Synauta
A GRADIANT COMPANY

CASE STUDY

ML for Reverse Osmosis increases permeate production by 6.2%, reduces CIP frequency

Brackish Mine Water
Reverse Osmosis Plant
Australia

Summary

Cleaning reverse osmosis (RO) membranes is critical to meeting daily production targets and avoiding the high costs of replacing membranes too early. Deciding when to clean a plant currently relies too heavily on guesswork or generic guidelines. Synauta's patent-pending solution predicts the optimal time to clean.

Phase 1: Machine Learning Readiness Report analyzed data, operations, constraints to prepare optimized cleaning recommendations.

Phase 2: Customer operators applied recommended daily set points. Over a two-month trial the Synauta software:

- Produced 6.2% more permeate
- Had 8.7% less cleans, saving on chemicals
- Almost doubled projected membrane life
- Enhanced operator decision making with clear recommendations on when to flush and when to clean.

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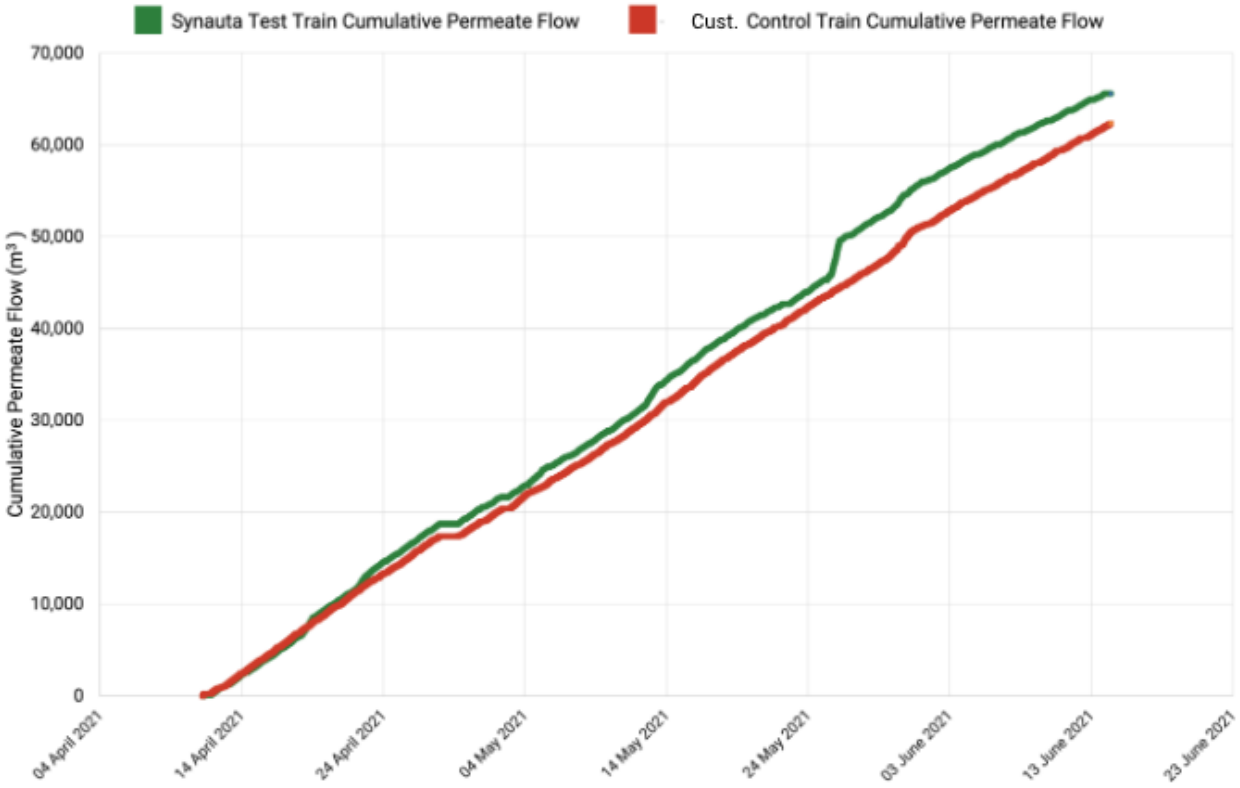
By predicting the best time to flush and clean, 6.2% more permeate was produced, all within operating constraints.

Projected membrane life could be doubled and 8.7% less cleans saved EDTA chemicals.

At a six-month deployment, conservative calculations show $225,000 OPEX savings.



Intro to the desalination plant featured in this case study

The customer operates more than 100 desalination plants around the world. The RO plant in Australia operates on a mine site and is used to concentrate mine tailings water. The concentrate is returned to the pond while permeate is reused per strict environmental regulations.

The plant uses a brackish water RO (BWRO) arrangement, with a reject recycle booster pump. The plant consists of 3 trains producing 790m^3/day per train (2,370m^3/day). Each train has 60 vessels and 4 elements in each. All trains on site had similar run hours logged before beginning the trial.

Challenge

Cleaning RO membranes is critical to meeting daily production targets and avoiding higher costs incurred by needing to replace membranes too early.

When the time between cleans is too short, this means the high and low pH CIP solutions accelerate degradation of the membrane by altering the polymeric surface layer that rejects salts. This reduces membrane life and results in capital costs for earlier replacements. Too long between cleans creates a situation where membrane performance cannot be regained to its prior state, or extreme cleans are required at the risk of irreversibly damaging the membrane.

With plant managers and operators busy ensuring the right quality and amount of water flows from a plant, and the amount of data available to use as inputs for optimizing cleans, it's unlikely anyone is taking the time to calculate the best time to clean or flush membranes to increase permeate production and membrane life.

Solution

Synauta processes a plant's RO data and uses machine learning, combined with operating costs and other relevant inputs, to recommend the best date to clean membranes. For BWRO plants an optimal clean time is recommended, which replaces generic guidelines and operator guesswork.

Synauta's solution sends cleaning recommendations well ahead of time, with a tailored notice period that suits operations, so membrane cleans can be organized without schedule conflict.

To achieve the optimization for BWRO, Synauta predicts the best cleaning time, to produce more permeate within constraints of the plant.

Specifically, for the customer's plant, Synauta also recommended permeate flushing intervals. Whilst less common in the RO industry, permeate flushes are sometimes used in high fouling scenarios to effect osmotic cleaning on the surface of the membrane. Synauta used deep in-house RO expertise to review the plant requirements and recommended this additional step.

To validate Synauta's savings for the customer, Synauta used the following metrics:

- Permeate production between permeate flush cycles
- Permeate production between clean-in-place cycles
- Projected membrane life, as determined by projecting differential pressure (DP) and salt passage increase into the future
- Chemical savings, as measured by comparing chemical cleans between test and control trains.

Business benefits

By applying Synauta's software on the test train, the customer's permeate production increased by 6.2%, the projected membrane life was almost doubled and, by performing 8.7% less cleans, the customer could save on chemical solution.

Combined, the OPEX savings realized through optimized RO for this 2,370m^3/day plant would amount to approximately $225,000 every year.

Increased permeate production means Synauta's customer can treat more water for their client, while remaining in the constraints of the plant and contractual or regulatory obligations.

The opportunity to increase membrane life is also a key driver to better manage cleans. Due to the harsh nature of the feed water at this plant, most membrane replacements are expected after 1-2 years. A method to manage membrane cleans more effectively means greater life expectancy for the business and a smaller annual OPEX budget line for membrane replacement. By cleaning less, the customer can also save on costly cleaning solution. Transportation costs to the remote site for chemical solutions shipped from overseas are reduced. Environmentally, less membranes go into landfill when they are not required to be replaced as early, and CO2e is reduced by shipping less chemical solution globally.

Phase 1: Machine Learning Readiness Report

Phase 1 comprised of a Machine Learning Readiness Report, where Synauta analyzed the plant data available to prepare for optimizing cleaning and chemicals. The report included an audit of flows, pressures, conductivity, energy use, and an ion analysis.

The readiness report identified plant constraints, including contractual obligations and operating conditions, to ensure the plant continues to meet performance targets.

The report also revealed the relevance of cleaning optimization, as well as the great importance of permeate flushing. Synauta's algorithms were subsequently adjusted to suit the business requirements of the plant.

Inputs for the machine learning were considered, such as changing feedwater conditions at the site, as well as the frequency of recommendations for cleans and permeate flushing. Plant data was also cleaned and validated for machine learning.

Plant operators on site (Service Technicians), the customer's remote-control room, and relevant customer stakeholders were briefed on the trial and the approach agreed.

Phase 2: Multiple benefits

Starting in April 2021, using Synauta's recommendations, operators began following the Synauta recommendations for permeate flush and cleaning times on the test train of membranes.

At the same time each morning, the operator on site would receive a notification containing set points for the permeate flush and clean intervals. Synauta also outlined any observations from the data and updates relevant to the trial. A report each day featured progress via different visualizations, such as how much more permeate was being produced.

To ensure no train was at an advantage over another, a test train and control train were selected (using randomized choice) to compare the performance of Synauta's optimizations with membranes under usual conditions.

For this case study, 2 trains have been directly compared as their historic performance was similar, while the third train was removed as its performance was deemed not similar enough for fair comparison.

6.2% more permeate produced

During the trial the cumulative permeate flow of the test train, compared to the control, had a 6.2% increase.

As permeate production increased with time, it was evident that the test train was outperforming the control. This is because, on average, the test train was cleaned in such a way that it maintained a higher permeability over time.

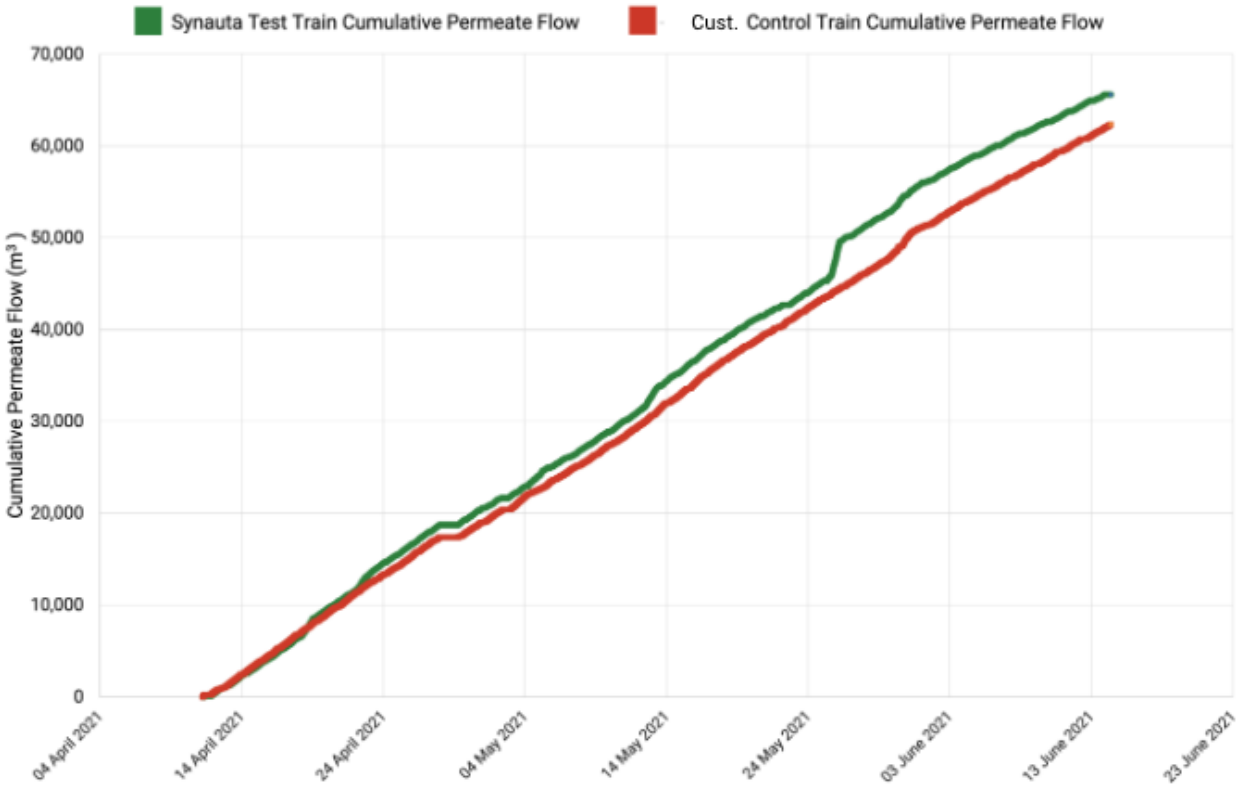


Figure 1: Cumulative permeate production

8.7% less cleans, saving on chemicals

The test train completed four less cleans, delivering an 8.7% saving compared to the control train. While machine learning recommendations saw the test train deliver 1.5% more permeate flushes, given permeate is cheap and chemical solution is expensive, this is an excellent result.

In evaluating this trial, Synauta worked in close collaboration with the customer to understand the nuances of cleans and chemical use at the plant. The site uses EDTA as a cleaning chemical and, while concentrations varied during the trial due to the pandemic, the concentration variation was consistent across the test and control trains.

Projected membrane life almost doubled

Synauta analyzed the differences in DP increase over time in the control train versus the test train (Figure 2). The customer replaces membranes when DP cannot be recovered from approximately 3.0 bar. We also analyzed the increase in Salt Passage over time. With the amount of data available, Synauta made conservative projections into the future regarding projected membrane life.

Salt Passage is not shown in Figure 2, as it was still improving in the test train due to the permeate flush's osmotic backwash effects and not yet restabilized by the time the plant shutdown for the season. Figures 3 and 4 support these projected membrane life results, showing better performance in the test train.

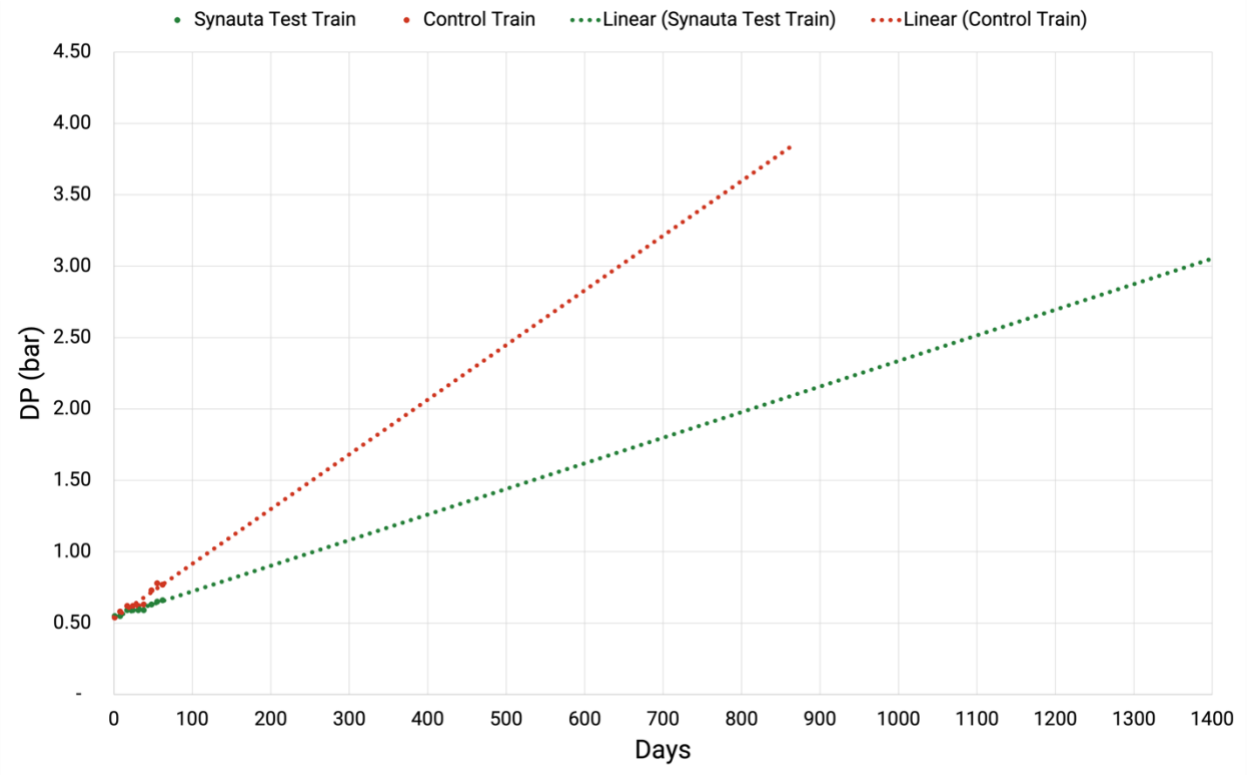


Figure 2: Projected Membrane Life

Compared to the control train, Normalized Salt Passage of the test train improved over time, which is not a regular occurrence to reverse the fouling state of an RO plant. The small number of additional permeate flushes allowed more effective osmotic cleaning of the test train membranes, enabling Normalized Salt Passage to improve.

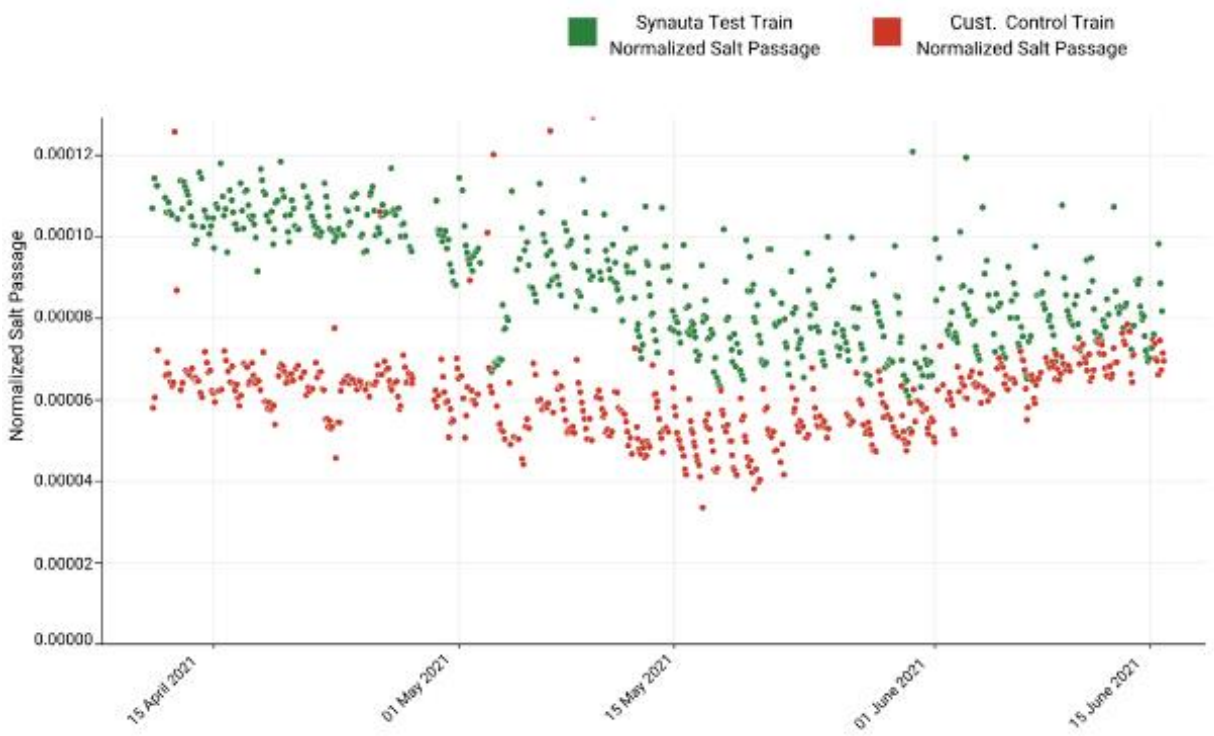


Figure 3: Normalized Salt Passage – Projected Membrane Life

Normalized Differential Pressure (DP) for the test and control trains tracked together until late May, when DP on the control increased dramatically. After this dramatic excursion in the control train DP, cleanings could not recover the DP to the same level as the test train.

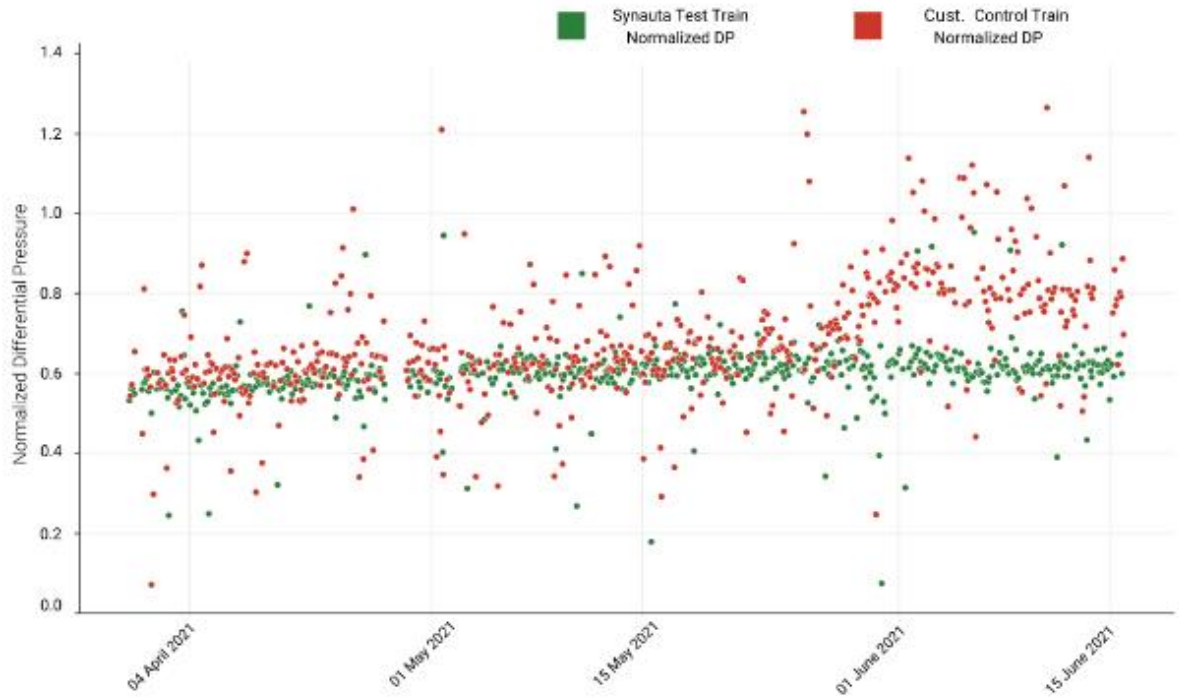


Figure 4: Normalized Differential Pressure - Projected Membrane Life

Enhancing operator decision making

Figure 5 shows permeate flush interval set points were different between the test and control.

Additionally, the data indicates that multiple times, after 1-2 days, operators would apply the same set point on the control train. At times when the control and test set points were markedly different, there was significant advantage to the test train. This shows Synauta's software successfully interpreted the entire context in the data and subsequently made accurate predictions, an excellent result in enhancing operator decision making.

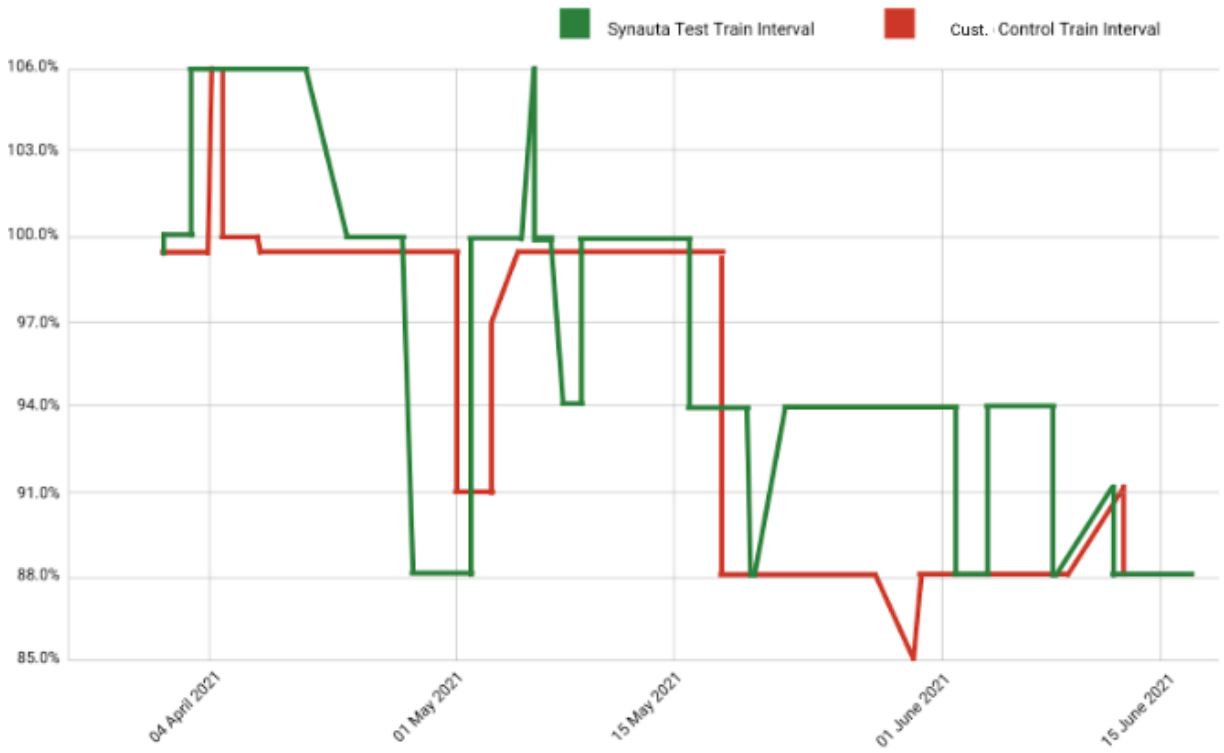


Figure 5: Permeate flush interval

What next?

This trial has strong results and shows machine learning can effectively optimize flushes and cleans at a remote RO plant site with challenging feedwater conditions.

We will also continue to compare trains, gathering additional data and strengthening the conclusions shared in this case study. Synauta also continues to improve our optimization models and realize savings at brackish water and recycled water plants of various capacities around the world.

About Synauta, a Gradiant company

Synauta is a cleantech startup collaborating with desalination innovators around the world. Founded in 2018, our vision is that we all live in a world where energy and water is not wasted.

We currently work with desalination and water reuse leaders in Europe, Australia, the Middle East, Southeast Asia, and North America. Together these companies share our goal of reducing energy and chemical use in reverse osmosis.

To optimize chemical cleans at brackish water plants, using our patent pending approach, Synauta applies a phased process:

- Phase 1 Machine Learning Readiness Report: Answers how much we can save you
- Phase 2 Semi-Auto Mode: Operators receive the optimal time to clean membranes in a format that works for them and the security of your systems

Through our solution we estimate the global industry can save more than 12 million tonnes of CO2e every year (*Synauta Environmental Benefits Quantification Report*, GHD, 2020).

The Synauta team brings a blend of global experience and industry knowledge across water markets, commercialization, and software.

Contact us for a Machine Learning Readiness Report to see how much your plant can save.

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