Developing Water Wise Cities

The Water Wise Resilience Assessment

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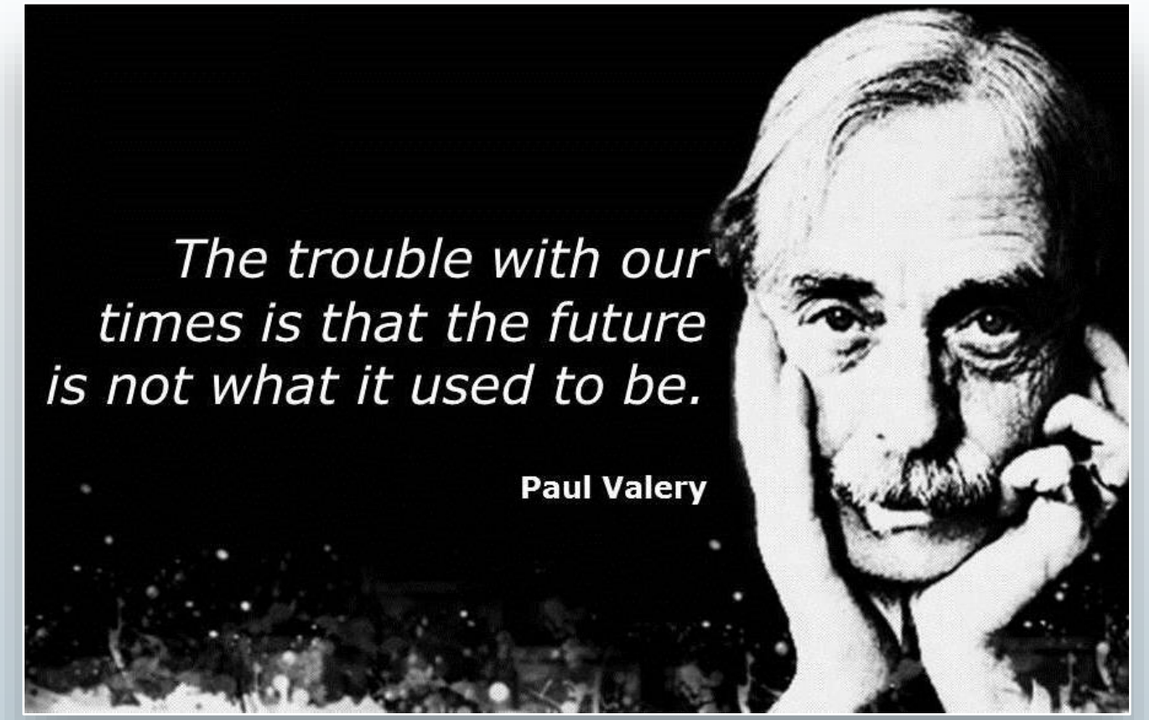
Motivation

Strategic planning for the water industry

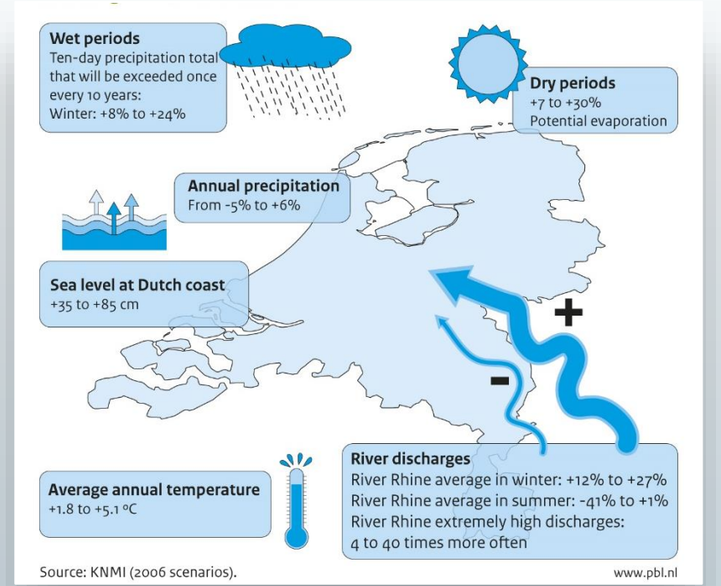
- Strategic planning is about formulating a **long term vision** and getting it **delivered**.
- It can be **incremental** (asset replacement) or more **forward-looking** (adopting more *distributed* solutions or moving into *circular* economy)
- But it is always subject to (significant) **uncertainty**.



DO WE SEE IT COMING? CAN WE GUARANTEE OUR ASSETS WILL HOLD?

Can we afford to plan for (and guarantee fail-safe) for every future?

CLIMATE IS CHANGING A LOT AND FASTER THAN WE WOULD HAVE LIKED



Supply patterns are affected (both in terms of quantity and quality)

DEMOGRAPHICS ARE ALSO SHIFTING THROUGH (ALSO) MIGRATION

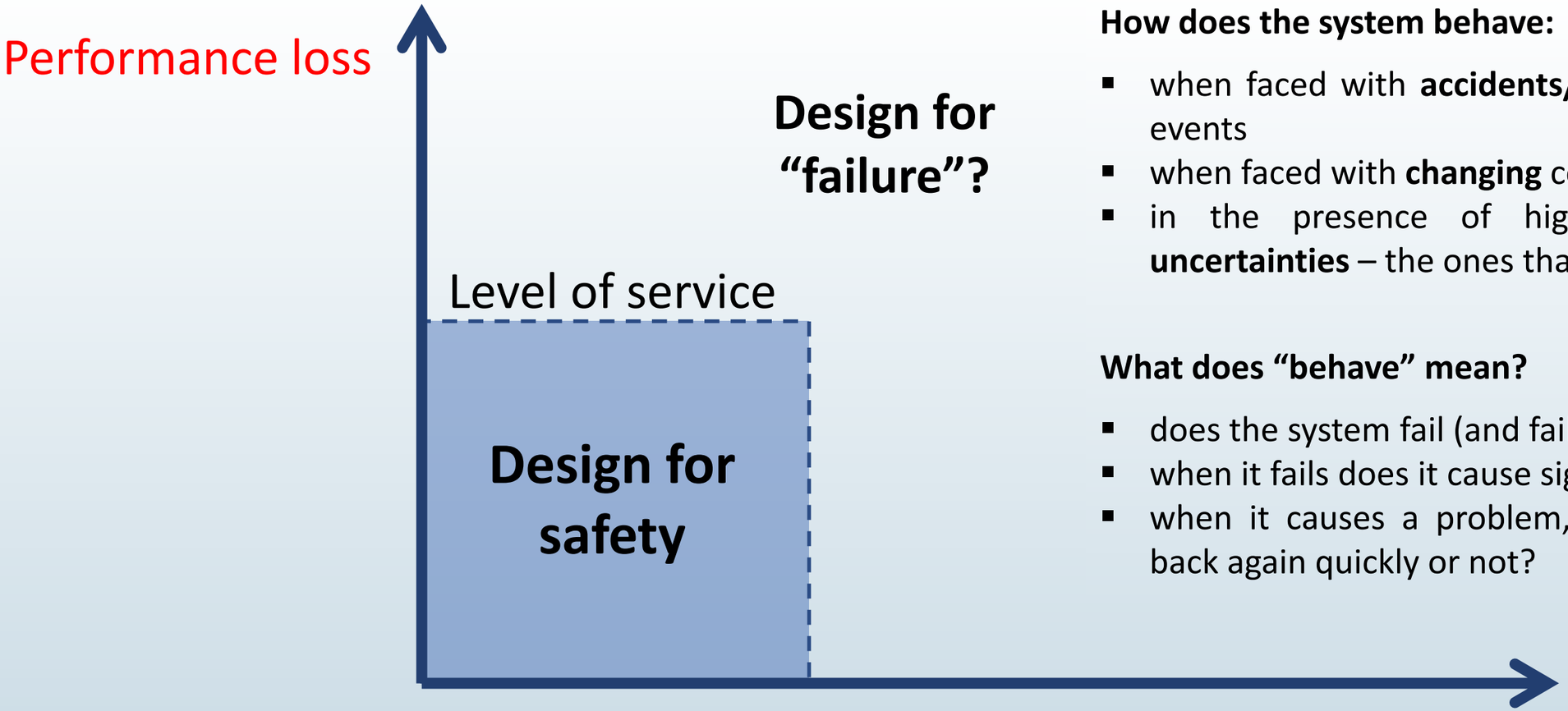
Mostly slow change in age distributions – but even this is now affected by geopolitical shifts

AND THE ECONOMY IS STILL IN TOO MUCH FLUX

The sector is always affected by energy prices and related policy – and these can change drastically.

Moving outside the comfort zone

Does our traditional approach still hold?



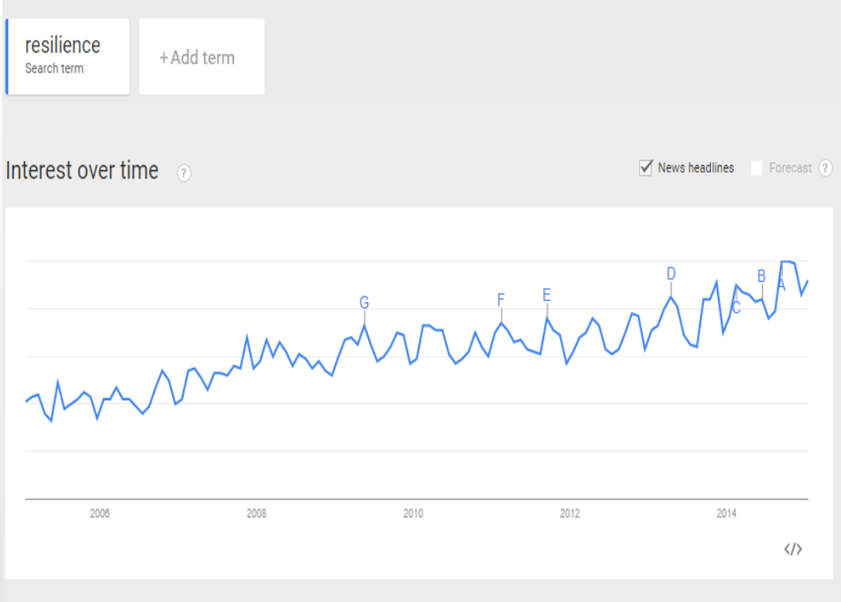
How does the system behave:

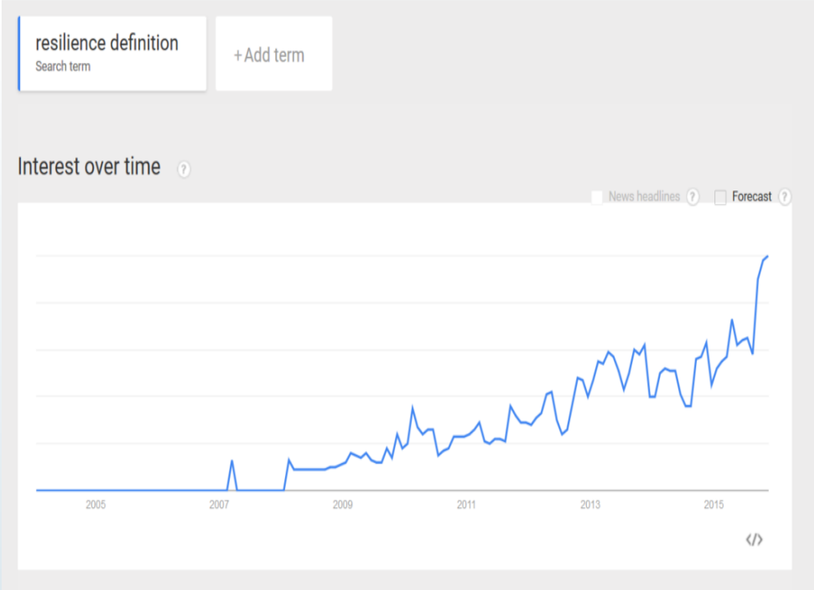
- when faced with **accidents/incidents** and/or **extreme** events
- when faced with **changing** conditions
- in the presence of higher order, longer term **uncertainties** – the ones that matter!

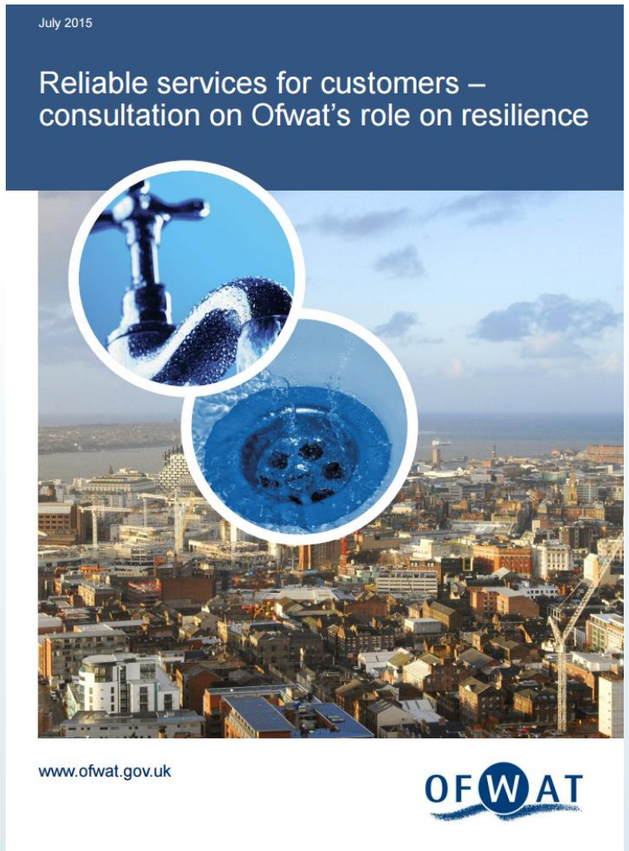
What does "behave" mean?

- does the system fail (and fail in which objectives?)
- when it fails does it cause significant problems?
- when it causes a problem, does the system bounce back again quickly or not?

Enter Resilience:
an elusive term (quickly) becoming policy







2000

From a **general term** suitable for coffee table **discussions**

2010

To (a quest for) an **operational terminology**

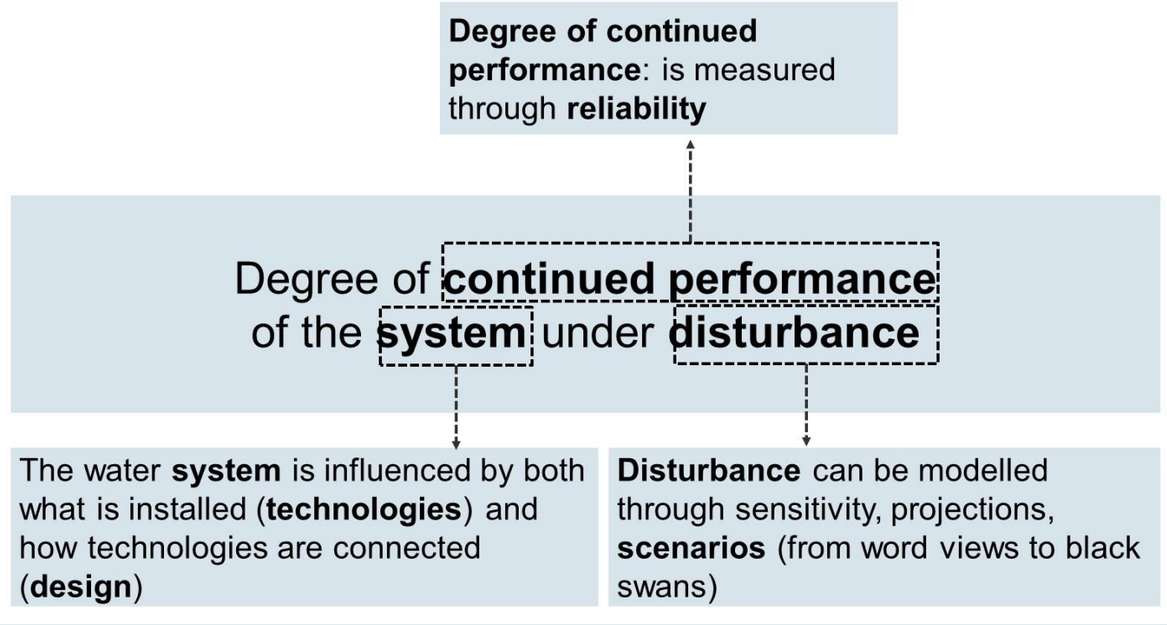
2015

To a **regulatory** requirement (6/2015)

Operationalizing Resilience

From first principles to usable definitions to quantifiable metrics

- Building on: ***"the capacity of a system to absorb disturbance … so as to still retain essentially the same function, structure, identity, and feedbacks***" based on Holling (1973)
- We defined resilience as: **"the degree to which a water system continues to perform under disturbance"**

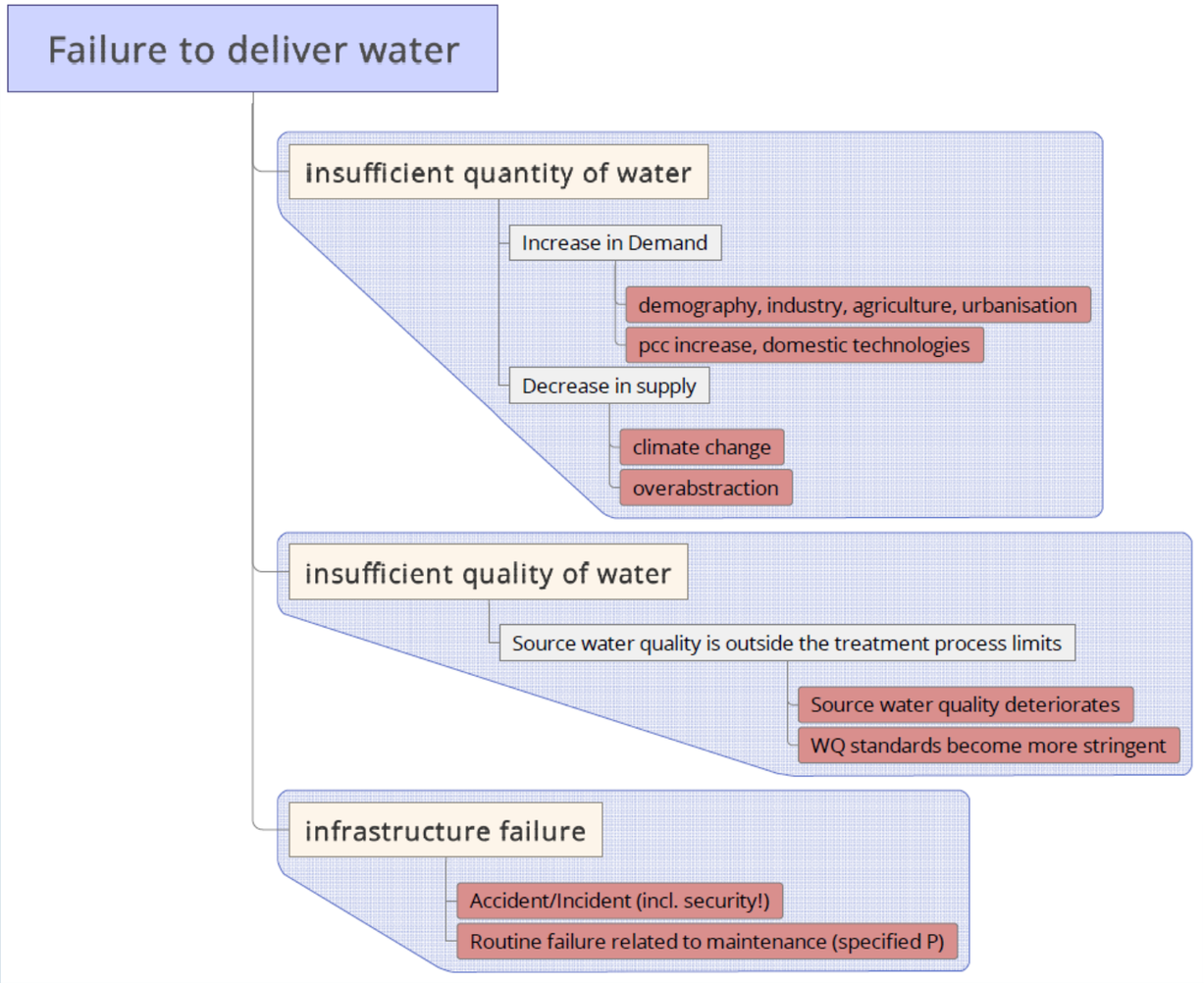


WHAT IS RESILIENCE REALLY ABOUT?

Measuring Performance: Reliability of what?

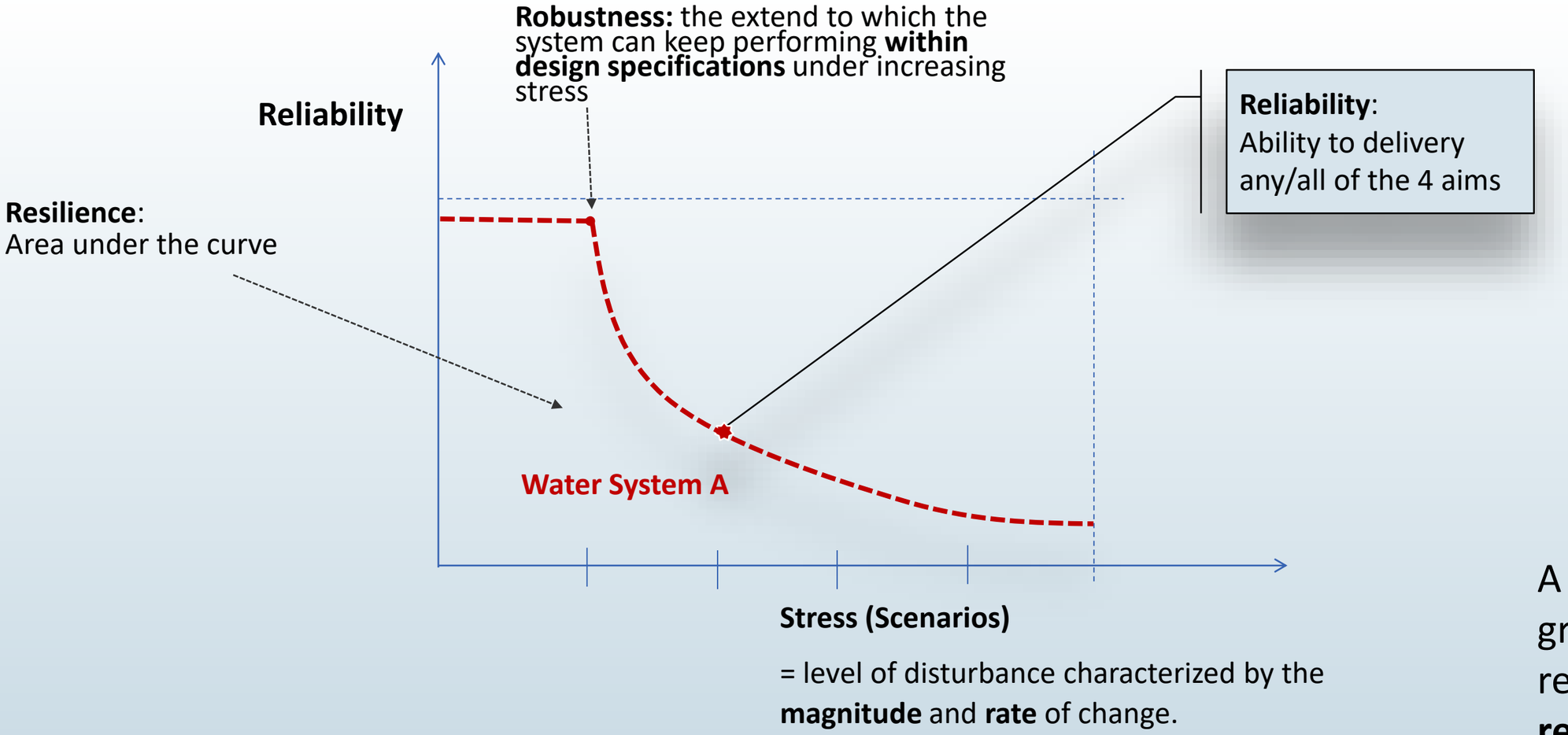
How does a system “fail”?

- **Reliability** is the ability of the system to deliver its objectives (quantity, quality, environment, customers)
- Several “**failure modes**” are identified (e.g. this quantity failure diagram, also includes quality causes)



Can we trace the trajectory of this change in reliability ?

Robustness and Resilience



= level of disturbance characterized by the **magnitude** and **rate** of change.

A **stress-strain** graphical representation of **resilience**

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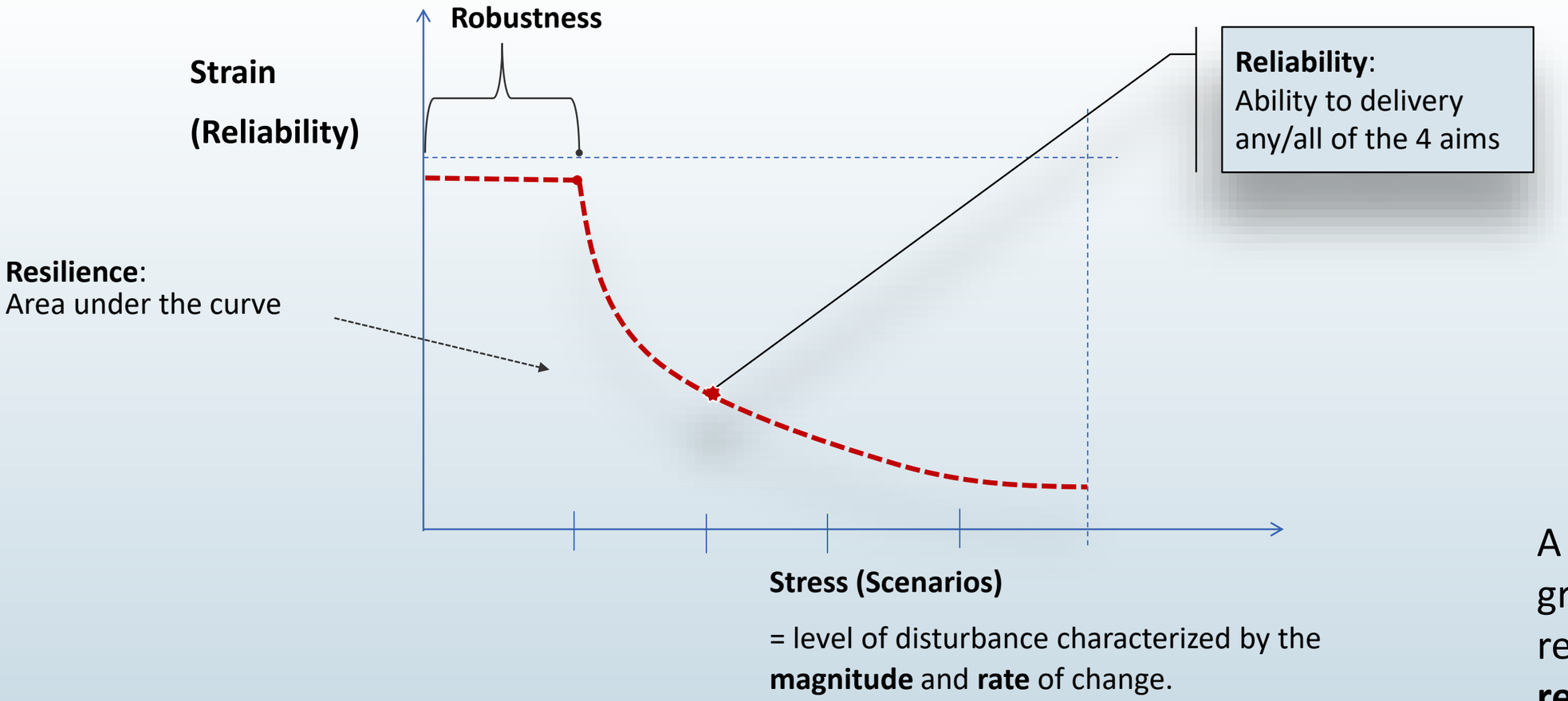
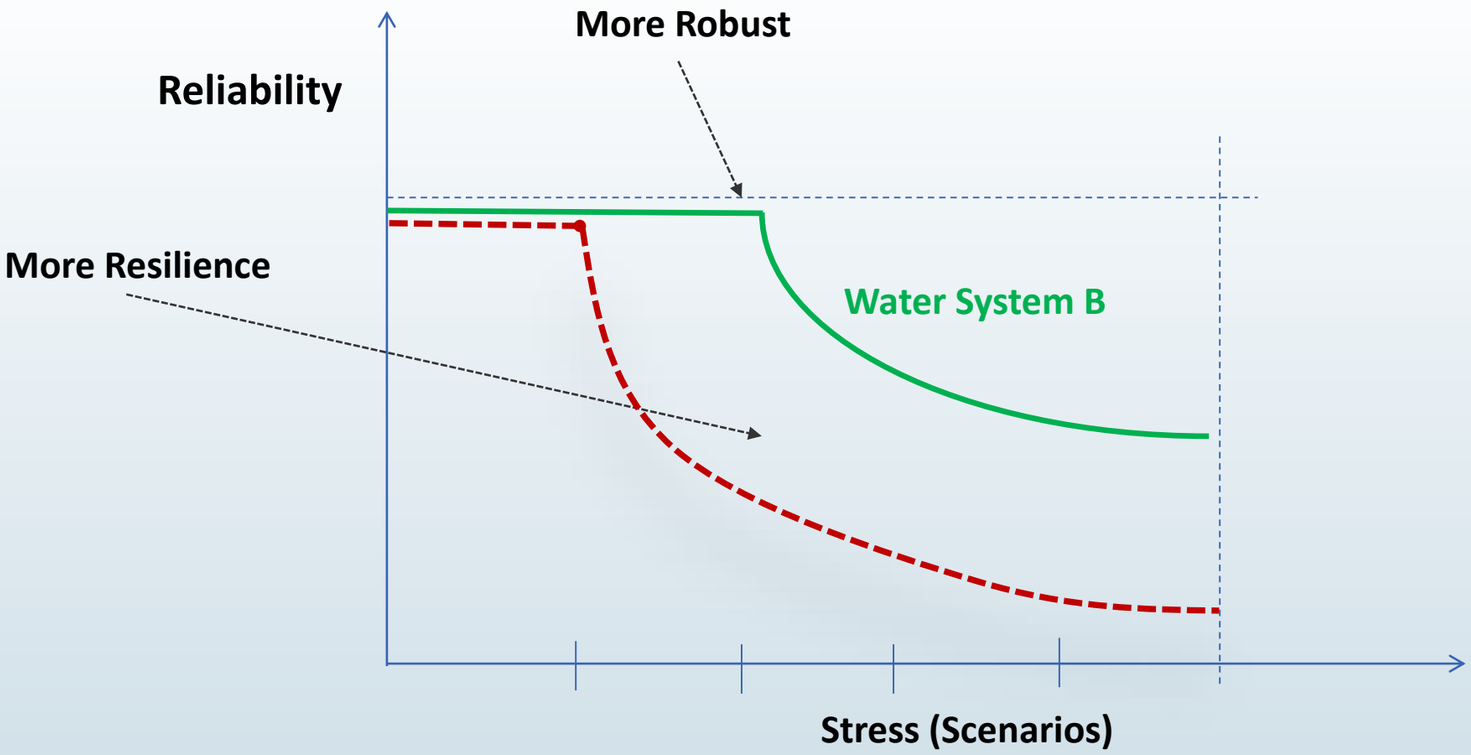
Robustness and Resilience



A **stress-strain** graphical representation of **resilience**

System level metrics

Robustness and Resilience



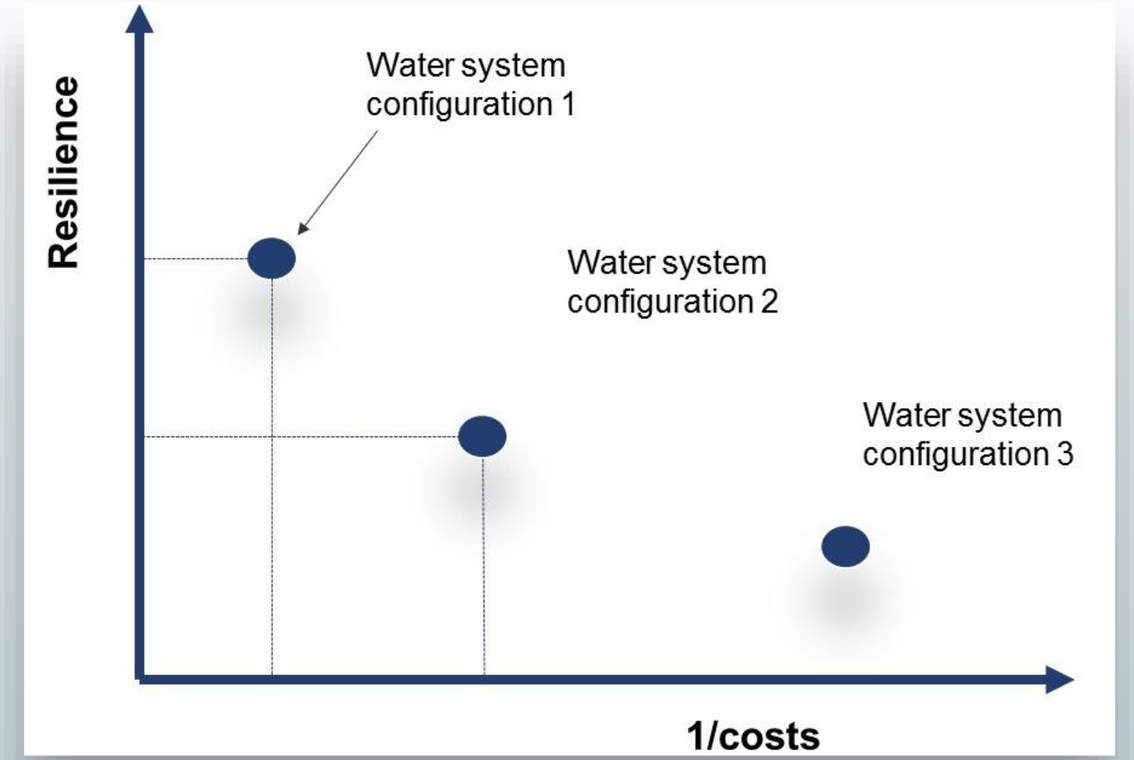
= level of disturbance characterized by the **magnitude** and **rate** of change.

A **stress-strain** graphical representation of **resilience**

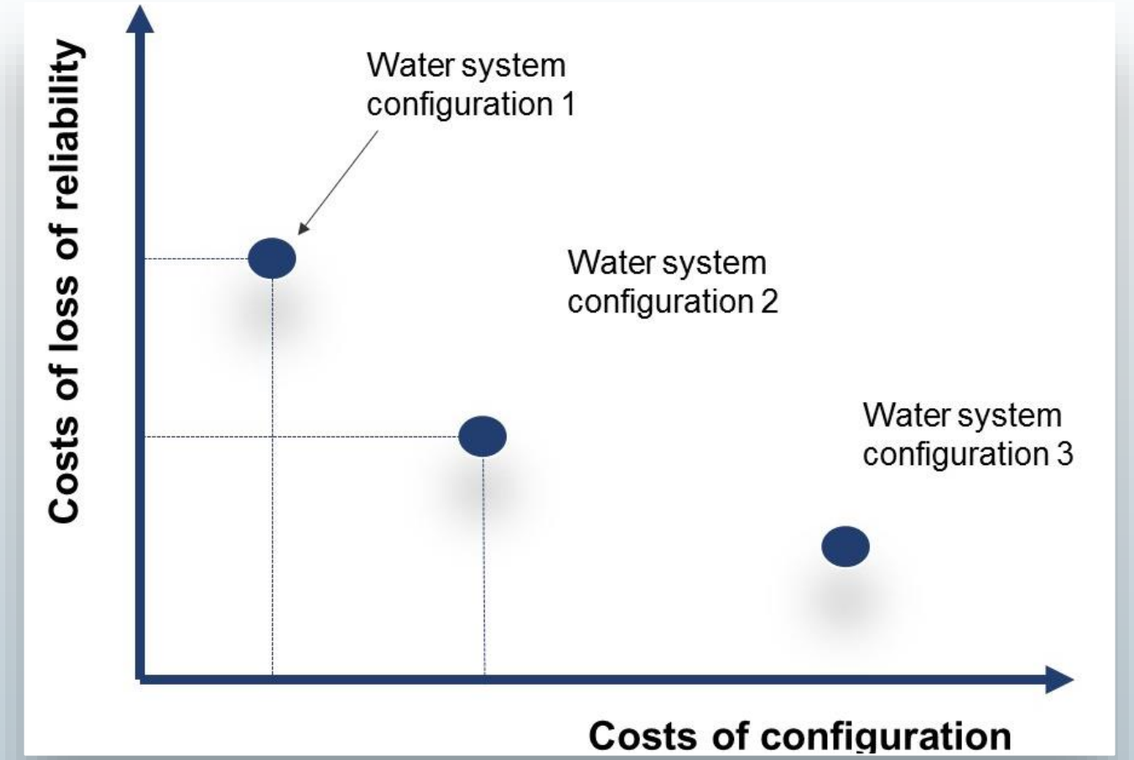
Comparing alternatives

Pareto fronts

RESILIENCE AND COSTS

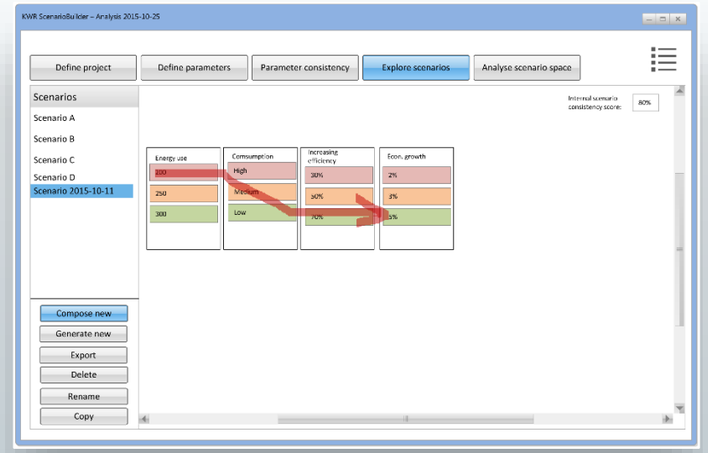


COSTS OF INVESTMENT VS COSTS OF INACTION

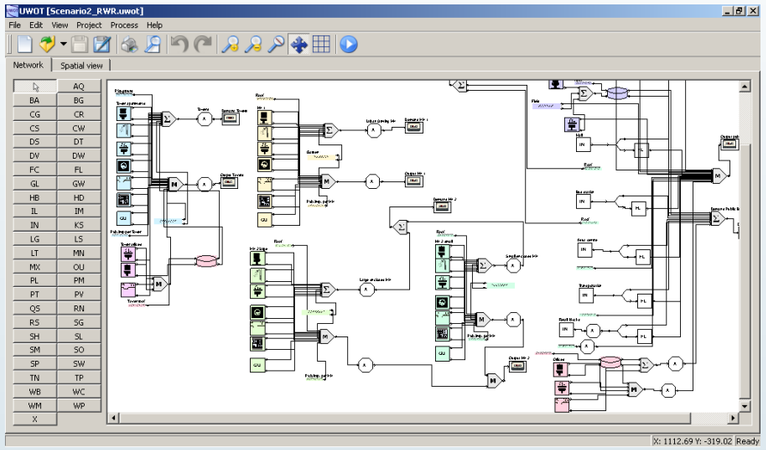


Can we actually produce these resilience profiles for a given water system?

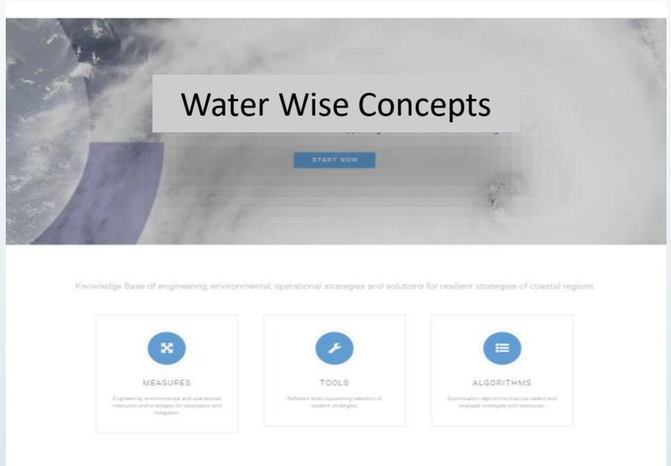
SCENARIO PLANNER



UWOT



KNOWLEDGE BASE

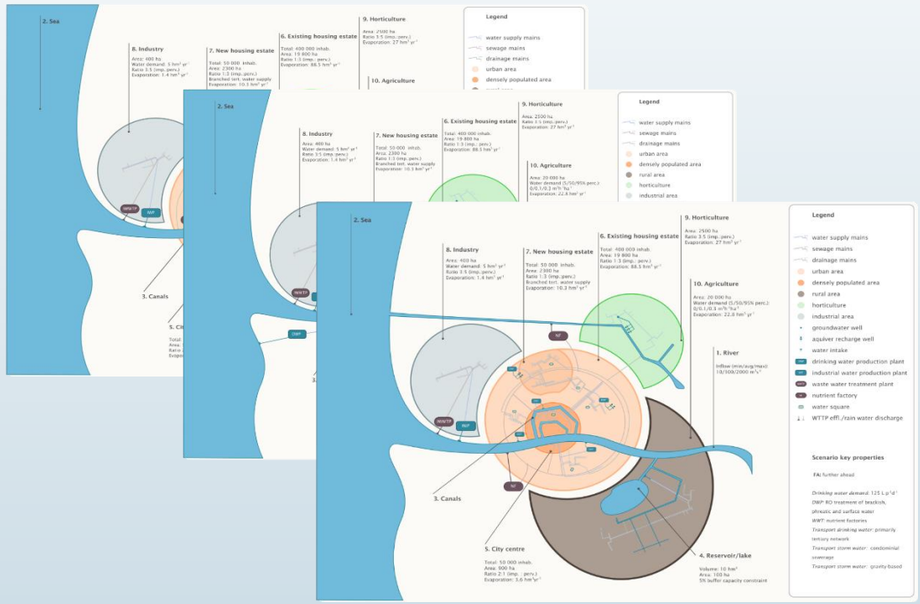


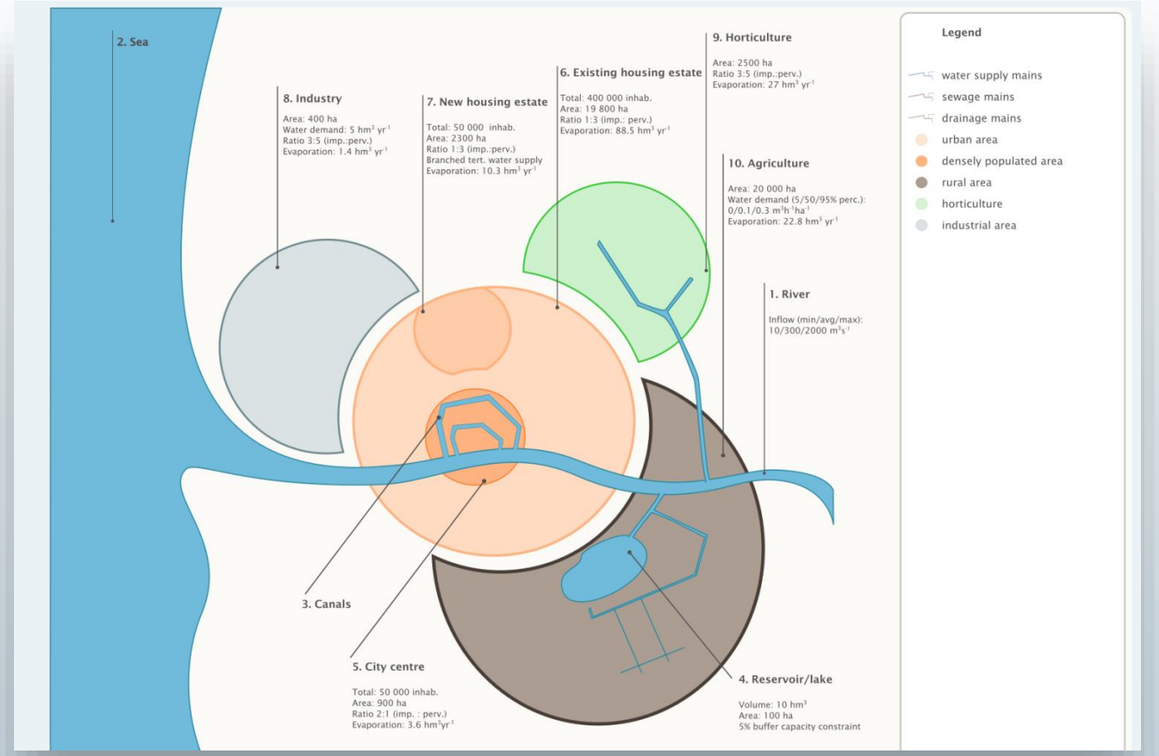
We are developing a **toolbox** able to **model** the system and **quantify performance** (and from there **resilience**)

We tested the approach (again!)

The WaterCity: a synthetic (but realistic) city

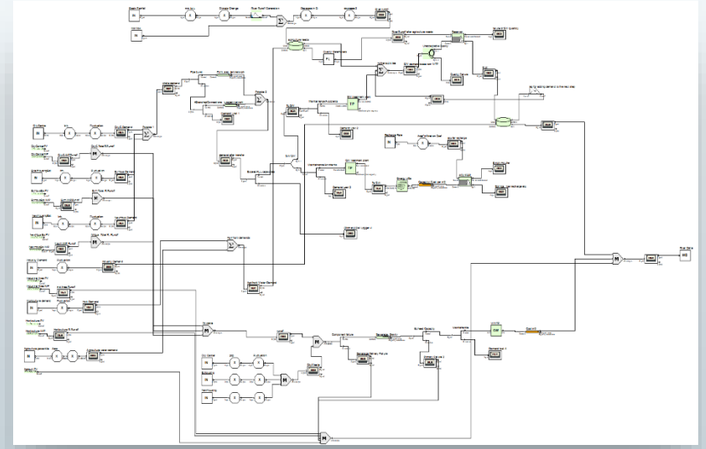
- Similar to WaterCIty #1 but more ‘Rotterdam’-like
- Developed 3 Configurations (BAU, NS, FA)



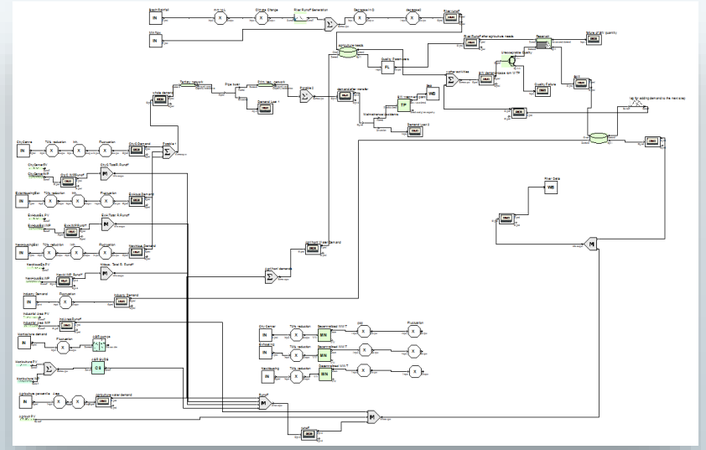


Developed 3 alternative system configurations

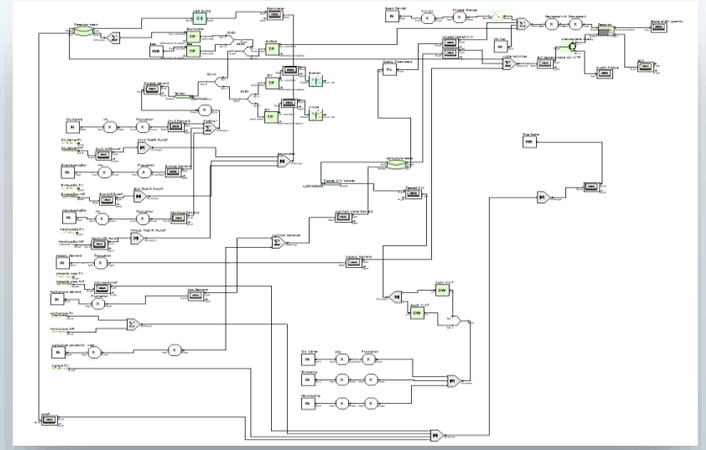
CONFIGURATION 1:



CONFIGURATION 2:

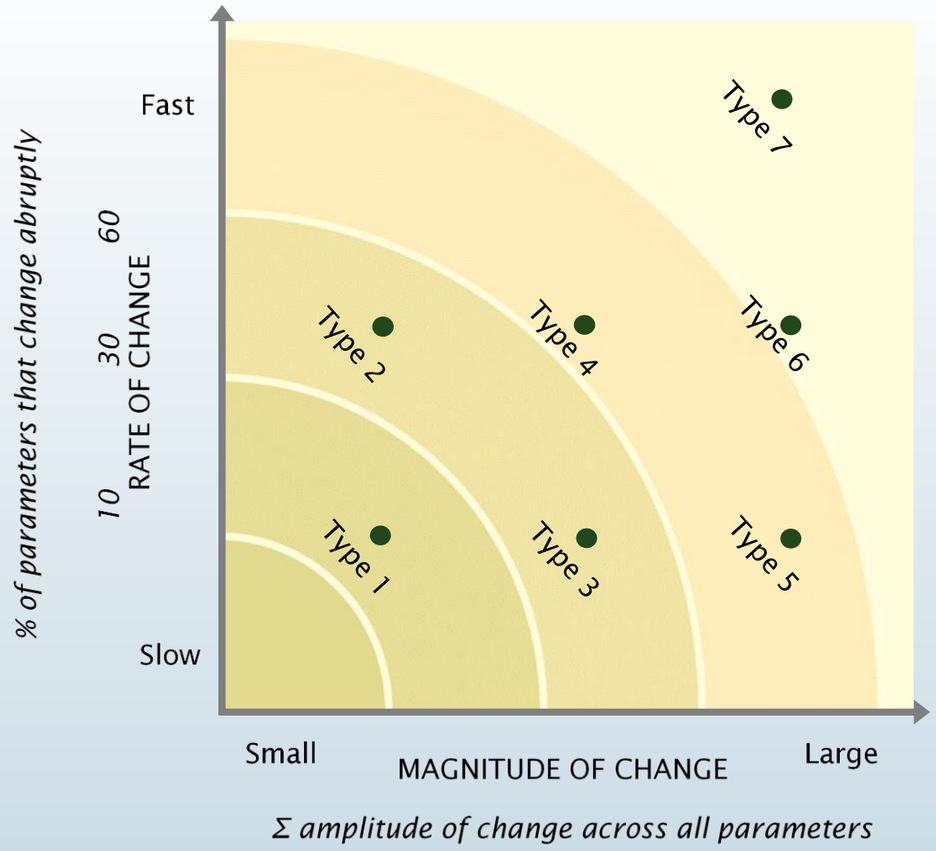


CONFIGURATION 3:



Developed 7 (+1) Scenarios for the WaterCity

Increasing disturbance (rate and degree)

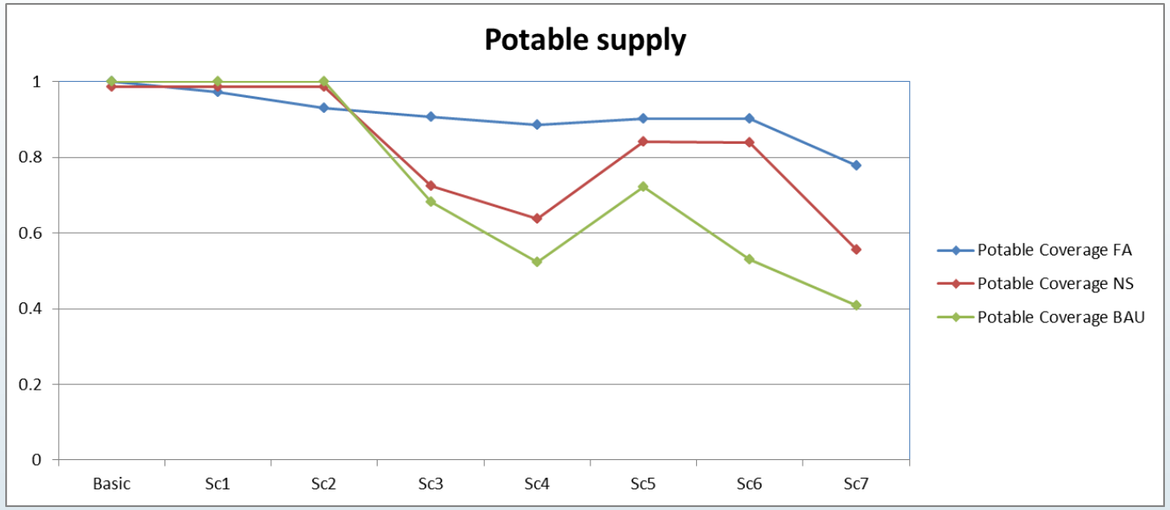


Parameter	Used
Population	✓
Number of households	✓
Age distribution	✓
Ethnic composition	✓
Knowledge development	x
Electricity price heavy users	
GDP (per capita) of city	x
Public Finances	
Temperature	✓
Average rainfall (winter)	✓
Average rainfall (summer)	✓
Industry water demand	✓
Phosphorus emission to surface water	
Horticultural water demand	✓
Domestic water use (technology)l/p/d	✓
Domestic water use (behavioural)l/p/d	✓
Water Governance	x
Risk acceptance	x
Trust in corporations	
Trust in government	
Environmental values	
Knowledge about water sector	x
Dominant ideology	
Quality Standards Drinking Water	✓
E. coli	✓
Viruses/protozoa bacteria	
Chloride	
Nitrogen	
Phosphorous	
Arsenic	
Cadmium	
Lead	
Glyphosate	
Carbendazim	
Carbamazepine	

Results

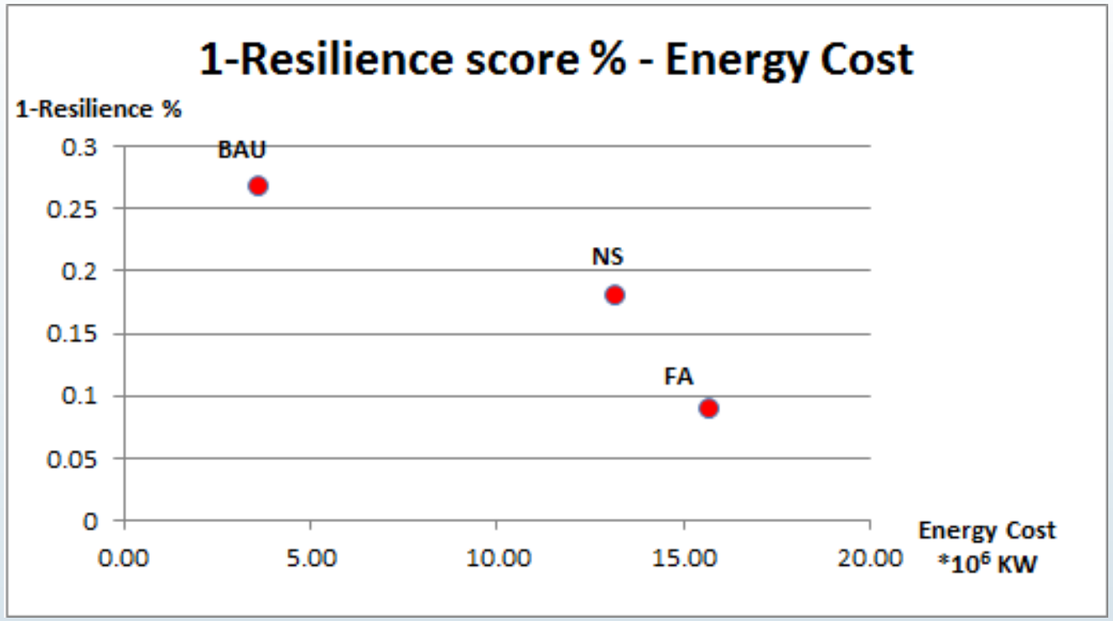
Comparison across the 3 configurations and the 7 scenarios

COMPARISON OF RESILIENCE PROFILES.



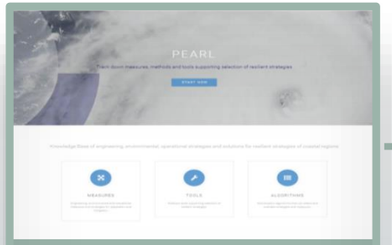
All three configurations are reasonably robust for the first scenarios (Basic, 1 and 2). But FA is more robust for bigger stresses, especially as NS actually has 30% less demand, retaining high levels of coverage. It should also be noted that in Sc1&2 FA fairs worse due to the bigger number of WTPs (100 vs. 2 /1), leading to more “maintenance related” accidents.

COMPARISON OF COSTS (ENERGY)

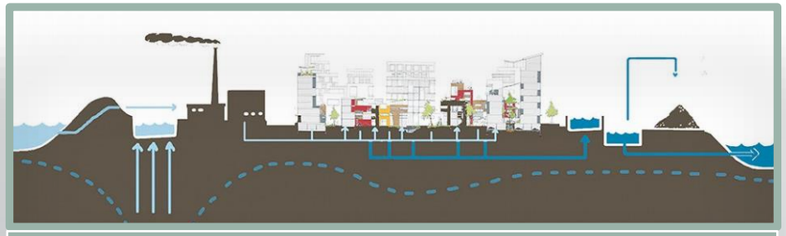


To improve resilience by the same amount from BAU to NS is much more resource intensive, than the move from NS to FA. NS to FA is implemented with small energy cost but the change in resilience is as high as the jump from BAU to NS.

The method at a glance

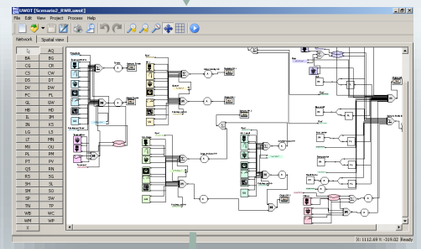


identify design options

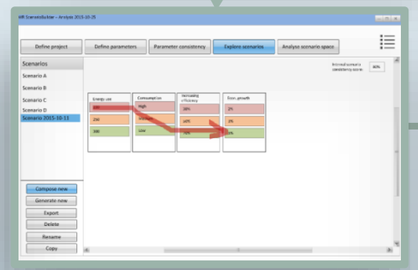


define your water infrastructure

Model the water system (UWOT)

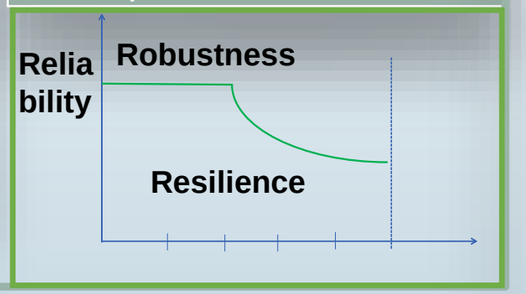


Stress test the system using scenarios



See how the system behaves under pressure

Obtain a Resilience Profile of your infrastructure



The Water Wise Resilience Assessment

Take away message

- A method that uses the concept of **resilience** to inform **strategic planning under uncertainty** and provide **evidence-based support** to water company **long term investment** decisions.
- Supported by a set of models and tools looking into **quantity** and **quality** (and in the future also environment and customers) and explore the **tradeoff** between:
  - the **behavior of your system under stress** when different promising technologies and options (*circular economy, distributed techs)* are deployed in alternative ways accounting for future uncertainties and
  - **efficiency** (and hence costs).
- It **fills a gap** between policy rhetoric, technology development and asset management building on systems thinking and hydroinformatics.
- It provides the Water Industry with **a new tool** (the "Water Wise Resilience Assessment Study") **supporting strategic asset management and long term systems planning**.

Thank you for your attention

@KWR_Water