ODOUR CONTROL STRATEGIES ON THE REGIONAL OUTFALL SEWER

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ABSTRACT

The Regional Outfall Sewer (ROS) conveys industrial and domestic waste from the Latrobe Valley to Dutson Downs for treatment. There are two main sections which comprise the ROS; a 40 km piped section that originates in Morwell, and 45 kms of open channel that starts east of Rosedale. The majority of the industrial effluent that is received is high in sulphates, which in turn leads to the generation of sulphides, and this is the reason for the frequent odour complaints from residents in the vicinity of the open channel section.

This paper discusses the different odour control strategies that were tried on the Regional Outfall Sewer in 2003-05 by Gippsland Water. In particular, pH based control will be discussed as a means of suppressing odours associated with hydrogen sulphide.

KEYWORDS

Hydrogen sulphide, Odour control, Sewer, pH, Industrial waste

1.0 INTRODUCTION

The Regional Outfall Sewer (ROS) conveys industrial and domestic waste from the Latrobe Valley to Dutson Downs for treatment. There are two main sections which comprise the ROS; a 40 km piped section that originates in Morwell, and 45 kms of open channel that starts east of Rosedale. Approximately half of the total flow in the ROS is industrial waste received from Australian Paper at Maryvale. Other industrial inputs include waste from National Foods (dairy processing waste) and Rosedale Leather (tannery waste). Two of these wastes, Australian Paper and Rosedale Leather, are high in sulphates due to the chemicals used in their processes, namely alum in the paper making and sodium sulphate in the tanning of cow hides.

Due to the composition of the waste, and the anaerobic conditions present in the pipeline, large quantities of sulphide are generated. This results in corrosion of the pipeline and the generation of odour at air valves and particularly in the open channel. Previously, odour was controlled using a mixture of oxygen and iron salts. There are three oxygen dissolvers in the piped section and six in the channel, as well as two iron salts dosing points in the channel. Despite these measures, Gippsland Water still received occasional odour complaints from residents and travellers along the Rosedale – Golden Beach Rd.

The combined cost of the iron salts and oxygen was of the order of $1.1million per year.

A number of commercial products are available for the control of odour. Gippsland Water decided to investigate alternative products for the suppression of odours with the dual objective of lowering the amount of hydrogen sulphide released from the channel and reducing operational odour control costs.

1.1 ROS Characteristics

The main cause of odour emissions from sewage systems is hydrogen sulphide, but there is also a smaller contribution from volatile organic sulphur compounds (mercaptans). These mercaptans are most likely higher in the ROS effluent than other industrial effluent due to the organic nature of the paper making process. The majority of hydrogen sulphide is produced from the anaerobic reduction of aqueous sulphates by sulphate reducing bacteria.

Table 1 shows a typical organic sulphide analysis of the ROS. The high concentration of hydrogen sulphide has been confirmed by residents' complaints that the odour they detect has a strong "rotten egg" component. For this reason, GW decided to focus on hydrogen sulphide reduction as the main strategy for reducing overall odour.

Table 1: *Typical Organic Sulphide Composition of ROS (Temple, 1998)*

Chemical	Concentration (ppb)
Hydrogen sulphide	40,933
Sulphur dioxide	1
Methyl mercaptan	1,633
Carbonyl sulphide	15
Dimethyl sulphide	86
Carbon disulphide	5
Dimethyl disulphide	2
Sulphates	480,000
Methanol	1,809
Ethanol	189
Acetone	80
Chloroform	1,875

Another characteristic that is unique to the ROS is the influx of industrial tannery effluent at Site 11 (See Figure 4), 7km upstream of the transition from pipe to open channel. Analysis of trends has shown that there is a strong correlation between the periods of discharge into the ROS by the tannery and peaks in the hydrogen sulphide as measured in the open channel at Site 12. Figure 1 shows this over a ten day period displaying a typical trend. There is a strong correspondence between pumping periods at the tannery and an increase in hydrogen sulphide (after approximately a four-five hour travel time) which is attributed to the conversion of the high sulphate load in the tannery waste. However, there are instances where the hydrogen sulphide does not significantly increase and the reasons for this are not understood.

1.2 Treatment Options

Odour control systems generally fall into two categories; chemical treatment and biological treatment. Manipulation of conditions to prevent the reduction of sulphates (addition of O_2, NO_3, H_2O_2), addition of chemicals that react with the H_2S to prevent the release of the gaseous form (eg. ferric sulphate), and increasing the pH to alter the chemical equilibrium and hence reduce release of H_2S (eg. using NaOH or $Mg(OH)_2$) are examples of chemical approaches.

Biological treatment includes addition of selected strains of bacteria, addition of nutrients to promote growth of certain bacteria, and the removal of biofilms from the pipe walls which contain the sulphate reducing bacteria.

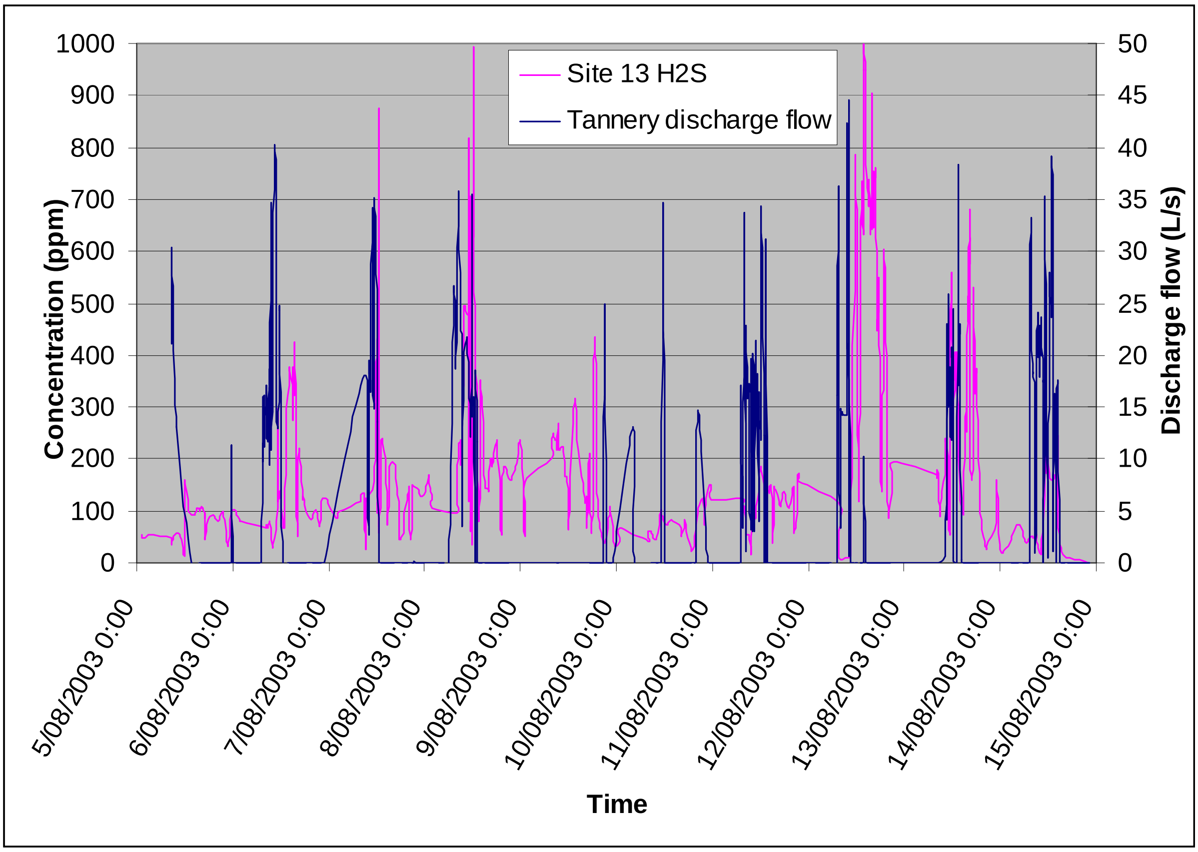

Figure 1: ***Relationship Between Tannery Pumping and Hydrogen Sulphide at Site 13***

Gippsland Water made the decision to trial a chemical treatment focusing on the increase of pH to decrease the amount of hydrogen sulphide released. This decision was largely based on cost estimates of different chemical and biological treatments that indicated that a biological agent would be more expensive.

At a higher pH, the equilibrium of the equation below shifts to the right, keeping the sulphide in soluble form, therefore preventing any hydrogen sulphide odour from escaping. Figure 2 shows the relationship between pH and hydrogen sulphide. The ROS typically had a pH of 6.8-7 at which the percentage of hydrogen sulphide is around 50%.

$$H_2S(gas) + H_2O \rightarrow H_3O^+(sol) + HS^-(sol)$$

However, while pH control is effective at controlling hydrogen sulphide, as the ROS composition in Table 1 shows, there are still other odorous compounds in the channel that are not affected by pH control. These compounds could still contribute to a considerable odour along the channel owing to their lower detection thresholds and sensitivity to human noses.

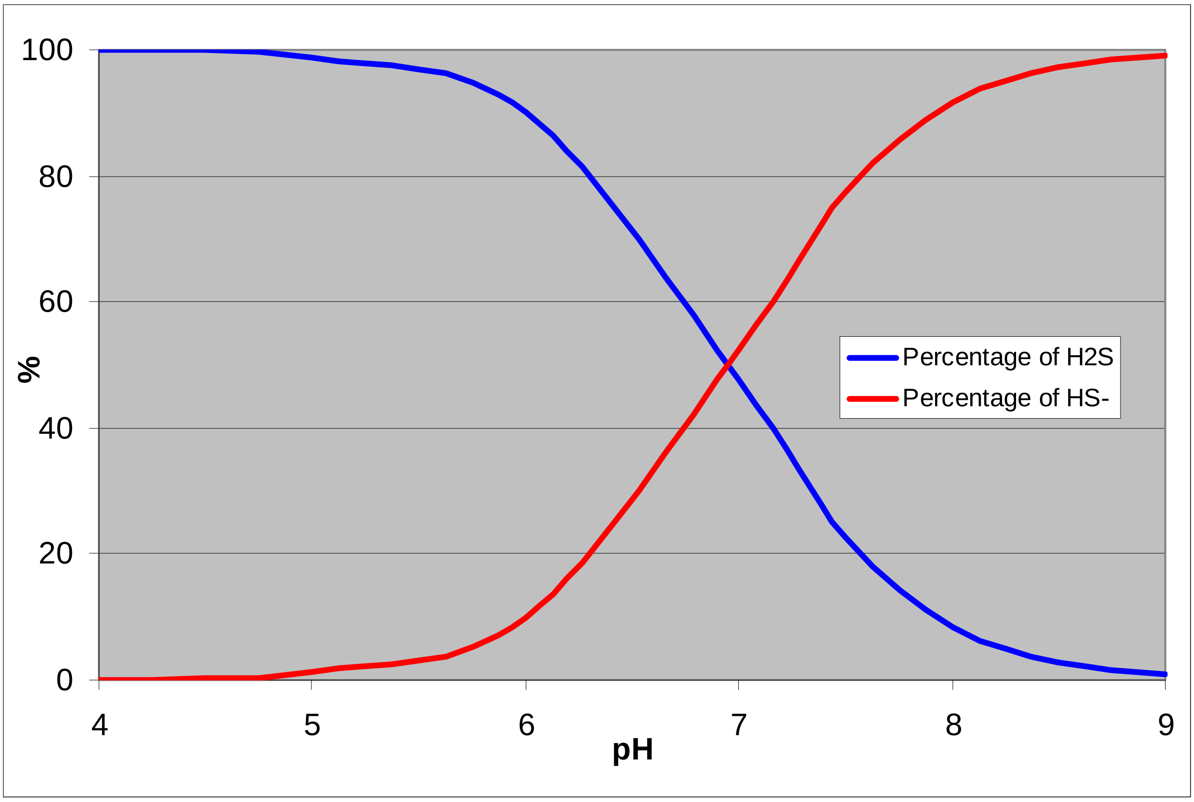

Figure 2: ***Relationship Between pH and H_2S***

Figure 3 below shows the relationship between hydrogen sulphide concentration in solution, temperature and the resultant hydrogen sulphide concentration in air. A concentration of 1000 ppm in air is regarded as immediately dangerous to human life and the graph shows that this can occur at hydrogen sulphide concentrations of as low as 4.0 mg/L in solution at ambient temperatures.

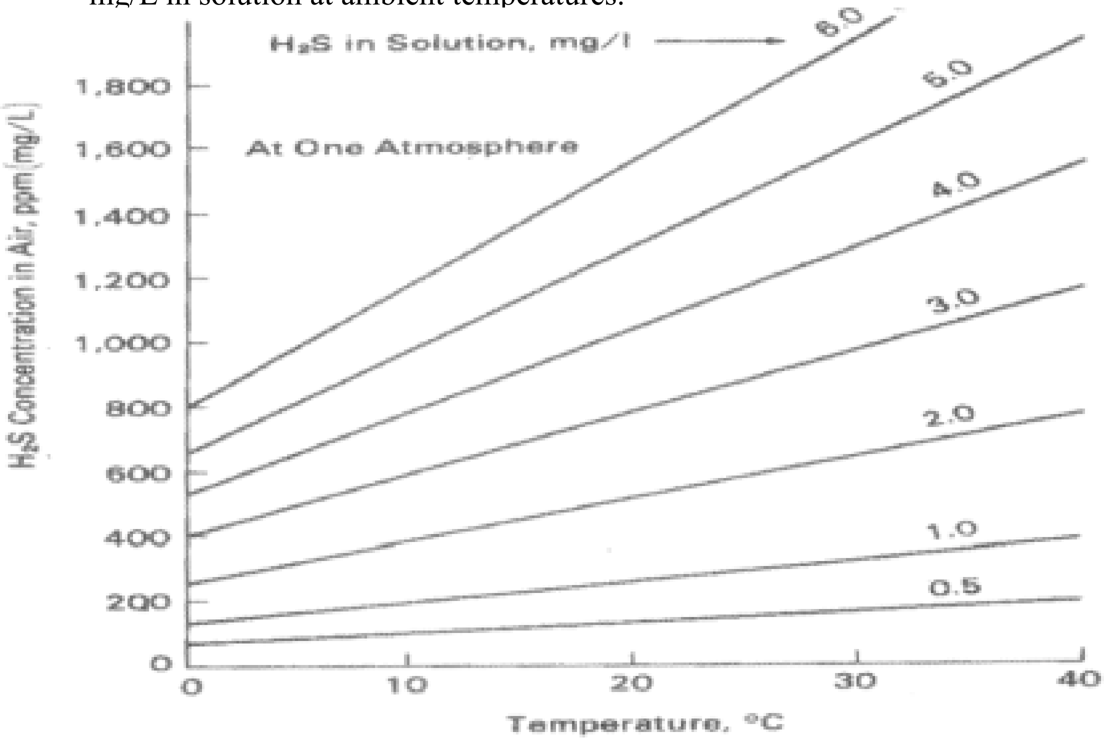

Figure 3: ***Relationship Between Hydrogen Sulphide Concentrations in Air and Solution and Temperature***

2.0 DISCUSSION AND RESULTS

2.1 Trial Using Magnesium Hydroxide Liquid

The first chemical that Gippsland Water trialled on the ROS was Magnesium Hydroxide Liquid (MHL) from Orica. The aim of the trial was to increase the pH of the ROS to around 8.5 where approximately 95% of the sulphide would be in the soluble form (see Figure 2). MHL was dosed into the pipeline at Site 11 (See Figure 4).

Three sites were selected along the channel to continuously monitor pH and hydrogen sulphide levels; Site 12, Site 14 and Site 22 (~35 km downstream). Site 12 was a site that had been used to monitor hydrogen sulphide and pH for a year previously. An auto sampler was also installed upstream of the MHL dosing to monitor the level of soluble sulphide in the ROS.

Background data was collected for a month prior to the trial starting in late September of 2003. The start of the trial was actually postponed for a couple of weeks to this date as the level of hydrogen sulphide in the channel was a lot lower than normal. This was found to be caused by the reduced output of the tannery.

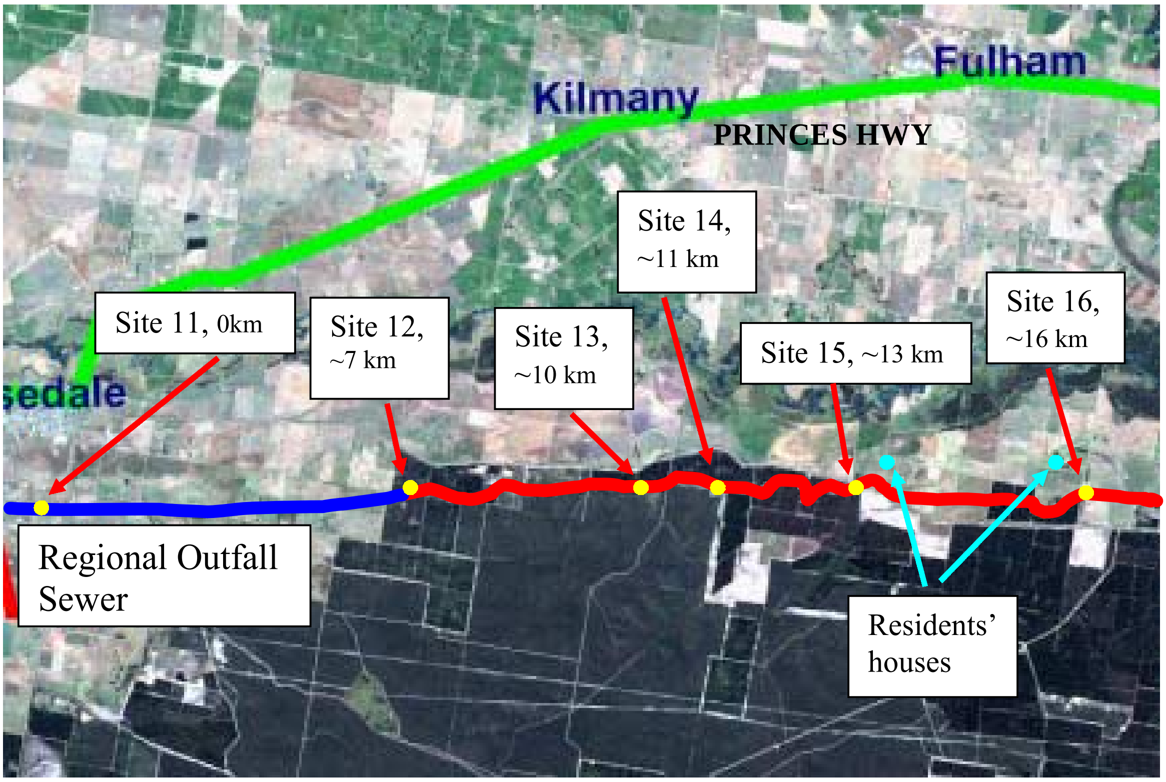

Figure 4: ***Diagram of End of the ROS Pipeline and Start of the Open Channel***

MHL dosing was commenced on the 24th of September. Gippsland Water adopted a cautious approach to the trial and kept dosing iron salts and oxygen initially. Once it was determined that the MHL was maintaining a steady pH profile along the channel, the iron salts dosing was turned off. The oxygen dissolvers were kept on, the plan being that they would be turned off once the hydrogen sulphide readings along the channel showed a significant decrease.

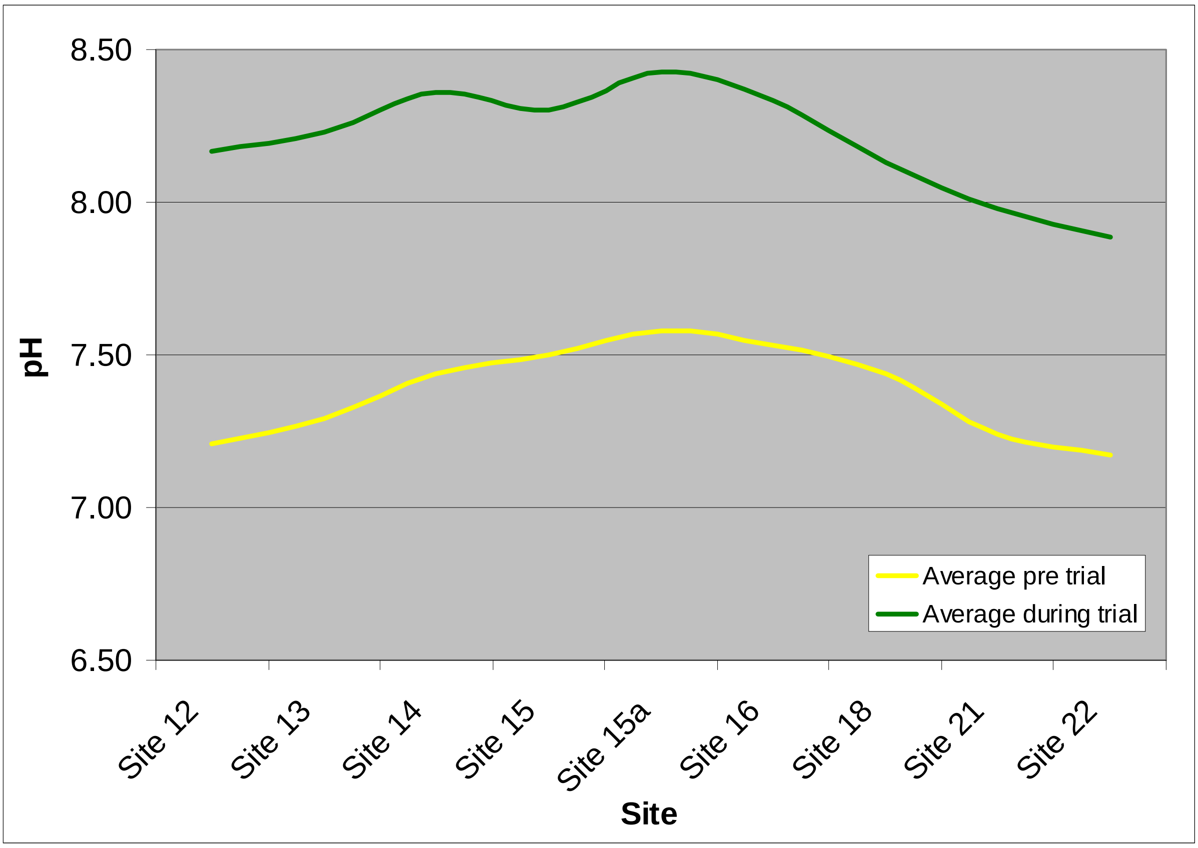

Figure 5: ***Effect of MHL Dosing on the pH of the ROS Channel***

Unfortunately the trial was unsuccessful in achieving what it set out to do. Figure 5 shows the effect of MHL on the pH along the channel. It was found that a pH of 8.5 was difficult to achieve consistently at any site and impossible to achieve along the length of the channel. Even to increase the pH to 8.5 in the vicinity of Site 15 would only be able to be done with a very high MHL dose rate. A cost analysis showed that this dose rate was not financially viable. When and where the MHL did increase the pH to 8.5 and above, there was no drastic reduction in the level of hydrogen sulphide. However, Gippsland Water did find that a pH based approach to the control of odour had potential and that more investigation should be done.

During the trial Gippsland Water experienced quite a few problems that skewed some of the data. On a couple of occasions the dosing pump broke down and two other occasions the MHL was unable to be delivered before the tank ran out. Some planned works also had to be carried out that required the shutdown of the ROS for a couple of days. Quite a few odour complaints were also received from residents which further confirmed the lack of success with the trial.

2.2 Trial Using Caustic Soda

Following the trial of MHL, it was decided to try caustic soda as the next chemical to control the pH. Compared to MHL, caustic soda is a stronger base but has less of a buffering capacity. Initially, the caustic soda was dosed at Site 11 but it was found that the elevated pH didn't extend as far down the channel as for MHL. This prompted a move of the dosing set up to Site 13.

The results from this trial showed that the caustic soda was capable of increasing the pH up to 8.5 but this effect dropped off relatively quickly. One of the drawbacks of the pH approach to odour management is that it doesn't remove any hydrogen sulphide from the system and once the pH drops back down, the hydrogen sulphide is released. However, at this time (March 2004), the price of caustic soda was very favourable in comparison to MHL and it was thought that some extra caustic soda dosing sites could be added to overcome this problem.

As with the MHL trial, there were numerous small incidents that affected the trial, including a chemical spill. This highlighted the importance of sufficient planning to minimise the risks to employee safety and the ROS system.

2.3 Combining MHL and Caustic Soda

At this stage, Gippsland Water decided to focus on controlling the odour at the site from where the bulk of the odour complaints were coming. This site, Site 15, is within 1 km of a resident's house. It was decided that the best strategy to control the pH at this site was to dose MHL and caustic soda in combination with each other. Dosing moderate amounts of MHL at the original site would raise the pH above 8, and then dosing caustic soda at Site 13 would boost the pH up to 8.5.

Further investigation determined that an improvement to the control of the dosing would decrease the operating cost. Previously, the dosing had mainly been done by manually setting a dose rate and adjusting it each day as flows and pH required. The new set up had the MHL being dosed at Site 11 at a constant rate and the caustic dosing at Site 13 controlled by a control loop combining pH inputs from Site 12 and Site 15 and a flow input from Site 12. A pH of 8.7 at Site 15 was chosen as the set point for the control loop. The reason for this set point was experience had shown that at a pH of 8.6 and above, the level of hydrogen sulphide was around 300 ppm which seemed to correspond with less odour complaints.

This system has been in place now since December 2004 and has shown that it can control the pH of the ROS quite well. Considering the travel times involved, and hence the lag time on the control loop, this is quite an achievement for the control system. Further optimisation is being investigated to cater for the different conditions from winter to summer and also the rising price of caustic soda.

An interesting effect of the oxygen dissolvers was observed during the trials. During normal operation they tend to generate foam on the surface of the channel which is especially noticeable at Sites 16 and 22 where the dissolvers are just upstream from a road crossing. When one of these dissolvers was turned off, a nearby resident that used that particular road frequently, complained about the odour. They also asked in their complaint to Gippsland Water why the nearby oxygen dissolver was turned off as there was no foam in the channel. A Gippsland Water employee that was on site in the days before and after the dissolver was turned off reported that there was no discernable change in odour. This led to the conclusion that the complainants perceived an increase in odour by using another indicator rather than the actual odour i.e. no foam in the channel meant the oxygen dissolver was off, hence it must be smellier.

Testing of the dissolved oxygen level and oxidation reduction potential upstream and downstream of different oxygen dissolvers has also shown that their effect is quite short; as little as 400 metres in some cases. It would seem as though that the physical confirmation of the operation of the oxygen dissolvers is enough at times to prevent complaints.

2.4 Recent Developments

While these trials were happening, Gippsland Water was also investigating other methods of reducing the odour in the open channel. One of these which showed promise was the construction of a balance tank at Site 11 for the tannery waste to discharge into before being introduced into the ROS. The theory behind this development was that by evening out the input of the tannery waste to the ROS over 24 hours, the sharp peaks in hydrogen sulphide could be smoothed out or eliminated.

Construction of this balance tank was completed in June 2005 and it is due to be commissioned in August. However its future use as intended above is in doubt due to changes in the operation of the tannery. Instead of tanning their own hides, they now buy pre-tanned hides, which considerably reduces the amount of waste that they discharge and also significantly reduces the sulphate load. At this stage, it is unsure if this is a temporary or permanent change to their process.

3.0 CONCLUSIONS

The outcome of these trials showed that it is possible to manage the odour of the ROS using chemical treatment to control the pH on the proviso that a suitable control system is installed. While the system is still imperfect, it is the most effective it has been for many years.

The management of the trials has also highlighted the limitations of temporary dosing set ups. It is important for the effectiveness of the trial and the safety of employees that all issues with these set ups are dealt with in the planning stage to reduce the impact of any incident.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

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