Smart Water and Wastewater Networks
Water 4.0

Technische Universität Berlin



Fluid System Dynamics

Fluid System Dynamics

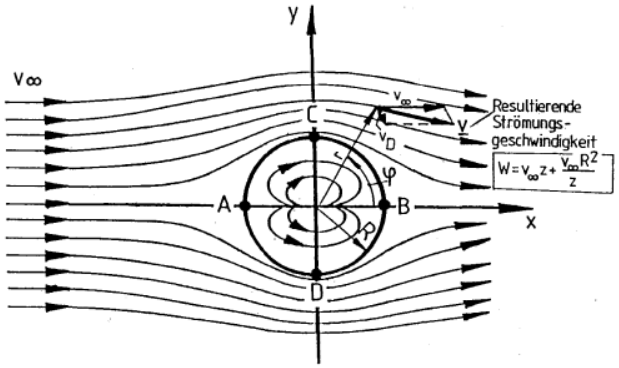
Laboratory 620 m², 5t , 200 kW

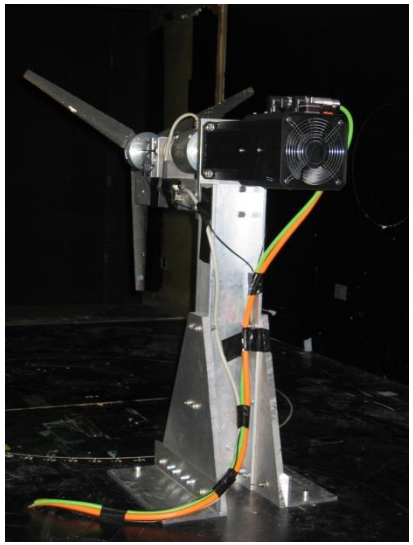
- Centrifugal pumps (DN 20 … DN350)
- Submersible pumps (DN 200)
- Model experiments (4 X 6 X 1,4m)
- Measuring technology (HSPIV, PIV, LDV)
- etc.

Fluid System Dynamics

Teaching

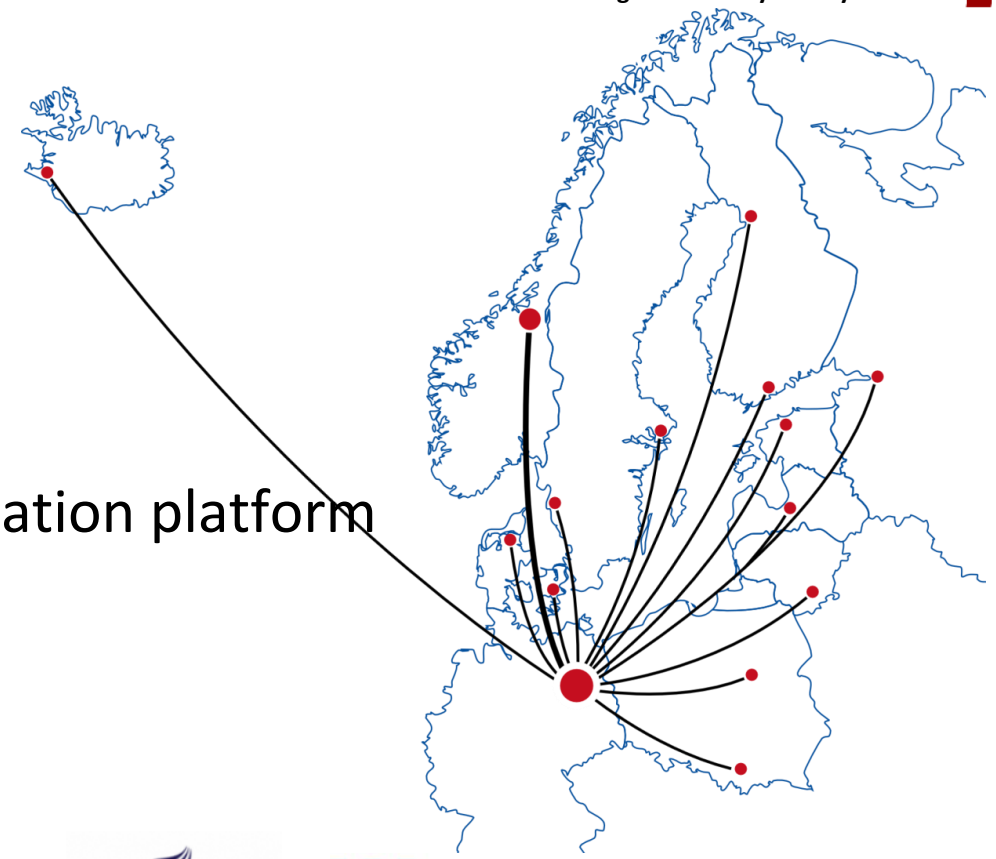
- Fluid mechanics
- Fluid dynamics
- Fluid-flow machines
- Wind turbines
- Measurement and sensor technologies





Professional Training:

Nordic Water Network



- Nordic Water Network
  - Interdisciplinary cooperation platform
  - Scientists and students
  - Water related topics

- Partners

Technische Universität Berlin

NTNU
Kunnskap for en bedre verden

AALBORG UNIVERSITET

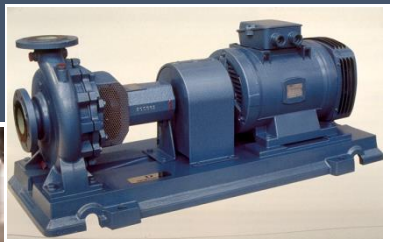
Politechnika Krakowska
im. Tadeusza Kościuszki

Industrial Revolutions – Water Revolutions

INDUSTRY

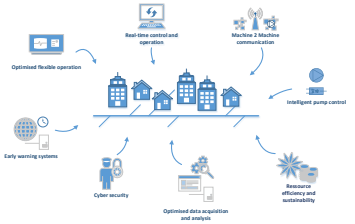
1. Mechanization

2. Electrification



3. Automation

4. Cyber Physical Systems



WATER

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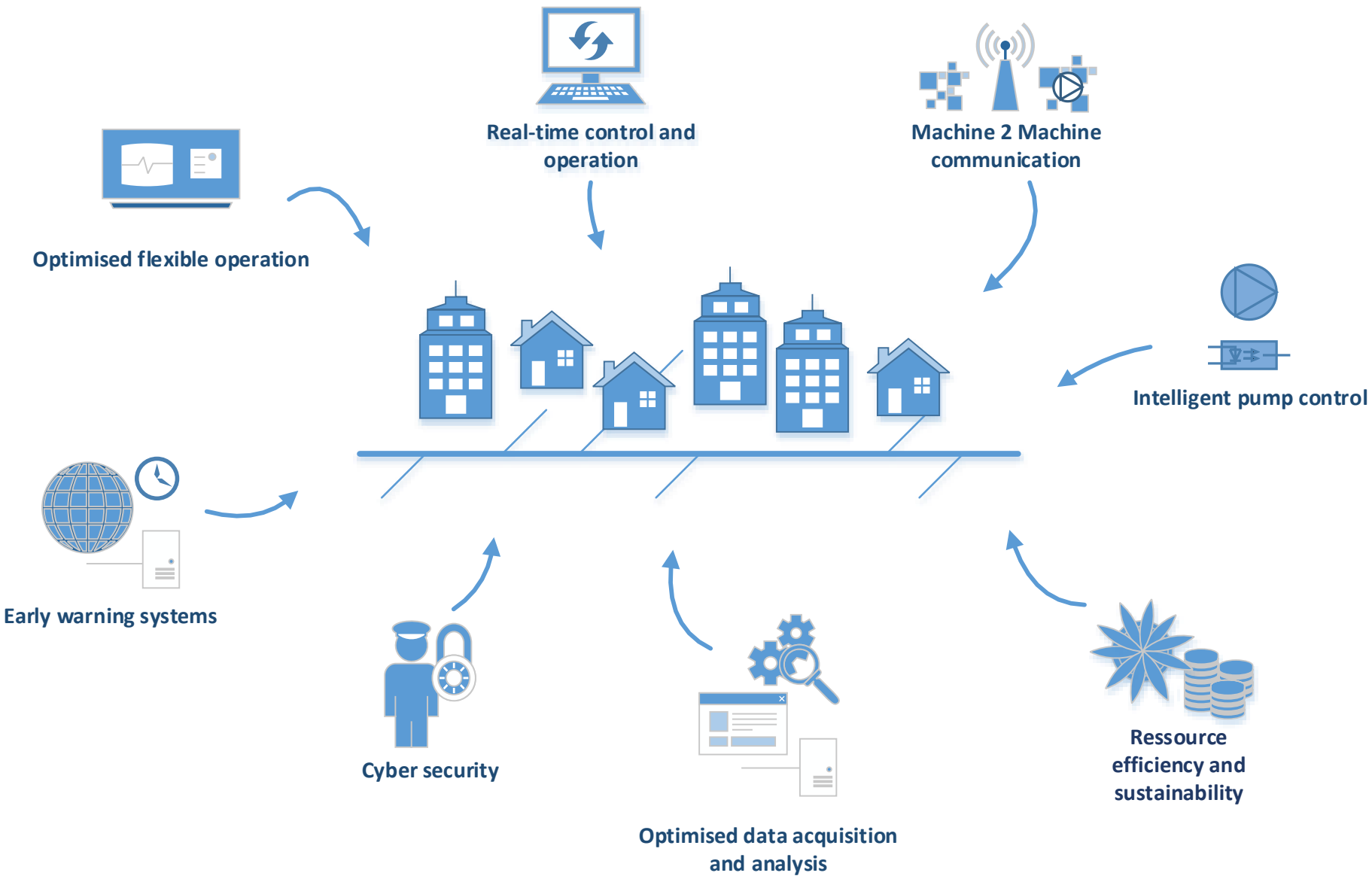
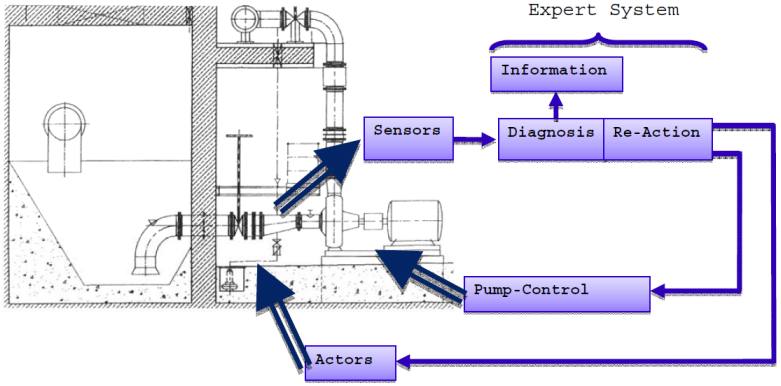
Fachgebiet Fluidsystemdynamik

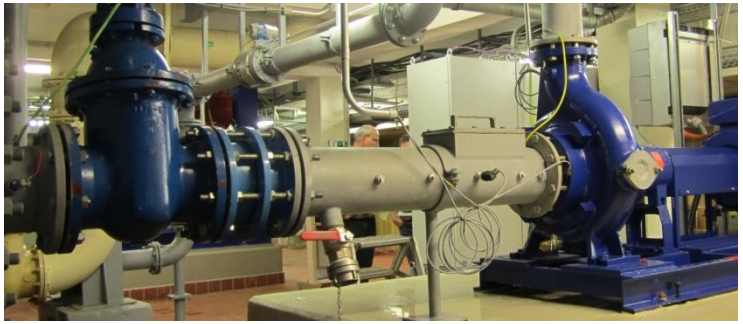
Smart Water and Wastewater Networks



IMEBA

Innovative mechatronic influence systems for the operational optimization of complex wastewater systems

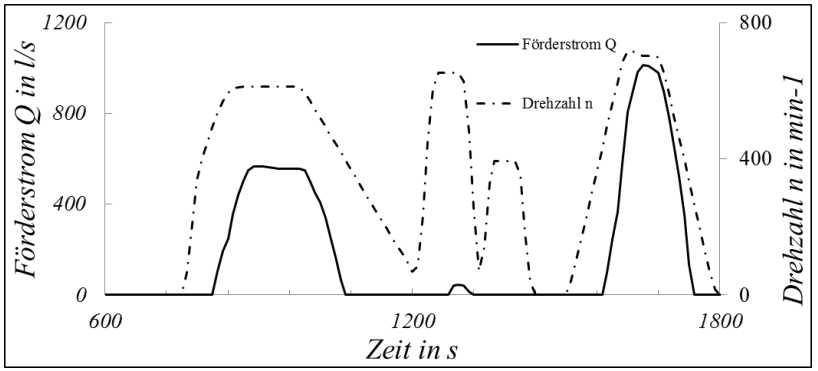


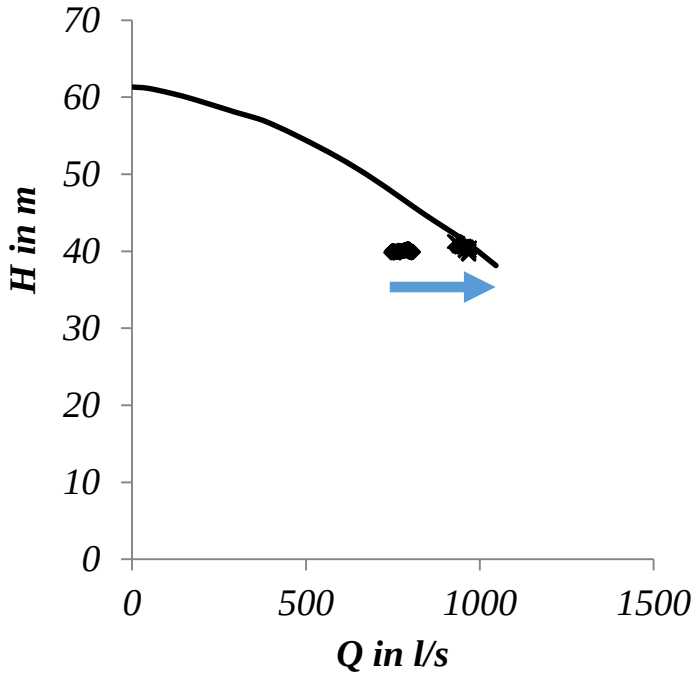


Teststands in laboratory and in wastewater pumping station Berlin-Lichtenberg

IMEBA

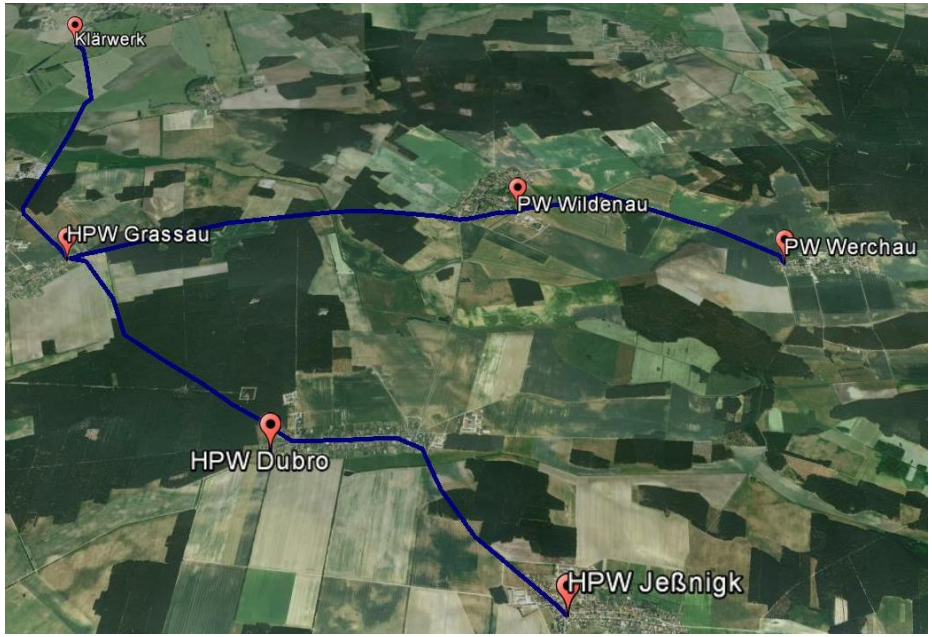
Intelligent pumping station – elimination of clogging

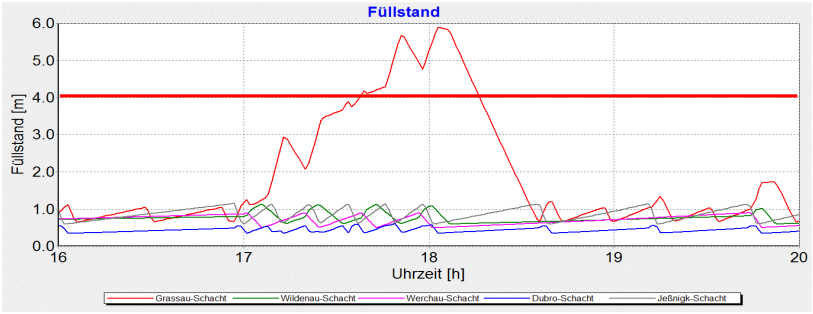


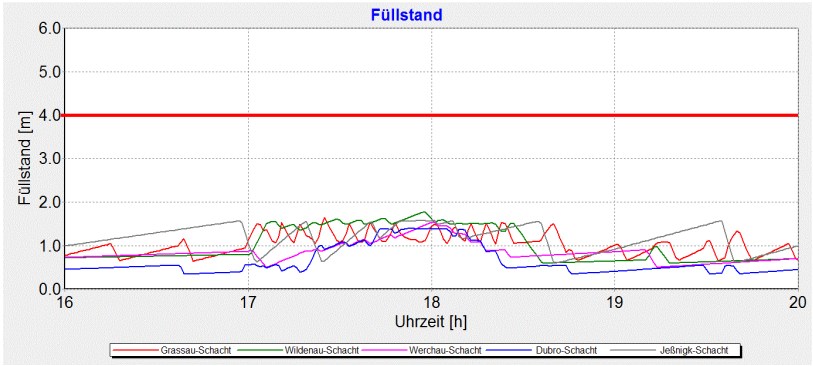


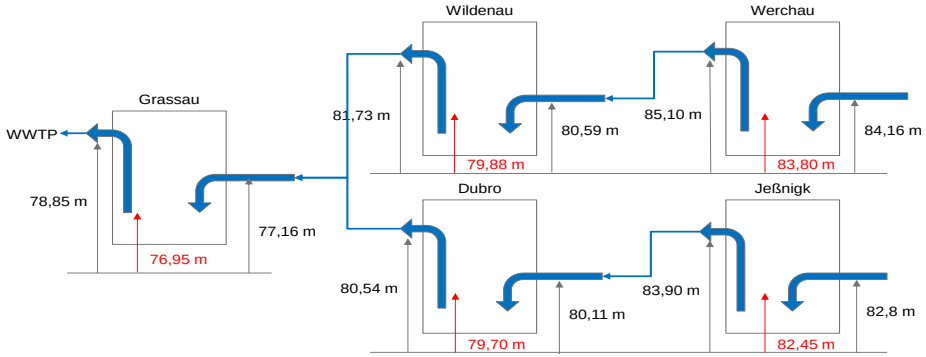
ZIM Herzberg

Pump to Pump Communication: Design of a decentralised intelligent network for 5 wet pit pumping stations









KURAS – Concepts for urban stormwater management and wastewater systems

Development and comparison of integrated adaptation strategies for urban wastewater systems

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KURAS – Concepts for urban stormwater management and wastewater systems

Building level

District level

Catchment level

Focal point Storm Water Management

Analysis of individual measures

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Benefit for the **residents**
1. on building level
2. Quality of open space
3. Urban climate / bio-climate

Benefit for the **environment**
4. Bio diversity
5. Groundwater
6. Surface water

Economic Effects
7. Direct costs
8. Use of resources

Result of Selected Instrument

Evaluation Indicators of the Effects

Individual Measures

	Measure type	Benefits at building level			Landscape quality	City climate		Biodiversity			Groundwater			Surface water bodies			Ressource use		Cost	
		Change in water consumption and waste-water production	Change in energy consumption	Supporting the natural water cycle	Average of absolute values of 4 indicators	Change in annual tropical nights	Change in annual heat stress (UTCI)	α-diversity from floristic surveys	α-diversity from faunistic surveys	ß-diversity from floristic surveys	Increase in groundwater recharge	Reduction in loads of zinc	Reduction in loads of chlorides	Peak runoff reduction for a 1-year rainfall event	Annual retention of total suspended solids	Annual retention of total phosphorus	Global warming potential 100yr	Cumu-lative energy demand fossil	annualised CAPEX	OPEX
		%	%	%	scale of 0-5	days ($q_{0.05}$)	hours ($q_{0.05}$)	number of species			Effectiveness	Through value		%	kg ha^{-1} yr^{-1}	kg ha^{-1} yr^{-1}	kg CO_2 m^{-2} yr^{-1}	MJ m^{-2} yr^{-1}	€ m^{-2} yr^{-1}	€ m^{-2} yr^{-1}
Vegetated buildings	Extensive green roofs	-35	-10	70	2.4	-1.0	-80.0	12.6 (n = 332)	34.8 (n = 38)	32.6 (n = 127)	no effect	no effect		81 (n = 2)	76 (n = 4)	-0.8 (n = 5)	0.154 (n = 1)	1.98 (n = 1)	1.32 (n = 133	1.50 (n = 76)
	Intensive green roofs	-45	-15	80	not eval.	-1.0	-80.0	20.2 (n = 5)	78.3 (n = 5)	1.3 (n = 3)	no effect	no effect		? (n = 0)	? (n = 0)	0.6 (n = 2)	0.520 (n = 2)	7.49 (n = 2)	2.44 (n = 28)	4.00 (n = 14)
	Green façades (earth-bound)	0	-25	35	2.0	*	*	11.0 (n = 2)	not eval.	not. eval	not eval.	not eval.	not eval.	not eval.	not eval.	not eval.	0.019 (n = 1)	0.23 (n = 1)	2 (n = 5)	15 (n = 3)
	Green façades (system-bound)	0	-25	35	2.8	*	*	not eval.	not eval.	not eval.	no effect	no effect		not eval.	not eval.	not eval.	0.259 (n = 2)	3 (n = 2)	30 (n = 32)	39 (n = 18)
Rain water use	Rain water use (for irrigation)	-30	not eval.	70	no effect	no effect		no effect			no effect	? (n = 0)	not eval.	? (n = 0)	85 (n = 12)	1.4 (n = 12)	0.280 (n = 1)	3.84 (n = 1)	0.95 (n = 92)	0.23 (n = 41)
	Rain water use (for service water)	-70	no effect		no effect	no effect		no effect			no effect	no effect					0.280 (n = 1)	3.84 (n = 1)		
	Rain water use (for indoor cooling)	-80	-90	70	no effect	no effect		no effect			no effect	no effect					not eval.	not eval.		
	Rain water use (for sewer flushing)	no effect			no effect	no effect		no effect			no effect	no effect					not eval.	not eval.		
De-paving	Permeable pavement	-50	not eval.	73	not eval.	-1.0	-80.0	not eval.	not eval.	not eval.	0.31 (n=46)	0.13 (n=16)	1.00 (n=1)	? (n = 0)	244 (n = 22)	1.7 (n = 25)	0.340 (n = 2)	3.05 (n = 2)	1.26 (n = 80)	not eval.
Infiltration	Swale infiltration	-50	not eval.	38	not eval.	-1.0	-80.0	23.4 (n = 27)	64.5 (n =1)	2.8 (n = 26)	3.44 (n=3)	0.09 (n=30)	2.90 (n = 9)	100 (n = 7)	752 (n = 8)	3.5 (n = 6)	0.030 (n = 1)	0.48 (n = 1)	0.17 (n = 10)	not eval.
	Infiltration basin			38	2.6	-1.0	-80.0	23.4 (n = 27)	64.5 (n =1)	2.8 (n = 26)	3.81 Storm	0.16 (n=5)	1.00 (n=4)				0.100 (n = 1)	1.52 (n = 1)	0.22 (n = 6)	not eval.
	Infiltration trench			30	no effect	no effect		no effect			4.25 (n=3)	? (n=0)	? (n=0)				0.140 (n = 2)	2.02 (n = 2)	0.52 (n = 13)	not eval.
	Infiltration pipe			30	no effect	no effect		no effect			4.25 (n=0)	? (n=0)	? (n=0)				not eval.	not eval.	0.22 (n = 3)	not eval.
	Infiltration shaft			30	no effect	no effect		no effect			5.18 Storm	0.09 (n=4)	? (n=0)				0.070 (n = 1)	0.65 (n = 1)	0.65 (n = 9)	not eval.
	Trough-trench infiltration			38	2.3	-1.0	-80.0	23.4 (n = 27)	64.5 (n =1)	2.8 (n = 26)	2.00 (n=2)	0.11 (n=4)	1.40 (n=4)	? (n = 0)	578 (n = 2)	2.3 (n = 1)	0.120 (n = 2)	1.83 (n = 2)	0.30 (n = 3)	not eval.
	Planted infiltration bed			38	2.5	-1.0	-80.0	23.4 (n = 27)	64.5 (n =1)	2.8 (n = 26)	4.94 Storm	not eval.	not eval.	100 (n = 1)	790 (n = 1)	3.9 (n = 1)	0.230 (n = 1)	2.67 (n = 1)	1.51 (n = 3)	not eval.
	Tree-trench			not eval.	not eval.	-1.0	-300.0	23.4 (n = 27)	64.5 (n =1)	2.8 (n = 26)	not eval.	not eval.	not eval.	not eval.	900 (n = 1)	not eval.	0.260 (n = 1)	2.25 (n = 1)	not eval.	not eval.
Artificial ponds and streams	Atrificial pond	-50	not eval.	41	2.1	-1.0	-300.0	7.1 (n = 30)	34.1 (n =55)	11.4 (n = 49)	no effect	no effect		100 (n = 1)	802 (n = 1)	4.0 (n = 1)	0.300 (n = 1)	4.11 (n = 1)	not eval.	not eval.
	Artificial stream	-50	not eval.	not eval.	not eval.			not eval.	not eval.	not eval.	no effect	no effect		0 (n = 0)	0 (n = 0)	0.0 (n = 0)	not eval.	not eval.	not eval.	not eval.
Treatment	Decentralized treatment at gully	no effect			no effect	no effect		no effect			no effect	no effect		0 (n = 13)	467 (n = 27)	1.5 (n = 1)	0.040 (n = 2)	0.5 (n = 2)	0.23 (n = 25)	0.44 (n = 7)
	Sedimentation basin (separate sewer system)	no effect			no effect	-1.0	-300.0	no effect			no effect	no effect		0 (n = 4)	333 (n = 23)	1.4 (n = 6)	0.060 (n = 2)	0.42 (n = 2)	0.42 (n = 9)	0.08 (n = 6)
	Lamella particle separator	no effect			no effect	no effect		no effect			no effect	no effect			548 (n = 4)	2.0 (n = 3)	0.020 (n = 1)	0.14 (n = 1)	not eval.	not eval.
	Retention soil filter	no effect			2.3	-1.0	-70.0	not eval.			no effect	no effect		98 (n = 1)	608 (n = 15)	3.1 (n = 6)	0.020 (n = 1)	0.2 (n = 1)	0.16 (n = 13)	0.09 (n = 4)
	Decentralized treatment of CSO	no effect			no effect	no effect		no effect			no effect	no effect		0 (n = 2)	315 (n = 1)	2.7 (n = 1)	not eval.	not eval.	not eval.	not eval.
Storage	Retention tank (combined sewer system)	no effect			no effect	no effect		no effect			no effect	no effect		? (n = 0)	not eval.	not eval.	0.020 (n = 1)	0.2 (n = 1)	0.07 (n = 31)	0.02 (n = 3)
	Retention sewer (combined sewer system)	no effect			no effect	no effect		no effect			no effect	no effect					0.020 (n = 1)	0.13 (n = 1)	0.11 (n = 14)	not eval.
	Storage activation (combined sewer system)	no effect			no effect	no effect		no effect			no effect	no effect					0.006 (n = 2)	0.04 (n = 2)	0.08 (n = 15)	not eval.
	Retention basin	no effect			not eval.	no effect		not eval.			no effect	no effect		98 (n = 3)	? (n = 0)	? (n = 0)	not eval.	not eval.	0.36 (n = 20)	not eval.

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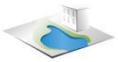
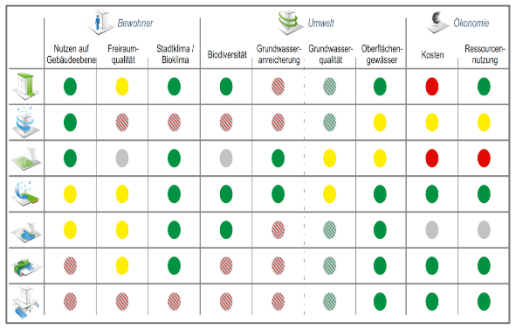
Potential: Best Measure per Category and Effect

- gut geeignet
- mittelmäßig geeignet
- schlecht geeignet
- keine Wirkung (= gut geeignet)
- keine Wirkung (= schlecht geeignet)
- Wirkung unbekannt

	Bewohner			Umwelt				Ökonomie	
	Nutzen auf Gebäudeebene	Freiraum-qualität	Stadtklima / Bioklima	Biodiversität	Grundwasser-anreicherung	Grundwasser-qualität	Oberflächen-gewässer	Kosten	Ressourcen-nutzung
	●	●	●	●	◍	◍	●	●	●
	●	◍	◍	◍	◍	◍	●	●	●
	●	○	●	○	●	●	●	●	●
	●	●	●	●	●	●	●	●	●
	●	●	●	●	◍	◍	●	○	○
	◍	●	●	◍	◍	◍	●	●	●
	◍	◍	◍	◍	◍	◍	●	●	●

Focal point Storm Water Management

Creating combinations of measures



Selected instrument

Local problems + goals in city districts

Effective measure combination for a city district

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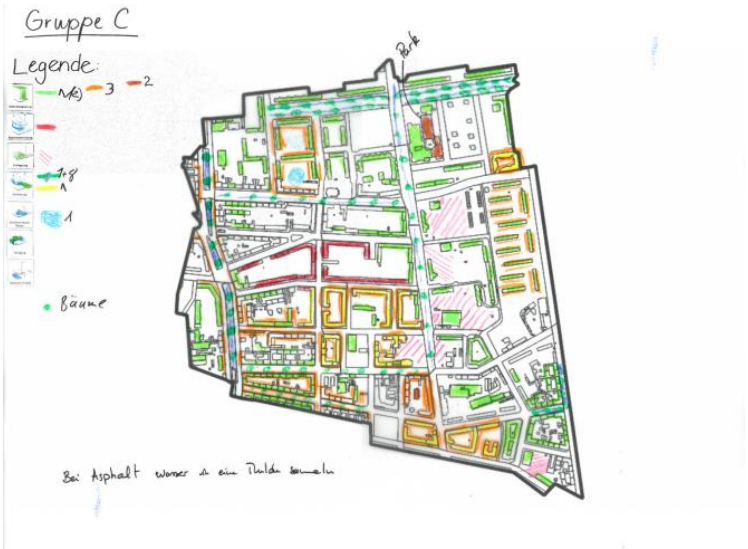
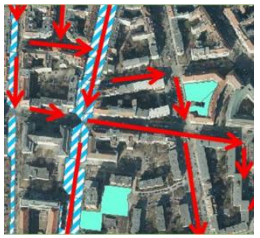
Results of the Measure Planning

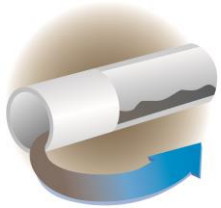


KURAS – Concepts for urban stormwater management and wastewater systems

Wastewater system:
Investigation / evaluation of about 40 measures in four clusters

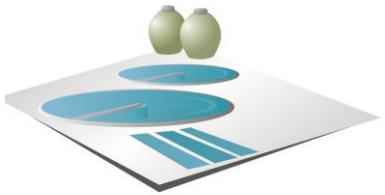


Surface



Sewer system

Pump



WWT

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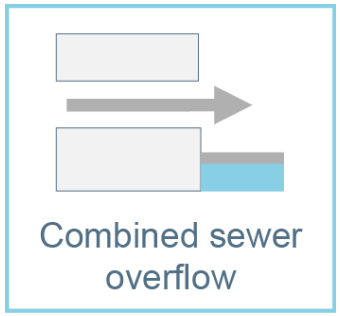
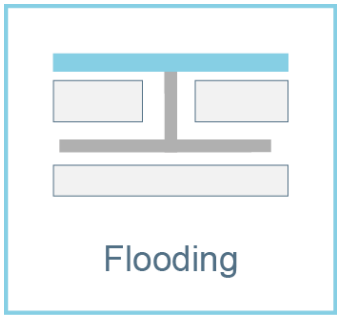
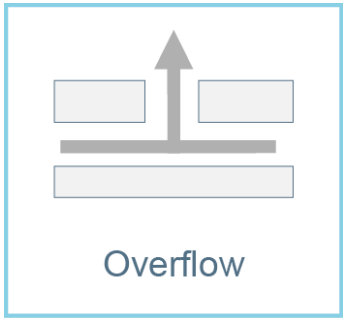
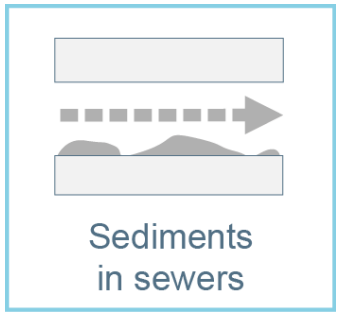
Focal point Waste Water Systems

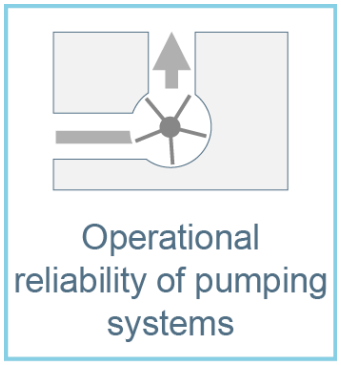
Definition of challenges: 6 priority spheres of activity

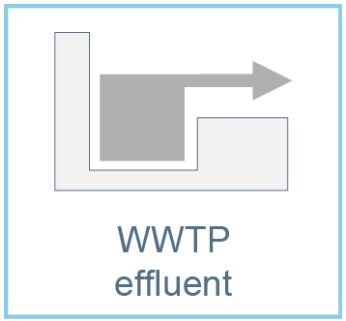








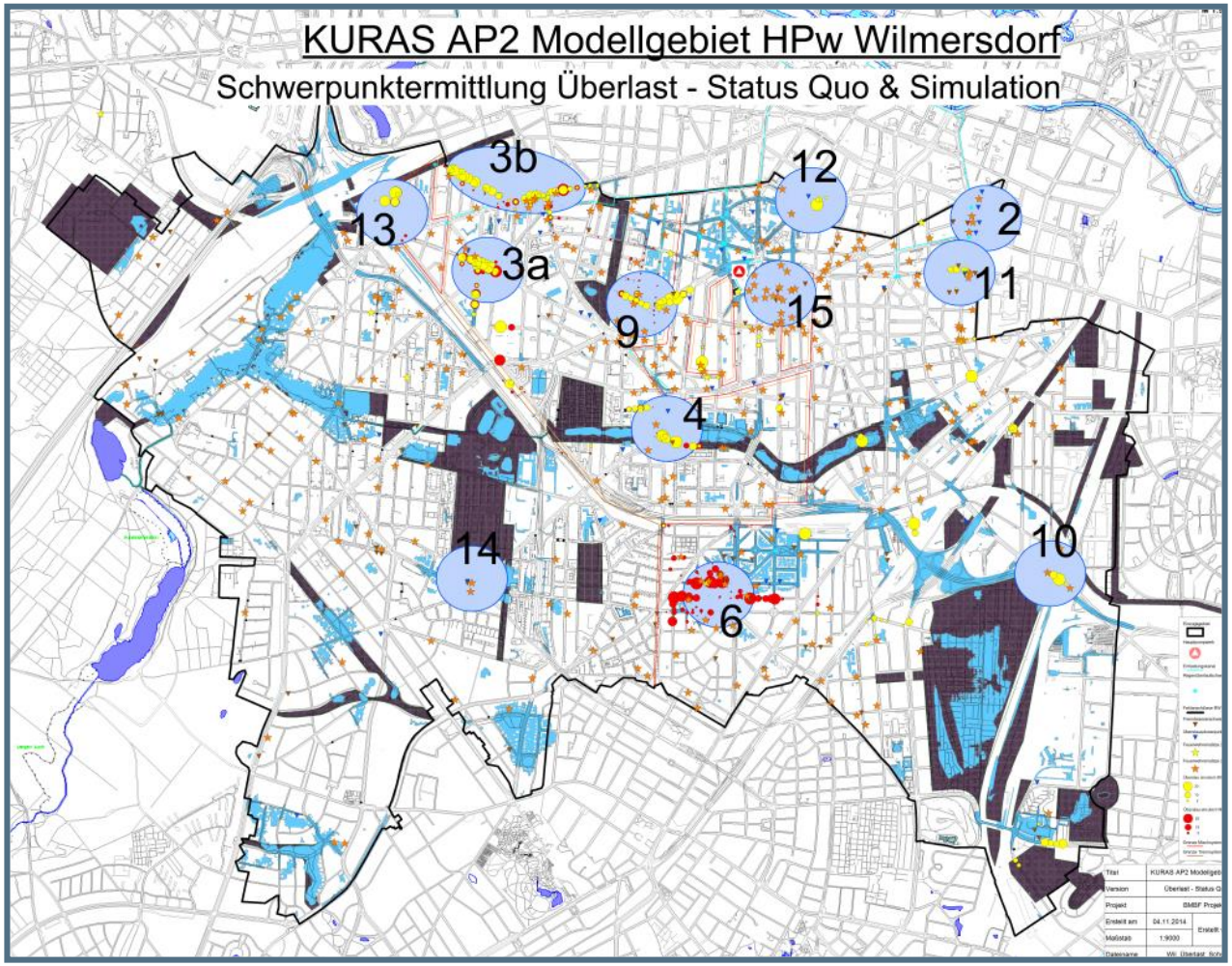




Time scale: 2050

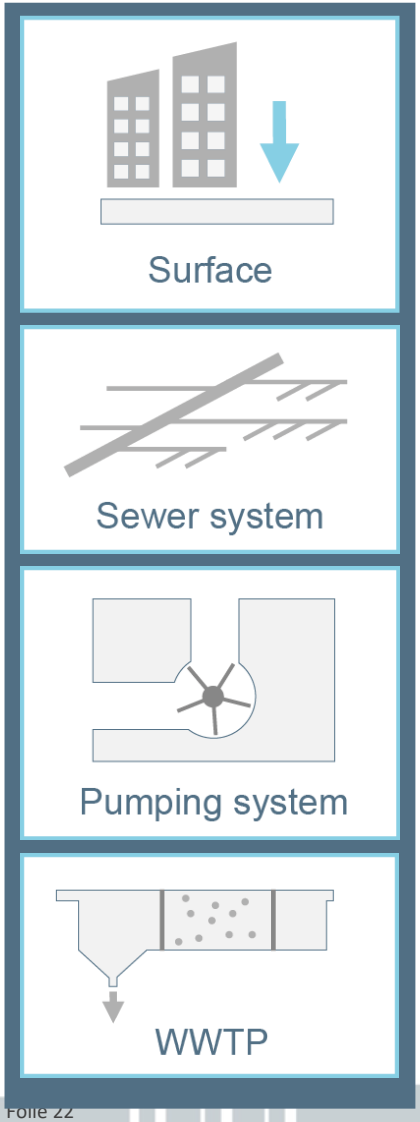
Problem analysis

Usage of weak point maps



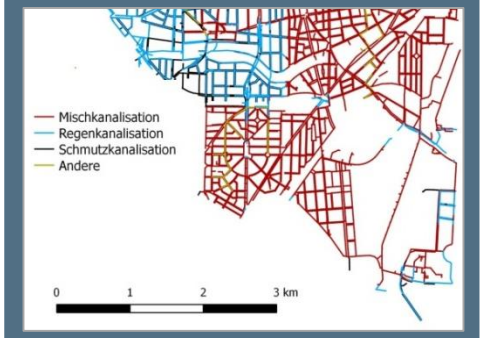
Analysis of Individual Adaptation Measures

Sub systems

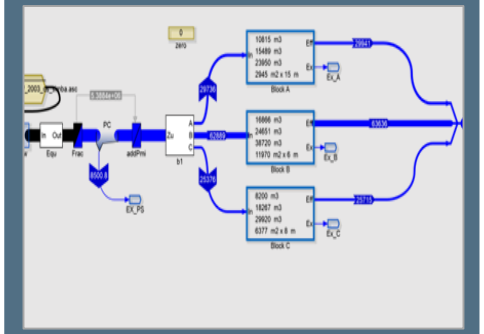


Investigative tools

1. Simulation of measures with **Infoworks CS → surface and sewer system**



2. Simulation of measures with **SIMBA# → treatment plant**

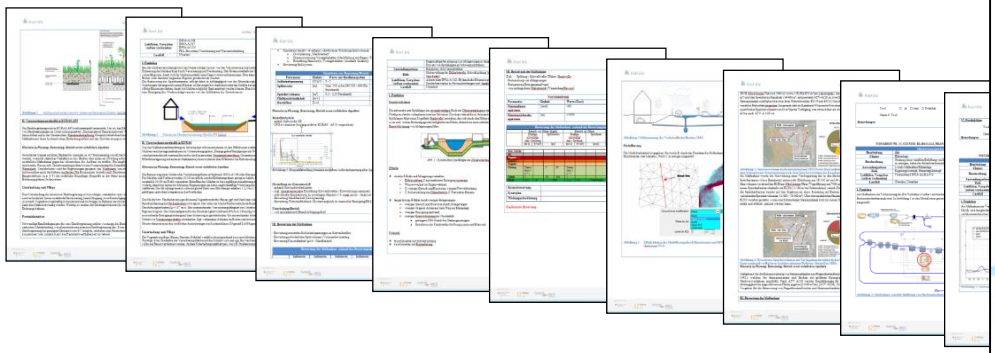


3. Experimental investigation **Commercial/industrial experiments in the waste water system**

Anpassungs-
maßnahmen

Analysis of Individual Adaptation Measures

List of measures



Available at www.kuras-projekt.de

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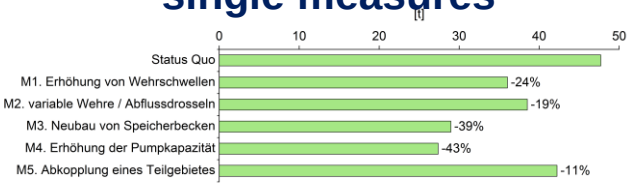
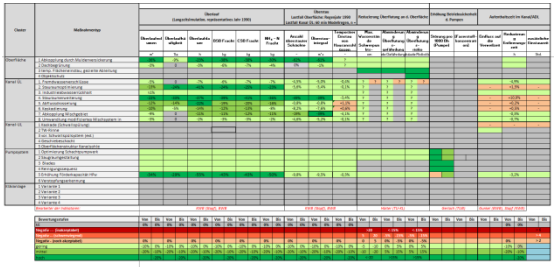
KURAS – Concepts for urban stormwater management and wastewater systems

Investigation of single measures

Evaluation of single measures

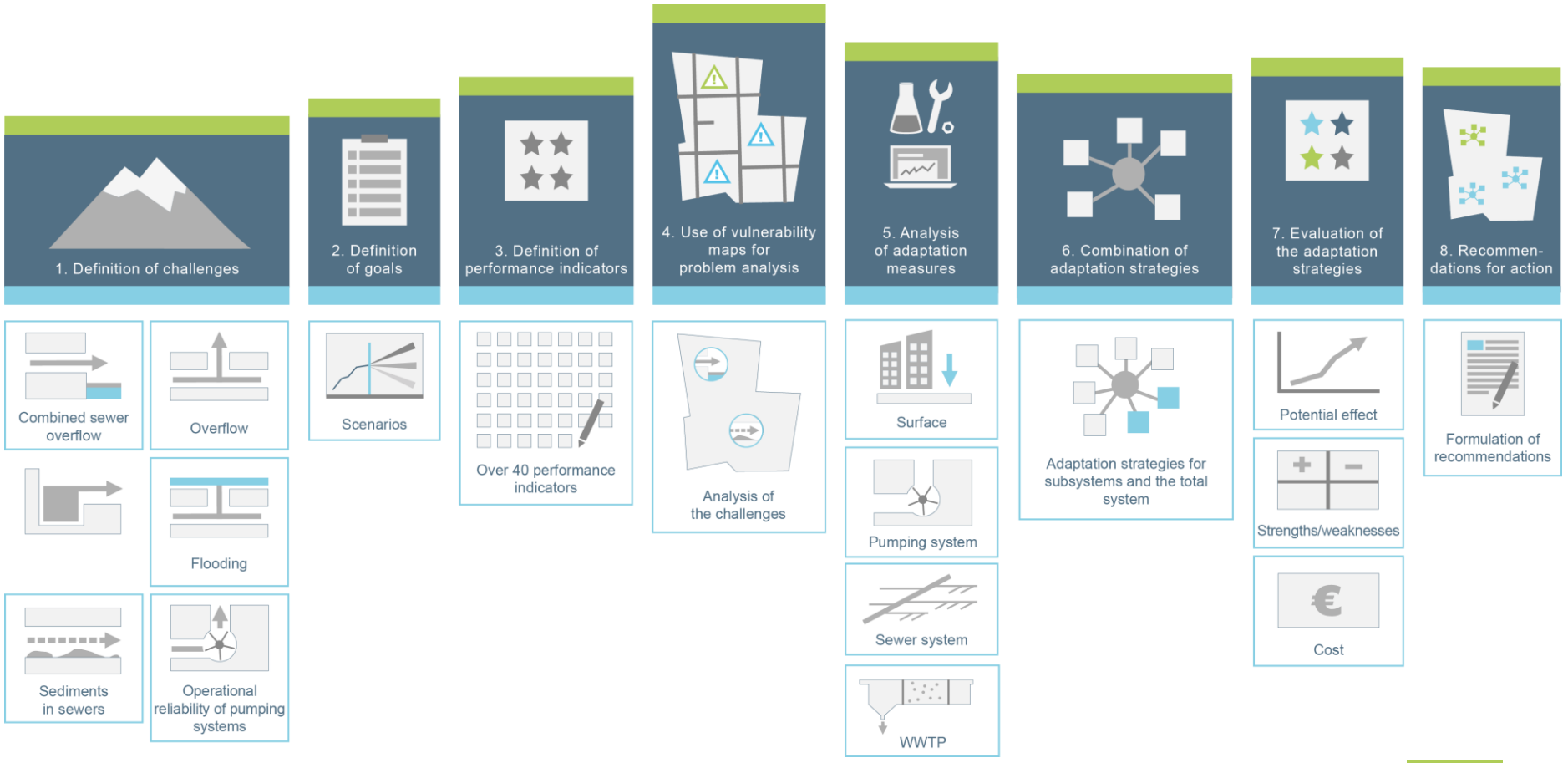


Integrated evaluation of total system



Combination of measures to adaptation strategies

Recommendations for Action



KURAS Outcomes

- **Measure portfolio** with key figures / evaluation / etc.
- **Selected instrument** for planning and evaluation of measures
- **Catalogue** for the planning and of the **measure combinations**
- **Guideline** for the implementation of the method
- **Ecological city map** (published by SenStadtUm)

Soon available on www.kuras-projekt.de

Conclusions

- Great potential to adapt the waste water infrastructure to future challenges through **measure combinations**
- Measure combinations mean increased benefits: **synergies in the system can be used**
- **„KURAS-Method“** for the integrated planning of adaptation measures for urban waste water systems was tested in Berlin and **works!**
- **Unique data set for Berlin** (analysis of individual measures and measure combinations) as well as **extensive guideline** for the application of the method is available in October on **www.kuras-projekt.de** !

Outlook – Water 4.0

- Einstein Center Digital Systems – Chair Water 4.0
- Innovative Infrastrusture for the Challenges of the future
- New projects: IoT / Big Data / Tele Control / etc.
  - Near real time control and operation
  - Early warning systems
  - Decision support systems
  - Optimised data handling
  - Intelligent asset management
  - Cyber security

Thank You for Your Attention