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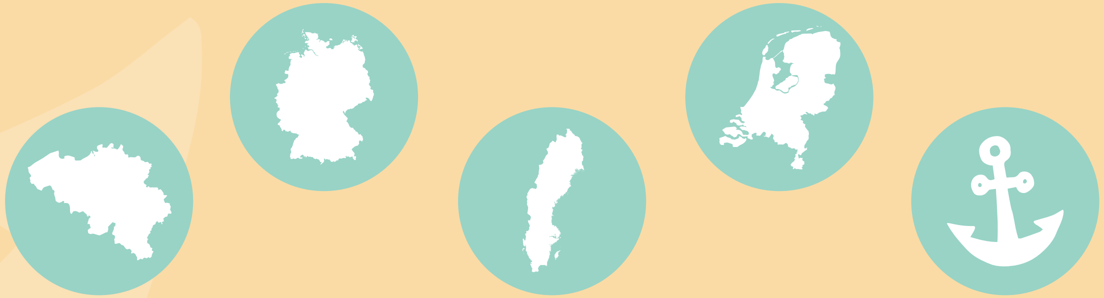
ANCHOR Greywater



4th Anchor Lunch Talk

December 2nd 2024

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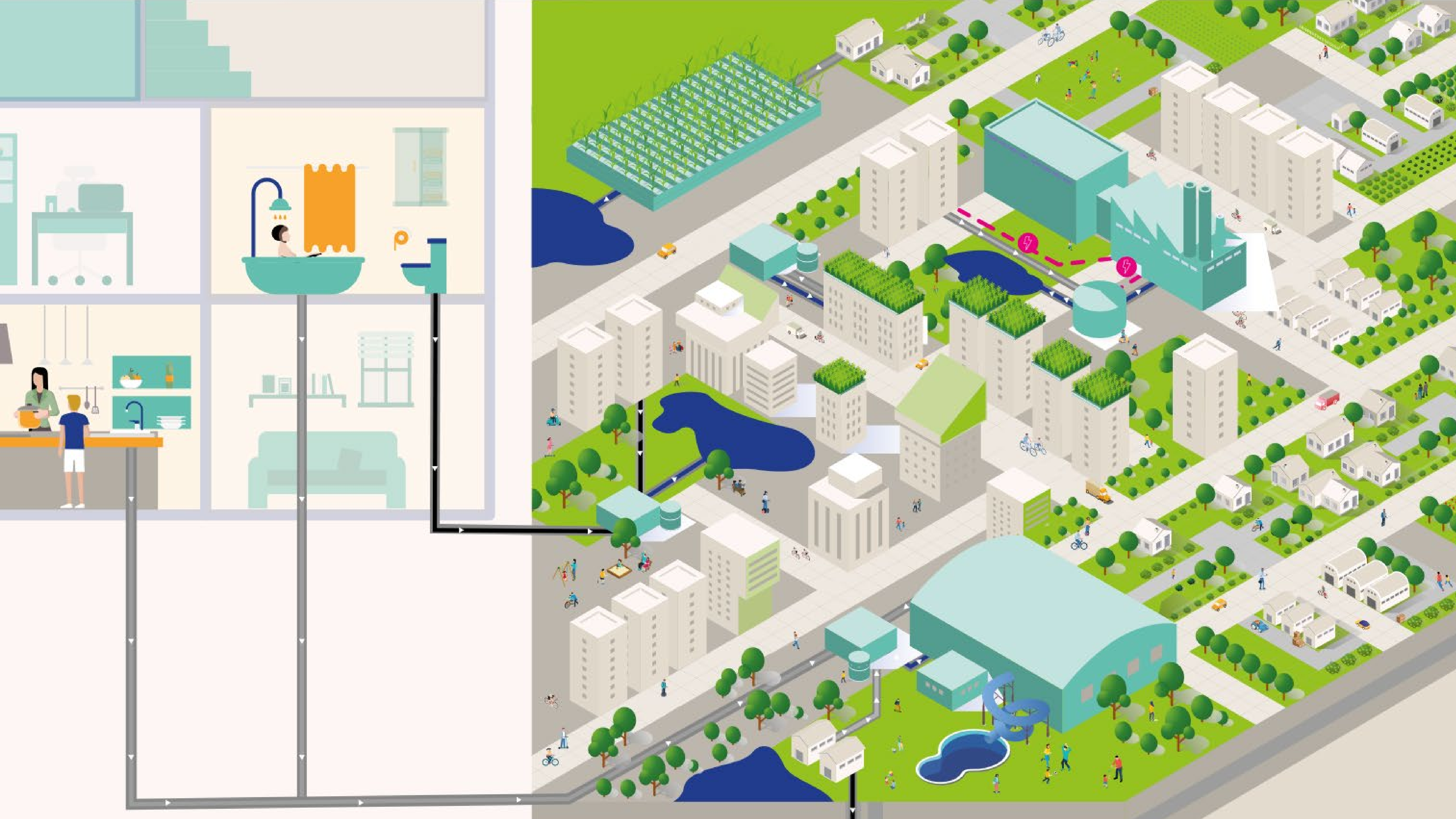
provincie Oost-Vlaanderen
vito
DuCoop
HAMBURG WASSER
Bauhaus-Universität Weimar
waternet waterschap amstel gooi en vecht gemeente amsterdam
KWR
Stockholms stad
NSVA NORDVÄSTRA SKÅNES VATTEN OCH AVLOPP

Let’s fuel ”
the transition towards
water wise
neighbourhoods



HOW?

- By gathering experiences from a **unique EU demo network** in Belgium, the Netherlands, Germany and Sweden with **source separation technology**, and expanding it with **new pilots**
- By mapping the impacts of **decentralized water systems** in urban areas
- By closely **engaging with stakeholders**
- By delivering **practical tools and transition knowledge**

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WHO?

vito

DuCoop

HAMBURG WASSER

Bauhaus-Universität Weimar

waternet
waterschap amstel gooi en vecht
gemeente amsterdam

KWR

Stockholms stad

NSVA
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Anchor Lunch Talks

AGENDA

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- Why should one collect greywater separately from blackwater? (Dr. Gregor Rudolph-Schöpping)
- Greywater treatment in Helsingborg (Ashley Hall)
- Greywater treatment in Hamburg (Lukas Cordts)
- Greywater treatment and industrial reuse in Ghent (Dries Seuntjens)
- Q&A

Gregor Rudolph-Schöpping | HAMBURG WASSER | 02.12.2024

Why should we have separate greywater treatment?

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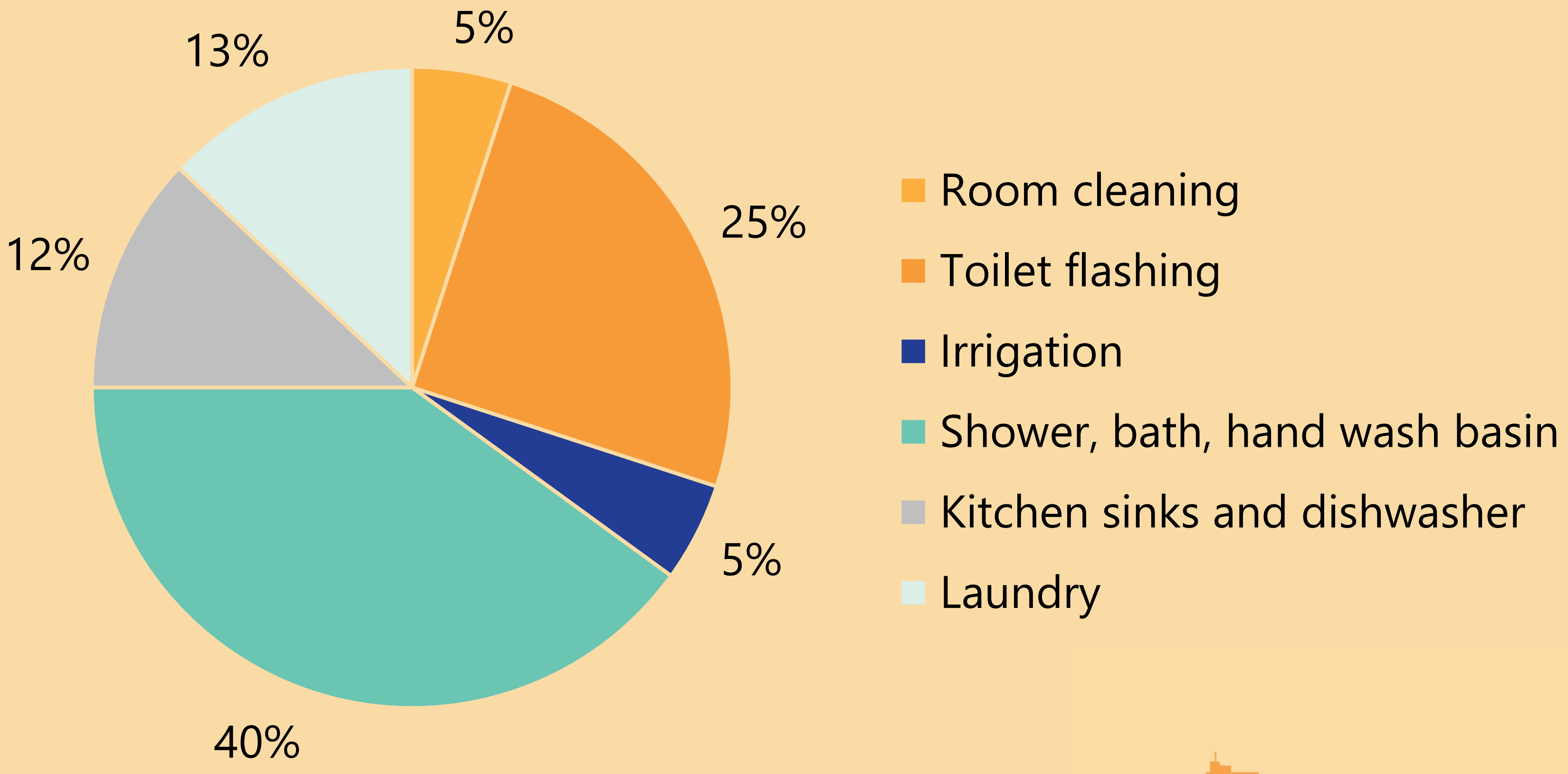
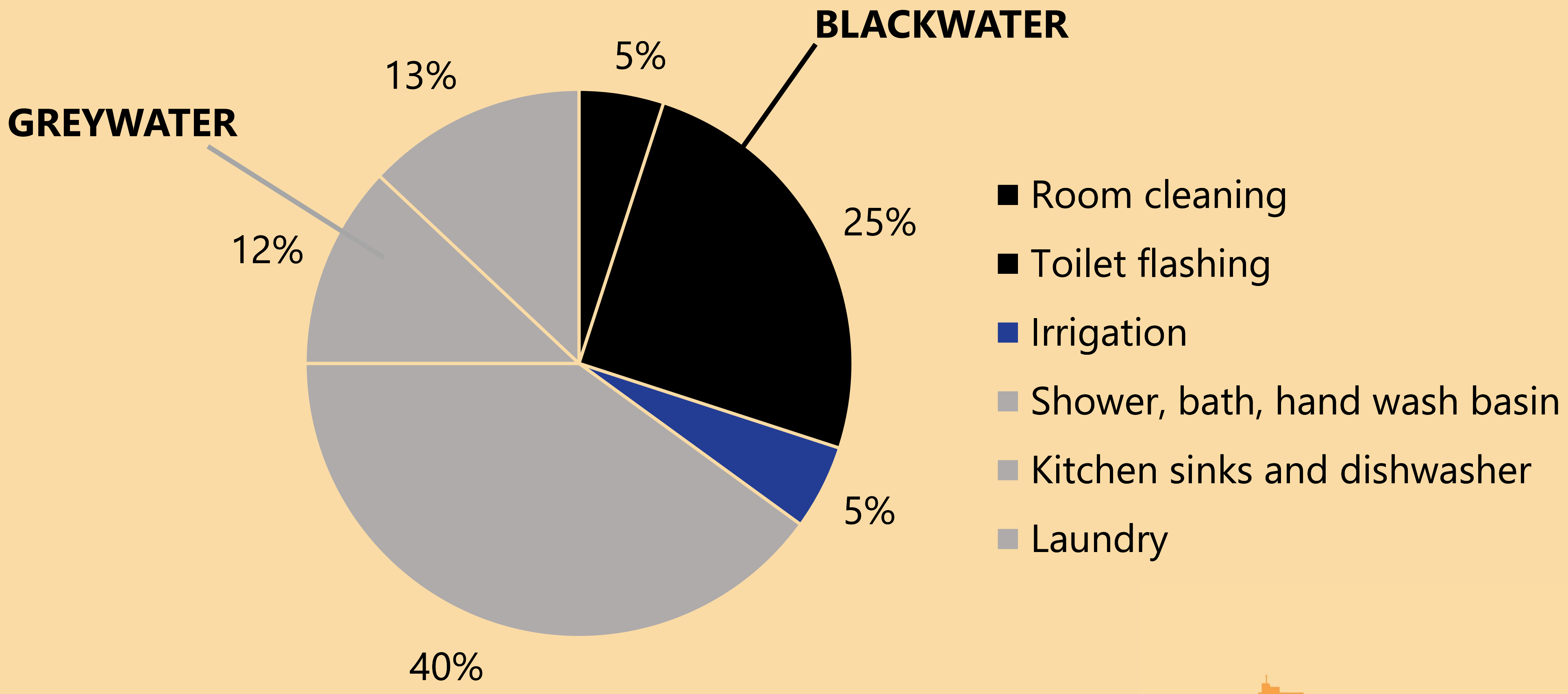
Motivation

- **Facing Extreme Weather:** Climate change is bringing more droughts and floods, challenging our water management.
- **Urgent Need for Sustainability:** We must adopt sustainable practices to manage our increasingly scarce water resources.
- **Rethinking Wastewater Systems:** We need novel and innovative thinking to adapt our traditional wastewater systems.

What do we use drinking water for?



Where does it end?

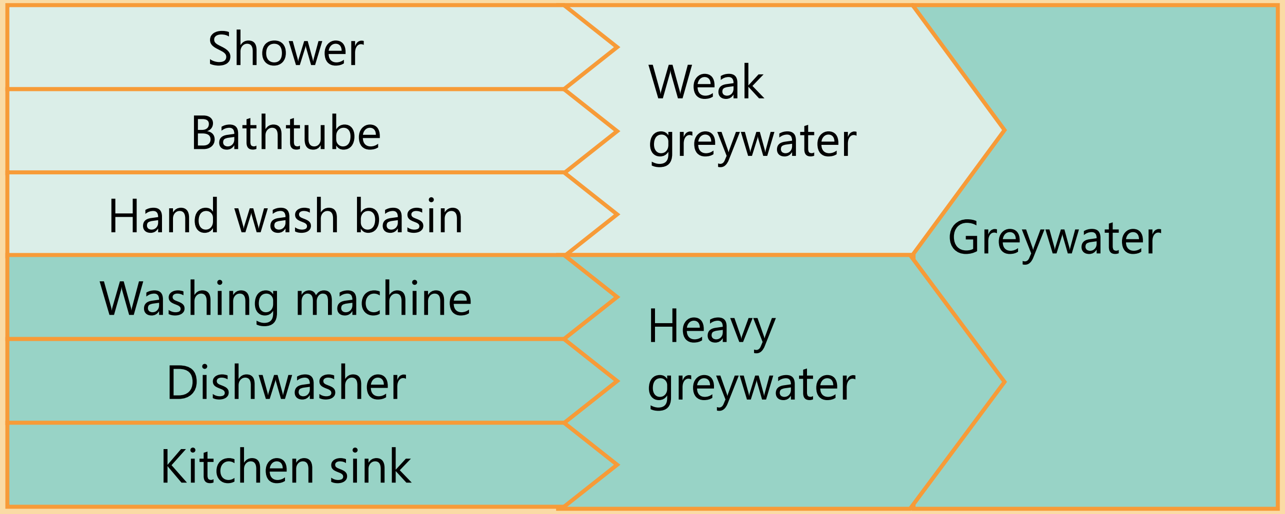


Composition of greywater

Showers, bathtub, and hand wash basin: Typically contains soap, hair, small amounts of dirt and certain micropollutants.

Washing machine: Contains detergents, microplastic, and sometimes small amounts of bleach.

Dishwasher and kitchen sink: Contains higher contamination levels from food particles, grease, and detergents.



Composition of blackwater

Essentially consists of urine, feces, flushing water and cleansing material and contains therefore a

- high load of organic matter,
- high load of nitrogen (mainly in the form of ammonia and urea) and phosphorus,
- high load of pathogens (bacteria, viruses, parasites),
- and high load of various micropollutants and chemical elements, including heavy metals and trace elements.

The importance of sustainable water management

- **Maximizing Water Conservation:** Recycling wastewater not only conserves water but also eases the burden on sewage treatment plants.
- **Environmental Benefits:** Reduces the environmental impact by lowering the demand on freshwater resources and decreasing wastewater discharge.
- **System Sizing:** Ensures efficiency and reliability, preventing overload and ensuring optimal performance.
- **Cost Efficiency:** Can lead to significant cost savings in water usage and wastewater management.

Benefits of greywater reuse:

- **Water Conservation and Reuse:** Reuse of greywater as service water can conserve groundwater and manage peak discharges.
- **Improved Treatment:** When treated separately from blackwater, process might become easier and more cost-efficient.
- **Health and Environmental Benefit:** Reduced risk of pathogen and micropollutants distribution.
- **Heat recovery:** Recovering heat from treated greywater is an effective way to reduce heat loss through wastewater discharge.

Typical treatment methods for greywater

Principle	Process
Near-natural	Constructed wetlands
Physical	Low pressure reverse osmosis
Anaerob	Upflow anaerobic sludge blanket (UASB)
Sessile biomass	Biofilter Rotating biological contactor Percolating filter
Suspended biomass	Activated sludge process Sequencing Batch Reactor (SBR) Membrane bioreactor (MBR)
Suspendes and sessile biomass	Fixed bed bioreactor (FBR) Moving Bed Biofilm Reactor (MBBR)

Potential reuse cases for treated greywater

- Toilet flushing
- Irrigation
- Natural discharge
- Heat recovery
- Microclimate improvement
- ….

ANCHOR project

- Ghent: Process water for soap production
- Helsingborg: Swimming pool water
- Kerkrade: Water for cloth washing
- Hamburg: Low water elevation in a local pond

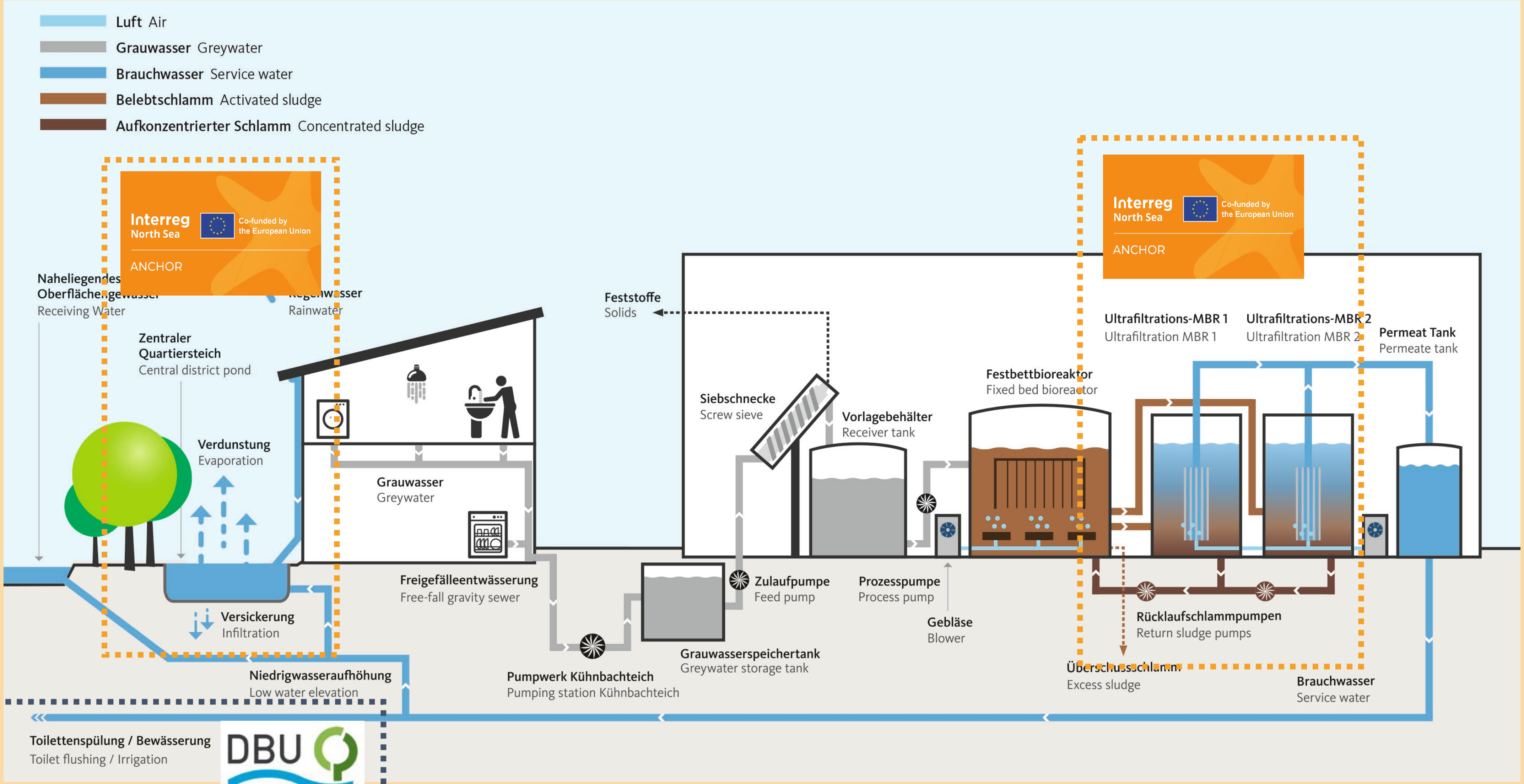
A holistic concept

HAMBURG WATER CYCLE
Abwasser trennen und recyceln
EIN KONZEPT VON HAMBURG WASSER

HAMBURG WATER Cycle in the Jenfelder Au

- New city quarter on a former 35 hectare military site
- Around 2200 residents with a connection to the HWC
- Largest area in the EU with source separation using vacuum technology for black water
- So far unequal in this size in Germany
- Realization from 2013 to the end of 2023
- 2019 commissioning
- Technical center for further development of recycling routes

Greywater recycling in the Jenfelder Au



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RecoLab

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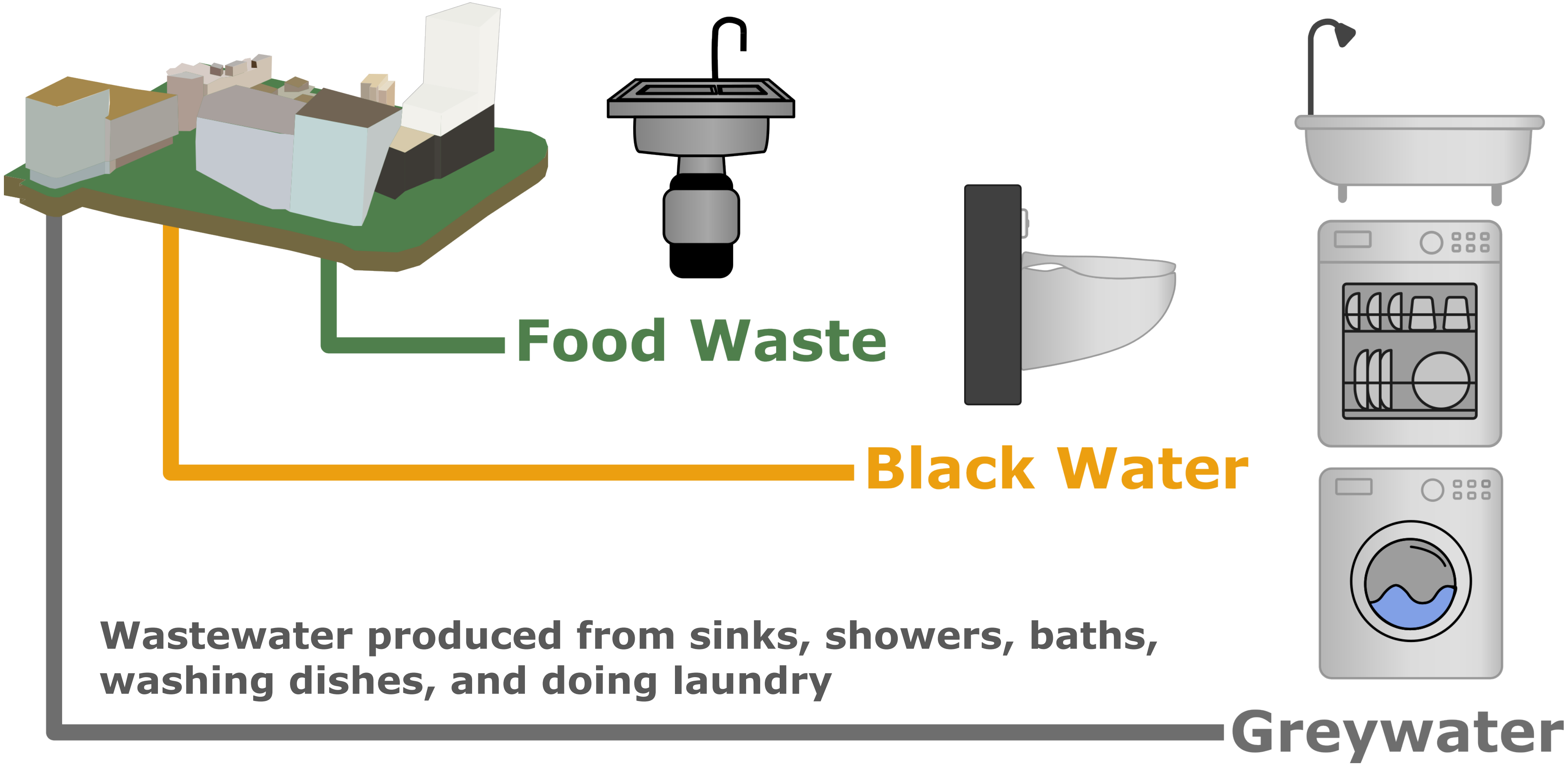
Greywater Treatment

Ashley Hall

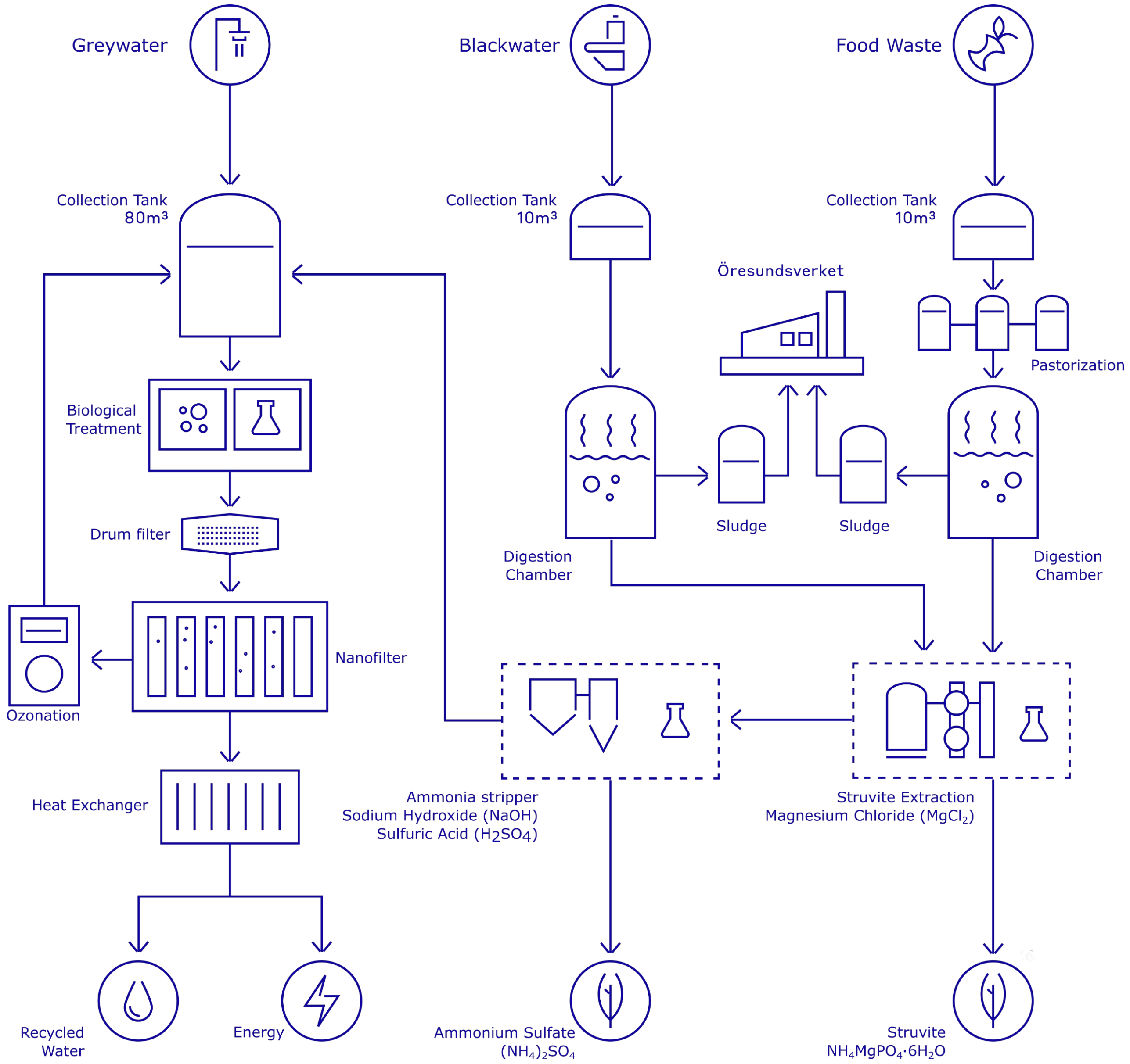
Oceanhamnen

Photo: Croisette Real Estate Partners and Knight Frank

Oceanhamnen

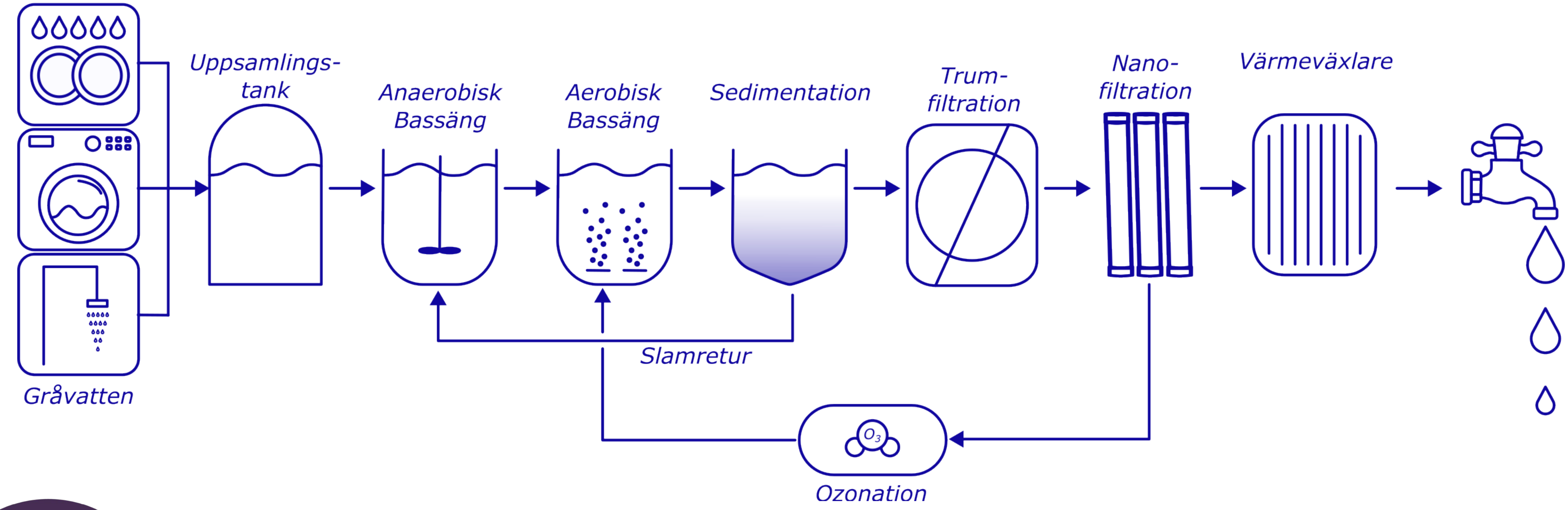


Treatment

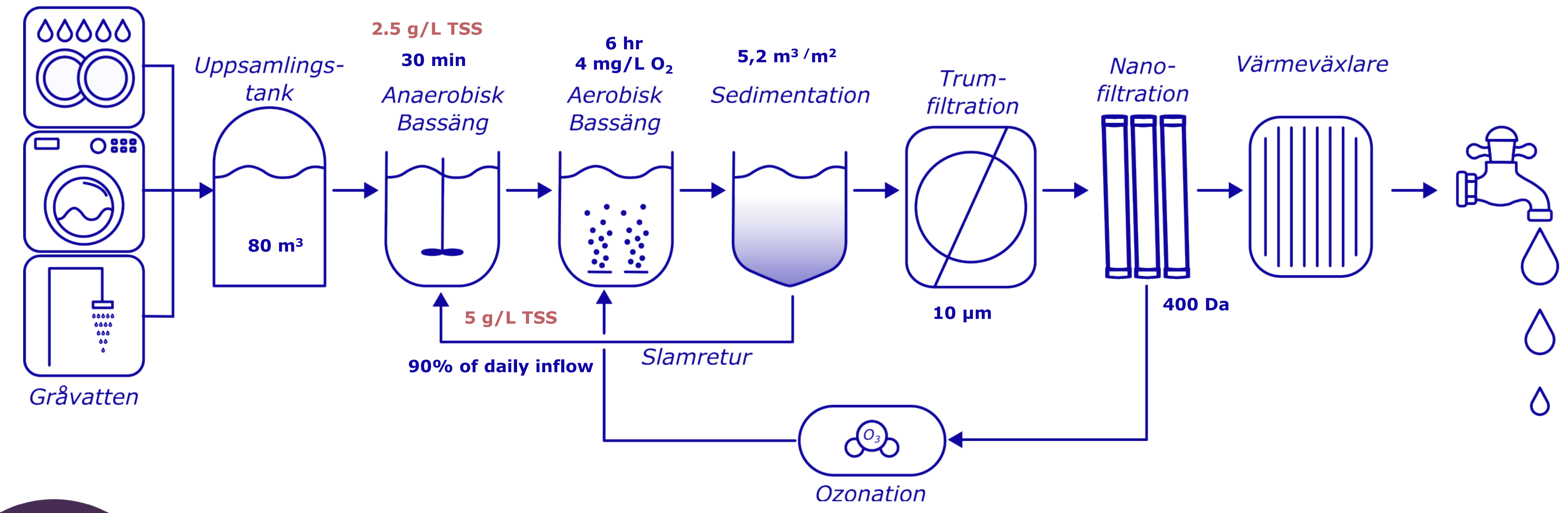


Greywater
Blackwater
Food Waste
Collection Tank
80m³
Collection Tank
10m³
Collection Tank
10m³
Öresundsverket
Pastorization
Biological
Treatment
Drum filter
Sludge
Sludge
Digestion
Chamber
Digestion
Chamber
Nanofilter
Ozonation
Heat Exchanger
Ammonia stripper
Sodium Hydroxide (NaOH)
Sulfuric Acid (H_2SO_4)
Struvite Extraction
Magnesium Chloride ($MgCl_2$)
Recycled
Water
Energy
Ammonium Sulfate
$(NH_4)_2SO_4$
Struvite
$NH_4MgPO_4 \cdot 6H_2O$

Greywater Treatment



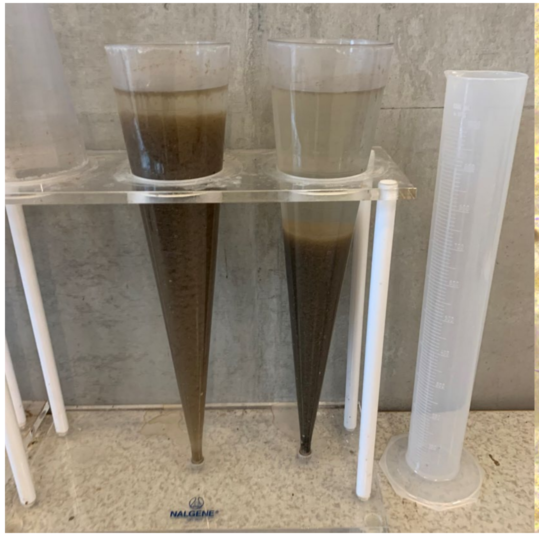
Greywater Treatment

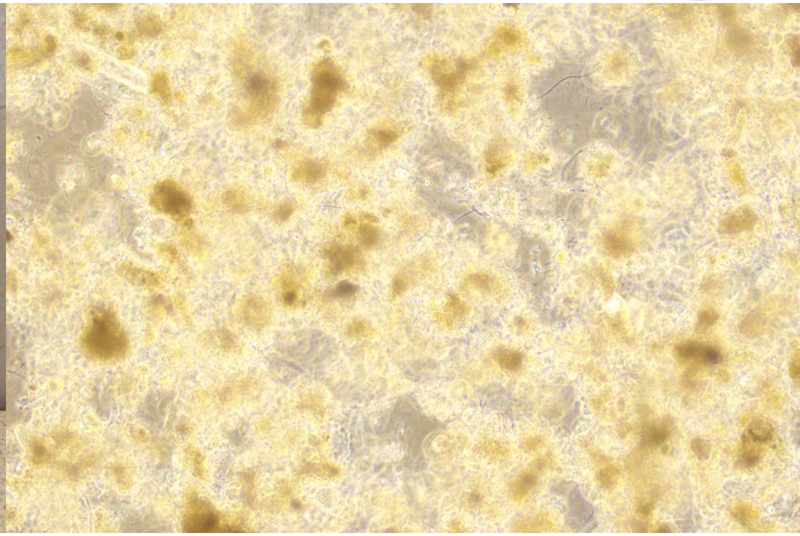


Operational Challenges

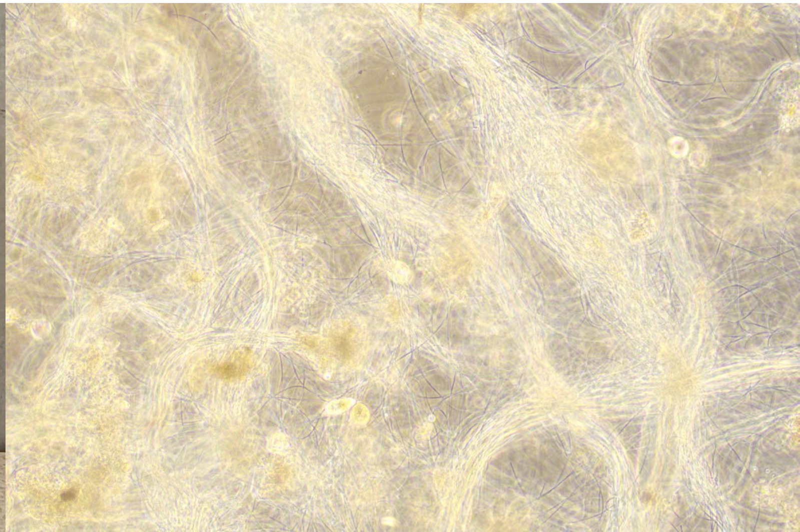
- Filamentous Bacteria
  - Nutrient Limitation?
  - High VFA content?
- Operational Parameters
  - No existing knowledge at our scale
- Sedimentation
  - Filaments cause bulking and poor settling
  - Drum filter after settling acts as a selector for filamentous bacteria and backwash is recirculated

Good





Bad



Water Quality – During Treatment

		Influent (n=159)	After Sedimentation (n=159)	Nanofilter Permeate (n=70)
COD	mg/L	516	156	14.9
Filtered COD	mg/L	274	-	-
BOD7	mg/L	230	-	-
TN	mg/L	15.5	6.95	3.08
NH4-N	mg/L	4.39	1.33	1.11
NO3-N	mg/L	0.52	0.87	1.57
NO2-N	mg/L	0.043	0.010	0.008
TP	mg/L	2.08	1.26	0.30
PO4-P	mg/L	0.69	0.38	0.23
Suspended Solids	mg/L	145	89	-
VSS	mg/L	143	89*	-
pH		7.19	7.22	7.77

*VSS exceeded TSS measurement so TSS was taken

Water Quality – Chemical

Parameter	RecoLab Nanofilter Permeate	Discharge[1]	Bathing[2]	Irrigation[3]	Drinking[4]
TN	3.08 mg/L	6 mg/L	-	-	-
NH4-N	1.11 mg/L	-	-	-	0.5 mg/L
NO3-N	1.57 mg/L	-	-	-	50 mg/L
NO2-N	0.008 mg/L	-	-	-	0.1 mg/L at production plant 0.5 mg/L at user
TP	0.30 mg/L	0.5 mg/L	-	-	-
Organic Carbon	14.9 mg/L COD	125 mg/L COD 25 mg/L BOD_5 37 mg/L TOC	-	≤10 mg/L BOD_5 class A 25 mg/L BOD_5 classes B, C, and D	No abnormal changes
pH	7.77	-	-	-	<10,5 at production plant 6.5-9.5 at user
Mercury	<5 ng/L	-	-	-	1 µg/L
Arsenic	0.49 µg/L	-	-	-	5 µg/L
Lead	<0.2 µg/L	-	-	-	5 µg/L
Manganese	<0.03 µg/L	-	-	-	50 µg/L
Organic Micropollutants	80% Removal[5]	80% removal	-	-	See Legislaton for detail

Color Code
Meets Requirement
Likely Meets Requirement
Dose not Meet Requirement

Water Quality – Selected Pathogens

Parameter	RecoLab Nanofilter Permeate	Discharge[1]	Bathing[2]	Irrigation[3]	Drinking[4]
E. Coli	<10 cfu/100 mL no leaks 510 cfu/100 ml when leaking	-	500-1000 cfu/100 mL Inland 100-200 cfu/100 mL Coastal	≤10 class A ≤100 class B ≤1000 class C ≤10000 class D	Detectable
Intestinal Enterococci	<10 cfu/100 mL	-	-	-	Detectable
Coliform Bacteria	<10 cfu/100 mL no leaks 655 dfu/100 mL with leaks	-	-	-	Detectable

Color Code
Meets Requirement
Likely Meets Requirement
Dose not Meet Requirement

Reuse Case

Photo: Niveau+

Summary

- Greywater can be treated to a high effluent quality with biological treatment and membrane separation in regards to chemical parameters.
- Biological treatment of greywater needs to be further optimized to reduce issues with settling.
- More research needs to be completed to determine compliance with pathogen regulations.
- The potential for water reuse is high from a technical perspective but the legislation on reuse is still unclear.

Water Practice & Technology

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Treatment of greywater with nanofiltration for nutrient removal – 2-year experience from Helsingborg

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[b] Division of Chemical Engineering, Lund University, Box 124, SE-22100, Lund, Sweden
[c] Nordvästra Skånes Vatten och Avlopp, Box 2022 SE-25002, Helsingborg, Sweden
*Corresponding author. E-mail: ashley.hall@swrab.se

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2. Directive 2006/7/EC concerning the management of bathing water quality, 37 (2006). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02006L0007-20140101
3. Regulation (EU) 2020/741 on Minimum Requirements for Water Reuse, 32 (2020). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0741&from=EN
4. Directive (EU) 2020/2184 on the Quality of Water Intended for Human Consumption, 1 (2020). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020L2184
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sweden water research

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Thank you!

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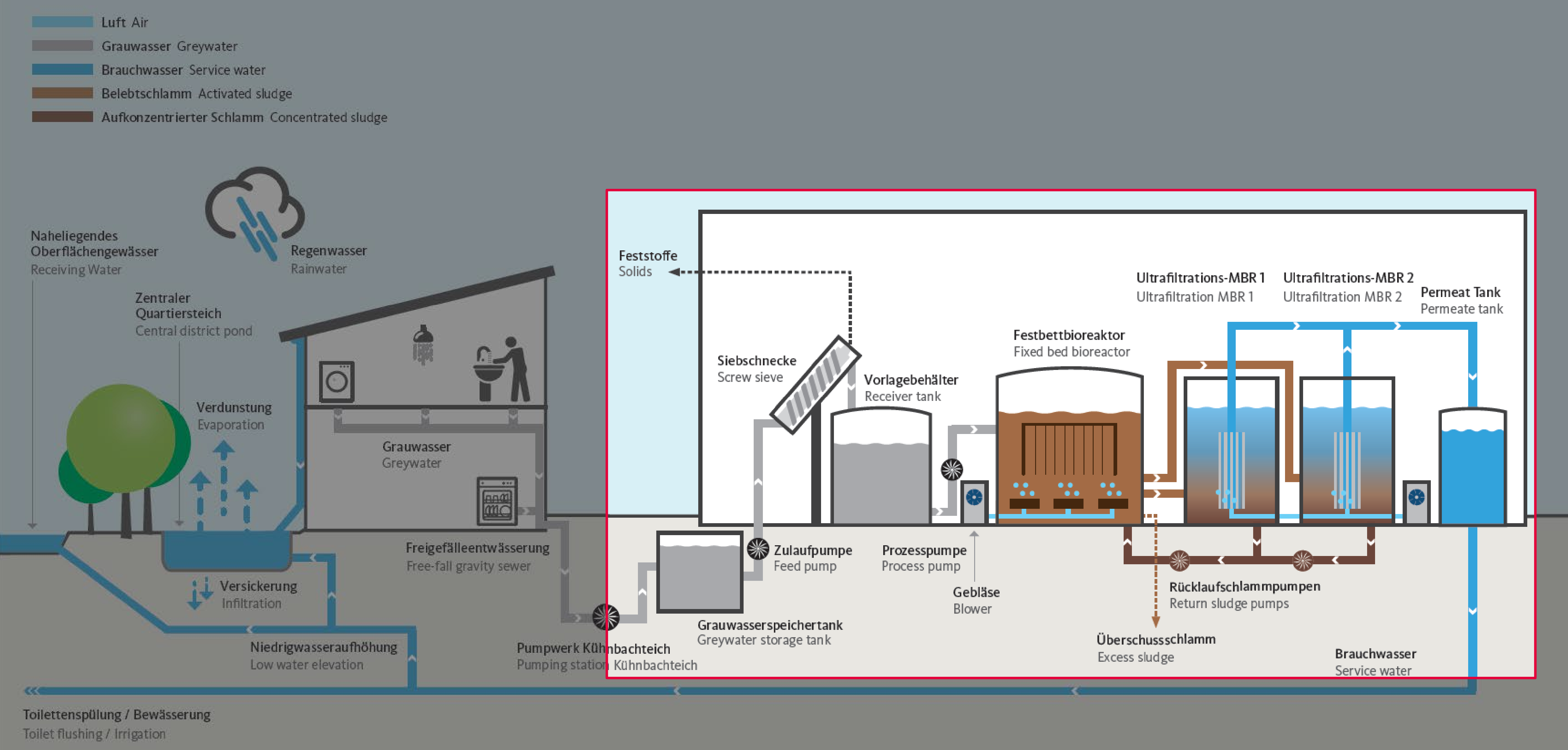
HAMBURG WASSER

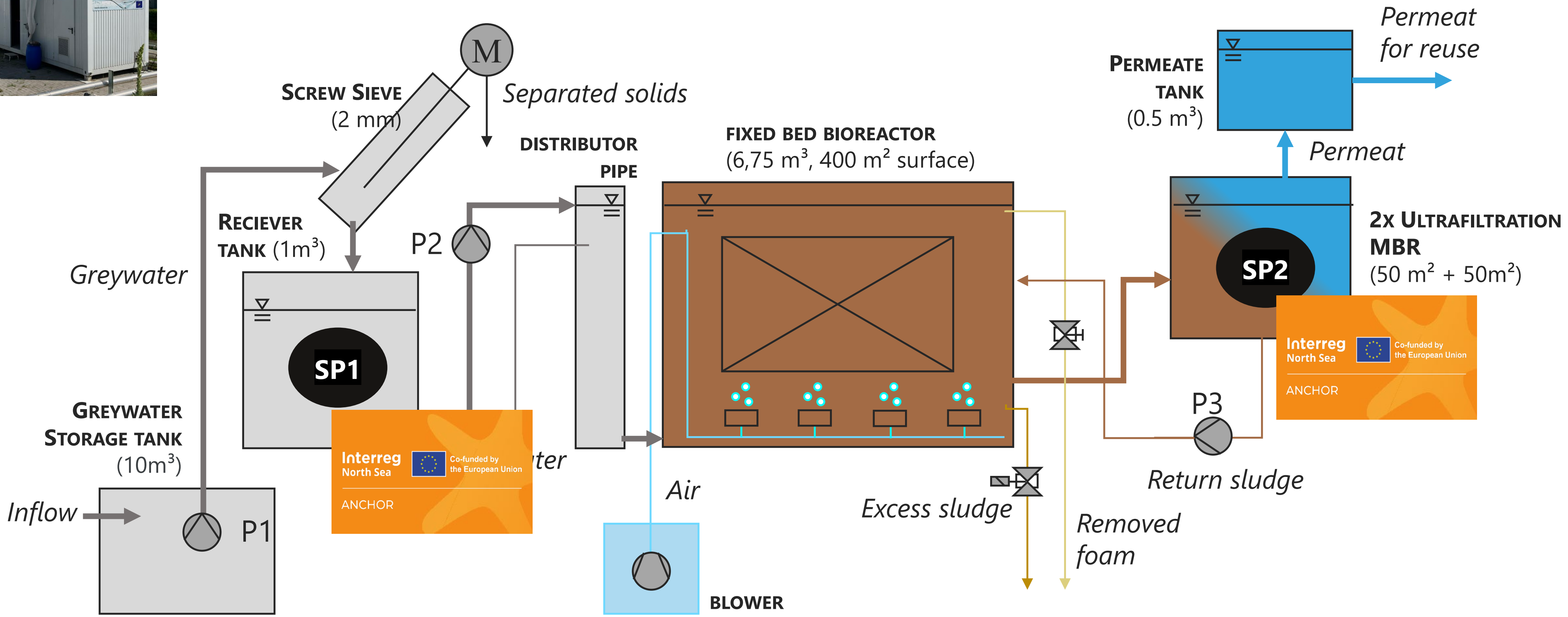
HAMBURG WASSER: Greywater treatment in the Jenfelder Au

02.12.2024, Lukas Cordts

Process overview



Plant flow diagram: Greywater treatment plant



Pump types:
P1: feed pump (centrifugal pump)
P2: process pump (eccentric screw pump)
R3: return sludge pump (eccentric screw pump)

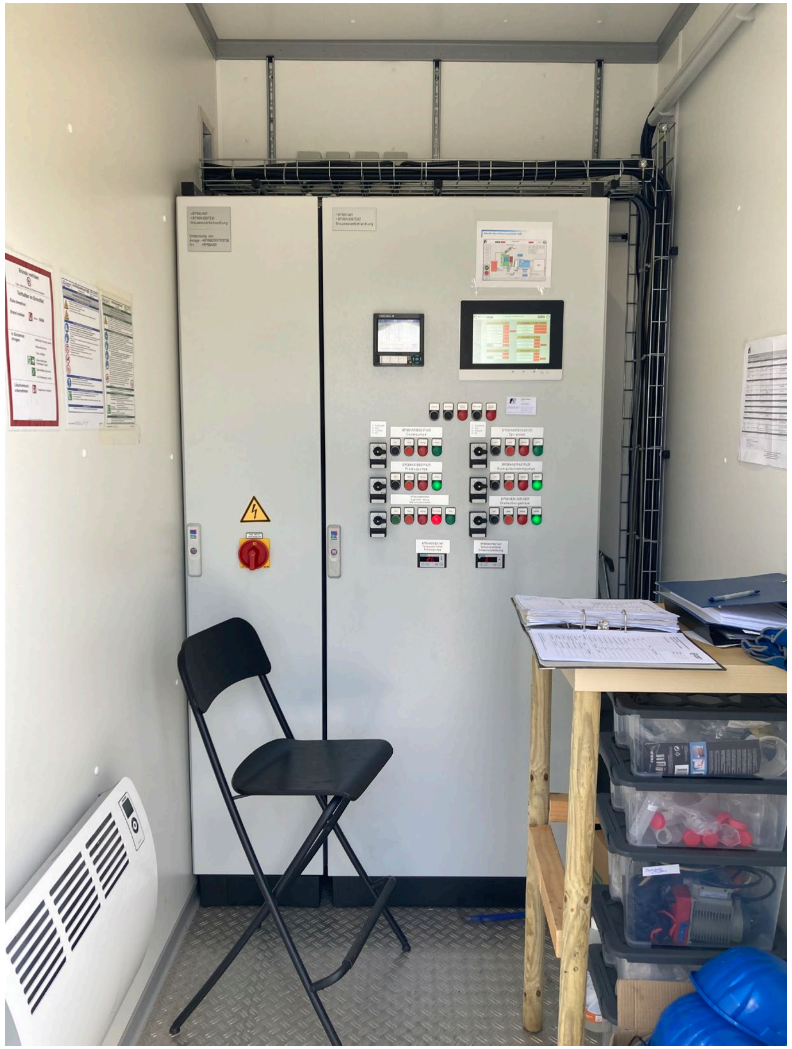
Process data:
Sludge age: 13 days
Sludge load: 0,054 kg BOD5/(KgDS/d)
Total solids: 6 g/l
Oxygen level: 2,0 mg/l

Sampling points:
SP1: Greywater
SP2: Permeate

Greywater storage tank (10 m³)

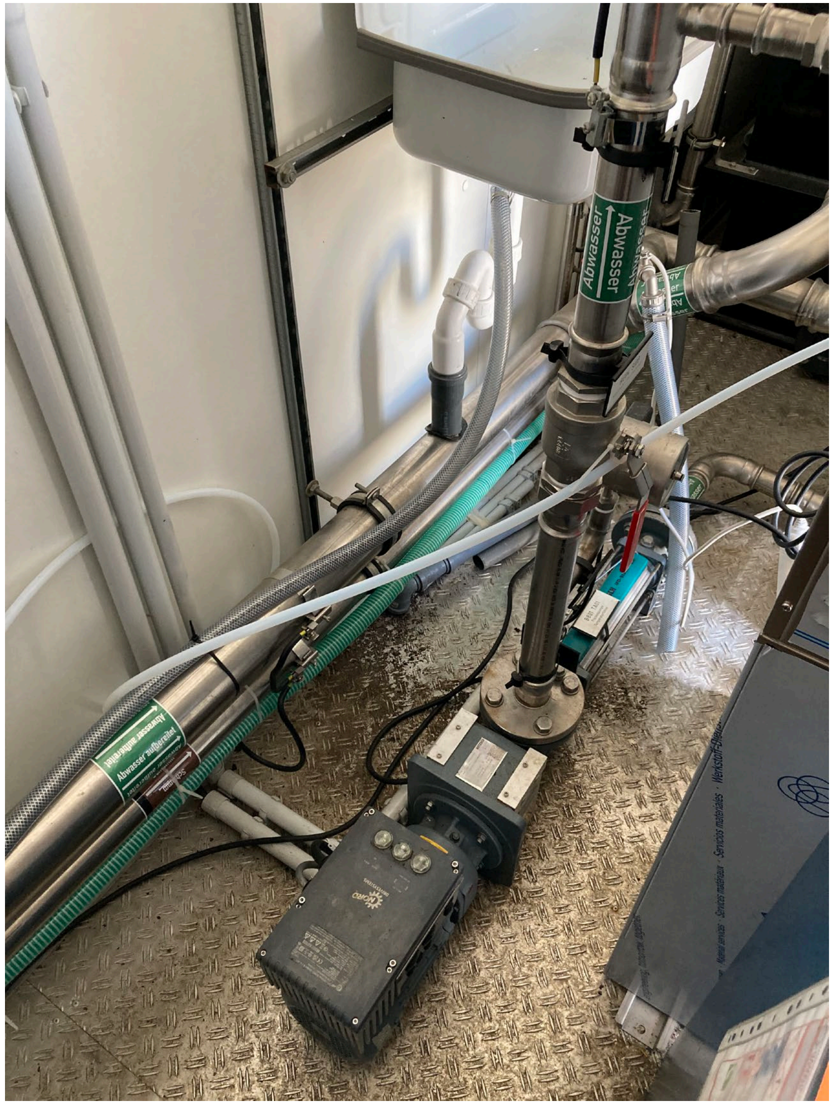
Pilot plant container

Container control unit



Screw sieve & reciever tank

Blower & process pump



Fixed bed bioreactor & foam remover

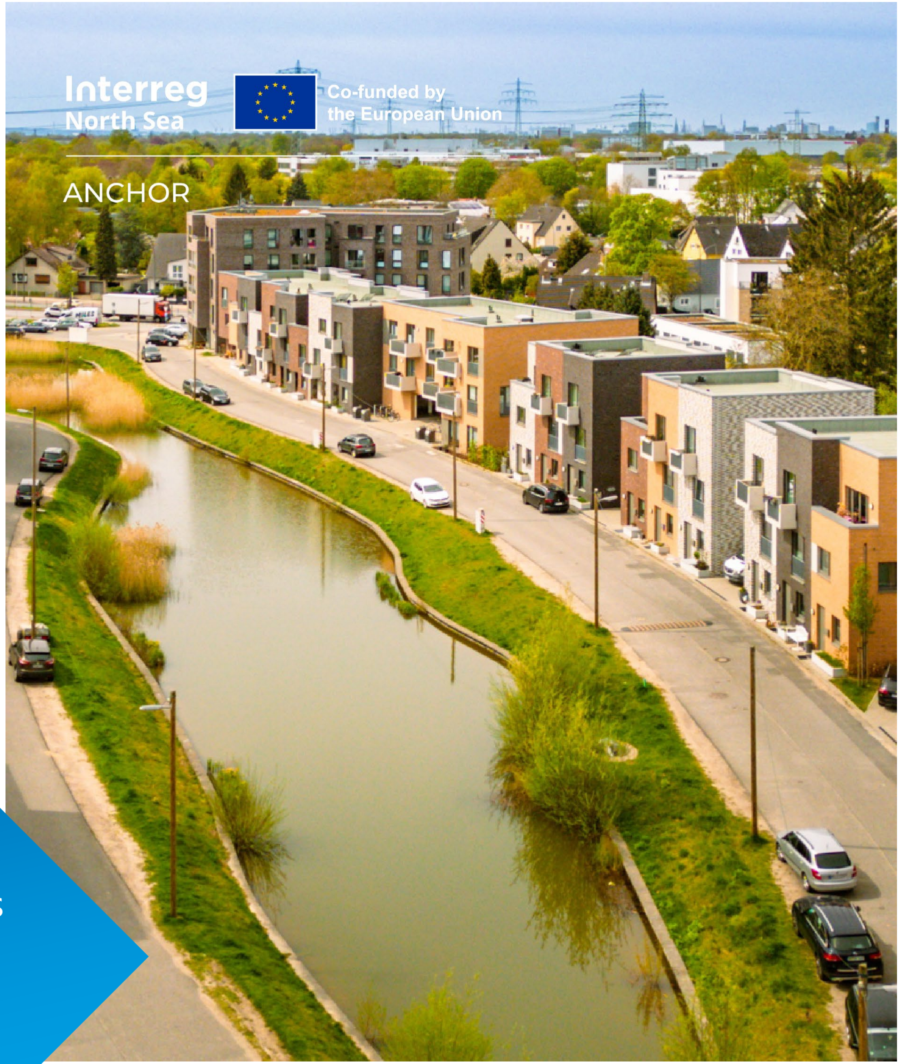
Return sludge pump & UF MBR (Manufacturer: Mena)

UF MBR (Manufacturer: Bremag)

Quality of greywater –rules and discharge permit

Parameter	Data sheet DWA M 277	Permit for water discharge	Effluent quality (UF)
Turbidity	< 2 NTU		< 0.07 NTU
COD		<= 50 mg/L	21 mg/L
BOD_5	< 5 mg/L	<= 8 mg/L	1.6 mg/L
TNb		<= 5 mg/L	3.4 mg/L
NH4-N		<= 1 mg/L	0.54 mg/L
total phosphorus		<= 1 mg/L	0.4 mg/L
pH	6,5 – 9,5	6-9	7,25 - 8,22
Total Coliforme	10.000 /100 mL		n.n. – 170 /100 mL
E. coli	< 1.000 /100mL		n.n. – 6 /100 mL
P. aeroginosa	<100 /100 mL		n.n – 1 /100 mL

Grey water pilot plant meets all criteria (technical and qualitative) for usage of class C2 according to data sheet DWA M 277, so low water elevation, toilet flushing and irrigation are unproblematic



Sustainable public services - our mission, our future.

Lukas.cordts@hamburgwasser.de

Thank you for listing. I am looking forward to your questions.

ANCHOR LUNCH TALK

Greywater treatment for industry water reuse at Ghent demo site

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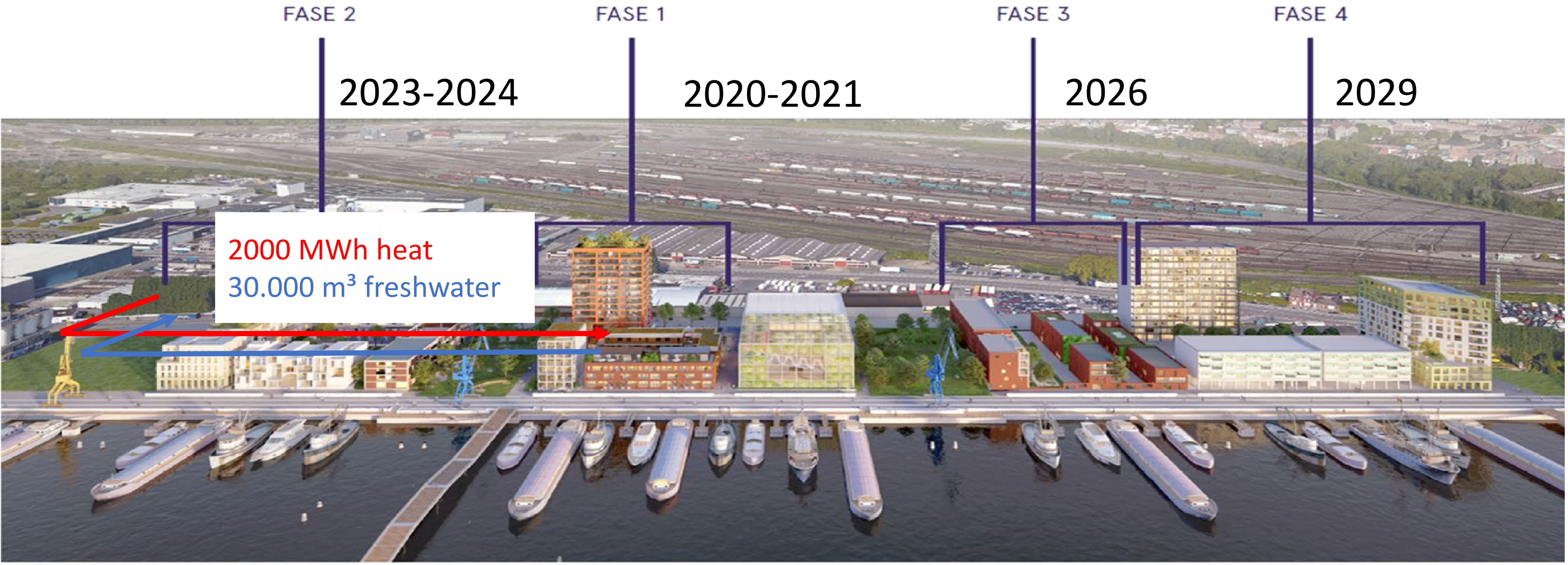
Project Status



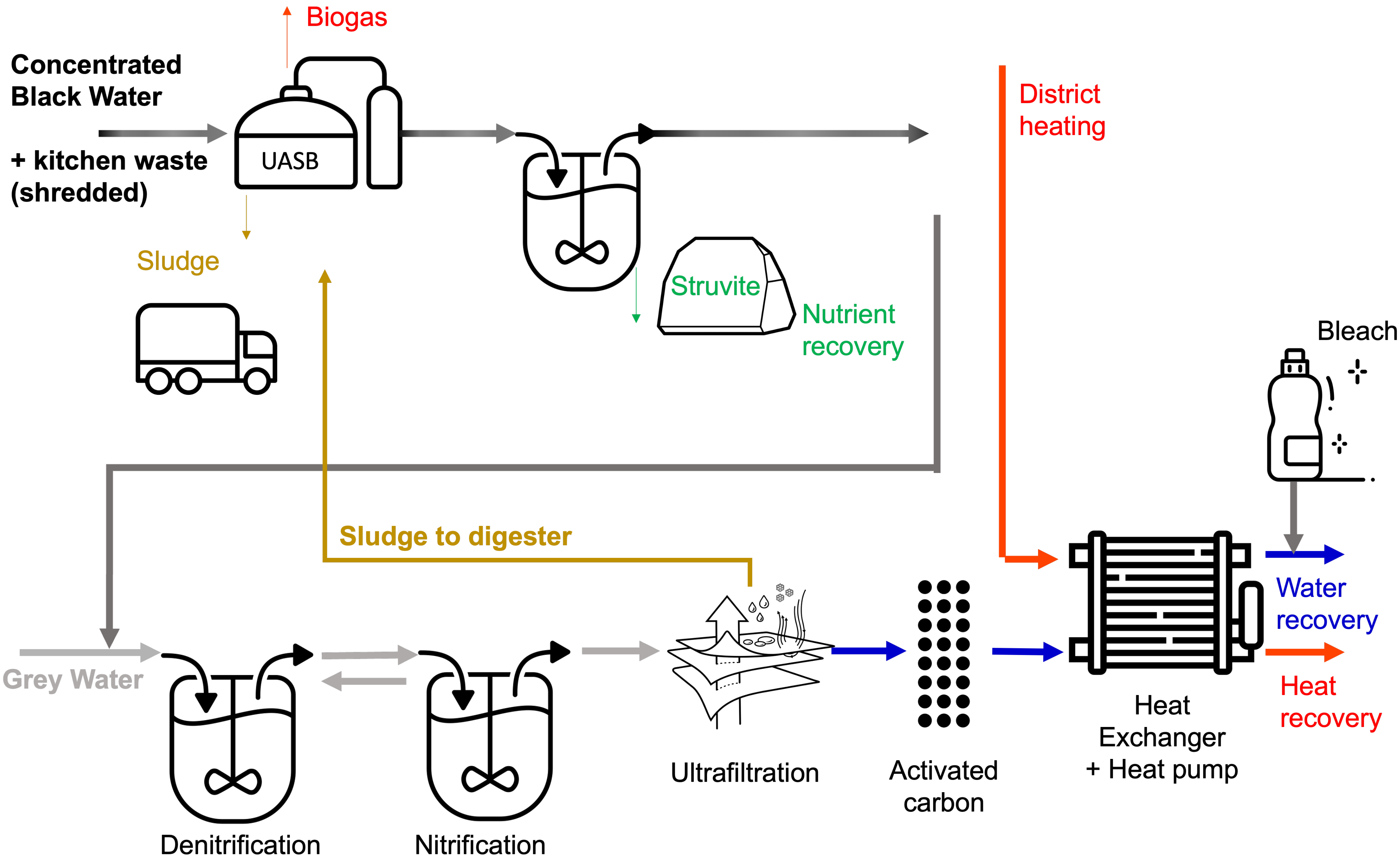
>400 Housing units + City complex (schools, sports infrastructure etc.)

What Water Quality do we want to achieve?

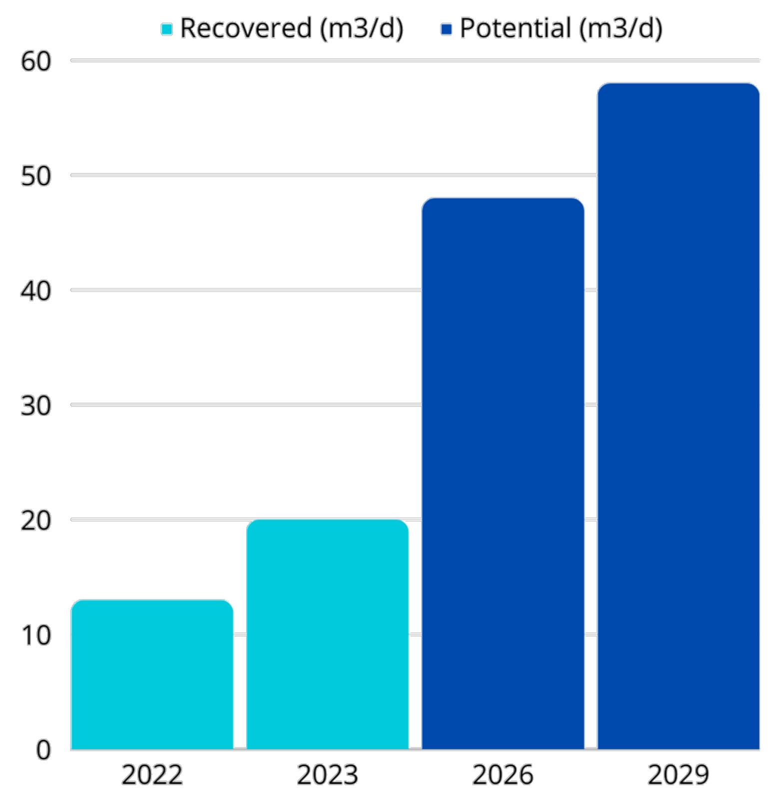
Three potential destinations

- Industry: Soap Factory (first pick)
- Refill rainwater pit (when it's empty)
- Surface water ('nearby Dokken')

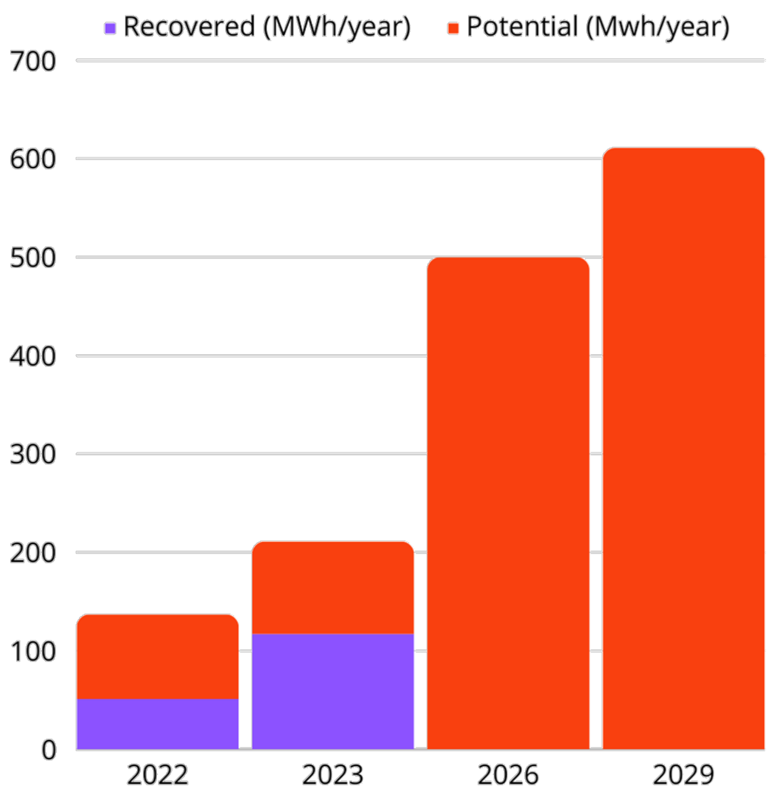
	Soap factory	Surface water
COD	20	125
TN		15
NO3-N	11	
NO2-N	0.3	
NH4-N	1.9	
TP	2	2
pH	6.2-9.2	6.2-9.2
Temp	<30 °C	<30°C
Pathogens	No pathogens	-
Heavy metals	Similar to tap water	VLAREM
Salts	Similar to tap water	VLAREM
Colour	< 25 hazen	-


Biogas
Concentrated Black Water
+ kitchen waste (shredded)
UASB
Sludge
Struvite
Nutrient recovery
District heating
Bleach
Sludge to digester
Grey Water
Water recovery
Heat recovery
Denitrification
Nitrification
Ultrafiltration
Activated carbon
Heat Exchanger + Heat pump

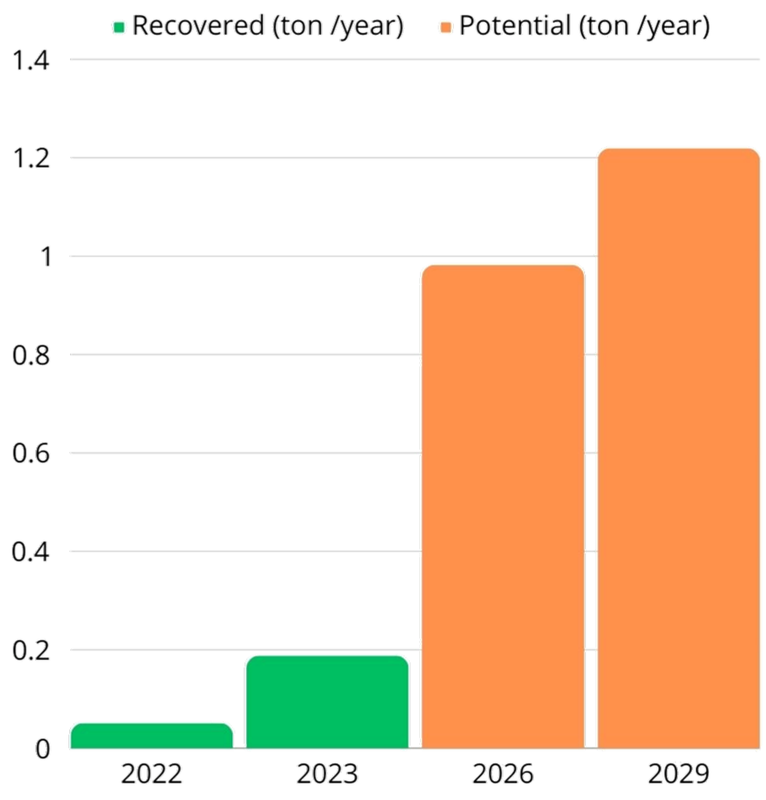
Performance – operations 2020 – 2023 → 2029 - outlook



Water recovered



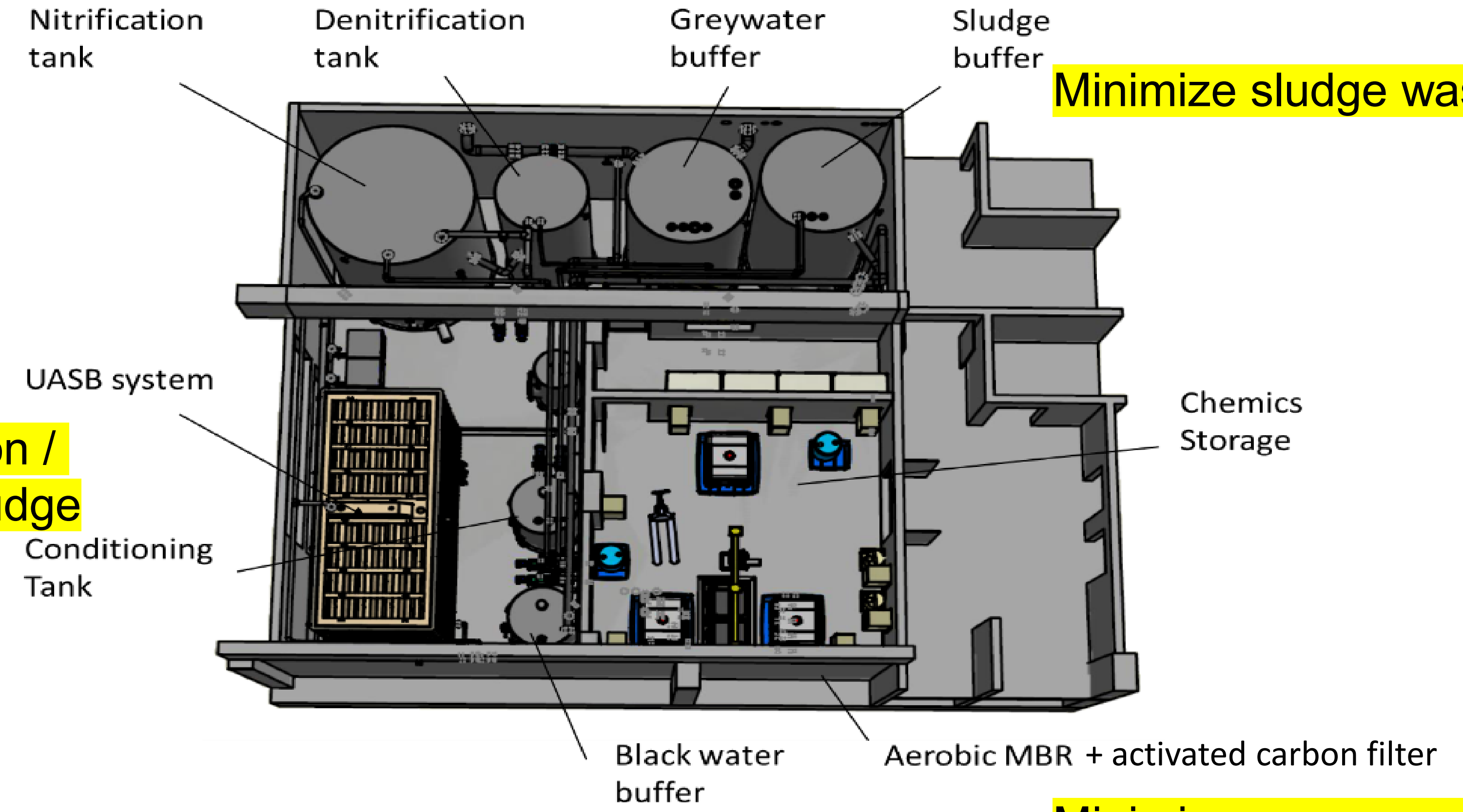
Heat recovered



Struvite recovered

Work within Anchor
Increase autonomy of water treatment plant

Minimize aeration cost
Minimize usage of chemicals : carbon source and $FeCl_3$



Minimize sludge waste

Prevent flotation / wash out of sludge

Minimize energy cost MBR
Guarantee perfect -colourless effluent for Christeyns

Succes factors for grey wate reuse

High-Quality Water Reuse for Industry: Balancing Cost and Impact

- ✓ **Reuse water is not (always) drinking water**
- ✓ **Higher quality standards require a multi-barrier approach, increasing costs.**
- ✓ Have alligned agreements on water quality and water uptake

Keep it simple

- ✓ **Minimize Risk:** Every treatment step adds potential for failure and maintenance.
- ✓ **Prioritize Impact:** Choose a treatment train that maximizes benefits for your needs.

Avoid Color Challenges:

- ✓ Black water treatment release more colour to the water than grey water treatment

Optimize with Automation:

- ✓ On-site greywater systems should ensure robust water quality with **minimal monitoring**.
- ✓ **Automate operations** to lower costs, ensure water quality and improve efficiency.

Thank you

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Anchor Lunch Talks

Next Lunch Meeting

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- When: February 10th 2025
- Topic: Digital study tour of Jenfelder Au in Hamburg

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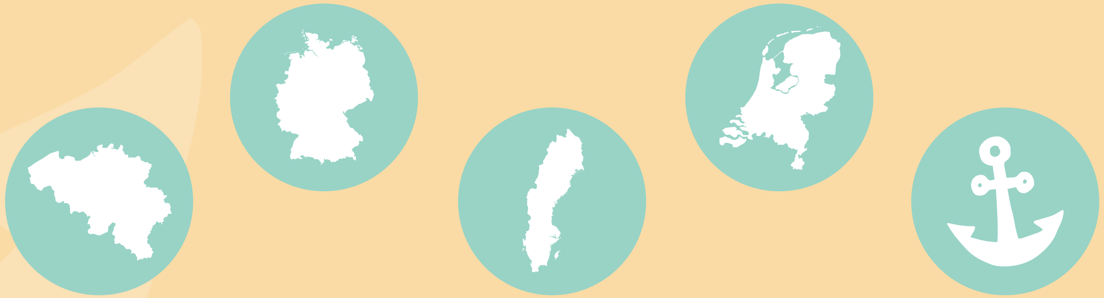
Thank you for attending!



Interreg ANCHOR project

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