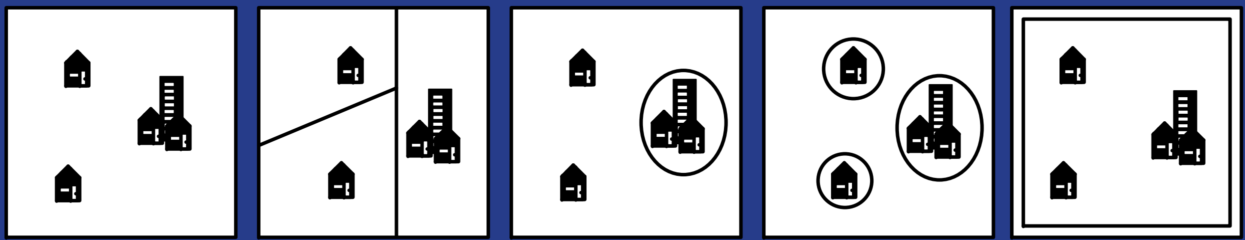
Cartesius institute

University of Twente
The Netherlands

Flood security strategies

An assessment of the strategies of compartmentalization and flood shelters



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Overview

- Introduction
  - Context
  - Objective
  - Case study area
- Scenarios
- Strategies
  - Compartmentalization
  - Flood shelters in self prepared cells
- Results
- Conclusions and recommendations

Context

- The development towards actual flooding probability
  not only overtopping can result in dike failure

- Consider dike ring area as a whole

- Focus shift from probability to consequences

- Is it wise to invest in a lower probability by investing in dike heightening or do we need to invest in reduction of consequences?

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Objective

Research objective:

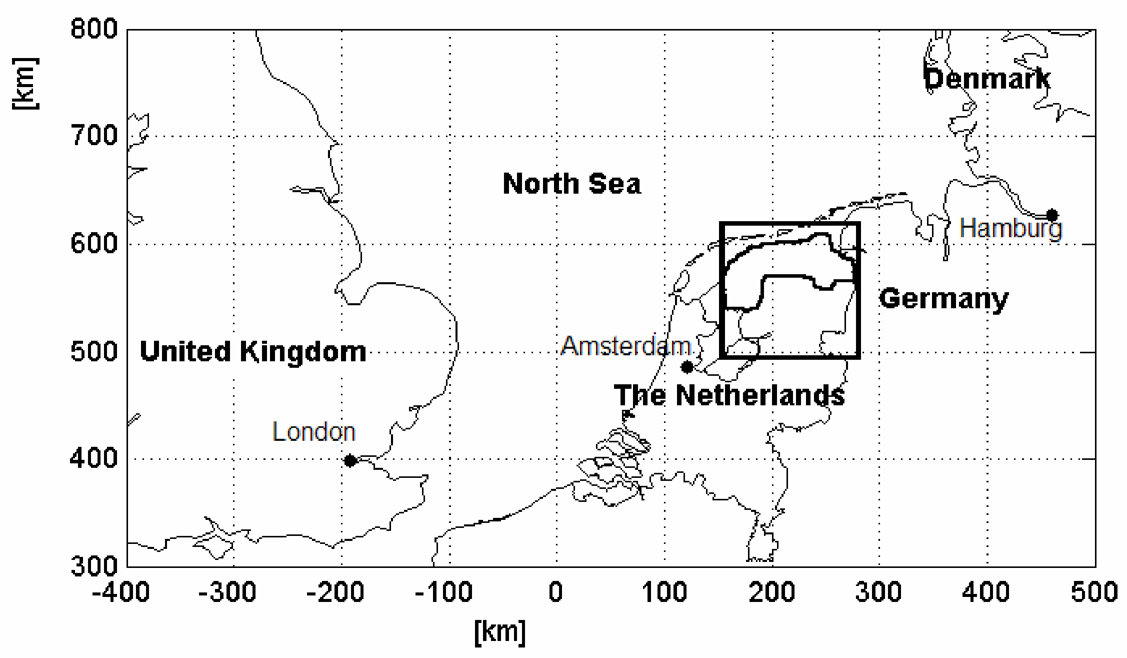
To design, analyze and compare flood security strategies that aim to decrease the <u>consequences</u> of a flood.

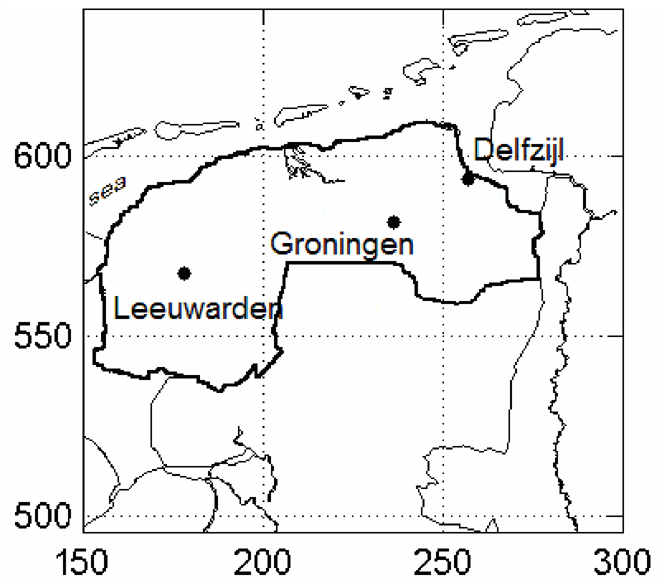
I do not discuss:

- Probability of failure
- Cost benefit analysis of the strategies

The case study location

Dike ring area 6, the Northern Provinces of the Netherlands
(i.e. Fryslân and Groningen)



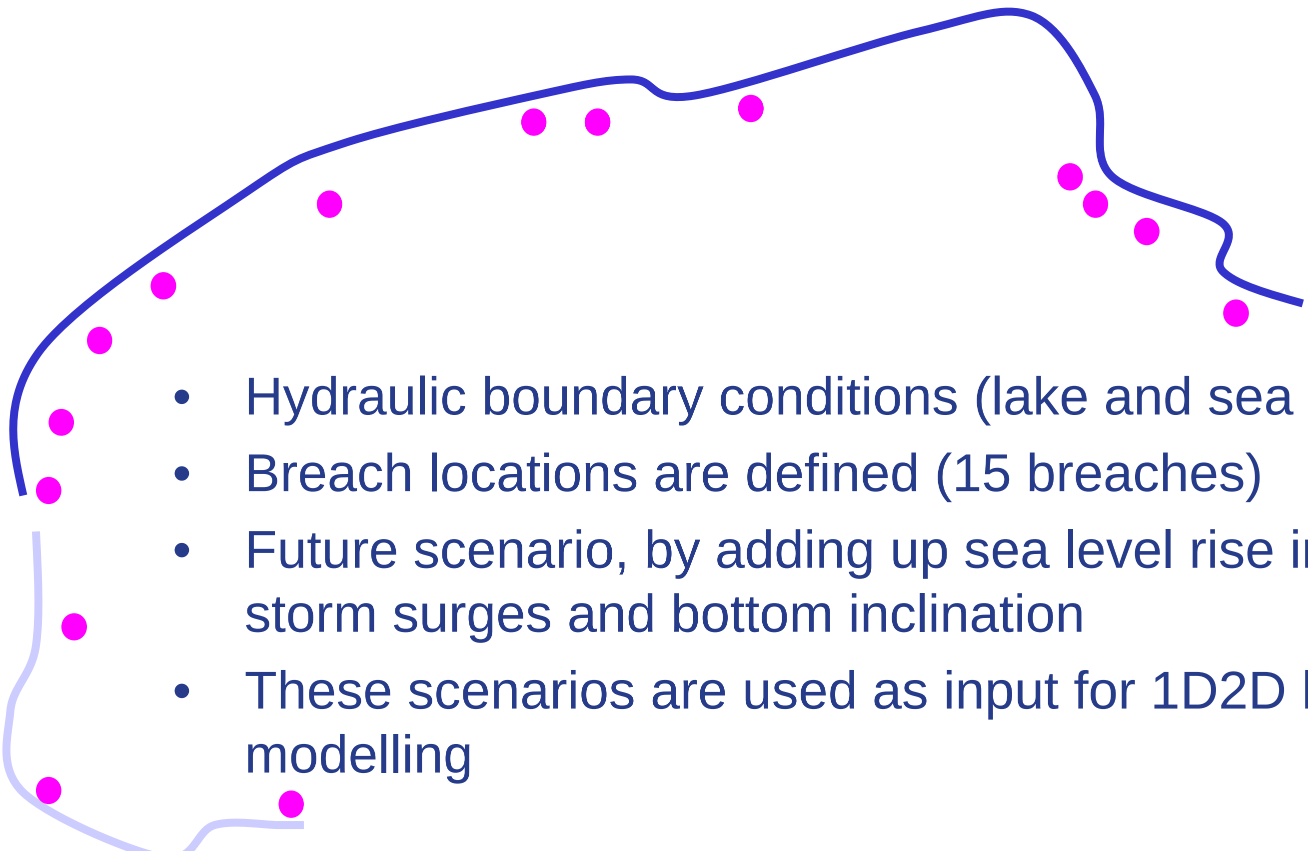


Overview | **Introduction** | Scenarios | Strategies | Results | Conclusions

Old (secondary) dikes are subject of discussion

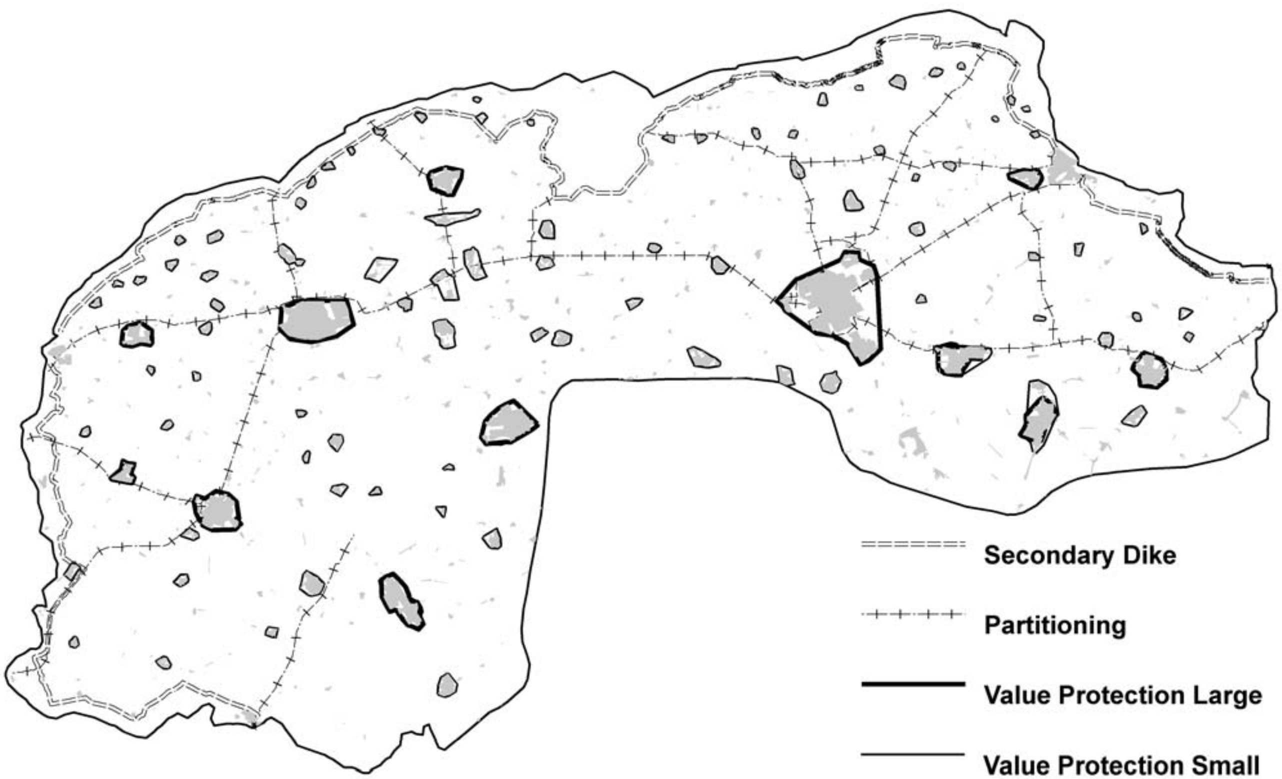
Artificial hills, ‘terpen’, are part of this landscape

Scenarios



- Hydraulic boundary conditions (lake and sea differentiation)
- Breach locations are defined (15 breaches)
- Future scenario, by adding up sea level rise increased storm surges and bottom inclination
- These scenarios are used as input for 1D2D hydraulic modelling

Strategies: compartmentalization



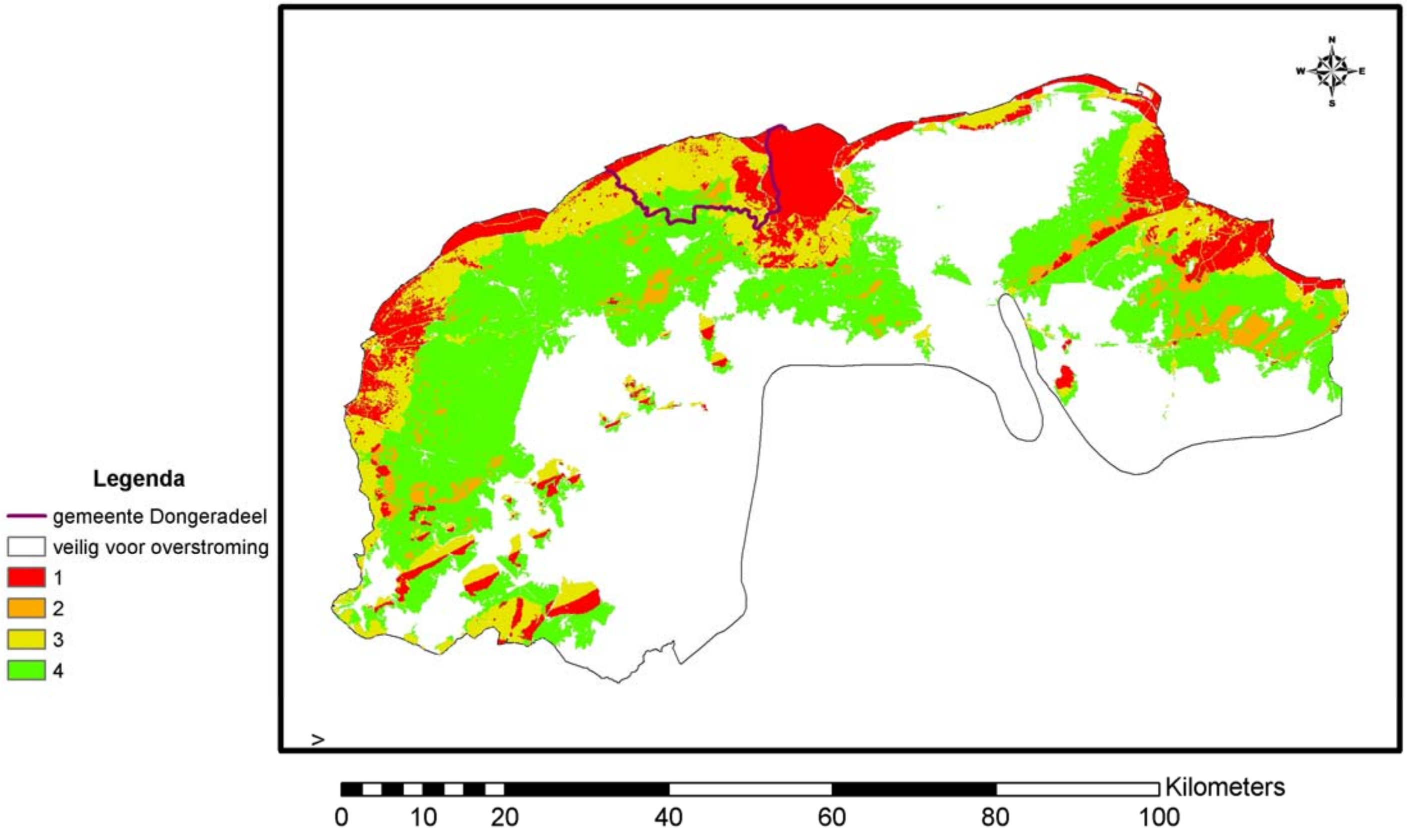
Strategies: Flood shelters

- Support self-preparedness
- Safe havens
  - High grounds
  - Water resistant buildings
  - Artificial hills ‘Terpen’

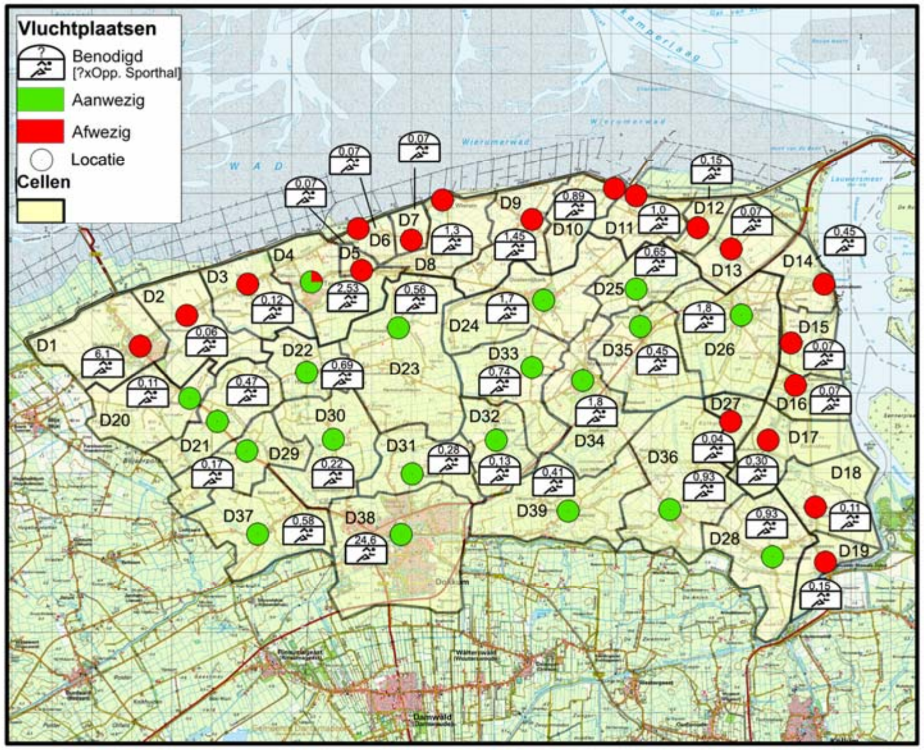
- Division in hazard zones
  - Determining distance

		Time to respond	
		Short < 5h	**Sufficient >5h**
Flood hazard (u*d)	**High >7**	Zone 1	Zone 2
	Low <7	Zone 3	Zone 4

Planning of flood shelters



Neighbourhood scale implementation

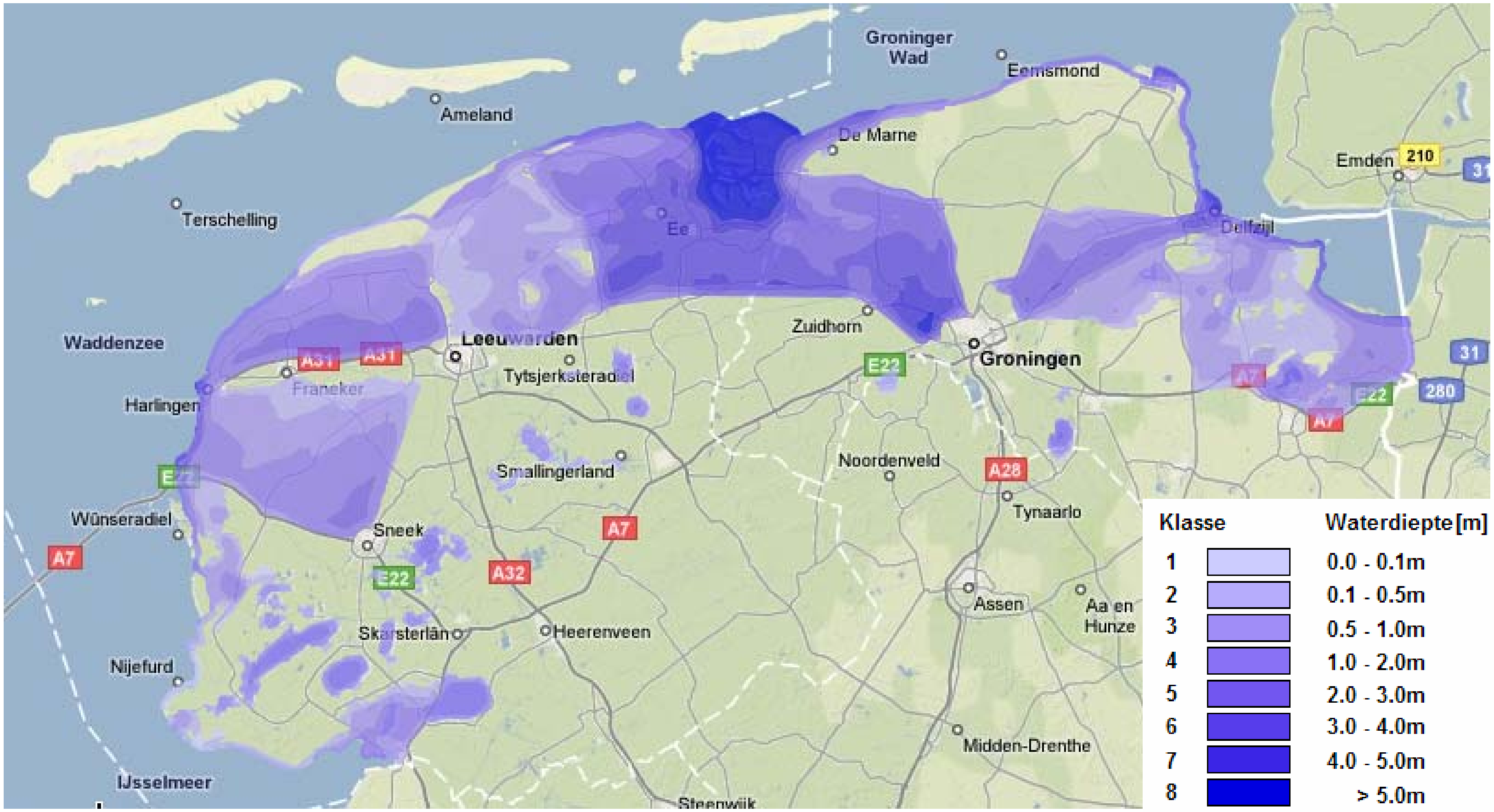


Van Reedt Dortland, M. De Fijter, W. and Hoekstra, A. 2008. Vluchtplaatsen in zelfredzame cellen als oplossing bij overstromingen (Dutch), *H2O* 41(7):35-38.

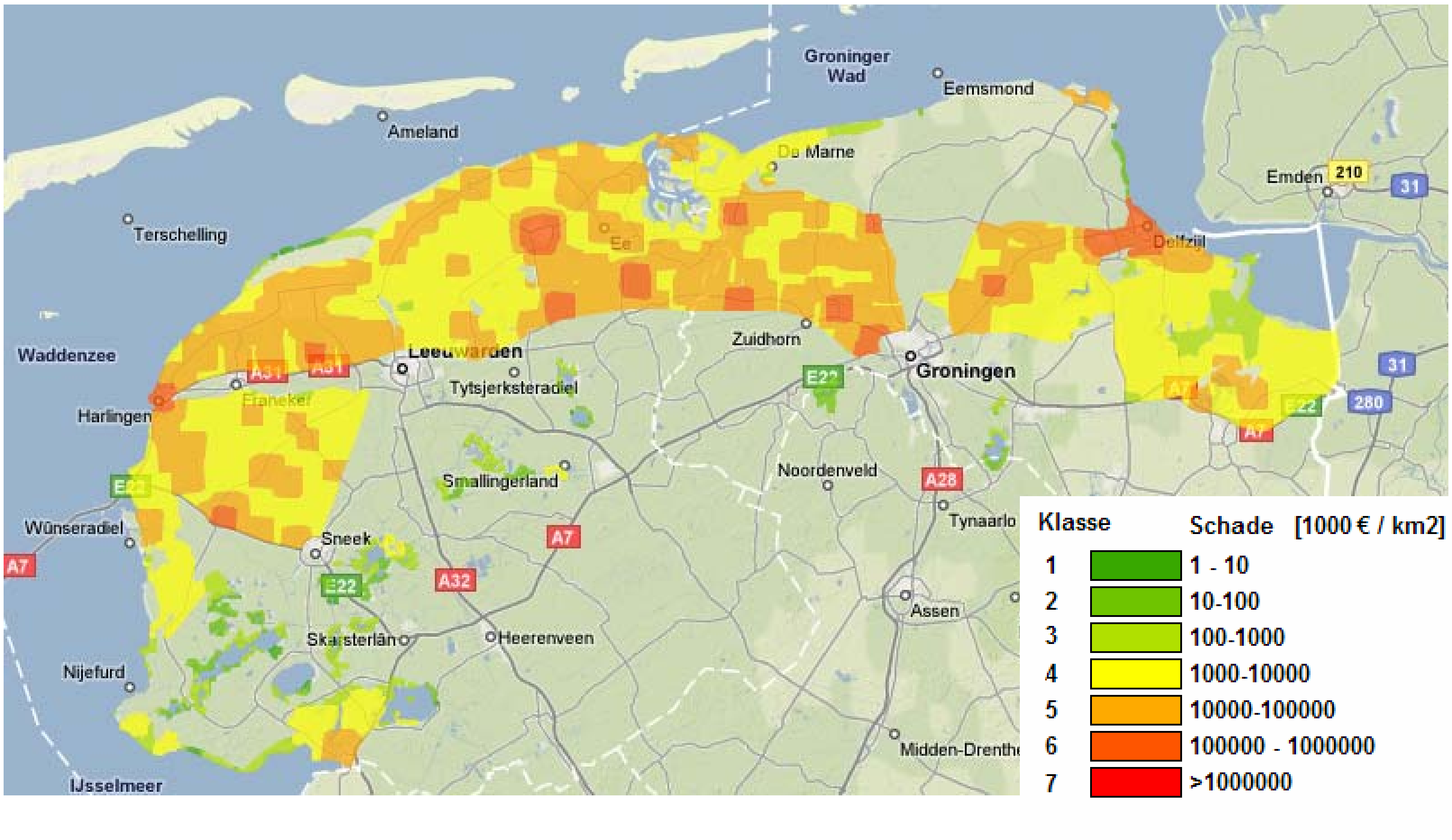
Assessment of strategies: Hydraulic, damage and casualty modelling

- Detailed 1D2D hydraulic modeling (Sobek)
- Damage estimation (HISSSM) containing damage functions:
  - Land use types
  - Maximum waterdepth
  - Rise rate
- Extensive database of GIS maps of results for publication on our website:
  - www.vluchtplaats.nl

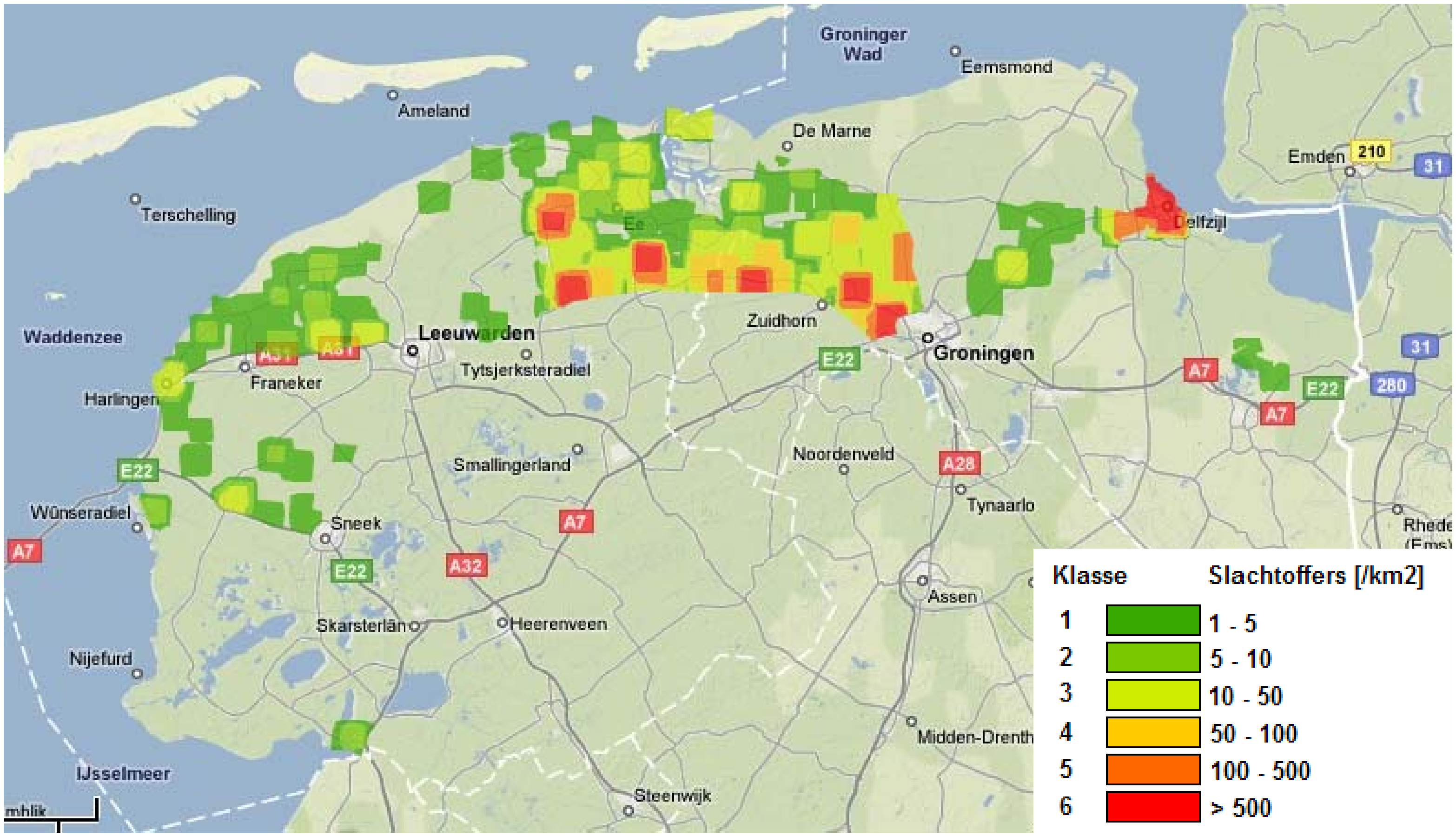
Flood pattern maps



Damage density maps



Casualty density maps



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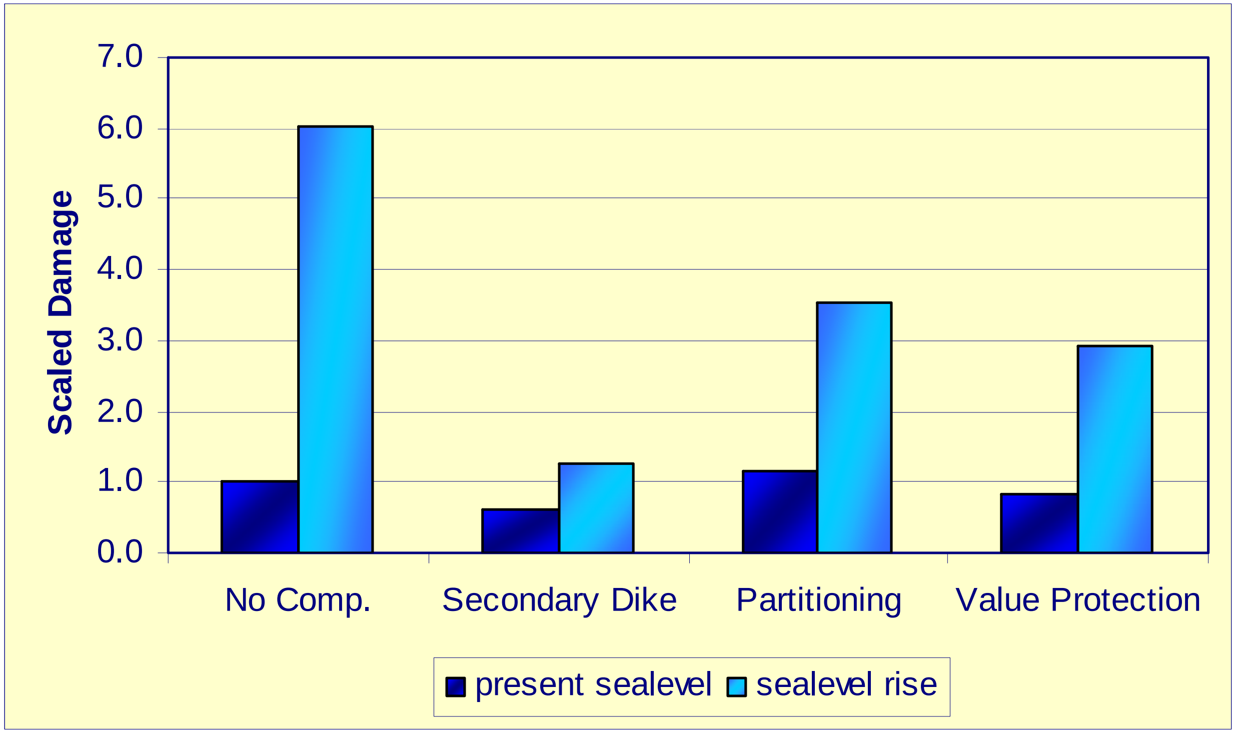
Summary of damage, affected inhabitants and casualties

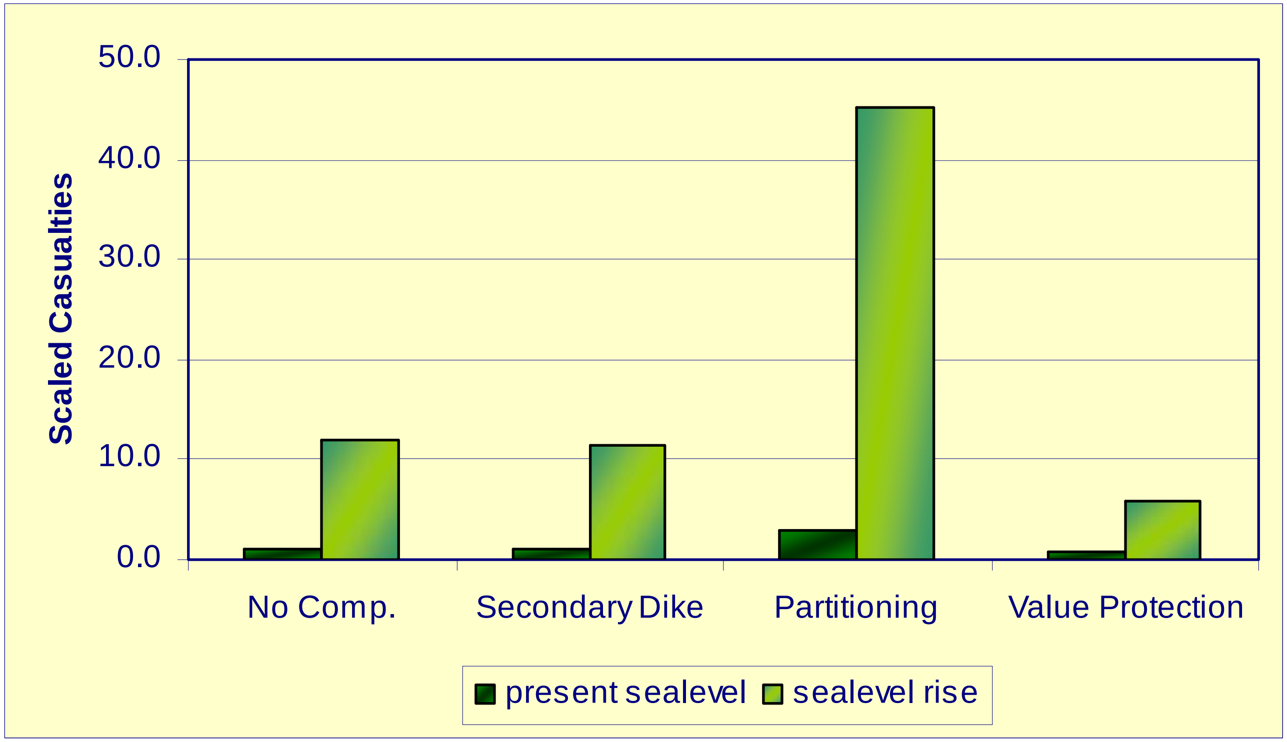
		Laissez-faire	Secondary dike		Partitioning		Value prot. Large		Value prot. Small		Flood shelters	
15 Breaks	Damage (Billion €)	**4.5**	**2.8**	*-39*	**5.2**	*15*	**4.2**	*-8*	**3.7**	*-18*	**4.5**	*0*
	Inhabitants (*1000)	**120**	**59**	*-51*	**116**	*-3*	**94**	*-22*	**66**	*-45*	**120**	*0*
	Casualties (*1000)	**0.3**	**0.3**	*4*	**0.8**	*193*	**0.3**	*-7*	**0.2**	*-16*	**0.04**	*-86*
Worst case	Damage (Billion €)	**24**	**5.5**	*-77*	**12**	*-50*	**12**	*-50*	**11**	*-57*	**24**	*0*
	Inhabitants (*1000)	**444**	**96.0**	*-78*	**218**	*-51*	**239**	*-46*	**161**	*-64*	**444**	*0*
	Casualties (*1000)	**8.7**	**1.4**	*-85*	**3.3**	*-62*	**0.6**	*-93*	**0.4**	*-96*	**1.5**	*-83*
15 Breaks + Climate	Damage (Billion €)	**27**	**5.7**	*-79*	**16**	*-41*	**17**	*-38*	**13**	*-52*	**27**	*0*
	Inhabitants (*1000)	**618**	**104**	*-83*	**215**	*-65*	**345**	*-47*	**189**	*-69*	**618**	*0*
	Casualties (*1000)	**3.5**	**3.3**	*-5*	**13**	*279*	**2.1**	*-39*	**1.7**	*-51*	**1.7**	*-50*
Worse case + Climate	Damage (Billion €)	**68**	**11**	*-83*	**33**	*-52*	**49**	*-35*	**33**	*-51*	**68**	*0*
	Inhabitants (*1000)	**1006**	**195**	*-81*	**333**	*-67*	**682**	*-44*	**321**	*-68*	**1006**	*0*
	Casualties (*1000)	**28**	**10**	*-65*	**61**	*119*	**23**	*-22*	**17**	*-39*	**15**	*-47*

Damage estimation for compartmentalization



Scaling 1.0 = 4.5 billion euros

Casualty estimation for compartmentalization



Scaling 1.0 = 289 persons

Preliminary conclusions

Given future scenarios the estimated damage for this region increases approximately with a factor 4 and the estimated casualties with a factor 10

The secondary dike strategy is promising, given the assumption that the secondary dike fails independent of the primary dike.

Partitioning can be very dangerous, depending on the flood scenario and can lead to an increased hazard

Self prepared cells using flood shelters are very promising, but need administrative arrangements and a proactive attitude of the inhabitants, which will be the greatest challenge

Recommendations

The probability of the scenarios has to be calculated in order to compare the risk to conventional strategies such as dike strengthening and dike heightening

Cost benefit analysis has to be performed to give insight in the feasibility of these strategies

Combination of strategies has not yet been assessed and would be interesting for areas close to the sea.

Do not (yet) destroy the old existing secondary dikes as they might turn out to be life saving by slowing down the flood

Further development of the administrative arrangements for self preparedness and awareness

Questions

? ? ? ?

? ? ?

Additional slides

Dike failure mechanisms

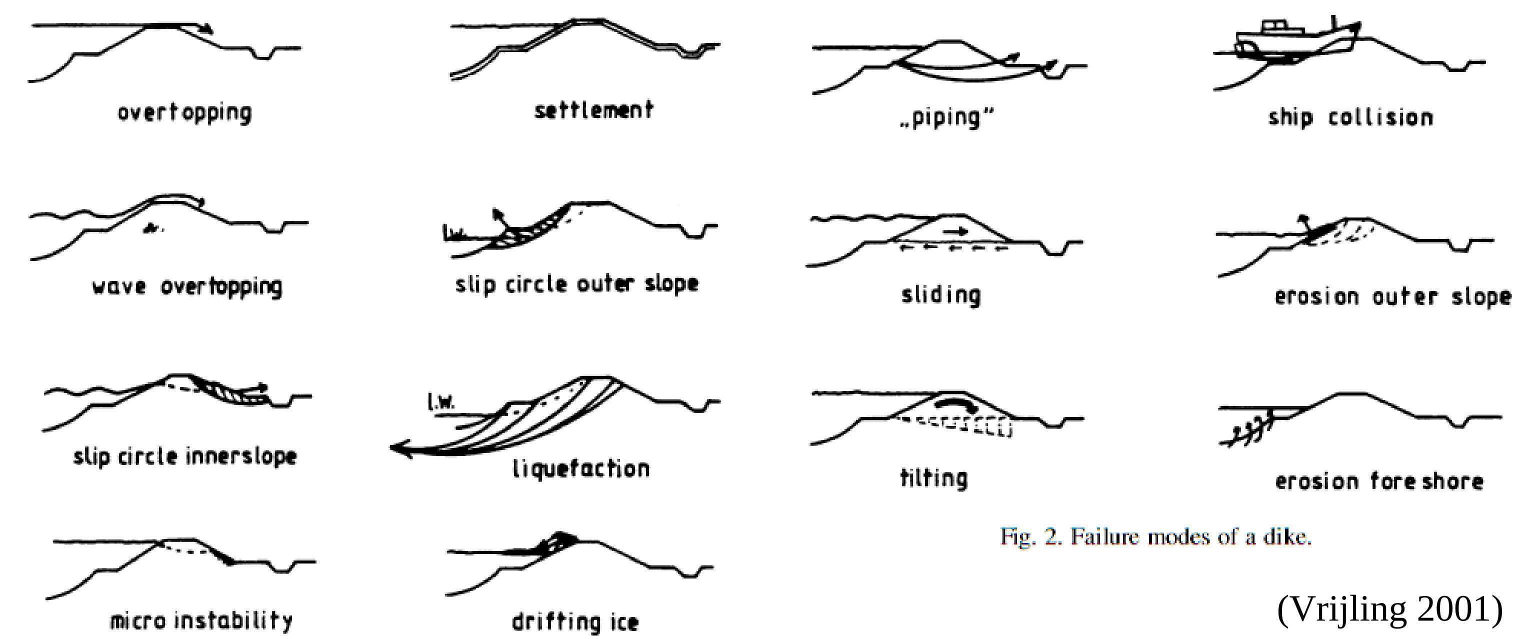
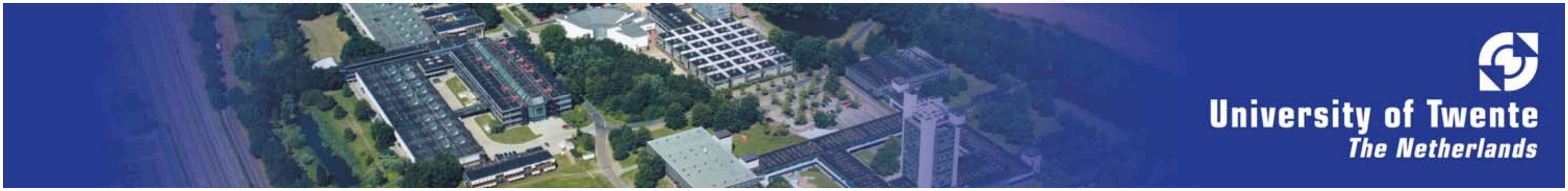


Fig. 2. Failure modes of a dike.

(Vrijling 2001)



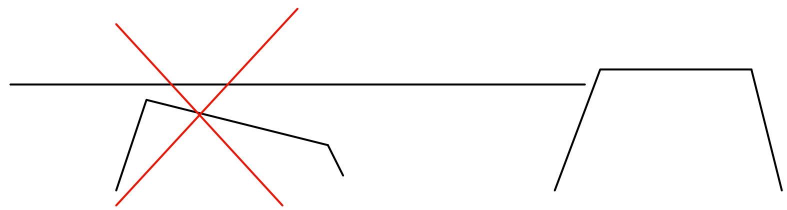
Dependent vs independent failure

Dikes fail when overtopping occurs

$P_{fail}|(H>H_{dike}) = 1$

All other mechanisms depend on the water level:

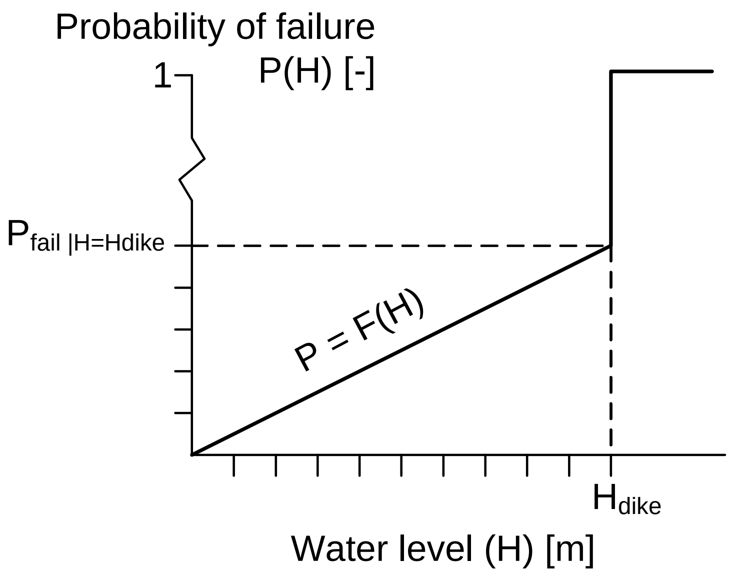
$P_{fail}|(H<H_{dike}) << 1$



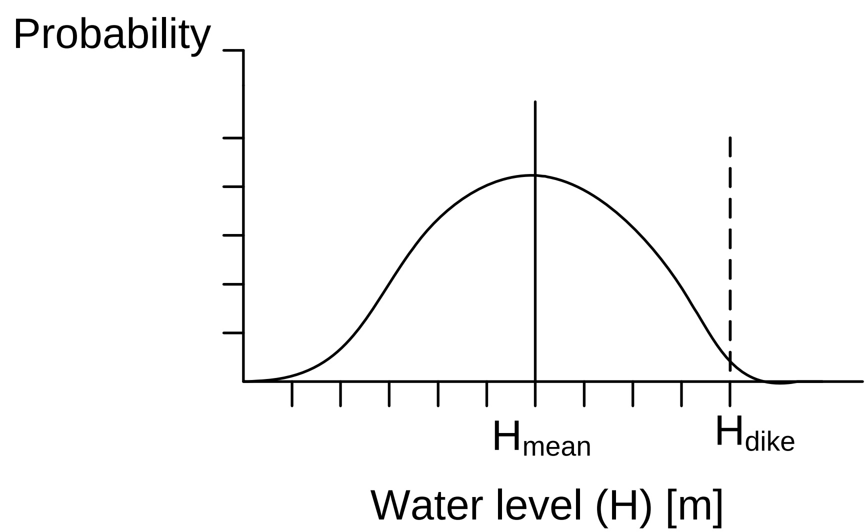
independent

dependent

Method


Probability of failure
P(H) [-]
1
P fail |H=Hdike
P = F(H)
H dike
Water level (H) [m]

X


Probability
H mean
H dike
Water level (H) [m]

Water levels at two breach locations