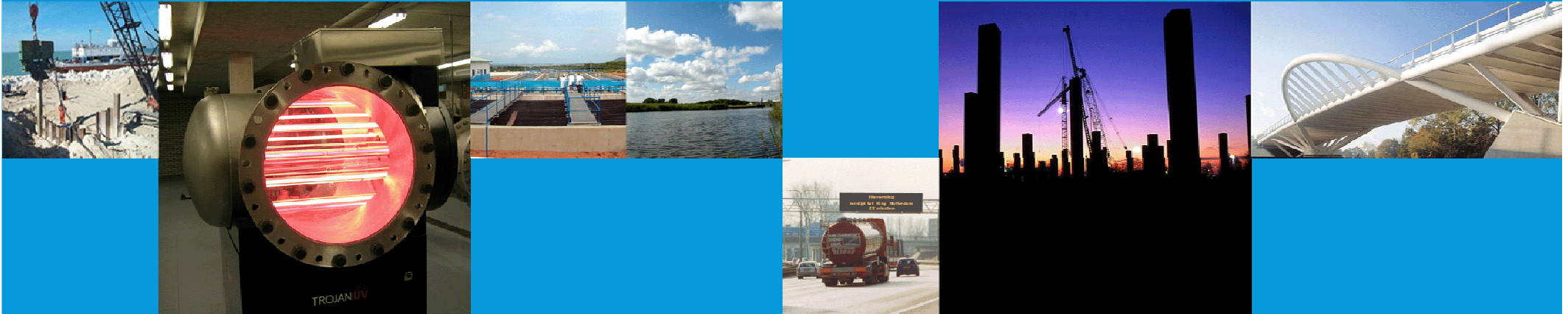


# Analyzing a Malfunctioning Clarifier with the Mixture Model



**Arie de Niet**

# Outline

- Problem Description
- Clarifier Physics
- Setup of Numerical Experiments
- Results
- Discussion

# Problem description

- Wastewater treatment: remove nitrogen and phosphorous in water with “active sludge”
- Secondary clarifier: separates water and sludge, water exits plant, sludge is re-used



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- Approach: COMSOL used to detect causes and test effect of measures



# Clarifier Physics

Sludge in view of wastewater engineers:

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Translation:

$$\begin{aligned}\phi_{in} &= SVI \cdot DS_{in} \\ &\approx 60 [ml/g ds] \cdot 2.5 [g ds/l] \\ &= 0.09 [1].\end{aligned}$$



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- Schiller-Naumann model for slip velocity
- Volume average viscosity
  
- Literature values for uncertain quantities

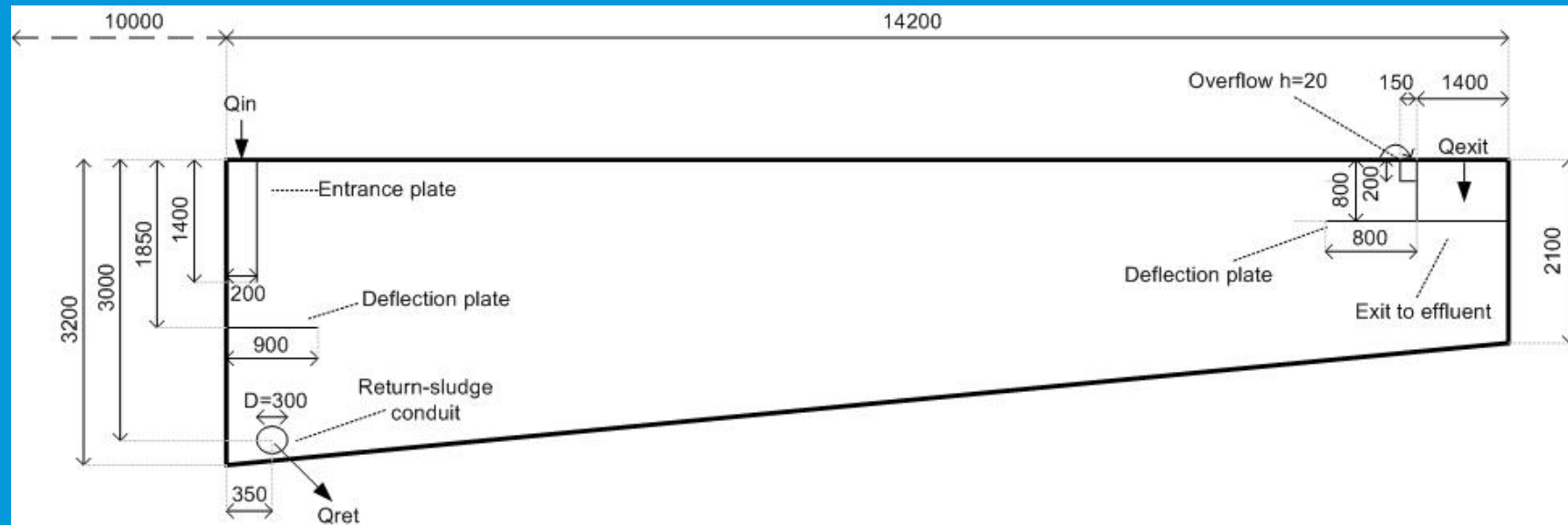
$$\rho = 1,025 \text{ kg/m}^3$$

$$\nu = 1e-3$$

$$d = 0.8 \text{ mm}$$

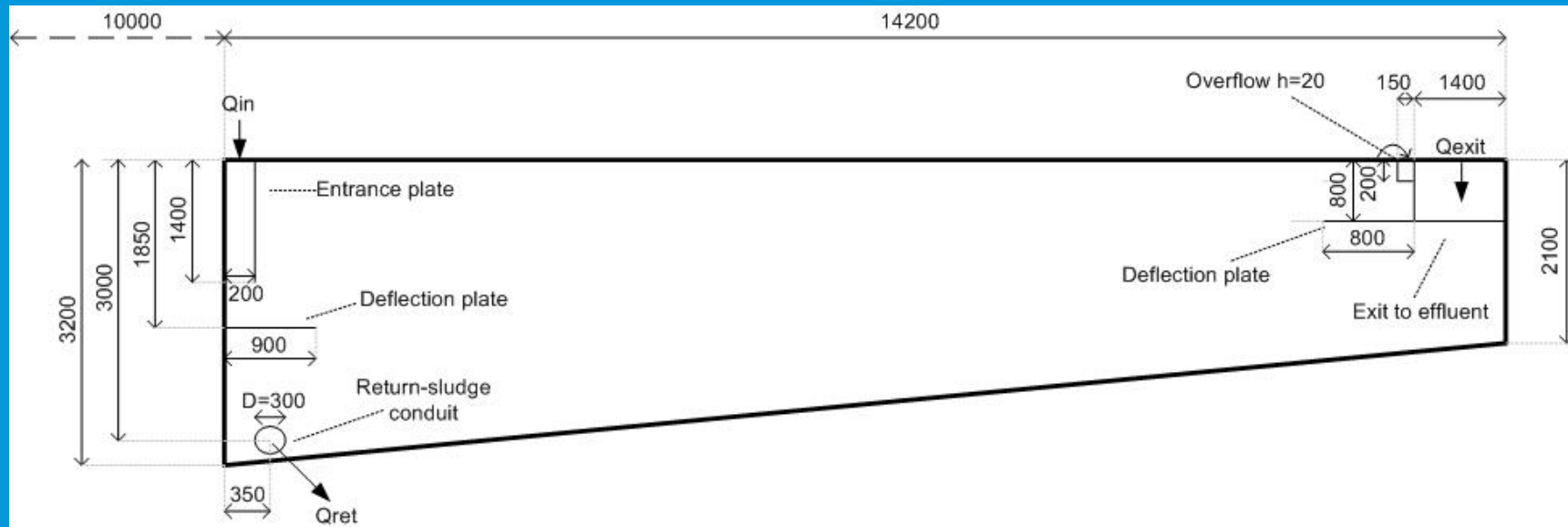
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- Geometry:



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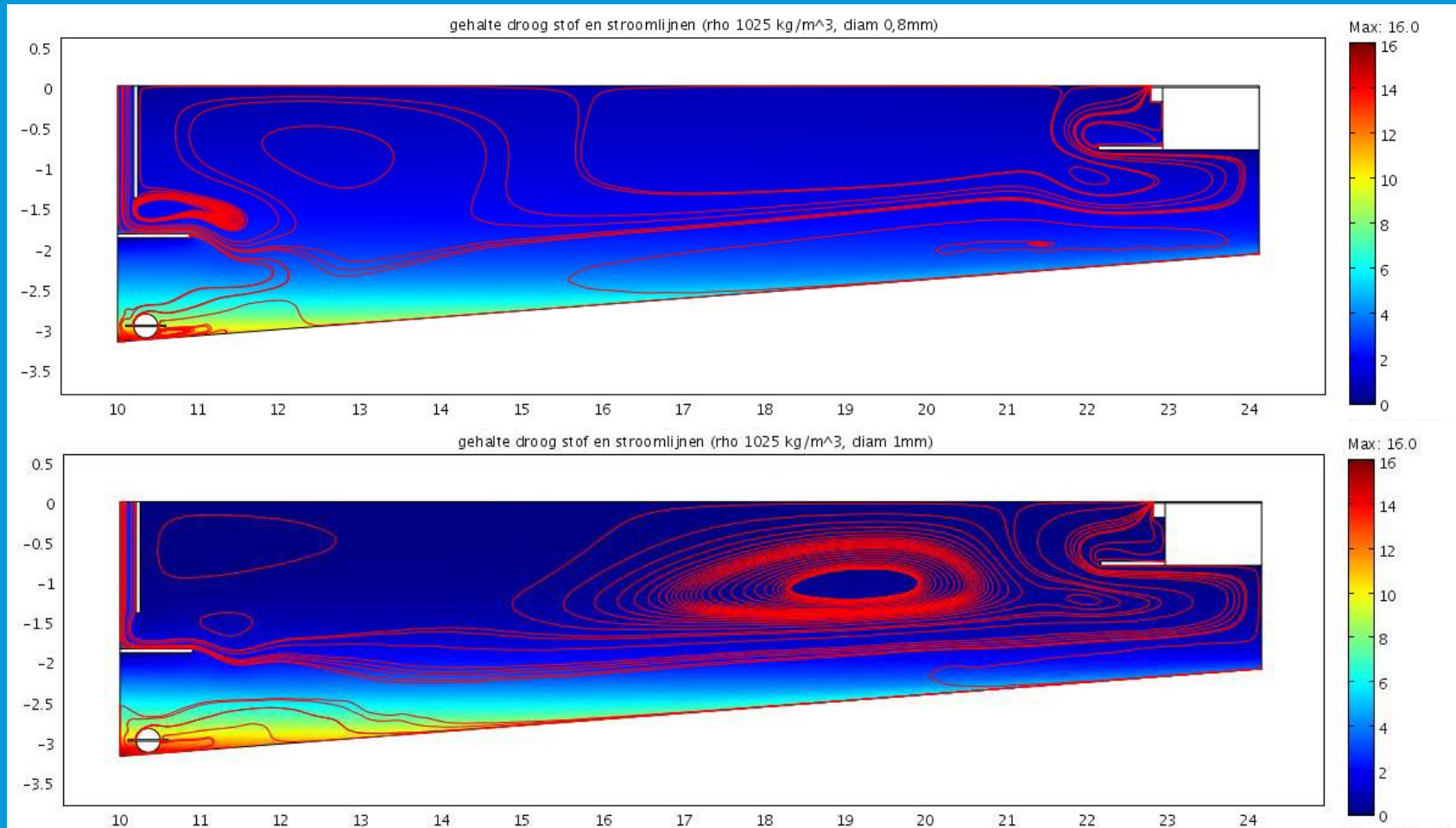
- Geometry:



- Density ( $\rho$ ), flock diameter ( $d$ ), position of plates changed

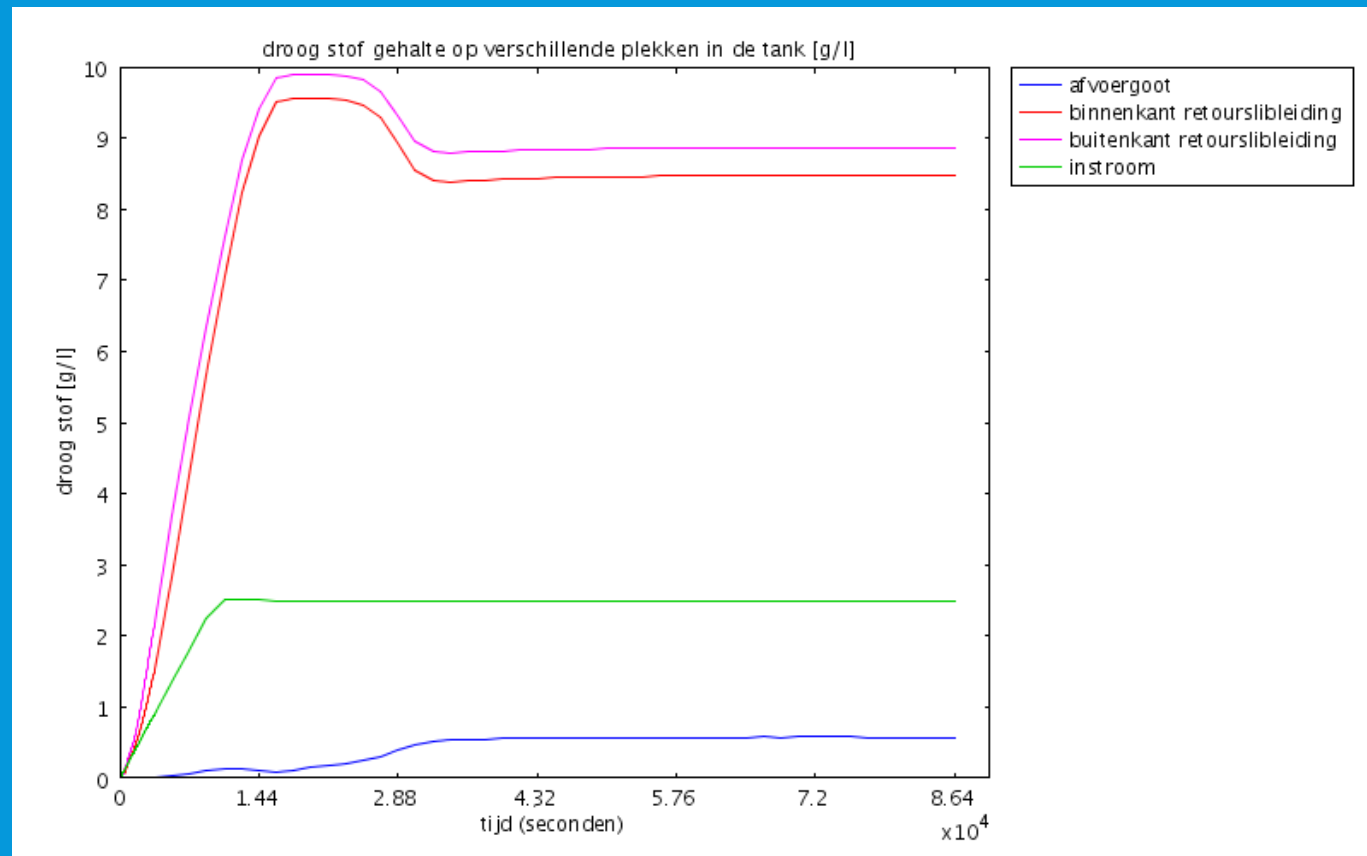
# Results: short circuit flow

- Flock diameter: 0.8 mm (top), 1.0 mm (bottom)



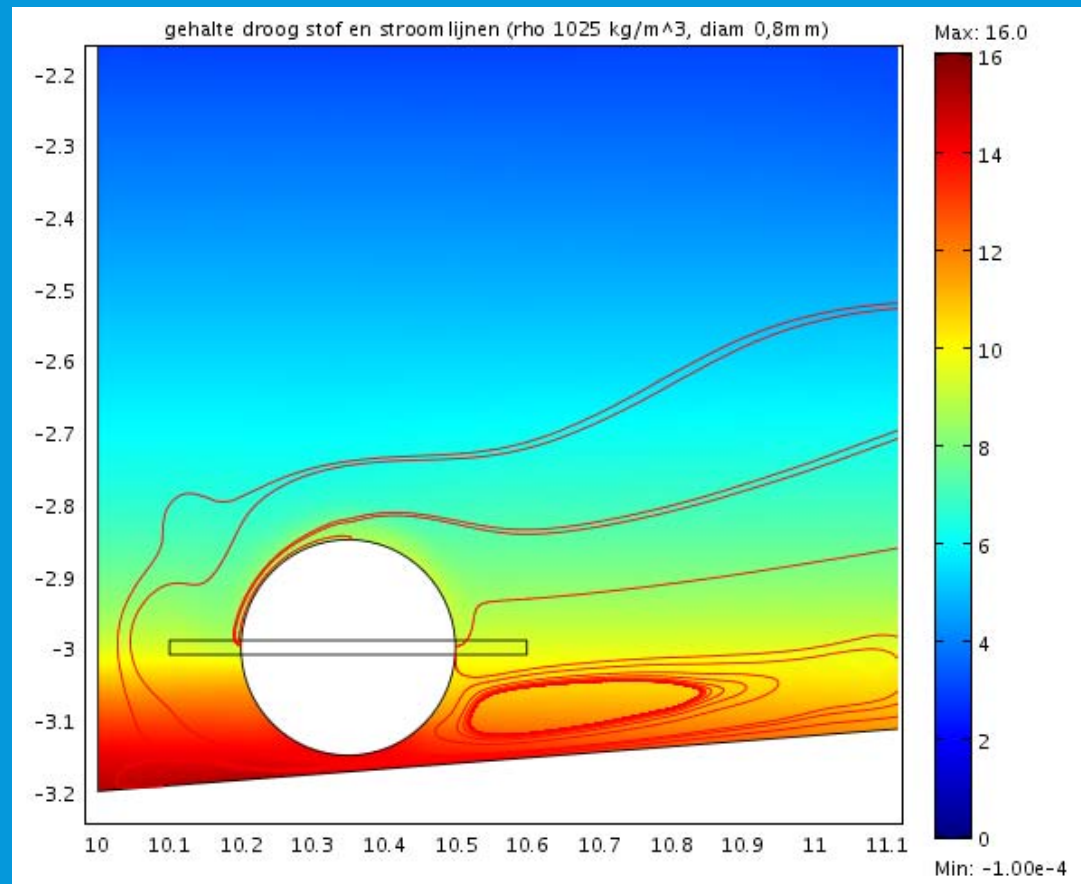
# Results: transition of state

- Grams dry solids per liter (DS) at several places in the tank during simulation for  $d = 0.8$  mm



# Results: accumulation of sludge

- Detail near return-sludge conduit





# Results: effect of measures

- Not effective: changes in position or slope of deflection plates
- Effective: slight increase in flock diameter or sludge density
- Sludge properties like diameter and density can be changed by injection of chemicals!

# Discussion

CFD simulation of the malfunctioning clarifier support the following conclusions:

- bad design is the main cause of malfunction;
- performance can be improved by adding chemicals that increase flock diameter or density;

