WASTEWATER TREATMENT
(Primary Treatment)

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PRIMARY TREATMENT

<u>Primary Sedimentation Tank:</u>

Functions:

- They remove most of the settleable solids <u>OR</u> about 40-70% of the total suspended solids from wastewater.
- Reduce BOD on secondary treatment unit. Since almost 60-80% of the total BOD of municipal wastewater is contributed by suspended and colloidal solids. Between 30 and 45% of the total BOD will be removed during this process.

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PRIMARY TREATMENT

Primary Sedimentation Tank:

Description:

- It is the first process where removal of substantial quantities of suspended solids, floating materials and materials causing biochemical oxygen demand in wastewater flow occurs.
- Sedimentation tanks, rectangular or circular, operate on a continuous flow-through basis, yet they maintain relative quiescence to permit suspended solids to settle if the specific gravity is greater than that of water, or to float if the specific gravity is less.
- Mechanical devices remove the accumulated suspended solids (sludge) from the tank bottom, while floatable materials (skimmings) are taken off the surface.
- The clarified liquor, known as primary effluent, is discharged over the tank's effluent weirs.
- Removal of suspended solids and biochemical oxygen demand is based on surface overflow rate and detention time.

PRIMARY TREATMENT

<u>Primary Sedimentation Tank:</u>

- **DETENTION TIME**:

The detention time of a settling basin (sedimentation Tank) is the THEORETICAL time for which a water particle will stay in it

D.T =

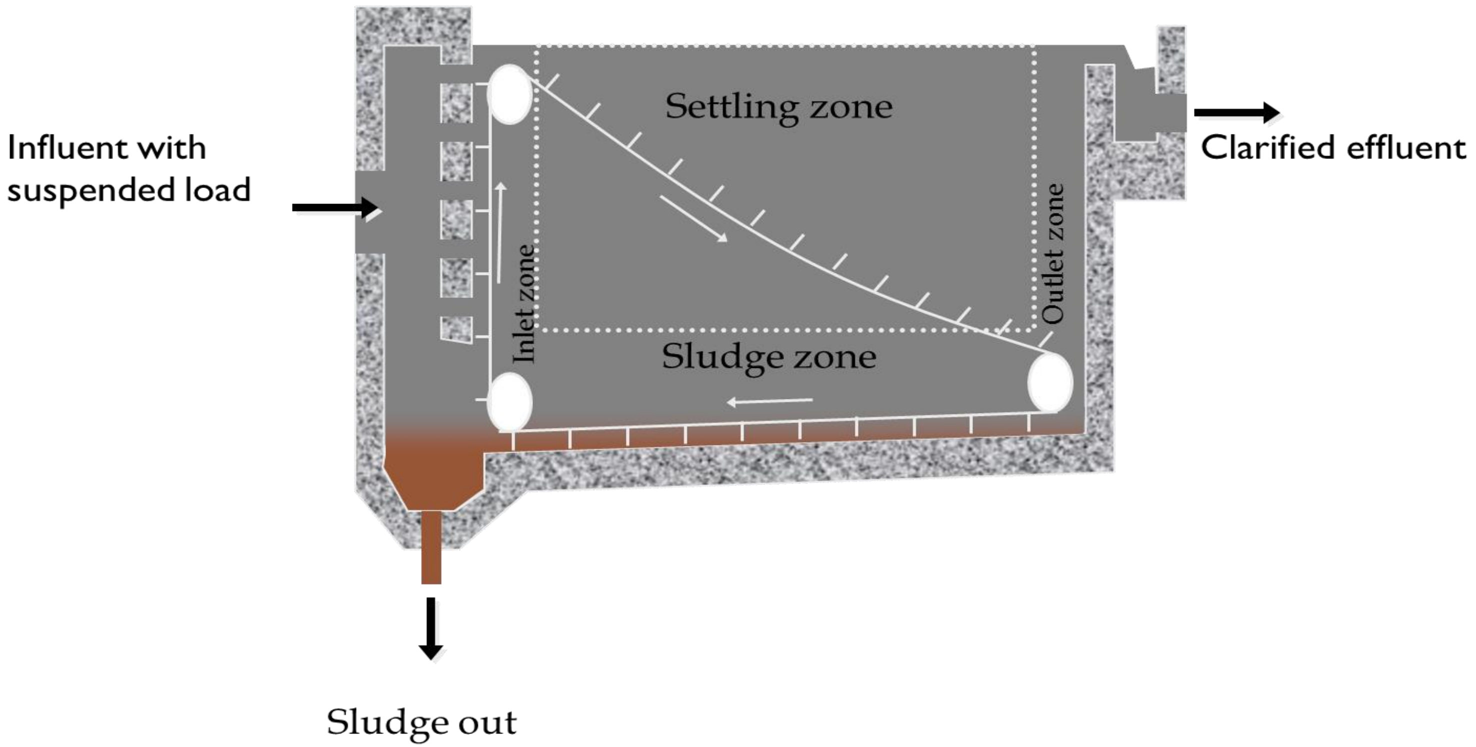
$$\frac{volume\ of\ \tan k}{Rate\ of\ \ flow} = \frac{V}{Q}$$

Detention times are usually specified on the basis of <u>AVERAGE FLOW</u> unless otherwise stated.

FLOW THROVGH TIME:

It is the actual time taken by the fluid to pass through the tank. It is generally determined by TRACER STUDIES using NaCL

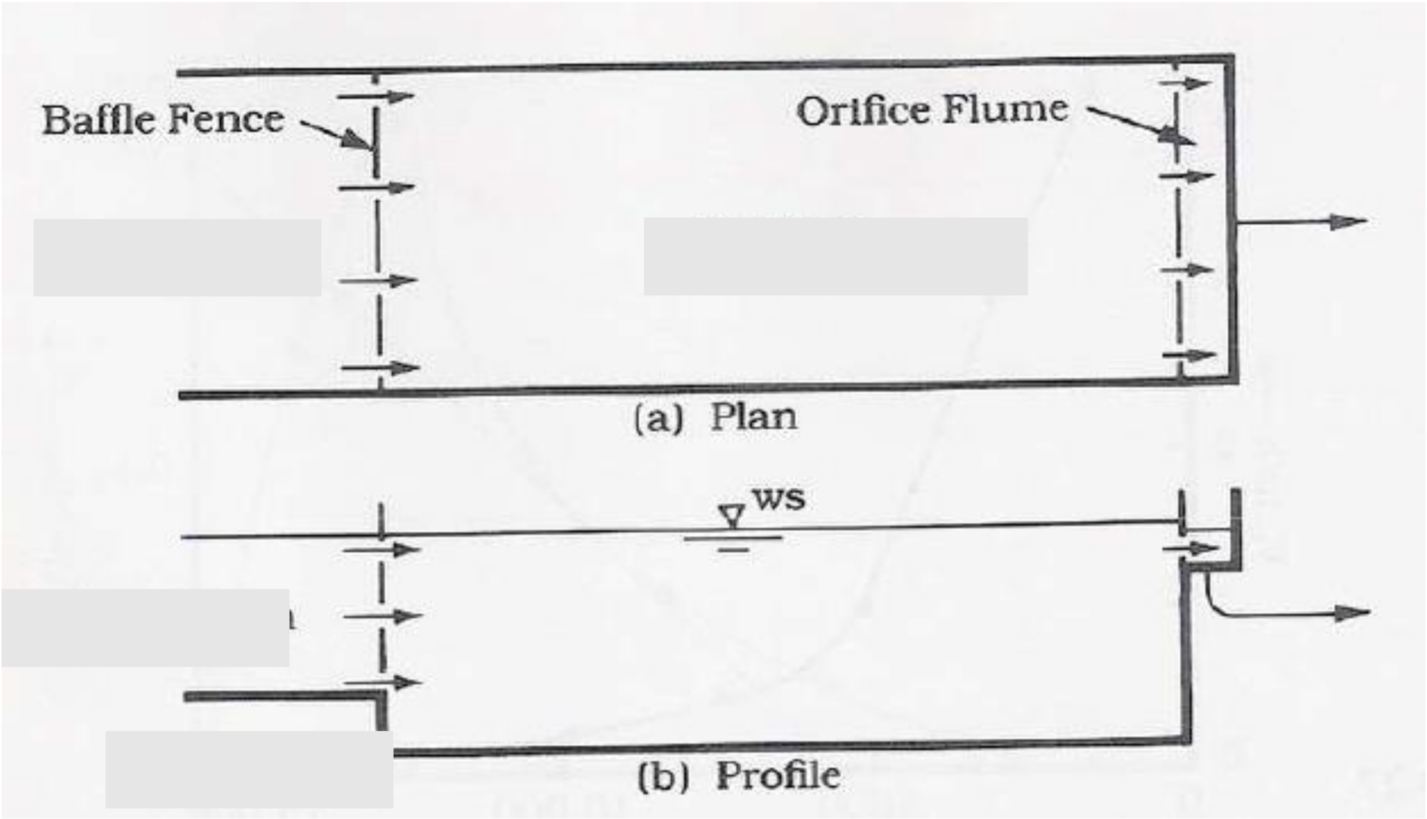
SEDIMENTATION BASIN ZONES

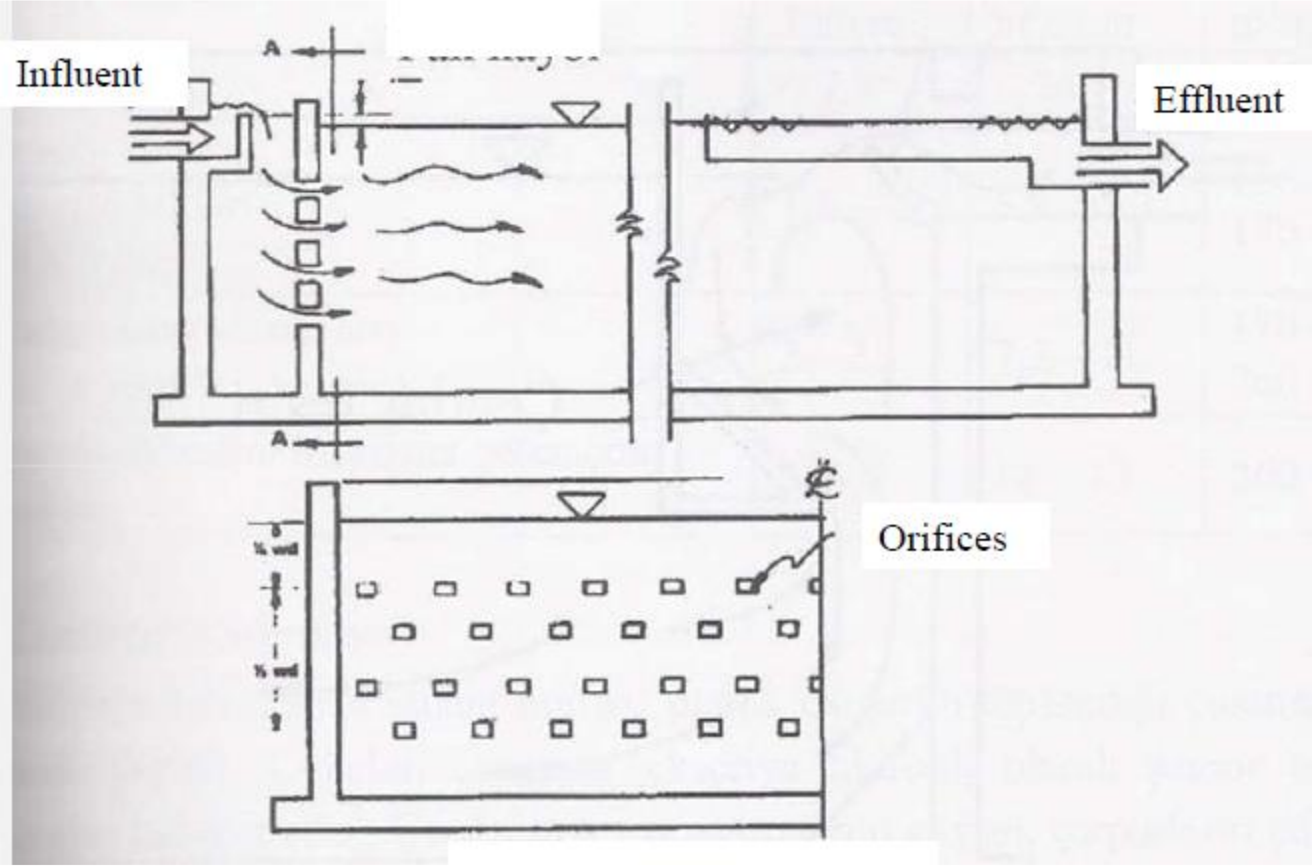


SEDIMENTATION BASIN ZONES

Inlet zone

- The inlet or influent zone should provide a smooth transition from the influent flow and should distribute the flow uniformly across the inlet to the tank.
- The normal design includes baffles that gently spread the flow across the total inlet of the tank and prevent short circuiting in the tank.
- The baffle could include a wall across the inlet, perforated with holes across the width of the tank.
- Basin inlets should be designed to minimize high flow velocities near the bottom of the tank.
- If high flow velocities are allowed to enter the sludge zone, the sludge could be swept up and out of the tank.
- Sludge is removed for further treatment from the sludge zone by scraper or vacuum devices which move along the bottom


Baffle Fence
Orifice Flume
(a) Plan
WS
(b) Profile



Influent
A
Effluent
A
Orifices

SEDIMENTATION BASIN ZONES

Settling Zone

- The settling zone is the largest portion of the sedimentation basin.
- This zone provides the calm area necessary for the suspended particles to settle.

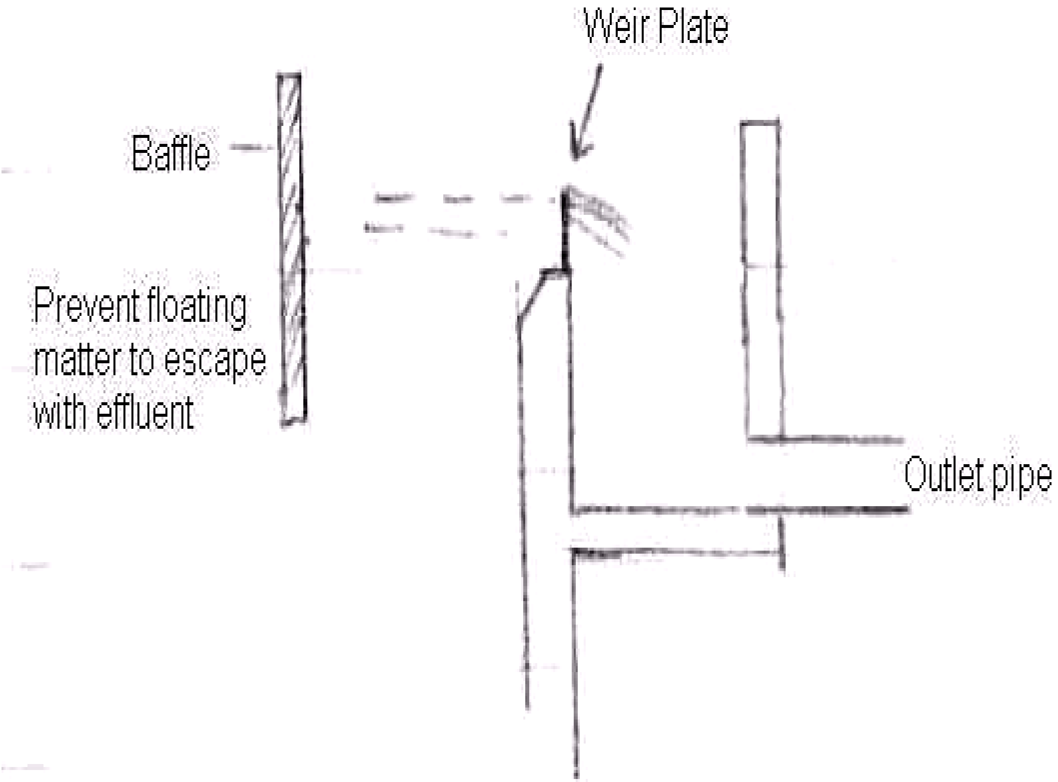
Sludge Zone

- The sludge zone, located at the bottom of the tank, provides a storage area for the sludge before it is removed for additional treatment or disposal.

SEDIMENTATION BASIN ZONES

Outlet Zone

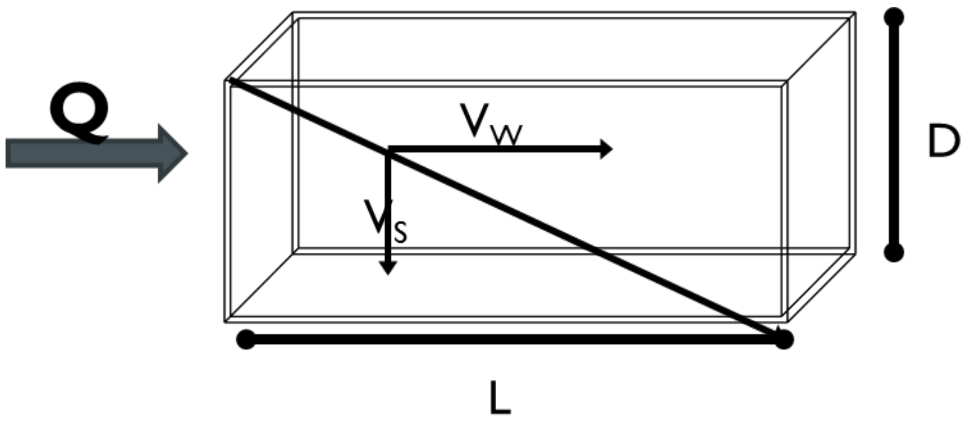
- The basin outlet zone should provide a smooth transition from the sedimentation zone to the outlet from the tank.
- This area of the tank also controls the depth of water in the basin.
- Weirs set at the end of the tank control the overflow rate and prevent the solids from rising to the weirs and leaving the tank before they settle out.


Weir Plate
Baffle
Prevent floating matter to escape with effluent
Outlet pipe

outlet

Ideal Settling Tank

1. Plug flow conditions exists in tank
2. Uniform horizontal velocity in settling zone
3. Uniform concentration of all particles
4. Particles are removed once they reach the bottom of settling zone
5. Particles settle discretely without interference from other particles at any depth



Two components of particle velocity in settling zone:

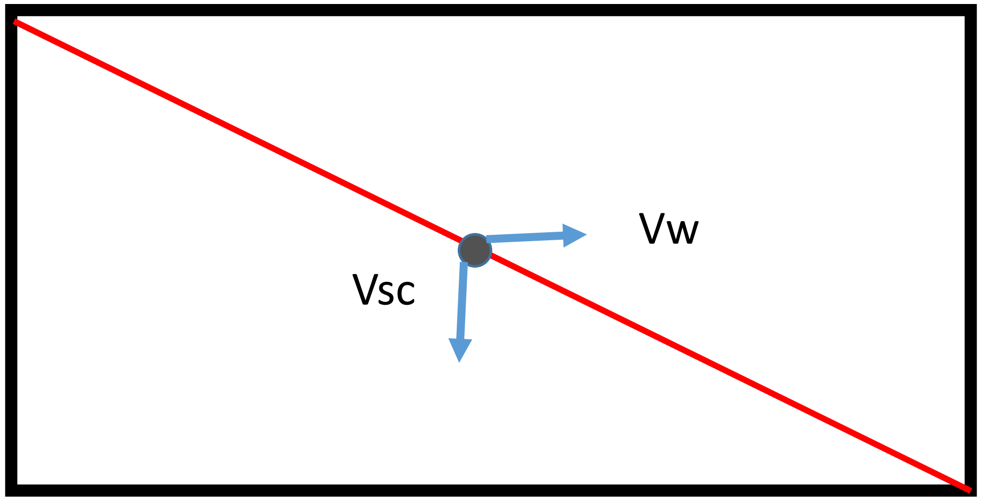
1. Horizontal Velocity (Vw)
2. Terminal Settling Velocity (Vs)

L=length of settling zone
D=depth of settling zone
W=width of settling zone
Vs=settling velocity of particle
Vw=horizontal velocity of water
Q=inflow to tank
V=volume of tank
As=surface are of tank

Ideal Settling Tank

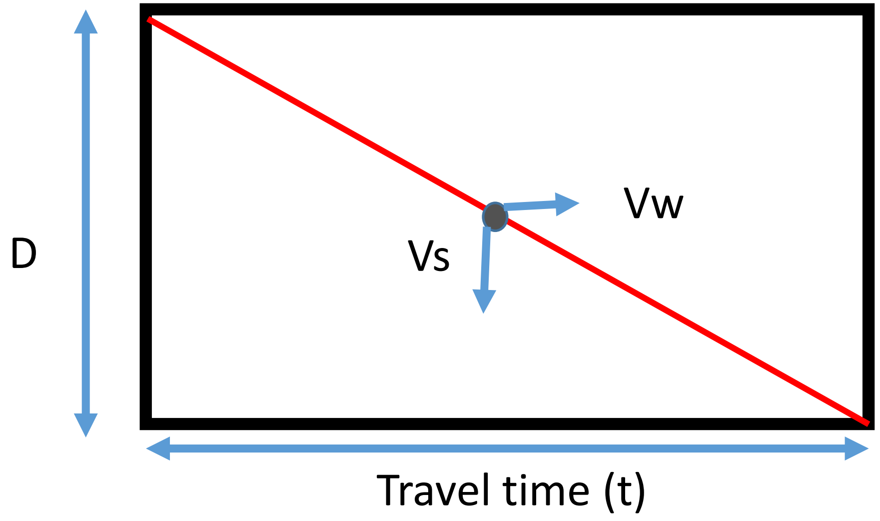
For ideal discrete settling of particles in a rectangular tank :

1. Horizontal Velocity (Vw)=Constant
2. Terminal Settling Velocity (Vs)=Constant



Vsc=Critical settling Velocity or fixed settling velocity

Ideal Settling Tank

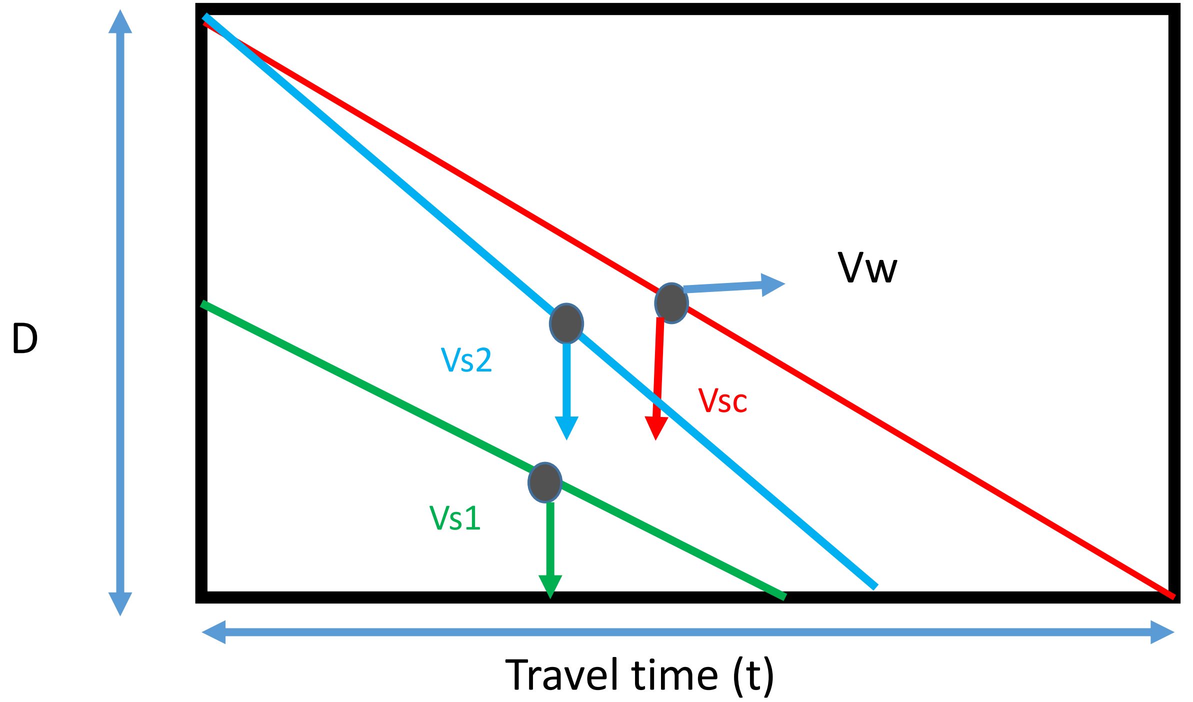


$$V_s = \frac{\textbf{Depth (D)}}{\textbf{Detention Time}(t_d)}$$

$$t_d = \frac{Volume}{Flow} = \frac{L * W * D}{Q} = \frac{\boldsymbol{A_s * D}}{\boldsymbol{Q}}$$

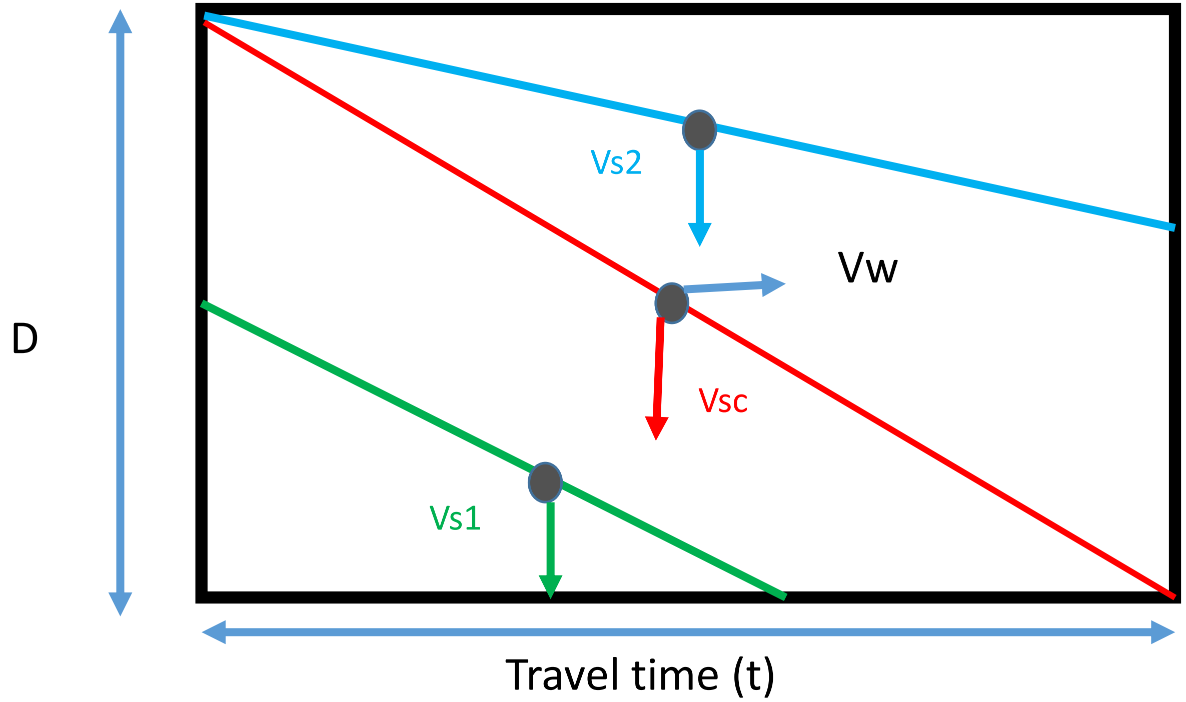
$$V_s = \frac{D * Q}{A_s * D} = \frac{\boldsymbol{Q}}{\boldsymbol{A}} = \boldsymbol{SOR}$$

Ideal Settling Tank

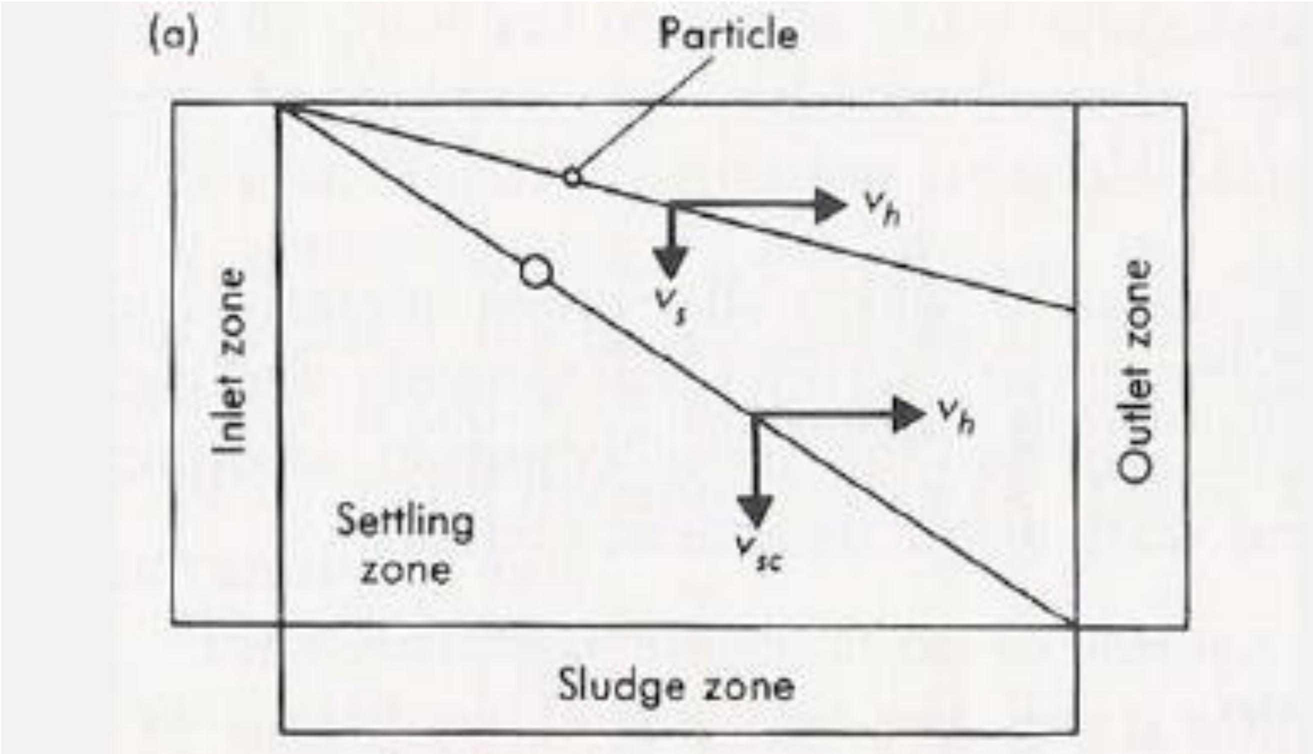


Particles having settling velocity (Vs) greater than Critical velocity (Vsc) will be removed 100% regardless of the position of particle at inlet

Ideal Settling Tank



Particles having settling velocity (Vs)less than Critical velocity (Vsc) will be removed in the ratio of Vs/Vsc. May also depend on their position at inlet.



All particles with $V_S > V_C$ → will be completely settled.

Particle with $V_s < V_c$ → will be removed in the ratio V_p / V_c

Removal Efficiency of Settling Tank

- Surface over flow rate is a critical design parameter.
- SOR is independent of depth and detention time
- Surface area of tank is a significant parameter.by changing surface area ,removal efficiency of tank can be enhanced.

	Tank-1	Tank-2
L	20	20
W	10	10
D	1	2
Vol	$200m^3$	$400m^3$

Both tanks will have same removal efficiency.

Removal Efficiency of Settling Tank

Thus if we increase D.T $= \dfrac{LWD}{Q}$ by increasing D then there will be no effect on removal efficiency and if we increase D.T by changing L × W then removal efficiency will increase.

L	20	40	10
W	10	10	10
D	1	1	4
V	200	400	400

RECTANGULAR BASINS

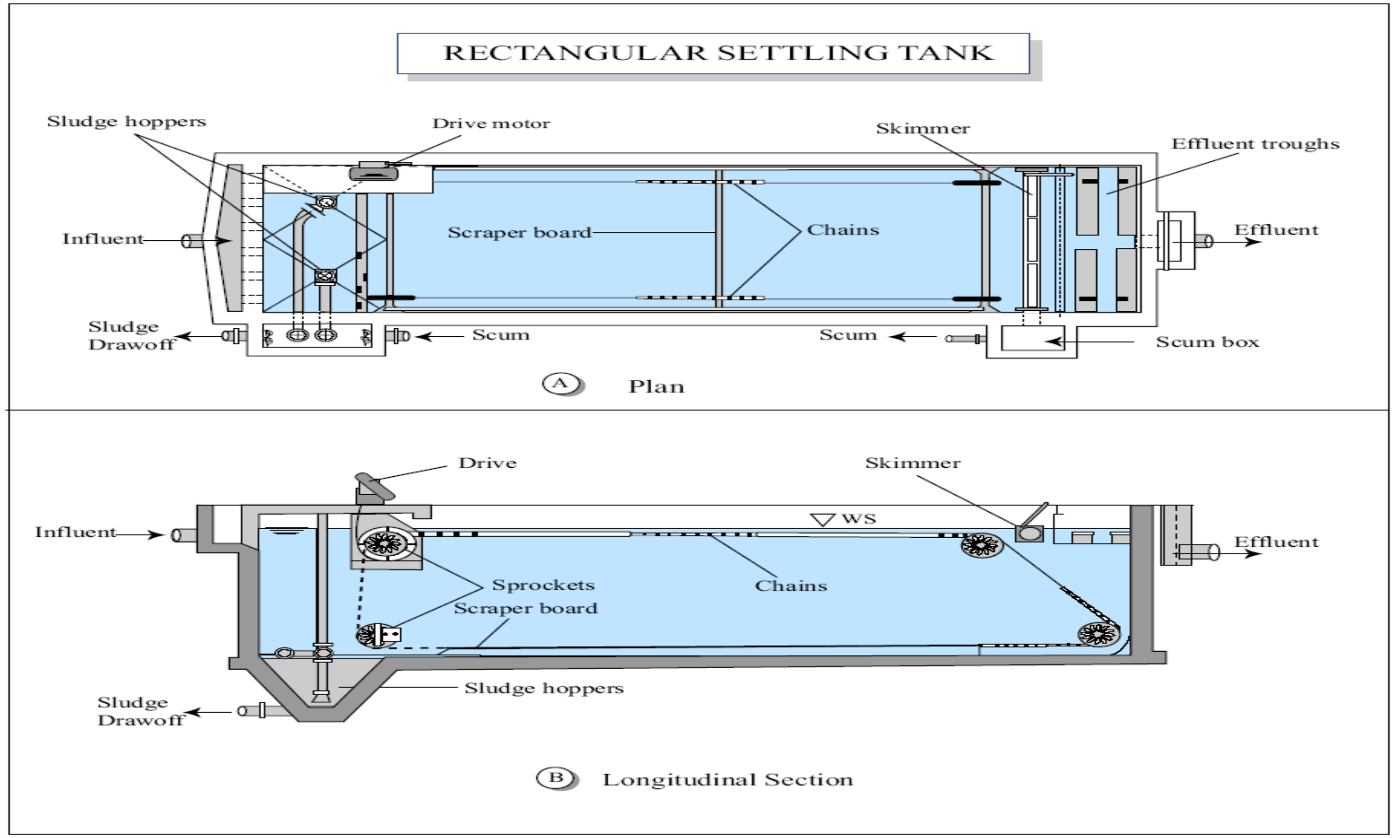


Figure by MIT OCW.
Adapted from: Reynolds, T. D., and P. A. Richards. *Unit Operations and Processes in Environmental Engineering*. 2nd ed. Boston, MA: PWS Publishing Company, 1996, p. 249. ISBN: 0534948847.

Design Criteria of Sedimentation Tank

Min. # of tanks	Two
Water depth	3-5m (2m or deep tanks 6.5m also used)
Detention time	2~8hrs
Overflow rate	20~33m^3/m^2/day
weir loading rate	≤250m^3/m/day
Sludge storage	20% extra volume required

Design Criteria Rectangular Sedimentation Tank

Length	30m
Width	10m(13m max)
L:W	$\leq$ 4:1(2:1 generally)
Bottom slope	1-2%(w/o scrapers)

Design Criteria circular Sedimentation Tank

Dia	30m(max)
Depth	3-5m
Bottom slope	8%(hopper bottom + scrapers)

Sedimentation Tank

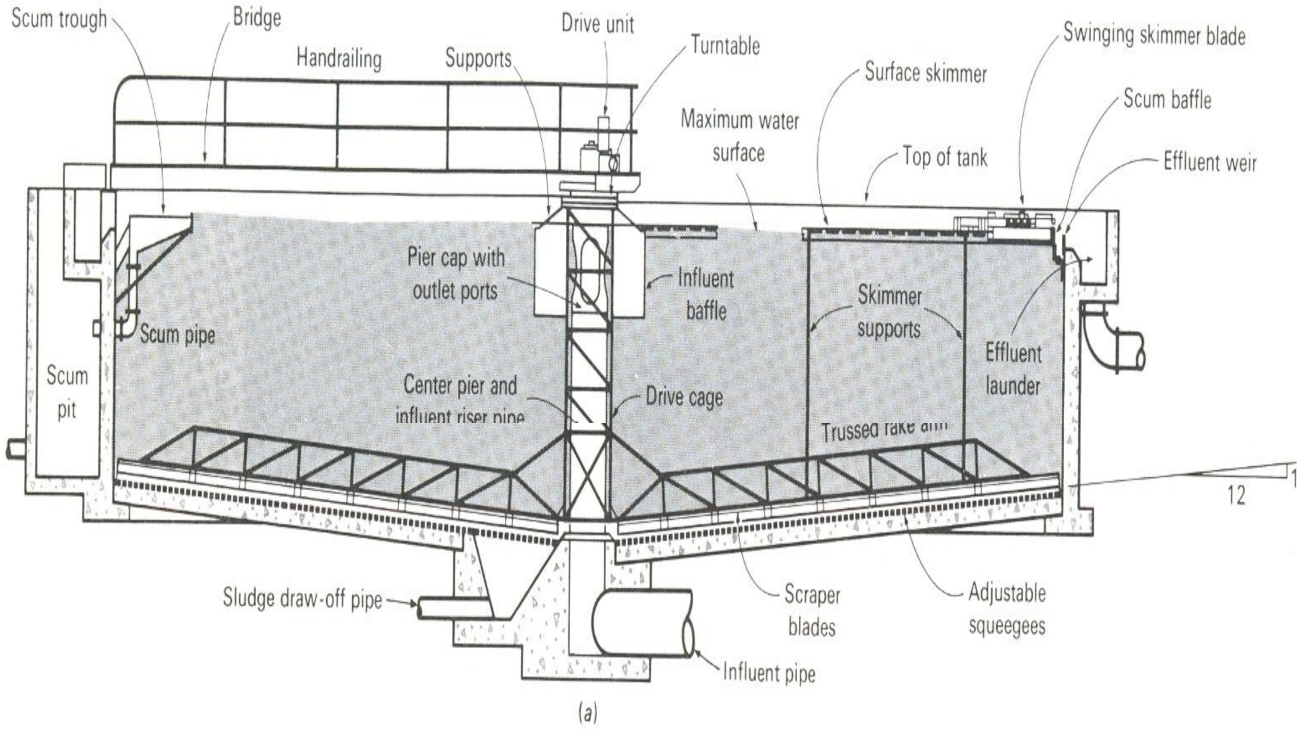


FIGURE 9-19a
Typical circular primary sedimentation tanks: (*a*) center feed (from Infilco Degremont).

Problem 1

Design a sedimentation tank to serve a population of 15,000 persons with an average water consumption of 350 lpcd.

Problem 2

Design a rectangular primary sedimentation tank for a community having a population of 46900 persons with an average water consumption of 200 lpcd. Use SOR = 20m/d, L:W = 3:1, detention time = 3 hour, weir loading rate = 250 m^3/m day. Take at least two units.

Problem 3

Design a circular primary settling tank ,if the average flow rate 5000 m^3/day with a peak factor of 2.5.The overflow rate is 35m^3/m^2.day

Problem 4

The average flow rate at a small municipal wastewater treatment plant is 20,000m^3/day.The highest observed peak daily flow rate is 50,000m^3/day. Design rectangular primary clarifier with a channel width of 6m.use a minimum number of clarifiers. Use a over flow rate of 40 m^3/m^2.day at average flow .Also design the tank on peak flow.

Problem 5

Design a circular primary settling tank ,if the average flow rate 5000 m^3/day with a peak factor of 2.5.The overflow rate is 35m^3/m^2.day

Problem 6

The average flow rate at a small municipal wastewater treatment plant is 20,000m^3/day.The highest observed peak daily flow rate is 50,000m^3/day. Design rectangular primary clarifier with a channel width of 6m.use a minimum number of clarifiers. Use a over flow rate of 40 m^3/m^2.day at average flow .Also design the tank on peak flow.