Management of Flood Risk

Living in a flood prone area requires management of flood risk. The primary task is to look out for and identify the risks:

- Is human health and safety at stake?
- What is the damage to homes, work-places and infrastructure?
- How is local culture and nature affected?
- Are there significant derived effects?
- Are there irrational or unacceptable flood risks?

When the risks have been identified they should be quantified. The modern risk concept states that the risk is the probability of flooding times the consequences of flooding. If 1000 houses are lost by floods in the 100 to 1000 year return period range, the risk contribution is simply 1000 x (1/100-1/1000) = 90 houses/year. All floods and consequences must be summed up to derive the total risk. Mortality, injury, damages, economic disruption, cultural and environmental consequences may all be quantified in this way. When the risks have been identified and quantified it is time to exercise due diligence:

- Is the level of protection uniform?
- Are the flood risks out of proportion to other common risks of life?
- What is the benefit/cost status between risk reduction and protective works?
- What can be done to reduce risk?
- How to improve evacuation?
- How to improve local households and shelters?
- What is the rescue and rebuilding capacity?
- What about the long range?

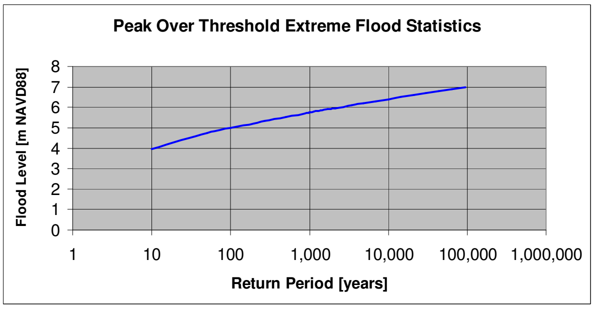

Figure 1 Peak over threshold extreme flood statistic from station Ribe, ref. /1/.

Extreme Flood Statistics

High water is the source of flood risk. A long term high water statistics is a must to quantification of risk. What is the 50 year flood, the 100 year, the 1000 year and higher? The peak over threshold statistical analysis of a long record of gauging, constitutes the best available statistical basis, ref. /1/. An example statistic from station Ribe in Denmark is displayed in Figure 1. From the statistic the return period of any external surge level may be read, e.g. the 1000 year flood exceeds a level of 5.74 m or 18.8 feet.

Quantification of Risk

However strong a levee or another hydraulic barrier, sooner or later it will succumb to the external environment. When households, companies and public infrastructure are flooded, a certain level of damage and disruption is generated. In Figure 2 is shown a realistic damage graph for a community of 7500 citizen protected by a huge sea dike, ref. /2/. The higher the inundation, the larger the damages. The damage is dominated by destruction of private property and public infrastructure. Ultimately every item is taken by extreme floods.

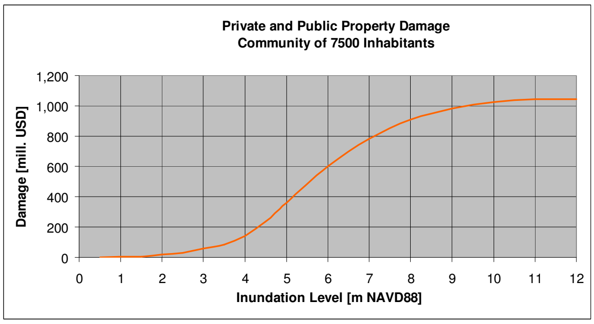

Figure 2 Property damage graph for a community of 7500 inhabitants living in a flood prone area, ref. /2/.

Assume that the levee line protecting the 7500 inhabitants is a strong and well maintained line that does not give way until the 1000 year storm attacks, ref. /3/. As the floods approach the 1000 year level increasing amounts of wave overtopping are generated, ref. /3/. When the 1000 year storm attacks, a singular breach is generated, ref. /3/. Higher storms generate more breaches and let in more water, ref. /3/. The external surge from Figure 1 and its internal inundation is illustrated in Figure 3. Ultimately the hydraulic barrier is broken completely down, and the original nature is back in rule.

The inundation indicated by the red curve in Figure 3, may be integrated with its consequences, as quantified by the damage graph in Figure 2. The actual result is a risk of 364,000 $/year. Based on this figure it is a simple management task to evaluate if the risk reduction by investing in the hydraulic barrier is in fair proportion to the investment. A benefit/cost proportion around unity should of cause be attempted.

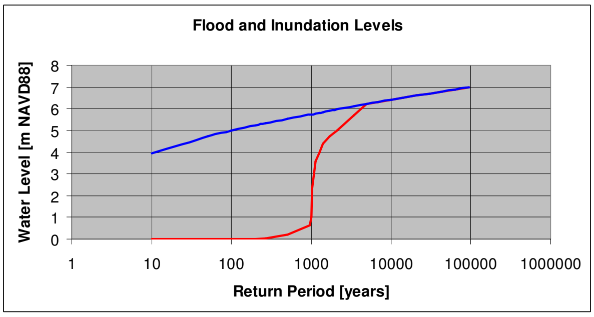

Figure 3 Flood levels and consequent inundation for a 1000 year levee.

Human Health and Safety

The first question when it comes to human health and safety is mortality. Mortality is the extreme consequence of people being trapped in inadequate shelters by inundation. The exposed population is the ones, who did not evacuate in time. The exposed population will be distributed in shelters of varying quality. Primary mortality derives from houses falling apart and people forced out of their shelters by rising waters. Secondary mortality derives from wounded, sick and otherwise disabled people under stress. The central questions thus become:

- How effective is evacuation?
- How large is the remaining exposed population?
- What is the quality of shelters of the exposed population?

If adequate answers may be found to these questions, mortality may be expressed as a function of the inundation. The mortality function may resemble the damage graph in Figure 2. The ultimate number of fatalities equals the entire exposed population. An example function, assuming 90 % evacuation efficiency, is depicted in Figure 4.

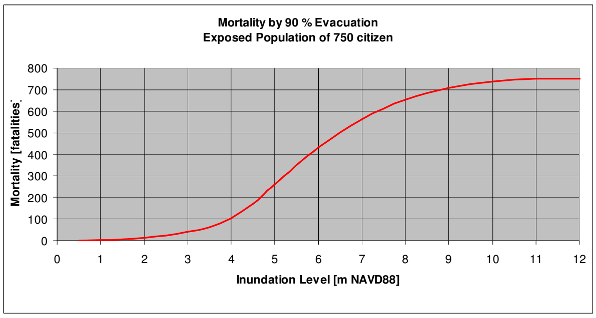

Figure 4 Mortality function for an inundation prone area with a 90 % effective evacuation system.

By integrating the inundation statistic in Figure 3 with the number of fatalities in Figure 4, a risk of 0.27 fatalities/year is found. This rate is just 0.3% of normal life expectancy. However without an effective evacuation system the rate would rise to 3%, which is significant. Thus it is very important to maintain and exercise the evacuation system, and to verify the evacuation efficiency, thereby keeping the mortality risk at a known low.

Injury and stress will affect the entire exposed population. Depending on the quality of shelters, sustainability and the rescue capacity, health problems could develop into unacceptable secondary mortality.

Conclusion

Management of flood risk is a matter of due diligence. If you understand your surrounding environment, your values, your community, the quality of your protective structures and your organisation, you may identify and quantify your risks. When you know your risks you may manage them to a level where everybody may feel safe for themselves and their community.

References

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/3/ Bernitt, L. and Lynett, P. (2010). Breaching of Sea Dikes, Proceedings of 32nd international Conference on Coastal Engineering, ICCE 2010.