



25th EXCHANGE MEETING PRELIMINARY PROGRAM

Date : Tuesday 10-10-2023

Surface disposal category A waste – ONDRAF/NIRAS site Dessel

VENUE : Tabloo, Gravenstraat 3, 2480 Dessel		
09h00 - 16h30		
08h30 – 09h00	Welcome Coffee	
09h00 – 09h10	Introduction	Maarten Van Geet – NIRAS/ONDRAF
09h10 – 10h05	Safety concept (45' + 10' Q&A)	Elise Vermariën - NIRAS/ONDRAF
10h05 – 10h35	Coffee break	
10h35 – 11h30	Performance Analysis (45' + 10' Q&A)	Eef Weetjens - SCK CEN
11h30 – 12h25	Hydrogeological aspects (45' + 10' Q&A)	Diederik Jacques - SCK CEN
12h25 – 13h30	Lunch	
13h30 – 14h25	Construction : outlines and planning (45' + 10' Q&A)	Wim Bastiaens - NIRAS/ONDRAF
14h25 – 14h50	Disposability (30' + 10' Q&A)	William Wacquier – NIRAS/ONDRAF
14h50 – 15h20	Coffee break	
15h20 – 16h15	Role and activities of FANC and Bel V in the cAt surface disposal (45' + 10' Q&A)	Geert Volckaert, Iwein De Baetselier – FANC Tom Vandavelde – Bel V
16h15 – 16h30	Conclusions	Rudy Bosselaers - NIRAS/ONDRAF
16h30 – 18h00	Drink	



ONDRAF/NIRAS

The safety concept for the Dessel surface repository

Elise Vermariën, Wim Cool
& Wim Bastiaens
(ONDRAF/NIRAS)

10 October 2023



Overview

**The disposal
concept**

**Safety
objective,
principles and
safety
functions**

**Operational
safety concept**

**Long-term
safety concept**

**Defence in
depth**



The disposal concept

The site at a glance



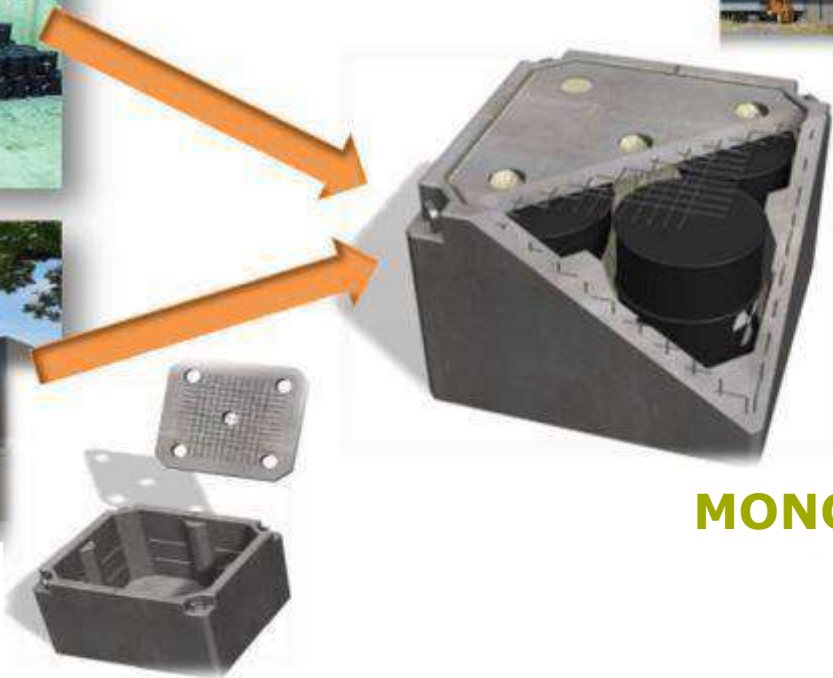
Disposal packages (monoliths)

Storage (Belgoprocess)



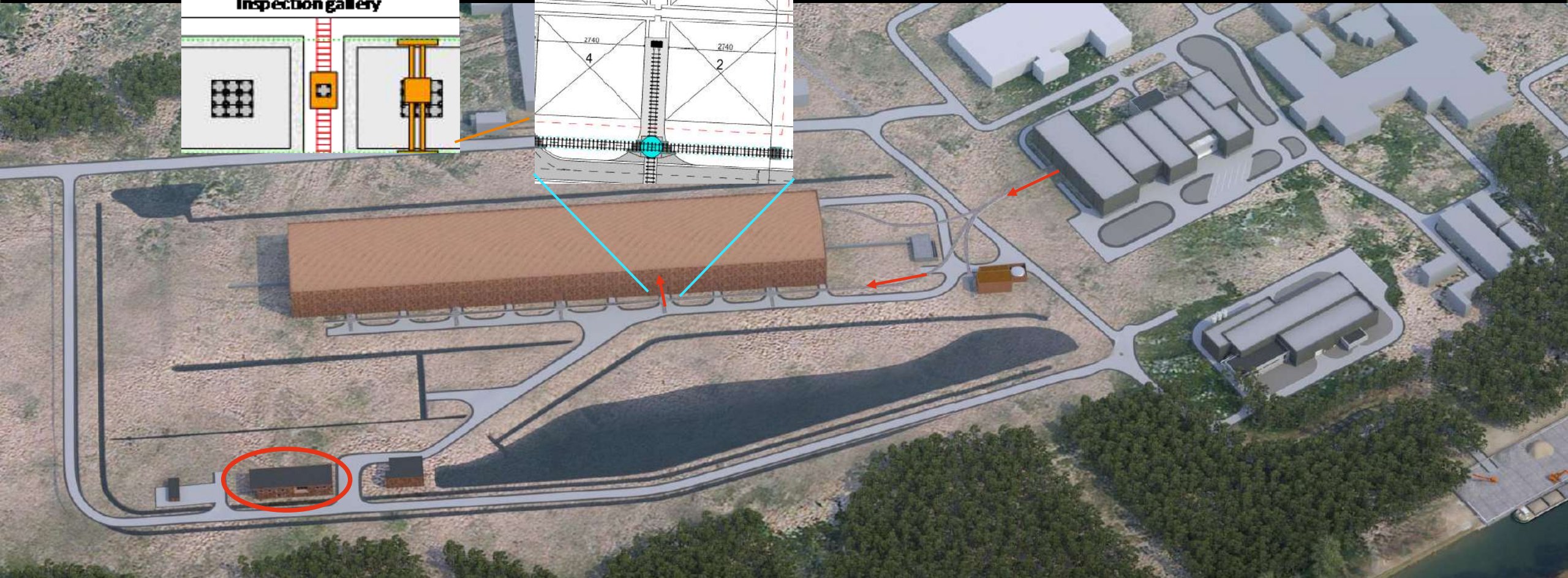
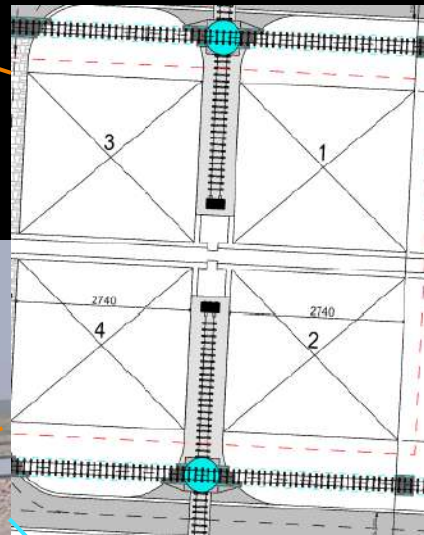
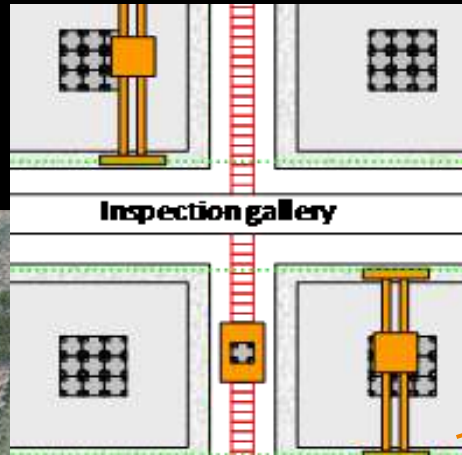
Caisson factory

Installation for the production of monoliths (IPM)



MONOLITH

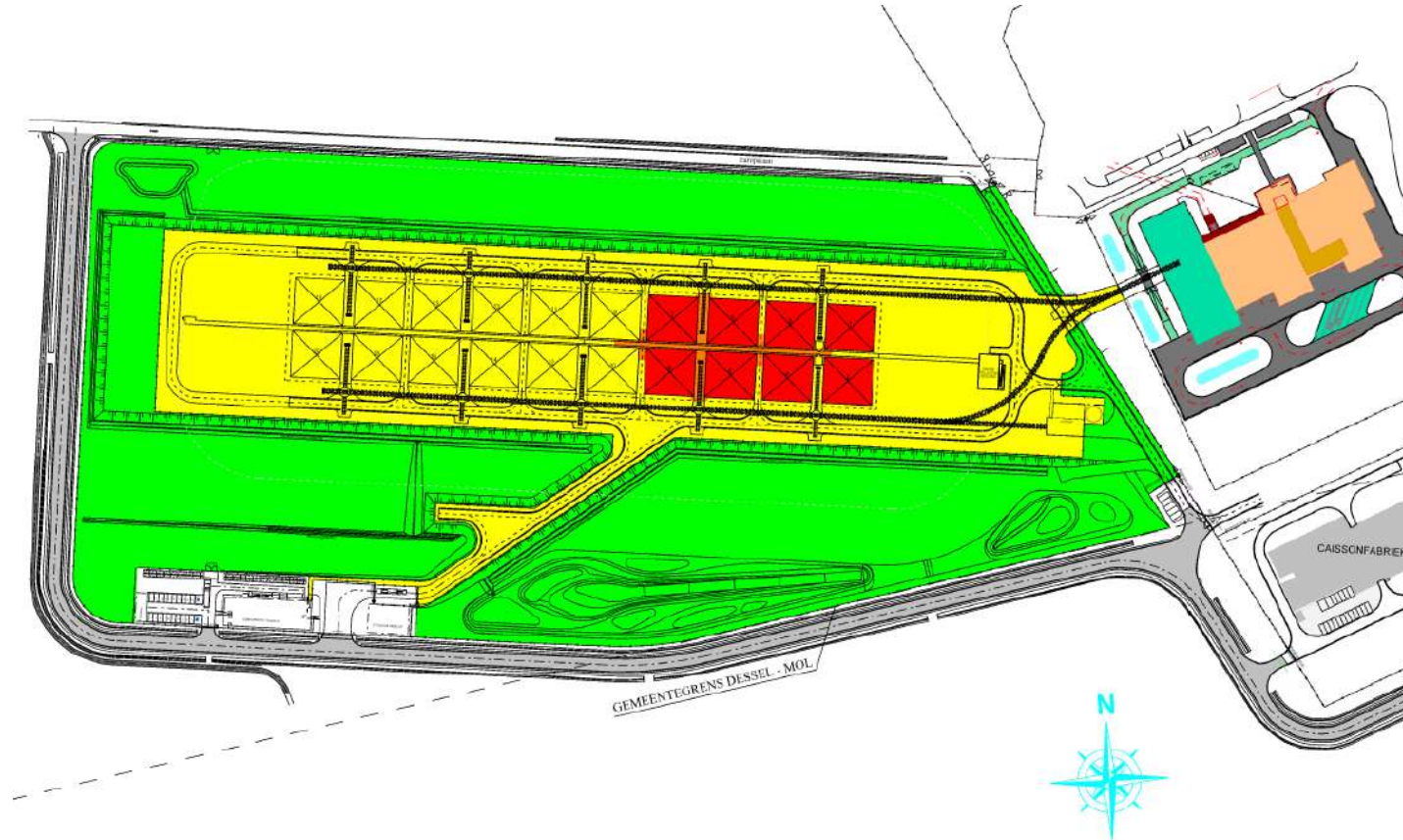
Trolley



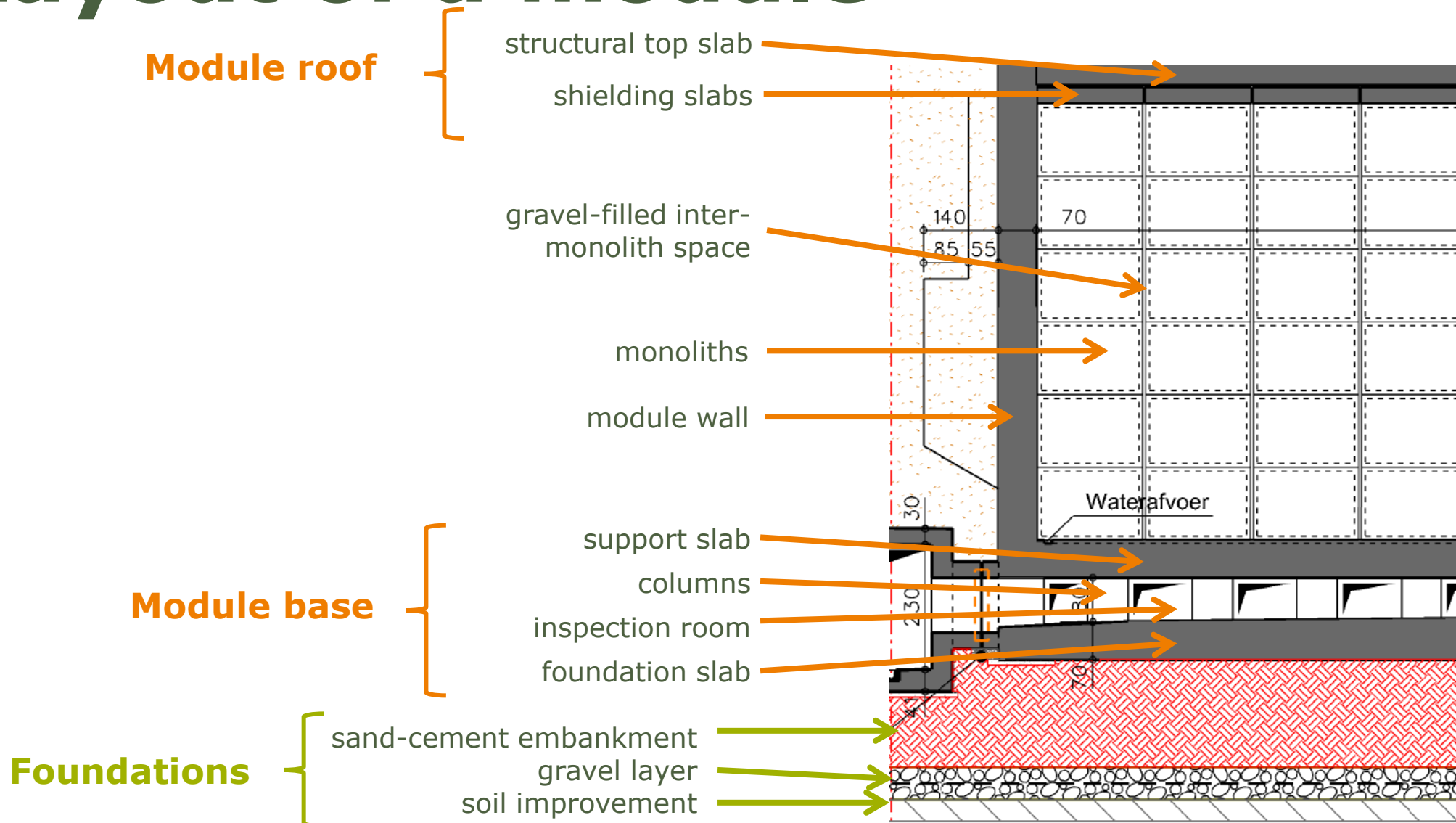
Control room (entrance cluster)
Operations are remote-controlled
and semi-automatic

Full capacity:
~ 1000 monoliths per year

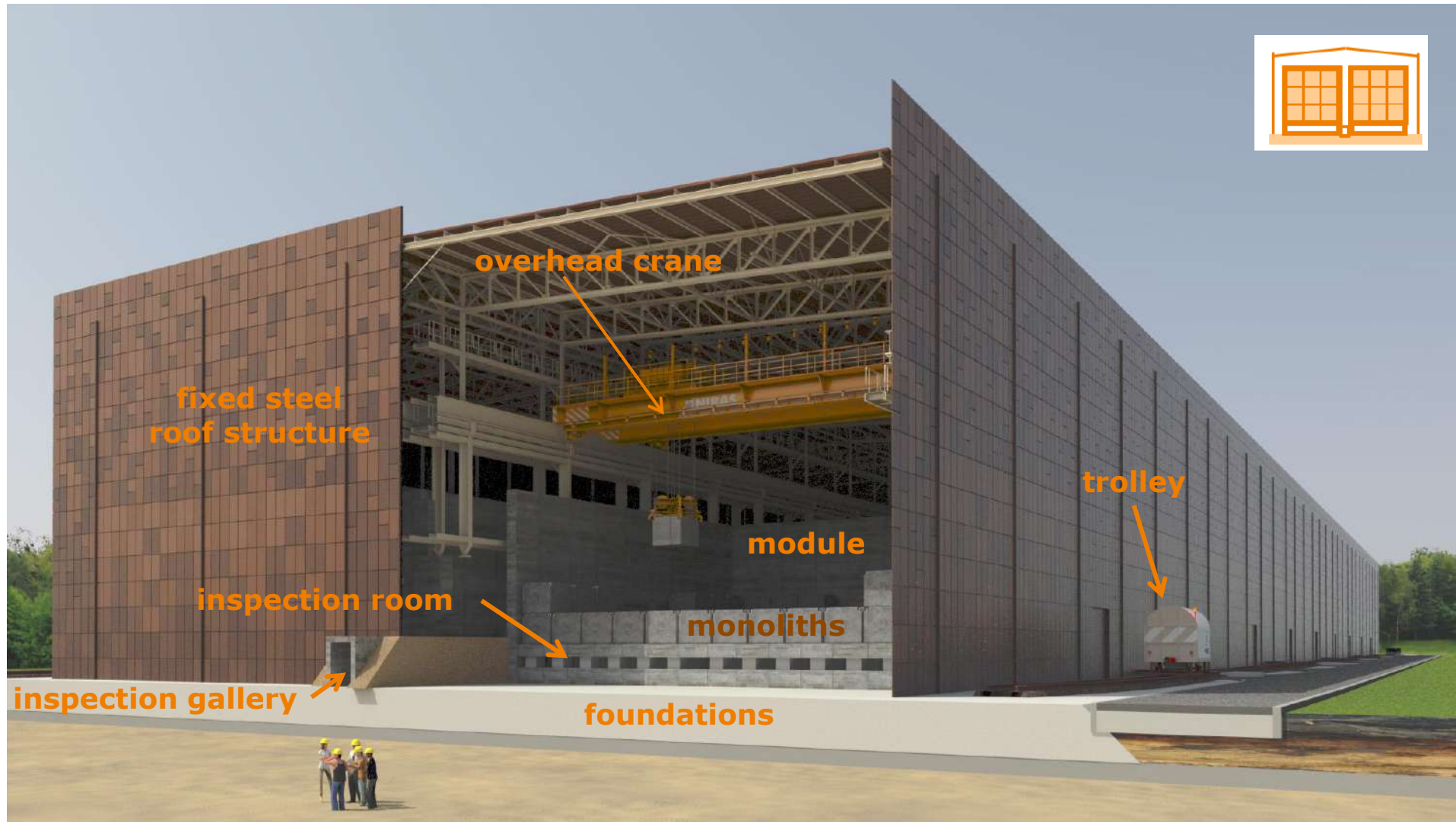
Zoning during waste emplacement



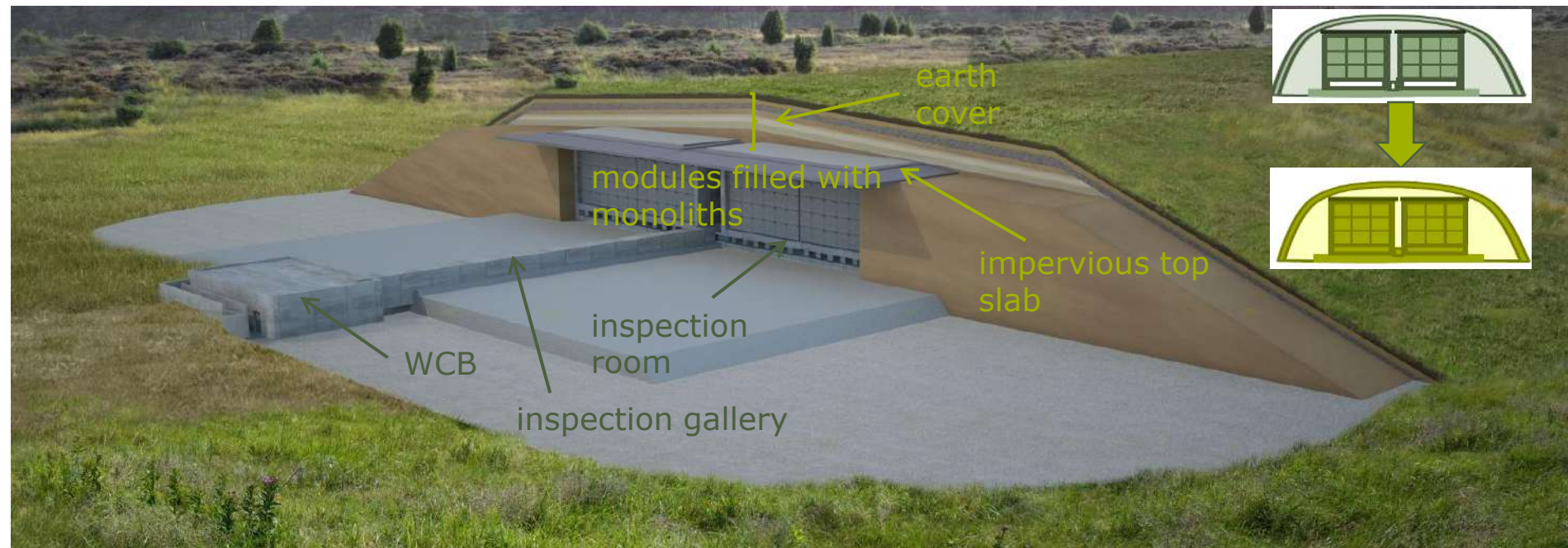
Layout of a module



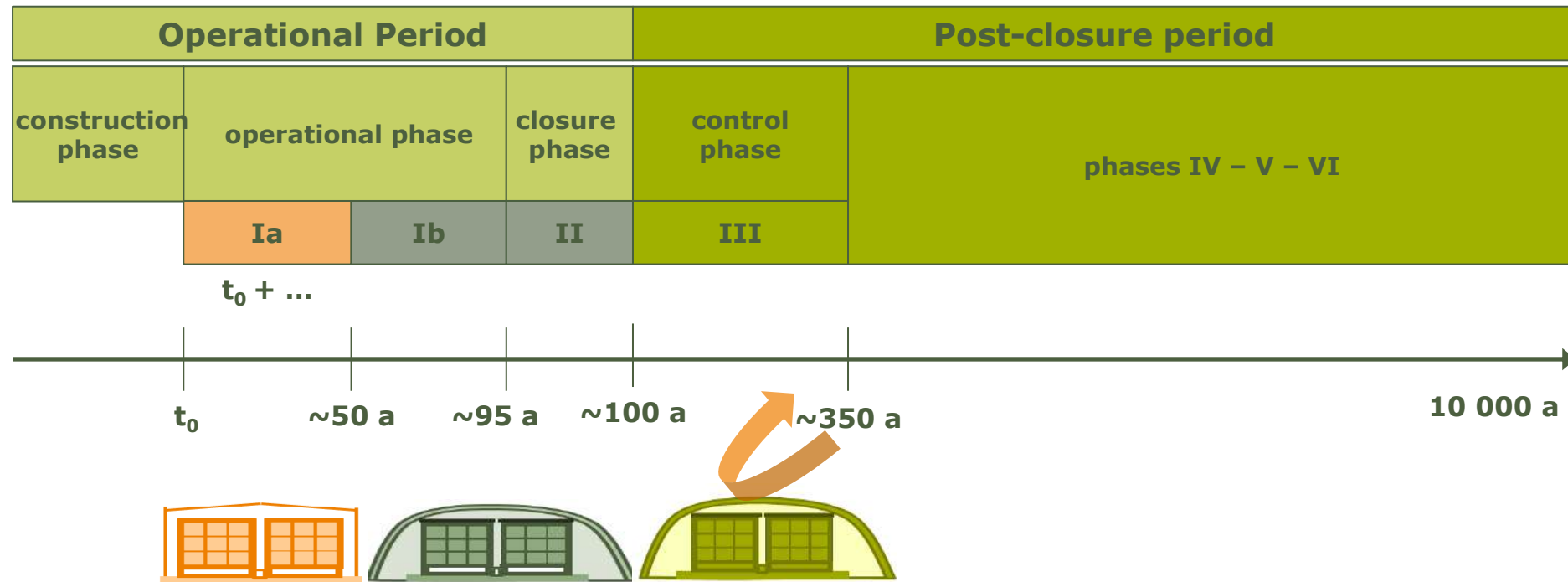
Disposal modules in operation



Filled modules



Timeframes





Safety objective, principles and safety functions

Safety objective and principles

Protecting humans and the environment

- **now and in the future, without imposing undue burdens on future generations**
 - ✓ operational
 - ✓ long term: passive safety
- **from harmful effects of ionizing radiation**
 - ✓ radiation protection principles
 - ✓ limiting the activity content of long-lived radionuclides
 - ✓ isolate and contain
- **by preventing accidents and, should an accident occur, limiting its consequences**
 - ✓ defence in depth

Safety functions

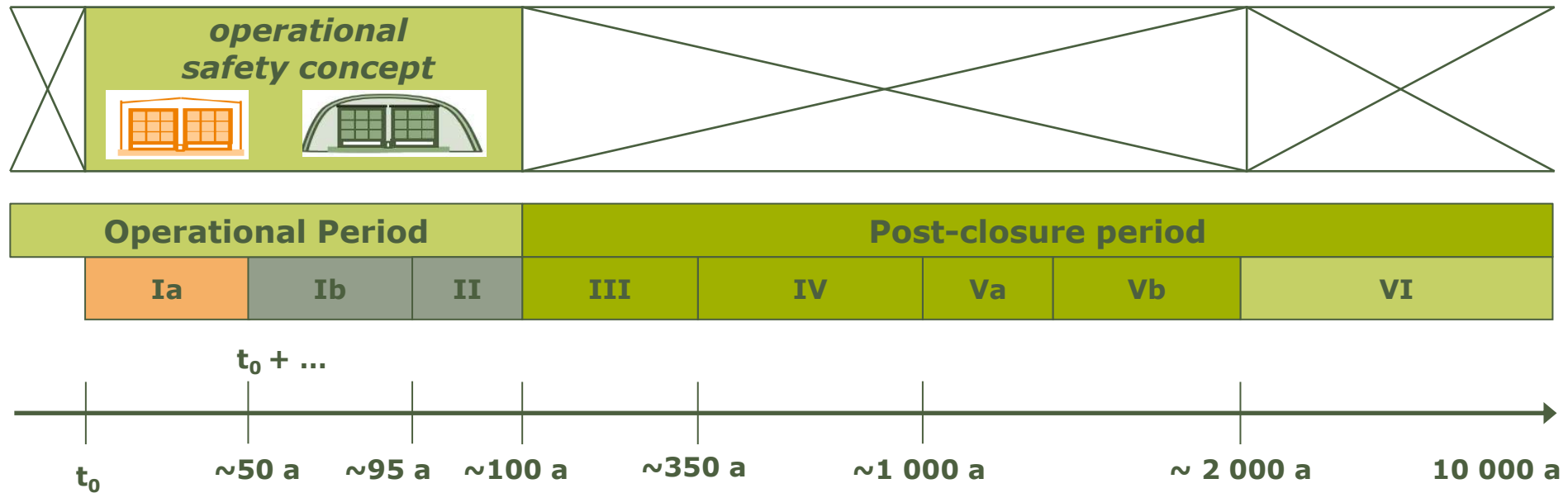
- Safety is ensured by a combination of **systems, structures and components (SSCs)**
- SSC properties allow for safety in both 'normal' conditions and in case of incidents/accidents → **safety functions**

Operational period	Post-closure period
Containment	Containment
Isolation	Isolation
Shielding	
Protection	Protection



Operational safety concept

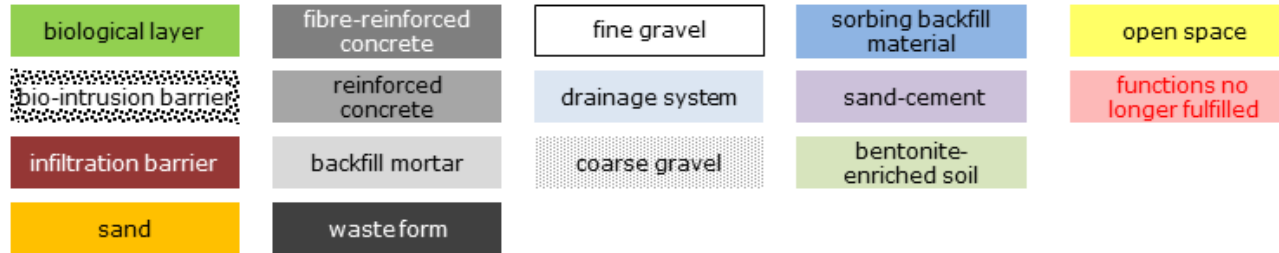
Timeframes



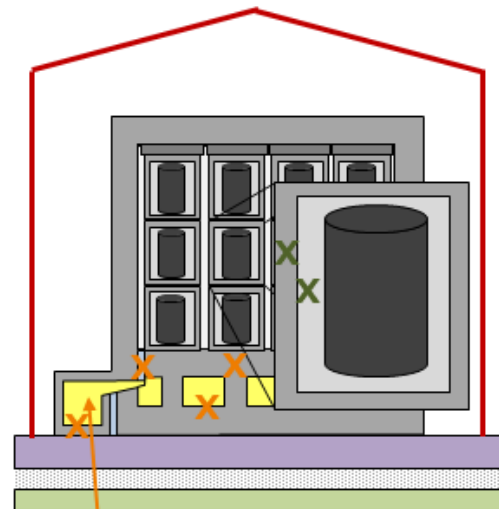
Containment

- Normal operating conditions:
 - ◆ **containment** of radionuclides inside monolith
 - ◆ no contamination
- Other SSCs help ensure containment in case of accidents

Containment

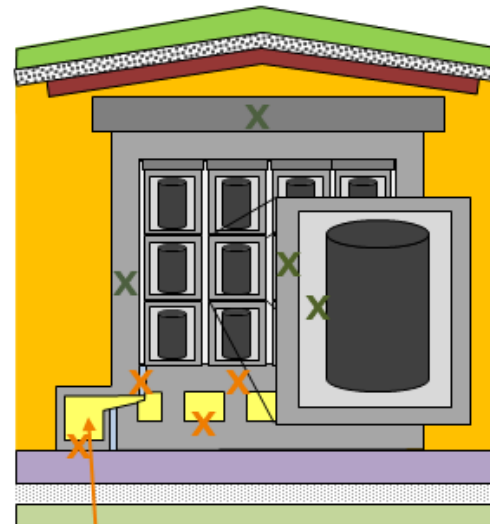


Phase Ia



collect water and drain towards WCB/BP

Phase Ib

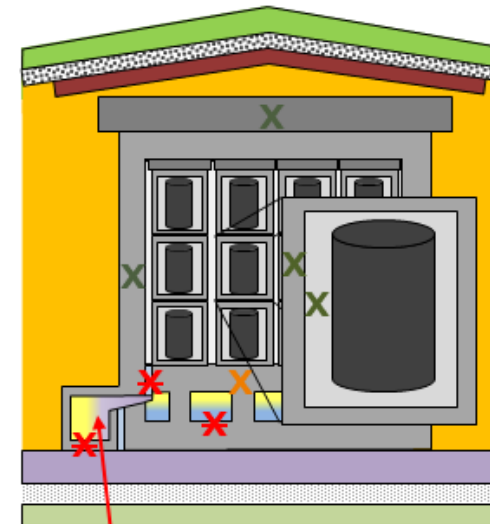


collect water and drain towards WCB/BP

Phase II

X: normal operating conditions

X: deviating operating conditions



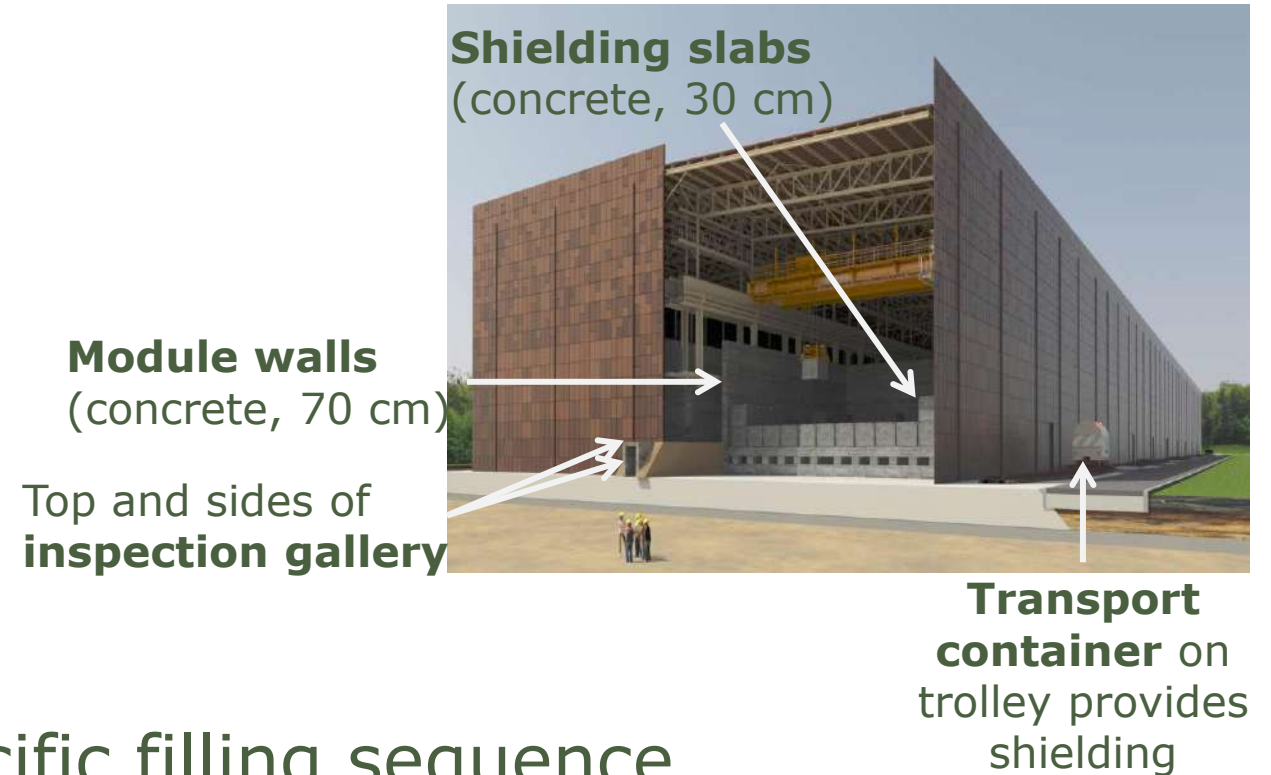
collect and drain towards WCB/BP

Limiting external irradiation

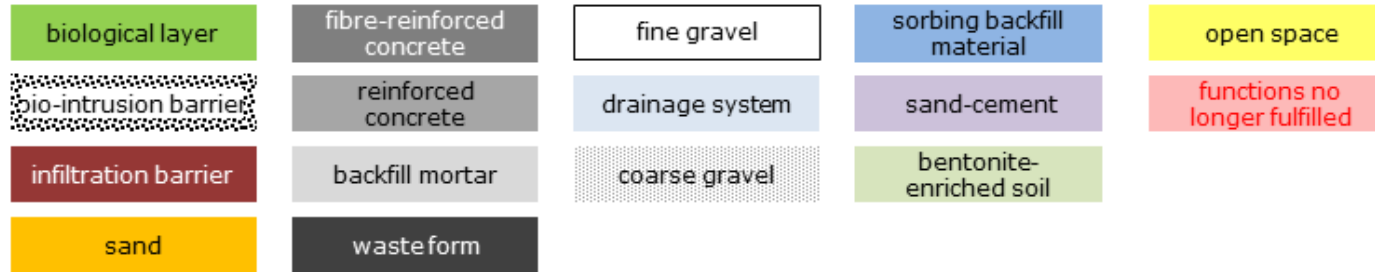
- **Operational radiation protection**
- **Shielding** by SSCs surrounding the waste
- **Isolation** by means of
 - ♦ barriers creating distance
 - ♦ collective measures
 - remote-controlled operations
 - fencing (controlled zone, disposal site)
 - ♦ individual measures
 - access controls (controlled zone, disposal site)
 - work permits

Shielding practices

- Shielding by mortar and caisson → **contact dose rate** limited to 20 mSv/h
- To the extent possible: **further** shielding of monoliths
- **Self-shielding** through specific filling sequence
 - ◆ Limited dose rate per layer of monoliths
 - ◆ Additional restrictions on topmost layer
 - ◆ More strongly radiating monoliths in the centre

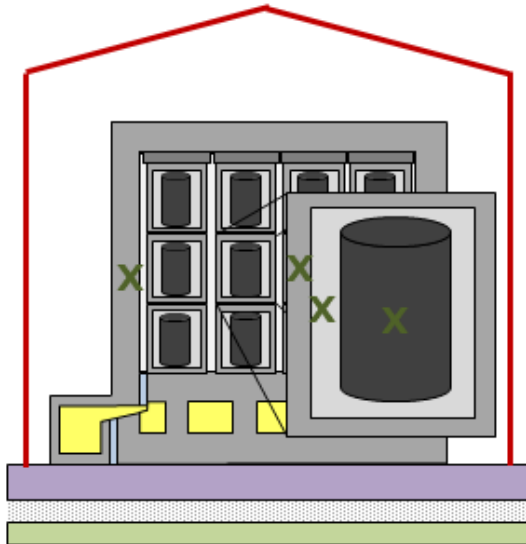


Isolation (w.r.t. intrusion)



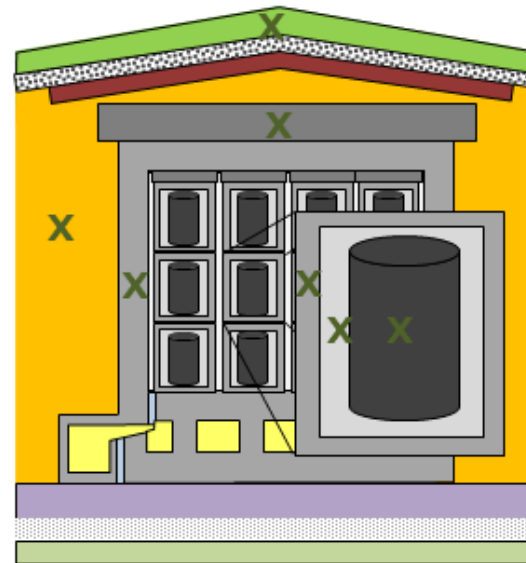
Phase Ia

Access control
Fencing around the site



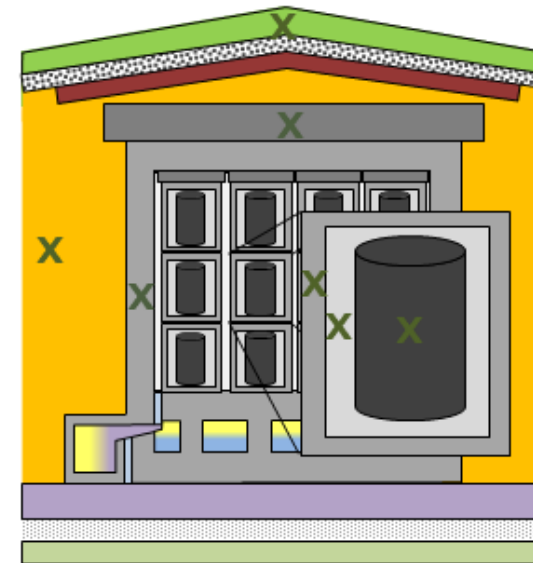
Phase Ib

Access control
Fencing around the site



Phase II

Access control
Fencing around the site



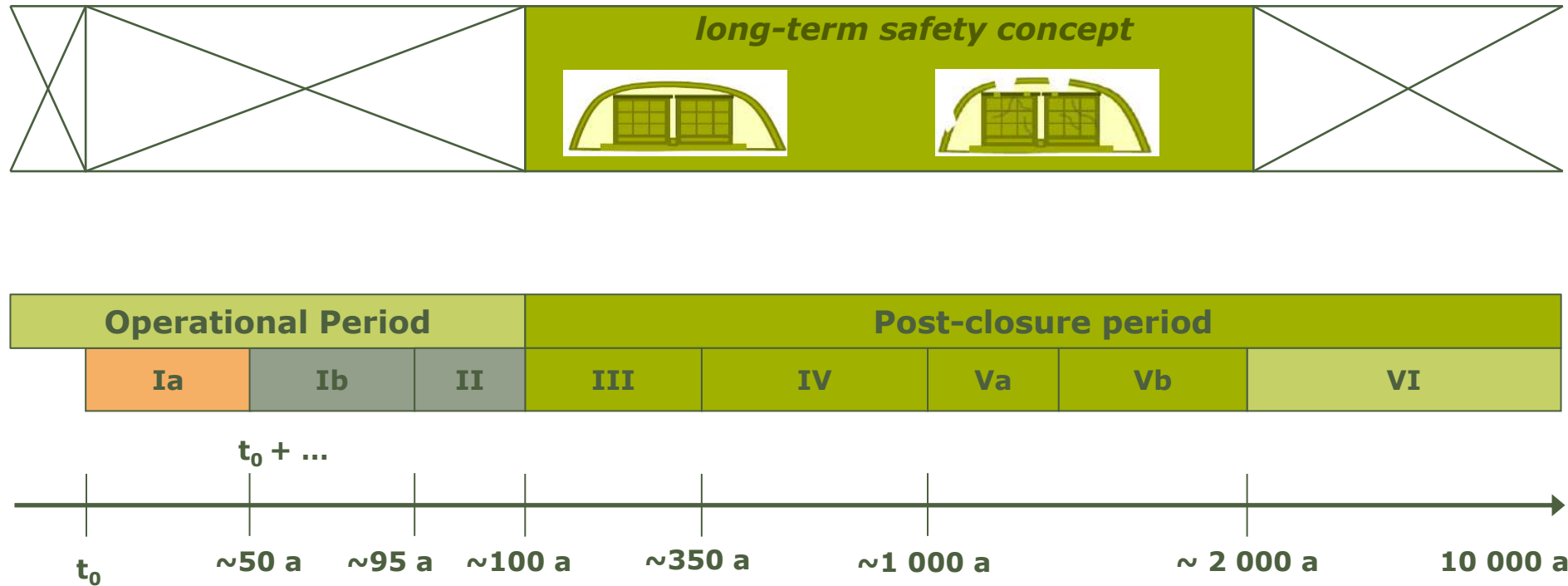
Protection

- Against threats/perturbations
 - ◆ to strengthen the fulfilment of operational safety functions
 - fire detection/fighting
 - SFP-crane
 - emergency supply
 - ◆ to ensure that long-term safety functions can be met
 - cover
 - foundations



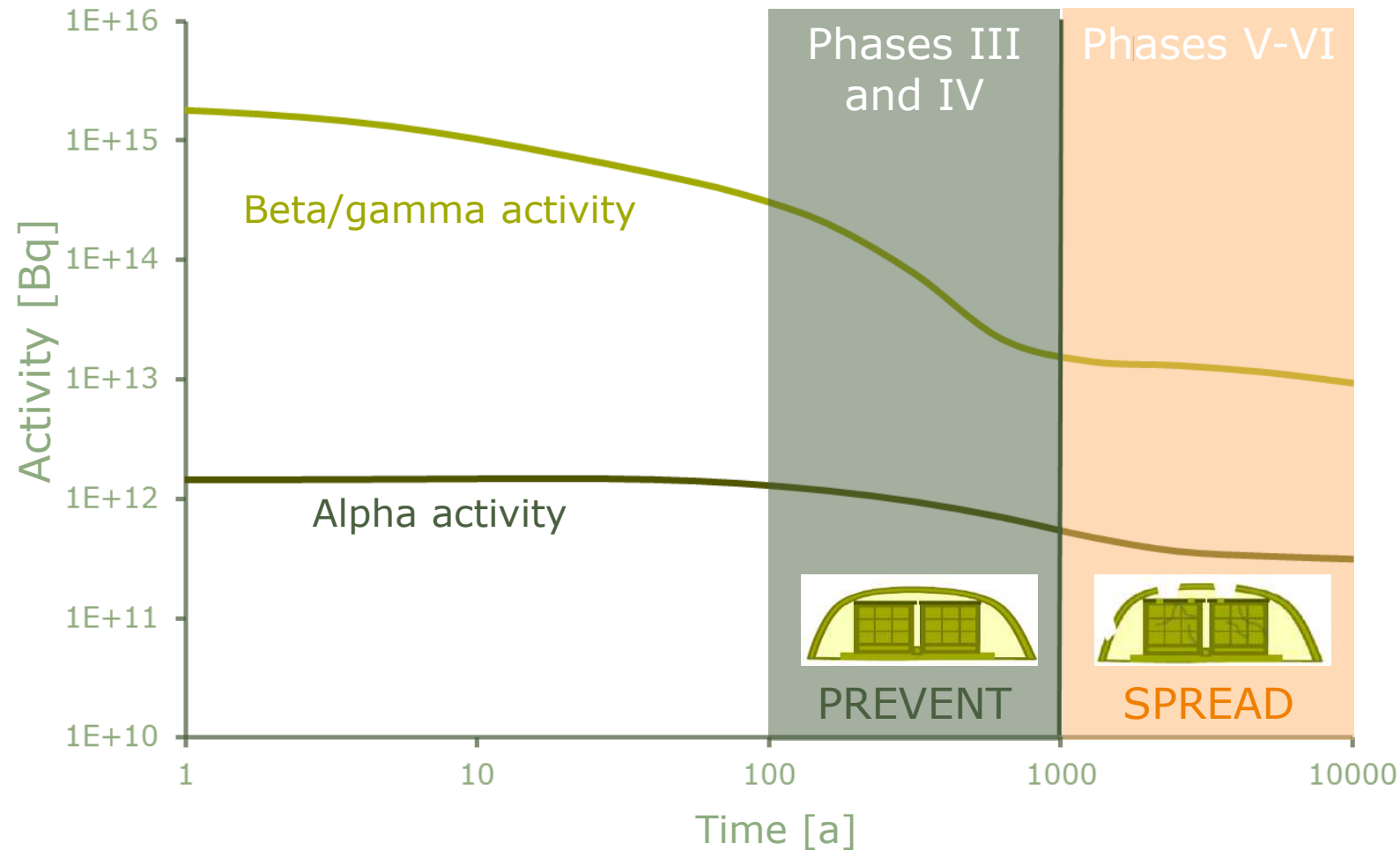
Long-term safety concept

Safety concept timeframes



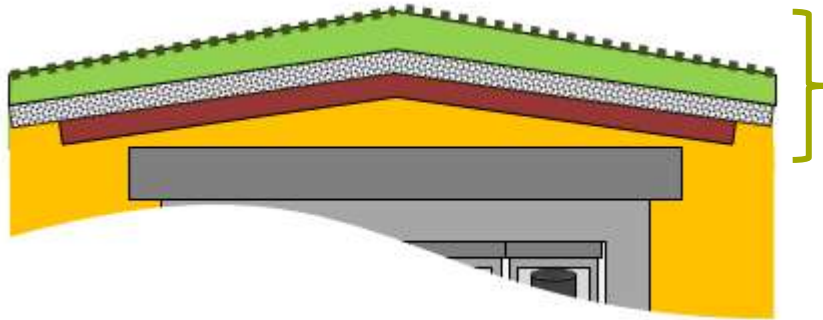
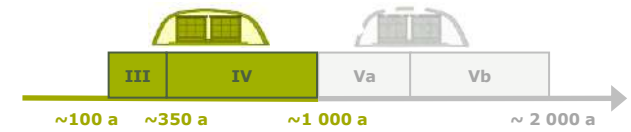
Containment

Graded approach $\sim$ residual hazard

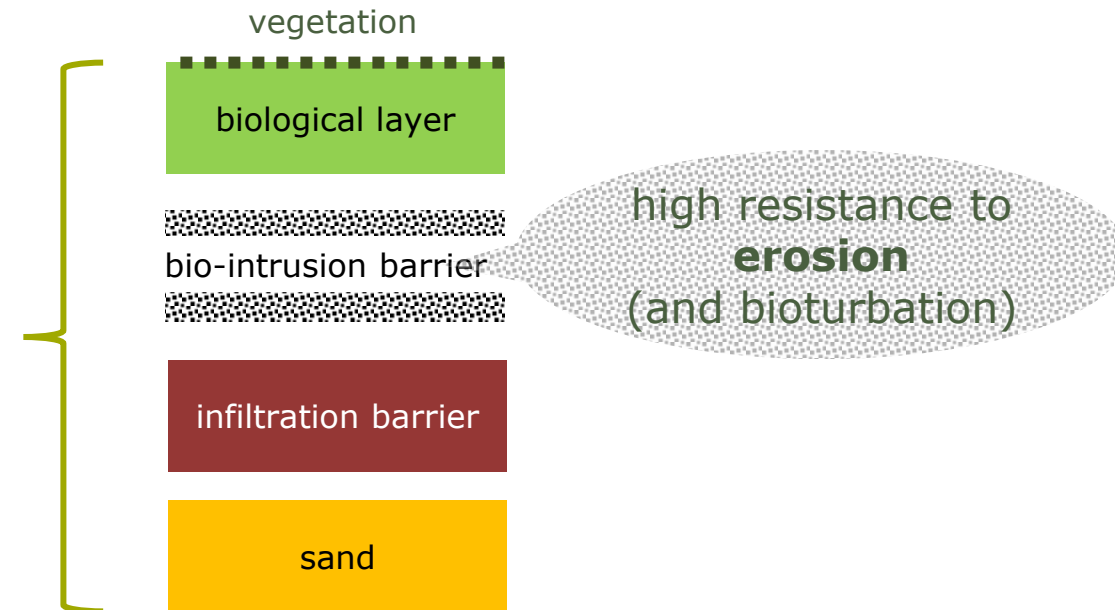


Earth cover

Protection of concrete SSCs for ~ 1000 years



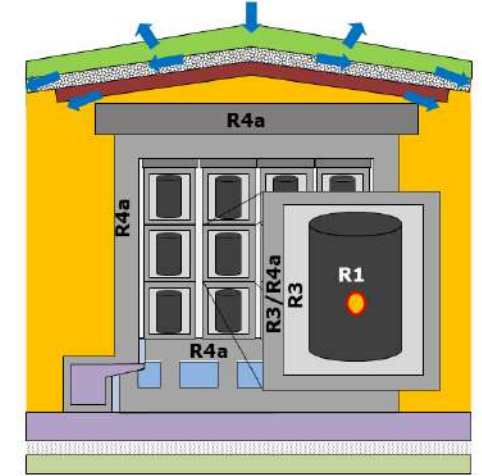
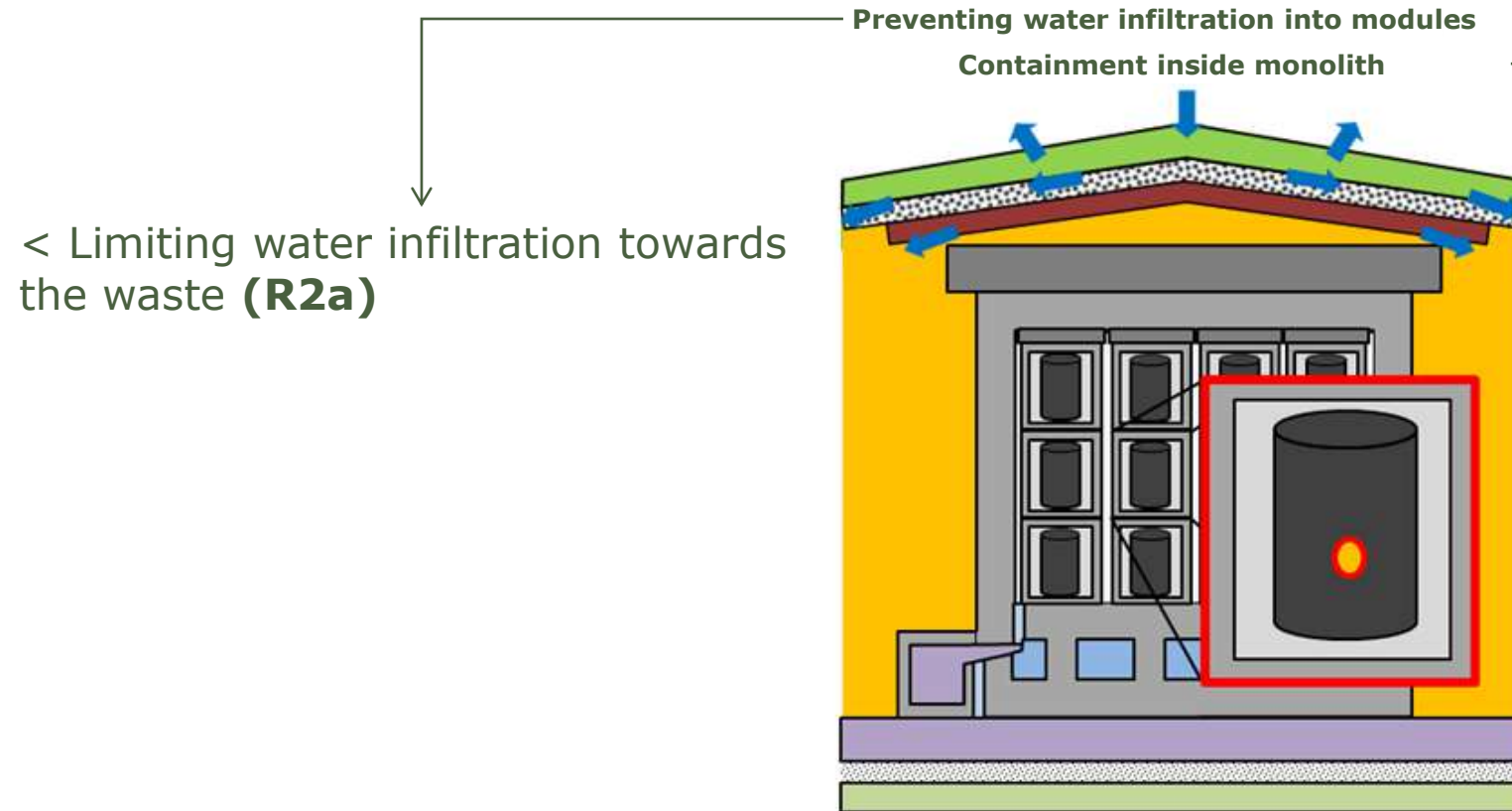
**BURIED
CONDITIONS**



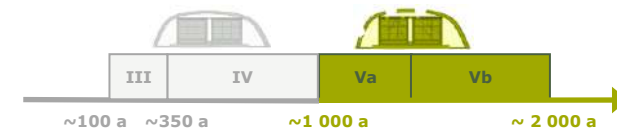
Containment < ~ 1000 years



Phases III and IV - Preventing radionuclide release

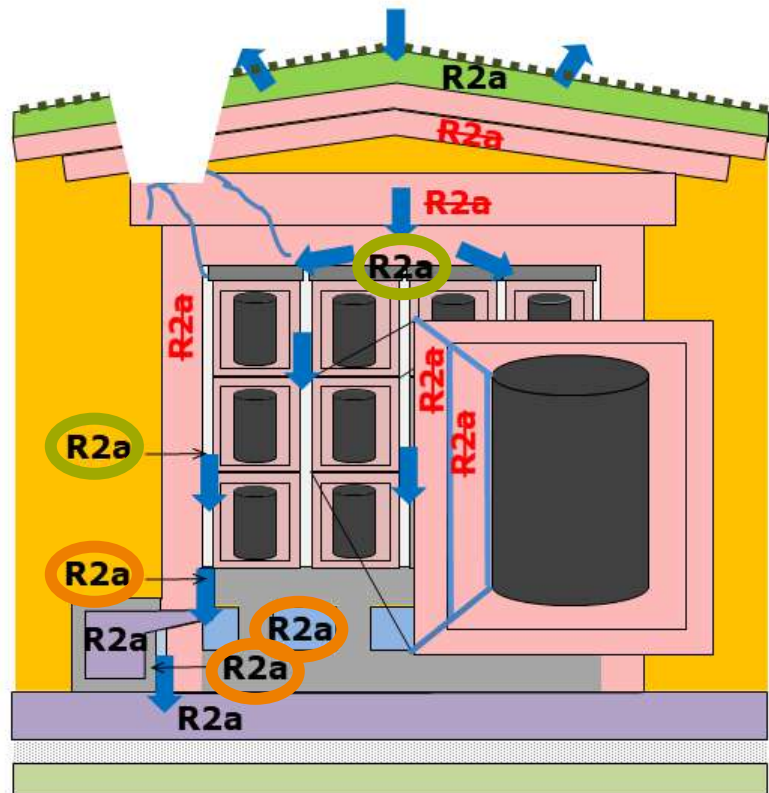


- Limitation of releases from the waste (R1)
- Sorption in backfill mortar/caisson (R3)
- Limited diffusion towards/in caisson and surrounding SSCs (R4a)

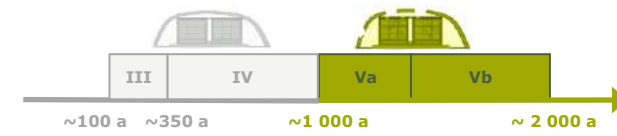


Containment > ~1000 years

Phases Va/b - Limited water infiltration towards the waste (R2a)

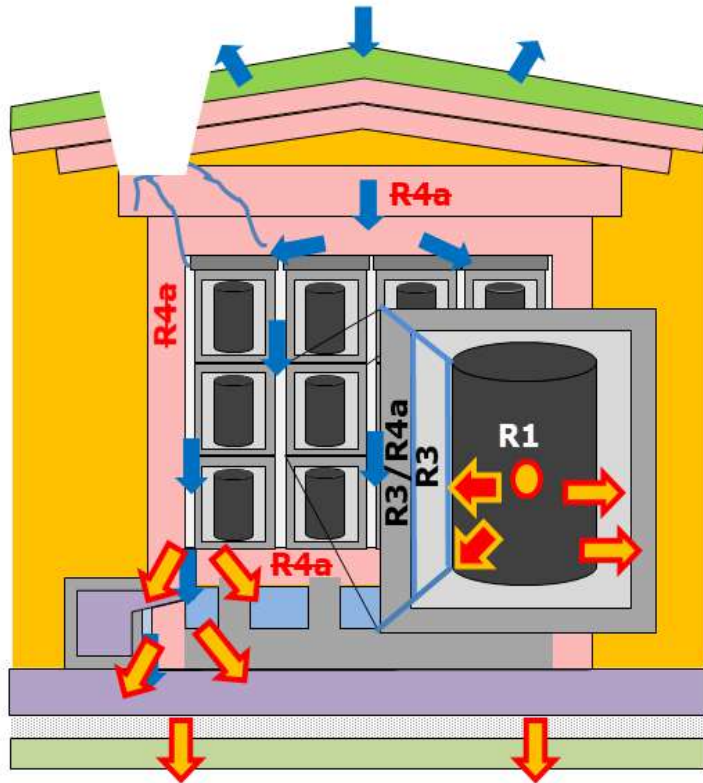


- Water infiltration into the modules can no longer be prevented
 - restricted only through evapotranspiration on earth cover remnants
- **Preferential** flow in inter-monolith spaces
- **Anti-bathtub system**
 - sand-cement to ensure further drainage



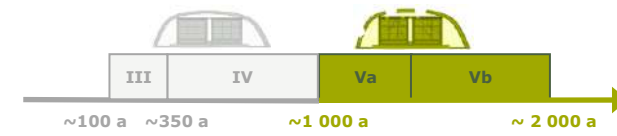
Containment > ~1000 years

Phases Va/b – Containment inside monolith



Releases from monoliths further continue to be limited and spread by

- Slow release from the waste (**R1**)
 - Sorption on cement
 - Waste characteristics
- Sorption in backfill mortar and caisson (**R3**)
- Slow diffusion in caisson (**R4a**)

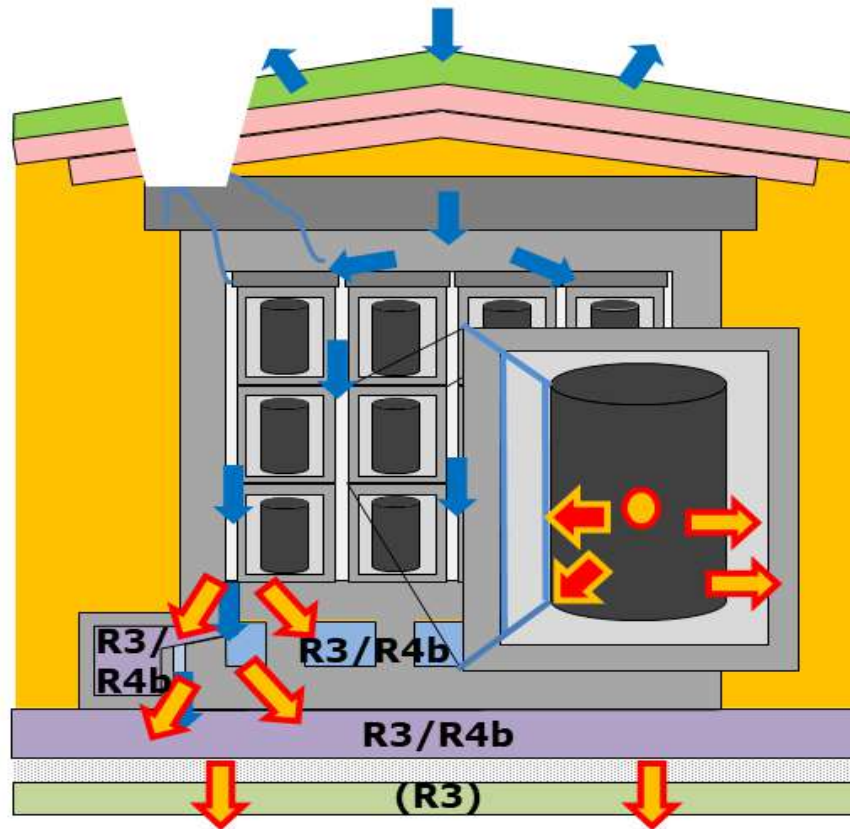


Containment > ~1000 years

Phases Va/b – Spreading and retardation outside monolith

Fractures as preferential transport routes

→ **bypass**

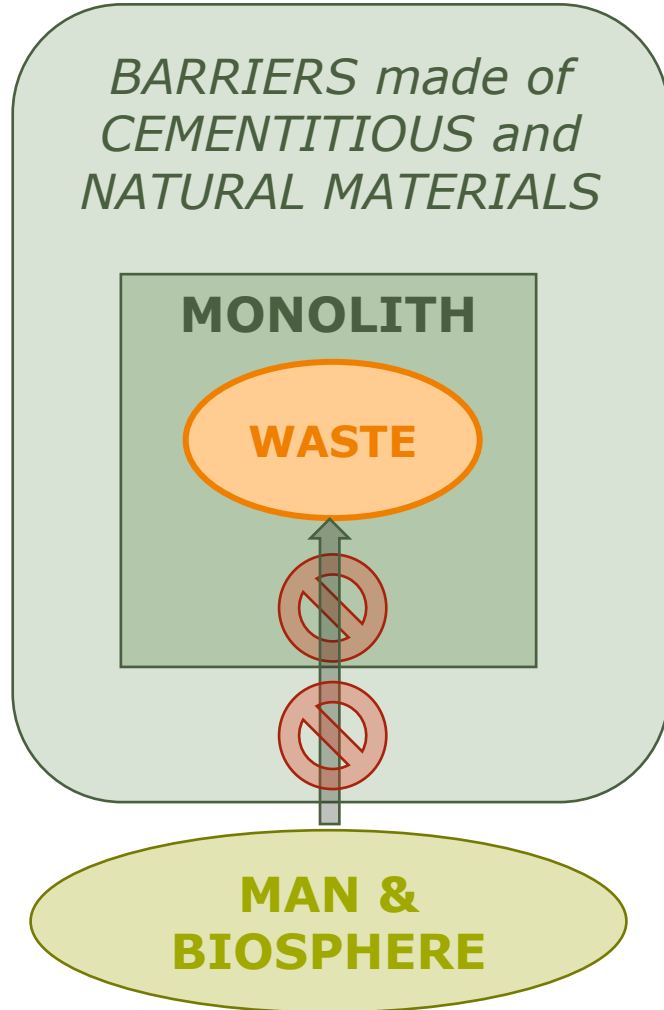


Conductive sorbing media spread the release of radionuclides from the system

- Spreading by **dispersion** in conductive material (**R4b**)
- **Sorption** in conductive material (**R3**)

Isolation

Prevent direct contact between man and waste

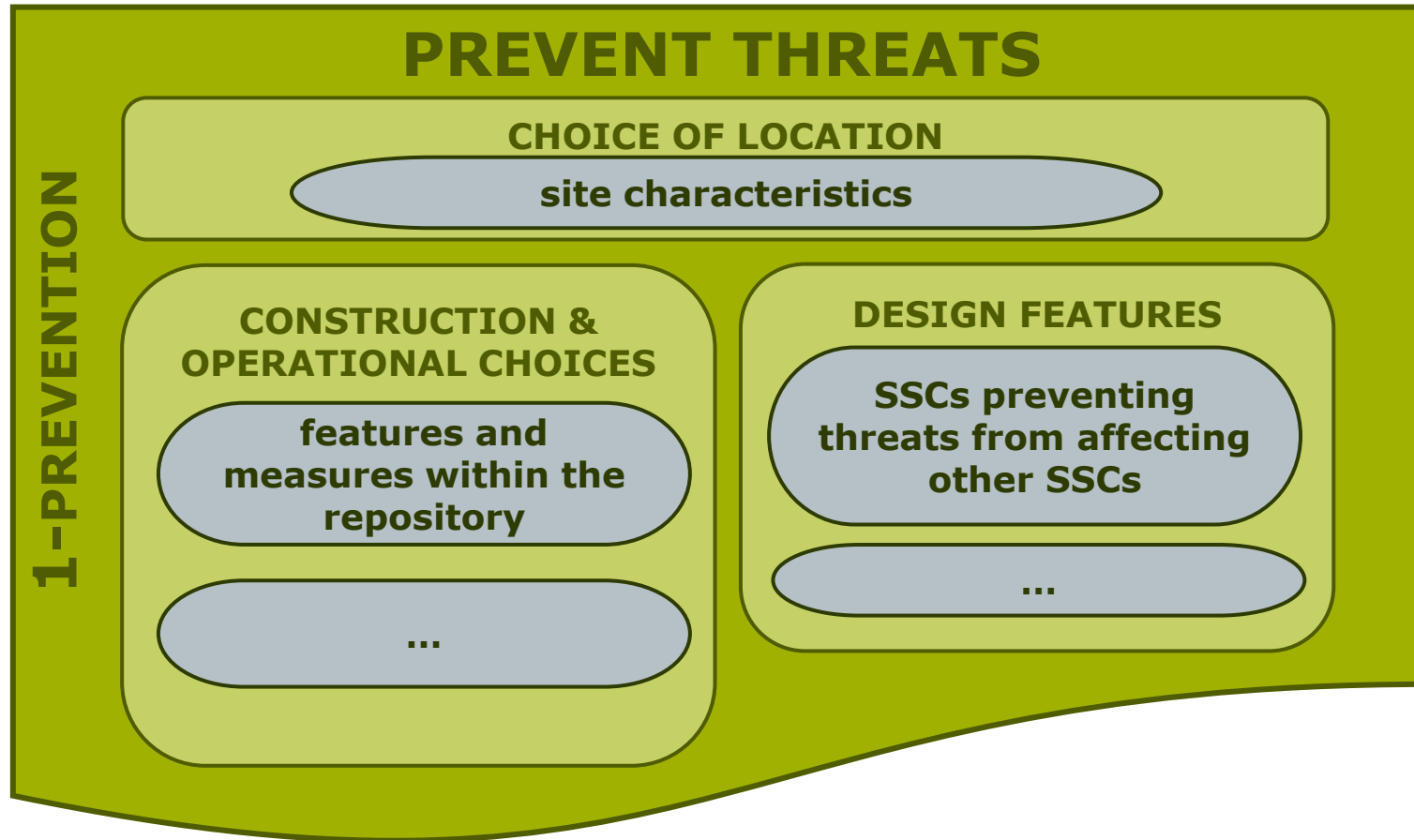


- disposal system configuration ensures isolation in absence of direct threats (e.g. intrusion)
→ **no direct contact**
- Surface disposal → possibility of inadvertent intrusion → **safety function I1**
 - ♦ $t < 350$ years (end of phase III): access restrictions
 - ♦ Phases III/IV: barriers around the waste render intrusion difficult and limit its consequences
 - Earth cover & side embankment
 - Concrete SSC's
 - Monoliths

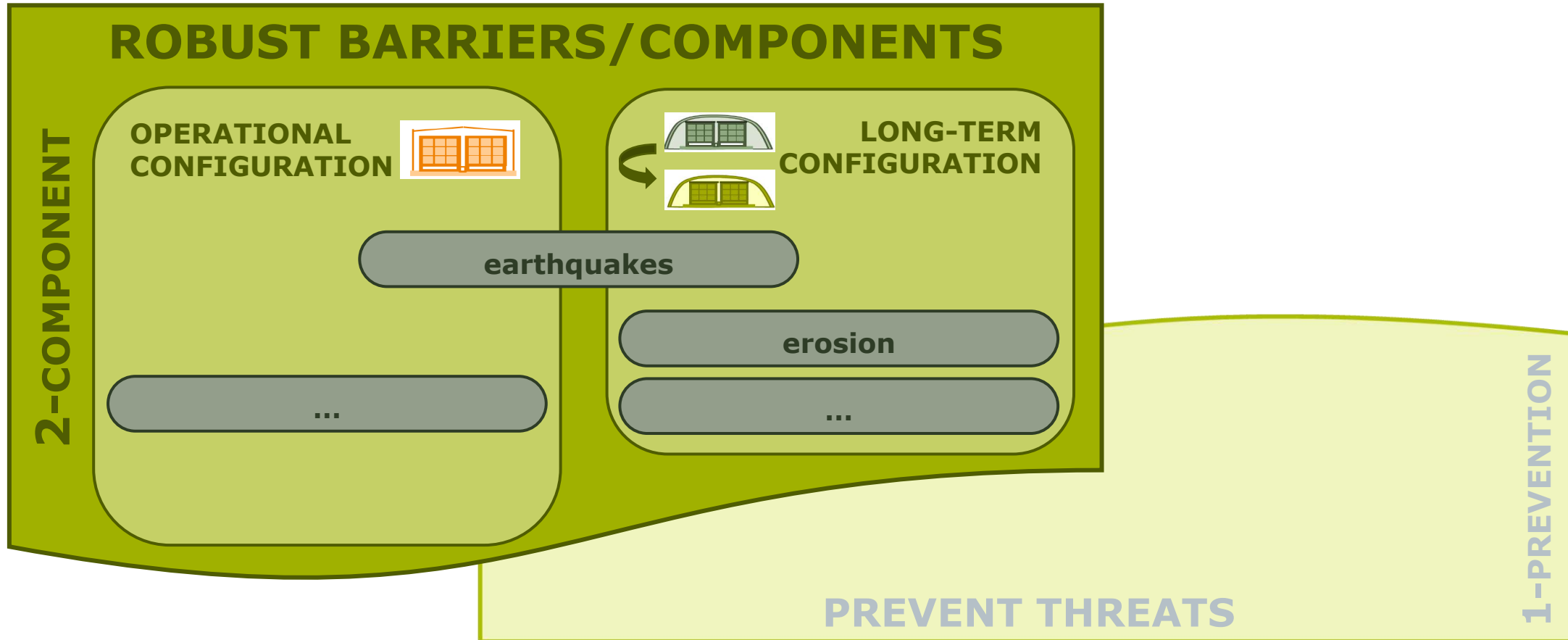


Defence in depth

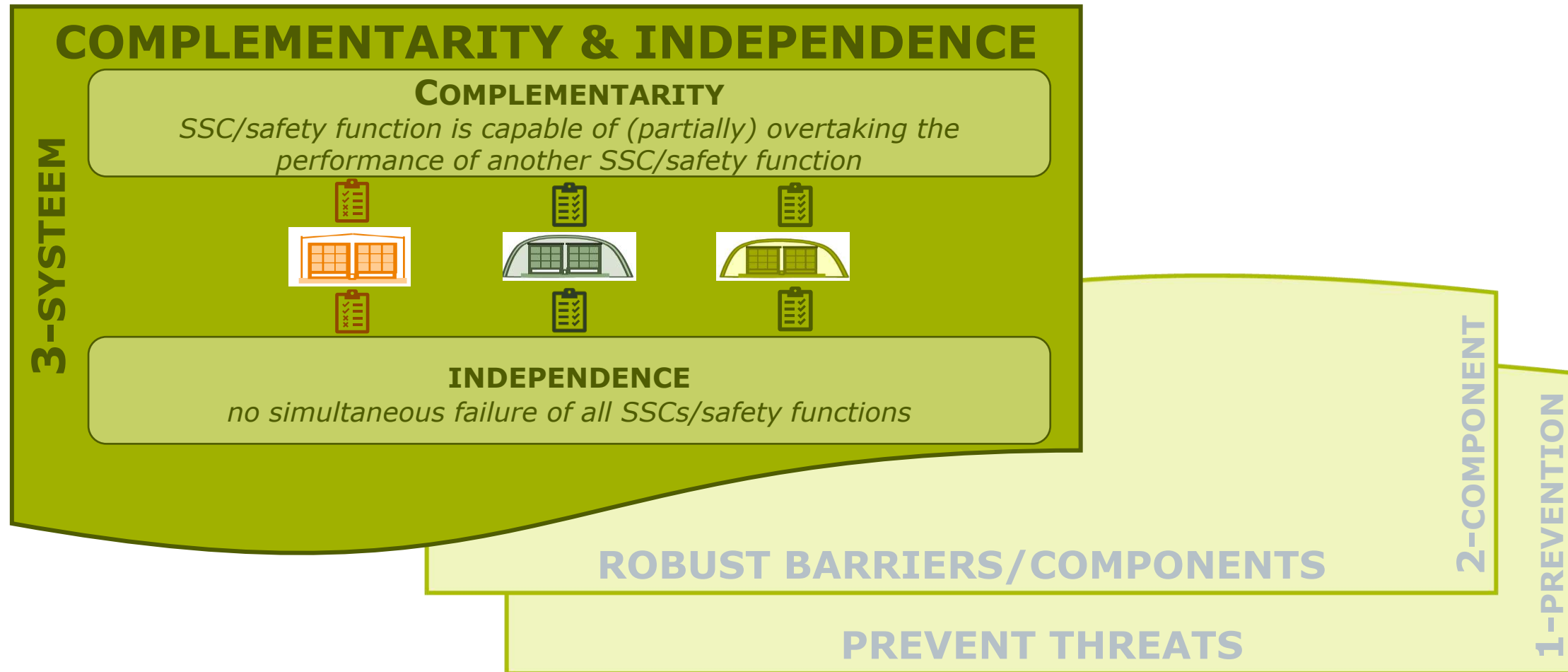
Level 1 : Prevention



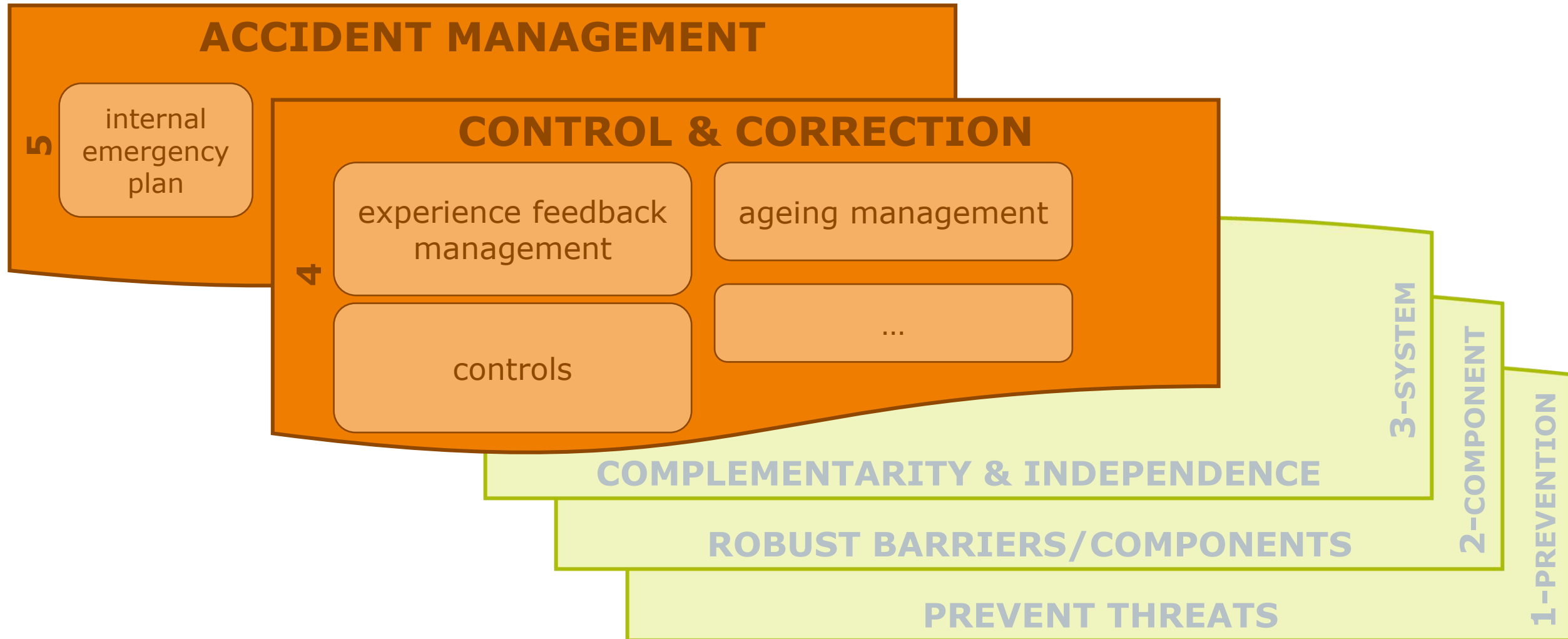
Level 2 : Component



Level 3: Disposal system

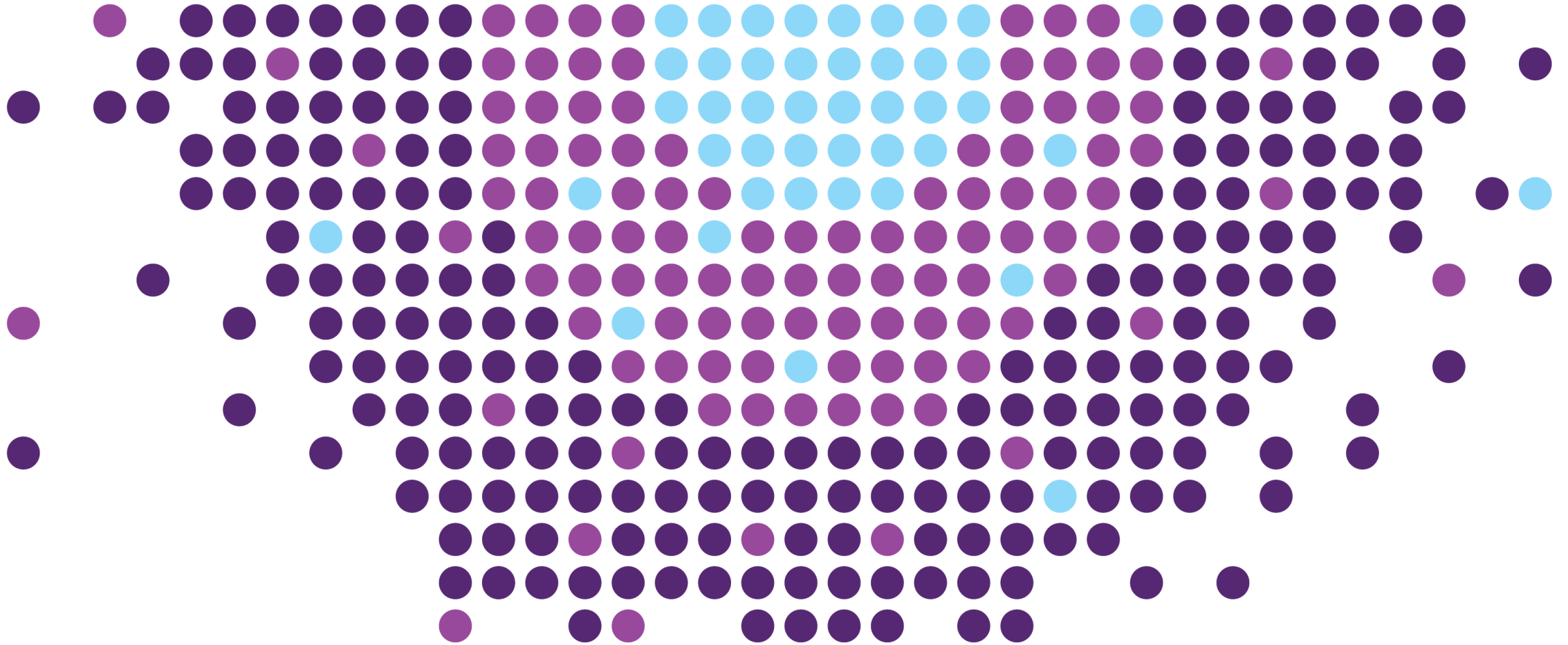


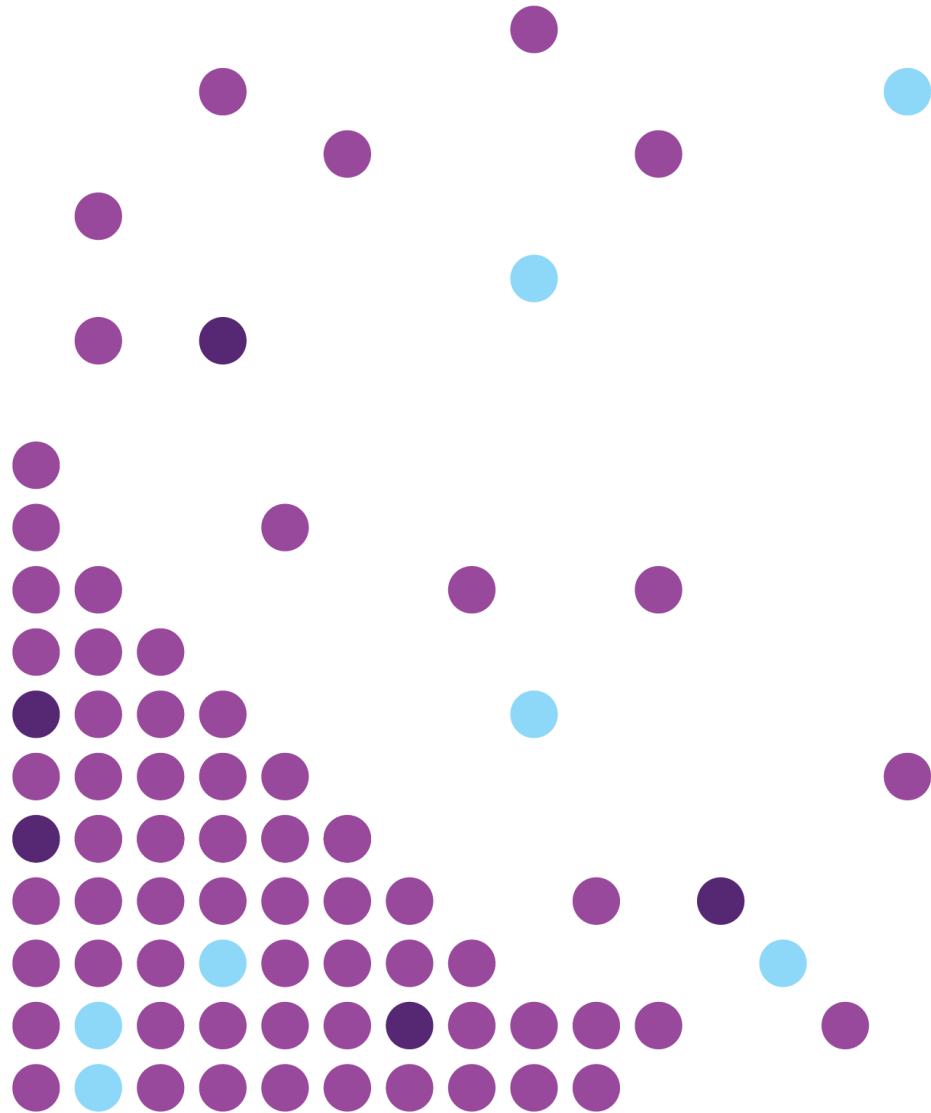
Level 4/5: “operational” measures



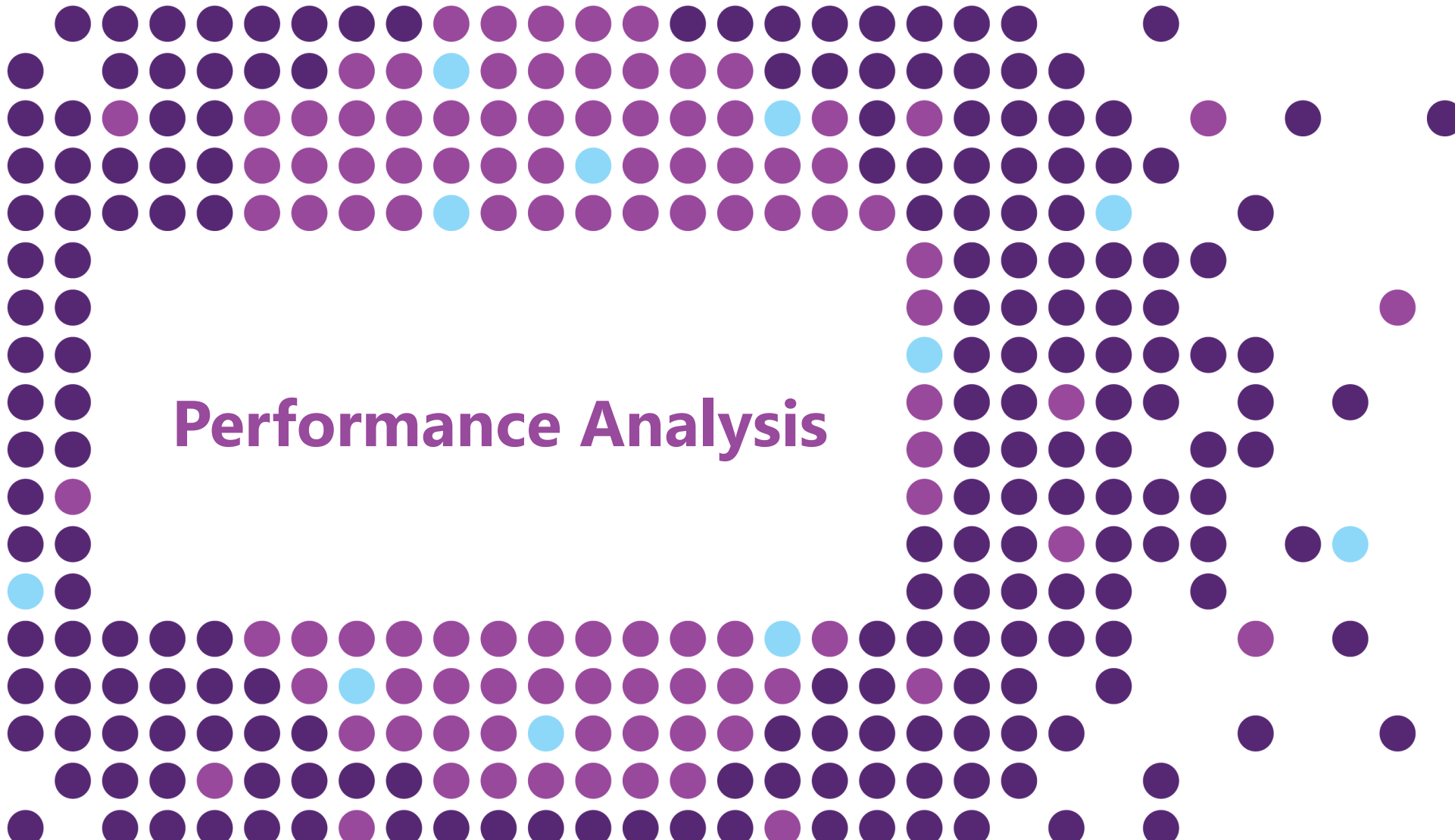
Humans and the environment are protected, now and in the future, by

- restricting the amount of long-lived radionuclides in the waste;
- radiation protection management;
- isolating the waste from the biosphere and contain the radionuclides;
- subsequent and independent elements of protection (defence in depth).





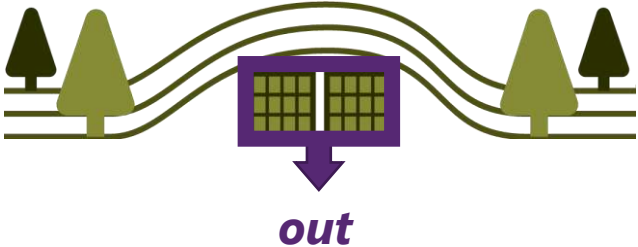
Performance Analysis — 3
Expected performance — 7
Robustness — 18



Performance Analysis

Safety Assessment

→ SC1 (2019)

IMPACT ANALYSIS 			
goal	Radiological impact acceptable?		
safety indicators	Dose	$\leq 0.1 \text{ mSv/a}$ $\sim 3 \text{ mSv(/a)}$	RS HIS/PS
	Risk	$\leq 10^{-5} \text{ a}^{-1}$ $\sim 10^{-6} \text{ a}^{-1}$	AES (all) AES (ind)
approach	conservative (no underestimation)		

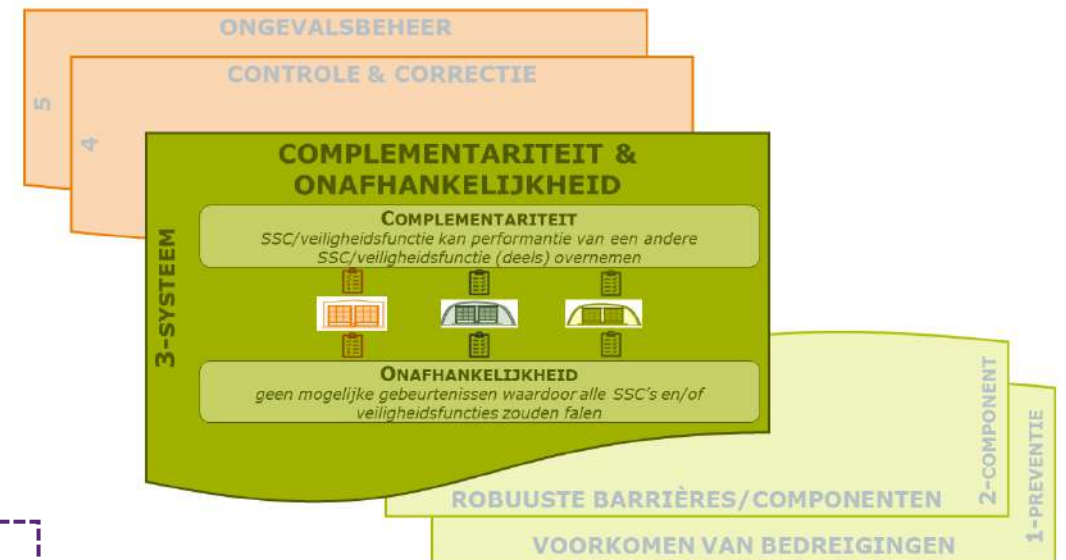
→ SC2 (2023)

PERFORMANCE ANALYSIS containment 			
goal	Safety concept effective (DID)?		
performance indicators a.o.	Mass-type	PI1 PI2 PI3	% decay Act/RT in component Concentration distribution
	Flux-type	PI4 PI5 PI6	Act/RT flux between comp's RT flux out cumulative RT flux out
approach	representative (best estimate)		

Performance Analysis: *containment*

objectives

1. Quantify the ***expected containment performance*** of the disposal system and of its components and safety functions
2. Demonstrate that the disposal system and its components are ***robust*** against possible threats/perturbations
3. Demonstrate that the containment performance is ***commensurate with the risks*** posed by the waste

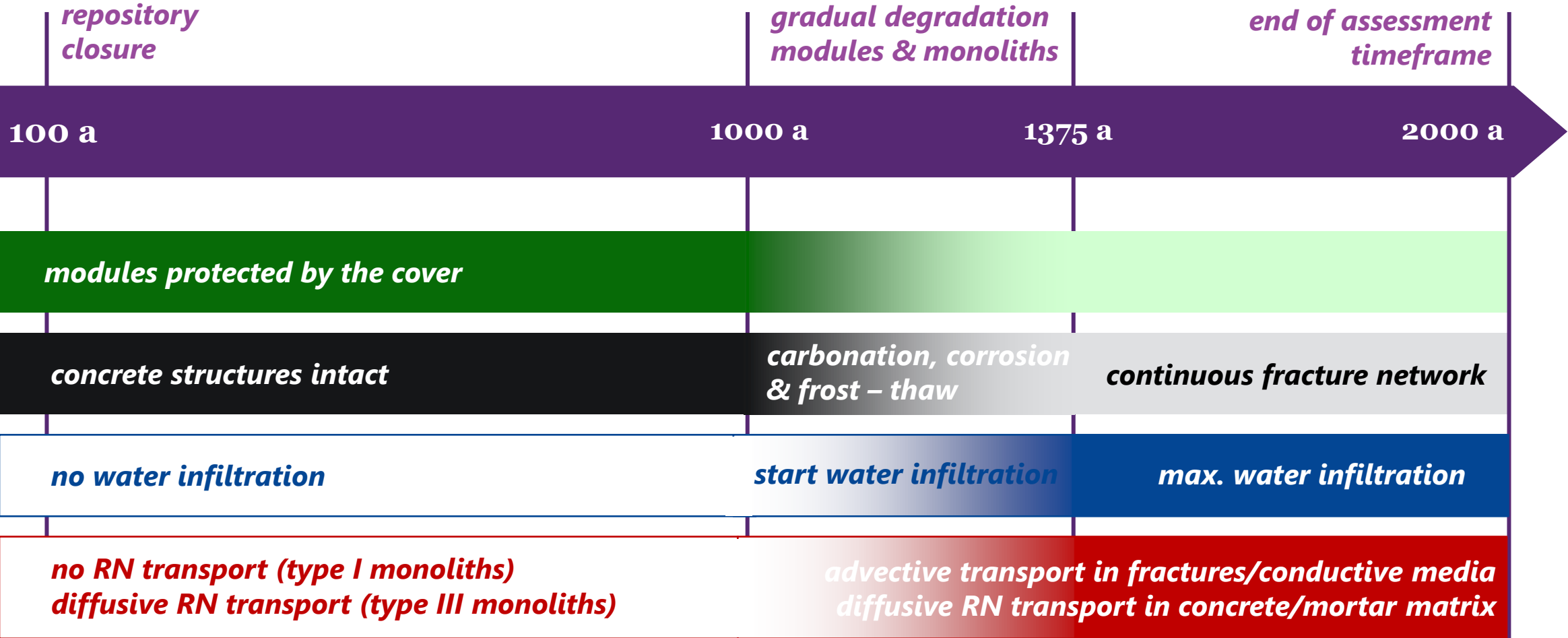


→ ***defence-in-depth principle***



Expected performance

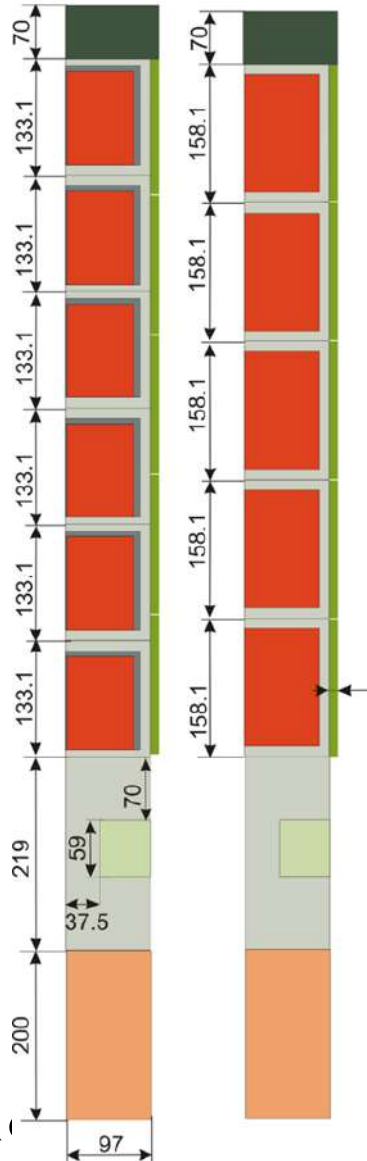
Expected evolution: EES





Performance Analysis model

TI - initial TIII - initial

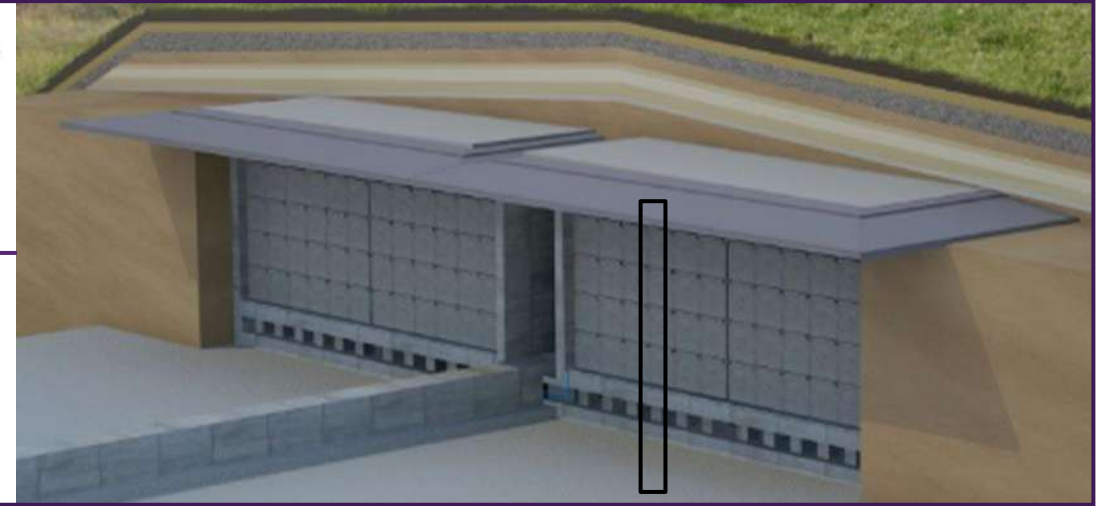


- redistribution layer
- concrete
- mortar
- waste form
- inspection room backfill
- embankment
- inter-monolith space
- fracture

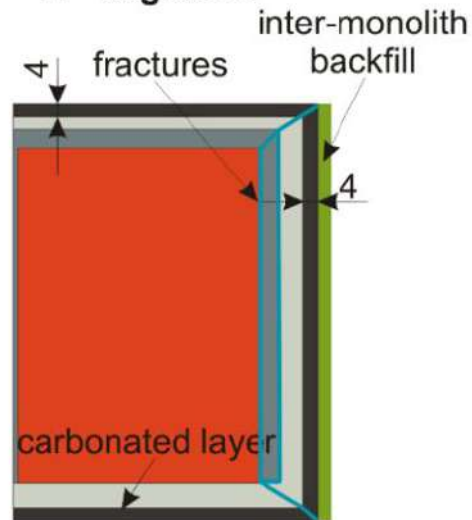
Type I



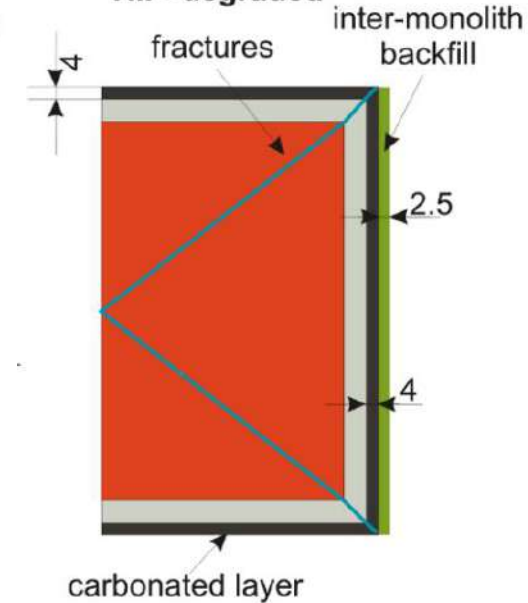
Type III



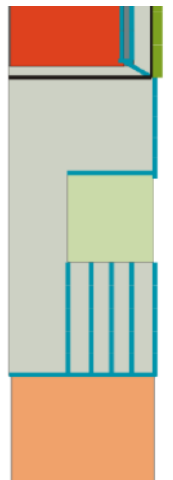
TI - degraded



TIII - degraded



module base - degraded



Performance indicators / output

Indicators

- **PI1**: decayed fraction in component
- **PI2**: activity/radiotoxicity in component
- **PI3**: concentration profiles
- **PI4**: flux between components
- **PI5**: flux out of disposal system
- **PI6**: cumulative flux out of disposal system
- **PI7**: residence time in component /
containment factor

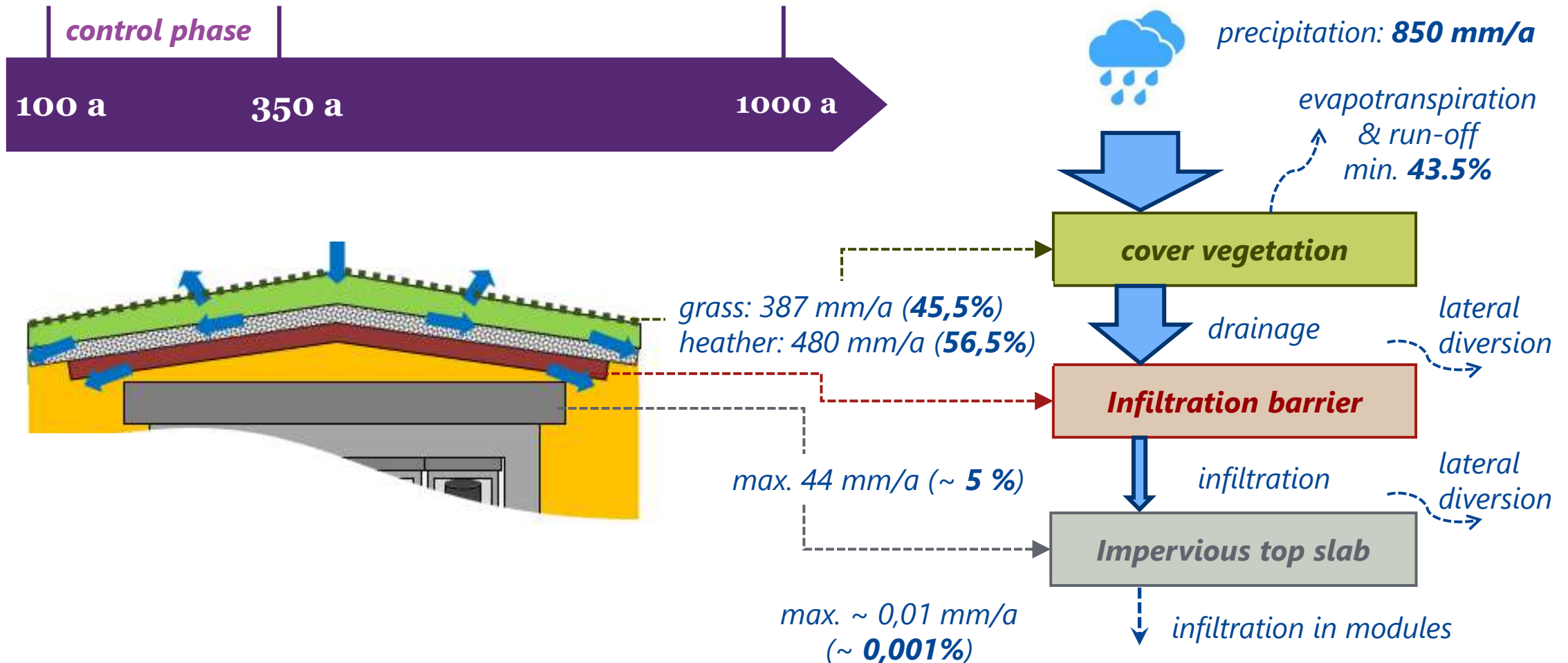
Activity distribution

- 100% in Type I monoliths
- 100% in Type III monoliths
- Weighted: 76% in Type I
24% in Type III

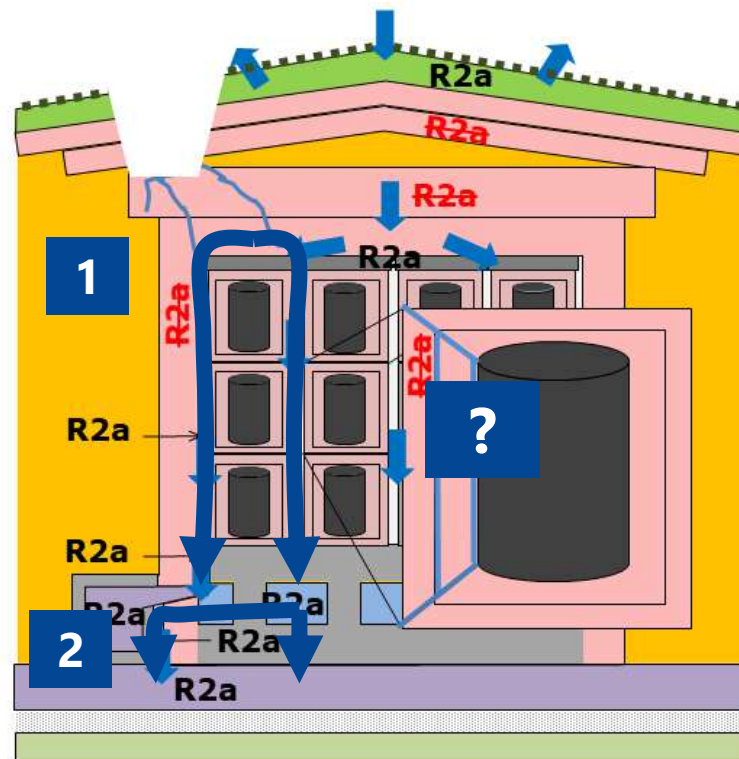
Sorption classes (on HCP)

- Class I: $K_d \leq 10^{-2} \text{ m}^3/\text{kg}$ (e.g. Be, I, Cs)
- Class II: K_d in between (e.g. Ca, Cl, Ni)
- Class III: $K_d \geq 1 \text{ m}^3/\text{kg}$ (e.g. Nb, Pd, act)

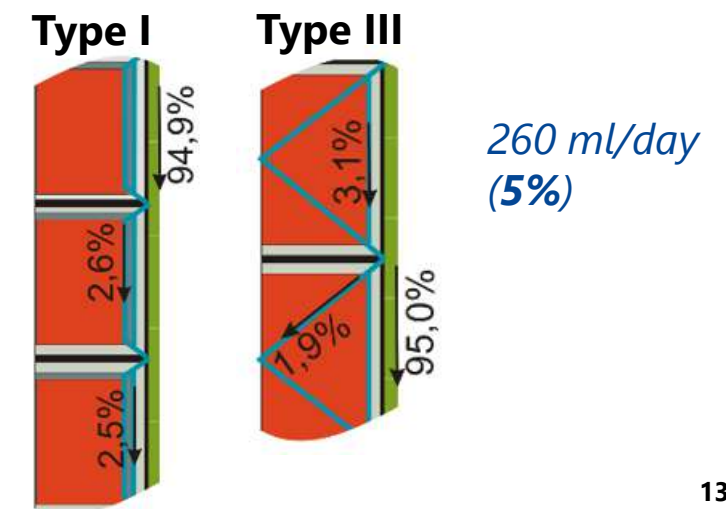
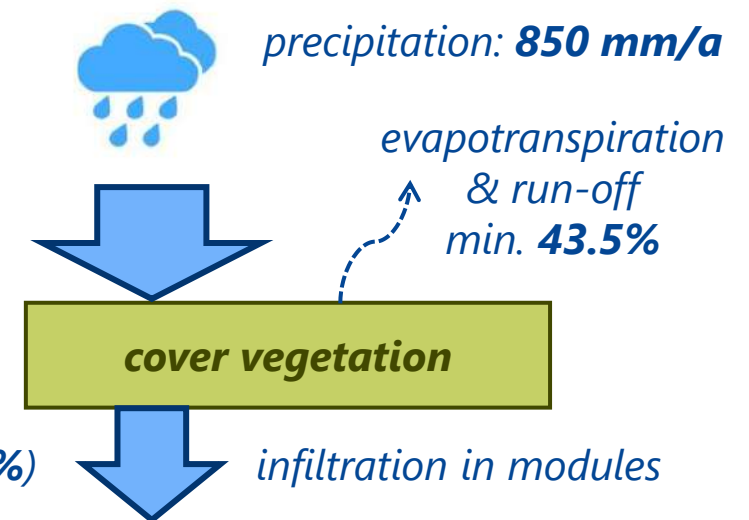
Limitation of water infiltration in modules (R2a)



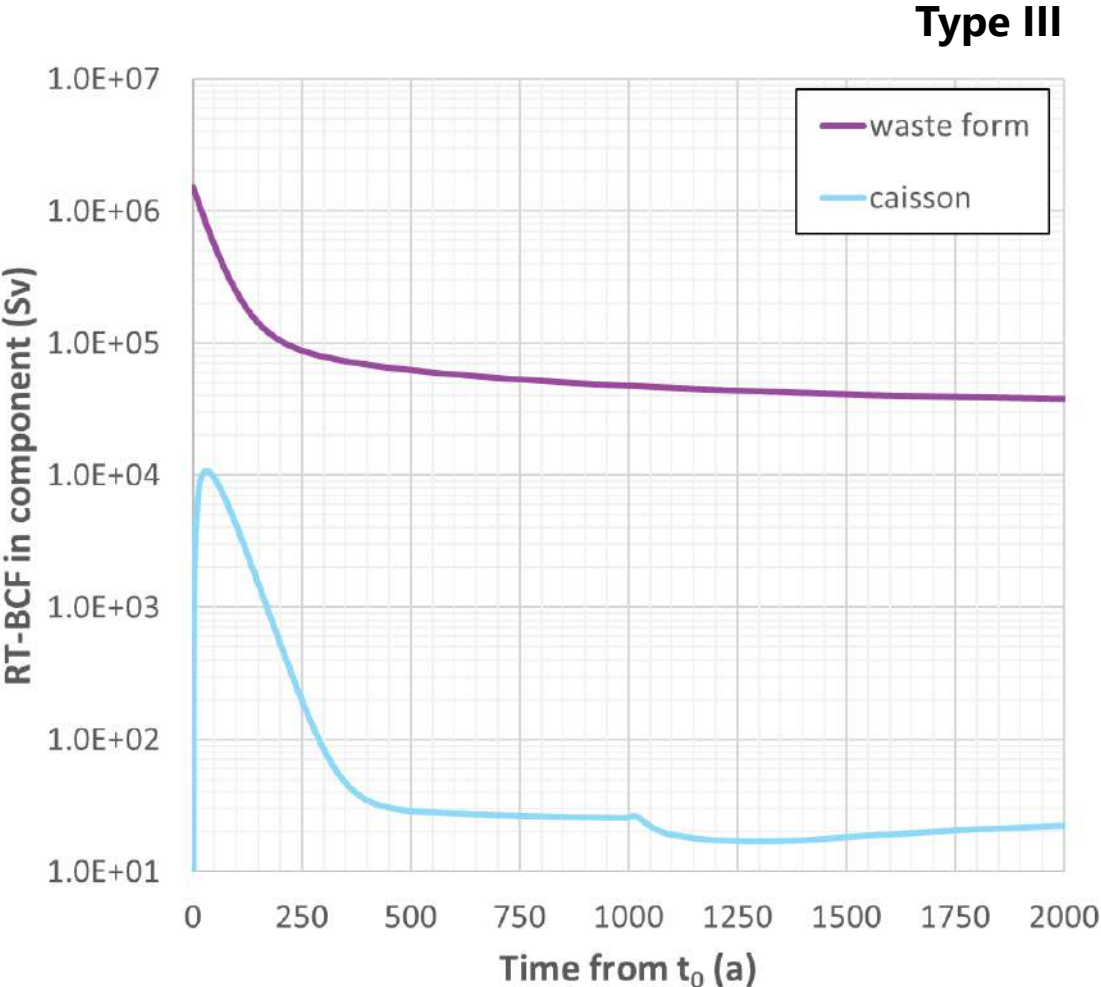
Diversion of water away from the waste (R2a)



1. Preferential flow between monoliths
2. Avoid bath-tubbing by proper drainage in module base



Containment inside monoliths (R1/R3/R4a)

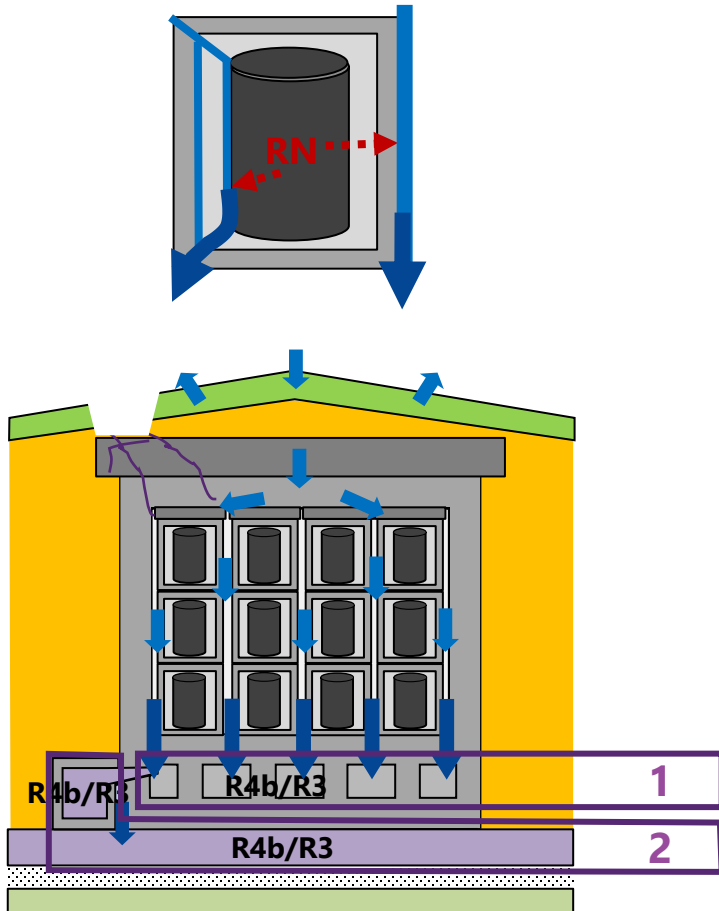


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Activity in monolith after 2000 a

	% decay	waste	mortar	caisson	total
¹⁰ Be	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%
¹²⁹ I	<0.01%	2.9%	1.1%	0.3%	4.2%
⁵⁹ Ni	1.8%	74.0%	12.0%	2.5%	90.3%
²³⁹ Pu	5.6%	92.9%	1.4%	0.1%	~100%

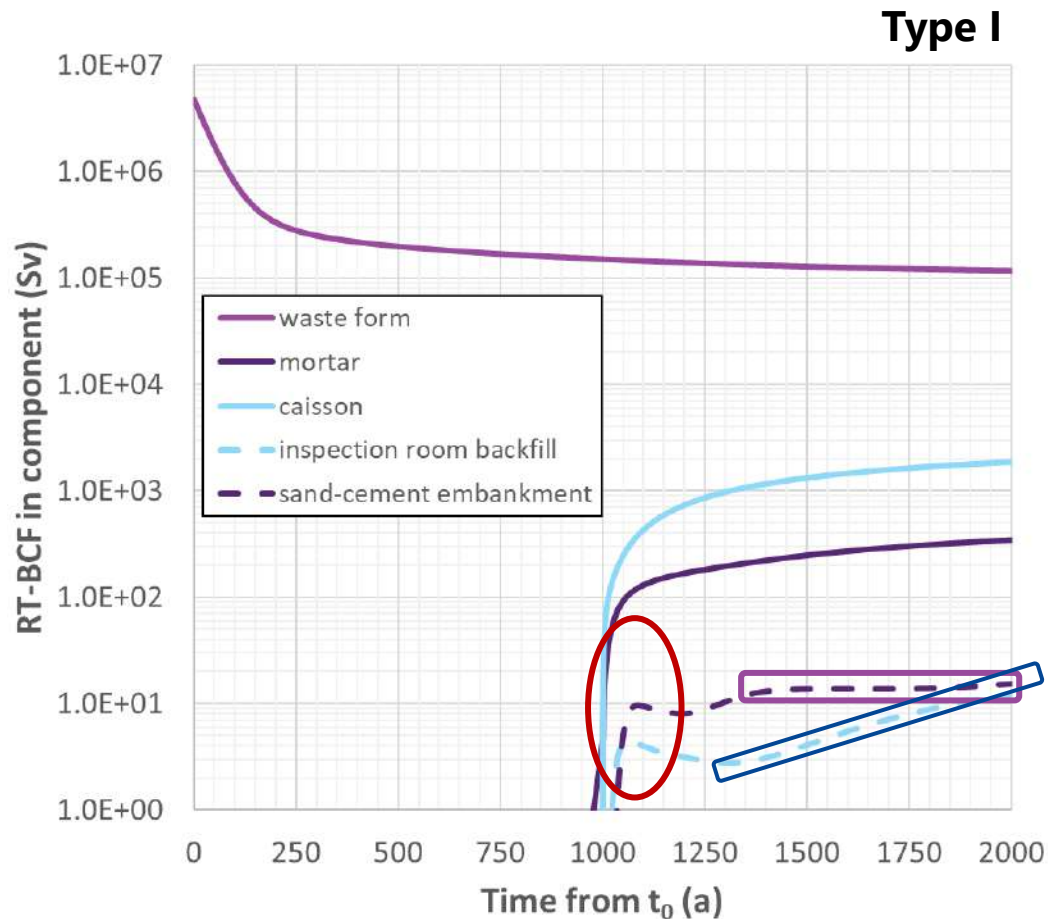
Containment outside monoliths (R3/R4b)



- Radionuclides that end up in fractures or the inter-monolith space (IMS) are further transported by advection
- Releases from the disposal system are still spread in time by dispersion in **Conductive Sorbing Media (CSM):**
 1. Grout backfill in inspection room
 2. Sand-cement in embankment, inspection gallery and connecting tunnels

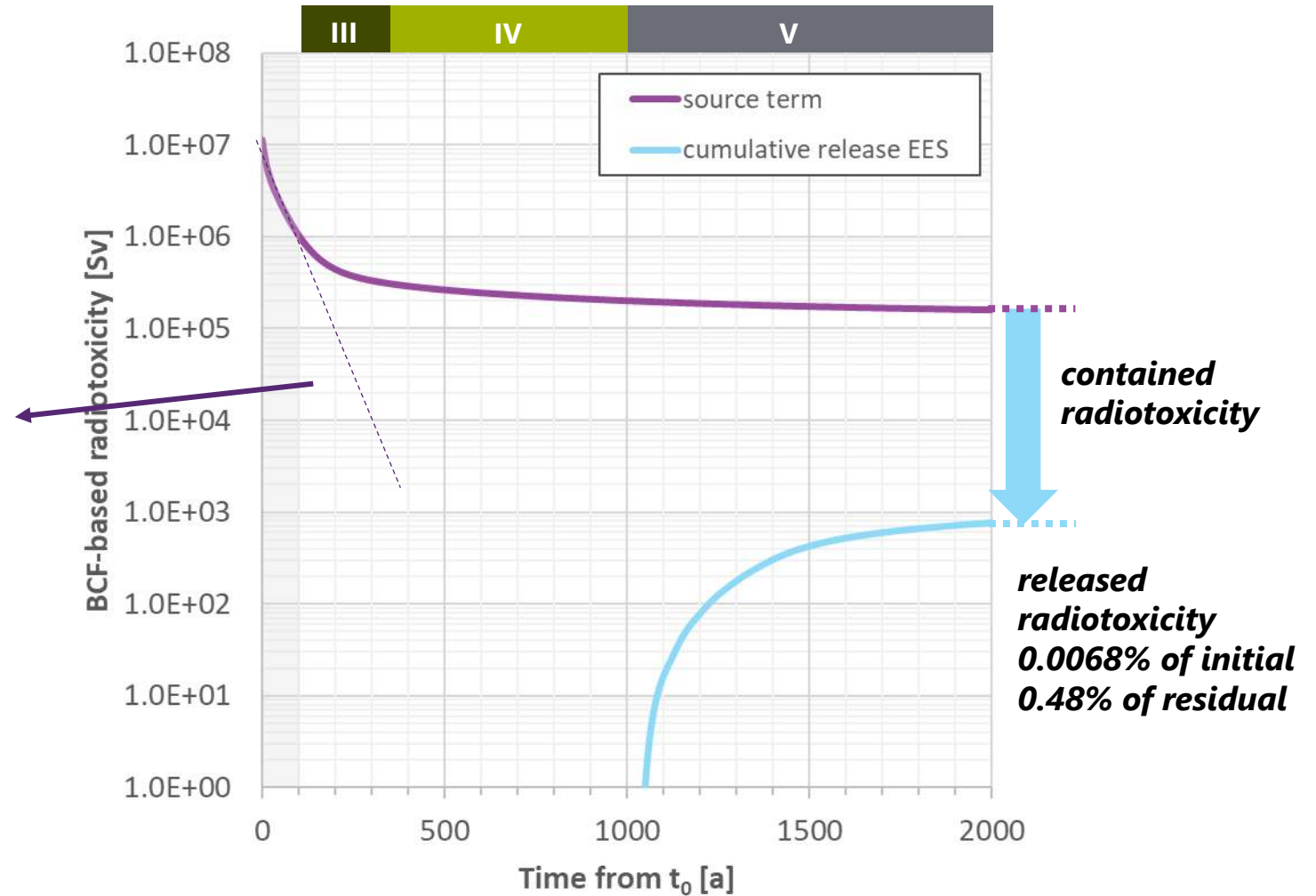
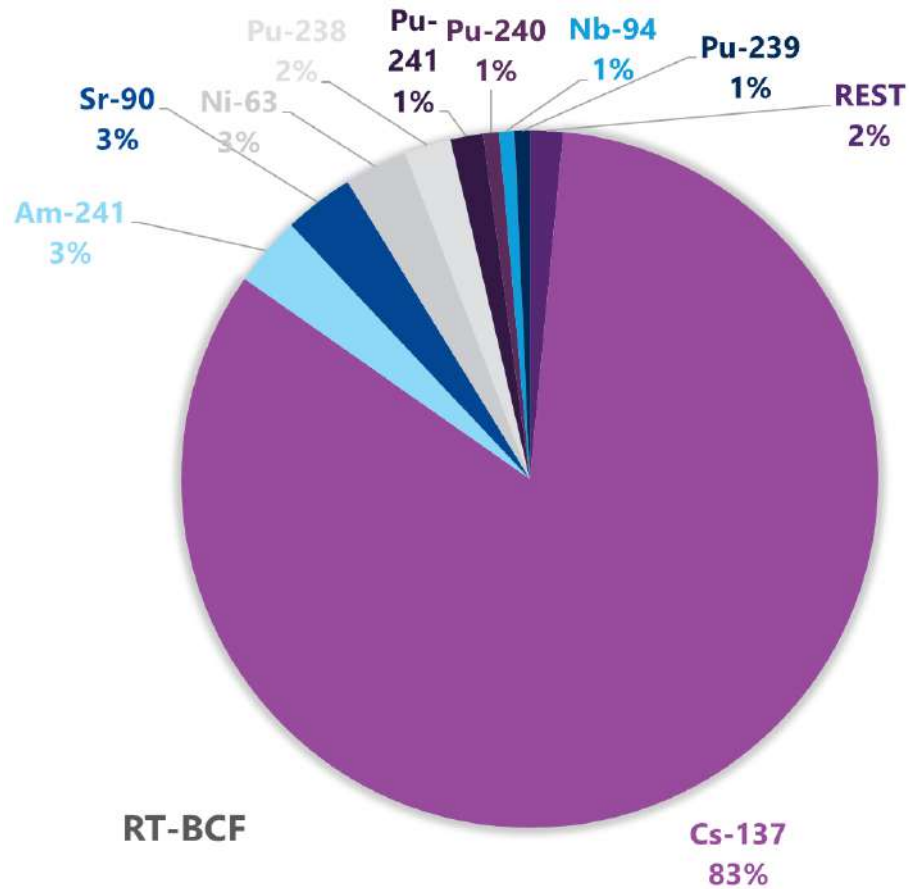
Containment outside monoliths (R3/R4b)

Role of conductive sorbing media



- Non-sorbed radionuclides **shortly accumulate** in CSM and are soon released again
- Moderately sorbed radionuclides are delayed, but reach a **plateau** (supply $\approx$ discharge)
- Well-sorbed radionuclides **accumulate** in the inspection room

Expected containment performance



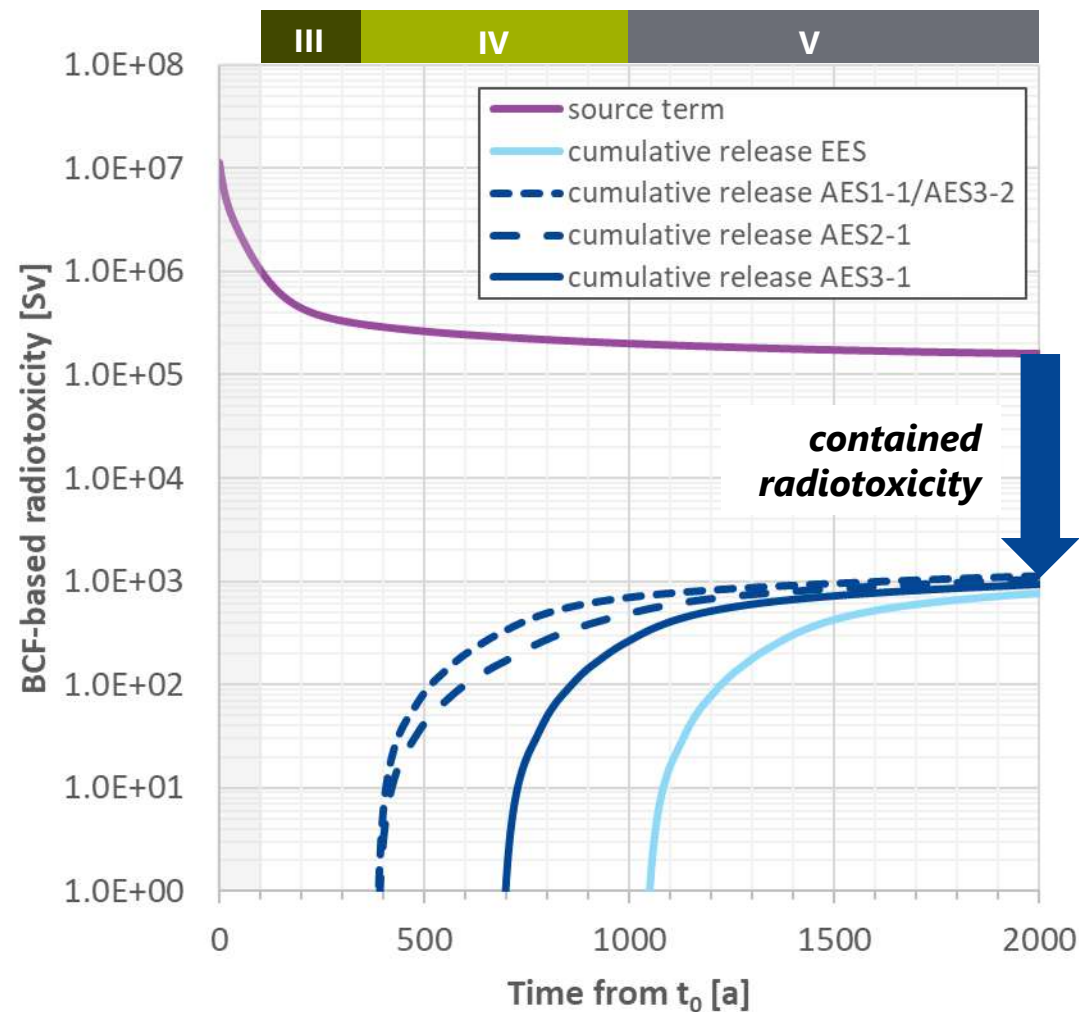


Robustness

Robustness against *threats*

1	Threats directly compromising the <i>protective</i> role of the earth cover	- Erosion (AES3-1, AES3-2) - Crash of small aircraft (AES2-1) - Earthquake (AES1-1)	Early gradual degradation
2	Threats causing a direct and <i>abrupt</i> degradation of cementitious SSCs	- Crash of a large aircraft (AES2-2) - Heavy earthquake (AES1-2) - Large scale excavation (HIS excav)	- Early abrupt degradation 50% water flow in monolith fractures - Extra fracture in Type I monoliths
3	Threats causing a <i>bypass</i> of SSCs that normally contribute to the containment capacity	Borehole drilling (HIS drill)	- Bypass of CSM (all monoliths in affected module) - Same as 2 (pierced stack)
4	Threats causing <i>internal</i> perturbations	undetected complexants in the waste form (AES4)	1% of the waste with zero sorption

Impairment of the cover

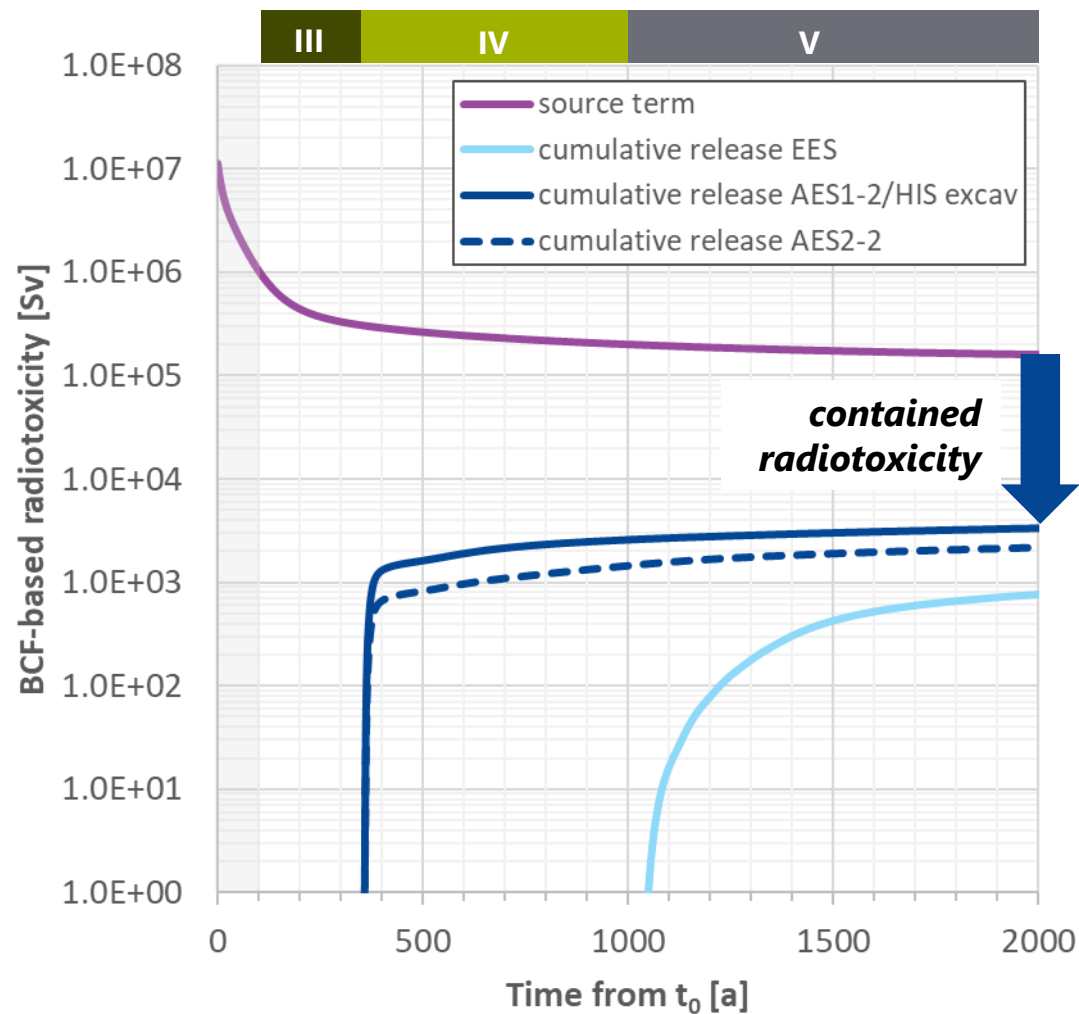


Cumulative released RT	EES	AES1-1	AES2-1	AES3-1
% of initial RT	0.0068	0.0102	0.0093	0.0084
% residual RT	0.48	0.72	0.65	0.59

Performance loss of the cover is compensated by:

- Efficient water diversion away from the waste (R2a)
- Slow release from the waste form (R1/R3)
- Dispersion in conductive sorbing media (R4b/R3)

Abrupt and extreme degradations



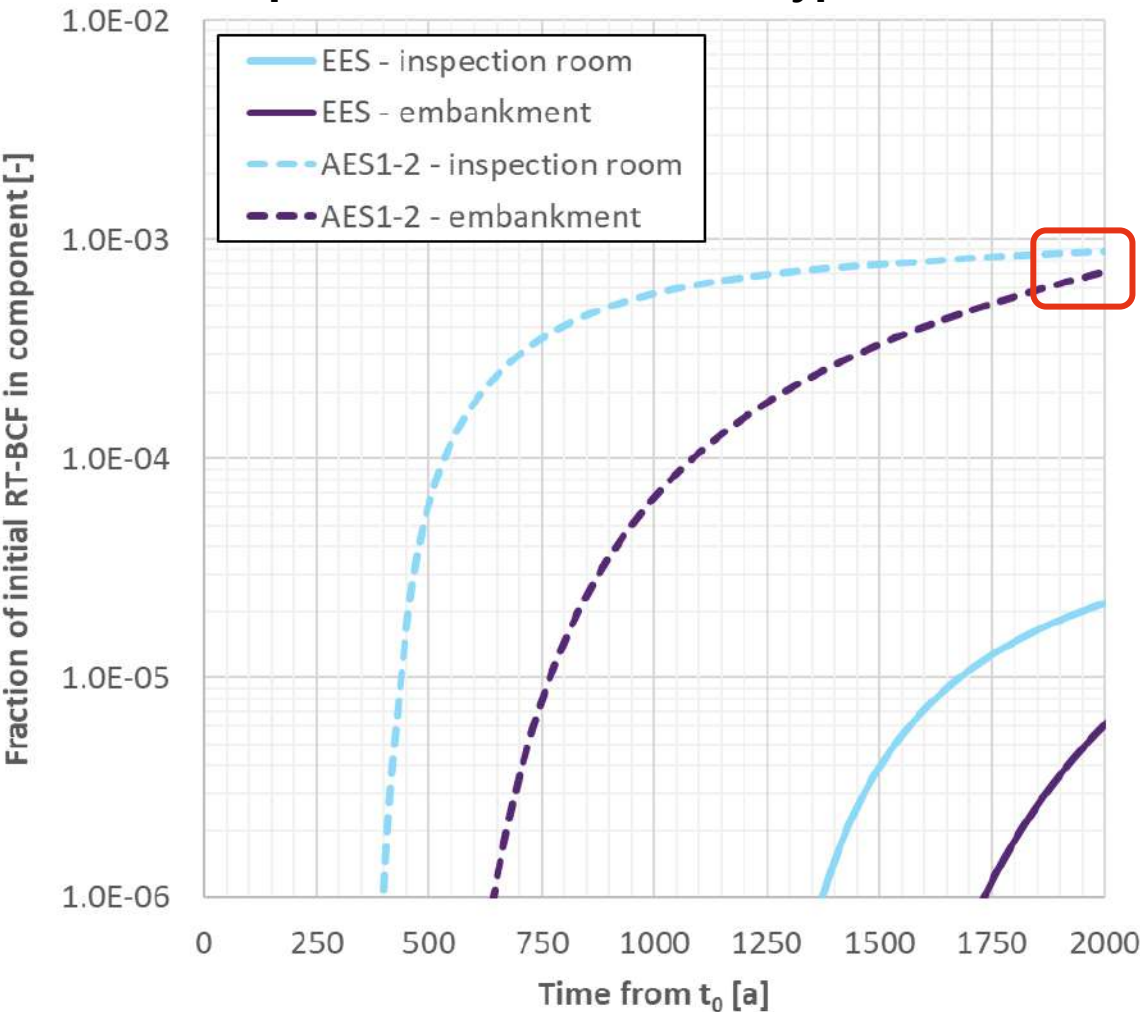
Cumulative released RT	EES	AES1-2	AES2-2	HIS excav
% of initial RT	0.0068	0.0302	0.0193	0.0302
% residual RT	0.48	2.13	1.36	2.13

Performance loss of cementitious barriers is compensated by:

- Slow release from the waste form (R1/R3)
- Dispersion in conductive sorbing media (R4b/R3)

Role of conductive sorbing media (bis)

Sorption class III nuclides in Type I monoliths

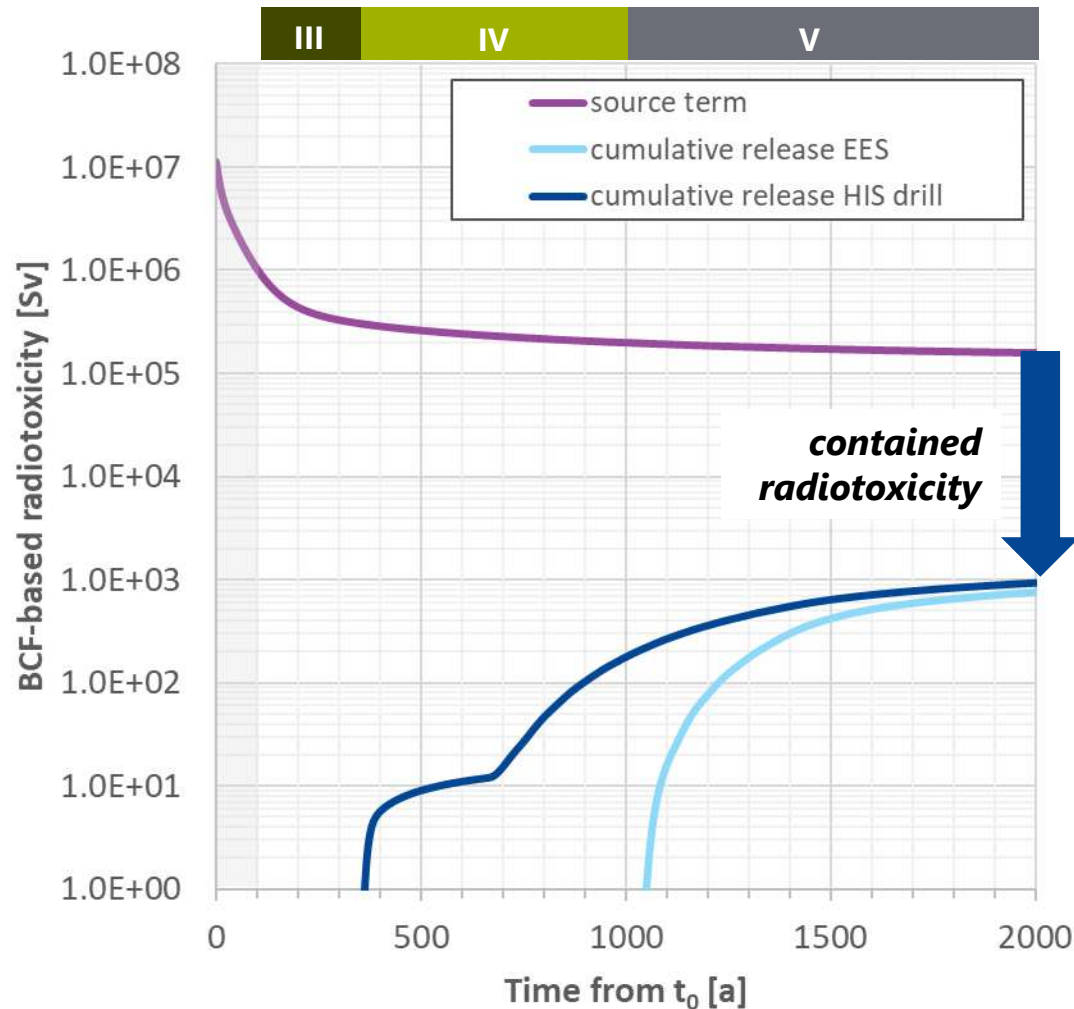


Theoretical transport time [a]

K_d [m ³ /kg]	Inspection room 60 cm thick	Embankment 2 m thick
0	< 1 a	< 1 a
0,1	17 a	37 a
0,5	84 a	185 a
1	167 a	370 a
10	1 668 a	> 2 000 a

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Bypass of conductive sorbing media (CSM)

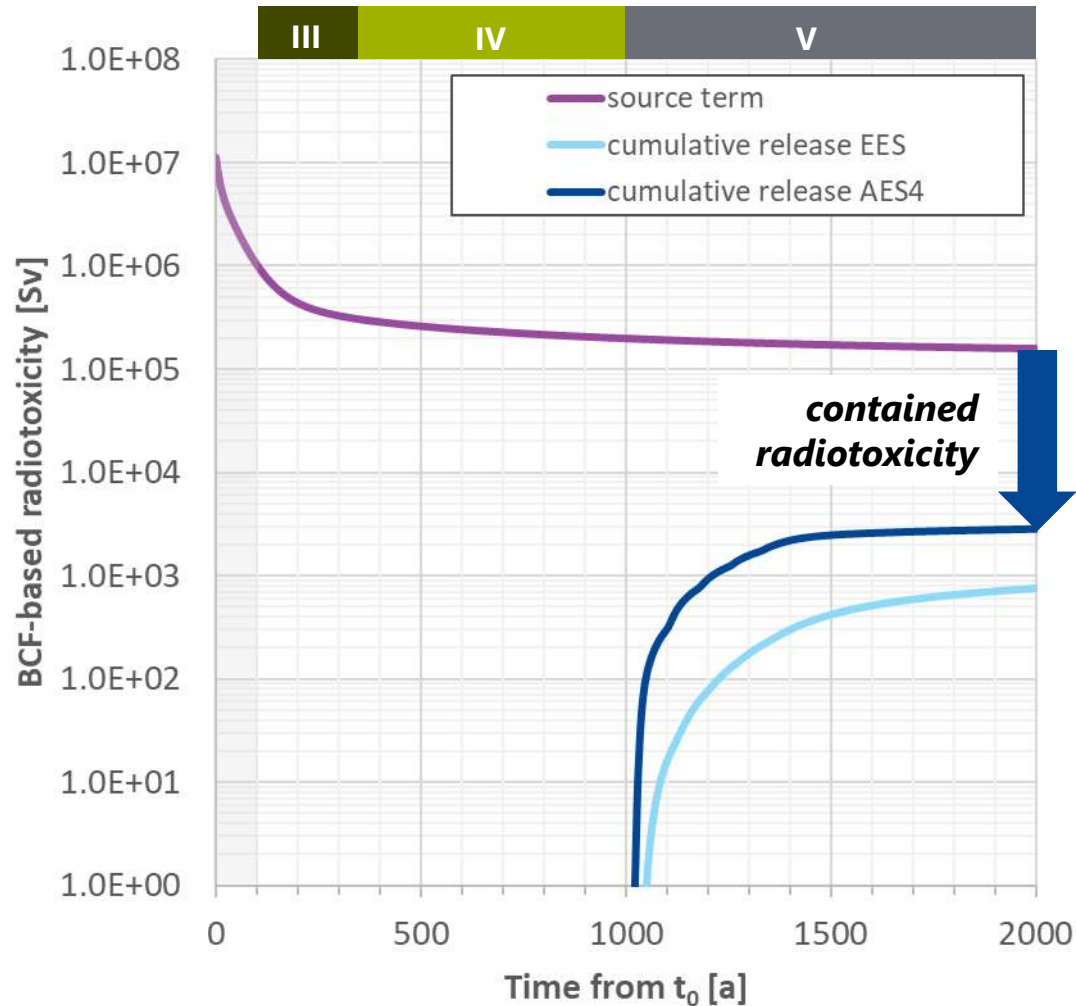


Cumulative released RT	EES	HIS drill
% of initial RT	0.0068	0.0084
% residual RT	0.48	0.59

Performance loss through bypass of CSM is compensated by:

- Efficient water diversion away from the waste (except for the pierced monolith stack) (R2a)
- Slow release from the waste form (R1/R3)

Internal disturbances (complexants)



Cumulative released RT	EES	AES4
% of initial RT	0.0068	0.0252
% residual RT	0.48	1.77

Local loss of sorption capacity due to undetected presence of complexants is compensated by:

- Protection by the cover (no *early* degradation)
- Efficient water diversion away from the waste (R2a)
- Slow release from the waste form and slow diffusion in the concrete/mortar matrix (R1/R4a)

Conclusions of FANC / Bel-V

R-SER-22-043-0-n

ONDRAF/NIRAS has performed a detailed performance analysis in which

- The complementarity of barriers and/or safety functions is demonstrated
- The disposal system shows an adequate level of robustness against reasonably foreseeable threats
- The performance of the disposal system is commensurate with the risks posed by the waste

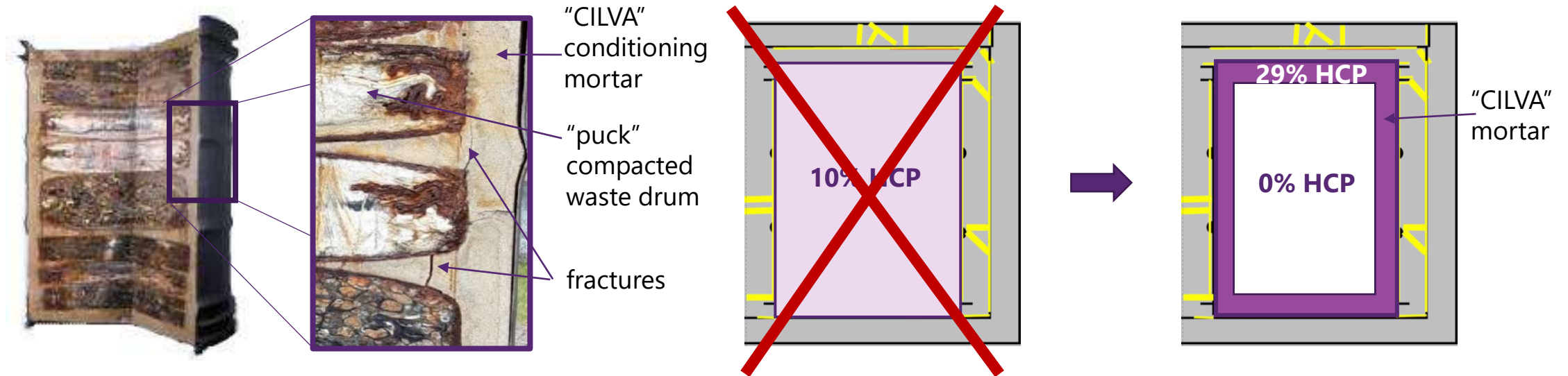
Conclusions of FANC / Bel-V

R-SER-22-043-0-n

The safety authority further asks to

- Update the impact analysis using the PA-model (one model for all)
- Evaluate the *bypass* potential for well-sorbed (class III) radionuclides in Heterogenously Cemented waste (HEC)

A potential “bypass” in HEC waste?



- To which degree can the sorption capacity in the conditioning mortar be bypassed by *well-sorbed* radionuclides that require some time to dissolve?
- Dedicated, representative model(s) in development...

The PA team

sck cen

Joan Govaerts

Janez Perko

Eef Weetjens

Diederik Jacques



Elise Vermariën

References

**SCK CEN report ER-0601
(OD-284)**

**§14.14 and §2.9
of the Safety Report**

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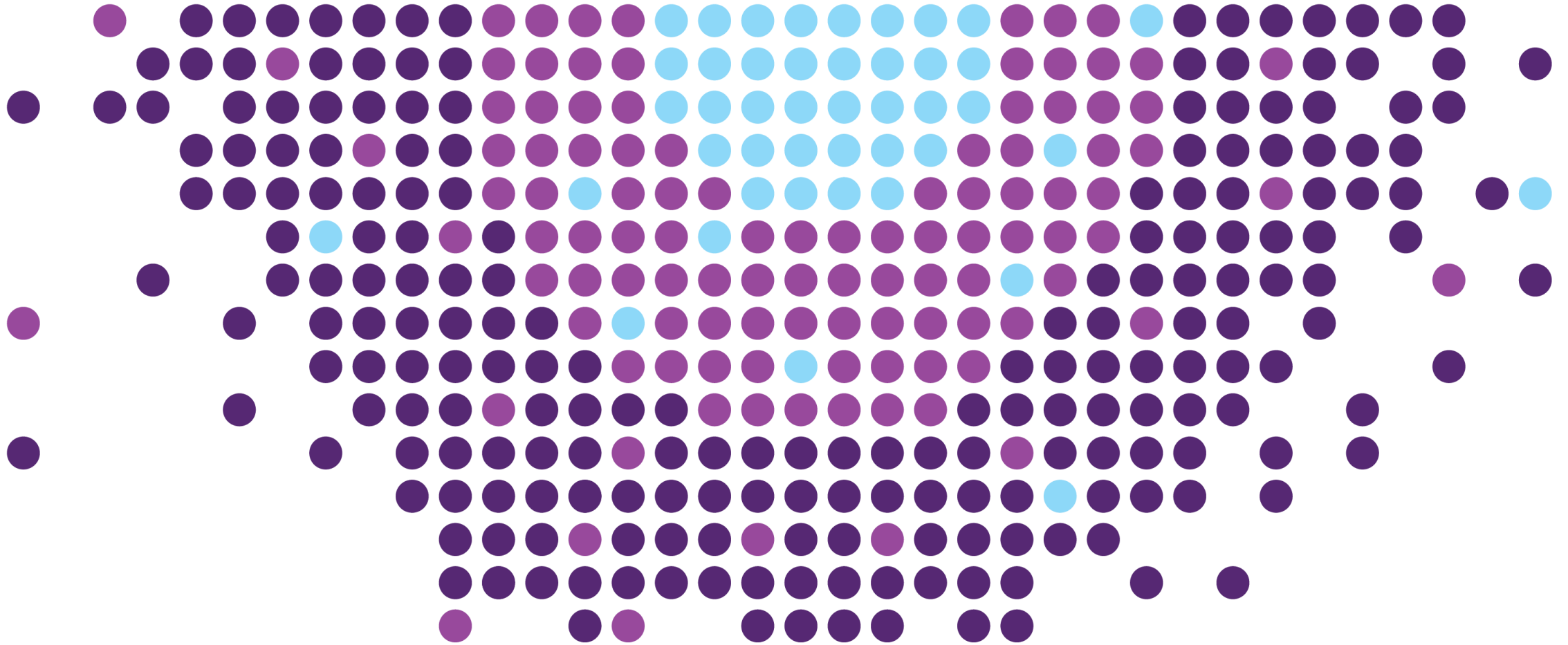
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Main author: Matej Gedeon

Contributions from Bart Rogiers, Koen Beerten,

Bertrand Leterme, ...

Discussions with ONDRAF – Laurent Wouters,

Frank Lemy, Elise Vermariën, Wim Cool, Olivier

Goossens, Lars Ghys, Rudy Bosselaere, ...

Discussion and input from IMDC – Jan

Walravens

....



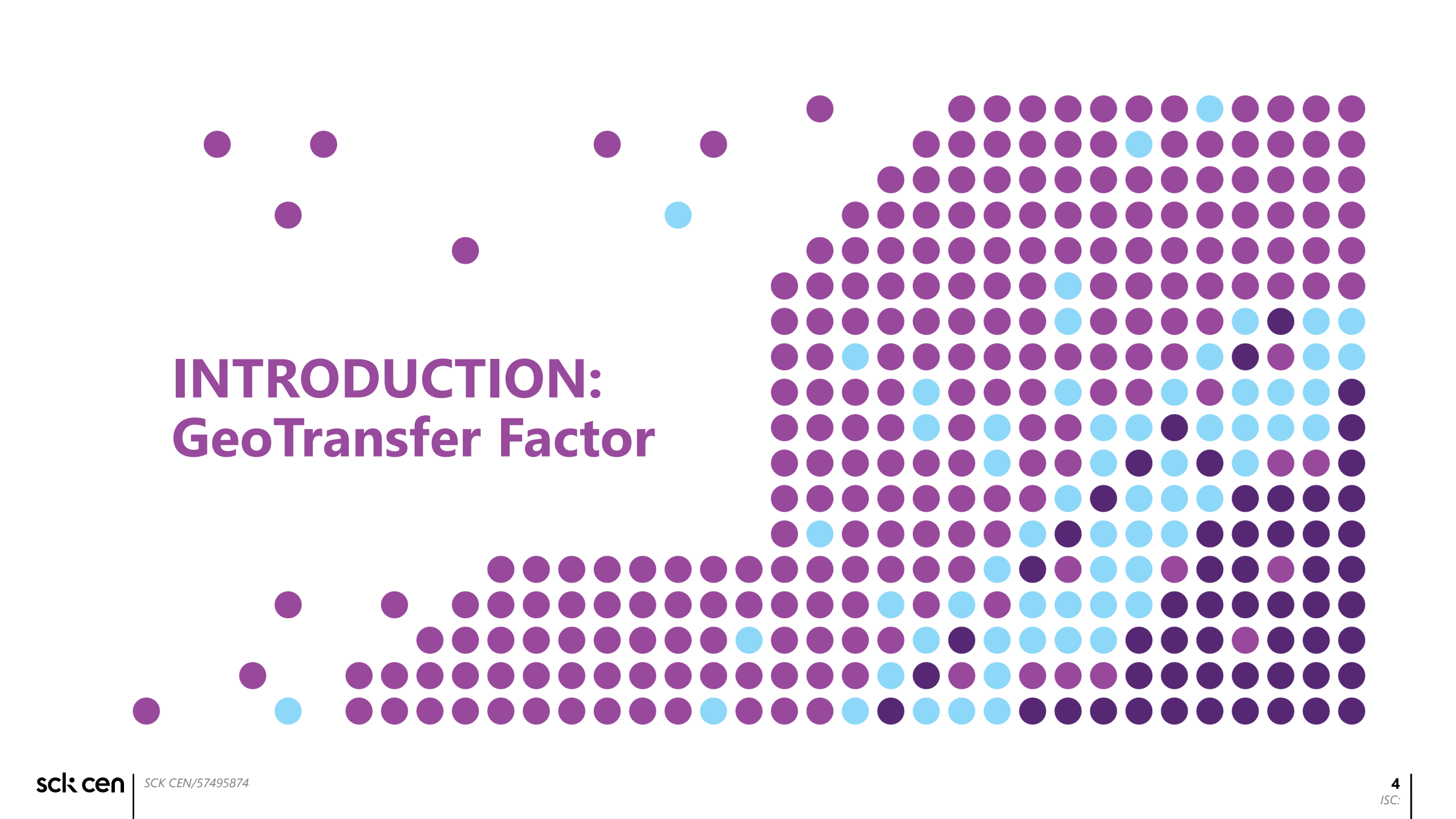
Introduction – Geotransfer factor

Knowing the environment

Ground water modelling

- Local Model
- Site Model
- Wetland model

Conclusions & Future work



INTRODUCTION: GeoTransfer Factor

Why do we need a Geo Transfer factor (GTF)

- To estimate the radiological impact of the disposal
- **Definition:** The ratio of the RN concentration in a biosphere receptor to the RN flux from disposal facility
- Higher GTF means there is a lower dilution in the geosphere
- Different biosphere receptors (pathways):
 - Private well
 - Wetlands

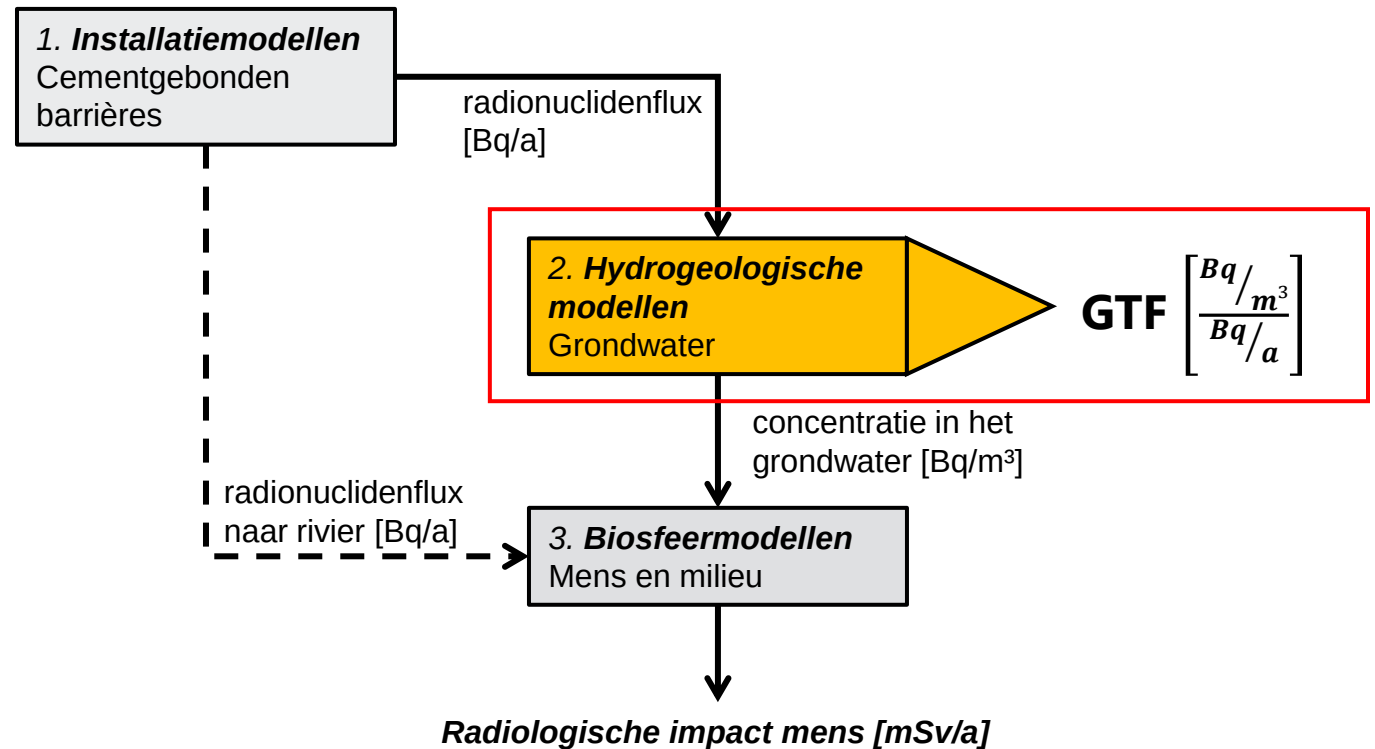
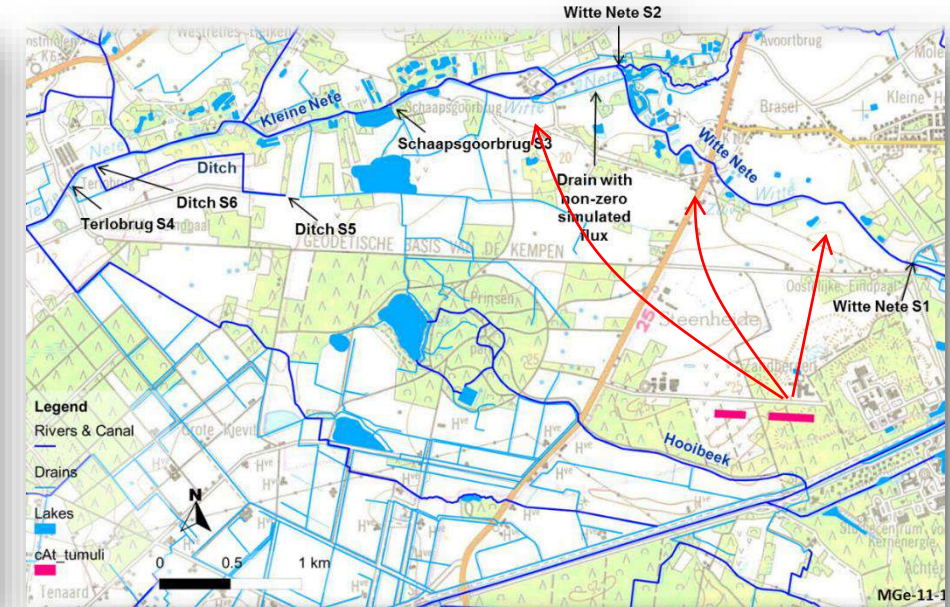
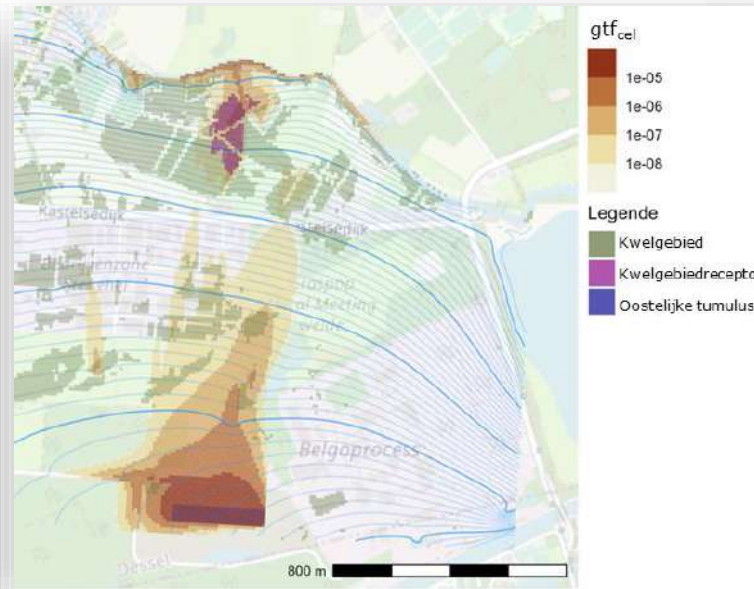
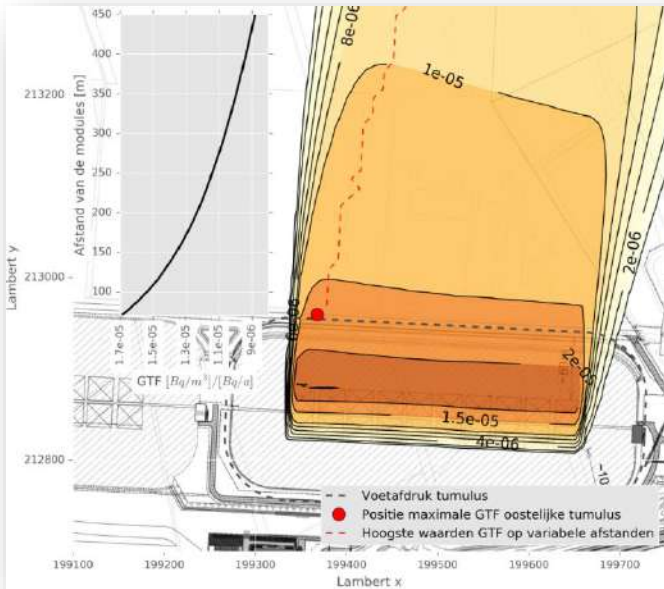


Figure adapted from the Safety file

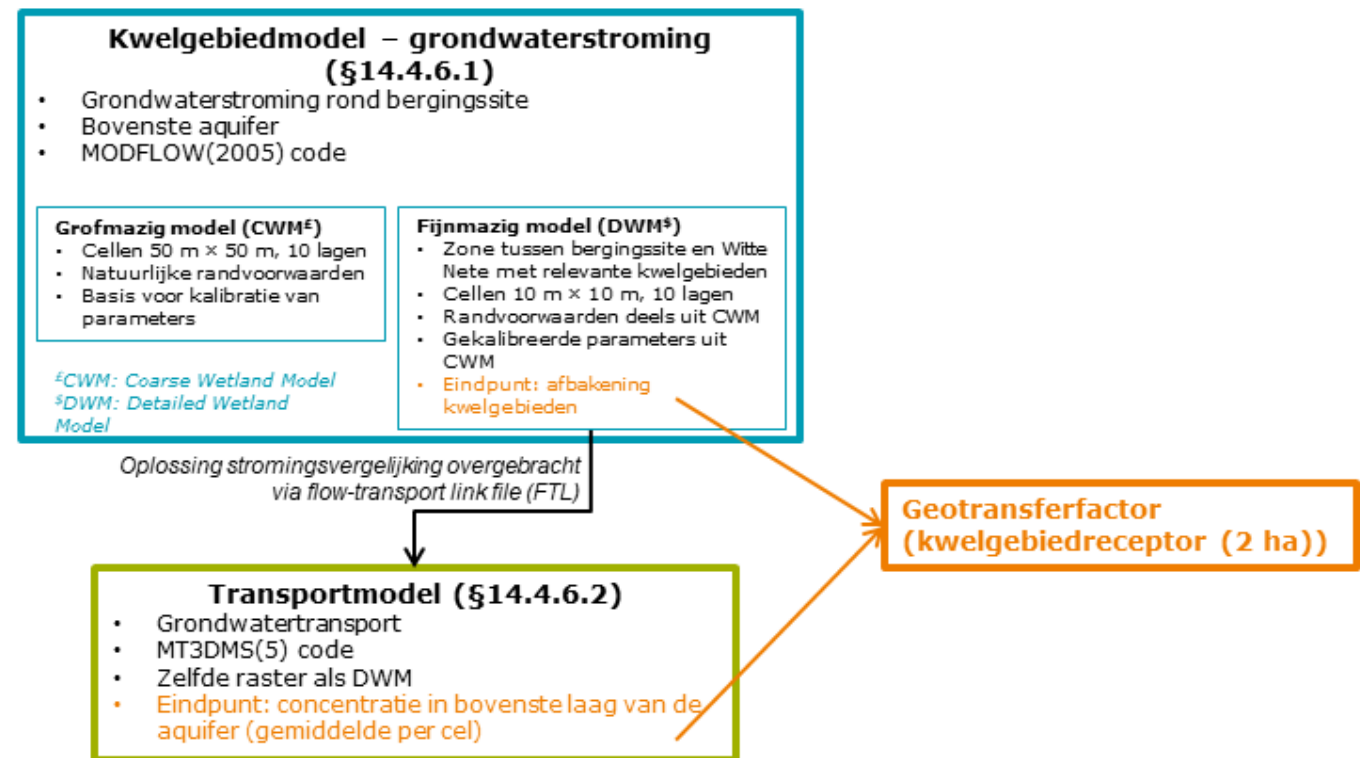
Why different GTFs?

- GTF is calculated for different biosphere receptors:
 - Private well: at the most adverse location at the foot of the tumuli
 - Wetlands: areas where (contaminated) groundwater reaches the roots of plants and a RN transfer can take place
 - River: drainage of (contaminated) groundwater to river network



How do we obtain GTFs?

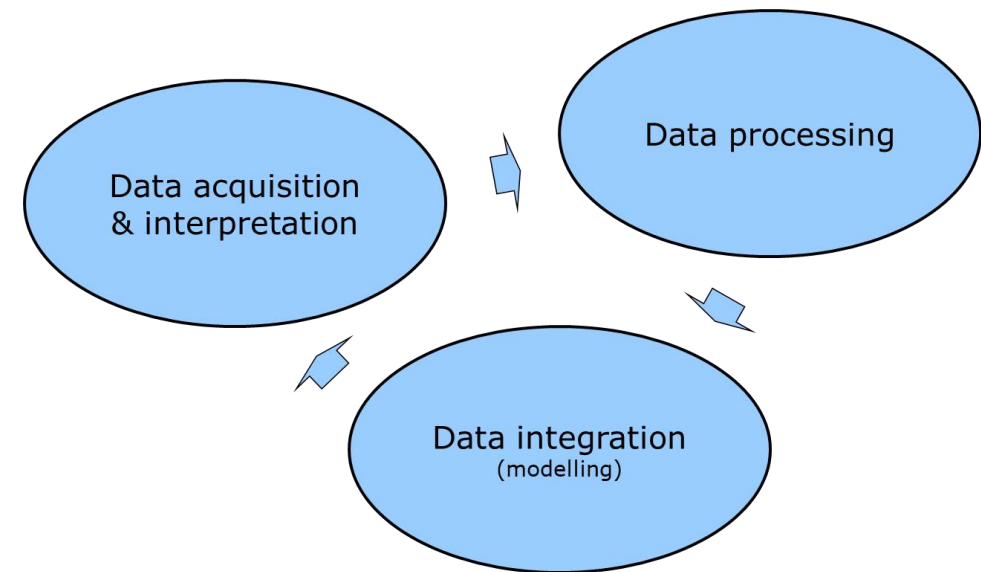
- Hydrogeological modelling
 - Groundwater flow model
 - Often using nested models to combine the natural boundary conditions with need for precision
 - Groundwater transport model
 - Using results from the flow model
 - Simulating constant activity flux through disposal tumulus
 - RN independent



KNOWING THE ENVIRONMENT

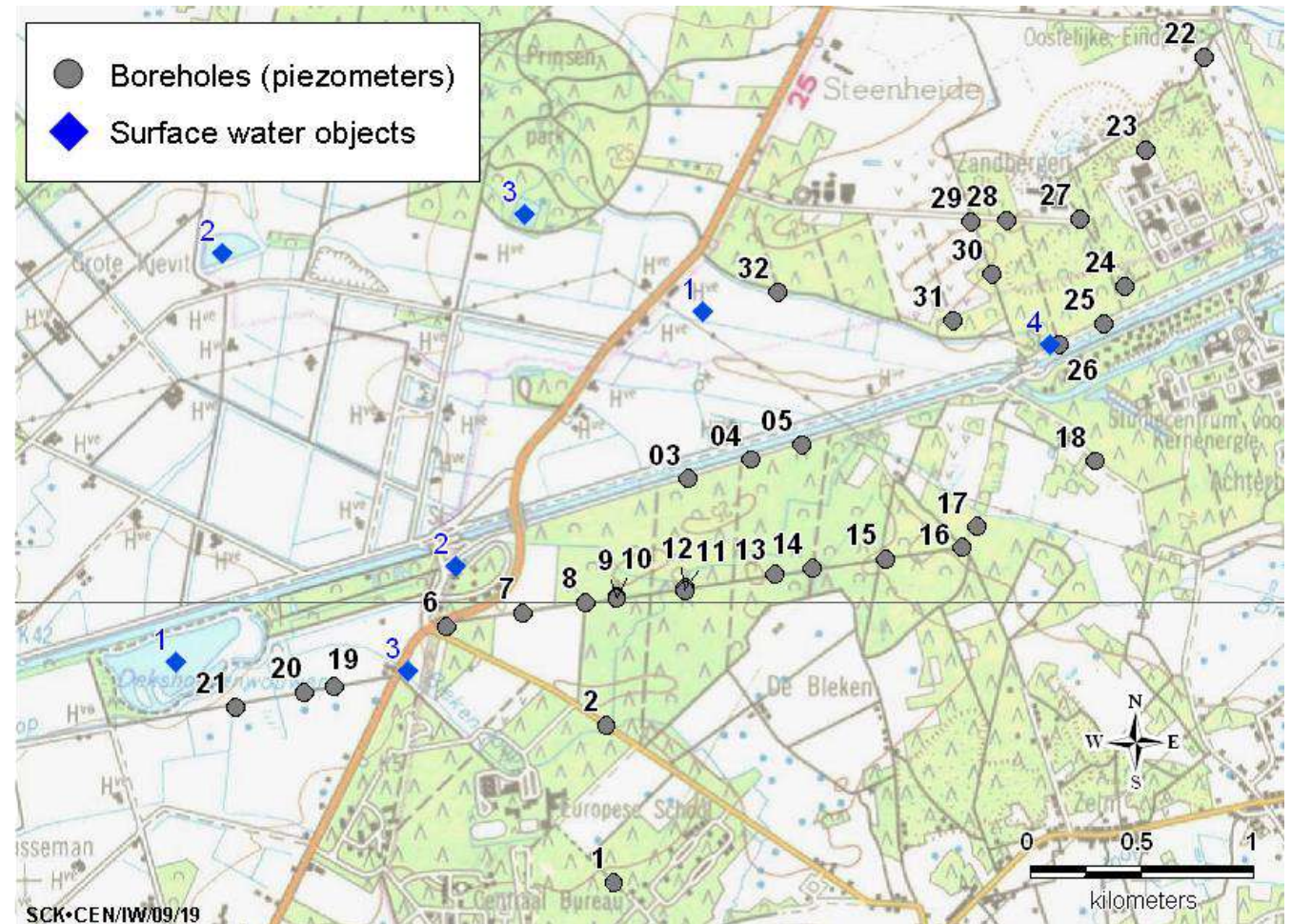
The characterization of the environment

- Long-term: starting in 1999 and lasting to date
- Stepwise iterative approach
 - Every site characterization campaign is followed by modelling
 - Every modelling is evaluated & then reviewed by the Safety Authority
 - This leads to further characterization to answer the raised questions
- Gradually focusing the site-characterisation efforts on building a solid safety-relevant scientific basis



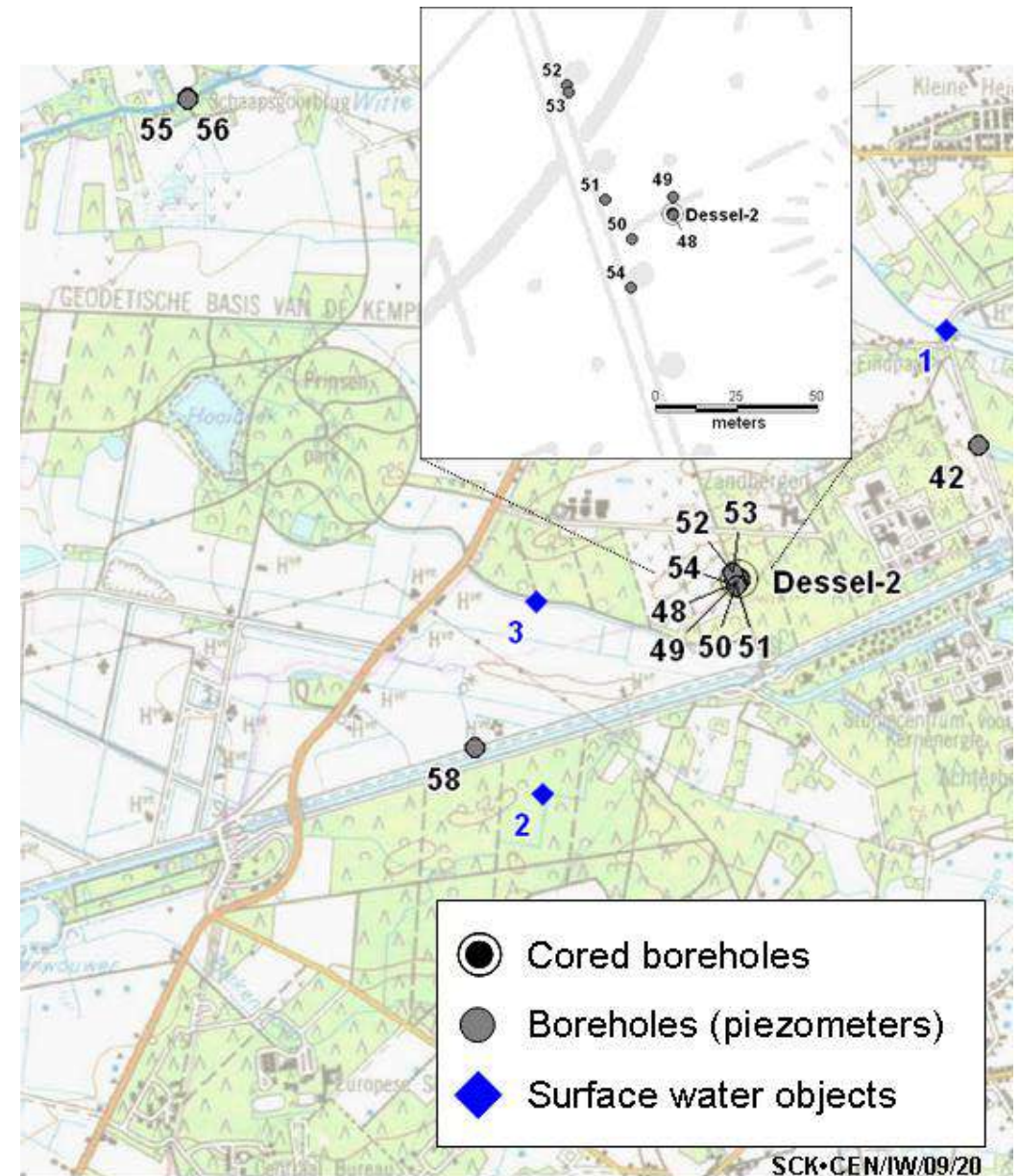
Campaign 1999 – 2000

- Focused on piezometry and surface water level observations
- Basis for the local piezometric network
- One pumping test L-11
 - South of the canal
- Initial modelling
 - *Role of Kasterlee Clay?*
 - *Boundary conditions?*



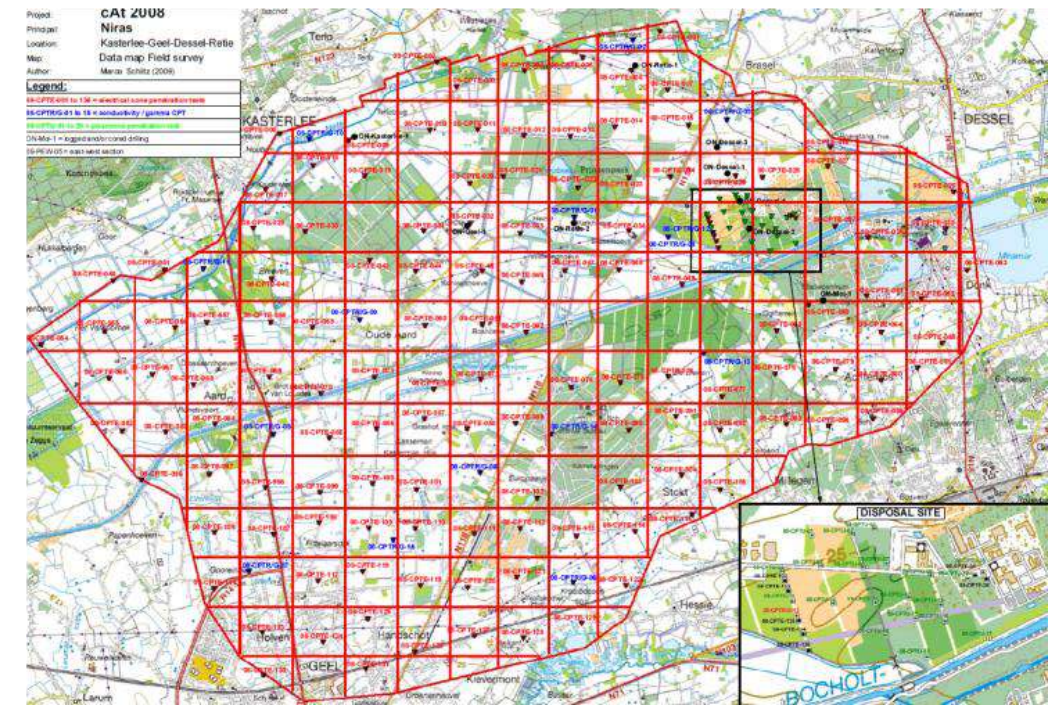
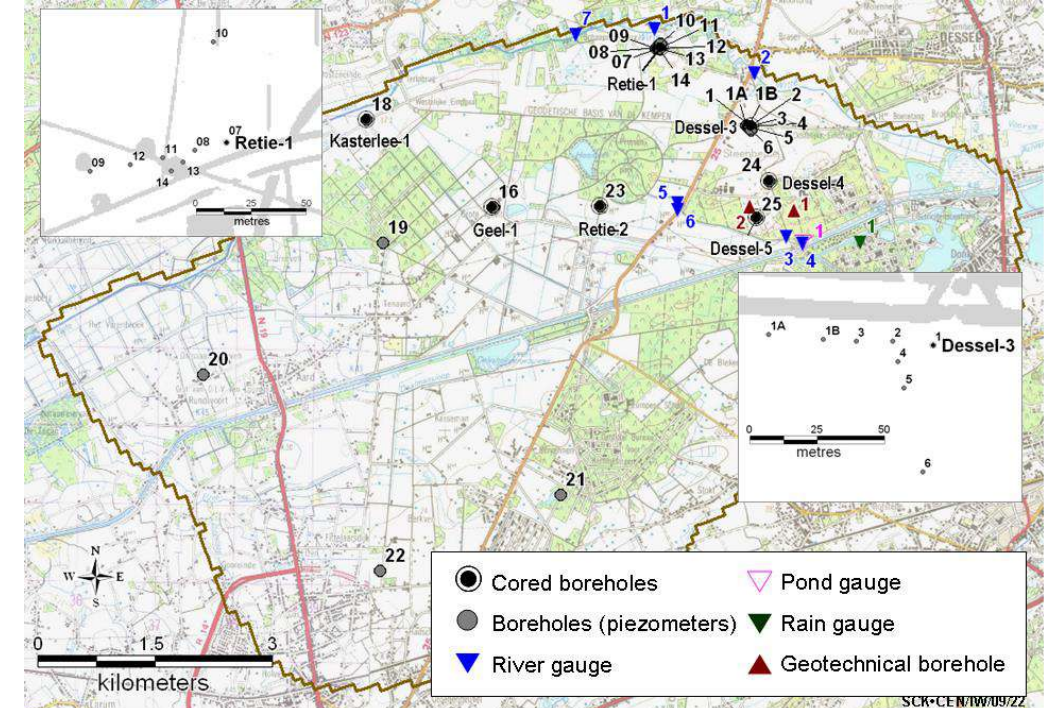
Campaign 2002

- Focused on hydraulic parameters at the cAt site
- Verification of the Kasterlee Clay (im)permeability
- Dessel-2 borehole cluster
 - 2 pumping tests
 - Core sample analyses
- Few extra piezometers and surface observations points
 - Focused on the boundary conditions (Nete, Hooibeek, sand pit, canal)
- Local model 1st iteration:
 - *Is Kasterlee Clay (dis)continuous?*
 - *Spatial coverage of observations?*



Campaign 2008

- Focus on the entire Local model area
 - Filling the white spots
 - Focus on the principal pathway
 - Piezometry
 - Pumping tests
 - Core sample analyses
- Kasterlee Clay continuity verification
 - **Cone Penetration Testing**
 - Performed on a regular grid
 - More precise stratigraphy
 - Detailed geometry of the Kasterlee Clay
- Local model 2nd iteration (SC 2013)
 - *Can we validate the flow direction and velocity?*



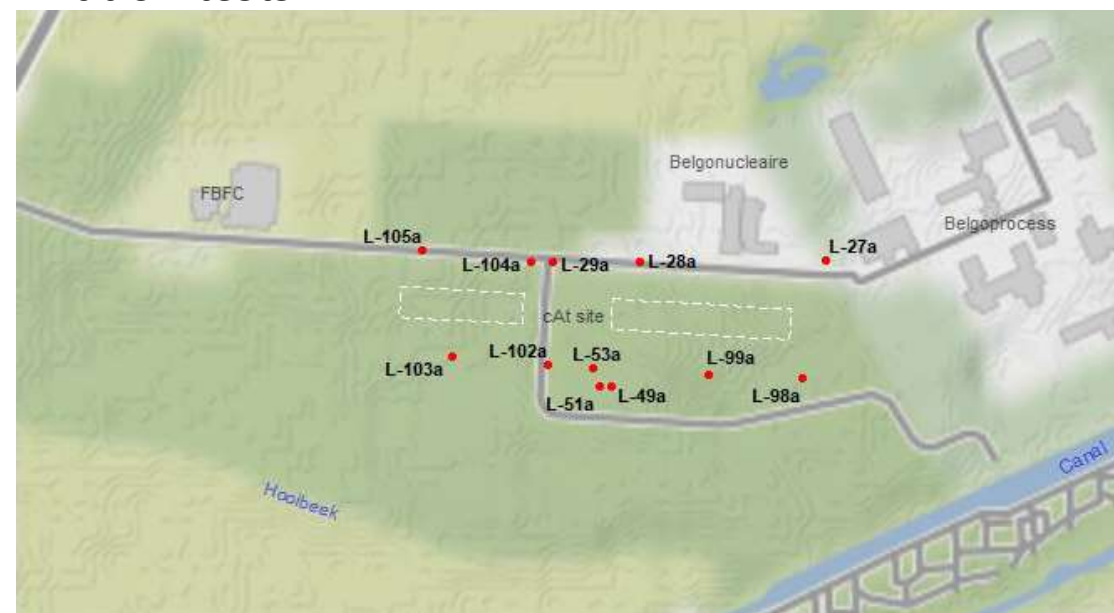
Campaign 2016 – 2019

- Focused on validation of the flow direction and velocity
- New temporary piezometers at the cAt site
 - monthly measurements -> daily interpolated maps
 - summary plots for flow direction under the tumuli
- Dilution tests
 - Existing and new piezometers
 - Long filters and minimizing the excavation disturbed zone
- Answers to the Safety authority
 - *Steady-state flow confirmed for the eastern tumulus*

Water table mapping



Dilution tests



GROUNDWATER MODELLING

Three models

- Private well Eastern tumulus
 - Steady-state model
 - Approved in 2019
- Private well Western tumulus
 - Transient model
 - Unfortunately, insufficient data for validation (see further)
- Wetland Eastern tumulus
 - Transient model with more details in wetland areas
 - Approved in 2023

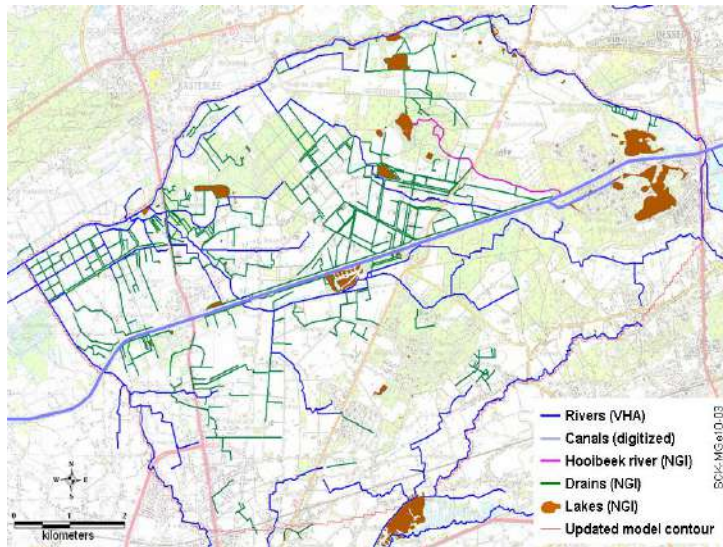
Steady-state Local model



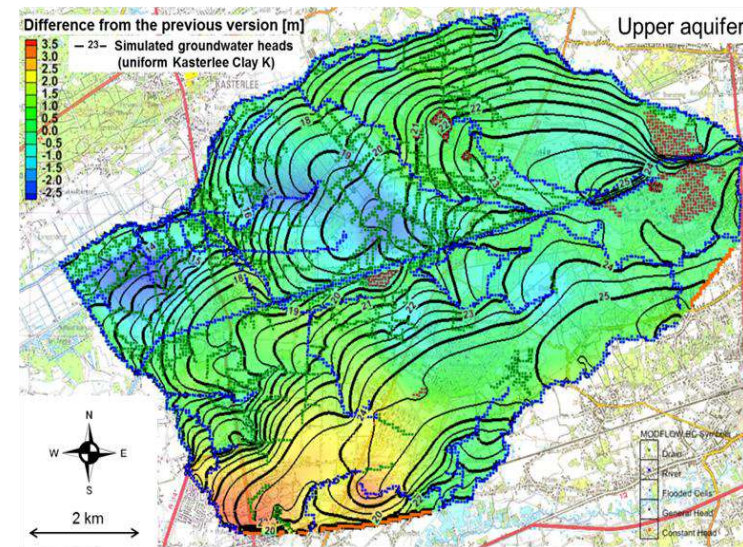
Steady-state model – Local model (safety case 2013)

- Constant boundary conditions lead to time-invariant flow and velocity field

Constant recharge flux; river, lake, drain levels

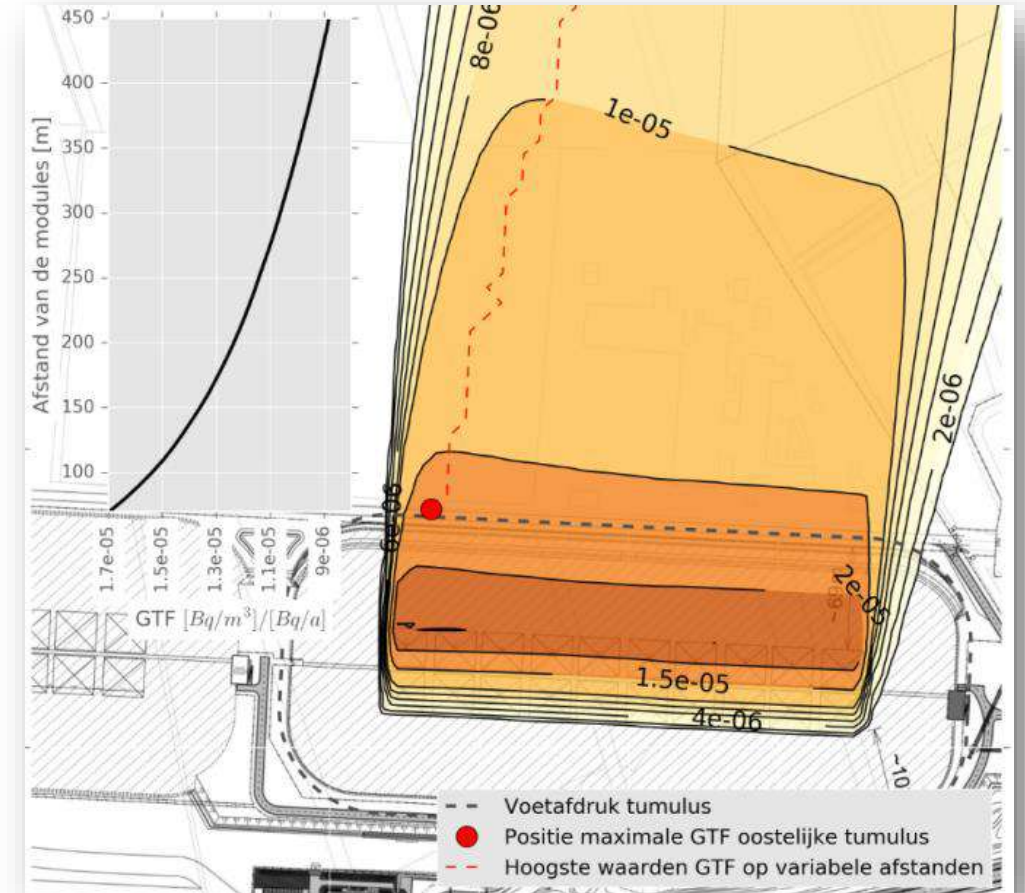
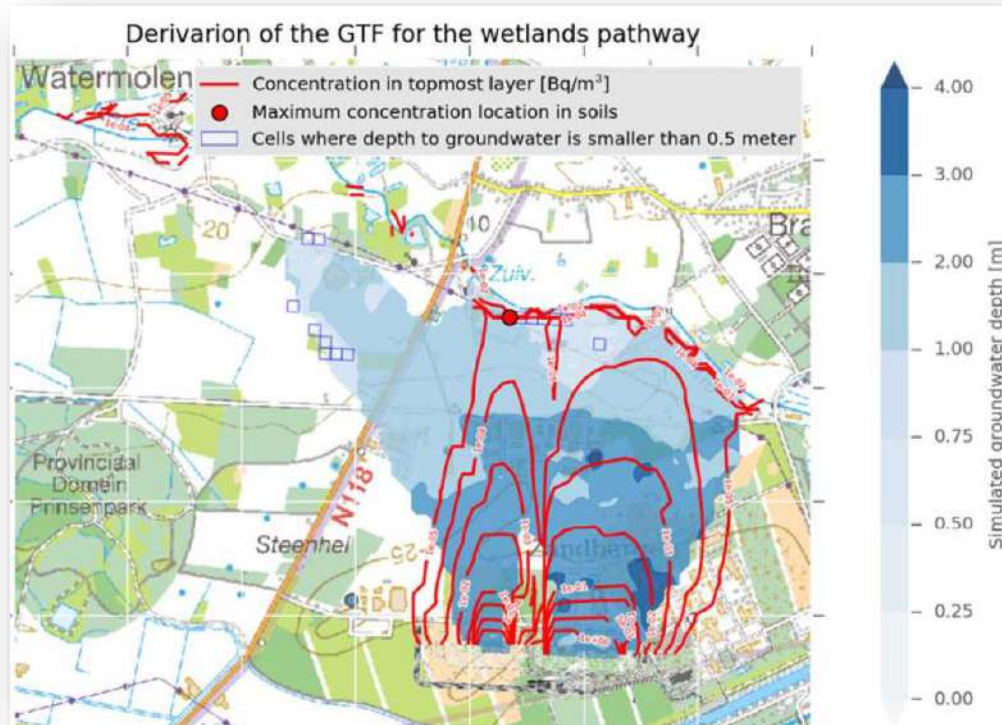


Single (equilibrium) flow-field representation



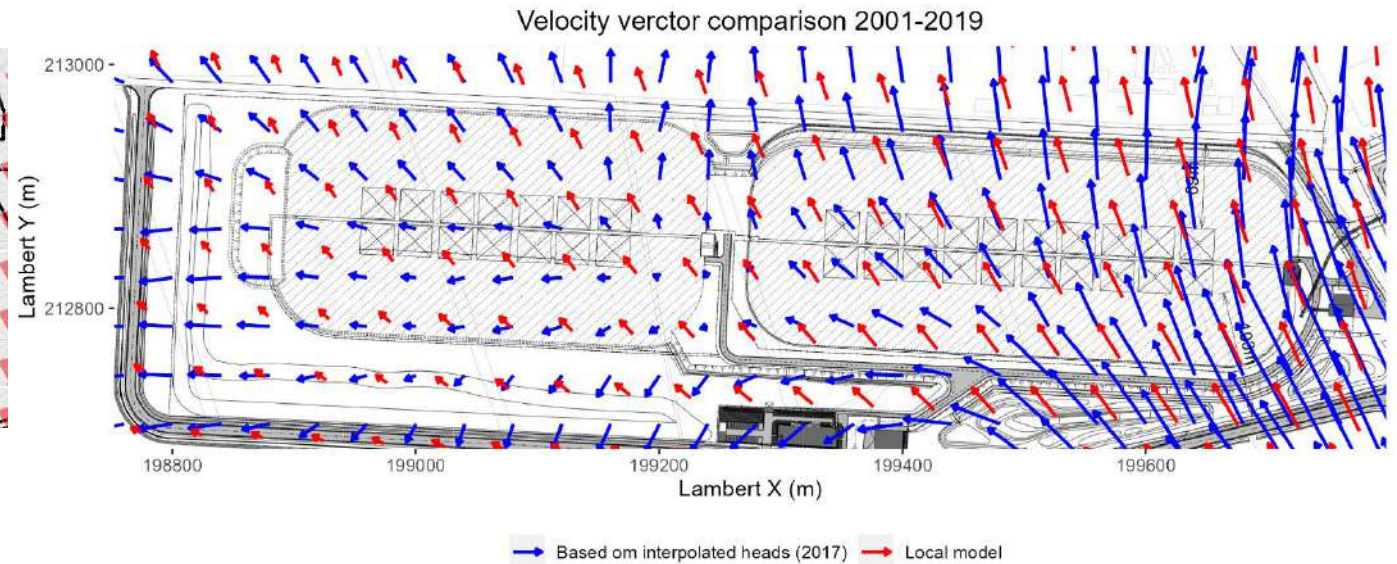
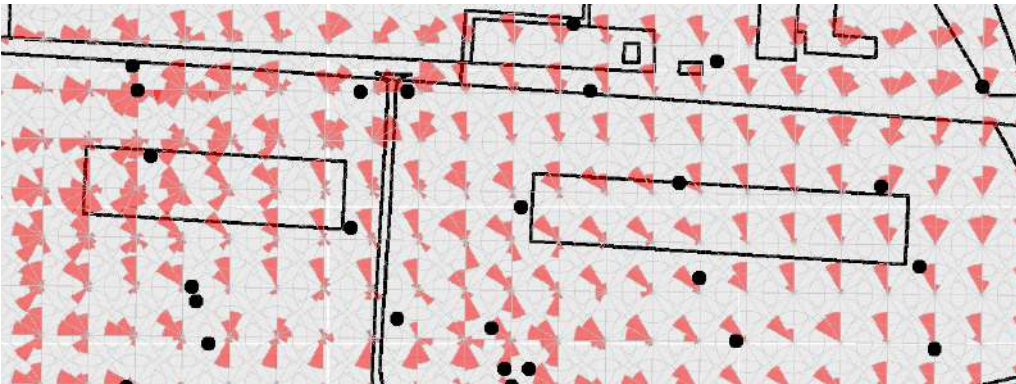
GTFs calculated

- The GTF was calculated for three receptors:
 - Eastern tumulus private well ($1.7 \times 10^{-5} \text{ a/m}^3$)
 - Wetlands: $4.7 \times 10^{-9} \text{ a/m}^3$ ($\ll \ll \text{GTF}_{\text{well}}$)
 - Rivers ($\text{Flux}_{\text{rivers}} = \text{Flux}_{\text{source}}$)



Invariant flow field is validated (for Eastern tumulus)

- Comparison between the single model result and daily interpolated heads
 - Eastern tumulus: reasonable fit & low variability (steady-state OK!)
 - Western tumulus: poor fit due a.o. to high temporal (seasonal) variability

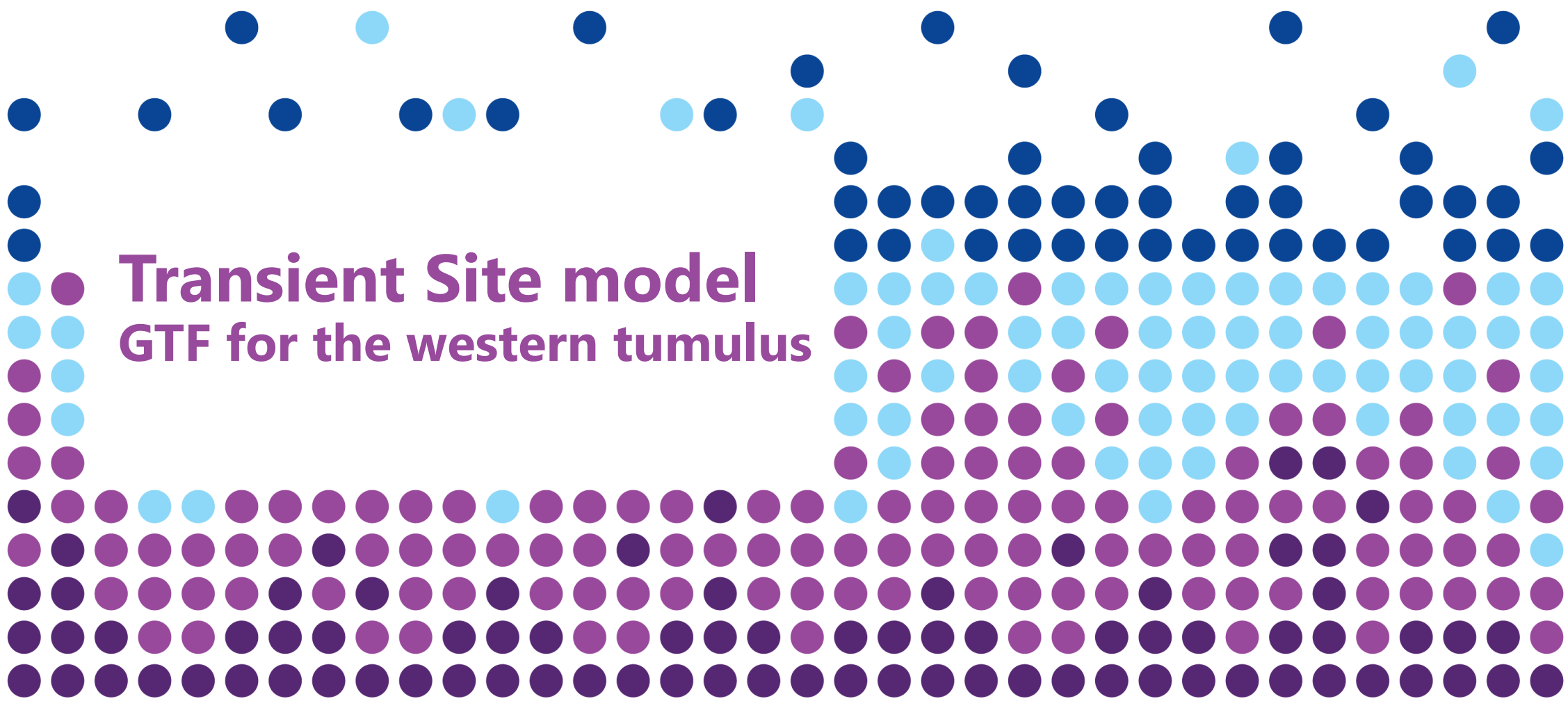


Hence – the safety authority requested

- To confirm the hydrogeological at the Western tumulus based on field data
- To develop a new hydrogeological model that:
 - correctly describes the actual conditions at the disposal site and its surroundings
 - allows to provide conservative estimates of the GTF for the Western tumulus
- To validate the model for the identification of wetland areas and the estimation of dilution in the upper part of the aquifer (eastern & western tumulus)

New data revealed the complex situation at the Western tumulus

- New data (see before) and new statistical data analysis revealed that a steady-state model with invariant flow fields (and velocities) is not representative for the Western tumulus
- Therefore, a model with variable boundary conditions (recharge, river levels) is required.

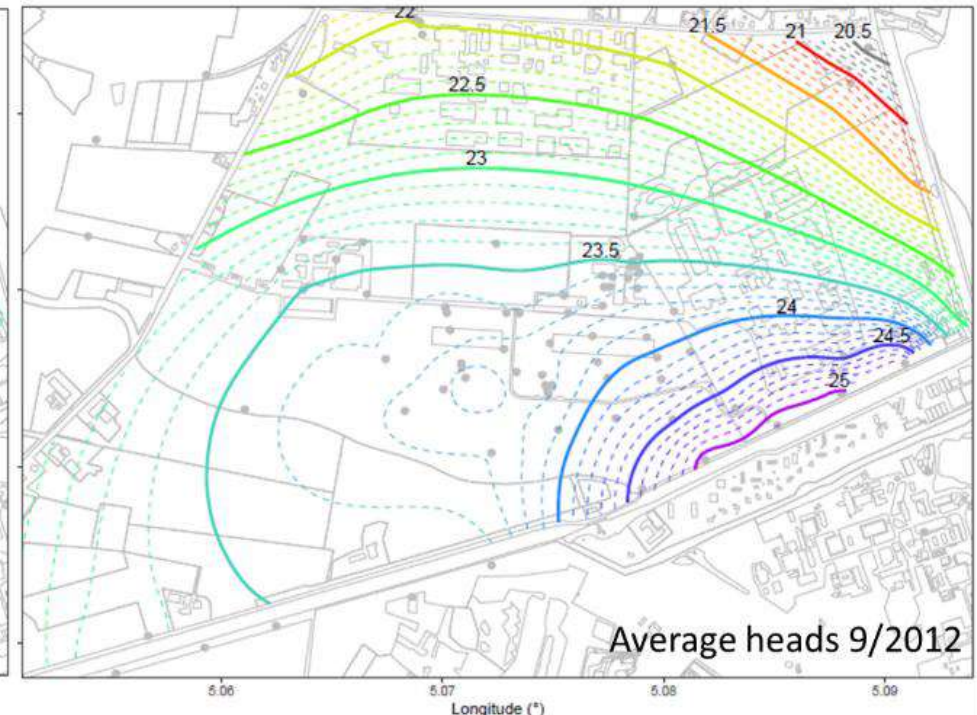
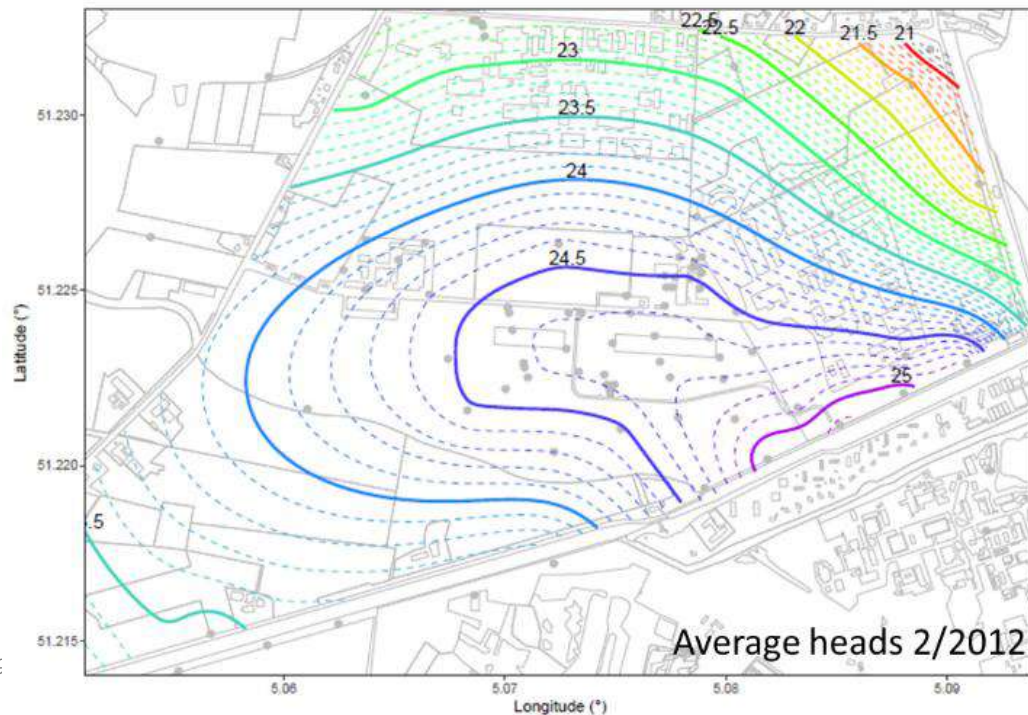
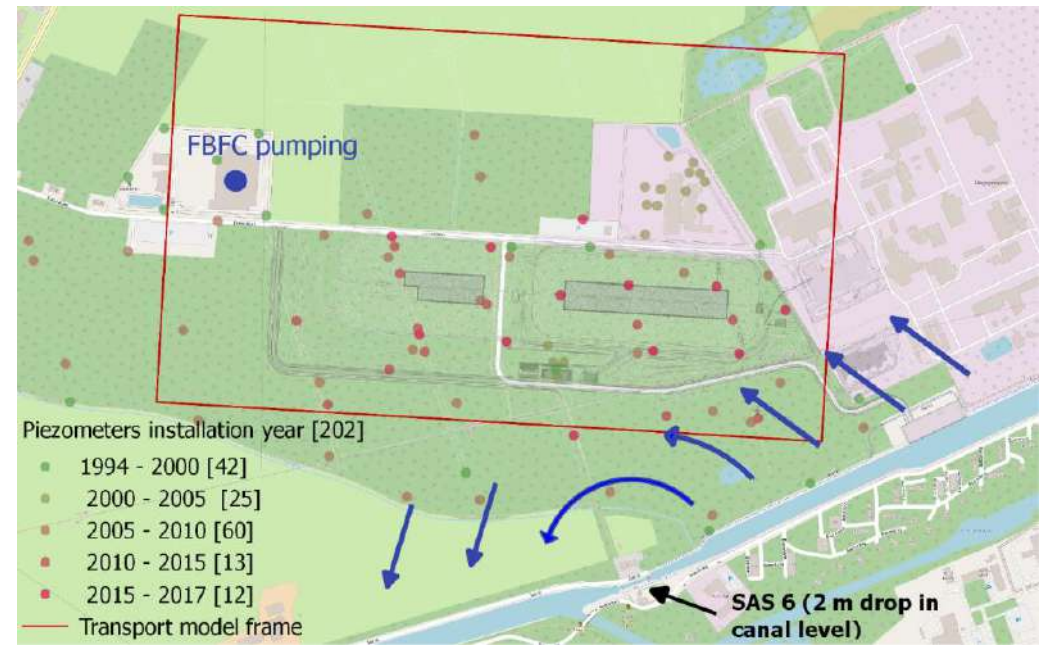


Transient Site model

GTF for the western tumulus

Hydrogeology at the western tumulus

- Flat groundwater table
- Influenced by
 - the leaking canal
 - seasonal recharge
 - pumping operations

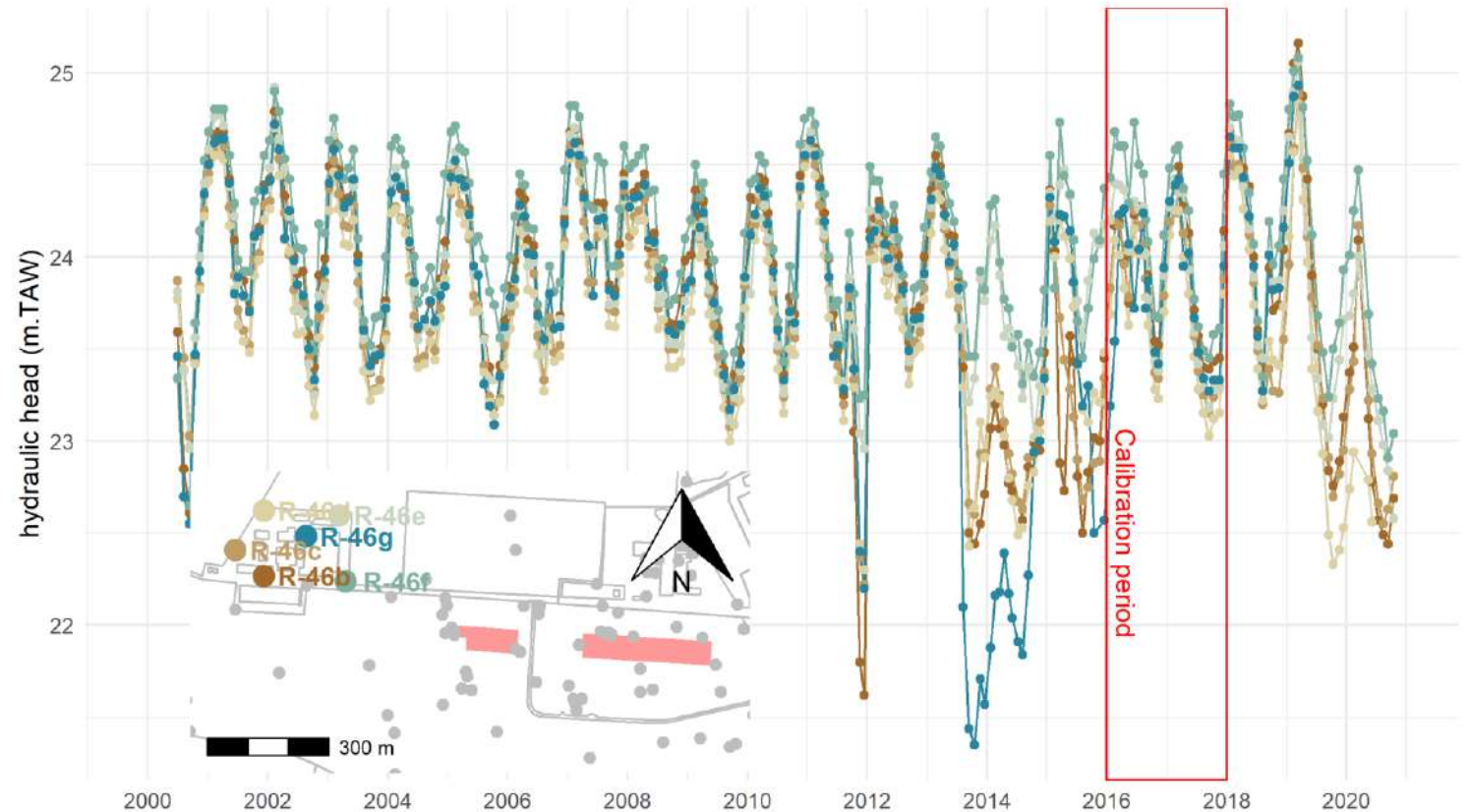


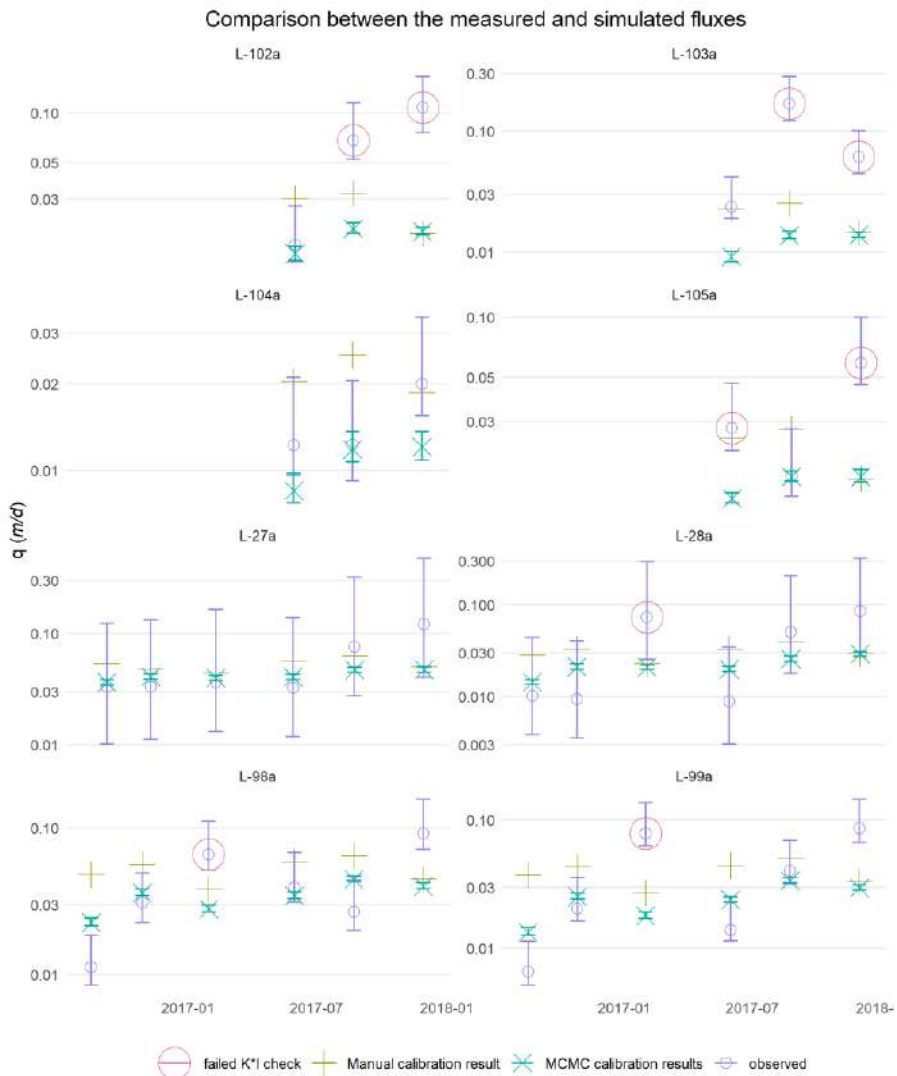
Site model

- Transient groundwater model
 - Extent focused on the upper aquifer
 - Grid refinement (child model) to increase the resolution of transport
 - Recharge dependent on transient precipitation, soil properties and land-use
 - Hydraulic parameters from site characterization and best knowledge

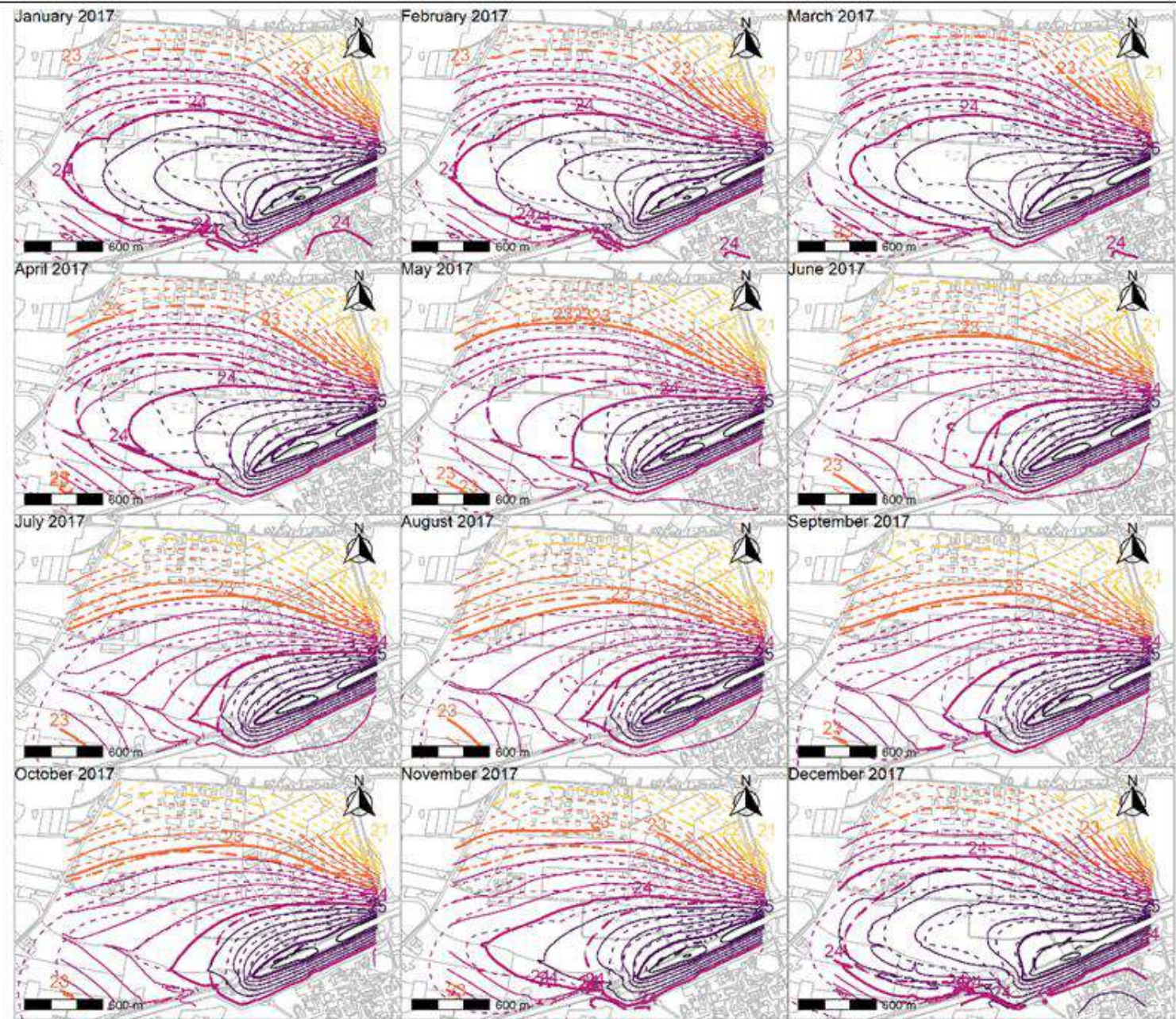
Calibration

- Calibration using the observed heads and fluxes
- Selecting period with limited influence of pumping (at FBFC, BP, NIRAS cAt)
- Manual and automated calibration





Parameters calibrated using MCMC

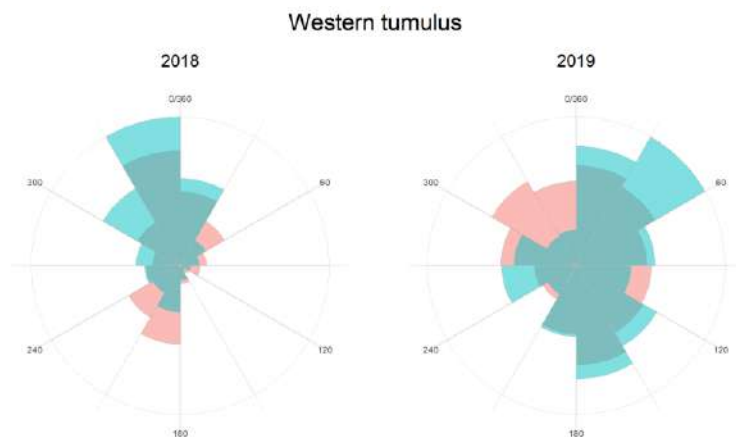


Validation

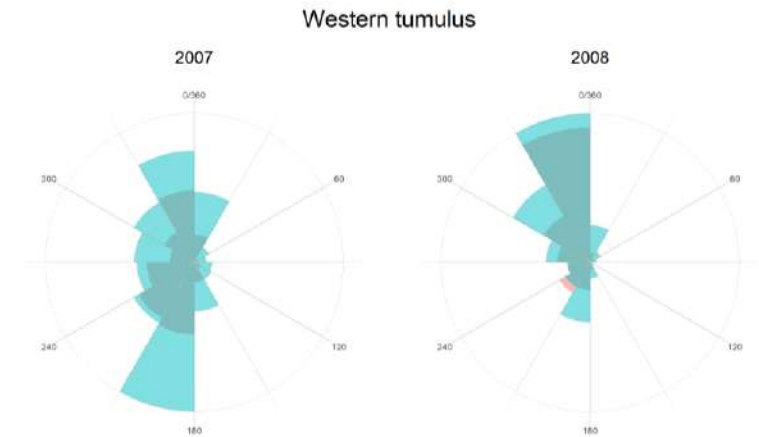
- Comparison of simulated with observed heads outside of the calibration period, turned out to be problematic, because:
 - The detailed observations period 2016 – 2019 influenced by pumping
 - Earlier periods not detailed enough
- Possibility to: either include pumping (no data available), or use less observations
- No good solution available...

Comparison between the hydraulic gradients from interpolated maps and the model

With
arbitrary
pumping



Period with
less detailed
data



Conclusions (Site model)

- The model cannot be satisfactorily validated
 - Need for a sufficiently long period of detailed observations without external influences (pumping)
- The GTF for the western tumulus cannot be calculated (for the moment...)
- Site characterization is entering a new phase:
 - Detailed piezometric measurements at the western tumulus using data loggers for a higher measurement frequency
 - Continuing the flux measurements



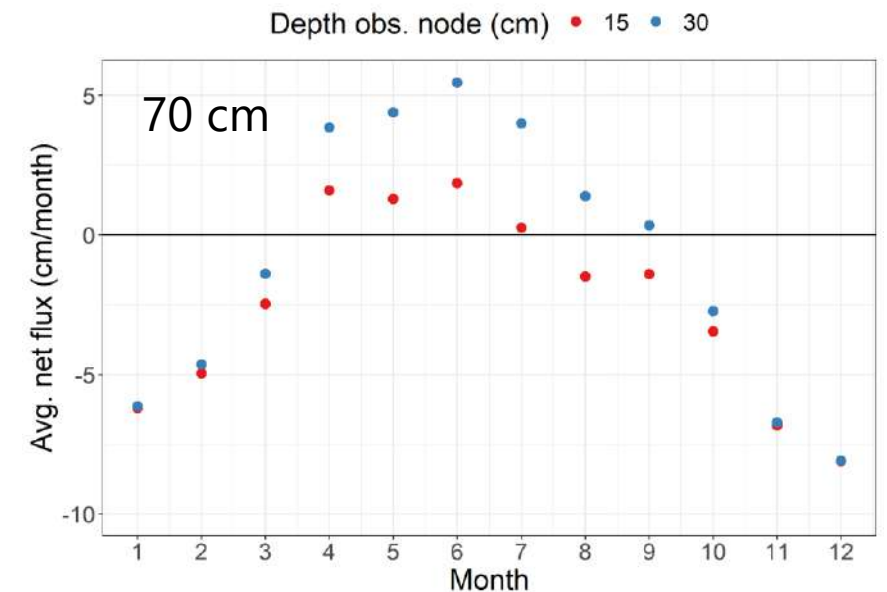
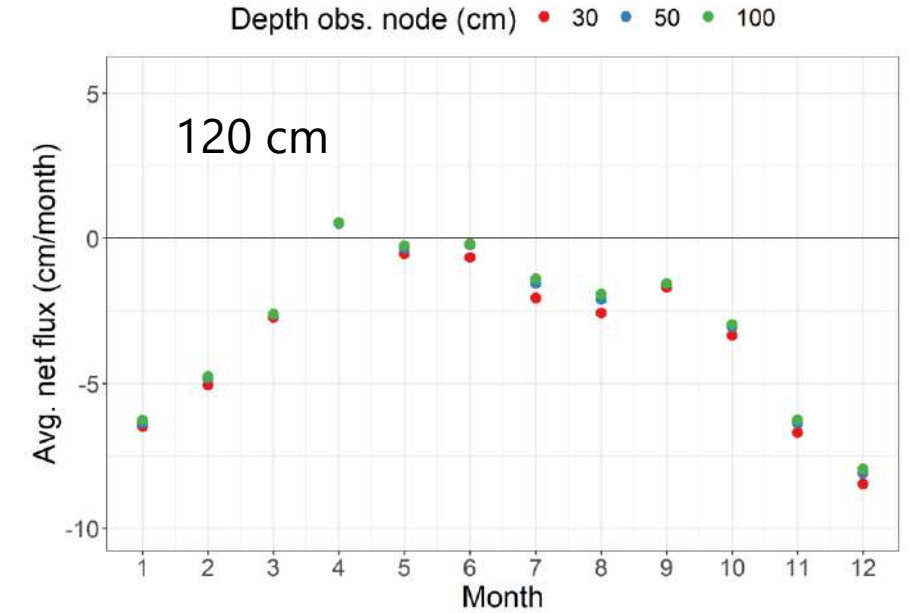
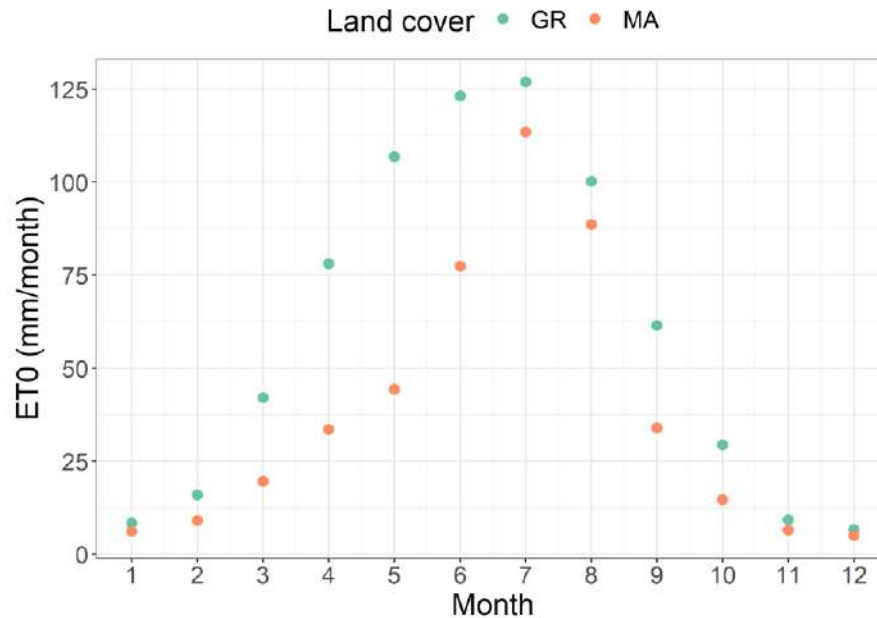
Validation of the wetlands positions and GTF of wetlands

But... what are “Wetlands”?

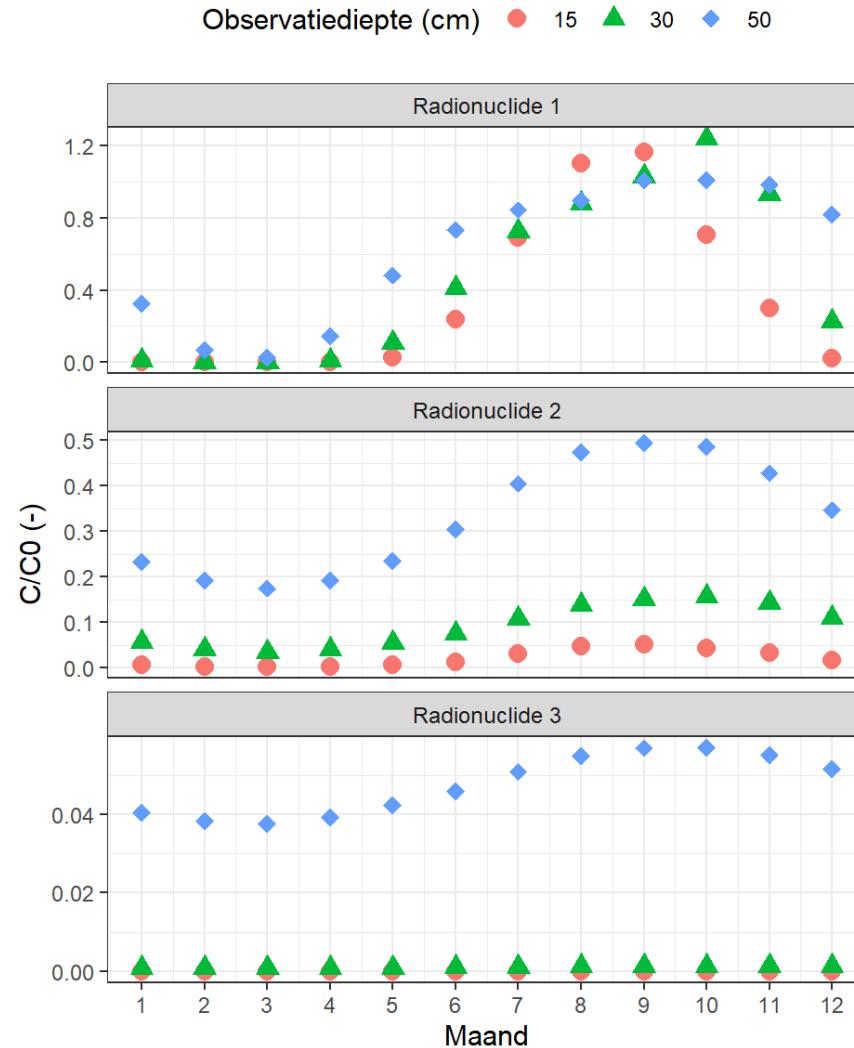
- Not in ecohydrological sense
- Entrance point of radionuclide in the soil and crop compartment (30 cm topsoil) via groundwater and upward fluxes

Delineation criterium

- Transient model – time of highest groundwater level does not coincide with time of highest upward flux.



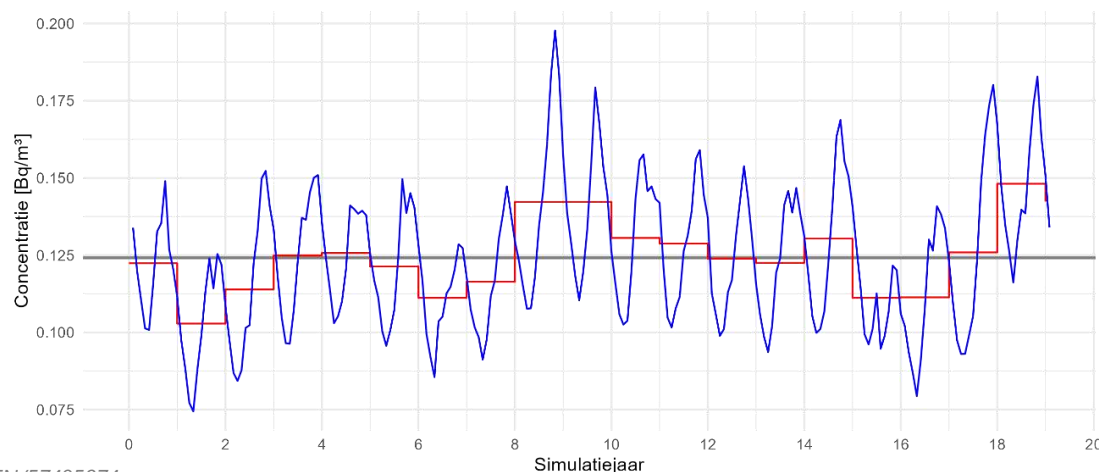
Delineation criterion



- Based on stylized scenarios: long-term average ground water level less than **70 cm** below surface in **April or May**.

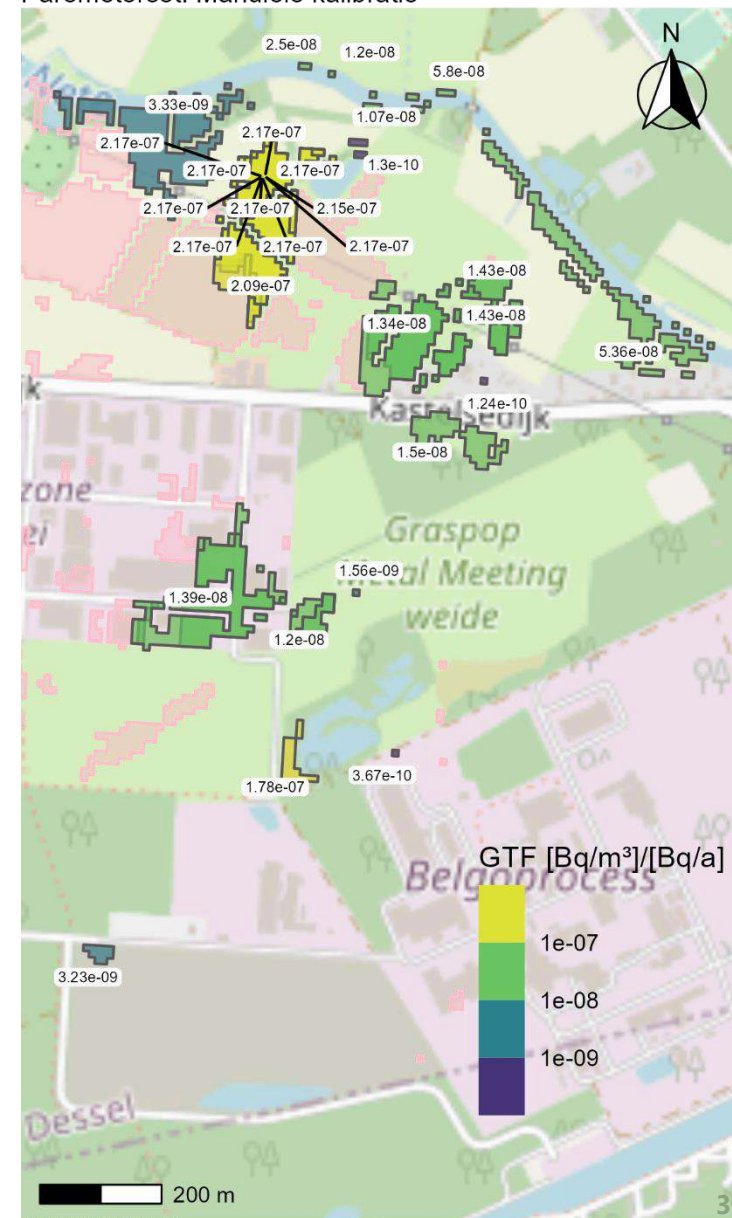
Wetland receptor definition

- Wetland receptor is defined in several steps:
 - Calculate the cell GTF
 - Based on long-term average concentration and source flux
 - Overlay with map of wetlands
 - Lookup all 2 ha areas (200 cells of 10×10 m) – potential wetland receptors
 - Selecting the highest value – wetland receptor



— Jaarlijkse concentratie — Lange-termijn concentratie — Maandelijks concentratie

Klimaat: CCI HYDR hoog/nat
Landgebruik: uniforme gras
Concept: geen kanaal & hooibeen
Parameterset: Manulele kalibratie



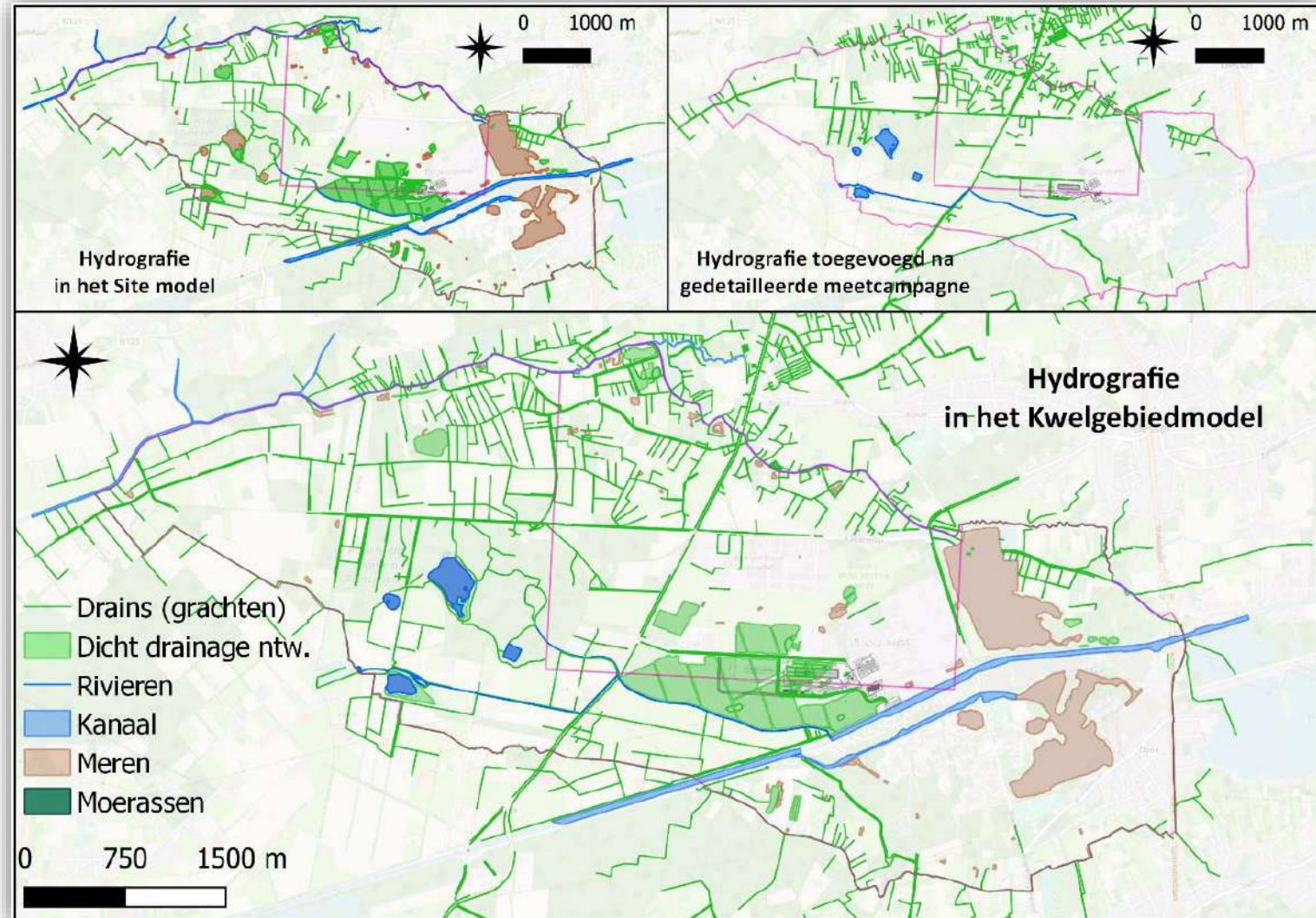
Building the flow model for the wetlands

- Largely based on the Site model:
 - Extent of the parent (coarse) model
 - Hydraulic parameters
 - Recharge
- Different focus:
 - Pathways of RN from the Eastern tumulus
 - Not in the immediate vicinity of the disposal site (relatively deep groundwater level)
 - Hydrology important, especially in the agricultural zone close to Nete River level dynamics



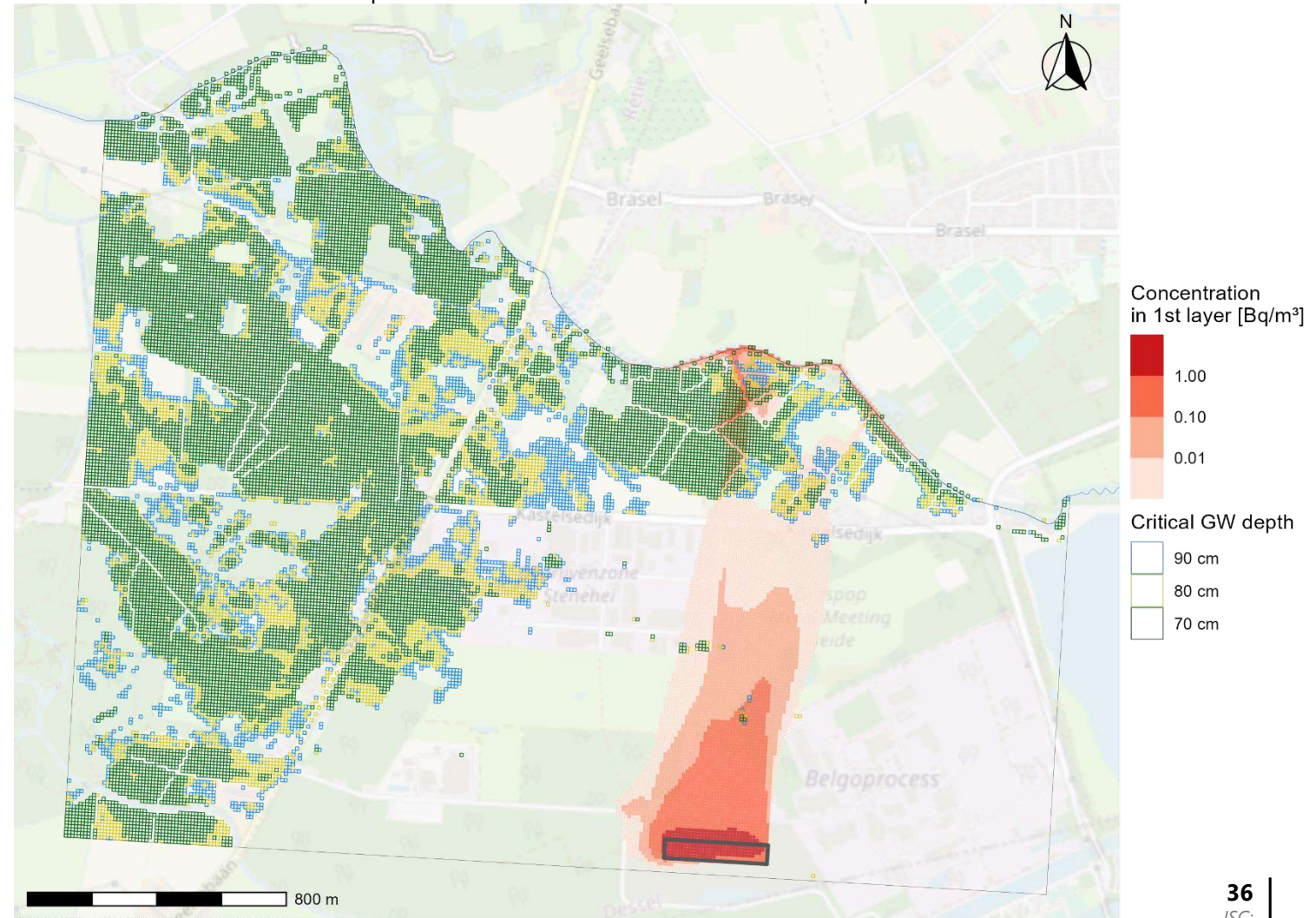
Wetland model detailed hydrography

- Field survey (IMDC)
 - Mapping & measuring the levels
- River hydraulic modelling
 - dynamic river stages



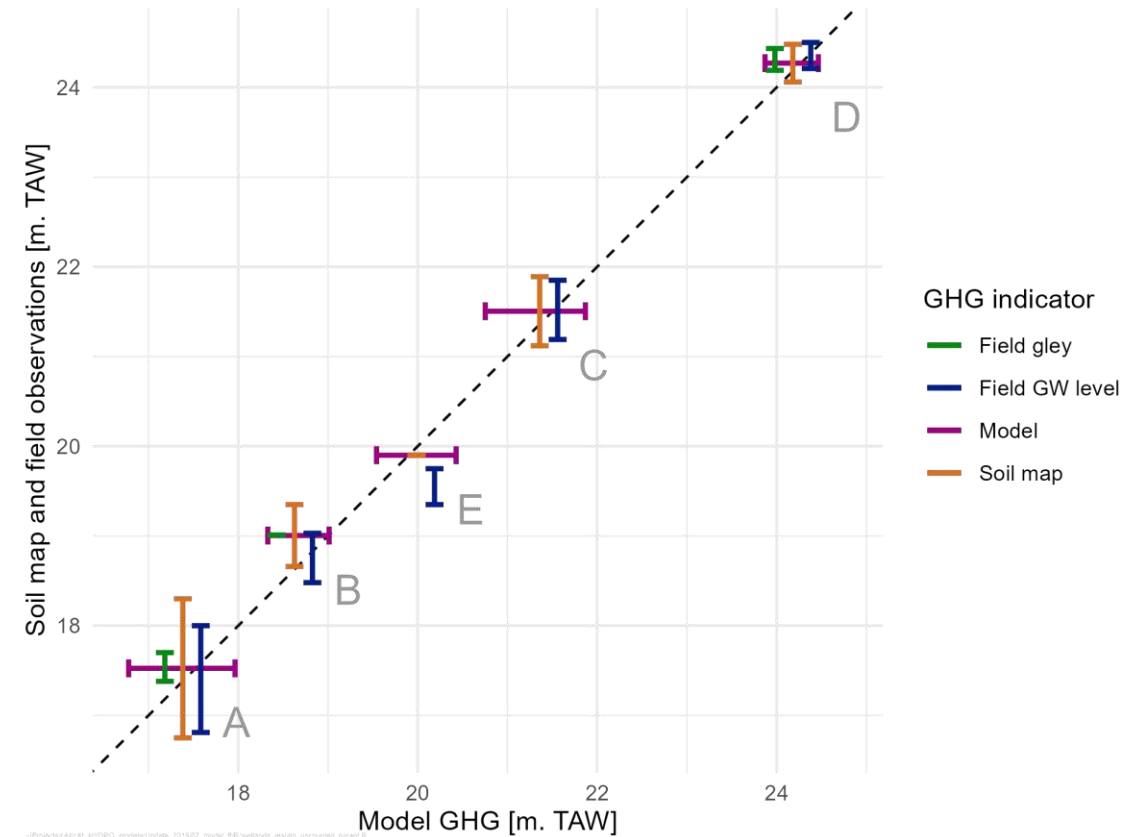
Wetland delineation

Wetland receptor extent delineation for different critical depths



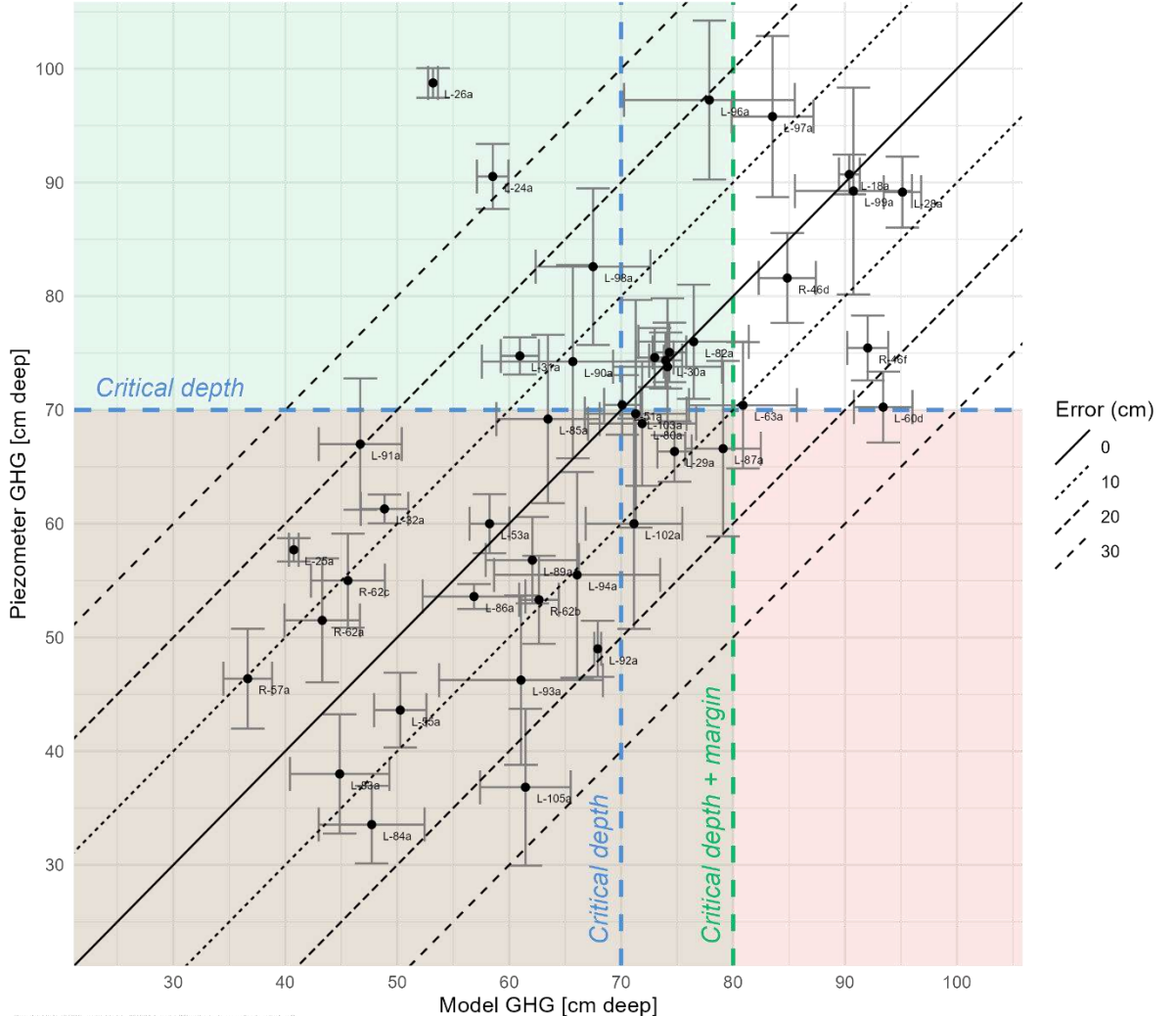
Validation of Wetland locations

Soil map information and field work



Validation of Wetland locations

Averaged groundwater levels



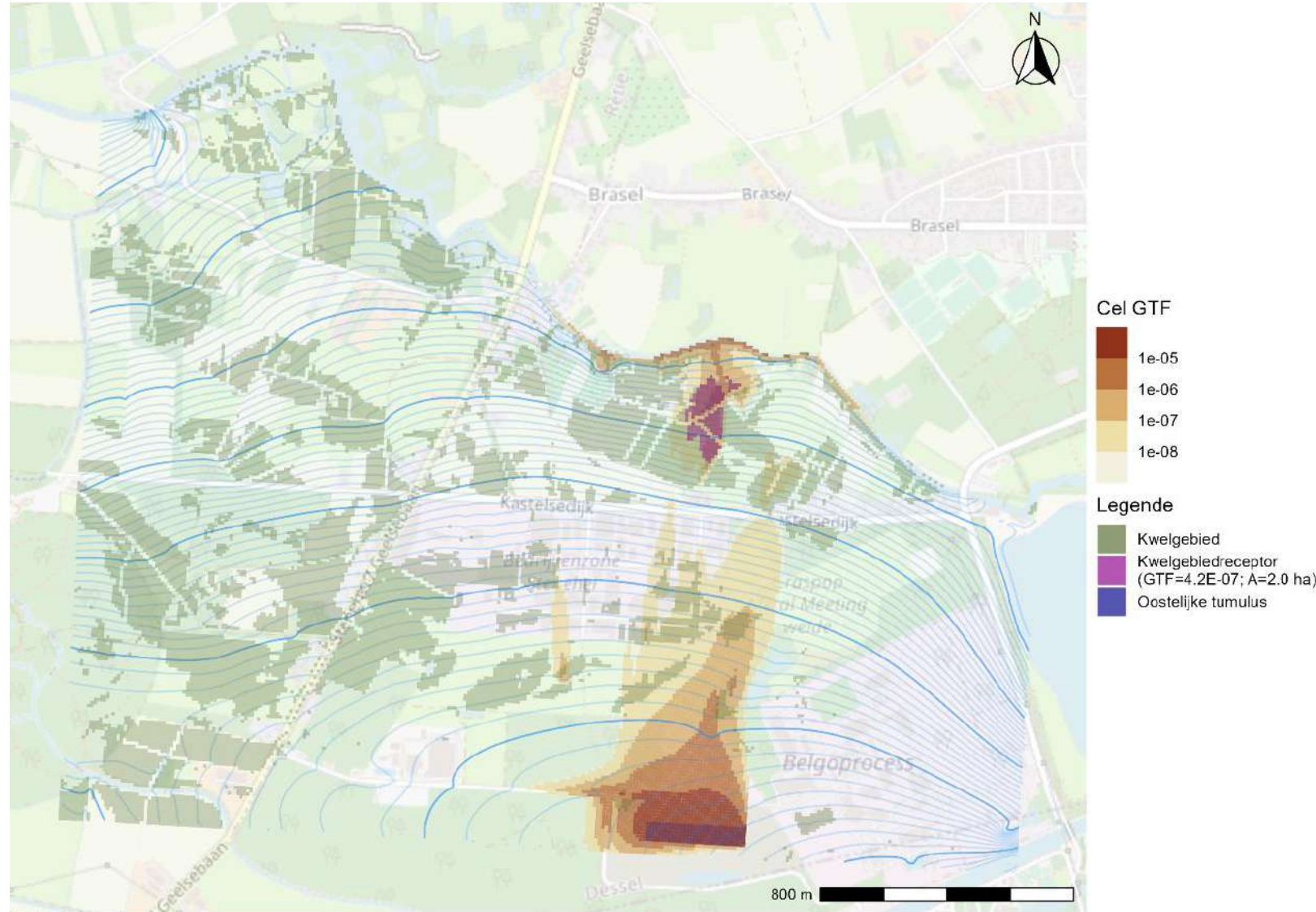
Towards a conservative estimate of the GTF

Consideration of possible future changes

- Step-wise approach
 - Variant 0 – application of the reference future climate on current land-use
 - Variant 1 – model adapted for the future climate simulations
 - Recharge excess eliminated: solved by in an iterative procedure
 - Reference variant – stylized model using a number of assumptions:
 - Uniform land-use
 - Reference climate scenario
 - Presence of the canal
 - Parameter set
 - GTF sensitivity:
 - Consequences of alternative choices & scenarios

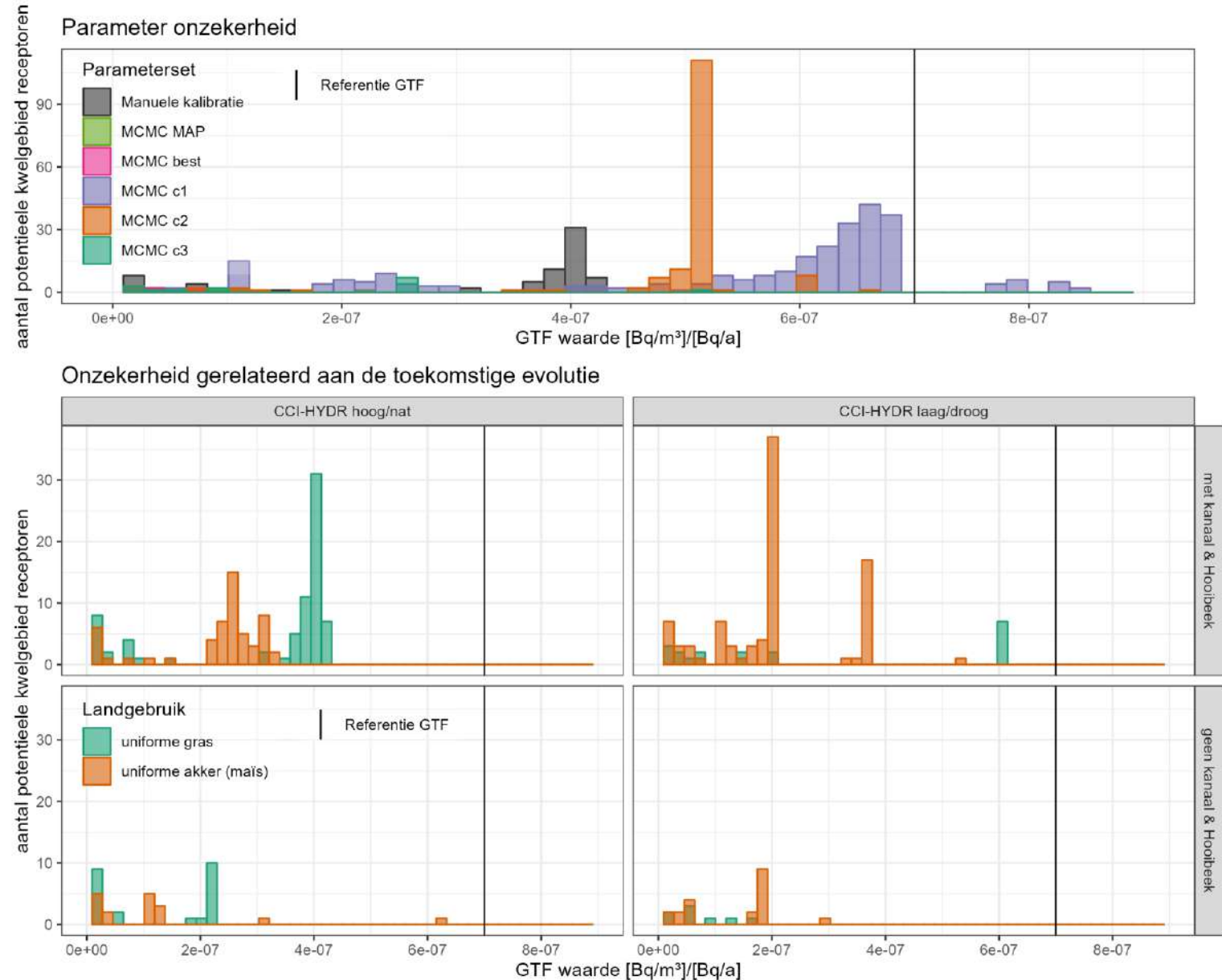
Results: reference variant

- Reference variant:
 - CCI-HYDR high/wet climate
 - Manually calibrated parameters
 - Uniform grass land-use
 - Canal exists
- $GTF = 4.2 \times 10^{-7} \text{ a/m}^3$



GTF sensitivity & selection of the reference GTF

- Reference
 $GFT_{wetl} = 7 \times 10^{-7} \text{ a/m}^3$



Conclusions

- New hydrogeological model based on newest field measurements
- Validation of the model for:
 - the delineation of wetlands in the environment of the disposal site
 - the estimation of the dilution in the uppermost aquifer
- New & higher (larger impact) GTF for the wetland receptor
- **Confirmation** – radiological impact for private well receptor is the highest



Conclusions & Future work

Conclusion

- Eastern tumulus
 - Private well receptor – steady-state flow model approach
 - Wetland receptor
 - Detailed model in the area of wetlands
 - Transient flow model
- Western tumulus – Private well receptor
 - Detailed model in the area of the disposal facility
 - Transient flow model
- Model calibration OK
- Model validation – lack to sufficient high-quality data

Future work - Continuous monitoring

- Extended and more in-depth monitoring of the area surrounding the Western tumulus
 - Coverage
 - More permanent structures
 - DAQ
 - Reducing the error
- Further monitoring of Eastern tumulus
 - Associated with the exploitation phase of the disposal facility
 - Radiological and chemical conditions in the vicinity of the disposal facility to detect any abnormal situation

Future work - Modelling work

- Validated model (Site model) for Western tumulus based on the new data
- Confirmation of GTF values used in the safety assessment

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Design and construction: outlines and planning

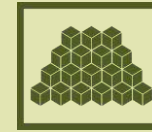
Wim Bastiaens

Content

- Disposal concept
some reminders
- Design process
some theory
- Construction of auxiliary facilities
some pictures
- Construction of the disposal facility
some facts and figures
- Demonstration projects
some RD&D and movies
- *Some concluding remarks*



Concept:
**Surface
disposal**



1

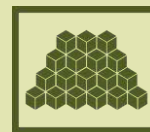
2

3

4

5





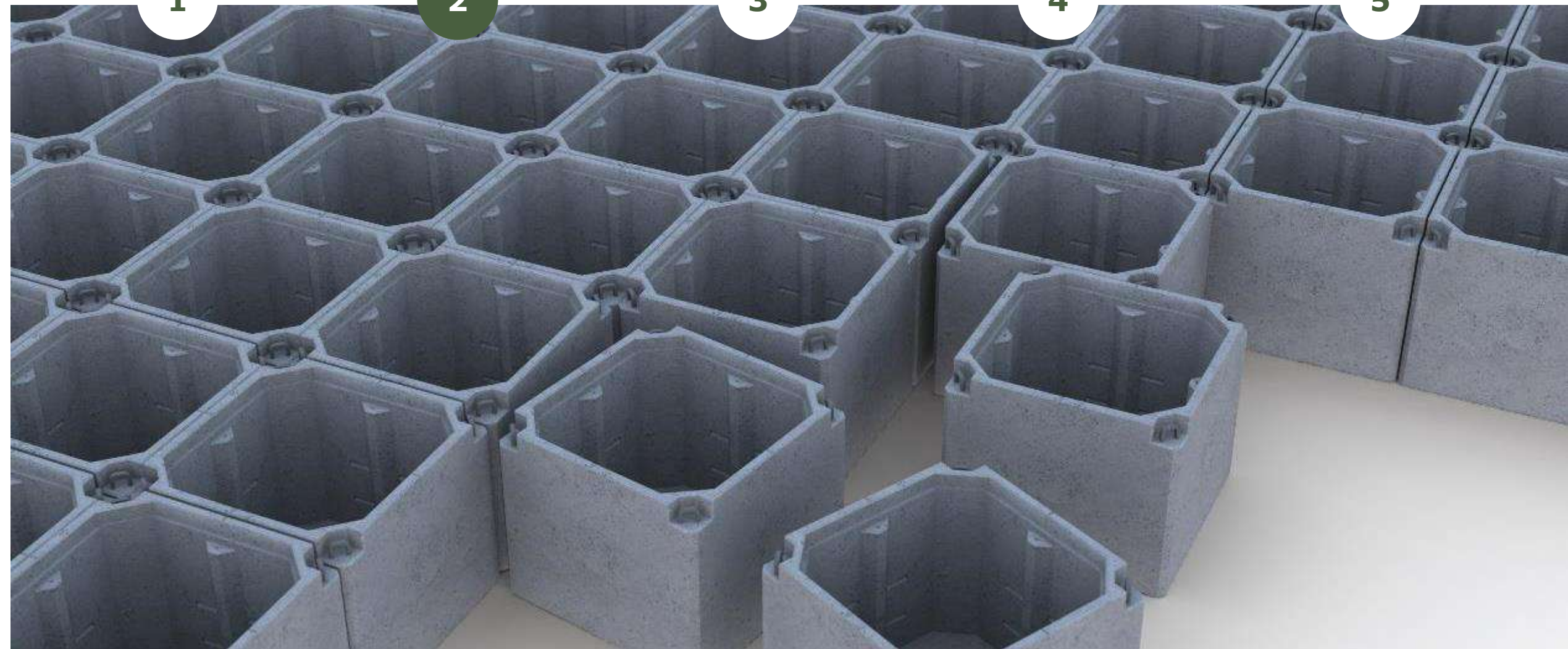
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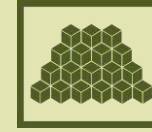
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2



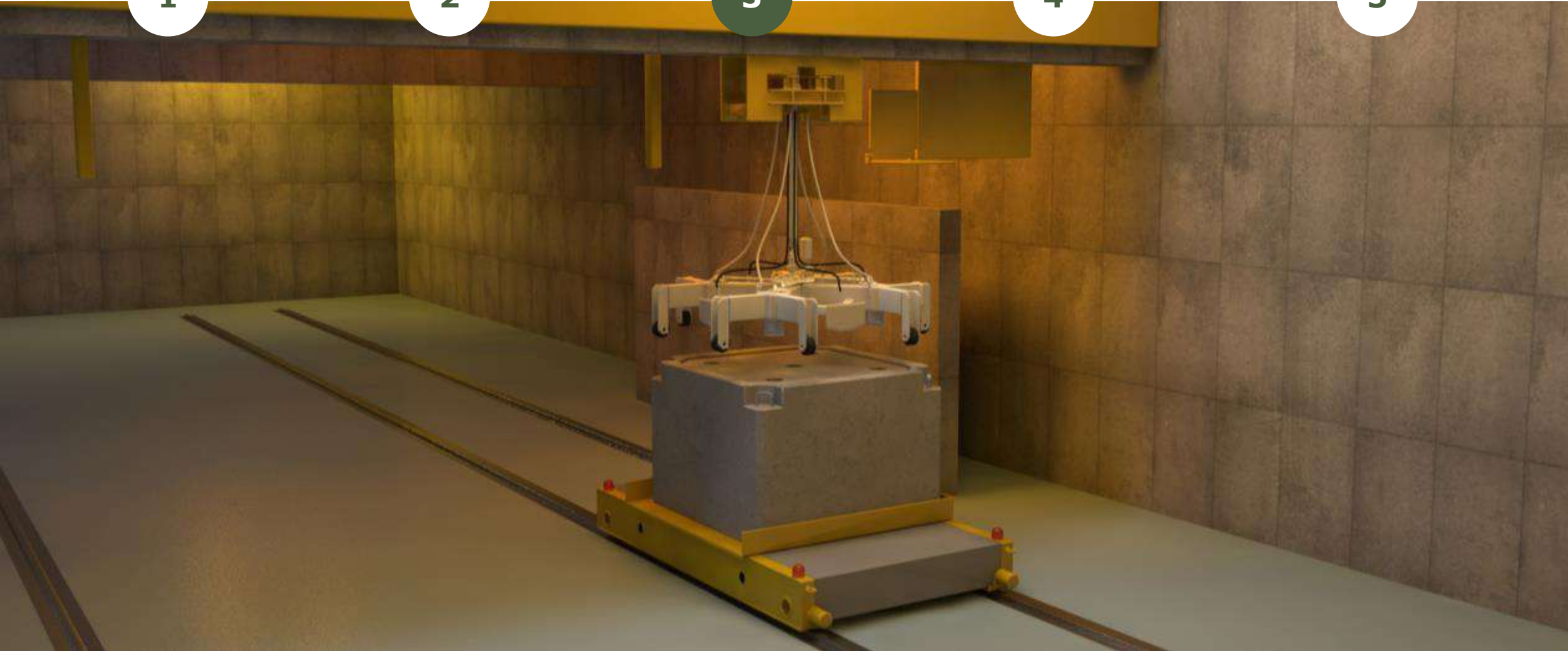
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4



5





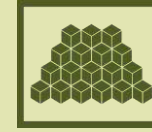
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2



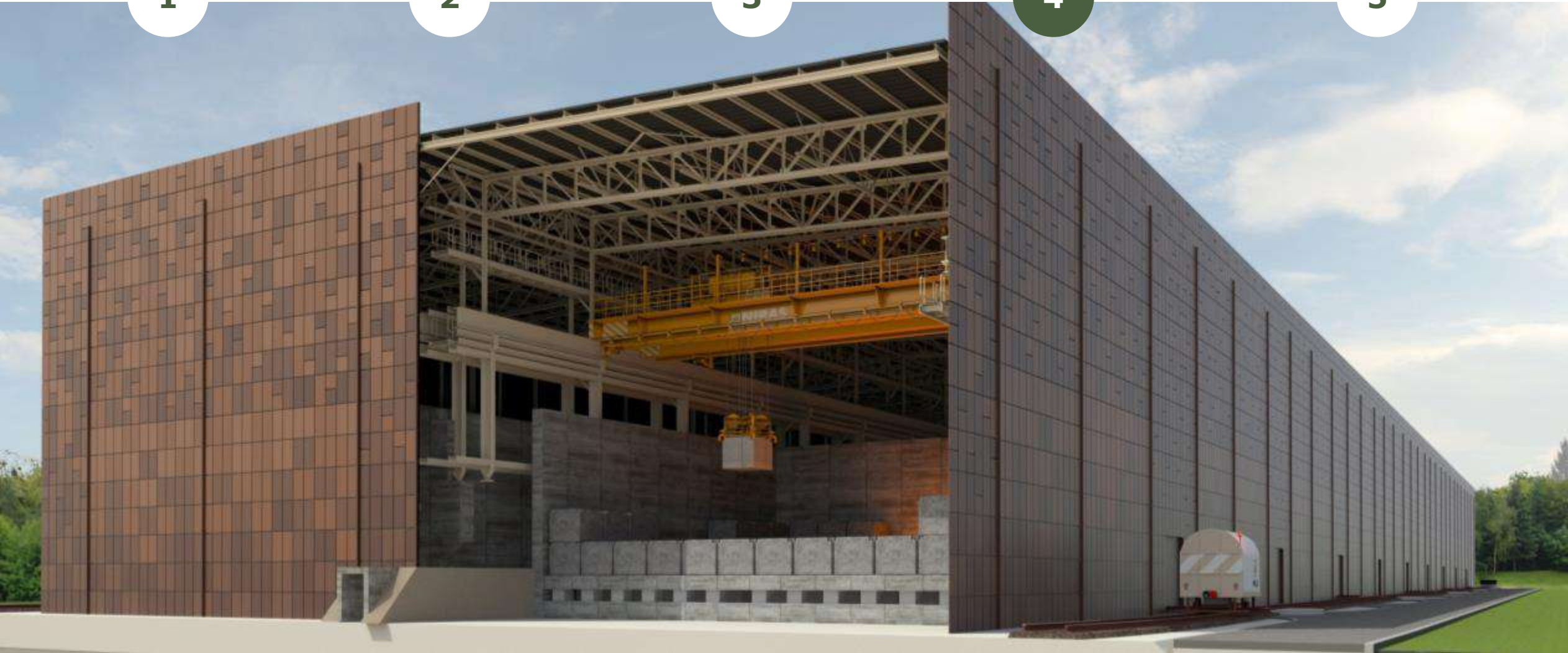
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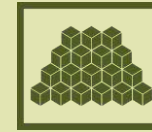


4



5





1

2

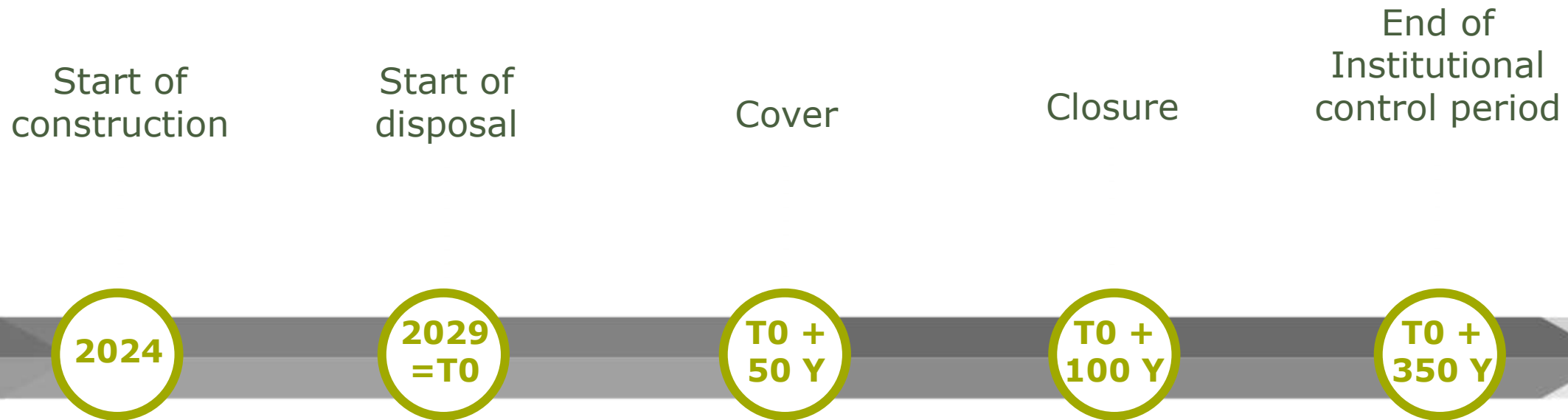
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4

5



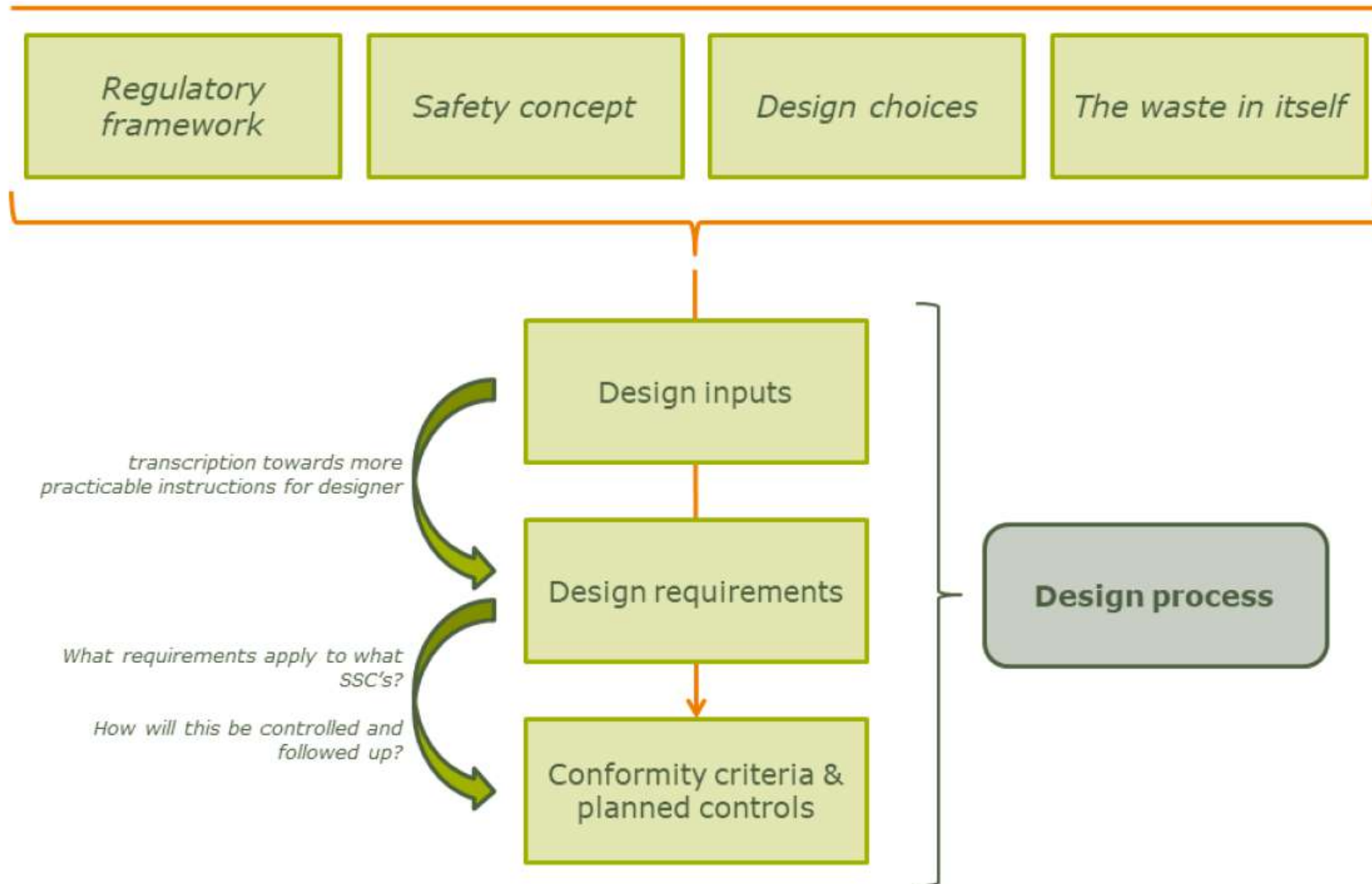
Overall planning



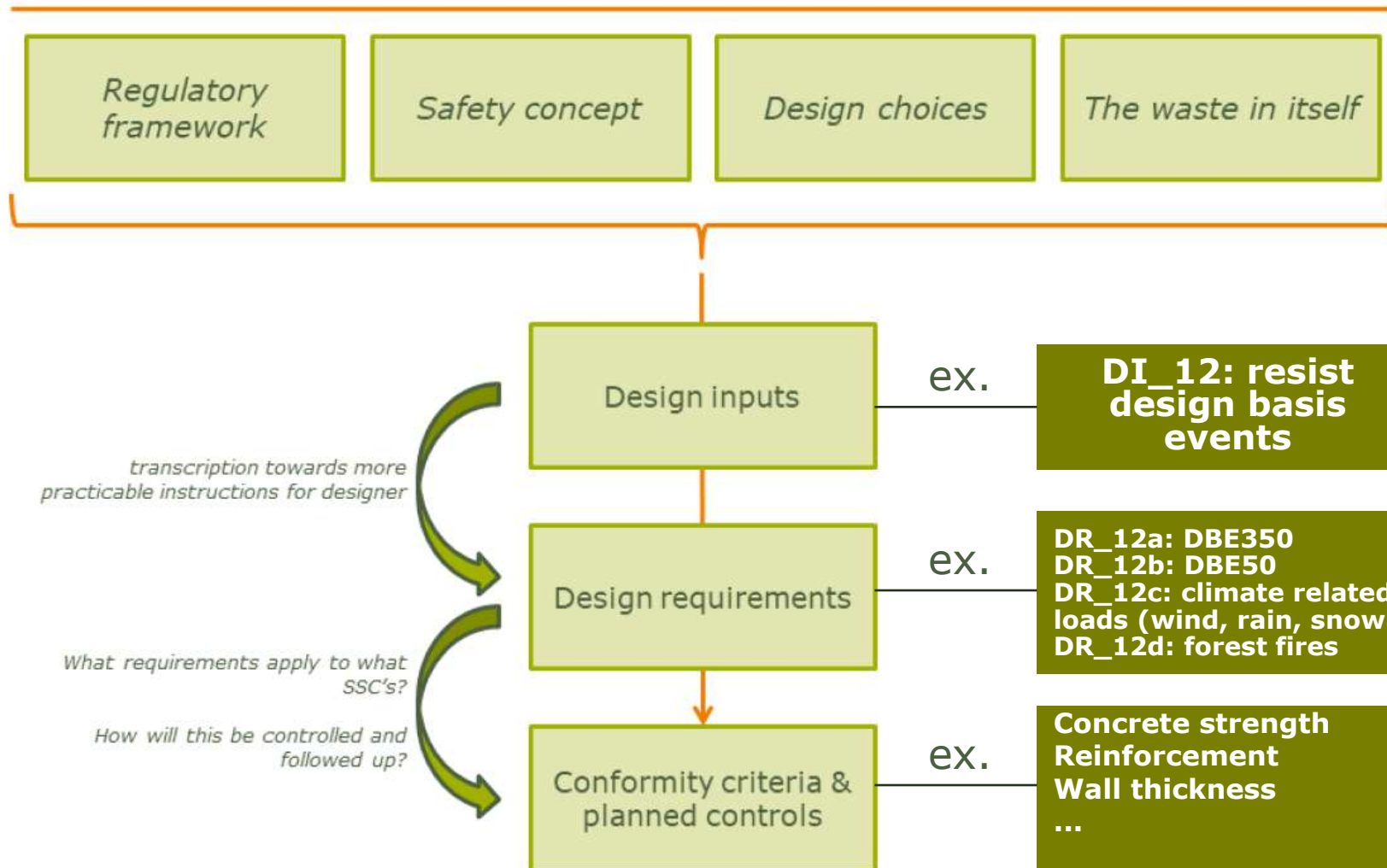


Design process

Design process (1/2)



Design process (2/2)





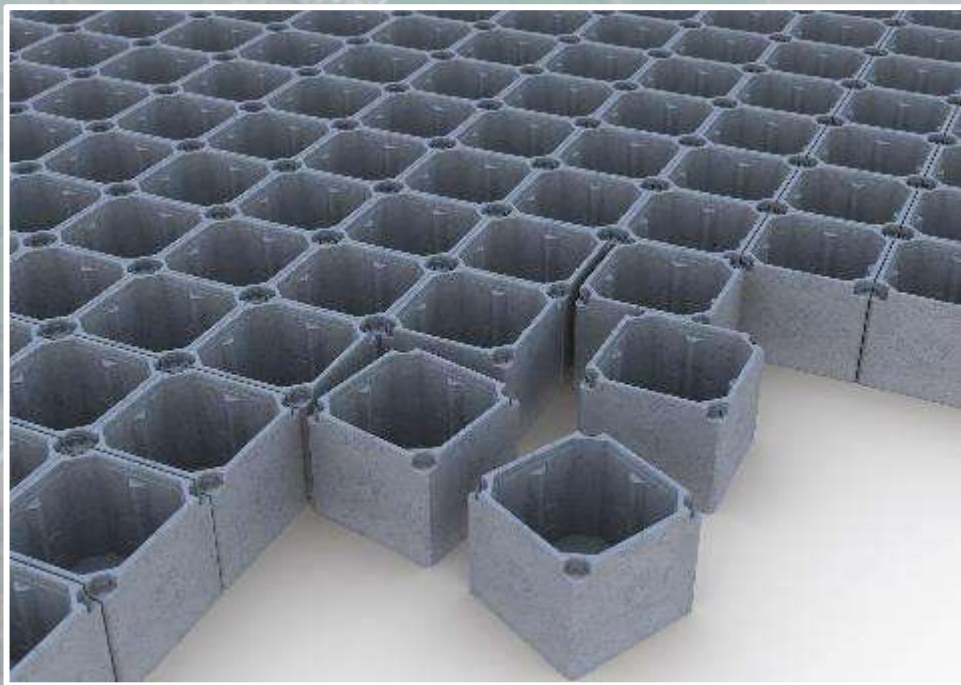
Construction of
auxiliary facilities

Aerial view of the site





STORAGE BUILDING FOR LOW-LEVEL WASTE



CAISSON PRODUCTION FACILITY



Caisson production facility



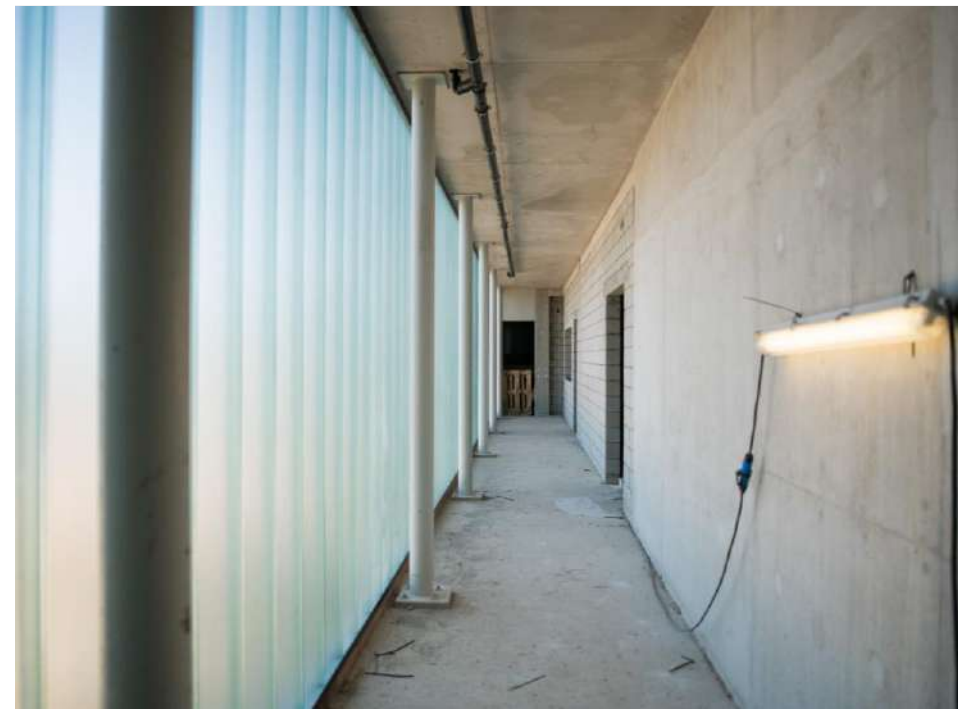
Caisson production facility



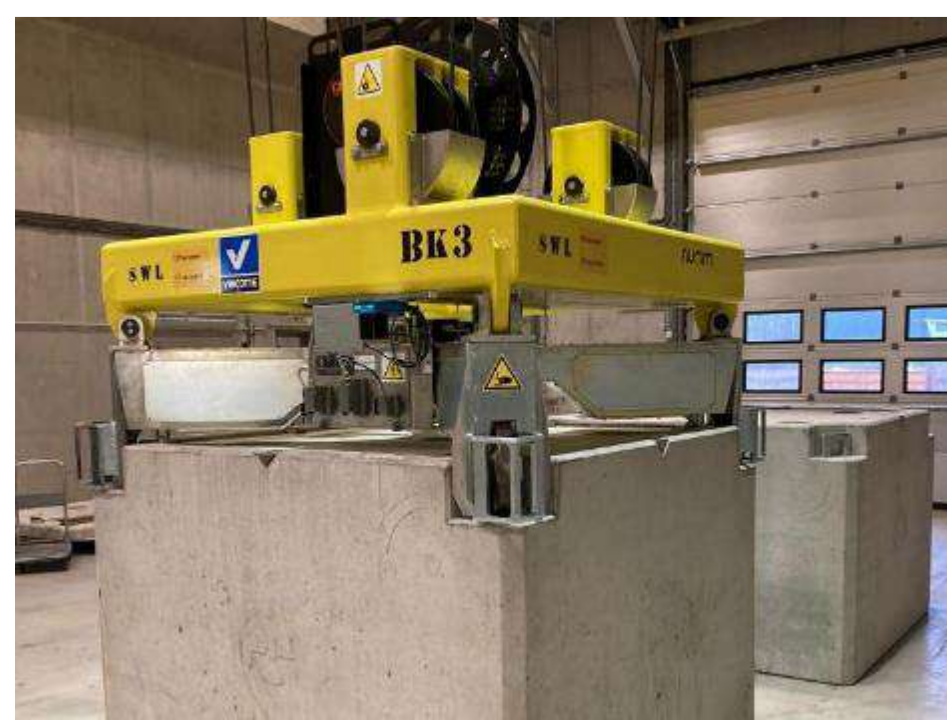


MONOLITH PRODUCTION FACILITY (IPM)

IPM







Design of the monoliths

- Reinforced concrete boxes
 - Project specific concrete composition
 - Controlled hardening conditions
- Three types
- Wall thickness 12 cm
- Surface: 1,95 m x 1,95 m
- Stacked 5 or 6
 - 1,35 m (Type I) or 1,62 m (Type II/III)
- 780 à 936 per module
- Max 20 ton
- Max 20 mSv/h contact dose rate
- Fibre reinforced alternative is being studied



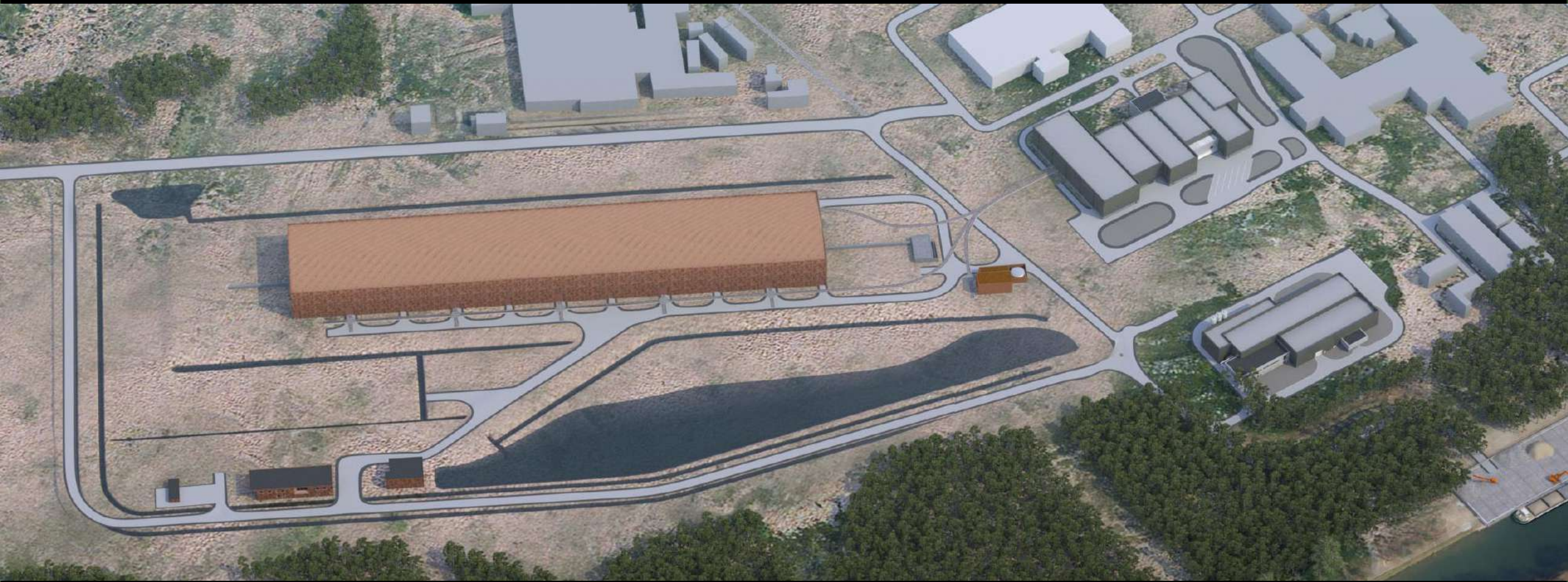


DISPOSAL MODULES AND ACCESS CLUSTER

This aerial photograph shows a proposed industrial site. Two large, rectangular buildings with orange roofs are the central focus, situated within a circular graphic overlay. To their right is an 'Access Cluster' containing several smaller, white-roofed buildings. The site is bordered by a body of water to the left and a wooded area to the right. A road and a river are also visible in the background.



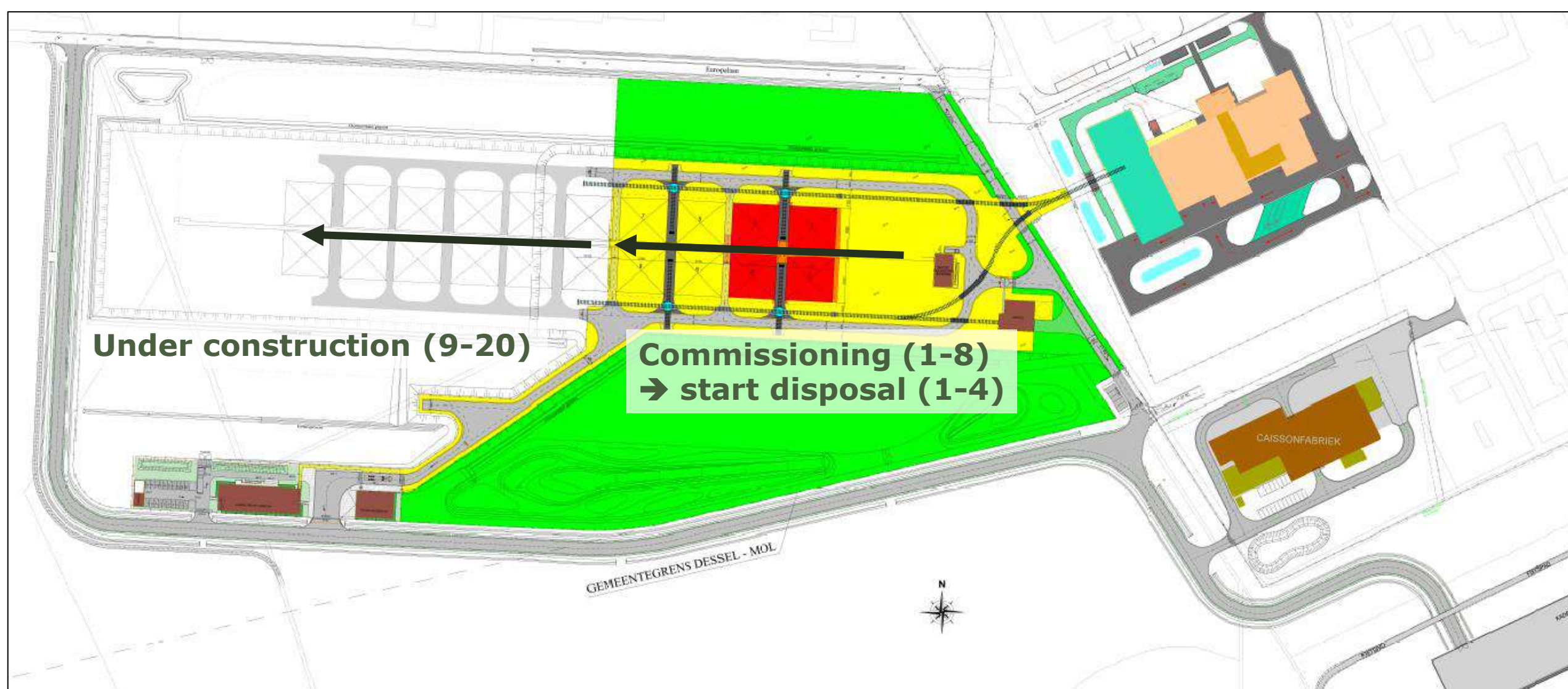
Construction of
disposal facility



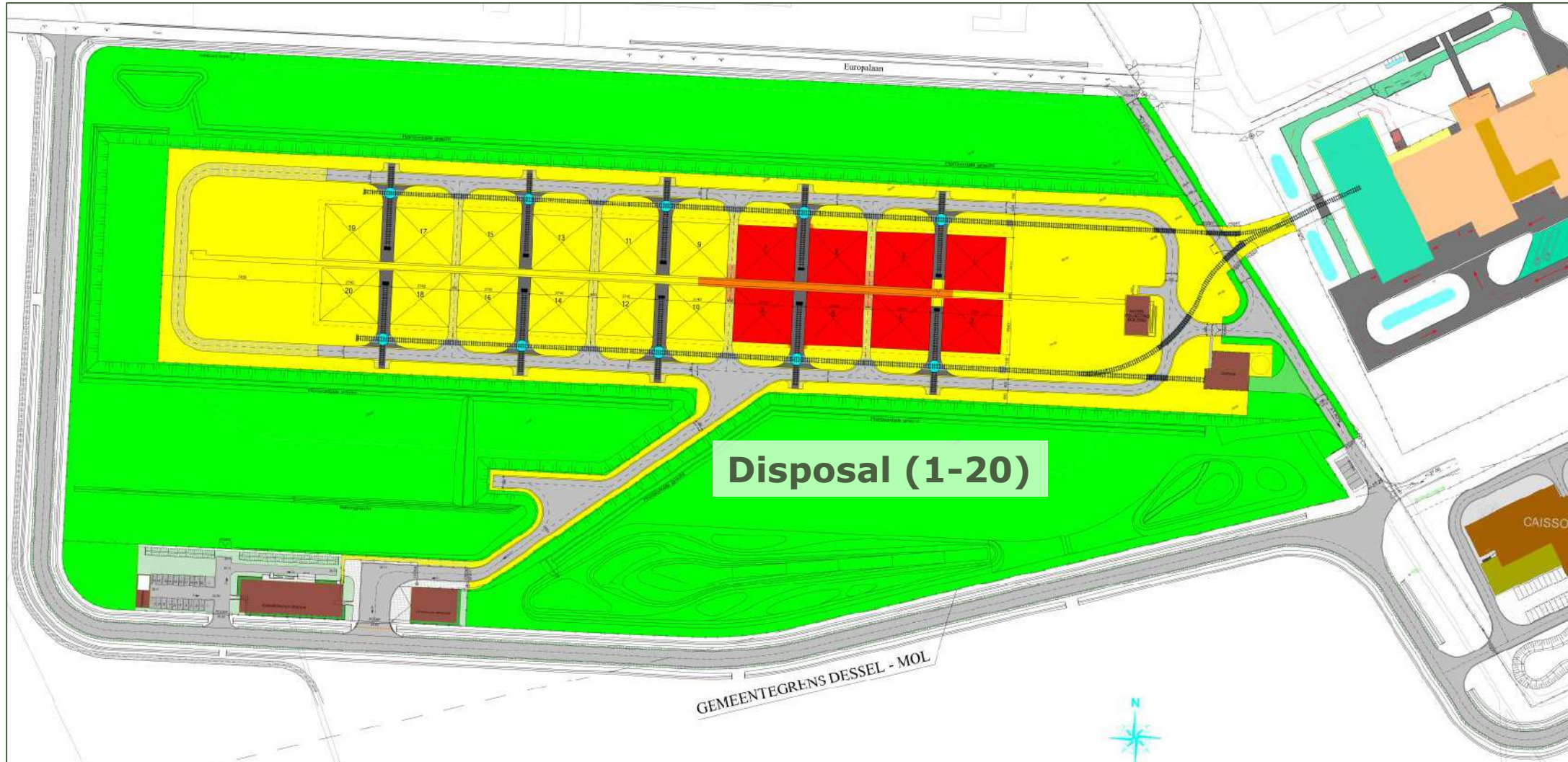


Site preparation

Construction sequence (20 modules)



Construction sequence (20 modules)

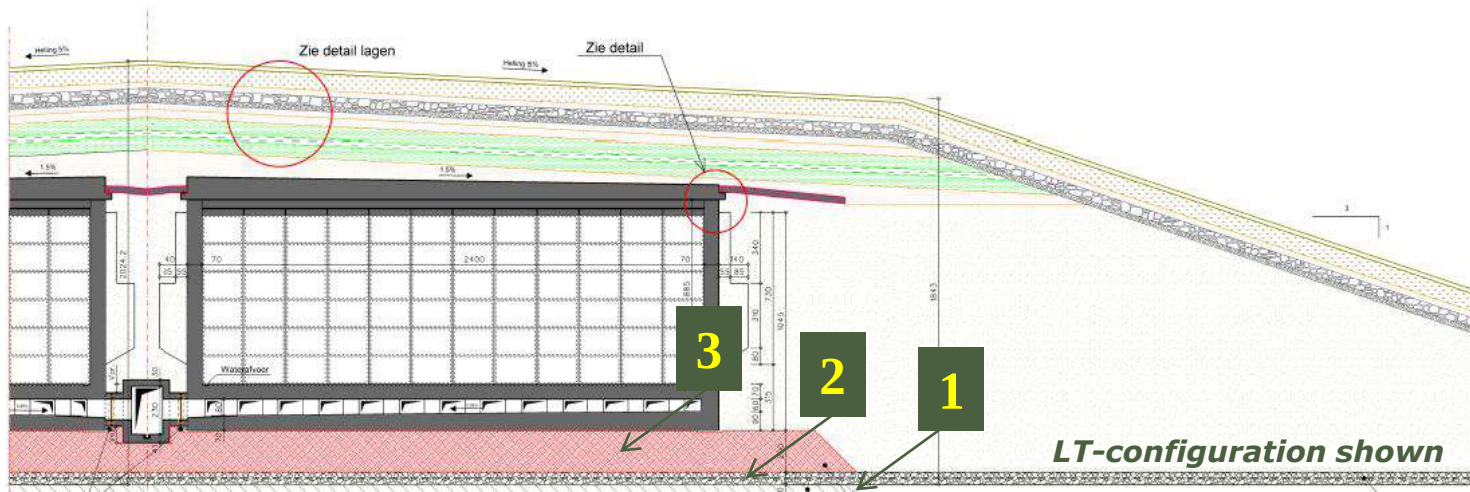


Construction – Foundations

1. Soil mixing (non-swelling bentonite)

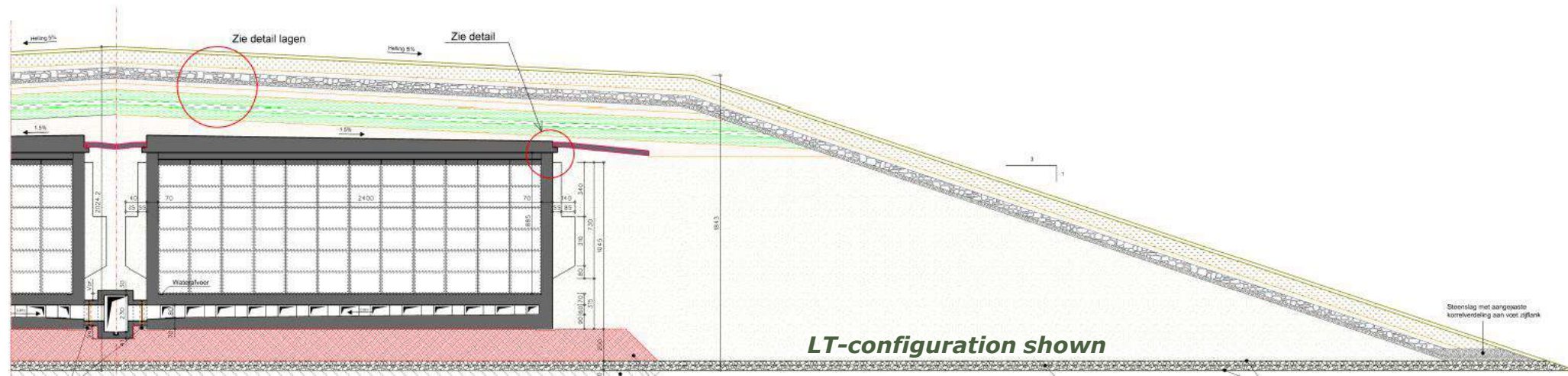
2. Drainage layer 0,6 m
• Gravel and geotextiles

3. Sand-cement embankment 2,0 m
• 5 w% cement



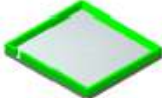
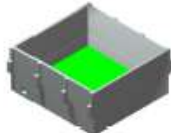
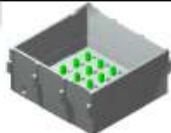
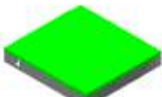
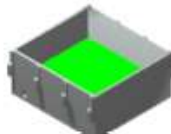
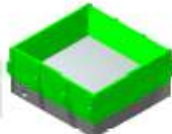
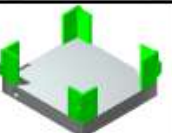
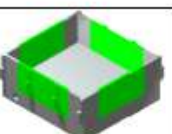
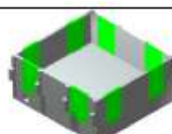
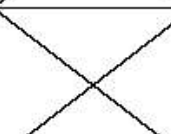
Construction - modules

- | | |
|--|--|
| 1. Walls | 70-85 cm thickness - 25 x 27 x 11 m ³ |
| 2. Concrete pedestal | roof structure fixing |
| 3. Foundation slab | 70-90 cm thickness |
| 4. Columns | 75 x 75 cm (12 x 13) |
| 5. Support slab | 70 cm thickness |
| 6. Structural topslab | 40 cm thickness |
| 7. (Backfilled) gaps between stacks | fine gravel, nominal width: 5 cm |
| 8. (Backfilled) inspection room | 60-80 cm height |
| 9. Drainage system (→ Anti-bathtub system) | |



Construction sequence of a module

- **Goals**
 - Limit (shrinkage related) cracks and construction joints
 - Technological feasibility
- **Construction sequence**
 - Construct walls first (1 phase – $\sim 1.000 \text{ m}^3$)
 - Semi-traversing formwork
 - Limit friction at the bottom of the walls & loosen internal formwork
 - Construct slabs & columns later using coupler systems to connect rebars
- On-site **concrete plant**
- Project specific **concrete mix** design with a focus on long-term durability
 - Attack mechanisms ?
 - ➔ limit risks by design
- Tested in **demonstration test** (see further)

	Phasage I	Phasage II	Phasage III	Phasage IV
Phase 1				
Phase 2				
Phase 3				
Phase 4				
Phase 5				
Phase 6				

Construction – steel roof structure

- Insulated, protects modules
 - from wind, rain, snow, temperature (variations)
- Each module is structurally independent
 - Cope with differential settlements



Construction – steel roof structure

- Insulated, protects modules
- Each module is structurally independent
- Fixed on concrete pedestals
- Runway beams are integrated



Construction – contractual matters (1/2)

- Public procurement
 - Negotiation procedure
 - Selection phase
 - Initial offer
 - Negotiation
 - Best And Final Offer
 - Contract (Q4 2024)
 - Divided in 2 lots
 - Civil construction works
 - Electromechanical works

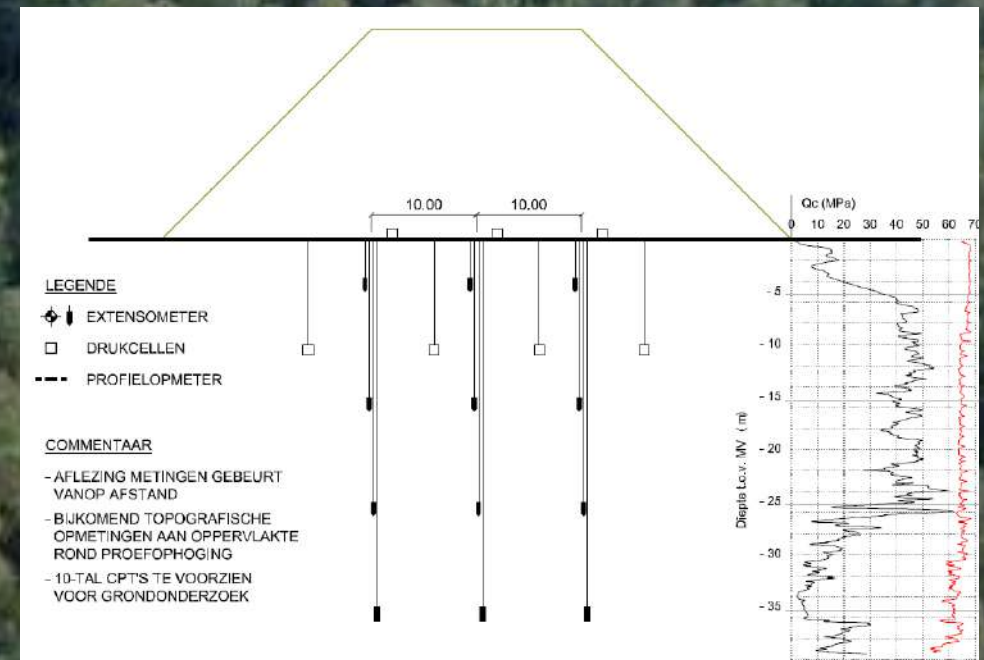
Construction – contractual matters (2/2)

- Also focus on
 - QA & QC
 - Starting from tender phase
 - Approval of intervention plans before works can start
 - Test panels (concrete & foundations)
 - Traceability
 - Environment
 - Transport
 - Treatment of concrete/water
 - Noise and dust control
 - Social measures





**DEMONSTRATE feasibility: test
materials and construction
techniques**



Testing settlements



**Testing & optimizing
construction techniques**

Demonstration test





Demonstration test

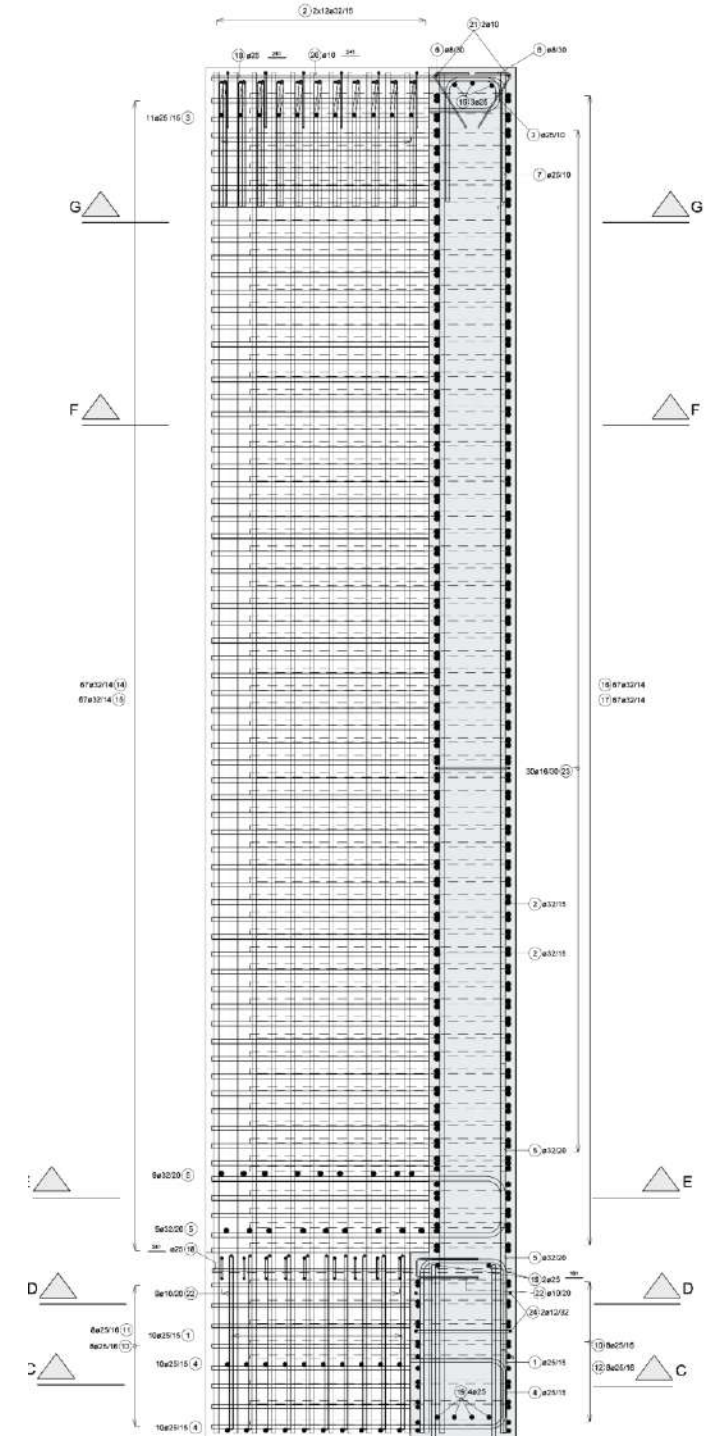


Several test panels to

- optimise concrete **composition**
- optimise **rebar configuration**
- optimize concreting operations: use **concreting tube**
- optimize **concrete compaction** → use **SCC** for the walls
- Optimise carbonation resistance (**CPF-liner**)



-
- A photograph of a tall, rusted metal tower under construction or repair. The tower has several large, irregular holes in its side. Scaffolding is visible around the tower, and the background shows trees and a building.









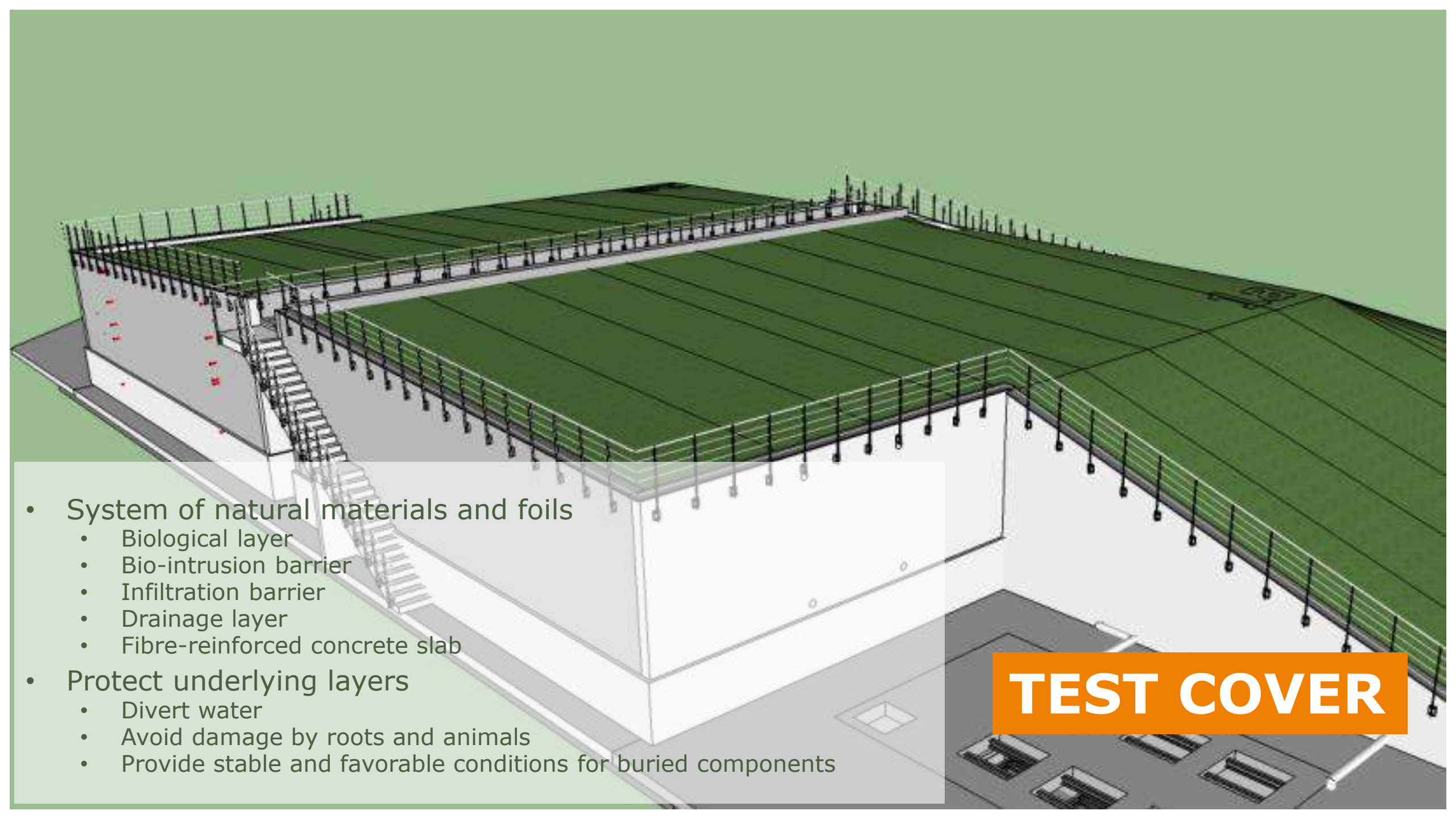
PROTOTYPES



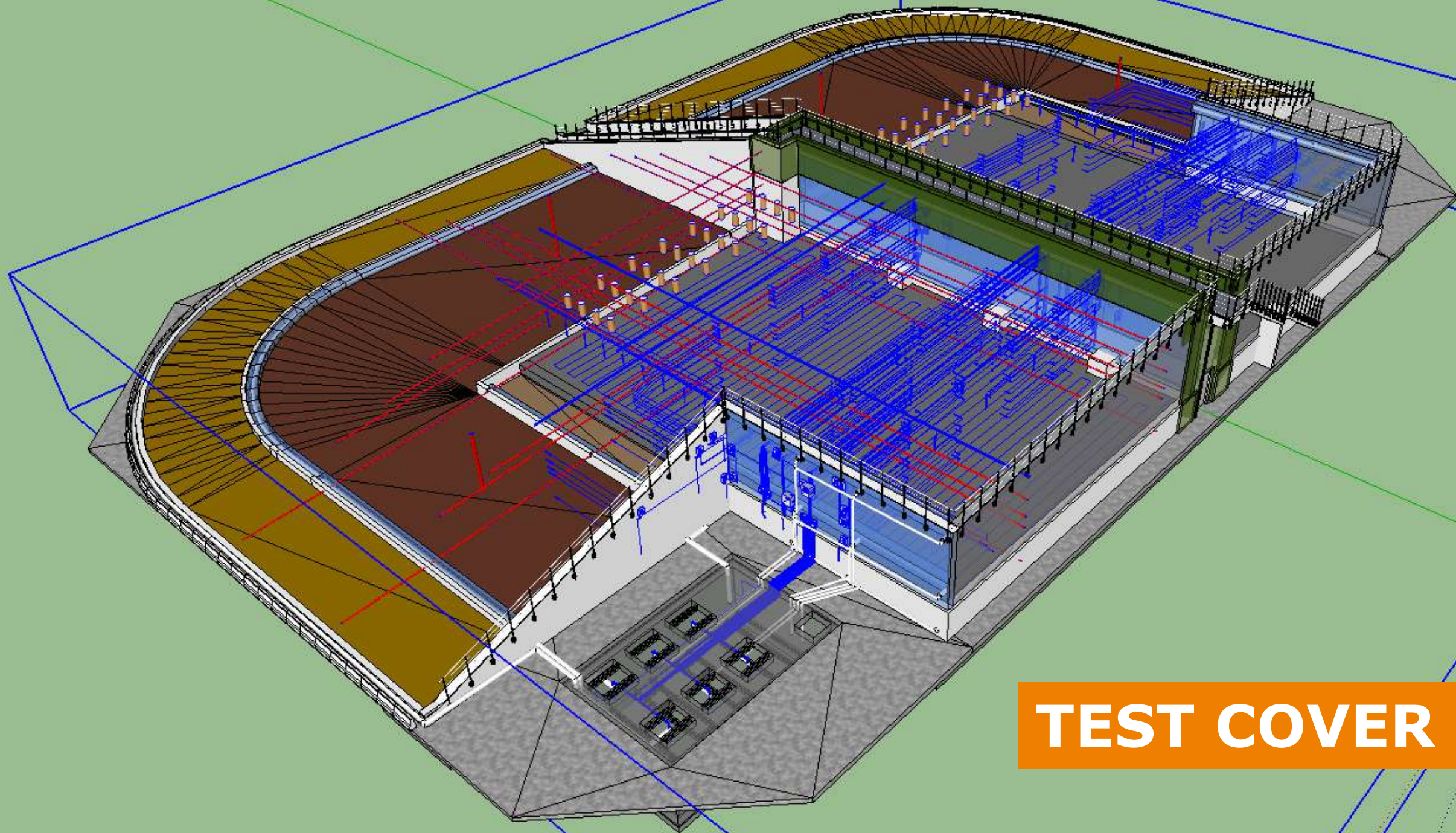
Testing robustness



Testing process equipment (IPM)

- 
- A 3D cutaway diagram of a 'TEST COVER' system. The diagram shows a large, rectangular concrete structure with a green, grass-like top surface. A cutaway on the left side reveals the internal layers: a top layer of natural materials and foils, followed by a fibre-reinforced concrete slab. Below the slab are various protective layers including a biological layer, a bio-intrusion barrier, an infiltration barrier, and a drainage layer. A set of stairs leads up to the top surface of the structure. The entire structure is situated on a grey base, possibly a road or foundation. An orange banner with the text 'TEST COVER' is located in the bottom right corner.
- System of natural materials and foils
 - Biological layer
 - Bio-intrusion barrier
 - Infiltration barrier
 - Drainage layer
 - Fibre-reinforced concrete slab
 - Protect underlying layers
 - Divert water
 - Avoid damage by roots and animals
 - Provide stable and favorable conditions for buried components

TEST COVER



TEST COVER

Some concluding remarks

- The design of the surface disposal facility was driven by **LT safety**
- **Feasibility** was also addressed, a.o. by large-scale testing
- **Auxiliary facilities** are constructed
- **Public procurement** procedure is ongoing
- LT safety is – to a large extent - realised during construction → **QA/QC**



Design and construction: outlines and planning

Wim Bastiaens



ONDRAF/NIRAS

Disposability of category A waste

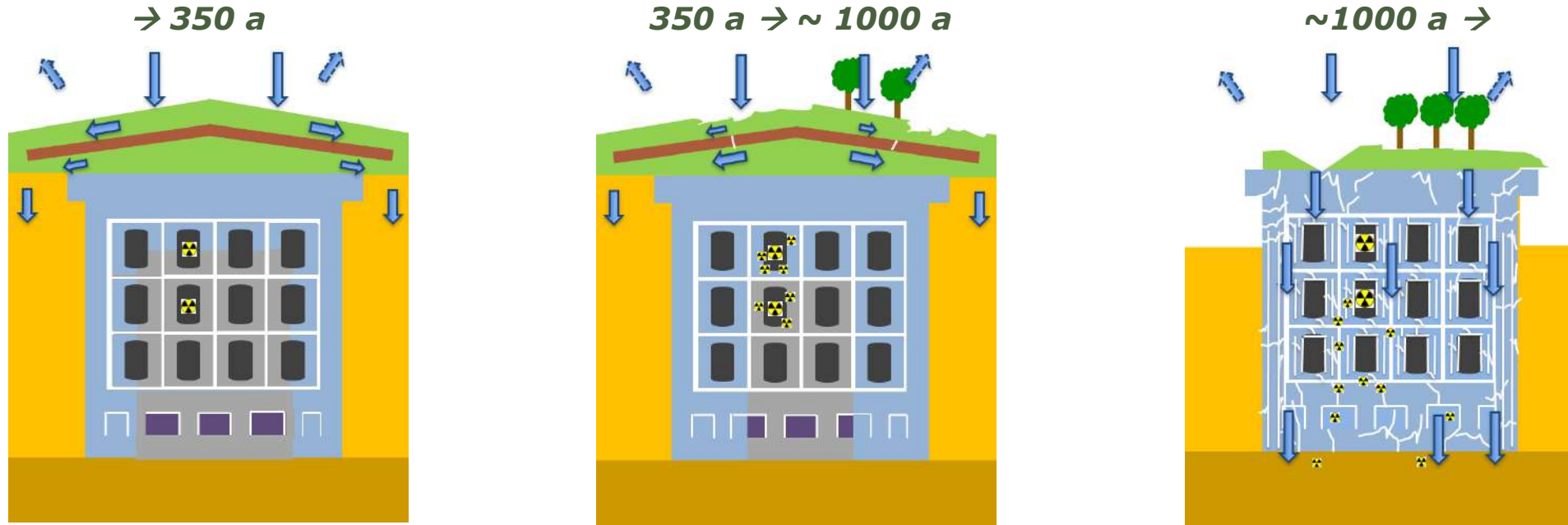
W. Wacquier

Oct. 2023

Context

- License application is underway
 - ◆ Royal Decree for the creation & operating licence in May 2023
 - ➔ Start of the Construction:
 - Public tendering on-going, 2024
 - Contractual delivery First Phase Q2 2028
 - ◆ Royal Decree for confirmation (expected ~ 2029)
 - ➔ Start of the Operation
- License with the **License conditions**
- Demonstrate that we are compliant with the **License conditions**
 - ◆ Construction
 - ◆ **Waste ➔ *Demonstration of the "Disposability" of the category A waste (conformity criteria)***

Why new conformity criteria?



→ The waste should not disturb the expected evolution of the system

No negative impact on the EBS

→ Limitation:

- **Chloride** (corrosion)
- **Sulphate** (attack of concrete)

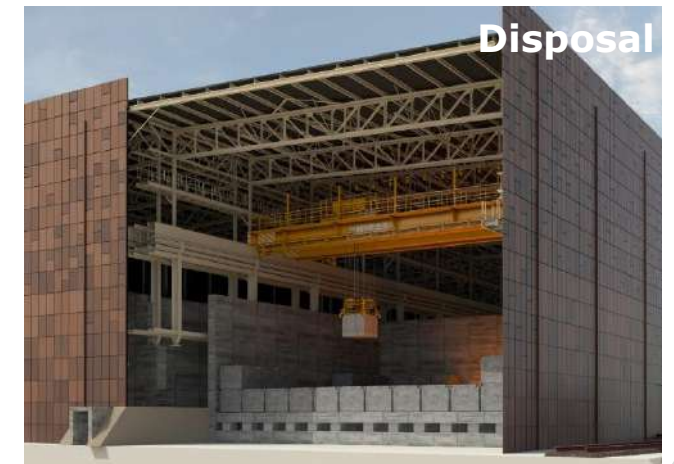
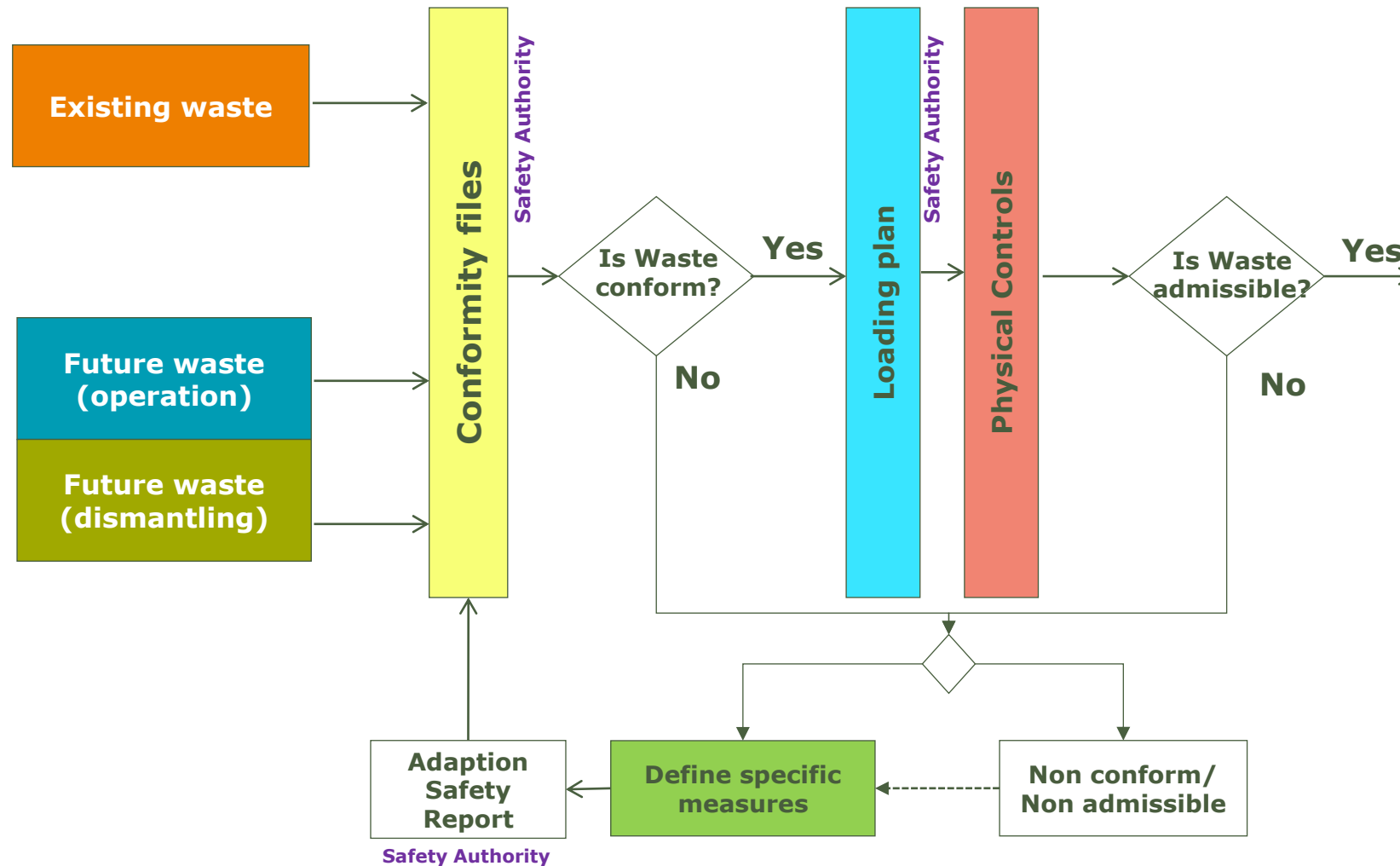
→ No expansive reactions

(e.g. **ASR = Alkali-Silica-Reaction** for concrete waste)

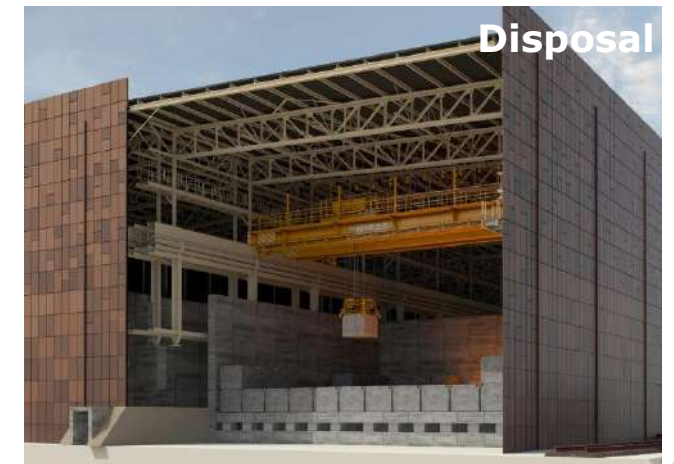
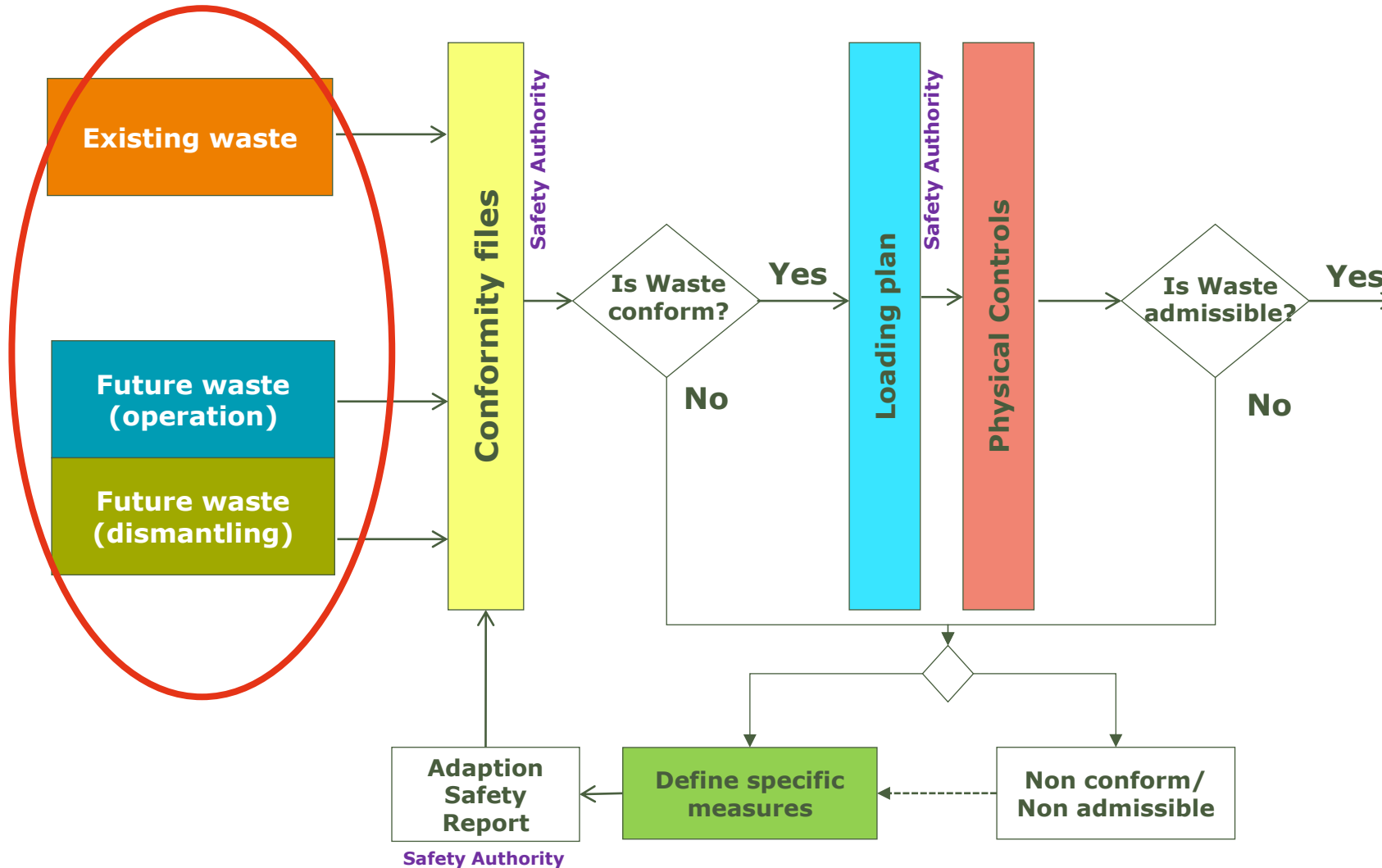
No significant increase of the radiological impact (leaching)

→ limitation **chloride and cellulose** (Complexation)

Demonstration of the “Disposability” of the category A waste : The process



Demonstration of the “Disposability” of the category A waste : The process



Inventory of category A waste: 32 Modules

Existing waste

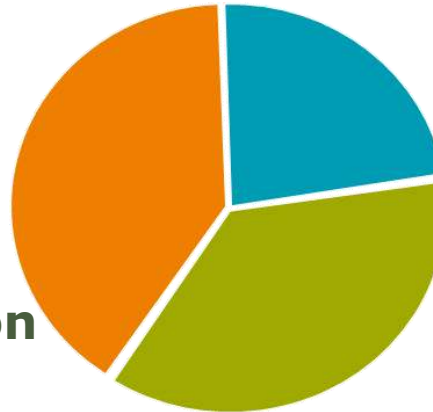
12.8 Modules

Future waste
(operation)

7.2 Modules

Future waste
(dismantling)

11.7 Modules



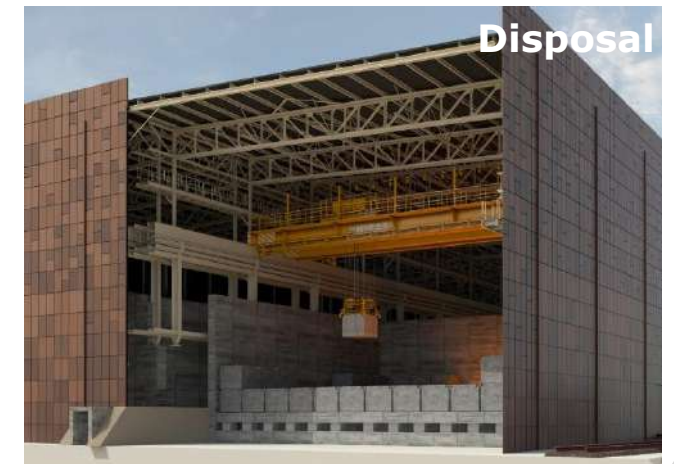
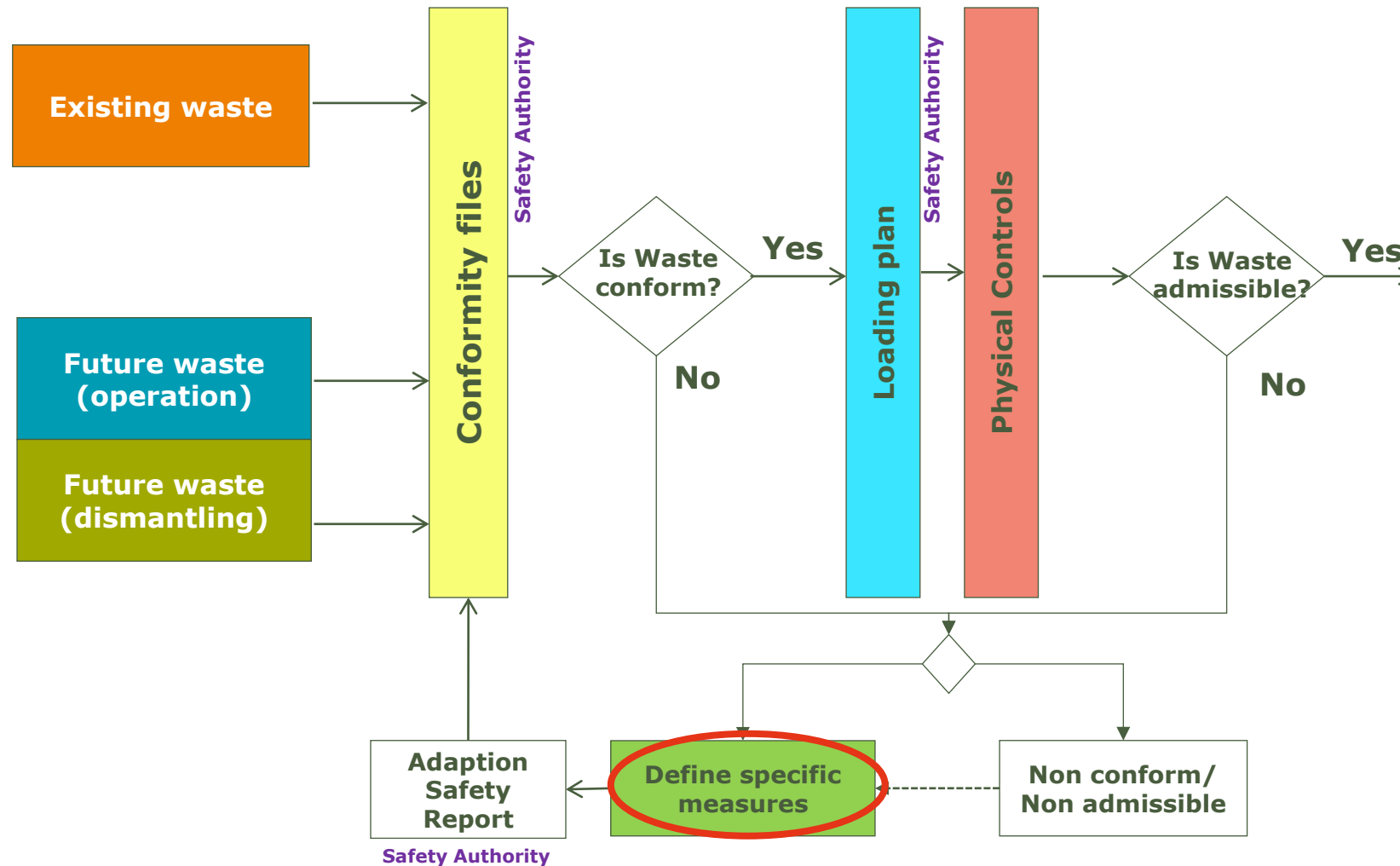
Waste produced based on
current ACRIAs
(i.e. generic surface disposal)

→ **loading of the missing information**
(to check conformity with the
conformity criteria) with waste
producers

Waste will respect the **new ACRIAs**
that are coherent with the conformity
criteria of the safety report

- **Extend the waste acceptance system (until disposal)**
- **Production of conform waste (waste producers)**

Demonstration of the “Disposability” of the category A waste : The process



Define specific measures

Modification of parameters / models

Objective: Reduction of the level of conservatism/uncertainty → new scientific knowledge (e.g. R&D on sorption values)

Modification of the EBS

Objective: Make the waste compatible with the disposal system by adapting the EBS - Engineered Barrier System (e.g. compressible materials, fiber reinforced concrete)

Modification of the waste

Objective: Make the waste compatible with the disposal system by adapting the waste (e.g. Thermal treatment of the waste)

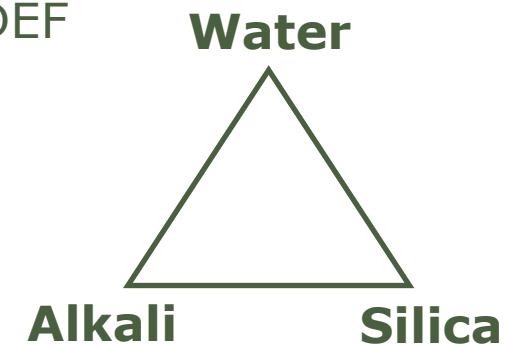
Avoiding processes that can lead to expansion

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon

- Two processes identified for cement materials: ASR and DEF

- ASR (Alkali-Silica-Reaction)**

- Swelling reaction that occurs over time in concrete between **highly alkaline cement paste** and the **silica** (aggregates, sand) in presence of **water**



- DEF (Delayed Ettringite Formation)**

- Ettringite is a normal product of early cement hydration
- If high early temperature in the concrete occurs, this will prevent the normal formation of ettringite
- A delayed formation could occur (rate and extent of the expansion depends on available water)
- And could create expansion and cracking of concrete

Avoiding processes that can lead to expansion

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon

- ♦ **For a cemented waste package:** conditioning matrix (heterogeneous waste) or waste form (homogeneous waste) must be **insensitive to ASR**
→ To be demonstrated through representative samples and appropriate tests (ASTM C 1260 or ASTM C 1293)
- ♦ **For a cemented waste package** the conditioning matrix (heterogeneous waste) or the waste form (homogeneous waste) must:
 - ♦ Have an evolution of its internal temperature $\leq 60^{\circ}\text{C}$
 - ♦ be **insensitive to DEF**. Insensitivity to be demonstrated through representative samples and appropriate tests
- In case of **Concrete Waste** in **waste package** or in a **MON_{III}**, must be insensitive to ASR and DEF. Insensitivity to be demonstrated based on the waste properties or through representative samples and appropriate tests

ASR – Link to disposability programme



**Risk observed for
Homogeneous
cementation of
concentrates
→ ASR Reaction**



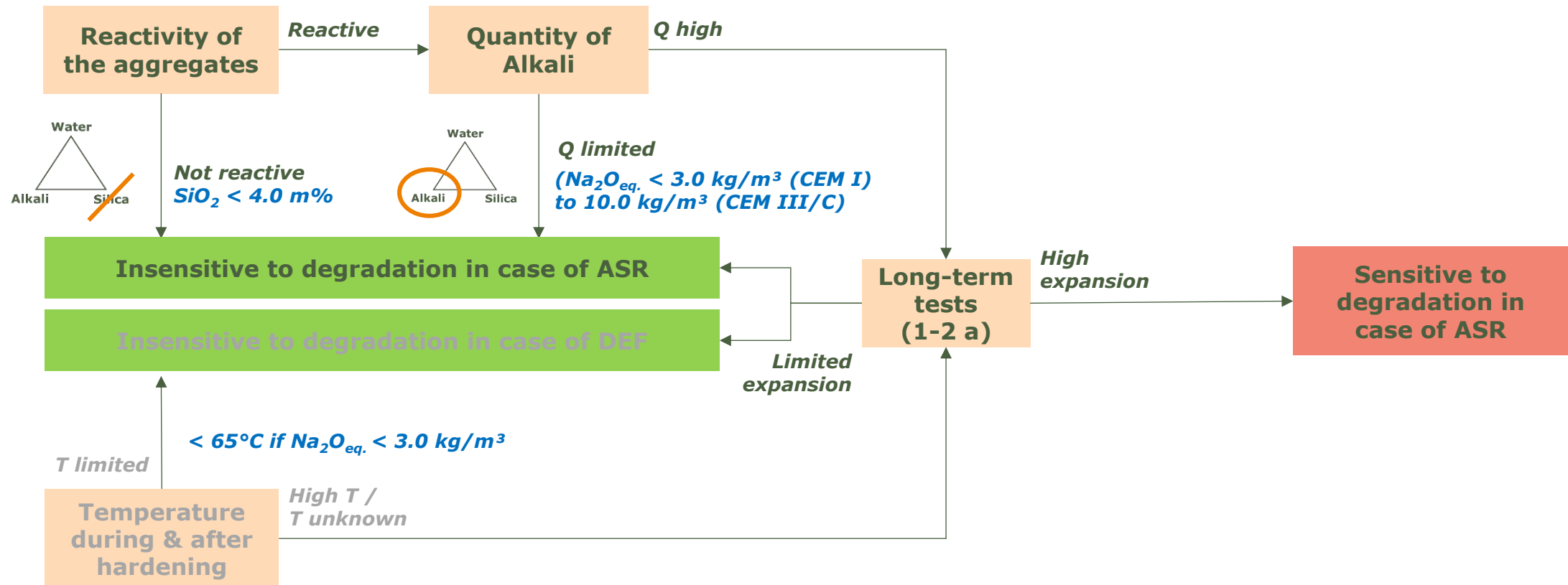
**“Concrete Waste”
(dismantling) represents
about 50% of the first
tumulus
→ ASR to be avoided**

ASR top 1 priority!

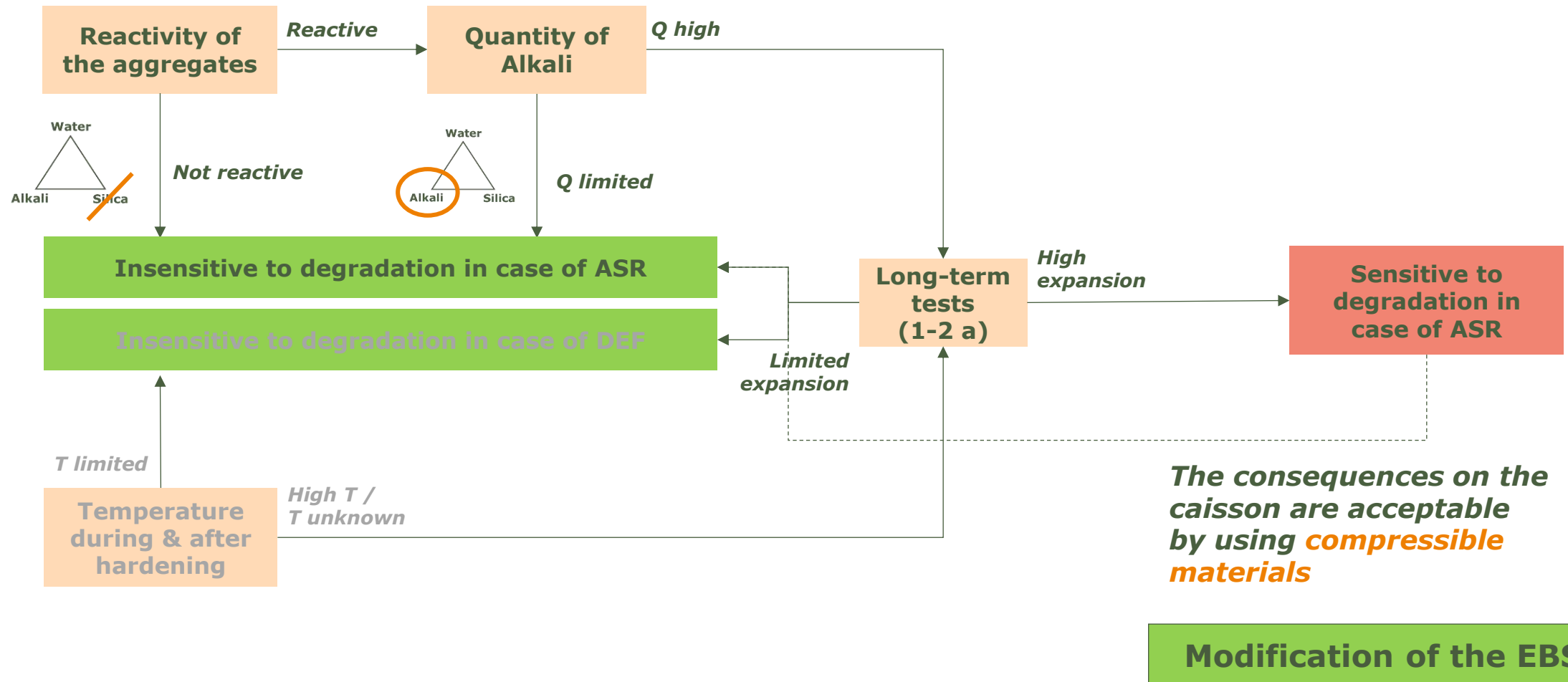
Raw estimate – for illustrative purpose only

Avoiding processes that can lead to expansion (expected evolution)

Processes that can lead to expansion of the waste must be avoided in the period during which the physical integrity of the SSCs is counted upon

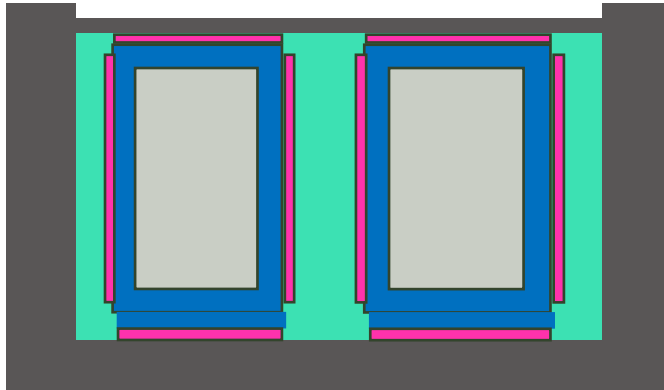


If not ... Compressible Materials



First conceptual prototypes – compressible material

Monolith Type I
with PE foam

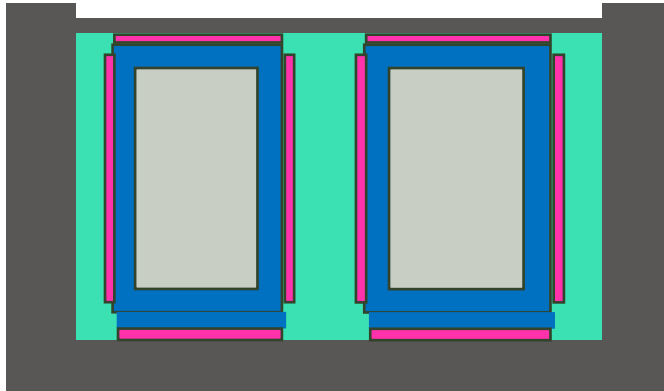


Long-term R&D studies ongoing (potential degradation of the material, impact on the sorption)

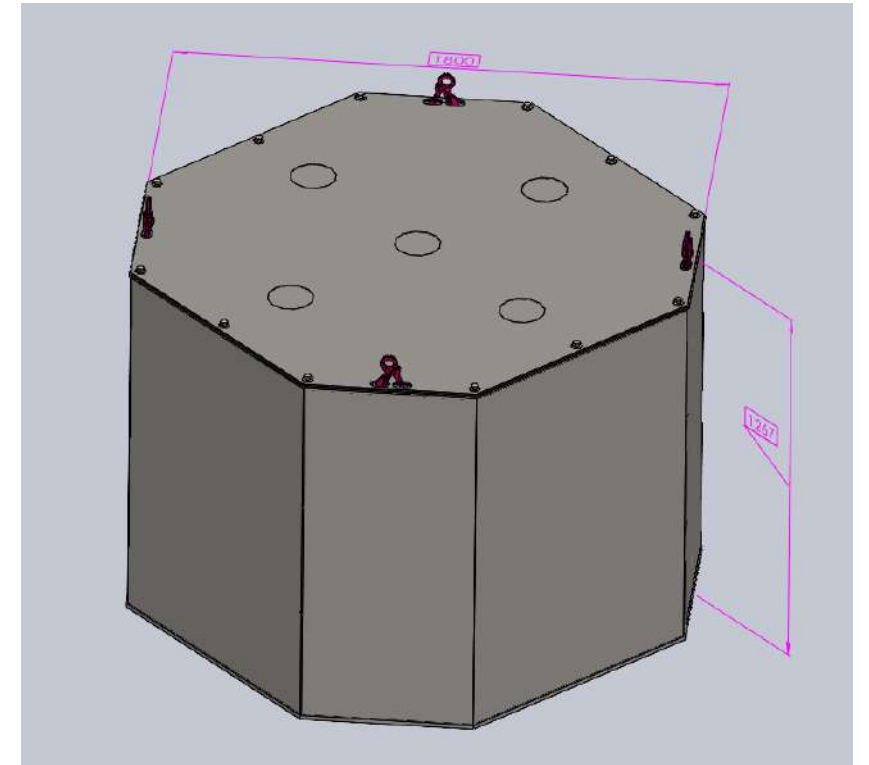
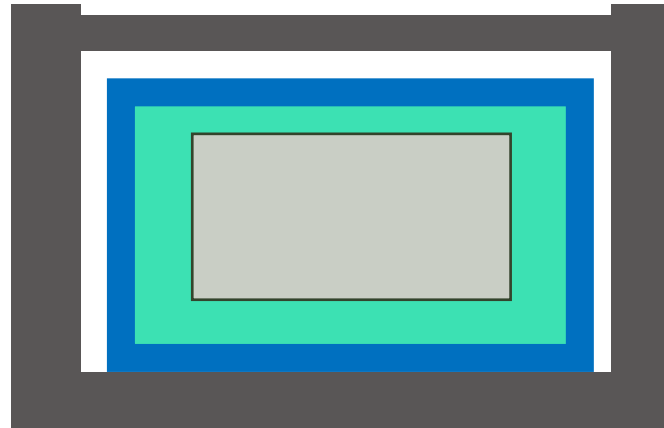
Conceptual Prototypes to be tested

First conceptual prototypes – compressible material

Monolith Type I
with PE foam



Monolith Type III
with a box

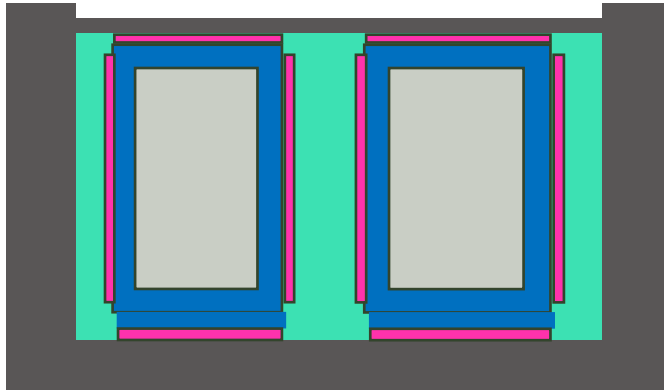


First Design of the box

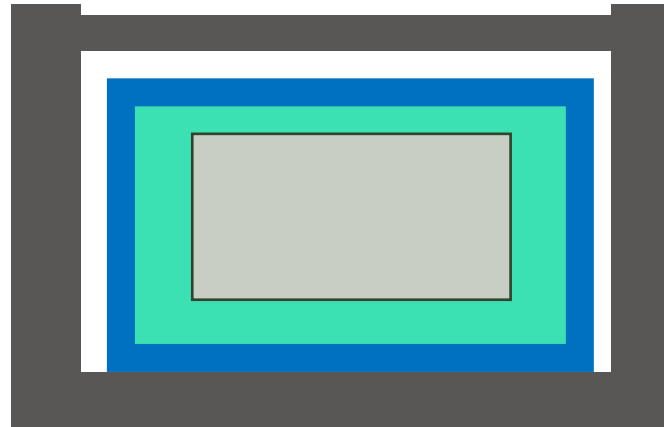
Conceptual prototypes to be built & tested

First conceptual prototypes – compressible material

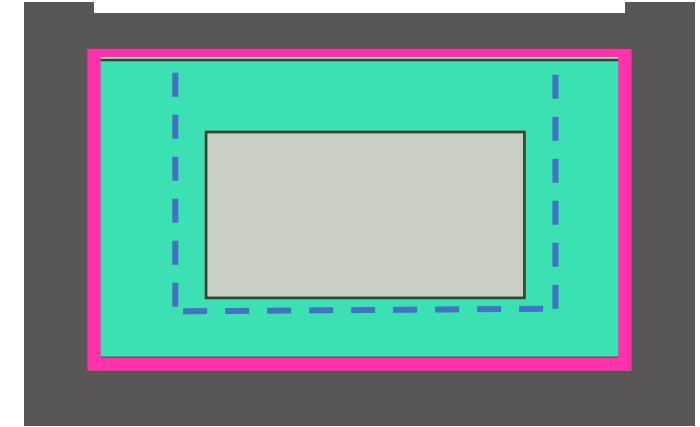
Monolith Type I
with PE foam



Monolith Type III
with a box



Monolith Type III
with RVC foam (carbon)



Carbon "inert"

Conceptual prototypes to
be built & tested

Limitation of Cellulose

Complexation due to the presence of cellulose (degradation product leads to the formation of complexing agent ISA) must not increase significantly the radiological impact

- Avoid, sort and incinerate
- If not possible, limitation to
 - ◆ **≤0.4 kg cellulose by monolith**
 - ◆ → limit by **waste package**: 0,4 kg divided by # of waste packages in a monolith
 - 220L: ≤0.08 kg
 - **400L: ≤0.1 kg**
 - 600L: ≤0.4 kg

ISA = Isosaccharine Acid

Cellulose – Link to disposability programme

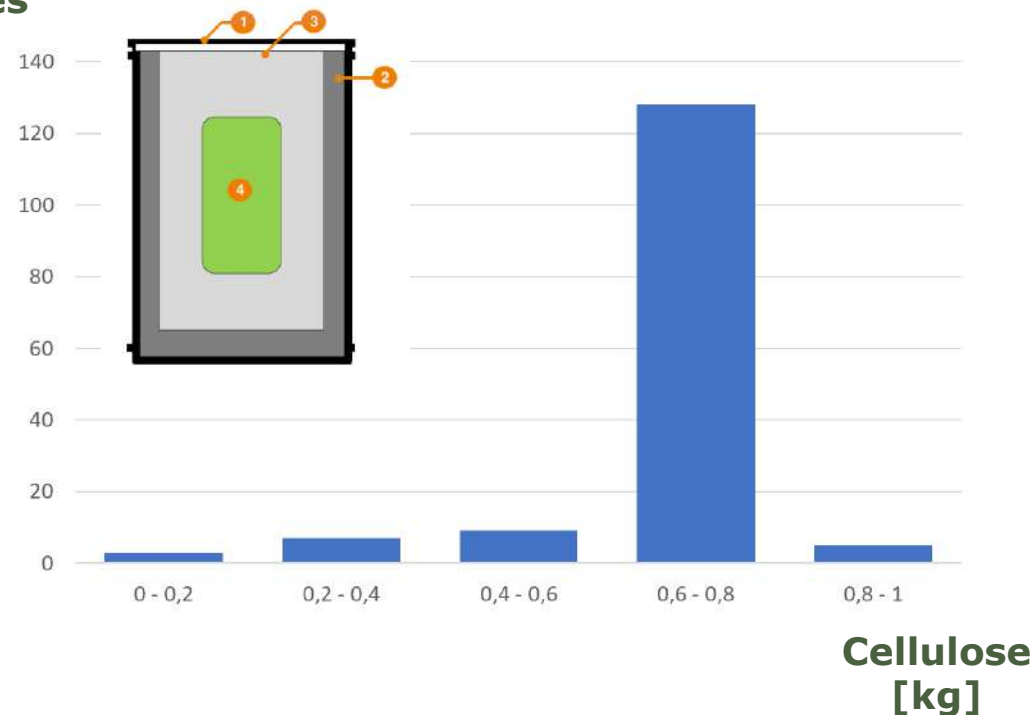
Supercompacted waste

- Cellulose allowed up to **10 – 20 kg / 400L**
- From 2010, limit for non-conditioned waste: no info required if $M_{\text{cellulose}} < 0.5 \text{ kg}$
3-5 compacted drums / 400L
→ Risk: **1.5 – 2.5 kg in a 400L**



~ 50% NPPs' filters with cellulose

waste packages



Raw estimate – for illustrative purpose only

Limitation of Cellulose (**expected evolution**)

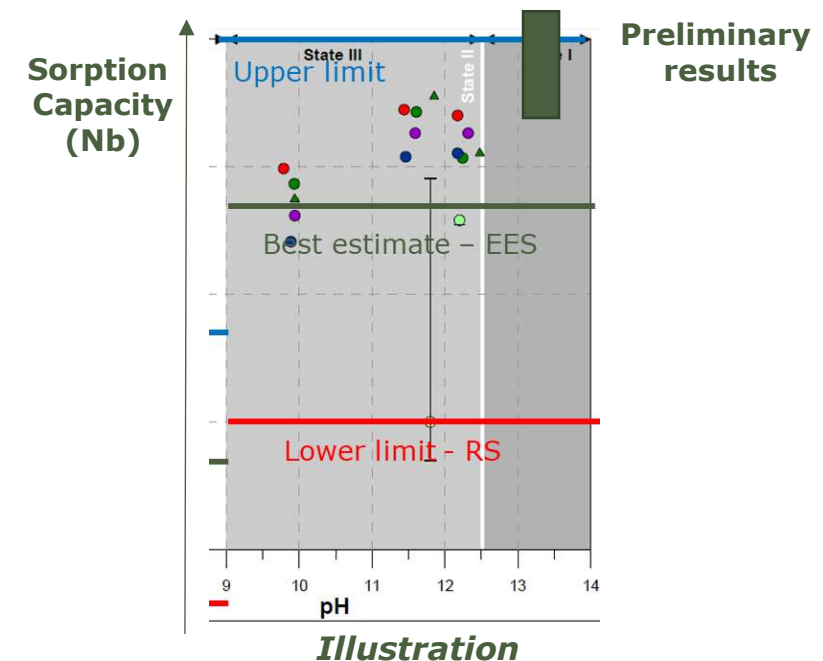
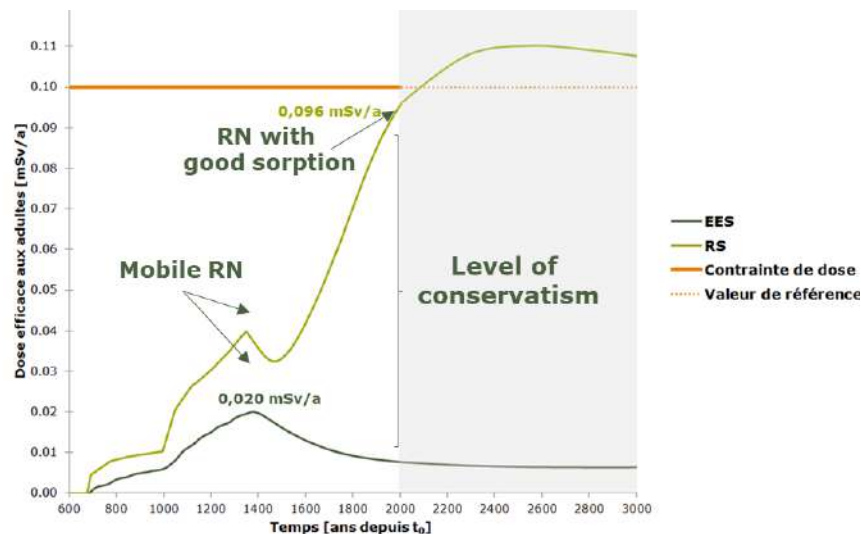
Complexation due to the presence of cellulose (degradation product leads to the formation of complexing agent ISA) must not increase significantly the radiological impact

- Avoid, sort and incinerate
- If not possible, limitation to
 - ◆ **400L:**
 - **0.1 kg if HCP [63-190[kg/m³**
 - **0.2 kg if HCP [190-316[kg/m³**
 - **0.3 kg if HCP [316-443[kg/m³**
 - **0.4 kg if HCP [443-570[kg/m³**
 - **0.5 kg if HCP [570-696[kg/m³**
 - ◆ **2.7 kg for a Monolith Type III**

Safety study OK

Limitation of Cellulose

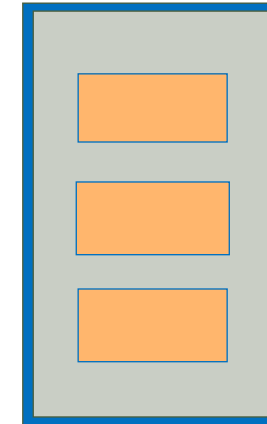
- Cellulose:
 - ◆ **Future waste: sorting!**
 - ◆ Existing waste: Modification of the conformity criteria ($\sim 2\text{-}3\text{ kg} / 400\text{L}$) by reducing the level of uncertainties and hence the high level of conservatism in the scenario
- ➔ R&D project on sorption on cement



Limitation of chlorides

- Chloride-ions in the waste must not disrupt the surrounding concrete barriers by accelerated reinforcement bar **corrosion** in the period during which the concrete barriers are considered as non-degraded
- **Complexation** by the presence of chloride-ions in the waste must not increase significantly the radiological impact from lixiviation

- For a Type I/II Monolith (**waste package**):
mass of chloride ions in waste form
 $\leq 0,4\text{m}\%$ of cement mass of conditioning mortar
- For a **MON_{III}**: mass of chloride ions in waste form $\leq 0,4\text{m}\%$ of cement mass of filling mortar
- Chloride-ions = not for covalente bond
→ PVC OK



400L:

Drum: 100 kg

Waste: 500kg

Conditioning mortar: 300kg
(Cement 100kg)

→ 0.4 kg /Cl⁻ 400L

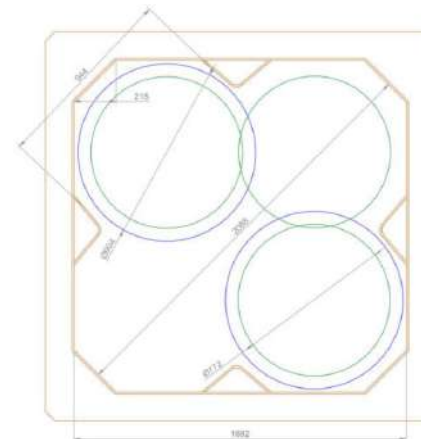
Limitation of chlorides (**expected evolution**)

- Chloride-ions in the waste must not disrupt the surrounding concrete barriers by accelerated reinforcement bar **corrosion** in the period during which the concrete barriers are considered as non-degraded
- **Complexation** by the presence of chloride-ions in the waste must not increase significantly the radiological impact from lixiviation

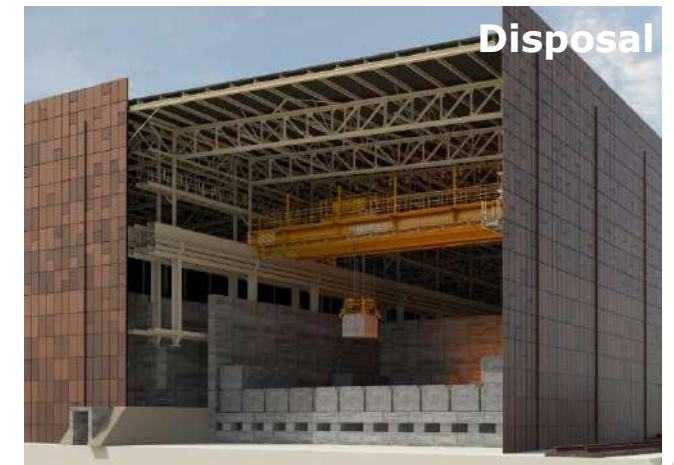
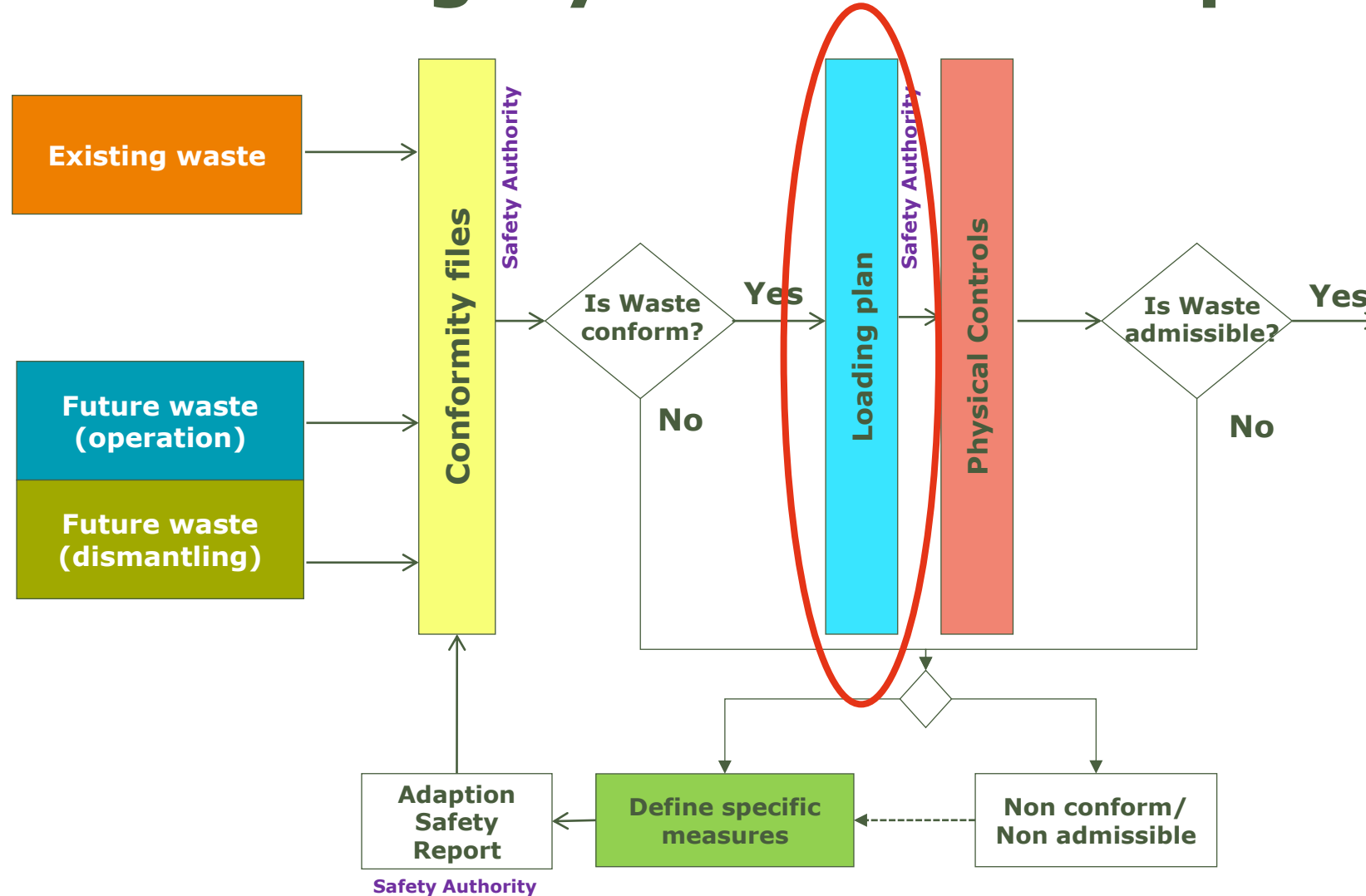
- For a Type I/II Monolith (**waste package**): mass of chloride ions in waste form $\leq 0,4\text{m}\%$ of cement mass (**Waste + conditioning mortar**)
- For a **MON_{III}**: mass of chloride ions in waste form $\leq 0,4\text{m}\%$ of cement mass (**Waste + filling mortar**)
- Chloride-ions = not for covalente bond
→ PVC OK

Other RD&D activities

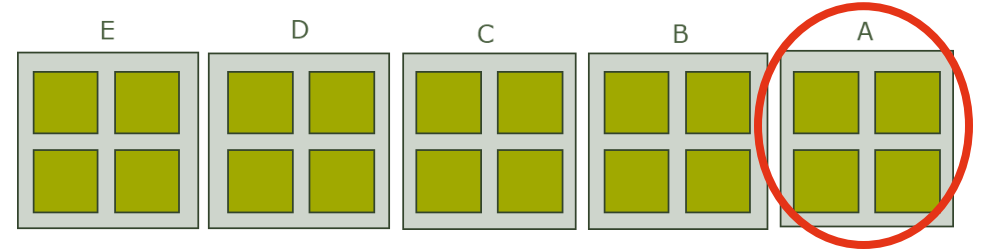
- Fiber reinforced concrete for the caisson
 - ◆ Resistance corrosion → 5 m%
 - ◆ However to increase the limit also sorption to consider (→ R&D project on sorption on cement)
- Development of inox watertight overpack
 - ◆ To be reassessed after realization of prototypes for compressible materials



Demonstration of the “Disposability” of the category A waste : The process

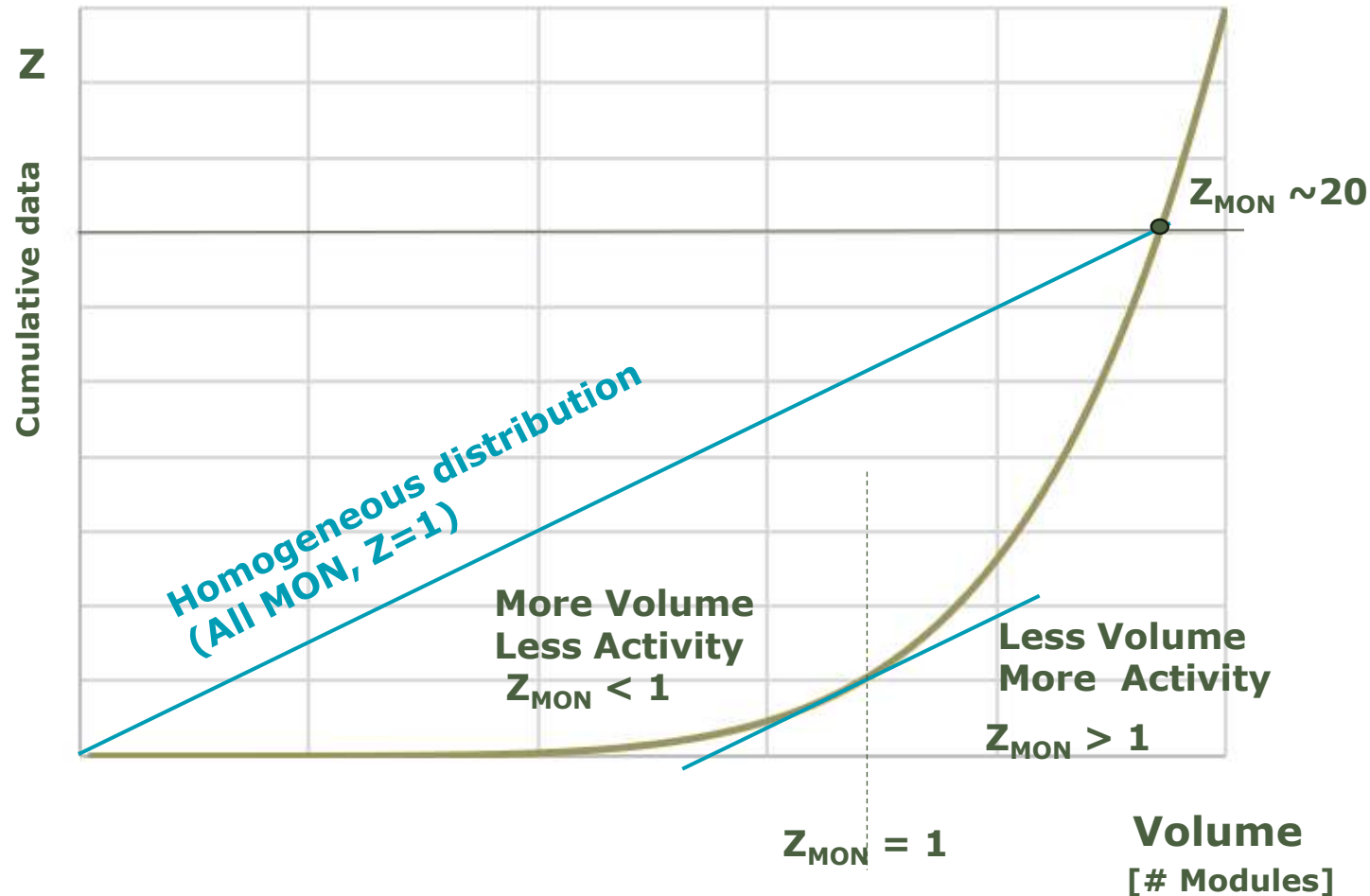


The Phased loading plan



- Focus on 1 phase
(4 modules filled simultaneously)
- **Preliminary loading Plan:**
 - ◆ Waste available for the operation of phase A
 - ◆ Existing waste & future waste
 - ◆ A priori conform waste & potentially conform waste (link BCDs)
 - ◆ First evaluation of the filling rules
- **Dynamic loading Plan:**
 - ◆ Continuous reality check & follow-up of the filling rules
 - ◆ Guide the production of the monoliths
- **Final loading Plan:**
 - ◆ Monoliths in the modules
 - ◆ Confirmation of the respect of the filling rules

Z is an important parameter for loading plan



Z defined for monoliths, modules, ...

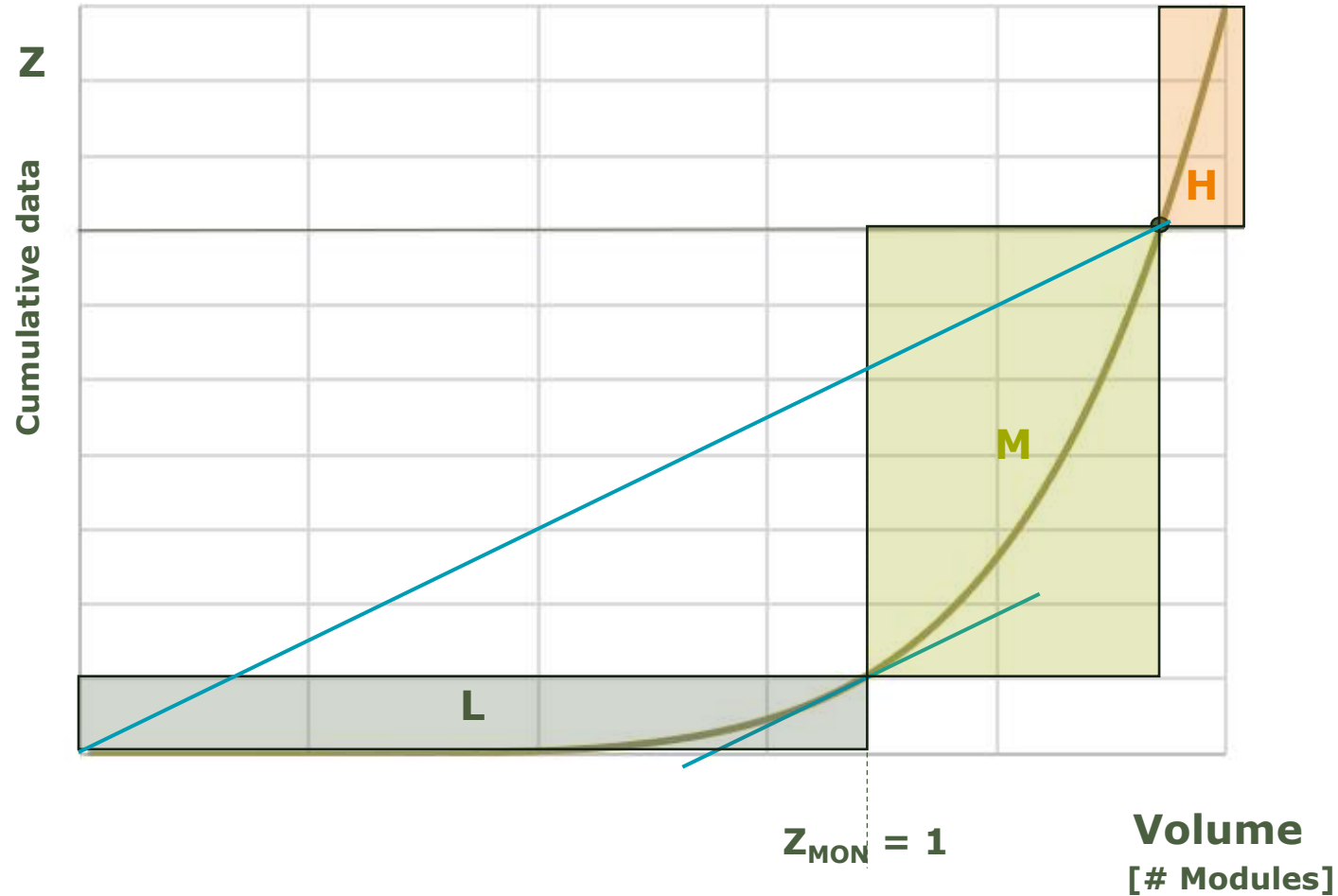
$$Z_{item} = \frac{1}{N} \sum_{i=1}^N \frac{\#items, tumulus oost \times A_{i,item}}{OLI_{i,tumulus oost}}$$

Z → 1 ("homogeneous")

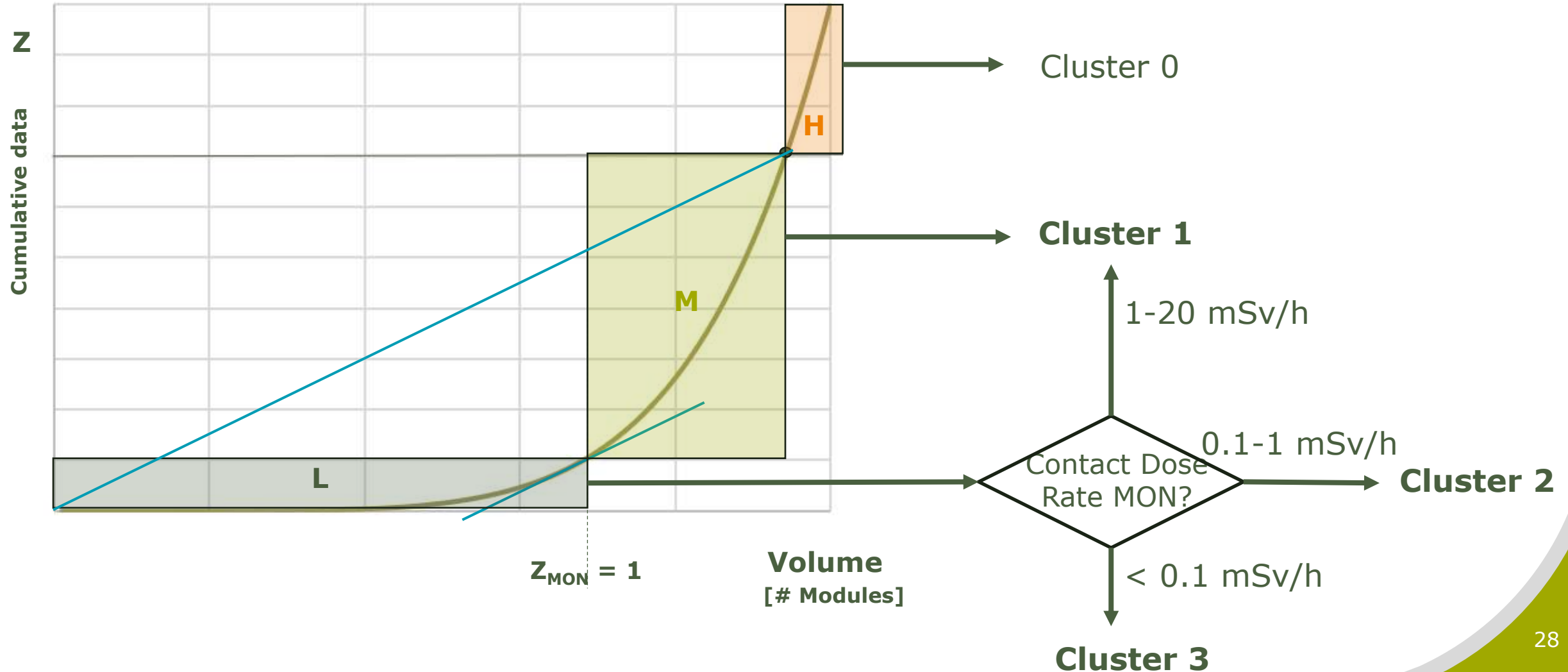
Waste with **more** activity than the acceptable average concentration must be compensated by waste with **less** activity than the acceptable average concentration

Specific rules for the loading plan to limit the heterogeneity

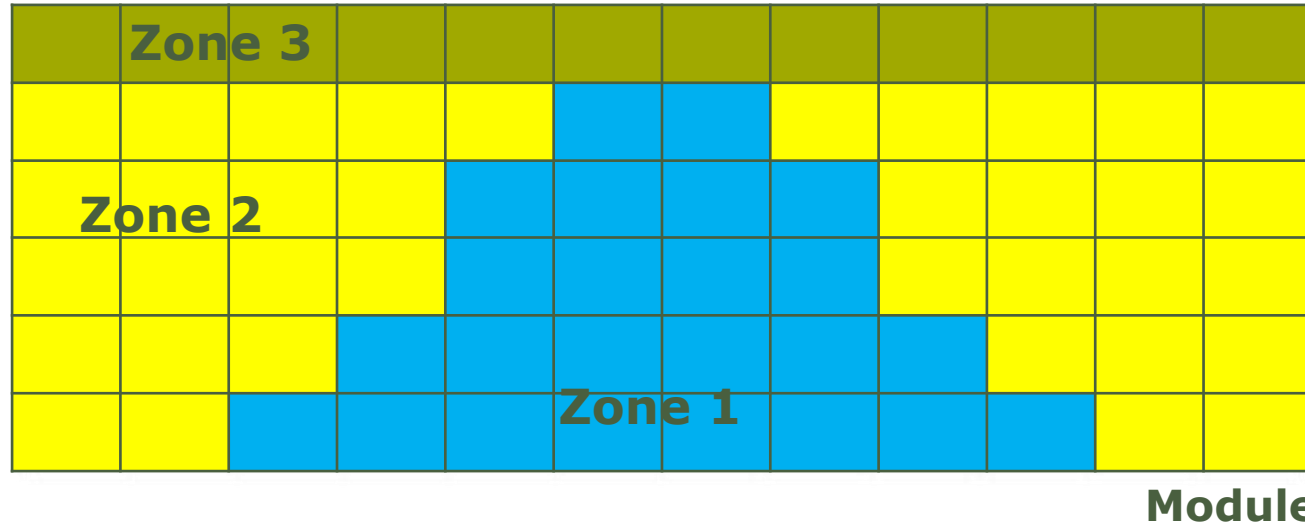
Based on the Z curve, definition of 3 slices



And clustering of waste packages



Clusters allocated in Zones in the Module



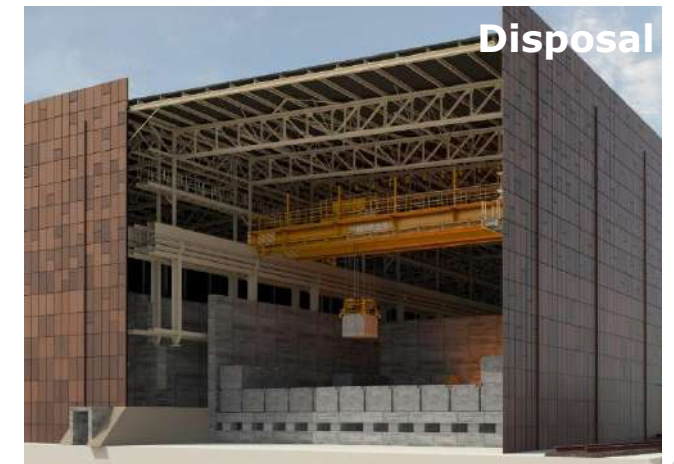
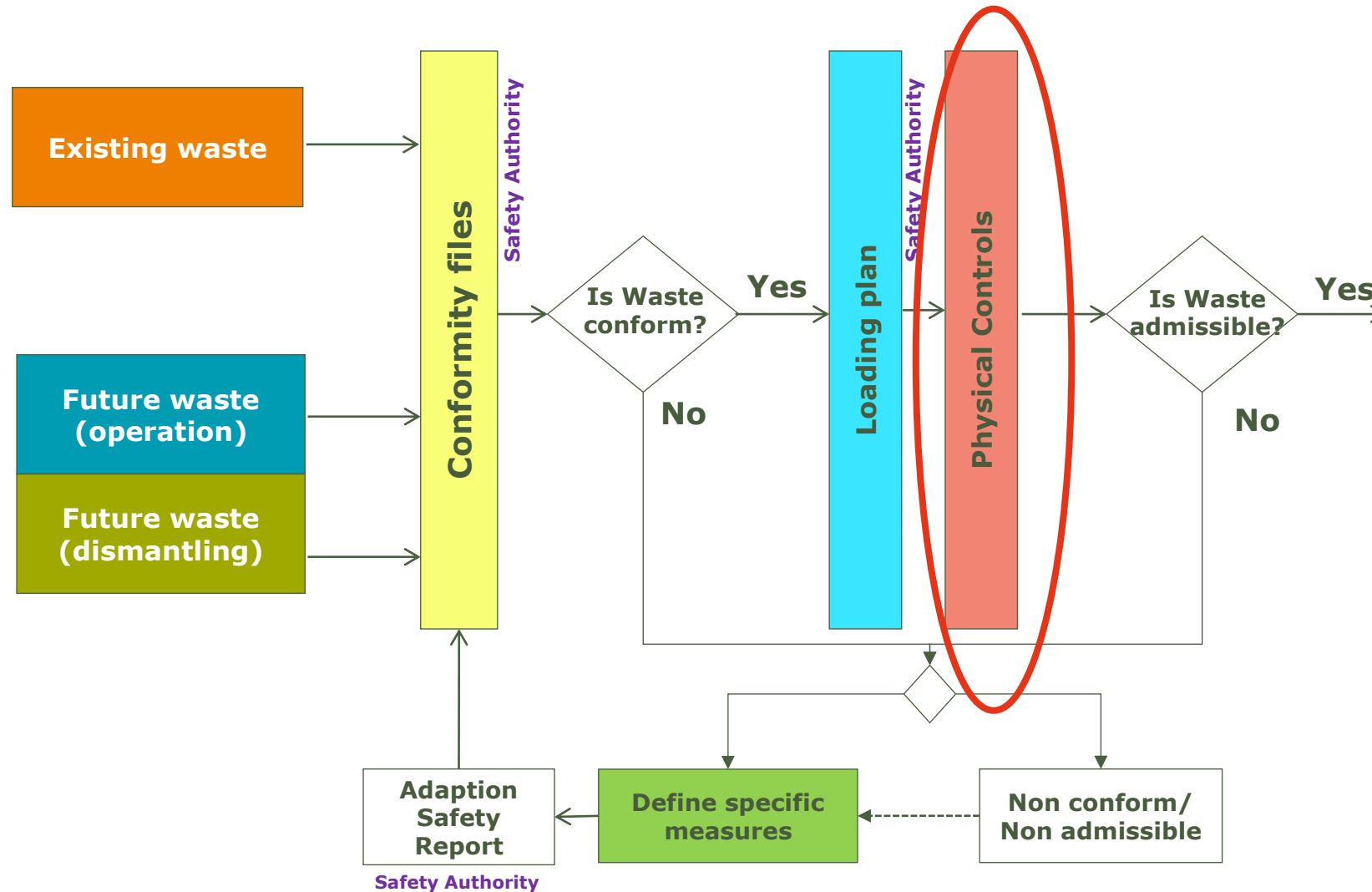
Cluster 1 in Zone 1

Cluster 2 in Zone 1/Zone 2

Cluster 3 in Zone 1/Zone 2/Zone 3

- Guide the loading of the modules
- Continuous follow-up & reality check during filling to ensure the respects of filling rules (dynamic loading plan):
 - Contact dose rate (outer stacks, by layer)
 - Heterogeneity (module/4-module)
 - Radiological impact (several scenario's)
 - ...

Demonstration of the “Disposability” of the category A waste : The process



Confirmation of the conformity of the waste through physical controls

	Standard controls	Complementary controls (DT/NDT)
Frequency	Every Waste Package (WP)	Sample-based
Control	Identification of the WP, visual control, collo, Visuele controle, non-fixed surface contamination, mass, dose rate (& comparison with the data from the inventory)	Relevant conformity criteria (Through conformity file)
Temporary solution	Manual	To be develop in existing installations
Finale Solution	Mobile installation 	Development of a dedicated building for DT/NDT controls

Destructive controls of legacy waste

Pilot project in the CILVA facility to control the content of the legacy waste (11 waste packages)
→ Building knowledge on adequate techniques for the controls on an industrial scale
& on the nature on legacy waste

Removal of drum



Core drilling



Cutting & dismantling of pellets



Sorting & characterisation of waste materials



Conclusion: Processes are setting up to ensure the disposability of cat. A waste

- Conformity criteria are defined & first modifications on-going
 - ◆ → Ensure production of (potentially) conform waste
 - ◆ → Extension of the Waste acceptance system (Reinforcement of Controls at the source)
- Development of solutions for non-conforming waste
 - ◆ Sorption tests for cellulose/chloride
 - ◆ Production & testing of prototypes with compressible material
- Development of methodologies for the loading plan
- Development of protocols for DT/NDT techniques to confirm the disposability of the waste



FANC

FEDERAAL AGENTSCHAP VOOR
NUCLEAIRE CONTROLE



BEL ✓

Role and activities of FANC and Bel V in the cAt surface disposal

Structure of the presentation

1. History of the licensing process
2. Overview of the license
3. Role of FANC + Bel V
 1. during construction
 2. during operation
 3. w.r.t. admissibility to disposal: “disposability”
4. Conclusion

(short) History of the licensing process

History of the licensing process

- 2006-2012 pre-licensing
- 2013-01-31 License Application
- 2013 → 2017 Application deemed incomplete, ~300 Q&A with NIRAS
- 2018 → 2019 Update by NIRAS of license application
- 2019-10-03 Scientific Council of FANC gives first favourable advice with some Q
- 2019 → 2020 National and international consultations
- 2019 → 2023 Answers from NIRAS on first advice
- 2023-02-24 Scientific Council gives second favourable advice
- 2023-03-29 FANC proposes license to Minister of the Interior
- 2023-05-16 Publication of Royal decree granting NIRAS the license

(brief) Overview of the license

Overview of the license

- License for the construction and exploitation of a surface disposal facility in Dessel in accordance with its safety report
 - covers the construction of and exploitation of 34 modules arranged in two tumuli
 - Construction of first set of 20 modules can start after hold point “ready for construction”
- Structure:
 - Generic conditions (similar for all class I nuclear installations related to a.o. construction, testing, commissioning, modification, periodic safety review)
 - Disposal installation specific conditions
 - Specific reporting requirement: activity report
 - Conditions on the waste to be disposed
 - Radiologic safety requirements (radiation dose and risk to public)
 - Condition related to construction of western set of 14 modules
 - Requirements w.r.t. the “structural closure of the facility”

Activity report

- For every 4 filled modules, NIRAS makes an activity report
- Overview of activities
- Updated inventory
- Occupational exposure
- Results of the monitoring programme
- Any incidents and accidents including lessons learnt/measures taken
- Any info requested by FANC
- This report will be made public (comment from public consultation)

- Exist as requirements on the level of the license Royal Decree and as criteria on the level of the safety report
- Example:
 - Requirements in the licence related to physico-chemical stability of waste
 - Criteria in the safety report related to exclusion of alkali-silica-reaction
- Only solid waste conditioned in a monolith
- Bounding total activity (34 modules) and activity concentration limit by critical radionuclide in the license
- Demonstration of respect of the waste criteria must be described in a 'conformity file'
- Waste must be part of an approved filling plan for 4 modules before disposal

Closure of the modules

- Modules must be structural closed after publication of the activity report and after approval by FANC
 - No further exploitation of these 4 modules, direct access to the waste monoliths is no longer possible
- The removal of the roof and conversion in tumulus i.e. the covering of the modules in earth layers is not part of the granted license. NIRAS will have to apply for a license for closure in due time.

Role of FANC + Bel V during construction

Role of FANC + Bel V during construction



- NIRAS must present the construction programme to FANC + Bel V
- FANC + Bel V can add witness points and hold points to the construction programme
- A witness points means FANC and/or Bel V is given the opportunity to witness a certain construction step
- A hold point means FANC and/or Bel V needs to approve a certain construction step/activity before the construction can be continued

Ready for construction

The first hold point is the hold point “ready for construction”. NIRAS needs to:

- Deliver various documents concerning competency development w.r.t. nuclear safety, radiation protection, redaction of safety reports, developing a suited safety culture and quality control
- Create the necessary procedures to manage construction
- Develop a QA/QC programme for the construction
- Apply its integrated management system for the construction

Role of FANC + Bel V during construction



- Regular follow-up meetings with NIRAS
- Various inspections on the construction site
 - The frequency depends on the evolution of the construction
- Major focus is the respect of the specifications defined in the safety report
 - Long term safety is strongly dependent on the quality of the construction
- NIRAS will apply a thorough QA system including handling of non-conformities
 - Including follow-up by health physics department, Bel V and FANC as required => may lead to dedicated inspections

Commissioning

- Commissioning of the installation is approved by Bel V
- Bel V needs to approve the testing programme (proposed by NIRAS) that enables commissioning
- After commissioning has taken place, FANC will propose a confirmation decree to be published as Royal Decree
 - This decree allows radioactive waste disposal operations to commence

Role of FANC + Bel V during operation

Role of FANC + Bel V during operation

- The surface disposal facility is licensed as a class I nuclear installation to which all current regulation applies
- Nuclear safety is the first and foremost responsibility of the operator
- NIRAS has its own health physics department that operates independently from the operator NISD (NIRAS Site Dessel) and whose role is to verify that the disposal facility is operated safely and according to the regulation and its operating license
- FANC and Bel V supervise the operator and the health physics department to ensure that each performs its role

Role of FANC + Bel V during operation

- During operation, FANC and Bel V will organise various inspections to verify safe operation of the facility
 - These inspections will be analogous to inspections in other class I facilities
- In addition, Bel V will review any modifications NIRAS wishes to make to its safety report
 - i.e. not requiring a modification of license conditions
- In case a modification requires changes to the license, a procedure similar to the licensing process needs to be followed
- Every 10 years (or depending on subject, every 4 filled modules), NIRAS needs to review its operation and identify points of improvement. FANC and Bel V oversee this periodic safety review

Role of FANC + Bel V during operation



- In addition to the steps typical for all installations, FANC + Bel V will also approve closure of sets of 4 modules. This includes filling the spaces between the monoliths and putting a concrete slab on the modules. This doesn't include removing the metal roof nor placing the covering layers.

Role of FANC + Bel V in admissibility to disposal

Role of FANC + Bel V in disposability



- NIRAS needs to demonstrate the conformity of the waste with the requirements in the license and the criteria in the safety report
 - including the rules for spreading the radioactivity over the disposal installation

Role of FANC + Bel V in disposability

- To demonstrate conformity, NIRAS will create a conformity file ('conformiteitsdossier') for groups of waste
- These conformity files need to be approved by Bel V during drafting and by FANC in its final version
 - Allows NIRAS to perform physical actions i.e. Belgoprocess can start taking waste out of storage for final control and conditioning for disposal (IPM)
- These files describe any testing (types and frequencies) for the waste to demonstrate that its physical condition corresponds to its description in the conformity file. These tests will take place as the waste is unloaded from its current storage facility.

Role of FANC + Bel V in disposability

- Once the conformity file of a waste package has been approved, NIRAS may add this package to its filling plan ('opvulplan')
- This filling plan ensures that the final location of the waste package conforms to the various limits on heterogeneity (spreading rules)
- The filling plan also needs to be approved by FANC and Bel V.
- On the basis of the approved filling plan, Belgoprocess can then operate its IPM facility to produce monoliths that fully conform to the surface disposal license and that have a foreseen placement in the disposal facility

Conclusion

Conclusion

- The creation of this surface disposal facility is a major step in ensuring the safety of nuclear waste management
- In every next step for the disposal facility, FANC + Bel V will perform their legal duties w.r.t. nuclear safety and protection of people and the environment for current and future generations
- The current license covers the building and operation of the disposal facility, not its closure
- FANC and Bel V will approve the conformity files and filling plan to ensure the waste is compatible with the operating license

More information:

<https://fanc.fgov.be/nl/informatiedossiers/radioactief-afval/beheer-van-radioactief-afval/berging/oppervlakteberging>

Thank you!



ONDRAF/NIRAS

Conclusions & Outlook

Rudy Bosselaers

10/10/2023

Major milestone reached

Journey of >15 years

**Nuclear License
granted**
'oprichtings- en
exploitatievergunning'

License application



Government decision

*Surface repository in
Dessel*

1st scientific Council

*'Gunstig voorlopig
voorafgaand advies'*

New challenges ahead



Construction

- First nuclear disposal facility in Belgium
- Strict building requirements to ensure long-term safety

Preparing for waste disposal

- Establishment of NIRAS Site Dessel (NISD)
 - NIRAS as a class I nuclear operator
- Start-up production of monoliths (caisson factory, IPM)
- Develop filling plan for the modules
- Continue & increase monitoring activities
- ...



New challenges ahead

Collaboration
NIRAS/ONDRAF – SCK CEN

Safety case

- Regular updates to ensure a conform & up to date safety case.
 - Continuous R&D needed
- Update(s) near-field models
- Hydrogeological measurements to confirm radiological capacity 2nd (Western) tumulus
- ...



Disposability

- Extend & adapt waste acceptance system for surface disposal
- Destructive and non-destructive tests on waste
- RD&D – increasing fraction disposable waste
 - Sorption tests
 - Development of compressible material
 - ...
- ...

Coming soon...

