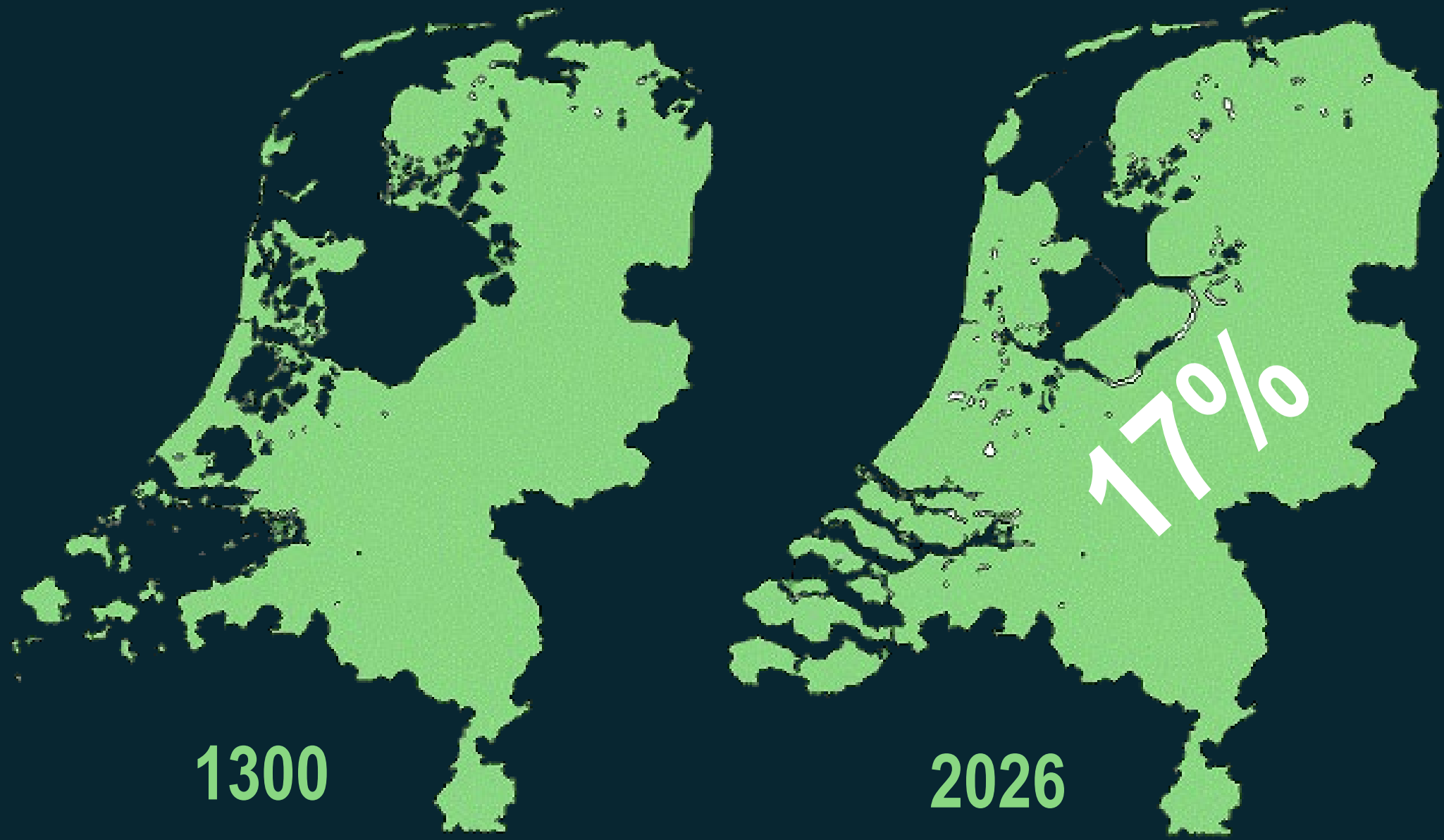
FRAGMENTED FLOOD DEFENCE DATA & DE DIJKATLAS

Maarten Podt | DEMAND Community Event | 27-01-2026

Foto: Chris Biesheuvel


1300
2026
17%

Inventory

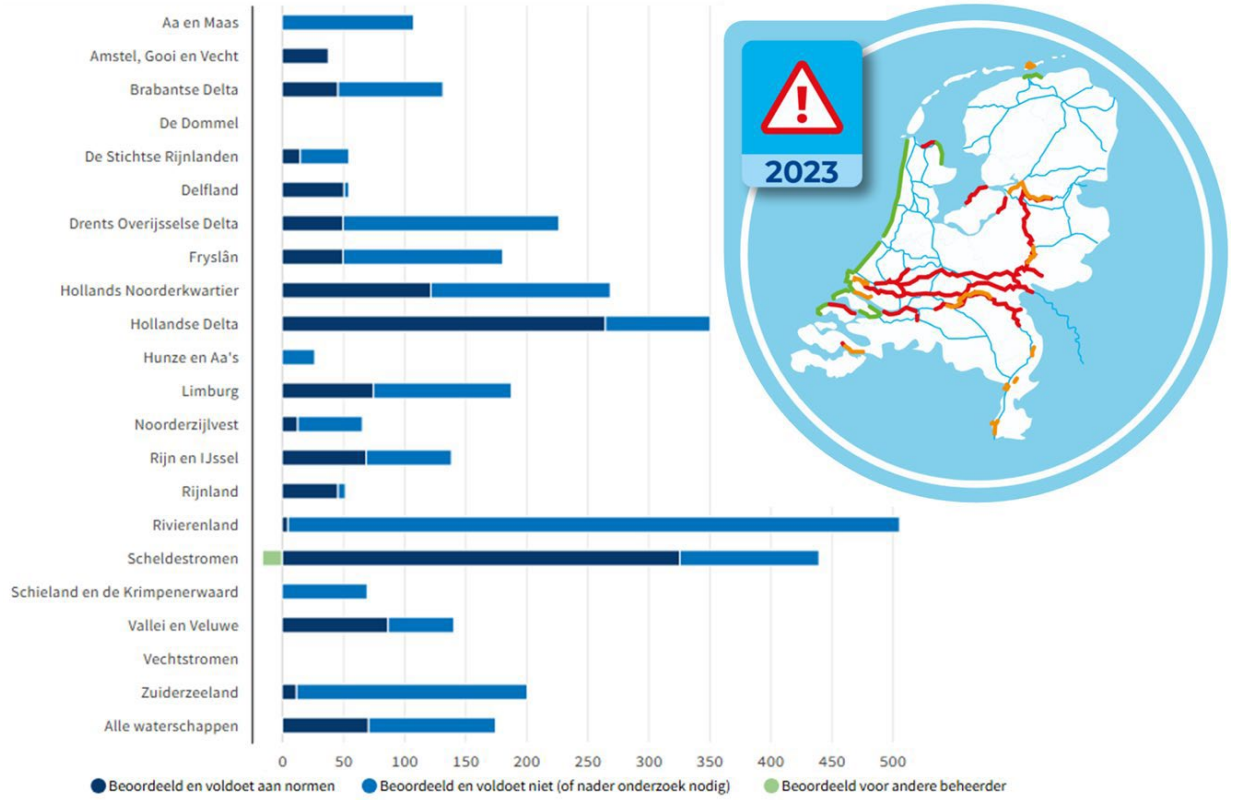
3.700 km primary flood defences

14.000 km secondary flood defences

13 Delta Works

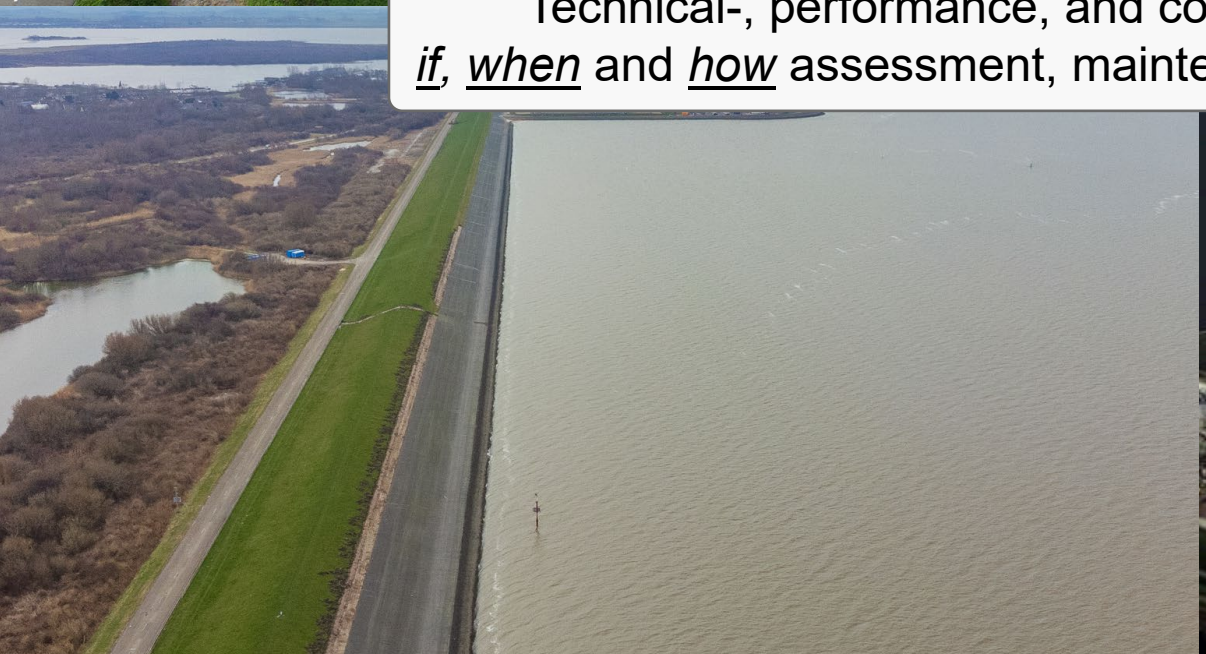
Challenge

Reinforce 1.400km before 2050



Flood defence data are the back-bone of asset management

Technical-, performance, and condition data underpin decisions *if*, *when* and *how* assessment, maintenance or reinforcement are required



Complex institutional context

Multi-used
- Main functionality = flood protection
- Dikes are often located in public space
- Multiple functions, multiple actors

Multi-managed
- Safety norms and supervision by het Rijk (national)
- Operations by the water authorities (regional)
- Reinforcement of dikes by market (public-private)
- Data are generated by multiple actors under different mandates

Multi-financed
- 50% door de Waterschappen (10% + 40% collective)
- 50% door het Rijk

HWBP
voor sterke dijken

Organisational fragmentation

Fragmented technological context

Rapid advancements in data collection
e.g. satellite observations, UAV, in situ sensor networks

Explosive amount of heterogenous data streams
Challenge shift from data collection > data integration

The construction sector is:
- a project-to-project based industry.
  - innovation trickles down slowly, many initiatives remain pilot-based
- collaborative and built on long-term relationships
  - mistrust, fragmented data and fragmented risk harms collaboration
- one of the lowest scoring sectors on the McKinsey industry digitization index (#21 out of 22)

Technological fragmentation

DATA FRAGMENTATION

The unintentional misalignment of flood defence data across organisational, technical, and lifecycle dimensions, resulting in incoherent technical asset representations.

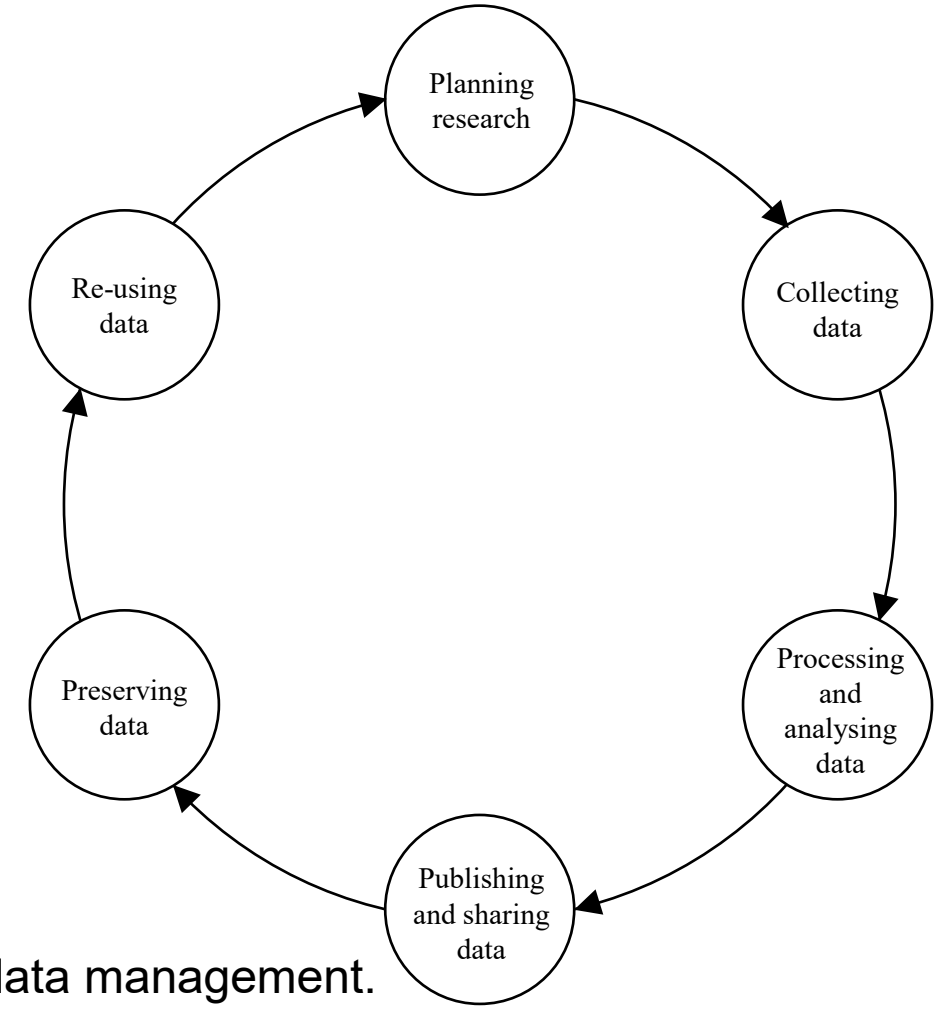
Data flows in Dutch flood defence management

Why?

Substantiate our observations of discontuinities in the data lifecycle with practical experience.

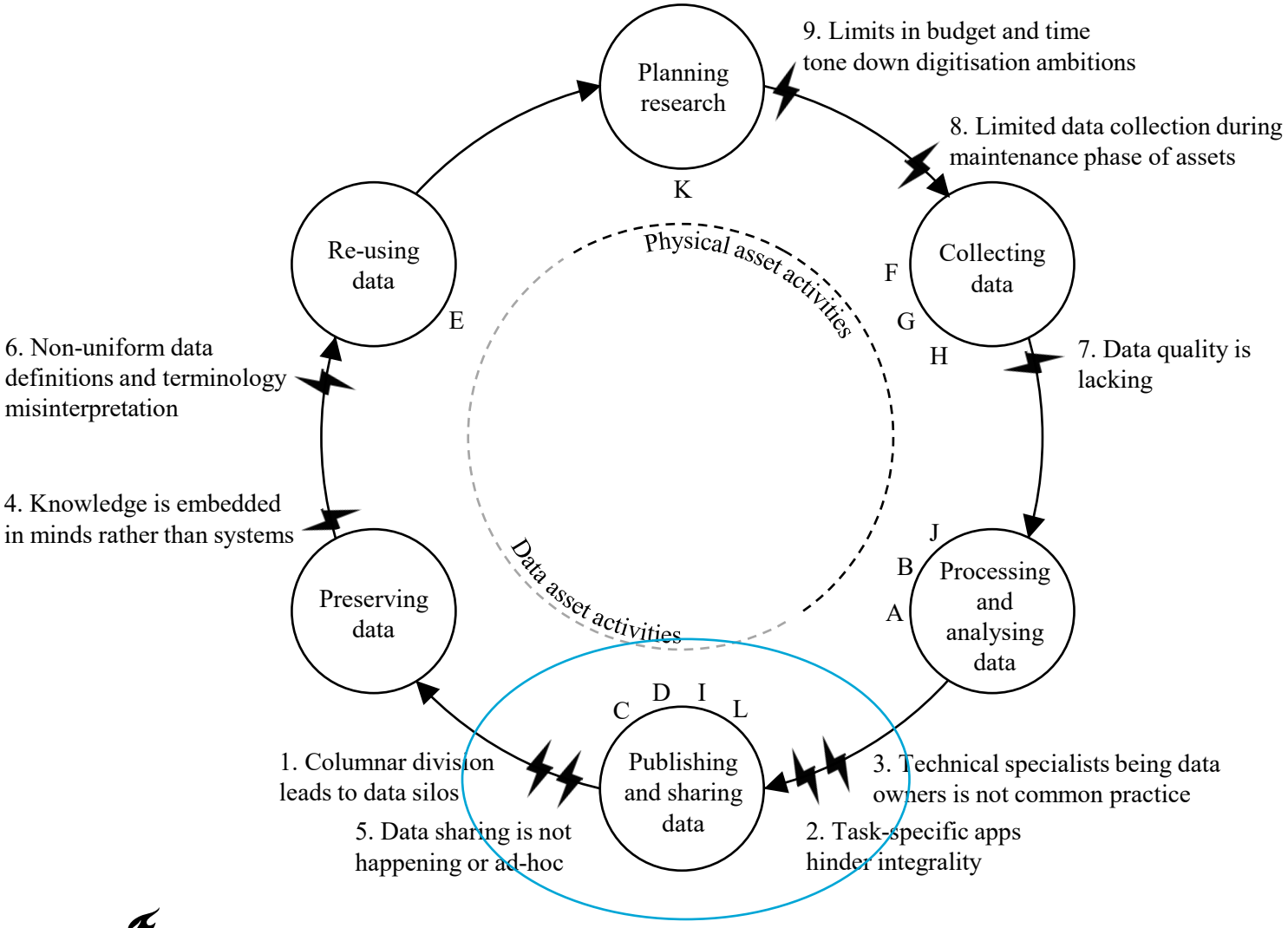
Approach

1. Interviews with data-, information- and asset managers and data governance specialists to understand their data practices.
2. Thematic analysis to identify discontuinities and best practices.
3. Summarised these BP and DC on the data life cycle framework.



A framework for good data management. Data lifecycle (UK Archive, 2019)

Data flows in Dutch flood defence management



Conclusion

Most discontinuities on the transition of physical asset management and data asset management.

Water authorities struggle with the more ‘abstract’ data activities.

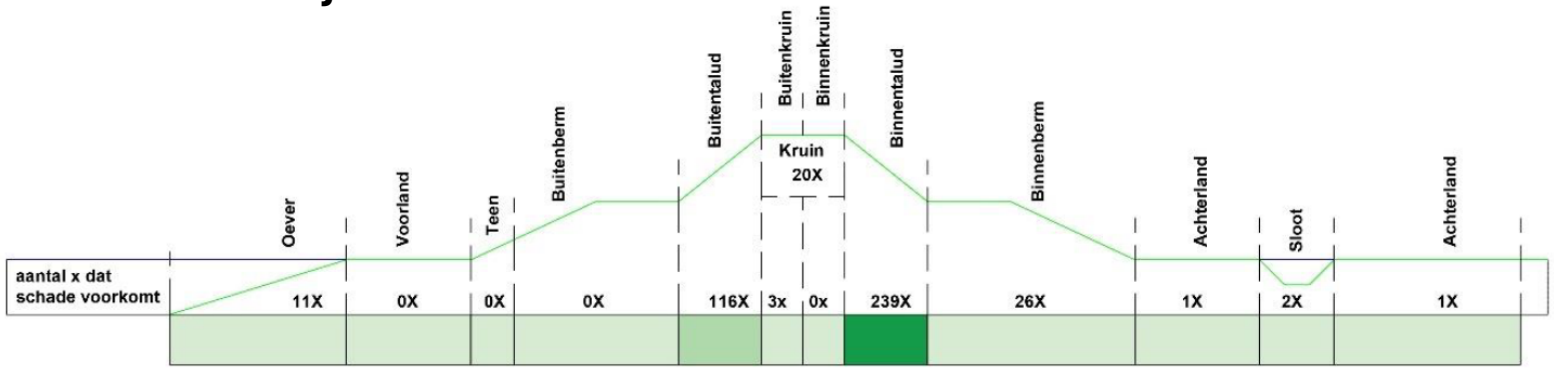
Podt en Rijke (2024)

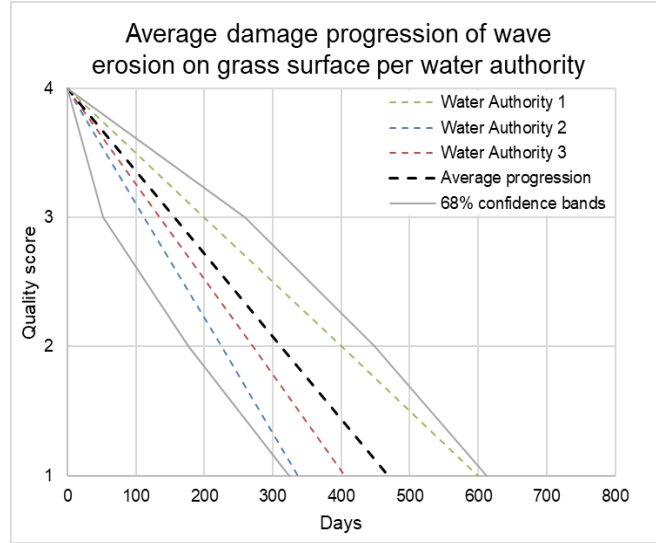
Table 3: Summary of best practices

#	Best practice	Relates to…
A	Stay clear of data warehouses that are set up for one specific question or need.	Processing and analysing data
B	Work from a data lake that stores data in its original, machine-interpretable format to allow for data science and AI analysis.	Processing and analysing data
C	Create an organisation-wide ‘single point of truth’ conform the FAIR principles and let it be managed by technical specialists.	Publishing and sharing data
D	Formulate a business case so data owners and process owners understand the necessity of data sharing and cooperate willingly.	Publishing and sharing data
E	Align data jargon through data dictionaries and data dashboards.	Re-using data
F	Expand standardised data models only with data fields that benefit all users.	Collecting data
G	Use collective data models as a minimum and add organisation specific fields.	Collecting data
H	Set minimum data quality rules per asset and make the asset owner responsible.	Collecting data
I	Create data quality dashboards to gain organisation-wide insight into data quality and data reliability.	Publishing and sharing data
J	To ensure continuity in data management, relieve technical specialists from data management tasks.	Processing and analysing data
K	Work with ‘data result managers’ who are responsible for deciding which information needs are invested in.	Planning research
L	Have regular meetings with other water authorities to share data practices to see where the organisation is lagging or excelling.	Publishing and sharing data

ADDED WITH EXPERIENCES

1. **Dataset Dijkveroudering**
2. **Prometheus**
3. **Taaie Dijken Klimaatrobuust**





Detail, volume, and availability varies greatly

Large variety of loosely applied data standards

A uniform, national and public technical dike dataset is missing

DE DIJKATLAS

SRM_

Technical dike data in the Netherlands

Water authorities are legally obliged (Woo) to manage and passive and actively share their dike data.
They do this in two ways:

1. through the **Legger:** presents the legal status of the flood defence
2. through the **Beheerregister:** presents the factual status of the flood defence

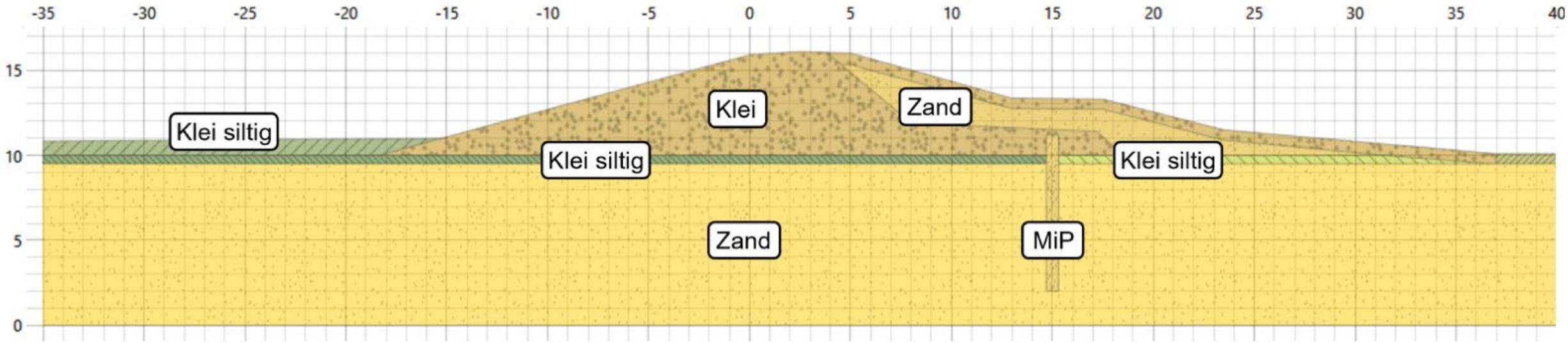
Until today it remains not well defined

Faalpad	Kruinhoogte	Kruinbreedte	Taluds	Binnenberm	Buitenberm	Ondergrond	Kern-materiaal	Bekleding toplaag	Bekleding onderlaag	Deklaag	Intreepunt	Uittreepunt	Dam- en diepwanden	Kabels- en leidingen	Kunst-werken
Overslag > erosie binnentalud > erosie kern	x	x	x		x		x	x	x						
Piping > zandmeevoerende wel > pipe > erosie				x		x	x			x	x	x			
Macrostabiliteit BI > afschuiven > erosie kern	x	x	x	x	x	x	x			x			x	x	x
Macrostabiliteit BU > afschuiven > erosie kern	x	x	x		x	x	x			x			x	x	x
Falen van bekleding > erosie kern			x				x	x	x						x

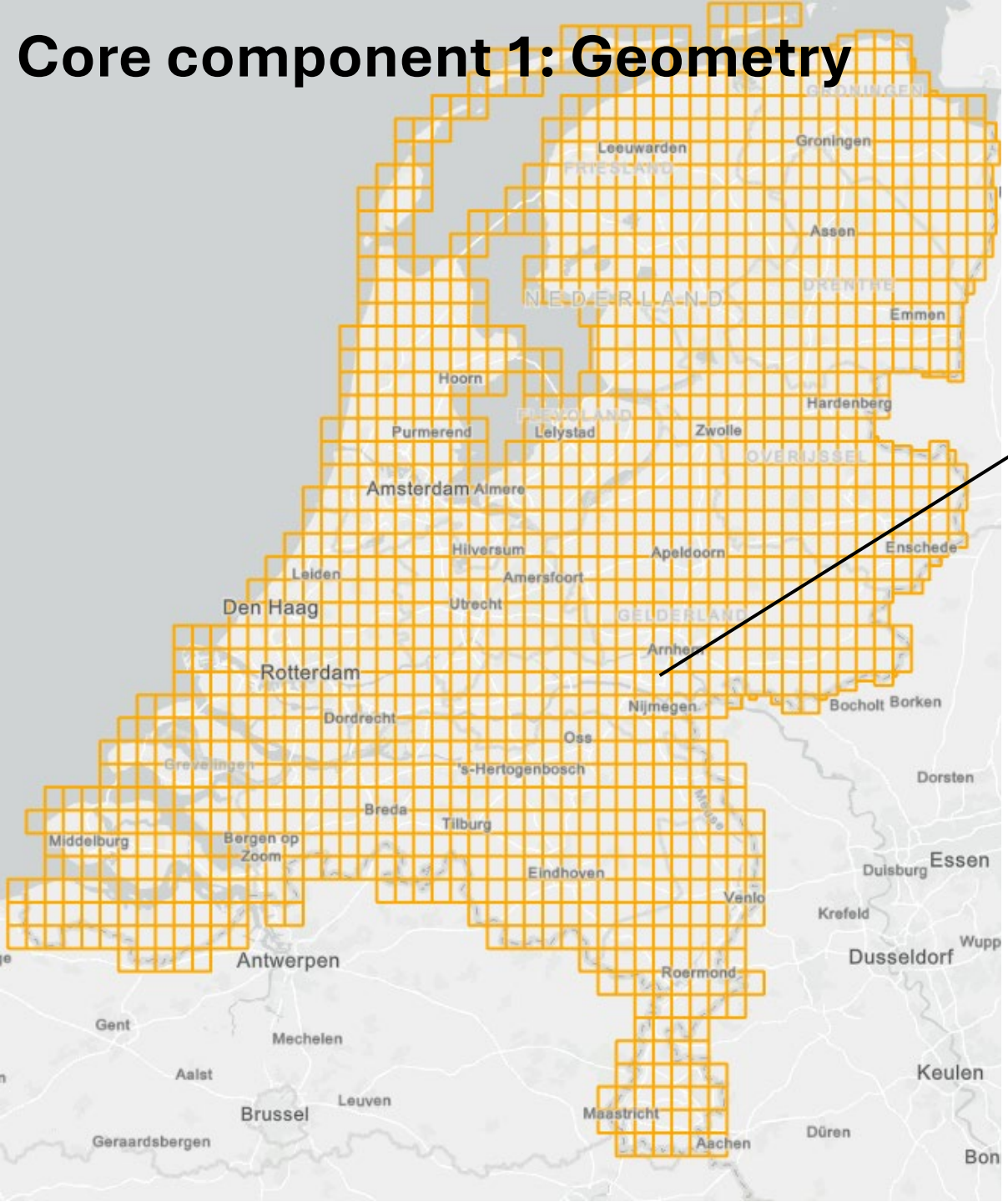
IDEA: combine all beheerregisters!

The 3 core components of the Dijkatlas

1. **Geometry**: kink lines from AHN
2. **Construction**: soil types from cone penetration tests from BRO
3. **Subsurface**: soil types to 50m deep from GeoTOP

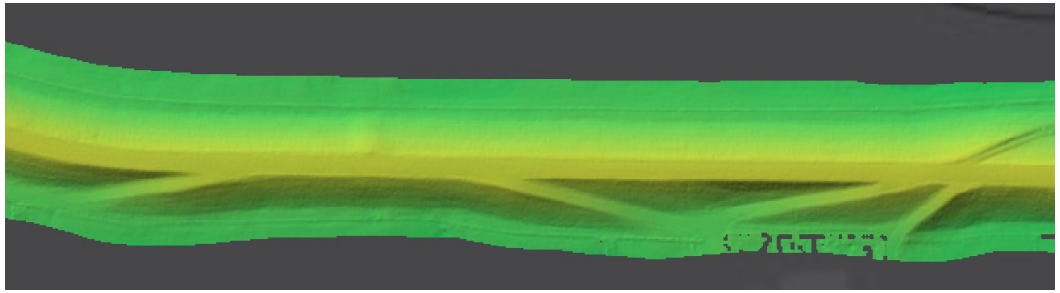


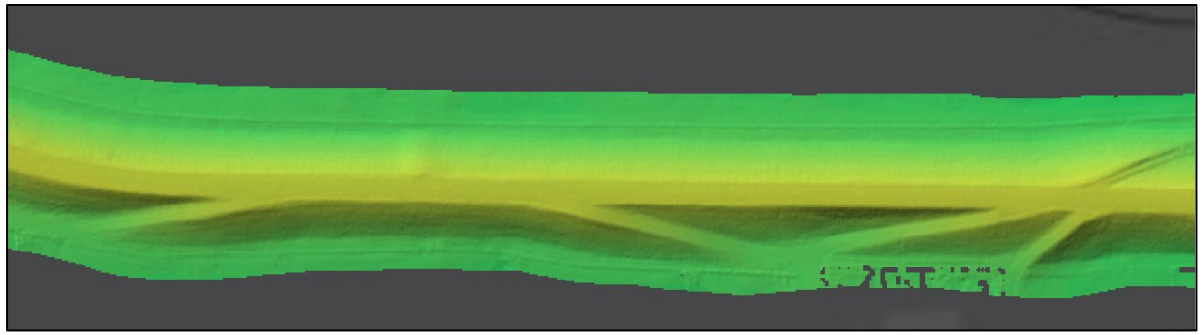
Core component 1: Geometry

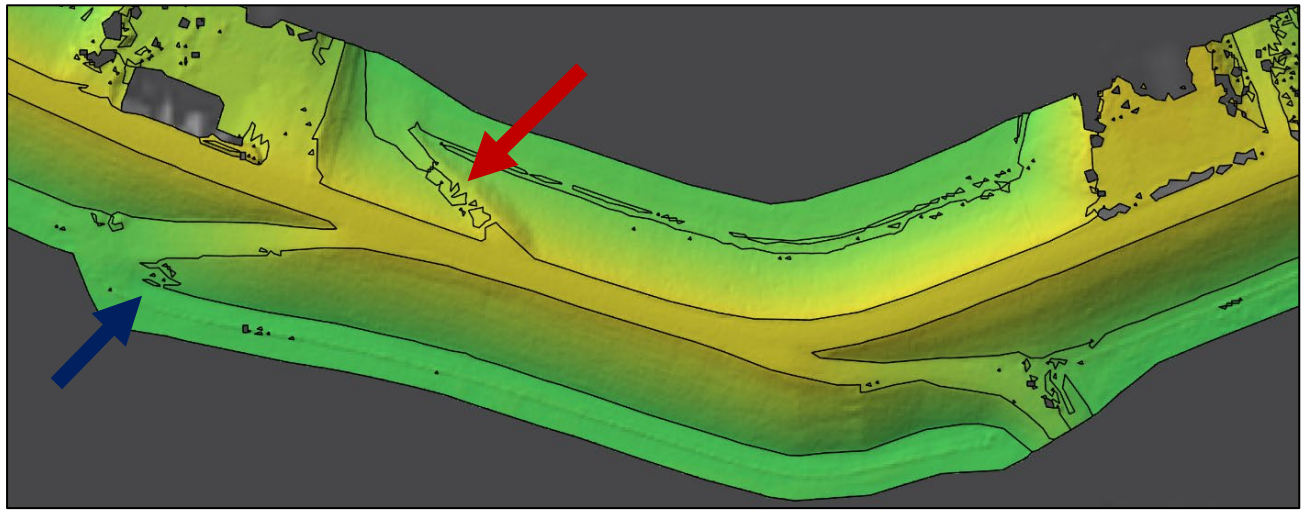


x 342 ≈ 740GB

1. Select kaartbladen
2. Bulk download > unzip > flatten
3. Mosaic flattened rasters
4. Mask on Waterstaatswerken +6m polygon

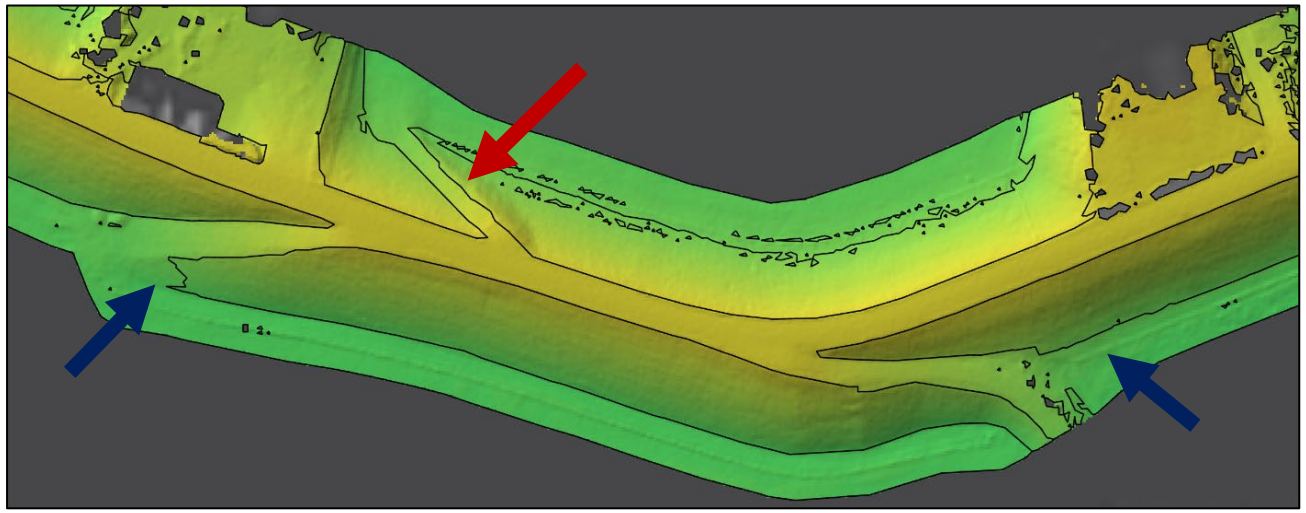






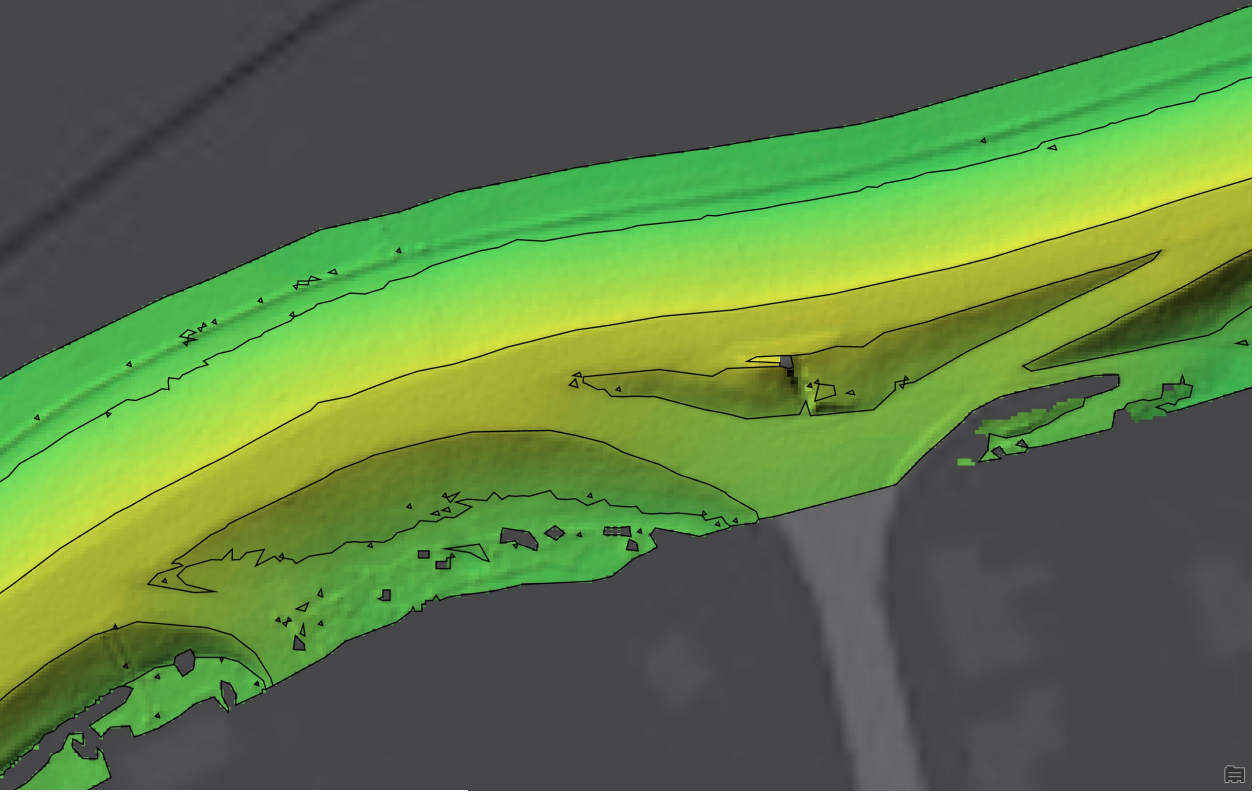
Binary classification with a break on **10** degrees

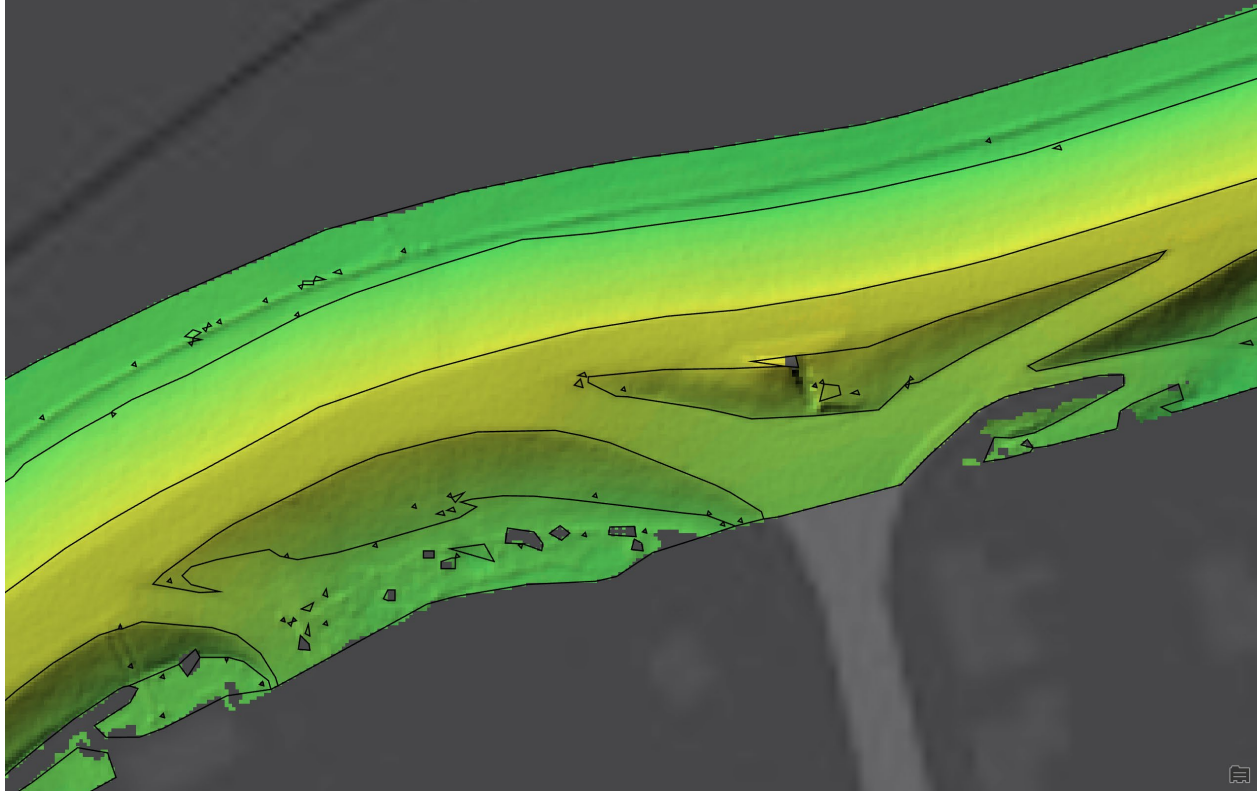
- Slope distinction on 1 : 5.7m
- Does not account well for access ramps
- Toe lines are clear in general.

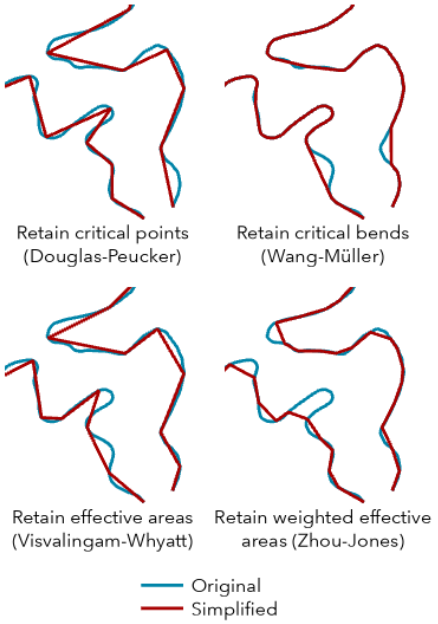


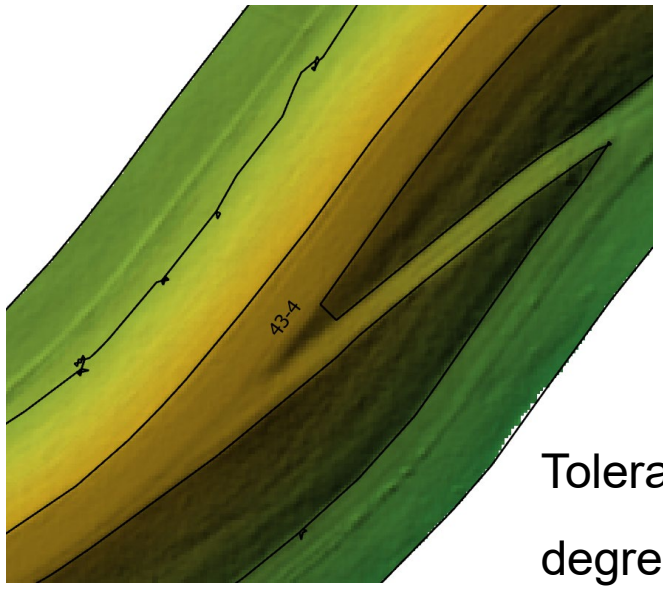
Binary classification with a break on **12** degrees

- Slope distinction on 1 : 4.7m
- Access ramps are generally clear
- Toe lines start to creep up



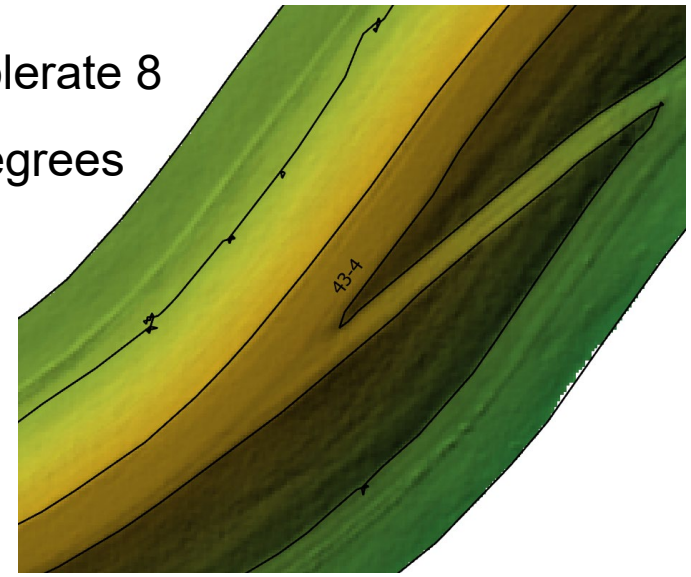


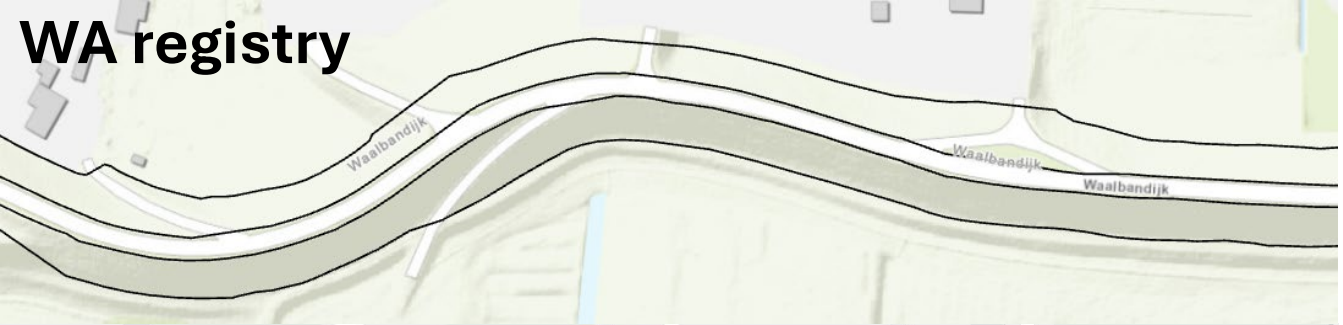


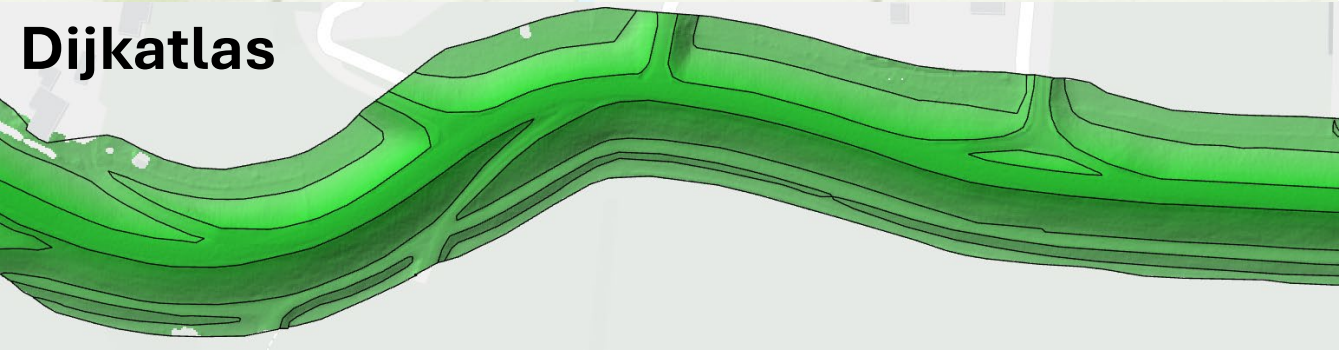


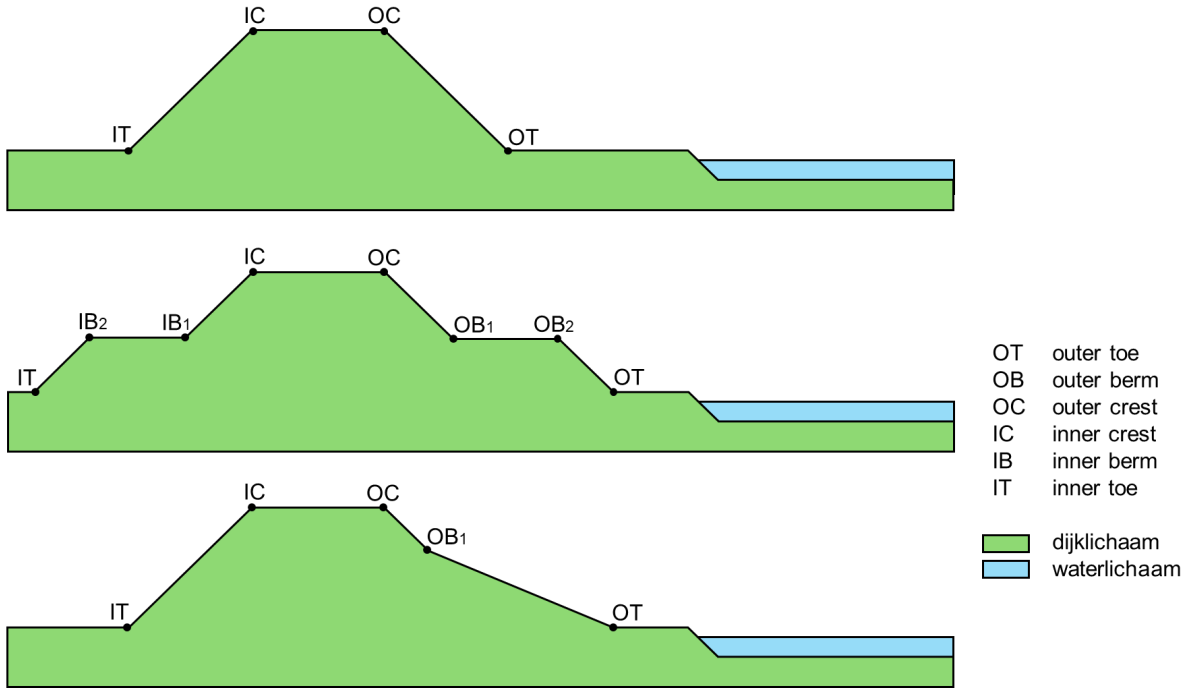
Tolerate 10 degrees

Tolerate 8 degrees




WA registry
Waalbandijk
Waalbandijk
Waalbandijk


Dijkatlas


IC
OC
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IC
OC
IB2
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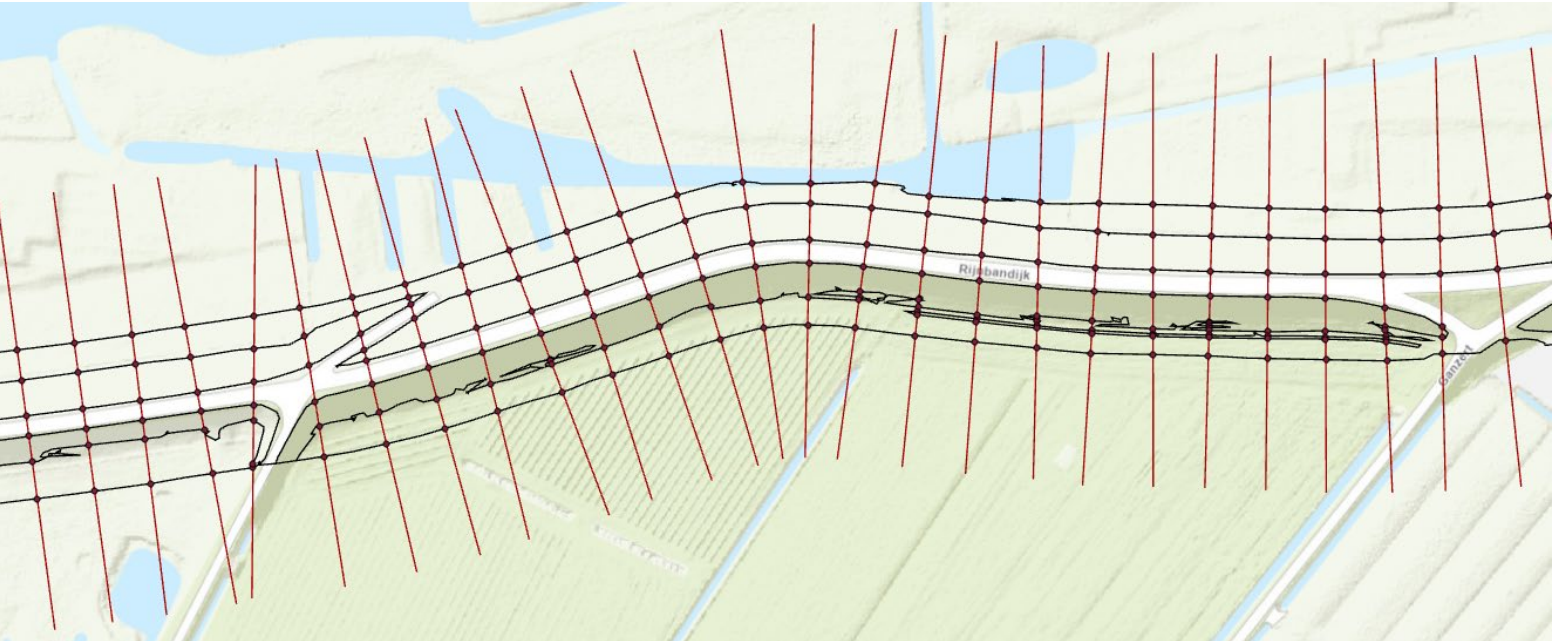
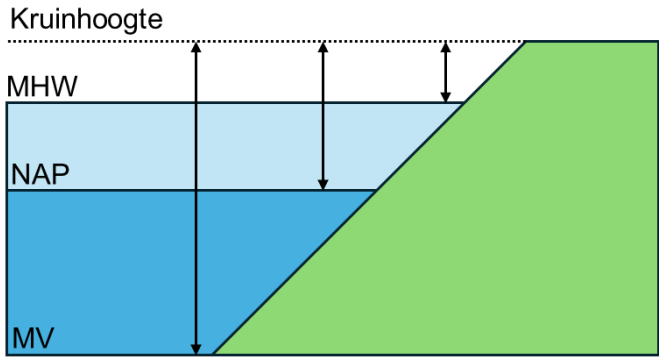
OB1
OB2
IT
OT
IC
OC
OB1
IT
OT
OT outer toe
OB outer berm
OC outer crest
IC inner crest
IB inner berm
IT inner toe
dijklichaam
waterlichaam


Rijksbandijk

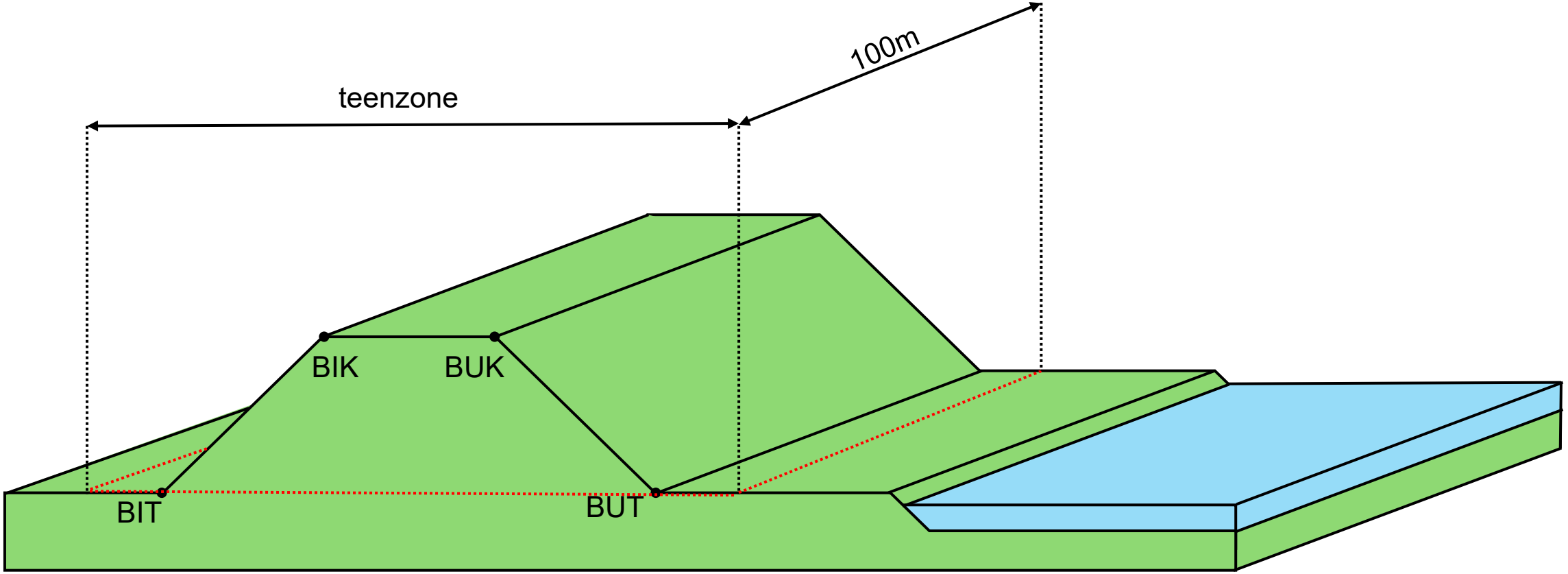

Kruinhoogte
MHW
NAP
MV

Van sonderingen naar kernmateriaal

Normtrajecten opgedeeld in uniforme dijkvakken van 100m.

Het contour van de dijkvakken is de teenzone. Marge iets buiten de teen.

Per dijkvakcontour het laagste punt



CPT to material construction

N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
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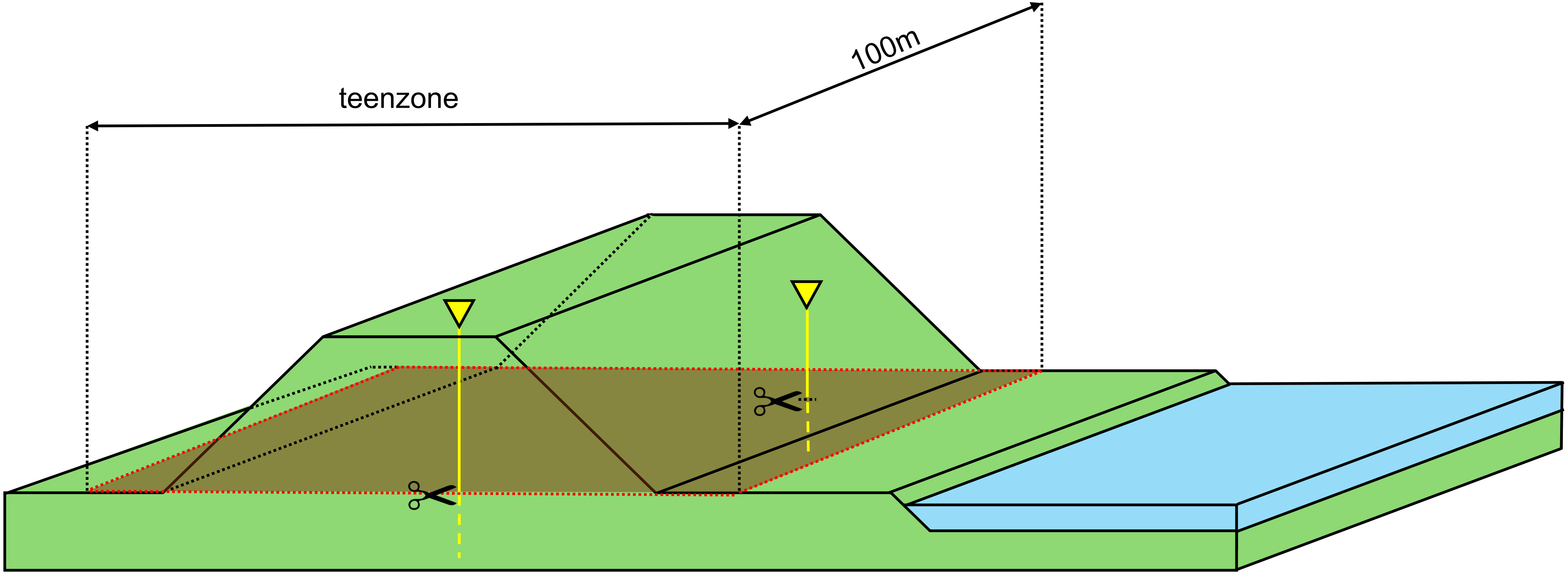


DB Browser for SQLite - C:\Users\ztude\Downloads\brocptvolledigeset_v2_0\brocptvolledigeset_v2_0.gpk

File Edit View Tools Help

New Database | Open Database | Write Changes | Revert Changes | Open Project

Database Structure | Browse Data | Edit Pragmas | Execute SQL

Table: bro_point

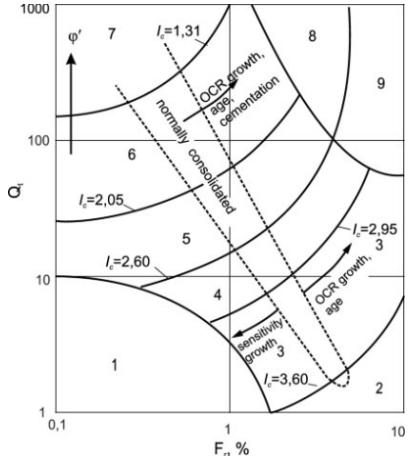
	bro_point_pk	bro_location_fk	x_or_lon	y_or_lat
	Filter	Filter	Filter	Filter
1	1	1	3.2966272500000	51.822102050000
2	2	2	3.3432876100000	51.812445010000
3	3	3	3.8482662600000	51.974124050000
4	4	4	3.8716477000000	51.980148280000
5	5	5	3.8409122900000	51.984130080000
6	6	6	3.7950779400000	51.978712030000
7	7	7	3.7454294700000	51.978767020000
8	8	8	3.8378427000000	51.992091190000
9	9	9	3.7960925200000	51.995698520000
10	10	10	3.8851212000000	52.001824540000
11	11	11	3.7635798800000	52.005822030000
12	12	12	3.8264221000000	52.042585300000

2cm tot 5mm

Cone resistance
Local friction
Friction ratio

CPT - CPT000000096117

OBJECTID	3611
bro_id	CPT000000096117
x	101524.76
y	433718.83
CPT tov nap	5.33
teen tov nap	-1.7748
hoogte tov teen	7.1048
% klei	72%
deklaag	0.7
kleidrempelhoogte	4.42



% soil type for each CPT,
cut-off on the lowest toe plane

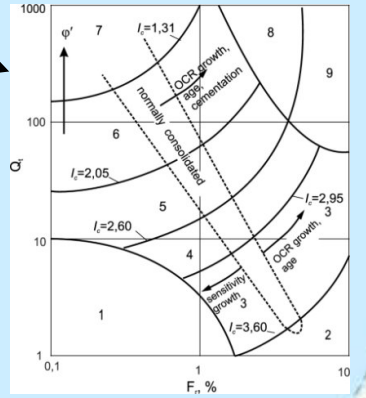
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	bro_id	x	y	CPT tov nap	teen tov nap	hoogte tov t	% klei	deklaag	kleidrempe	2	3	4	5	6	7	-1 c
2	CPT000000	126829.3	441340.5	0.653	0.0303	0.6227	0%	0.7	0	93%	0%	0%	0%	0%	0%	7%
3	CPT000000	127879	442462.2	1.983	1.0231	0.9599	0%	0.7	0	66%	34%	0%	0%	0%	0%	0%
4	CPT000000	127912.5	442510.1	1.81	1.0231	0.7869	0%	0.7	0	9%	60%	31%	0%	0%	0%	0%
5	CPT000000	136393.7	445380.8	1.864	1.662	0.202	0%	0.7	0	100%	0%	0%	0%	0%	0%	0%
6	CPT000000	138361.1	442934.4	3.42	1.1555	2.2645	0%	0.7	0	100%	0%	0%	0%	0%	0%	0%
7	CPT000000	138428.9	442700.1	3.634	1.3942	2.2398	0%	0.7	0	76%	24%	0%	0%	0%	0%	0%
8	CPT000000	138540	442453.8	2.7	1.704	0.996	0%	0.7	0	84%	16%	0%	0%	0%	0%	0%
9	CPT000000	119280.5	562012.7	3.78	1.563	2.217	0%	0.7	0	2%	98%	0%	0%	0%	0%	0%
10	CPT000000	116704.6	560207.6	7.655	0.4037	7.2513	65%	0.7	4.01	0%	19%	15%	65%	0%	0%	0%
11	CPT000000	118918.2	561613.5	6.224	0.2778	5.9462	0%	0.7	0	4%	81%	15%	0%	0%	0%	0%
12	CPT000000	119443.6	562171	6.416	0.409	6.007	25%	0.7	0.8	2%	38%	35%	25%	0%	0%	0%
13	CPT000000	115683.1	558897.6	7.518	0.4058	7.1122	40%	0.7	2.14	0%	21%	38%	40%	0%	0%	0%
14	CPT000000	116335.3	559730.3	7.38	0.3748	7.0052	60%	0.7	3.5	0%	40%	0%	57%	3%	0%	0%
15	CPT000000	120024.3	562815.7	7.788	0.351	7.437	77%	0.7	5.03	0%	18%	6%	73%	4%	0%	0%
16	CPT000000	120450.1	563237.5	7.633	0.2967	7.3363	38%	0.7	2.09	11%	46%	4%	38%	0%	0%	0%
17	CPT000000	120508.7	563717	7.696	0.334	7.362	61%	0.7	3.79	0%	39%	1%	58%	3%	0%	0%
18	CPT000000	110337.7	434931.1	5.8	-1.4666	7.2666	0%	0.7	0	27%	72%	1%	0%	0%	0%	0%
19	CPT000000	110338.5	434916.2	4.5	-1.4666	5.9666	0%	0.7	0	59%	39%	2%	0%	0%	0%	0%
20	CPT000000	121287.1	565110.8	5.184	0.0102	5.1738	42%	0.7	1.47	0%	25%	33%	42%	0%	0%	0%
21	CPT000000	121306.6	565116.4	5.066	0.0319	5.0341	6%	0.7	-0.4	3%	59%	32%	6%	0%	0%	0%
22	CPT000000	121347.9	565130	4.951	0.0319	4.9191	40%	0.7	1.27	0%	8%	51%	40%	0%	0%	0%
23	CPT000000	121359.8	565134.2	4.939	0.0319	4.9071	57%	0.7	2.1	1%	0%	42%	53%	4%	0%	0%
24	CPT000000	121775.3	565496.9	5.165	0.215	4.95	13%	0.7	-0.06	1%	50%	37%	13%	0%	0%	0%
25	CPT000000	121798.6	565524.6	5.237	0.215	5.022	57%	0.7	2.16	0%	32%	11%	57%	0%	0%	0%
26	CPT000000	121815.1	565543.7	5.171	0.215	4.956	47%	0.7	1.63	0%	11%	43%	47%	0%	0%	0%
27	CPT000000	121744.3	565460.2	5.248	0.2415	5.0065	39%	0.7	1.25	6%	25%	30%	39%	0%	0%	0%
28	CPT000000	121756.1	565474	5.203	0.2415	4.9615	21%	0.7	0.34	1%	2%	77%	21%	0%	0%	1%
29	CPT000000	109913.1	426731	3.1	1.0455	2.0545	0%	0.7	0	70%	30%	0%	0%	0%	0%	0%
30	CPT000000	112455.2	558396	6.42	1.2562	5.1638	18%	0.7	0.23	0%	19%	63%	18%	0%	0%	0%
31	CPT000000	112537.3	558358	6.17	0.4559	5.7141	56%	0.7	2.5	9%	28%	7%	56%	0%	0%	0%
32	CPT000000	112713.2	558266.4	6.2	0.261	5.939	61%	0.7	2.92	3%	28%	8%	61%	0%	0%	0%
33	CPT000000	112625.9	558312.6	6.24	0.274	5.966	51%	0.7	2.34	2%	24%	22%	51%	0%	0%	0%
34	CPT000000	112887.8	558167.1	6.24	0.3709	5.8691	14%	0.7	0.12	0%	37%	48%	14%	0%	0%	0%
35	CPT000000	113244.5	557998.5	3.69	0.256	3.434	43%	0.7	0.78	8%	44%	6%	43%	0%	0%	0%
36	CPT000000	113247.8	558006.6	6.56	0.256	6.304	32%	0.7	1.32	0%	16%	52%	32%	0%	0%	0%
37	CPT000000	113157.8	558037.1	6.55	0.256	6.294	9%	0.7	-0.13	11%	47%	33%	9%	0%	0%	0%
38	CPT000000	113425.7	557930.3	6.02	0.295	5.725	60%	0.7	2.74	0%	12%	28%	60%	0%	0%	0%
39	CPT000000	113507.4	557871.8	4.92	0.228	4.692	33%	0.7	0.85	1%	26%	41%	33%	0%	0%	0%

Potential ductility in dikes

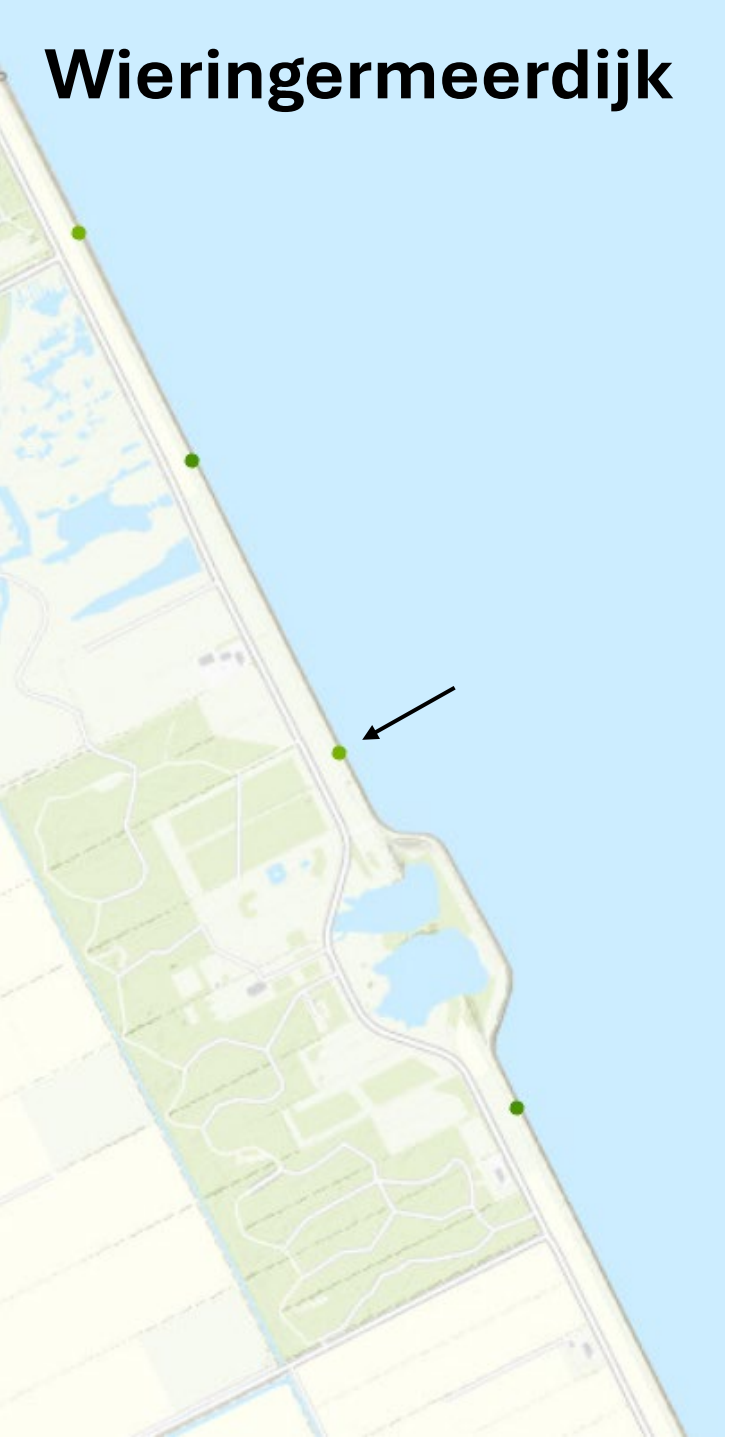
Waarom nu veel meer groen / potentiële taaiheid?

1. Enkel de kruinsonderingen
2. Verbeterde interpretatie van de genormaliseerde Robertson
3. Kleidrempels > erosiebestendige drempels

Robertson zones	Beschrijving Robertson	Interpretatie	Kleur code	Erosie-bestendig
1	Sensitive, fine grained	Gevoelige klei		
2	Clay organic	Veen		?
3	Clay & silty clay	Klei		✓
4	Silt mixtures	Silt / leem		
5	Sand mixtures	Kleiig zand		
6	Sands clean and silty	Zand		
7	Dense to gravelly sand	Grindig zand		
8	Stiff sand to clay sand*	Compact zand (verkit)		✓
9	Stiff fine grained*	Compacte klei		✓



Wieringermeerdijk



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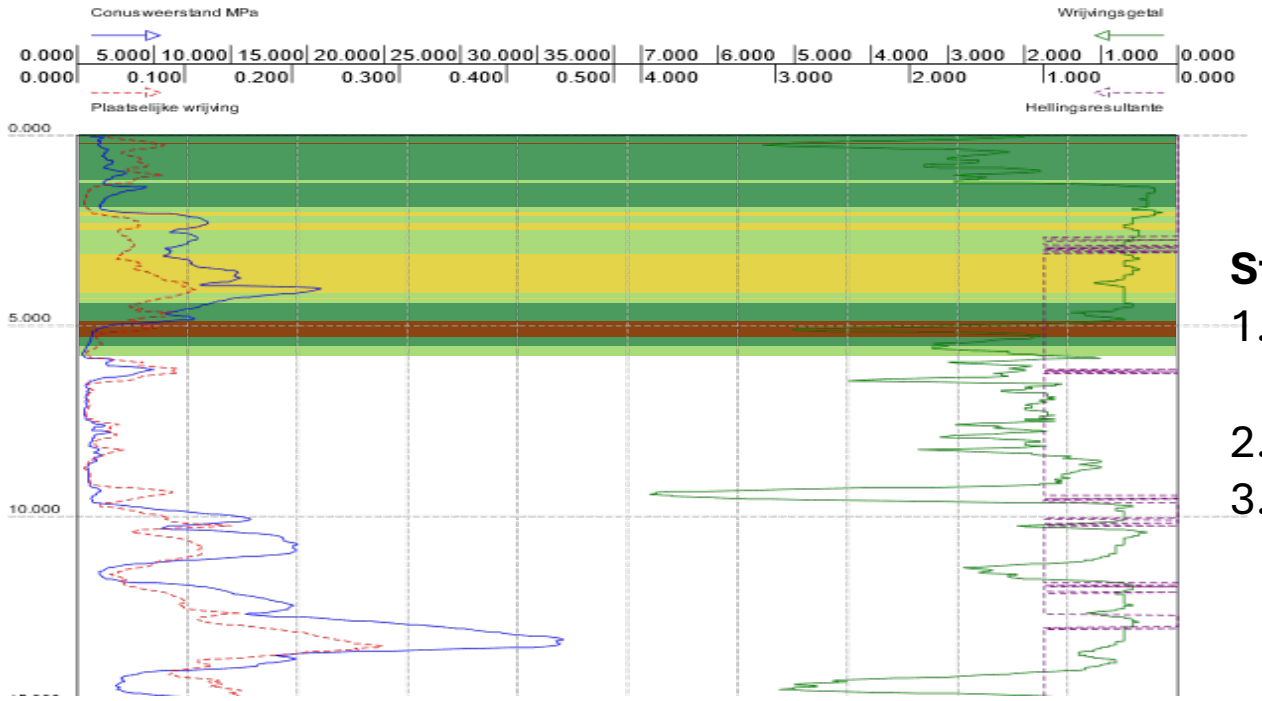
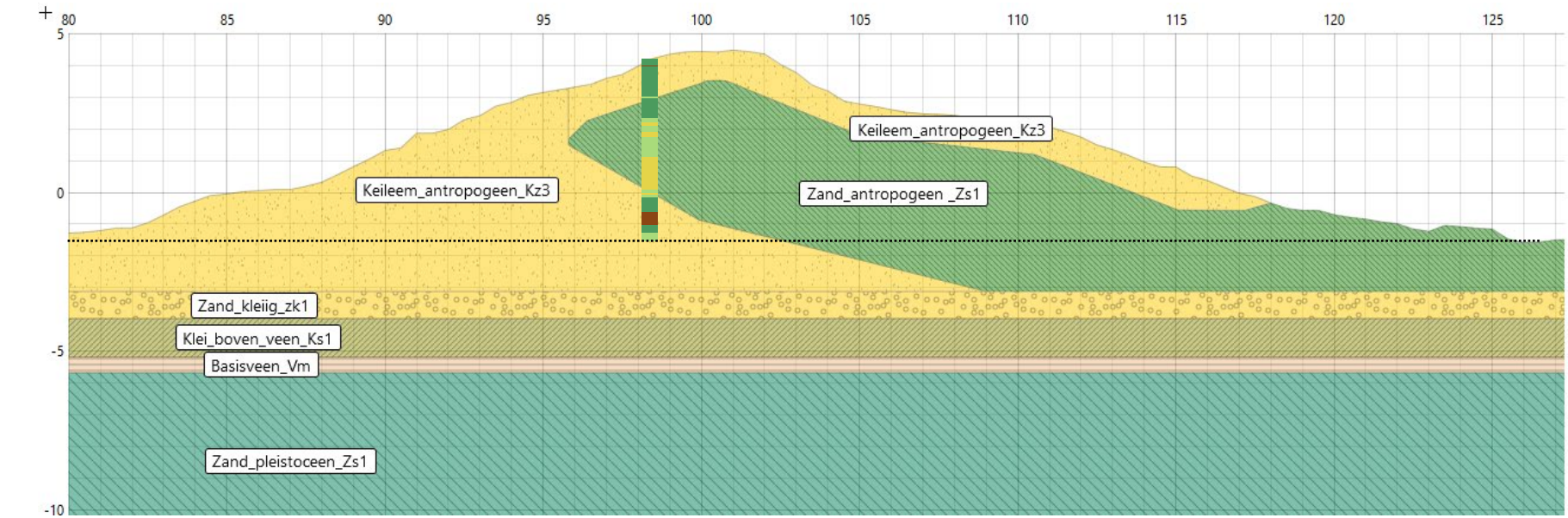


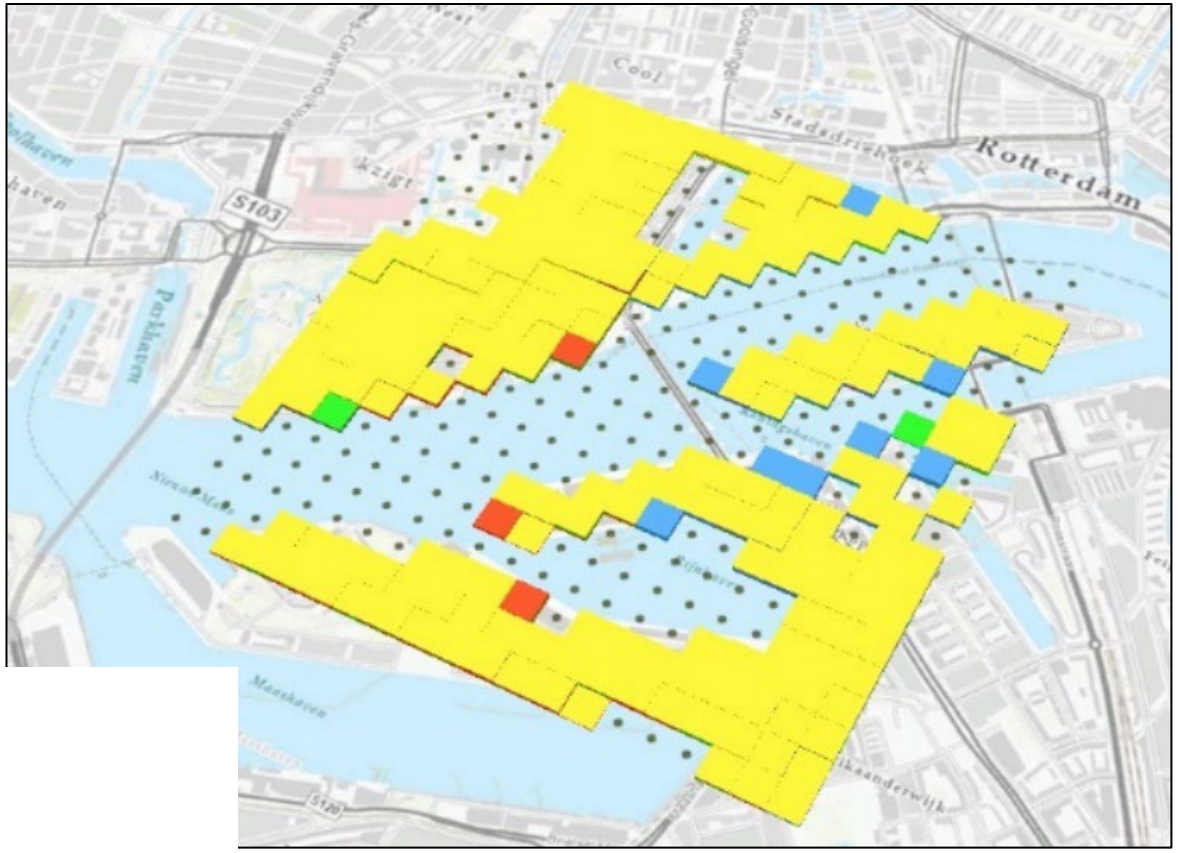
Stappen per case

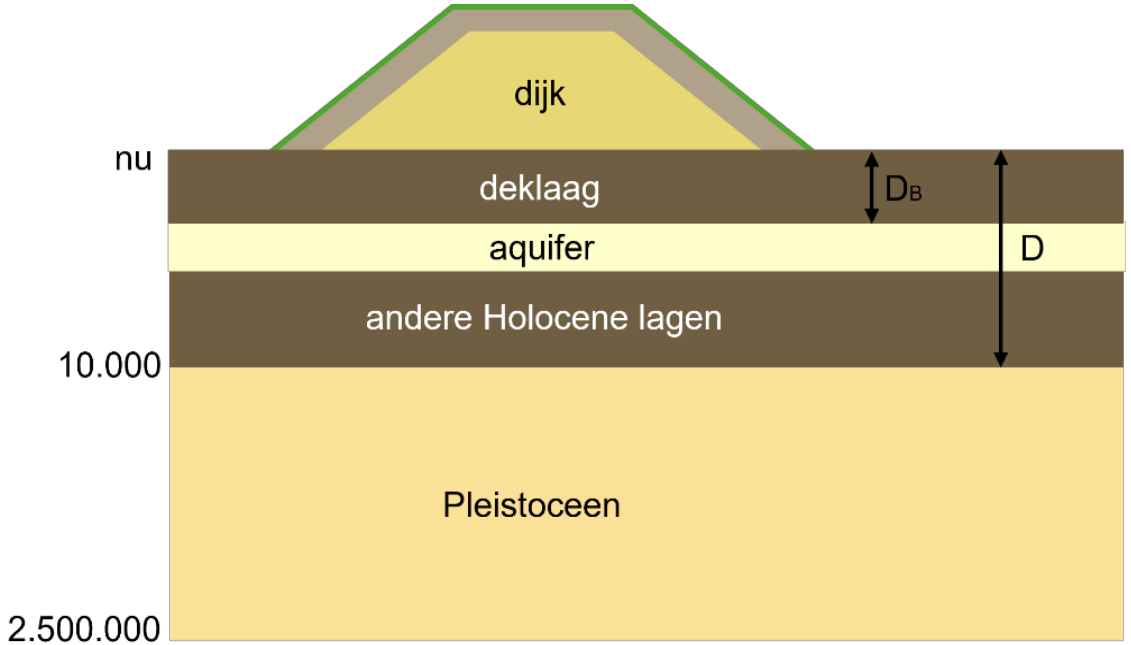
1. Robertson classificatie (qc en fs)
2. Afsnijden op teen (mv)
3. Valideren met
   a) Geotechnisch dwarsprofiel
   b) Sondeerstaat



Coomponent 3: subsurface

Grid_Compressed_data - 3	
x	139000
y	441500
(0, ' t.o.v. mv')	3
(-0.5, ' t.o.v. mv')	3
(-1.0, ' t.o.v. mv')	2
(-1.5, ' t.o.v. mv')	2
(-2.0, ' t.o.v. mv')	2
(-2.5, ' t.o.v. mv')	1
(-3.0, ' t.o.v. mv')	2
(-3.5, ' t.o.v. mv')	1
(-4.0, ' t.o.v. mv')	1
(-4.5, ' t.o.v. mv')	2
(-5.0, ' t.o.v. mv')	1
(-5.5, ' t.o.v. mv')	3
(-6.0, ' t.o.v. mv')	3
(-6.5, ' t.o.v. mv')	6
(-7.0, ' t.o.v. mv')	6
(-7.5, ' t.o.v. mv')	1
(-8.0, ' t.o.v. mv')	7
(-8.5, ' t.o.v. mv')	7
(-9.0, ' t.o.v. mv')	7
(-9.5, ' t.o.v. mv')	1
(-10.0, ' t.o.v. mv')	7
(-10.5, ' t.o.v. mv')	2





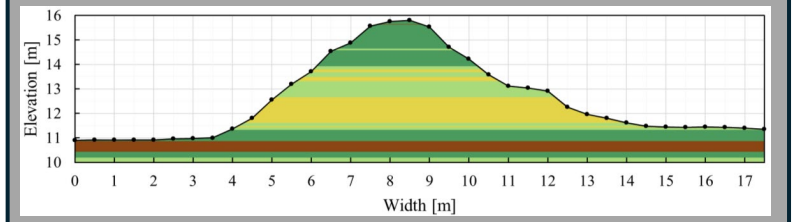
De Dijkatlas

A technical dike dataset as a platform for automated safety assessment, parametric dike design, and predictive maintenance.
Three **Proof-of-Concepts** to demonstrate the importance of robust data management and high-quality data collection.

Automated safety assessment

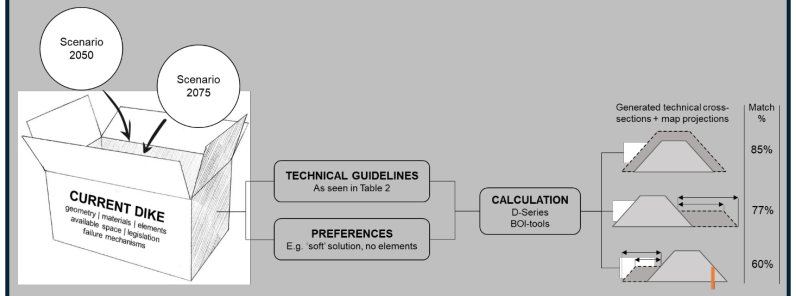
RAAK-Pub Dijken van Data

1. Software integration
2. GEOLIB for Dijkatlas output as input for modelling software.
3. Validation: 20+ steekproeven vergelijken met WBI2017/2023-beoordelingen
4. Expert-testcases: waterkeringsbeheerders aan het roer van de Dijkatlas



Parametric design

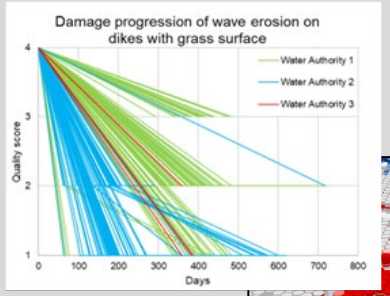
Technical guidelines	Emerging requirements and contradictions
NEN 5104 Geotechnical - Classification of unimproved soil samples (1989)	Describes how soil in the Netherlands had to be classified up to 2020. This standard is officially no longer applicable and has been replaced by NEN-EN-ISO 14688, but it is still extensively used in practice.
RAW (1995 & 2020)	In the RAW (Dutch standard for integrated contracting), the requirements from the technical report 'Klei voor Dijken' have been adopted as standard specification requirements. The RAW is revised every five years, and RAW 2020 is now available. However, the requirements for clay and sand have not changed since 1995.
Technical report 'Klei voor Dijken' (1996)	This report is a compilation of experiential knowledge and fundamental research on the behaviour of clay. Unlike previous guidelines, no requirements for silt content are specified here.
Addendum to the technical report 'Waterkerende Grondconstructies' (2007)	The silt content requirements are reintroduced because observations from practice showed that problems arise when these are not adhered to.
Addendum I to the 'Leidraad Rivieren' (2008)	A further specification on silt content and layer thickness requirements are further in comparison to the Addendum to the technical report 'Waterkerende Grondconstructies'.
Report 'Studie voor richtlijnen klei op buitentaluds in het rivierengebied' (2010)	A study particularly focused on the interaction of clay and the grass revetment on the dike. Introduction of a new classification of clay erosion categories: firm clay, lean clay, and unsuitable clay, replacing categories 1, 2, and 3. This classification was later incorporated into the WBI (Water Safety Assessment).
Report 'Toepassen klei met hoger zoutgehalte in dijklichamen' (Kruse, 2013)	A justification for the application of clay with slightly higher salt content under specific conditions, accompanied with explanations of compensatory measures.
Report 'Klei eigenschappen in verband met het project Ruimte voor de Rivier IJsseldelta' (2015)	A justification for the application of clay with slightly higher organic matter content under specific conditions, accompanied with explanations of compensatory measures.
Report "Vier quick wins grond en klei" (Rijkswaterstaat, 2018)	A report on clay erosion categories, assessment bandwidth, permeability, and improved methods for clay compaction and its quality control.
Manual 'Handboek Dijkenbouw' (2018)	A compilation of requirements from the publications mentioned above. Explicit attention is given to the applicability of other soil types besides sand and clay. It includes a qualitative indication of consequences when threshold values are exceeded.

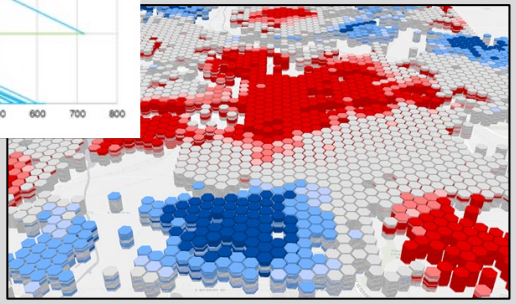


Predictive maintenance

Predict dike damage and aging processes

- Spatial hotspot analysis
- Emerging hotspot analysis in space and time
- Random Forest boosted prediction with geographically weighted regression

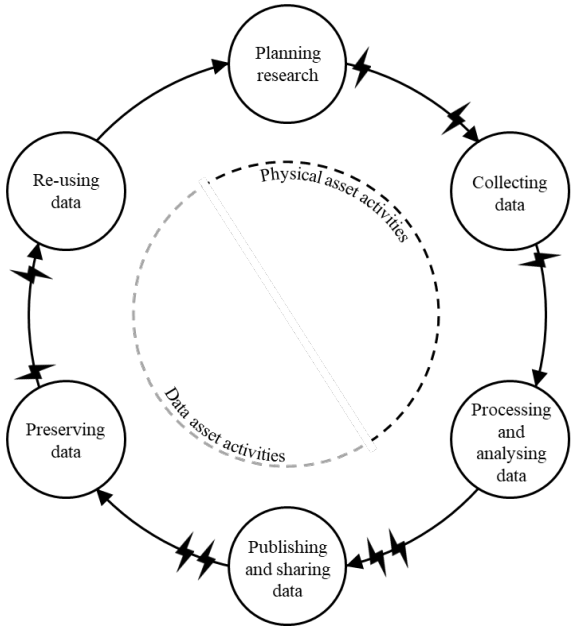




Draw lessons from various data management practices among flood defence asset managers.

Progress synthesis

- A diagnosis of data lifecycle discontinuities in flood defence asset management
- Flood defence data remains fragmented, despite tons of data and variety of standards
- De Dijkatlas as a scalable data product demonstrating the payoff of strong flood defence data management



QUESTIONS? TIPS? COLLABORATE!

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Foto: Chris Biesheuvel