¹ "De Nederlandse waterkeringen op de schop" **fu**Delft

thenis lezing voor leden van de Rotary te Woerden. 24 oktober 2017

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Teaching

- Engineering projects, BSc-theses
- Hydraulic structures
- Fieldwork Hydraulic Engineering
- Internships
- MSc-theses

Organizational tasks

- coordination BSc-thesis
- misc. others

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The 1953 flood (Zeeland & Zuid Holland)



The 1953 flood (Zeeland & Zuid Holland)











"This may never happen again!"

The closure at Ouwerkerk





Advice on further action:

- plans did exist, but were not considered before 1953
- high-quality scientific basis of the advise
- focus on safety and economic development (including freshwater management)



¹¹ The Delta Plan





- reduction of exposed coastline with 700km
- closure of estuaries with dams and storm surge barriers
- safety standards based on cost-benefit analysis
- national dike improvement plan



How safe is safe enough?

<u>Risk</u> as a measure for the safety:

Flood risk = probability of a flood x consequences

Consequences = ecomomic damage (€)

Balance between investments for better flood protection and reduced flood risk per dike ring area



Flood probability is related to occurrence of high water levels



¹⁴ Main design parameter: height



dike height should suffice to limit wave-overtopping discharges to acceptable amounts regarding:

- erosion protection of the inner slope
- capacity of the hinter-laying water system

The system of flood protection



TUDelft

¹⁶ **Dike ring areas**



per area equal risk, but different flood probability



¹⁷ The Deltaplan





dams + barriers

De Bosatlas van Nederland waterland

¹⁸ Storm surge barrier Hollandse IJssel **T**UDelft



Dewatering sluices Haringvliet

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²⁰ **Oosterscheldedam**





²¹ **Oosterscheldedam**





²² Societal changes since 1970s



Around 1970 in society much more emphasis was given to the environment: Strong lobby for not closing the Oosterschelde with a dam



The change in thinking

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²⁴ **Oosterschelde storm surge barrier T**UDelft



²⁵ Markerwaard → Markermeer



foreseen problems with groundwater, finance

+ societal changes: more apprecation of recreational and ecological values of the Markermeer



²⁶ Meanwhile: unforeseen nature development **fu**Delft



²⁷After Delta Works: improvement of river dikes **T**UDelft



²⁸ The river dikes



1970s: Strong protest against demolishing houses for dike improvements in Brakel and Sliedrecht

Brakel, 1972 (Ab van de Beek)

²⁹ The river dikes





Strong lobby, not always based on facts

Jan Bervaes argued that no dike at all would be able to withstand the ice dams that had occurred in the past, so dike reinforcement would make no sense at all.

³⁰ **Dike improvement, saving the houses**





Stork plan (Plan Ooievaar)



Aim: revival of the complete biotic river system in relation to societal activities (agriculture, shipping, flood protection, mineral extraction and recreation)

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³² Room for the river (*Ruimte voor de rivier*) **⁴U**Delft



³³ Cities still not sufficiently protected **F**UD

Raising the dikes in the centre of Rotterdam and Dordrecht was in fact not possible:

- too expensive
- socially not acceptable
- culturally not acceptable

Problem solved by the Maeslantkering in Nieuwe Waterweg

The Maeslant storm surge barrier **fu**Delft

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³⁵ Urban development



(rozenbergguarterly.com

Amsterdam, Bijlmer ca. 1970

Ideas of the Modern Movement (Le Corbusier, Giedion, etc.), resulted in open spaces in contrast to voluminous tower buildings.



Consequences: decay, poverty and crime!



³⁷ Urban development



Modern Movement: also aimed at a good accessibility over land (highways) and good protection against floods (large-scale dikes).





Urban development

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Rotterdam, De Boompjes

(Mark Voorendt, 2016)

³⁹ Urban development



 \rightarrow since 1980s: counter-movement: combining durable flood protection with spatial quality in multifunctional water fronts.



⁴⁰ Multi-layered safety (*meerlaagsveiligheid*) **⁴⁰** UDelft

flood risk = flood probability x consequences

Dutch policy of flood risk reduction in three layers:

- 1. Prevention
- 2. Spatial planning
- 3. Disaster management





⁴¹ Kierbesluit Haringvlietsluizen









Haringvliet: Haringvlietsluizen een kier

Home

- Water
- Projectenoverzicht
- Haringvliet:

Haringvlietsluizen op een kier

- Doelen en resultaten
- Hinder en maatregelen
- Planning
- Veelgestelde vragen
- Nieuws

Waarom

Sinds de Haringvlietdam in 1970 voltooid is, is het Haringvliet afgesloten van de Noordzee.

- Door de Haringvlietsluizen op een kier te zetten kunnen trekvissen, zoals zalm en zeeforel, de sluizen passeren richting hun paaigebieden, die stroomopwaarts liggen.
- We zetten de sluizen op een kier vanaf 2018.

Alle doelen en resultaten

Hoe



De Haringvlietsluizen gaan op als de waterstand van het Har lager is dan van de Noord

Trouw

HOME RELIGIEEN FILOSOFIE GROEN DEMOCRATIE SAMENLEVING CULTUUR OPINIE

Haringvliet is klaar voor de kier

GROEN Cokky van Limpt – 20:15, 4 augustus 2016



Artist impression van Scheelhoek, Zuldendiep en Blok de Wit. © Trouw

DELTANATUUR In 2018 gaan de Haringvlietsluizen op een kier en stroomt er voor het eerst in 47 jaar weer zout water in het Haringvliet. Achter de dam wordt de natuur voorbereid op brak water en bescheiden extra getij.



⁴² Kierbesluit Haringvlietsluizen

compensation against salinisation Haringvliet

(www.kierharingvliet.nl)



displacement freshwater intake points eastward (75 M€)

⁴³ Volkerak-Zoommeer en Grevelingen



(partial) re-introduction of tidal movements



by openings in the Brouwersdam and Philipsdam

Per 1 January 2017: new standard



Criteria that determine the safety standard:

TUDelft

- individual death criterion
- economic optimum
- multiple deaths criterion

Max. failure probabilities per dike segment, not per dike ring area

Failure probability

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The flood probability of a dike ring area is related to the failure probability of the flood defence system.

multiple structures / dike sectionsmultiple failure mechanisms



Failure probability

probability density functions of loading S and strength R



 $p_f = P(Z < 0)$



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⁴⁷ Failure probability





for multiple loads and resistances:

 $p_f = \iint_{Z < 0} \dots \iint_{Z < 0} f_{r_1, r_2, \dots, r_n, s_1, s_2, \dots, s_n}(r_1, r_2, \dots, r_n, s_1, s_2, \dots, s_n) \cdot \mathrm{d}r_1, \mathrm{d}r_2, \dots, \mathrm{d}r_n, \mathrm{d}s_1, \mathrm{d}s_2, \dots, \mathrm{d}s_n$

Climate change: sea level rise

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De zeespiegelstijging in Noord-Europa kan veel groter worden dan tot nu toe werd aangenomen. Uit onderzoek blijkt dat er een risico bestaat dat de zeeën rondom Scandinavië, Engeland, Nederland en Duitsland deze eeuw ongeveer **1,70 meter** zullen stijgen. (26 juni 2015)

Onderzoekers slaan alarm over zeespiegelstijging

Climate change: sea level rise



Dillingh (KNMI), 2008: 0,19 m / century



Figuur 1 Verloop van de gemiddelde zeestand, gemiddeld over de zes hoofdstations

in practice: mid-scenario sea level rise used for design: 0,60 m / century

⁵⁰ "De Nederlandse waterkeringen op de schop" **T**UDelft

Hydraulic engineers are used to deal with uncertainties. Involve them in designing flood defences. Otherwise: pray and be prepared yourselves!



⁵¹ Thank you for your attention!



