BGE TECHNOLOGY GmbH

MODERN2020

Development of a Monitoring Concept for a HLW Repository in Germany in Close Relation to the Safety Case

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Development and Demonstration of monitoring strategies and technologies for geological disposal

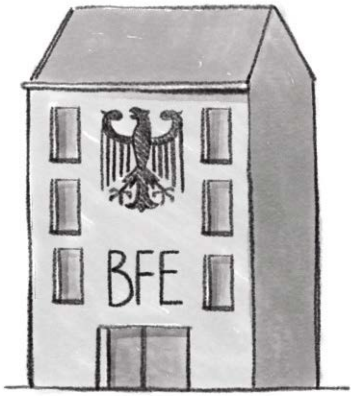
This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement n° 662177
BGETEC has received co-funding from the German Federal Ministry of Economics and Energy.

Actors

BMU (Federal Ministry of the Environment)

New Player:

Regulator

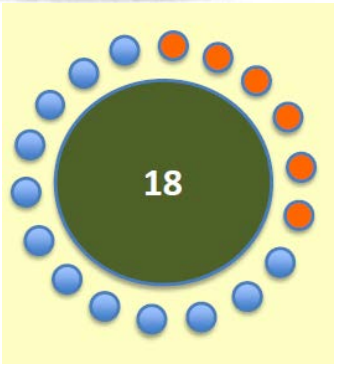


Implementer

National Monitoring Body

Pictures taken from:
https://www.bfe.bund.de/DE/soa/akteure-aufgaben/akteure-aufgaben.html

National Monitoring Body



- Pluralistic composition to represent public participation
  - 12 recognized public personalities
  - 6 free nominated citizens (2 young persons, 16-27)
- Free to deal independently with any scientific issue in the field of radioactive waste disposal (may ask for support from scientific organizations)
- Ask questions to regulator and implementer at any time and make public statements and comments
- Can get access to all files either at implementer, regulator or any other involved institution

The NBG is assigned to

Process Monitoring

- How site selection is performed
- How decisions are made
- How transparency is handled
- How participation is handled
- ….

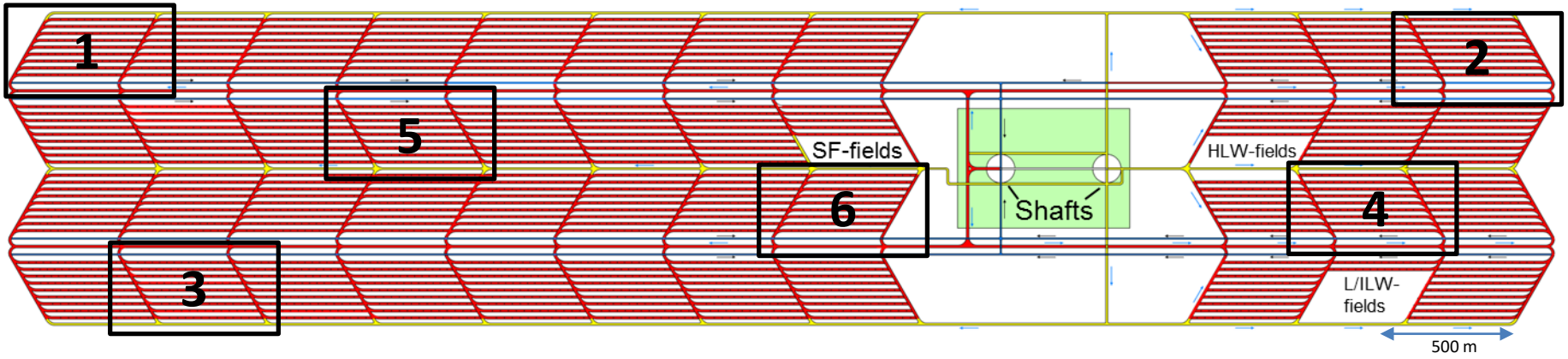
Repository Monitoring

?

Picture taken from:
https://www.bfe.bund.de/DE/soa/akteure-aufgaben/akteure-aufgaben.html

Monitoring Concept

Repository design from the German ANSICHT Case

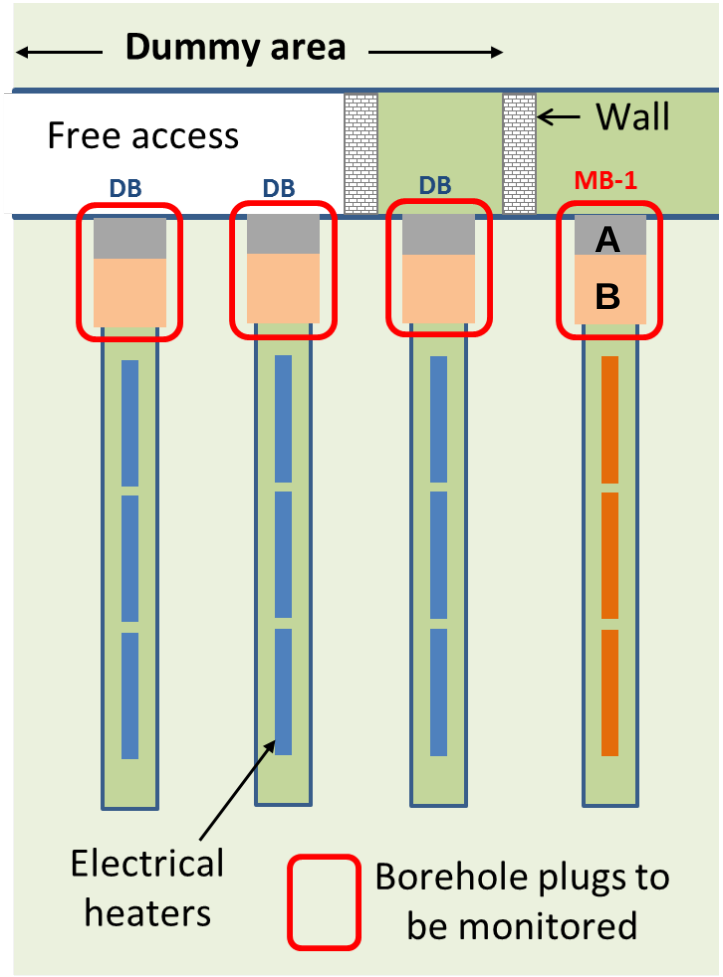


I. Shall be based on representativeness
II. Shall be developed as a learning concept

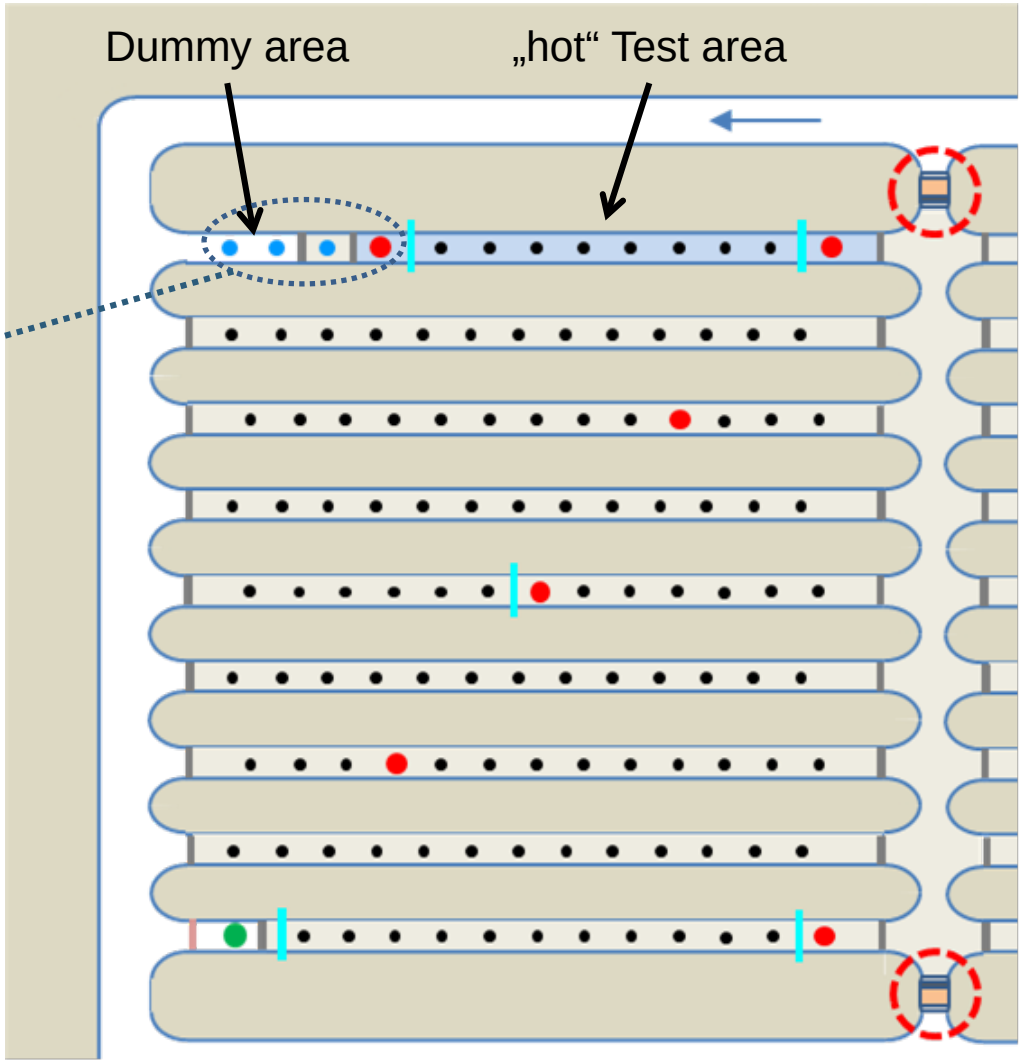
Equipment installation and monitoring in **1** → Lessons learned → Improved concept and/or installation and monitoring in **3** → etc.

Field **1** (backfilled and sealed) will be monitored for several decades. That allows evaluation, what kind of helpful information could be obtained during post-closure monitoring.

Monitoring Field 1



A = Abutment
B = Bentonite



- Emplacement borehole (EB)
- Monitoring borehole (MB)
- Dummy borehole (DB)
- Sacrificial borehole (SB)

- Seal
- Air lock
- Wall
- Monitoring-section

Performance Targets and Processes

Safety Case → Sealing concept → Borehole seal → **Safety Function**

The borehole seal shall minimize the advective fluid flow into the borehole and out of it.

Safety Case → Site specific FEP-catalogue

Process No.	Description of selected processes
I	Fluid inflow from the drift above through abutment and bentonite plug
II	Mechanical load on the abutment from above
III	Convergence of the emplacement borehole (after emplacement)
IV	Fluid pressure from below due to thermal expansion and gas generation
V	Saturation evolution of the bentonite plug
VI	Swelling pressure evolution of the bentonite plug
VII	Chemical alteration of minerals (swelling pressure reduction)
VIII	(Heat flow) temperature evolution in bentonite plug
IX	Fluid flow through the bentonite plug out of the borehole
X	Displacement of the abutment in direction to the drift above

Performance Targets

PT-1 Permeability of the bentonite element $k \leq 1 \cdot 10^{-17}\ m^2$	**PT-2** Swelling pressure of the bentonite $p_q \approx 1\ MPa$
PT-3 Expansion of the bentonite element $\leq$ 3% of its length	**PT-4** Bentonite element shall be free of tensile stresses $\sigma_{III}^{eff} = \sigma_{III} - p \geq 0$

Construction requirements

Screening Methodology

Process No.	Description of selected processes
I	Fluid inflow from the drift above through abutment and bentonite plug
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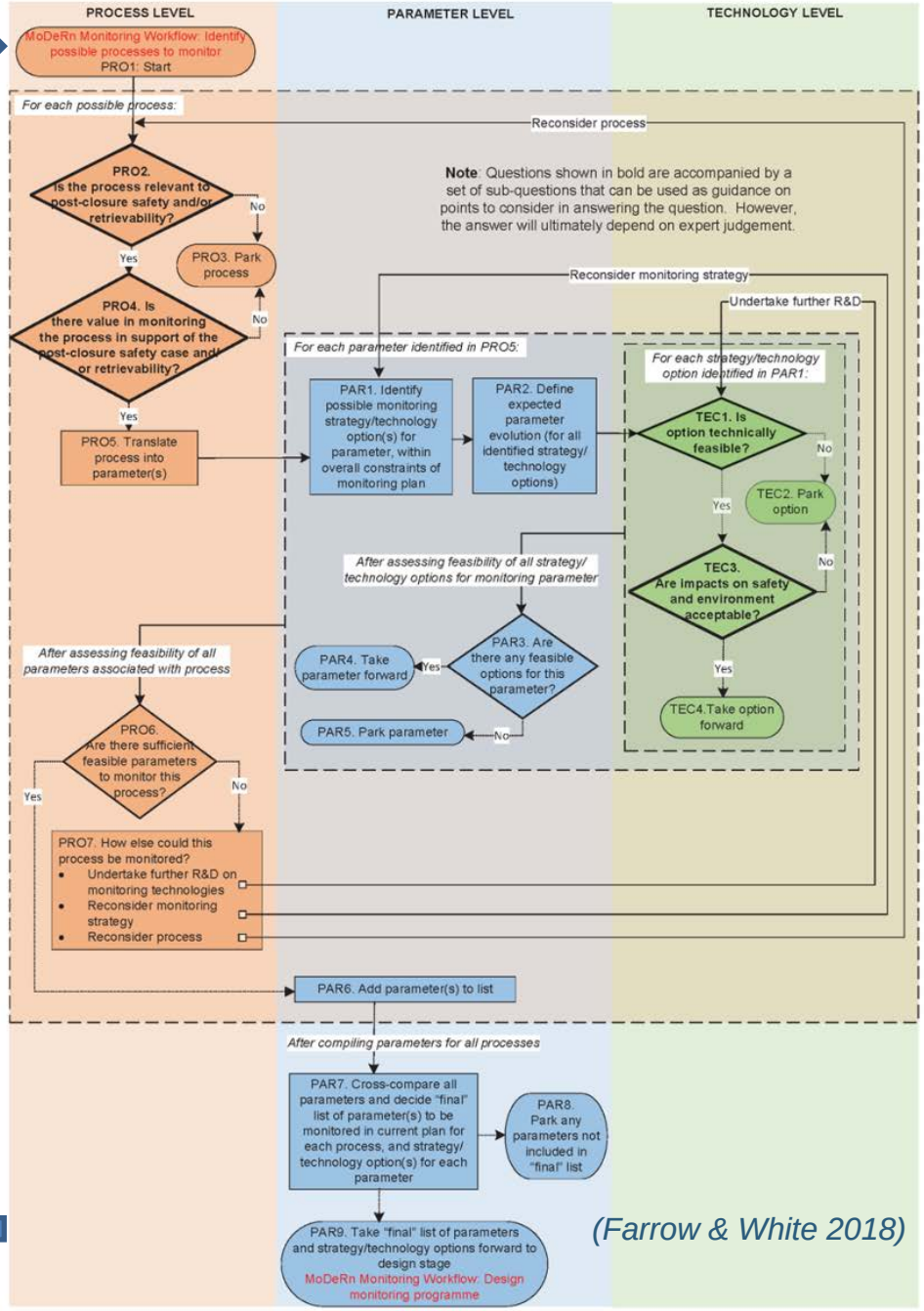


(Farrow & White 2018)

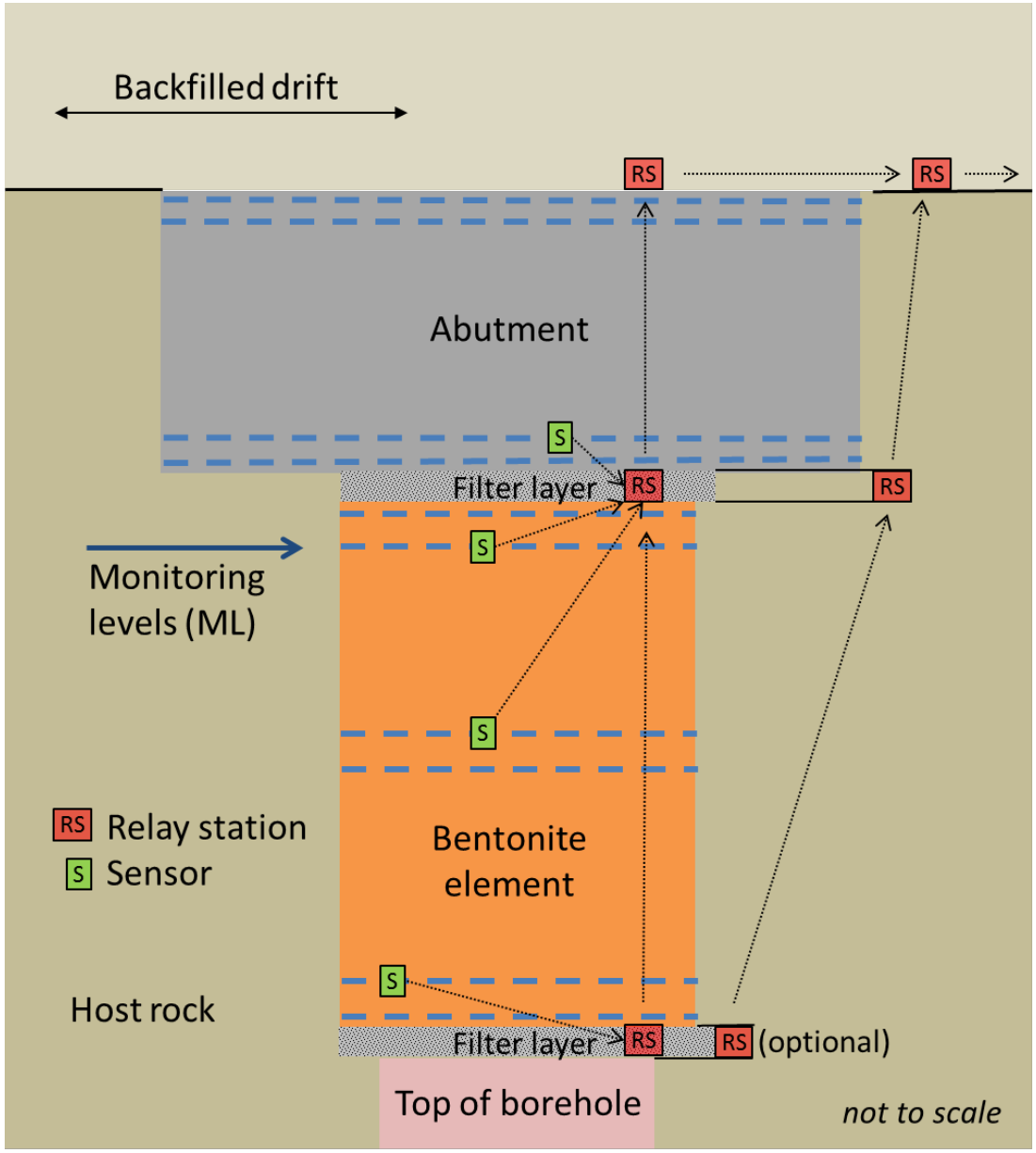
Monitoring concept for borehole seal

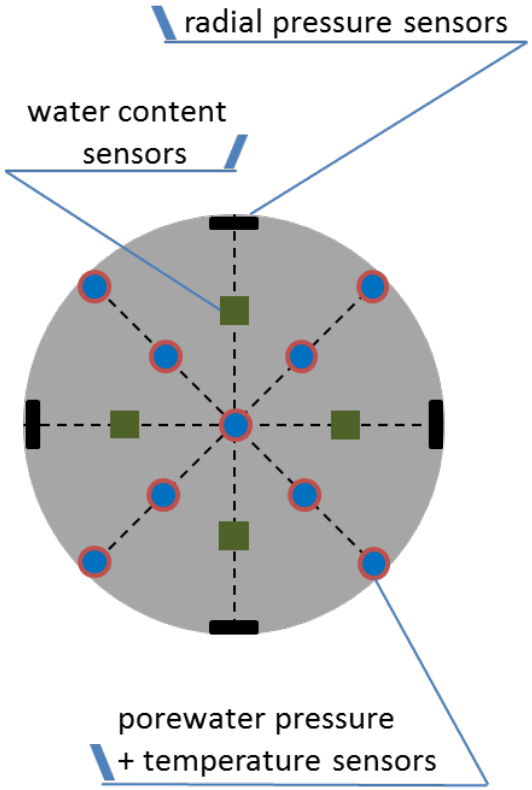
Parameters worth monitoring for PT evaluation

Screening example for borehole seal monitoring is illustrated on

Poster

Monitoring Concept for Borehole Seal

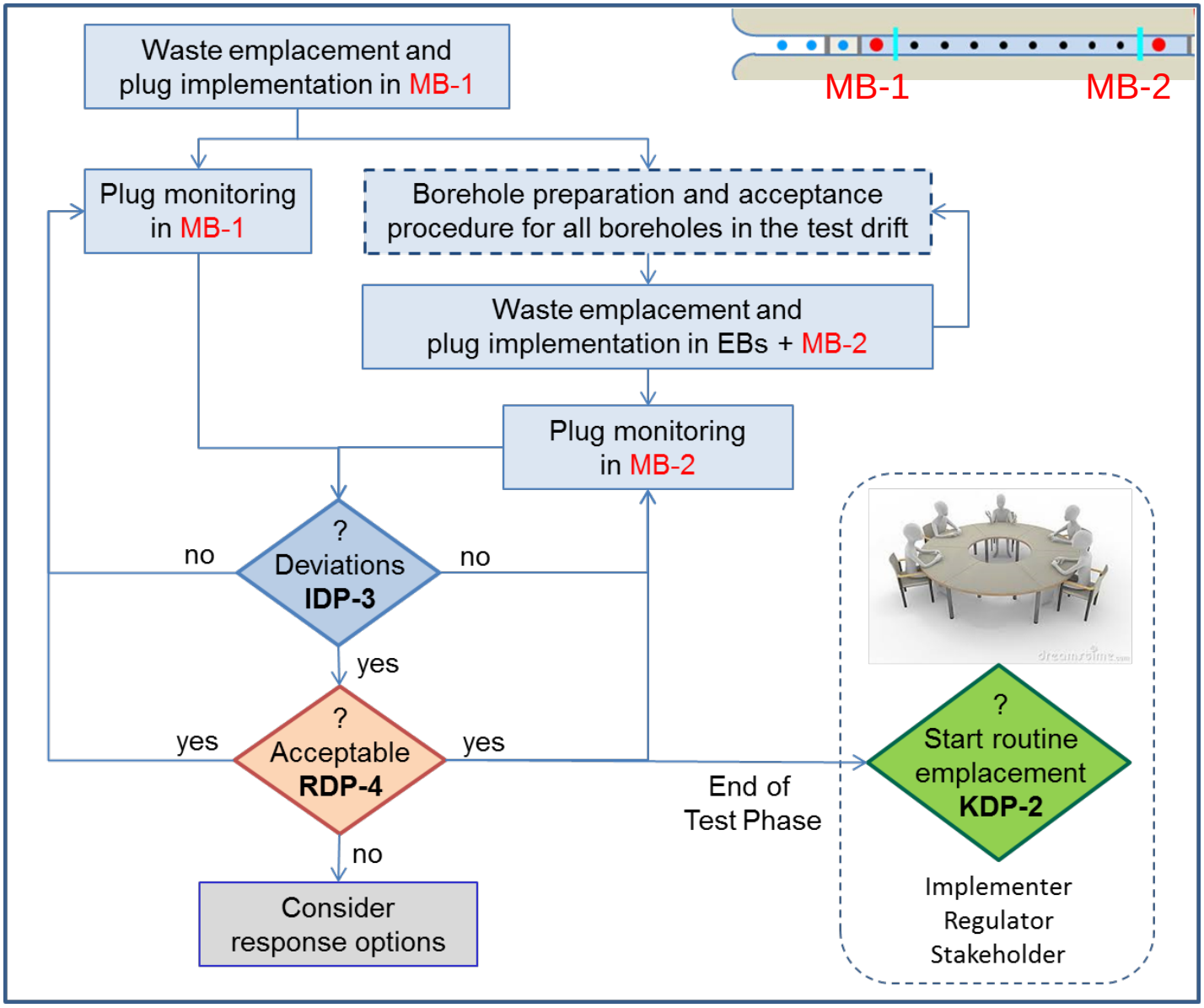




Similar concepts for

- drift seals
- backfill
- sacrificial boreholes
- shaft seals (ongoing)

Test Phase



National Monitoring Body ?

Idea:
In case of non-agreement

Stakeholder
Veto (justified)

The BMU will
- consider the veto-justification and
- potentially initiate an external expert appraisal.

Decision by the BMU

Decision points: **IDP** = Implementer / **RDP** = Regulator / **KDP** = Key

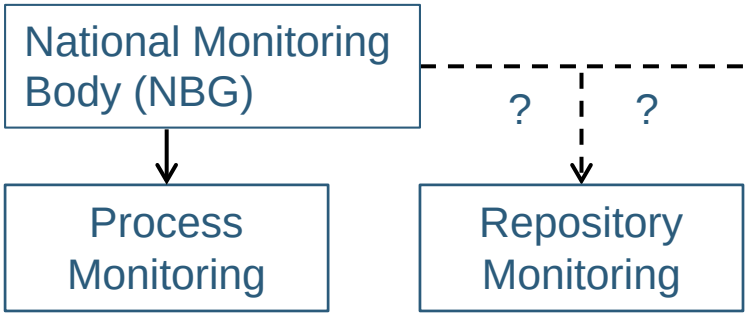
Conclusion

I. Monitoring concept = Learning Concept
- improvements of EBS components or the Monitoring components/concept
- evaluation of the potentially added value of post-closure monitoring

II. Preliminary technical concepts have been developed for EBS monitoring

III. Monitoring results are intended to be used as
- an input to repository programme decisions
- a tool for providing transparency and participation

New player:



Participate in decisions ?
Get veto-rights ?

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Many Thanks!

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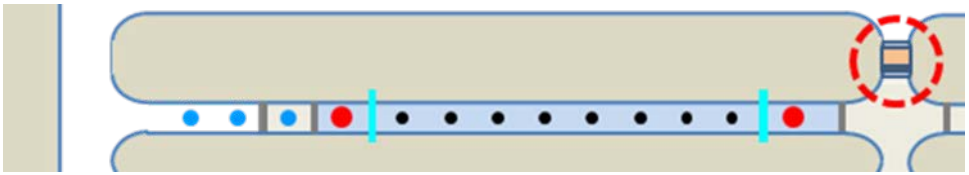
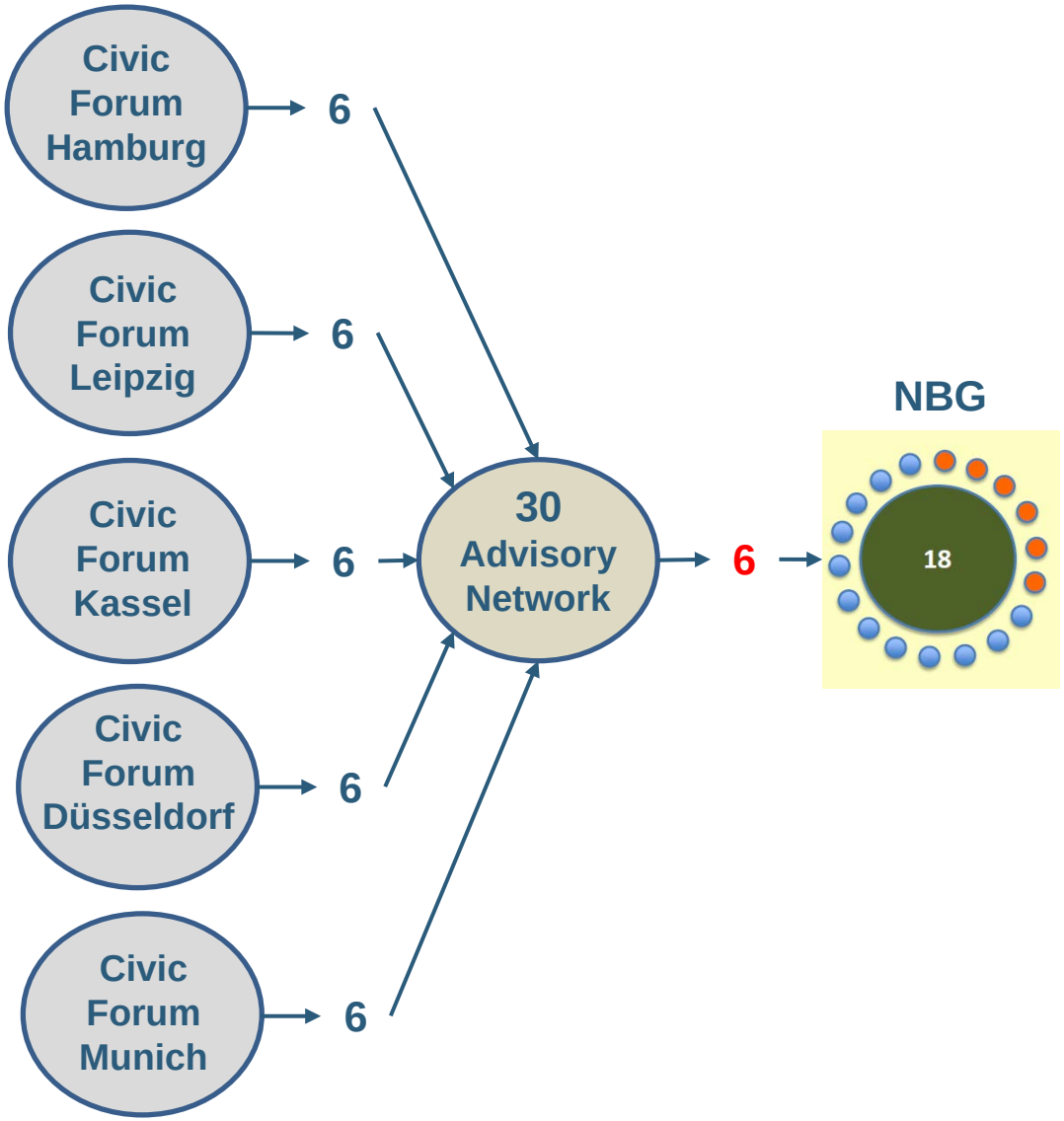


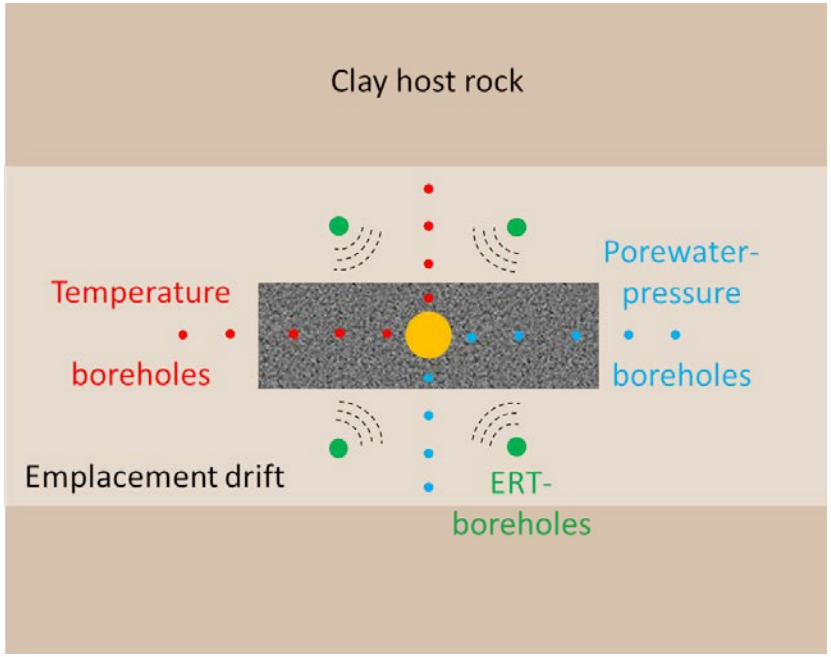
Backup-slides

Election Procedure

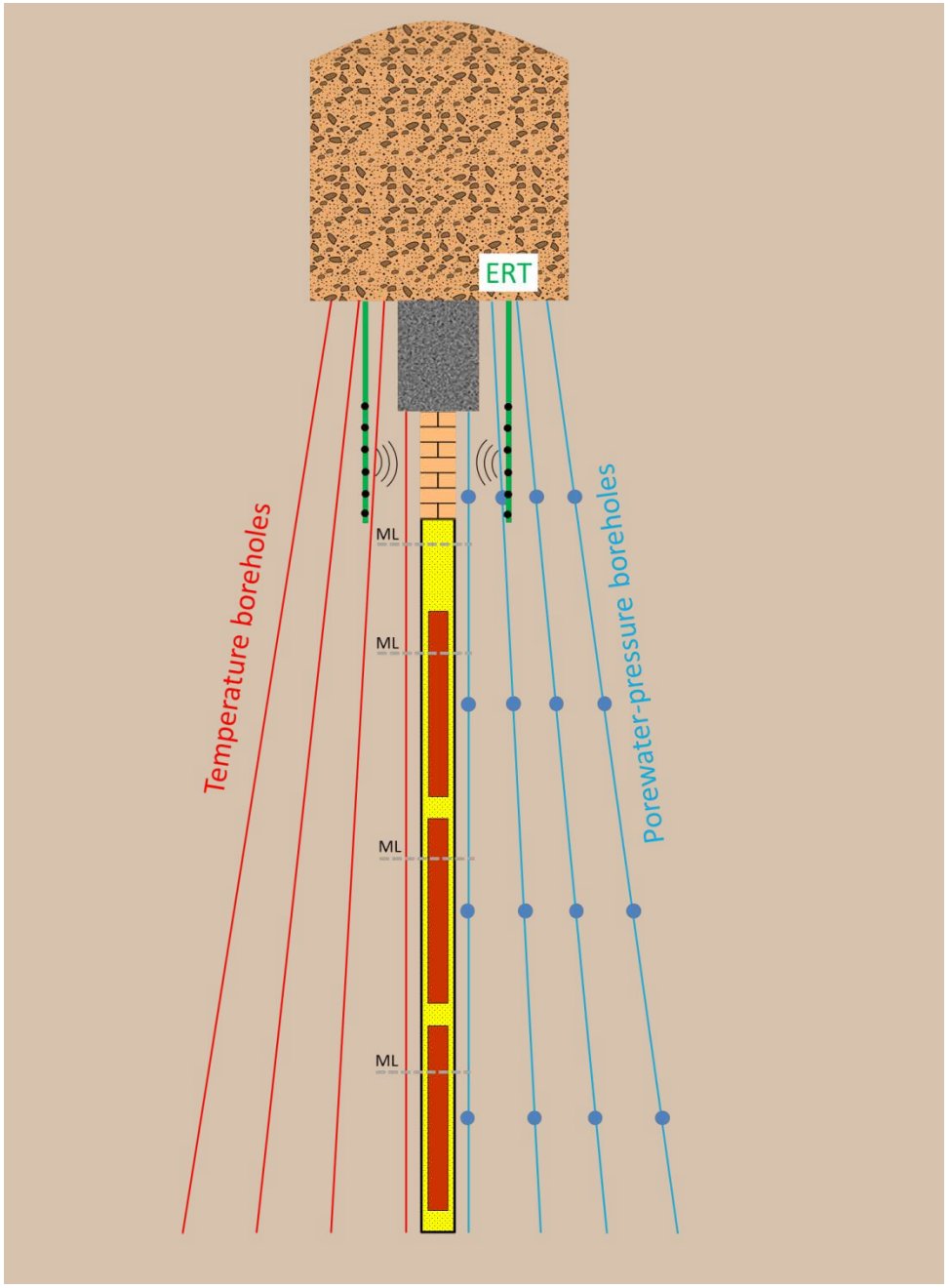
69,000 Phone calls (by random)
120 People said yes
24 in each Civic Forum (5)



Monitoring Concept for Sacrificial Borehole

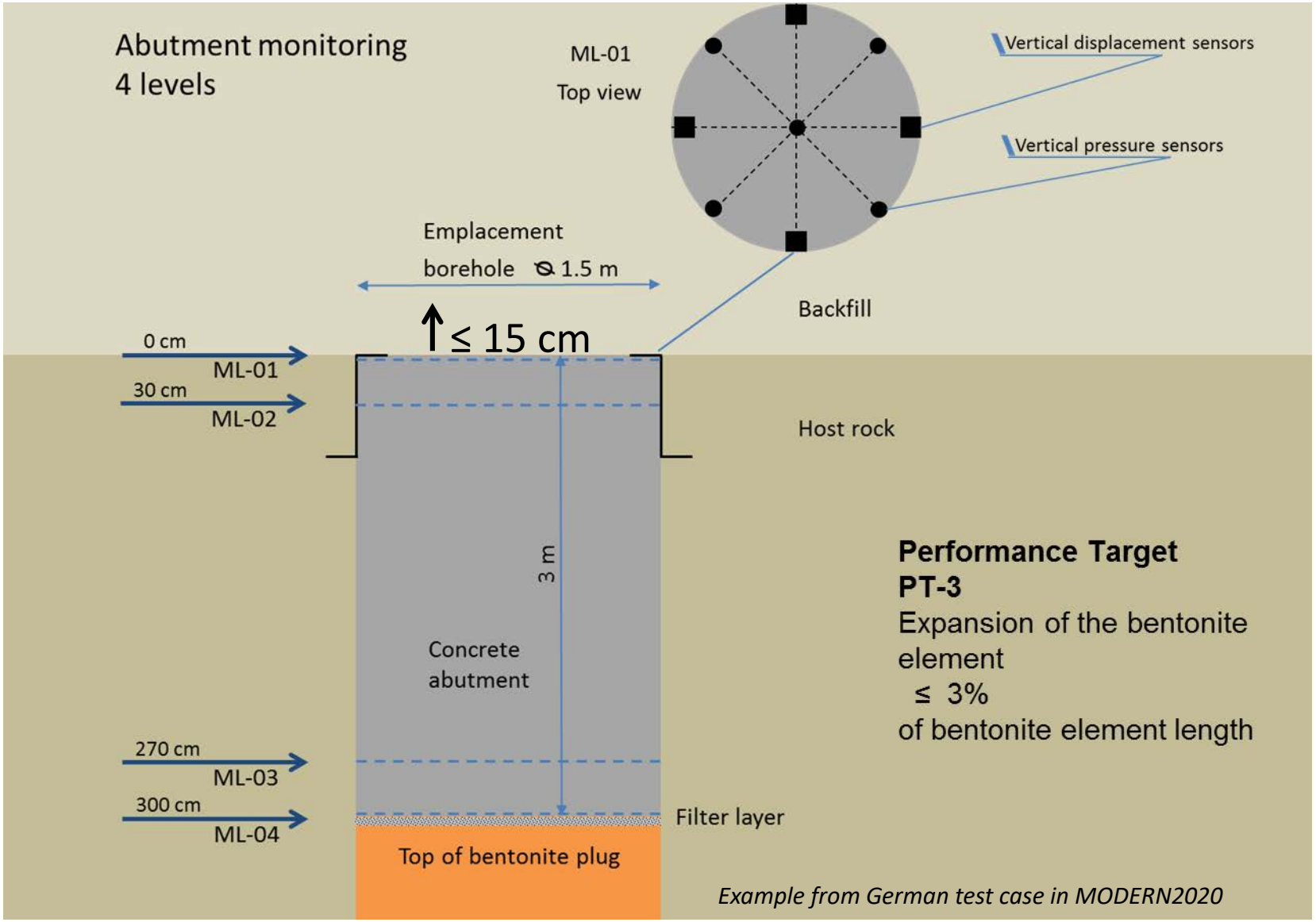


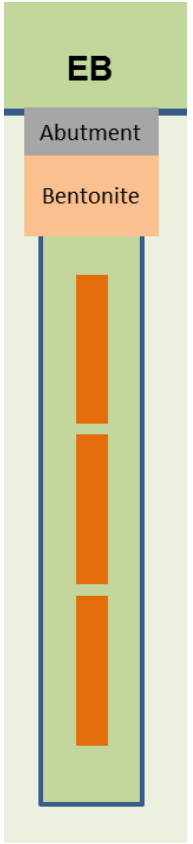
Top view



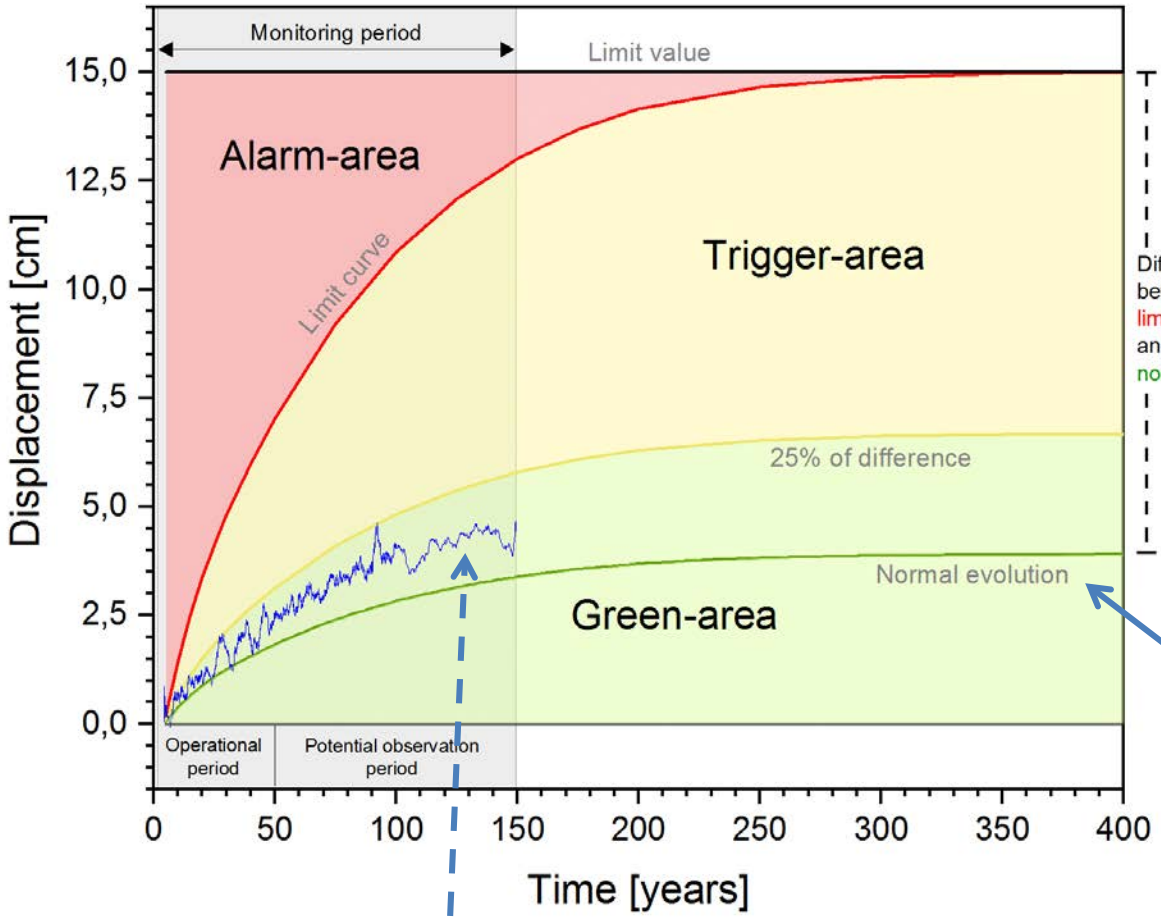
Vertical cross-section

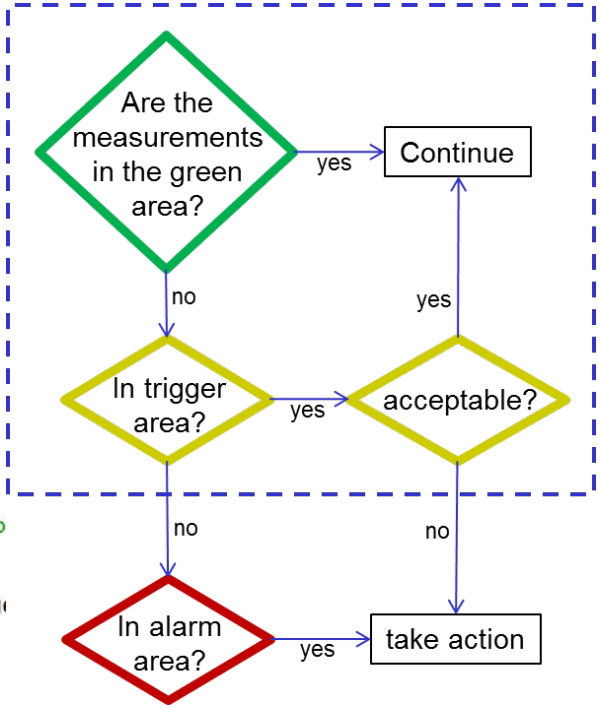
Specific plug monitoring (Example)



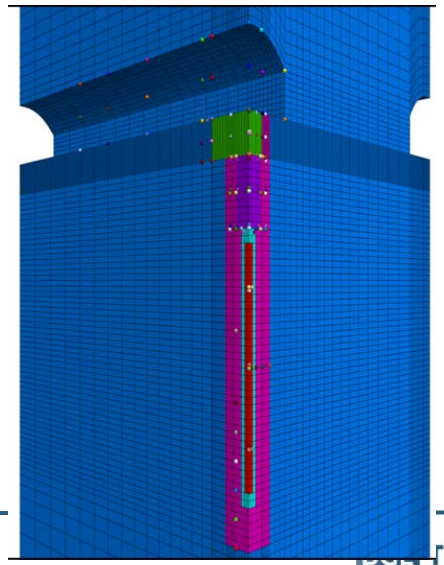


Decision based on specific monitoring results





Mean curve of the 4 displacement sensors



Example from German test case report

Response plan (Example)

Continue monitoring until decision for termination is made

As part of the root cause analysis …..

Perform predictive calculations to analyse whether the performance target can still be met or if the limit curve will probably be exceeded

Decide to re-open, analyse, and re-build the monitored plug or parts of it

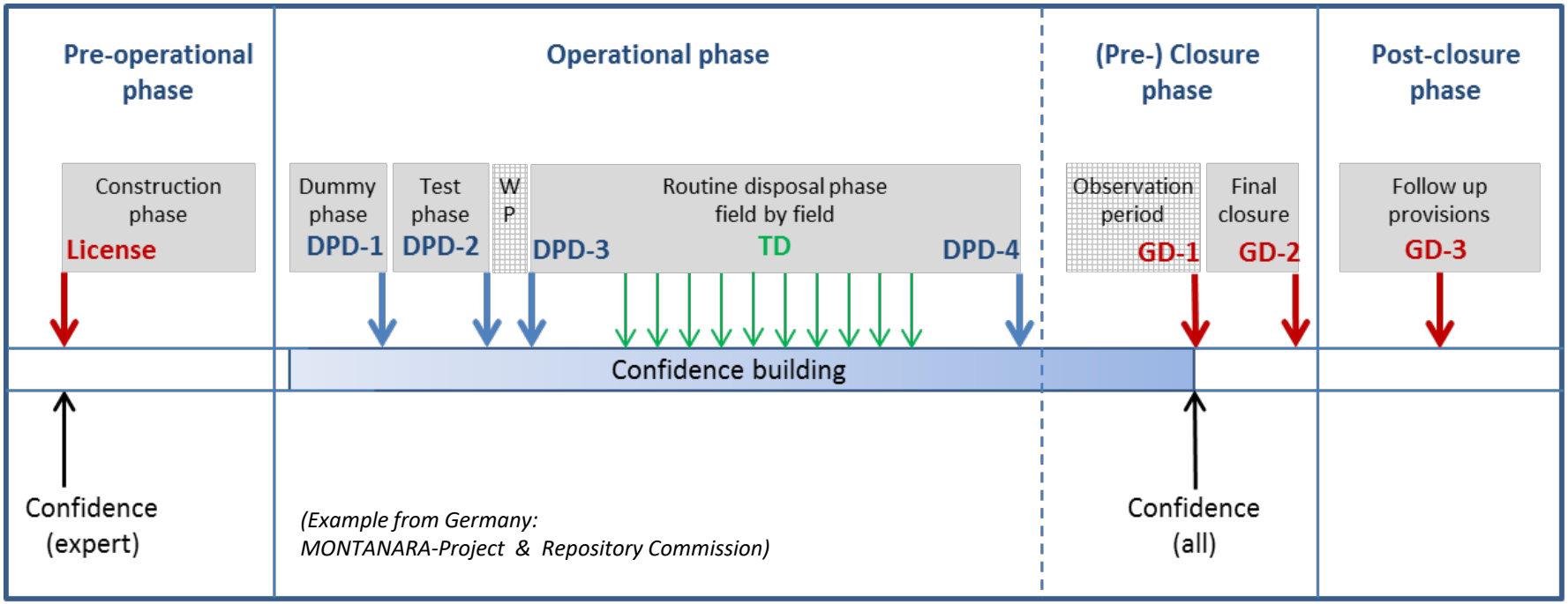
Green area	
Continue monitoring until decision for termination is made	
Check results (DBs, TBs) on a regular basis (e.g. 1/month)	
Report results to regulator on a regular basis (e.g. half-yearly)	
Record/document results in a specific monitoring data base (raw data, processed/qualified data, way of processing/qualifying, etc.)	

Trigger area	
1 General	Report the arrival at the trigger area to regulator at its first occurrence (even if only 1 sensor is involved)
	Potentially decide to interrupt disposal operation
	Continue monitoring
2a Monitoring system behaviour	Consider sensing system failure and check sensing system seriously
	Consider sensor(s) recalibration if possible
	Consider signal correction if possible
	Consider to exchange sensor(s); depends on time of failure occurrence
2b LL (Lessons Learned)	Consider to improve sensors of the same type to be installed at following monitoring boreholes or use other sensor types
	Consider to use the *dummy area* for tests

Trigger area	
3a Plug behaviour	Perform model analyses of deviating results
	Identify input parameter configuration leading to the deviating curve
	Perform predictive calculations to analyse whether the performance target can still be met or if the limit curve will probably be exceeded
	PT can be met: decide to accept deviation or to take action anyway (may depend on the course of the curve)
	Limit curve will probably be exceeded: decide on action to be taken
	Potentially decide to re-open, analyse, and re-build the monitored plug (or part of this plug; depending on the time that has already passed); includes re-opening of the drift
	Depending on the re-opening analysis other - not monitored - plugs may be re-opened and re-build as well (depending on the time that has already passed)
3b LL	Check whether there are hints indicating that deviations are due to monitoring system induced weakening of the barrier performance !
	Consider to improve plug design and material for following boreholes
	Consider whether installation improvements of plug components are necessary for future installations in following boreholes (may include QC improvements)
	Consider to use the *dummy area* to perform further tests

Alarm area	
1 General	Stop disposal operation
	Report the arrival at the alarm area to regulator
	Continue monitoring until decision for termination is made
2 Plug behaviour	Perform additional model analysis to check whether there is a chance that the curve goes back into the trigger area
	Decide whether to wait and see or to take action
	Decide to re-open, analyse, and re-build the monitored plug or parts of it; includes re-opening of the drift
	Depending on the re-opening analysis other - not monitored - plugs may be re-opened and re-build as well
3 LL	Improve the complete plug design
	Improve installation procedures (and QC)
	Consider to use the *dummy area* to perform further tests
	Consider to change the disposal concept (e.g. reduce the amount of heat release); decide whether to retrieve the waste from already filled boreholes (max. 10 boreholes in test phase) or leave them as they are (new safety assessment). And just change the concept for new boreholes. May include a second test phase.

Repository Phases & Key Decisions



License	- start construction
DPD-1 = Disposal Programme Decision	- end of dummy phase / start of test phase ?
DPD-2 = Disposal Programme Decision	- include waiting period (WP) ?
DPD-3 = Disposal Programme Decision	- start routine waste disposal ?
TD = Technical Decisions (multiple)	- seal emplacement fields ? / use response plan ?
DPD-4 = Disposal Programme Decision	- include observation period ?
GD-1 = Governance Decision	- end of observation / start final closure ?
GD-2 = Governance Decision	- post-closure monitoring ?
GD-3 = Governance Decision	- end monitoring ?