Improving Operational Efficiency at the Gold Coast Desalination Plant (GCDP)

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Abstract

The Gold Coast Desalination Plant (GCDP) has undertaken a program aimed at boosting operational efficiency. This initiative focused on key operational areas and identified several opportunities for improvement which included:

- Optimising chemical dosing e.g. antiscalant suppliers and dosing rates, and Sodium silicate dosing requirements for the Lime Saturators.
- Adjusting Reverse Osmosis (RO) operational setpoints using Machine Learning, and,
- Performing intake bypass reduction trials.

Feasibility of these opportunities was investigated through a staged approach, including desktop assessments, laboratory experiments, and finally, operational trials. The objective of these trials was to demonstrate the effectiveness of efficiency opportunities by achieving operational improvements while strictly adhering to environmental and water quality compliance standards.

Initial trials utilising machine learning for generating Reverse Osmosis (RO) setpoints proved promising. However, permanent adoption proved challenging due to the operational challenges.

The Intake bypass reduction trials also demonstrated good results however, control system and SCADA updates are required to fully realise benefits.

Following the findings from chemical dosing optimisation reviews and subsequent trials, the site achieved a 50% reduction in the cost per Megalitre for antiscalant. Furthermore, the Sodium Silicate dosing trial demonstrated that this chemical is essential for the long-term, sustainable operation of the Lime Saturators.

Introduction

The Seqwater Gold Coast Desalination Plant (GCDP), is a seawater reverse osmosis desalination facility that forms an integral part of the South-East Queensland Water Grid. Located in Tugun, Queensland, the plant is owned by Seqwater and has been operated and maintained by Veolia Water Operations since its commissioning in 2009. The plant is capable of producing 133 megalitres per day of potable water.

Figure 1

Seqwater SEQ Water Grid Map and off-grid water treatment plants

Note. Adapted from "SEQ Water Grid Map" by Seqwater, 2024 (https://www.seqwater.com.au/seq-water-grid). Copyright 2024 by Seqwater.

Like other desalination plants across Australia, GCDP has high energy and chemical use, along with strict water quality and environmental compliance requirements. As a result, improving efficiency is an ongoing focus. Small changes to chemical use, process settings, or energy performance can provide meaningful benefits, but any change must still maintain water quality compliance and be practical for staff to manage.

To support this, the GCDP team undertook an investigation as part of a broader plant improvement program aligned with Veolia's GreenUp strategy. GreenUp is Veolia's global 2024–2027 strategy focused on accelerating ecological transformation through three key themes; decarbonising, depolluting, and regenerating resources.

This review identified the first pass RO system and intake system as areas where energy savings could be made to reduce carbon emissions. In addition, several chemical dosing systems were identified as areas to reduce resource consumption. This paper outlines three initiatives from the investigation; antiscalant usage, sodium silicate in the lime saturators, and Specific Energy Consumption (SEC) review and trials including intake bypass reduction and Machine Learning for RO setpoints.

Discussion

Antiscalant

At GCDP, antiscalant is dosed to both first and second pass RO feedwater to reduce scaling on the membrane surface and help maintain performance. Although antiscalant is a high-cost proprietary chemical, it is offset by the membrane life and performance it helps maintain.

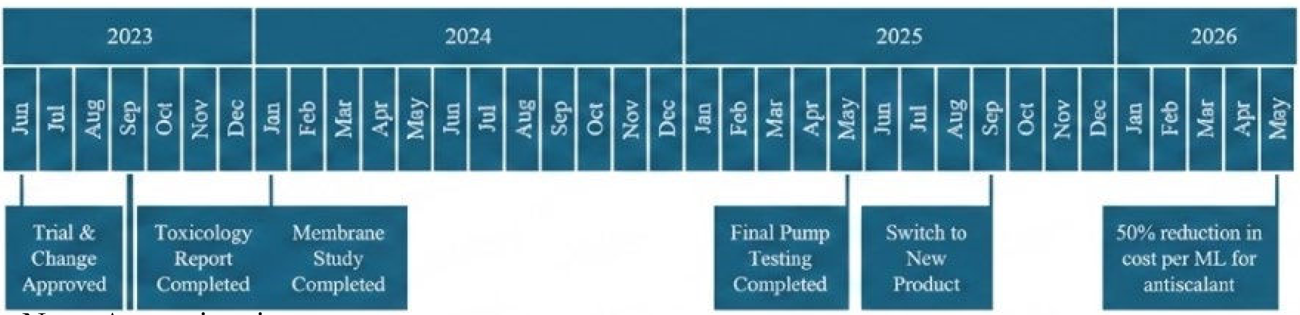
A review of antiscalant use at GCDP was undertaken which identified an opportunity to change product suppliers. Initial modelling of the proposed alternative product identified a number of advantages including lower consumption rates, reduced delivery frequencies and transport costs, ability to bulk supply rather than Intermediate Bulk Container (IBC) supply, a reduction in operational resources required to unload and decant IBCs and subsequent reduced potential for chemical exposure, and lower unit cost. The results of this review demonstrated improved operational outcomes and a significant financial saving potential that warranted further investigation.

Due to the importance of antiscalant in ensuring RO membrane performance, efficiency and integrity, potable water quality requirements and environmental compliance requirements, meant that a transition to a new product could not be made based on theoretical benefits alone. Consequently, a comprehensive due diligence assessment was mandated to evaluate the proposed alternative. This review included the following items

- **Independent Toxicology Assessment** – to confirm the proposed product presented low environmental risk at expected discharge concentrations.
- **Independent Membrane Performance trials** – to demonstrate the suitability of the proposed product for the GCDP membrane systems; and
- **Dosing Feasibility Review** – to confirm the chemical could be safely stored and transferred using existing infrastructure

The process from initial trials to full scale plant implementation took several years to complete, timeline outlined in figure 2, requiring significant upfront work to demonstrate the product was suitable for use while ensuring plant performance, RO membrane integrity, potable water quality and environmental compliance was maintained.

Figure 2
Timeline Outlining Antiscalant Optimisation Process



Note. Approximation

Since implementation the site has observed a 50% reduction in the costs per megalitre for antiscalant usage. Additionally other benefits realised include a reduced number of antiscalant deliveries, improved utilisation of operational resources as IBC transfers are no longer required and the subsequent risk of chemical exposure is avoided. There has been no detected impact to RO membrane performance and no environmental impacts observed within the receiving environment as a result of this change.

The diligence taken in the initial stages of this project demonstrates the proposed product is suitable for use at the GCDP and significantly mitigates multiple risks associated with a product change. Despite this process taking several years, the outcomes achieved significant financial and operational benefits.

Dosing lime saturators with sodium silicate.

Unlike antiscalant, this work was driven more by operability and maintenance concerns than direct chemical cost. Sodium silicate and polyelectrolyte are dosed to the lime saturators to reduce lime water turbidity and assist with solids settling. Compared with polyelectrolyte, sodium silicate is more difficult to manage on site as it crystallises in pipes and tanks. This led to the original bulk storage system being replaced with a temporary IBC-based supply system.

Figure 3

Lime Saturator during accumulated solids removal

This prompted a review of whether sodium silicate dosing could be reduced or removed while maintaining plant performance. A literature review suggested sodium silicate could potentially be reduced or replaced by increasing the polyelectrolyte dosage. Bench-scale results indicated Sodium silicate dosing was not required, saving up to $46,000 per year without adversely affecting the process and mitigating the operational challenges.

As with the antiscalant review, the GCDP team progressed this work through a Management of Change process and staged plant trial. While the revised dosing achieved the required lime water quality, it also caused an unforeseen change in sludge bed characteristics. The altered dose setpoints were only implemented on 2 of the Lime saturators, with 1 saturator maintaining the existing setpoints. Following implementation , the sludge bed over time became denser and severely compacted, additionally the overflow weirs started to build up with fine and soft lime solids rapidly, unlike the hardened solids that normally form over time. Plant production was low at the time of the initial implementation of the trial, hence initially the impacts associated with the change in dosing strategy were not readily visible and the health of the saturator was as expected. Once the plant operated for more prolonged periods the sludge bed became denser and lead to one of the lime saturators scrapers becoming bogged with the solids extraction system unable to operate due to the density of the sludge, hence a vacuum truck was required to remove the accumulated solids and return the saturator to production.

Throughout the trial there were also issues with the sludge extraction system from the lime saturators. The compaction of the sludge bed likely blocked the extraction point, which would have exacerbated the issues observed as sludge was not being adequately removed for a period during the trial.

The trial was stopped and the original dosing setpoints reinstated. The plant trial identified an operational issue not apparent in the bench-scale results and confirmed the important role sodium silicate plays in the lime dosing system.

Currently the lime saturator at GCDP relies on manual sludge blanket level reading to determine the blanket level. Throughout the operational trial, manual assessments of the sludge blanket were conducted using a sludge judge; however, it is suspected that the excessive density of the accumulated solids resulted in inaccurate height measurements from the sludge judge. Post the trial one of the improvements identified was the need for online sludge blanket level monitoring to allow operational staff to have an early indication of a rising blanket and allow the ability to make changes before issues occur. A project is currently in progress to install blanket level detectors on each of the saturators.

The sodium silicate trial revealed that bench-scale laboratory results do not always translate predictably to full-scale plant operations. While the trial aimed to reduce costs annually through reduced sodium silicate dosing and improve operations of the system, unforeseen changes in sludge bed characteristics led to operational challenges, including sludge compaction and extraction system failures. This experience underscored the critical role sodium silicate plays in maintaining lime saturator performance and highlighted the importance of comprehensive monitoring systems (such as online sludge blanket level detection) during operational trials.

Machine Learning and Bypass Reduction and trials

Compared to conventional water treatment, desalination is energy intensive because of the high pressure needed to operate the RO filters. Small improvements in Specific Energy Consumption (SEC) can equate to large financial and environmental benefits. Just like chemical dosing, any changes need to be balanced to ensure that water quality and operational standards are maintained.

SEC improvement was investigated and two related streams of work are outlined below:

- **Machine Learning Optimisation** – used to better understand plant performance and identify opportunities to optimise RO operating setpoints (RO recovery and Permeate flow). This work showed promise, but permanent implementation was challenging due to the practical limits of plant control philosophy and day-to-day operability. To ensure reliable results from the model, ideal operational conditions were required e.g. stable RO feedwater quality, no production changes, or RO train swap overs and continued production over a sustained period. This proved difficult to achieve depending on operational demand for the plant.

- **Bypass Reduction Trials** – To ensure an efficient mixing of the discharge water into the sea, a minimum flow through the plant discharge diffusers is required. At production rates less than 100%, additional flow from the plant influent is redirected and bypassed from the main process stream back into the plant discharge steam to ensure the minimum flow requirement is achieved for efficient mixing at the plant outfall. An initial desktop analysis using historical SCADA data and the Roberts Model showed that reduced bypass flows could still maintain EA compliance with the revised dilution requirement. This work demonstrated a potential saving of 3 to 4% of total SEC. This identified a practical opportunity to reduce intake pump power consumption and lower emissions, however while also highlighting the need for updated alarms, controls, and trial validation before wider implementation. Currently there are a number of Environmental warning alarms on SCADA that have been set based on the current operational setpoints of the plant, the reduction in bypass flow caused a number of these alarms to trigger during the trial. In order to reduce alarm fatigue on the operators a further review of these parameters is currently in progress.

SEC improvement initiatives, including machine learning optimisation and bypass reduction trials, showed promise but revealed practical limitations. Machine learning-based RO setpoint optimisation required ongoing manual operator review and implementation, limiting its effectiveness for permanent automation. Bypass reduction trials demonstrated potential energy savings but exposed the need for updated alarms, controls, and refined operational parameters to prevent alarm fatigue and ensure environmental compliance.

Conclusion

The Gold Coast Desalination Plant's operational efficiency improvement program demonstrates that achieving meaningful gains in energy consumption, chemical costs, and environmental performance requires a balanced, methodical approach that prioritises compliance and operational practicality. The three key initiatives undertaken; antiscalant optimisation, sodium silicate dosing review, and specific energy consumption (SEC) improvements—collectively illustrate both the opportunities and complexities inherent in optimising large-scale desalination operations.

The program reinforces that small, incremental improvements in chemical use, process settings, and energy performance can deliver meaningful operational, financial and environmental benefits. However, any operational change must be carefully validated through staged trials, comprehensive risk assessments, and continuous monitoring to ensure water quality compliance, environmental stewardship, and practical operability are maintained.

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References

SEQ Water Grid Map, by Seqwater, 2024 (https://www.seqwater.com.au/seq-water-grid). Copyright 2024 by Seqwater