



Floods – an insurable risk?

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# 1 Introduction

You wake up one morning, press the light switch, and nothing happens. You open the curtains and, peering out, can scarcely believe your eyes: a murky brown lake stretches out across what should be the parking lot, and the roof of your car is just visible above the surface of the water. In the bathroom, you discover that early risers appear to have used up the last drop of the town's water supply. You'll just have to make do with bottled water, so you go downstairs to get some. Only you don't get far, as the stairs lead straight down into water – the ground floor of your house is flooded.

A nightmare. And yet every year thousands of people undergo the same experience and worse. The initial shock often gives way to a second, when the people affected realise that their possessions, now worthless, were not insured. As often as not, though, flood insurance cover is either not available or too expensive for them to afford. Even where insurance protection against flooding does exist, the policyholder often has to bear a large part of the loss himself.

These facts indicate that, unlike the widespread fire insurance products, flood insurance involves a set of special problems, and the situation for the insured is often less than satisfactory. The brochure in hand examines these problems. It describes and illustrates the flood risk in concrete terms, and shows how people cope with it. A close look is taken at the insurance aspect, although national peculiarities or particular insurance products are not examined; rather, the focus lies on the concept of insurability and on risk assessment possibilities.

Swiss Re's companion publication, "Floods – an insurable risk? A market survey" profiles the insurance solutions used in selected markets. Its information on flood hazards and past events aims to assist the reader in drawing up plausible assessments on the varying significance of flood cover in the individual countries.

Extensive flooding sorely tries the patience of those affected, as clean-up work cannot be started until after the water has receded. Simply entering a flooded building can be extremely dangerous, since electrical appliances may still be live.

### **Western Europeans still have little experience of natural disasters**

In December 1993 and January 1995, Belgium, Germany, France and the Netherlands were overtaken by floods. At the time, the economic losses from the two events were estimated at well over USD 1 billion and USD 3 billion, respectively. Of these amounts, 50% was insured in the first case and 30% in the second, with percentages differing widely from one country to another.

Although described as “once-in-a-century” events, neither of them was strictly speaking a “disaster”, because in most places the dikes held against the floodwaters.

In Holland and Germany, for example, property worth several hundred billion USD is located in the flood-prone areas behind dikes and floodwalls. If these defences are breached, damage in the double-digit billions can be expected. The consequences for the insurance industry would remain within bounds, however, owing to the low penetration level of flood insurance. Even so, since the overall risk is high, the insurance industry must attempt to find a solution to the issue of flood cover.

## 2 Insurance principles: a yardstick for insurability

Flooding affects more people worldwide than any other form of natural disaster. And yet insurance cover for the risk of flooding is not widespread. Because this cannot be for lack of demand, an explanation must be sought in the insurance business itself. To find an answer to this question, some of the key insurance principles<sup>1</sup> that decide whether a particular risk is insurable or not have been listed below:

- **Mutuality:** A large number of people who are at risk must combine to form a risk community.
- **Need:** When the anticipated event occurs, it must place the insured in a condition of financial need.
- **Assessability:** The expected loss burden must be assessable.
- **Randomness:** The time at which the insured event occurs must not be predictable, and the occurrence itself must be independent of the will of the insured.
- **Economic viability:** The community organised by the insured persons must be able to cover its future, loss-related financial needs on a planned basis.
- **Similarity of threat:** The insured community must be exposed to the same threat, and the occurrence of the anticipated event must give rise to the need for funds in the same way for all concerned.

In the case of flooding, the mutuality requirement is not met when frequently affected risks are the only ones insured. Since the proportion of buildings that are clearly and seriously threatened by flooding is generally less than 1% of a country's real-estate stock, any such risk community would be too small to carry an economical solution for both insurer and insured. This is probably the most important reason why insurance cover against flooding is not widespread.

Nevertheless, there is a need for insurance protection, because flooding often causes very serious damage.

Small-scale floods happen fairly often. The resulting losses can be analysed statistically, allowing the loss burden to be assessed. However, as with all natural hazards, statistics are not entirely reliable when it comes to major, catastrophic flood losses: since their probability of occurrence is small, statistics often fail to take them into account. Catastrophe scenarios may help in such cases, for though they contain many assumptions, they nonetheless yield useful results for risk assessments.

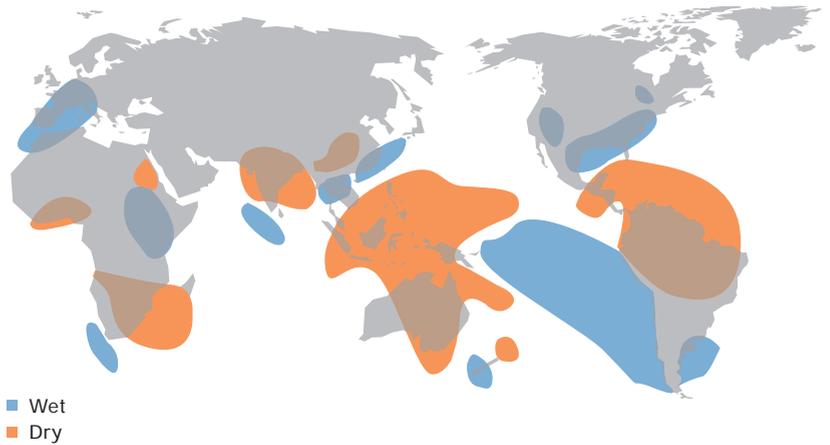
<sup>1</sup> Source: Gruss, W. *Versicherungswirtschaft*. Bern (CH): Verlag Peter Lang

Randomness is present to varying degrees. Losses that recur every few years are in principle foreseeable and should therefore be excluded from insurance cover. Less frequent occurrences are normally not foreseeable, although the terms need to be defined more precisely here: if flood cover is only sought when a flood crest is approaching, then the damage is foreseeable. Or if an El Niño occurrence is forecast, the risk will rise considerably in certain regions. This must be countered with a circumspect underwriting policy and suitable protective measures. Similarly, engineering projects that change watercourses or the progressing settlement of river banks alter the risk for better or worse and, in a sense, in a foreseeable way. For example, the flood plain of a river may be protected by the erection of embankments; but the water will run off faster, resulting in higher water levels and an increased risk further downstream. Insurers can observe such developments, which tend to be long-term, and adopt the appropriate underwriting measures where necessary.

When flood protection measures fail in a densely populated region – which thankfully rarely happens – enormous losses result. The region's economic viability is threatened as a result, since all those insured against such an event must be compensated. A once-in-a-century loss occurrence may well over-tax local risk-carriers financially. In such situations, an international risk community is an effective remedy.

A similarity of threat is present only to a limited degree, since the term "flooding" comprises various types of occurrence, such as storm surges, flash floods and dike failures. However, the common denominator is water, and all these events generally give rise to serious damage to insured property.

Of the six insurance principles mentioned, the most serious obstacles to a functioning flood insurance system are mutuality, assessability and economic viability. However, the present brochure shows that these hurdles are not insurmountable.

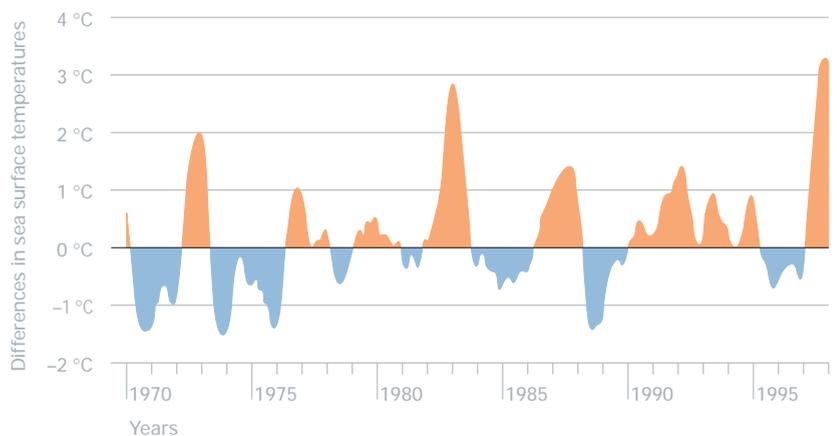


### El Niño: are floods predictable?

El Niño is a meteorological phenomenon that originates in the South Pacific and influences the weather around the world. In 1997/1998 the phenomenon was unusually pronounced (see Swiss Re's *sigma* no. 3/98). Nevertheless, the flooding was overall less disastrous than had been feared, in many places due to protection measures being implemented in good time. El Niño events occur every three to seven years

on average, and always threaten more or less the same regions (see map).

With today's meteorological data, the El Niño phenomenon can be predicted months in advance. However, this early-warning system, a welcome advance in itself, makes insuring property more difficult since it facilitates forecasts on possible flooding in individual regions.



One way of indicating the force of an El Niño event is to collate the sea surface temperatures measured at various locations and compare these with the mean value. The index produced by the Japan Meteorological

Agency (above) shows the five-month sliding mean of these temperature anomalies in the tropical Pacific over the last thirty years. There were intensive El Niño events in 1972, 1982 and 1998.

### **Lahars – an endless calamity?**

In June 1991 Mount Pinatubo in the Philippines spewed out some 6 billion cubic metres of volcanic ash which settled in a loose form. In the ensuing months heavy rainfall saturated the soil, and the excess rainwater flowed directly off in gullies and ditches. In doing so, it carried large quantities of ash with it. Mudflows – so-called lahars – of several thousand cubic metres per second and at temperatures of up to 70 degrees Celsius devastated large rural areas. 83 people lost their lives.

It will be a long time before the situation around Mount Pinatubo stabilises. Years after the eruption, heavy rainfalls can trigger lahars which threaten many settlements on the island of Luzon.

The lahars jeopardise large areas, since the masses of mud may form dams which give way at any time and thus release the retained water. Lahars may therefore cause more serious damage than typical river floods.

From the scientific viewpoint, lahars should for insurance purposes be classified as a “flooding” hazard rather than as a “volcanic eruption” hazard, since the behaviour of mudflows is more similar to that of water than lava, and lahars do not necessarily occur simultaneously with an eruption.

### 3 Characteristics of various types of flooding

Scarcely any natural hazard comes in more varied form than floods. Rivers overflow their banks, city storm drains become overloaded, coastal dikes give way in the face of a storm surge, waves inundate coastal areas following a quake – these are only a few causes of flooding. Where closer definition is required, we find a whole series of terms such as “river flooding”, “dike failure”, “storm surge”, “flash flood”, “tsunami” or “ice jam”.

#### **River flooding**

Prolonged rainfall lasting days or even weeks saturates the soil. As a result, an increasing proportion of rain flows straight into the watercourses. Tributaries lead the masses of water into the main river channel which before long becomes incapable of handling the added inflow. Embankments on either side of the channel generally ensure that the floodwater reaches the sea without causing any damage. However, if the inflow of water exceeds the capacity of the channel or if the flood protection fails for other reasons, the result is extensive, long-term flooding.

Occurrences: A small-scale but nonetheless catastrophic river flood occurred in the Florence area in 1966, when the Arno overflowed after a day of heavy rainfall, flooding some 300 square kilometres of land.

The Australian flood of 1990 is an extreme example in terms of extent: over 220,000 square kilometres of southern Queensland and northern New South Wales were flooded – roughly the area of the United Kingdom.

In 1997, continuous rainfall over several days led to some 6,000 square kilometres being flooded along the Odra River in Poland, causing damage amounting to over USD 2 billion.

#### **Storm surge**

Storm surge, which can cause enormous damage, is triggered primarily by a combination of storm systems and tides. Storm-force onshore winds may “pile up” the water against a coast over hours. Particularly at high tide, vast quantities of water are amassed along the coastline and may flood large areas of land. High waves may further aggravate this situation. Where low-lying coastal areas are protected by dikes, seawater cannot flow back into the sea after flooding has occurred. Furthermore, a storm surge moving up a river estuary can cause damage over great distances inland.

Occurrences: In 1953 a storm surge caused disaster in Europe, with England and the Netherlands being the worst hit. There were 1,800 deaths, and tens of thousands of houses were destroyed.

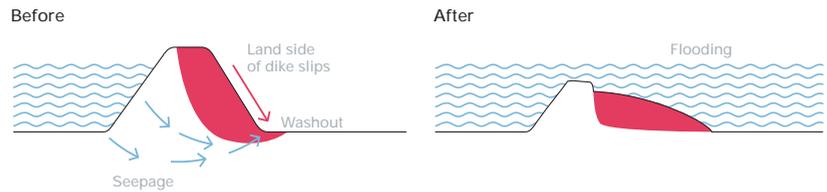
There is scarcely a country more gravely threatened by storm surges than Bangladesh, which was severely hit in 1970 and 1991, for example, when the death tolls reached 300,000 and 140,000, respectively.

#### **Tsunami**

Seaquakes, volcanic eruptions and gigantic landslides on the seabed trigger low waves which move outwards in deep waters at a speed of hundreds of kilometres per hour, and hurtle onto the shore in the form of enormous breakers. A tsunami will break over a section of coastline with a degree of ferocity that varies according to the force of the triggering event, the shape of the coastline, and the form of the underwater slope. Some coasts have recorded a rise in water levels of up to thirty metres. Great devastation, and

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## Dike failure



Dikes and embankments are often erected along larger water channels and in low-lying coastal areas to allow the neighbouring land to be settled or farmed. When these protective structures fail, enormous economic damage results. But why do they fail in the first place?

Dikes and embankments often consist of compacted earth from the surrounding area. Even when they are overgrown with grass and shrubbery, their resistance to strong currents, high waves and damage from flotsam is low. When a flood crest or storm surge overtops the crown of the dike, the erosion on the landward side causes it to fail relatively swiftly.

Equally important, though less well known, is that a dike may already be weakened by water seeping through it (see illustration). Narrow dikes and embankments with steep sides built of permeable materials are particularly at risk in this way. Animal burrows and dead roots also weaken the construction. Strong seepage currents are often indicated by "boiling water" at the foot of the dike, with water gushing out of a hole in the ground. In such cases, swift action is necessary to save the dike or embankment.

above all the highest numbers of fatalities, are generally recorded in coastal areas lying within several hundred kilometres of the triggering event. Occurrences: In 1993 a tsunami broke over the Japanese island of Okushiri, destroying the town of Aonae and killing two hundred people. Over 3,000 people lost their lives in Papua New Guinea in 1998, when a seaquake off the coast threw up a tsunami six to ten metres high. The Lisbon earthquake of 1755 also produced a tsunami that brought death to large numbers.

#### **Dam burst**

Throughout the world there are tens of thousands of large water reservoirs that put the areas lying below them at risk. Extremes of precipitation, landslides, design defects or subsidence can cause the failure of an earth or concrete dam. Most disasters occur during the construction phase or shortly after completion of the project. In recent decades, on average, one or two major dam bursts per year have been recorded worldwide.

Occurrences: On 9 October 1963 in northern Italy, a landslide of 240 million cubic metres into the Vaiont reservoir triggered a flood wave that burst over the 265-metre-high dam, killing 3,000 people.

On 5 June 1976, the almost 100-metre-high Teton earth dam in Idaho, USA, broke, killing eleven people and making 25,000 homeless. Property damage totalled half a billion dollars.

On 11 August 1979, 68 communities along the Macchu River in India were devastated following the failure of a 26-metre earth dam reinforced with masonry. Some 150,000 people were affected, and thousands died.

#### **Flash flood**

Flash floods can happen practically anywhere. They are capable of causing great damage locally and are the most frequent type of flood. A flash flood is set off by high-intensity local precipitation that may continue for several hours. A large portion of the rain cannot be absorbed by the ground and runs off along the surface. As a result, floods occur not only along small or medium-sized watercourses, but wherever the masses of water meet. This often overloads the sewer systems, causing them to back up and allowing water to penetrate buildings from underground as well.

Occurrences: On 3 October 1988, a stationary thunderstorm cell led to torrential rainfall lasting several hours in the area of Nîmes, France. Nine dead and a damage toll of around USD 1 billion were the result.

In Switzerland, on 24 September 1993, the town of Brig was devastated by the raging torrents of the Saltina river. Damage amounted to over USD 400 million.

**Ice jam**

In many regions of the world, the rivers freeze over in winter. When the ice breaks up in spring, an ice barrier can result where floes get caught up on obstacles such as bridges. If the river ice breaks up first in the higher reaches of the river and the floes are pushed down into still-frozen sections, ice build-ups are formed which can dam the water. This can result directly in flooding; and when such ice barriers break up, they may trigger flood waves that can cause great damage downstream.

Occurrences: In Europe, on account of the warm winters of recent decades, ice jam occurrences have become rare. There were such losses, for example, in January 1997 on the Moselle River in Germany. Today, however, such losses are usually limited because ice barriers can be broken up artificially.

**Mudflow**

Heavily soaked, loose soil lying on a slope can slide downhill spontaneously. If the saturation level is sufficiently high, the flow can become a fast-moving mass of mud that follows gullies and the beds of watercourses. A mudflow is a combination of landslide and flood: the high density of the water-and-rock mixture, together with considerable flow velocities, give the mudflow an enormous destructive potential. The area affected is narrowly limited. However, mudflows can occur repeatedly within a few days, and the material deposited in low areas can dam flowing water. They often occur in conjunction with flash floods and river flooding.

Occurrences: In August 1987, Switzerland was hit by violent storms. Innumerable mudflows in the Alps, such as the one triggered by the Zervraggia creek in the canton of Grisons, played their part in causing damage that totalled several hundred million dollars.

**Lahar**

The Indonesian word "lahar" denotes a mudflow on the cone of a volcano. When a volcano erupts large amounts of ash, the next heavy rainfall transports this ash downhill as a mudflow. The result can be deposits metres high and stretching across dozens of square kilometres. If a snow and ice-covered volcano erupts, the ice melts in the heat, the resulting mass of water is mixed with volcanic ash and rubble and hurtles down into the valley below.

Occurrences: On 24 May 1926, the Japanese volcano Tokachi-dake on Hokkaido erupted, melting large quantities of ice. The toll: 5,080 houses destroyed, 144 people dead.

In 1985 a lahar on the Nevado del Ruiz in Columbia buried 23,000 people. The destruction obliterated 5,100 houses, 58 industrial sites and 343 businesses.

On the Philippine island of Luzon in 1991, the Mount Pinatubo volcano erupted for the first time in 600 years (see page 10). Ashfall and lahars devastated 86,000 hectares of agricultural land and destroyed 11,979 houses.

### **Groundwater**

If the groundwater level is only a few metres below the surface, precipitation and infiltration from neighbouring watercourses swollen by flood can cause the water table to rise to the point where basements are damaged by seepage, or indeed entire buildings are destabilised and destroyed. Changing rainfall conditions over months and years can also lead to a rise in the water table. Occurrence: In 1995, a flood in Bonn demonstrated the possible extent of the financial consequences from a single building when the foundations of the Schürmann building, a major construction project, were destabilised: damage amounted to some USD 100 million.

### **Meteorite impact**

Meteorites strike Earth more often than many people think. However, a meteorite falling into the sea seldom causes a devastating flood wave: to do so it would have to be several hundred metres in diameter. We can expect a meteorite of this calibre to hit the earth only once in several tens of thousands of years. Objects less than a hundred metres in diameter are broken up by heat during entry into the atmosphere; ferrous meteorites, however, are an exception.

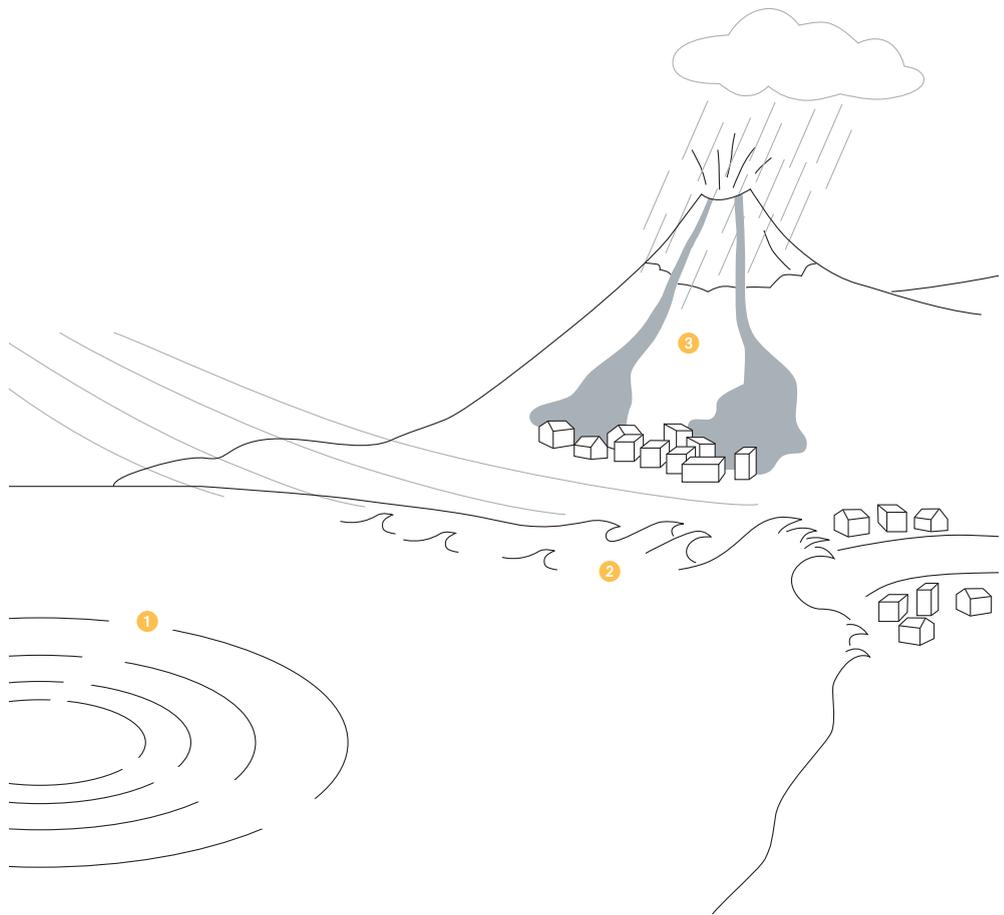
Occurrence: The last big meteorite strike on dry land was in 1908 in Siberia, where a body fifty to three hundred metres in diameter devastated an area of over 2,000 square kilometres.

The majority of all flood occurrences can be easily classified according to the event types described above. Occasionally, however, classification is difficult, which in turn can lead to problems for insurance.

As a rule, the risks covered are set out precisely in the insurance terms and conditions. The simultaneous occurrence of several event types is perfectly possible. It happens, for example, that extensive and prolonged precipitation leading to river floods is aggravated by relatively short-term local downpours, which themselves lead to a local flash flood. In addition, mudflows can occur. Improbable but not impossible is the simultaneous occurrence of storm surges and river floods. Things become even more complicated when other natural hazards are involved. Thus, flooding frequently occurs in conjunction with tropical cyclones (hurricanes, typhoons), whose high wind velocities cause extensive damage. In the same way, hailstorms and flash floods often occur simultaneously, and tsunami damage can occur in tandem with earthquake damage.

In such cases, it is sometimes impossible to assign damage unequivocally to one occurrence or the other. If the insurance covers losses from one type of risk only, loss adjustment becomes considerably more difficult, for each element of damage must be allocated to its respective cause. Reinsurance of event losses can also encounter such claims settlement problems, since it is necessary to clarify in each case what damage is associated with the occurrence reinsured.

## The most important types of flooding at a glance



### Definition of flooding as an insured peril – not an easy task

The insurance industry worldwide has many different definitions of the term “flooding”. None of them is either entirely correct or wrong, because loss event types can differ from one country to another. The following very comprehensive formulation is an example:

The term “flooding” is understood to mean the temporary inundation, either partial or complete, of normally dry land with water, suspended matter and/or rubble

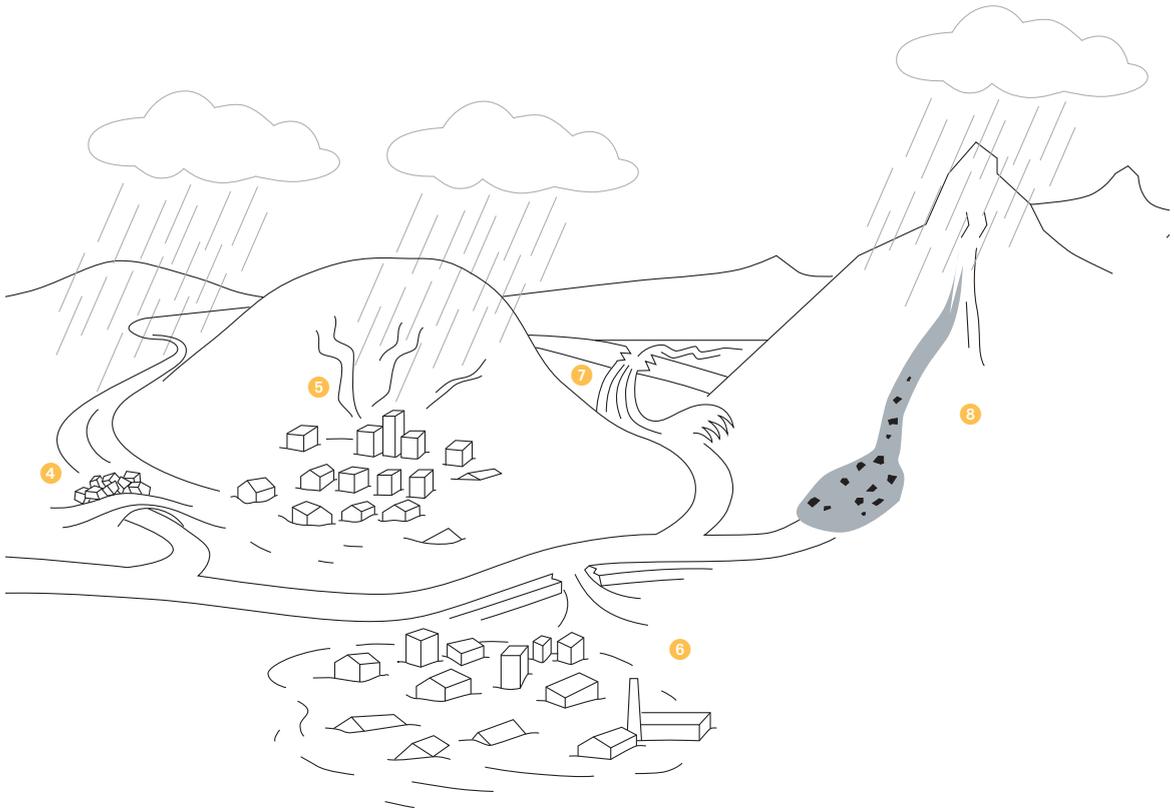
caused by:

- the overflowing of rivers, streams, channels, lakes etc;
- precipitation;
- storm surge;
- tsunami;
- waves or seawater;
- mudflow, lahar;
- failure of water-retaining structures (dams, dikes);
- groundwater seepage;
- water backup in sewer systems.

**1 Tsunami**  
Seaquakes, volcanic eruptions or gigantic landslides on the seabed trigger low waves which move outwards in deep waters at a speed of hundreds of kilometres per hour, and hurtle onto the shore in the form of enormous breakers.

**2 Storm surge**  
Storm-force onshore winds may “pile up” the water against a coast over hours. Particularly at high tide, vast quantities of water are amassed along the coastline, and this can flood large areas of land. The situation may be aggravated even further by high waves.

**3 Lahar**  
When a volcano erupts large amounts of ash, the next heavy rainfall transports this ash downhill as a mudflow. A similar process occurs when the ice-cap of a volcano is melted by lava.



**4 Ice jam**

When river ice breaks up in the spring, floes can get caught on bridges or other obstacles. This greatly reduces the cross section of the watercourse, damming the water upstream and causing it to overflow the banks. If the barrier breaks suddenly, damage can also result downstream.

**5 Flash flood**

Short, violent rainfalls over a small area cause the level of smaller watercourses to rise considerably. Sudden floods, erosion and rubble deposits are the result. In built-up areas, the sewer system is often overburdened, resulting in damage from water backing up.

**6 River flooding**

As the result of days or weeks of continuous rain, rivers can overflow their banks. This can leave thousands of square kilometres of land in the river plains under water for weeks.

**7 Dam burst**

Extremes of precipitation, landslides into reservoirs, design defects or subsidence are the main reasons for the failure of an earth or concrete dam. Most disasters occur during the construction phase or shortly after completion.

**8 Mudflow**

Loose soil on a slope can become so heavily saturated by intensive precipitation that a spontaneous slide results. The wave of water and solids hurtles downhill along gullies and the beds of watercourses, and is extremely destructive.

**Enormous damage is possible even in a small area**

On 24 September 1993 at 6.00 pm, many streets in the small town of Brig (Switzerland), were transformed within minutes into raging torrents. The reason was the Saltina, a local watercourse which drains an area of 78 square kilometres. After heavy rainfalls the Saltina became dammed up at a bridge, and for hours a major portion of the discharge channelled its way through the narrow streets of Brig. The water between the houses was up to three metres deep. When the floods subsided, some 250,000 cubic metres of

sand and rubble were left in and around the buildings. 25,000 truck journeys were required to remove it.

Although the built-up area affected was less than 0.5 square kilometres in extent, losses totalled more than USD 400 million, over half of which was insured.

The danger represented by mountain torrents is often underestimated. If constructions limit their flow, or the local topography offers a wide potential for new discharge routes, even buildings far removed from the watercourse can be seriously affected. Flood mitigation can only protect the threatened areas to a

certain degree and very often only at considerable expense. The intensity of such occurrences can lead to enormous losses even in a very small area.

## 4 Understanding damage processes and identifying loss accumulations

Major flooding can cause enormous losses. For those affected this is often a surprise, especially when nothing of the kind has happened in decades, and the business of loss prevention has taken a back seat as a result. However, if one understands the damage processes involved in a flood and knows the reasons why water can cause such enormous damage, then there will be no more room for surprise. Loss processes can best be illustrated using individual loss cases.

### Damage processes involved with a single object

In August 1994, typhoon Doug caused flooding in Taiwan. A high-grade steel factory nearing completion was also badly hit. A large proportion of the production equipment came into contact with water. At USD 100 million, the damage amounted to over 15% of the sum insured of USD 600 million.

Also in August 1994, in Libya, the underground pipeline of the world's largest water distribution system was heavily damaged while still in construction. The insured loss amounted to USD 40 million.

In Switzerland in 1994, an industrial plant producing water-resistant (!) sanitary fittings was hit by a flash flood. This flooded the entire warehouse, causing a total loss.

The three cases selected show that water can also destroy objects that are water-resistant and thus cause unexpectedly serious losses. How is this possible?

The individual damage processes which determine the extent and amount of the losses are as varied as the different aspects of the natural hazard of "flooding". The most important ones are:

**Depth of water:** Water can cause many different types of damage. Absorptive materials swell up and burst. Electrical systems suffer short-circuits. Empty tanks are destabilised and their supply lines spring leaks. Metals corrode, especially when salt water is involved. Another damage-relevant factor is that floodwaters always transport particulates and are burdened with chemical or biological substances. These are transported by the water into the smallest cracks and cavities, and deposited there. Later, while the water can easily be removed, the deposits cannot. They damage or destroy the material.

Furniture, wall and floor coverings, electronic components, clothes, paper goods or foodstuffs can, as a result of flooding, be reduced to garbage or – even worse – to hazardous waste. Machines, masonry, infrastructural systems and vehicles can be cleaned and repaired, but this involves heavy expenditure. The higher the water level rises, the more property gets wet and the greater the resulting damage. This shows that the water level has a decisive influence on the amount of damage.

**Flood water velocity:** The current in a watercourse can erode banks and underwash buildings close by. This can even result in the collapse of the affected buildings. Overflowing rivers, breached flood barriers and very heavy local rainfalls can also produce these current effects in areas far distant from the river itself.

Currents do not, however, only cause damage to the structure of buildings. They sweep objects away and carry them downstream. Uprooted trees or semi-submerged cars often cause damage when swept against structures, and debris is deposited over a wide area.

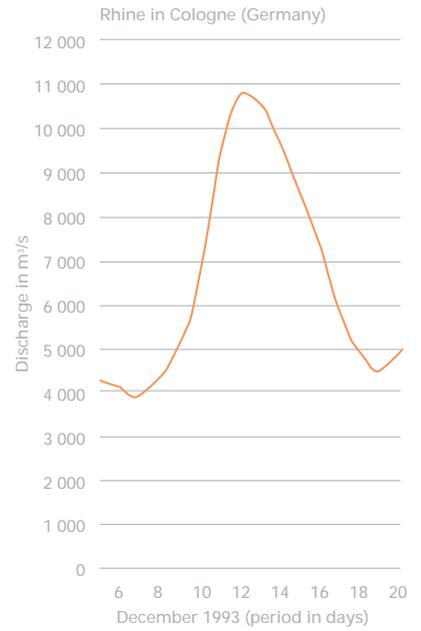
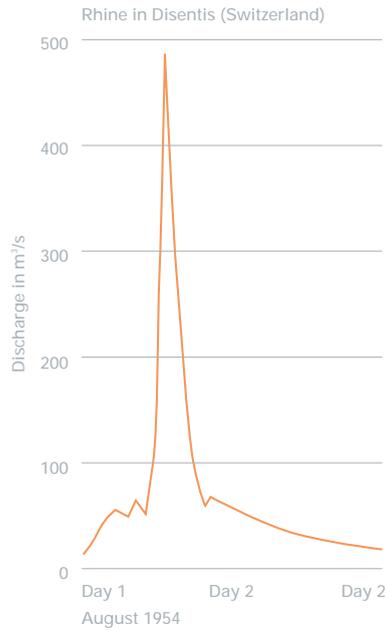
Typical current velocities in a watercourse on a low gradient are between three and ten kilometres per hour. Some rivers in the Australian bush have current velocities of less than one kilometre per hour. In fast-falling rivers, velocities of over twenty kilometres per hour are not infrequent. Once the water has left its river course, its current velocity declines markedly unless there are special topographical conditions.

**Surge:** Flood waves as a consequence of dam failures or after the break-up of a stoppage in the watercourse can easily sweep entire buildings away. The same applies to large waves breaking on coasts during storm surges.

**Transportation of debris:** When in flood, rivers transport large amounts of debris. Depending on the velocity of flow and the ground conditions, the rubble is composed of anything from gravel to fine sand. Deposits outside the watercourse can be a few centimetres to over a metre deep. Basements filled to the ceiling with deposits are no rarity. Frequently the material has to be laboriously removed with shovels and wheelbarrows, and this is of course reflected in the costs of clearing up.

**Speed of rise:** The speed with which the flood waters rise is a major factor in loss mitigation. In the event of a cloudburst, the water can be metres high within minutes. In the case of larger watercourses on the other hand, the level rises perhaps by only a few centimetres per hour. This situation permits counter-measures to be undertaken, provided that the early-warning organisation functions.

Small watercourses react far more quickly to heavy rainfall than big ones. This results in different early-warning periods.



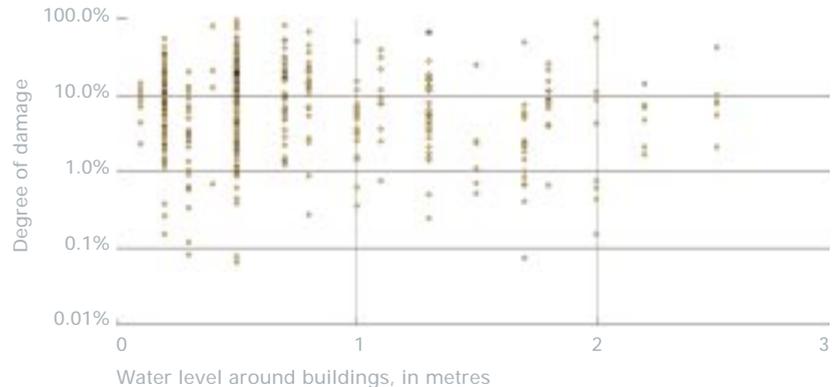
**Standing period:** After river flooding or storm surges the water can stand for weeks. The general rule is that the longer the water stands, the greater the losses are likely to be. The reasons are that organic materials start to rot, poor mortar can disintegrate, metals corrode, germs multiply very swiftly depending on water temperature, and watertight buildings are torn from their moorings as a result of rising ground water.

The devastating interplay of these factors can result in unpredictable damage for a property owner. If there is no insurance cover, there will be no compensation. To avoid ruinous consequences, sufficient cover should be bought to ensure that large-scale damage is also covered. Minor damage must however be borne by the insured. This is reasonable and bearable for the insured – and essential for the insurance industry.

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## Many different damage processes, different loss consequences

Vulnerability: contents of residential buildings  
Loss analysis of a small town in Switzerland



With several hundred individual degrees of damage (individual loss values in relation to the relevant sum insured), this figure illustrates the many different effects of a flash flood on insured objects.

Despite similar water levels around the buildings, the loss values differ by several orders of magnitude (note the logarithmic scale). It follows that factors other than the depth of the water also have a considerable influence on the loss.

Various definitions are used to classify types of damage. One solution has a simple structure made up of three classes:

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<b>Direct losses:</b>	Damage to buildings, contents, motor vehicles, infrastructure or persons; costs of clearing up, loss mitigation and disposal.
<b>Indirect losses:</b>	Damage resulting from business interruption and power failure; costs of transportation, detours, assistance, storage, accommodation, drinking water supply and communications.
<b>Intangible losses:</b>	Detours or tailbacks on the journey to work, psychological impairments, losses of intangible values, or moving out of the area at risk.

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### **Loss accumulation resulting from the overall event**

In 1993 a flooding of the Mississippi resulted in economic damage of USD 18 billion. Vast areas were under water for weeks. The enormous loss amount was made up of hundreds of thousands of individual losses to buildings, dams and roads for example, each of which was subject to its own loss process. Looking from individual cases of damage to the effects in general, the following factors can be said to play a significant role:

**Area affected:** The most important factor regarding loss accumulations is the affected area. It is of course relevant whether the flooded area is built-up or undeveloped.

**Early-warning period:** Only in the cases of river flooding and storm surges is the early-warning period long enough to implement any significant loss-reducing measures. This period primarily depends on the size of the drainage area and on possibilities of observation, forecasting and giving the alarm. The general rule regarding river flooding is that the larger the river drainage area, the longer the early-warning period.

**Disaster aid:** Disaster aid comprises all measures taken when the event is imminent or has already occurred. Organisations such as the fire brigade, armed services and civil defence thus play an important part in loss mitigation.

Knowledge of the factors involved is essential in assessing the risk, as they are closely linked with the damage caused to individual property. Geographical and chronological elements also affect the accumulation of individual losses. The combination of all facts concerning the damage process and the loss accumulation resulting from the overall event facilitate a well-founded estimate of the flood risk. Such estimates form the basis for workable insurance solutions.

### Living with the residual risk

In recent decades the Netherlands has invested billions of dollars in protecting the country against storm surges. Work is still in progress, and the goal is now within sight. The polder areas – low-lying land reclaimed from the sea – will in a few years' time be protected at least against a once-in-a-millennium storm surge. However, there always will be some residual risk. The loss potential of the densely-populated polders, estimated at between USD 10 billion and far in excess of USD 100 billion, is enormous. And yet it is generally only global corporations that are insured in the Netherlands.

The Greater London region is faced with a similar situation. The Thames Barrier and adjoining embankment systems are to protect the city from a once-in-a-millennium storm surge. In contrast to the Netherlands, most property is insured here. Accordingly, the loss potential is high: it may be estimated at USD 30 billion or more, since not only London, but vast areas along the east coast would also be affected.

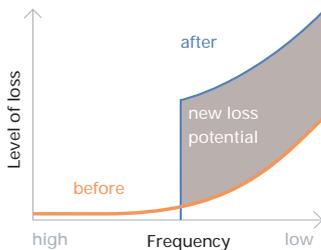
Opinions are divided as to whether such events should be insured or whether indeed they are insurable at all. One thing is certain: the risk must be distributed among reinsurers throughout the world, and the primary insurers and the insured

parties will also have to bear a considerable share of the loss.

# 5 Alternatives to insurance?

Flood protection measures frequently give rise to a false sense of security, which in turn increases the loss potential. Where floods become rare owing to the construction of protective measures, tremendous property values accumulate in the course of time without any parallel adjustment of the protective measures. If an extreme event occurs and the flood

Loss/frequency relation before and some time after the construction of flood protection



protection fails, the resulting losses are many times more serious than would previously have been the case. A company providing flood cover must keep a wary eye on such developments.

There are, of course, numerous ways of countering the risk of flooding, of which the insurance of property is only one. Six basic possibilities – some of which can be combined with one another – are available for minimising the risk.

## Avoiding areas at risk

The avoidance of areas at risk is certainly the least expensive and most practical method of reducing the hazard of flood damage. And yet there are various arguments against this solution: for various reasons, the settlement of river plains is highly attractive. Flat, high-yielding land is eminently suited to agricultural use and poses no particular problems to the construction of buildings. Moreover, there is an adequate supply of water, which is both a vital element and an inexpensive means of transportation and disposal.

## Suitable forms of construction

It is perfectly possible to design buildings in areas at risk in such a way that they sustain little or no damage from flooding. However, constructions of this kind are often costly and their utility very limited, so that they tend to be implemented only in exceptional cases.

## Protection of individual property

Where individual objects are at risk or the value or significance of a building is very high, flood proofing is a priority measure. In this connection we speak of passive flood protection. Often even a minimum of expenditure will prevent a major loss.

## River engineering and flood protection

Most property is protected by means of active flood protection measures. Dams and dikes, retention systems for large quantities of water and relief watercourses are used to keep the water levels under control.

## Mobility

Losses can be prevented if the early-warning system works and movable property can be shifted quickly.

## Insurance

In combination with other measures, insurance offers a simple and low-cost possibility for covering the residual risk, which is always present.

These possibilities for minimising the flood risk have their limitations, advantages and drawbacks. They are all directed at reducing the risk to an acceptable level through an optimum combination of measures. This can only be achieved if the state, the insurance industry and property owners share this task among themselves. Ideally, the responsibilities should be distributed as follows:

### State

Prevention, information and cure are the main tasks of the state. The state must ensure that areas at risk are registered and, where possible, avoided. Furthermore, investments which have already been made in high-risk zones must be protected. For this purpose, the state has the instruments of zoning and building regulations at its disposal. It can also invest in active flood protection, and must systematically monitor and maintain flood protection structures in order to ensure their effectiveness.

The state may conduct information campaigns to sensitise its citizens to the danger and induce them to adopt preventive measures. If a disaster occurs, an early-warning system will save lives and prevent, or at least reduce, losses. The state may also render flood and storm insurance compulsory.

Finally, the state must establish a "safety net" for those consequences of disasters which, despite insurance cover and individual efforts, overtax those who have suffered losses. For this purpose, deployment schedules for disaster relief workers, the swift implementation of emergency measures and special equipment are just as important as the encouragement of reconstruction work by way of low-interest loans and tax relief.

### Insurance industry

For a large group of exposed parties who, by irregular chance, may be hit by floods, insurance is an economic solution for mitigating the consequences of flood events. As it operates worldwide, the insurance industry is also capable of insuring even very large potential losses. Still, insurance alone is not enough: the insurance industry must also assert measures for the protection of insured objects.

### Property owners

It is primarily the task of the property owner to ensure that he does not suffer any losses that threaten his livelihood when a flood occurs. His responsibilities include the readiness to identify hazards and taking reasonable steps to minimise them.

The interplay among state, insurance industry and property owners is not without its problems. For example, the state may be reluctant to invest in flood protection, at the expense of the insurers. Similarly, the insurance industry may want to cover only a small share of the potential loss, while the policyholders are generally reluctant to accept high deductibles. Yet all those involved must bear in mind that, especially in high-risk countries, effective protection can be achieved only by joint action. A steady exchange of information between the state, the insurance industry and the policyholders fosters the necessary mutual understanding and creates the basis for a successful joint approach to the problem.

**Potential economic loss resulting from a major event  
(extensive failure of flood protection)**

Loss burden as a percentage of GDP	Extent of loss		
	> USD 10 bn	USD 3–10 bn	USD 0.5–3 bn
> 2%	Netherlands China	Czech Republic South Africa Poland	Ecuador Israel
1–2%	Italy Germany United Kingdom	Switzerland Argentina	Portugal Austria
< 1%	USA	Australia Spain Canada France Brazil Japan	Philippines Taiwan Belgium Indonesia

Many factors affect a country's flood potential. Topography, precipitation, the size of the rivers and the season of the year in which the precipitation occurs are just as important as the area available for settlement, or investments in flood protection. The differences in loss potential between one country and another are enormous, and the problems facing a

country in recovering from a major disaster can only be forecast to a limited degree. In every case, however, the insurance industry is capable of contributing to recovery even from major occurrences.

## 6 Overcoming obstacles to insurability

At the start of this publication, those principles of insurance were presented and assessed which are essential in deciding whether cover can be offered against flooding or not. Three principles were shown to be of particular concern: mutuality, assessability and – depending on the loss potential – economic viability. The following section examines the issue of insurability in more detail. It should be noted that not all event types listed in section 3 are of the same significance in insurance terms. The relevant events are those which may occur with great intensity and affect large areas; the selection may differ from one country to another.

### **Antiselection: the main obstacle**

When rivers burst their banks or coastal areas are hit by storm surges, the same areas are affected time and again. The only differences between events lie in their intensity and in the consequences of these elemental forces for the affected landscapes. Where water has once been, it will generally return at some point. This is why insurance cover is in particular demand in areas which are repeatedly affected and in areas which are clearly at risk. This results in an “adverse” risk selection, which insurers refer to as “antiselection”. Repeated losses with no compensation for the insurer lead to high premiums, which can well be of the order of several thousandths of the sum insured.

In many cases, the parties at risk are not prepared to pay this high price, and hope that the state will pay compensation in the event of a disaster. Conversely, owing to the lack of demand, insurers do not offer any cover in these situations anyway. Exceptions arise when there is stiff competition among insurance providers: insurer and policyholders then agree on a premium which is not commensurate with the risk. This often results in unintended cross-subsidies among different lines of business.

There is no need for insurance in the absence of disasters. When losses do occur, however, and the state for understandable reasons does not provide compensation, there is a surge of indignation – also directed at the insurers for failing to offer any cover. In order to counteract such situations, insurance solutions should be worked out “in the dry years” which will then take effect in the event of a disaster. What ways are there to address the issues of antiselection and high premiums?

During a storm in Seattle (USA), in 1997, a stream swept away a bridge, creating an insurmountable obstacle. With no usable alternative crossing in the vicinity, the consequences are serious. Detours and tailbacks can be the order of the day for the following months. Power, communication and sewage lines laid under bridges are another major aspect: if these are damaged, daily life can be seriously impaired over large areas.

### Effect of antiselection on the risk premium

If premiums which are commensurate with the risk are charged for flood-prone property along rivers, and each insured party pays according to his own risk, then premiums are very high. However, if the loss burden is distributed over the entire population of a country in the form of a solidarity-based insurance solution, the standard premium works out considerably less. The example below shows this in a simplified form, and proceeds from the following set of assumptions:

- Settlements along rivers are protected against a once-in-a-century flood.
- Depending on how close the property is to the river, less frequent floods lead to average losses between 0 and 50% of the sum insured. To keep the example simple, deductibles are not considered.
- Local torrential rain can cause damage anywhere. The risk premium for this risk is set at 0.05‰.
- The diagram below shows the distribution of property.

Risk-adequate premiums as a function of the size of the risk community



This figure shows the development of the risk premium when the property insured is successively less exposed. If all property were insured at the same price, the premium would be 0.2‰. However, if insurance were limited to property which was in the 100 to 500-year risk zone, the premium would be ten times as high, ie 2.2‰. This

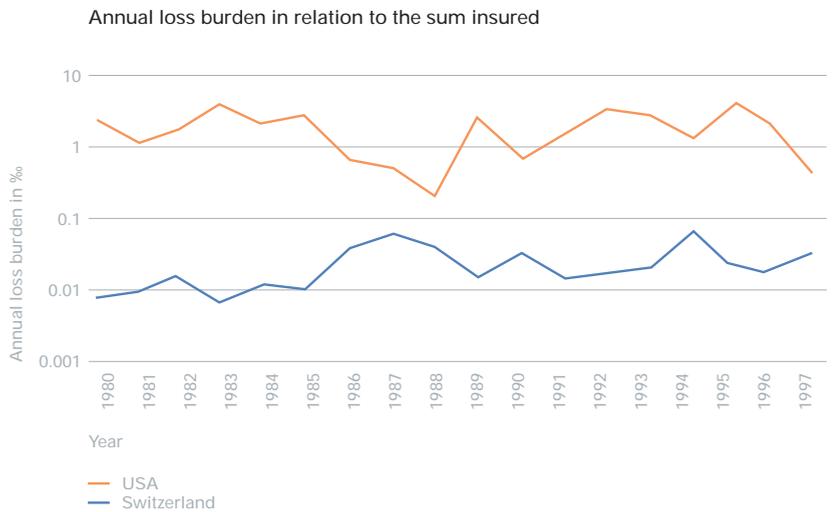
example demonstrates that compulsory insurance at a standard premium requires considerable solidarity from those insured parties who are less seriously at risk. This situation could be partially mitigated by a slight graduation of the premium in line with the actual risk.

The example opposite is supported by a practical loss record going back almost twenty years. The portfolio of the US state insurance scheme NFIP (National Flood Insurance Program) primarily comprises property at risk in some 3.8 million policies. 95% of these cover residential property and contents. The premiums are graded according to exposure and range from 2‰ to 10‰. Property is not covered at full value in every case.

In the period under consideration, the annual loss burden fluctuated between 0.3‰ and 4‰ of the sum insured.

Against this scenario is set the portfolio of the Swiss cantonal real estate insurers, which comprises just under 2 million objects. Because compulsory insurance is in effect here, there is no antiselection problem. The maximum loss burden in 1994 was 0.06‰.

Although neither the contents of the two portfolios nor the situations in the two countries are identical, the enormous difference in the annual loss burdens can be assumed to be primarily due to the high degree of antiselection in the US portfolio. Note the logarithmic scale of the loss axis.



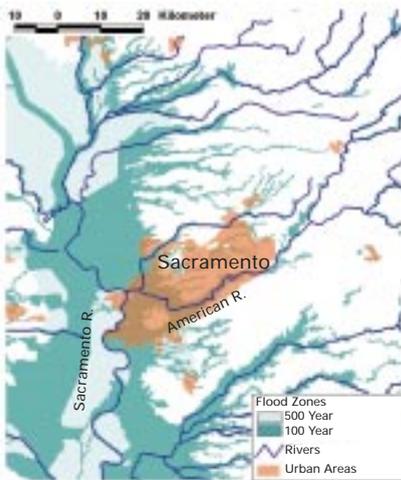
#### Enlarging the risk collective

- In countries where flooding is only one of several natural perils that occur, cover can be offered as a package along with other perils. For example, if a lot of damage is caused by storms, a package combining storm and flood cover can be used to counter antiselection, since storms do not usually affect the same regions as floods. Better still would be a compulsory combination with fire insurance. If the earthquake risk is also included, the resulting cumulative potential should be borne in mind.
- If the state makes insurance compulsory, the antiselection issue is likely to be averted. The extent to which this kind of solution can be asserted in the free market economy is a matter of conjecture. Its acceptance does rise, however, when the premiums are set in line with the risk.
- Many people are not aware that their property is at risk from infrequent occurrences. If it were generally better known, for example, which river and coastal area could be hit by a once-in-a-millennium disaster, and to what extent, the demand for cover might be stimulated, because a disaster of this kind could happen tomorrow. Similarly, it is often forgotten that exceptional rainfall can cause damage almost anywhere and that a great deal of property is therefore at risk, although to differing degrees.

#### Reducing loss frequency and loss amount

- Property affected on average every ten years or more frequently should not be insured. In such cases, it is worthwhile ensuring first that protective measures are implemented. The widely-applied rule of not insuring, or providing only limited cover for property which has sustained damage within the last ten years is in some ways unfair and thus inappropriate. In order to establish a fair classification into frequent and infrequent losses, the probability of occurrence must at all events be included in assessing property of this kind. Even property that was hit by a once-in-a-century occurrence only last year may perfectly well be eligible for insurance.
- In fire insurance, the risk has for decades been assessed by experts who stipulate protection measures. Why should there not be flood protection regulations, just as there are fire prevention regulations?
- In cases where minor damage occurs repeatedly, flat deductibles can ensure that protection measures are adopted, and that losses are mitigated when damage occurs. Depending on the loss exposure and the vulnerability of the risk, deductibles should account for one to several per cent of the sum insured.
- Many of the values insured under “contents” have a relatively short service life and are highly susceptible to loss. If the contents are insured not for their replacement value but for their current value, the insured is unable to make profit if a loss occurs.

Example of a hazard map



The problems of adverse risk selection (antiselection) are known. What is lacking in many countries is information as to which areas are threatened and which are not. In the USA, risk zones are established in the maps of the FEMA (Federal Emergency Management Agency). These hazard data are now also available in digital format and can be efficiently used with the aid of geographical information systems.

### Charging risk-adequate premiums

For this purpose, premiums and the scope of cover must be graduated. In areas of high risk, higher premiums and/or deductibles must be demanded. This promotes acceptance of a solidarity-based solution which includes less exposed insured parties in the risk collective.

### The assessability of major losses: the second obstacle

Two main issues need to be addressed here: what influence do major losses have on the risk premium, which is often only derived from statistical data on regular minor losses? And: how great is the loss potential arising from possible major disasters? These questions can be answered with the aid of well-founded studies, for which the following minimum information is required:

- What was the extent and intensity of past events? What factors have altered since then?
- Which rivers or coastal areas are typically hit by one event at the same time?
- How is the terrain structured? Where do potential risk areas lie?
- What hydrological data are available in respect of precipitation and discharge?
- What is the nature of the protective measures?
- What is the distribution, type and vulnerability of the insured property values?
- What are the terms and conditions of insurance? What does the scope of cover comprise?
- What loss experience has been gathered, including that from other countries?
- How are the climatic trends assessed?

As this list suggests, setting up an insurance tariff and assessing possible losses is a complex matter which can only be accomplished through interdisciplinary cooperation between insurance experts and natural scientists. Leading reinsurers and specialist consultant firms can offer valuable assistance in answering these questions.

### Economic viability: possibly a further challenge

Where high potential losses are expected, the insurance industry can only guarantee comprehensive compensation if the insurance terms and conditions, the interaction between primary insurers and reinsurers, and possibly alternative risk transfer methods, are harmonised to the best possible degree.

### Limiting the cover provided

Maximum compensation pay-outs per policy in industrial insurance business make sense if they are aligned to the effective maximum possible loss. For personal lines of business, however, this cover limitation is not appropriate, because the insured would be insufficiently covered in the case of a total loss – that is, precisely when he most urgently needs cover.

Pooling losses, reinsuring and possibly limiting cover

If a number of insurance companies share the market amongst themselves, it can be worthwhile setting up a mutual loss pool. The pool members cede all losses into this pool and are charged in line with their market share. This has the advantage of a balancing-out effect via the pool when individual companies are very badly hit and find themselves in financial difficulties. If in addition the pool is reinsured, the cover capacity also increases.

Any type of pool offers the possibility of limiting the liability of insurers or of the state. In concrete terms, if the event limit is exceeded, all claims payments are proportionally curtailed, which means that no cover promises are made which cannot be redeemed in extreme cases. This solution does, however, require administrative arrangements to allow the event limit to be applied.

Including alternative risk transfer

The new ART solutions (ART = alternative risk transfer) are another form of ensuring that losses can be financed. By issuing securities in respect of disaster risks, for example, the capital market is involved in the coverage of major occurrences. In the last three years, new capacity of over one billion USD was created for major earthquakes and storms. In principle, such solutions are also applicable to flood events.

Tailor-made ART solutions for major corporations are set up differently. Three examples of this are “funding solutions” (saving for the event of loss), “liquidity schemes” (liquidity injection in the case of a disaster) and “contingent equity schemes” (share capital increase in the case of a disaster with an obligation on the insurer to take up a portion of the stock).

### **Different solutions are possible**

Insurance solutions are offered in different countries with varying degrees of success. It is interesting to note that markets with the highest insurance density share borders with regions where there is no cover – and this despite a similar risk of flooding. There is often affordable (cross-subsidised?) cover for trade and industry, but not for personal lines. Sometimes even state solutions and compulsory private cover occur together.

The table below classifies different insurance solutions and their effect on antiselection, the resulting possible loss, and the expenditure required for an appropriate risk assessment. There is however no ideal solution for “cheap, comprehensive insurance protection for all on a voluntary basis”. Depending on the national circumstances, one or another type of insurance may be suitable. In countries with large accumulations of property in river plains or along coastlines, antiselection is of greater significance, since areas at risk can be more easily demarcated. Where enormous investments have been made in protective measures, questions as to loss potential are central. Big differentials in the intensity of the threat will give rise to a debate on the topic of “solidarity”; the premiums of highly exposed insured parties must be co-borne by the insurance community, so that they can afford protection and in an emergency are not dependent on the state or on private charity.

Insurance solution	Risk of antiselection	Loss potential	Cost of risk assessment
Facultative individual cover (eg industrial property, Italy)	high	medium	high
Facultative package solutions (eg residential property, Germany)	medium	medium	medium
Compulsory package with fire cover (eg UK)	low	high	low
Compulsory state solutions (eg France)	low	high	low
Facultative cover with low limit (eg Austria)	high	low	medium
Compulsory cover with graduated premiums and deductible	low	medium	low

The situation must be precisely assessed from case to case, and possible solution variants weighed up. Good solutions demand exact knowledge of the risk and the need for insurance. It is also worthwhile casting a look beyond one’s own frontiers to see how others deal with the matter. A useful aid in this is the Swiss Re publication, “Floods – an insurable risk? A market survey”, which gives an overview of the various approaches in 24 different markets.

## 7 Risk assessment by the insurer

Whichever solution is selected for the insurance of flood risk, there can be no dispensing with a well-founded risk assessment. This must be directed at ascertaining the relationship between loss extent and probability of occurrence. Or to put it another way, the risk assessment must answer the question of what losses occur how frequently. This gives an indication of the average loss burden and loss potentials, which respectively furnish the basis for calculating the insurance premiums and the required reinsurance protection.

For over ten years, Swiss Re has been using an easily-understood approach to the estimation of property damage due to flooding. Information has to be gathered in respect of the four topic areas listed below. This must be checked and then collated so as to provide a quantitative statement, the loss frequency relation:

- The hazard posed by flooding: What happens where and how frequently?
- The vulnerability of the property insured: What individual losses are to be expected from what intensity of occurrence?
- The spatial distribution of the insured properties: What property is located where?
- The insurance terms and conditions: What conditions of cover have what effect on the claims burden?

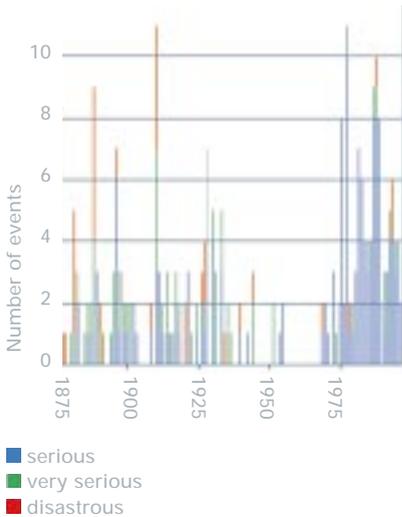
For each topic area there is a plethora of information which can be included in the risk consideration. However, considerations of quality and the cost/benefit ratio necessitate a certain selectivity. It must be ensured that all four areas are equally thoroughly investigated, because there would be little point, for example, in working out the sum insured in the basement of the buildings insured if little is known about the regions at risk.

Depending on event type, different information and data must be collated. The following sections show how the Swiss Re concept functions, taking the example of river flooding.

### **Hazard**

As with other types of event, local characteristics also play a decisive role in the case of river flooding. The two most important factors are the exact altitude of the insured property and the flood characteristics of the neighbouring bodies of water. As a rule, there is no relevant information available in usable form, and so other records have to be consulted. Ideally, for risk analysis the insurer will have access to hazard maps produced by a competent institution. These indicate where and with what frequency a flood can occur. As yet, such maps are relatively rare. The most widely known examples are the FEMA maps in the USA, which are available for a large number of urban areas. For the rivers of England too there are country-wide maps, although they only cover once-in-a-century events. In many other countries, hazard maps exist for local areas but none for country-wide standard reference. However, the need for such aids has been widely recognised, and work is in progress to fill this gap.

Flood events in Switzerland  
1875–1996



Flood events occur at irregular intervals even when considered over longer periods: decades with very many or only few events alternate. These cycles have too long a duration for the insurer to be able to balance them out without adjusting premiums.

Where hazard maps do not exist, a precise estimate of the threat is very cost-intensive, especially when an entire portfolio comprising thousands of policies has to be examined. The following points may be considered in a risk estimate (listed in descending order of importance):

- Topographic situation (river plain, narrow valleys?)
- Description and mapping of past events (areas affected, intensity, losses?)
- Flood protection in the area under examination (dams, dikes, retention, object protection, protection goals?)
- Size and shape of the river drainage area (reaction of the body of water to various precipitation patterns?)
- Early warning (time of response, institutional warning system?)
- Seasonal behaviour of the body of water (summer and winter floods, monsoon or snow-related?)

Even general statements can be of assistance where there are no hard data available:

- In desert or steppe regions (annual rainfall < 600 mm) the intensity of an event generally increases, the less frequently it occurs, significantly more strongly than in tropical regions with high rainfall. This also applies to the size of the drainage area: on big rivers, the water levels which are expected to occur once in a century and once every two hundred years do not differ significantly, but on small rivers they certainly do.
- Flood protection measures prevent frequent damage, but may considerably increase the loss burden resulting from infrequent events.
- Objects lying more than ten metres above mean water level are largely immune to flooding from rivers or the sea.
- A flood can cause underground damage via the sewage system or cable shafts, even where the object is at some distance from the overground area affected.

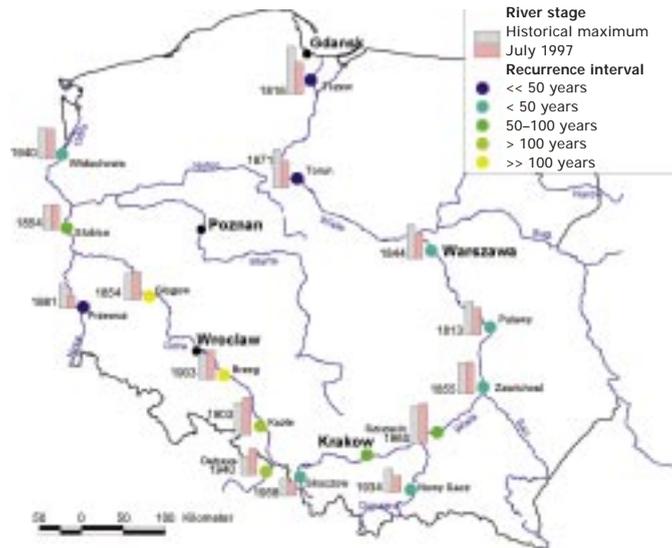
### Conclusion

Without hazard maps, the insurer is very often only able to quantify the risk of river flooding at great expense and using his own specialists.

## Flooding, Poland, July 1997

Maximum water levels before and during the floods of July 1997 in Poland, and estimated recurrence interval for water levels of 1997 (coloured dots).

## Recurrence interval of event loss, using Poland 1997 as an example



Major events which occurred not too far back in the past are very useful for risk considerations. The recurrence interval of a loss – the number of years during which a particular event loss is expected to recur – plays an important role for the insurer. In the case of major flooding it is difficult to establish this. The media may well come up with ideas on the subject, speaking for example of “once-in-a-century” events. But what exactly is meant by this?

The recurrence intervals as normally postulated by hydrologists state how many years elapse on average before a certain discharge (roughly indicated by the water level) will again be reached or exceeded at any one gauge station. But they give no information on the frequency of occurrence of the event, or on the resulting damage. To take one example: If the highest water levels at a particular place during a period of one hundred years are known, and if the second highest water level during the hundred years is measured on one occasion, then this or a higher water level can be expected to occur twice in a hundred years. The probability of the occurrence or, in other words, the frequency of this or a higher water level at this place is therefore two per cent per year.

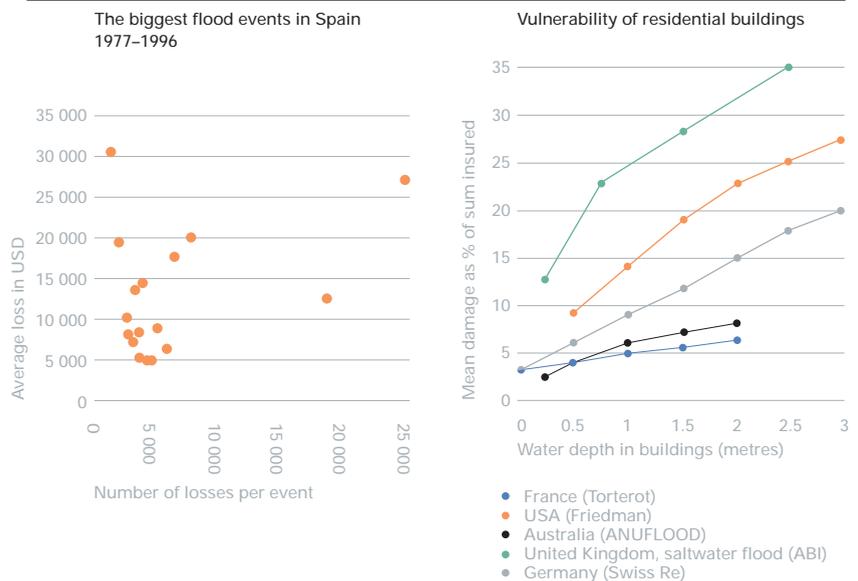
To put it another way, the recurrence interval is fifty years, calculated on the basis of the reciprocal value of two per cent.

A river flood mostly hits large areas with plenty of gauging stations. In our example in Poland, water levels with a very long recurrence interval occurred only in the upper reaches of the rivers. Further downstream, the recurrence intervals became progressively shorter. What value should therefore be associated with the event? The highest value, or an average? The question must be left unanswered, because it is dangerous to transfer values relating to water levels to the event loss without further investigation. For example, if the affected area had very little in the way of property on it, the damage would have been very small, and there would have been little talk of a “once-in-a-century” loss.

Even so, the recurrence intervals of water levels can serve as some indication of how frequently a particular event loss can be expected. However, the extent of the damage caused by other events must also be taken into consideration.

## Vulnerability

Dirty water damages property in very different ways. A television set or a sensitive machine for example will often end up as a write-off. A bicycle or a factory shop on the other hand will be only slightly damaged. In order to quantify this loss pattern, for every object a vulnerability rating derived from earlier losses would have to be established. However, the effort involved would be enormous. For example, if a vulnerability rating were to be defined for a washing machine, a risk assessment would also need to take into account its exact location, its value and the specific hazard. It is therefore advantageous to define as small a number of property categories as possible. Swiss Re frequently works with seven so-called risk classes: residential, agricultural and commercial/industrial, with a distinction always being drawn



Vulnerability as a result of flooding can be expressed in an average loss amount, for example. This single value is typically derived from many single losses resulting from past events. The diagram above left, based on the biggest events in Spain (> 1000 losses) over the last twenty years, shows that these average values vary from one event to another. This can have various causes: the buildings affected were not of the same type, the event types were different, or their intensity differed.

A first step in the direction of a differentiated perception is to define vulnerability per risk class, and to also take the water level in the buildings into account. In this connection we speak of stage-damage functions, examples of which are given in the diagram above right for various countries. There are considerable differences between countries, which are primarily due to the differences in construction type. When applying graphs of this kind it is important to remember the uncertainties which they also contain.

between buildings and their contents. Another class is business interruption. If individual building classes comprise completely different construction types, their loss characteristics must be clarified. If the differences are large, as for example between timber-framed and all-masonry constructions, a further distinction becomes essential. Industrial buildings must often be examined individually because their loss characteristics vary considerably.

Vulnerability can be defined as a single value – that is, independently of the intensity of the event – or as a function of one or more event parameters. The former approach is appropriate when there is little information available on the hazard and distribution of property. Otherwise, vulnerability can be defined as a function of the factors of “water depth”, “speed of rise”, “standing time”, “flood water velocity”, “depth of deposits”, “early-warning period” and “disaster aid” (see section 4). Since many of these factors cannot be accurately quantified, only the most essential parameter, water depth, is often considered. Other factors are taken account of – if at all – by means of a fixed surcharge.

Reliable figures relating to vulnerability are available only to a very limited extent, and are rarely published. Particularly in the field of industrial insurance, increased efforts must be made to provide a good basis for risk assessment. This includes analysing the losses arising from every major event.

### **Distribution of property**

Where hazard zones are defined with maps, the location of insured property should be established with the same degree of precision, that is, on the basis of coordinates. In personal lines, coordinates can increasingly often be gathered by access to address or street databases which are on offer for commercial use. Coordinates for industrial sites must be ascertained separately, since postal addresses are not necessarily identical with the location of the production facility. Nowadays, this is a simple matter using satellite technology (Global Positioning System).

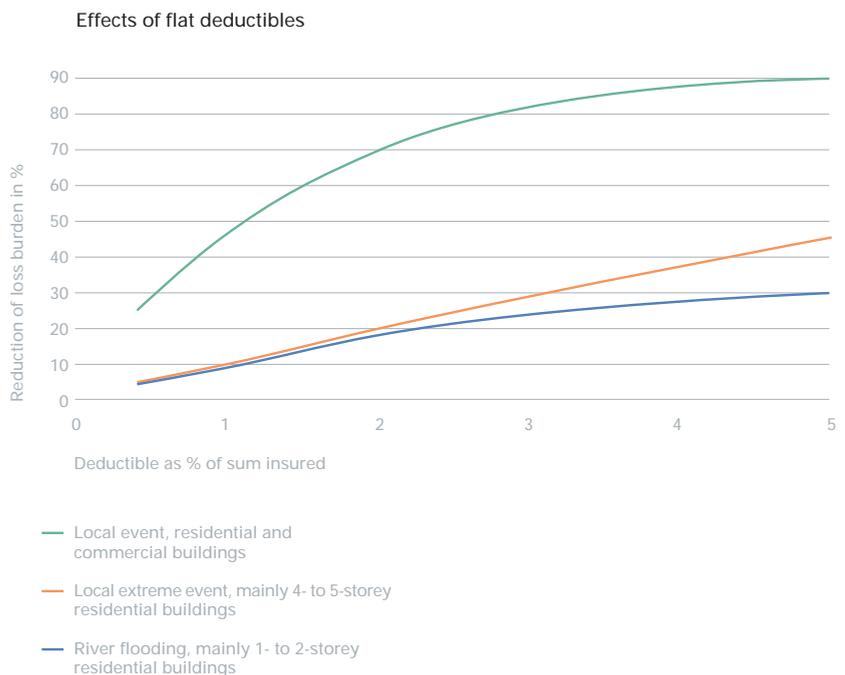
Even so, the coordinates-based approach is currently still regarded as being too cost-intensive. Modern software products which can overlay coordinates lists with flood zones and thus pinpoint threatened locations will simplify the process in the near future.

Where the areas at risk are insufficiently known, the distribution of property must be performed by town, administrative or postcode area, broken down into the defined risk classes. This approach also suffices for accumulation control. Since it is primarily the basements and ground floors of buildings which are at risk, the vertical distribution of property should be taken into account. For example, the number of storeys above and below ground must be distinguished or – better still – the sum insured assessed up to two metres above ground. Water depths of more than two metres rarely occur.

## Insurance terms and conditions

Concerning the insurance terms and conditions, two main factors are of decisive importance for the loss burden: scope of cover and deductible. For the purpose of simplicity we also include under the latter heading a loss limit that may be applied. Exclusions such as “sewage system back-up” reduce the number of claims significantly. Conversely, the exclusion of losses in respect of dam failures or storm surges can heavily reduce the insured loss potential. The insurance terms and conditions should always be adjusted to a country’s specific risk situation, and closely examined for loss potential.

The reduction of the loss burden by means of a flat deductible cannot be defined in generally applicable terms. The effects differ, depending on the type of risk, the intensity of the event and the height of the building. The data shown here are taken from rare events in Switzerland and Germany.



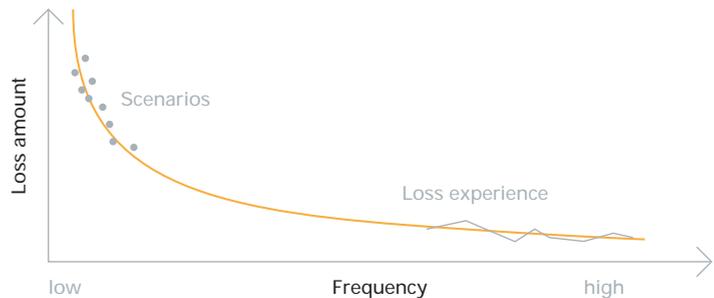
## Collating the various types of information

When information on hazard, distribution of property, vulnerability and insurance terms and conditions is available, this must be quantified and combined. A simple approach – if not entirely definable in mathematical terms – is to derive the loss frequency relation from individual events, basing it on previous loss experience and considerations of scenarios. If loss figures are available, they can be used as the basis for calculating the influence of frequent losses (basic loss burden) in statistical terms. For rare losses, the above information is taken as a basis for drawing up scenarios from which the loss potential is calculated in each case. A probability of occurrence must be

allocated to these scenario losses in order to permit a statement on the premium. This allocation often causes problems (see page 39, “Recurrence interval of event loss”).

#### Loss-frequency curve

Curve ascertained by means of scenarios and loss experience



#### Individual risk assessment versus portfolio assessment

The assessment of flood risk for a single location requires reliable information on the points set out above. For an industrial plant at risk it is worthwhile consulting a local expert with detailed knowledge of the hydrological situation in the vicinity of the plant and, ideally, of the vulnerability of the plant under examination. This expert is able to assess the hazard, determine protection measures in cooperation with the management, and provide the insurer with the necessary information for setting the price.

If thousands of policies from one portfolio are examined jointly, it is also possible to proceed with less precise data. Errors may occur in individual cases, but these will balance out to a certain extent over the large number of locations.

#### Experts and/or expert systems are necessary

In order to gather and evaluate all the data and assumptions which form part of a risk assessment, experts are necessary. Swiss Re has employed experts in these fields for many years. Computer programs and checklists simplify the work when a good information base is to hand, facilitating a standard procedure. For example, if hazard maps are available, and if the vulnerability is known, even a non-hydrologist can reliably estimate risks.

## 8 How can reinsurance contribute?

In future, losses totalling billions will become more frequent as a result of floods, because comprehensive flood protection and the concomitant illusion of security will lead to an increased concentration of values in threatened regions. High dikes that have never yet been breached convey a feeling of security and cause the residual risk to fall into neglect. If a dike does fail, the consequences are devastating.

Where flood cover is widespread, this can lead to very high fluctuations in the insurer's loss burden. This holds true in particular where events are likely to affect large areas, or in urban areas that are well protected against flooding. Furthermore, floods may occur in combination with other risks that are commonly also insured against. For example, hurricanes and typhoons, as well as storm surges in the North Sea, lead to heavy wind and water damage.

Reinsurance offers ways in which to cap the peaks of the primary insurers' loss burdens. This is primarily the province of the traditional reinsurance products. However, where very great loss potentials are concerned, products from the sector of alternative risk transfer (ART) can also be applied. With these products, a part of the risk may be transferred to the capital market, for example, or tailor-made solutions may be developed for major industrial clients.

Before a reinsurance solution is worked out, the concrete risk situation of the insured properties has to be analysed. This cannot be done without specific information. Moreover, there is a difference between the assessment of individual major objects and that of an entire insurance portfolio.

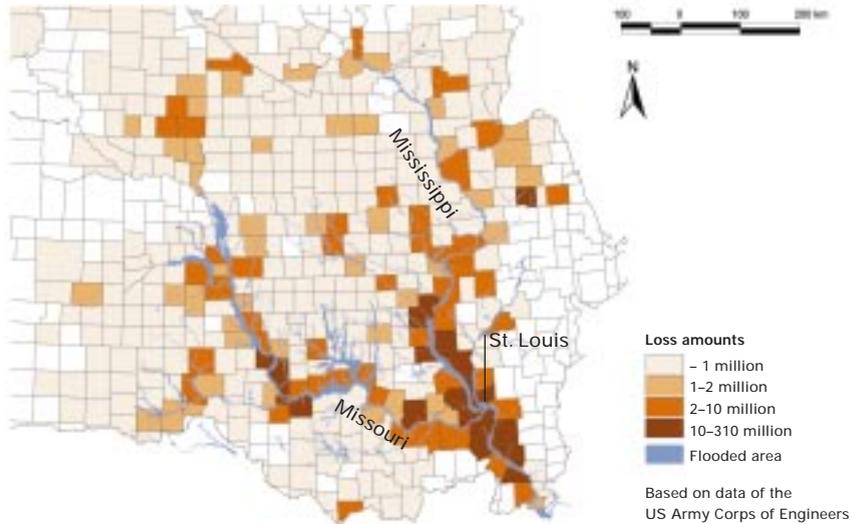
Concerning individual property, detailed information on the insured object is required for the risk assessment. Ideally, an inspection report will have been prepared by an expert who knows the local hazard and is able to estimate its effect on the insured object. If this is not the case, the primary insurer should at least complete a questionnaire relating to the flood risk. The questionnaire enables the reinsurer to make a rough risk assessment (see page 50). The most important piece of information in this respect is the precise location of the risk, which nowadays can simply be determined by means of GPS (Global Positioning System) in geographical coordinates of latitude and longitude. This precise locating system enables the reinsurer to call up the local hazard from a database and prepare a rough risk assessment.

If an entire portfolio with at least several hundred locations is under consideration, the primary insurer's customary accumulation data – which he should always keep up to date – is sufficient. An accumulation table should at the very least indicate the number of policies and the sum insured per risk class, aggregated for each accumulation zone (for example per postal zone). Corporations with more than one location should also provide precise information on property distribution. It is not sufficient to present the sum of insured objects at all company premises, because large buildings in particular are located in attractive, but high-risk, river plains. Also valuable are details of the vertical property distribution, that is, the number of storeys below and above ground, and of the sum insured per storey.

Coping with major floods represents a tremendous challenge for the state. Getting supplies going again, opening roads and making damaged houses habitable once more – these tasks place an enormous strain on crisis management teams, rescue services, armed forces and the directly affected population. The insurance industry can relieve the state considerably by taking care of the financial settlement of property damage. Of course, all insurance companies should be in a position to pay for the damage. Reinsurers provide assistance by assessing loss potentials and creating reinsurance programmes during “dry periods” in order to ensure that an event is approached effectively from an insurance point of view.

## Accumulated losses can be very high indeed!

Flood losses of residential/commercial/industrial property in USD millions per county



The biggest ever flood loss to the US economy occurred between April and September 1993 in the north-western part of the Mississippi basin, amounting to USD 18 billion (1993 values). Months of heavy rain swelled the main rivers and their tributaries, dikes were breached at over 1,000 points, and some 60,000 square kilometres of mainly agricultural land were flooded. A flood of this magnitude had not been observed in the previous 160 years.

Around 100,000 houses were damaged. The major portion of the damage was sustained by agricultural, transport, commercial and industrial businesses. But the infrastructure too was badly hit.

The insured portion of the total damage accounted for only some 15%. At USD 2 billion, the farmers were very well compensated by the Multi-Peril Crop Insurance programme and the Federal Crop Insurance Corporation. The State insurance programme for

flooding, NFIP, which mainly insures residential buildings and contents, had to pay out some USD 250 million. Here, the insurance penetration was only some 10%. Commercial and industrial businesses together sustained estimated insured losses of USD 600 million, a considerable proportion of this being accounted for by the transportation industry.

The Mississippi disaster showed the insurance industry most impressively what huge areas can be affected in big river basins, and how long a flood may last in these areas. The duration is of particular relevance for reinsurance, which provides cover for events as a whole, and has the difficult task of defining the beginning, end and extent of an event.

If a portfolio is to be covered by way of non-proportional reinsurance, the insurer and the reinsurer must agree on what is to be considered an event cover or indeed an event. Should a river flood be allocated a maximum duration in which the losses are added up? Should water levels be used as the yardstick for the beginning and the end of an event? Or should the values of measured rainfall also play a part? To date, questions of this kind have only been answered in part and must therefore be discussed between insurer and reinsurer. Different solutions may well be applicable from one country to another.

Swiss Re is constantly developing its know-how in the field of flood hazards and risk assessment, with the aim of becoming familiar with local risk situations worldwide and thus being able to advise its clients in an optimal way. For this purpose, the specialists at Swiss Re use state-of-the-art computer systems. Areas at risk are recorded digitally, which facilitates swift and competent risk analyses. These enable clients, market managers and flood experts to derive the appropriate reinsurance programmes.

In recent years, China has repeatedly been hit by devastating floods. One of these disasters occurred in July/August 1998, when embankments along the Yangtse gave way to the masses of water and vast areas were flooded.

In China, there are enormous concentrations of value in the direct vicinity of rivers. The picture shows the Yangtse river in flood and the skyline of Wuhan, a city with 7 million inhabitants. Despite tremendous flood protection efforts, forecasts on flooding and the country's unparalleled experience in dealing with flood disasters, the issue of insurance is becoming ever more important in Chinese risk management.

The situation in China shows in an exemplary fashion that an economically viable insurance solution requires close cooperation between the state, insurers and global reinsurers. Any solution of this kind also requires a high level of solidarity among all insured parties.

## 9 Floods are insurable!

The situation seems paradoxical: while enormous accumulations of property are threatened by flooding and major loss events are becoming more frequent, comprehensive insurance cover is lacking in many places. The reasons for this are many and diverse, and yet some similarities can be detected.

Many countries do have some form of flood cover. Compared on a global scale, some of these insurance solutions function well, whereas in the vast majority of countries, only few companies are insured, and residential buildings often have no insurance protection at all. This is generally explained by the high price for cover. This situation will remain unchanged as long as flood insurance is only an issue for those who are often confronted with losses. The number of policyholders whose premiums need to cover the losses is simply too small. The risk collective must at all events be increased if the risk of flood is to be insured effectively. This becomes possible

- if the state and the insurance industry highlight the threat and promote risk awareness. As long as no major flood events occur, their potential extent remains largely unknown. This is why so often, after a disaster, the size of the areas which have been hit gives rise to feelings of amazement and helplessness. A person who is at risk, and knows this, buys insurance cover.
- if the state and the insurance industry promote solidarity between those who are seriously at risk and those who are barely at risk. There is no viable alternative to a cooperative approach to the problems. Where several natural hazards together constitute a threat, a comprehensive package covering different types of hazards increases the balance of a portfolio. But where flooding represents the outstanding danger, an obligatory combination with fire insurance is indispensable. Both solutions incontestably involve subsidising the seriously threatened insured parties by those who are less exposed. This is fairer than if compensation were paid out of general taxation. Any strain thus imposed on feelings of solidarity can be counteracted by a policy of graduated premiums and deductibles.

Swiss Re is willing to contribute its share in terms of research, communication and its core business of reinsurance to facilitate the implementation of flood insurance schemes that are reasonable for all parties involved in as many markets as possible. Even so, success can only be achieved if all parties – the state, the insurance industry and the insured parties themselves – each make their contribution to the common endeavour.

# 10 Risk assessment questionnaire for floods, storms and earthquakes

Items in italics must be checked during inspection.

Date:	Your name:	
Policyholder:		
Location:	Country:	
Type of risk:	Code no.:	
<i>Longitude:</i>	<i>Latitude:</i>	<i>Altitude (m above sea level):</i>
Sum insured (currency: ): ):	Building:	
Contents/machinery:	Bl:	

## Surroundings

Topography:	<input type="checkbox"/> plain	<input type="checkbox"/> valley floor	<input type="checkbox"/> hillside	<input type="checkbox"/> hill-top	
Hydrology:					
Name of body of water:					
<i>Distance from water:</i>	<i>km</i>	<input type="checkbox"/> river	<input type="checkbox"/> sea	<input type="checkbox"/> lake	
<i>Height of risk above mean water level:</i>	<i>m</i>				
At risk from flooding:	<input type="checkbox"/> yes	<input type="checkbox"/> no	<input type="checkbox"/> unknown		
Surroundings:	<input type="checkbox"/> densely built-up		<input type="checkbox"/> open		
	<input type="checkbox"/> industrial	<input type="checkbox"/> residential	<input type="checkbox"/> forest/bush		
<i>Soil type:</i>	<input type="checkbox"/> rock	<input type="checkbox"/> gravel	<input type="checkbox"/> sand	<input type="checkbox"/> silt	<input type="checkbox"/> clay
Extent of premises:	m x		m		

## Building(s)

Type:	<input type="checkbox"/> reinforced concrete	<input type="checkbox"/> steel frame	<input type="checkbox"/> timber frame	<input type="checkbox"/> bricks/mixture
Age:	<input type="checkbox"/> 0-5 years	<input type="checkbox"/> 6-15 years	<input type="checkbox"/> 16-40 years	<input type="checkbox"/> > 40 years
Maintenance:	<input type="checkbox"/> very good	<input type="checkbox"/> good	<input type="checkbox"/> moderate	
<i>Design criteria, building code:</i>				
<i>Earthquake:</i>	<i>storm:</i>			
Roof:	<input type="checkbox"/> flat	<input type="checkbox"/> inclined		
Shape of building:	<input type="checkbox"/> regular	<input type="checkbox"/> irregular		
Height of building:	m			
Cladding:	<input type="checkbox"/> yes	<input type="checkbox"/> no		
Glass front:	<input type="checkbox"/> yes	<input type="checkbox"/> no		
Shutters:	<input type="checkbox"/> yes	<input type="checkbox"/> no		
Large openings:	<input type="checkbox"/> yes	<input type="checkbox"/> no		
Basement:	<input type="checkbox"/> yes	<input type="checkbox"/> no	<input type="checkbox"/> in part	
<i>Sum insured up to 2 m above ground:</i>				<i>% of total sum insured</i>

## Contents, machinery, stock

Type, interior/open-air:			
Anchorage to floor:	<input type="checkbox"/> above	<input type="checkbox"/> below	<input type="checkbox"/> average
Pipes/sprinklers EQ-proofed:	<input type="checkbox"/> yes	<input type="checkbox"/> no	
<i>Dependence on utilities:</i>	<input type="checkbox"/> high	<input type="checkbox"/> low	
<i>Sum insured up to 2 m above ground:</i>	<i>% of total sum insured</i>		



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Graphic design:  
Markus Galizinski, Zurich

Photographs:  
ARC, Lausanne (CH):  
page 13 bottom  
Bilderberg, Hamburg (D):  
page 6 (photographer: Dorothea Schmid), page 24  
Foto Natura, Wormerveer (NL):  
page 8 (photographer: Huub Smeding)  
GAMMA, Paris (F):  
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NASA (USA):  
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