

# USE OF AN SRT CALCULATOR TO ASSIST WITH WASTEWATER TREATMENT PLANT OPERATION



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# USE OF AN SRT CALCULATOR TO ASSIST WITH WASTEWATER TREATMENT PLANT OPERATION

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## ABSTRACT

The Solids Retention Time (SRT) is an important operating parameter of an activated sludge wastewater treatment plant, as it gives an indication of the plant's biological state. An overly long SRT is associated with extra aeration demand, and can limit settling capacity in clarifiers and Sequential Batch Reactors (SBRs). There is also a relationship between SRT, temperature, and the ability of the plant to nitrify. The Mixed Liquor Suspended Solids (MLSS) concentration is frequently used instead of SRT as the basis for plant operation as it is simple to measure and is generally part of regular plant monitoring. Often MLSS gives a reasonable approximation of SRT, however this convergence can drift over time with changing influent loads and chemical dosing. SRT cannot be measured directly as it is a function of the influent loads, chemical dosing, sludge wasting rates, and solids capture efficiencies.

A spreadsheet-based SRT calculator was developed for the Colac Water Reclamation Plant (WRP) to account for all these factors. The aim was to produce a simple tool that was easy to use and provided operators with information on the current sludge age, the wasting set points required to reach a targeted sludge age, and also provided a direct correlation between the MLSS observed within the reactors and the SRT. This paper discusses the theory behind the development of the SRT calculator, how it was customised to the Colac WRP, and the experiences of the operator using it in actual operation.

## 1.0 INTRODUCTION

Solids Retention Time (SRT), and Mixed Liquor Suspended Solids (MLSS) are two parameters commonly used to help control wastewater treatment plant (WWTP) operation. The SRT, also called 'sludge age', is a particularly important parameter in activated sludge processes as it gives an indication of the plant's biological state. The biological state of the plant affects:

- Carbon (BOD) removal;
- Nitrification (conversion of ammonia to nitrite/nitrate);
- Condition of the biomass (and therefore settlability).

Optimisation of the SRT allows the operator to define the most efficient point of operation to achieve the treatment goals of the plant. These goals could include: minimise aeration, achieve advanced biological nutrient removal, maximise settler (clarifier etc) capacity, maintain tolerance to variable influent and toxic shocks, or minimise sludge production. Another reason to know the SRT of the plant is to assess the effect of any changes in the plant. Often it will take at least one sludge age to see noticeable effects of any process changes or improvements.

The SRT can be controlled by adjusting the volume of activated sludge wasted from the system (WAS). However the SRT of a system is not straightforward to measure, as it is related to influent loads, chemical dosing, sludge wasting rates, and solids capture efficiencies in thickeners, belt presses, and centrifuges. The solids capture efficiencies are often not well known on a site.

The Mixed Liquor Suspended Solids (MLSS) concentration is frequently used instead of SRT as the basis for plant operation as it is simple to measure and is generally part of regular plant monitoring. MLSS measurement is as straightforward as taking a sample of the mixed liquor and performing a solids test on it.

Often, instead of targeting an SRT, WWTP operators and managers will target a particular MLSS concentration in their reactors. This can work very well, as the target MLSS is based on observed performance of the plant, and also the MLSS has a relationship with SRT, for a given loading. The WAS volume is adjusted accordingly – if the MLSS is higher than the target, the WAS is increased. However if the influent load drifts over time, and the MLSS remains constant, the SRT will change. Or temperature changes could mean that the SRT may seasonally go outside of the optimal operating range, causing or preventing nitrification. A good way to infer this is that many plants notice a decrease in settlability due to the temperature changes in autumn or spring.

Focus on the MLSS concentration is useful for tracking plant operation, however the SRT is critical for setting the targets as it relates to biomass biology and therefore gives a fuller picture of what is going on in the plant than MLSS does. Even when SRT is targeted, the MLSS will still continue to be measured and monitored as it provides useful information, and as a cross reference to the SRT.

A spreadsheet could be used to make the process of calculating the SRT straight forward, so that SRT could be directly used for WWTP operation.

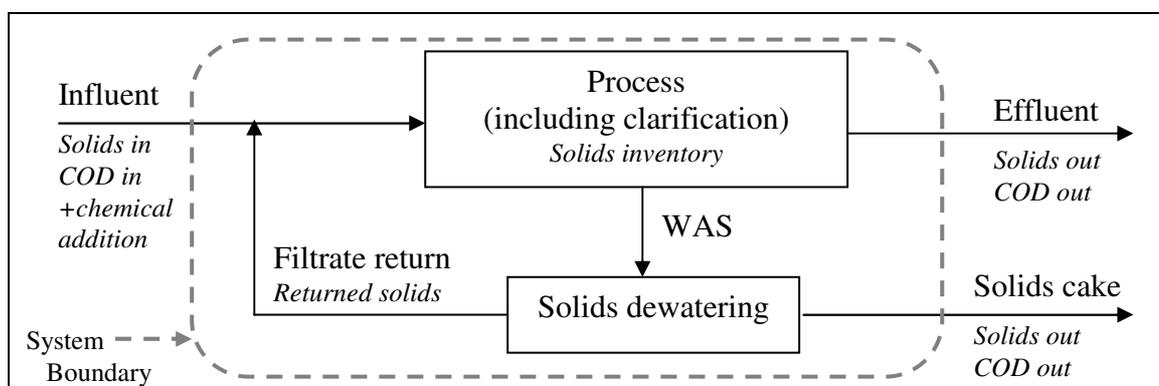
## 2.0 DISCUSSION

### 2.1 Measurement of SRT

Solids Retention Time (SRT) is defined as the average retention time of biomass in the system (see Equation 1). The usual units for SRT are days. Although the SRT for a treatment plant cannot be measured directly, it can be determined by undertaking a solids mass balance over the system.

$$\text{SRT (days)} = \text{total solids mass present in reactor} / \text{solids mass removal per day. (Eqn 1)}$$

Figure 1 shows the components of the solids mass balance.



**Figure 1:** *Process diagram: solids mass balance over an activated sludge system*

Note that the solids leaving the system are often in the form of the dewatered cake. It is important to note that some solids are returned to the system as part of the filtrate (or centrate, or supernatant) return from the dewatering process, and these solids should be accounted for in the solids balance.

The solids inventory in the process is made up of:

1. Solids entering in the influent, these will accumulate in the reactor over the sludge age:
  - a. Inert particulates (sand, grit etc), which are not measured as COD.
  - b. Undegradable particulate COD, which are solids that have a COD value but will not be broken down within the system.
2. Biomass grown on the incoming available degradable COD.
3. Biomass residue, also called endogenous residue.

Equation 1 gives the current SRT. But if the current SRT is outside of normal operating targets, how much activated sludge needs to be wasted to get to the desired SRT? Or if the influent load increases, how should wasting be adjusted to continue to maintain a consistent SRT?

A spreadsheet based calculation tool was developed to answer these day to day questions in a user-friendly way.

## **2.2 Colac SRT Calculator**

Colac Water Reclamation Plant (WRP) is located in Colac, 150kms south-west of Melbourne in Victoria. It is an SBR system which treats around 5ML/day of wastewater, comprising of both domestic waste and a significant industry load. A spreadsheet-based SRT calculator was developed to provide operators with information on:

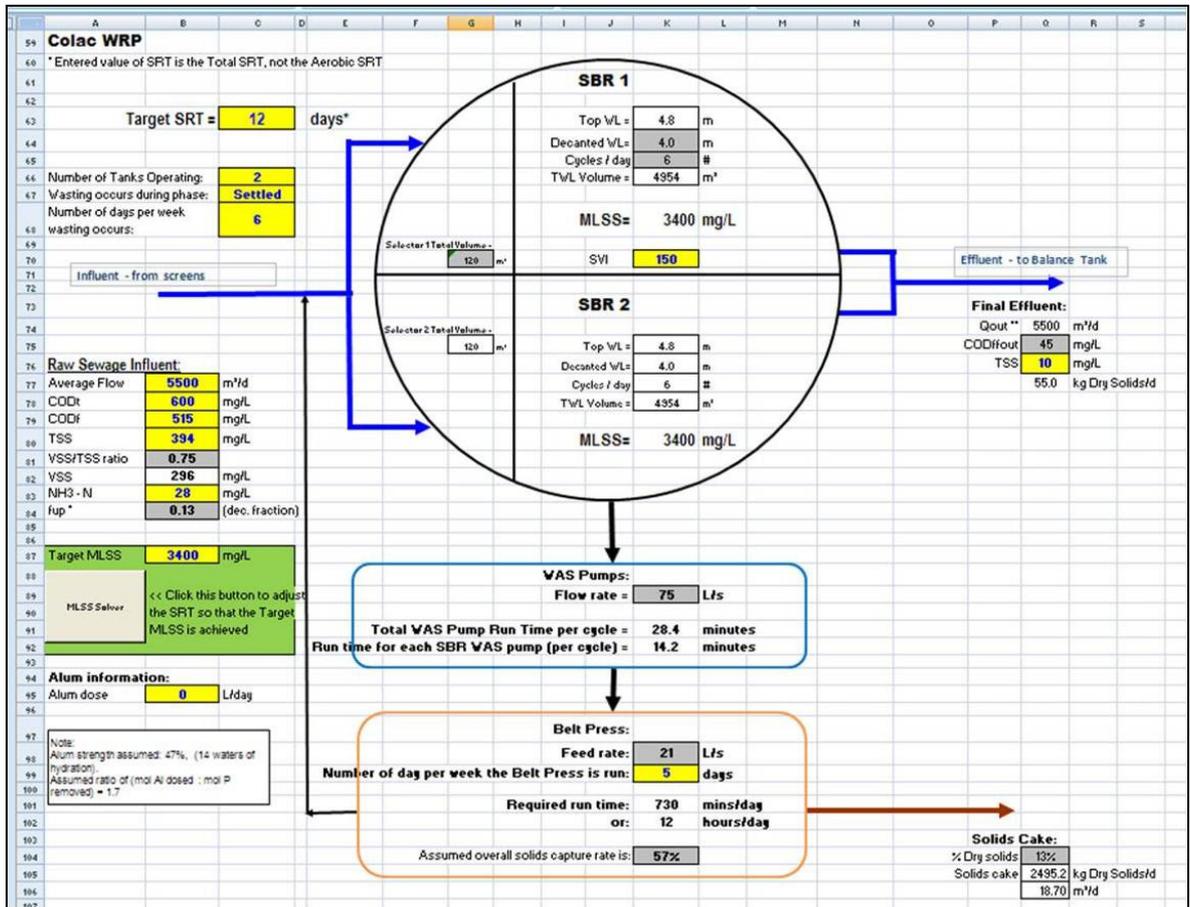
- the current sludge age,
- the wasting set points required to reach a targeted sludge age,
- a correlation between the MLSS observed within the reactors and the SRT.

The spreadsheet was designed to be a simple tool that would help the operators to maintain the plant within optimum operational boundaries.

## **2.3 Using the SRT Calculator**

The SRT calculation spreadsheet is presented in Figure 2. The target SRT is entered into the top left hand yellow box, and the spreadsheet will calculate the expected WAS pump run time and the required belt press run time. The MLSS concentration that could be expected at this SRT is shown inside the reactors.

Alternatively, a target MLSS can be entered in the green box area, and by clicking on the grey button inside the green box, the spreadsheet will calculate the SRT at that MLSS concentration.



**Figure 2:** A screen shot of the Colac WRP SRT Calculator

## 2.4 Inputs to the SRT calculator

- Target SRT.
- Target MLSS (alternative to target SRT).
- SBR dimensions and number of cycles per day.
- Operating set points: the number of tanks operating, whether wasting occurs during the settled or mixed phase, number of days per week that wasting occurs.
- Influent and effluent characteristics. The average values are used as the microbial population will grow to the average influent feed.
- Solids Volume Index (SVI) of the sludge.
- Chemical dosing. Chemicals such as Alum can affect the sludge production.

## 2.5 Outputs of the SRT calculator

- WAS pump run time.
- Belt press run time.
- Volume of solids produced.

## 2.6 Setting a Target SRT

Two methods that could be used to determine the best SRT to aim for are outlined below. A combination of both methods might be the most useful; such as starting with operational experience, then using the theoretical requirements as a sense check.

1. **Operational experience:** This is often how the target MLSS is set. For example –
  - a. “The plant works best at an MLSS of 4500-5000mg/L.”
  - b. “The clarifiers can’t handle an MLSS above 8500mg/L.”
  - c. “At less than 3000mg/L the sludge tends to not settle properly.”
 So the target MLSS could be entered into the calculator to find the SRT at this MLSS and then from that point onwards the SRT is targeted instead of the MLSS.
  
2. **Theoretical requirements:** Determine the target SRT by what needs to be achieved in the plant. For example –
  - a. “We want BOD removal only, so the SRT should be set below 8 days in winter and 4 days in summer.” (It is also recommended to check the nitrite and nitrate to ensure nitrification is not occurring).
  - b. “The target SRT for nitrogen removal via nitrification at our plant is greater than 15 days in winter or 10 days in summer.” (Check via ammonia concentration).
  - c. “The plant tends to get some toxic influent, so we want a mature sludge that has time to adjust.”
  - d. “We are constrained by the amount of solids we can process, so sludge production needs to be minimised as much as possible – SRT of 30 days.”
  - e. “We want to minimise filamentous bacteria in our process so a SRT of 15-20 days is our aim.”

## 2.7 Customising the SRT Calculator to the Colac WRP

### 1. Matching to process configuration

The SRT calculator was set up to mirror the process at Colac – i.e. two SBR basins with a selector zone. WAS is pumped to a holding tank before being fed to the belt press, so although the WAS pump run time is calculated, the belt press operating hours are more important for Colac to determine the actual solids wasted.

### 2. Training Workshop and calibration

A workshop was held onsite to calibrate the calculator and allow the operator get familiar with how it works. The units used in the calculator were checked against the units used on site, for example the WAS pump is measured in L/s. The inputs were entered into the spreadsheet. The spreadsheet calculations were also compared against what was currently observed on site to verify it was giving reasonable predictions. A belt press solids capture efficiency study was undertaken and found that the belt press solids capture was 57%.

## 2.8 Experience of Operators using the SRT Calculator in actual operation.

The Senior Operator at the Colac Water Reclamation Plant, uses the SRT calculator once a week, on a Monday, to set the belt press run times for the week.

The operator undertakes a quick check on the influent parameters such as flow and concentration, which usually stay reasonably constant. This check is simply a rough mental estimate – no verification is undertaken. He then enters a target MLSS (usually around 3200mg/L). The spreadsheet calculates the SRT and belt press run times for that MLSS. The operator then sets the belt press run time in the SCADA system. The belt press is turned on and off automatically by the control system. The target MLSS is set by the WRP management, as MLSS has always been the default parameter and it can be compared to historical data.

It would be useful to set targets for SRT as an alternative to MLSS. At an MLSS of 3200mg/L, the SRT for Colac WRP was 18 days. At Colac, the MLSS often doesn't quite reach the target of 3200mg/L over the week, which may be due to variation in the influent loads compared to the average, WAS pump inaccuracies, the calculator may need further calibration, or it simply takes about one sludge age to reach equilibrium.

Before getting the SRT calculator, the operator would adjust the wasting based on intuition and experience with the plant, and the current MLSS. The MLSS results are more consistent as a result of having the calculator.

While MLSS is a sound operating target when there are few changes to the process or influent, targeting an SRT becomes most useful when there are changes in the influent or process, or when the SRT will have a big impact on the system (such as preventing nitrification, poor sludge settling, or reducing aeration costs). At Colac, the production volumes at nearby industrial sites have a significant impact on the treatment plant, so when there are changes in these volumes, the SRT calculator could be used to adjust wasting to ensure that a consistent SRT is maintained.

## **2.9 Future Improvements to the Calculator**

### **Operator suggestions:**

- It would be useful to have the wasting required to produce a step change in the system – instead of slowly reaching a new equilibrium by wasting at the new rate, how much wasting is required up front to produce an instant change in the MLSS/SRT. However this is not recommended – all changes should be completed slowly over an extended period
- Show the amount of sludge wasted - the total WAS volume. The spreadsheet already calculates this but doesn't display it, so this is a simple improvement to make.

### **AWT's next step**

Having the SRT calculator integrated into the monitoring and control system. This would be a web-based application, which would automatically average the influent parameters over say the last month, and the current MLSS and wasting times to determine the current SRT, and also suggest the wasting times going forward to reach the target SRT. The operator wouldn't need to figure out whether the daily fluctuations in influent are still within the average, or whether there is a drift upwards or downwards.

## **3.0 CONCLUSION**

An SRT calculator was developed for Colac WRP, and used by the operator to target an MLSS concentration. Although the spreadsheet was designed to calculate SRT, in practice it is a useful way to link the SRT and MLSS. Previously the SRT was difficult to use for plant operation, however now that this tool is available, it would be possible to set a target SRT for plant operation instead of MLSS.

## **4.0 ACKNOWLEDGEMENTS**

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