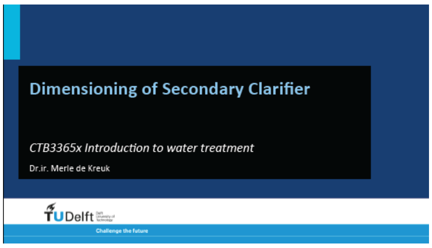
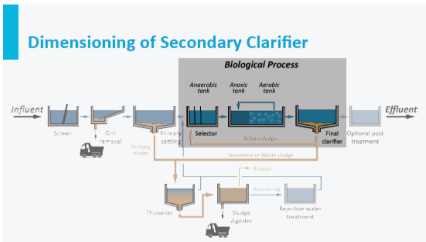
CTB3365x – Introduction to Water Treatment

W4c – Dimensioning of secondary clarifier

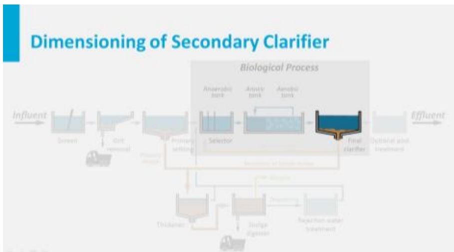
Merle de Kreuk



Today we will tackle the third unit of the biological part of the sewage treatment
plant.

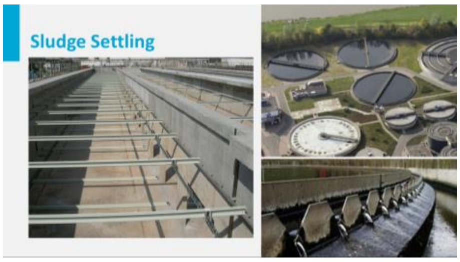


You learned the dimensioning of an aeration tank, the flow and concentration of the return sludge and we will continue with sizing the final clarifier.

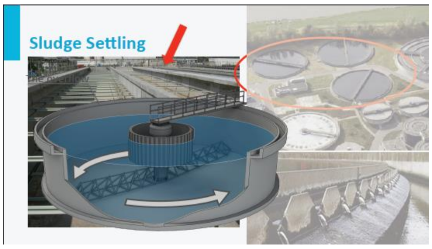


The design that is given in this lecture is based on the Dutch design guidelines and optimization guidelines

Guidelines from Germany or EPA guidelines from the United States are based on different principles and might lead to somewhat different results.
The final clarifier is nothing more than a unit for separating secondary sludge from the effluent, the treated sewage.
It should function well and should be large enough to prevent the wash out of sludge to the surface water at all times.
Can you think of reasons why this should be prevented?
If not, look back to the lectures before.



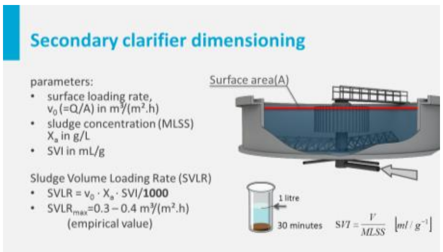
In the pictures you see some examples of settling tanks or final clarifiers.
These are round ones, but they are also occasionally rectangular like you typically see for primary settling tanks.



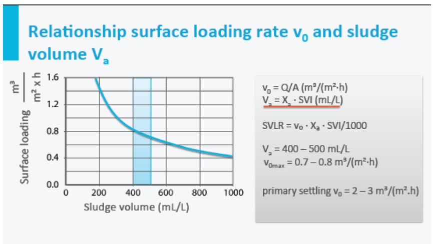
The arm that moves around the tank is forcing the settled sludge to the middle and can also remove floating particles if needed.
The overflow of the settling tank is shaped as VI notched weirs to guarantee a well distributed calm flow.

Final clarifiers must have large volumes too, because they should be able to store sludge during storm water flows, as you have seen in the examples of last lecture.
The final clarifier design is based on two parameters the surface loading rate and the sludge volume loading rate.
The surface loading rate is the simplest as it is nothing more than the flow divided by the surface area of the clarifier tanks.
The sludge volume loading rate is a guideline for the volume of sludge that can be added to a final clarifier,

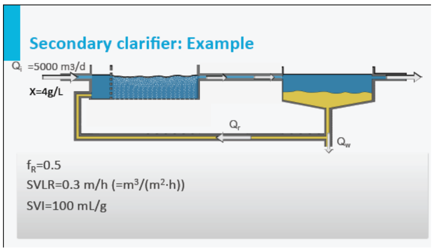
depending on the sludge concentration in the flow from the aeration tank and



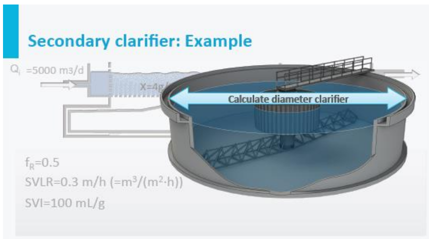
the sludge volume index or diluted sludge volume index.
The Sludge Volume Loading Rate generally lies between 0.3 and 0.4 m3 / m2 /hr.
This is an empirical value based on experiences of many full scale installations.



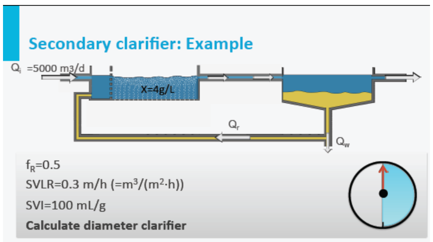
The applicable surface loading is visualized in this graph .
The sludge volume is the volume that the sludge occupies in one liter of mixed liquor, calculated by multiplying the Sludge volume index, times the sludge concentration.
To determine the sludge volume to estimate the surface area of the final clarifier, the sludge concentration in the aeration tank is taken as its equilibrium concentration during storm water flow.
Generally the sludge volume lies between 400 and 500 mL, which means that the general surface loading rate is between 0.7 and 0.8 m3/m2/hr.
To compare the surface loading rates for primary settling tanks generally lie between 2 and 3 m3/m2/hr.



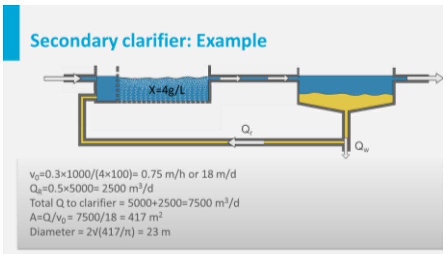
Now we will practice to design a final clarifier.
We take the following situation; an influent flow of 5000 m3 per day combined with a sludge recycling ratio of 0.5, a given sludge volume loading rate of 0.3 m3/m2/hr and the sludge has an SVI of 100 mL/g.



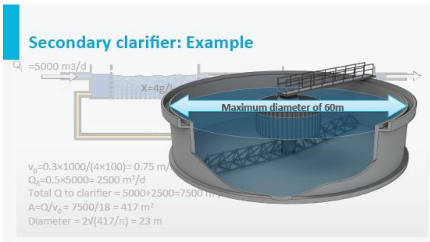
With these data, you should now be able to calculate the diameter of the settling tank.



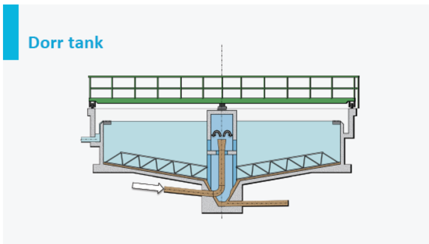
Have you figured out where to start?
With the sludge volume loading rate, you can calculate the surface loading rate v0,



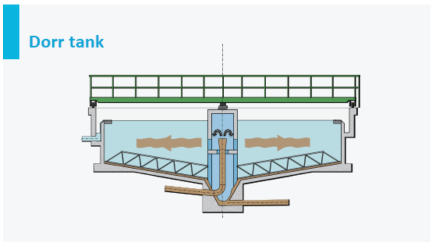
which is 0,75 m/h.
Since you always have to work with the same time units, you can recalculate this to 18 m/d.
Then you have to calculate the flow to the final clarifier, which is the influent flow plus the sludge recycle flow.
In this example that equals 7500 m3/d.
You know that the surface loading rate is defined as flow divided by the surface area, so with that knowledge, you can calculate the required surface area.
In this example that equals 417 m2.
This could be designed as a round clarifier with a diameter of 23 meters.



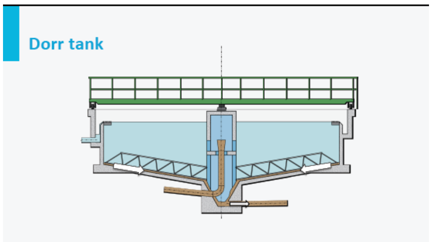
Clarifiers can be built with maximum diameters of 60 meters although the typical range is from 10 to 40 m.
If the calculated diameter becomes larger, you should choose to build multiple clarifiers with smaller diameters.



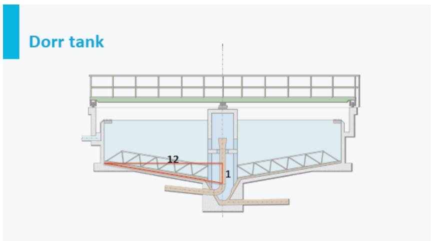
One of the common designs of a round final clarifier is the Dorr tank.
As you can see, the sludge is fed in the center, in an influent diffusion well, designed in such way that the sludge is mixed and can start forming larger flocs.



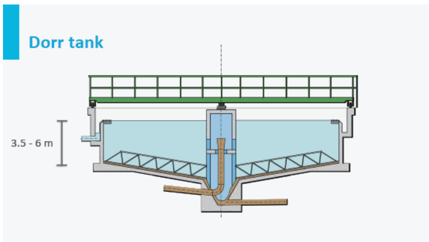
From here, the sludge water mixture flows slowly to the outside of the tank where the overflow weir is situated. With increasing diameter, the flow rate of the water decreases, allowing the biomass to settle.



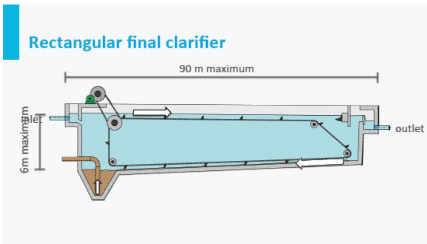
The slowly rotating arms force the sludge into the central cone, where it is collected and send back the sludge recycling pump.



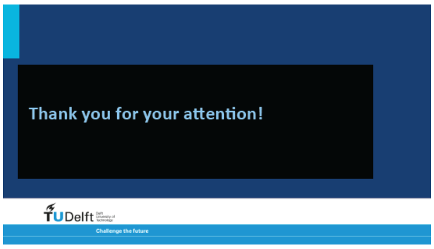
The slope of the bottom of the tank is designed as .1 in 12 (vertical:horizontal) and in general tanks have a sidewater depth of 3.5, but can also be as deep as 6 meters.



Ideally, the tank radius should not exceed 5 times the sidewater depth.



Final clarifiers can also be rectangular in design.
The settled sludge is then transported via chained beams to the beginning of the tank, while the floating layer can be transported with the beams passing the surface of the tank to the end, where it can be removed via a separate weir before the overflow weir.
Length and depth of these tanks have a maximum of 90 and 6 m.



On the website you will find more and slightly more difficult exercises to practice the design of final clarifiers.