately, building classification schemes used by the insurance industry are typically based on non-catastrophic perils such as fire and theft. As a result, we often have to make inferences about loss potential from events such as flood based upon an understanding of the damageability of a typical mix of buildings at a particular location (e.g. city or CRESTA).

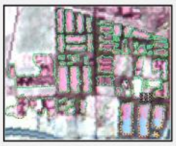
EXPOSURE: ECONOMIC AND INSURED IED

What is the Industry/Insured Exposure Database (IED)?

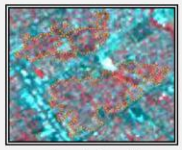
- Distribution of economic/insured values and building counts to 50 m grid cell resolution; split by RMS line of business and coverage:
  - Residential: buildings, contents, additional living expenses
  - Commercial: buildings, contents, business interruption
  - Industrial: buildings, contents, business interruption
  - Agricultural: buildings, contents, business interruption
- Database used internally (AAL, EP) and externally (portfolios, ART, etc.)



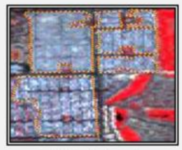
High-Rise Buildings



Industrial



Low Intensity Residential



High Intensity Residential

RMS has an Industry Exposure Database (IED), which contains the distribution of insured values and building counts down to a 50 meter grid cell resolution. Exposures are split by the main lines of business and coverages as shown here. The database is used by RMS internally to estimate industry loss potential, and externally for portfolio management and analysis of alternative risk transfer mechanisms.

EURO OCCUPANCY CLASSIFICATION: LINES OF BUSINESS

- Lines of business are generic categories of policy type used in aggregate modeling
- Agricultural lines
  - Likely to be fragile, wooden structures, often in floodplains
- Commercial lines
  - Lower risk in city centers – however, modern commercial often built in newly developed floodplains
- Industrial lines
  - Often single story – often built in areas too risky for residential
- Residential lines
  - Newer developments more likely in floodplains in many areas

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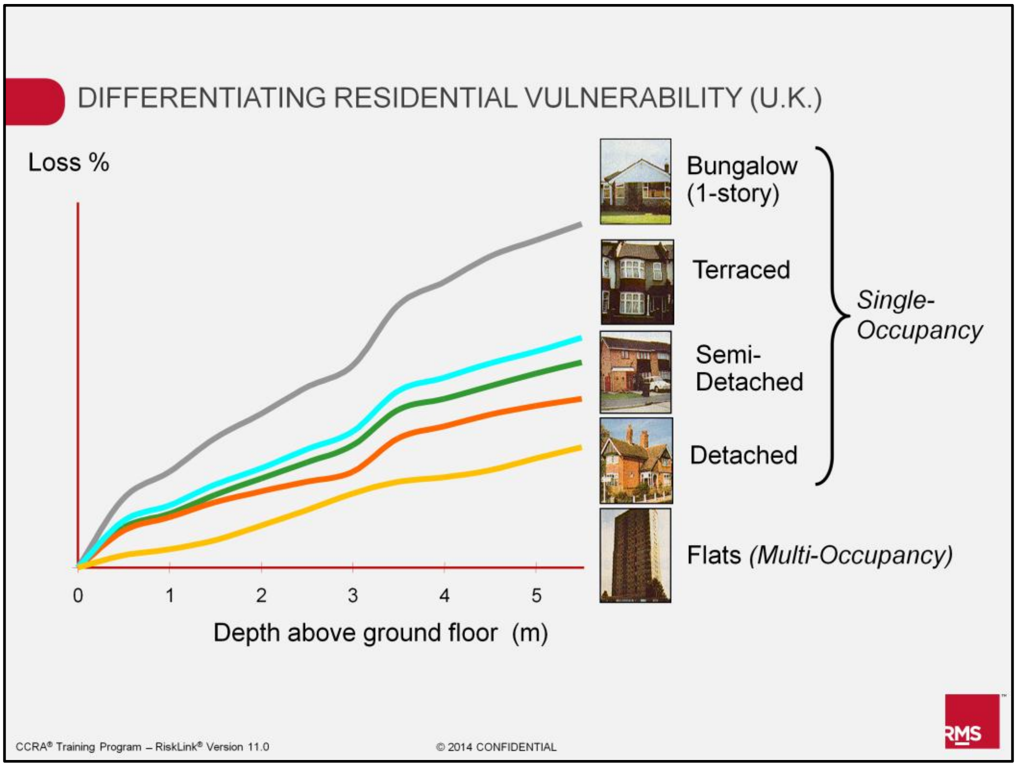
The IED includes four principal lines of property insurance: Agricultural, Commercial, Industrial, and Residential.

Agricultural lines often include relatively fragile wooden structures and/or lightly-built barns. These structures are often in floodplains because areas that are protected by defenses, or are less likely to flood, typically turn into populated, urban areas.

Commercial lines tend to be lower risk because they are able to take advantage of the flood protection schemes that are already in place in urban city-centers. However, modern commercial properties, in particular warehouses, industrial estates, and certain classes of shopping centers, are starting to be built more often in floodplains. This is because floodplains are still generally undeveloped and therefore land is available for these types of properties, which need substantial area. This has been particularly true since the 1960s.

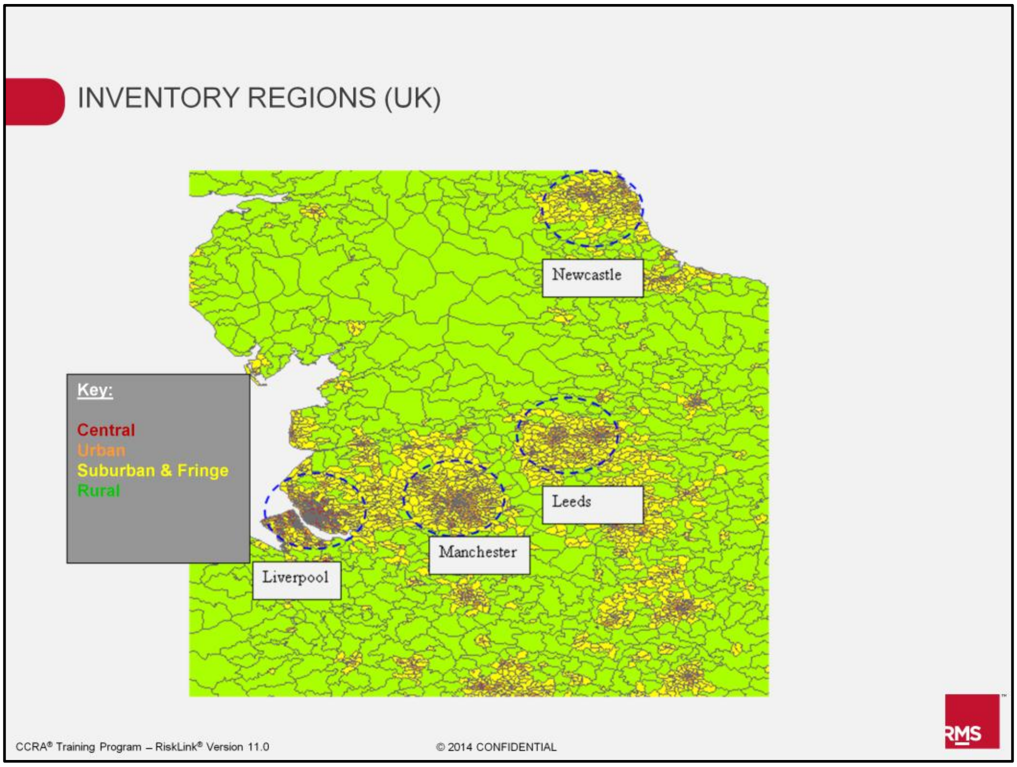
Industrial lines cover a range of different structure types. They are typically single story structures, and again, can frequently be found in floodplains for the same reasons noted above.

Lastly, we often find that older residential lines may have lower flood risk than newer developments. Again, this is the case because as populations increase, this may be the only land available for development.

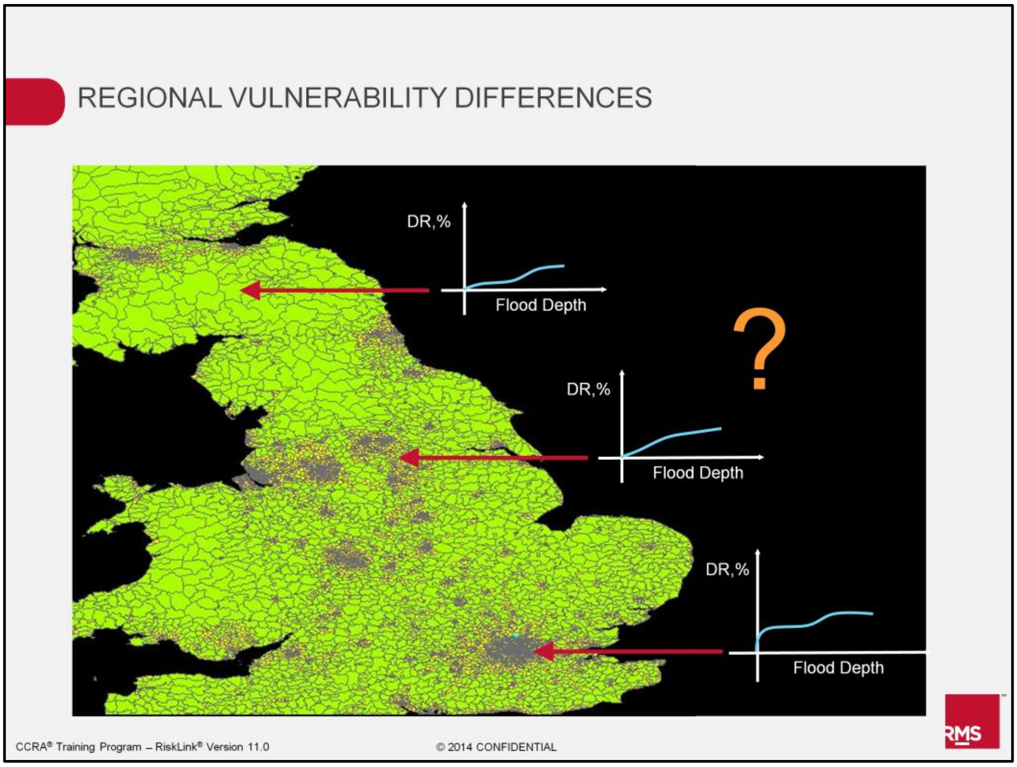


One of the simplest elements of flood vulnerability concerns the number of stories. Because of the nature of floods, the fewer the stories, the greater the impact an event will have as a percentage of the building value. For example, a one-story building that encounters a flood depth of 2.5 meters may see close to a 100% loss; however, a two-story building that encounters the same water depth will have a lower loss as a percentage of the value because the upper floor will be completely protected.

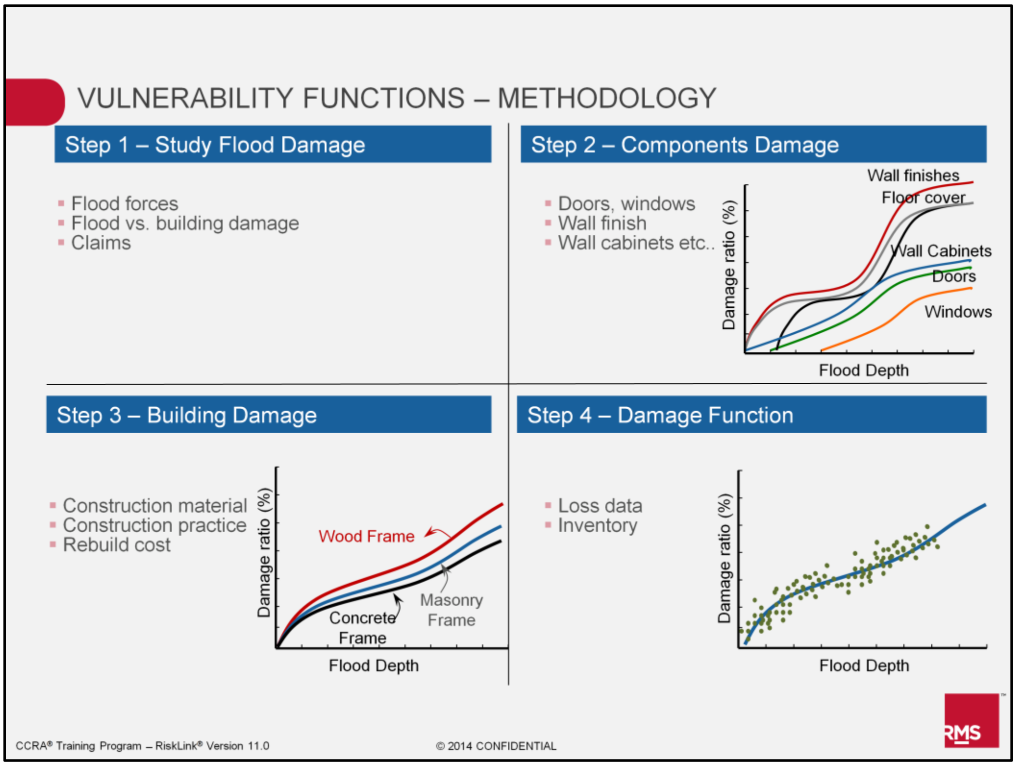
For multi-story buildings, the ratio of loss to the overall value of the building is going to be relatively small for all flood depths. The exception is an apartment on the ground floor. While the building may be a multi-story building, that particular risk is entirely located on the main (ground) floor and is, therefore, completely subject to the flood event.



If not all building attributes are known, the inventory calculates the vulnerability based on the typical building attribute mix in a given inventory region. For example, in a more central region, such as a city center, more high rise buildings might be expected, so the vulnerability for a commercial building might be expected to be lower than for a commercial building in a more rural area.

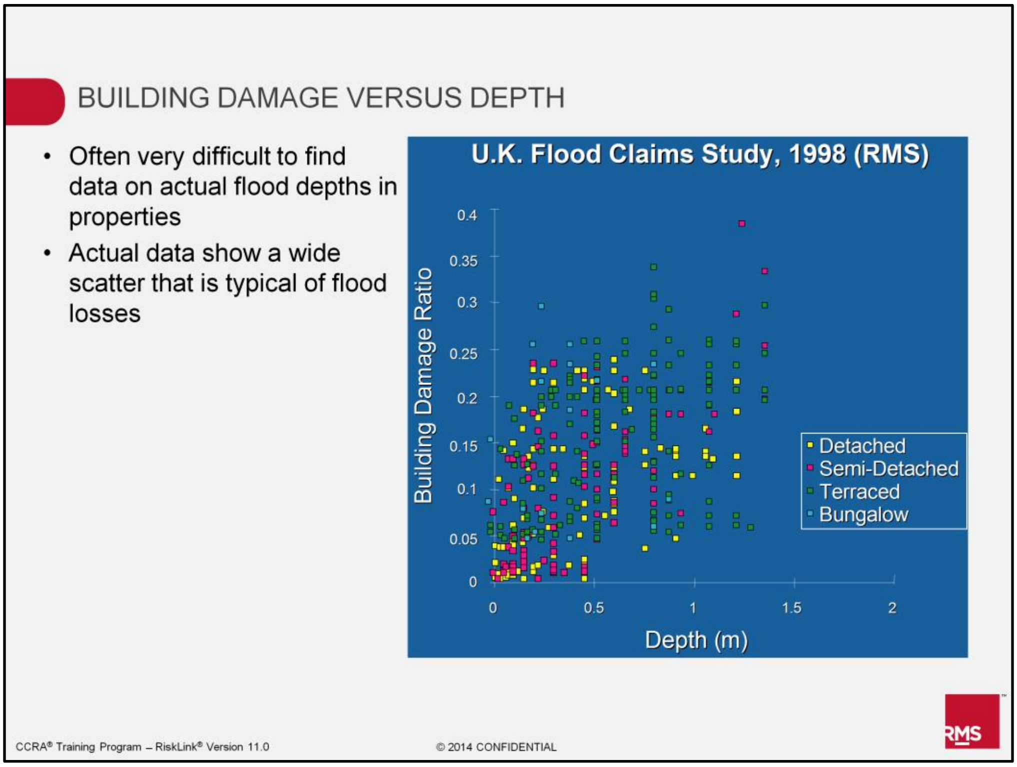


The vulnerability may vary for a given building attribute in different parts of the same country. To account for this, vulnerability regions are applied for a given building attribute, such as when it is known that timber frame properties would exhibit different vulnerabilities in the South of the U.K. than in the North.



In order to come up with engineering-based curves for flood vulnerability, we first did an intensive study of the construction material for each building type and the various components of the houses. The resulting curves were then altered based on the loss experience of previous flood events.

This slide shows the steps taken to derive our flood vulnerability curves. Notice that the final curve shown in step four is the mean damage ratio (MDR) by flood depth.



Flood is one of the more challenging areas of vulnerability science because it is often quite difficult to match data on the flood depth for individual properties with the precise loss data.

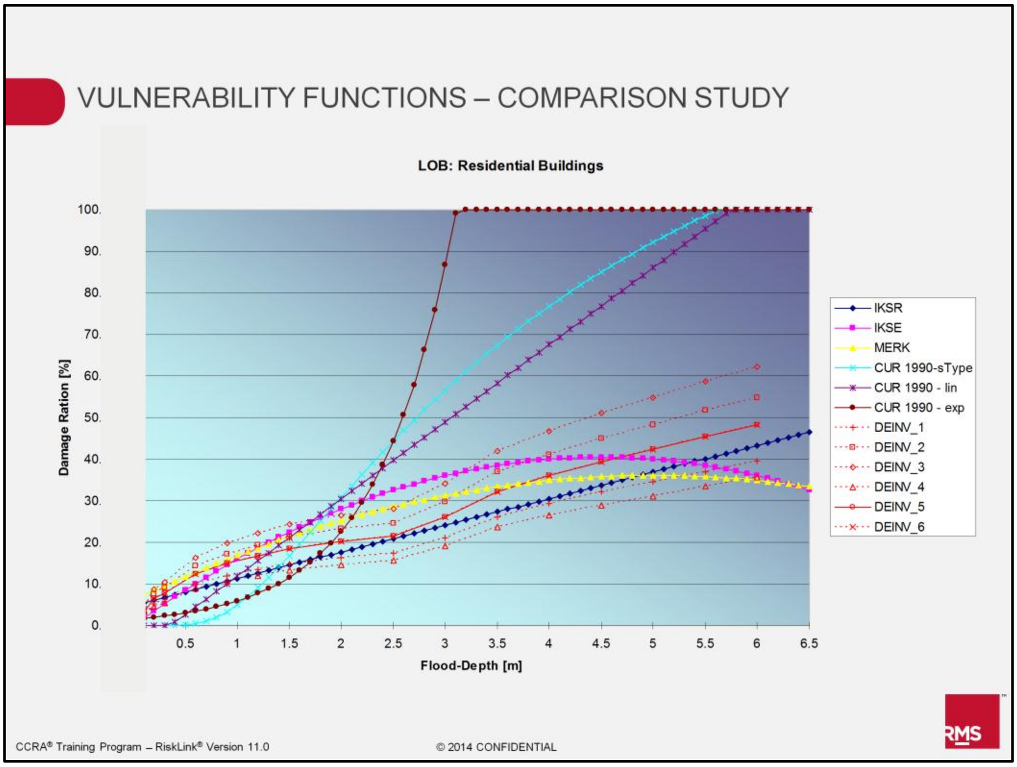
When developing vulnerability functions for wind, for example, it becomes relatively simple to take measured wind speed observations at one point and then transfer those wind speed observations onto the levels of insurance loss that may have been experienced 10 or 20 kilometers away. We cannot do this for flood, however, because the peril is so localized. The only method is to acquire flood depth data for individual properties, which is difficult to find.

This slide shows loss ratios by flood depth, which we collected from a survey of losses by property following the Easter 1998 flood for four different classes of buildings. The first three classes — detached, semi-detached, and terraced — are two-story buildings. The bungalows are one-story.

This data has a lot of scatter in it, which is a function of the construction materials and wall coverings, which determine whether the property has survived inundation with very low levels of loss or whether the levels of loss are quite high even for low flood depths.

For example, you can see that for flood depths of up to 0.5 meters, the damage ratio can reach 25% of the total value of the property.

We typically find this data has a wide scatter, and we need to understand and include that scatter when we are trying to model flood losses.



In the Germany flood model development, we compared the resulting vulnerability curves with published curves. The wide range of possible curves is quite remarkable and indicates that there is no consensus of the overall shape of basic vulnerability curves despite recent loss experiences.

In the past people often used only one or two different curves to describe vulnerability, since the scatter around the observed data is quite large. Also, some of the parameterizations that can be found in literature and previous studies are only valid up to three or four meters flood depth.

AGENTS OF FLOOD LOSS

- Inundation
  - Duration
  - Pollution
  - Long-term deterioration (e.g. mold)
- High velocity erosion and undermining
  - Wave action (for coastal flooding)
- Loss of use
  - Alternative living expenses and business interruption

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Under most circumstances, velocity is not a primary determinant of damage. We are principally concerned with inundation. However, duration of the inundation can be critical, in particular because many building materials will deteriorate the longer they are under water.

Pollution can be a significant factor, because it is characteristic for floods in urban areas to cause the sewage system to overflow. Oil tanks can also become flooded, which displaces the contents.

High velocity flow is a particular problem in two situations: first, those locations exposed to wave action (including a tsunami wave) and second, in areas of steep topography, as in mountains. High velocity can also cause damage close to the breach in a flood defense. For coastal flooding, wave action introduces a high velocity component into the flood and can be the principal source of damage. Waves can also mean damage reaches higher levels in a building.

The agents of flood loss can also include the way in which a building that has been flooded becomes uninhabitable for some period afterwards due to the contamination, deterioration, and moisture content of the building. This means that people and businesses will become displaced.

DETERMINANTS OF INUNDATION FLOOD LOSS

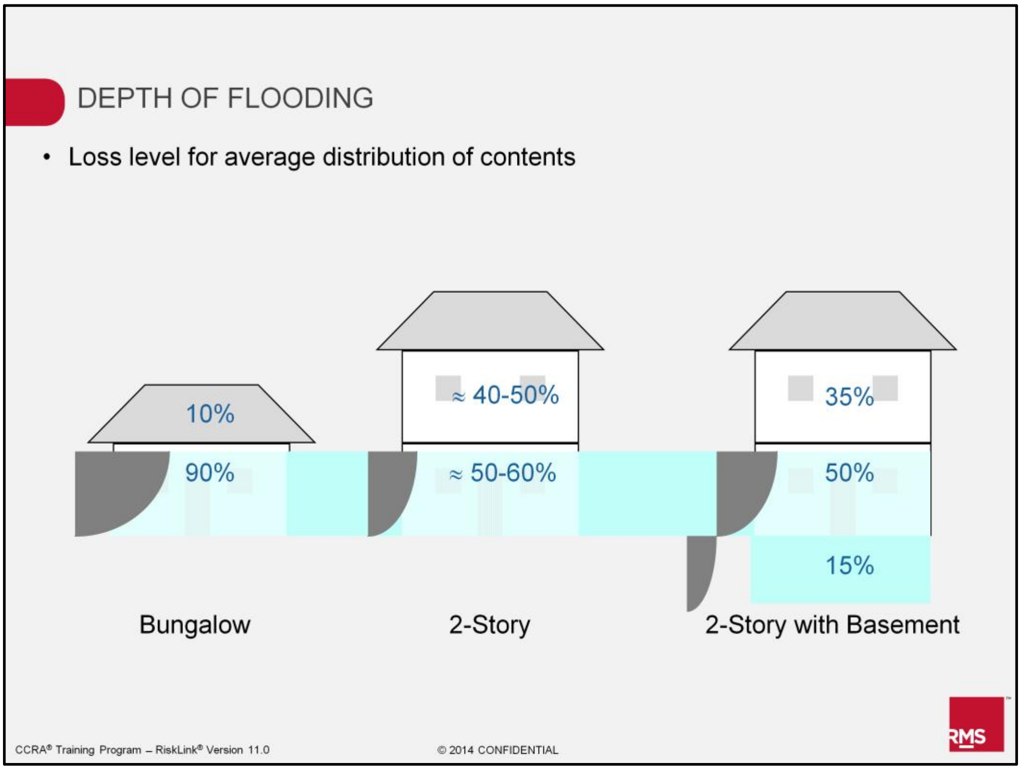
- Flood depth in building
- Presence of basement
- Value distribution with height in the building
- Nature of flooring/wall materials and any flood proofing
- Potential for spoilage of contents
- Nature of business disruption, contingency plans, etc.

In order to link flood loss to flood depth we need to have an understanding of the value distribution within a property. If the property has a basement, a lower floor below the ground floor, then we can have significant flood loss even without the ground floor being flooded. However, what is located in this basement can be quite variable from one location to another. In cities where there is high value property it is not uncommon to find basement apartments. In cities where property values are lower, they may be used only for storage.

Within any given room, there is more value close to the floor than there is close to the ceiling. So as flood waters rise proportionally, much more damage is caused in the first meter than in the last meter. This is applicable to each floor.

The materials from which the flooring and walls are made is also a principal determinant of flood loss. For properties that have been flooded before, it may be that the owners have considered putting in flood proofing. It should be noted, however, that the chance of finding flood proofing is partly correlated with whether people can easily get flood insurance for a property.

Different contents will have different degrees of spoilage from flood water, which can also be critical.



These schemas show the typical distribution of property values by story and by roof.

- For a single-story bungalow house, about 90% of the value of the contents will typically be located in the first story, and then only about 10% will be stored in the roof space.
- For a two-story building, around 50 to 60% will typically be on the first floor.
- For a building with a basement, we may find on average that about 15% of the total value of contents will be located in the basement and about 50% on the ground floor. Note that these percentages are quite variable.

These value distributions are important for predicting contents losses with regard to different flood depths in a building.

POLLUTION AND LONG-TERM DETERIORATION EFFECTS

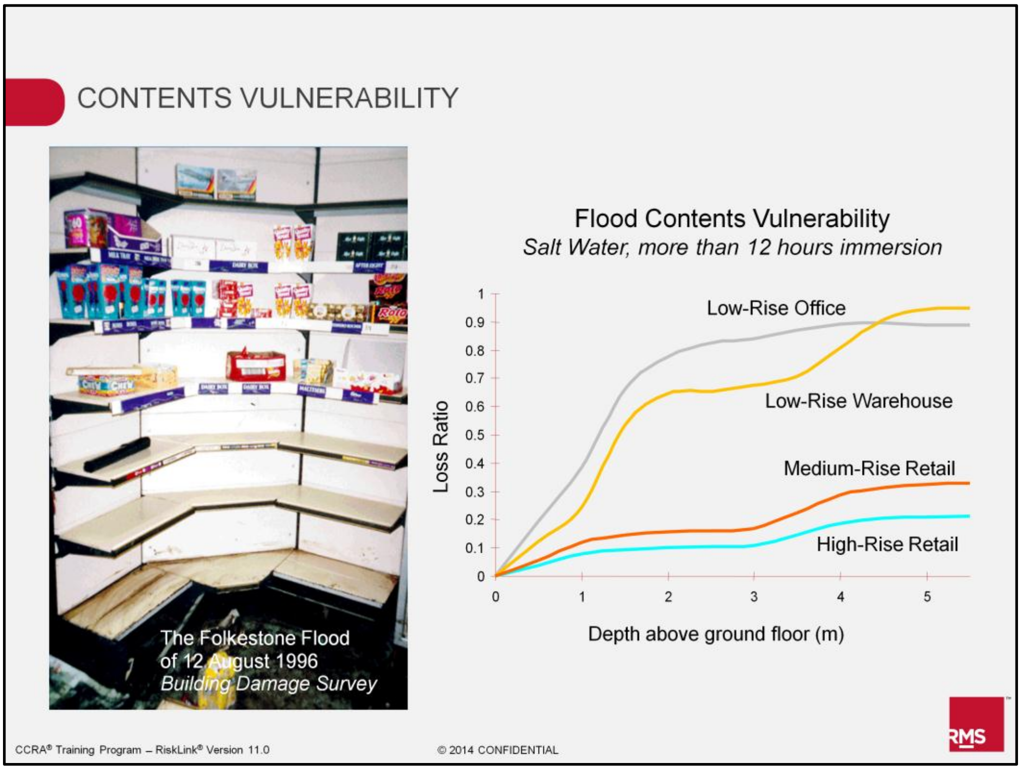
Pollution

- Most flood water is contaminated (sewage, heating oil, etc.)
- Requires decontamination in clean-up

Deterioration

- Even short-term immersion can lead to disintegration of modern sheetrock plasters
  - Brick and older plasters more enduring
- Mold effects can be significant where property is not fully dried
  - Exacerbated where property is waterproofed without proper aeration

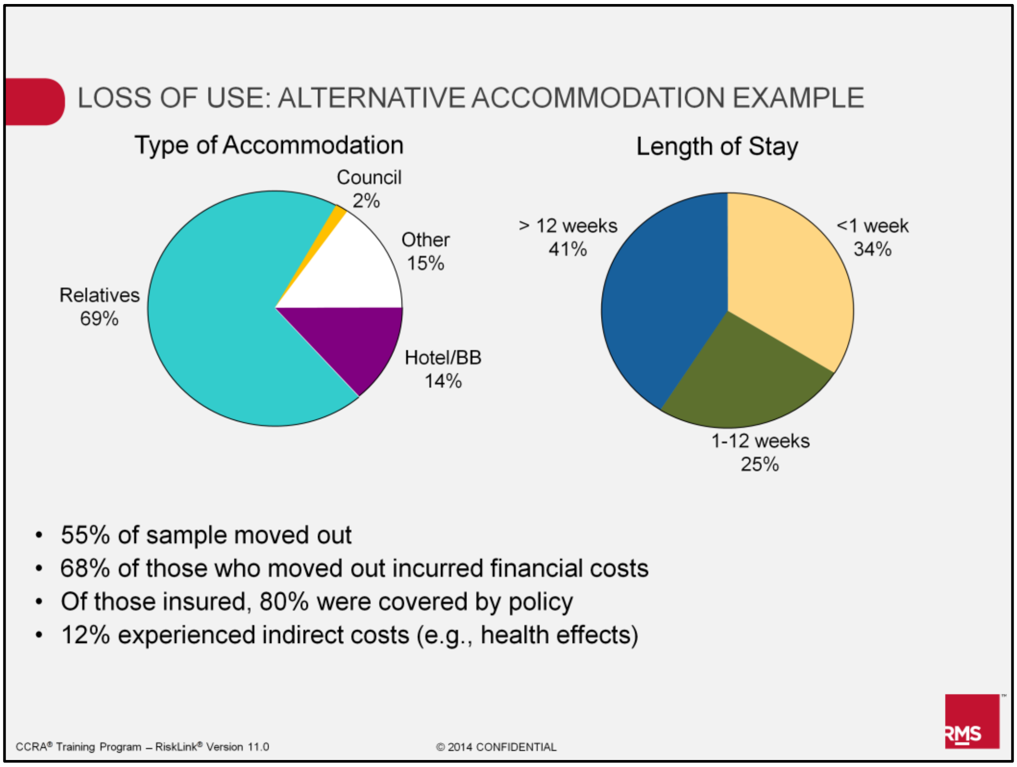
We have already mentioned the issues around pollution, contamination, and deterioration. One of the key issues around deterioration that we did not address, however, is mold. Mold becomes significant when a property is not fully dried out. The effects may not be solely the result of flooding. They may also be the result of air conditioning systems malfunctioning, which means that it may be difficult to ascertain the exact source of the damage. Having said that, long-term mold damage can often be attributed back to flood. In some regions it may be common to find mold exclusions in insurance policies, but it may be difficult to apply these where there has been explicit inundation flooding.



Contents vulnerability can be quite variable by commercial occupancy type. This slide shows data that was captured from a flood event in southern England. It shows what kind of losses you can anticipate for different occupancy types. Again, the number of stories is clearly the most critical factor. For example, we may find that a warehouse may have more of its materials stored up higher off the ground on the main (ground) level than an office location.

As illustrated in the picture on the left, all the goods up to some level had been completely destroyed. But above that level they have survived untouched. The exact distribution of the values within a given property is therefore a very sensitive variable when determining the loss from flood.

The type of contents can also play a significant role in the loss – both from a property perspective and from a business interruption perspective. For example, take two stores located next to each other. One is selling cement and one is selling tires, and both were affected by a major flood. The one selling tires was back in business the day after the flood while the one selling cement was going to be out of business for some time - wet cement is no longer useable but wet tires are. So the nature of the contents can also make a difference.



We have already touched on the fact that alternative living expenses (ALE) for residential lines and business interruption (BI) for commercial lines can be significant for flood because the nature of the damage may make it difficult to move back into a property for some time after the event.

This is an RMS survey from 1998 where we examined what happened to people who moved out of their properties following a major U.K. flood. It was interesting that only 14% of the people moved into hotels, while a lot of people stayed with relatives. The number of people who obtained payment from their insurance policy for this displacement was fairly small among the overall proportion, although 68% of those who moved out did incur financial costs. It is unclear if this is because they did not attempt to obtain payment or if their policy did not cover ALE.

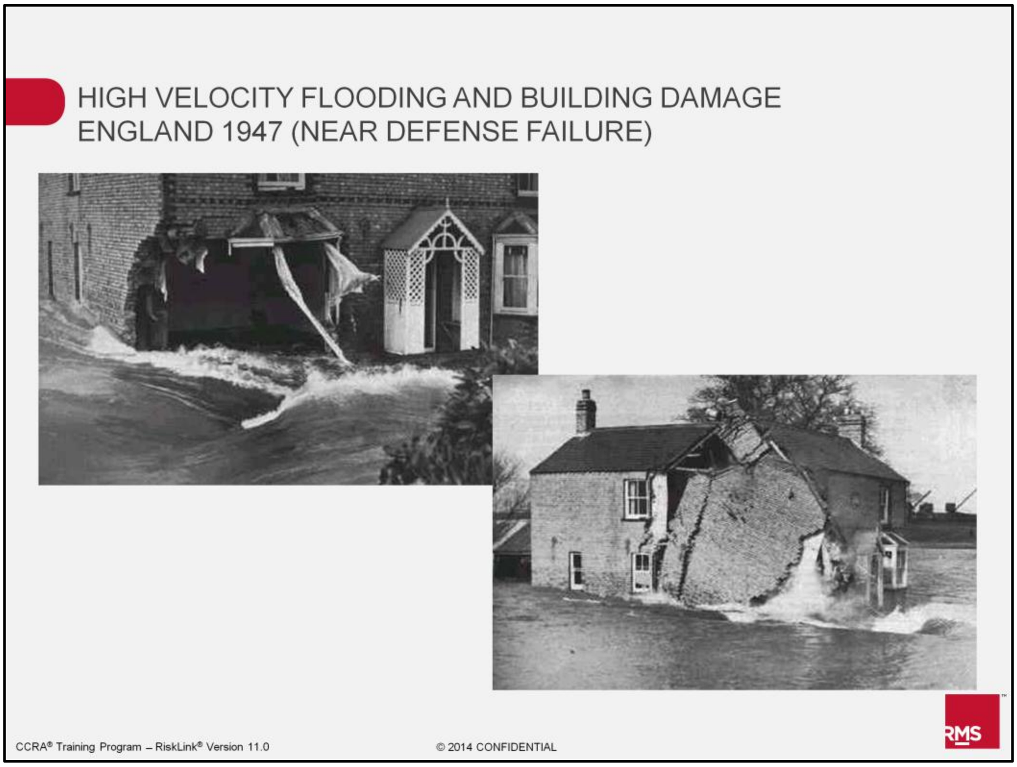
URBAN FLOODING IN UNDERGROUND SPACES

- Underground train systems flooded
  - Taipei: Typhoon Nari Sept 2001
  - Prague: Central European Floods Aug 2002
  - Boston: Nor-Easter Oct 1996
  - Seoul: May 1998
- Chicago: 1992
  - Intersection of old coal transportation tunnel during river works caused extensive damage to the downtown area
- Houston: Tropical Storm Allison, 2001
  - Underground car parking flooded (leading to flooding of underground medical facilities)
  - Underground shopping areas and pedestrian tunnels flooded

There is an increasing trend in urban areas for basements to be interconnected, oftentimes through subway systems. There have been a number of cases in the past decade when subway systems have become flooded. Examples shown here include Taipei, Prague, Boston, and South Korea. Subway systems are quite vulnerable to significant flood damage, and once water enters a system, it will take some time to remove it.

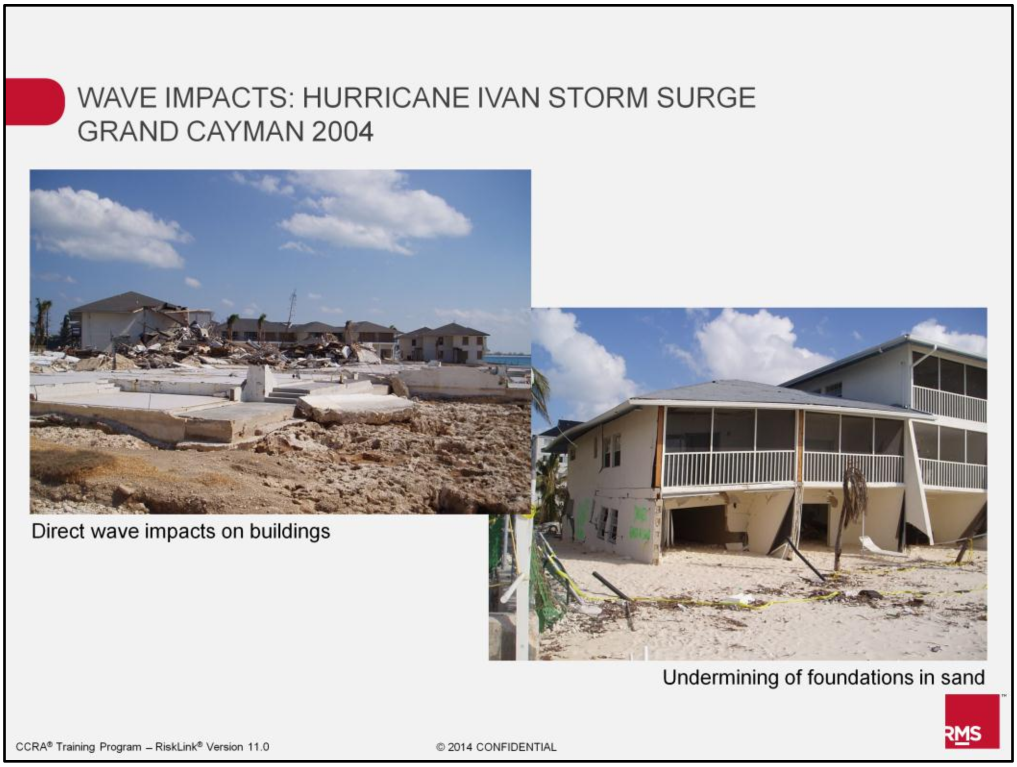
In Chicago in 1992, there was a major catastrophic flood when river works intersected an old coal transportation tunnel and flooded a significant number of the basements in the downtown area.

A recent event associated with underground flooding is from Tropical Storm Allison in 2001, when an underground parking garage flooded into the basements of some hospitals in Houston, which contained high-value medical equipment. The result was losses of several hundred million dollars. At the same time, water also got into pedestrian tunnels underneath some buildings on the edge of the downtown of the city.



These are some examples of high velocity flooding. Once the speed of the water is about two or three meters a second, we can expect significant damage to properties.

Wood frame properties are more vulnerable than masonry, but even masonry properties can be significantly eroded at high water velocities. This is an example where the water was moving fast because of its proximity to where a breach had formed in a neighboring flood defense.



Even higher levels of damage can be expected where properties are susceptible to wave action. These are two images taken from Georgetown in Grand Cayman after Hurricane Ivan in 2004. The picture on the left shows some buildings that were identical to the buildings in the background, but were on a slightly more exposed location next to the sea. Wave action has removed those buildings completely and the foundations have been stripped bare.

The picture on the right shows how waves have undermined the foundations of sand and the building has sagged as the layer of the beach has been removed. High levels of damage are characteristic of coastal locations, in particular in intense windstorms such as hurricanes.

FLOOD VULNERABILITY
KEY CONCEPTS

- Flood loss rises rapidly with water depth
- Catastrophic floods typically cause 1% the number of claims found in catastrophic windstorms (but average claims may be 20x larger)
- Key information required to get a better understanding of flood loss is not generally collected by insurers
- Modeled losses are very dependent on classification

This concludes Unit 3 of the Flood Modeling course. Please ensure that you have a solid understanding of these key concepts before proceeding to Unit 4.