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## Introduction

At the Western Treatment Plant (WTP), the production of Class A recycled water involves both ultraviolet (UV) and chlorine disinfection processes. The effectiveness of the chlorine treatment is governed by the concentration-time (CT) principle, which includes a critical control point (CCP) for pH. According to chlorine validation requirements, the pH must not exceed 9.0.

During summer, algal or diatom blooms in the L55E lagoon system (Pond 10) can cause the pH of the feedwater to rise. As a result, pre-treatment of high-pH feedwater has become a key focus at WTP. Addressing this issue not only ensures compliance with CT parameters but also improves the effectiveness of chlorination, enhancing the removal of E. coli. and coliforms detected downstream in the Chlorine Detention Basin.

## Rationale of CO<sub>2</sub> Dosing

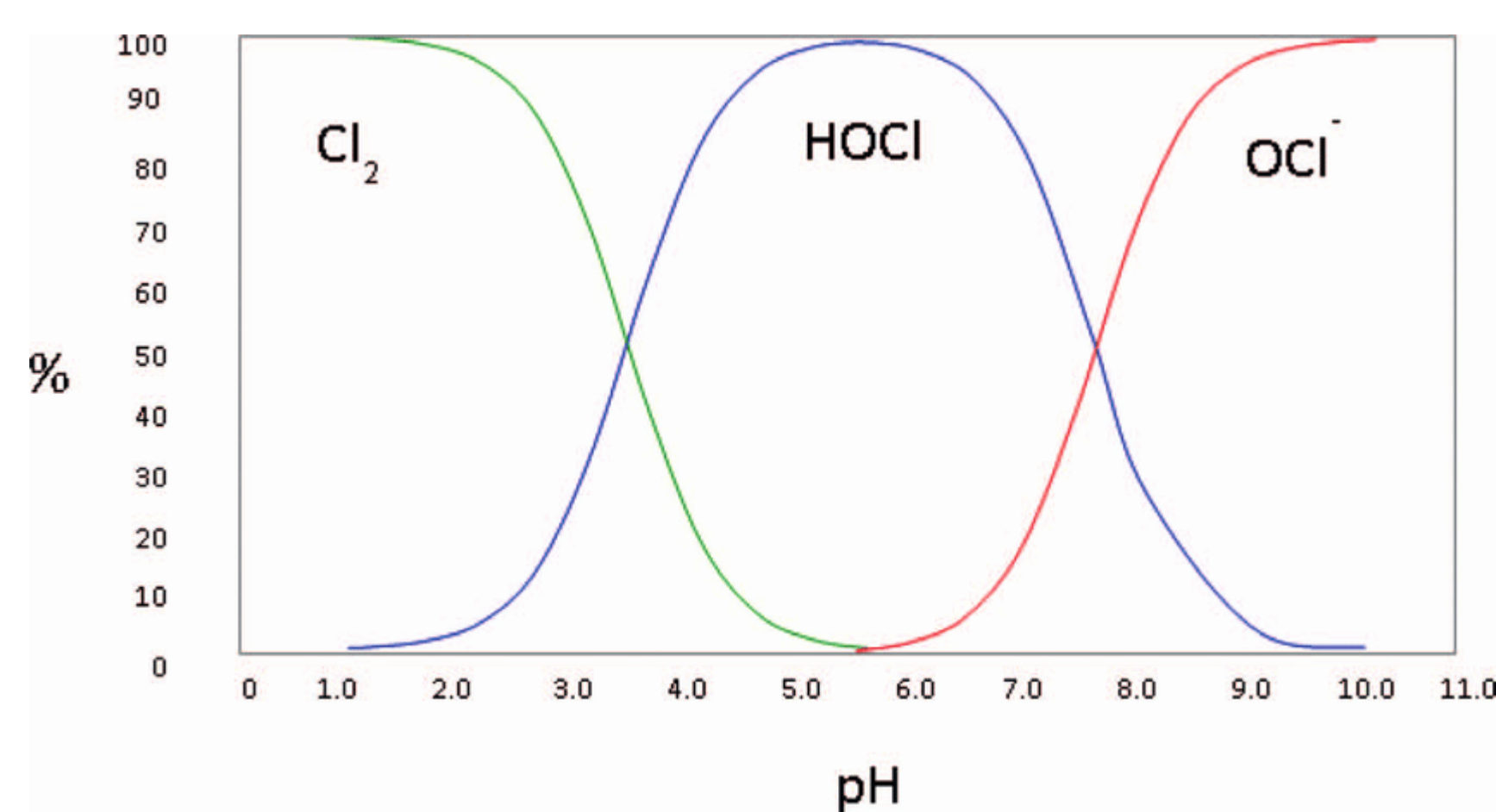


Figure 1 Proportion of chlorine species as a function of pH.

Gombas, D., et al. "Guidelines to validate control of cross-contamination during washing of fresh-cut leafy vegetables." Journal of Food Protection 80.2 (2017): 312-330.

The most effective chlorine species for disinfection is hypochlorous acid (HClO), which is approximately 80 to 100 times more potent than the hypochlorite ion (OCl<sup>-</sup>). As pH decreases from 8.0 to 7.0, the proportion of HClO increases significantly - from around 25% to 80% - potentially tripling the theoretical chlorination performance.

- Safe** – Forms mild, non-corrosive carbonic acid (H<sub>2</sub>CO<sub>3</sub>).
- Effective** – Can lower pH from 9 to as low as 4.6.
- Even distribution** – Dissolves well and can be dosed uniformly.
- No chlorine interference** – Unlike citric acid, CO<sub>2</sub> doesn't form toxic byproducts.
- No downstream impact** – Non-hazardous and safe for Class A recycled water.

## Laboratory Results

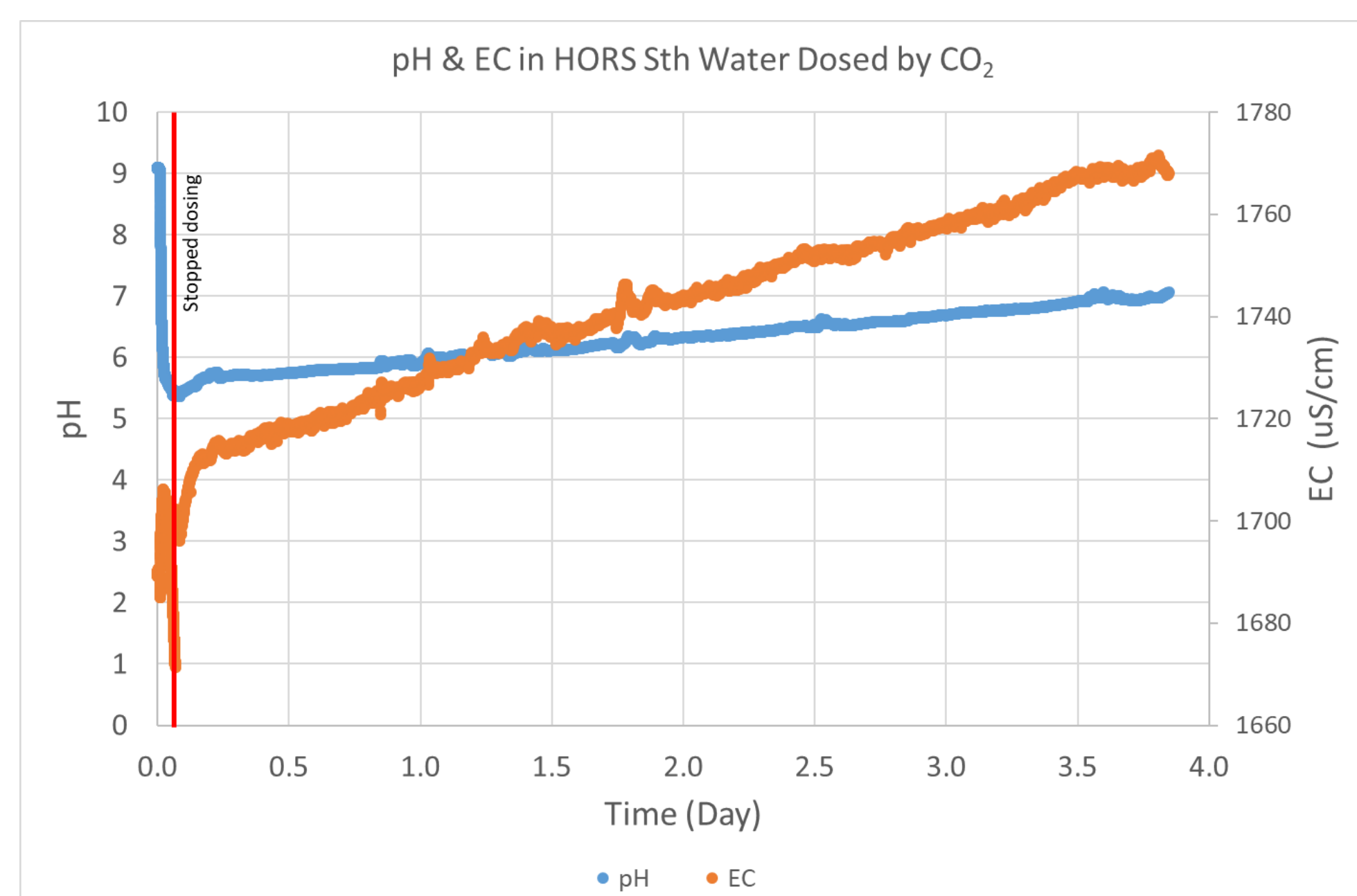
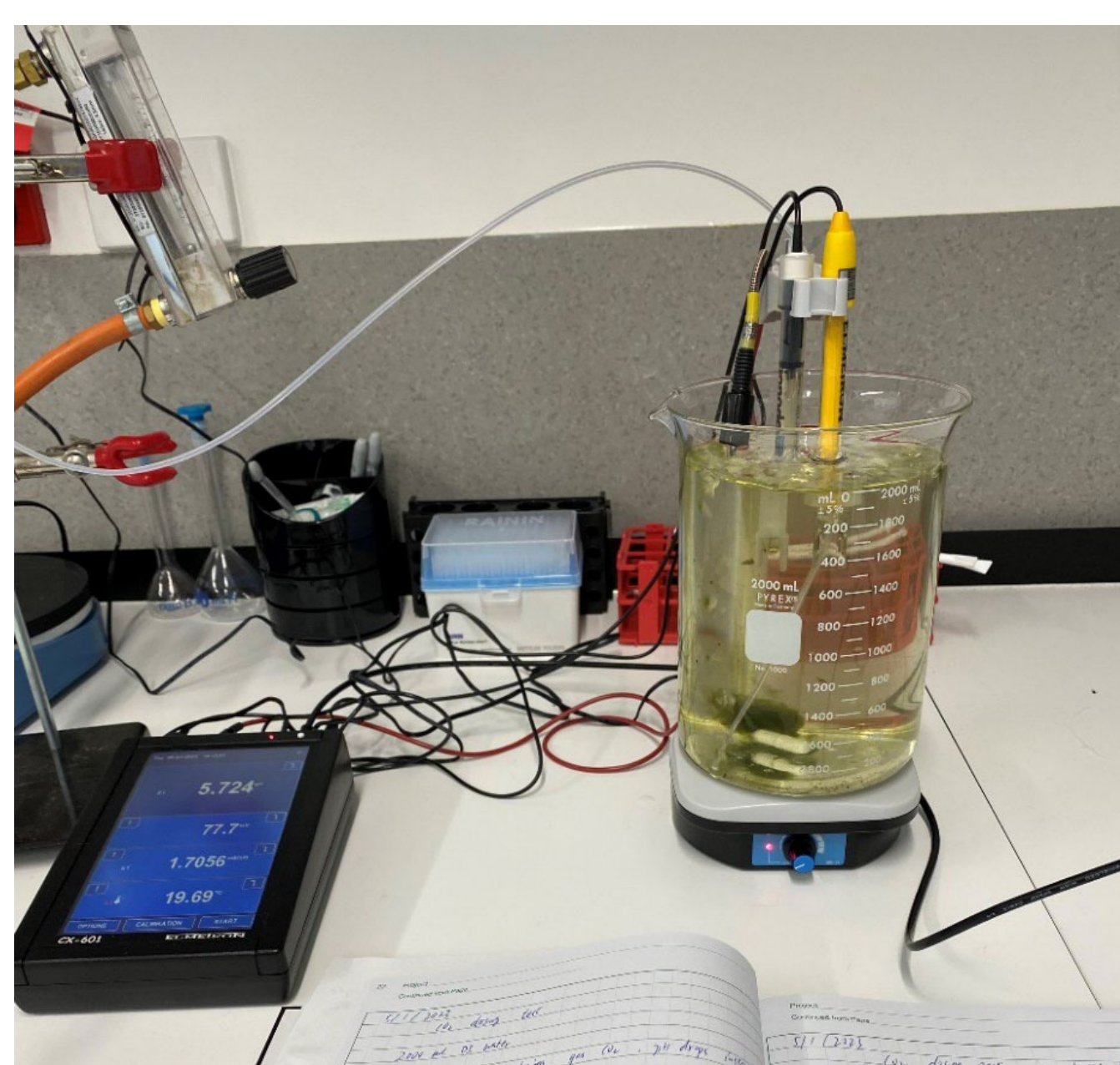


Figure 2&3 Laboratory setup and pH response to CO<sub>2</sub> dosing.

## Full-Scale Trials Results

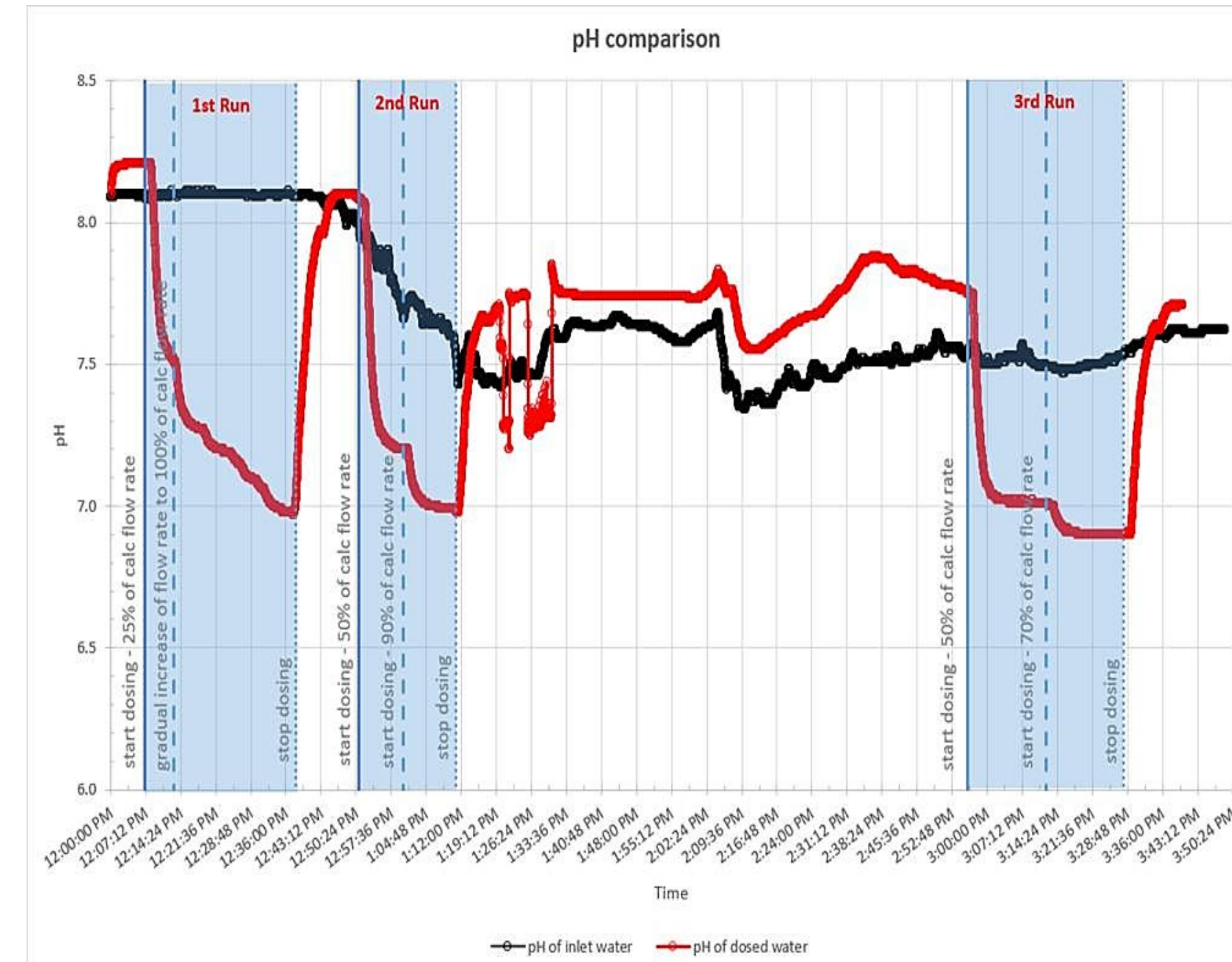


Figure 4 pH response to CO<sub>2</sub> dosing in 1<sup>st</sup> full-scale trial.

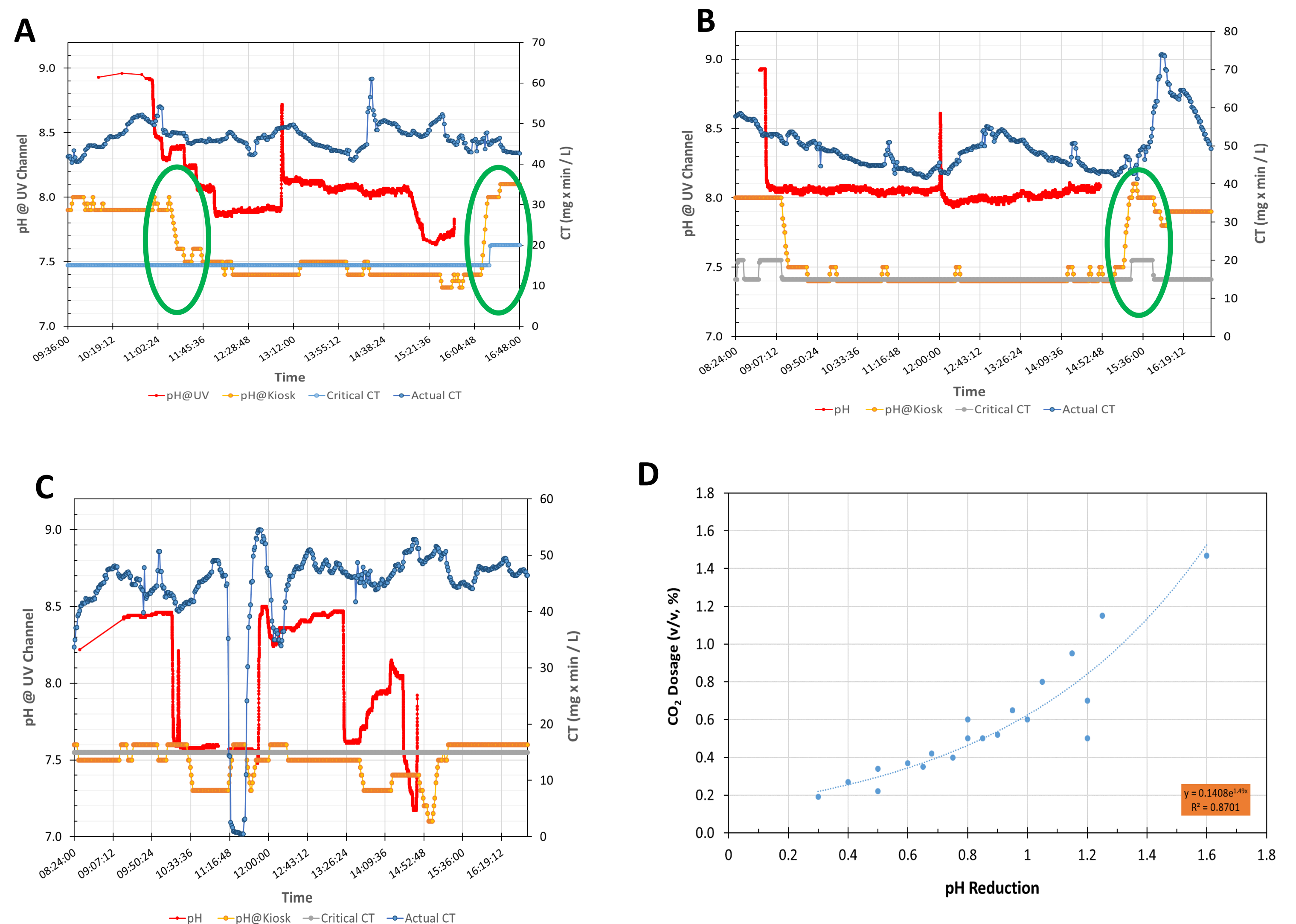


Figure 5A, B, C pH and CT responses to CO<sub>2</sub> dosing in 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> full-scale trials. Figure 5D CO<sub>2</sub> dosage as a function of pH reduction.

## Conclusions

Key results drawn from the trials confirmed the followings:

- Dosing CO<sub>2</sub> is safe - No detectable damage to assets was recorded during the day.
- Dosing CO<sub>2</sub> at the air relief valve gives instant, effective, and efficient pH reduction.
- CO<sub>2</sub> dose rate is around 0.03 (gaseous CO<sub>2</sub>:water, v:v) to reduce pH by 1 unit (from 8 to 7).
- No CCP exceedance happened because of the trial.
- Chlorination performance is probably enhanced by CO<sub>2</sub> dosing.

## Cost Benefit Analysis

Dosing CO<sub>2</sub> @0.3% (v:v) for 80 MLD,

	Chlorine Cost	CO <sub>2</sub> Cost	Total Cost
Chlorine only	\$3,474	\$0	\$3,474
Chlorine + CO <sub>2</sub> dosing	\$3,293	\$303	\$3,596

The CO<sub>2</sub> cost can be almost offset by savings from lower chlorine cost. Meanwhile, recycled water quality will be enhanced due to more efficient chlorination.

## Post-Trial Update

The successful process optimisation has now been adopted as a permanent change in the class A facility at WTP.

### Participants

Dr Lee Wan  
Ravi Appathurai

### Contributions & Acknowledgements

Laboratory experiments, Full-scale trial design & management, Data analysis, Report  
Full-scale trial management