Deltares

FAQ
What are flood probabilities and how are they calculated?

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What constitutes flooding?

In order to determine how probable floods are, it is important to determine first what a flood actually is. If a small amount of water overflows a dike without causing significant damage, that will not immediately be classified as a flood. The same goes for when heavy rainfall leads to water in the streets for a short period of time. This is described as “water nuisance”. Flooding refers only to the situation in which a large amount of water flows out of the sea, river or lake into a land area, with considerable damage as a result. In the Netherlands, a flood is usually associated with a breach of a dike, quay wall or dune. If a flood defence of this kind fails on the coast, the large rivers (the Rhine and Meuse) or the large lakes (IJsselmeer and Markermeer), enough water will usually flow into the hinterland to be considered a flood.

However, flood defences of this kind are not present everywhere. For example, there are no dikes on large sections of the banks of some tributaries of the Meuse, such as the Geul. In that case, flooding occurs when, during or after a period of heavy rainfall, the capacity of the river is not adequate to accommodate the large amounts of water. The river will then burst its banks and the land alongside will be inundated.

What is a flood probability?

A flood probability is the probability that a flood will occur in a given period of time. We can determine this probability for a specific location, a dike section (a set of flood defences), an entire water system such as the Meuse, or for the whole of the Netherlands (in other words, the probability of flooding somewhere in the Netherlands).

How do we calculate flood probabilities?

The “hydraulic load” of a flood defence plays an important role in the calculation of flood probabilities. The hydraulic load is a generic name for the threats that the water can represent to the flood defence. In general, this hydraulic load can be described in terms of the water level and the characteristics of waves (wave height, width and direction). In some cases, the flow rate of the water plays an important role as well. The spread of the hydraulic load over time is also important. In general, there will be more problems if high water levels and waves persist for a long time.

In short, the probability of failure of a flood defence is determined as follows:

1. The identification of the hydraulic loads that may occur in the locality of the flood defence and the quantification of the probability of these hydraulic loads.
2. The determination of the hydraulic loads that the defence is not expected to be able to cope with. In other words: which hydraulic loads are expected to result in a breach and therefore in

FAQ

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flooding?
3. The determination of the flood probability on the basis of the results of step 1 and step 2.

[**1**]

The approach to calculating hydraulic loads and the associated probabilities differs according to the area. That is because the causes of high water are not the same everywhere. On the coast, storm events are the main cause; on rivers, extreme precipitation. And in the lower reaches of the Rhine and Meuse (the Dordrecht region), both storm events and extreme precipitation can lead to high water.

Different numerical models are therefore used for the different types of water systems to determine the probabilities of hydraulic loads. The weather model used for the Meuse in Limburg draws up a large number of weather scenarios for the catchment. Then a simulation model is used to calculate the resulting discharge of the Meuse in all these weather scenarios. The probability of occurrence is subsequently determined on that basis for all possible river discharges. Next, a different simulation model is used to determine the water levels on the Meuse associated with the various river discharges. The final step is to determine, using a realistic scenario for wind speeds, which waves will accompany these water levels.

[**2**]

The main purpose of a flood defence is to protect the hinterland from flooding. If a breach (or hole) is created in the dike during high water, the defence will no longer fulfil that role and the defence will fail. There is a range of processes that can result in flooding: these are referred to as ‘failure mechanisms’. For example, a combination of high water levels and waves can cause water to overtop the dike. The amount of water that passes over the dike is not usually the direct problem. But if numerous, or large, waves impact the dike for a long time, the inside (in other words, the land side) may be damaged, possibly resulting in a breach. Models have been developed for these and other failure mechanisms in order to determine the hydraulic loads (see under 1) that may trigger these mechanisms. For an overview of possible failure mechanisms (in Dutch), see:
https://v-web002.deltares.nl/sterktenoodmaatregelen/index.php/Faalmechanisme

[**3**]

On the basis of the information from step 2, it is possible to determine the hydraulic loads at which a flood defence will fail. On the basis of step 1, the probability of occurrence can be determined for each of these hydraulic loads. The sum of the probabilities for all hydraulic loads leading to failure provides the flood probability.