SBR – System Overview





Outline of Contents

Indah Water — Syarikat Pembetungan Nasional Anda — Your National Sewerage Company

- ☐ Overview of SBR System
- ☐ Design Considerations for SBR System
- ☐ Recommended design parameters
- ☐ Advantage / Disadvantage of SBR
- ☐ Variation of SBR Systems

SBR Systems

Historical Prospective:

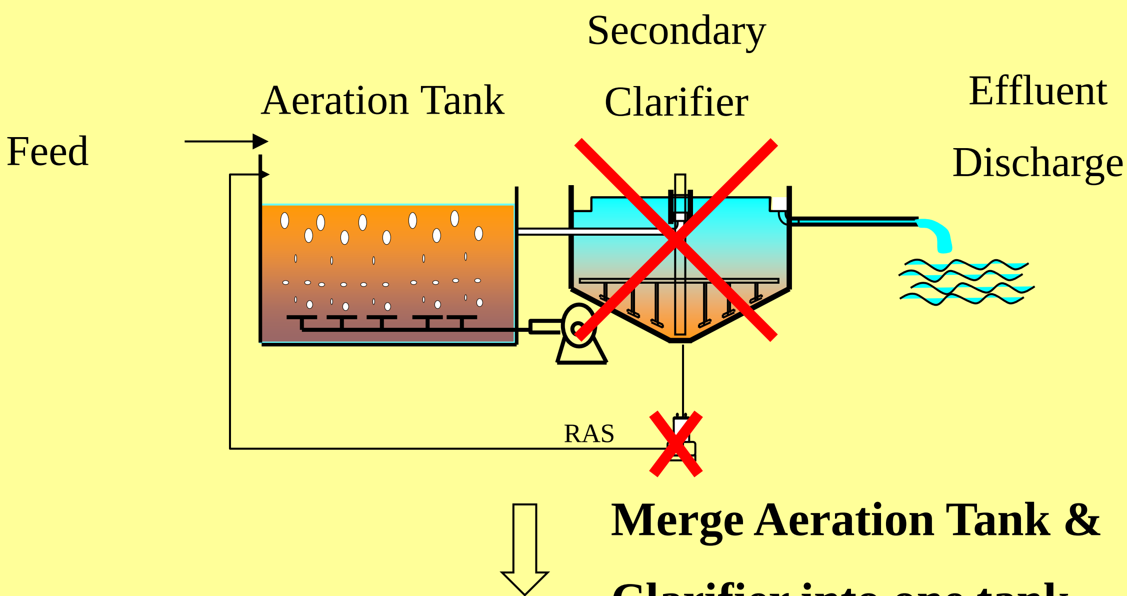
- Fill and draw first shown beneficial use - Arden and Lockett in England.
- Many difficulties associated with "batch" processes, continuous flow become popular.
- Resurgence of "batch":
  - when Pasveer's modification of OD to intermittently aeration and discharge;
  - Goronszy's use of continuous feed and intermittently aeration and discharge.

Today's prospective:

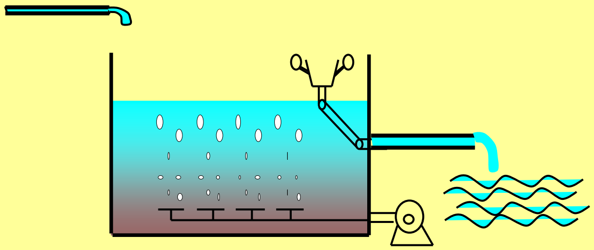
- Hardware devices controllable: motorized / pneumatic valves, motorized shaft, etc.;
- Advent of PLC making operator's control: automated;

Batch processes - popular again due to many difficulties resolved and benefits demonstrated.

Sequencing Batch Reactor merges aeration & clarifier:



Merge Aeration Tank & Clarifier into one tank



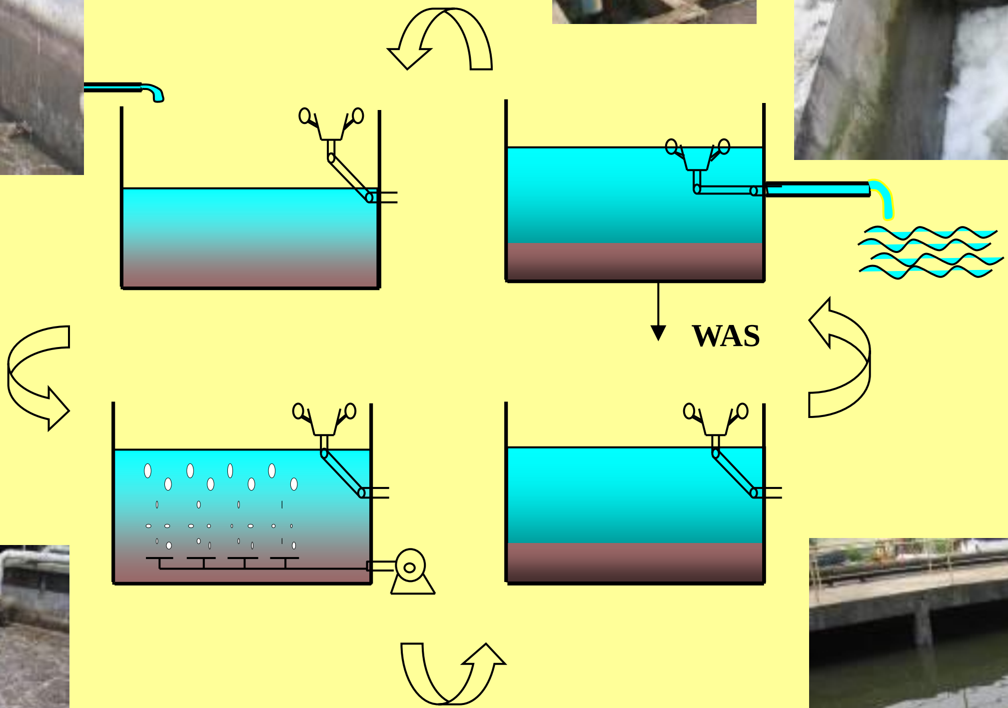
SBR Systems

SBR (Sequencing Batch Reactor):

- Sewage feeds to a reactor, biological oxidation and clarification take place at same reactor
- Operated on alternative sequence of cyclical mode.
- There are five (5) basic sequences in a cycle, namely:
  - Fill
  - React (Aeration)
  - Settle
  - Decant
  - Idle (optional- mostly not use)

SBR System

IndahWater Syarikat Pembetungan Nasional Anda
Your National Sewerage Company



(1) Fill

(4) Decanting

(3) Settle

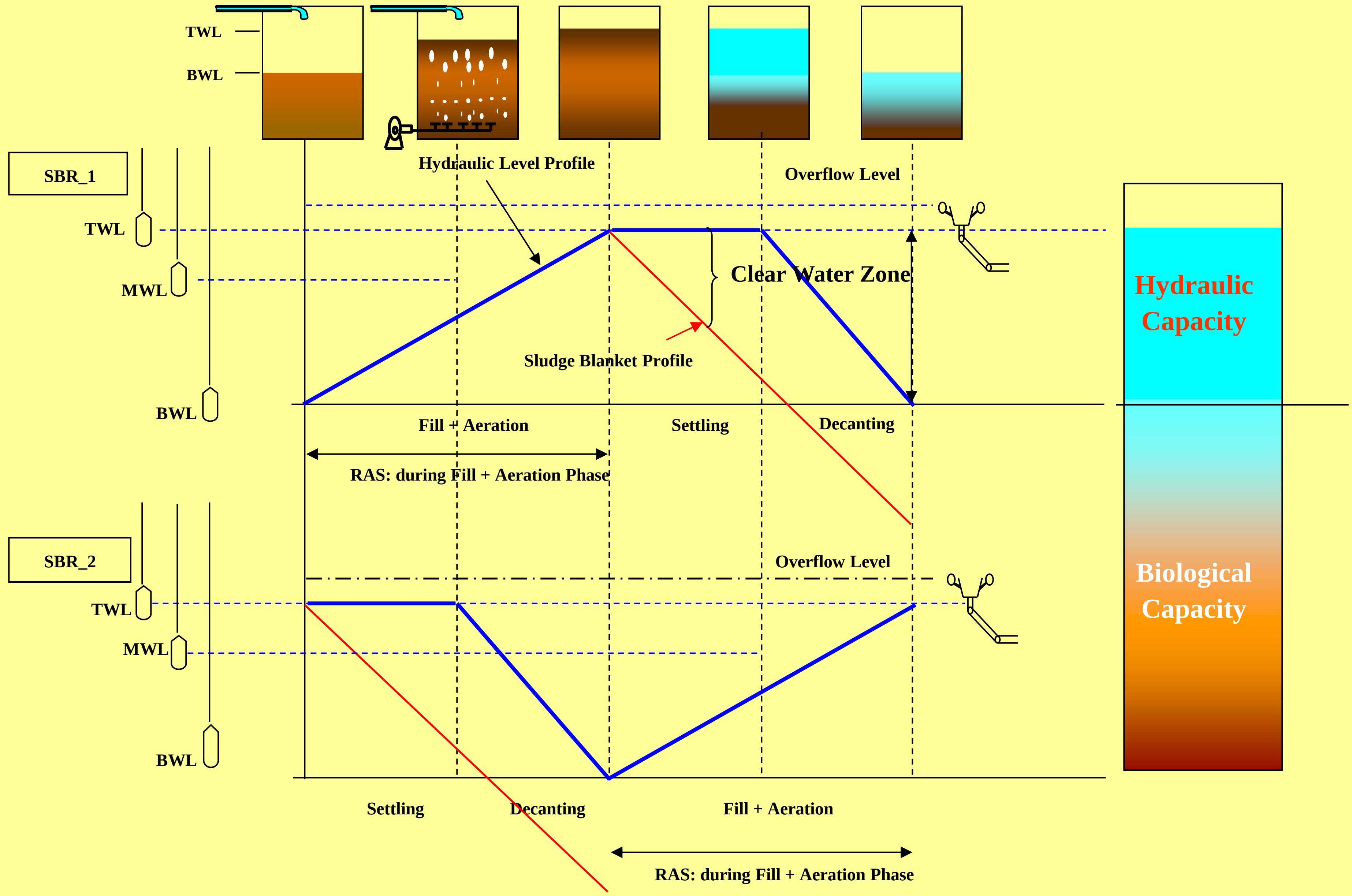
(2) React

Outline of Contents

Indah Water Syarikat Pembetungan Nasional Anda
Your National Sewerage Company

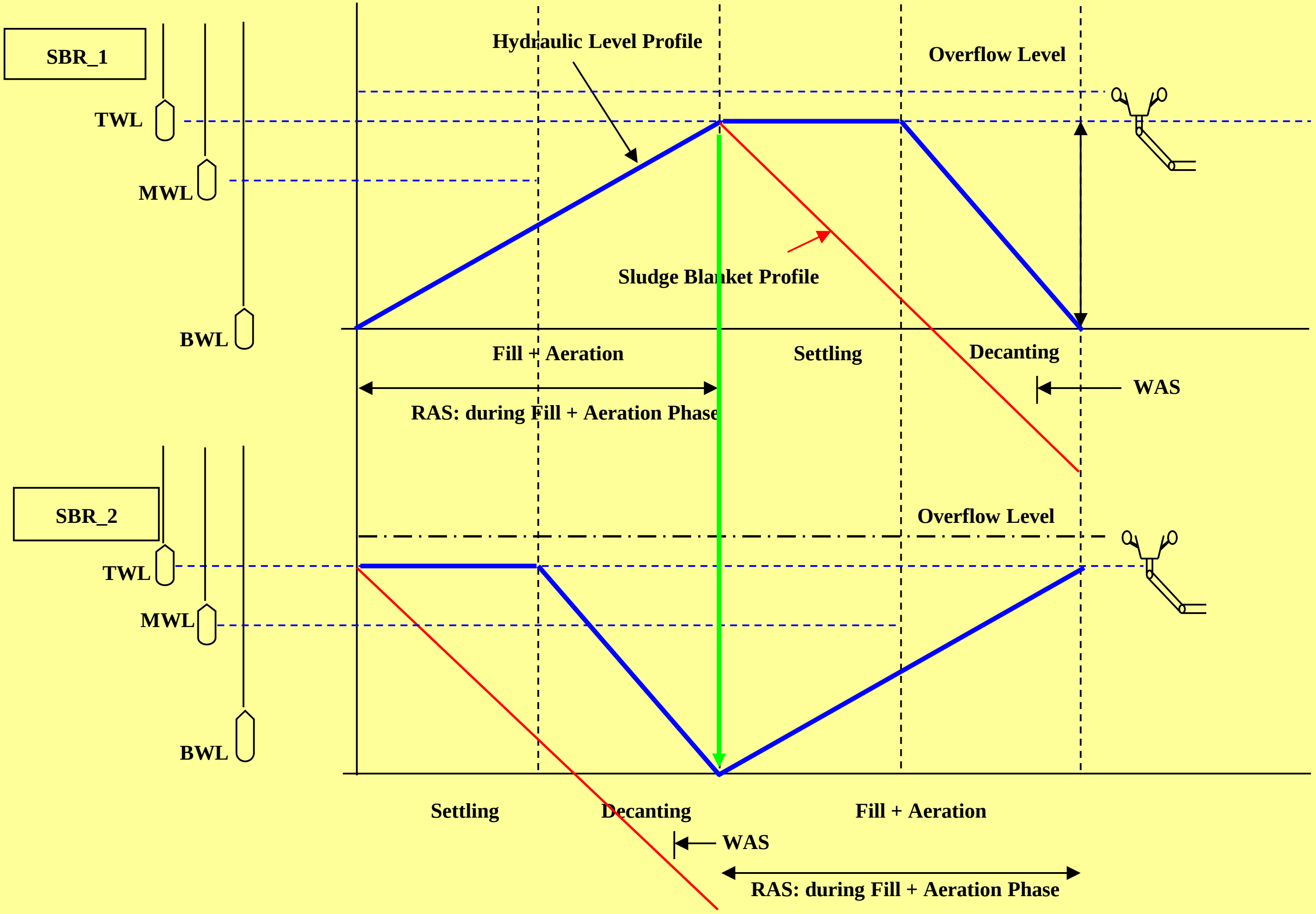
- ☑ **Overview of SBR System**
- ☐ **Design Considerations for SBR System**
- ☐ **Recommended design parameters**
- ☐ **Advantage / Disadvantage of SBR**
- ☐ **Variation of SBR Systems**

SBR Cycle: Hydraulic & Sludge Profile

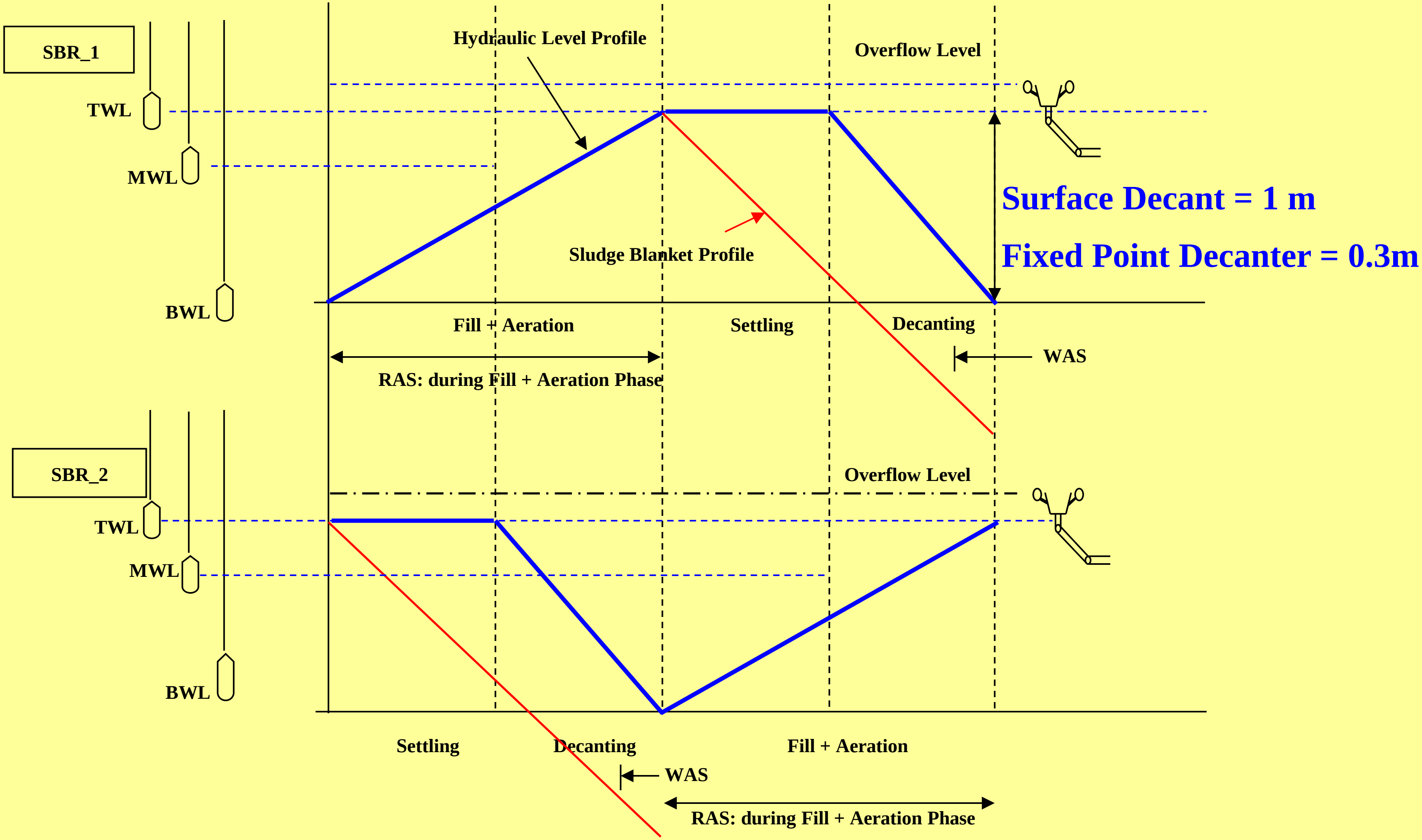


SBR Cycle: Hydraulic & Sludge Profile

$$N_{SBR} = t_{cycle} / t_{fill}$$



SBR Cycle: Hydraulic & Sludge Profile



SBR Cycle: Hydraulic & Sludge Profile

Indah Water — Syarikat Pembetungan Nasional Anda — Your National Sewerage Company

Correlation of Zone Settling Velocity with MLSS & SVI

Correlation of V_i and MLSS based on work and studies by Daigger 1993 and Wahlberg, 1995

$Ln(V_i) =$
$1.87 - (0.1646 + 0.001586xSVI)\ X_t$

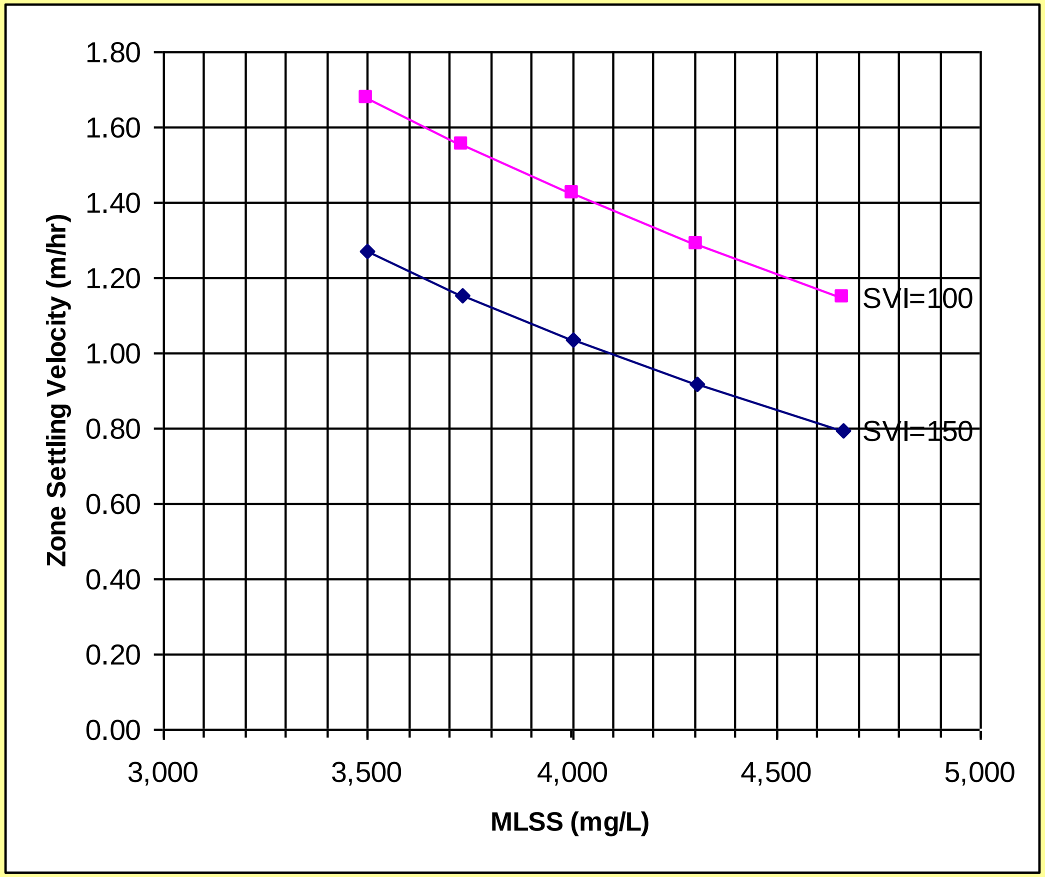
$V_{design} = Vi / (SF=1.25)$

where:

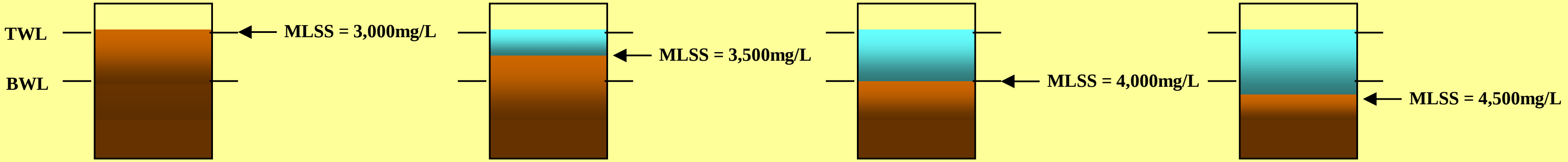
V_i = Zone settling velocity or interfacial settling velocity (m/hr)

SVI = Sludge Volume Index, (mL/g)

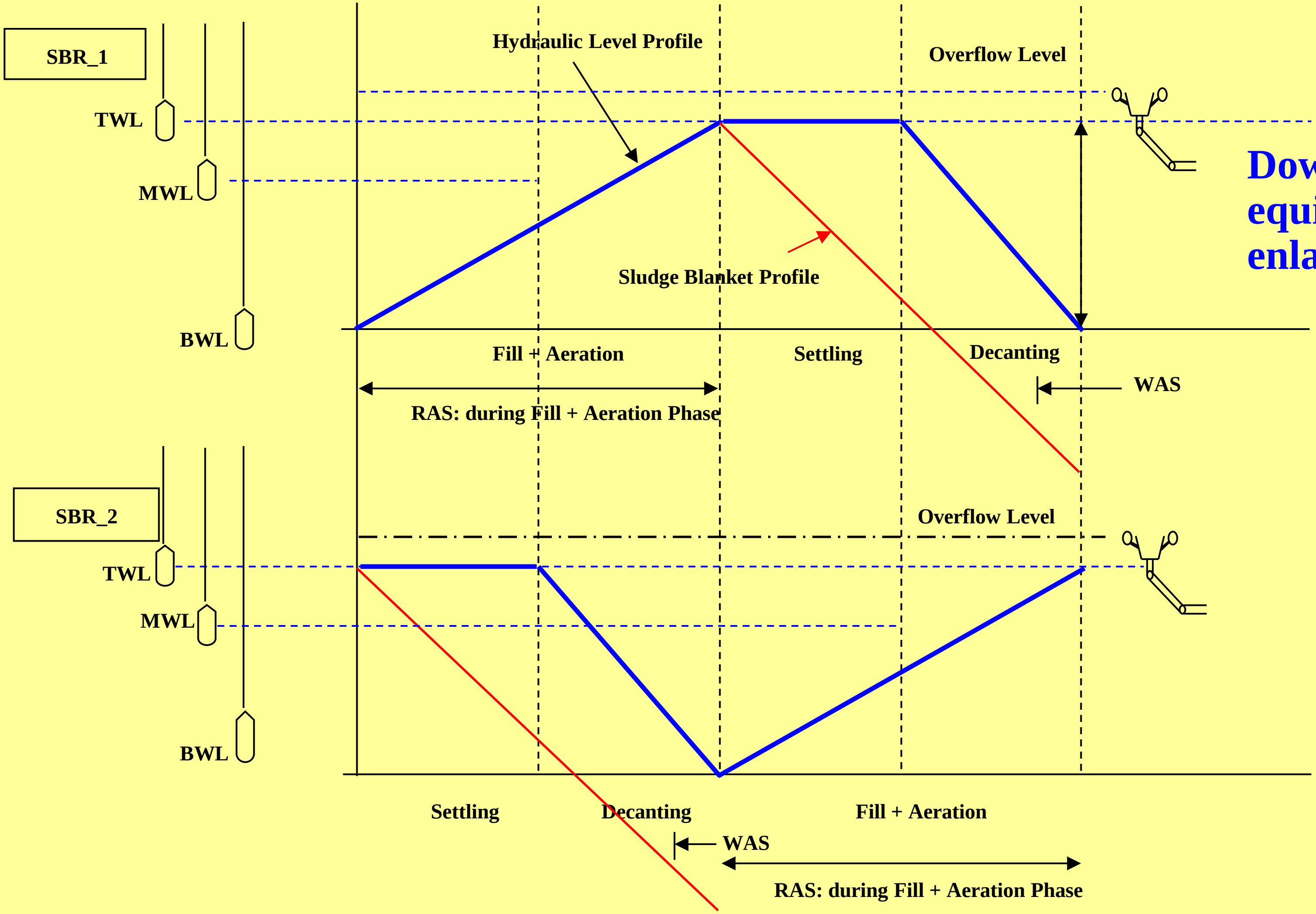
X_t = MLSS concentration, (g/L)



MLSS at TWL = 3,000 mg/L

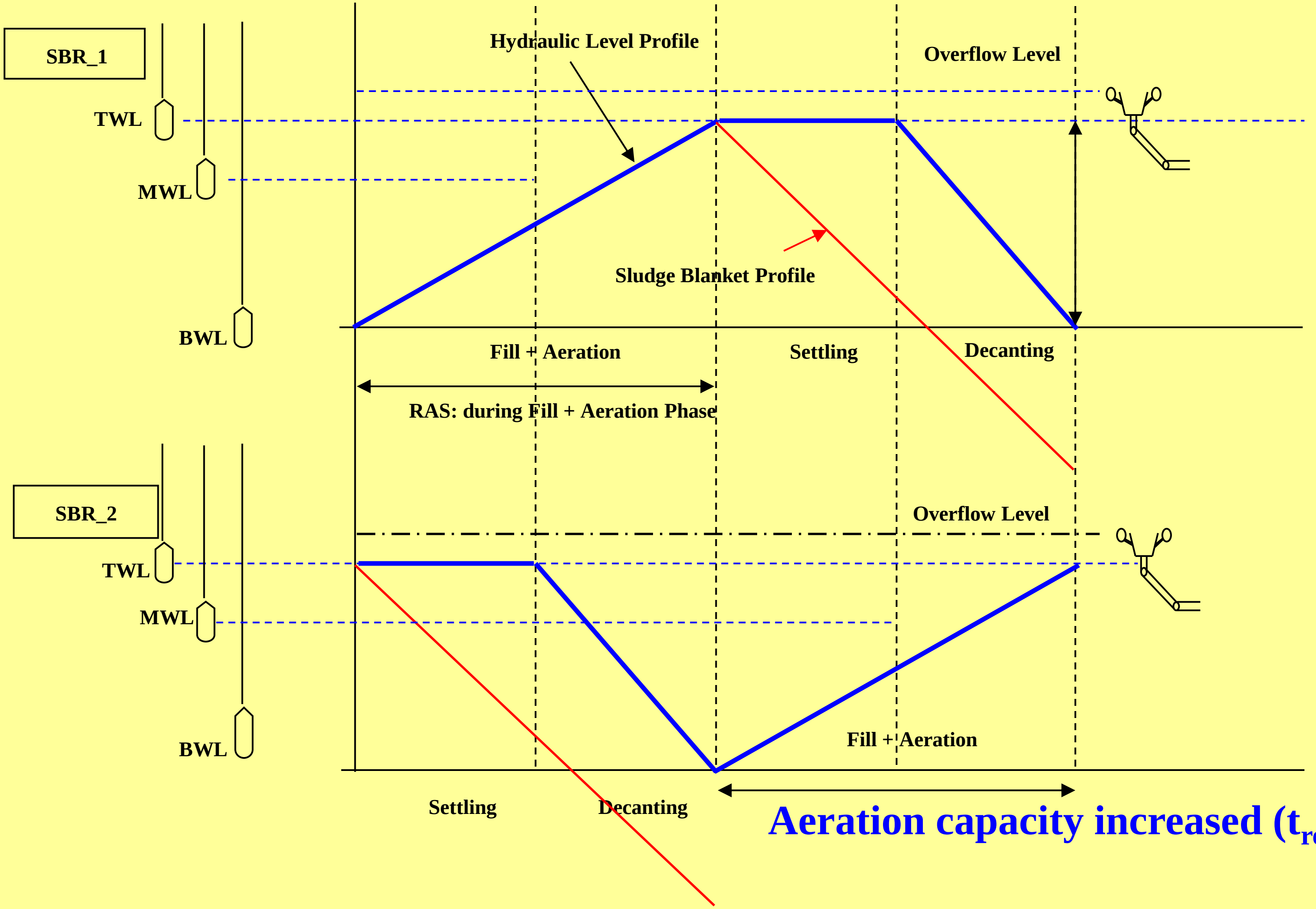


SBR Cycle: Hydraulic & Sludge Profile



Down stream equipment sizing enlarged

SBR Cycle: Hydraulic & Sludge Profile

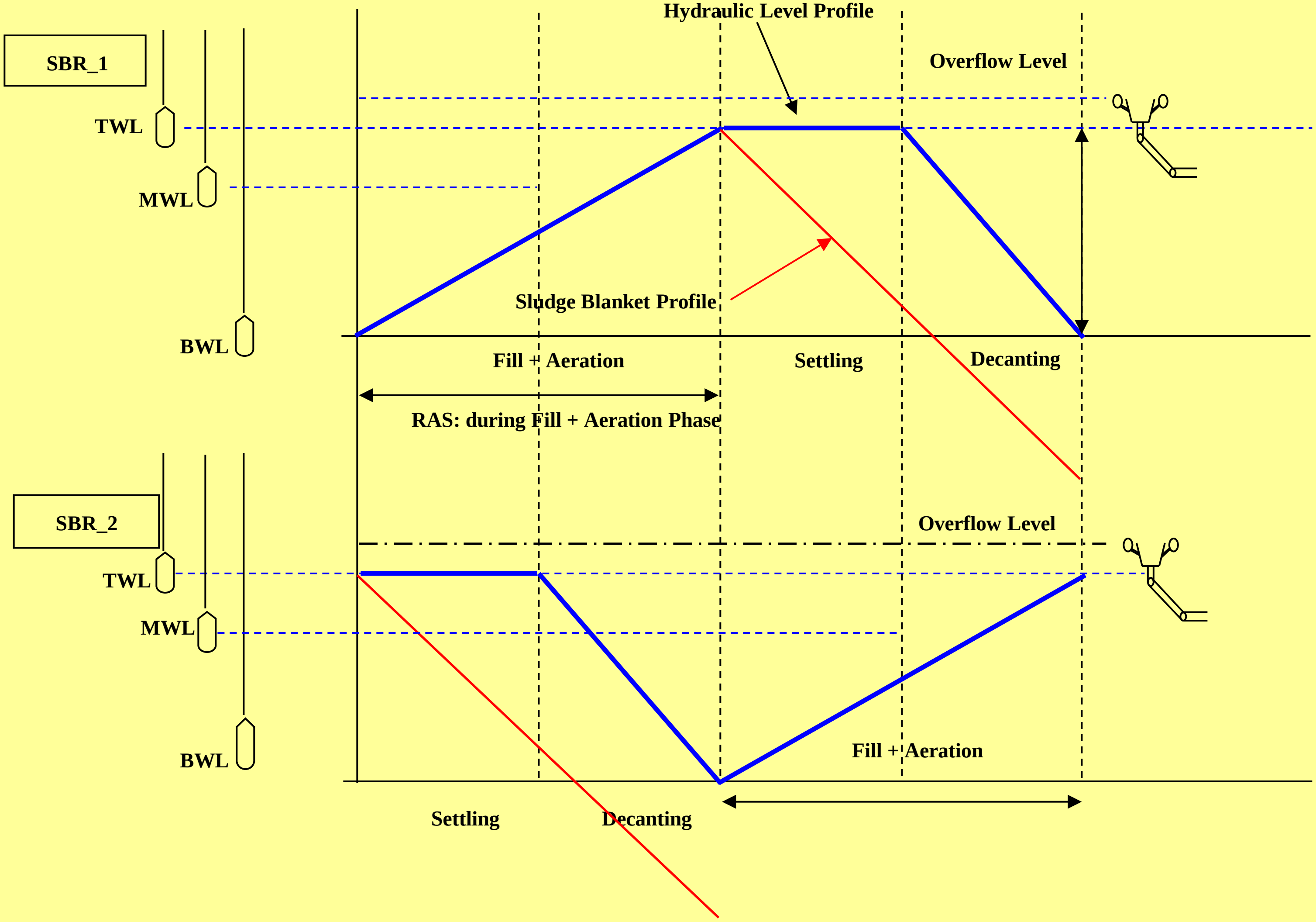


Aeration capacity increased (t_{react} / t_{cycle} <1)

SBR Cycle: Hydraulic & Sludge Profile

N_{cycle} **(cycle/day)= 24(hr/day) /** Σt_{cycle} **(hr/cycle)**

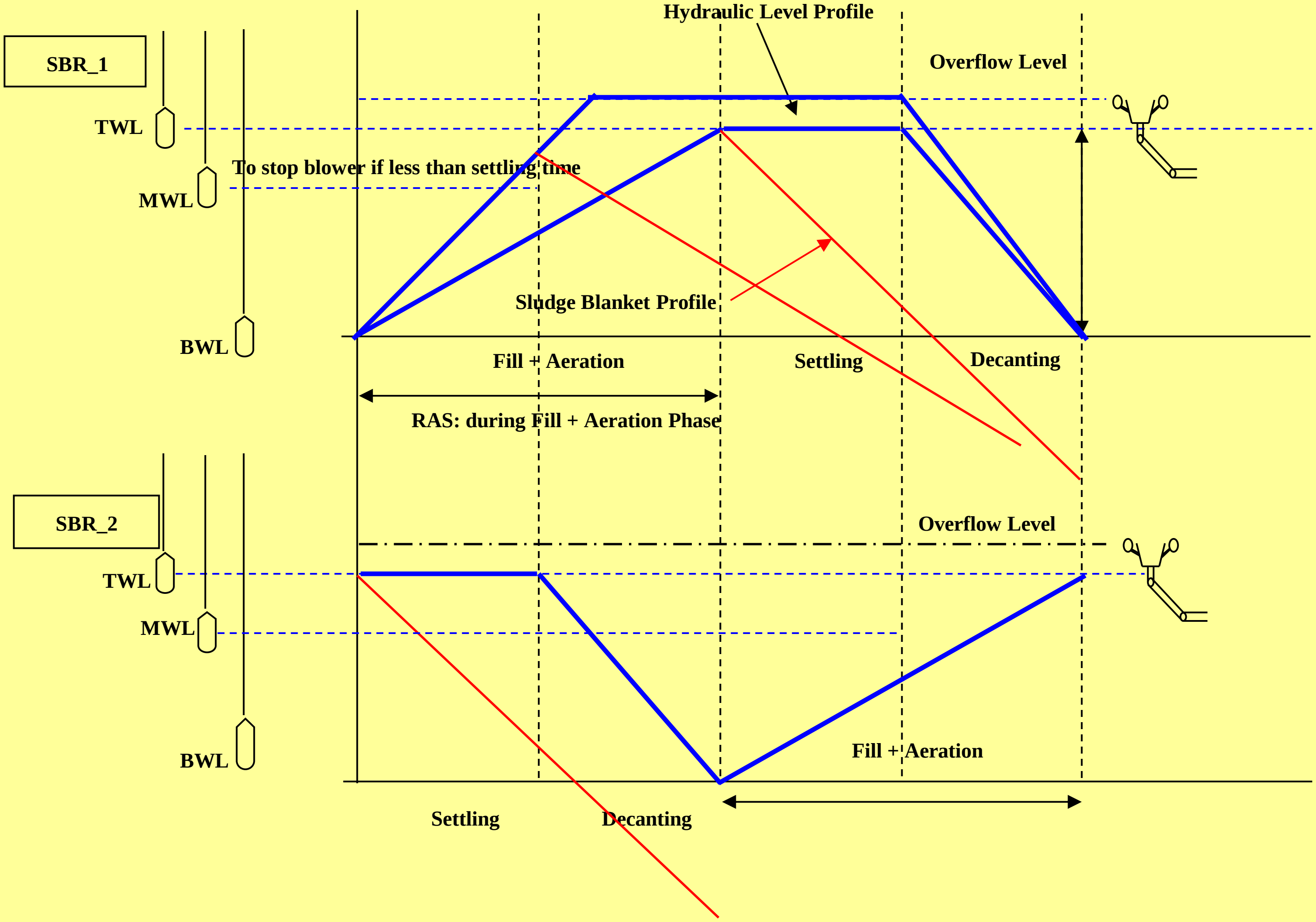
Preferably unique round number for each SBR Tank



SBR Cycle: Hydraulic & Sludge Profile

IndahWater
Syarikat Pembetungan Nasional Anda
Your National Sewerage Company

High Flow: Need to stop aeration: allow settling earlier



Outline of Contents

IndahWater Syarikat Pembetungan Nasional Anda
Your National Sewerage Company

- ☑ **Overview of SBR System**
- ☑ **Design Considerations for SBR System**
- ☐ **Recommended design parameters**
- ☐ **Advantage / Disadvantage of SBR**
- ☐ **Variation of SBR Systems**

Recommended Design Parameters

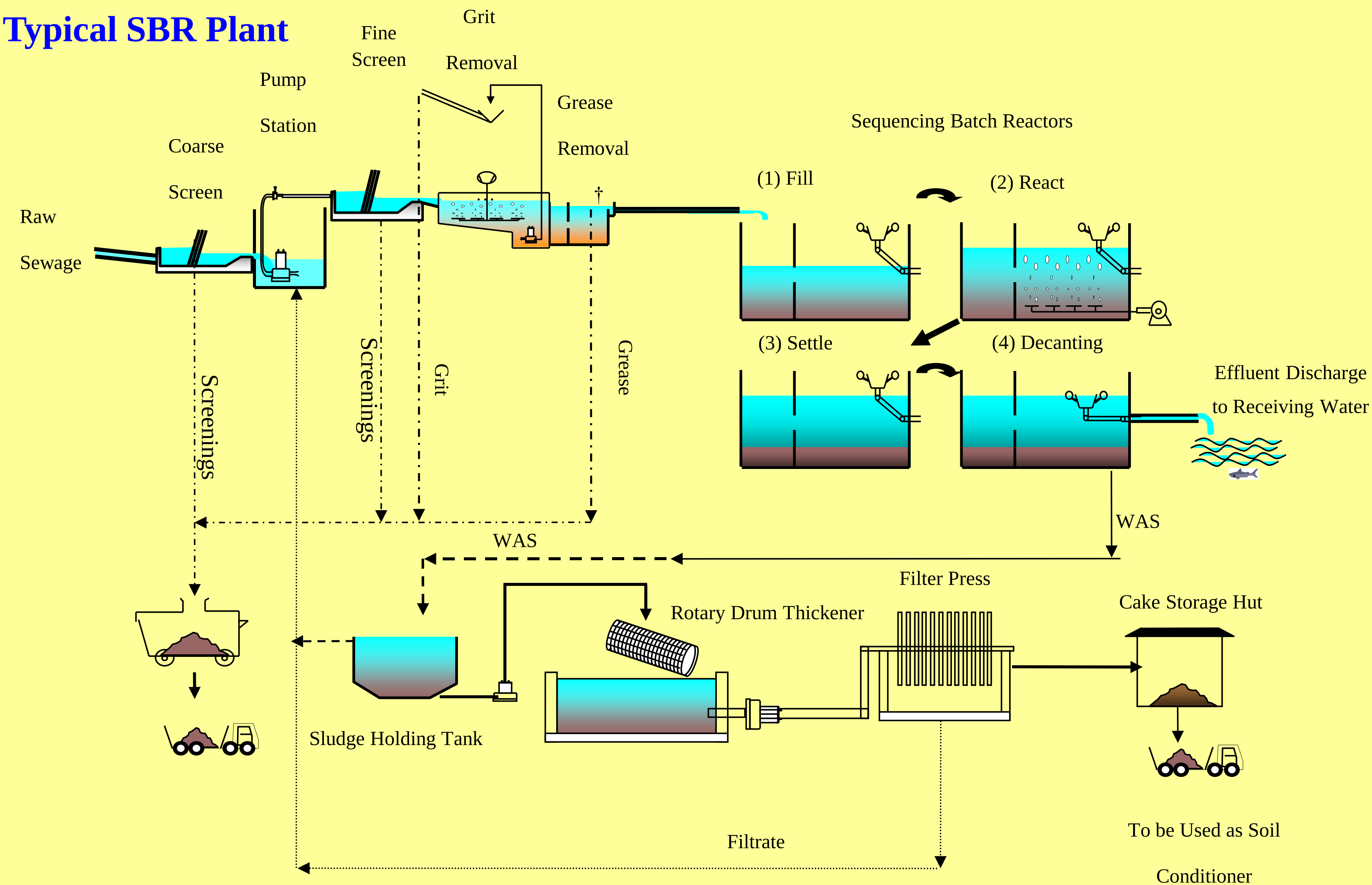
Indah Water
Syarikat Pembetungan Nasional Anda
Your National Sewerage Company

Parameter	Unit	Continuous Fill and Intermittently Decant	Intermittently Fill and Intermittently Decant
No. of Reactors	Unit	Minimum 2	Minimum 2
Hydraulic retention time at Qavg (at average water level	hr	18 – 24	18 – 24
F/M Ratio	d^{-1}	0.05 – 0.08	0.05 – 0.30
Sludge Age	D	20 – 30	10 – 30
Sludge Yield	kg sludge/ kg Load	0.75	0.75
MLSS (End of Decant)	mg/L	3,000 – 4,500	3,000 – 5,000
Cycle Time	Hr	4 – 8	4 – 8
Oxygen Required DO (Reactor) DO (Effluent)	 mg/L mg/L	 0 ~ 6.5 2.0	 0 ~ 6.5 2.0
Minimum Settling Time (before start of decant)	Hr	> 0.6 for decant from TWL downward > 1.0 for fixed points decant	> 0.6 for decant from TWL downward > 1.0 for fixed points decant
Decant Time	Hr	≥ 1.0	≥ 1.0
Decant Depth	M	Max 1.0 (surface decant only)	max 1.5 (surface decant only)
Decant Volume	%	Not more than 25% of volume of Biological Reactor at TWL	Not more than 30% of volume of Biological Reactor at TWL
Decanting Device Loading Rate*	$m^3/m/hr$	≤ 20 for decant from TWL & if SOR(decant) <20 $m^3/m^2.d$ ≤ 15 for decant from TWL & if SOR(decant) <30 $m^3/m^2.d$ ≤ 10 for fixed points decant regardless of SOR	≤ 20 for decant TWL & if SOR(decant) <20 $m^3/m^2.d$ ≤ 15 for decant from TWL & if SOR(decant) <30 $m^3/m^2.d$ ≤ 10 for fixed points decant regardless of SOR
WAS	Kg Sludge/d	$WAS = \frac{\text{Total Solids in System}}{\text{Sludge Age}}$	$WAS = \frac{\text{Total Solids in System}}{\text{Sludge Age}}$
Fill Volume	m^3	$V_{fill} = (Q_P\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no EQ) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by EQ)	$V_{fill} = (Q_P\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no EQ) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by EQ)

SBR System

Indah Water — Syarikat Pembetungan Nasional Anda — Your National Sewerage Company

Typical SBR Plant



SBR System

Construction Cost

Year (Construction)	**Unit**	2002	2000	2000	2001
Size	(in PE)	**50,000**	**20,000**	**15,500**	**12,000**
Flow	(m^3/d)	11,250	4,500	3,488	2,700
Total Cost	(RM in Million)	**4.80**	**3.40**	**3.52**	**2.36**
C&S Cost (exclude Pilling)	(RM in Million)	2.47	1.64	1.72	0.94
M&E Cost	(RM in Million)	2.33	1.76	1.80	1.42
Cost / PE	(RM/PE)	**96**	**170**	**227**	**197**
Cost / m^3	(RM/m^3)	207	391	516	526

Electricity Cost

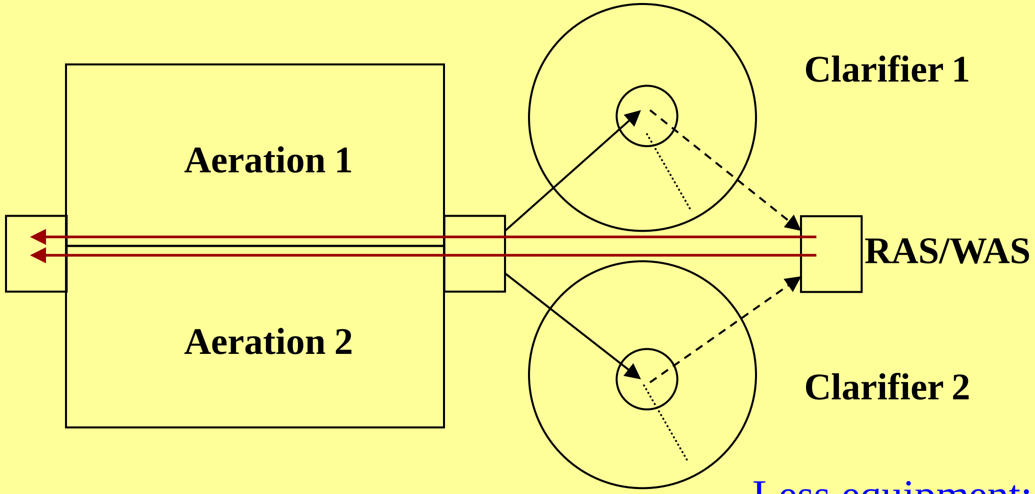
Size	(in PE)	<5,000	<10,000	<20,000	<50,000
Electricity	(RM/PE/yr)	8.73	3.03	1.48	1.66

Outline of Contents

- ☑ **Overview of SBR System**
- ☑ **Design Considerations for SBR System**
- ☑ **Recommended design parameters**
- ☐ **Advantage / Disadvantage of SBR**
- ☐ **Variation of SBR Systems**

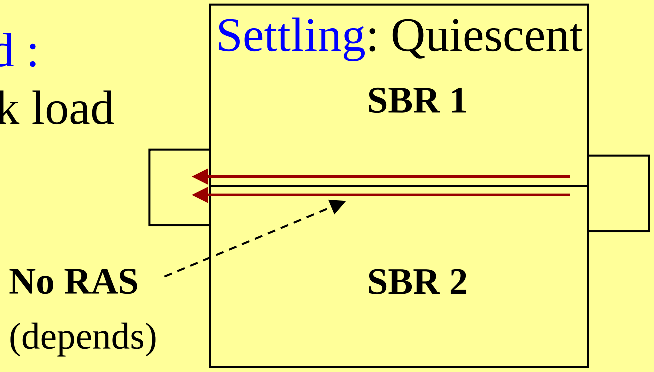
SBR advantages

Smaller land area requirements:
Eliminated clarifiers



Less equipment: No scrapper

Batch feed :
Less shock load



Multi-Process operation in one tank:

Nitrification / Denitrification

Simultaneous phosphorous removal

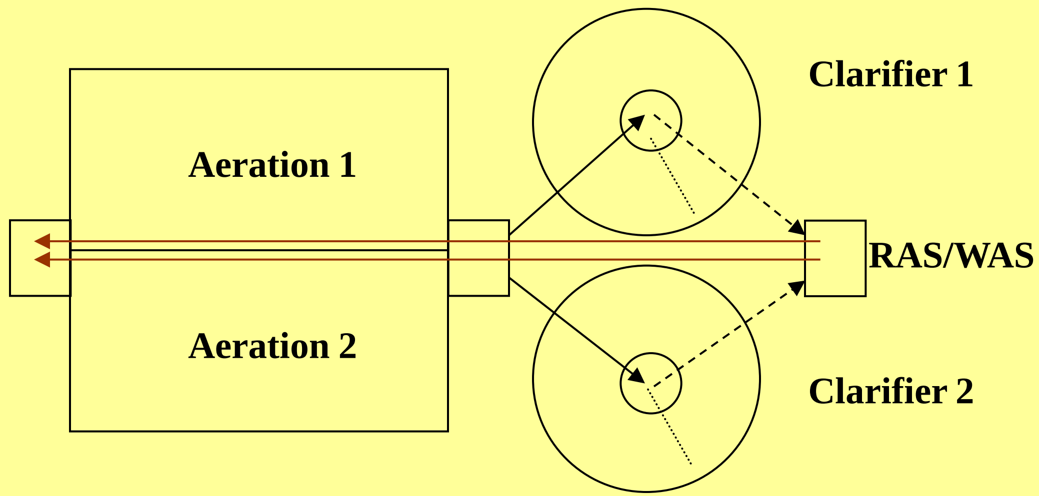
PLC control:

Fully automated process

Process modification simply change process timing

SBR System

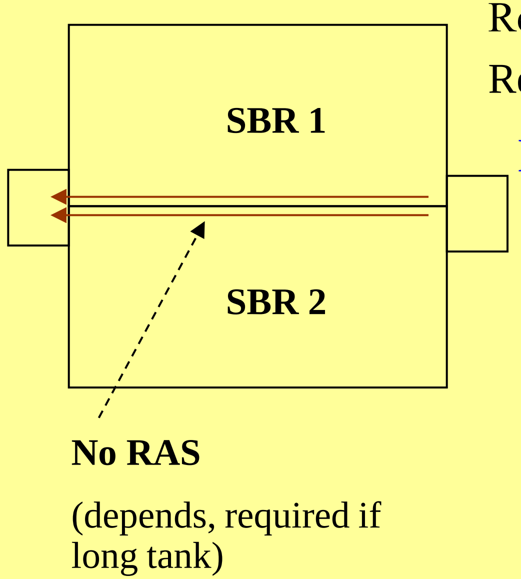
SBR disadvantages



When SBR equipment failure:

Repair “urgent” - no “by-pass”

Replacement aeration devices - more complicated



Downstream equipment bigger:

2 hours of feed is released in 1 hour or less

Operator PLC control:

– panic when “faults”;
– blur on batch processes;
– Technician - re-trained PLC literate;

Outline of Contents

IndahWater Syarikat Pembetungan Nasional Anda
Your National Sewerage Company

- ☑ **Overview of SBR System**
- ☑ **Design Considerations for SBR System**
- ☑ **Recommended design parameters**
- ☑ **Advantage / Disadvantage of SBR**
- ☐ **Variation of SBR Systems**

Emergence of SBR Systems

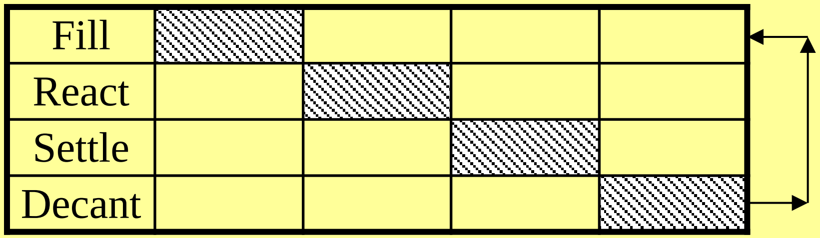
SBR (Sequencing Batch Reactor) has emerged as <u>an alternative</u> to continuous flow activated sludge systems with following reasons:-

- Advent of PLC;
- Small land area requirements;
- Less unit processes; less capital & O&M cost;
- Less labor: automated control by PLC's;
- Batch: equalized variation and shock load (hydraulic & organic);
- Improve effluent quality: quiescent settling;
- Many parameters removal in a batch processes;

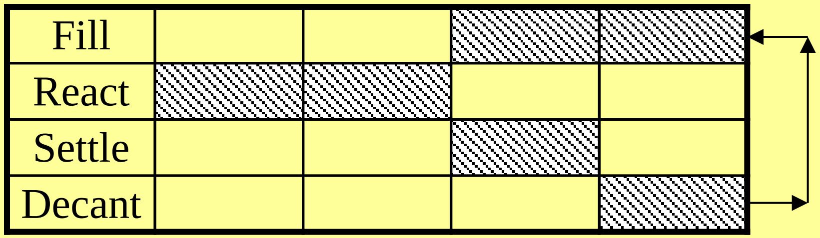
Since then, variation from the original fill and draw SBR system…..

Variation of SBR Designs

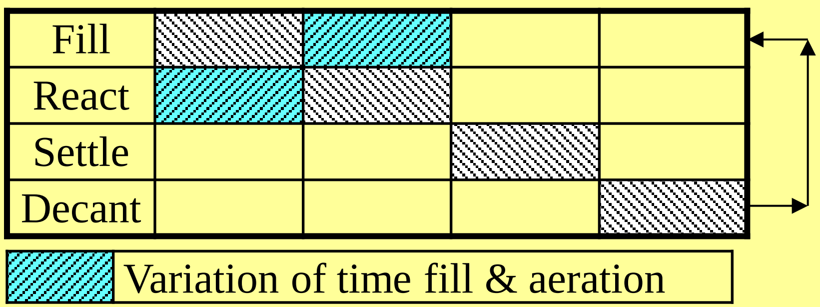
SBR: Anoxic / Anaerobic / Mixed Fill



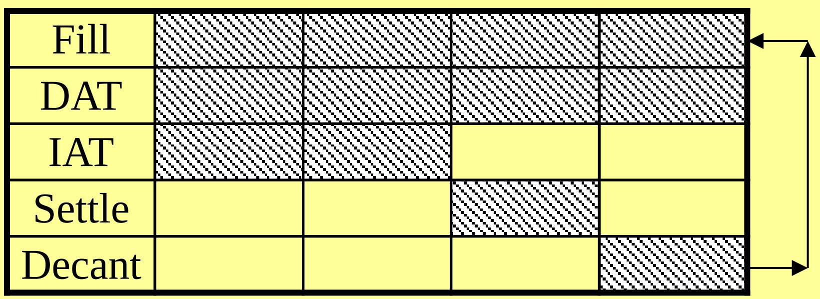
SBR: Settle-Decant Fill



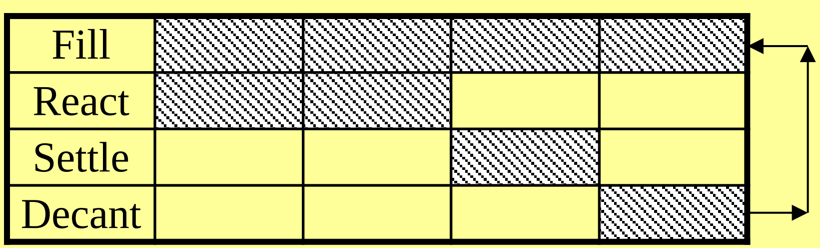
SBR: Fill-Aerate



SBR: Intermittently Decanted EA



SBR: Continuous Fill



Note:

Some with RAS or internal recycle from back to inlet zone to improve F_o/X_o

Other Variations

Decanter:-

– Surface skimming decanter (arm drive or floating);

– Siphon lock fixed position decanter;

– Fixed points actuator controlled decant valves;

– Floating weir decanter

Other Variations

Aeration Devices: -

- Diffuser system

  (coarse or fine in tube or disc diffusers);

- Jet aerators, ejectors, or submersible aerators;

- “Sinkair” aerator, and floating aerators.

Other Variations

PLC system: -

- Different brand and different programming languages used;

- Hand wire with timer;

Outline of Contents

- ☑ **Overview of SBR System**
- ☑ **Design Considerations for SBR System**
- ☑ **Recommended design parameters**
- ☑ **Advantage / Disadvantage of SBR**
- ☑ **Variation of SBR Systems**

Summary of SBR Systems

Reviewed of SBR System:

- Looked at emergence of SBR: advent of PLC & controllable components & its beneficial uses;
- Described SBR process & its cycle charts;
- Identified various design considerations;
- Provided recommended design parameters;
- Evaluated benefits and draw backs of SBR system;
- Outlined variation of SBR by processes and by equipment;

In summary:

- SBR alternatives to continuous flow system;
- Variation in processes & equipment emerges must be evaluated;
- Its transient design parameters must be adopted carefully;
- Advantages and disadvantages of the system must be reviewed in an overall view dependence on types of application, operations and control requirement.