



Rijkswaterstaat
Ministerie van Verkeer en Waterstaat

Flood Protection Standards in the Netherlands

Towards Tolerable Risk

Rijkswaterstaat
Centre for Water Management
Durk Riedstra

2010, June 15th, Londen



Outline

I. Flood Protection Standards in the Netherlands

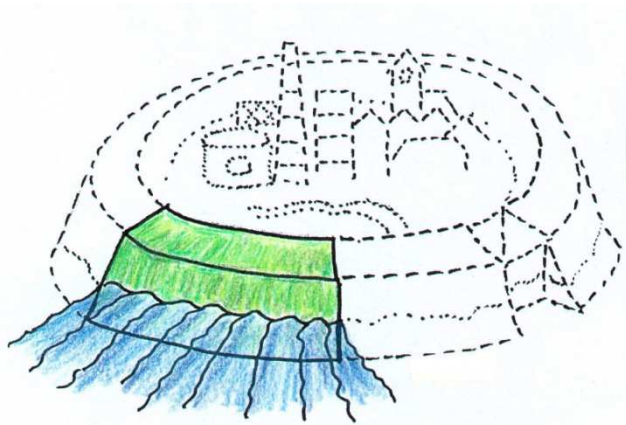
- Current Flood Protection Standards & Advise Delta Committee 2008
- Towards a risk-based approach
 - Individual Risk
 - Societal Risk
- Dealing with Tolerable Risk, results and discussion

II. Focus on evacuation



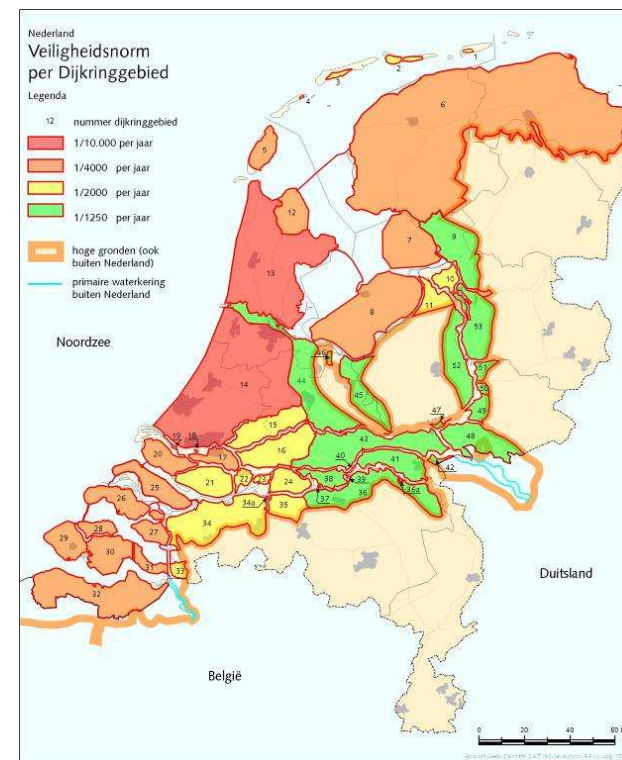
Flood Risk Management in the Netherlands

Current approach



	'60s
	exceedance frequency
	overflow & wave overtopping
	dike ring section
	cost-benefit analysis

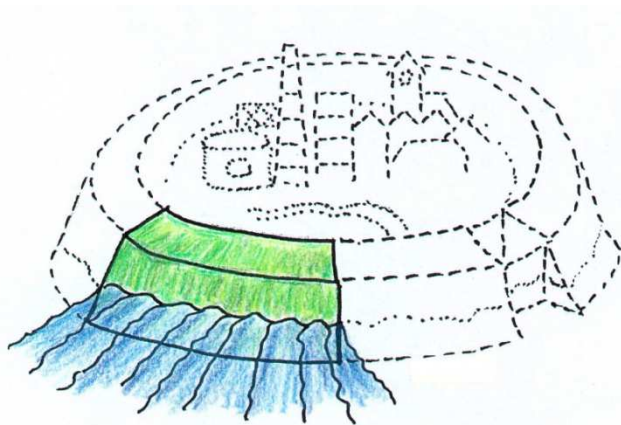
Current Flood Protection Standards





2nd Delta Committee (2008)

Current approach



New approach



'60s	> 2011(?)
exceedance frequency	risk (probability x consequences)
overflow & wave overtopping	all failure mechanisms
dike ring section	dike ring
cost-benefit analysis	idem + loss of life risk analysis



2nd Delta Committee (2008)

The new protection standards based should be based on:

- Basic level of protection for every citizen
→ Individual risk
- Protection against large social disruption
→ Societal risk
- Cost-benefit analysis

→ Two track approach ...

1. FLORIS (research project)
2. Flood Risk Management 21st century
(policy evaluation)

→ www.deltacommissie.com

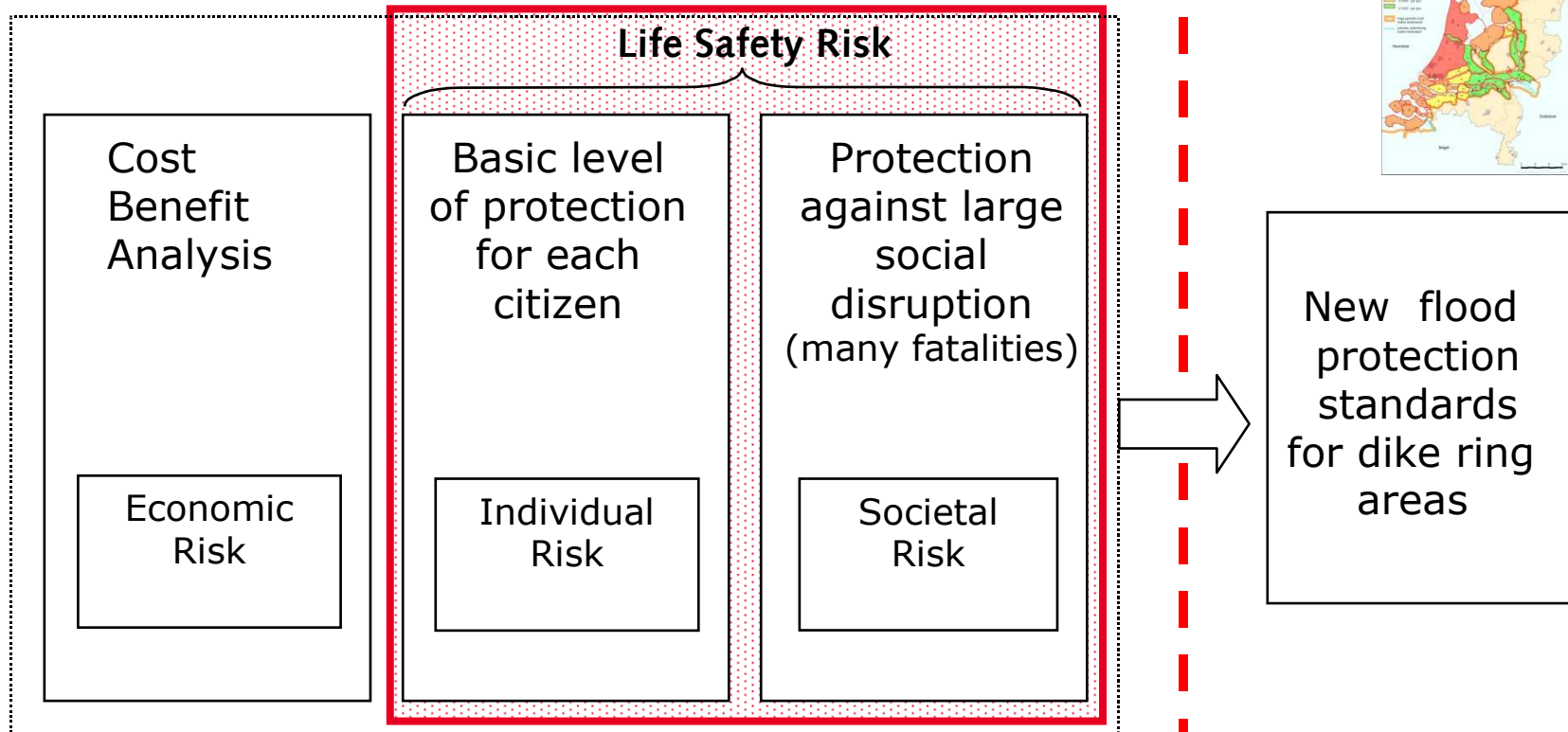




Approach Flood Risk Management 21st century

→ *towards new flood protection standards*

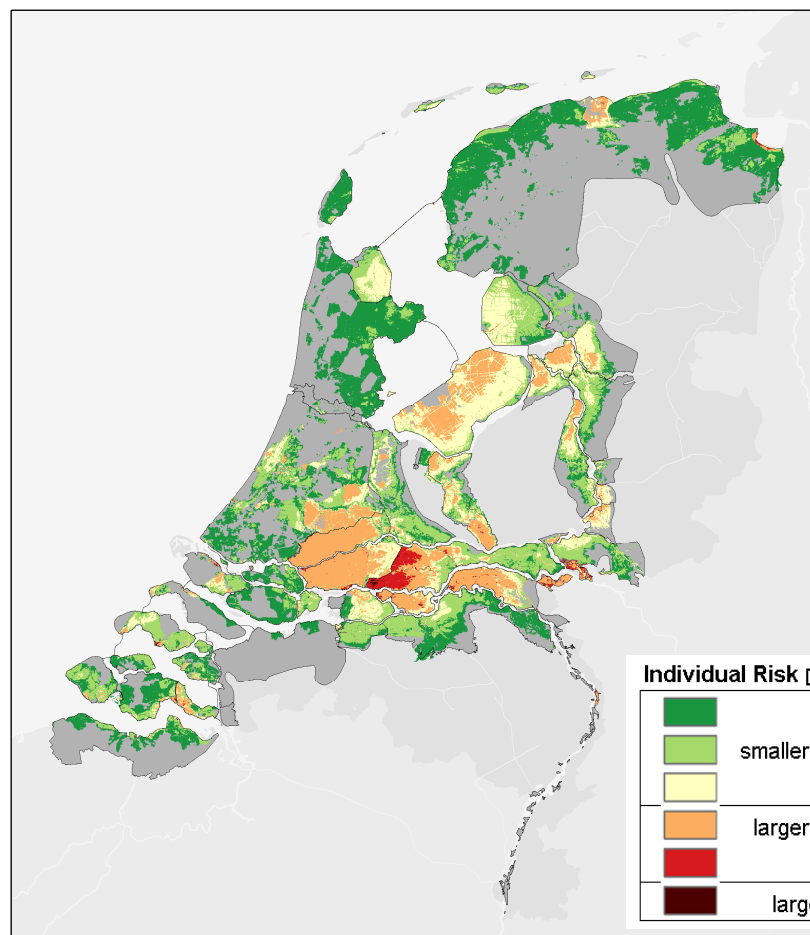
only ± 5 classes
are allowed



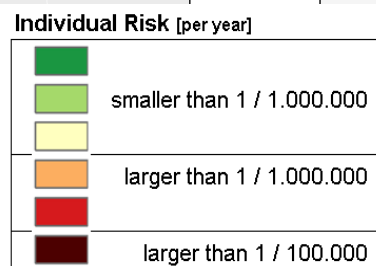
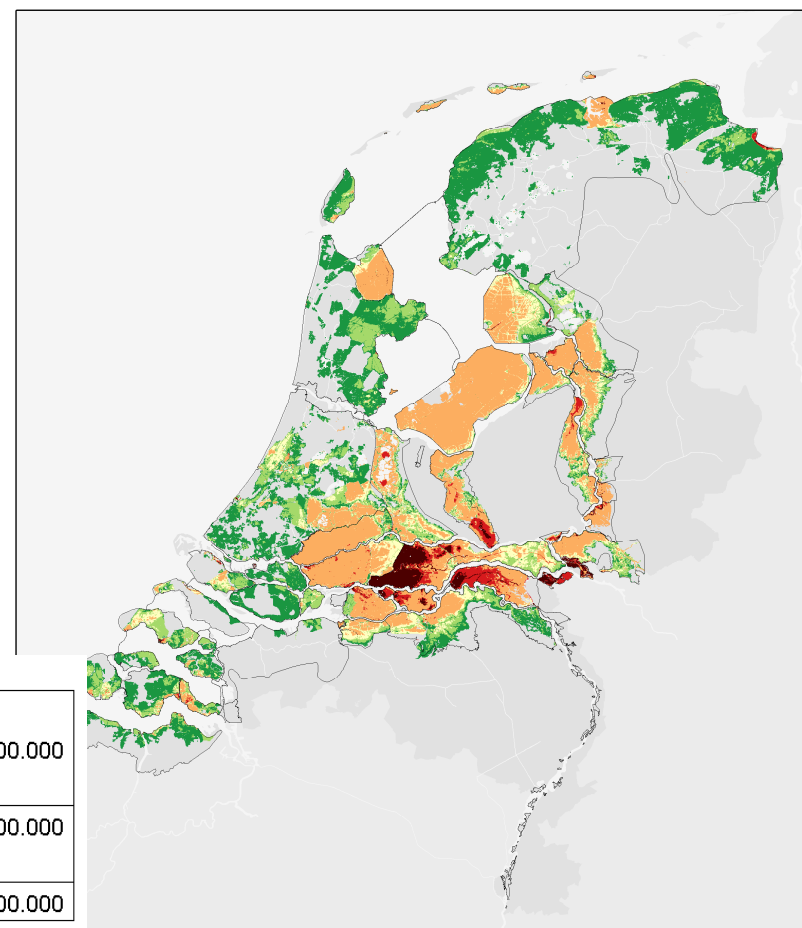


draft results

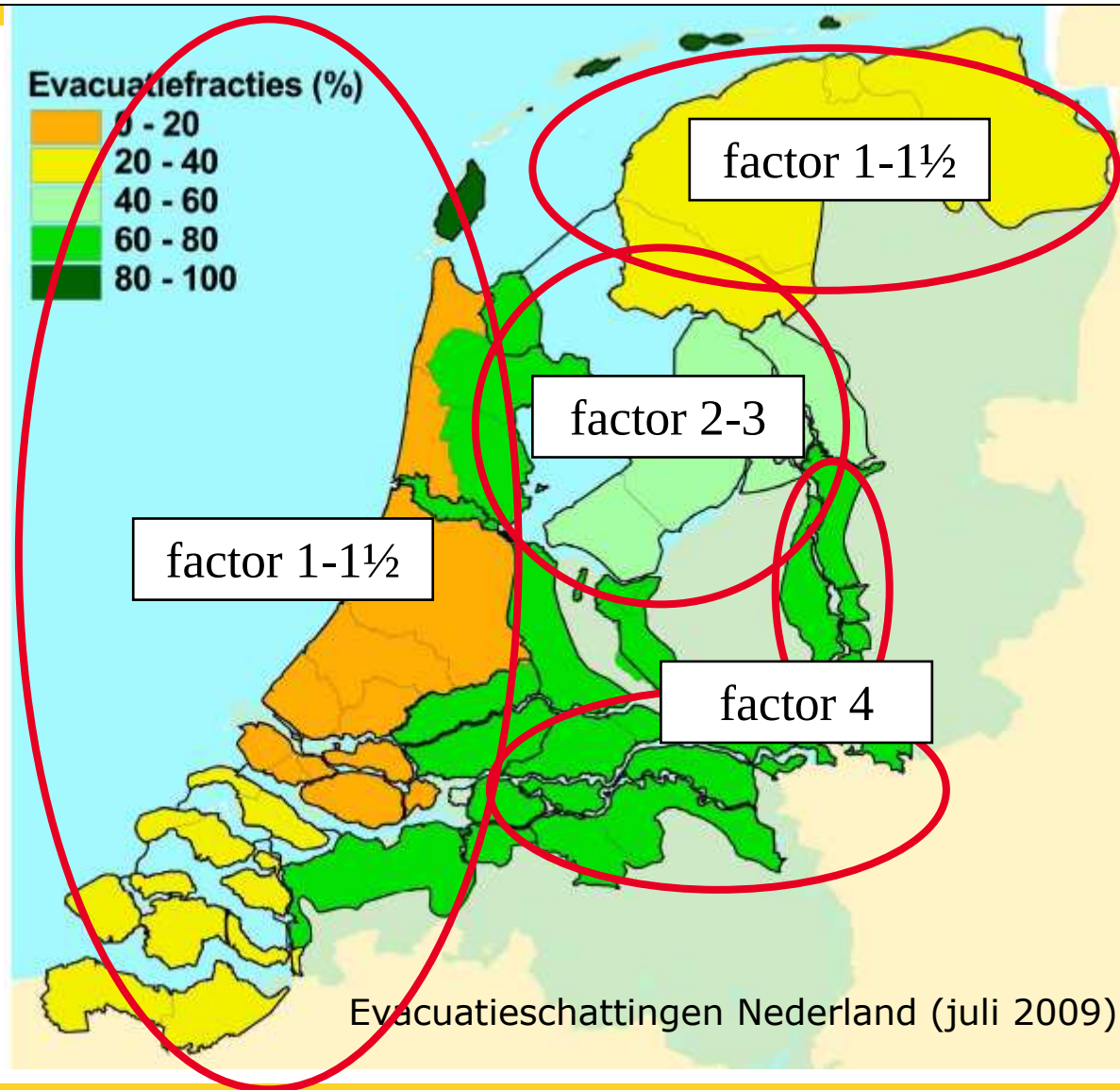
Individual Risk (situation in 2015) *with evacuation*



without evacuation



Difference in protection level WITH & WITHOUT evacuation

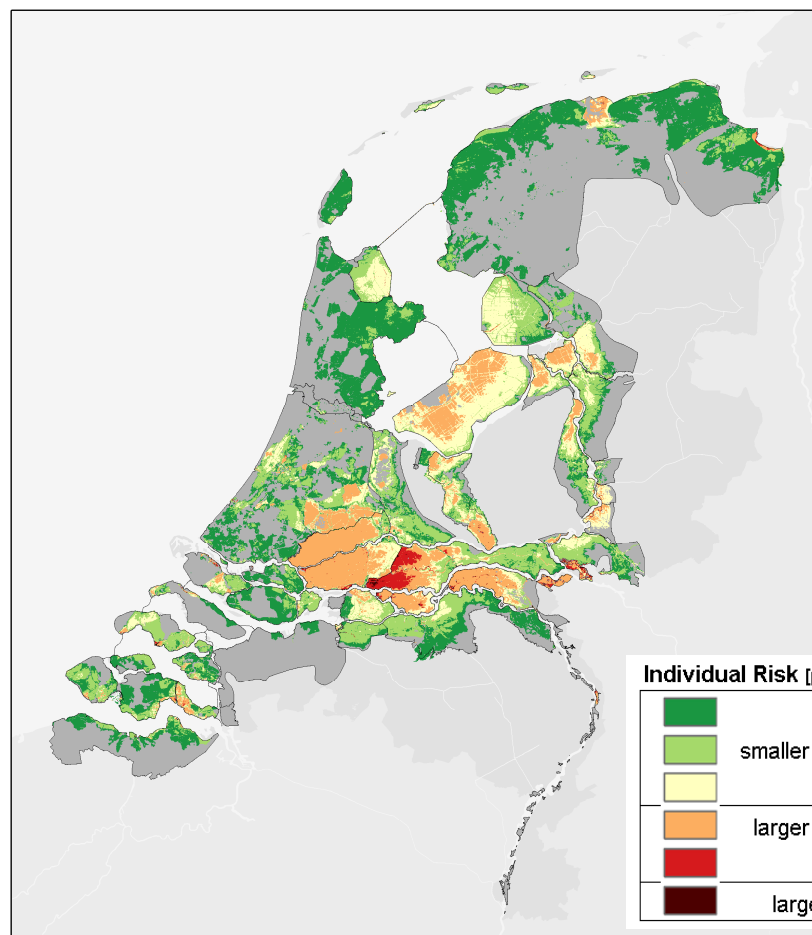




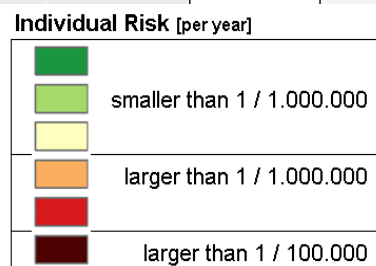
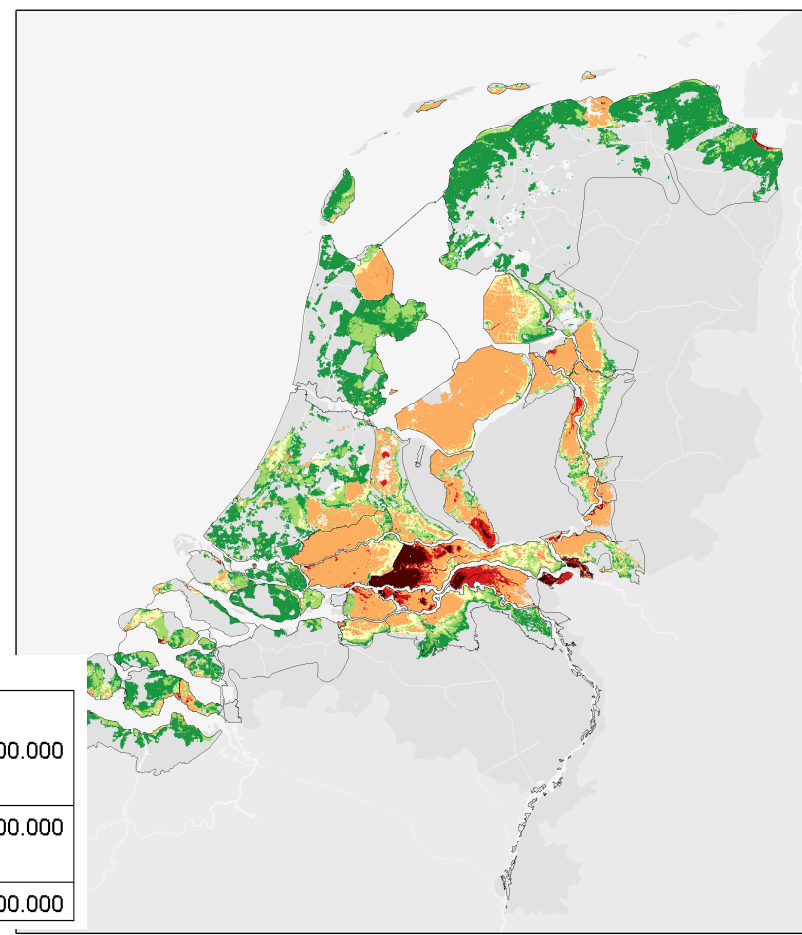
draft results

Individual Risk (situation in 2015)

with evacuation



without evacuation





Tolerable Individual Risk?

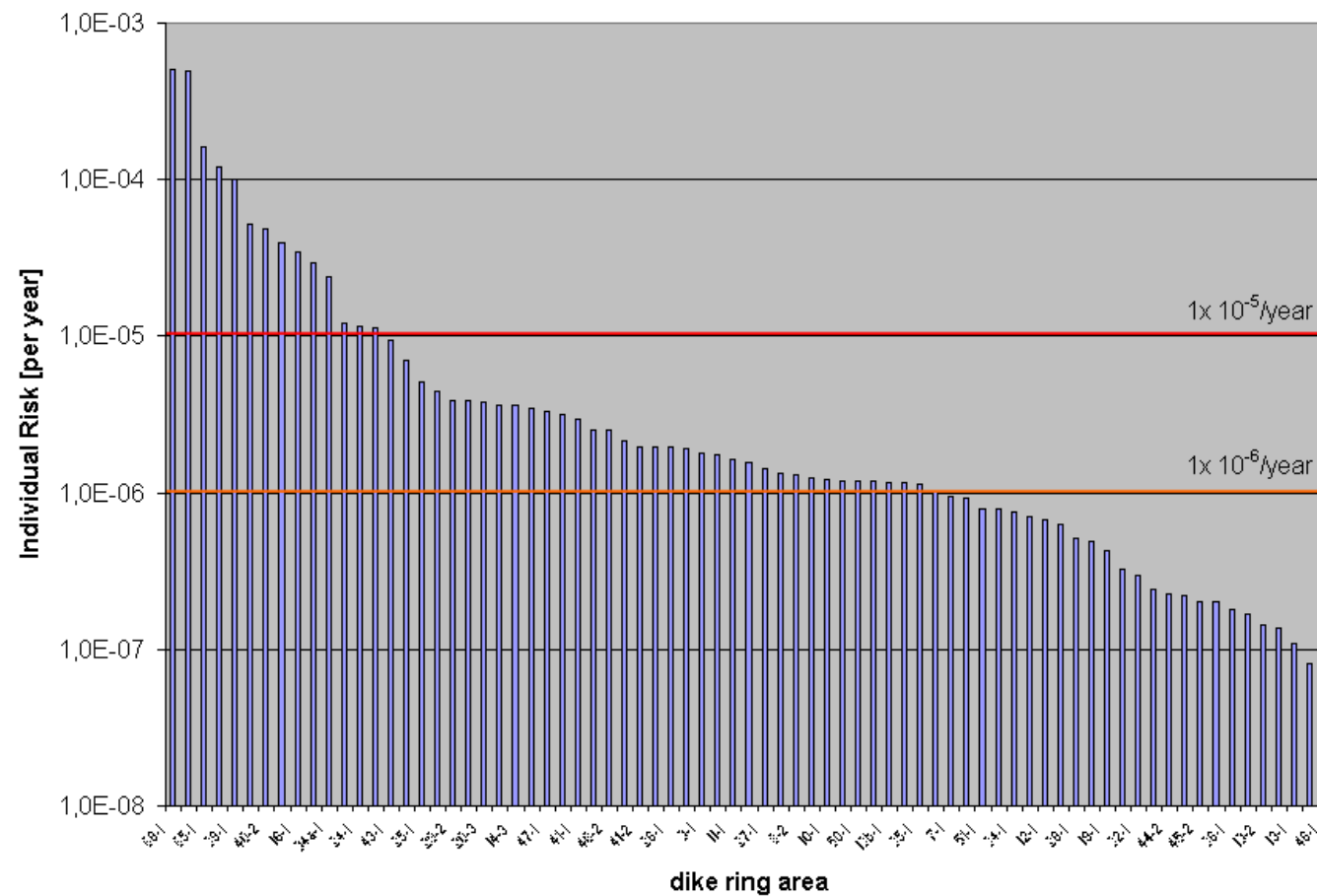
Discussion:

- **maximum** or average value?
- for **populated areas only** or complete dike ring area?
- **with** or without evacuation?
- Proposed Tolerable Individual Risk Limit (draft!)
 - Option 1 → 1×10^{-5} /year for populated areas
 - Option 2 → 1×10^{-6} /year for populated areas
 - Tolerable Risk Limit Industrial Safety the Netherlands = 1×10^{-6} /year



draft results

Max. Individual Risk per dike ring area in populated areas



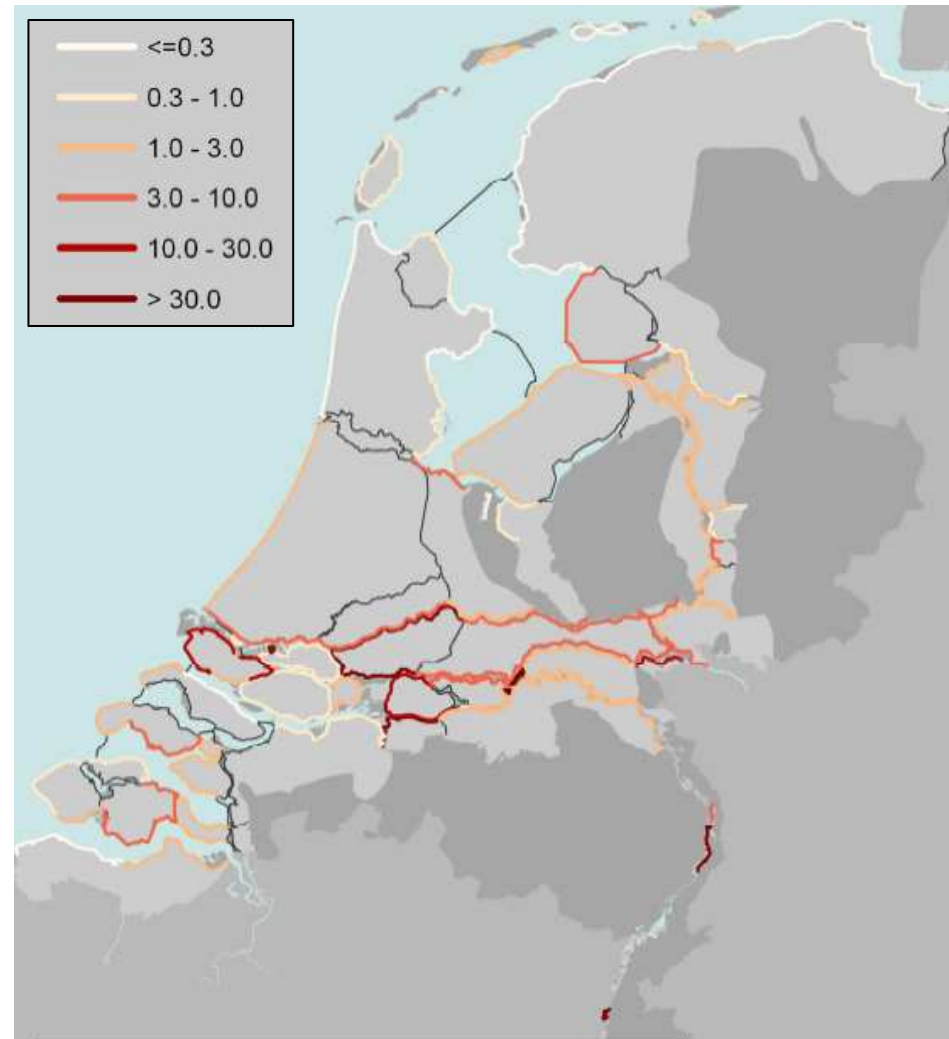


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Optional Risk Reduction

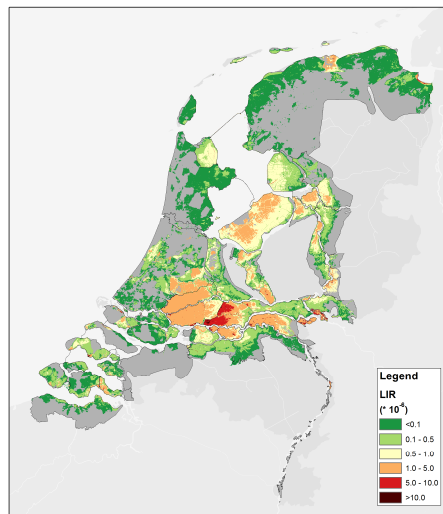
→ from **Individual Risk** point of view

→ Risk limit: 1×10^{-6} /year
for populated areas (option 2)



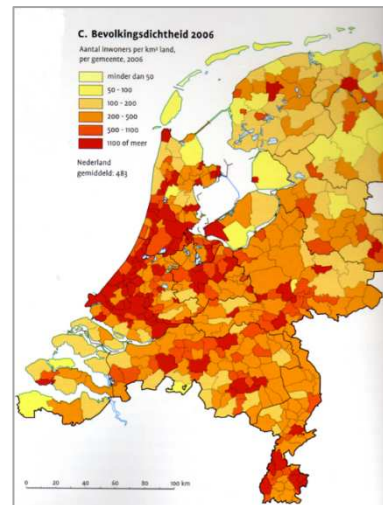


Societal Risk

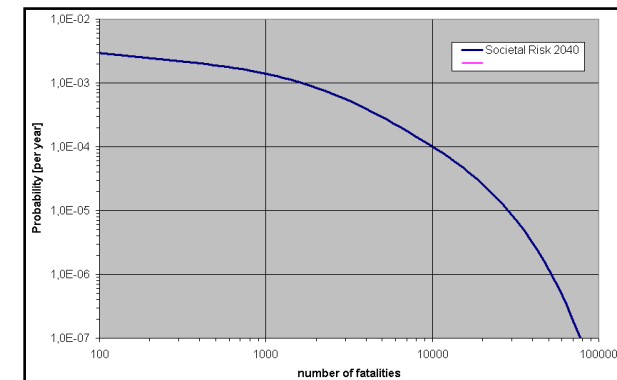


Individual Risk

+



Population Density

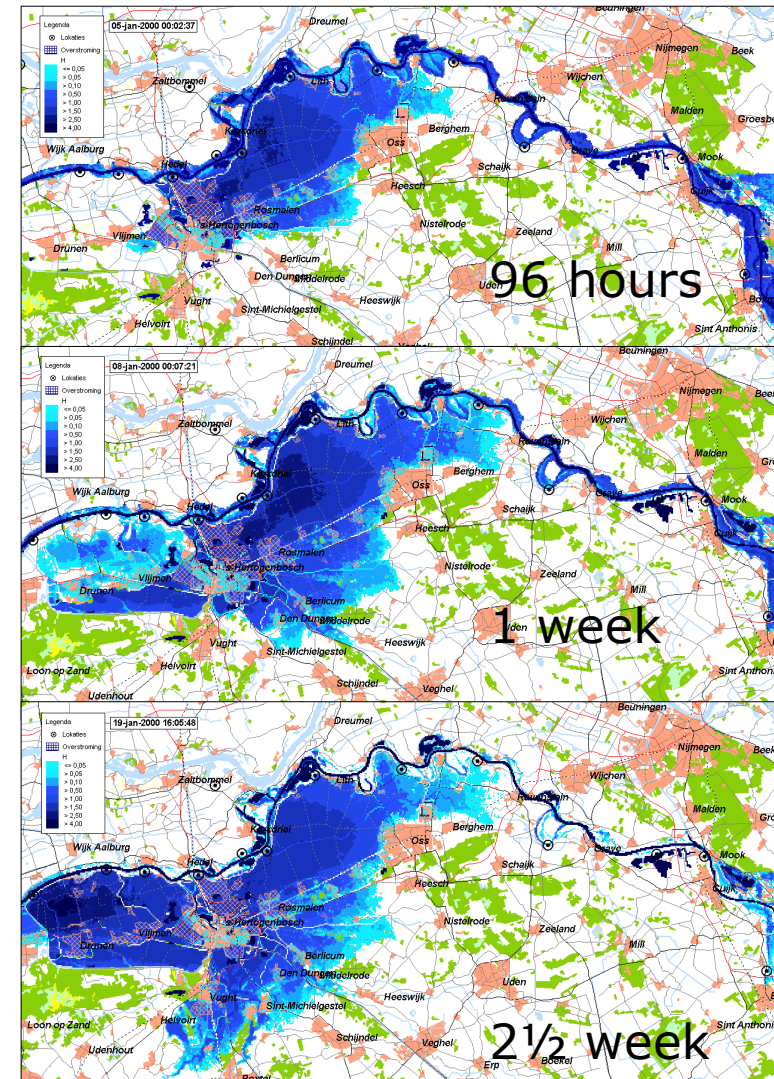
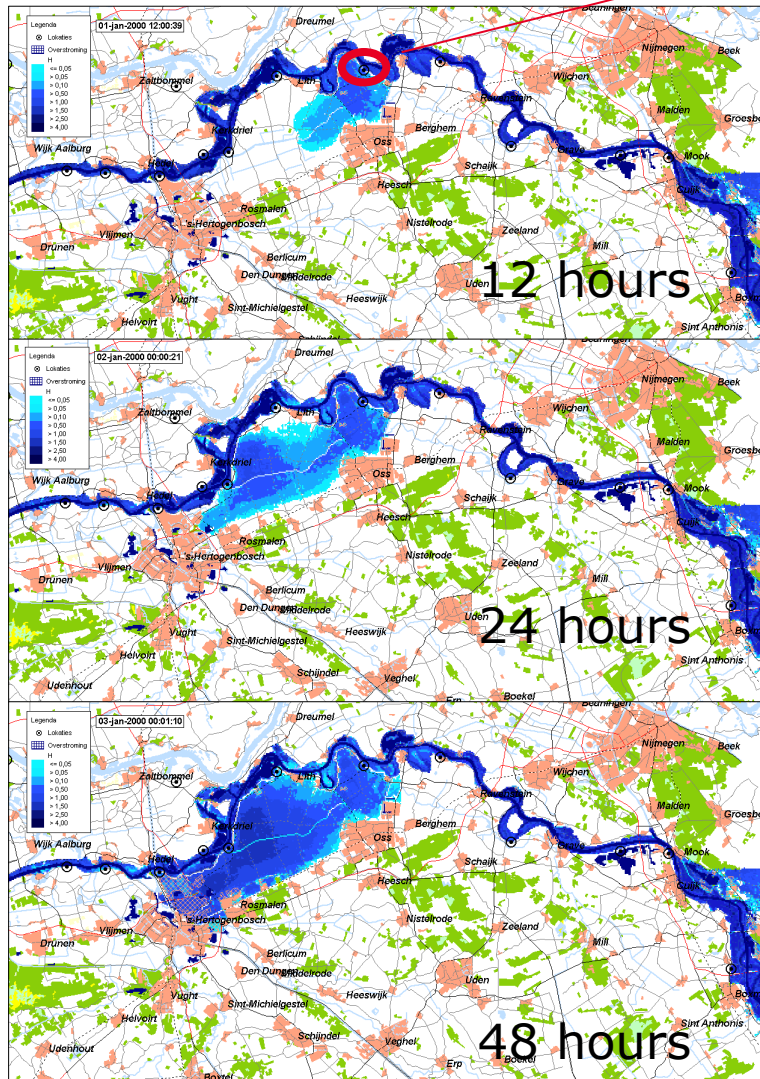


Societal Risk (or FN) chart

Flood scenario (example)



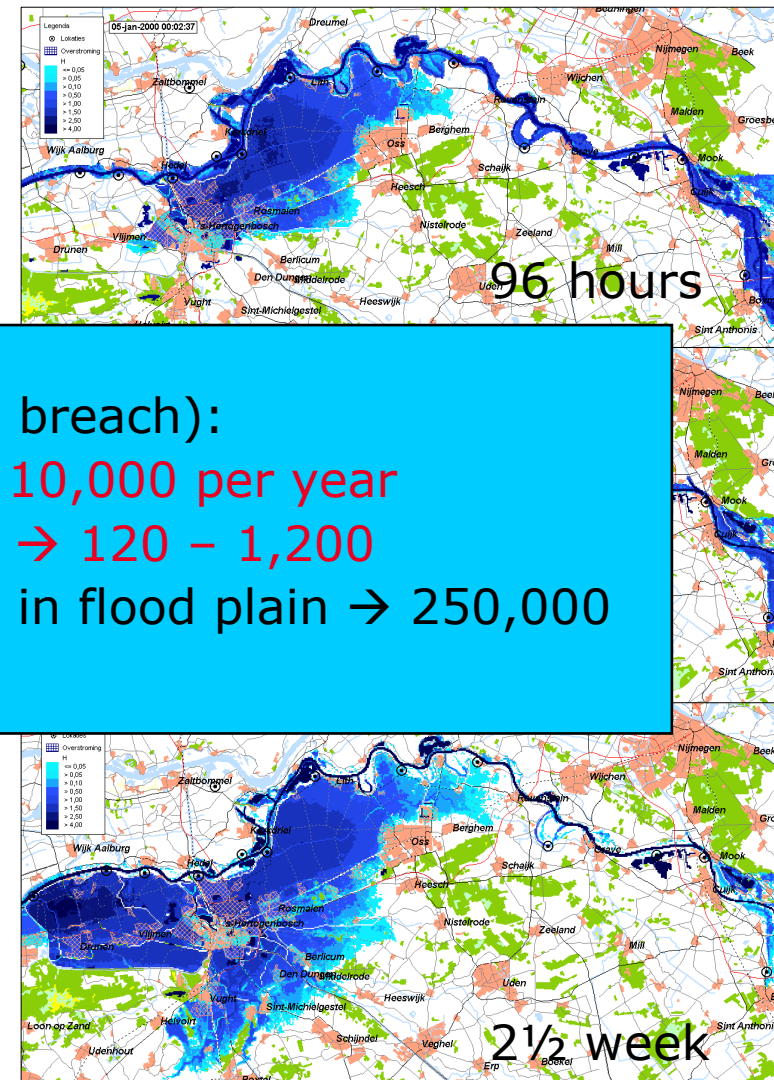
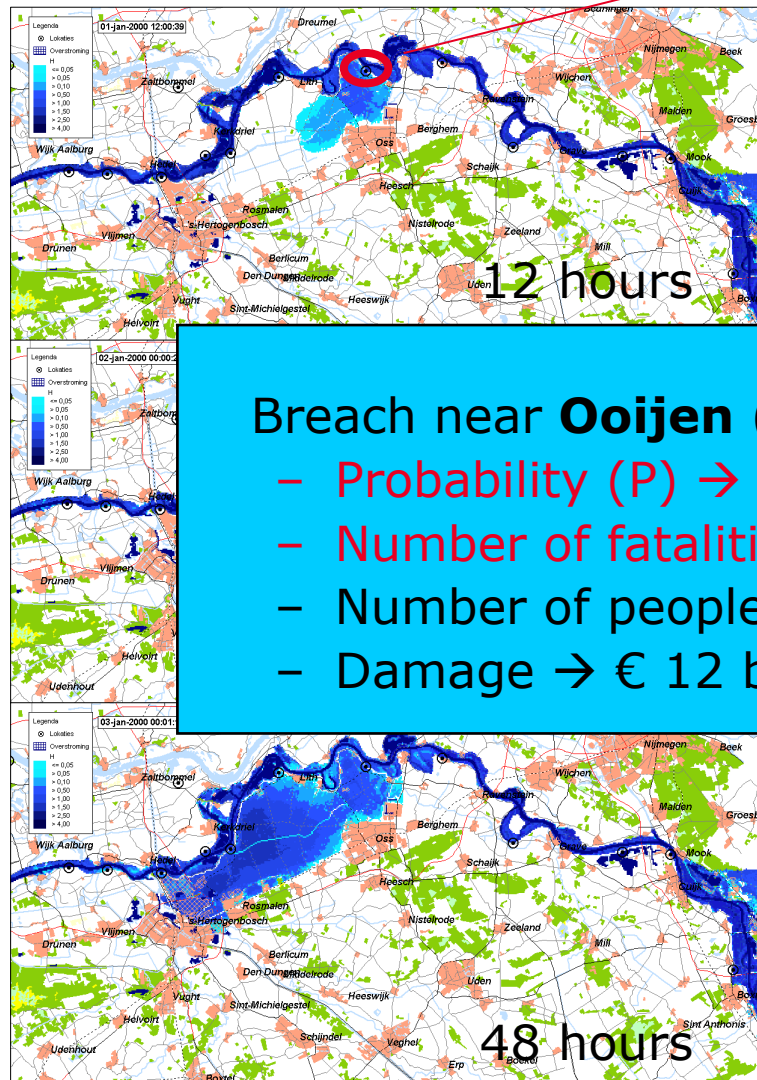
(breach along the river Meuse)



Flood scenario (example)



(breach along the river Meuse)



Breach near **Ooijen** (single breach):

- Probability (P) → $\pm 1 / 10,000$ per year
- Number of fatalities (N) → 120 – 1,200
- Number of people living in flood plain → 250,000
- Damage → € 12 billion

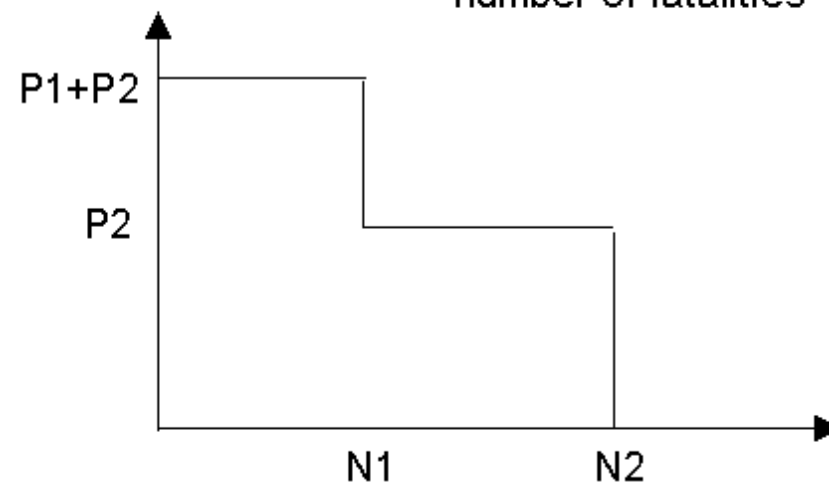
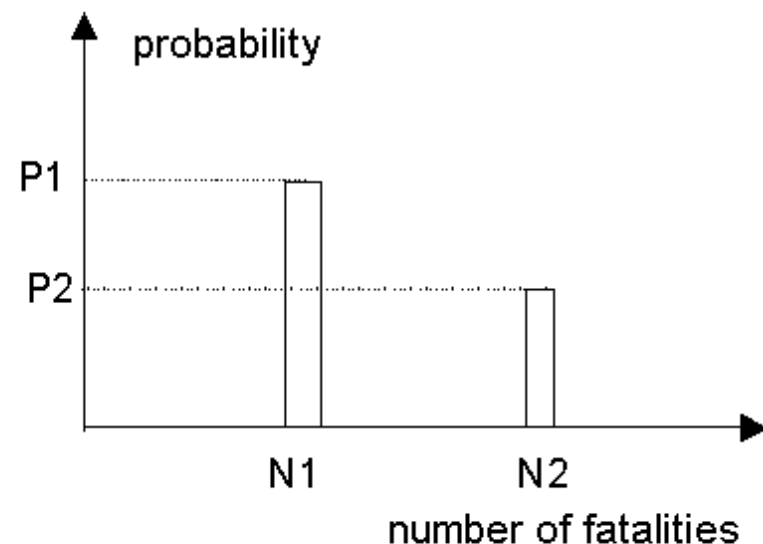


Societal Risk chart

- Flood scenario 1:
 - Probability $P1$, fatalities $N1$
- Flood scenario 2:
 - Probability $P2$, fatalities $N2$
- Etc.

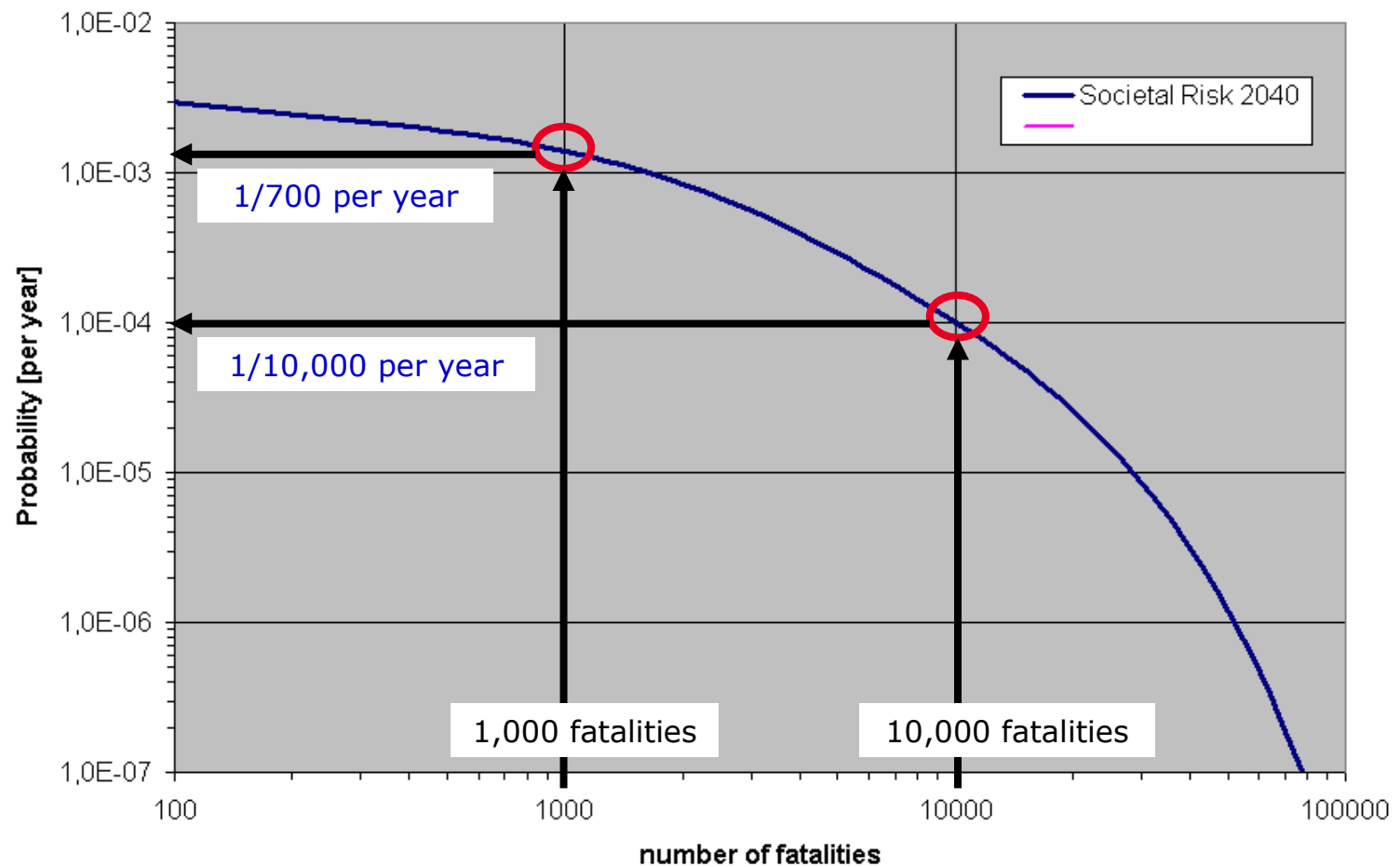
Societal Risk calculations:

- All flood scenarios considered
- Single & multiple breaches



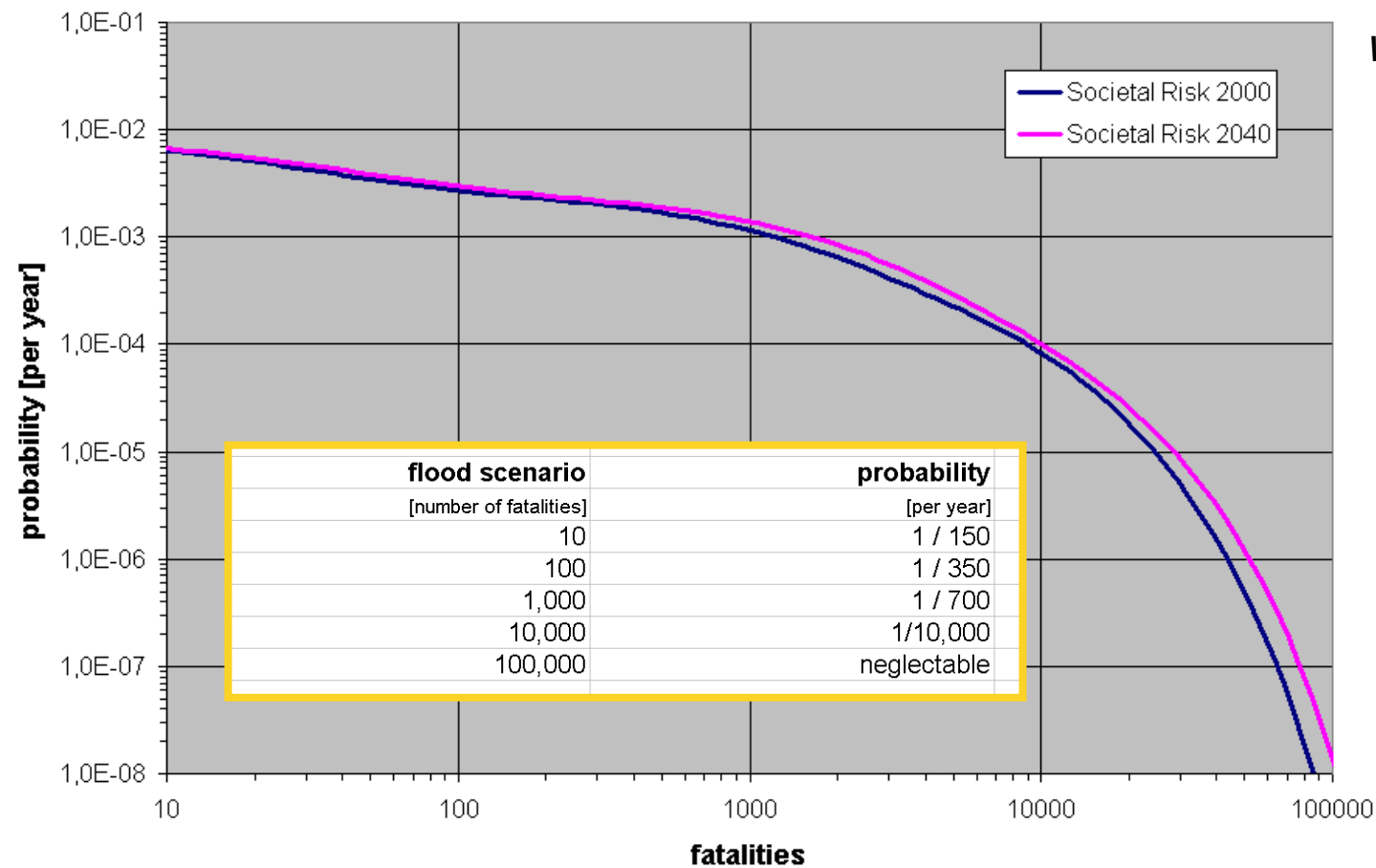


Societal Risk chart (2)



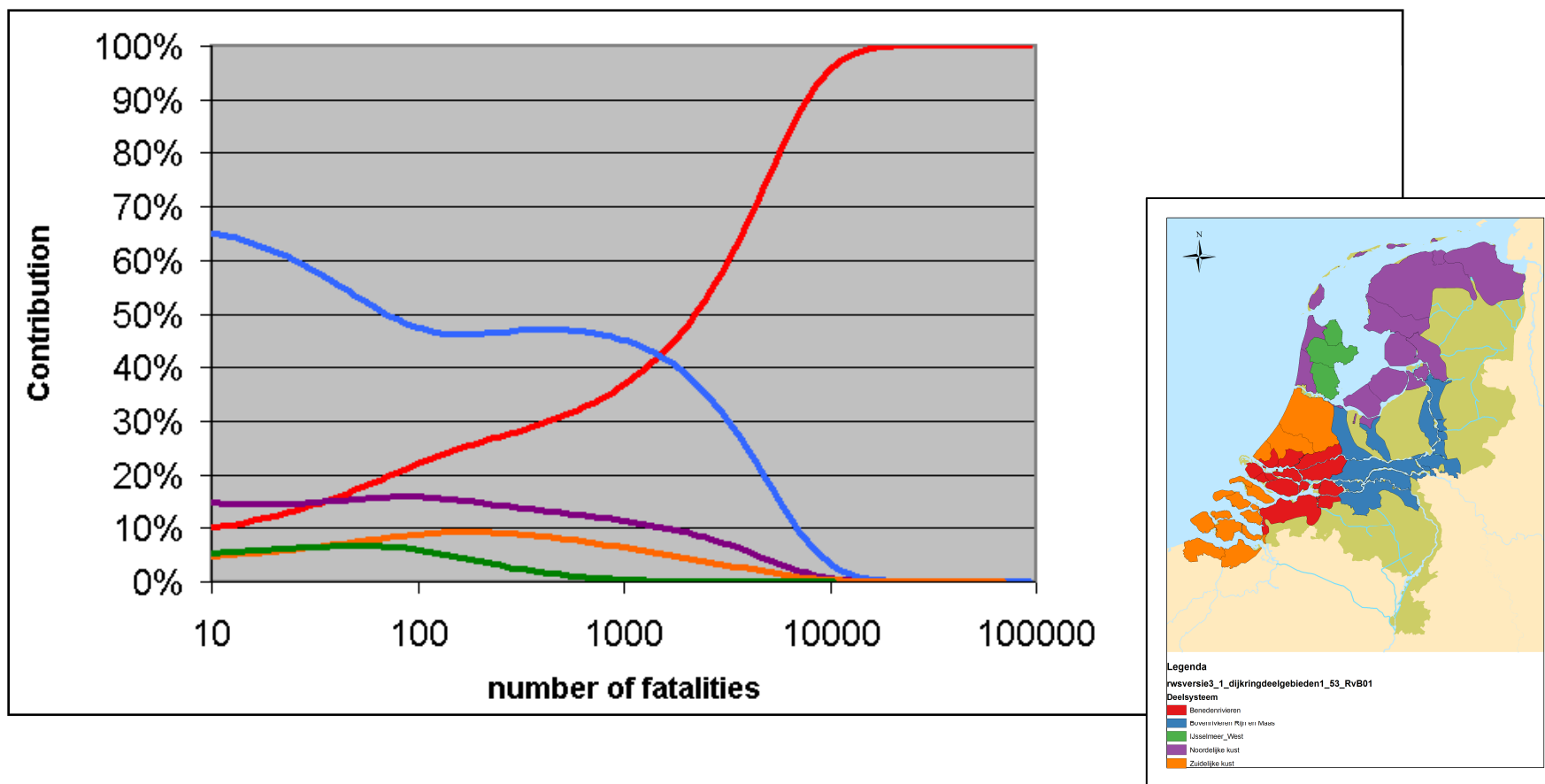


Societal Risk (national level)





Contribution of 'water regions' to national societal risk





Tolerable Societal Risk?

Discussions:

- Should risk limit refer to **national scale** or value per dike ring area?
→ More than 1 dike ring area can be flooded during one event
- Risk neutral or **risk averse**?
→ a flood event with 10× more fatalities should have a 100× less probability (accepted approach industrial safety)
- **with** of without evacuation?
- Level of Tolerable Societal Risk ???



Tolerable Societal Risk according the Dutch Expertise Network for Flood Protection



PII: S 0 9 5 1 - 8 3 2 0 (9 7) 0 0 1 3 5 - X

Reliability Engineering and System Safety **59** (1998) 141–150
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Acceptable risk as a basis for design

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^c*Simtech, Rotterdam, The Netherlands*



Tolerable Societal Risk according the Dutch Expertise Network for Flood Protection

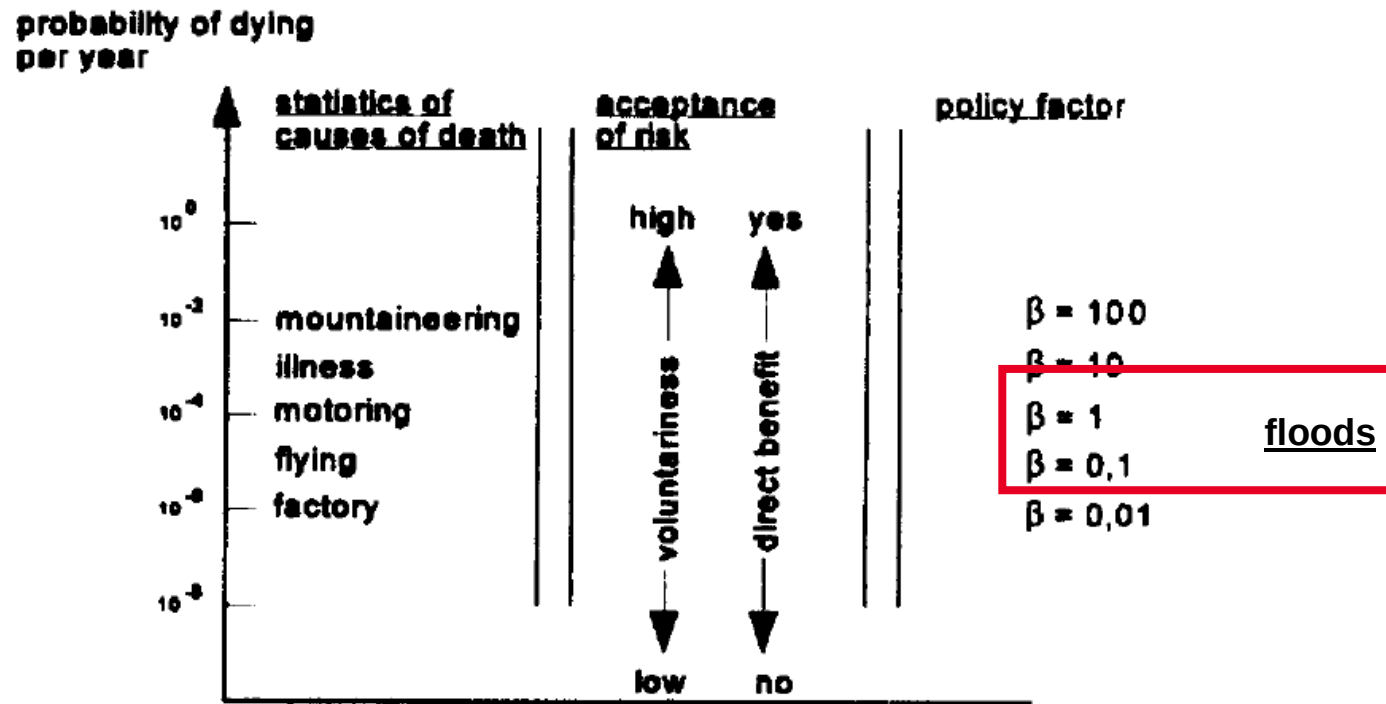
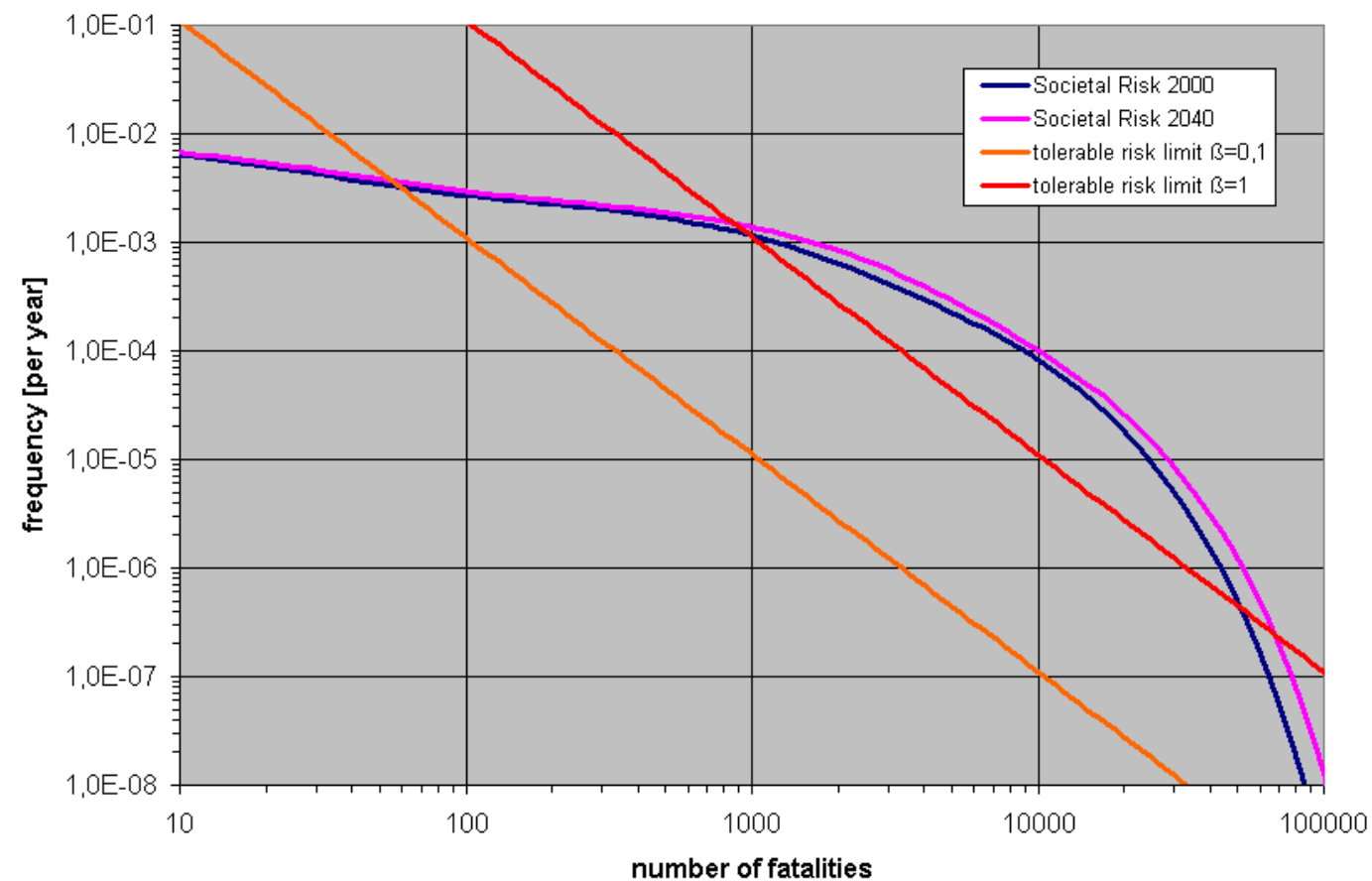


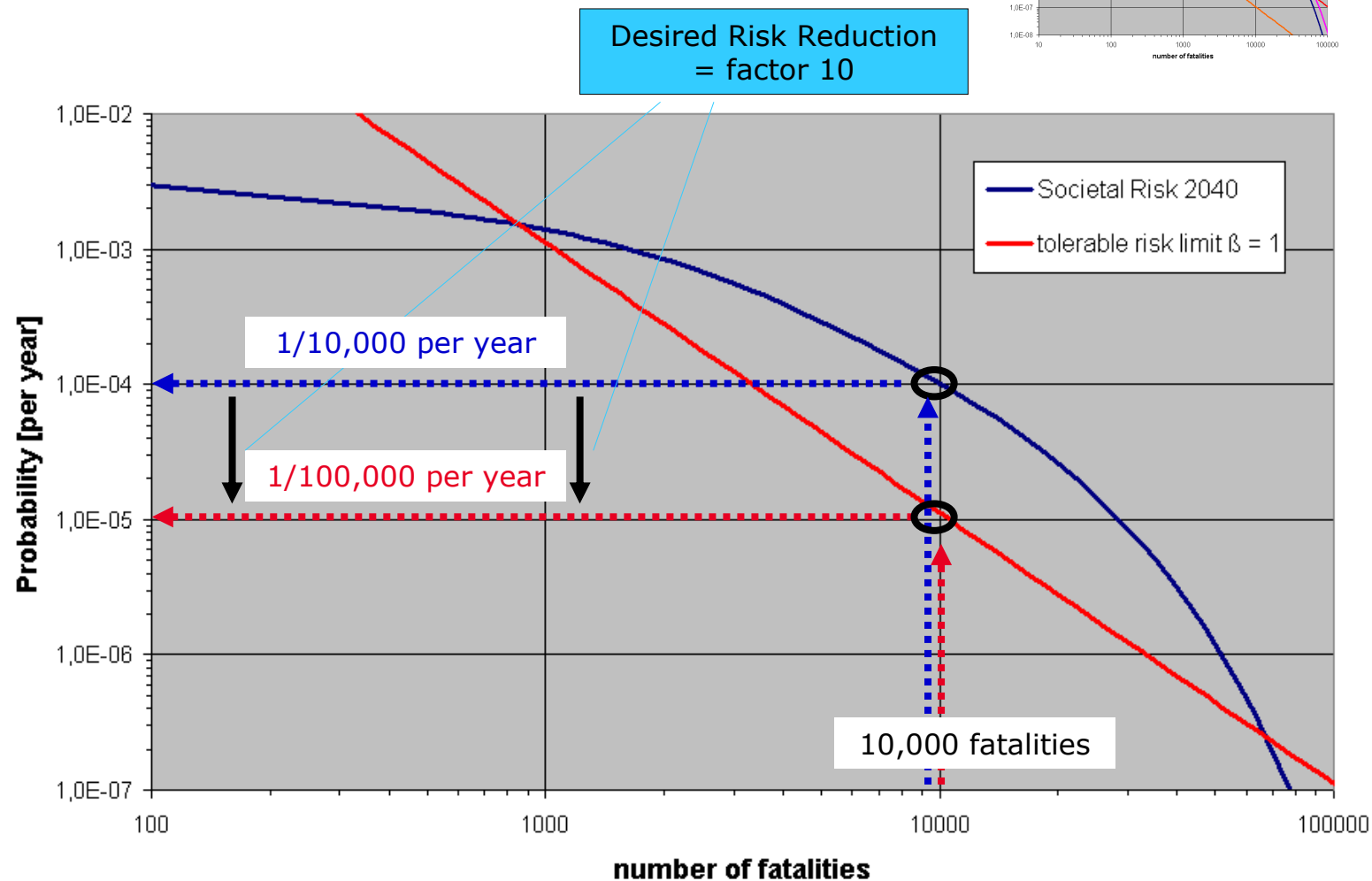
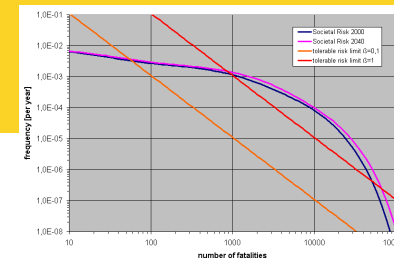
Fig. 2. Personal risks in Western countries, deduced from the statistics of causes of death and the number of participants per activity.



Tolerable Societal Risk according the Dutch Expertise Network for Flood Protection



Societal Risk





Risk reduction

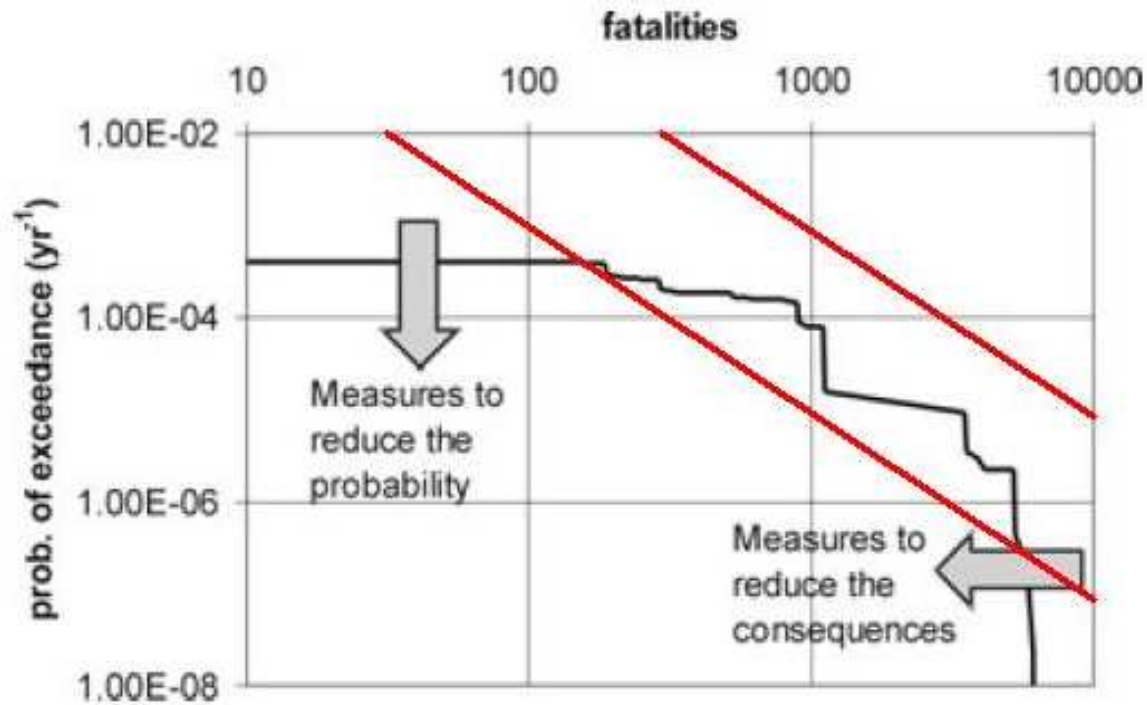


Fig. 13. FN curve indicating the effects of two types of measures.

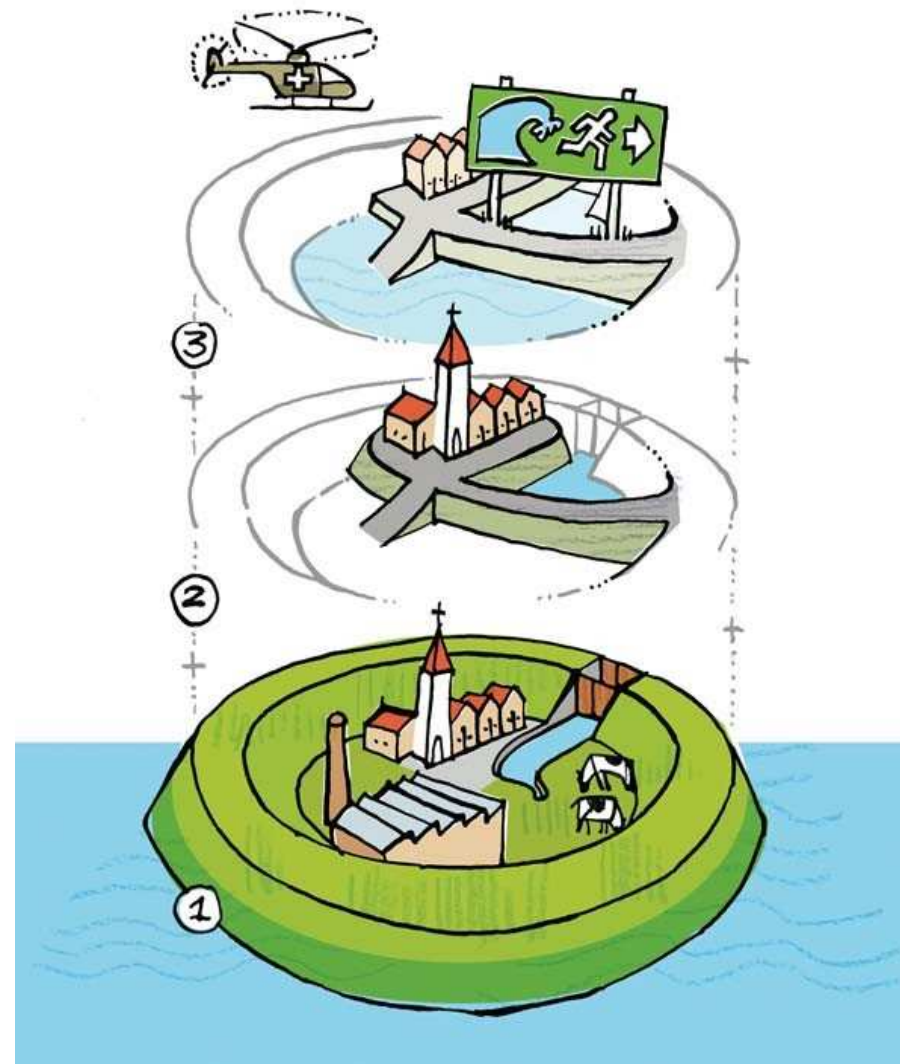


Risk reduction

Preparation / response
(emergency response)

Pro-action
(spatial planning)

Prevention



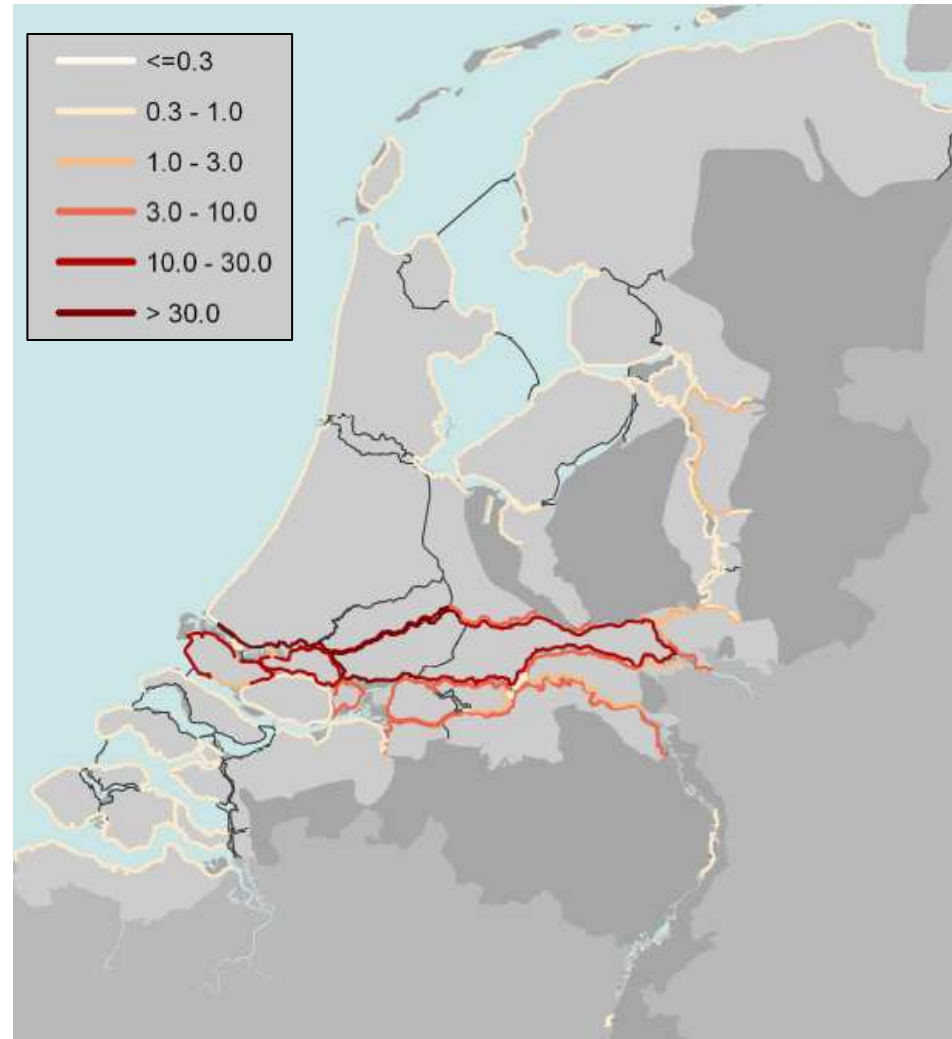


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Optional Risk Reduction

→ from **Societal Risk** point of view

→ Societal Risk limit: $\beta = 1$
(risk reduction by prevention only)





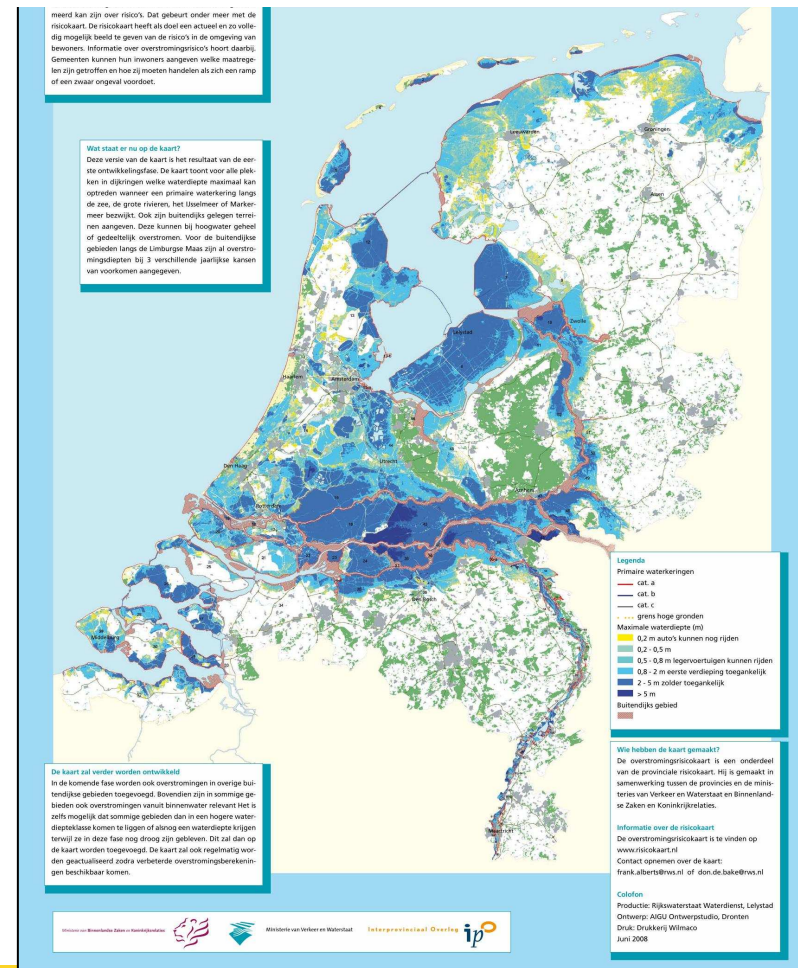
Possibilities for evacuation in the Netherlands

*Study by the Taskforce Flood
Management*

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Durk Riedstra



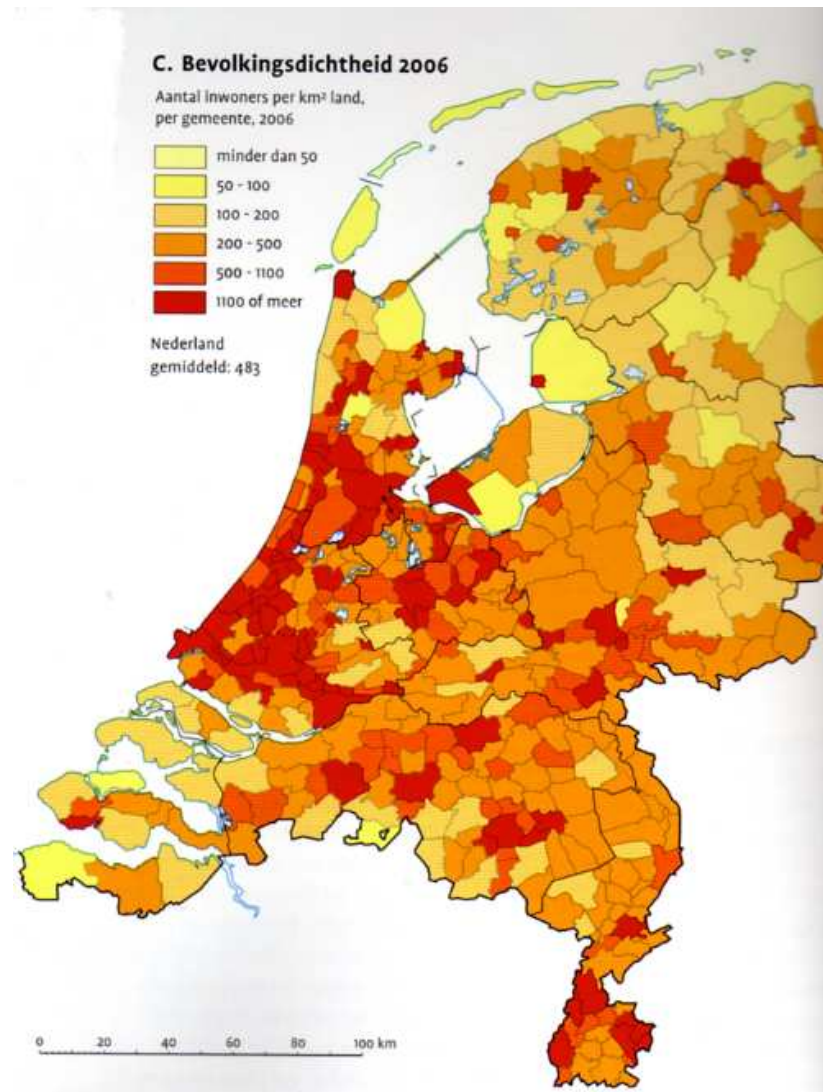
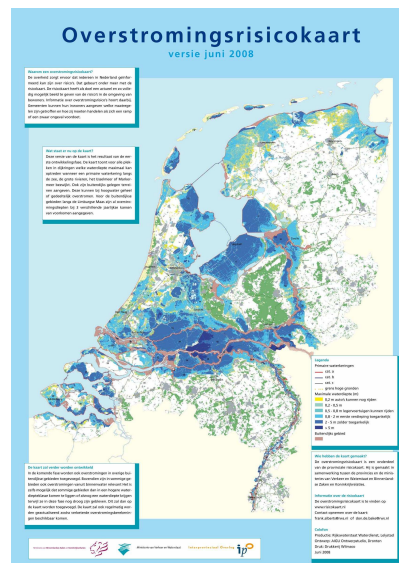
- Water levels up to >5 meter





Population density

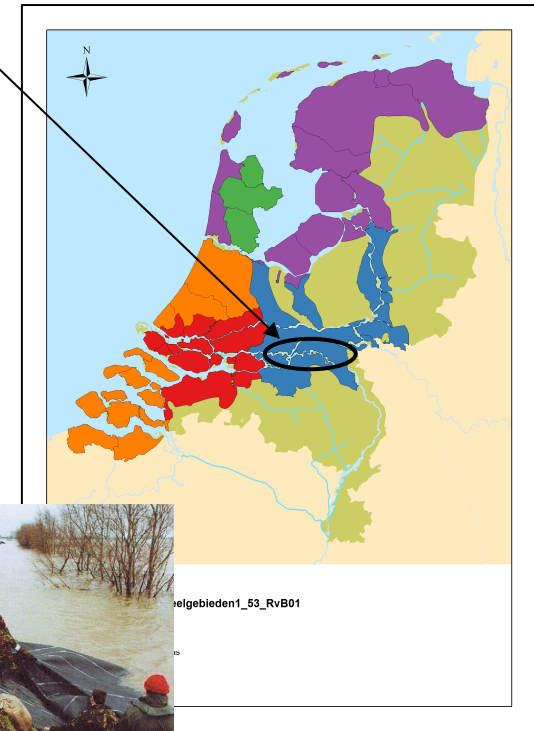
- ± 16 million inhabitants
- 34.000 km²
- Average population density 483 / km²





Little experience with evacuation in the Netherlands ...

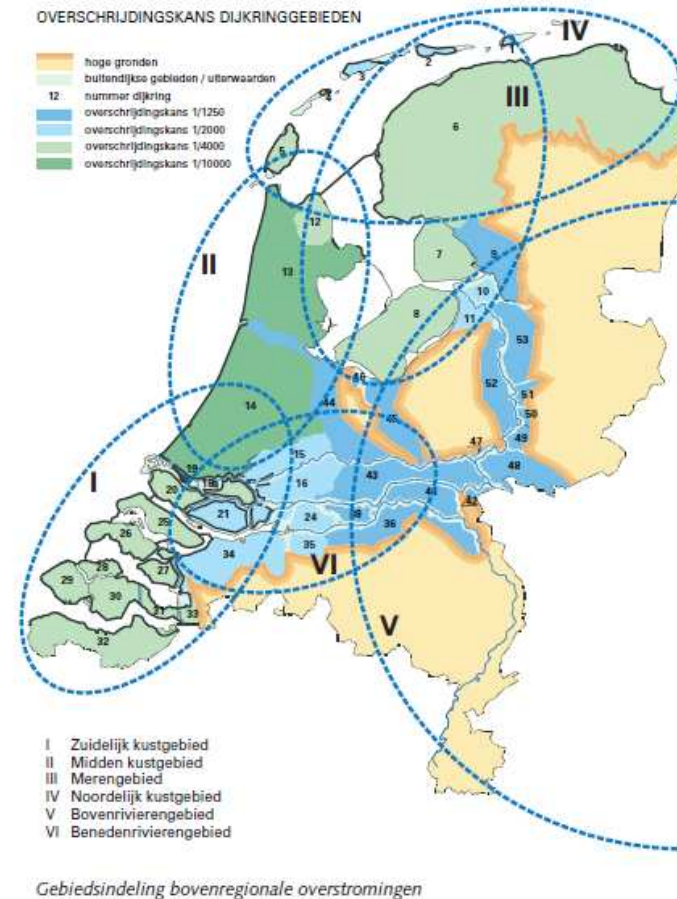
- 1995: critical situation within the 'upper river'-area;
 - 250,000 inhabitants were evacuated





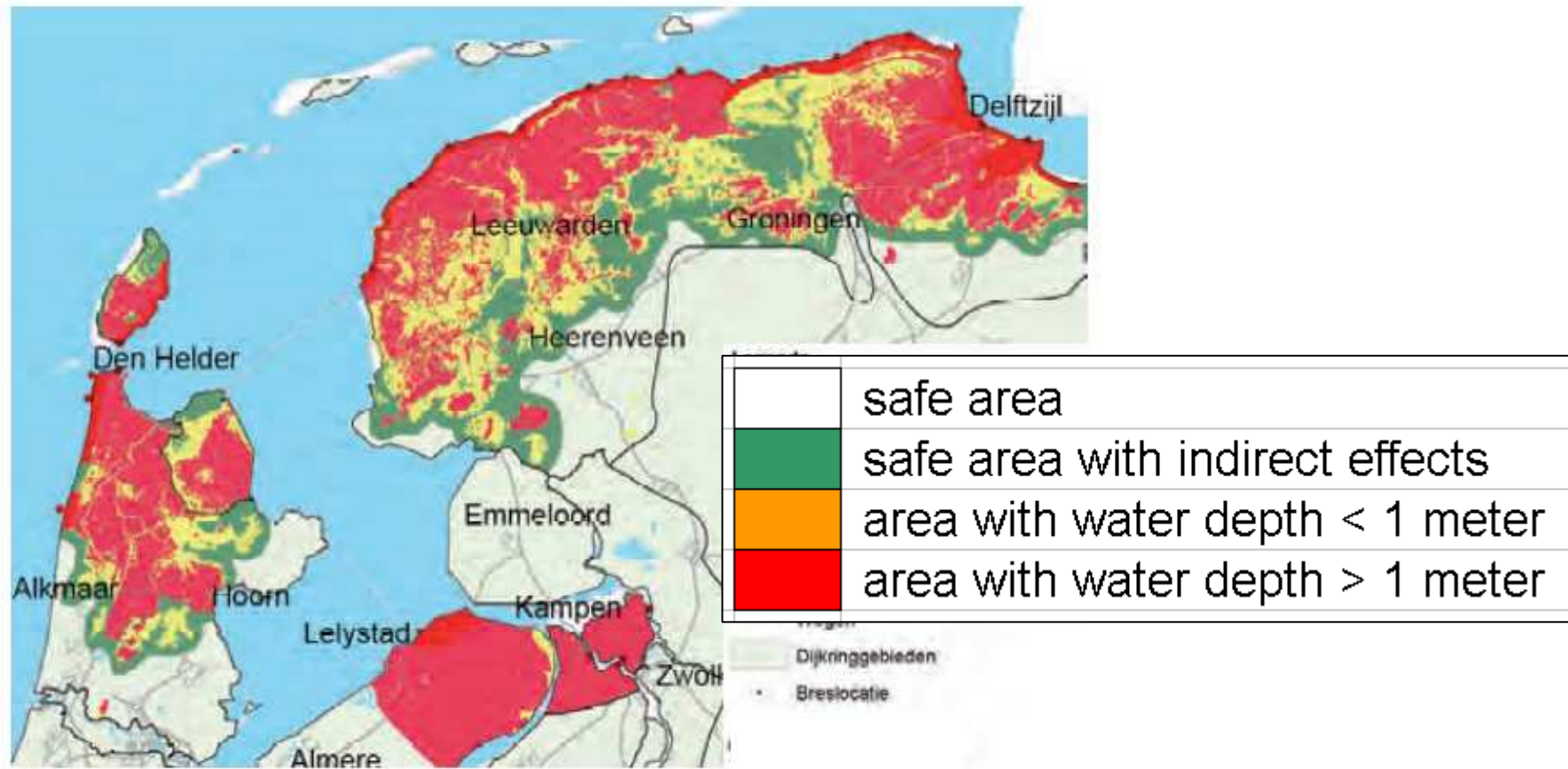
“Taskforce flood management” (2006 – 2008)

- Installed after Kathrina:
 - Is our country prepared for a large scale flood?
- Objective: to improve emergency response to flooding
 - How much time do we need for evacuation?





Flood maps

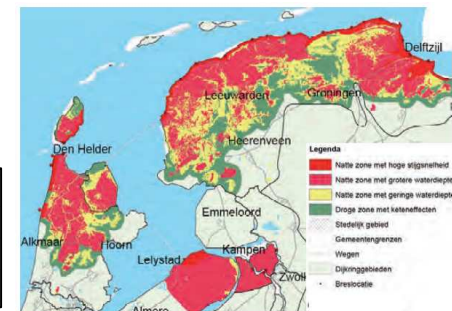




Rescue capacity needed

- Assumptions
 - 85%–90% of the inhabitants are able to evacuate themselves or find a shelter
 - Rescue capacity is focused on most 'vulnerable' people
 - 20% not responding to an evacuation call
- Evacuation strategies
 - I. Evacuation of people from the red & yellow areas
 - II. Evacuation of people from the red areas only

	safe area
	safe area with indirect effects
	area with water depth < 1 meter
	area with water depth > 1 meter



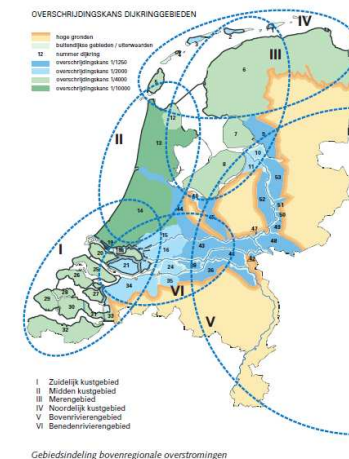


Results

safe area
safe area with indirect effects
area with water depth < 1 meter
area with water depth > 1 meter

	evacuation time needed	decision time to evacuate	strategy
	[days]	[days before breach]	evacuated areas
Coast West	2½ – 3	4 – 5	
Coast North	1¼ – 2	3 – 4	
Lake IJssel	1	2	
Rhine / Meuse region	3	4 – 5	
Rhine / IJssel region	1½	3	
Tidal rivers	3	4 – 5	

- Prediction time available for critical situations
 - Storm surge (north sea, lake IJssel): ± 1 – 2 days
→ *But no evacuation possible the last 24 hours*
 - Extreme river discharge: ± 2 – 4 days





Conclusions

1. Rescue capacity is insufficient to evacuate all (vulnerable) people
2. In order to reduce the number of casualties & fatalities it is necessary to improve (public) awareness towards flood risk

Paradoxes

- I. How to improve public awareness in a country with very high safety standards
→ *is not everybody safe in the Netherlands?*
- II. Decision to evacuate: uncertainty versus time ..



Recommendations

- after a large scale exercise in 2008
- Clarify and improve the national command structure
 - including 'time table'
- Make traffic management plan for evacuation events
- Emergency plans for each 'safety region'