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pH BUFFERING IN THE GREAVES CREEK WATER SUPPLY SYSTEM

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ABSTRACT

Maintaining the pH in the delivery system within the Australian Drinking Water Guidelines (1996) has been one of the greatest challenges facing the operators of Greaves Creek Water Filtration Plant (WFP).

Following commissioning of Greaves Creek WFP in 1991 and the commencement of water quality testing in the system, the lack of pH buffering in the raw water source (alkalinity < 4.0mg/L) became a significant issue. The original lime dosing system at the plant was designed for pH control with little regard to alkalinity (buffering capacity). As a result, whilst the plant met process guidelines (pH 7.0-8.0), the low buffering capacity meant there was a significant increase in pH at the extremities of the distribution system.

A series of process changes and optimisation projects were initiated to improve the consistency of pH control and the pH buffering of the final water. By controlling the pH buffering capacity of final water at Greaves Creek WFP, there has been a significant reduction in the pH levels at the extremities of the supply system.

1.0 INTRODUCTION

Sydney Water's Asset Management division completed a *pH Study Report* in May 2002, which focused on assessing compliance with the Australian Drinking Water Guidelines (1996) pH values of 6.5 to 8.5. The report covered each of the water distribution systems of Sydney Water, analysing compliance to the guidelines and assessing the cost/benefit of achieving 100% compliance to these values.

The report concluded that whilst Sydney Water 'meets the long term performance requirements of the ADWG for pH across all delivery systems' there was significant variation in performance between systems.

The Greaves Creek water supply system had the poorest compliance to the ADWG pH guidelines, with 79.3% of samples complying to the 6.5-8.5 pH range. The system did achieve 100% compliance to pH in the range of 6.5-9.2.

Within the Greaves Creek water supply system two sample sites caused the majority of the pH failures. These were:

Reservoir Zone	Address	Suburb	No. of Obs	No. Failures	% Failures	Max pH
Mt Victoria WS445	Bush Fire Brigade Hall Harley Ave	Mt Victoria	3	3	100	8.9
Mt Victoria WS445	14 Beaufort Ave	Mt Victoria	53	38	71.7	9.14

1.1 Greaves Creek Water Supply System Overview

Greaves Creek WFP, commissioned in 1991, supplies water to the Upper Blue Mountains townships of Blackheath, Mount Victoria and Medlow Bath.

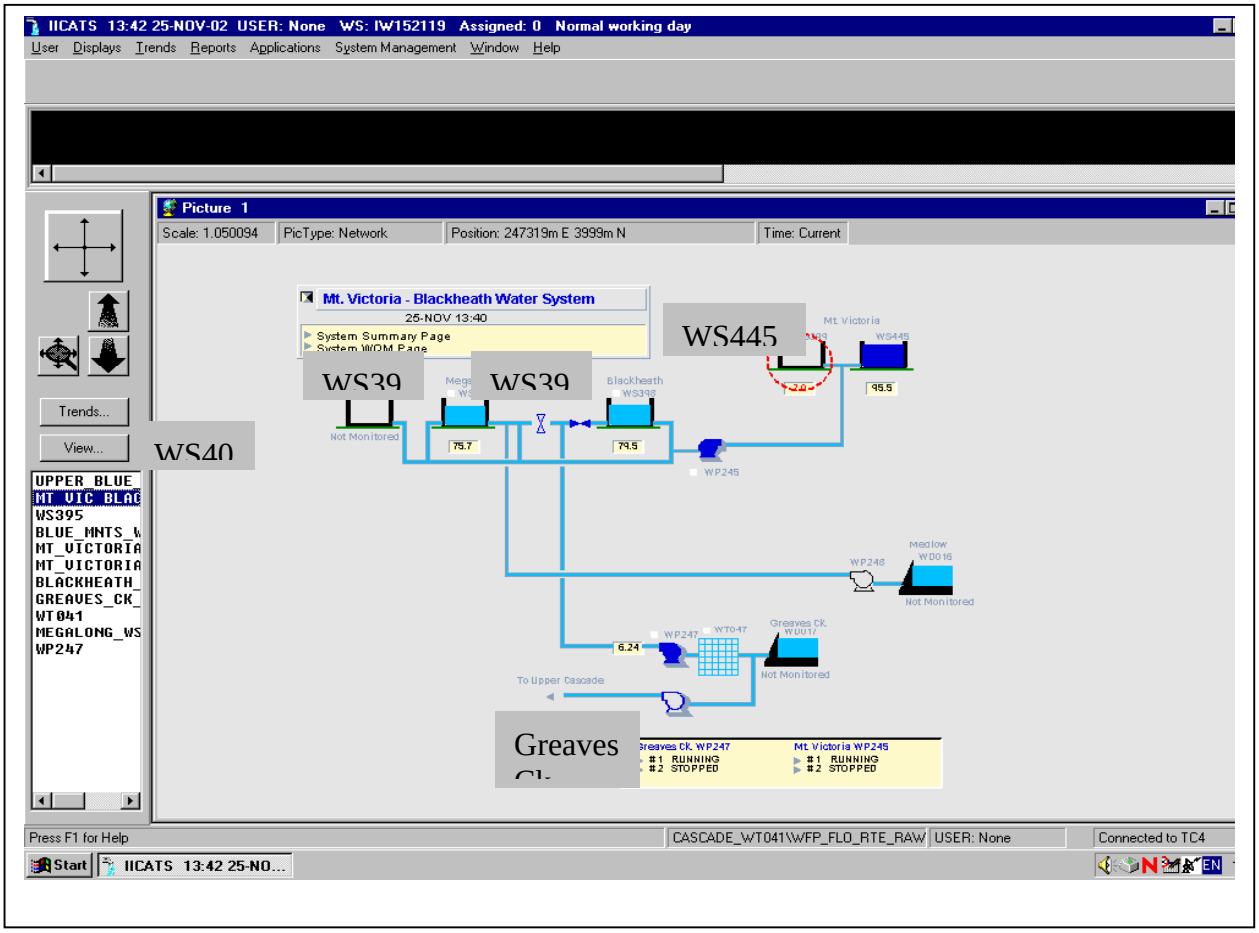
Raw water for Greaves Creek WFP is sourced from the two dams located upstream of the plant, Lake Medlow and Lake Greaves. The raw water is typically characterised by relatively high colour (10-20 TCU at 400nm wavelength), low turbidity (1.0-3.0 NTU) and extremely low alkalinity (1.5-4.0 mg/L).

The general treatment process at Greaves Creek WFP is direct filtration. Prior to the changes described in this report, the water was treated using Polymerised Ferric Sulphate (PFS) and cationic polymer (LT410) as coagulants, an acrylamide polymer (LT20) as a flocculant aid, and lime to control the coagulation pH. Post filtration lime and CO_2 were added to provide pH correction and some buffering capacity. Chlorine and fluoride were also added.

Several changes have been made to improve the pH in the Greaves Creek Supply System, including the addition of carbon dioxide dosing into the final water and the installation of a new lime dosing system in 1999.

Water from Greaves Creek WFP is pumped directly to Blackheath Reservoir (WS398), which gravity feeds into Megalong Reservoir (WS397), and Shipley Reservoir (WS401) (Figure 1). Water is also pumped from Blackheath Reservoir to Mt Victoria Reservoir (WS445).

Figure 1: ***Greaves Creek Water Supply System***

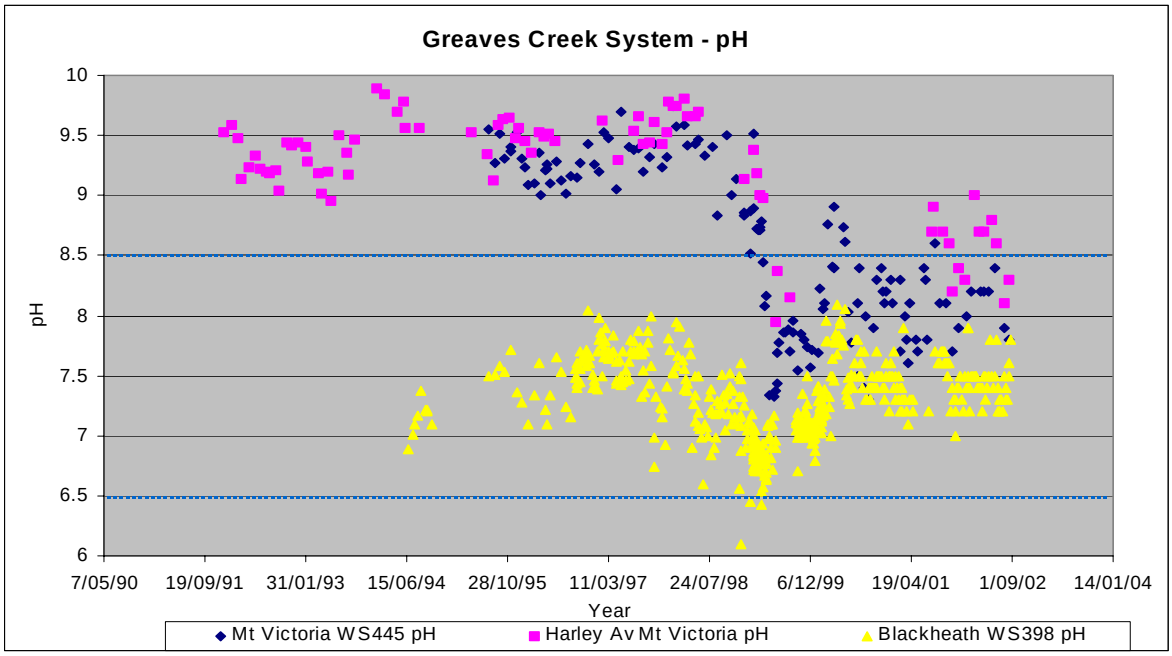


The Greaves Creek supply system consists of a network of cement lined steel mains. Leaching of the cement lining occurs as the water ages in the pipelines, resulting in an increase in pH as the water moves further from the filtration plant. As a consequence, the sample sites at the extremities of the system, particularly those in the Mt Victoria Reservoir zone, are the source of most pH failures.

1.2 Review of pH Compliance

Figure 2 shows the pH levels at Blackheath Reservoir, Mt Victoria Reservoir and Harley Avenue, Mt Victoria. There was a clear improvement in 1999, when carbon dioxide dosing (post filtration) was introduced. As a result of the CO_2 dosing and commissioning of a new lime plant, the final water alkalinity at Greaves Creek WFP increased from an average of 6 mg/L to 20 mg/L. Before this change, all samples at Harley Avenue exceeded the upper NHMRC guideline of 8.5.

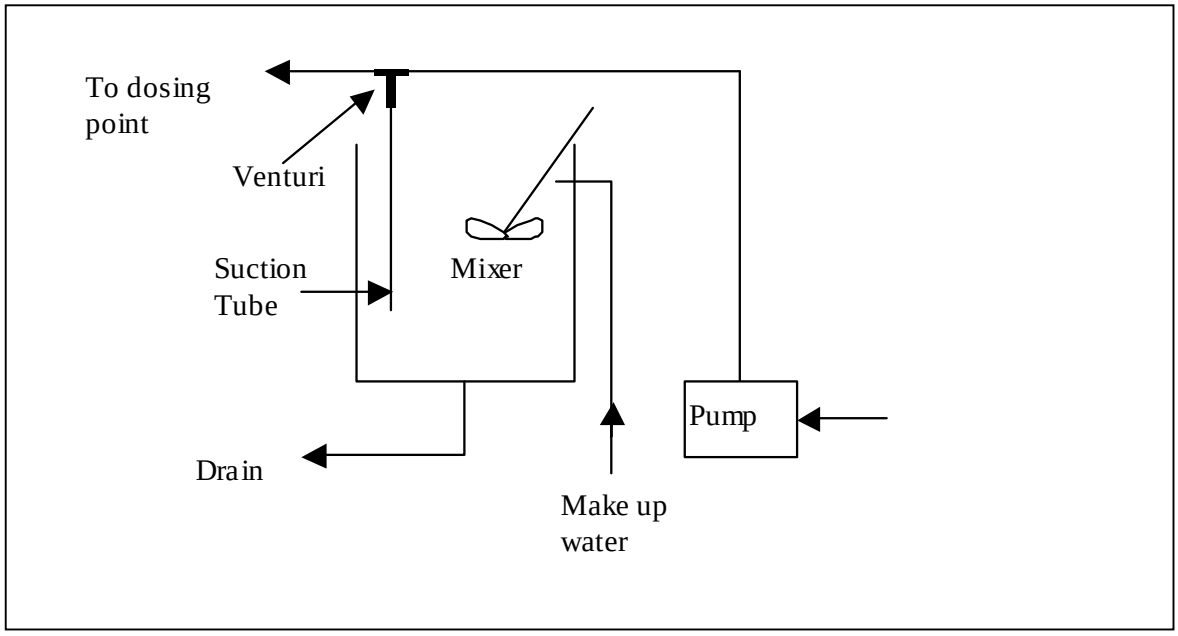
Figure 2: ***Blackheath Reservoir, Mount Victoria Reservoir and Harley Avenue pH Trends***



1.3 Improvements to Post-Lime Dosing

In June 2002, several major modifications were made to the lime dosing plant at Greaves Creek WFP (Figure 3).

Figure 3: ***Greaves Creek Lime System Operational Layout***



As a part of this project, the suction tubes of the venturi system were changed from the original design (Figure 4). The production officer's at the plant had noted a strong correlation between lime blockages in the suction tubes and the lime dose rate. At a final water alkalinity of less than 20mg/L there were few problems with lime blockages in the suction tubes.

The suction tubes were re-designed to draw lime through the bottom of the tube (diameter 20 mm), and the tube length was shortened to prevent sludge from the bottom of the tank being dosed. The plant team also introduced regular flushing of the sludge from the base of the tank, and made some minor modifications to the mixers to prevent sludge build up.

These modifications also significantly improved the safety aspects of the plant.

Figure 4: ***Lime System Suction Tube Prior to Modifications. Hole Diameter = 3mm***

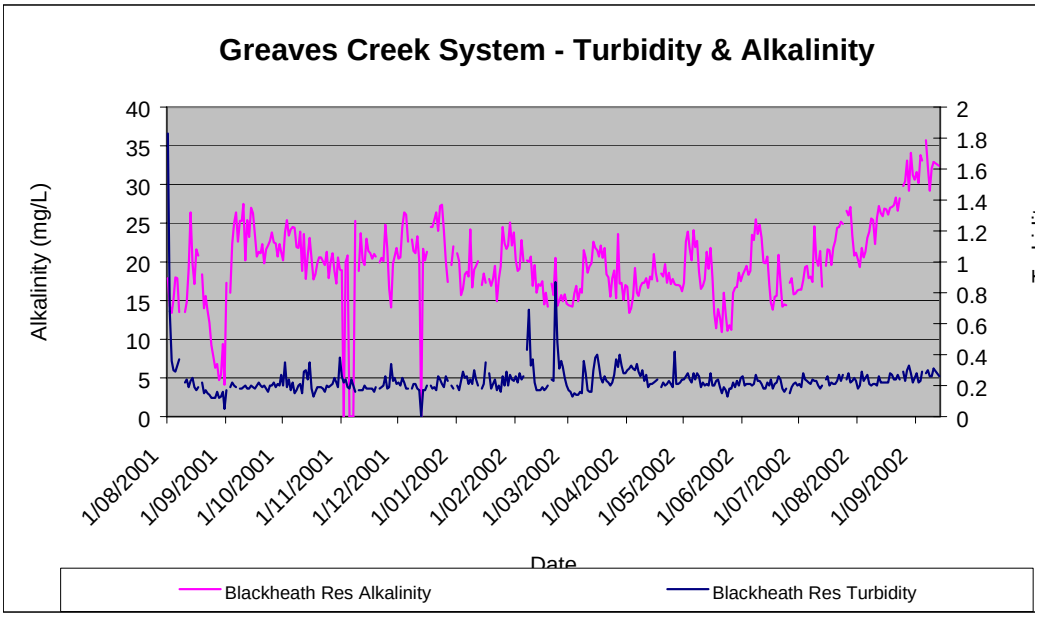
2.0 DISCUSSION

Following the modifications to the lime plant, a trial was commenced to assess the impact of increasing final water alkalinity at Greaves Creek WFP on the pH in the supply system. In order to effectively monitor the change, production officers at Greaves Creek WFP firstly examined the pipe layout of the system to improve their understanding of the dynamics of water movement within the system. Key points were identified for monitoring to give a good picture of the relationship between pH and water age in the supply system.

The post lime dose was gradually increased to improve the alkalinity of the water in the Greaves Creek Water Supply System. At an alkalinity of 30mg/L, the change in pH of the water through the supply system was reduced sufficiently to achieve a pH of between 8.2 and 8.3 at the outlying sites in the system

The plant could reliably achieve this level of final water alkalinity (30mg/L), without compromising other water quality parameters such as turbidity (Figure 5).

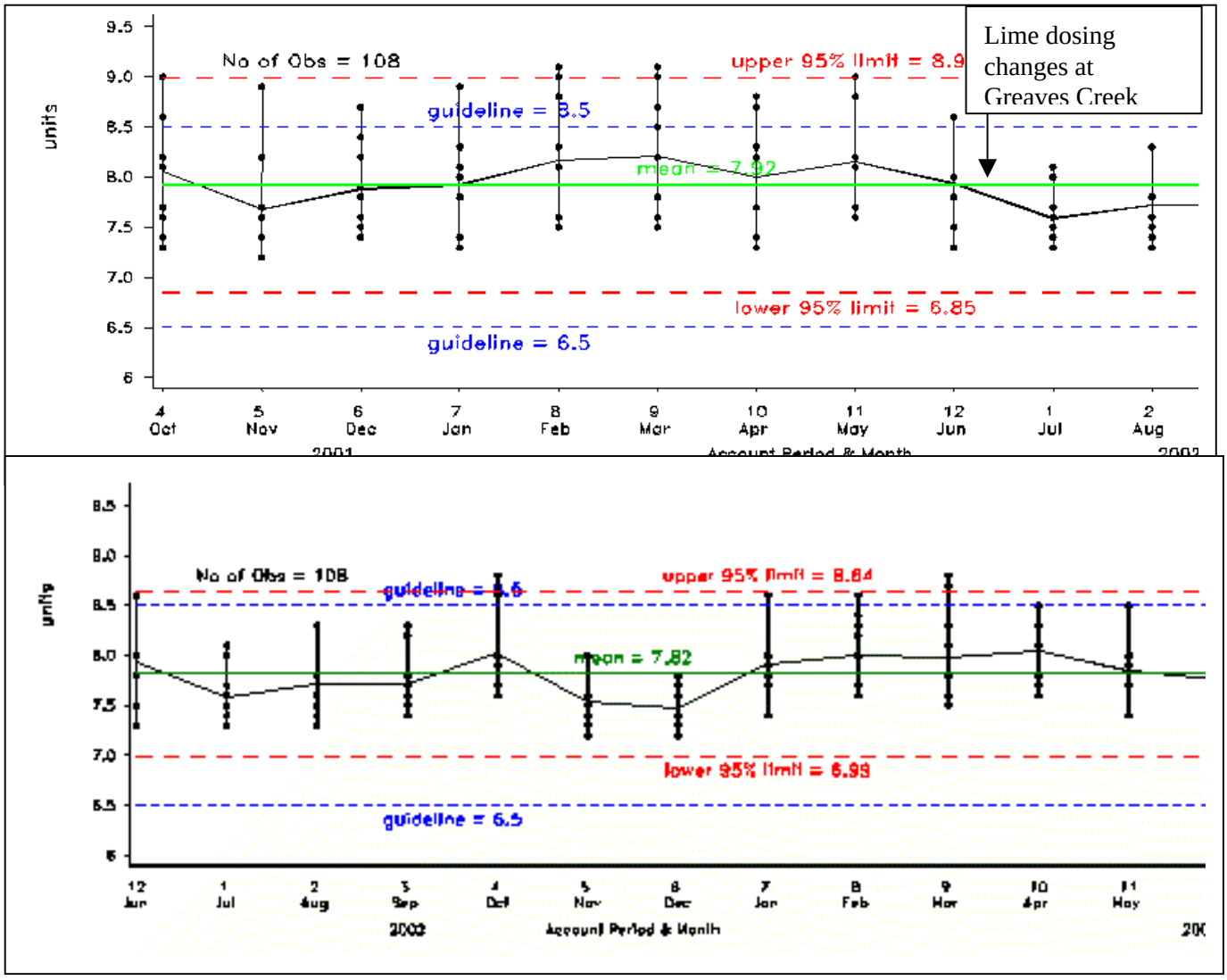
Figure 5: ***Alkalinity & Turbidity at Blackheath Reservoir***



2.1 Greaves Creek Supply System pH

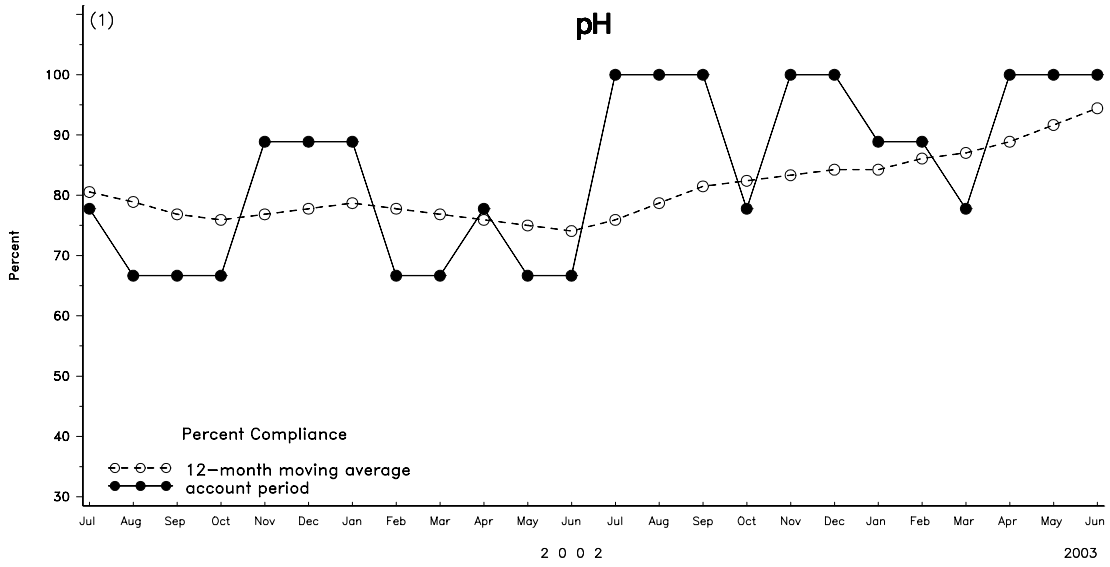
The variation in pH between all of the sample sites within the system was reduced, resulting in a system which is more pH stable (Figure 6). The higher pH values are at sample sites further from the WFP, where the water age is greater. The lowest value represents Blackheath Reservoir (fed directly from the WFP) and the highest is an outlying site in the Mt Victoria Reservoir Zone.

Figure 6: ***Greaves Creek System pH October 2001-2002 (top graph) and June 2002-2003 (lower graph).***



Since the changes in June 2002, the performance of the Greaves Creek Distribution system to the NHMRC pH guidelines improved significantly (Figure 7). For eight of the 12 months after the dosing changes were implemented, there was 100% compliance to the pH guidelines. This was the first time that monthly pH samples had achieved 100% compliance to the NHMRC (1996) Guidelines.

Figure 7: ***Greaves Creek Delivery System Compliance to NHMRC pH Guidelines***



The reduction in compliance in October 2002 was directly related to a problem at the plant where the carbon dioxide dosing system was off-line and the alkalinity of the final water was around 8mg/L.

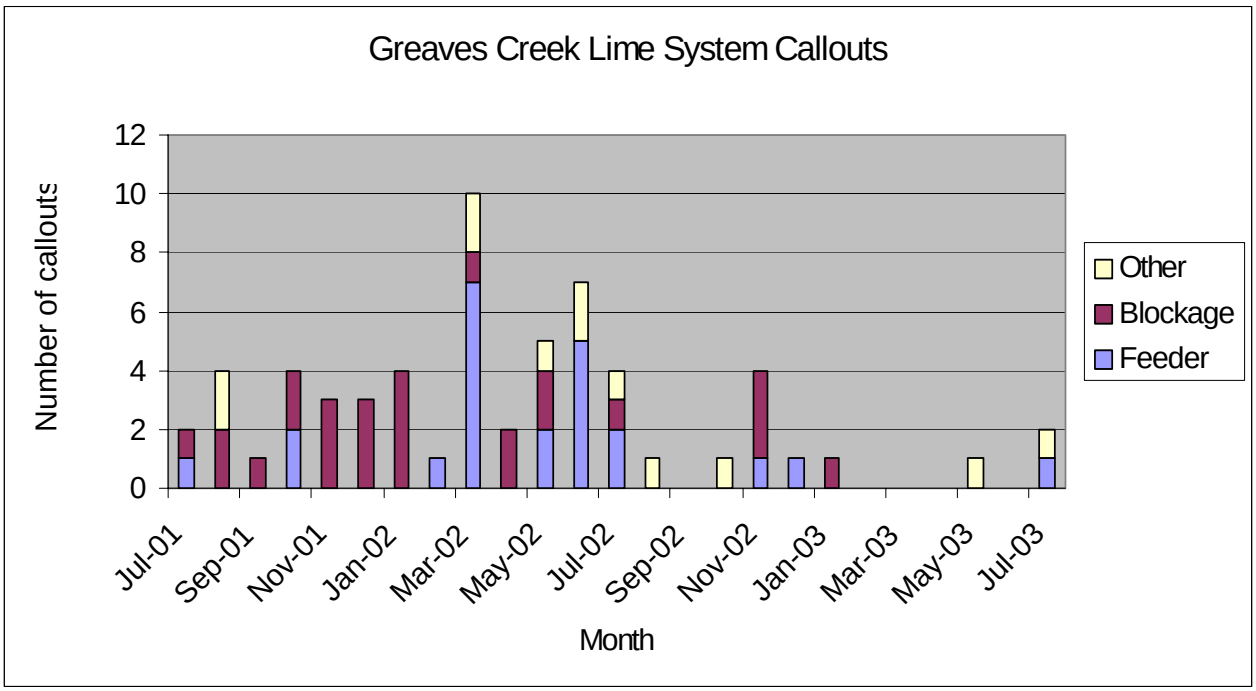
The pH failures in January and February 2003 can also be attributed to low alkalinity water being generated by the WFP, as the old lime dosing system was run due to problems with the new dosing system.

The two pH failures in March 2003 were at Harley Avenue, Mount Victoria. This site is located at the end of the main. The Mount Victoria Bush Fire Brigade draws water from the sample site. Low alkalinity water had been fed into the distribution system during January/February, and significant rainfall during March may have reduced demand from the Fire Station, resulting in increased retention time in the main.

2.2 Lime System Problems and Callouts

Prior to the modifications to the lime system, the lime dosing system could not consistently maintain the dose rate required to achieve a final water alkalinity above 20mg/L, without causing increased problems with blockages in the dosing system. Whilst the dose rate was significantly increased in June 2002, the average number of callouts (overtime events) relating to lime system blockages reduced from 3 per month to <1 per month (Figure 8). This can be attributed in part to the modifications made to the lime plant, and in part to the improved preventative maintenance program implemented for the lime dosing system.

Figure 8: ***Lime System Callouts (overtime events) at Greaves Creek. Callouts Classified 'Other' Relate to Faults with the Air Compressor, Ppumps & Slurry Tank Level***



3.0 CONCLUSION

Continual improvement to the Greaves Creek WFP lime dosing system, with the aim of better pH stability in the Greaves Creek Supply System, through increased alkalinity has been successful. Alkalinity in the final water now averages 30 – 35mg/L compared to around 6mg/L when the plant was commissioned in 1991.

At the Water Filtration Plant, recent modifications to the lime plant have resulted in significant improvements in the operational safety of the lime system, an economic saving through a reduction in call outs, and an improvement in the reliability of the lime dosing system.

The process used for assessing the impact of these modifications has also improved the knowledge and understanding of the dynamics and water quality issues within the Greaves Creek Water Supply System by the production officers at the filtration plant.

In the system, the improved buffering capacity of the water has resulted in the Greaves Creek Water Supply System achieving significantly improved compliance with the NHMRC (1996) pH guidelines of 6.5 –8.5 pH units.

4.0 ACKNOWLEDGEMENTS

We would like to thank the Blue Mountains Team, Lachlan Joyner, Phil Duker and Percy Ridley from Sydney Water for their help and support with our project.