Deltares
Enabling Delta Life

Cost-effectiveness of monitoring and site investigation for levees

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"Hoe verder met de afgekeurde dijken: monitoren of versterken?"

Mini-symposium 4 July 2014, Aula, TU Delft

Part 1: Risk-based inspection and maintenance planning (English)

Three presentations:

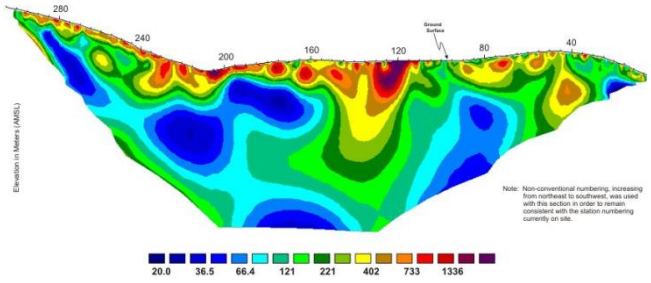
- Prof. Michael Faber (Technical University of Denmark): "Benefits of risk-based inspection and maintenance in Offshore and Marine Applications – Lessons learnt"
- Prof. Raphaël Steenbergen (TNO & Universiteit Gent): "Bridges live longer with monitoring"
- Dr.ir. Timo Schweckendiek (Deltares & TU Delft): "Cost-effectiveness of monitoring and site investigation for levees"

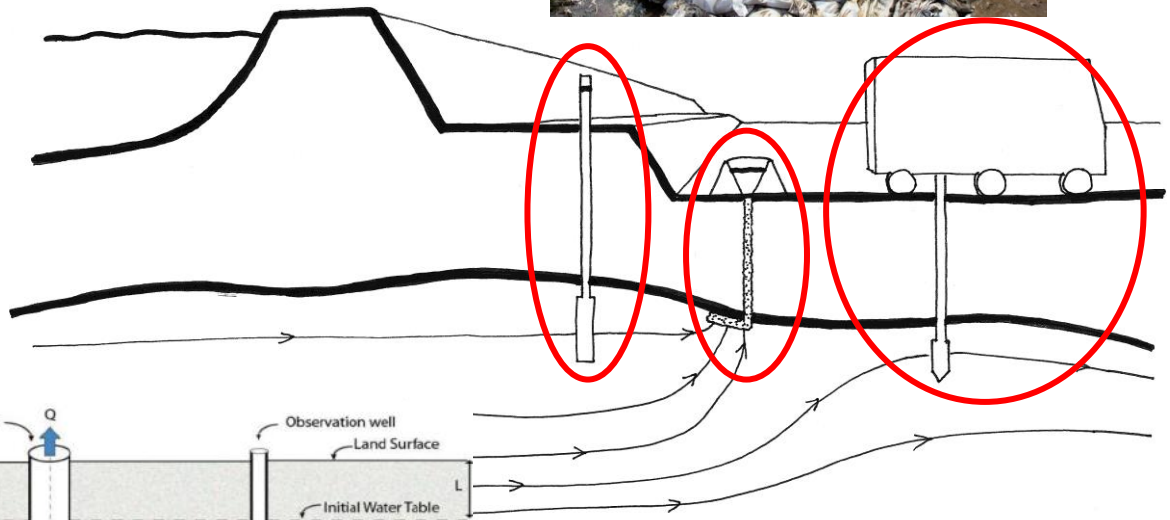
OUTLINE

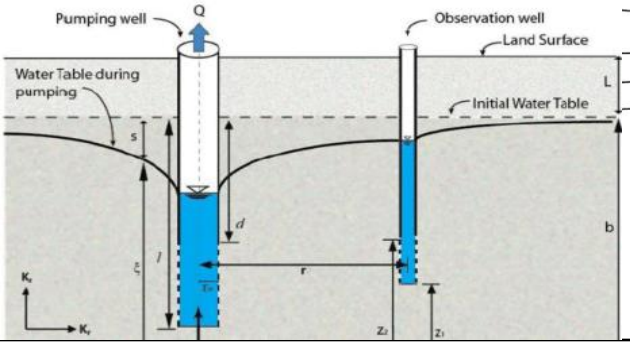
1. Decision framework
2. Dominant uncertainties
3. Cost-effectiveness
4. Thoughts for the debate

Monitoring and site investigation

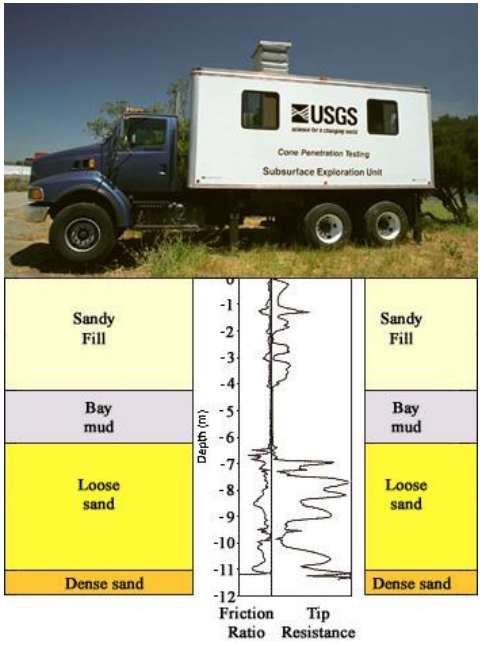
What can we do? (e.g. for piping)







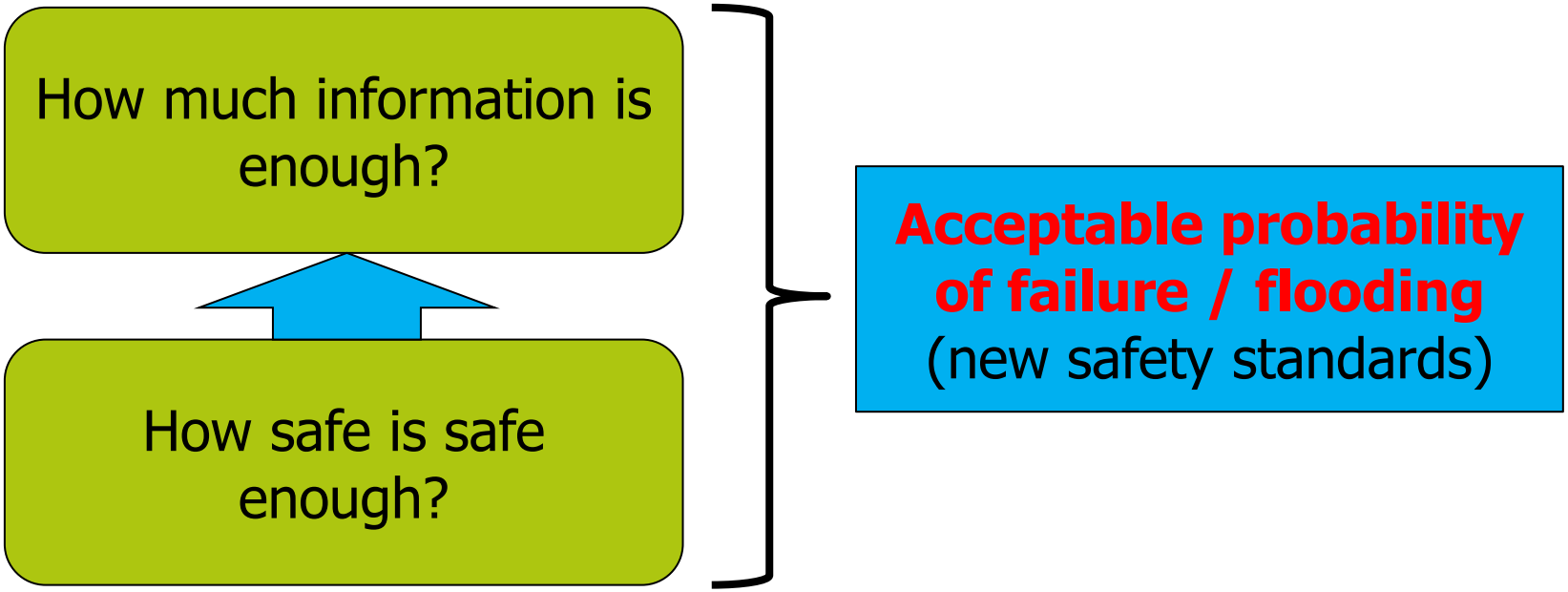
Long-term monitoring and inspection, not early warning!



sketch courtesy of Mercedes García Ballester

Decision framework

How much should we invest?



Decision framework

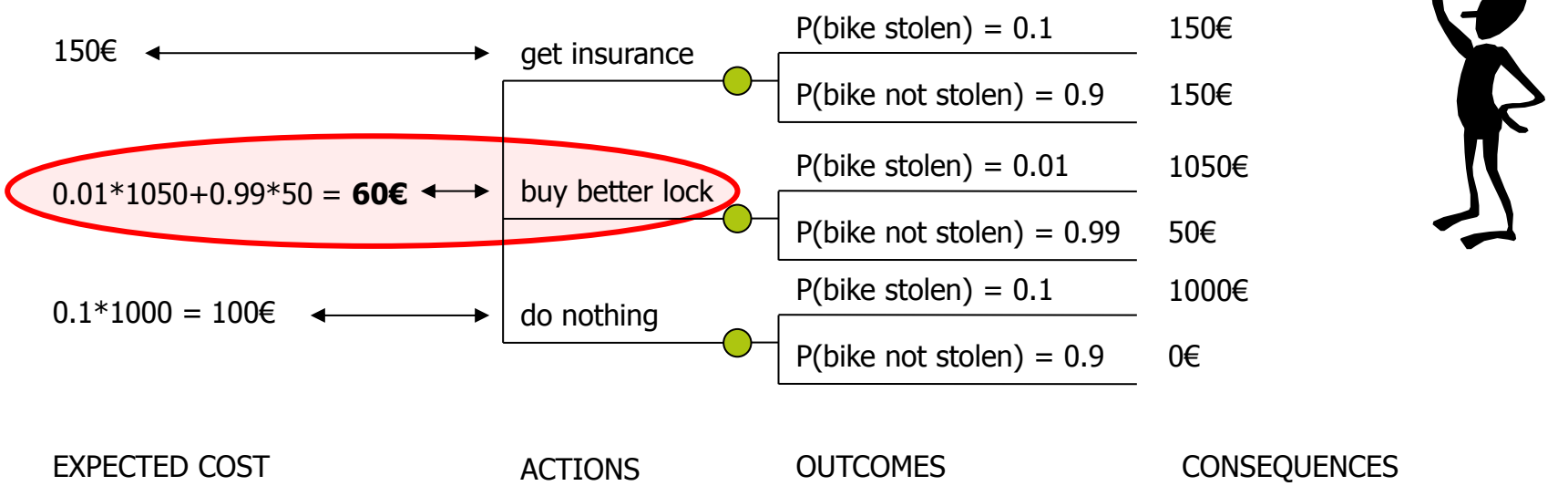
Decision tree (everyday life)

Should I get an insurance or a better lock for my new bike?

value bike: 1000€

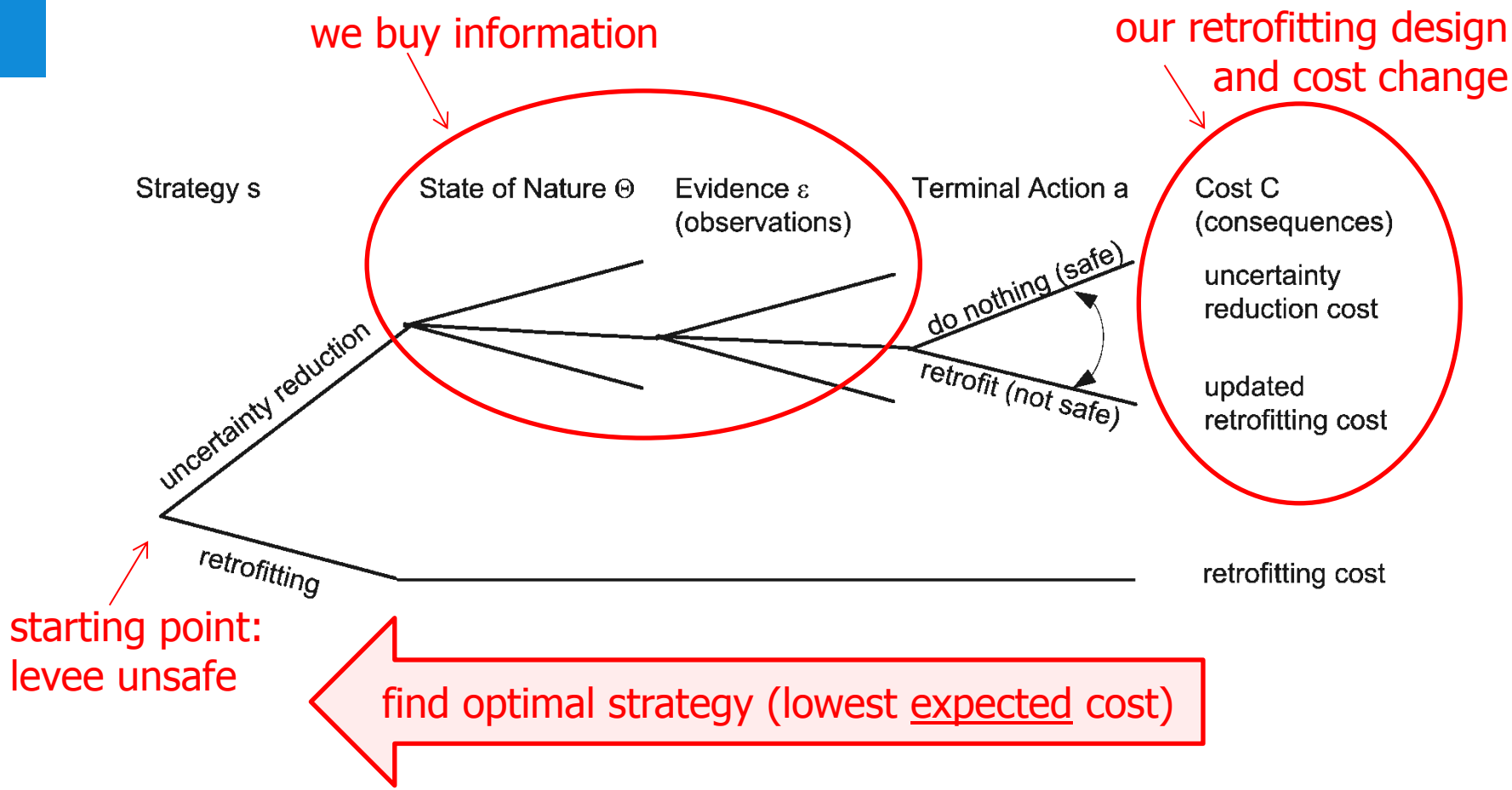
insurance: 150€

better lock: 50€



Decision framework

Decision tree (site investigation and monitoring)



Decision framework

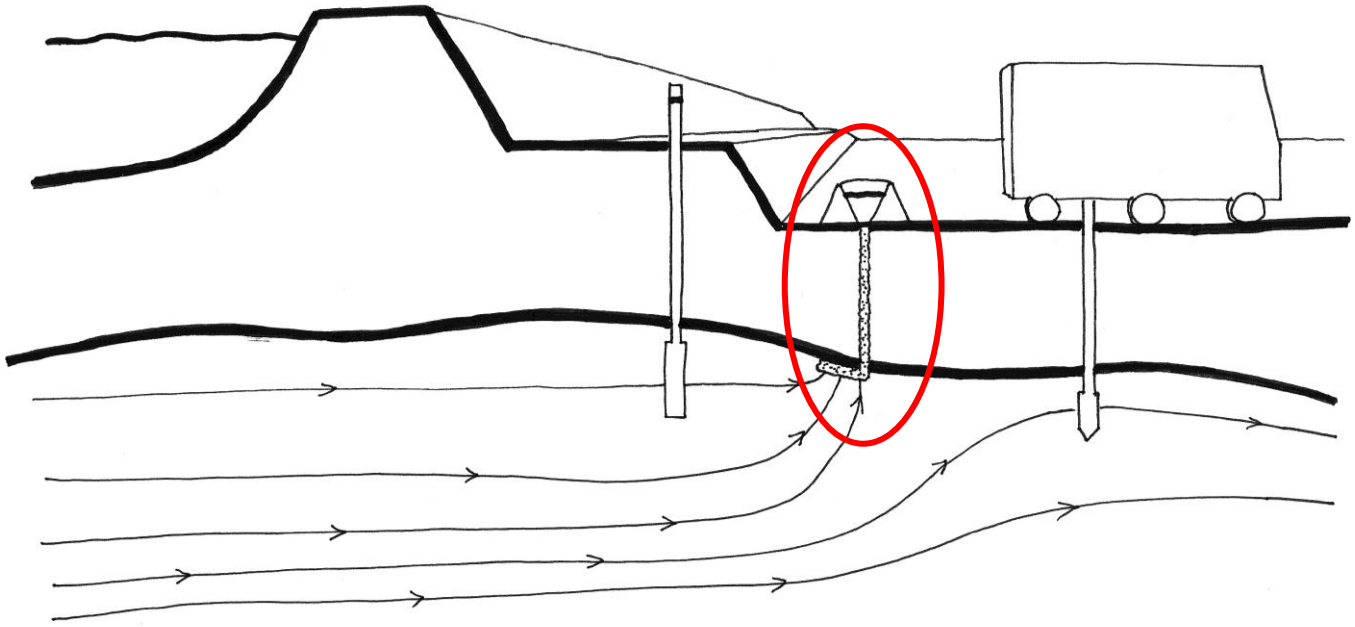
Essence

Invest just as much as you need to be "safe".

- Focus on the dominant uncertainties and get the "low-hanging fruit"!
- Sometimes we just can't measure enough and reinforcement will be necessary anyway (low value of information).
- Enough is enough (i.e. safety target is met).

Field Observations

In Dutch: “bewezen sterkte” (of zwakte…)

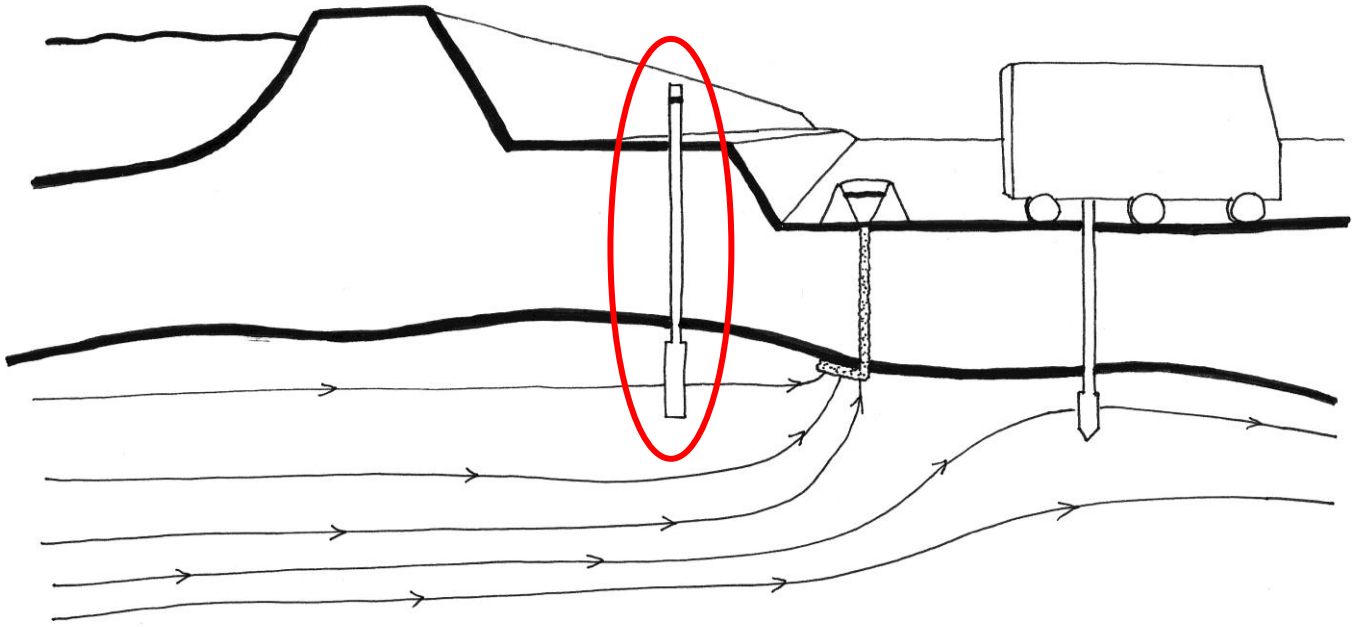


- Observed performance during extreme (test) loading.
- Information readily available but hardly used.
- Probability of failure can change considerably (both ways).

sketch courtesy of Mercedes García Ballester

Monitoring

What should we monitor?



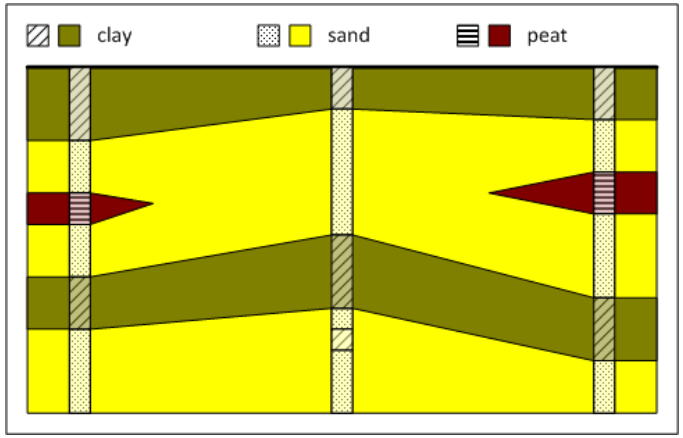
- Pore pressure response of the aquifer!
- Driving force for uplift, heave and piping! (plus crucial for slope stability)
- Should be monitored by default where piping is an issue.

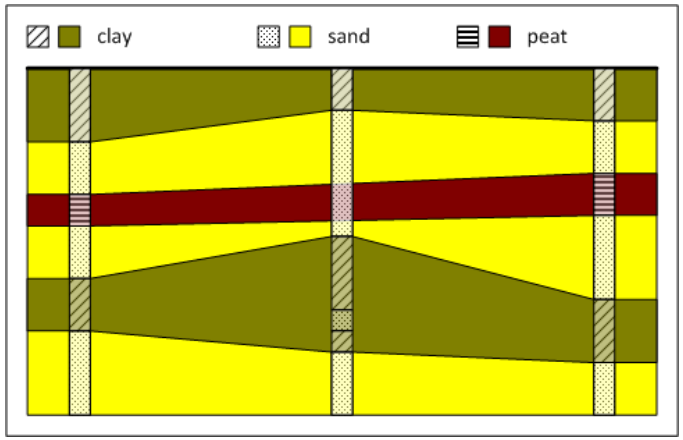
sketch courtesy of Mercedes García Ballester

Site investigation

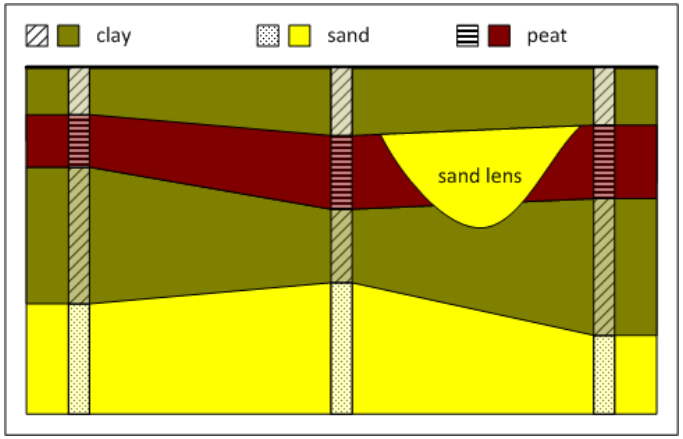
Dominant ground-related uncertainties

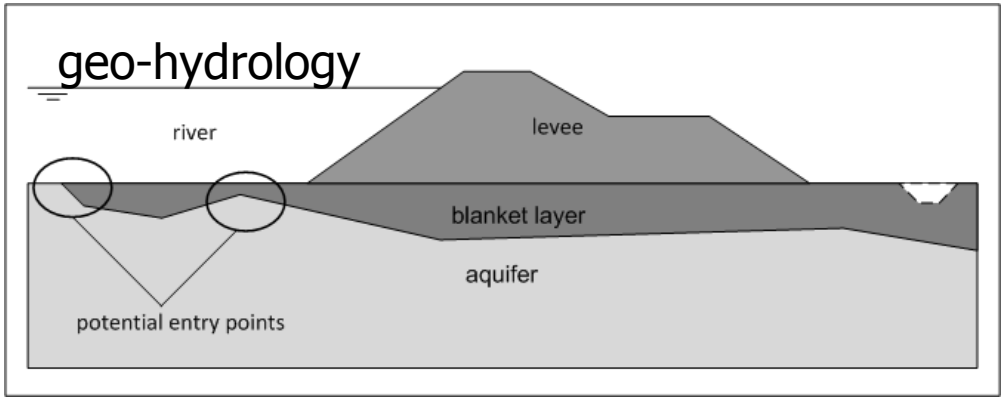
stratification





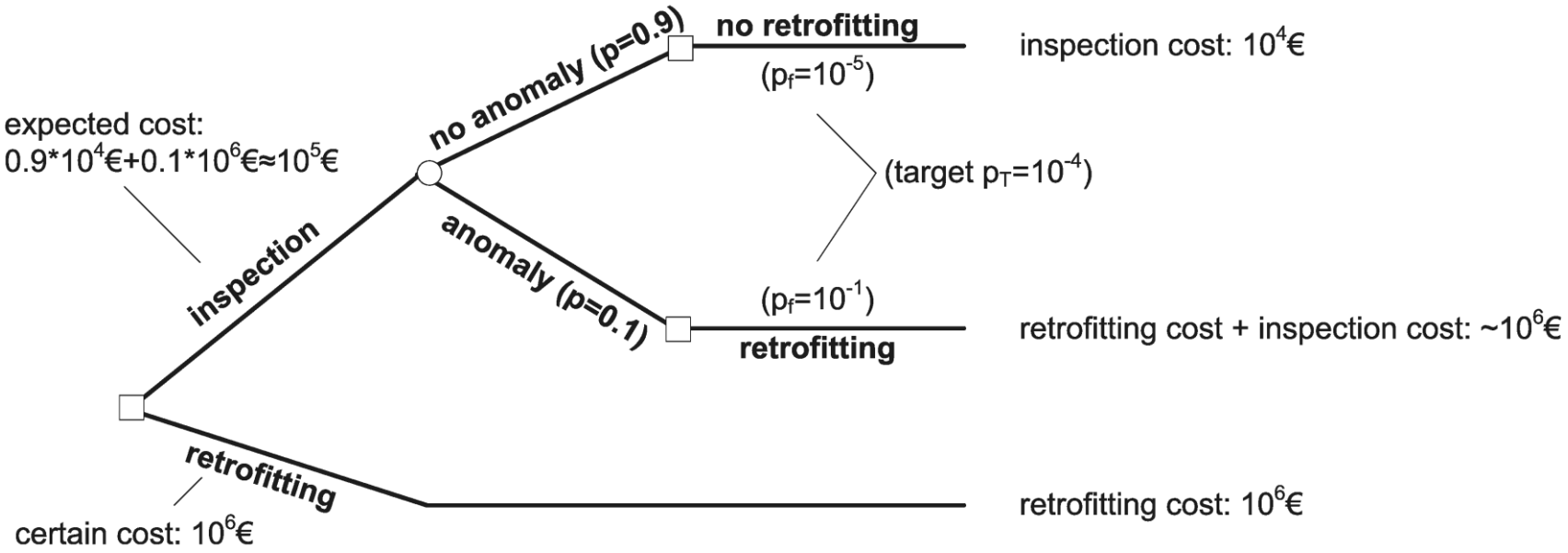
"anomalies"





Cost-effectiveness

Example (decision tree, simplified)



Benefit cost ratio

$$BCR \approx \frac{10^6 - 10^5}{10^4} = \frac{9 \cdot 10^5}{10^4} = 90$$

Thoughts for the debate

Some propositions and questions

1. Given the estimated extent of the "piping problem", we are not using monitoring and site investigation to its full potential. Why?

2. What are investment decisions of monitoring and site investigation based on in practice currently?
   (If the answer is "experience", what do we mean by that?)

3. How can we stimulate cost-effective use of monitoring and site investigation? (simple rules?, monetary incentives?)