



Borehole Erosion Test

Introduction in the Netherlands

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14 September 2023

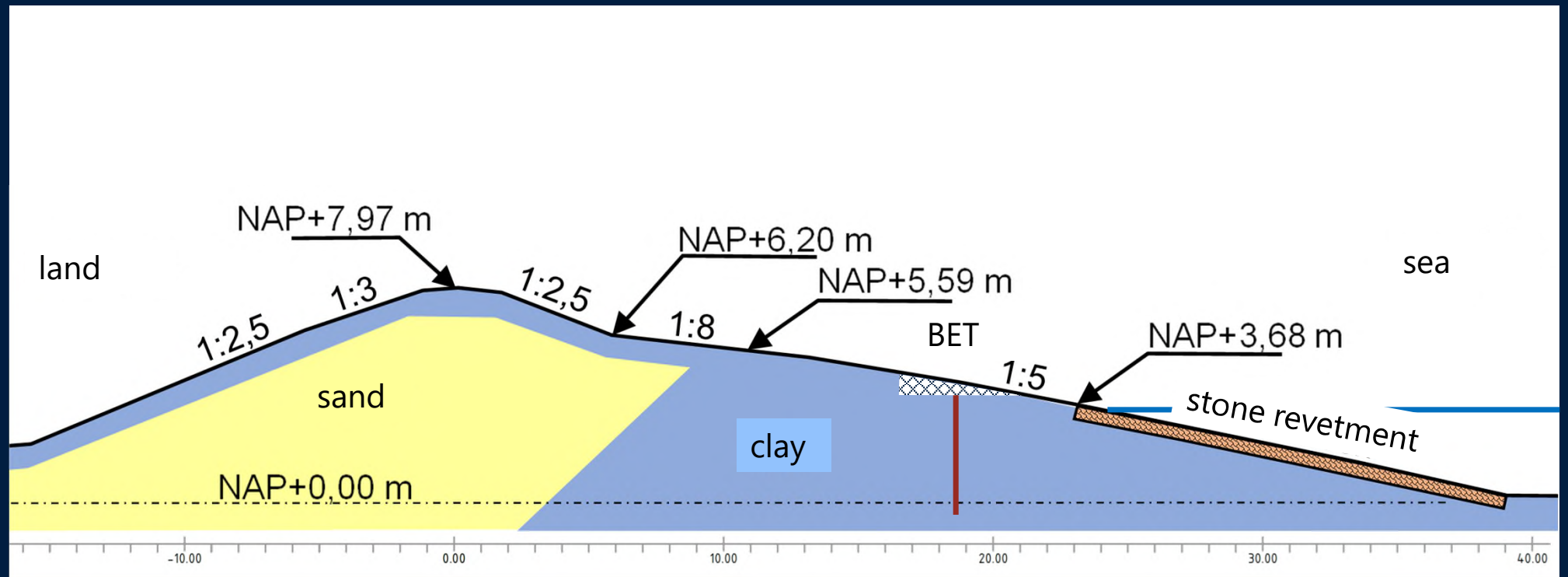
Timeline

- 2014** First BET (Texas)
- 2017** BET paper in geotechnical journal
- 2019** First BET in a levee (Sacramento)
- 2021** First BET in the Netherlands (pilot)
- 2023** First BET in a Dutch levee

Project location



6 BETs in Groningen seadike



Test procedure for one cross section

3 x BET
4 m



2 x Borehole A
6 m



JET
HET

2 x Borehole B
6 m



PET
PHET
RETA
geo

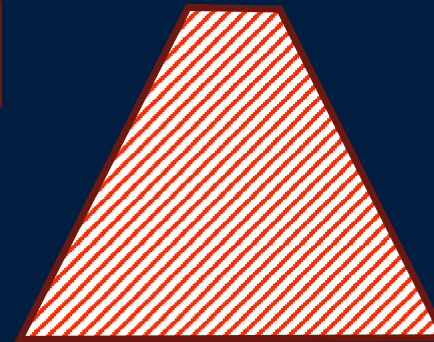
6 x CPT
15 m



1 x trial pit
1.5 m



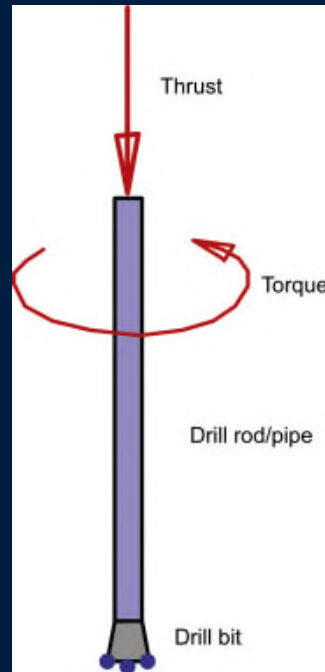
Geoscan
5 m



Clay blocks
for Delta flume



Drilling borehole



Rotary drilling

Depth: 4 m

Drill pipe diameter: 60 mm

Drill bit diameter: 90 mm

Water supply



Water tank volume: 12 m³

Pump capacity: 120 m³/hr

Max. flow rate in borehole: 39 m³/hr

Leakage in borehole: 0.02 m³/hr



Flow event



Duration: 10 minutes

Max. flow velocity: 1.4 m/s

Max. used water volume: 6.5 m³

Mechanical caliper measurements



After each flow event:

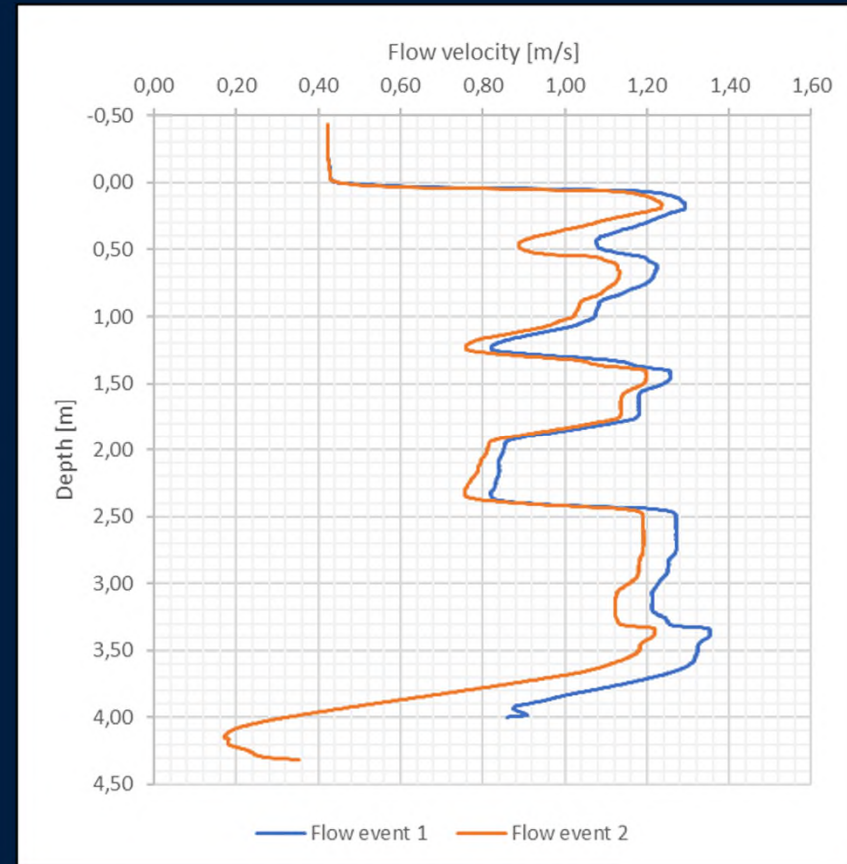
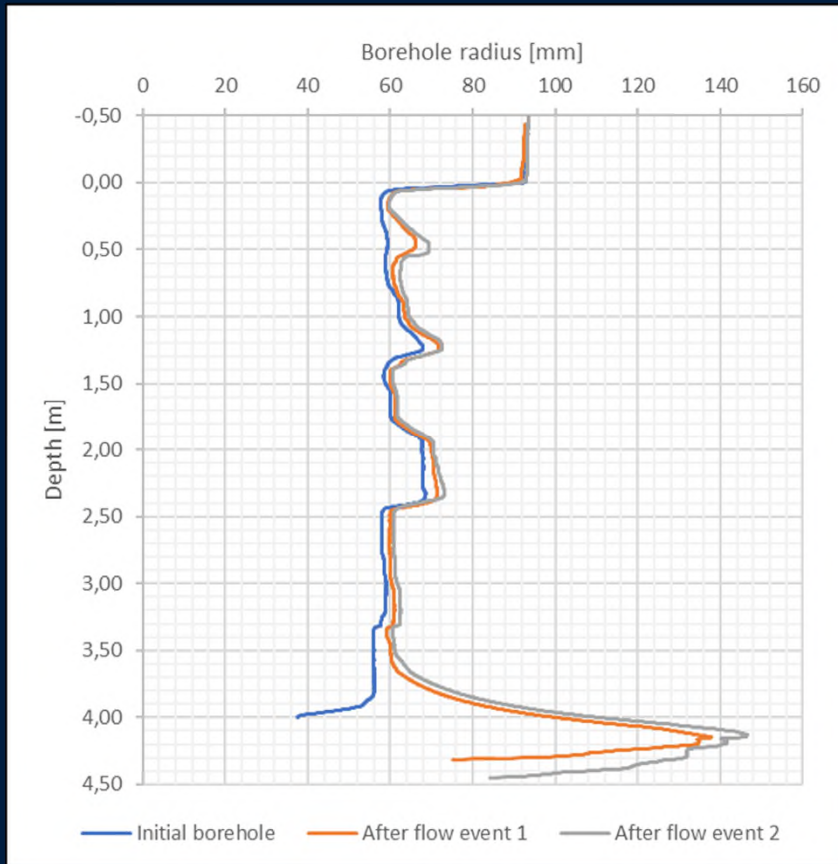
2 diameter measurements

2 directions

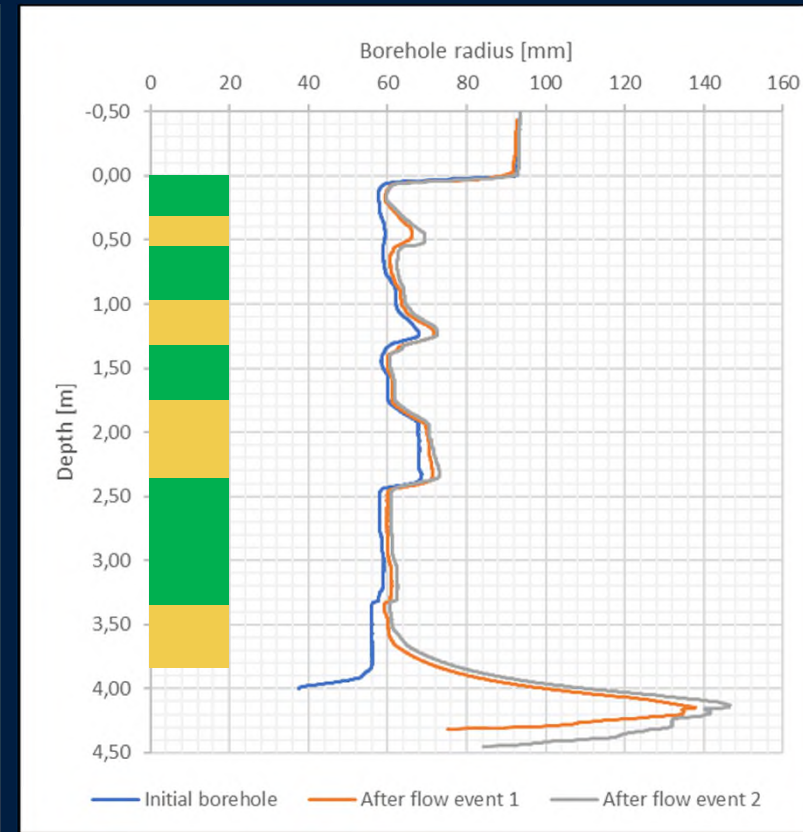
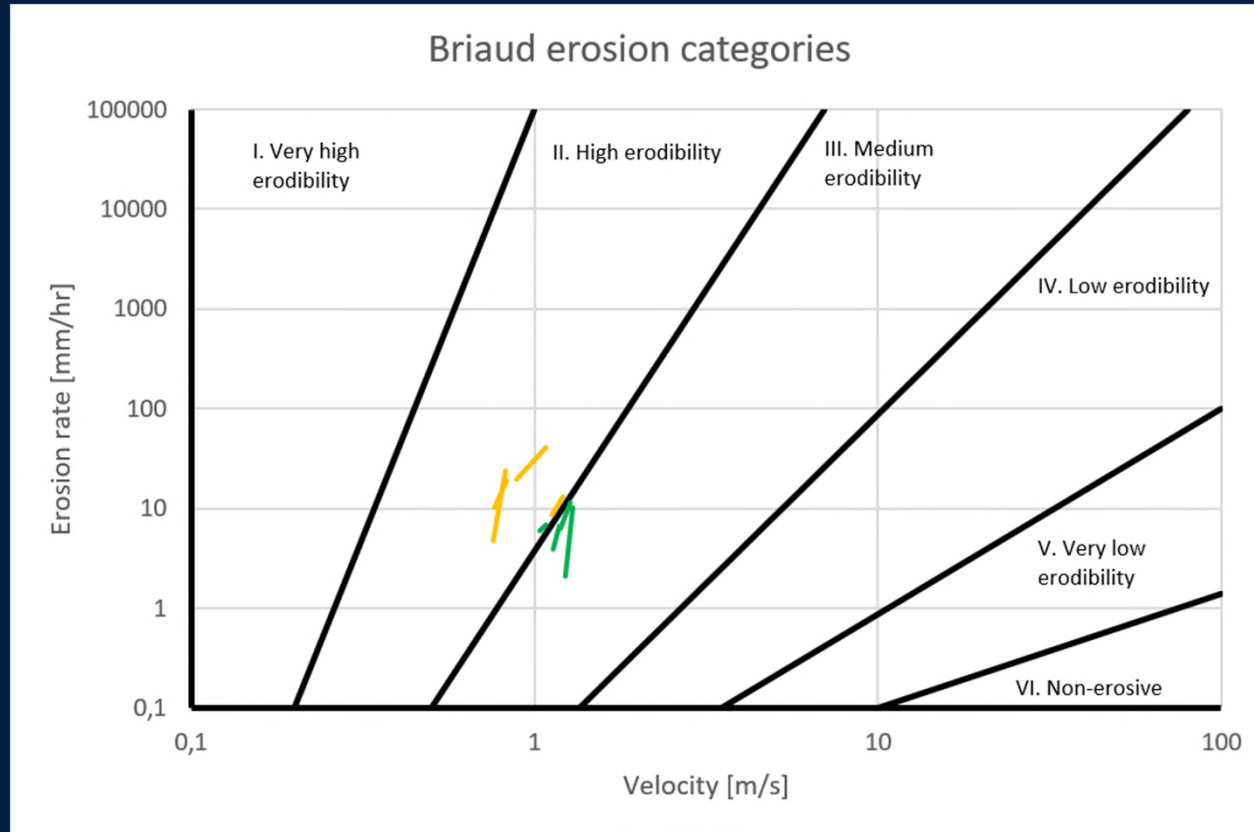
Vertical interval: 2 mm



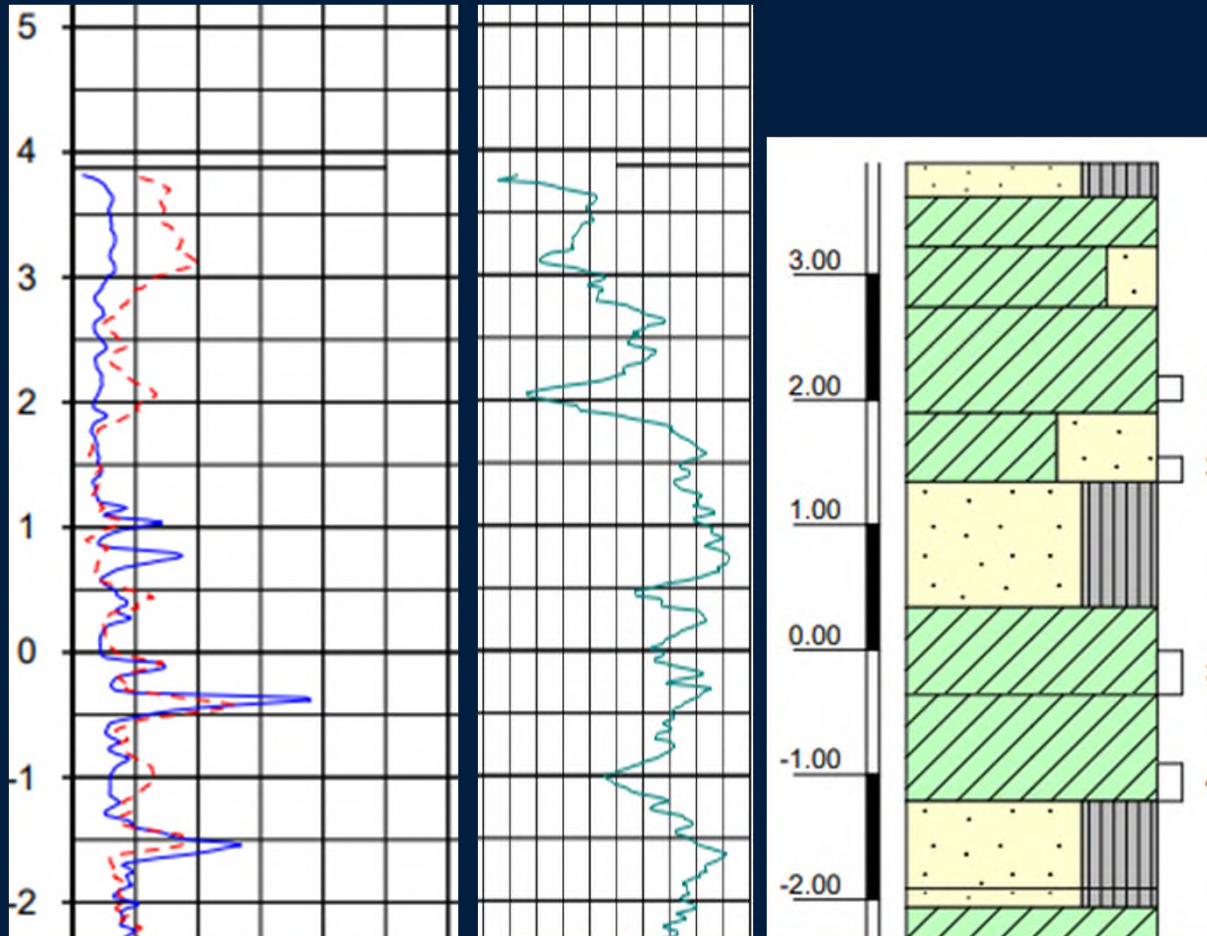
Results BET 2



Data reduction BET 2



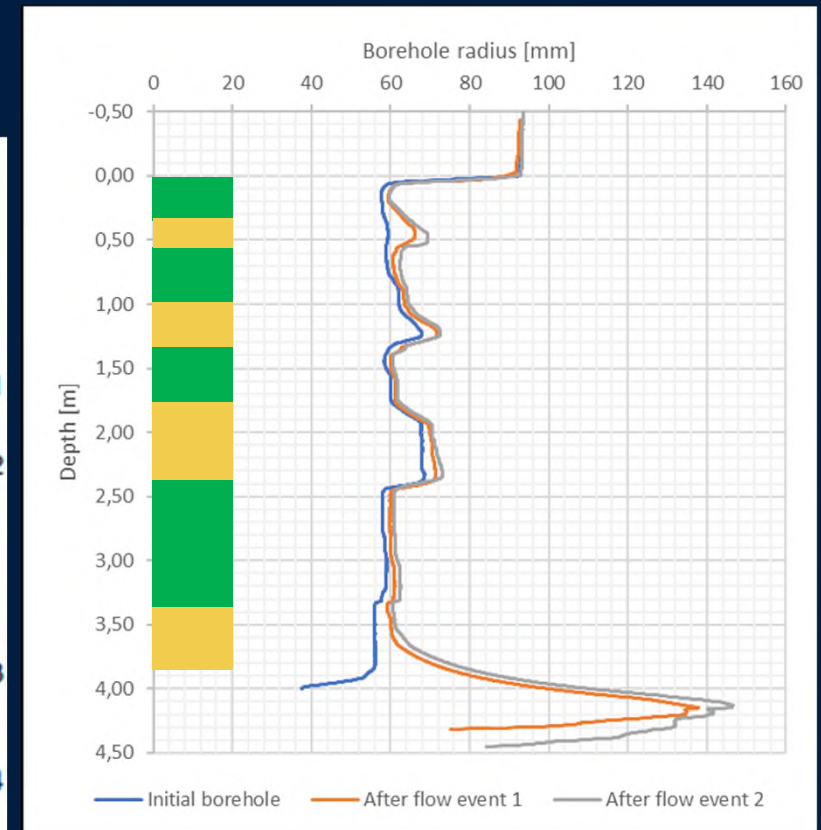
BET 2 vs CPT / borehole identification



cone resistance

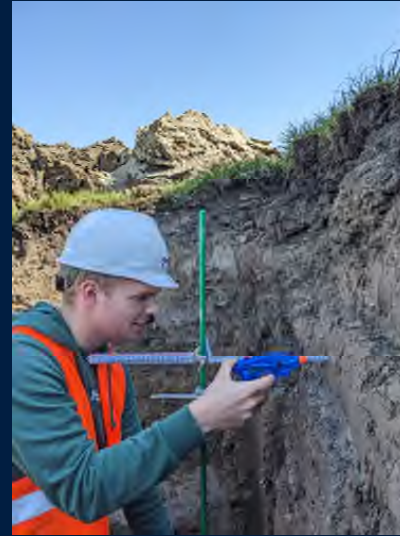
friction
number

borehole



BET 2

Trial pit and Geoscan

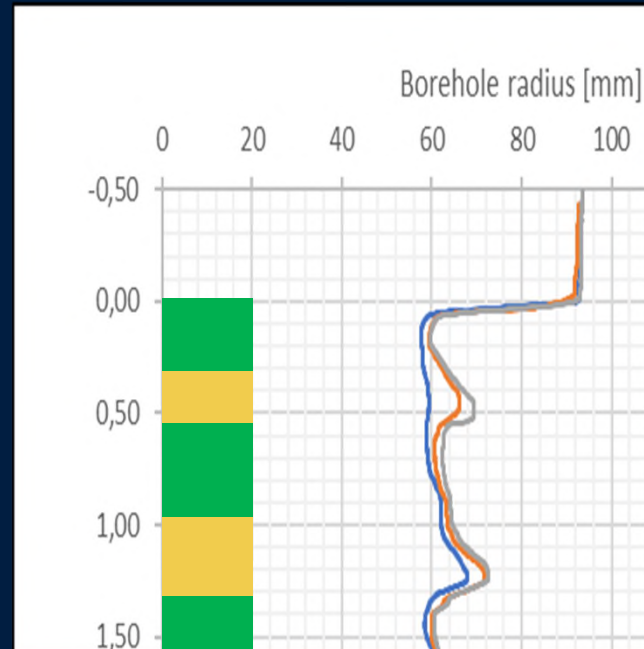


BET 2 vs trial pit observations

clay
 clay, sandy
 clay
 clay, sandy



trial pit
 (source: Hijma)



BET 2 (detail)

	penetrometer [kPa]	torvane [kPa]	pocket erodometer [mm]	water content [%]
	120	55	-	-
	110	50	36	23
	125	60	13	28
	70	45	32	23

Field tests

BET 2 vs soil erosion testing results



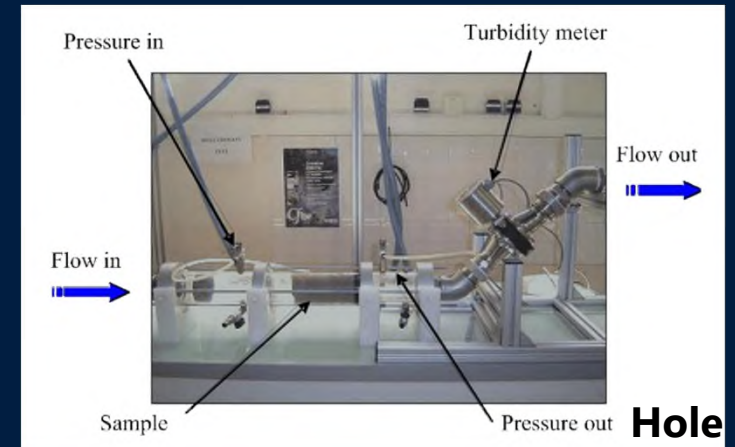
geophyConsult

Parameter estimation

Jet erosion



Hole erosion



Category estimation



Recommendations

Gain experience with the BET in more levees.

Modelling the levee heterogeneity is necessary for levee erosion prediction, but CPTs and borings are not appropriate for detection of erodible layers. The BET is a practical way for soil erosion profiling.

Do more small scale soil erosion tests for parameter estimation.

Soil erosion parameters are necessary for erosion prediction and BET calibration. These soil erosion parameters are not correlated with strength parameters nor with the Dutch 'clay erosion categories'. That is why the understanding and availability of small scale erosion tests should be increased.

Compare Dutch and international erosion prediction models.

The Dutch wave erosion model is mainly based on Delta flume tests, but is not calibrated with small scale soil erosion tests yet. International soil erosion models are well-documented, but have hardly been tested for Dutch practice. It would be interesting to combine the best of both.

The logo features the word 'FUGRO' in a bold, white, sans-serif font. The letter 'F' is significantly larger and stylized, with a horizontal bar extending to the left and a vertical stem that tapers to a point at the bottom. The letters 'U', 'G', 'R', and 'O' are smaller and positioned to the right of the 'F'.

FUGRO

Unlocking Insights
from **Geo-data**