German experience in wetland systems applications

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FORUM ICWS 2016

IWA the international water association
WETLAND SYSTEMS FOR WATER POLLUTION CONTROL

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Dipl.-Ing. Environmental Engineering
TU Berlin, 1988
Focus on Water Protection

AKUT Environmental Engineering: Foundation in 1988
Research activities since: 1992, Active in foreign countries since: 1998
Staff in Germany: 17
Staff in other countries: 43
Annual turnover (average last 3 years) 2.2 Mio EUR

Spin-off companies
Mobile Environmental Protection Centre (MUTZ GmbH)
AKUT Solar House and Building Technology (AKUT Solar GmbH)
AKUT Peru SAC, Lima
AKUT Solutions GmbH

Member of Global Wetland Technology (**GWT**) Association

GLOBAL WETLAND TECHNOLOGY

AKUT - Field of activities

AKUT Partner

Activities

- Consulting and planning
- Research and development
- Capacity building and training
- Construction on a turn-key basis

Topics

- Waste Water Treatment
- Surface Water Ecology
- Bathing Water Treatment
- House and Building Technology
- Biogas Plants
- International Development Cooperation

AKUT Projects - Wastewater Treatment

Specialization in rural areas, AKUT places emphases on low cost and innovative processes as:

- Sequenced Batch Reactor (SBR),
- Pondb SBR
- Anaerobic technology
- Constructed wetlands
- Sludge dewatering.

Research Projects for Decentral Wastewater Treatment

- **SLASORB** (**Sla**g as **Sorb**ent**):**
  EU investigation project with Arcelor Mittal, Ecole de Mines, Epinature, Institut für Baustoffforschung e.V., Arbeitsgemeinschaft Hüttenkalk e.V. and Stadtwerke Zehdenick, Constructed wetlands reduction efficiency for phospor

- **KLEA** (**Development of climate friendly energy self sufficient WWTP for small comunities**)
  BMBF I+D project with TU-Berlin, Botana Bau GmbH und EMSR Wiemann, development of anaerobic pre-treatment with biogas harvesting for energy production in German climate

- **PARASOL:**
  BMBF I+D project with TU-Dresden, Elimination of Methan-emissions from mechanical pre-treatment systems with Constructed wetland

- **AQUANES**:
  European Horizon2020 project for evaluating combined wastewater treatment technologies with **N**atural and **E**ngineered **S**ystems.

German Experience in Wetland Systems

Low operational costs

Simple Operation

Minimal Energy Need

Stable Treatment Performance

Ecological Extra Benefit

What are the expectations to natural water treatment?

German Experience in Wetland Systems

Typical Objections

- Huge use of land
- No control mechanisms
- No dimensioning tools
- Clogging and ice in winter time
- Odours

What are the expectations to natural water treatment?

History of Treatment Wetlands in Germany

- Wastewater land treatment for Berlin starting 1875
- Reedbed systems start in the 1970s
  (K. Seidel/ R. Kickuth)
- Research period 1980s/ 1990s (Horizontal flow -> vertical flow)
- Regulation period starting 1990s (DWA-A 262, IÖV/FLL)
- Modern times: 2000 until today (DBU, AquanNES)

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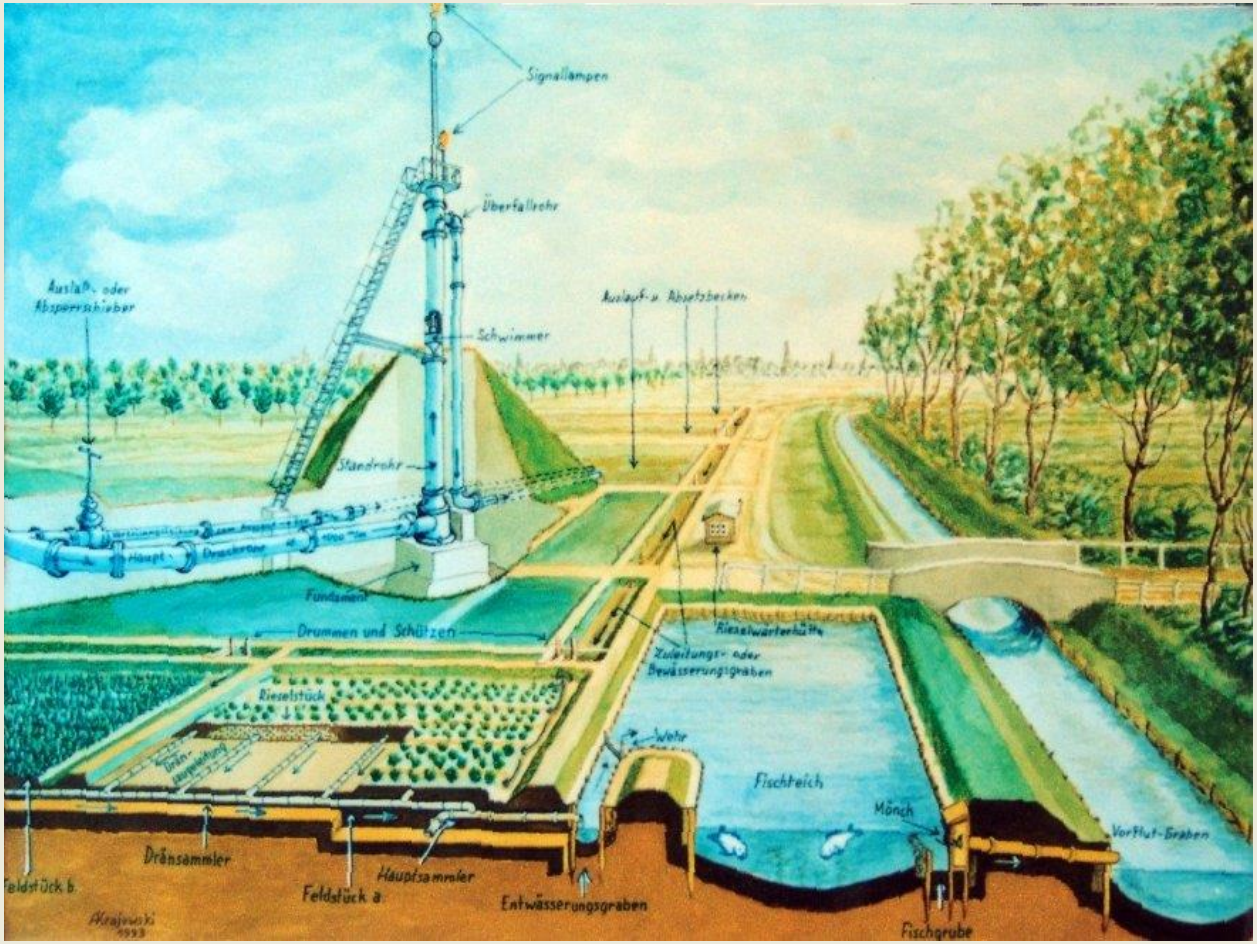
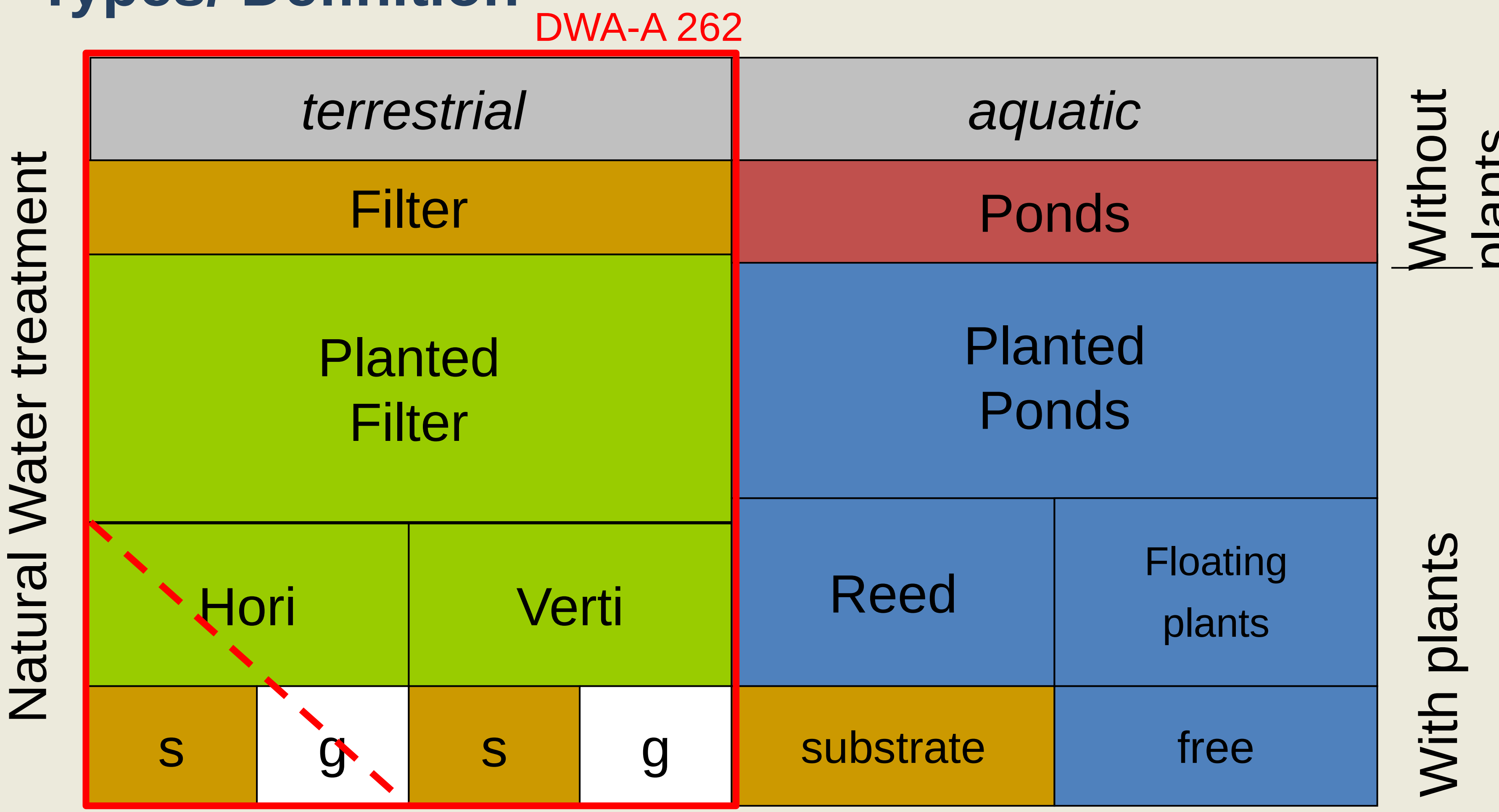


Berlin, 1880
Irrigation fields

Graph
A. Krajowski

Land treatment of waste water near Berlin during 19th century

Types/ Definition



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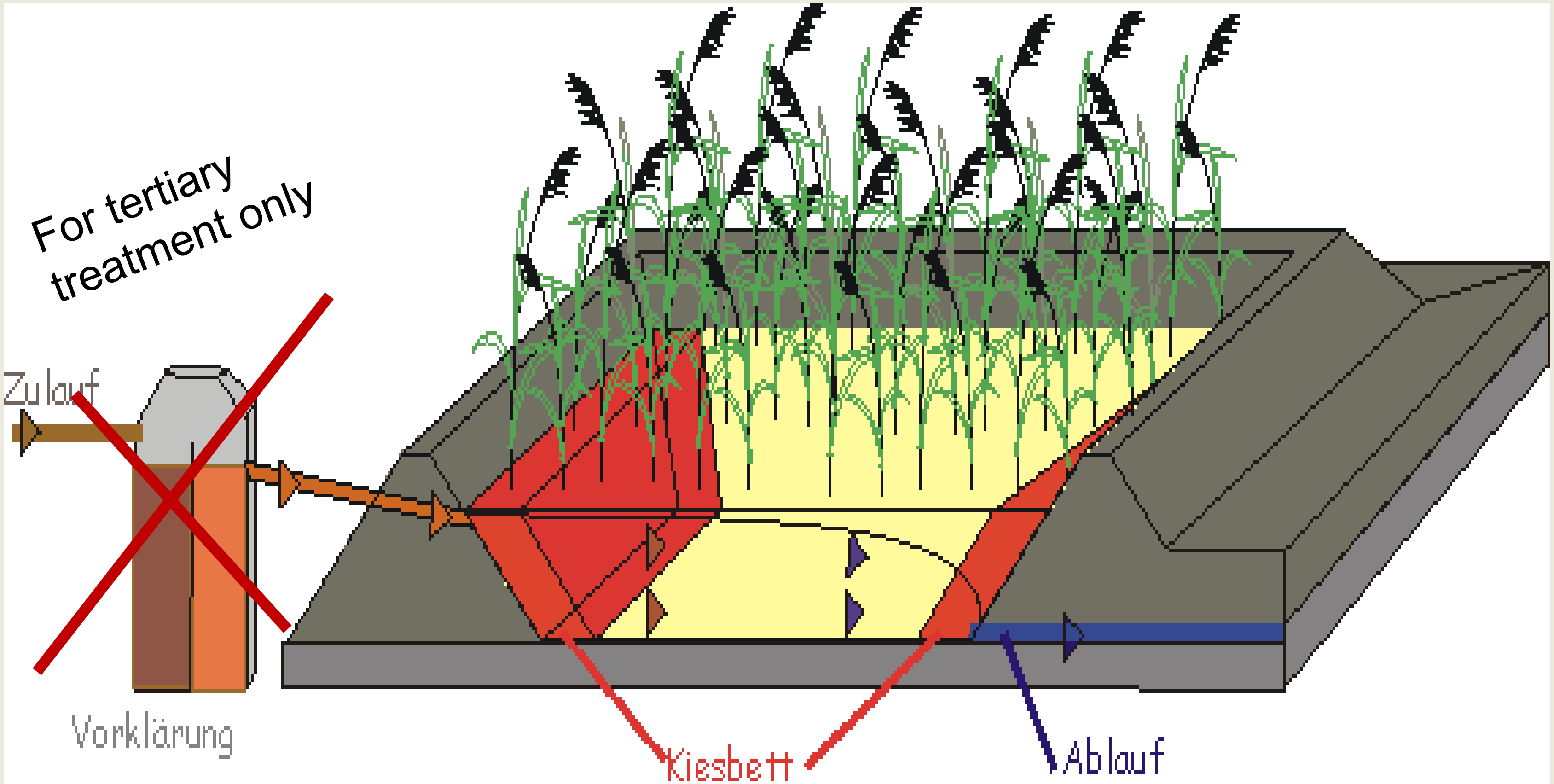

Quelle: F&N Umweltconsult

Horizontal flow treatment: low oxygen input, anaerobe treatment, produces CH_4 and H_2S

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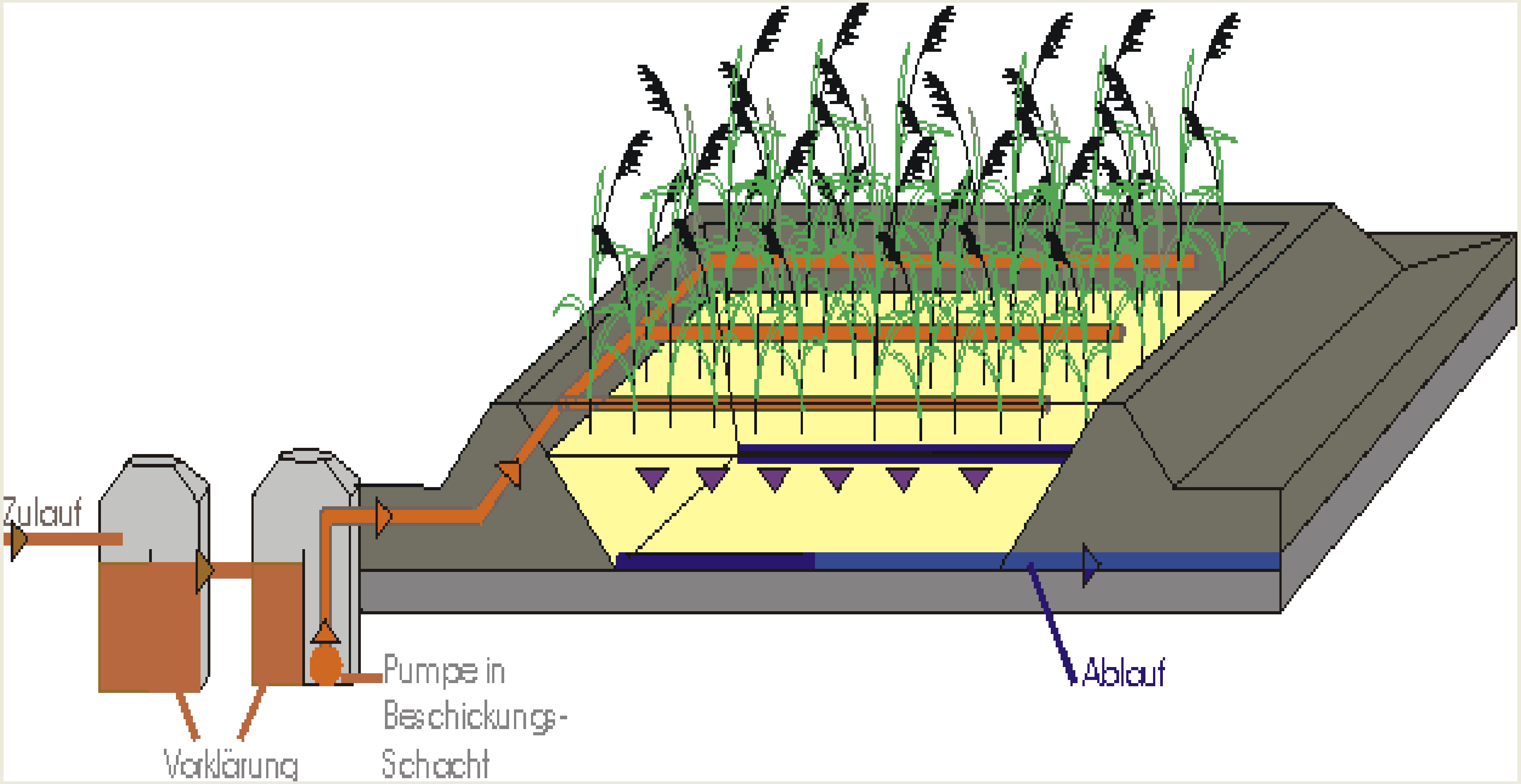

Quelle: F&N Umweltconsult

Vertical Flow Treamtent: High Oxygen input.
>> COD removal, nitrification

DWA-A 262 (April 2016, draft version)

Principles for dimensioning, construction and operation of treatment wetlands for domestic wastewater treatment

- Primary: Pre-treatment (compulsory)
- Secondary: Description of several wetland types (sand, gravel, one-stage, two-stage)
- Tertiary: Post-treatment (optional, P, N, pathogen removal)

Scope of new guideline is 4 p.e. up to more than 1.000 p.e.

Draft guideline undergoes public discussion within three months after publication in April 2016. After that the document will be finalized (End of 2016)

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Table 17: Summary of main design parameters for treatment wetlands in small wastewater treatment plants

Parameter	Unit	Raw wastewater vertical flow wetland	Vertical flow wetland with coarse sand (0 mm to 4 mm), as second step after raw wastewater vertical flow wetland	Vertical flow wetland with sand (0 mm to 2 mm) as main biological treatment step	Two-stage vertical flow wetland with fine gravel (2 mm to 8) mm as first stage	Two-stage vertical flow wetland with coarse sand (0 mm to 4 mm) as second stage	Actively aerated vertical flow wetland with gravel (8 mm to 16 mm)	Actively aerated horizontal flow wetland with gravel (8 mm to 16 mm)	Filter trench with fine gravel (2 mm to 8 mm) and coarse sand (0 mm to 4 mm)
Specific area $A_{BF,spez}$	m²/PE	≥ 1,2	≥ 0,8	≥ 4	≥ 1	≥ 1	≥ 1	≥ 1	≥ 3
Minimum area	m²	4,8	4	16	4	4	4	4	12
Dose volume per m²	l/m²	≥ 20	≥ 20	≥ 20	≥ 20	≥ 20			≥ 20

Example parameters Small systems DAW-A 262 (draft version): valid only in complete context of this guideline

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Parameter	Unit	Vertical Filters									
		Raw wastewater vertical flow wetland	Vertical flow wetland with sand 0 mm to 4 mm as second step after raw wastewater filter	Vertical flow wetland with sand 0 mm to 2 mm as main biological treatment step	Two-stage vertical flow wetland Gravel filter 2 mm to 8 mm as first step	Two-stage vertical flow wetland Sand filter 0 mm to 4 mm as second step	Actively aerated vertical flow wetland with gravel 8 mm to 16 mm	Vertical flow wetland with lava sand 0 mm to 4 mm as main biological treatment step	Vertical flow wetland with lava sand as overflow sand filter	Vertical flow wetland with sand 0 mm to 2 mm as polishing step	Horizontal flow wetland with coarse sand 0 mm to 4 mm as polishing step
Unit		4.2	4.3.3 C	4.3.3 A	4.3.3 B		4.3.3 D	4.3.3 E		4.3.6	4.3.6
Specific area $A_{bF,spez}$ for seprated sewer networks	[m²/E]	≥ 1,2	≥ 0,8	≥ 4*	≥ 1	≥ 1	≥ 1	≥ 3			
Specific area $A_{bF,spez}$ for combined sewer netowrks	[m²/E]	≥ 1,5	≥ 1,0				≥ 1	≥ 3	≥ 1		
or COD loading over the entire area of the filter A_{bF}	[g/(m²·d)]	≤ 100	≤ 25	≤ 20	≤ 80			≤ 20		≤ 20	≤ 16
and COD loading over the area of the filter in operaiton $A_{bF,Betrieb}$	[g/(m²·d)]			≤ 27						≤ 27	
CSB-Raumbelastung	[g/(m³·d)]						≤ 100				
und CSB-Flächenbelastung der Anströmfläche A_{an}	[g/(m²·d)]										≤ 200
Hydraulic loading rate over the entire filter area A_{bF} during dry weather	[l/(m²·d)]	≤ 250		≤ 80				≤ 80	≤ 500	≤ 80 ≤ 120 bei ≥12°C	
Hydraulic loading rate over the area of the filter in operation $A_{bF,Betrieb}$	[l/(m²·d)]							≤ 240	≤ 500		
Dosing interval	< 12 °C h			≥ 6	≥ 3	≥ 3	≤ 4			≥ 6	
	≥ 12 °C h			≥ 6						≥ 3	
Hydraulic loading rate	[l/(m²·min)]	≥ 10	≥ 6	≥ 6	≥ 10	≥ 10		≥ 10		≥ 6	
Dose volume per m²	[l/m²]	≥ 20	≥ 20	≥ 20	≥ 20	≥ 20	≥ 6	≥ 20		≥ 20	
Area per orifice of distribution network	[m²/orifice]	≤ 50	≤ 1	≤ 5 besser ≤ 1	≤ 1	≤ 1	≤ 1	≤ 25		≤ 1	

NOTE
*) See Section 5.5.2.

Example parameters municipal systems DAW-A 262 (draft version): valid only in complete context of this guideline

A: Vertical flow wetland with sand (0 mm to 2 mm)

The filter must be constructed according to the following requirements (see Figure 6)

- ≥ 50 cm filtration layer, sand 0 mm to 2 mm, washed
- ≥ 20 cm drainage layer, fine gravel 2 mm to 8 mm, washed

The permeability of the filtration layer should preferably be in the range of $k_{fA} \approx 10^{-4}$ m/s (calculated according to Equation 15). The effective grain size (d_{10}) should be 0.2 mm ≤ d_{10} ≤ 0.4 mm.

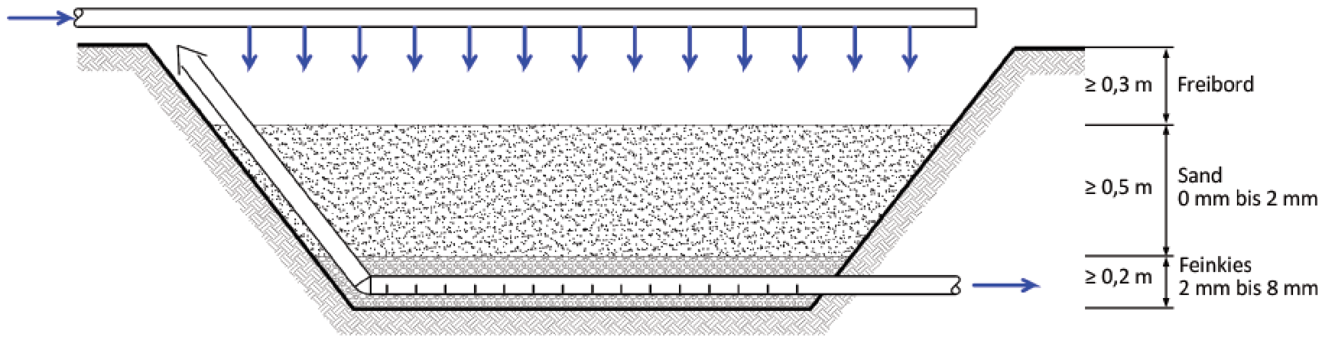

Figure 6: Vertical flow wetland with sand (0 mm to 2 mm), schematic with basic dimensions.

Example parameters DAW-A 262 (draft version): valid only in complete context of this guideline

How to do it right?

Min. area
2-4 m²/ p.e.

Flow monitoring and batch feeding

Key parameter: oxygen input

Grain size distribution and drainage

Fast infiltration, fresh wastewater

Lessons learned:

- Natural systems need to be designed properly considering laws of ordinary wastewater treatment (biofilm process, filtration and chemical/ physical interactions with plants and substrates)
- DWA-A 262 guideline provides key parameters for safe design
- DWA guidelines are no construction manual, civil or environmental engineers are needed
- If basic knowledge is respected design can follow landscaping needs as well and social or ecological benefit may be produced (biodiversity, recreation, water retention, …)
- Concerning European and German Water Law DWA-wetlands represent the „state of the art“ (Organics, Ammonium removal)

Wetland Applications

- Domestic Sanitation (Treatment and Re-Use)
- Municipalities (Seperate and Combined Sewage)
- Industrial Wastewater (Sludge dewatering)
- Stormwater management (Retention and Treatment)
- Tertiary treatment (Pathogens, Pharmaceuticals, N, P)
- Diffuse Pollution (Nitrogen and Phosphorus retention)
- Surface Water Treatment (Rivers and artificial ponds)

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Combined technical treatment and engineered wetlands (Lalendorf)

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Combined Sewage treatment, Friesener Berg, 140 p.e.

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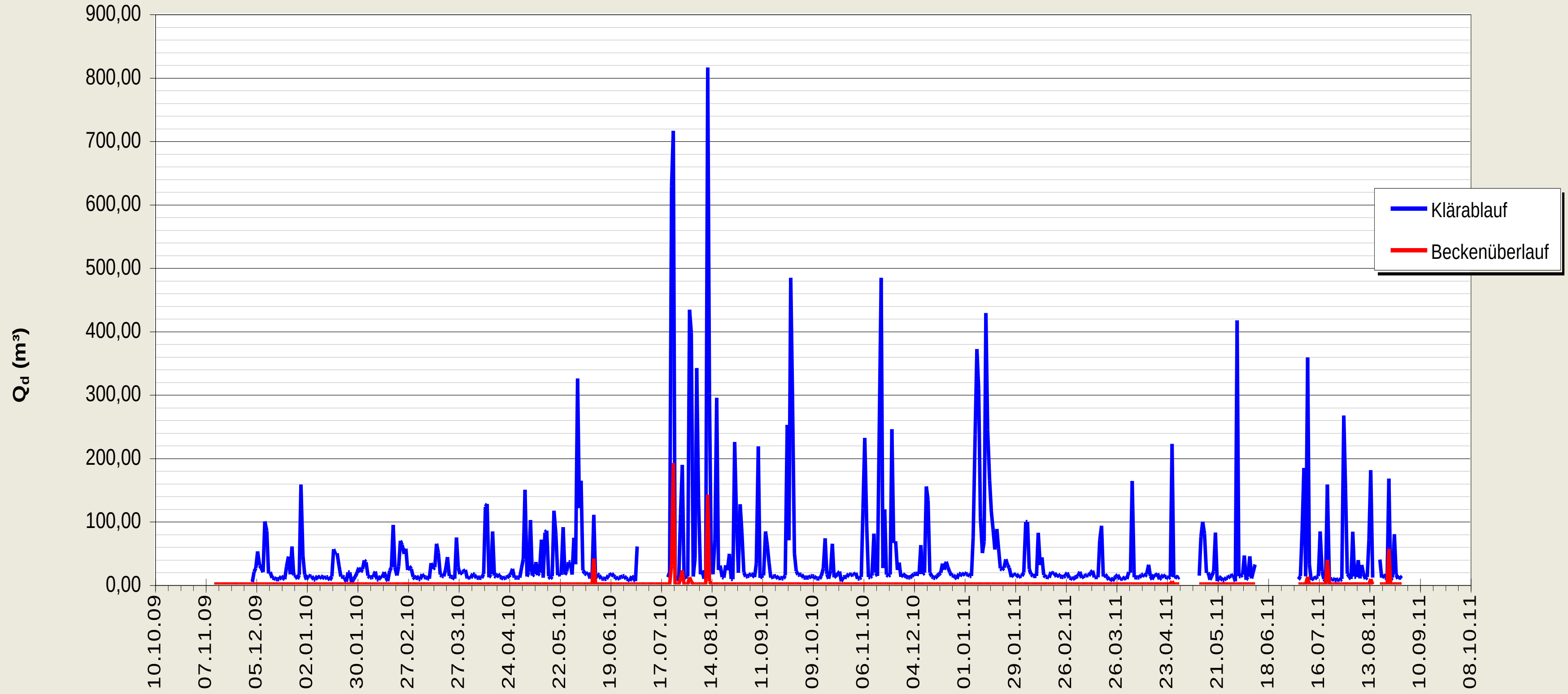
Water balance of combined sewage treatment



Combined Sewage treatment, Friesener Berg, 140 p.e.

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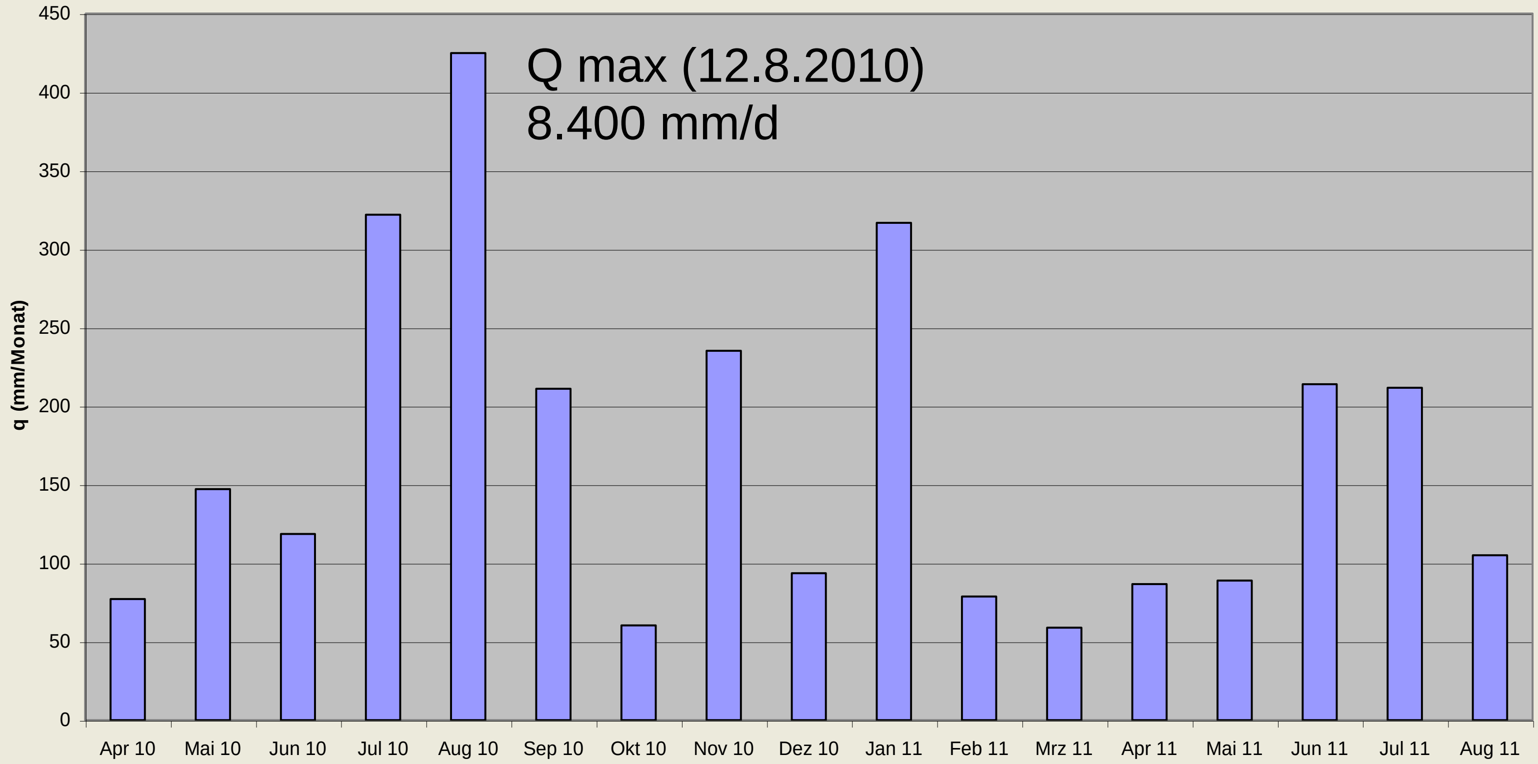
Monitored mean monthly loading rate of wetland filters



Combined Sewage treatment, Friesener Berg, 140 p.e.

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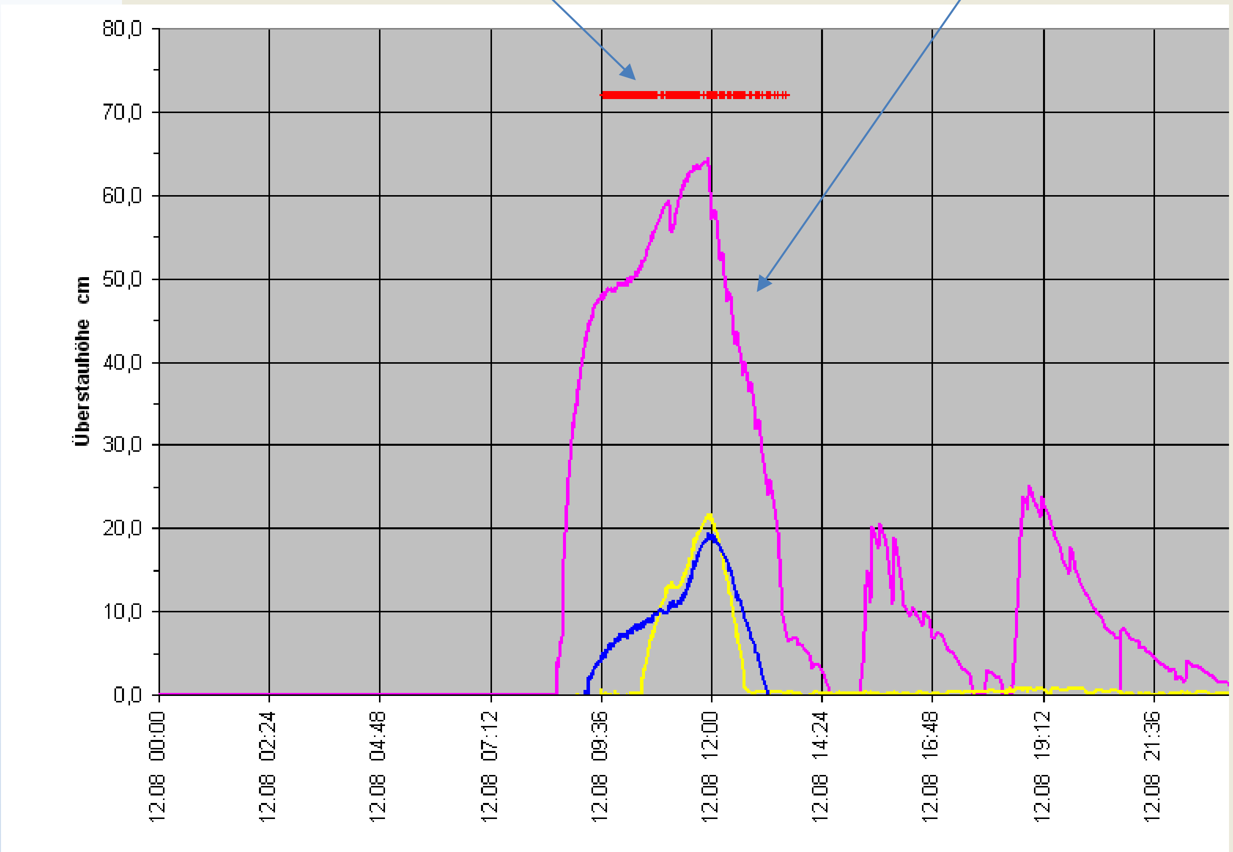
Combined Sewage treatment, Friesener Berg, 140 p.e.

Overflow

Retention



Water retention at extreme situation on top of filter layer
(815 m³/d treated, 140 m³/d overflow)

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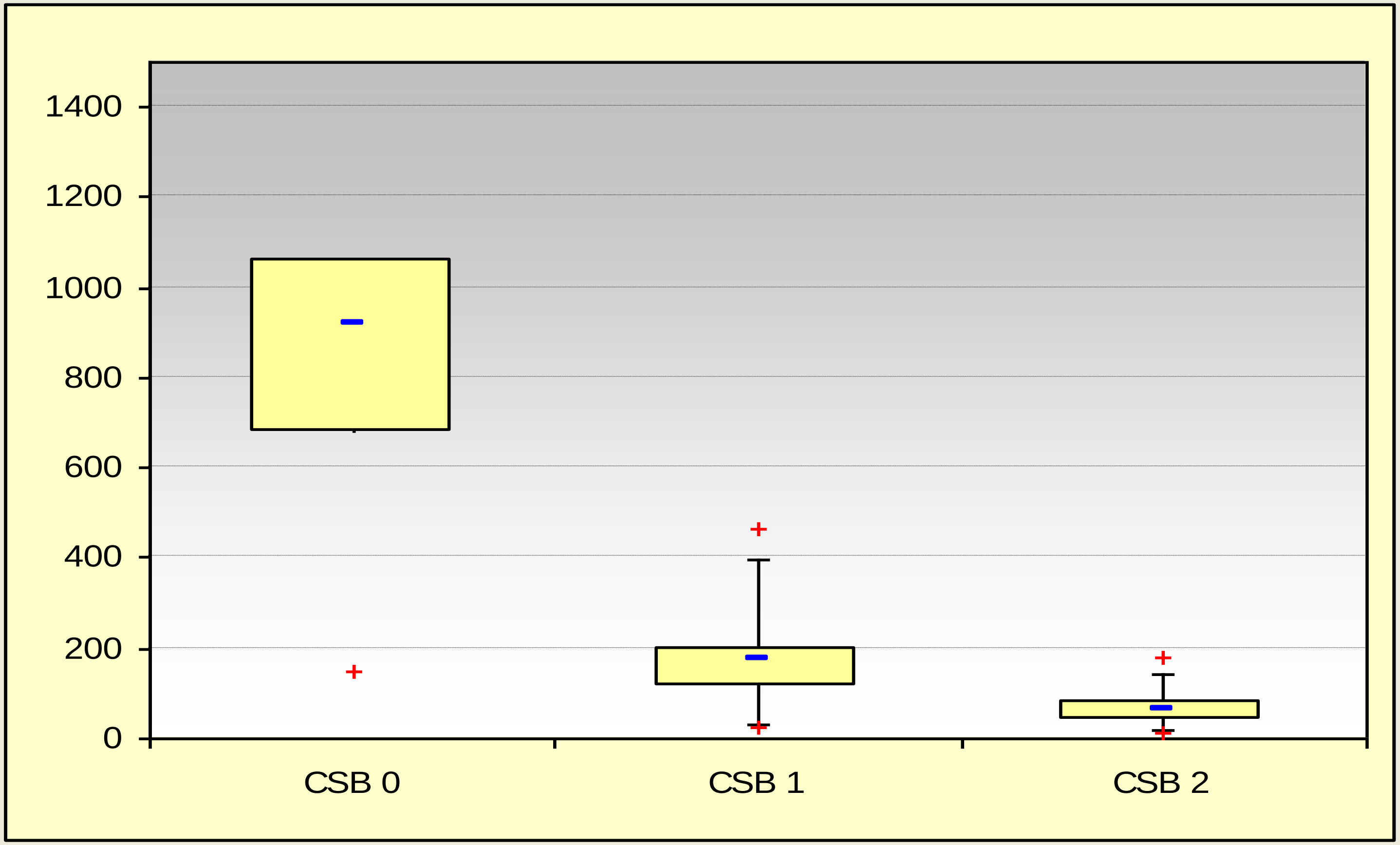
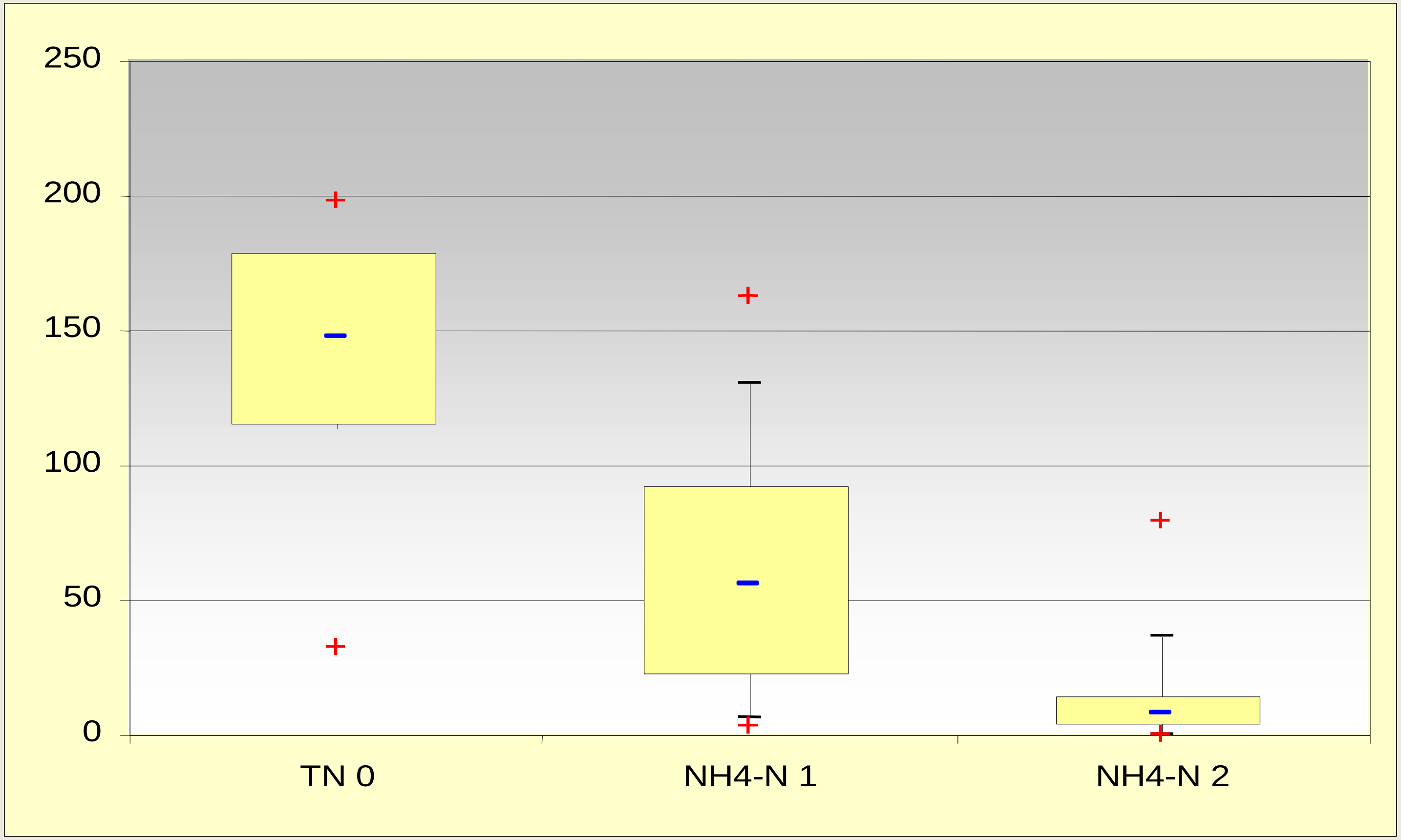


Combined Sewage treatment, Friesener Berg, 140 p.e.

Monitored COD concentrations In, 1st, 2nd stage



Combined Sewage treatment, Friesener Berg, 140 p.e.

Monitored Nitrogen concentrations In, 1st, 2nd stage

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CSB Reinigungsleistung bei unterschiedlicher hydraulischer Belastung (K. Wischniewski, Bachelorarbeit TU Berlin 2011)

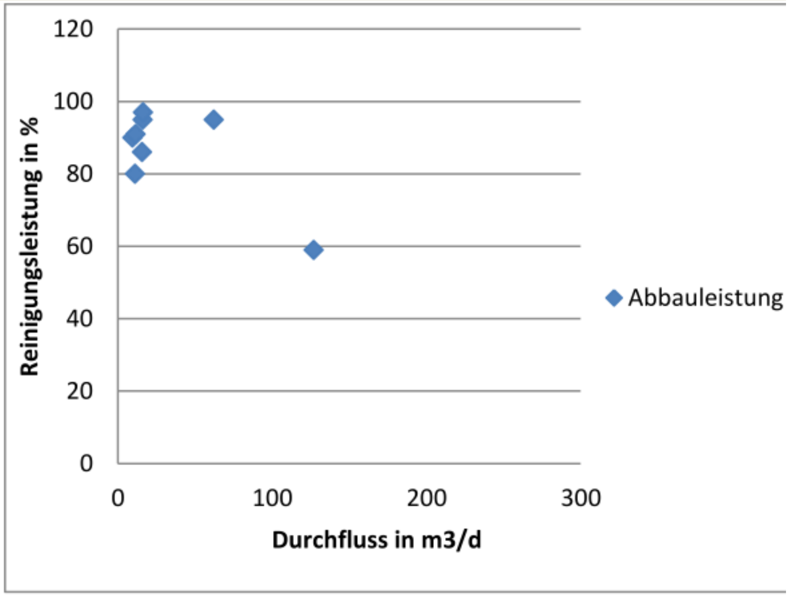


Abbildung 48 Abbauleistung CSB in Abhängigkeit der Reinigungsleistung (%)

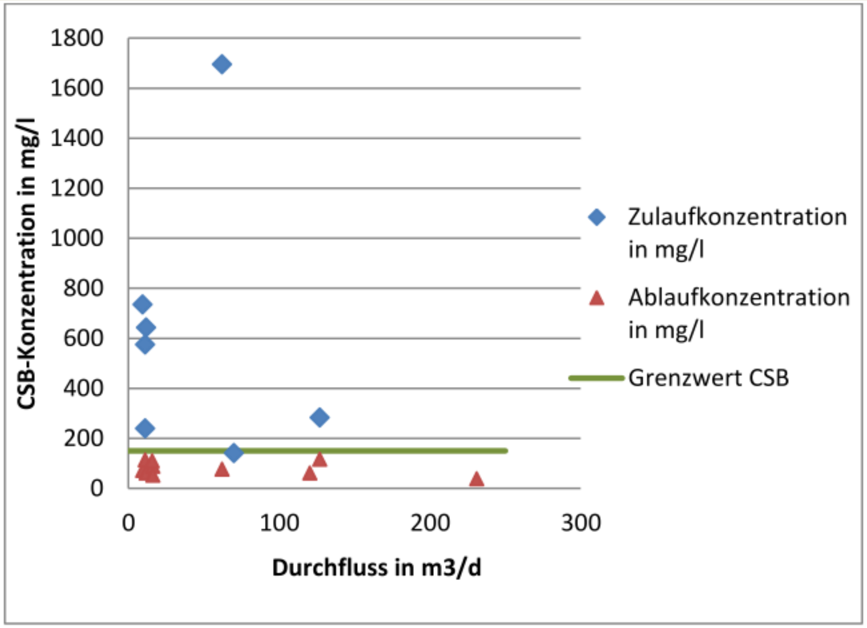


Abbildung 49 Abbauleistung CSB in Abhängigkeit der Zu- und Ablaufkonzentrationen

Combined Sewage treatment, Friesener Berg, 140 p.e.

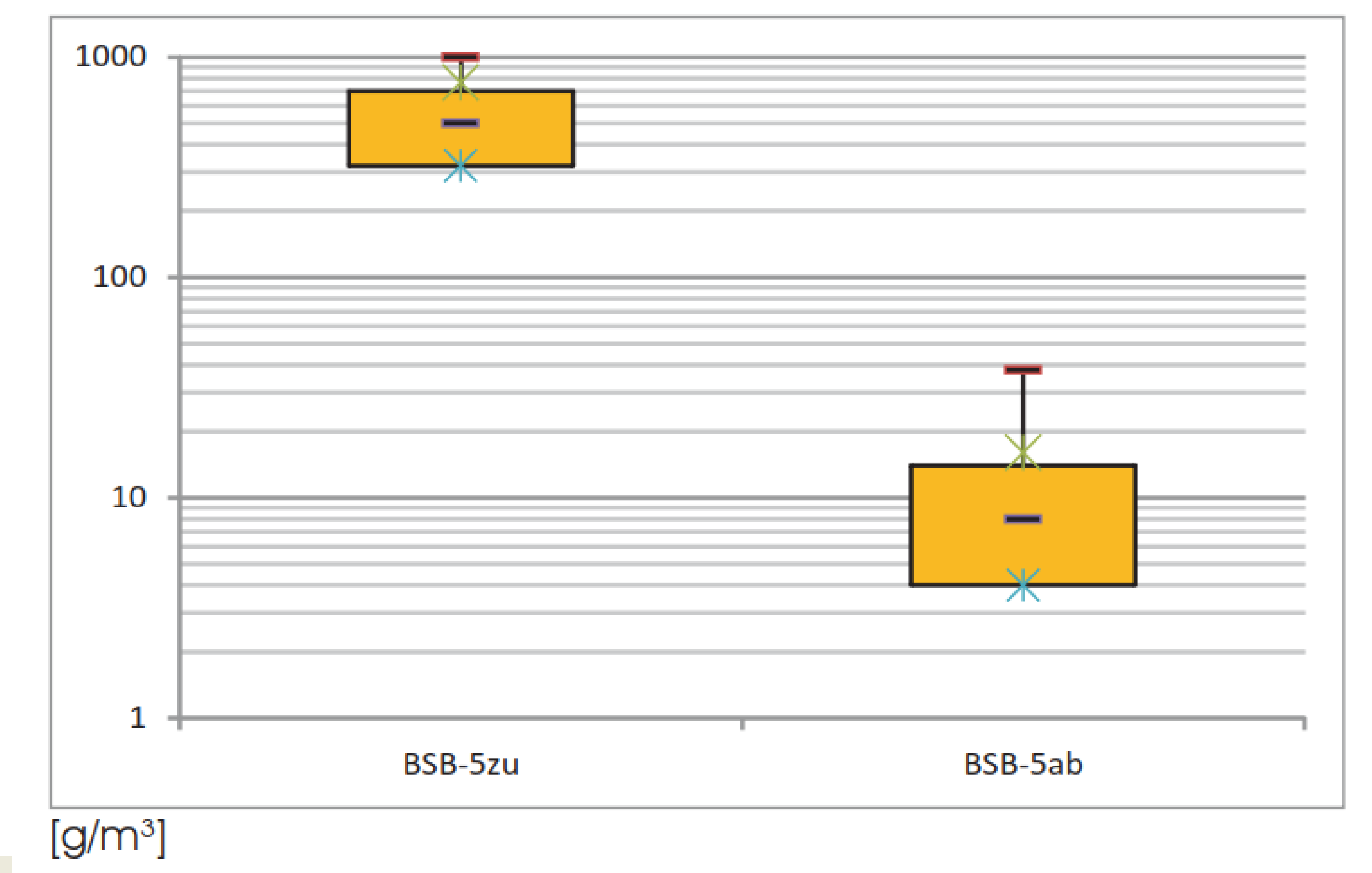
Seperate Sewage, Krawinkel, 70 p.e.

Straßendorf, NSG

2 parallele Vertikalfilter,

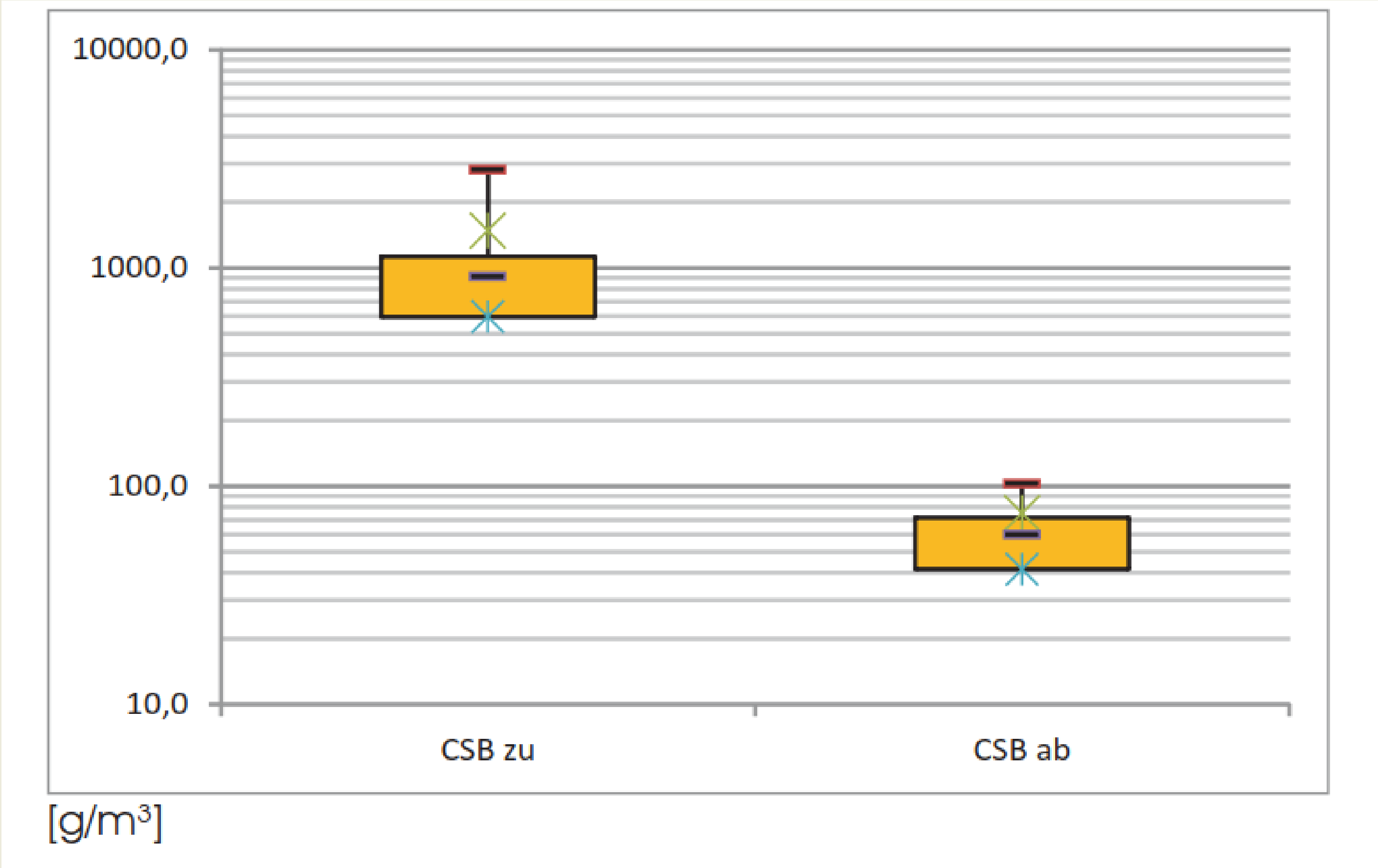
Baujahr 2000, für 70 E

Monitoring Results Krawinkel



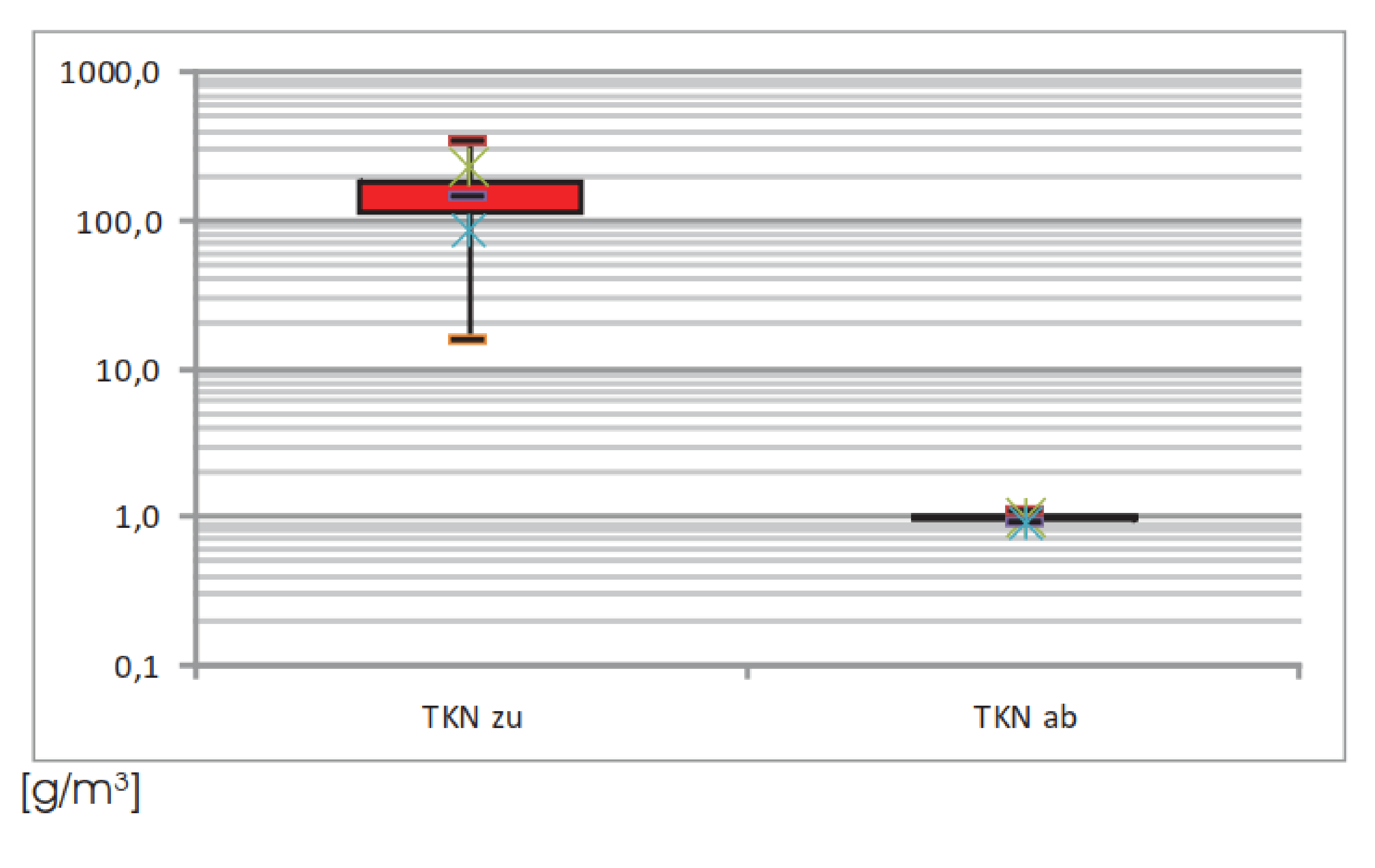
BOD

Monitoring Results Krawinkel



COD

Monitoring Results Krawinkel



Nitrification

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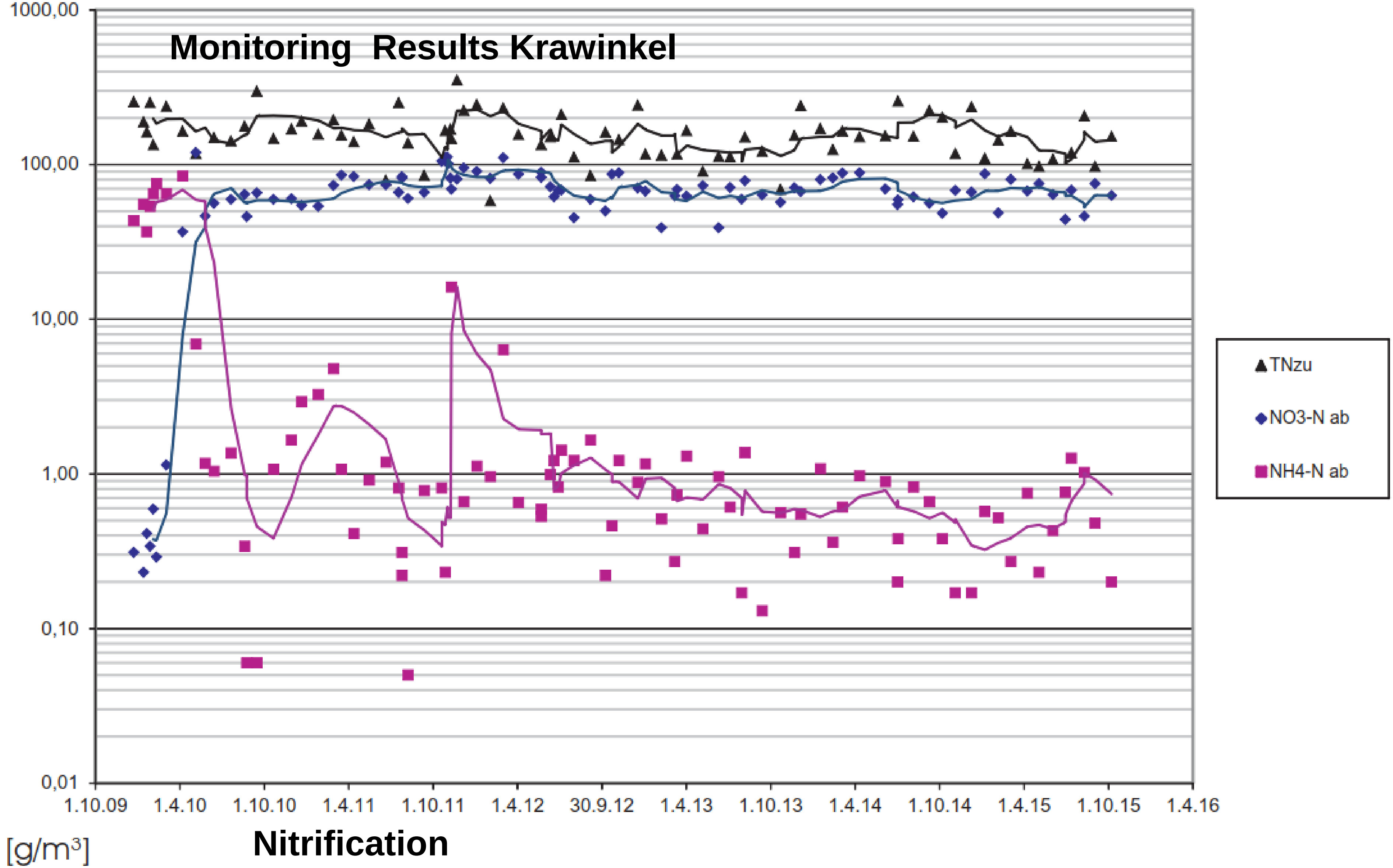

Nitrification

Grey water re-use 1987 until now (Berlin)

Surface water treatment

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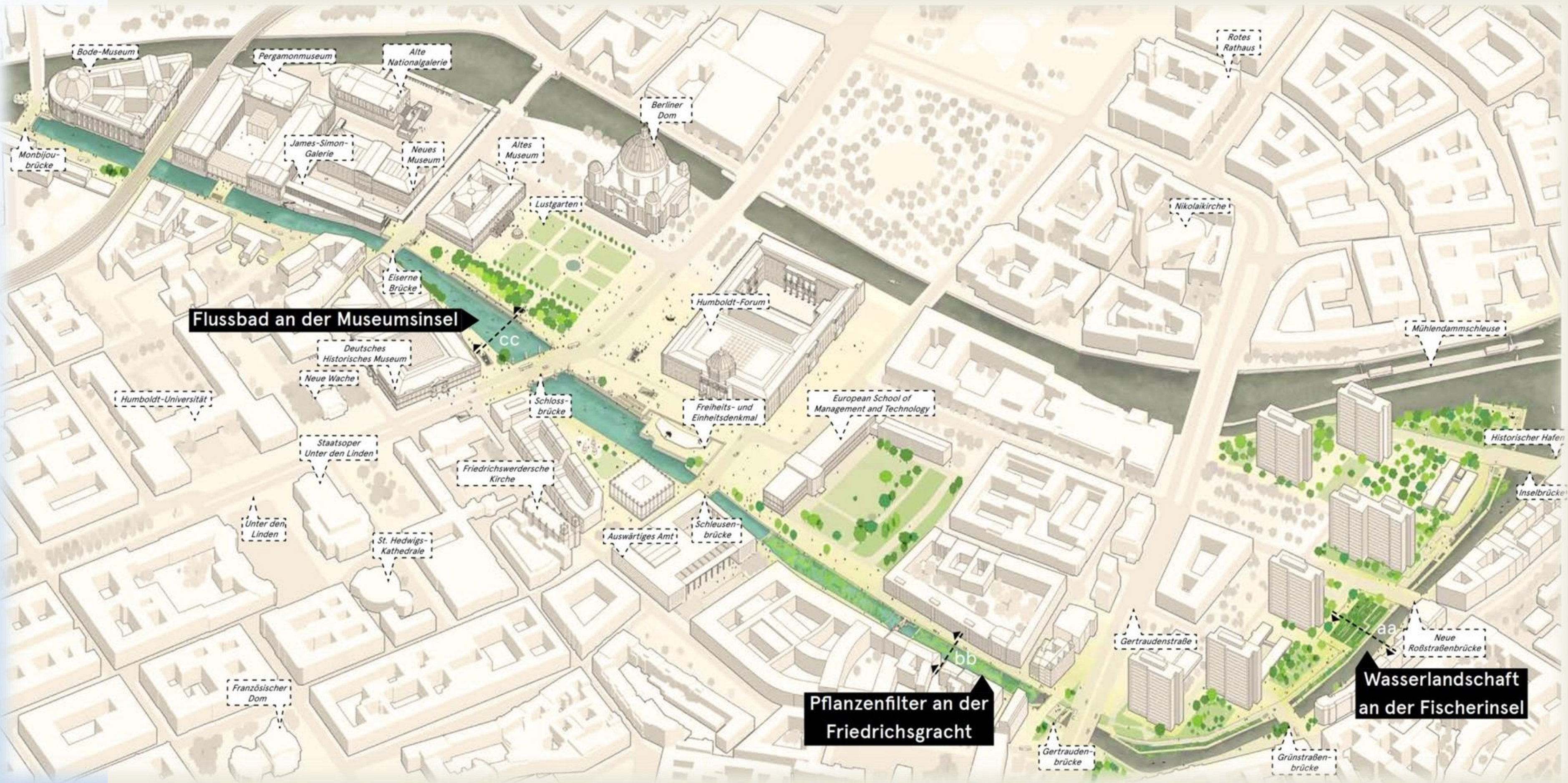
Surface water treatment



River Spree, surface water treatment „Flussbad“ project

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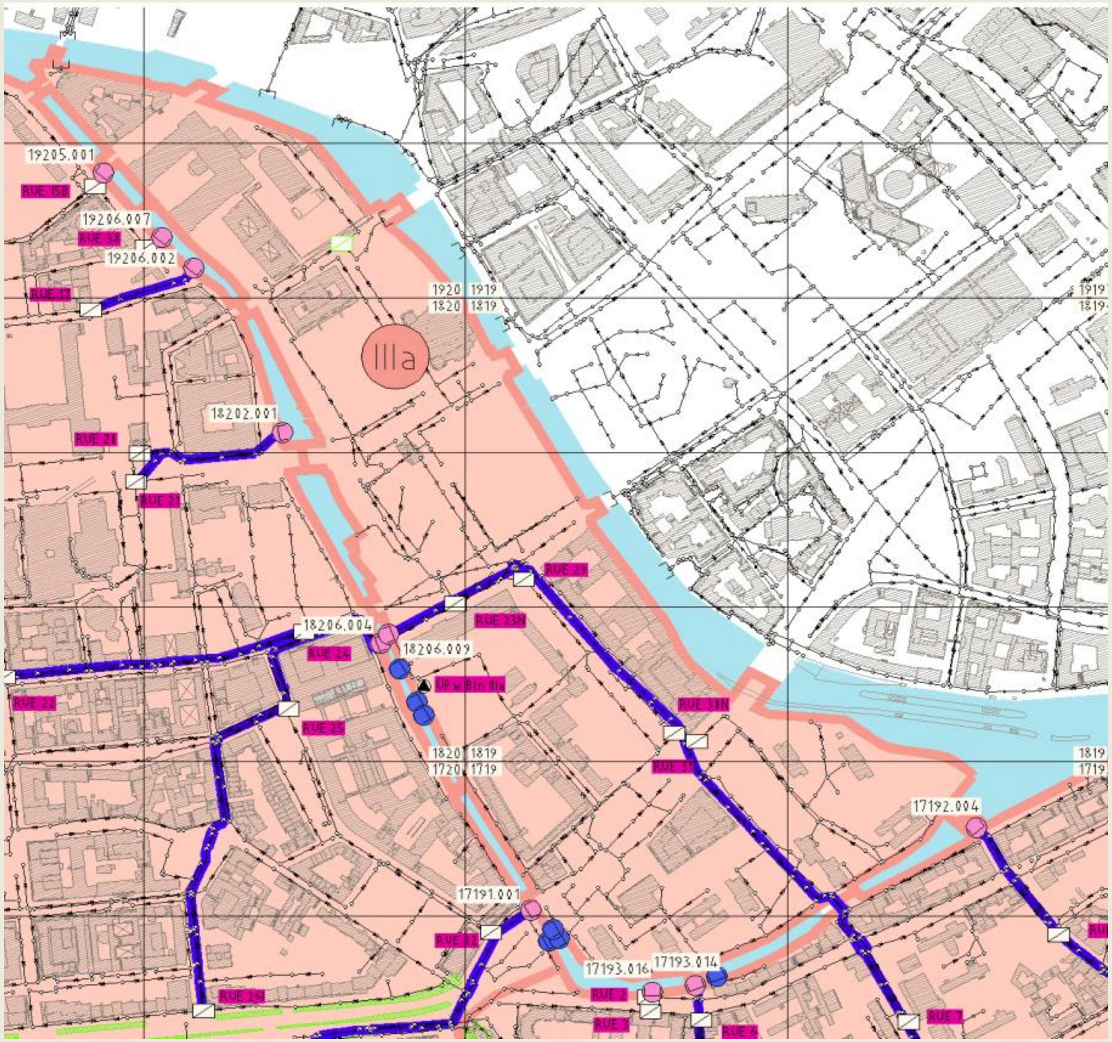

River Spree, surface water treatment „Flussbad“ project

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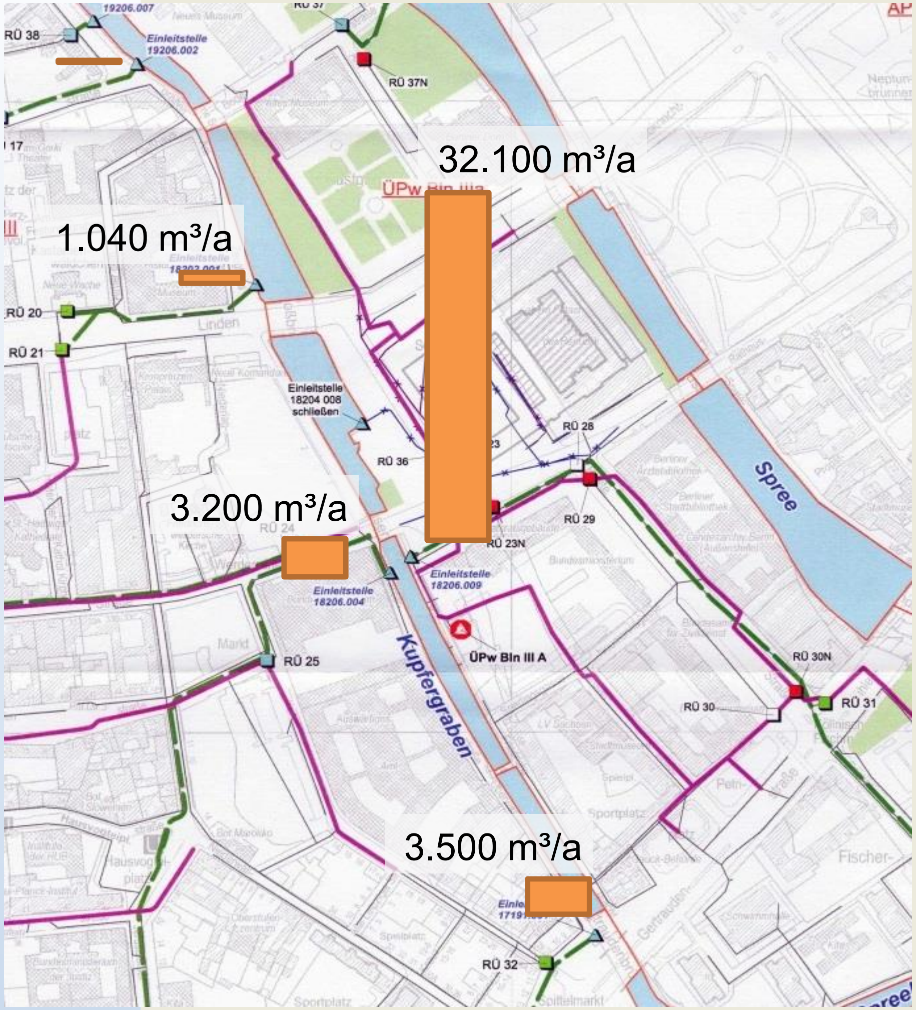

Übersichtsplan BWB aus Projektdatenpool

- 7 MW-Einleitstellen dargestellt
- Nennweiten: DN 300 - DN 1800
- Jahresmengen: 160 – 32.100 m³/a
- Information zu Spitzenabflüssen liegen nur für Modellregen n=1 a^{-1} vor

River Spree, surface water treatment „Flussbad“ project

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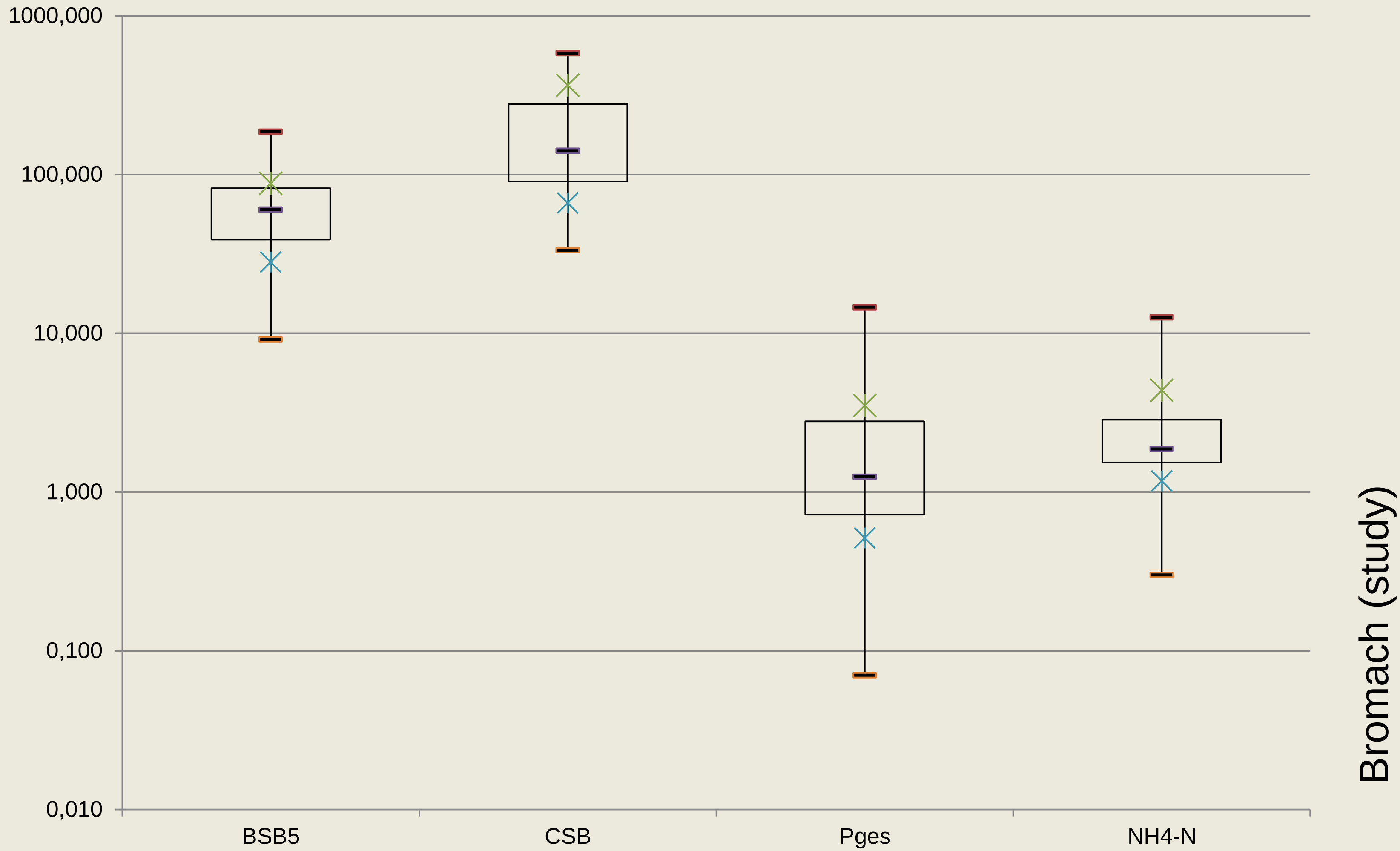
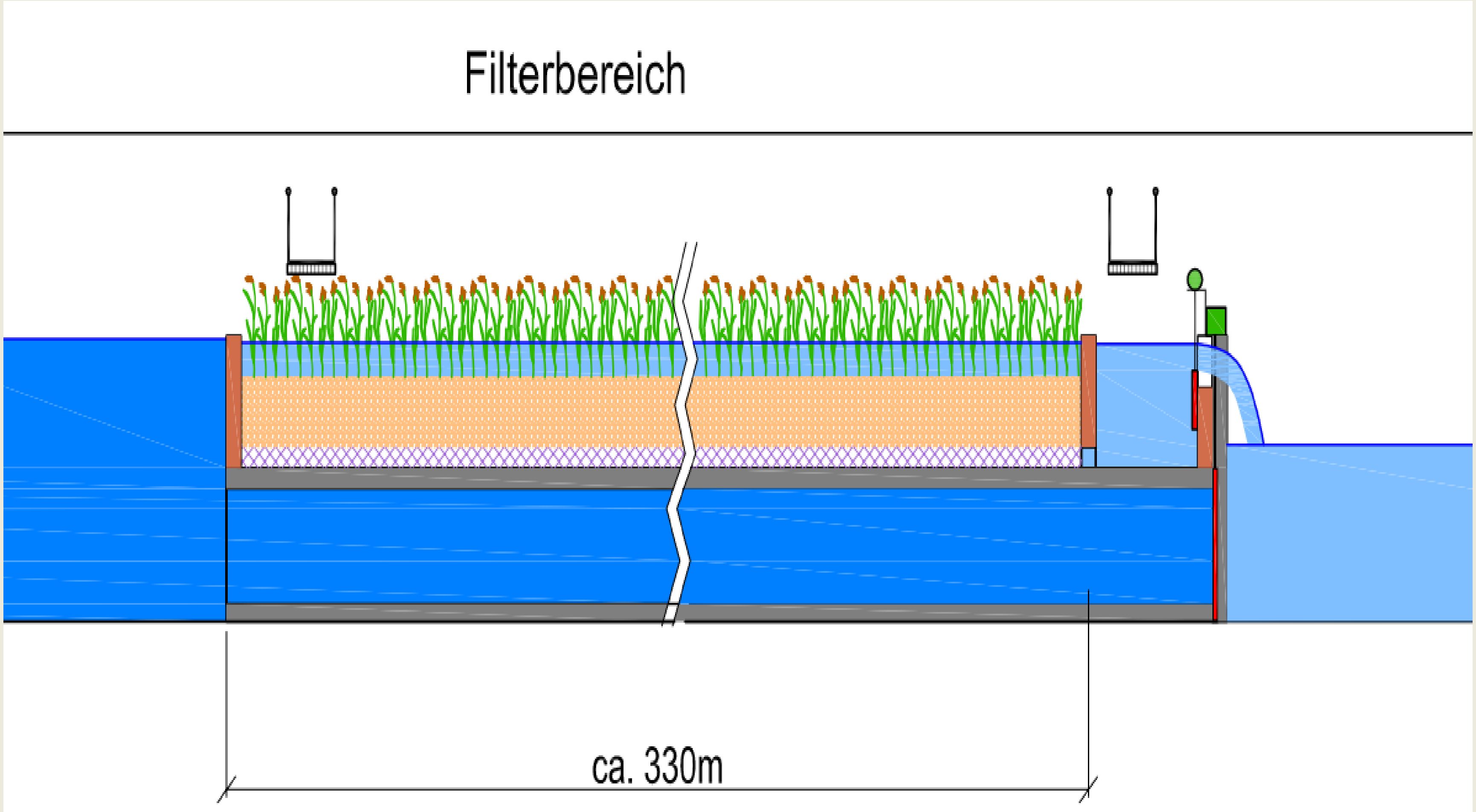


Combined Sewer Overflow – Cotaminants Concentrations



River Spree, surface water treatment „Flussbad“ project

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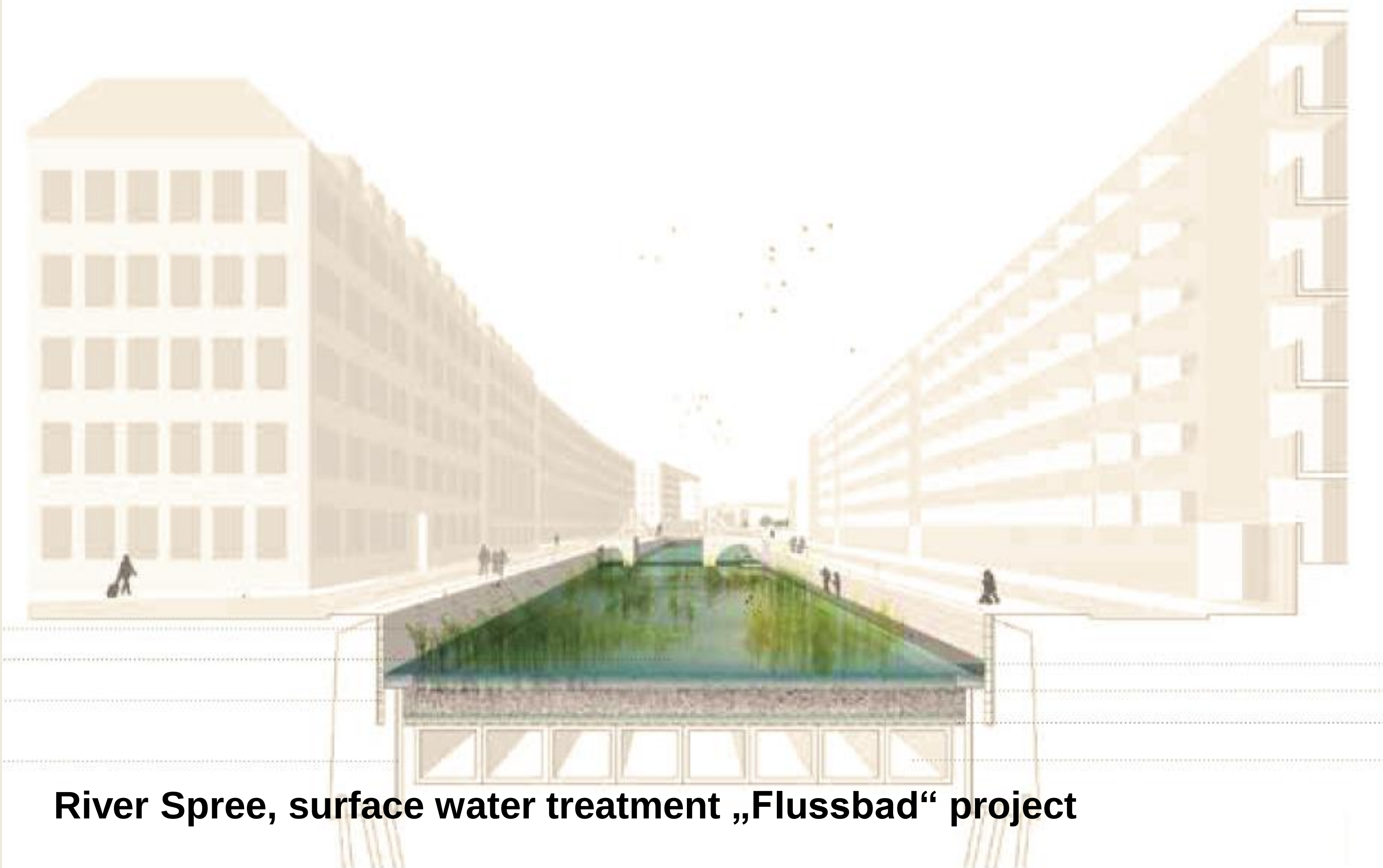

River Spree, surface water treatment „Flussbad“ project

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River Spree, surface water treatment „Flussbad“ project

Tertiary Treamtent according to DWA-A 262 in China
20.000 m² Vertical flow wetland (Changshu, 2014)