2.2.3 Modeling of D6 Sewer System (Gold Coast Water)

D6 sewer system of Gold Coast Water was used to validate the oxygen related components of the sewer model as both the sulfide and oxygen data was available. Sulfide and DO concentrations measured at 750 m from the wet-well were used for this purpose.

Following model parameters were used:

- kH_2S=7.5 g/m^2-day
- Biofilm oxygen consumption rate = 16 g O_2/m^2-day

Biofilm oxygen consumption rate used in the simulation was taken from the results of the laboratory study on oxygen injection. A typical oxygen consumption rate (40 mg/L-h) was converted to aerial oxygen consumption rate (16 g O_2/m_2-day) taking into account the A/V ratio of the reactor.

The hydraulic retention time (HRT) has a significant impact on sulfide generation, and also in oxygen consumption when oxygen is injected. The variation in HRT as a result of the change in flow rate was calculated and the results are presented in Figure 15. The HRT typically varied from 0.8 hours to 3.5 hours with an average of 1.8 hours.

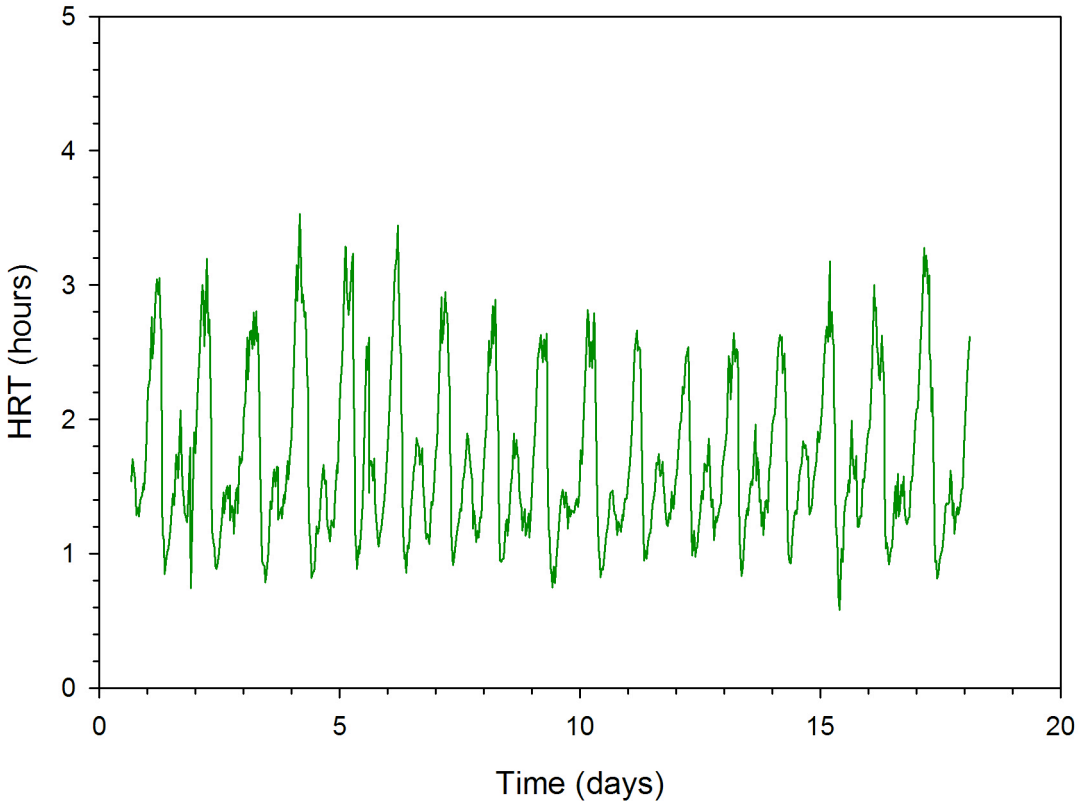

Figure 15. Variation in HRT (in 735 m length of D6)

2.2.3.1 Case I: No Oxygen Injection

Simulation of D6 system was carried out for a period when oxygen was not injected. This was aimed to validate the model parameters, especially ones related to sulfide generation.

Available Data

Following data was available:

1. Flow data from 16/05/2007 to 22/05/2007. All the negative flows and flow <25 L/s and > 150 L/s were considered as outliers and were ignored, 0.00 hours is 16/05/2007 Midnight.
2. Wetwell data:
    a. pH, DO and temperature data taken from the probe measurement results (16/05/2007 to 22/05/2007).

b. Sulfide data for the above period was not consistent. Measured data for a period from 23/05/2007 to 29/05/2007 (one week later) was taken as feed data.
c. There is an indication from few grab sample measurements that the sulfide concentration at 750 m varied considerably. However, no data was available for feed concentration. An average sulfate concentration of 56 mg S/L (average of the data obtained with IC measurement) was therefore assumed.
d. All other parameter concentrations were taken as typical values from previous modeling work.

3. Data for 735 m:
    a. Dissolved sulfide data taken from SCAN measurements.
    b. pH, DO, and temperature data taken from probe measurements.

The variation of feed H_2S concentration as measured by S::CAN sensor is presented in Figure 16. The feed sulfide concentration varied from 0 to 8 mg S/L, and a clear diurnal pattern was observed. The variation in the sulfide concentration was possibly due to infiltration of sea water resulting in high sulfate concentration and hence high sulfide generation.

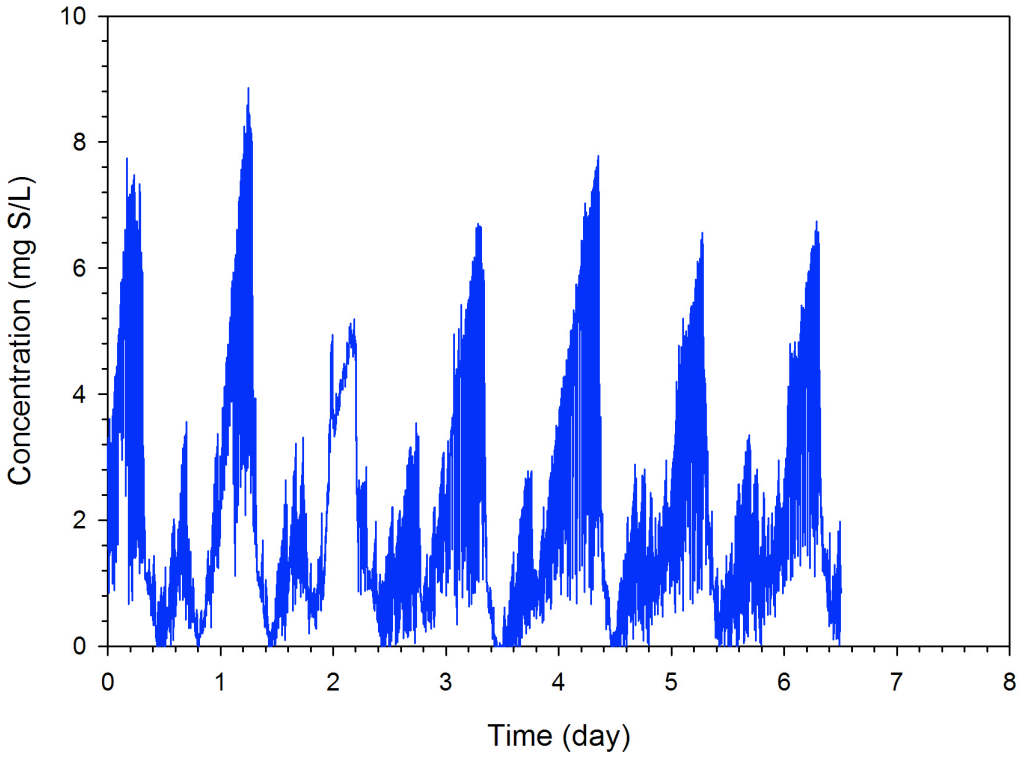

Figure 16. Variation of feed sulfide concentration (23/05/2007 to 29/05/2007)

Simulation Results

Simulation was carried out for a period of 6 days starting from 12:00 AM on 16/05/2007. The results of simulation are shown in Figure 17. As shown in the figure, the model was able to predict the changes in sulfide concentration reasonably well. The trend was well matched. However, a time shift is observed in the profile, the reason for which is unknown at this stage. Through this fit of the data, validity of the parameter values such as k_{H2S} is confirmed.

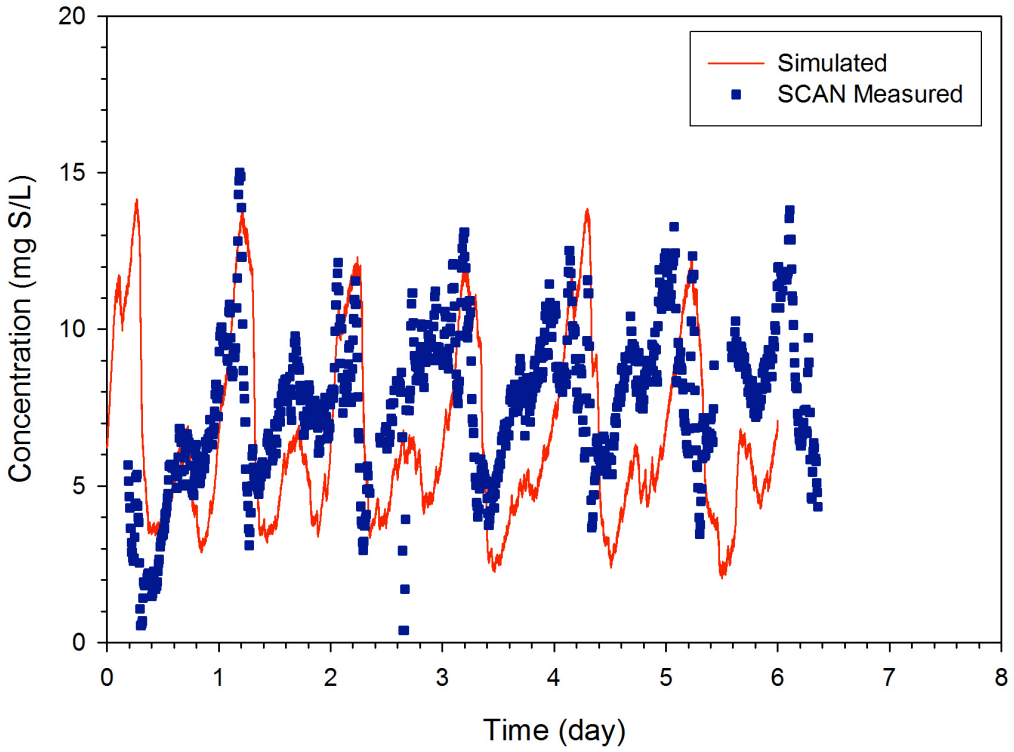

Figure 17. Comparison of simulation results with measured H_2S concentration

2.2.3.2 Case II: With Oxygen Injection

Available Data

Following data was available for this case:

1. Flow data from 7/06/2007 to 25/06/2007. All the negative flows and flow <25 L/s and > 150 L/s were considered as outliers and were ignored. No flow data available from 0-0.55 days.
2. Wetwell data:
    a. pH, DO and temperature data taken from the probe measurement results (16/05/2007 to 22/05/2007).
    b. Sulfide data for the above period was not available. Data for 17/05/2007 to 12/06/2007 was taken as feed data. It was assumed that the feed concentration didn't change during this period of time. One week data was available. This was used to reproduce three more weeks data.
    c. There is an indication from few grab sample measurements that the sulfide concentration at 750 m varied considerably. However, no data was

available for feed concentration. An average sulfate concentration of 56 mg S/L (average of the data obtained with IC measurement) was therefore assumed.

d. All other parameter concentrations were taken as typical values from previous modelling work.

3. Data for 750 m:
    a. Dissolved sulfide data taken from SCAN measurements. The SCAN measured total sulfide concentrations are based on the average pH values. As such, the variation in pH was not accounted for.
    b. pH, DO, and temperature data taken from probe measurements.

Simulation Results

Simulation was carried out for a period of 18 days starting from 12:00 AM on 17/05/2007. This covered the periods of both with oxygen injection and without it. The parameters validated in previous simulation (case without oxygen injection) were used.

A comparison of simulation and measured H_2S concentrations is shown in Figure 18, while that of simulated and measured DO concentrations is shown in Figure 19. As the comparison shows, the model was able to predict accurately the changes in both DO and H_2S concentrations. A very good fit was observed between the measured and simulated DO levels and same is true for H_2S concentration. The good fit observed validates: (1) the sulfide oxidation model (both biological and chemical); and also (2) the parameters related to the oxidation model (biofilm oxygen consumption rate etc.).

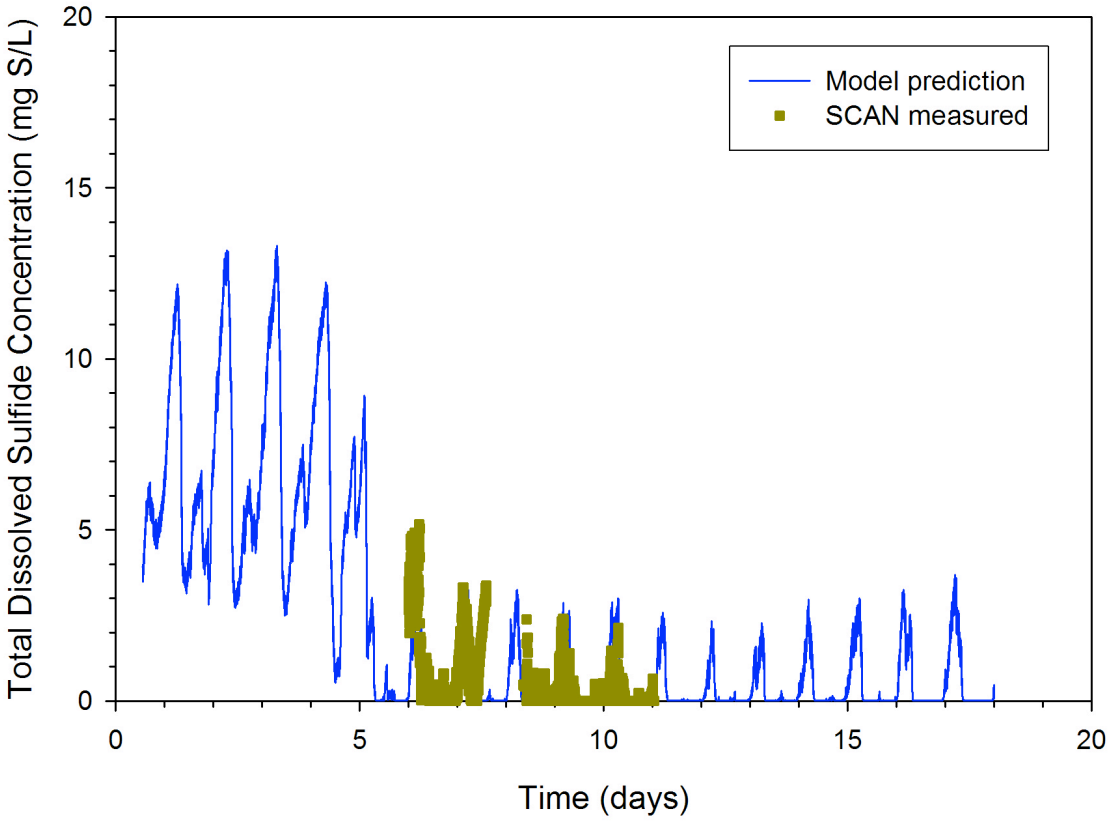

Figure 18. Measured versus simulated sulfide concentration at 735 m (measured data available only from Day 6 to Day 11)

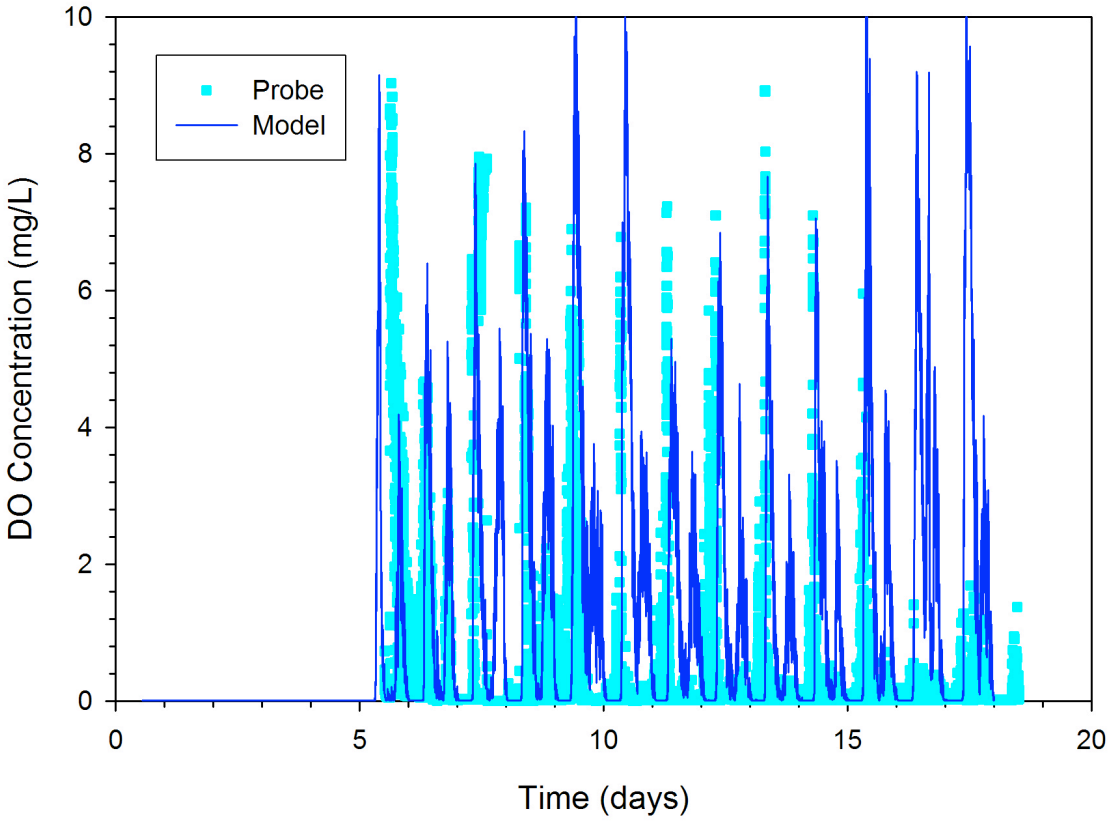

Figure 19. Measured versus simulated DO concentration at 735 m

A close look on the effect of HRT on oxygen consumption and sulfide generation is presented in Figure 20. As seen in the figure, oxygen did not reach 735 m at a period when HRT was long. As a result of this, there was some sulfide generation. However, during a short HRT, sufficient oxygen was available at 735 m, and hence no sulfide was present. This is a typical behavior in a sewer system subjected to intermittent pumping, and it highlights the importance of choosing a right location (thus manipulating HRT), and a right oxygen dose. A choice should be made in such a way that oxygen is available throughout the pipe during all the pump cycles, and at the same time keeping the level of oxygen low at the exit when the sewage is discharged to a treatment plant.

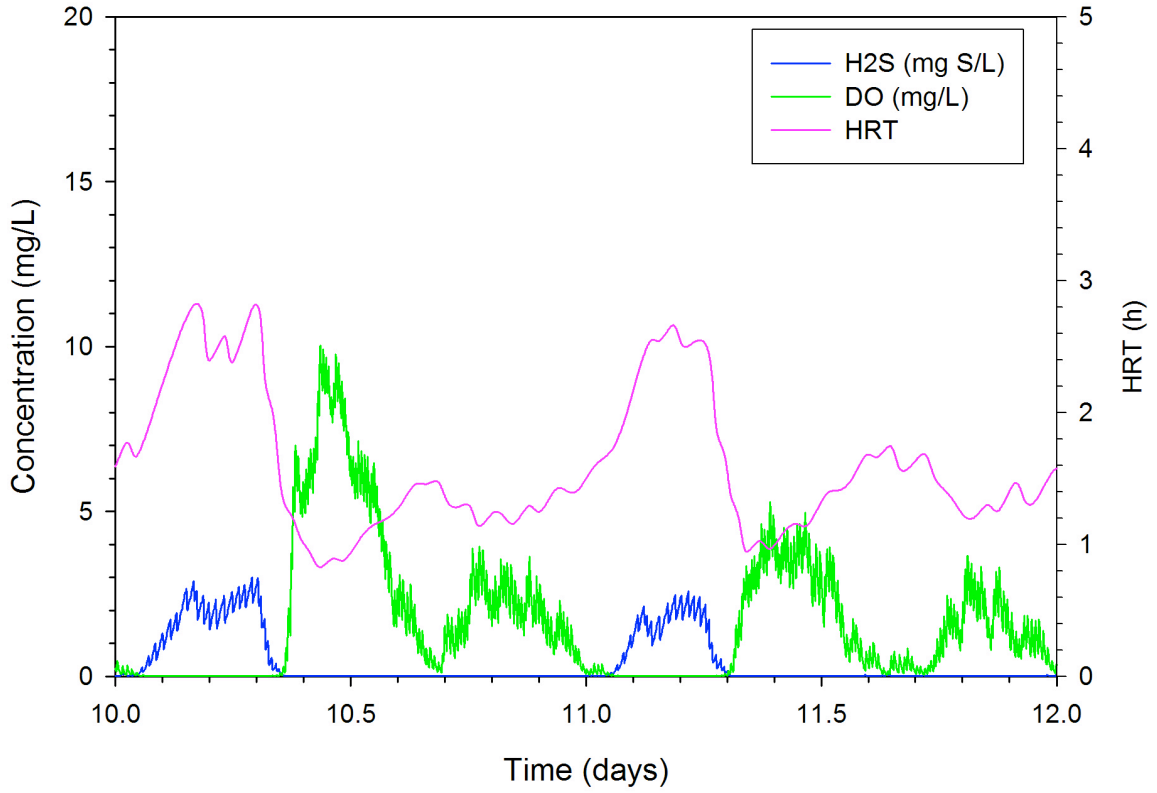

Figure 20. Effect of HRT on sulfide and DO concentrations at 735 m