ULTIMATE

WATER SMART INDUSTRIAL SYMBIOSIS

CS9: Development of a joint control system for an industrial and a municipal WWTP

A. Kleyböcker, L. Rodenkam Melchiorsen, J. Schütz, L. Lundgaard, S. Bendix Larsen

CS9 in Kalundborg (Denmark)

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869318

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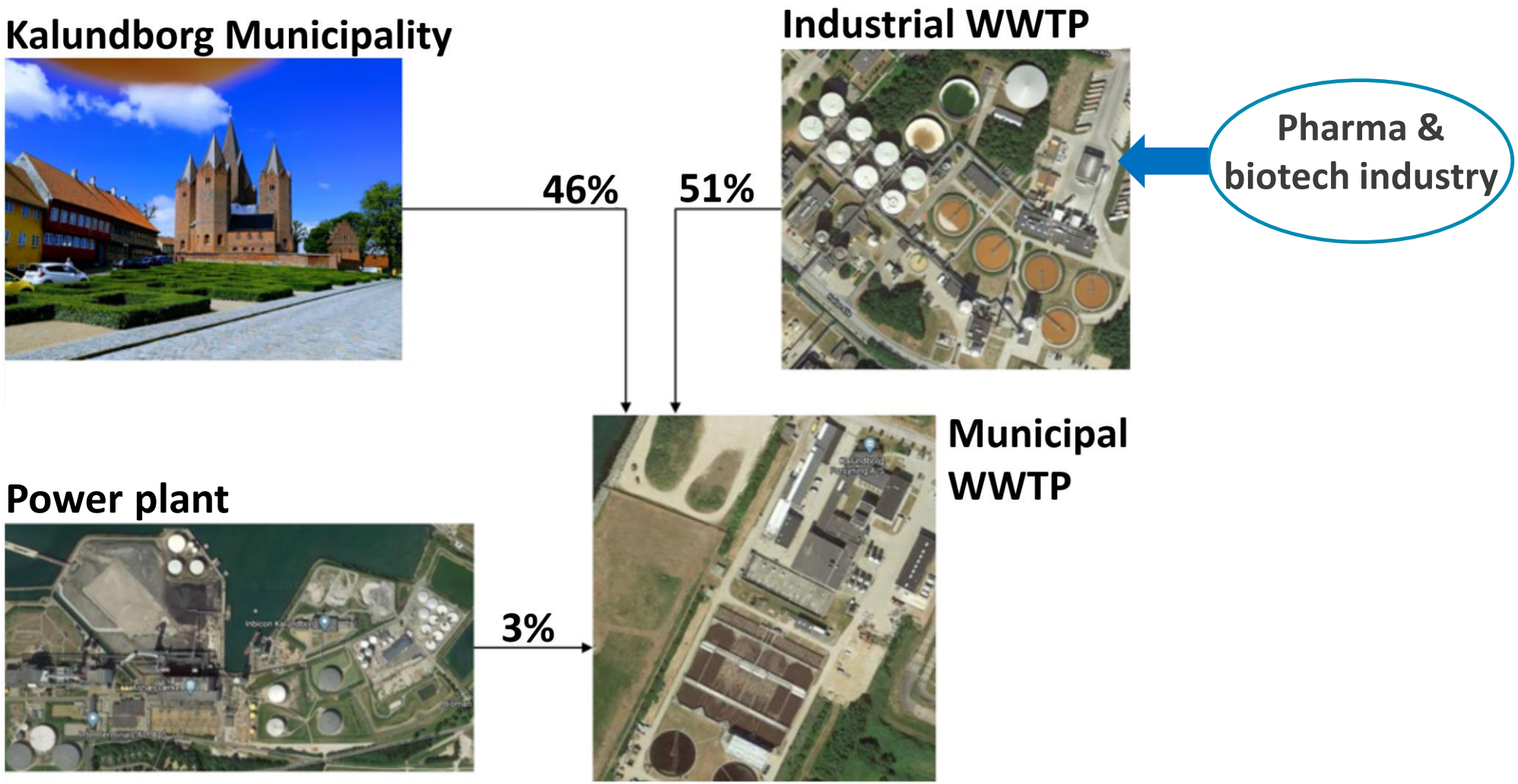
Situation at the start of Ultimate



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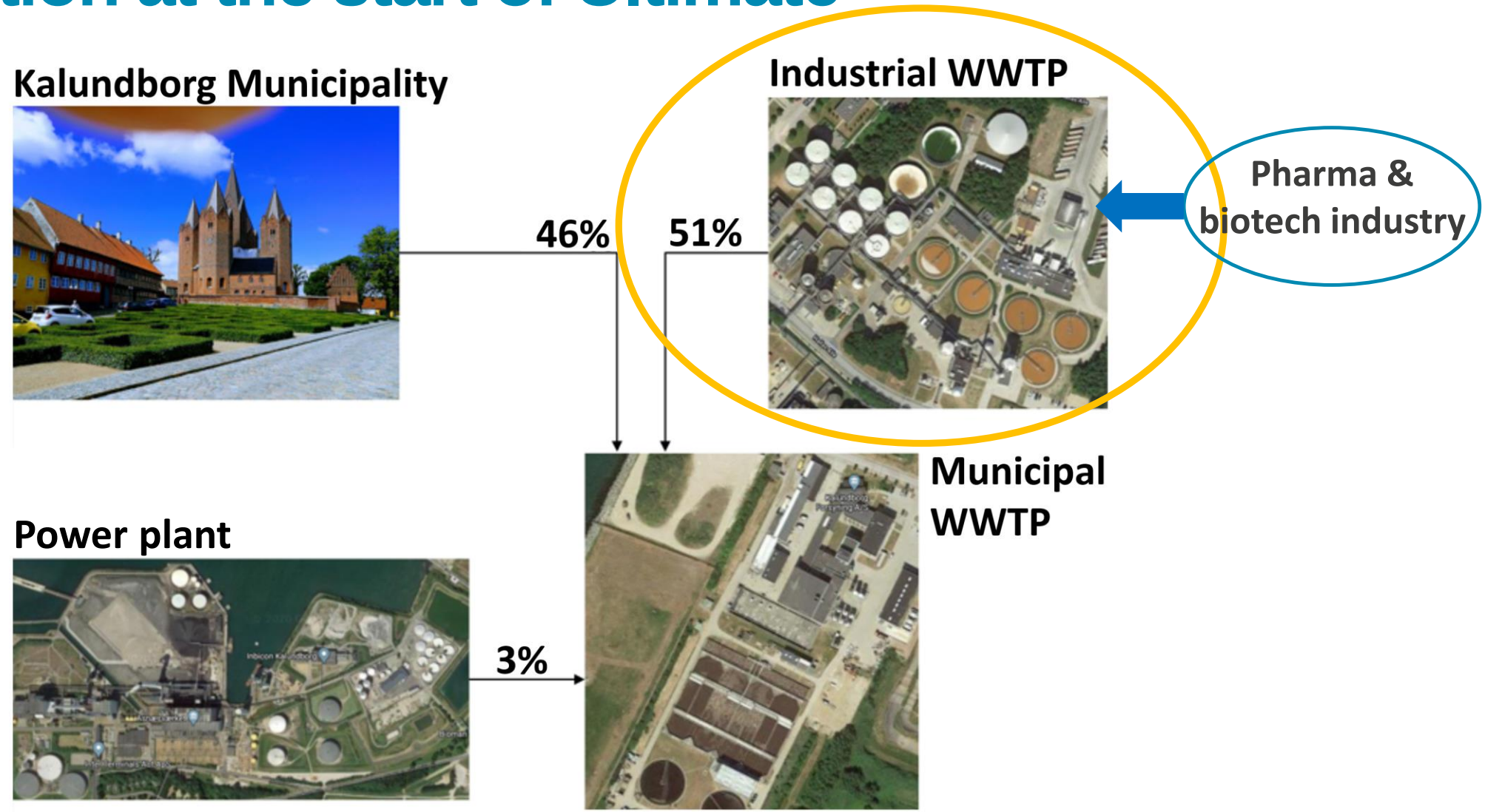

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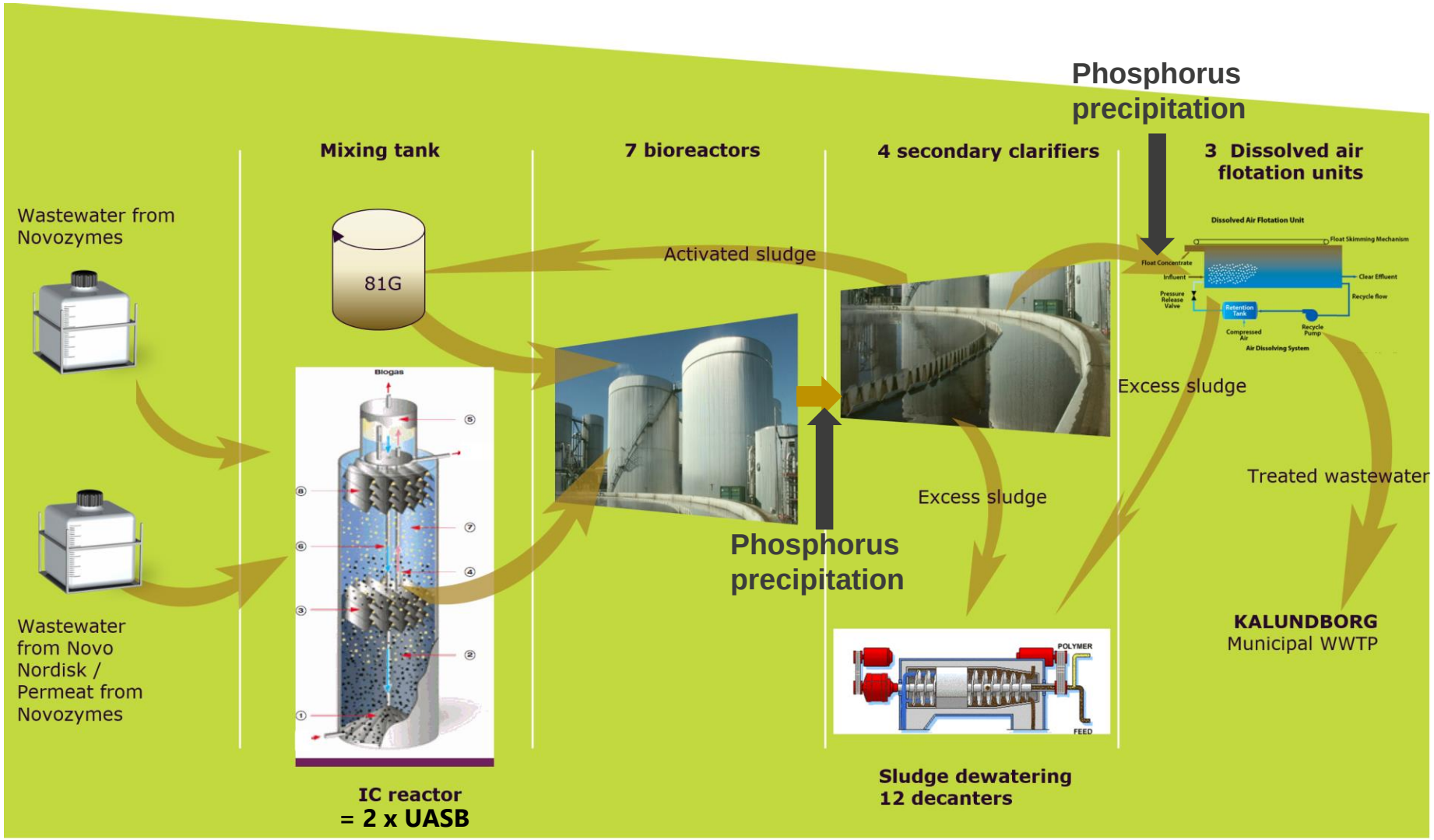
Industrial wastewater treatment plant:
own control system & chemical phosphorus removal



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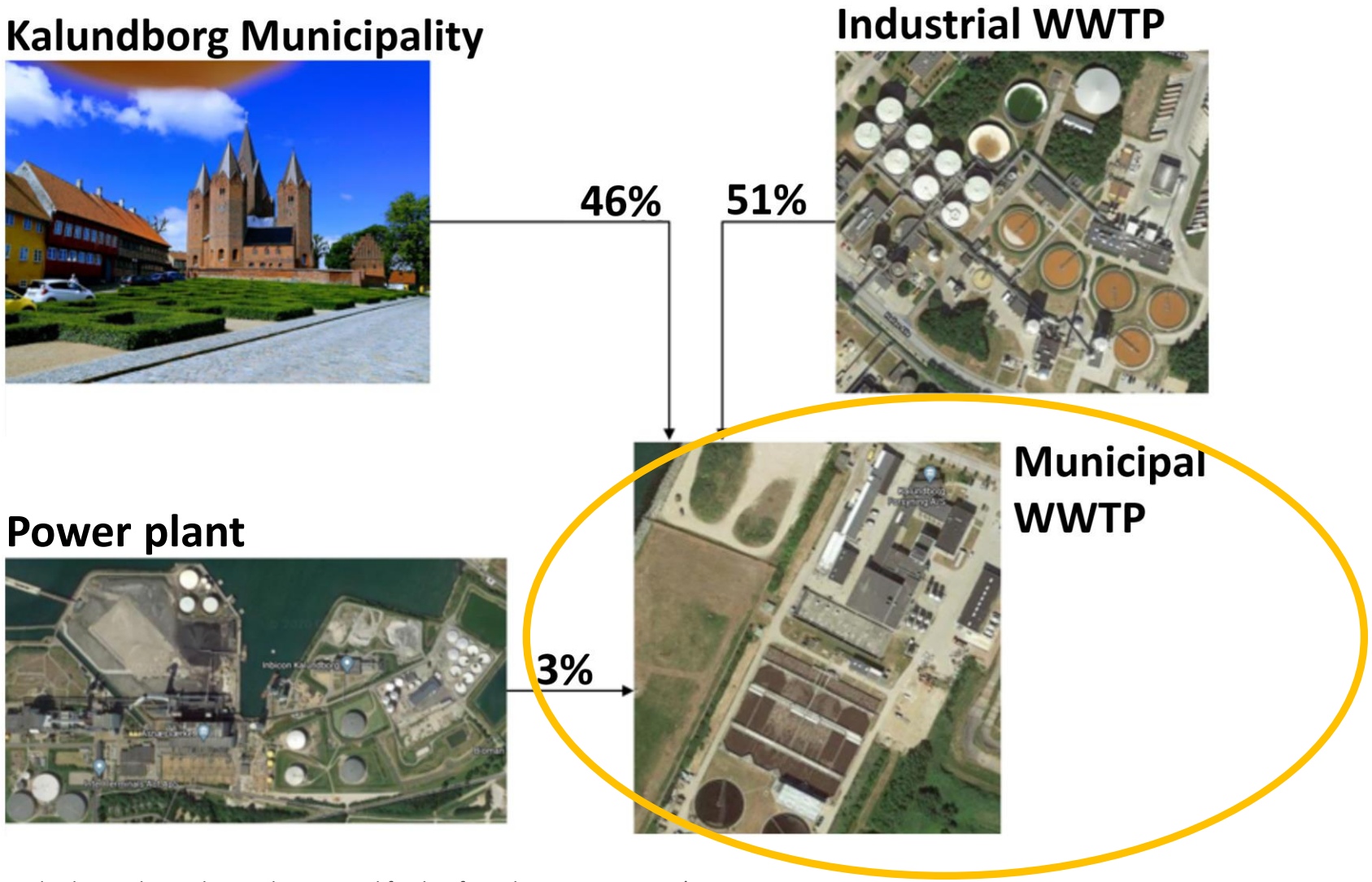

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Municipal wastewater treatment plant:
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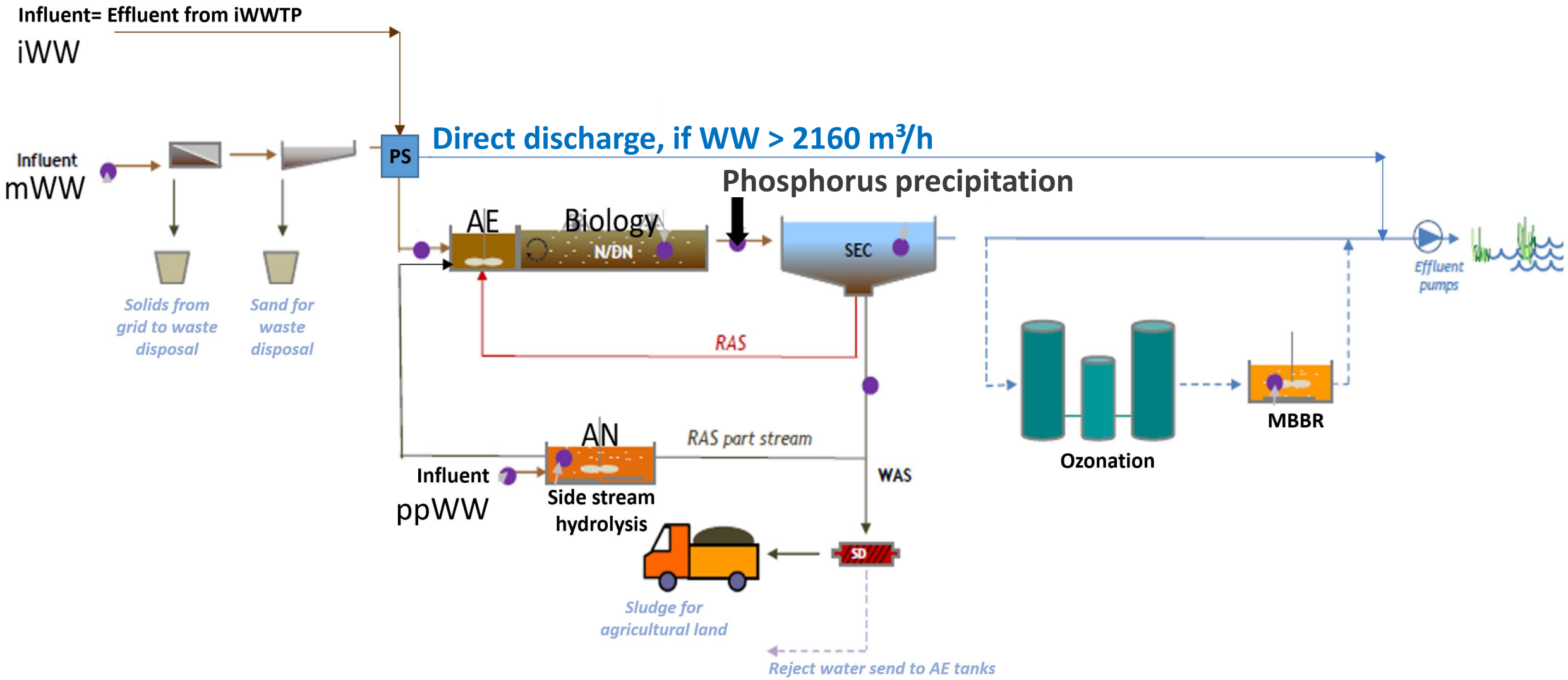

Joint Control System

Objective:

Reduce energy consumption

→ Predictive controlled nitrogen elimination (O_2 concentration as low as possible via predicting NH_4, NO_3, TN and COD loads to the municipal WWTP)

Options:

Reduce chemicals consumption for phosphorus elimination

→ Change to enhanced biological phosphorus removal

Reduce direct discharges to recipient

→ iWWTP = hydraulic buffer during high loading situations

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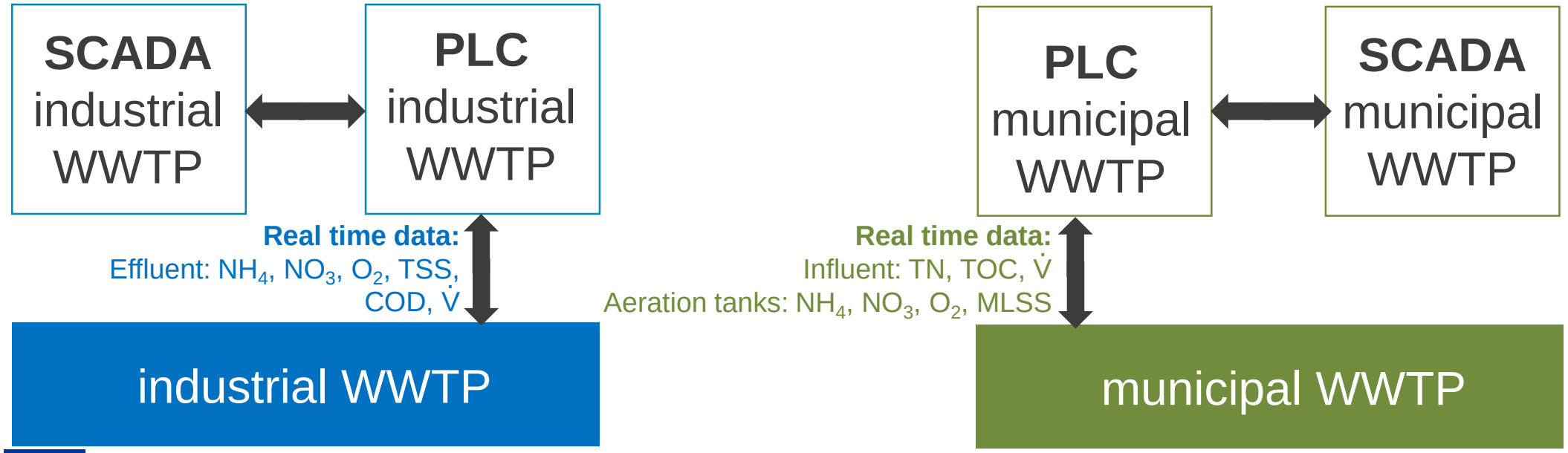
Joint Control System

SCADA	Supervisory Control and Data Acquisition
RTU	Remote Terminal Unit
PLC	Programmable Logic Controller
WWTP	Wastewater Treatment Plant



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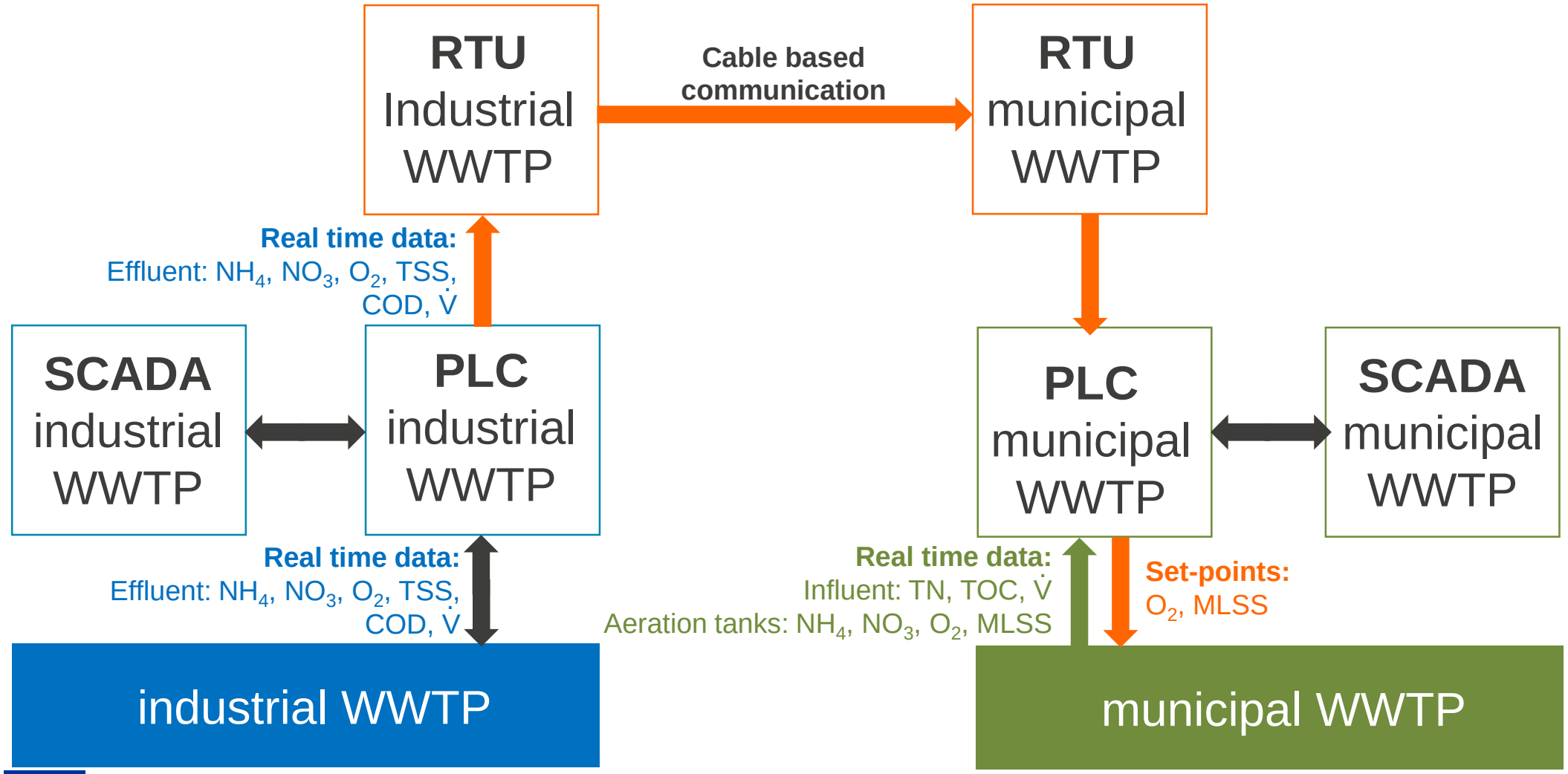

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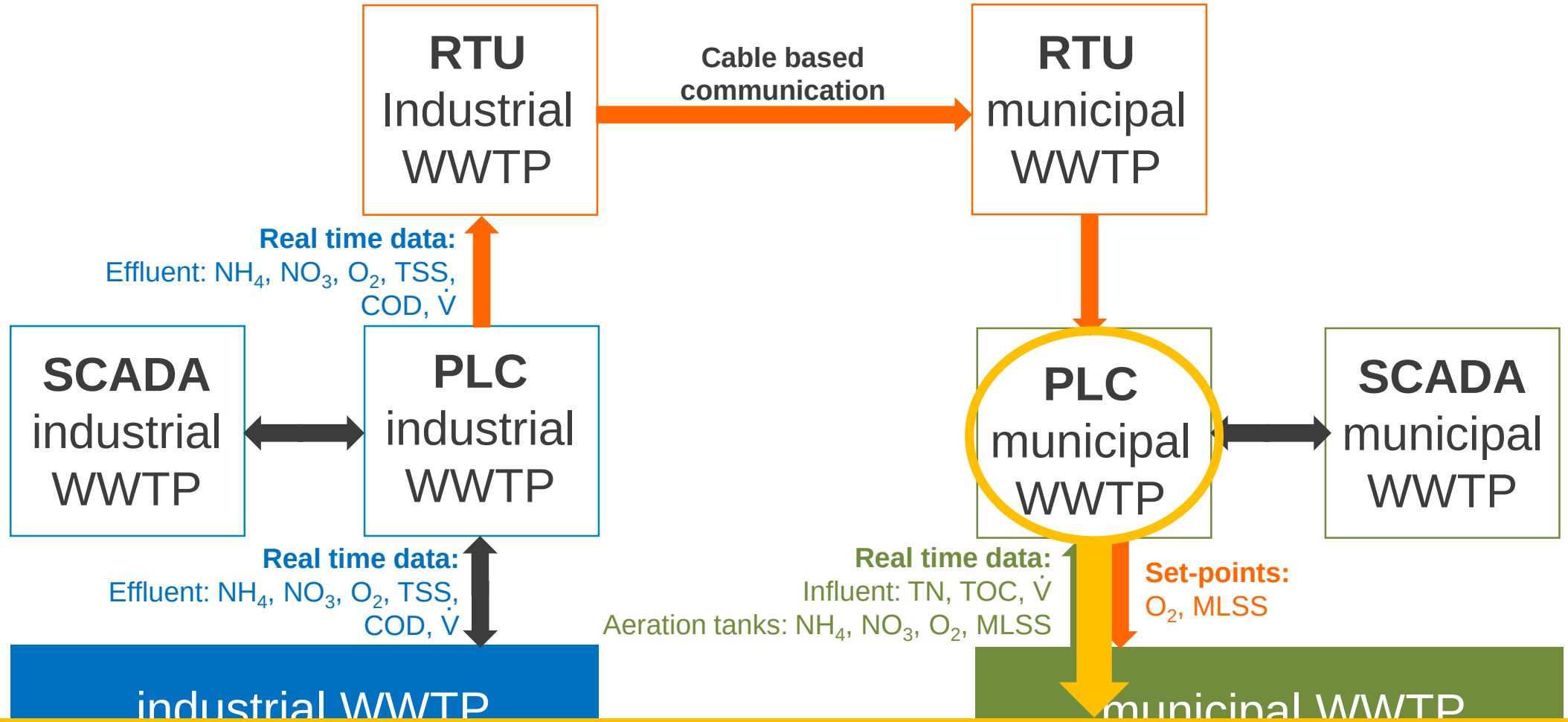

Which functions have to be implemented

to generate the right set-points?

Development of functions and test via digital twin

via software:

→ Challenge: wastewater results not only from municipality, but also from industry

→Functions for modelling have to adapted

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Development of digital twin:

High quality data required to gain reliable results from modelling

Fractioning

- Influent mWW ✓
- Influent iWW ✓
- Influent mixed WW ✓

Steady state modelling with standard blocks

- Variation: different set-ups ✗
- Balancing of COD, TSS, ✓
- Balancing of N and P ✗
- Comparison between model results and measurement ✓
- Simple aeration model ✓
- Simple precipitation model ✓
- Calibration of the model ✗
- Validation of the model ✗

Improved model

- Dynamic model
- Improved aeration model
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Digital twin

- Final set-up
- Improved model

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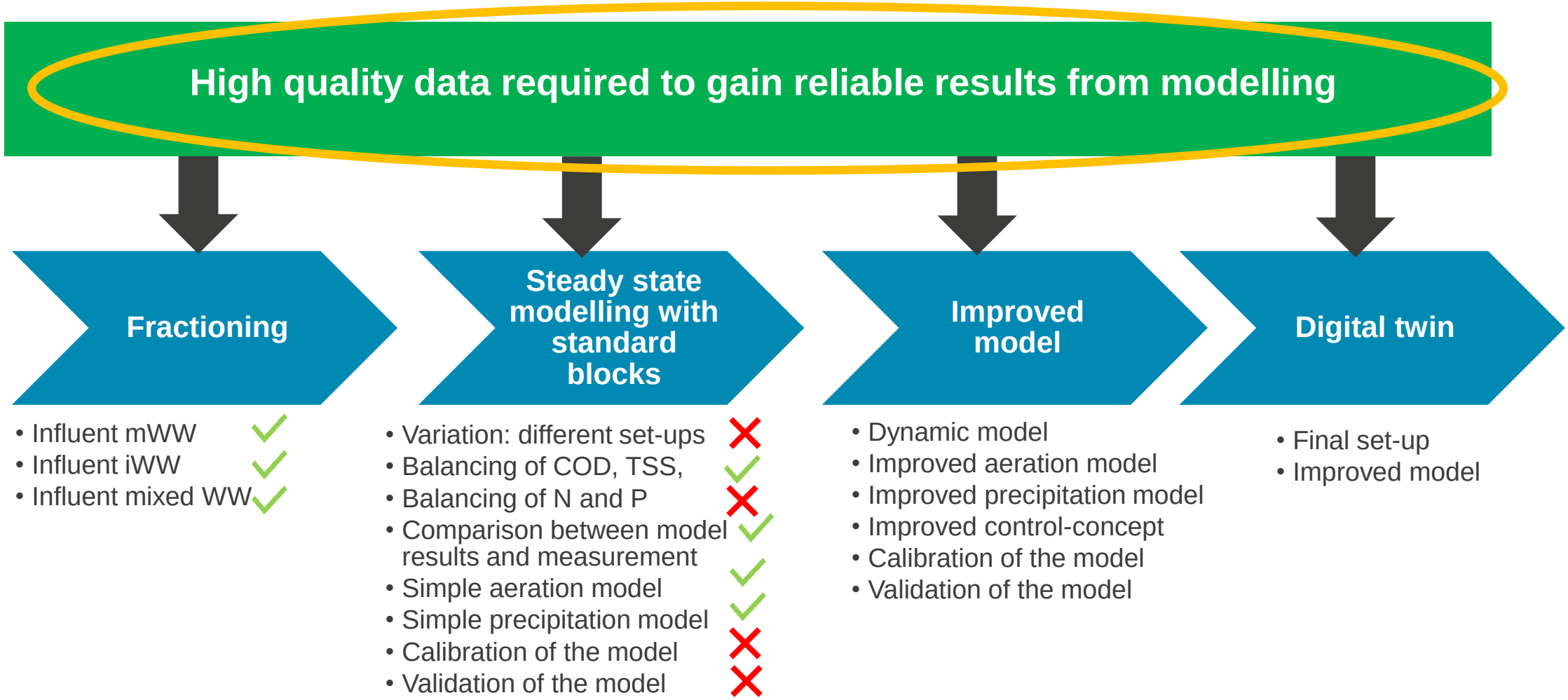

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Data generation and management

- Evaluation of historical process data (online & routine measurements)

ADDITIONAL:

- Measuring campaigns to determine diurnal variations (influents to the mWWTP, to the conventional activated sludge dichtes and effluent of mWWTP)
- Phosphate release experiments
- Installation of new multi-sensors for real time data

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Measuring campaign to determine the diurnal variation

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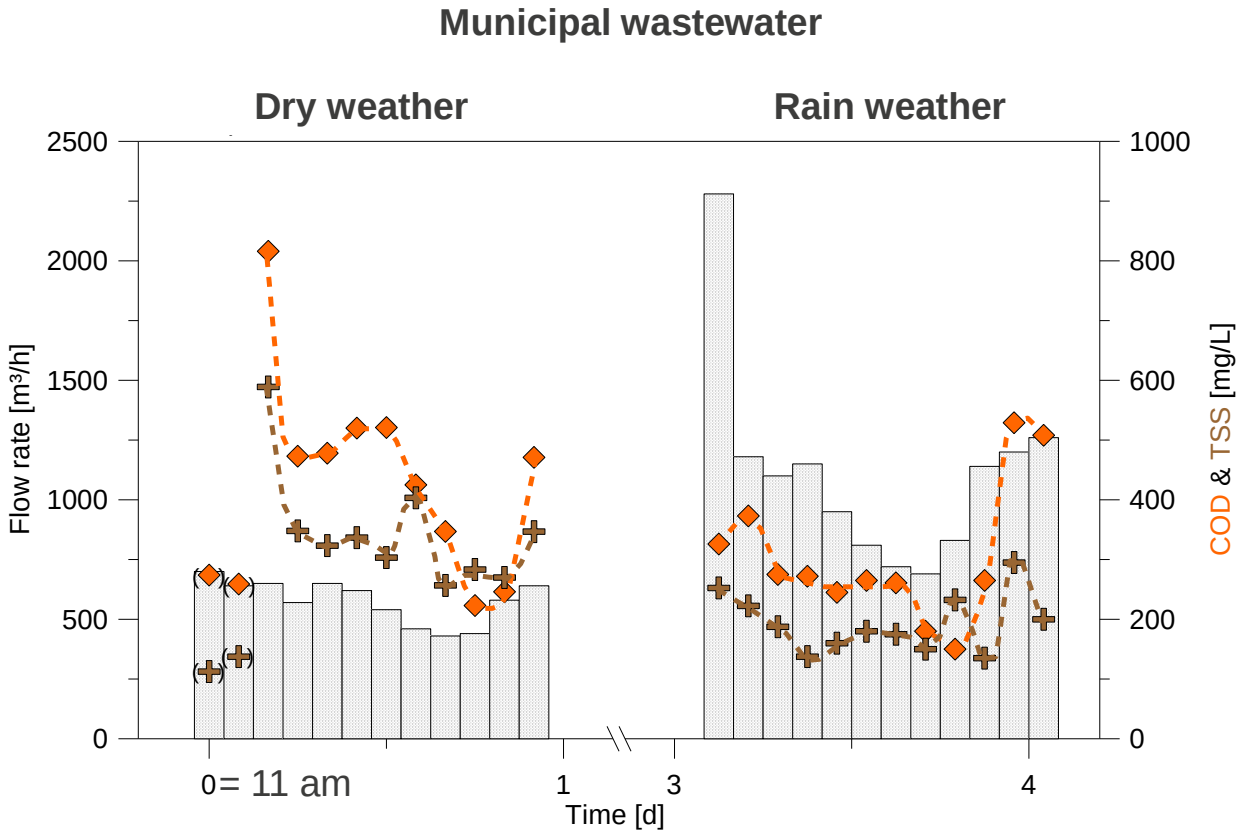
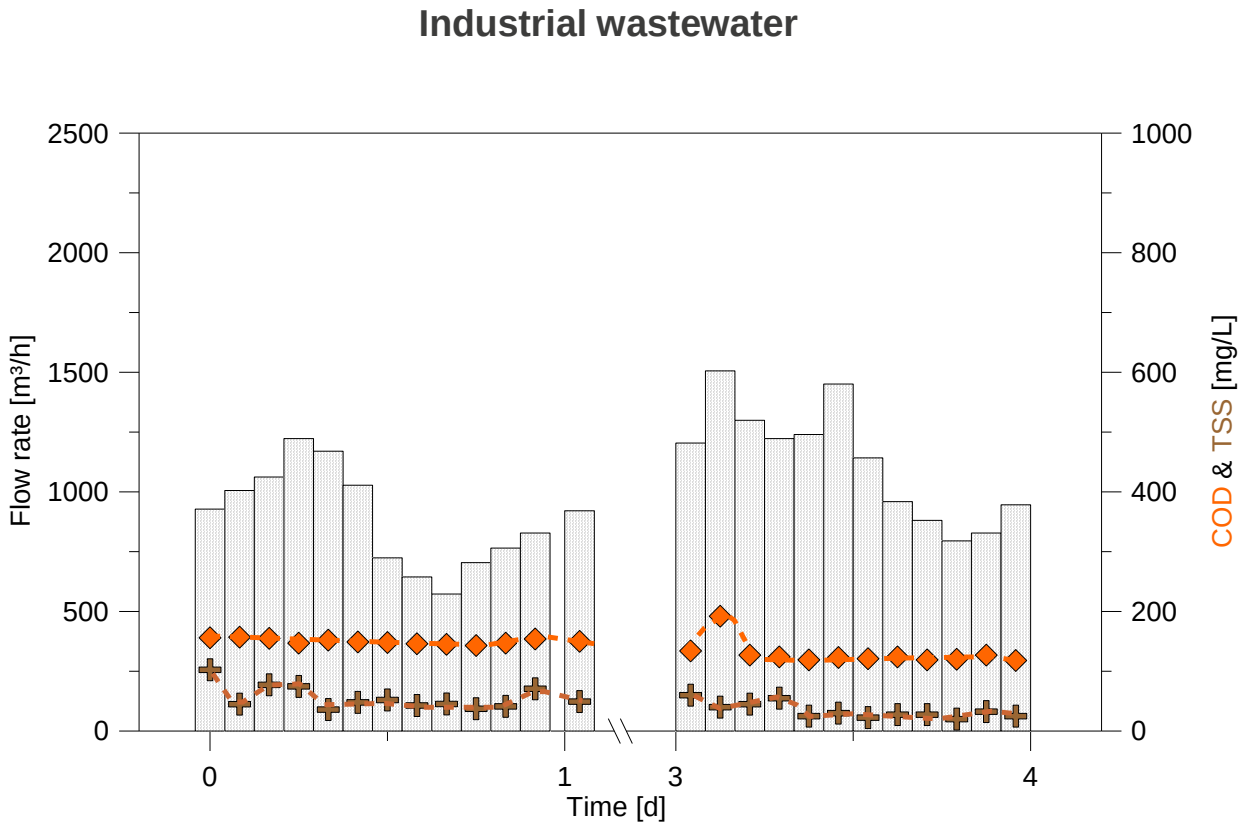
Measuring campaign to determine the diurnal variation Chemical oxygen demand & Total suspended solids





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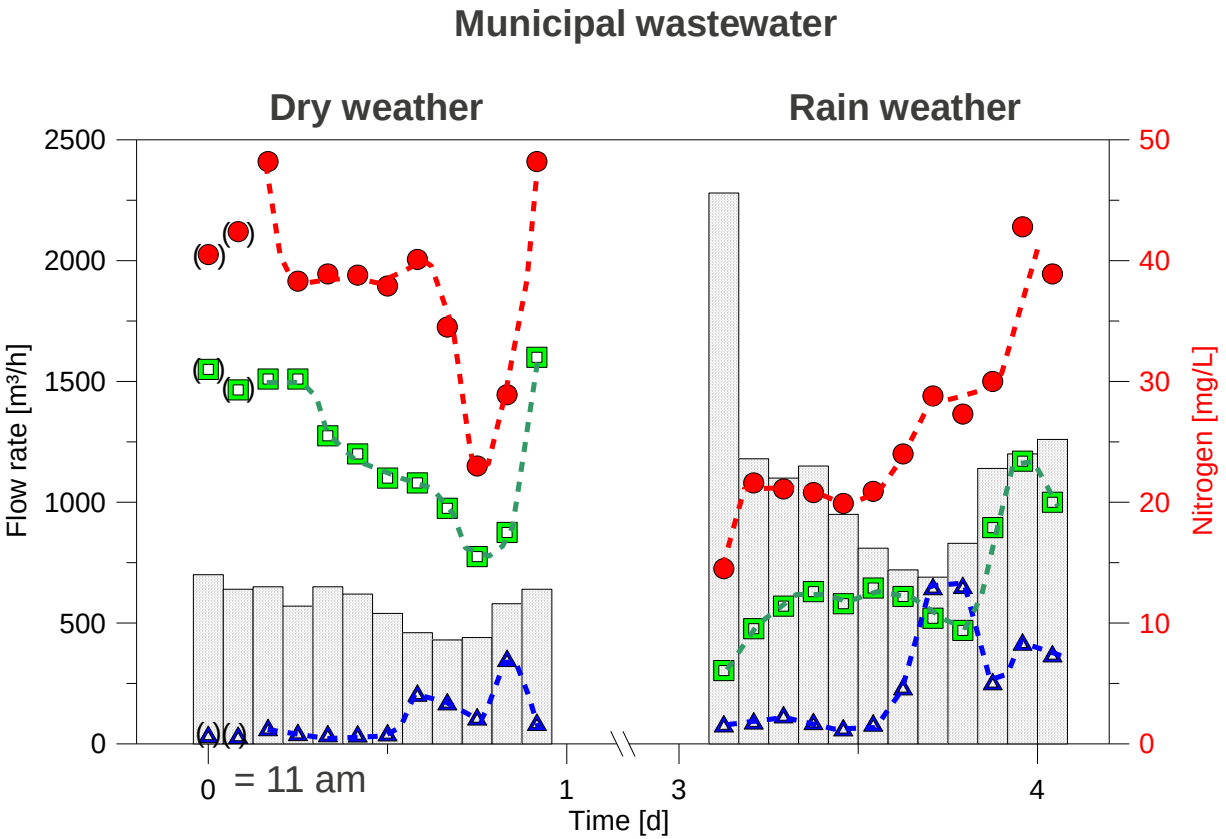
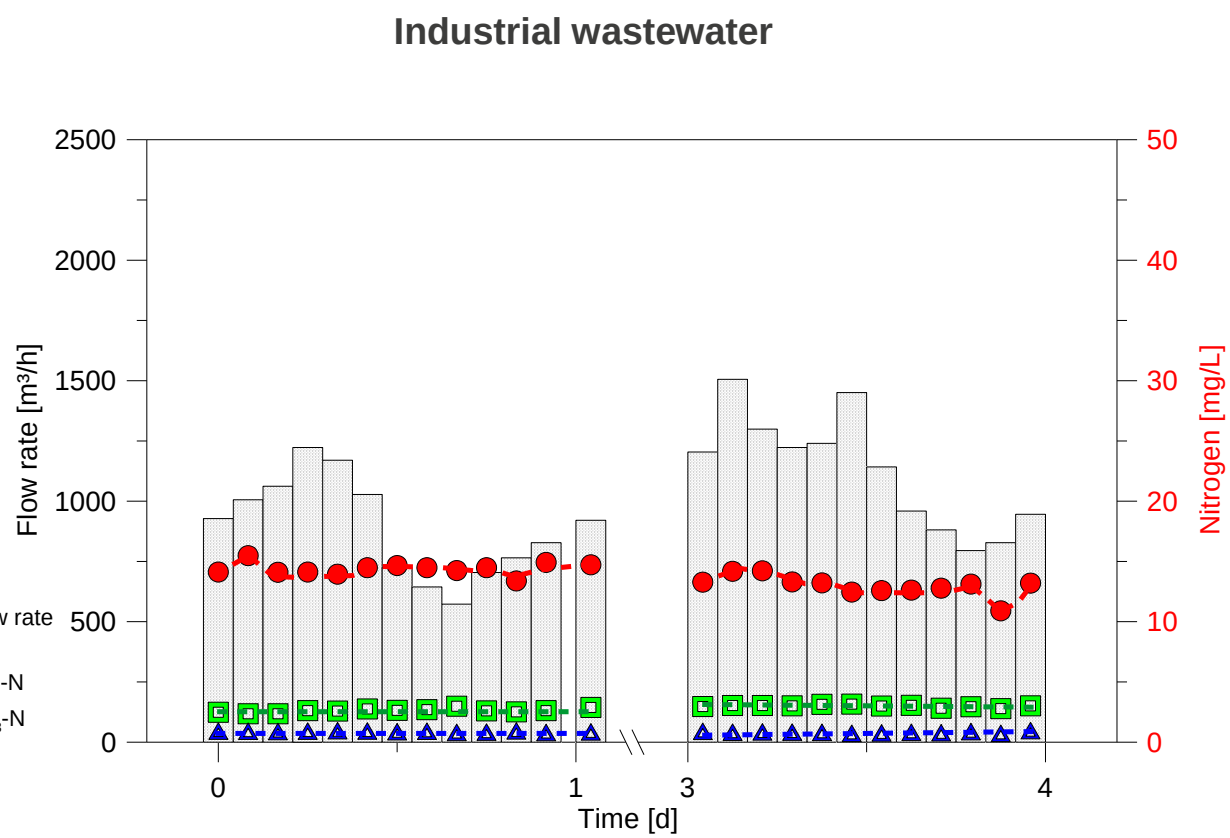
Measuring campaign to determine the diurnal variation
Total nitrogen, Ammonium, Nitrate





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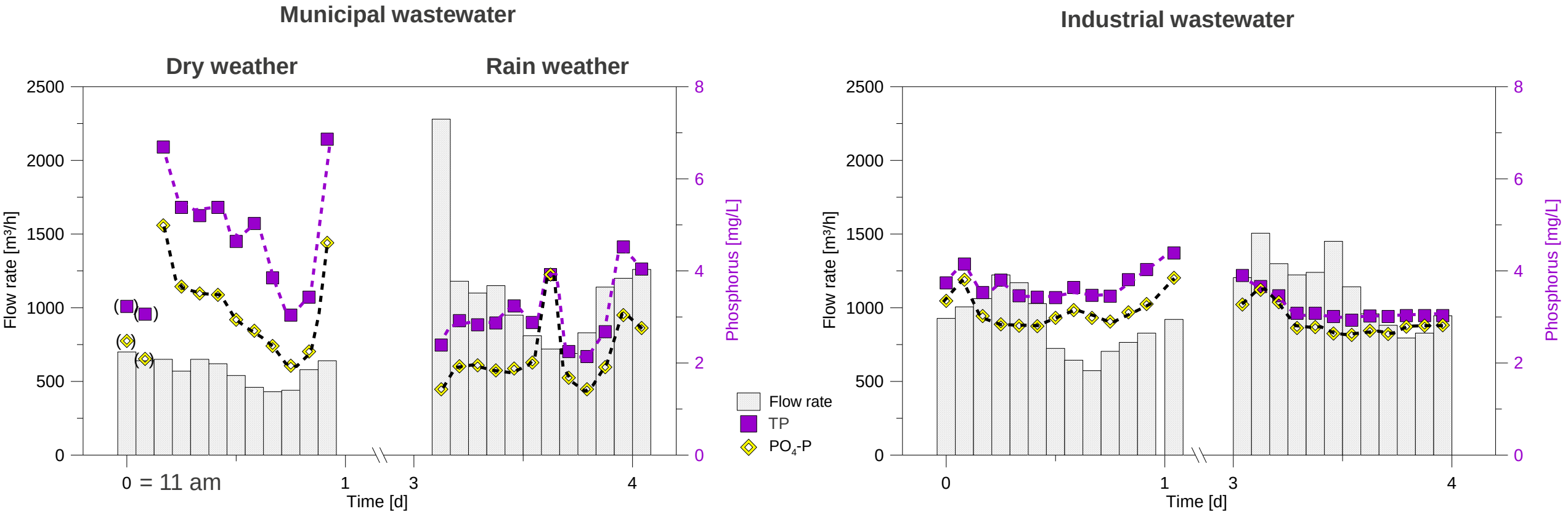
Measuring campaign to determine the diurnal variation Total phosphorus & Phosphate



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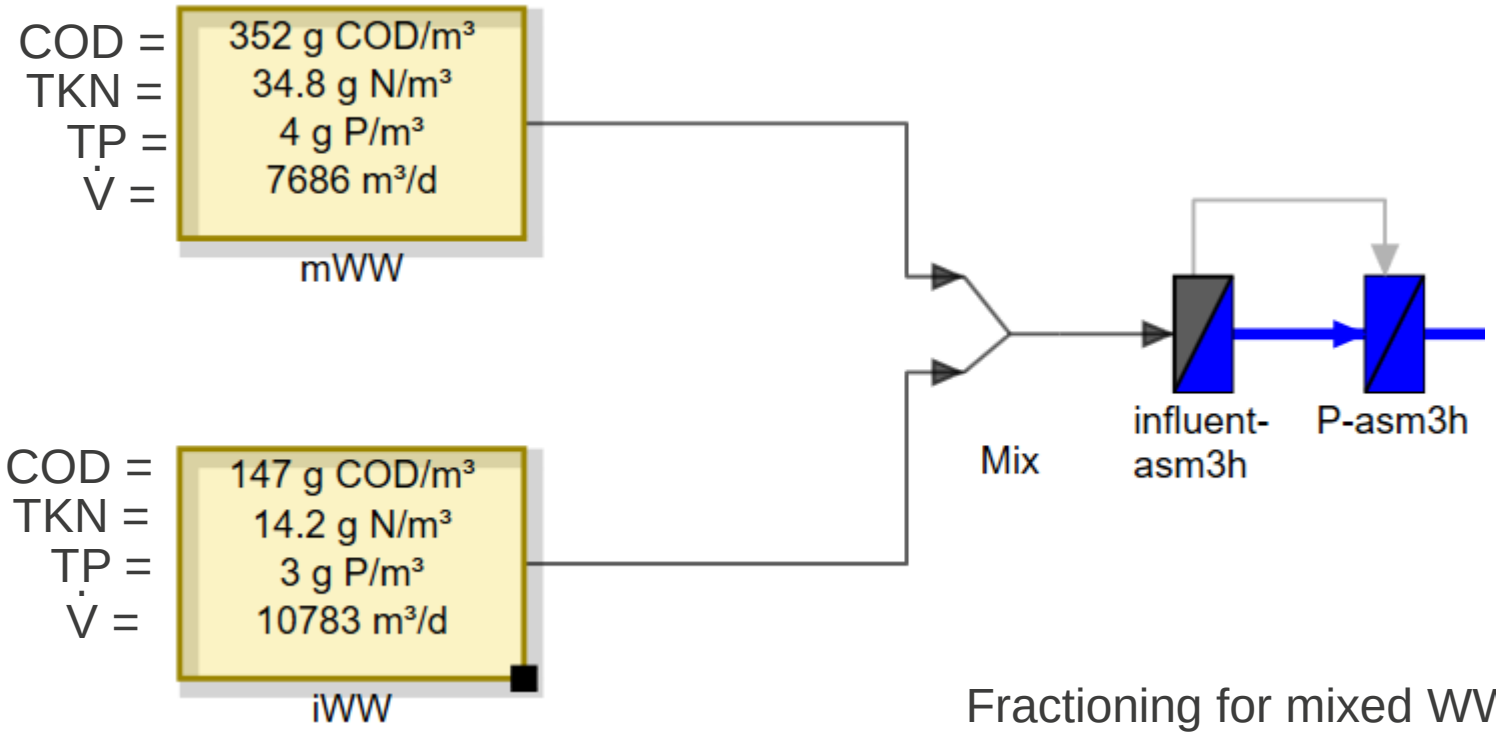
Modelling: Fractioning parameter



Symbol	Calc.
C_{COD}	= 232 mg/l
X_{SS}	= 132 mg/l
$S_{COD,inert}$	= 50 mg/l
$X_{anorgSS}$	= 35 mg/l
X_{COD}	= 151 mg/l
S_{COD}	= 81 mg/l
$X_{COD,inert}$	= 106 mg/l
C_{BOD}	= 76 mg/l

Fractioning for mixed WW:

f_S = 0.215

f_B = 0.265

f_A = 0.70

ratio of COD to VSS = **1.56** g COD /(g TSS)

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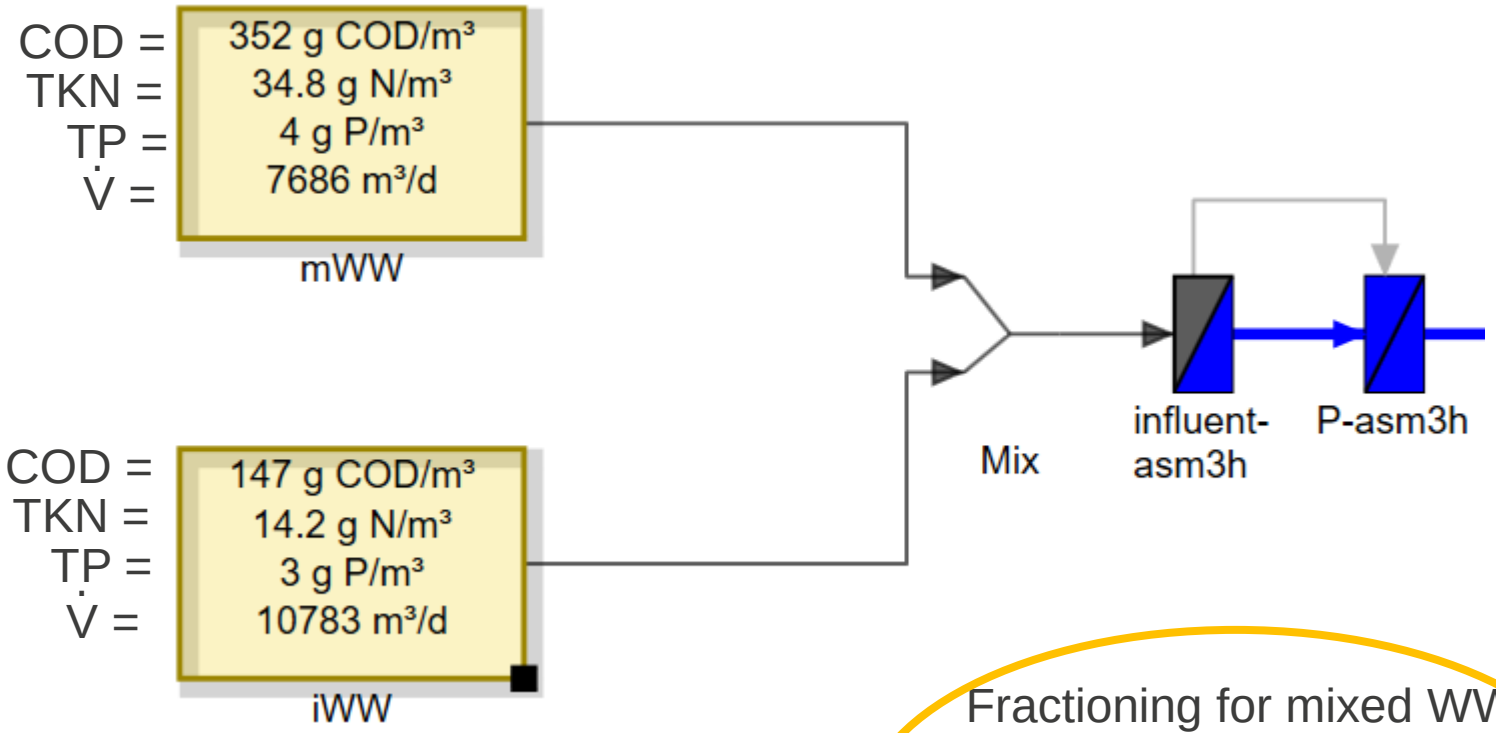

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Fractioning of the influent mix: municipal & industrial WW

What do those factors mean?

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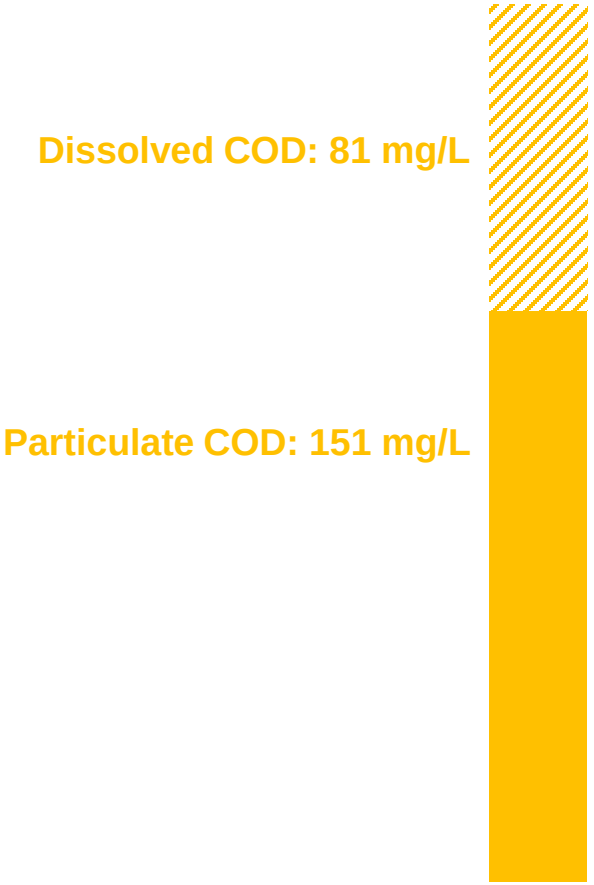

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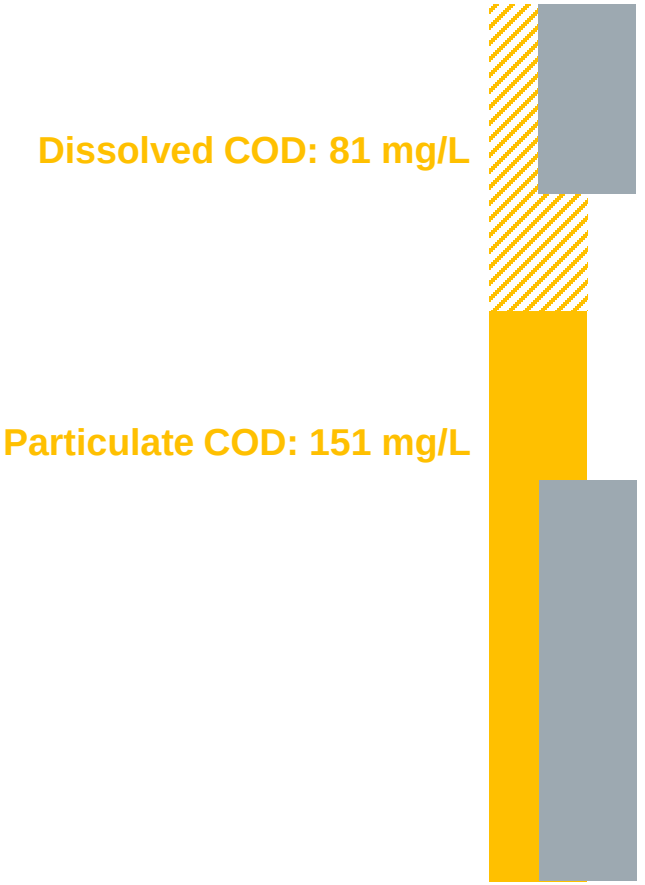

Dissolved inert COD: 50 mg/L
(f_S=0.215 of total COD)

Particulate inert COD: 106 mg/L
(f_A=0.7 of particulate COD)

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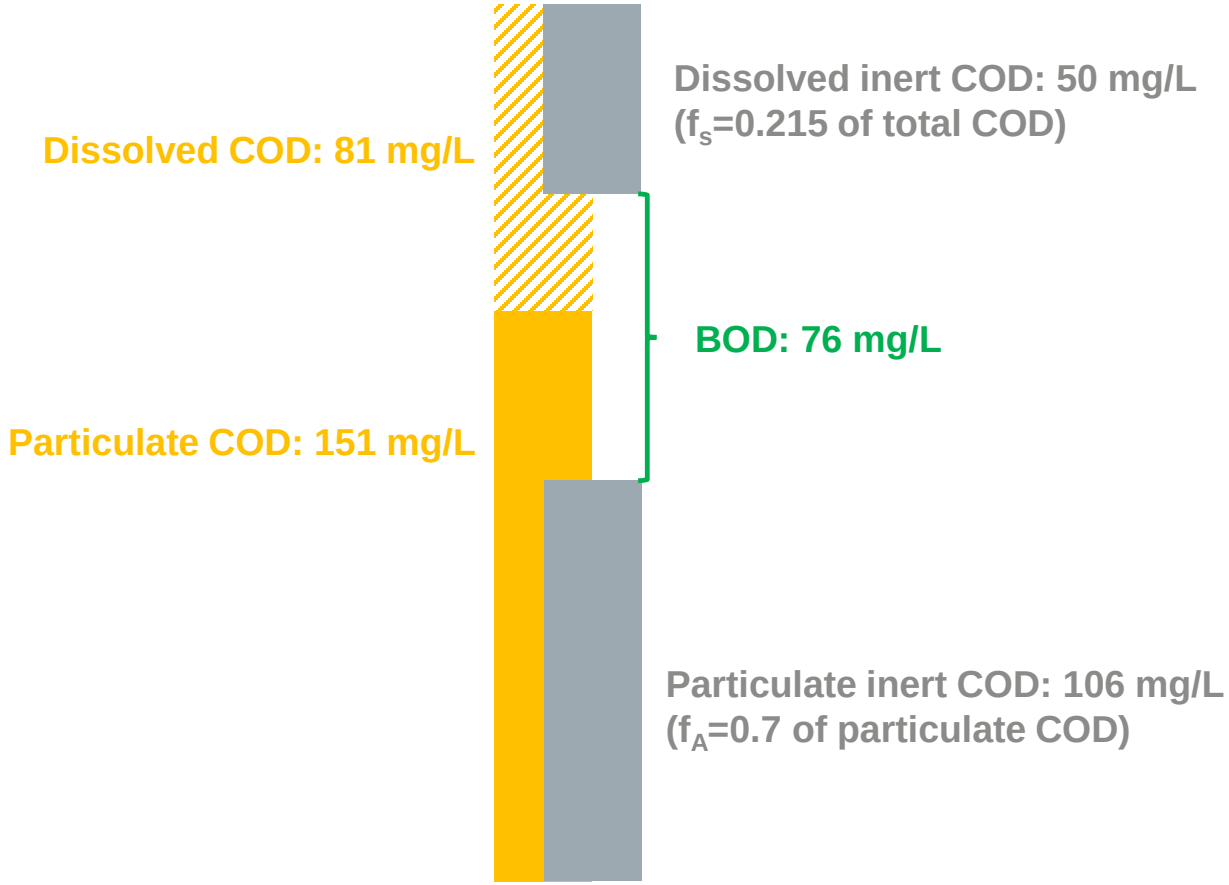

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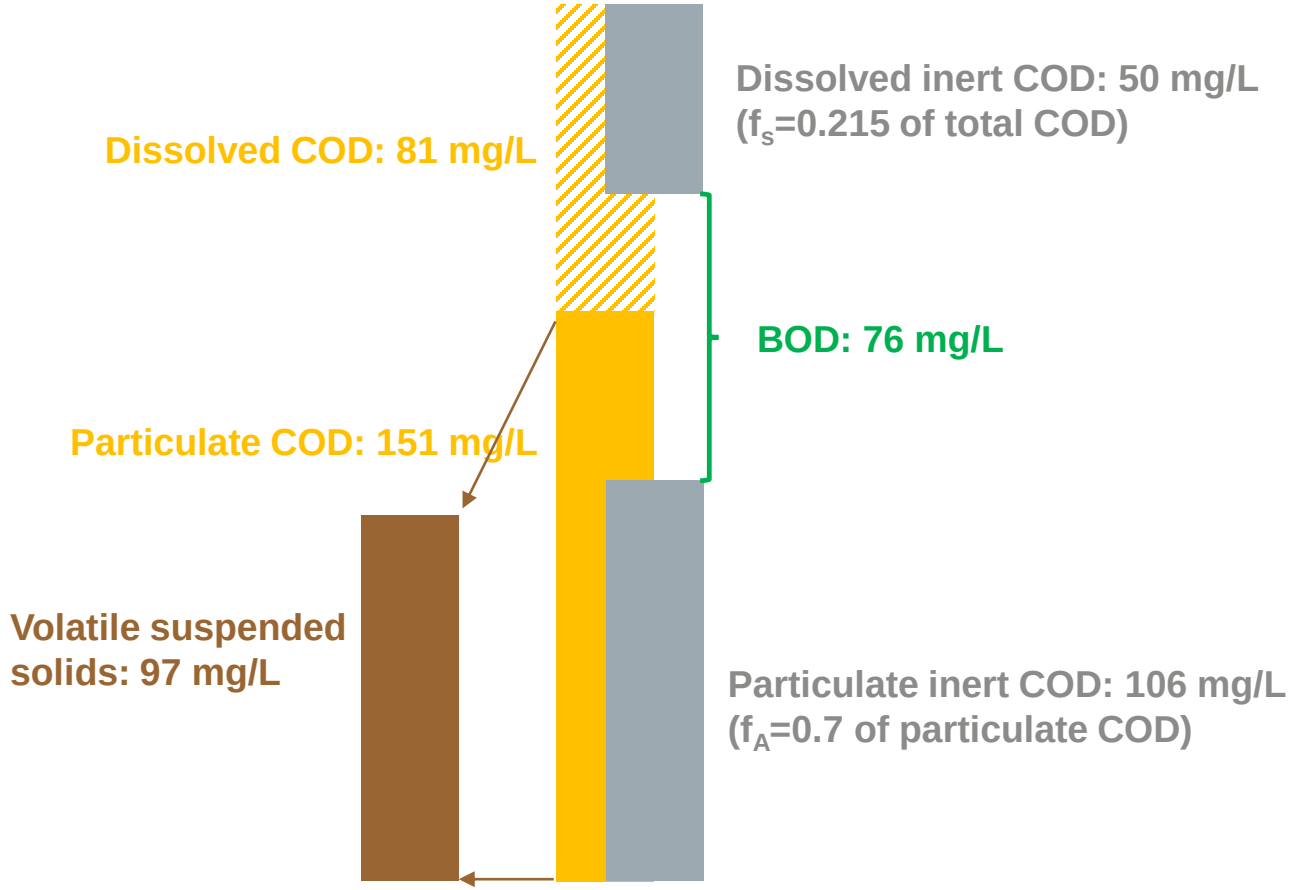

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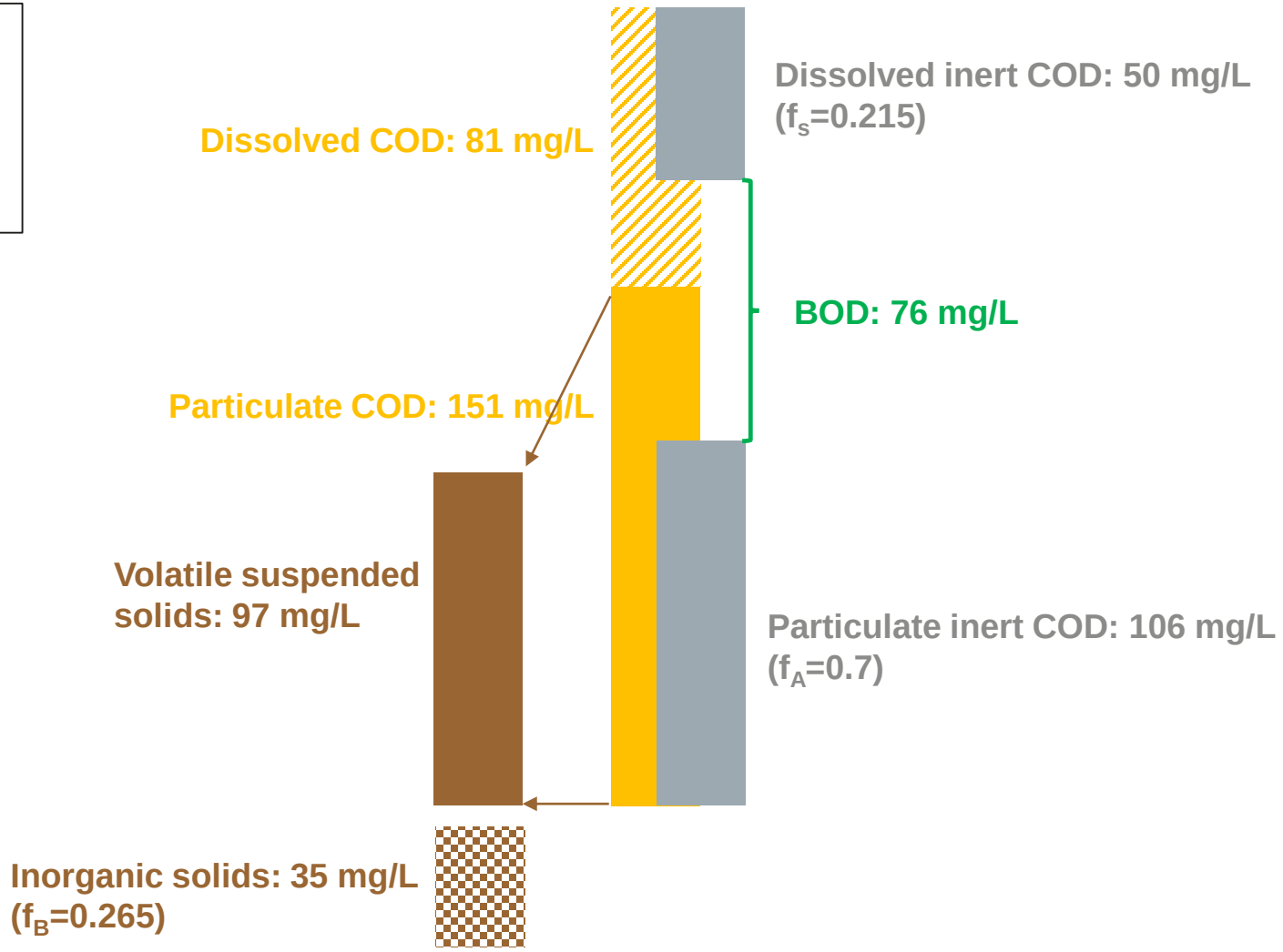

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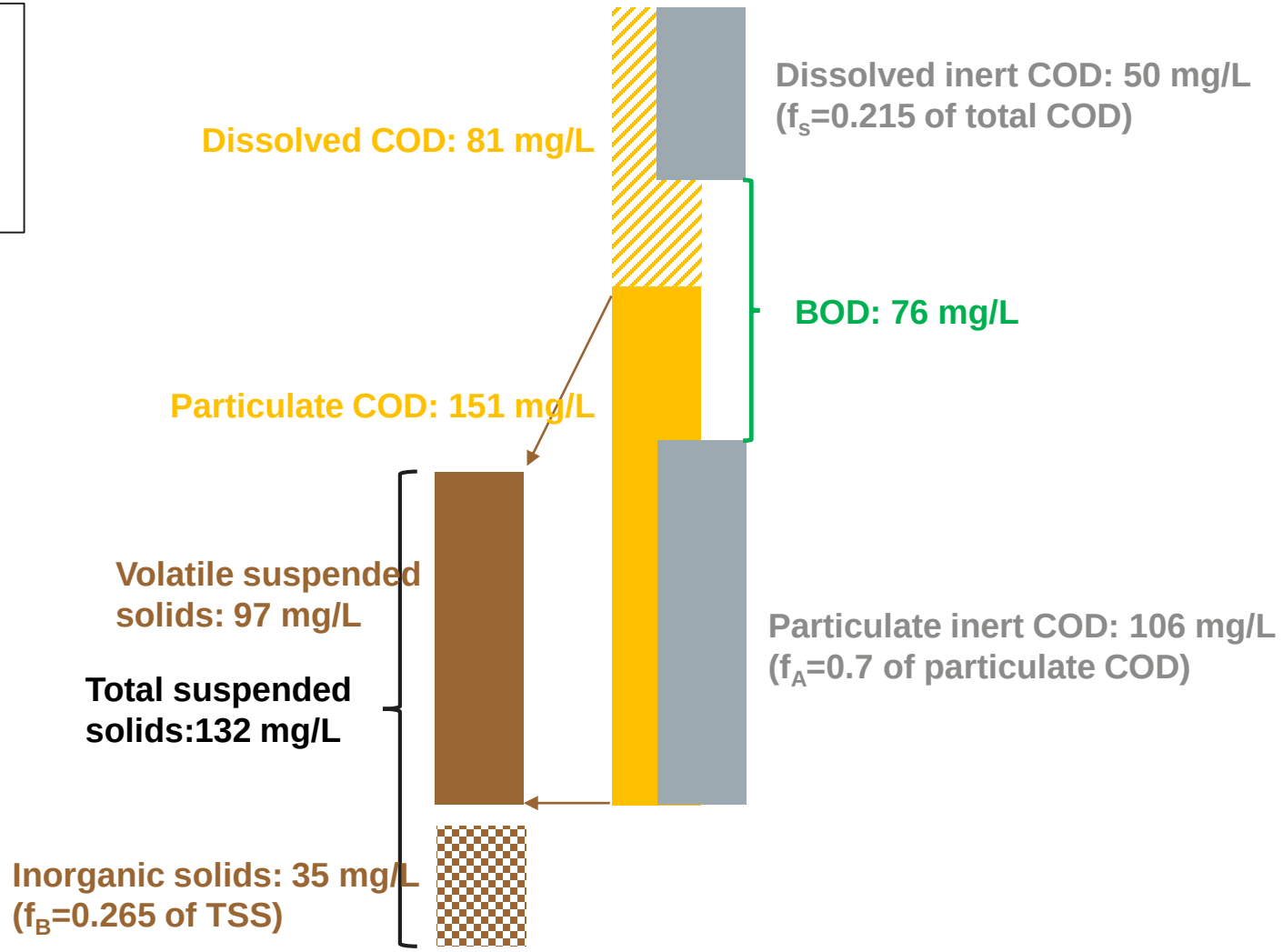

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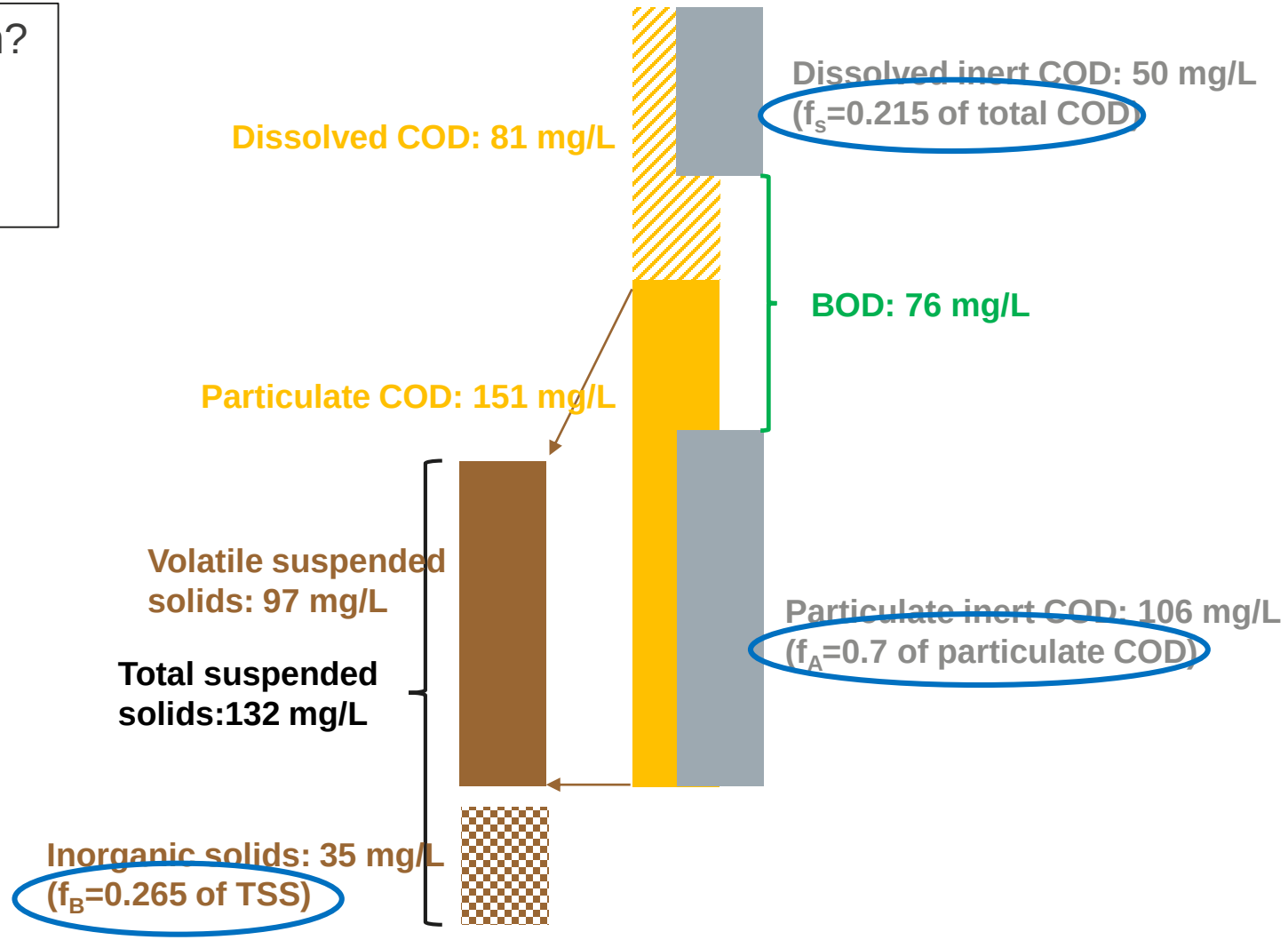

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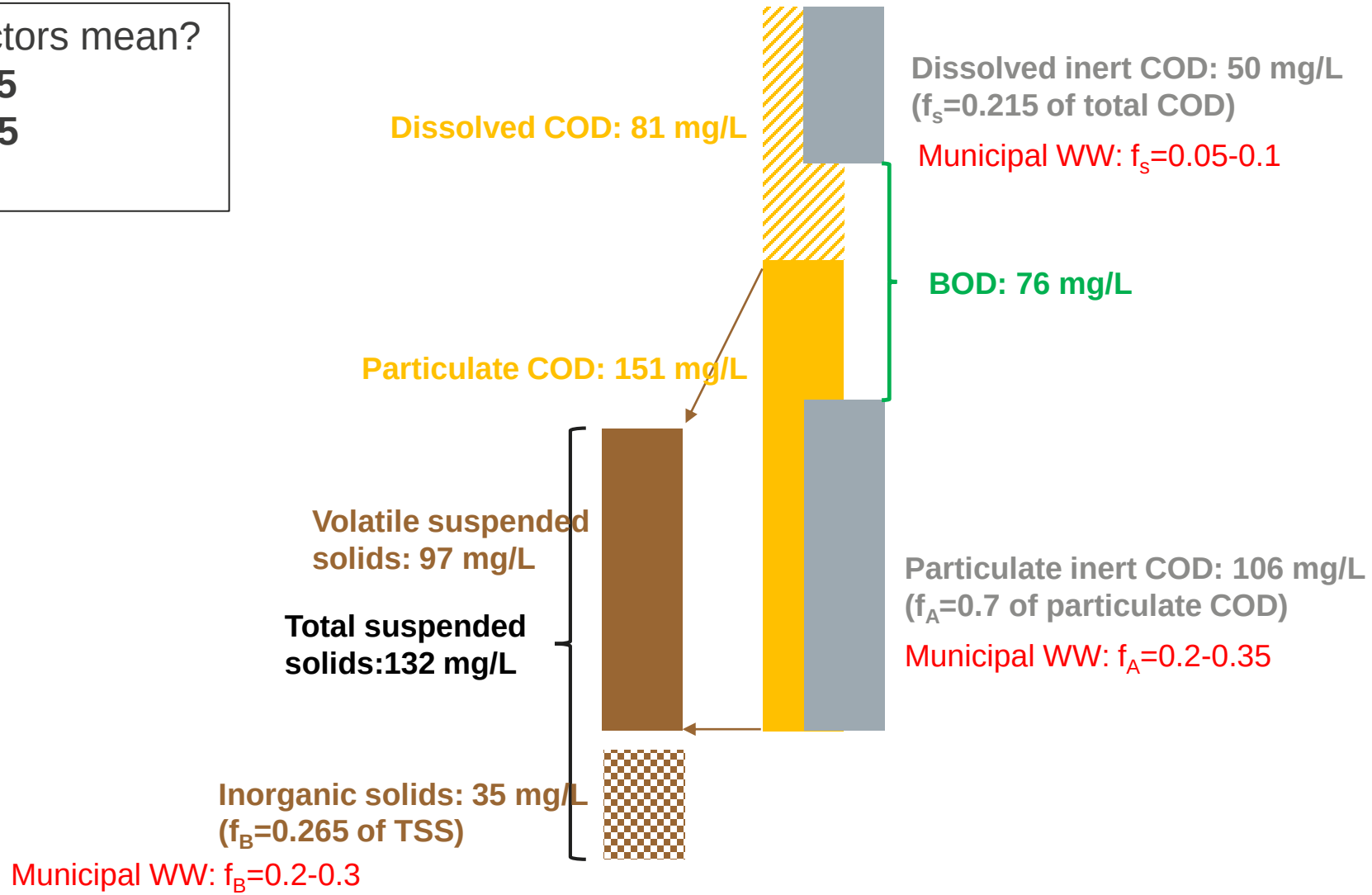

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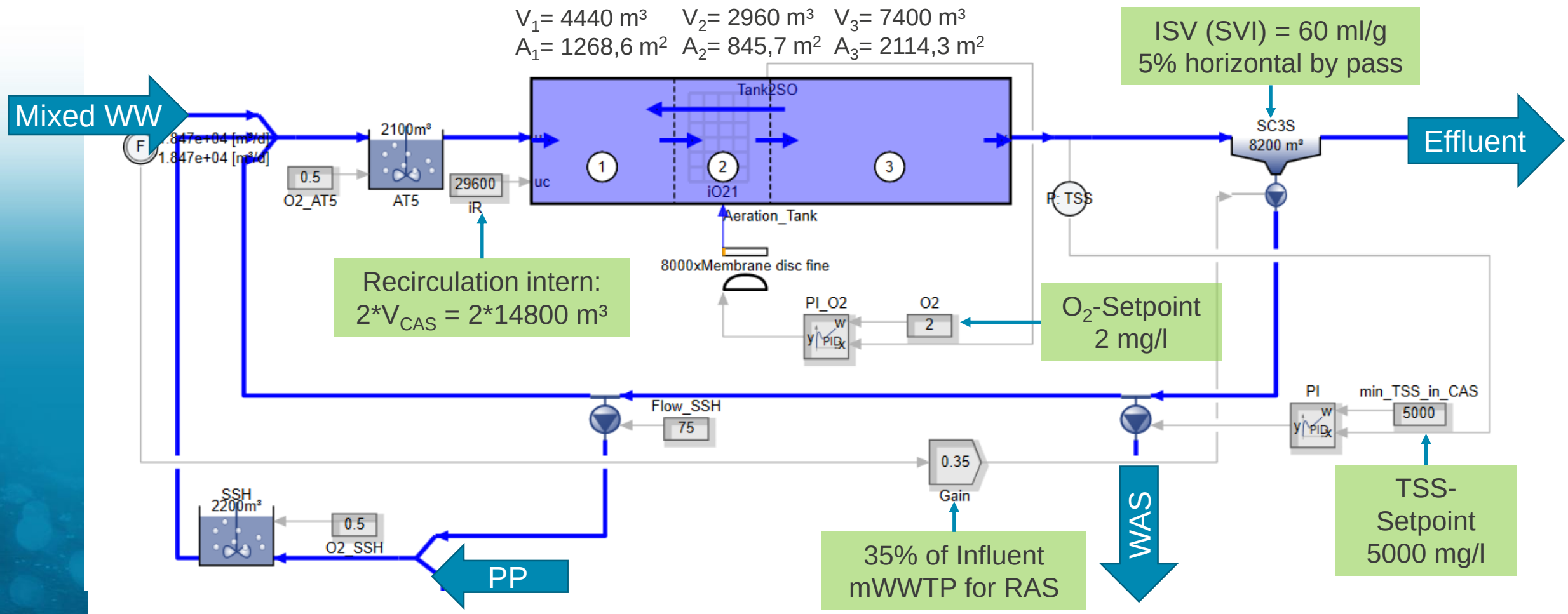
Modelling: #SIMBA Model-Overview Basic Set-UP 1



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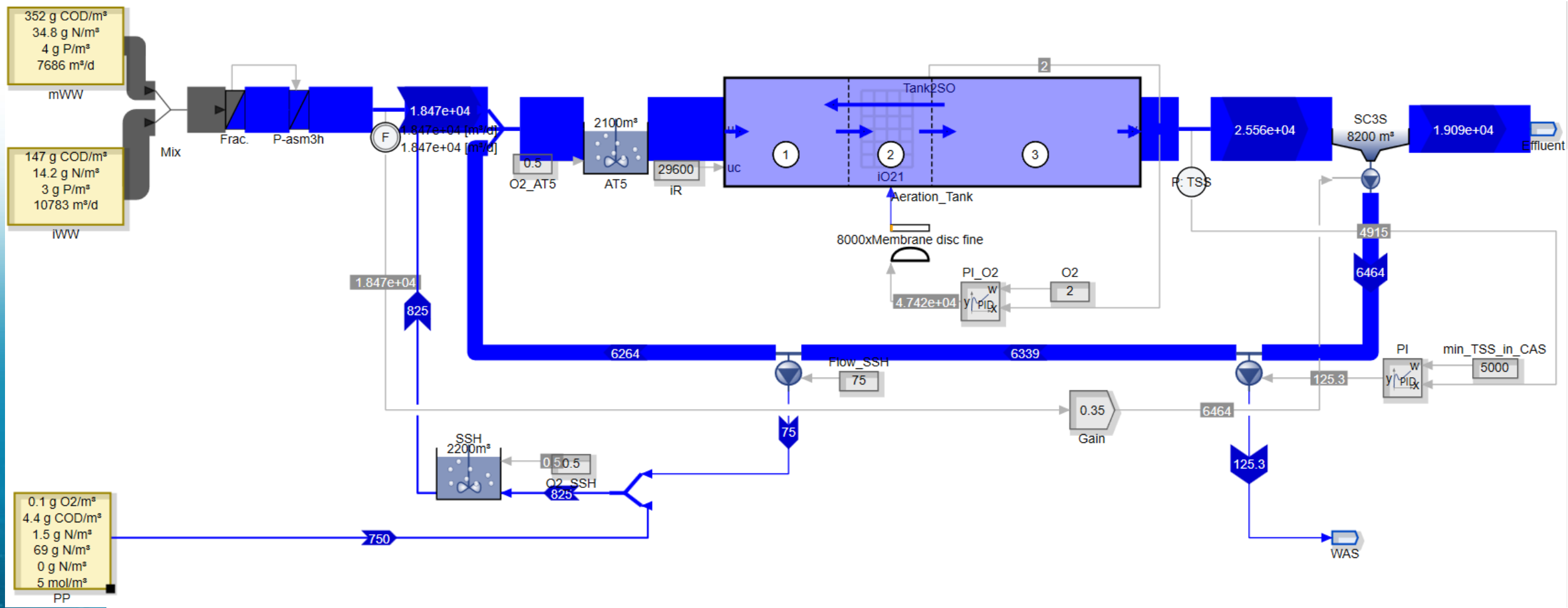
Modelling: #SIMBA - Flow [m³/d]



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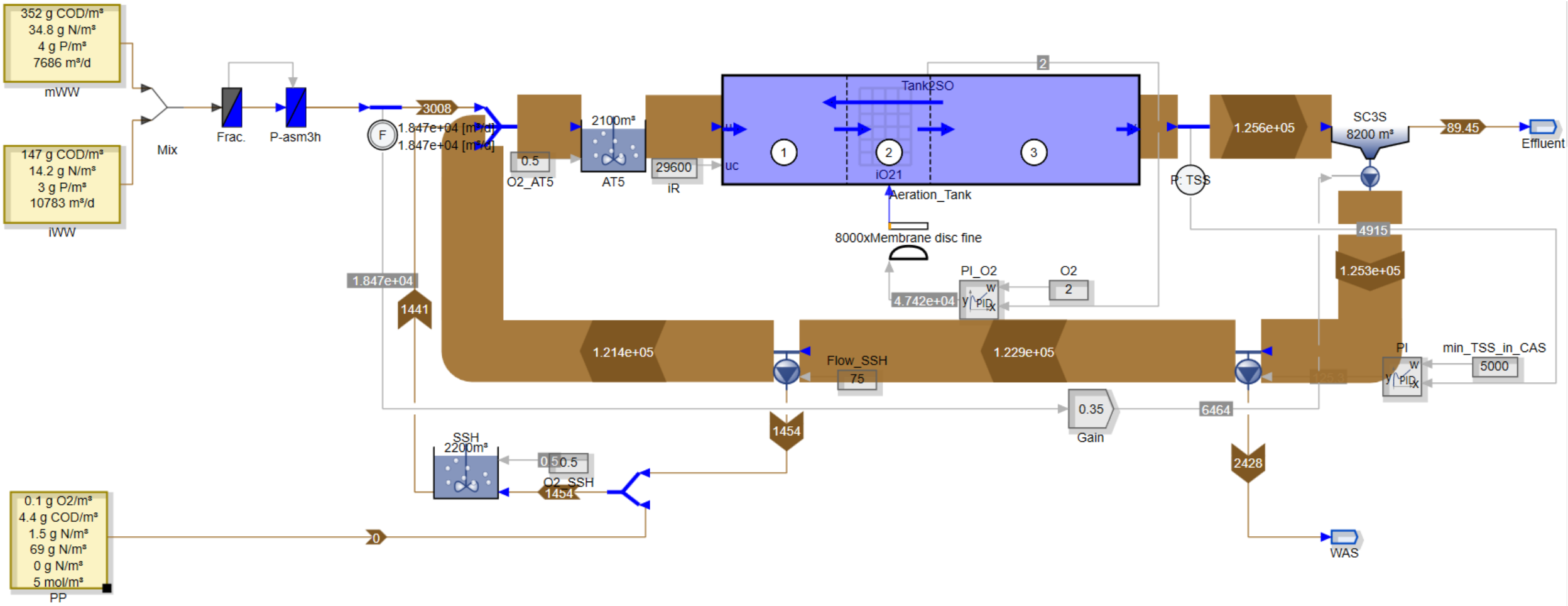
Modelling: #SIMBA - Total suspended solids [g/d]



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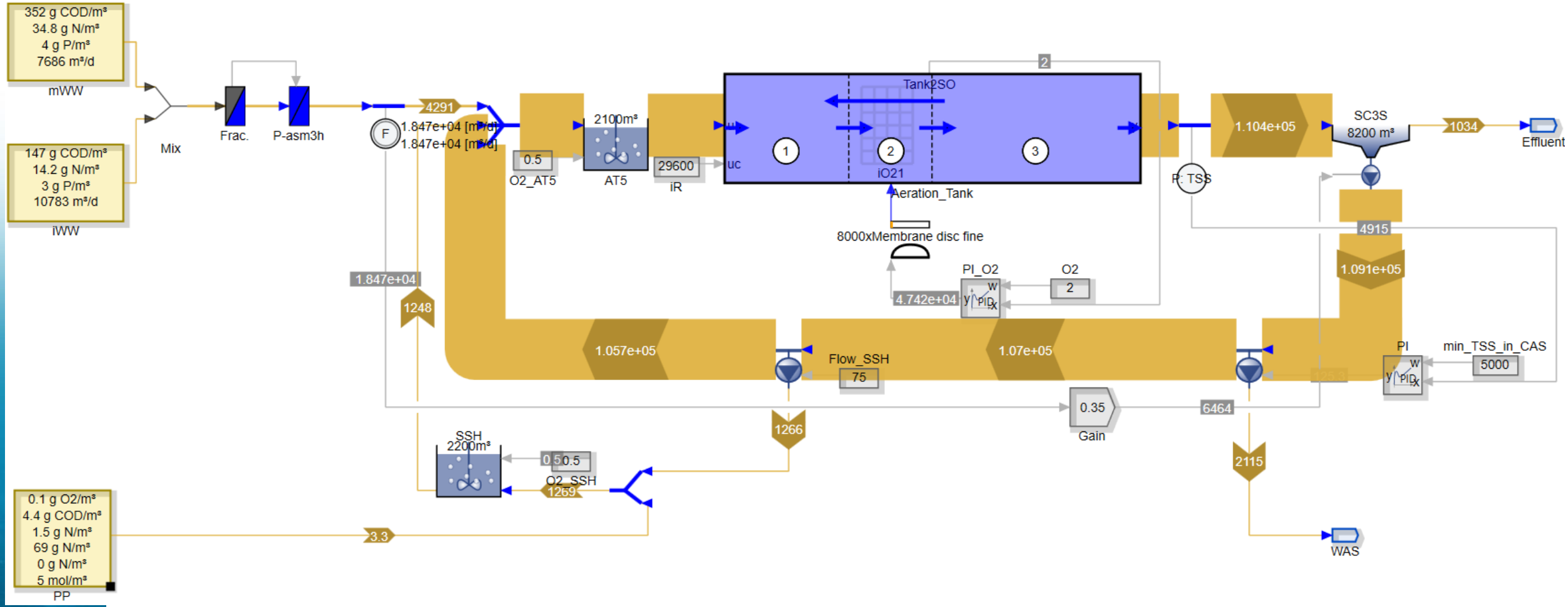
Modelling: #SIMBA – Chemical oxygen demand [g/d]



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Thank you for your attention!

Contact:

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Lars Lundgaard <lalu@kalfor.dk>

Sille Bendix Larsen <SBXL@novozymes.dk>

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