If the sea were to flood the southern parts of the agglomeration that covers most of the western part of the Netherlands, the death toll would be in the thousands, as predicted by a calculation method developed at Delft University of Technology (TU Delft). Evacuation would save precious few lives. So how can a disaster of this magnitude be averted?

Maaike Muller

Living on the edge

Evacuation is not an option

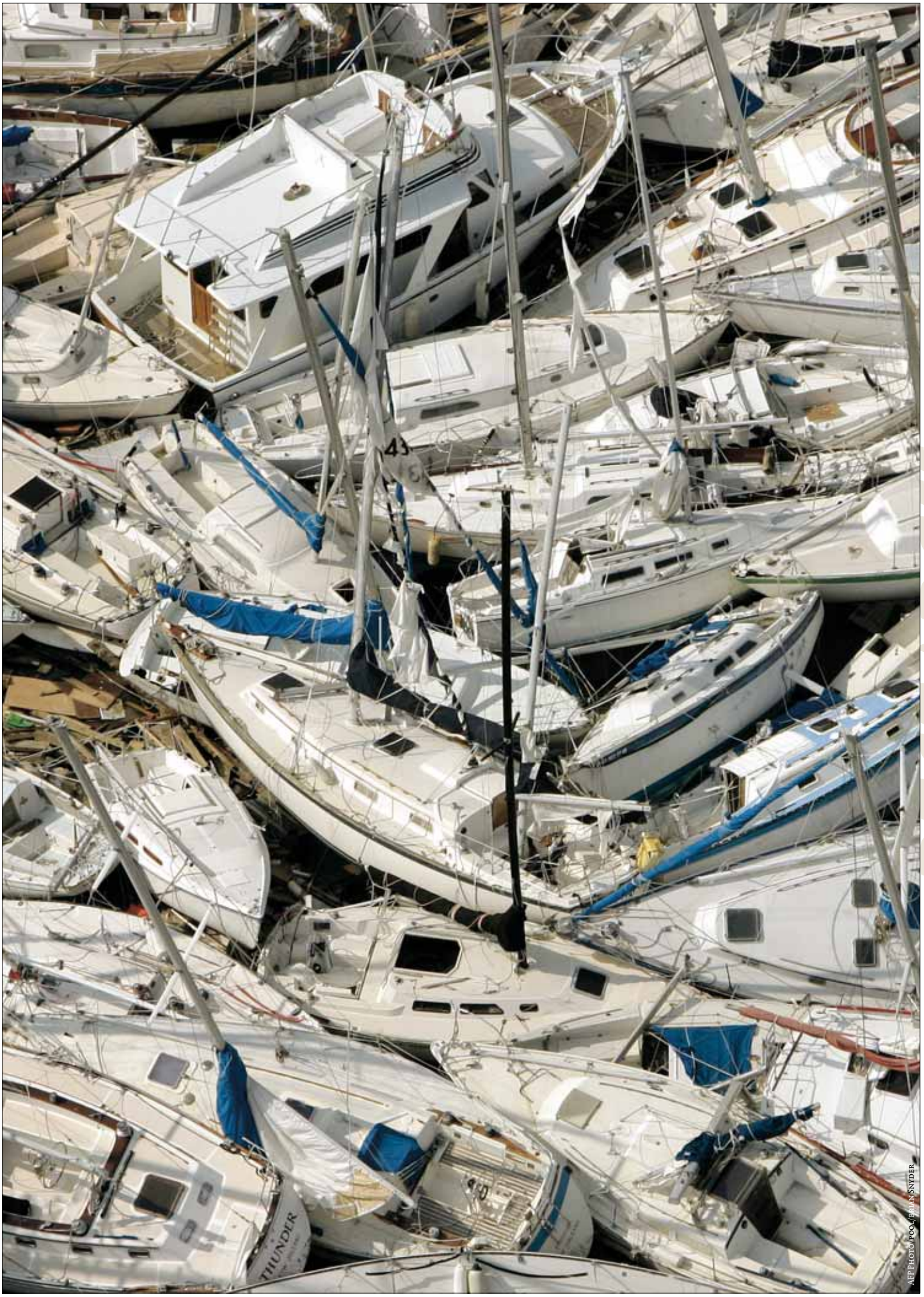
There is a fierce northwester blowing. The sea defences near The Hague and more to the south give way, and the sea water comes rushing in to flood the low-lying land behind. Swimming certificates won't do you any good. Cars will be floating about, and even entire houses will be washed away. Thousands of people will drown.
More precisely, if such a scenario were to become reality, the calculation method developed by doctoral student Bas Jonkman predicts a number of more than four thousand casualties. Jonkman's method for estimating the number of victims of a major flood mercilessly demonstrates that should such a flood occur, evacuation will save no more than six hundred lives. "A North Sea gale can be predicted one day or perhaps two days in advance," Jonkman explains. "Before the evacuation can start, the authorities have to convene, and everybody will have to be alerted. The population will then have to gather their belongings, collect grandma, and look for the cat. It will all take quite a bit of time." And once all the people have bundled themselves into their cars, the traffic will be gridlocked. "If the seawalls break at that point, we'll all be in deep trouble."

'A North Sea gale can be predicted one day or perhaps two days in advance'

Until recently, rules of thumb were being used to estimate the possible number of victims. Jonkman's casualty model is more accurate. It consists of a number of modules, including a model that simulates the evacuation and determines how many people will be left behind in the area when the sea rushes in. How many of those people will die depends on the speed with which the water comes in, the rate at which it rises, and the depth it finally reaches.
In order to predict all this, Jonkman used a model developed by TU Delft and the WL Delft Hydraulics research institute. "Other factors will also contribute, for example the construction quality of houses, but we can't include them, because there is simply too little information available."

The flood of '53

Jonkman combined the models to simulate the evacuation and the progress of the flood. Most of the time devoted to his work for his doctorate, which he hopes to complete soon, was spent on making the casualty functions, however. 'If the water ends up being four metres deep, 20 percent of the people in the area will not survive' is an example of such a function which calculates the number of victims using the model data.
Jonkman based his casualty functions on data from the 1953 flood, when 1,836 people lost their lives as large parts of the south western isles were inundated. He searched through commemorative publications, combined lists of inhabitants, traced water depths. He also used data from the flooding of England's east coast in 1953 and the flood in Japan in 1959. The information is slightly dated, but then catastrophic floods for which useful data still exist don't happen all that often. Until August 2005 that is, when hurricane Katrina breached the levees around New Orleans.
The world was suddenly confronted with the terrible effect of such a flood. As was Jonkman. On the other hand, he was able to use the event to test whether his model produced realistic results. He travelled to New Orleans and together with a fellow researcher from the LSU Hurricane Center in Baton Rouge collected the data he needed (see text box).
As was only to be expected in the chaos of a flooded city, it was not a question of simply asking for information which would then be provided in nicely laid out tabular format. The figures describing the event and its aftermath had to be reconstructed bit by bit. For example, the velocity of the water as it poured into New Orleans was never measured, but it does have a major impact on the ▸▸



AFP PHOTO/POOL/BRIAN SNYDER

Some major flood disasters

	Cause	Casualties	Affected persons
1 February 1953 **Netherlands,** SW	Gale	1836	250,000
1 February 1953 **UK,** East Coast	Gale	304	32,000
26 September 1959 **Japan,** Ise Bay	Typhoon	5101	430,000
29 August 2005 **USA,** New Orleans	Hurricane	1100 *(current count)*	410,000

SOURCE: JONKMAN

chances of survival of the city's population. A computer simulation was used to calculate the information after the fact, and the LSU Hurricane Center used satellite pictures to determine the depth of the water throughout the city. The model used these depths to arrive at an estimate of two thousand victims. "That figure is of the same order of magnitude as the 1100 bodies recovered so far." Although his method calculated almost twice as many casualties as occurred in reality, Jonkman is satisfied, because his system came a lot closer than others, for example an American firm of consultants that came up with a death toll of 60,000.

Acceptable risk

Jonkman's calculations arrived at just the right moment. The Dutch Ministry of Transport, Public Works, and Water Management intends to revise its current assessment of flood prevention standards. These standards, which were defined in the 1950's, determine the acceptable risk of an inundation (see text box). The envisaged approach will look at inundation risks by including not just the probability of such an event, but also the effects, economic damage, and number of victims. The insight into the number of victims and the effect of evacuation on the casualty number provided by the method fits in well with the discussion about the acceptable risk of inundation and what to do to reduce the probability or minimise the effects.

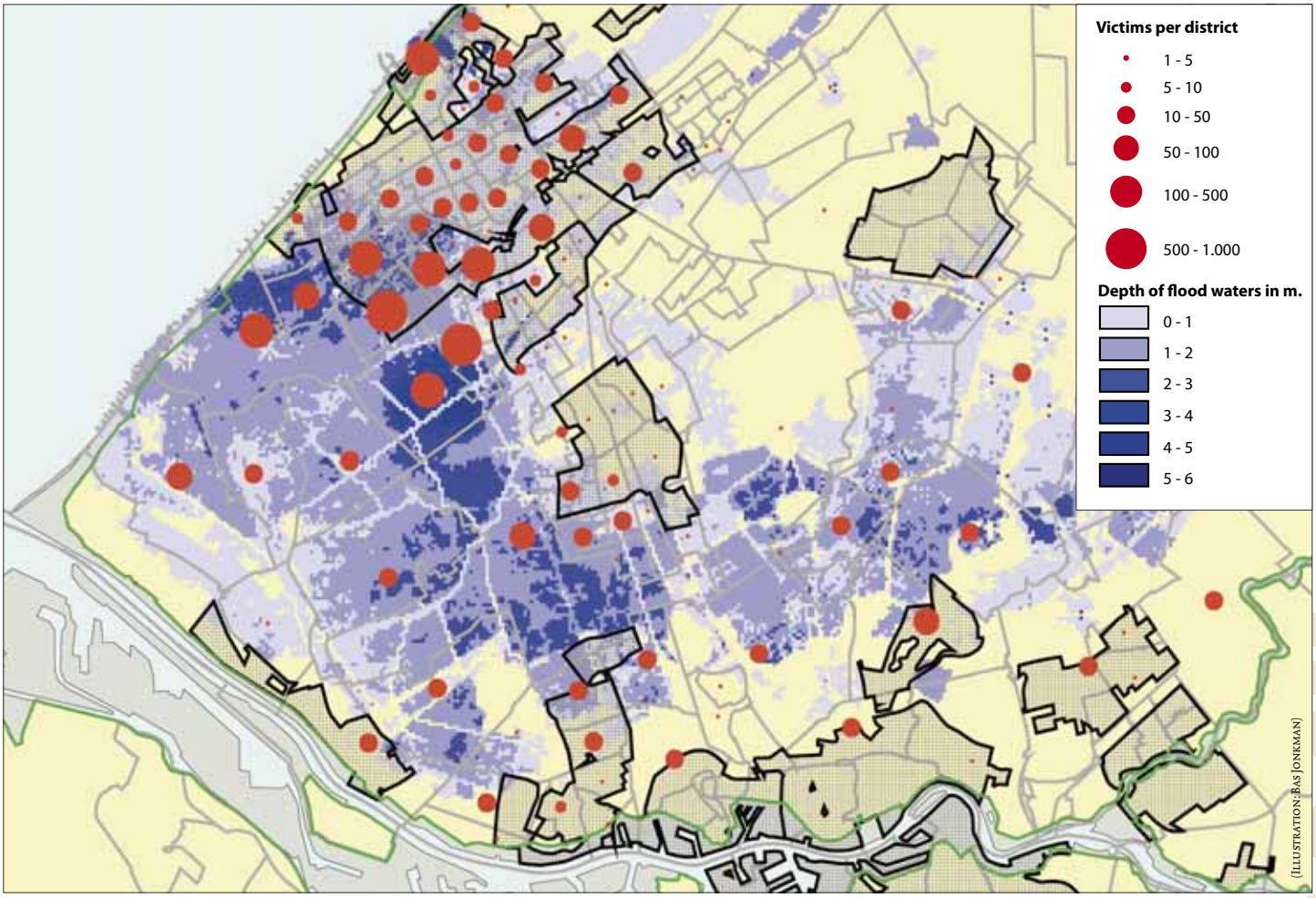
"The current vogue is to look at measures to minimise the effects. After New Orleans the Dutch government immediately called for contingency planning," Jonkman says. Dr. Ben Ale, professor of safety and contingency planning, agrees with this development: "The powers that be tend to think too lightly about evacuation. Jonkman's casualty model, and in particular the graphics that accompany it, make you realise that you can just forget about moving a couple of million people before the water arrives. Evacuation simply is not an option."

According to the model, evacuation may save many lives in low-lying areas alongside the Dutch rivers, where

Cover: Ezra Boyd, data: Hampton Peele, Rob Cunningham, DeWitt Braud, G. Paul Kemp

Collection data in New Orleans

Six months after disaster struck in New Orleans, Bas Jonkman travelled to the stricken city to collect data he could use to test his model, which calculates the number of victims after a flood. "Whole sections of the town have been devastated. There is still no drinking water, no power. People may be glad to be alive, but they have lost everything they owned," says Jonkman. He collected the data on the victims themselves from the mortuary. Even in the streets, there were signs pointing to the many people who perished. "Every house was marked with a cross to indicate that it had been searched, and a number indicating the number of dead that had been found there. Conducting casualty research is all very fine, but at times like that you suddenly realise what it is all about."



If the seawalls at Den Haag and Ter Heijde are breached, the resulting floods would claim approximately 4,000 lives. And another 700,000 residents of South Holland would be directly affected by the floodwaters if they were not evacuated. These predictions are based on a calculation method devised by Bas Jonkman. His method also reveals the areas where the most casualties would occur.

advance warnings will come earlier and the population is fewer in number. In a densely-populated area close to the sea however, contingency plans can do little to prevent a mounting death toll. That is not to say that the call for contingency planning is misguided in these areas. "Once the water comes pouring in, there will be millions of people standing all along the dykes. Whatever the case, it makes sense to think about what to do with all those people," says Professor Ale. He and Jonkman agree that there are better ways to prevent large numbers of casualties than evacuation, such as improving the seawall to reduce the risk of flooding.

The problem is, what is an acceptable risk for a flood claiming thousands of victims? Politicians will weigh safety against other factors, such as the cost involved in securing the additional safety. Plans for new housing construction in deep-lying areas show that the weighing of pros and cons does not always result in better safety. In Gouda, a shortage of housing has resulted in plans to build new houses to the west of the city. "In this case, it was decided to accept the risk and to ensure that the land remains dry. This is a political balancing act, but it cannot be avoided, Ale says. "On the other hand, if you accept the idea that sea levels are rising, it may not be the wisest option. But then, you could also adopt a don't care attitude and sit back to wait for the inevitable to happen. As long as it doesn't happen while you're at the helm, you won't have a problem. And the chances that it will are not all that great."

The Netherlands was never as safe before?

The government is ignoring its own safety standards. It turns out that 24 percent of our dikes do not meet the statutory safety limit, while the status of another 32 percent is unknown. These are the results of a survey of the country's primary flood defences. "The survey is like an MOT test for dikes and dunes, and at this moment they simply do not pass," says Dr. Ir. Marcel Stive, professor of coastal engineering. He is exceedingly annoyed by the Ministry's assertion that the Netherlands is safer now than it has ever been before.

Granted, the risk to any individual being killed by a flood is less than that of dying from a bee sting, but the group risk, i.e. the probability of a large number of people being killed by a single flood event, is considerable. In fact RIVM, the Dutch Government Institute for Public Health and the Environment, has calculated that the flood risk exceeds all other external risks put together, such as chemical plant accidents and other manmade risks.

More information: Ir. Bas Jonkman, S.N.Jonkman@tudelft.nl; Professor Dr. Ben Ale, B.J.M.Ale@tudelft.nl; Professor Dr. Ir. Marcel Stive, M.J.F.Stive@tudelft.nl.