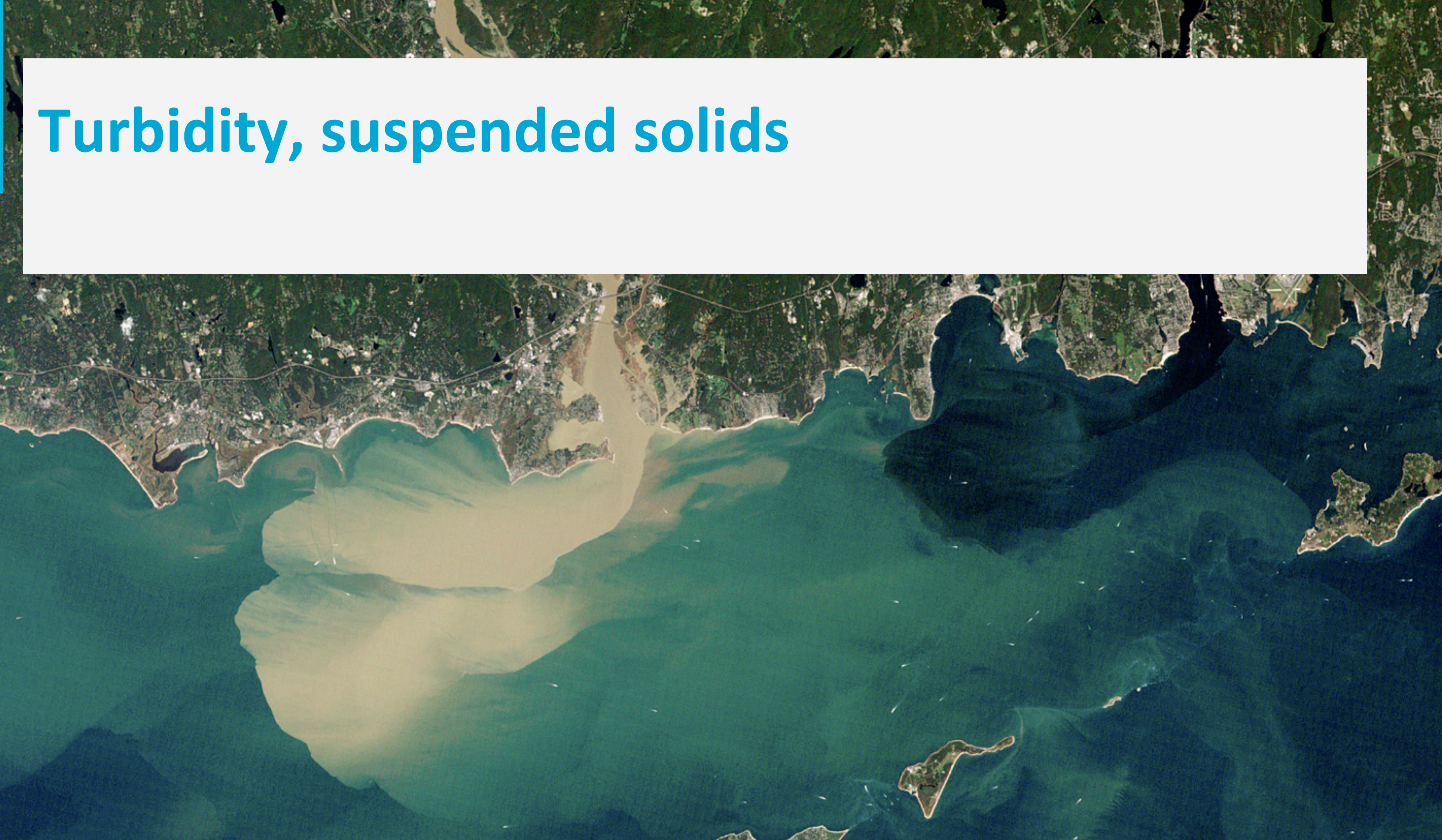
Sedimentation

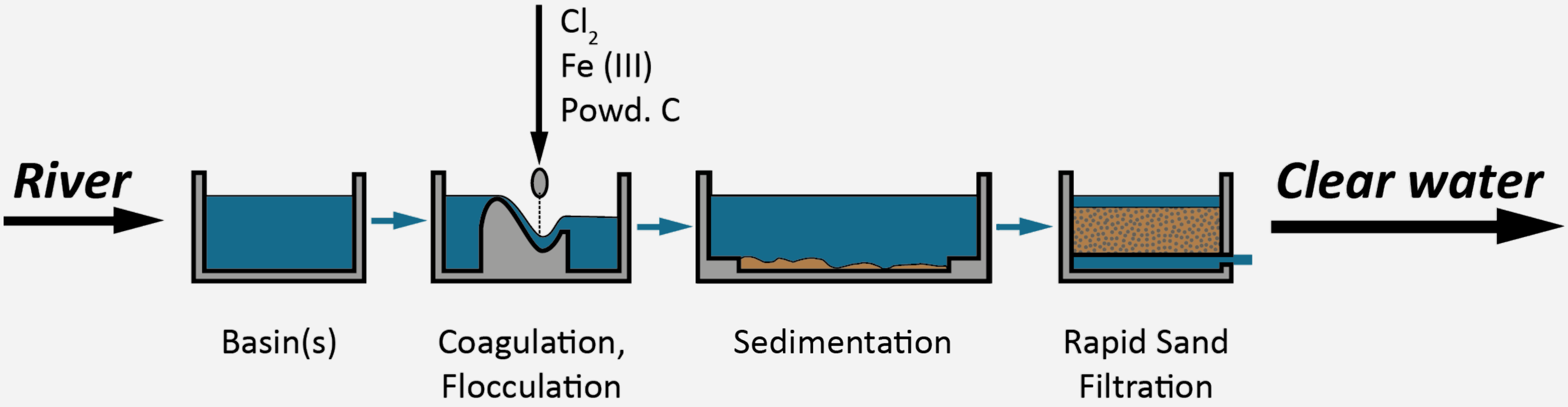
CTB3365x Introduction to water treatment

Prof.dr.ir. Luuk Rietveld

Turbidity, suspended solids



Sedimentation



Settling tank, Cornelis Biemond, Waternet

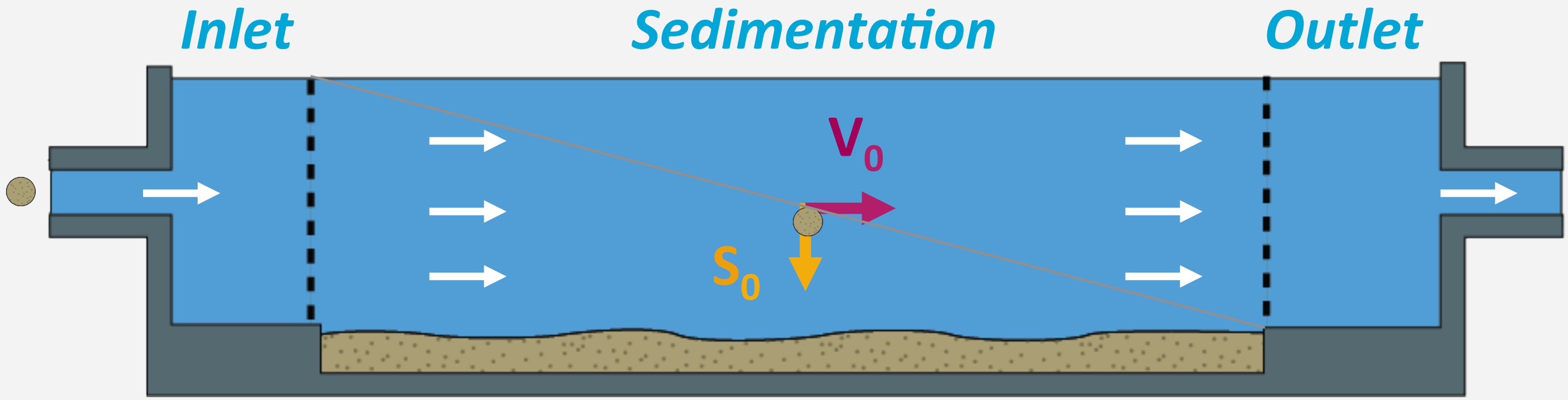
- $Q = 21000\ m^3/h$
- $L = 300\ m$
- $B = 120\ m$
- $H = 2.5\ m$

- $v_0 = 0.0194\ m/s$
- $s_0 = 1.6 \cdot 10^{-4}\ m/s$

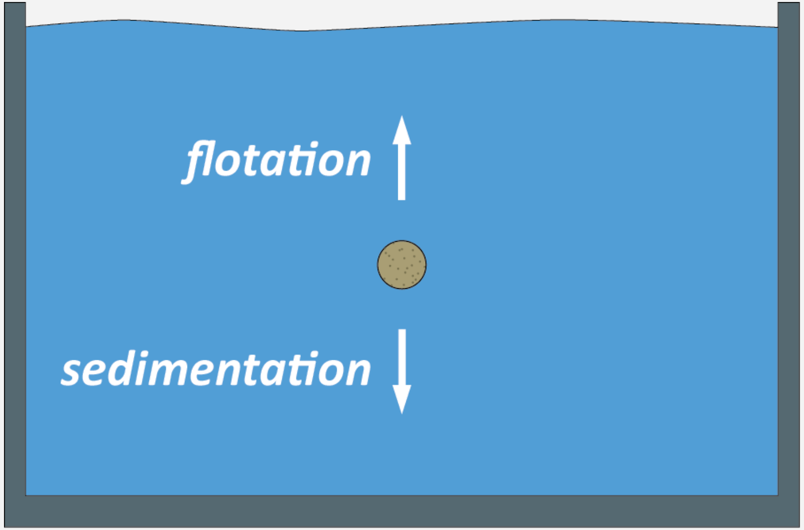
Theory Sedimentation

Flow velocity [m/h]: $v_0 = \frac{Q}{B \cdot H}$

Surface loading [m/h]: $s_0 = \frac{Q}{B \cdot L}$



Settling of discrete particles



$$F_d = c_D \cdot \frac{\rho_w}{2} \cdot s^2 \cdot A$$

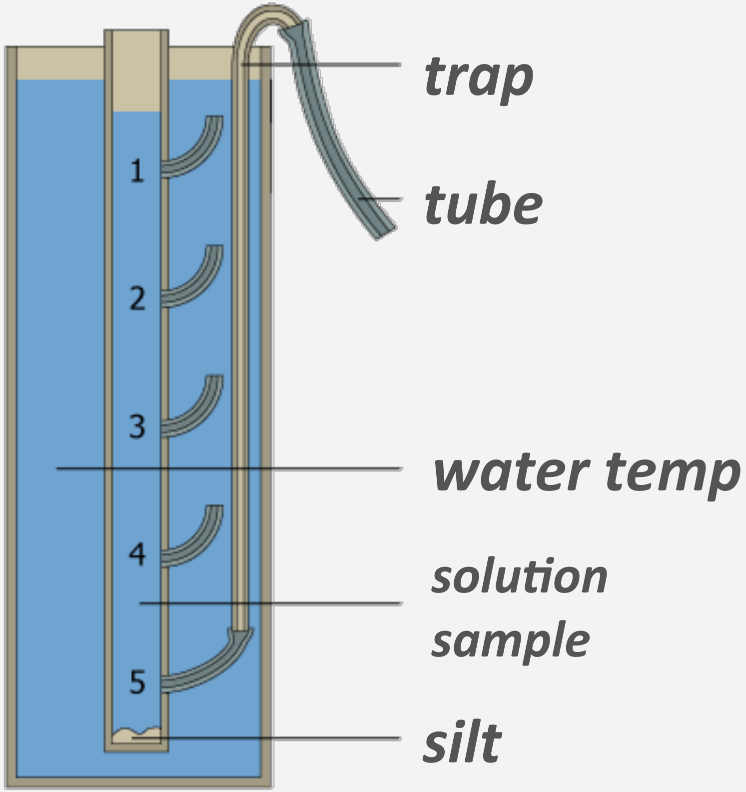
$$F_i = (\rho_s - \rho_w) \cdot g \cdot V$$

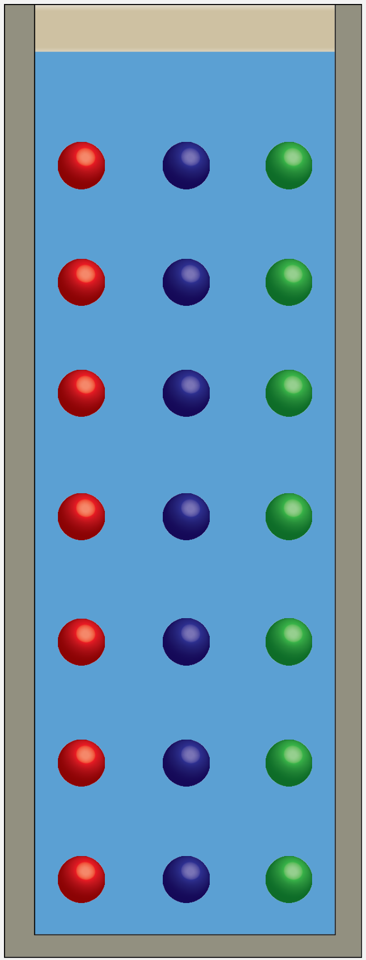
Stokes' law

$$s = \frac{1}{18} \cdot \frac{g}{v} \cdot \frac{\rho_s - \rho_w}{\rho_w} \cdot d^2$$

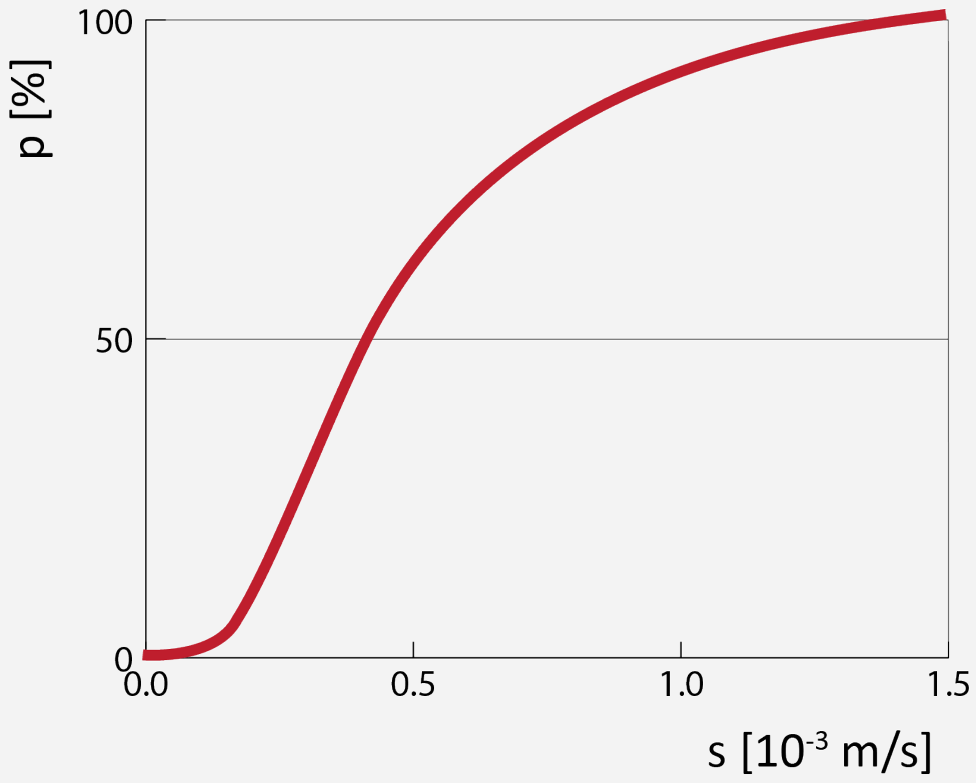
s	= sedimentation or flotation rate	[m/s]
g	= gravity acceleration	[m^2/s]
v	= kinematic velocity	[m^2/s]
ρ_s ρ_w	= density of particle and fluid	[kg/m^3]
d	= diameter of the particle	[m]

Quiescent settling test

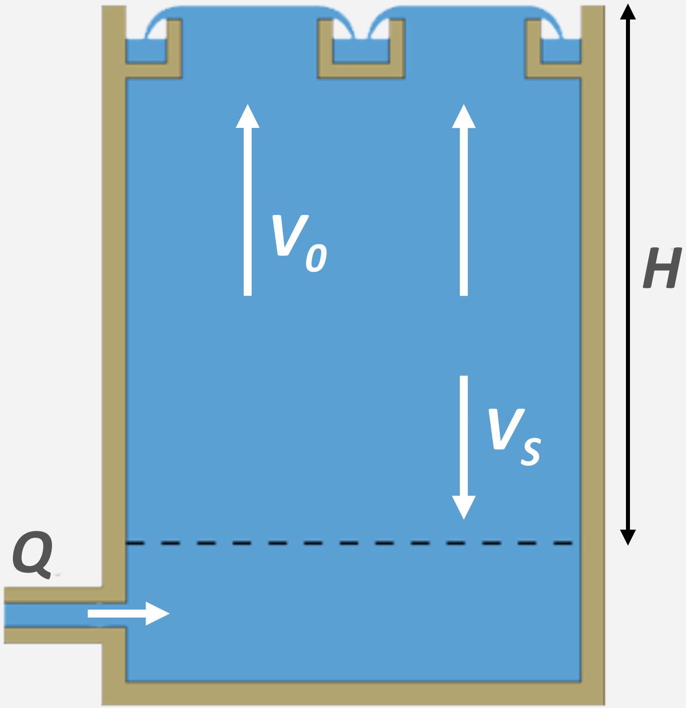




Cumulative frequency distribution of settling velocity



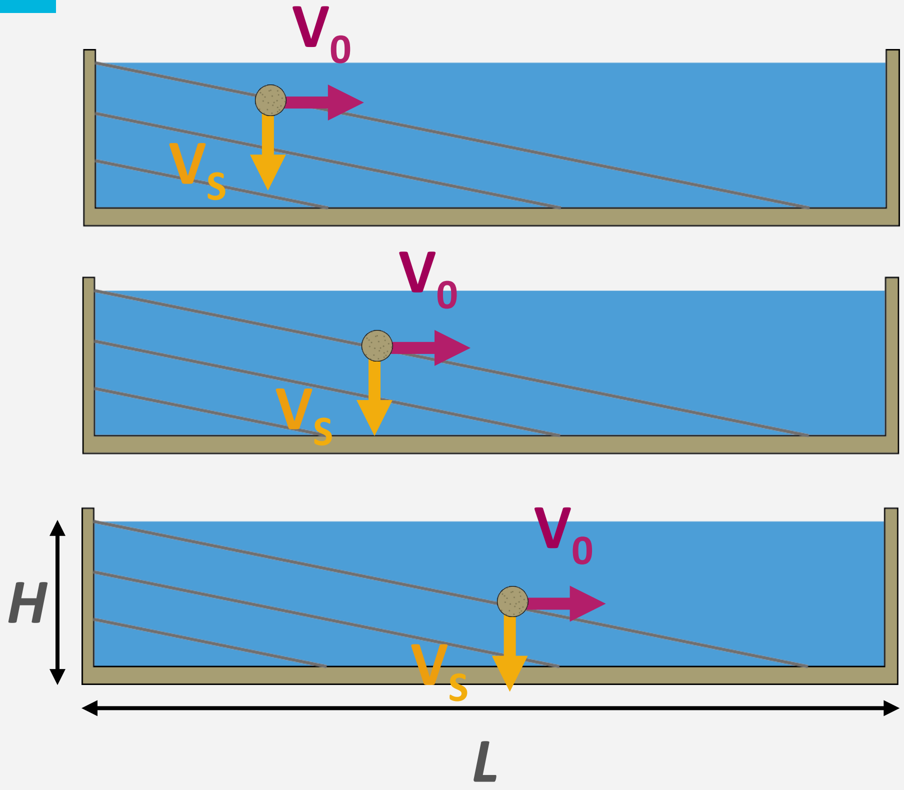
Vertical sedimentation



- $v_S \geq v_{S0}$ *Settle completely*
- $v_S < v_{S0}$ *Does not settle*
- $$v_0 = \frac{Q}{B \cdot H} = v_{S0}$$

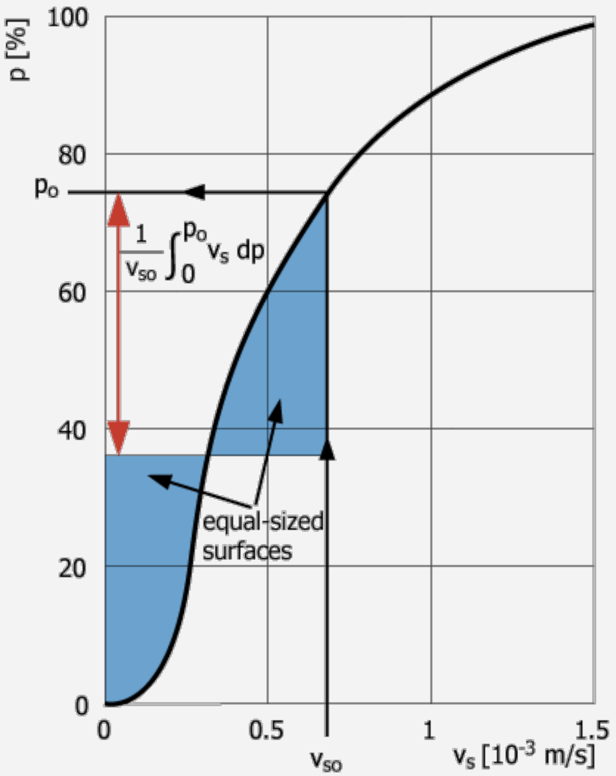
Horizontal sedimentation

$$v_0 = \frac{Q}{B \cdot H} = v_{S0}$$



- $v_S > v_{S0}$ *Settle completely*
- $v_S = v_{S0}$ *Settle completely*
- $v_S < v_{S0}$ *Partial settling*

Efficiency of horizontal sedimentation

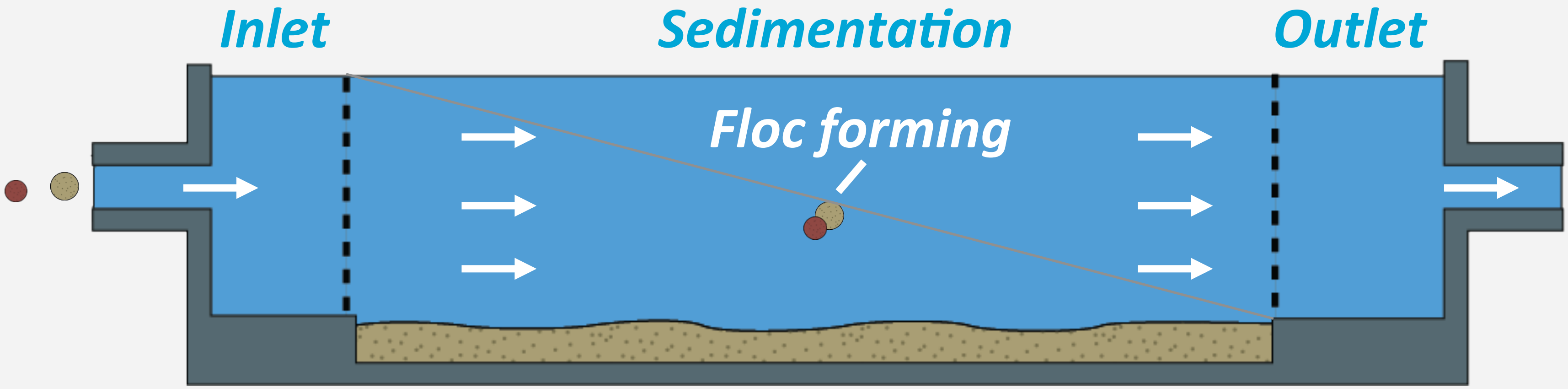


- $v_S \geq v_{S0}$ *Settle completely*
- $v_S < v_{S0}$ *Partial settling, depends on H*

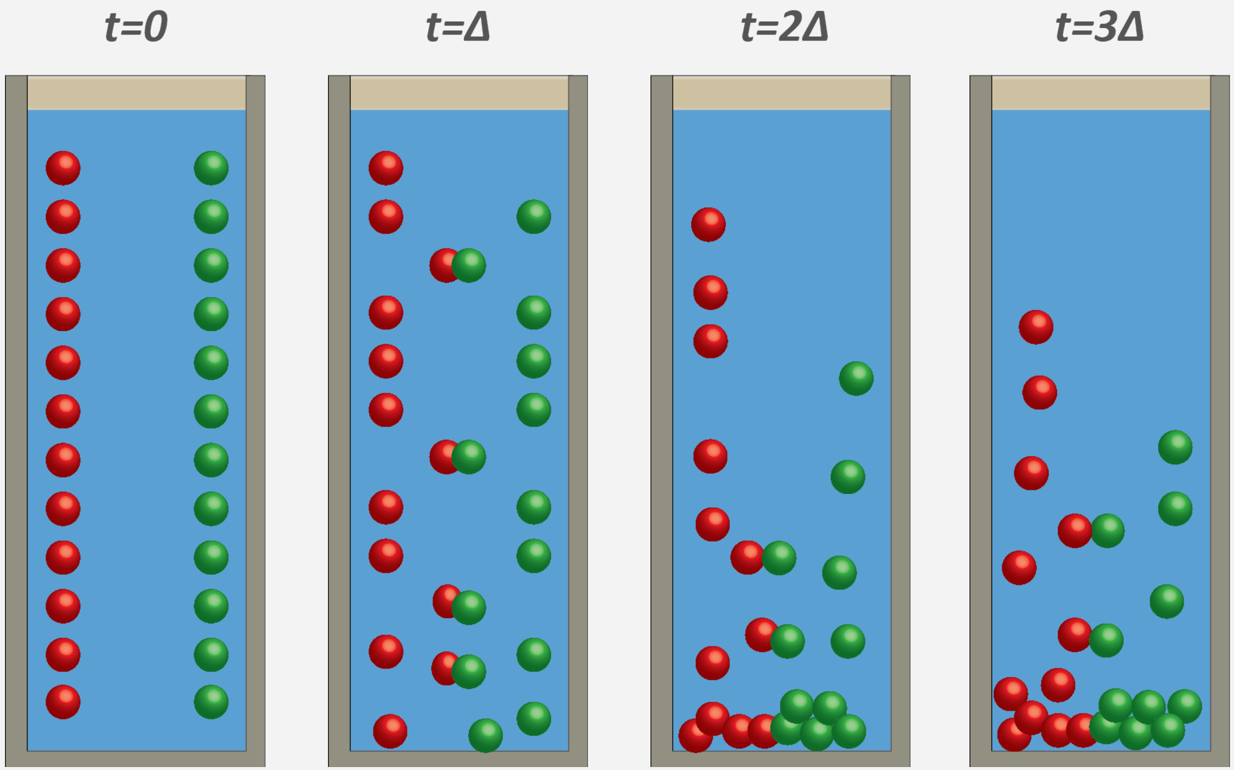
- $$r = (1 - P_0) + \frac{1}{v_{S0}} \int_0^{P_0} v_S \, dP$$

Flocculent settling

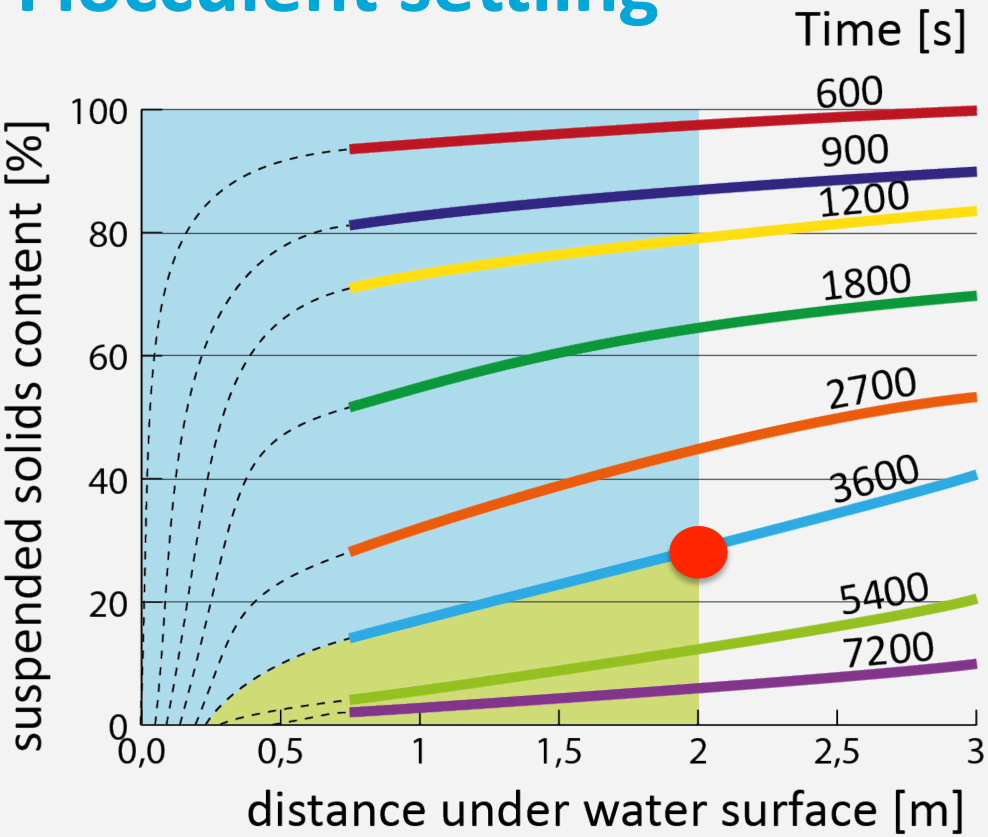
- *Flocculation causes increasing settling velocities*
- *Depends on tank height*



Flocculent settling



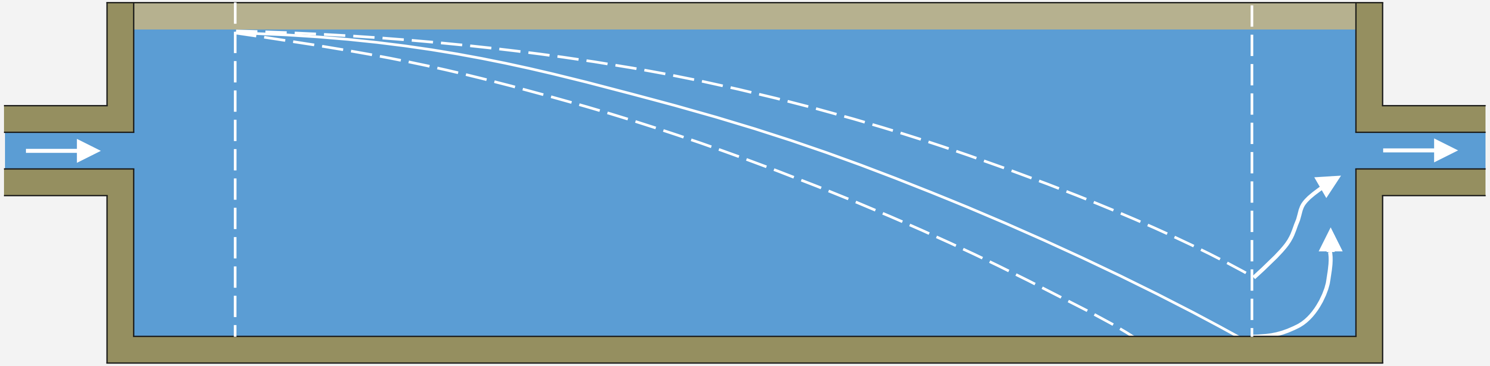
Flocculent settling



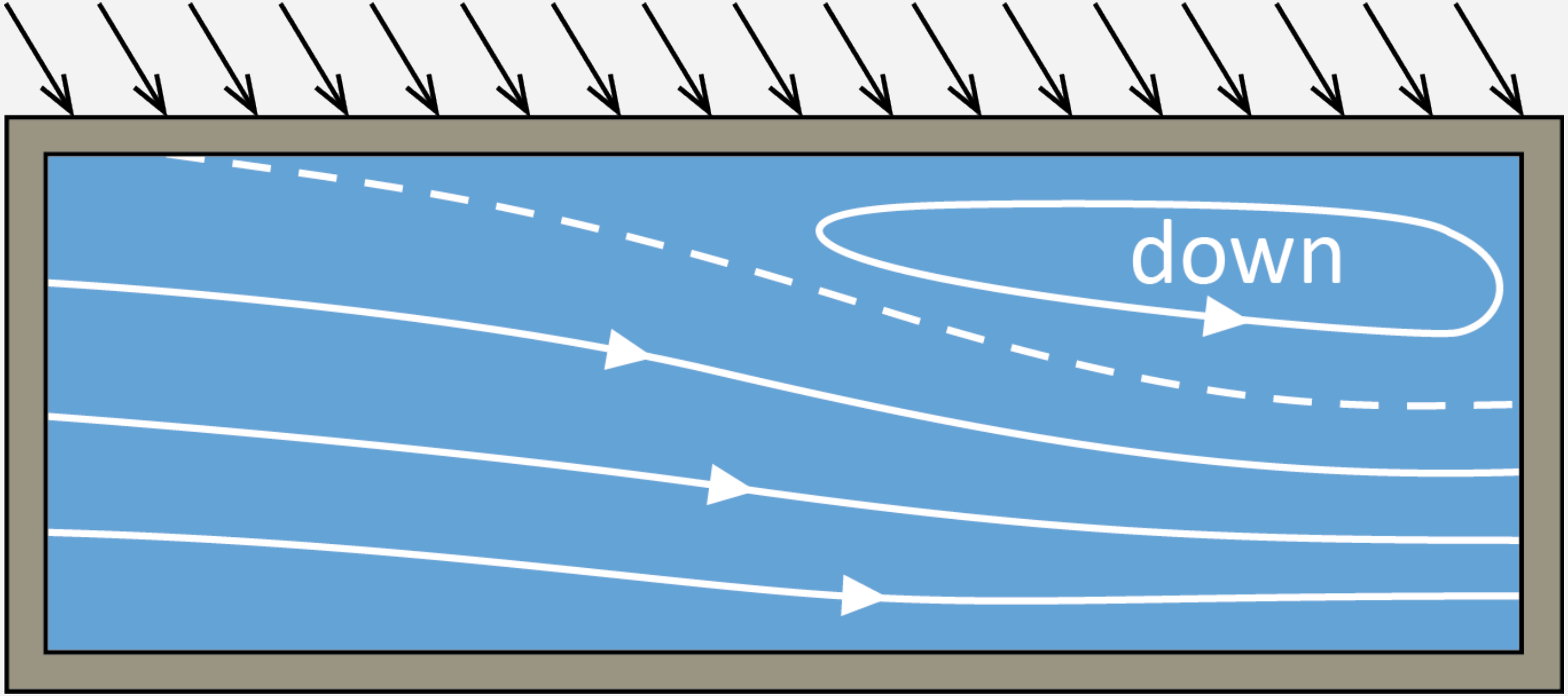
Influence of turbulence

Reynolds number: $Re = \frac{v_0 \cdot R}{\nu}$ ➡ $v_0 = \frac{Q}{B \cdot H}$, $R = \frac{B \cdot H}{B + 2 \cdot H}$ ➡ $Re = \frac{Q}{\nu} \cdot \frac{1}{B + 2 \cdot H}$

- Re > 2000; turbulent flow
- Re < 2000; laminar flow



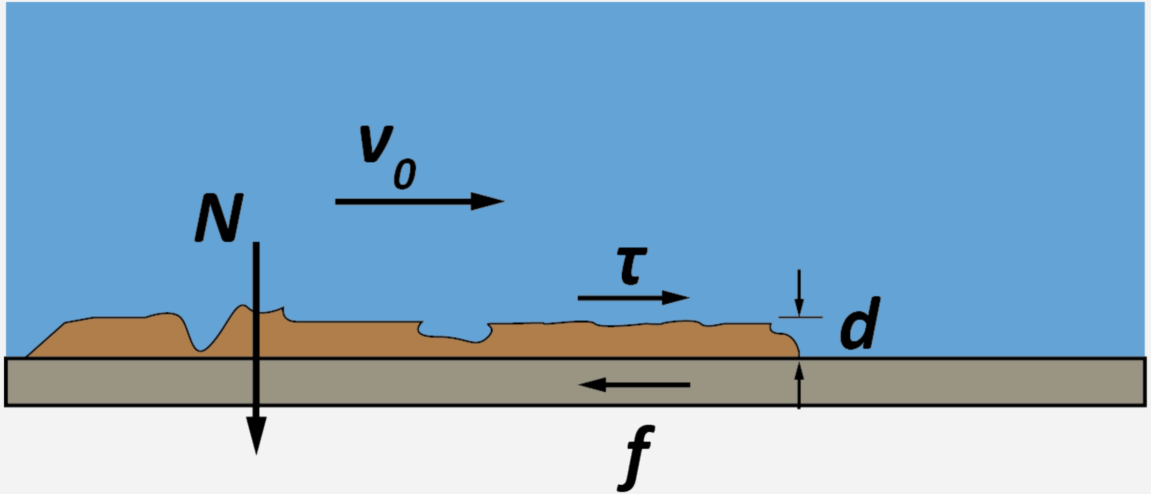
Short circuit flow



Shear stress

$$v_{sc} = \sqrt{\frac{40}{3} \cdot \frac{\rho_S - \rho_W}{\rho_W} \cdot g \cdot d}$$

$v_0 < v_{sc}$ ***: no bottom scour***



$$\tau = \frac{\lambda}{8} \cdot \rho_w \cdot v_s^{\,2}$$

$$f = \beta \cdot (\rho_w - \rho_s) \cdot g \cdot d$$

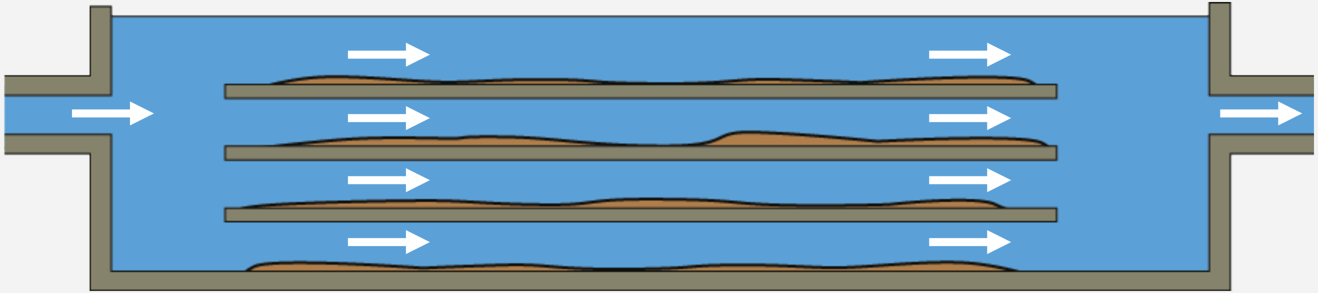
Settling tank WRK I/II

- $Q = 21000\ m^3/h$
- $L = 300\ m$
- $B = 120\ m$
- $H = 2.5\ m$

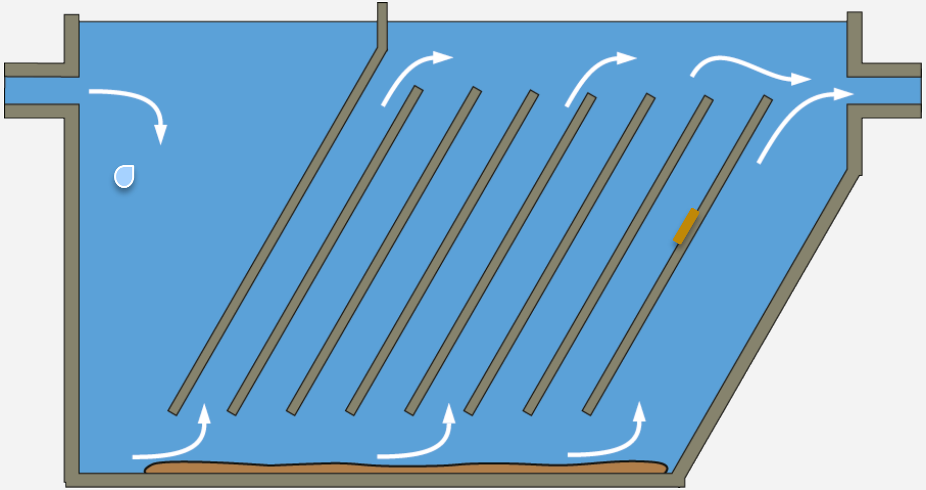
- $v_0 = 0.0194\ m/s$
- $s_0 = 1.6 \cdot 10^{-4}\ m/s$
- $T = 20°C$, $m = 1.0E^{-6}$

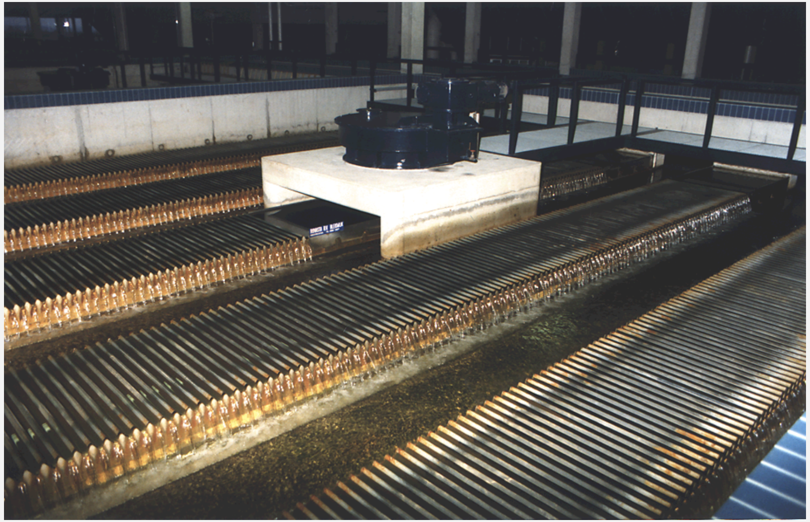
- $R = 2.22$
- $Re = 43000$ **turbulence**
- $C_p = 1.7 \cdot 10^{-5}$ **stable**

False bottom tanks

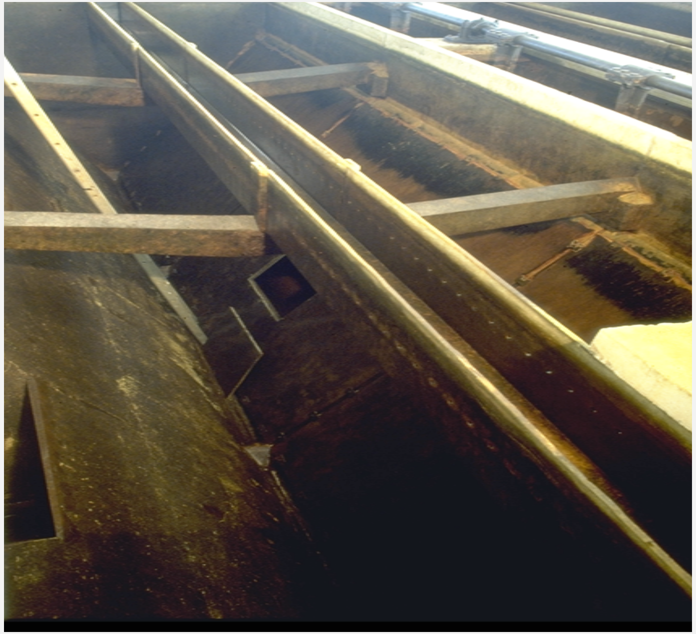


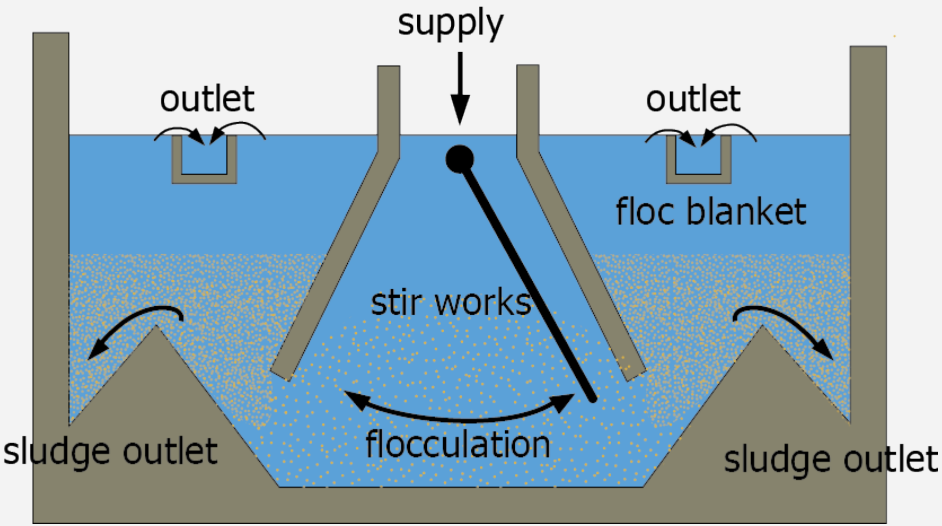
Tilted Plate settling



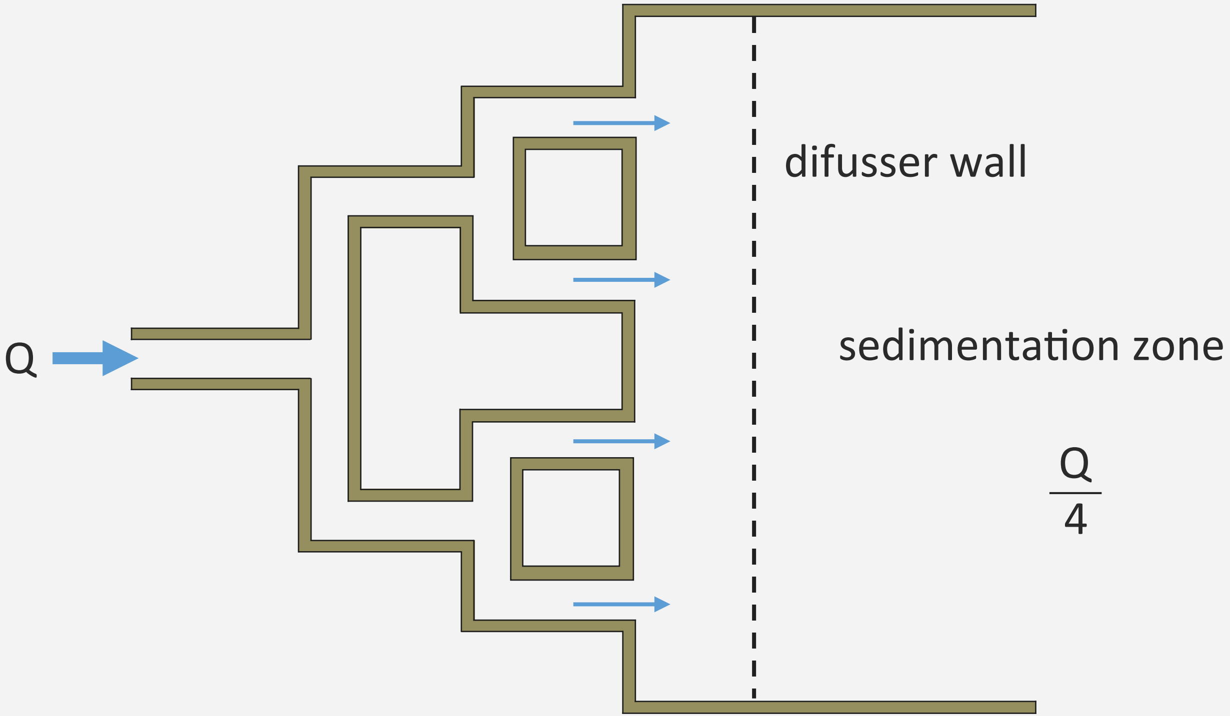


Floc-blanket clarifiers at Berenplaat

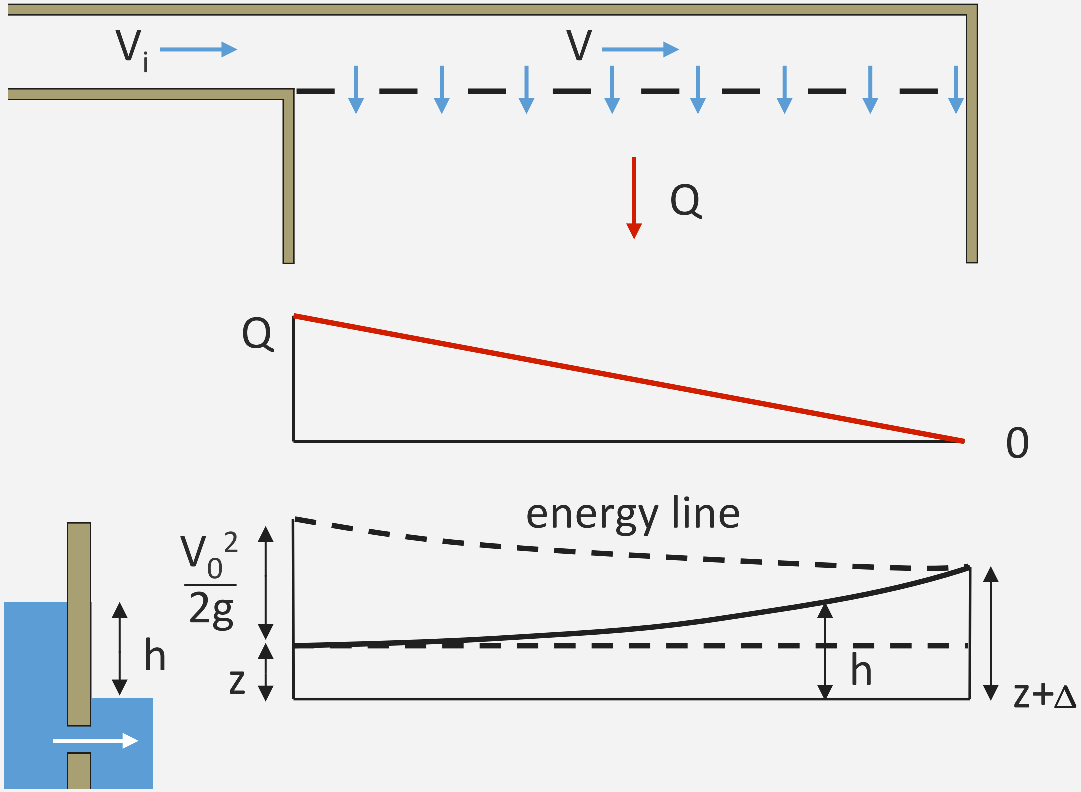




Inlet construction



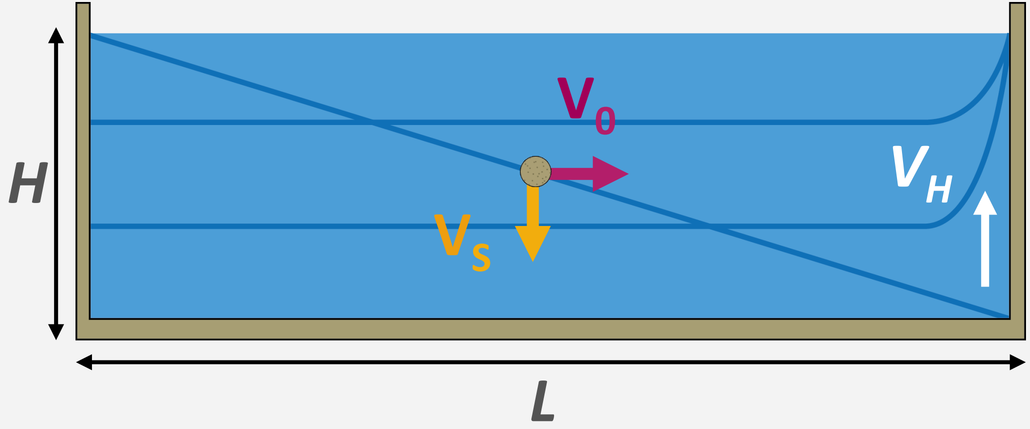
Feed channel



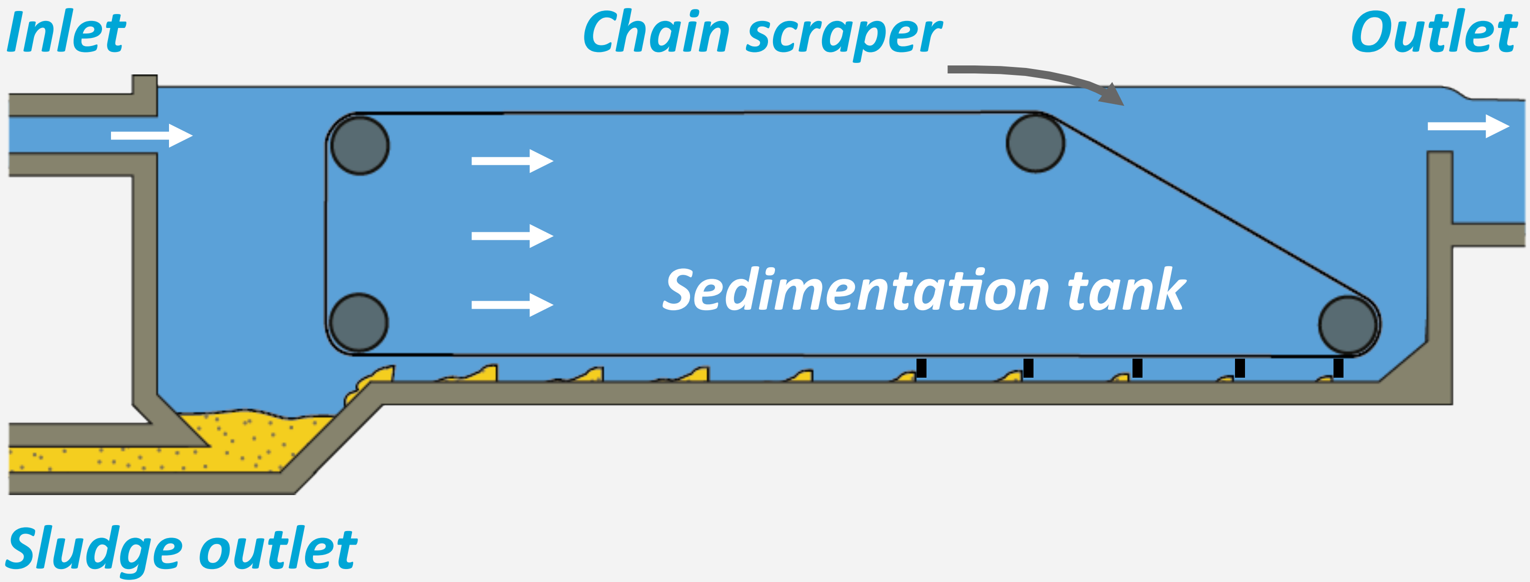
Outlet channel

$$v_H = \frac{1}{5} \cdot \frac{Q}{B \cdot H} \leq v_{S0}$$

$$\frac{L}{H} < 5$$



Sludge removal device



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TU Delft
Delft University of Technology