

Drinking water

Current situation and future challenges

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Drinking Water: Interplay between Quantity and Quality

Quantity

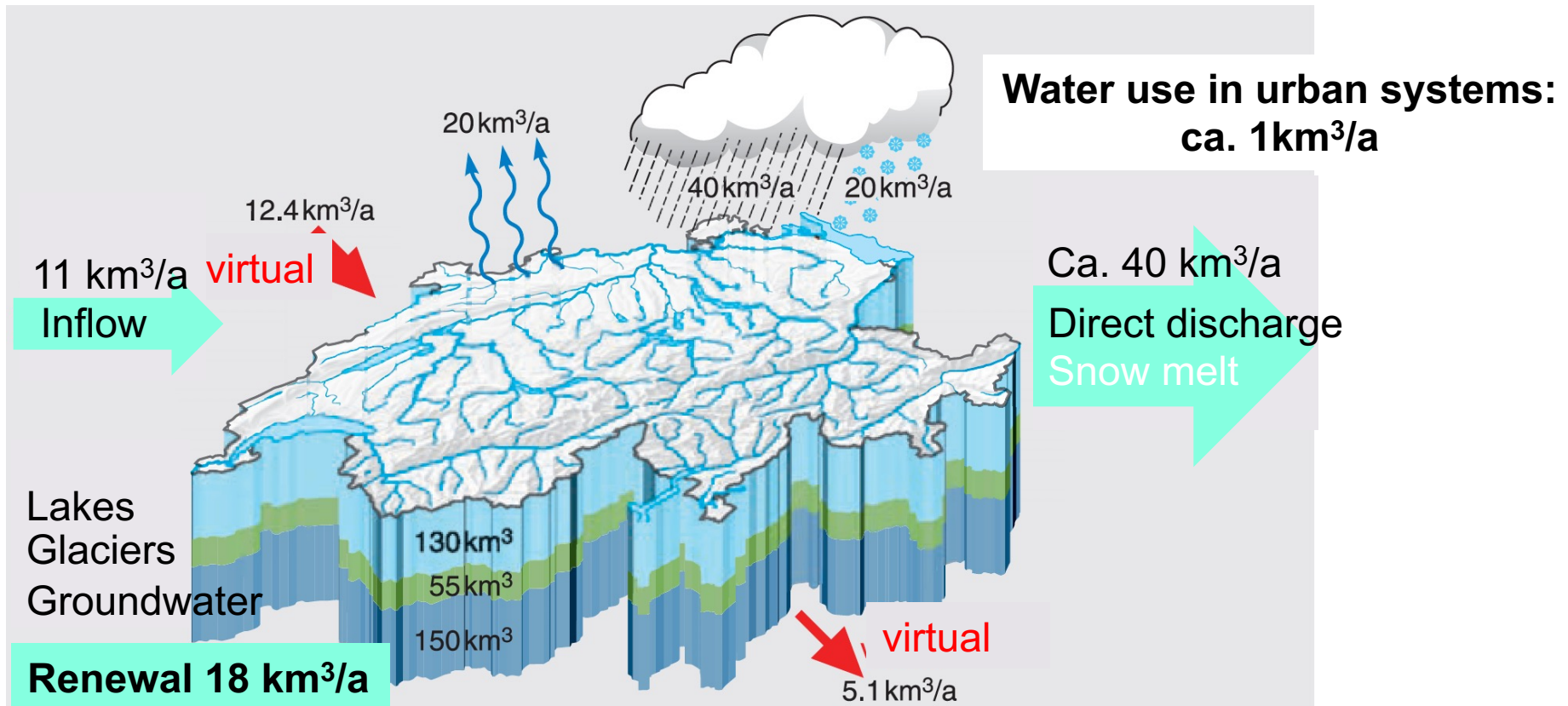
- Precipitation
- Inflow
- Storage capacity
- Water use



Quality

- Hygiene
Viruses, Bacteria, Protozoa
- Chemical Parameters
Water hardness, pH, DOC, dissolved O₂, taste, odor, color, micropollutants (inorganic/organic)

Water balance in Switzerland



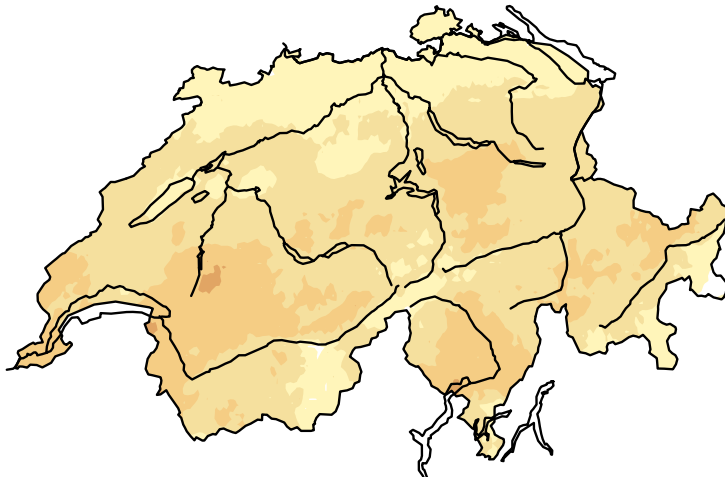
Precipitation in Switzerland – Forecast 2060

Precipitation Deviation (%)

Abweichung von der Normperiode 1981-2010

Summer 2060

RCP8.5
Mittlere Schätzung



-25 -15 -5 5 15 25

Deviation %

Klimaszenarien CH2018

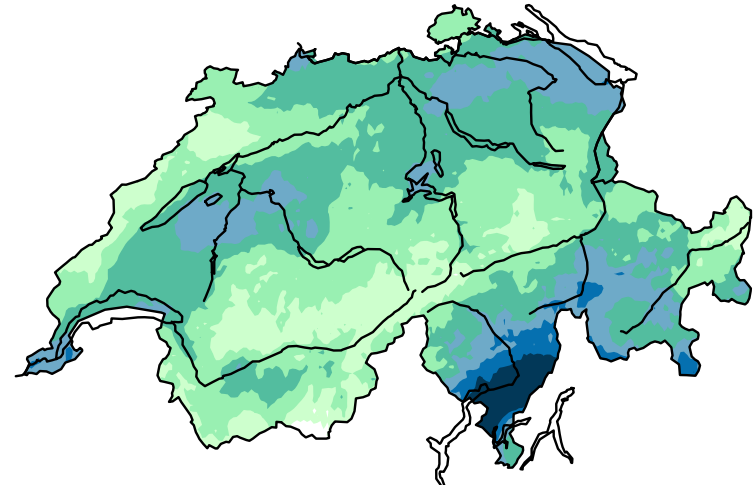
Less precipitation/more intense
Higher demand for irrigation

Precipitation Deviation (%)

Abweichung von der Normperiode 1981-2010

Winter 2060

RCP8.5
Mittlere Schätzung



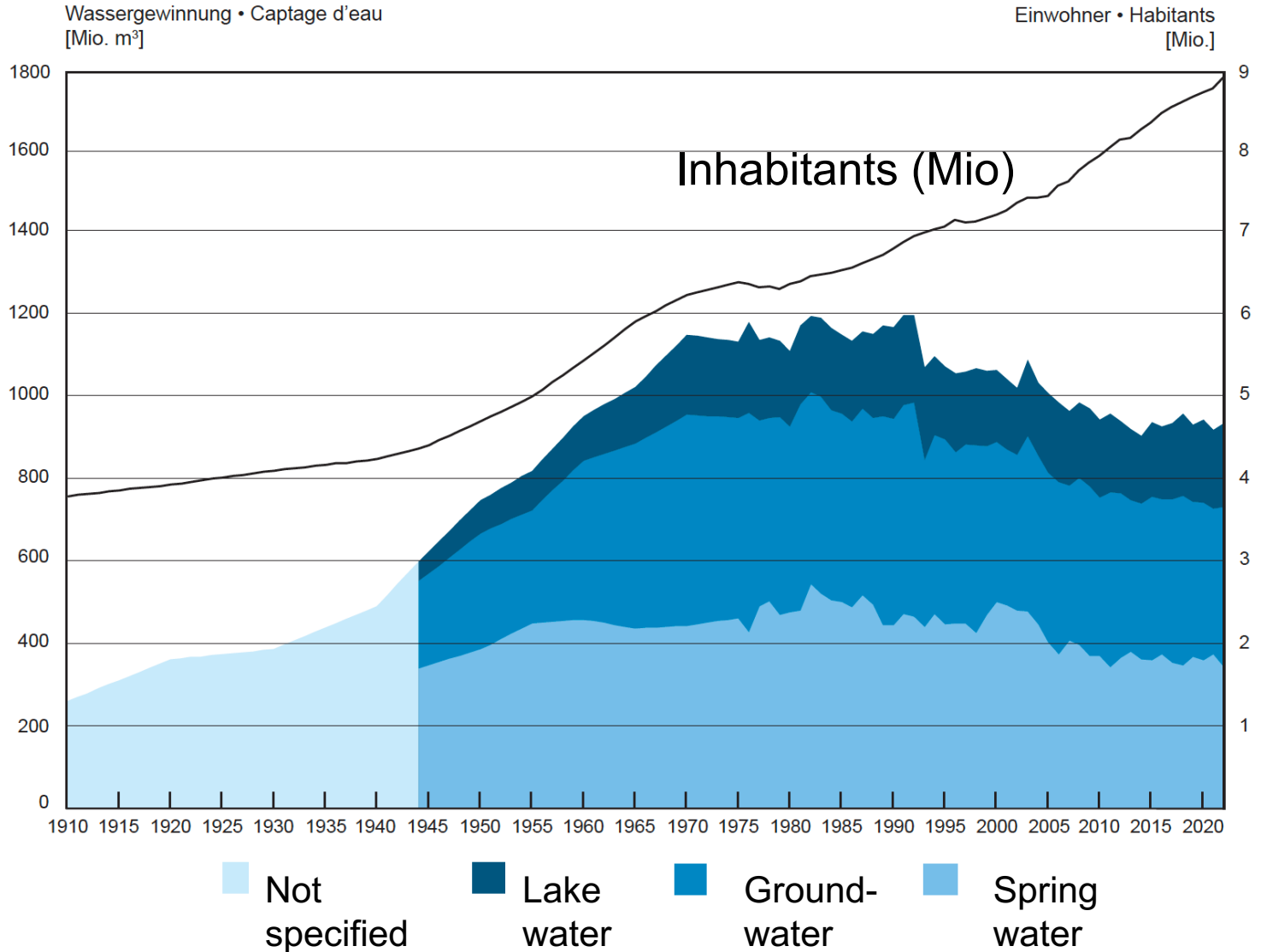
-25 -15 -5 5 15 25

Deviation %

Klimaszenarien CH2018

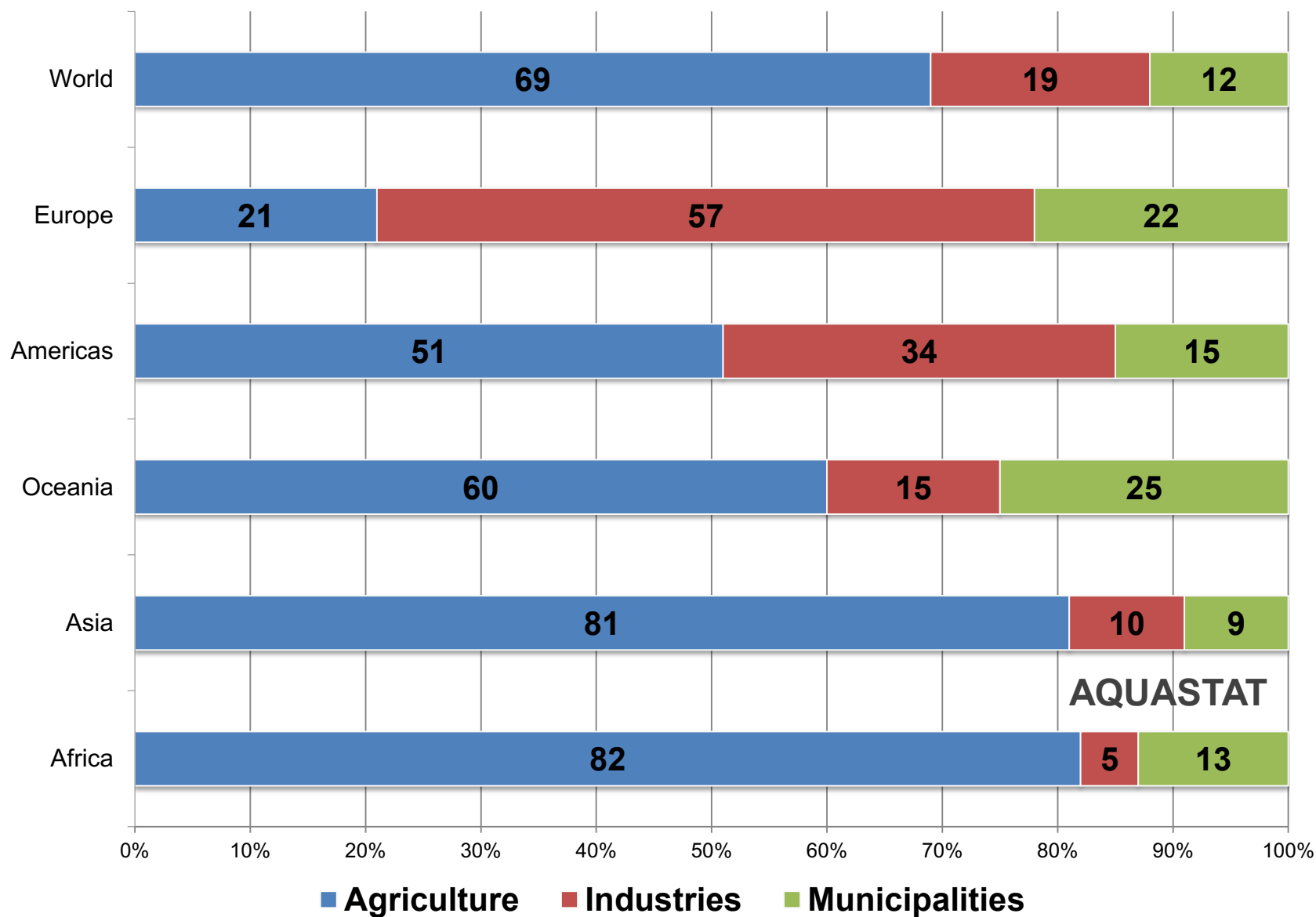
More precipitation/less snow
Less retention/buffer capacity

Development of municipal water use in Switzerland

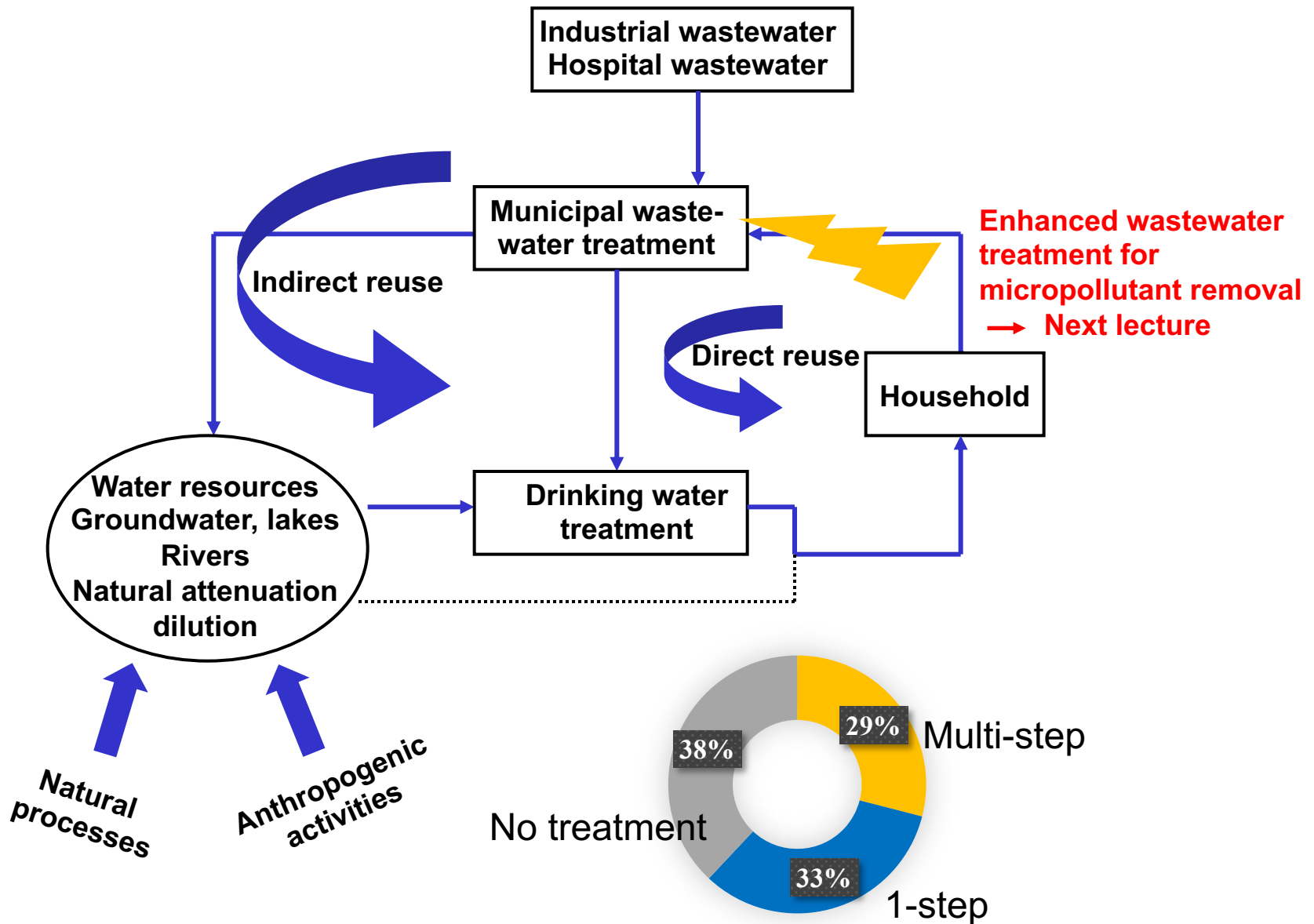


Water production in Switzerland

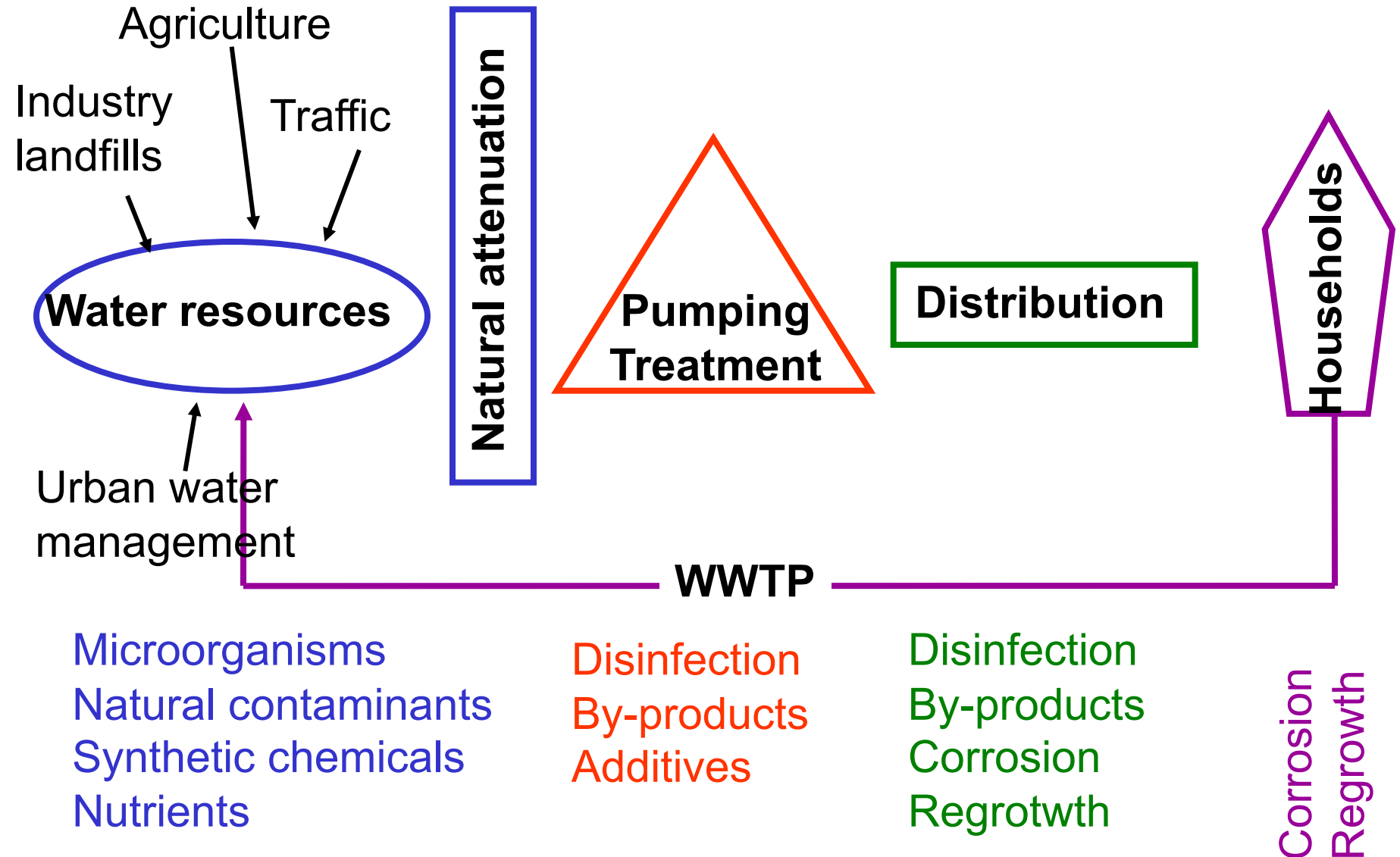
Water withdrawal ratios by continent



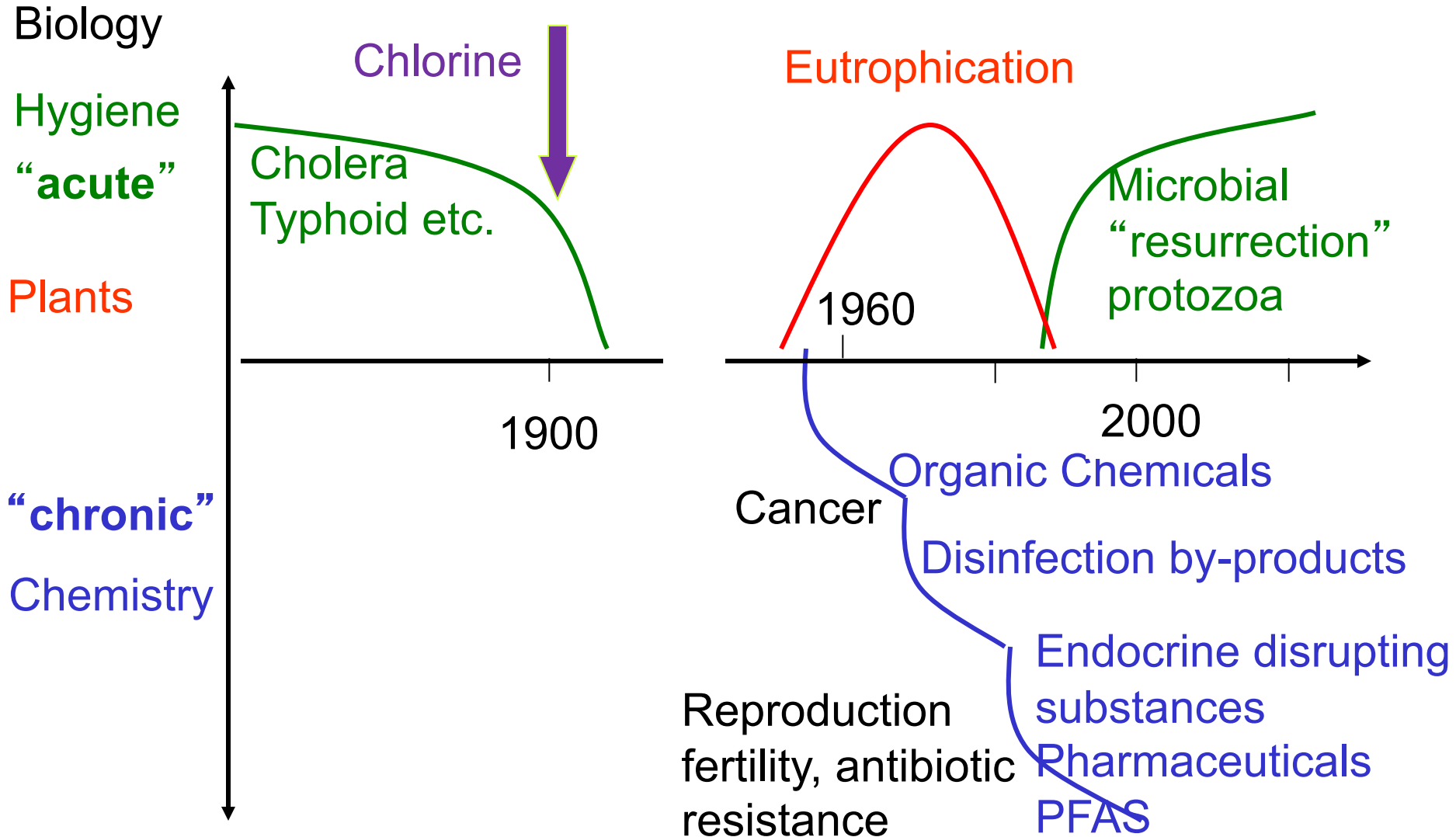
Water quality: The anthropogenic/urban water cycle



Water supply: Possible disturbances of drinking water quality



Development of drinking water problems in industrialized countries in the 20. century



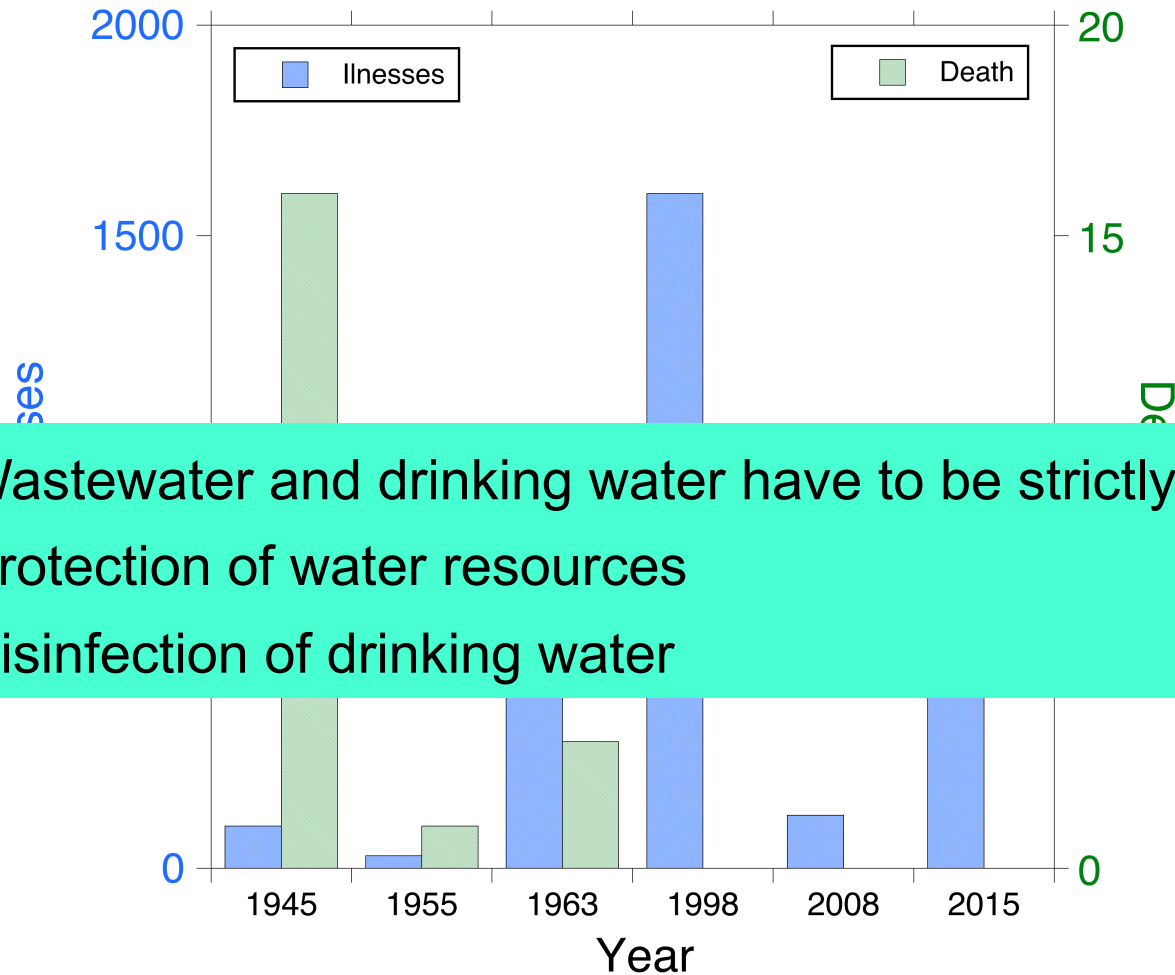
Early water supply in Zurich (> 150 years ago)



1884 Typhoid epidemic
1600 Cases of infection
160 Death

Hygienic problems in drinking water in modern Switzerland

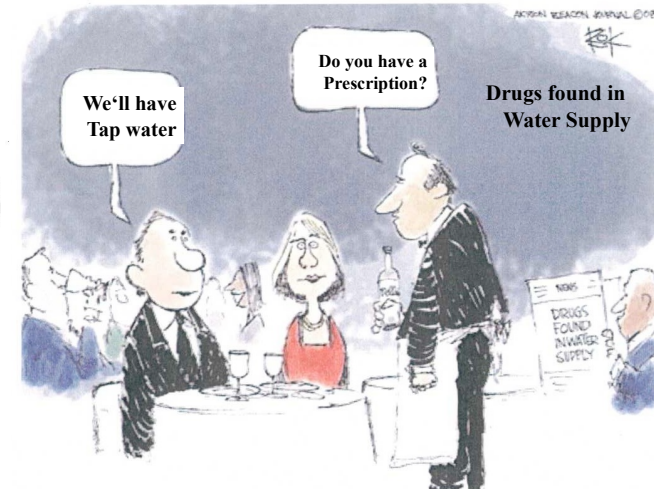
Until 1900: Cholera/Typhoid epidemics in Zürich and other cities



- Wastewater and drinking water have to be strictly separated
- Protection of water resources
- Disinfection of drinking water

Diverse present drinking water issues

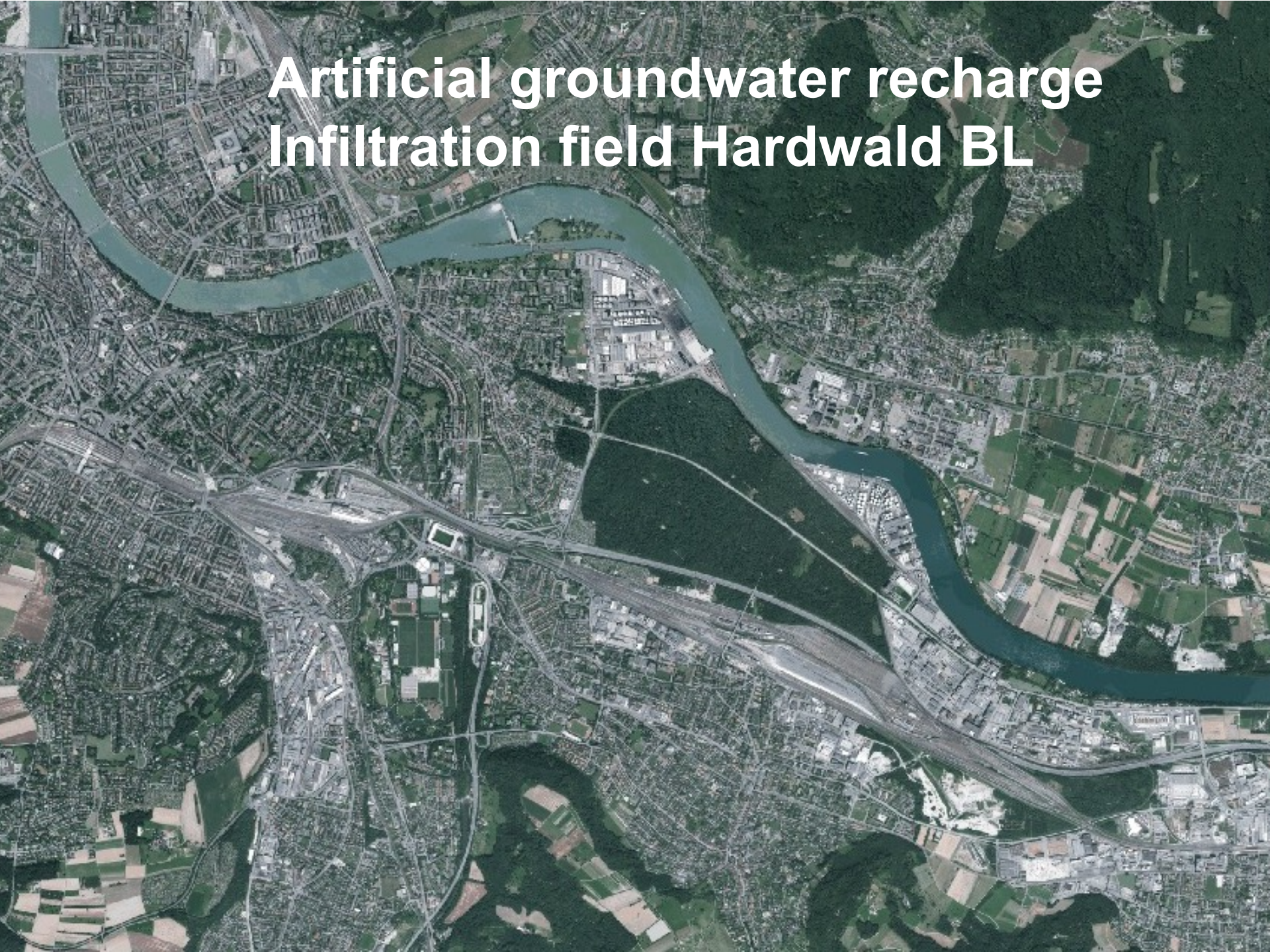
- Pesticides in groundwater: Metabolites of cholorothalonil (ca. 1 Mio people affected in the Swiss Plateau) -> Action plan pesticides
- Forever Chemicals (Per- & polyfluoralkyl substances, PFAS). Depending on the drinking water standard 25% of Swiss drinking water could be affected
- Hormones in drinking water: A persistant rumor
- Quagga muscles in Swiss lakes
- Micro- und nanoplastics
-



Unit processes and process combinations for drinking water treatment

- Sedimentation
- Filtration
 - Filtration/sand - coagulation (particles-colloids)
 - Membrane filtration (particles – molecules - ions)
 - Activated carbon (particles/adsorption - molecules)
 - Biological filtration (particles/adsorption/degradation)
- Chemical Oxidants
 - Disinfection
 - Chemical Oxidation
- UV-Disinfection
- Process combinations

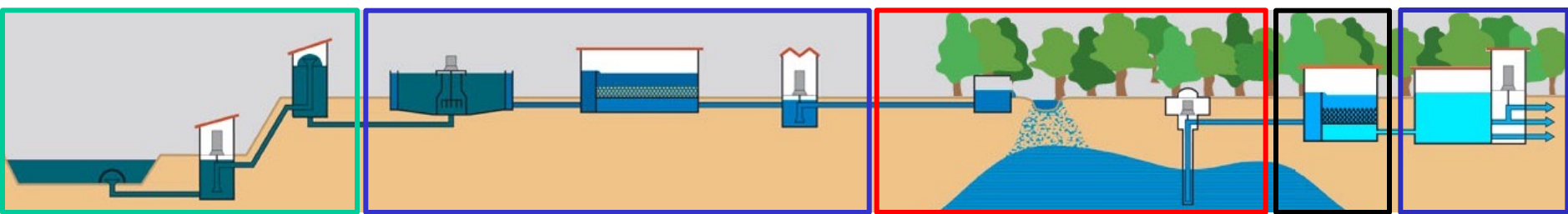
Artificial groundwater recharge Infiltration field Hardwald BL



Infiltration field Hardwald BL



Artificial groundwater recharge: Hardwald, Baselland



**1. River Rhine
pumping station**

2. Pre-treatment
(Sedimentation / Rapid sand filtration)
Particle removal

3. Artificial recharge
(Hardwald forest)
Biological
treatment

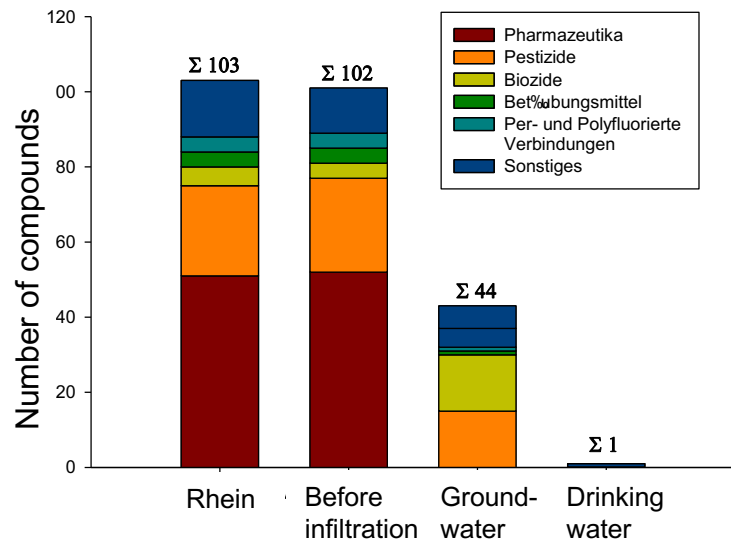
**4. GAC
Filter
UV**

5. Distribution

Physical-
chemical
post-treatment

Rhine river
Sandfilter
Groundwater

DOC 1.66 mg/L
DOC 1.54 mg/L
DOC 0.55 mg/L

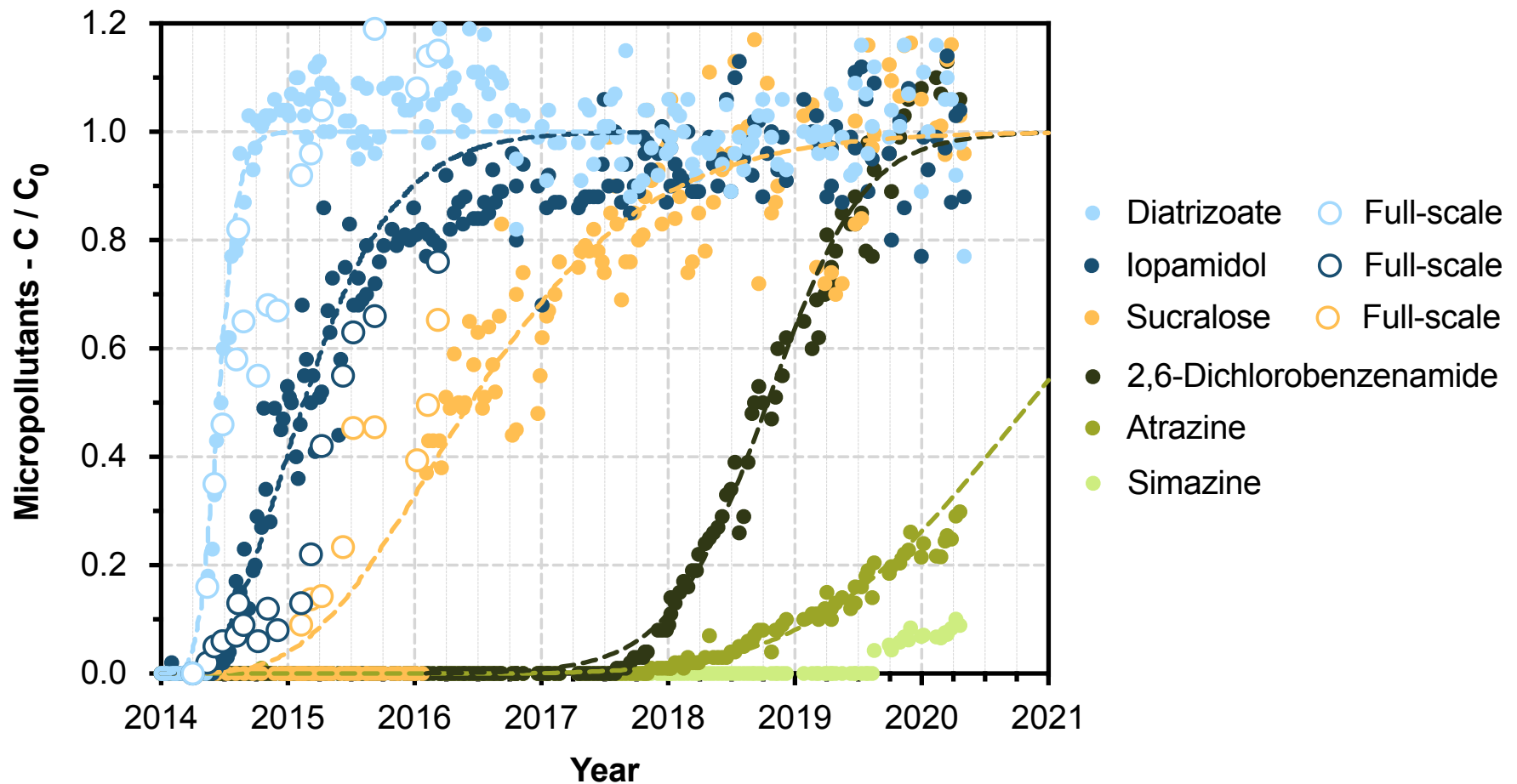


Pilot plant to investigate micropollutants abatement

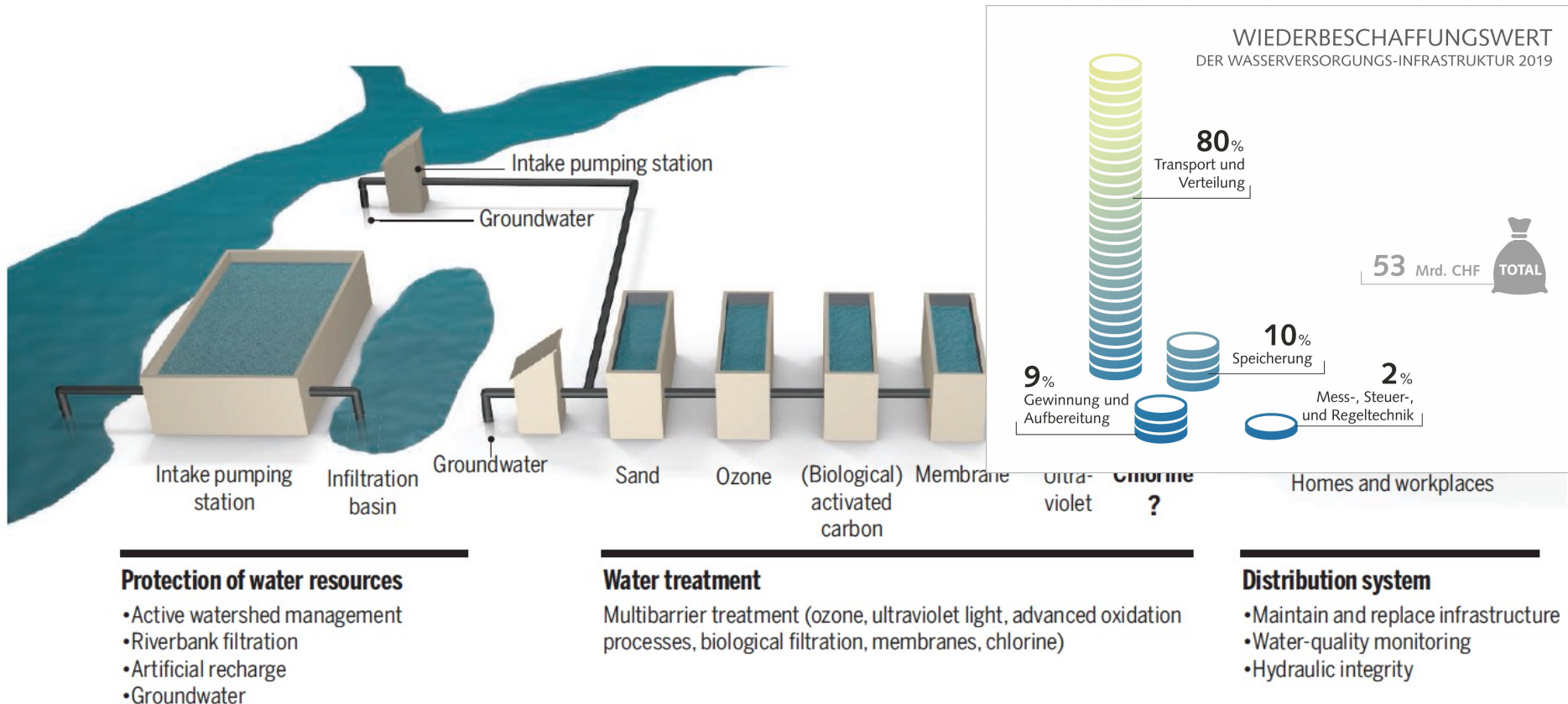


Activated carbon – Breakthrough of micropollutants

Rapid small-scale column tests and full-scale



Drinking water as a multibarrier system: no or limited residual disinfectant required in distribution system



Protection of water resources

- Active watershed management
- Riverbank filtration
- Artificial recharge
- Groundwater

Water treatment

Multibarrier treatment (ozone, ultraviolet light, advanced oxidation processes, biological filtration, membranes, chlorine)

Distribution system

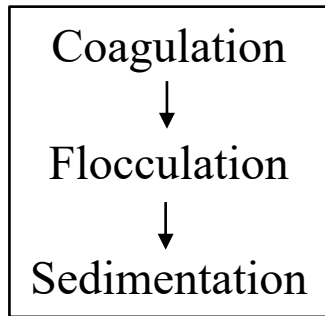
- Maintain and replace infrastructure
- Water-quality monitoring
- Hydraulic integrity

Article on moodle

Rosario-Ortiz, F., Rose, J., Speight, V., von Gunten, U. and Schnoor, J. (2016) How do you like your tap water? Science 351(6276), 912-914.

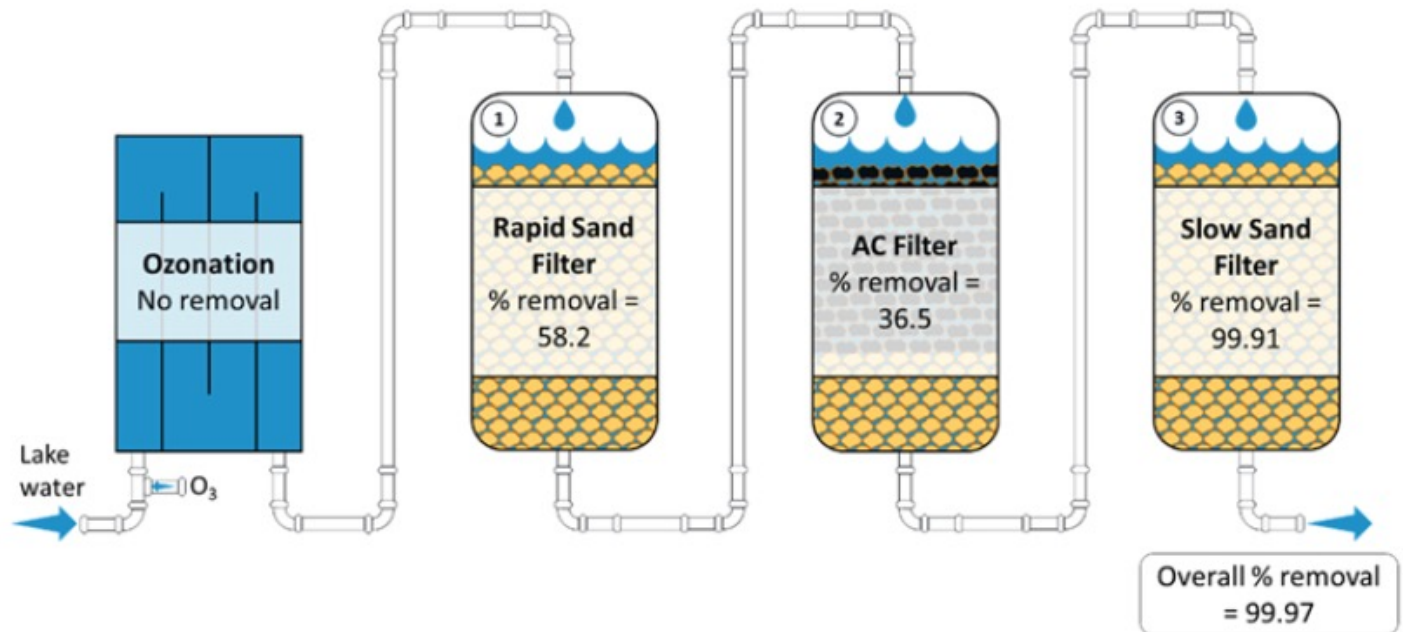
Removal of nanoplastics (160-220 nm) Entfernung von Nanoplastik (160-220 nm) during filtration: Pilot experiments and Computer simulations

Au/Pd doted
nanoplastic was dosed



≥ 90% NP removal

Removal of nanoplastics during typical drinking water treatment processes



Droughts in Switzerland in 2018 (2022, etc.):

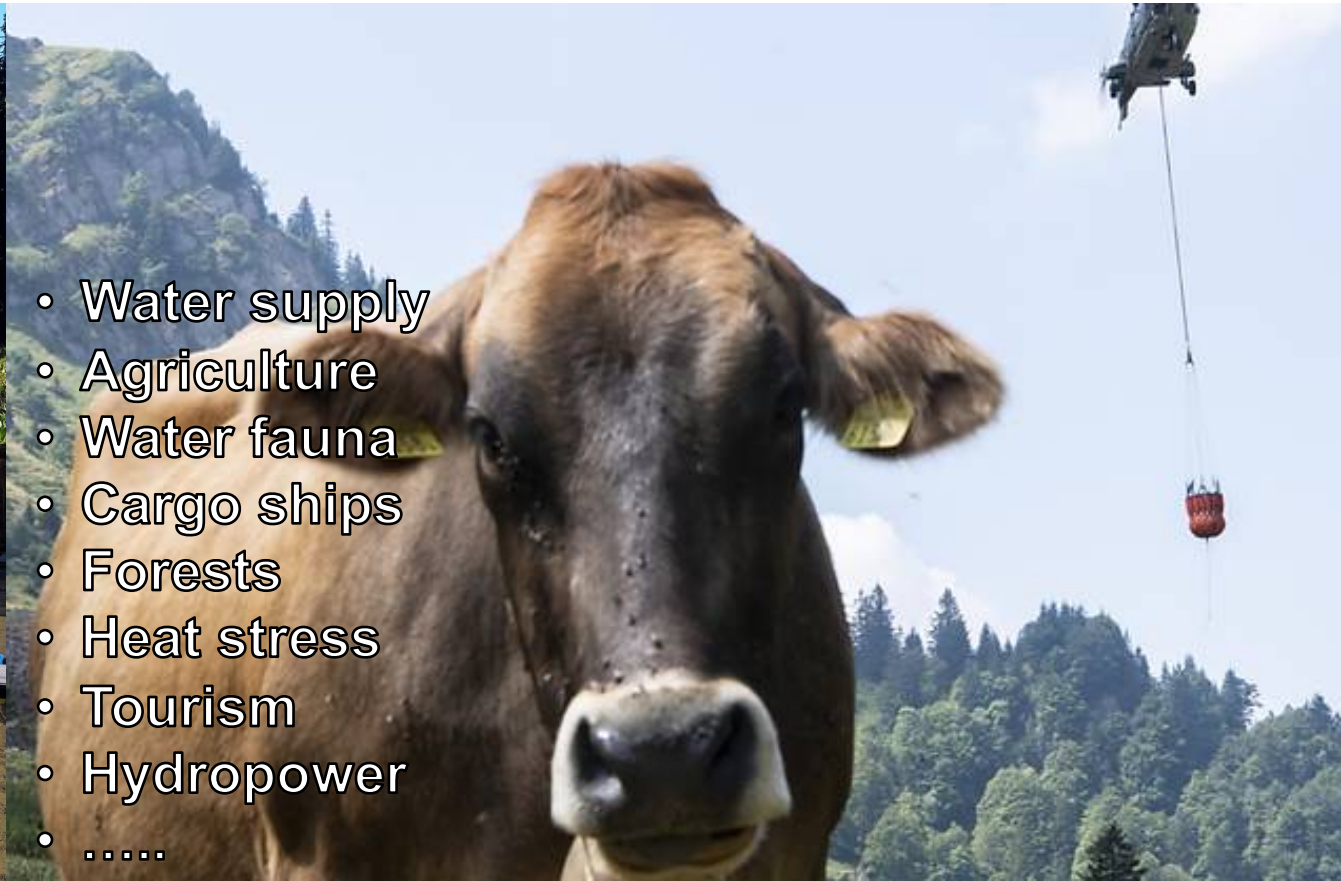


https://www.schweizersee.ch/lac_brenet/



Lac Brenet, Anthony Anex, Keystone

- Water supply
- Agriculture
- Water fauna
- Cargo ships
- Forests
- Heat stress
- Tourism
- Hydropower
-

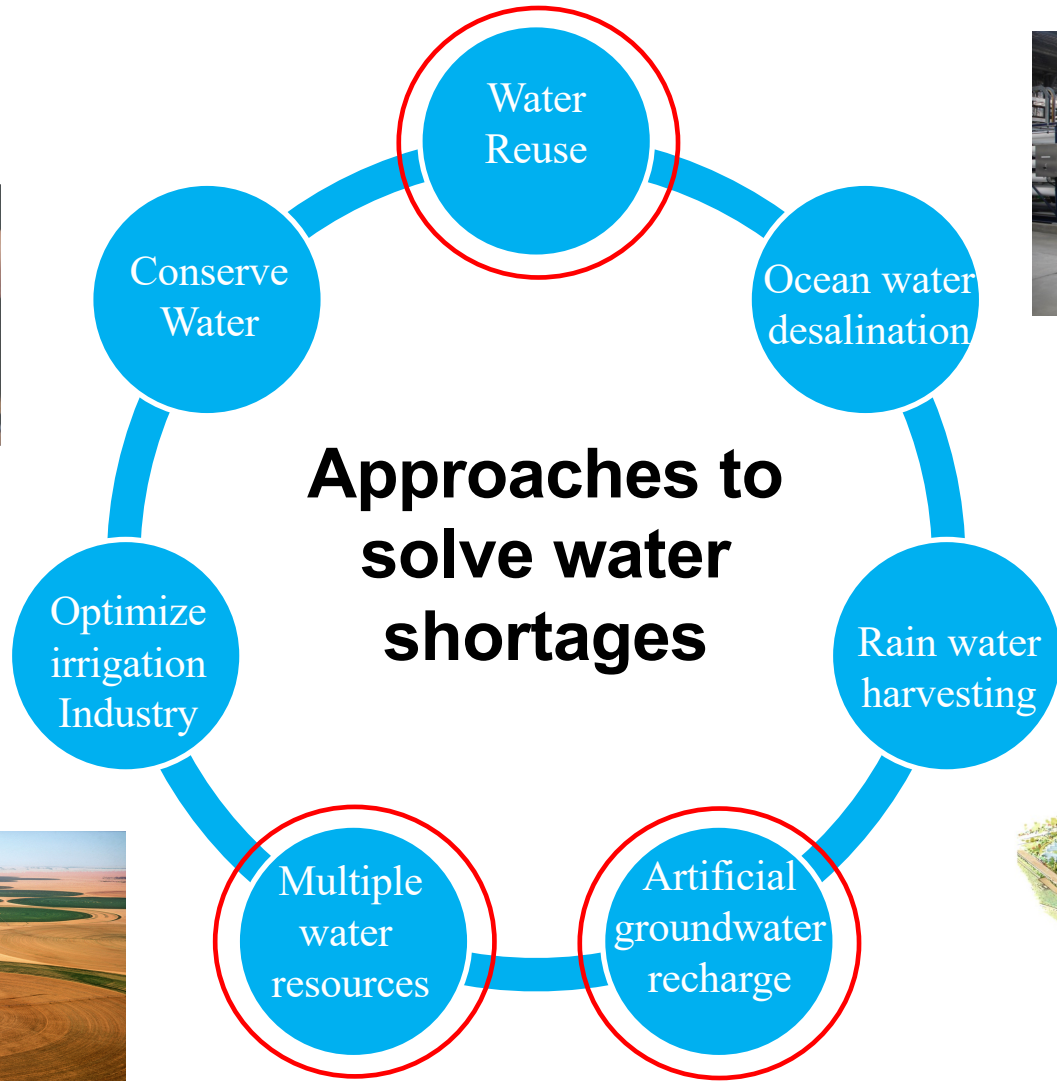


Water crises worldwide



- Windhoek (Namibia, end of 1970s)
- Australia (2000s, Perth, Brisbane)
- California (drought: 2011-2017, 2019-?)
- South Africa (2017/2018)
- Italy, Spain, Greece
- Singapore (water autonomy)
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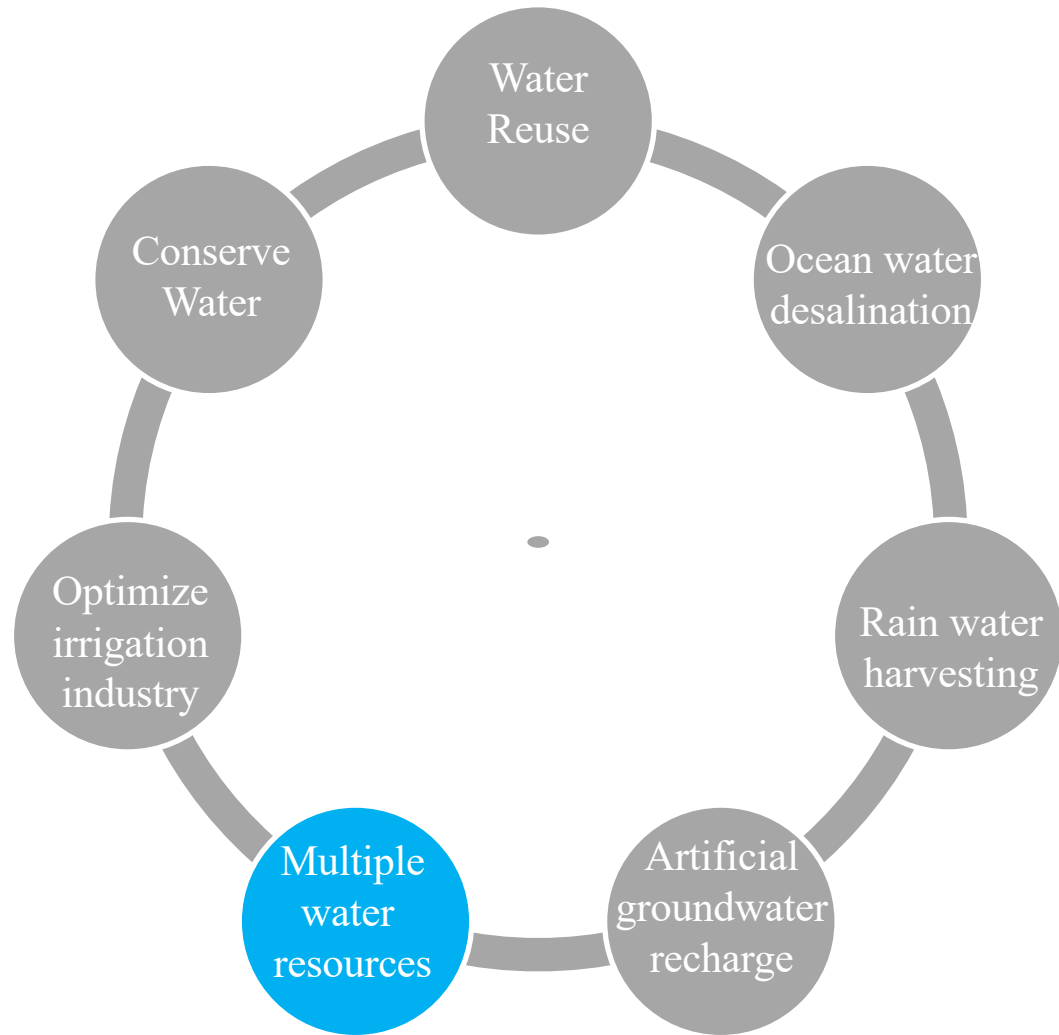
Wem gehört das Wasser?
Lars Müller Verlag, 2006



Reverse Osmosis



Rory M. Shaw
Wetland Park, LA



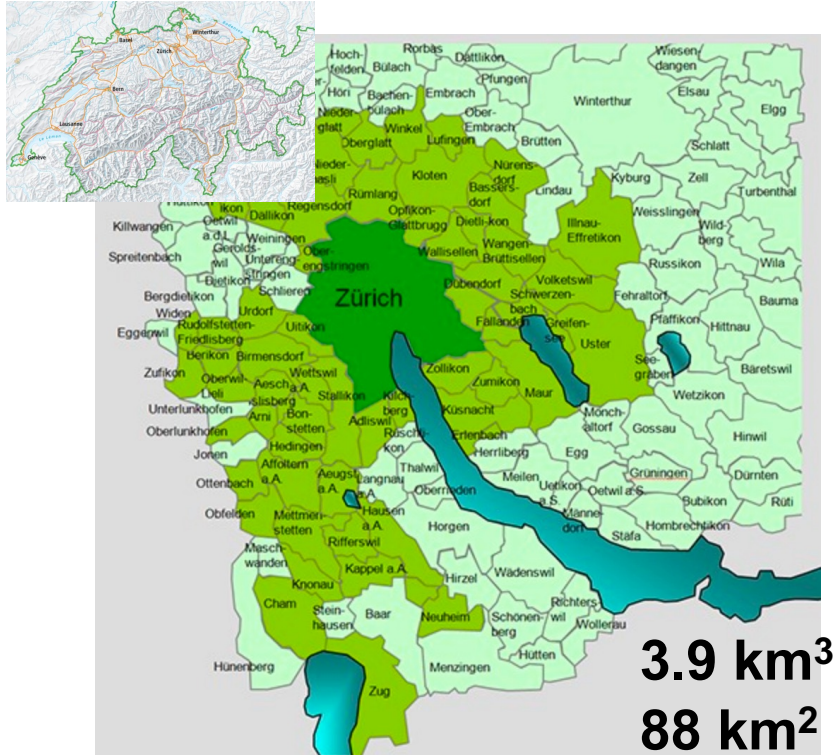
Multiple water resources



Brunnen am Zumiker Rastplatz Mühlitobel, Zürichsee-Zeitung, 16. August 2016

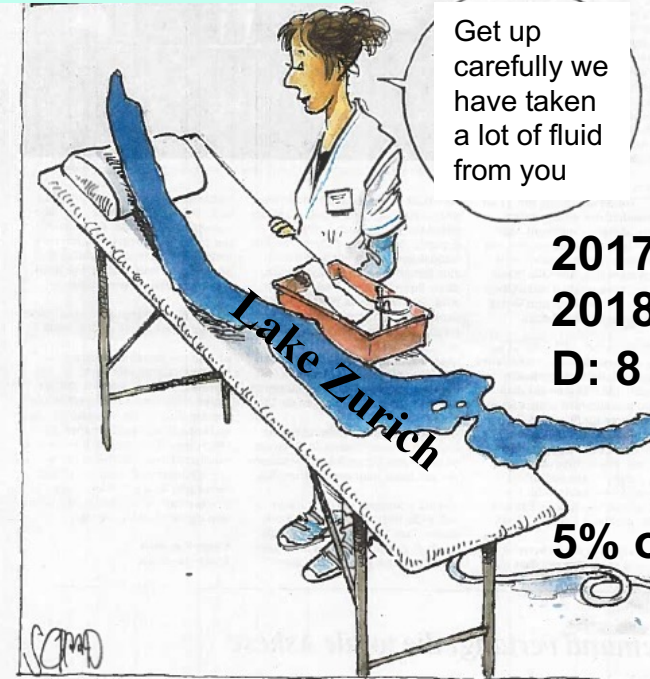
A resilient solution through multiple water resources

Water provision from the water supply Zürich to 67 communities



Water donation

Summer 2018



2017: 43 cm

2018: 51 cm

D: 8 cm

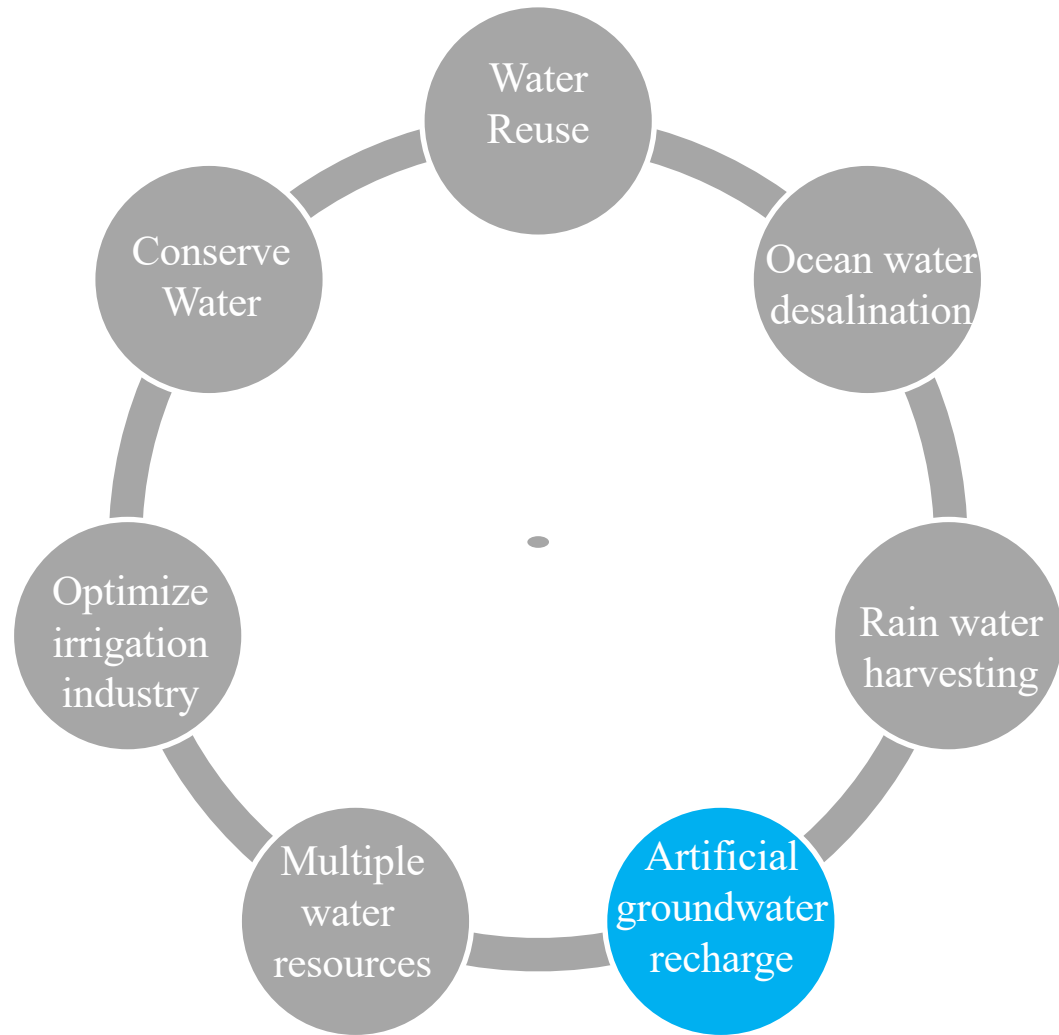
5% of the inflow

Schaad, TA, Sept. 2018, A. Peter WVZ, Jan. 2019,

<http://www.hydrodaten.admin.ch/de/2104.html>

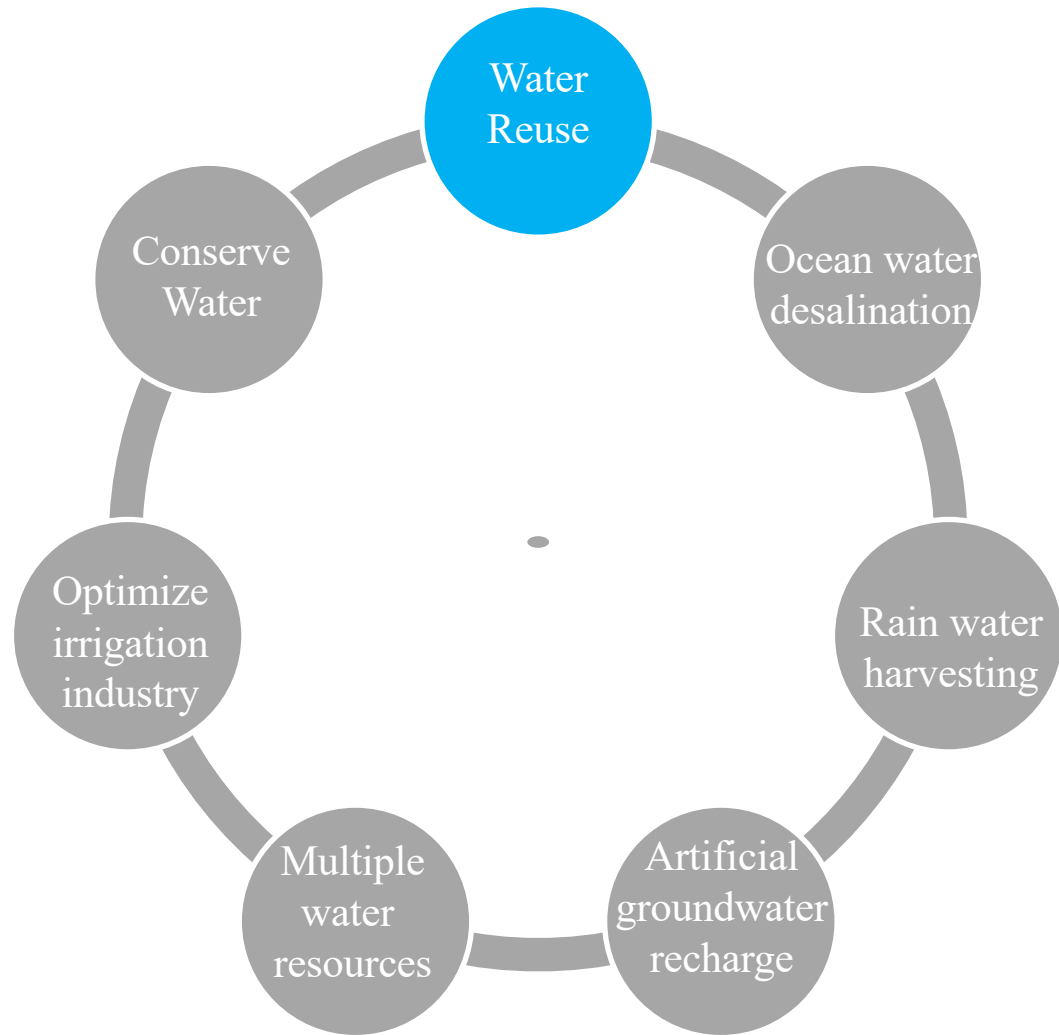
[https://www.stadt-](https://www.stadt-zuerich.ch/dib/de/index/wasserversorgung/wasserverteilung/versorgungsgebiet.html)

[zuerich.ch/dib/de/index/wasserversorgung/wasserverteilung/versorgungsgebiet.html](https://www.stadt-zuerich.ch/dib/de/index/wasserversorgung/wasserverteilung/versorgungsgebiet.html)

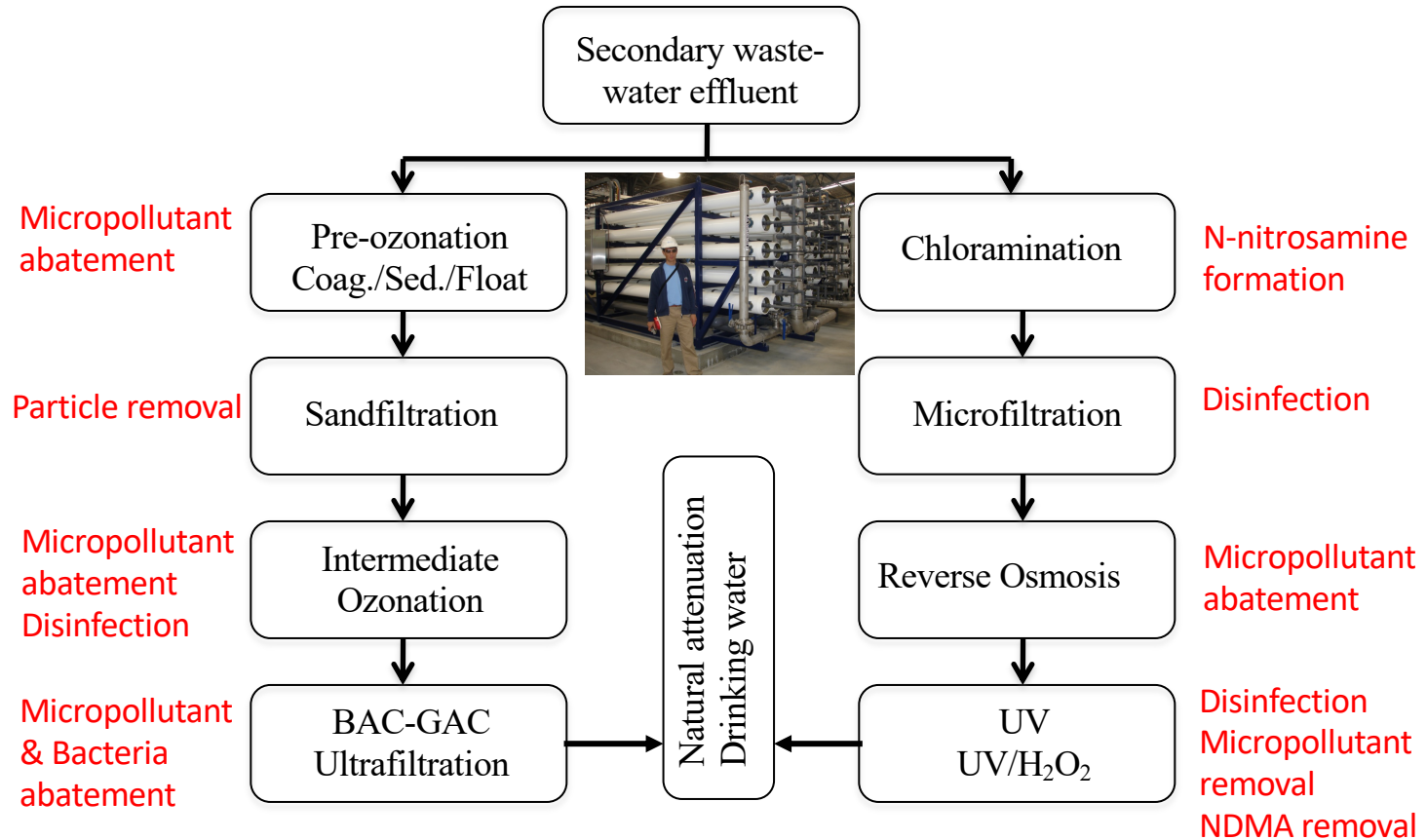


Artificial groundwater recharge in Hardwald BL

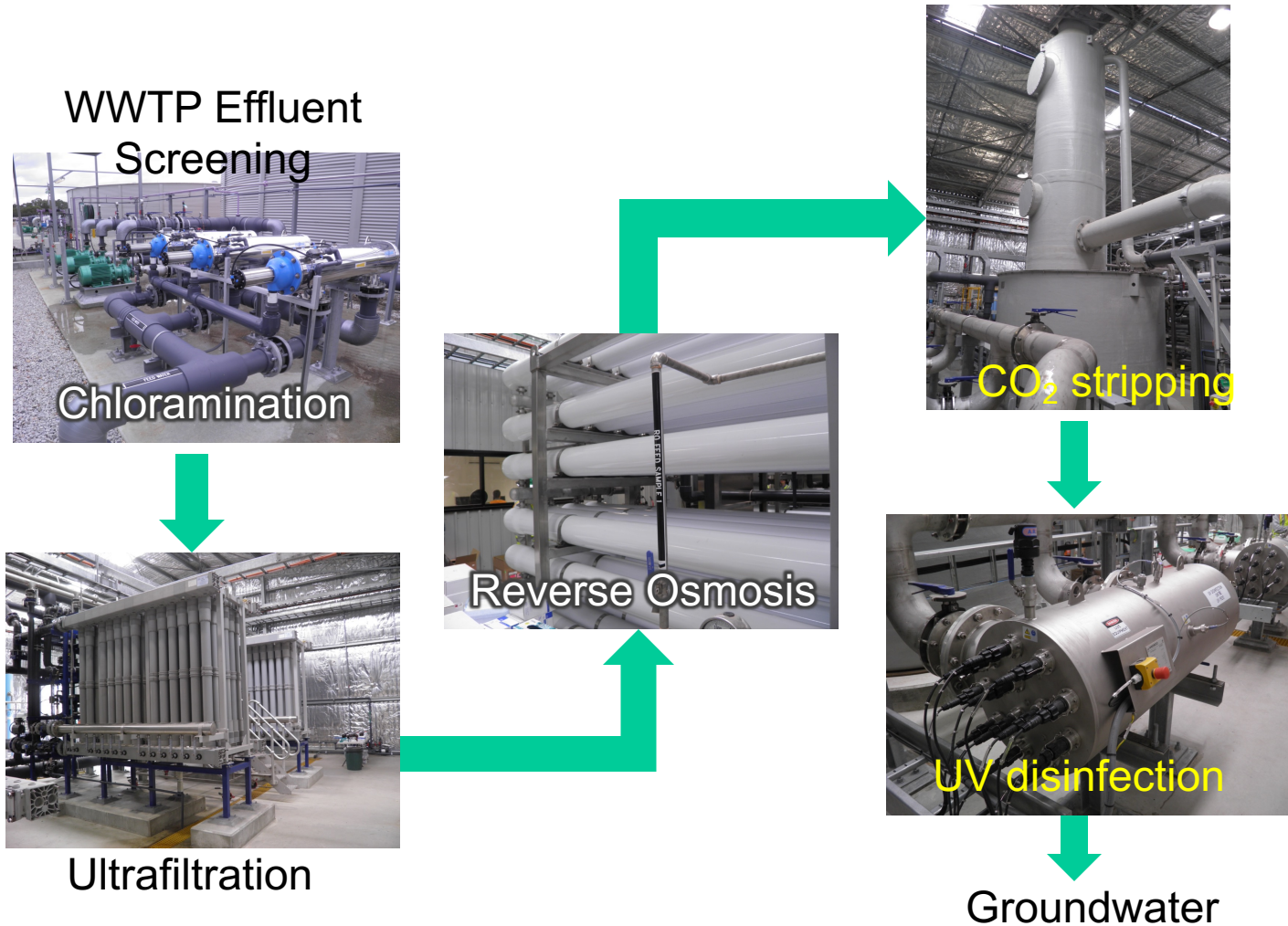




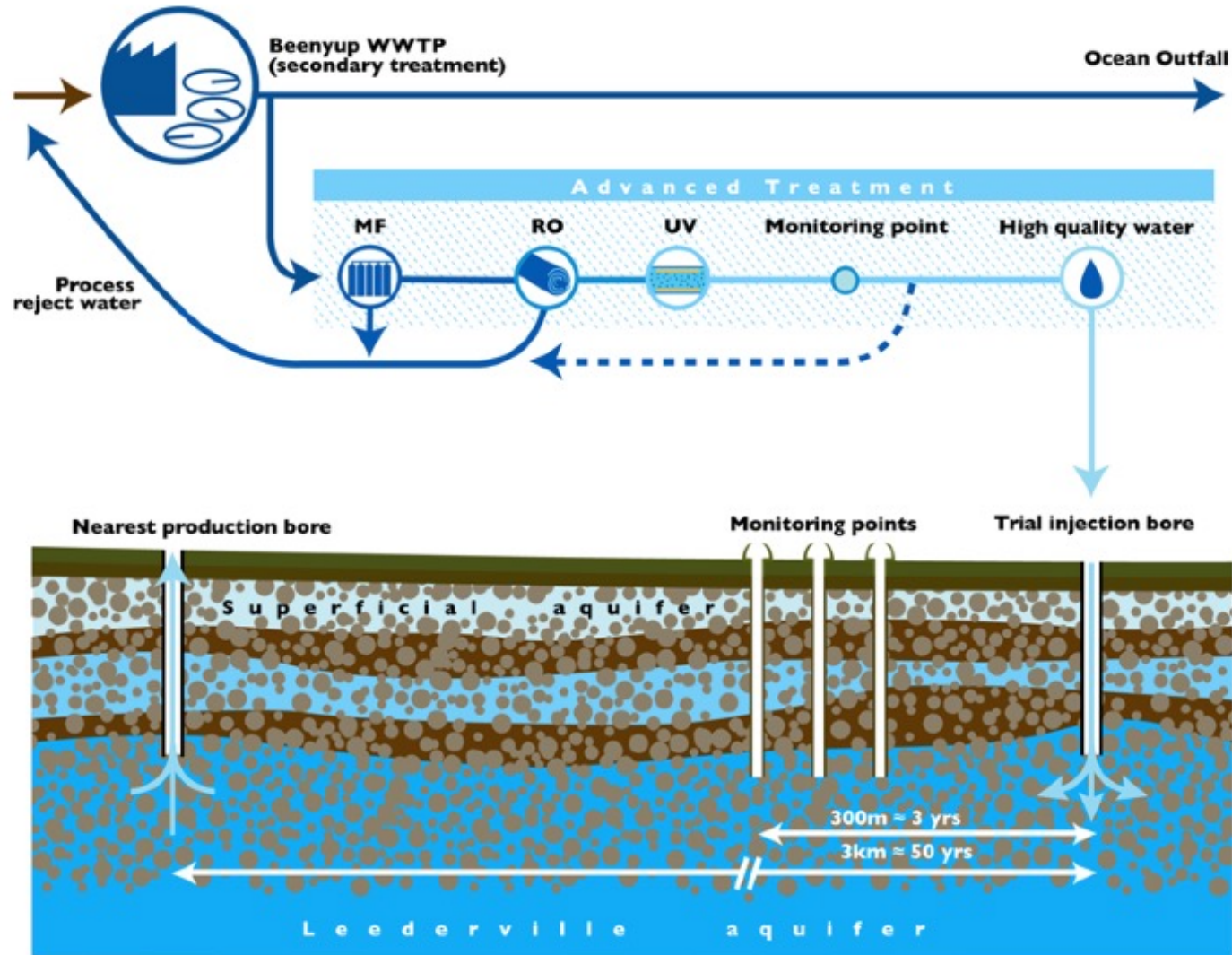
Intended (in)direct potable reuse



Water reuse trial plant (Perth, WA)



Wastewater-recycling in Perth Western Australia

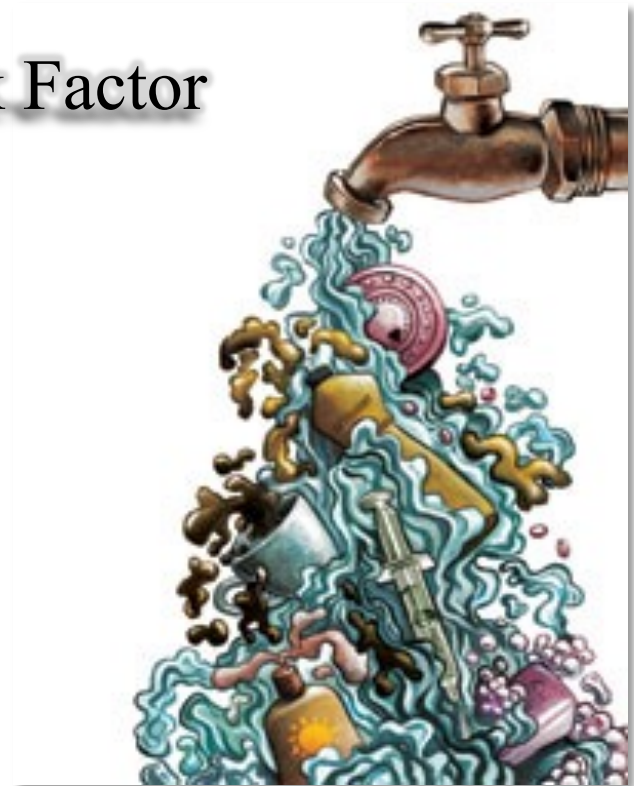


What is the perception of recycled wastewater in the media/in the public?



By Paul Lachine

The Yuck Factor



Source: <http://www.hcn.org/issues/354/17227>

Closing the anthropogenic water : (in)direct potable reuse

- Technical feasibility has been demonstrated
- Process optimization for improvement and/or alternatives
- Public perception as an important factor (Singapore vs Australia)
- Scientists and engineers must be engaged in public debate and clearly communicate benefits and problems to allow an objective assessment

Drinking water quality

- Hygiene!
- Drinking water has a very high status as food (no free choice)
- Often only small fraction of pollutants from drinking water
- Drinking water standards: Human toxicology/precaution
- 4 pillars: Water resources protection, drinking water treatment, distribution, household
- OECD states: small differences in legislation (Human toxicology vs precaution)