Ministry of Infrastructure and Water Management

HWBP voor sterke dijken

HWBP-DIV

Insights erosion tests Hedwige-Prosper, impacts of droughts and animal burrowing

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Objectives presentation

- To share what was discovered during the experiments in the Hedwige Prosperpolder in order to identify a shared view on the status of this discovery
- To discuss the impacts of climate change
  - change in the physical climate: impact of droughts
  - change in the policy climate: impact of animal burrows

Hedwige Prosperpolder.

Outline presentation

Reference case

Impact loads on erosion of clay layer

Impact of drought on erosion

Impact of animals on erosion

Shared Slide

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Reference case loads

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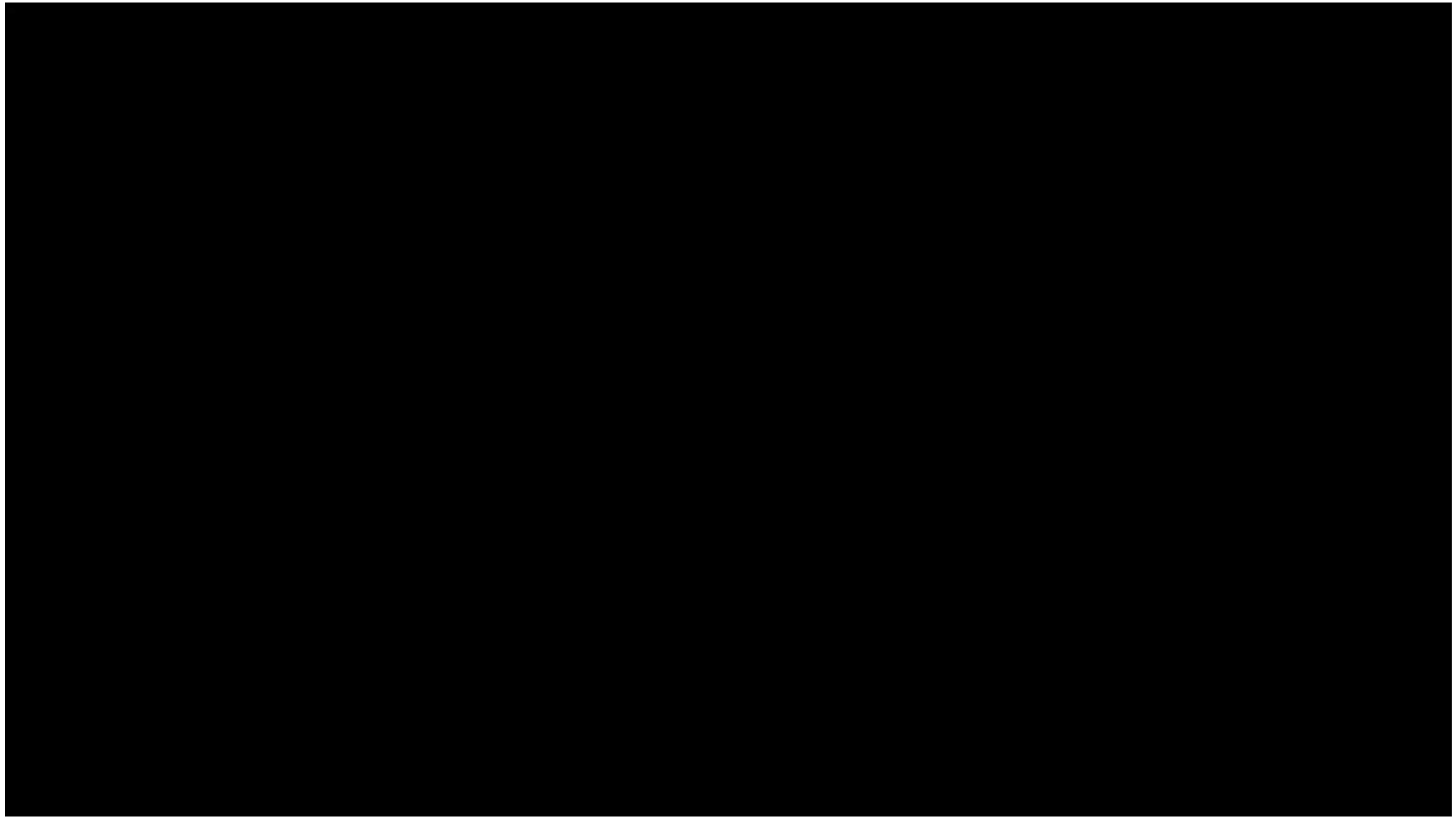
Overflow



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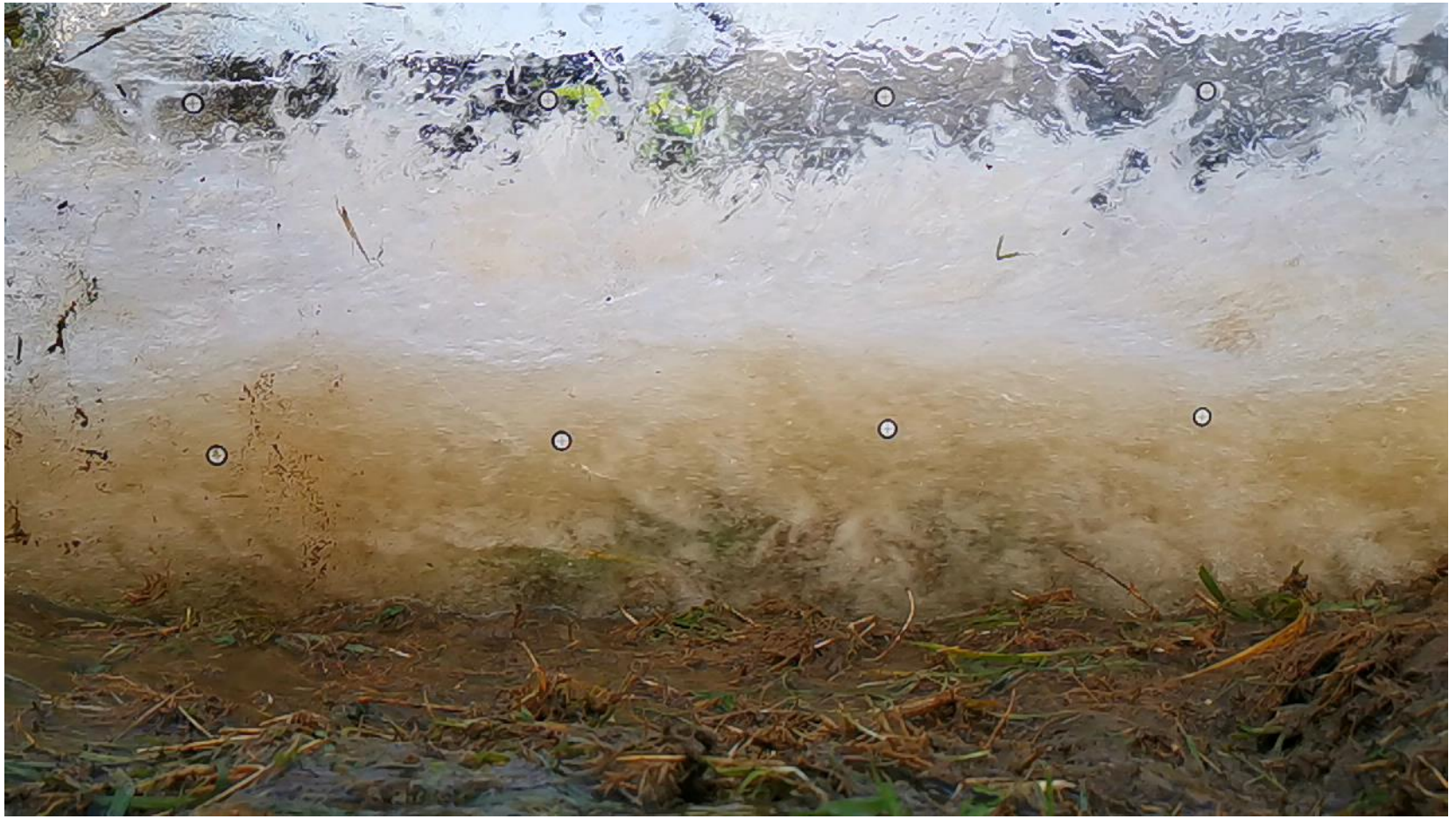
Loading due to overflow.



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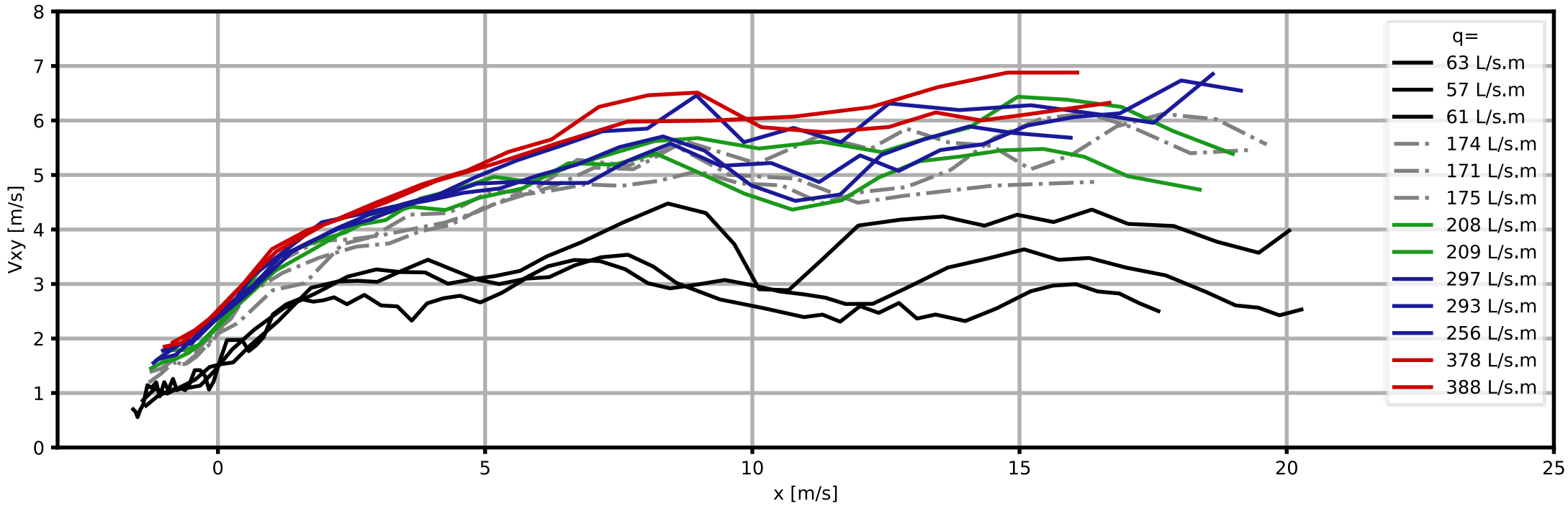
Flow velocities

How fast does the water flow down the landside slope at a discharge of 200L/s/m?
Larger or smaller than 5m/s



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Response of grass at given flow velocities

- Vegetation is flattened
- Some bare spots
- Some local erosion of clay
- No large scale erosion

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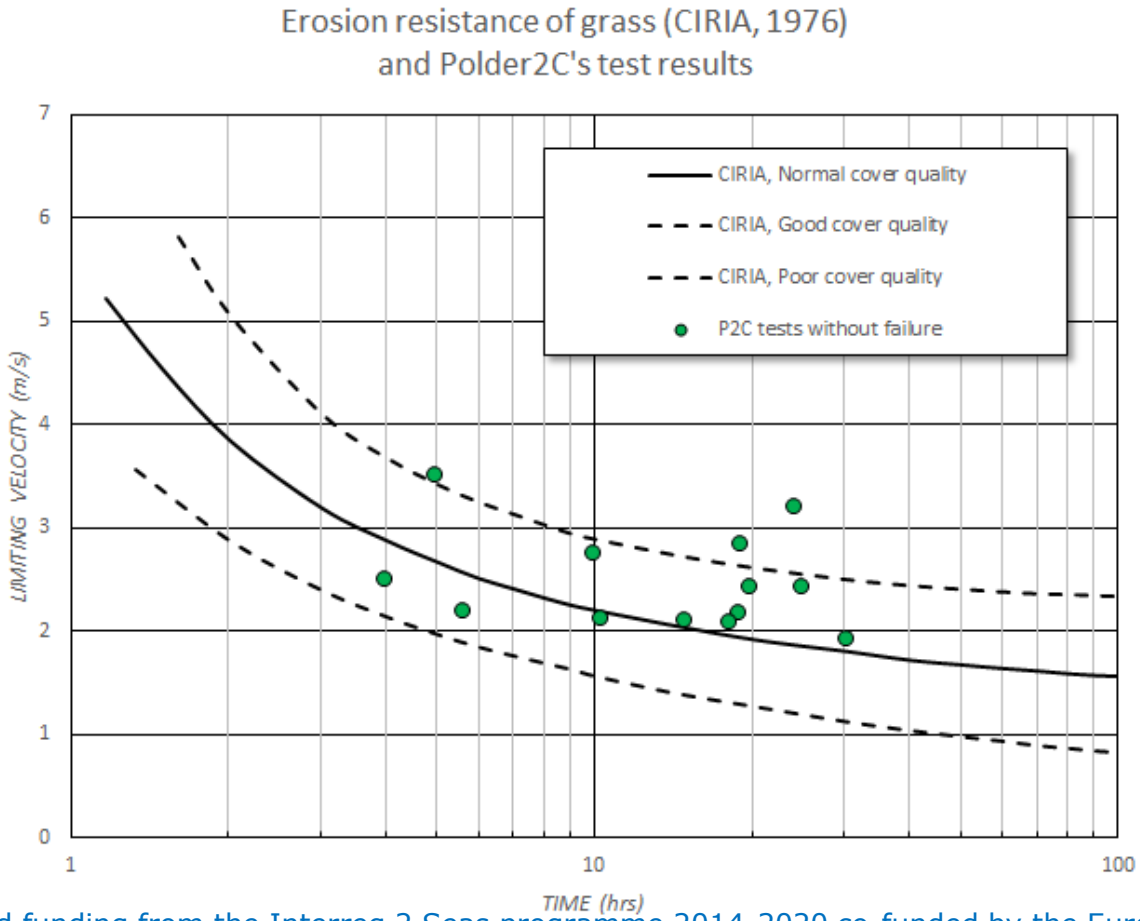
What the data shows



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Wave overtopping on grass covered landside slopes

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Wave overtopping

- Average overtopping discharges varied from 50-200 L/m/s
- Sign. wave heights tested: 50, 100, 200 cm

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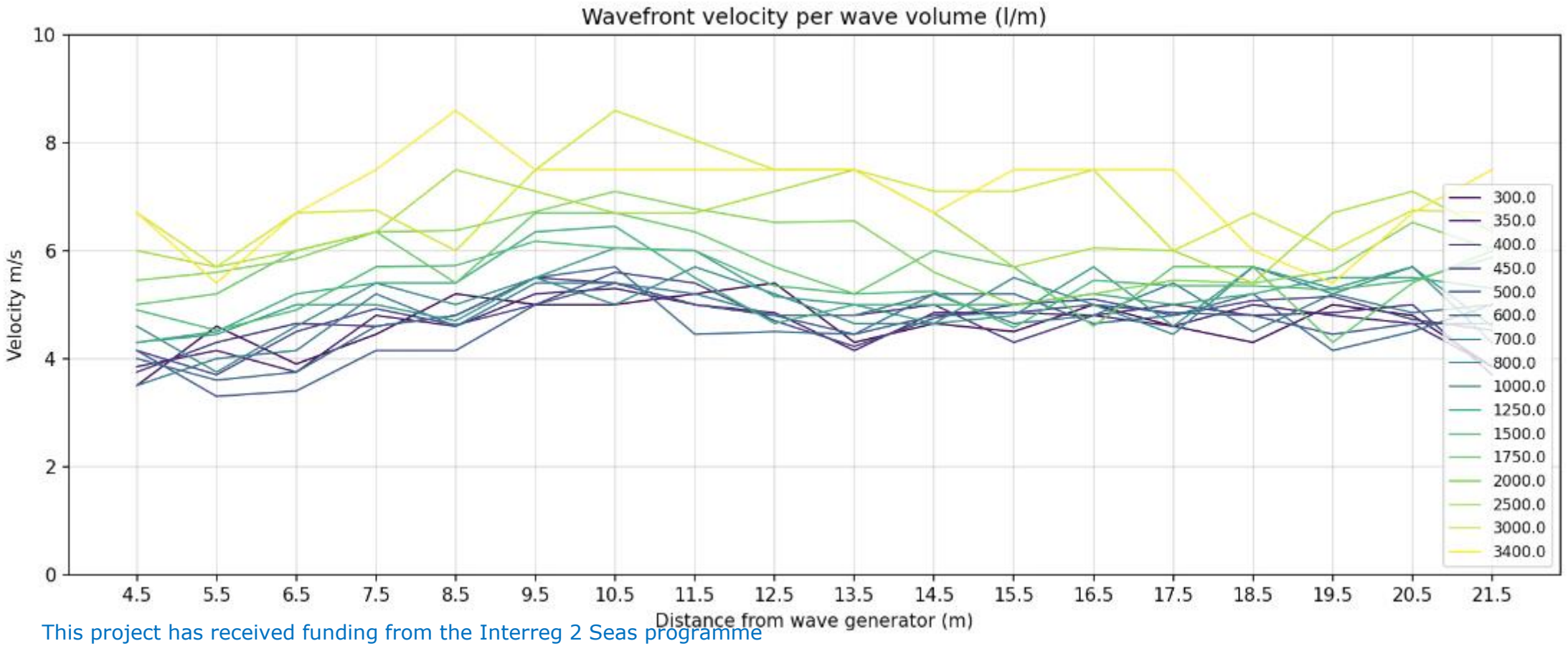
Wave front velocities



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Comparison to other experiments

- Wave overtopping tests on well maintained grass resulted in no failure of the grass cover. Most front velocities were < 7m/s which corresponds with the critical velocity of a good grass cover.
- The level of acceleration of the flow was significant less during overtopping than during overflow.

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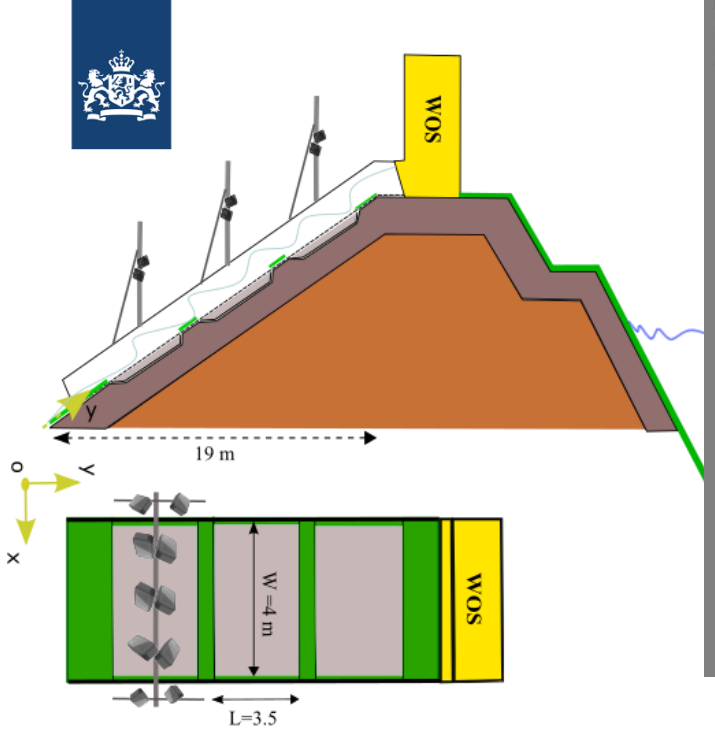
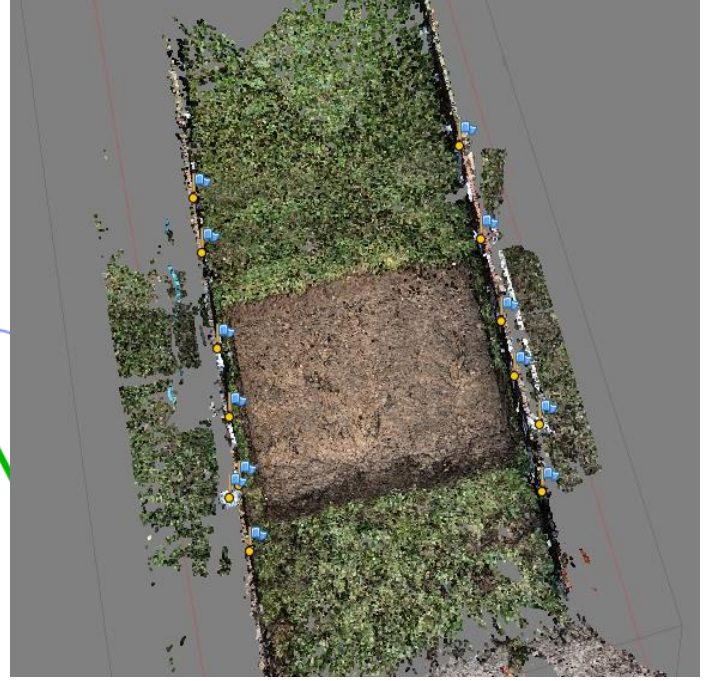
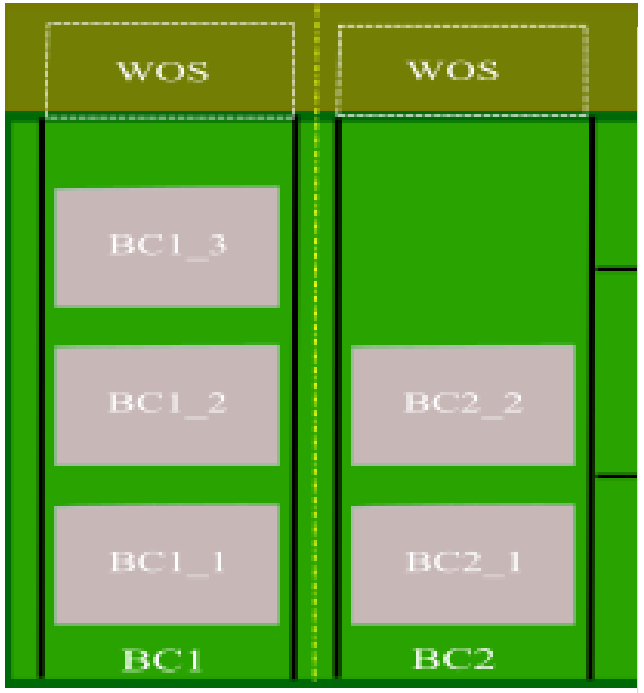
Erosion of clay

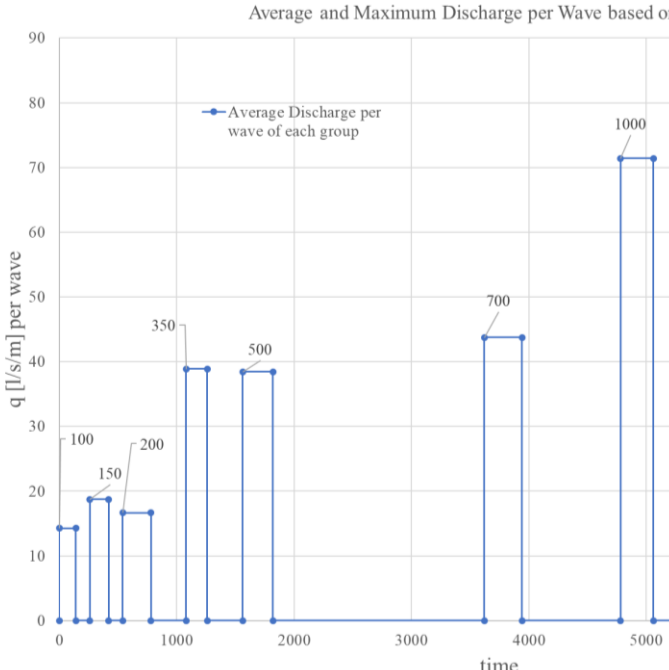
Introduction

- Tests executed on Prototype scale
- Sections of exposed clay 4x4m
- 5 sections tested
- 3 sections regular waves, 2 sections irregular waves









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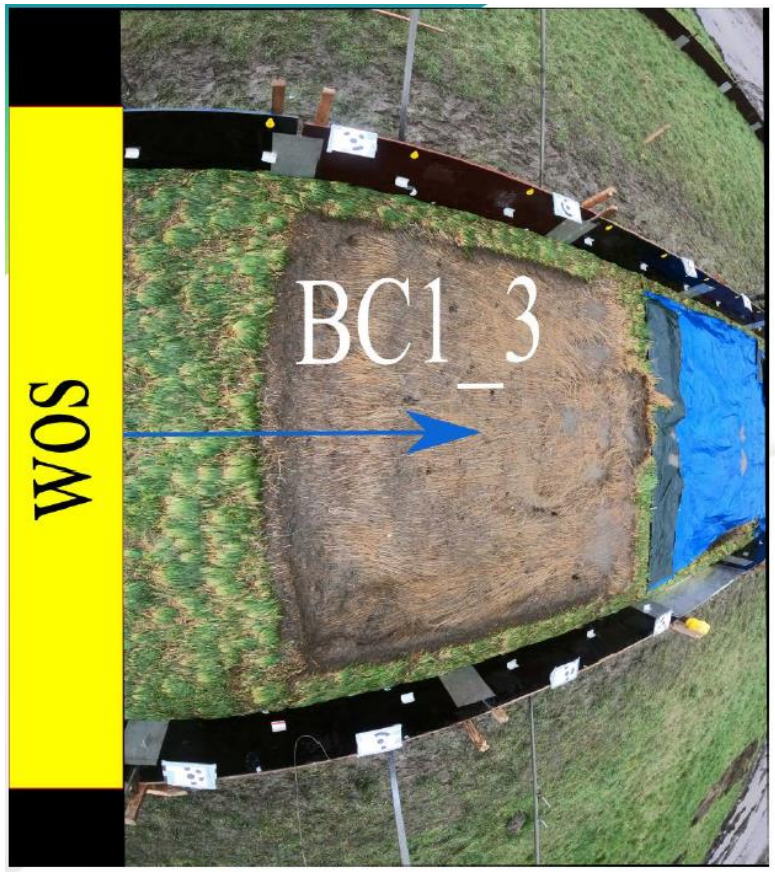
Tests

Regular waves

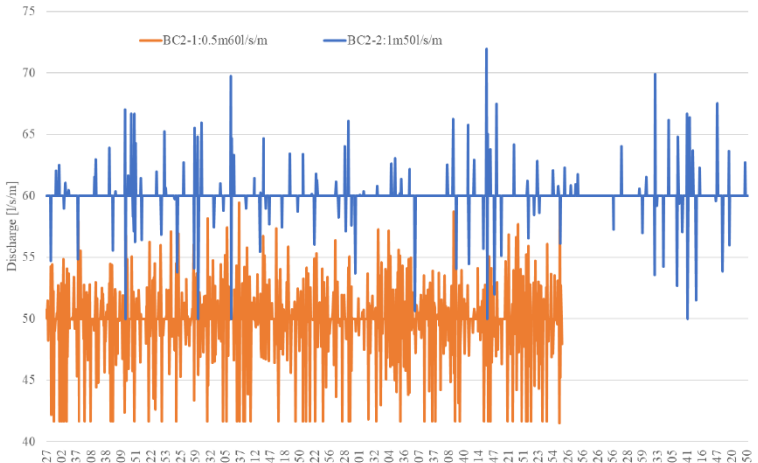
Bare clay: Section 1 (BC1)														
BC1_1	N	20	20	20	20	20	20	20	10	10				
	Vol [l/m]	100	150	200	350	500	700	1000	1500	2000				
BC1_2	N	10	10	10	20	20	20	20	20	20	10			
	Vol [l/m]	1500	2000	1500	1000	700	500	350	200	100	1500			
BC1_3	N	10	10	10	10	10	20	20	20	20	24	20	5	5
	Vol [l/m]	1500	2000	2500	2000	1500	1000	700	500	350	200	100	2500	3000
Lime-treated clay														
LTC2_B	N	200	200	100	100	50	25	20						
	Vol [l/m]	100	250	500	1000	2000	3000	3400						

Irregular waves

Hs [m]	q [L/s/m]
0.5m	60
1m	50



Outflow Hydrograph-Irregular Waves



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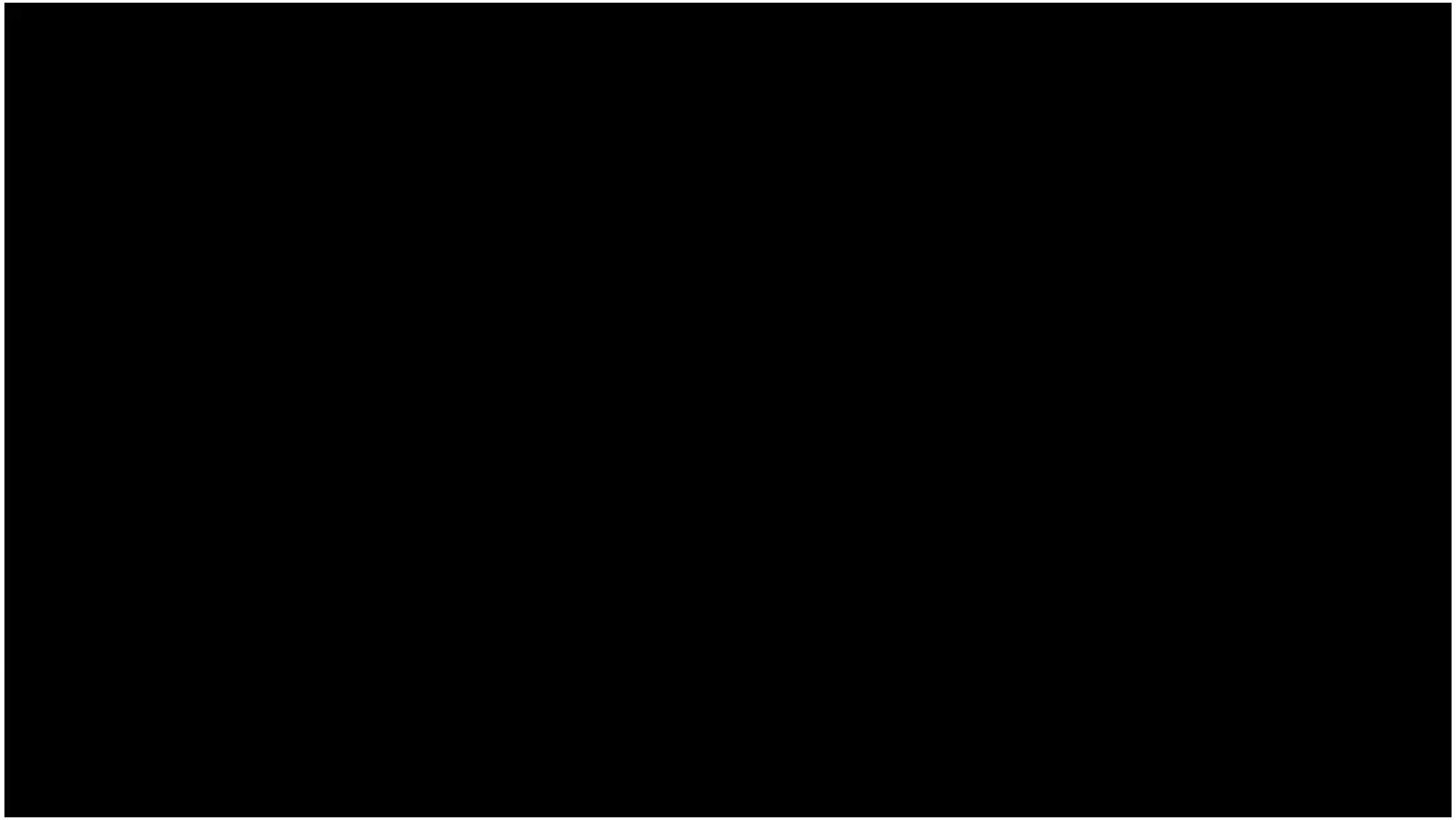
Wave overtopping on barren clay



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Question

You saw overtopping on barren clay with large volume and small volume waves. For the same unit discharge overtopping…

A: **Large waves** lead to faster erosion (“coastal conditions”)

B: **Small waves** lead to faster erosion (“river conditions”)

C: There is **no difference** in erosion rate

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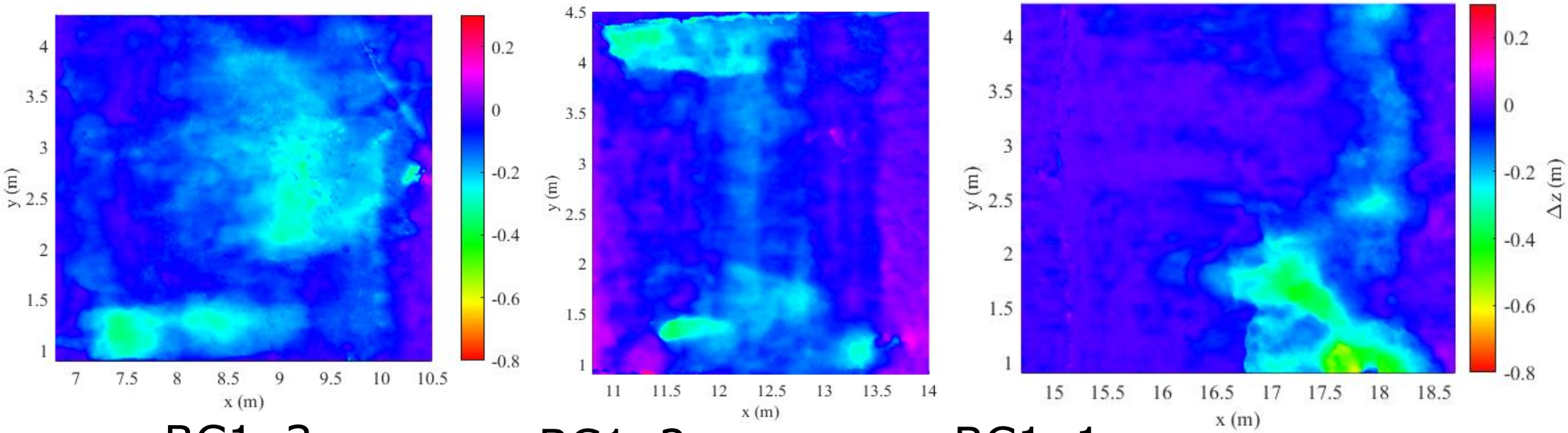
Total erosion depth



- BC1_3
- BC1_2
- BC1_1

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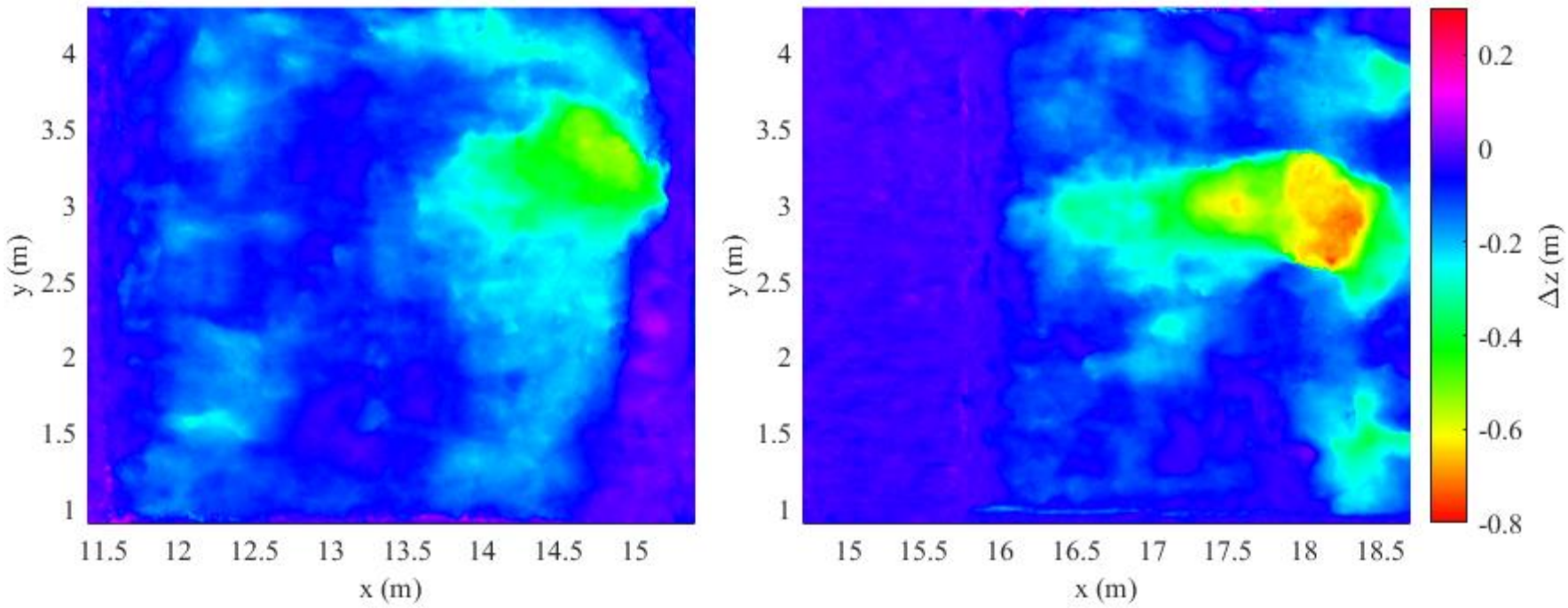
Total erosion depth



- BC2_2
- BC2_1

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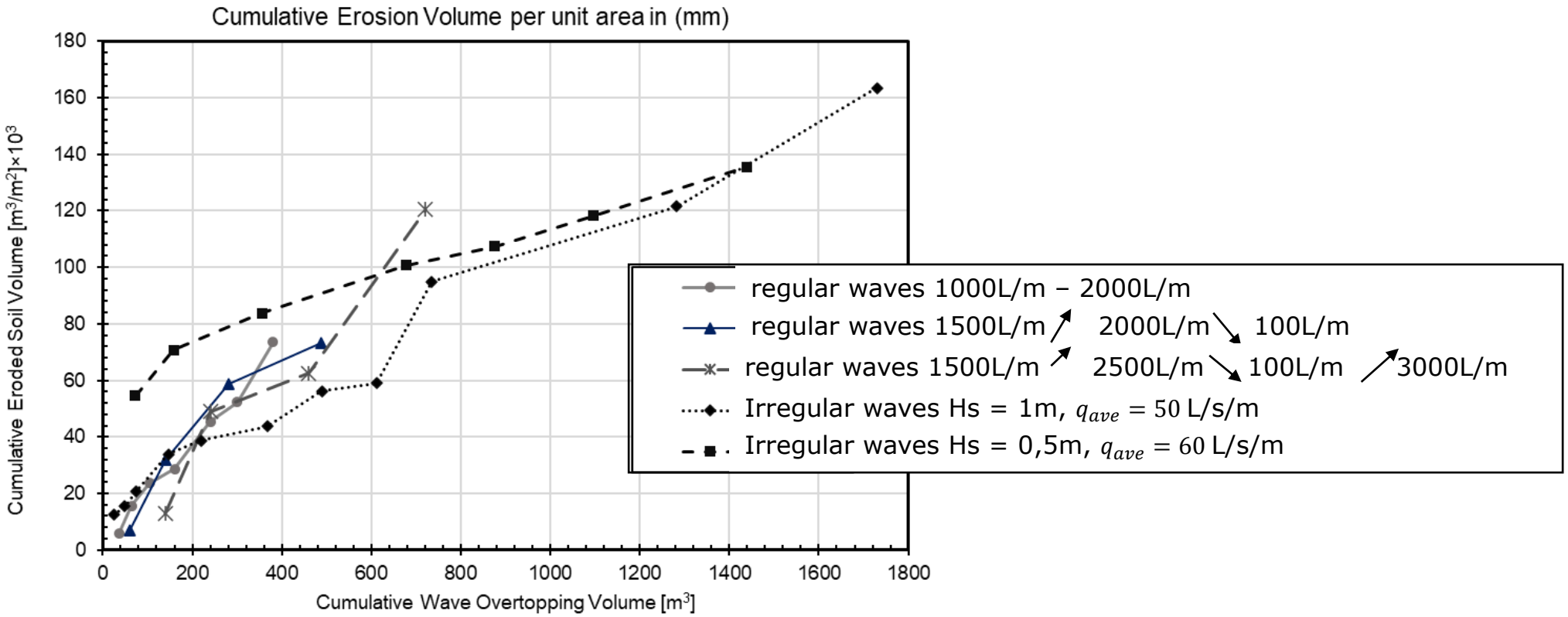
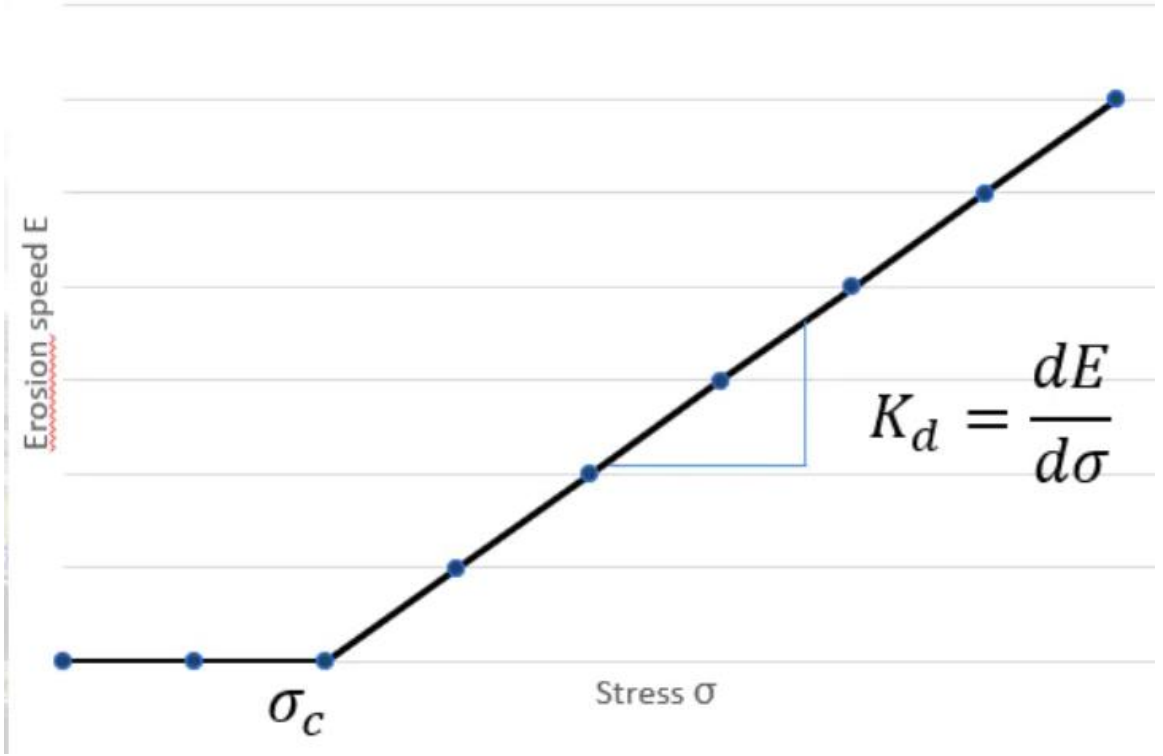
Results



Looking at the gradients, similar cumulative overtopping discharges give similar erosion rates, provided U>Uc

Erosion modelling parameters considered



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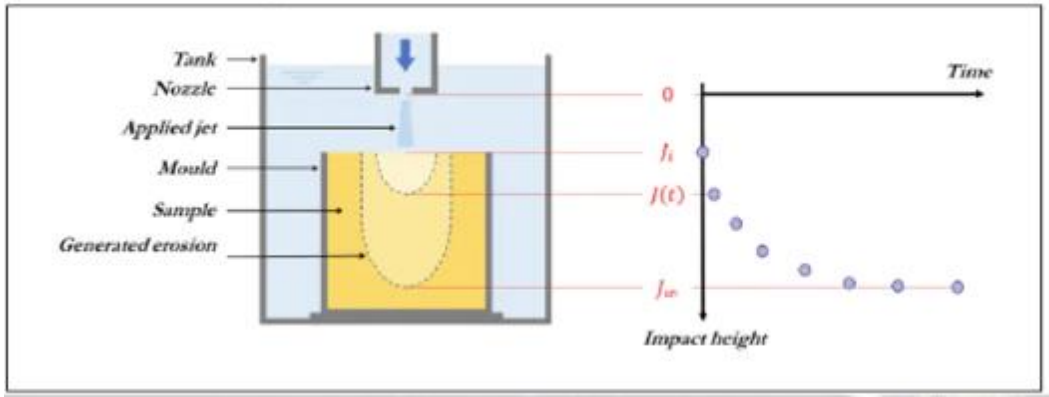
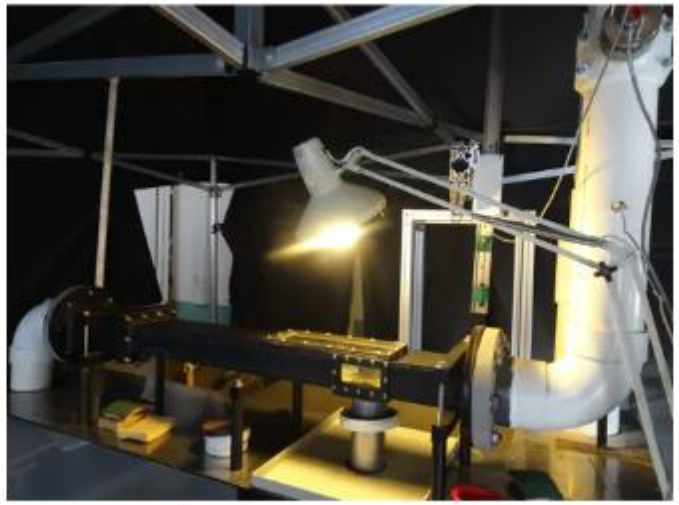
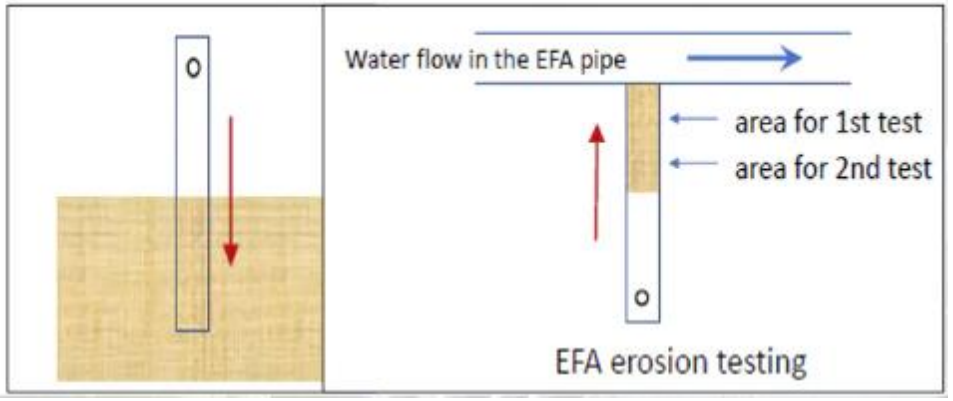
JET and EFA methods

JET





EFA



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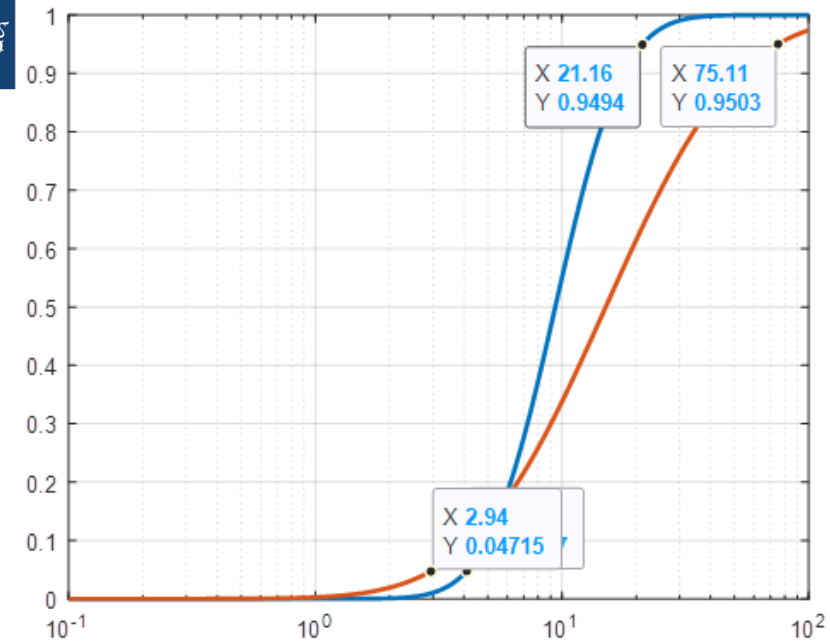
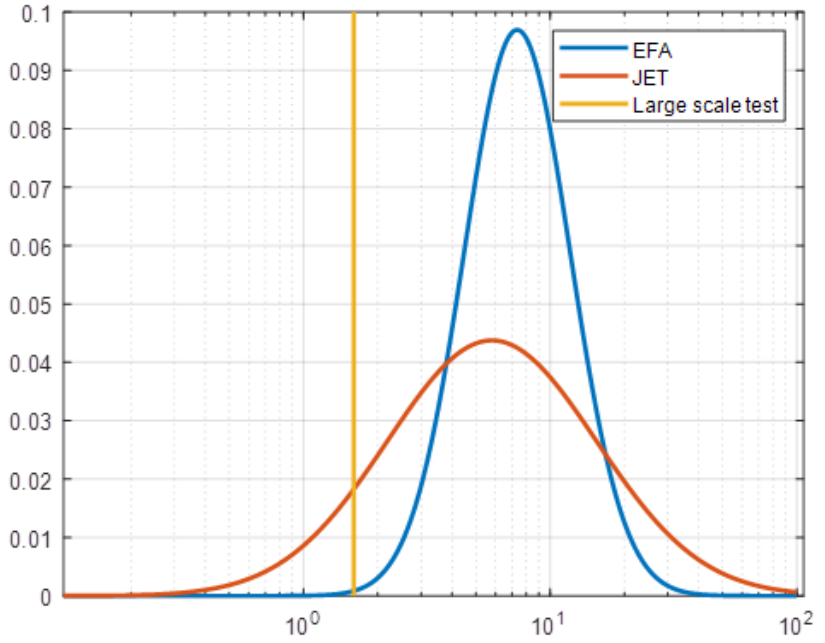
Method comparison

Test	K_d [cm³/Ns]	τ_c [N/m²]
EFA	8	0,325
JET	6	48,4
Real scale	1,6	?





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Further steps

- Development erosion model (ISL)
- Validation model against large scale tests Delfzijl on bare clay (2006)
  - Determine soil erodibility Deltzijl using EFA
  - Predict erosion progression

Effects of drought

Crack on landside slope of Standhazensedijk

- Occurred during dry Summer of 2018
- Didn’t disappear afterwards (2022)

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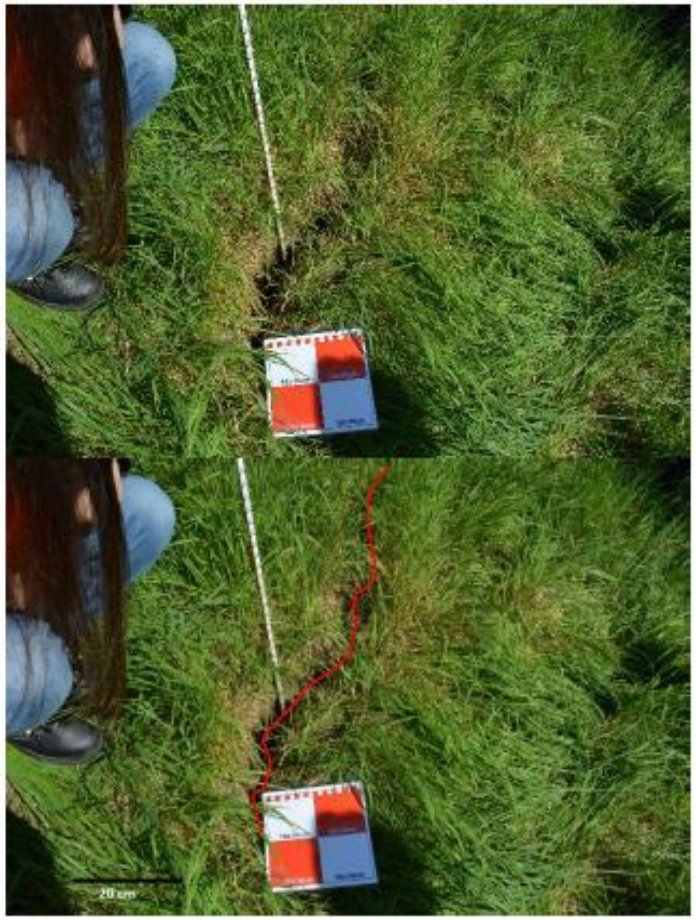
Crack on landside slope of Kamperzeedijk



- Occurred during dry Summer of 2018
- Didn’t disappear afterwards (2022)

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Crack on landside slope of Hedwige

- Occurred during dry Summer of 2021
- Partly closed after two weeks of mild rain
- Disappeared afterwards (2022 – removal of entire levee)

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With so many levees in the Netherlands with a clay cover on a sand core …

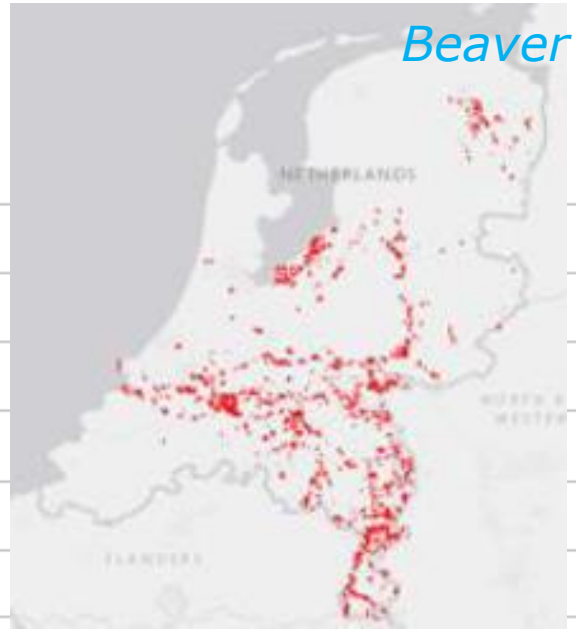
- "Any drought cracks will close before flood conditions arrive" (Dutch guidelines, since about 2000)
- "The clay cover provides a nearly impervious layer, limiting the phreatic surface inside the levee" (paraphrase of Dutch guidelines regarding slope stability of levees)

IJsseldijk at Reevediep, south of Kampen

Effects of animal burrows on erosion

Interlude – why look at burrowing animals?

Beaver observations in 2022



- Beaver became extinct in the Netherlands in 1826
- Reintroduced around 1990
- Strongly protected, population grows by 60% every 5 years

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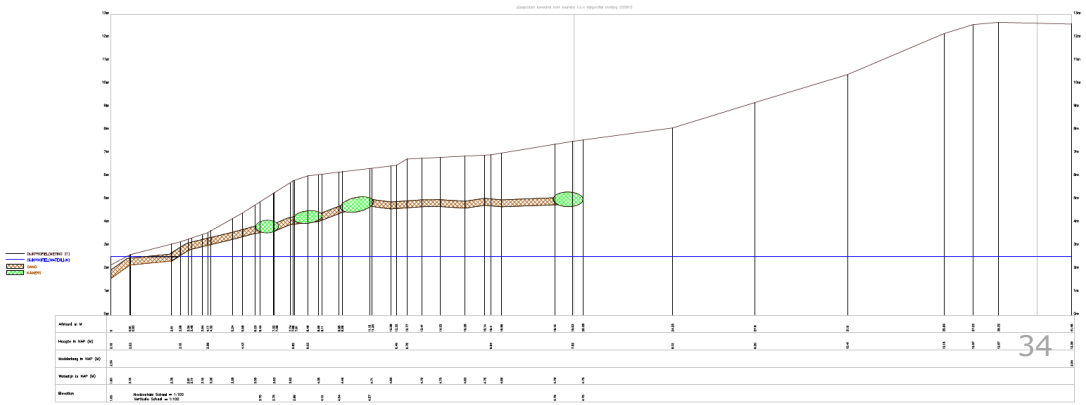
Beaver burrows at Wamel (July 2022)

Impact on safety against flooding estimated to be 100 to 14,000 times higher



Change in policy regarding burrowing animals

- Beavers may be cute, and so are badgers …
- … yet muskrats are exterminated because of fears of their impact on flood safety

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Overflow test on the stability of a tree, with apparent mole burrows (failure after 1 h 7 min)

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Overflow test on a fox/rabbit hole (failure after 1 h 13 min)

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Sheep cliff

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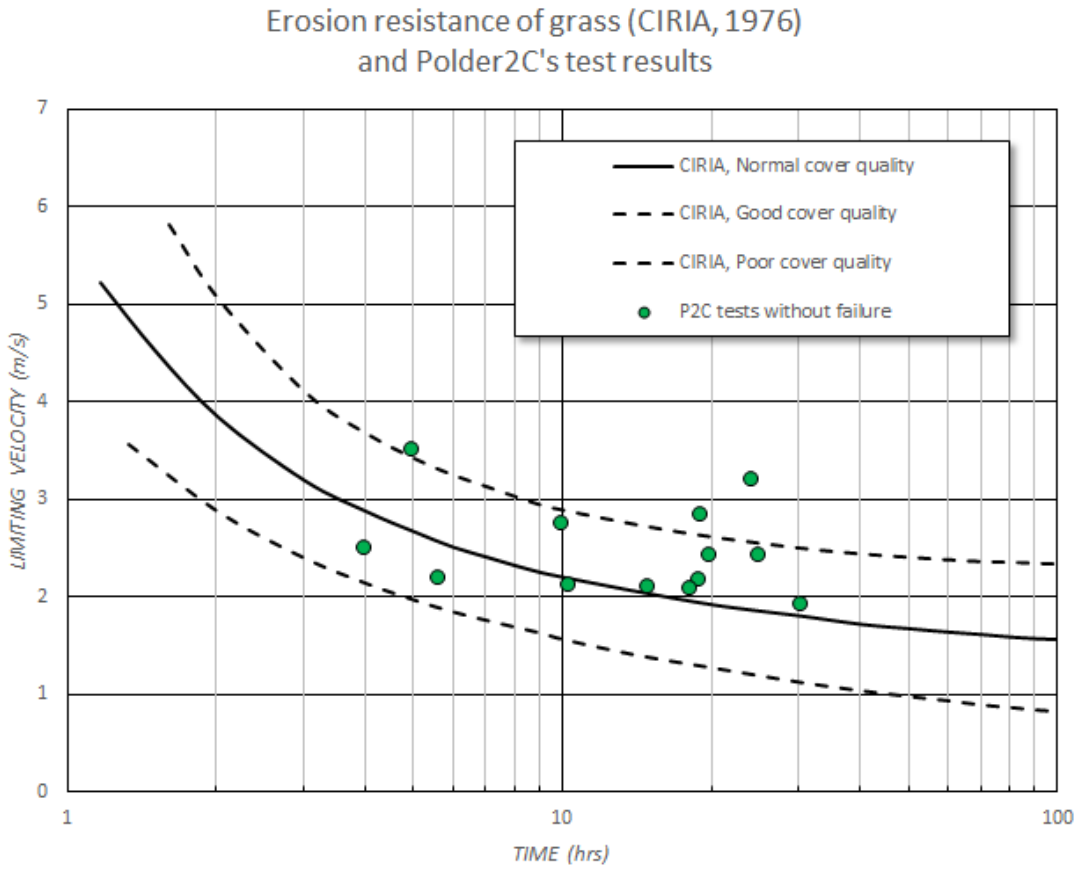
Overflow tests



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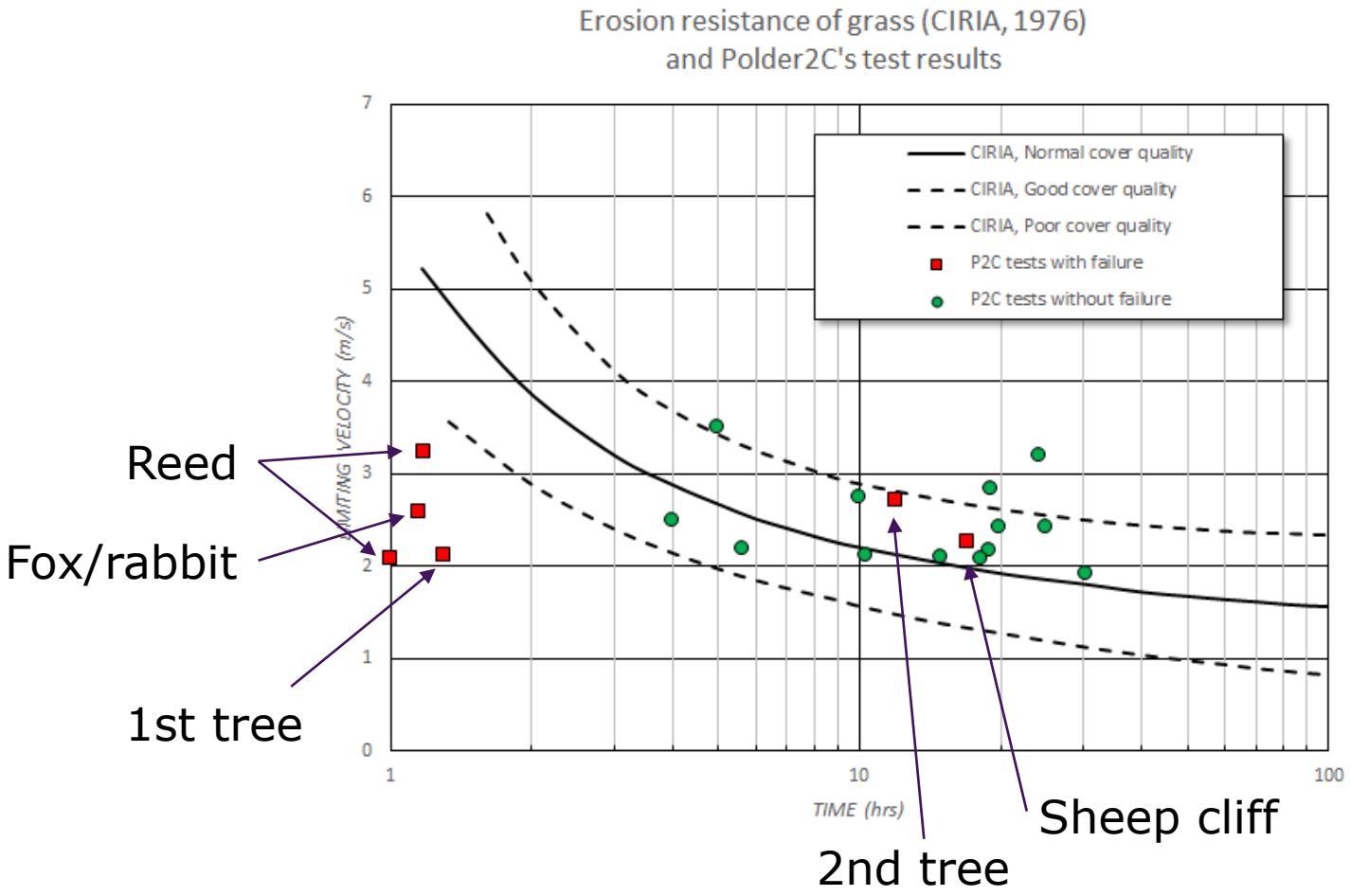
Overflow tests with animals



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Shared Slide

Gezamenlijke sheet

Shared slide

- There is a need for a easy practical method to determine the erosive properties of local soil.
- What is the quantitative impact of changes in materialogical conditions on erosion properties ?
- How sensitive are levees with a sand core and clay cover for drought cracks and animal burrows ?

Thank you for your attention.