Final Report

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Environmentally friendly, carbon negative coagulant for wastewater treatment – full-scale trial.

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Contents

1.0 Abstract

This study presents the results of a 30-day full-scale trial evaluating the use of Tanfloc, a tannin-based coagulant, in the Dissolved Air Flotation (DAF) system at the Red Meat Processor's wastewater treatment facility in Inverell, NSW. The project began with an initial site visit, where bench-scale tests were conducted using facility wastewater, followed by replicated full-scale coagulation trials. Based on these trials, recommended upgrades were proposed and implemented by the Red Meat Processor to optimise the DAF system's performance.

The subsequent 30-day full-scale trial using Tanfloc assessed outcomes across sustainability, technical performance, and economic viability. The results demonstrated significant removal rates of Total Suspended Solids (86%), Fats, Oils, and Greases (94%), and Biochemical Oxygen Demand (63%), leading to enhanced wastewater quality and increased sludge recovery. Additionally, the system achieved notable reductions in Total Nitrogen (55%), Total Phosphorus (58%), and Total Dissolved Solids (21%), supporting wastewater reuse measures.

The enhanced sludge characteristics and improved sludge management allowed future anaerobic digestion initiatives, aligning with the Red Meat Processor's sustainability and resource recovery objectives. Moreover, the use of Tanfloc contributed to the recovery of valuable by-products, such as third-grade tallow from the sludge, generating additional revenue for the facility.

These findings confirm the effectiveness of using a tannin-based coagulant which has a lower carbon footprint compared to conventional metal-based coagulants used in DAF systems for wastewater treatment in the red meat sector. The positive outcomes in water quality, sludge management, operational efficiency, sustainability and feasibility highlight its potential for broader industry adoption, reinforcing the benefits of optimised wastewater treatment processes.

2.0 Executive summary

The purpose of this research is to evaluate the use of Tanfloc, a tannin-based organic coagulant, as a sustainable alternative to conventional metal-based coagulants in wastewater treatment at the Red Meat Processor's (RMP) red meat processing facility. The main problem being addressed is the need for more eco-friendly and efficient solutions in wastewater treatment, as traditional methods using metal-based coagulants lead to equipment corrosion, pH adjustments, and a higher carbon footprint. The research findings will help drive the adoption of greener, cost-effective practices in wastewater management within the red meat processing industry. The results will support the transition to sustainable treatment methods, reduce environmental impact, improve operational efficiency, and meet decarbonisation goals, ultimately benefiting industry stakeholders and contributing to the circular economy.

The objectives of the research are:

- Efficient removal of major contaminants to improve the quality of treated wastewater.
- Reduction of greenhouse gas (GHG) emissions and a smaller carbon footprint.
- Enhanced operational efficiency and decreased chemical reliance, particularly in relation to equipment corrosion and pH dosing.
- Improved sludge recovery and management processes.
- Introduction of positive financial outcomes.
- Assessment of the scalability and applicability of tannin-based coagulants in various red meat processing facilities.
- Development of a framework for transitioning to sustainable wastewater treatment practices, setting the foundation for future sustainability efforts in the red meat sector.

The project methodology began with an initial site visit including jar testing and turbidity analysis before and after coagulation and flocculation to evaluate the effectiveness of Tanfloc and polymer for wastewater treatment. It also encompassed an assessment of the existing Dissolved Air Flotation (DAF) system which was optimised along with the dosing system by RMP. After that, a second site visit and a 30-day full-scale trial were conducted to assess the system's performance and the efficiency of the automated Tanfloc and polymer dosing.

To evaluate the efficient removal of major contaminants, wastewater samples were collected before and after DAF treatment and sent to external laboratories for analysis of key water quality parameters, including FOG (Fats, Oils, and Grease), TSS (Total Suspended Solids), TN (Total Nitrogen), TP (Total Phosphorus), COD (Chemical Oxygen Demand), BOD (Biochemical Oxygen Demand) and TDS (Total dissolved Solids).

The findings of this study demonstrate that Tanfloc significantly improves wastewater treatment efficiency by enhancing contaminant removal. The treatment achieved an 86% removal of TSS, 94% removal of FOGs, 63% removal of BOD, 55% reduction in TN, 58% reduction in TP and 21% reduction in TDS, substantially facilitating downstream treatment. This improved separation allows better sludge quality (fit for biogas production) and enhanced recovery of valued-based by-products on site, such as third-grade tallow. Due to reduced BOD in the DAF clarified stream, Tanfloc also leads to reduced energy consumption in aeration in the subsequent wastewater treatment stages. A detailed economic assessment, considering RMP’s operation found a payback period of 1 year if Tanfloc dosing is implemented on site. Offering both economic, operational and sustainable advantages, Tanfloc is particularly beneficial for facilities aiming to integrate resource recovery and sustainability initiatives into wastewater treatment processes.

It is important to note that this trial compared the no-dosing scenario to dosing with Tanfloc, rather than directly evaluating Tanfloc against other coagulant alternatives. While the results indicate significant improvements over no chemical treatment, further research is needed to determine how Tanfloc performs in comparison to conventional coagulants.

The project results present significant advantages for the red meat processing industry such as benefits by improving wastewater treatment, reducing energy consumption, and lowering chemical usage, which cuts operational costs. Tanfloc’s ability to decrease and improve sludge quality, enhance the recovery of third-grade tallow and enable biogas production also supports sustainability goals and enhances resource efficiency compared to metal-based coagulants. Its successful case studies in red meat facilities demonstrates scalability, providing a clear pathway to carbon-neutral wastewater treatment and regulatory compliance across the industry.

To maximise these benefits, the Red Meat Processor should establish a long-term monitoring framework to track wastewater quality, sludge composition, and treatment performance, while conducting regular process audits for optimisation. Additionally, staying proactive in adopting new technologies and reviewing regulatory compliance annually will help align practices with sustainability goals and evolving environmental regulations.

3.0 Introduction

This research project includes the results of a 30-day full-scale trial evaluating the use of Tanfloc, a tannin-based coagulant, in the Dissolved Air Flotation (DAF) system at the Red Meat Processor’s wastewater treatment facility in Inverell, NSW. The study evaluates the sustainability, technical performance, and economic feasibility of this innovative coagulant as an alternative to conventional metal-based coagulants used in DAF systems for wastewater treatment in the red meat sector.

Key objectives include:

- Efficient removal of key contaminants to enhance the quality of treated wastewater.
- Mitigation of greenhouse gas (GHG) emissions and a lower carbon footprint.
- Operational efficiencies and reduced chemical dependency related to equipment corrosion and pH dosing, respectively.
- Improved sludge recovery and management.
- Financial positive benefits.
- Assess the scalability and applicability of tannin-based coagulants across different red meat facilities.
- Establish a framework for transitioning to a sustainable wastewater treatment process, setting future sustainability initiatives in the red meat sector.

Providing data-driven insights into the use of Tanfloc at the Red Meat Processor (RMP) will support their broader adoption across the red meat industry. This aligns with the industry's environmental responsibility and decarbonisation goals, facilitating a shift toward low-impact, resource-efficient wastewater treatment while reinforcing circular economy principles.

4.0 Project Objectives

The main goal of this project is to assess the sustainability, technical performance, and economic feasibility of using Tanfloc—a carbon-negative, tannin-based organic coagulant—in DAF systems of wastewater treatment in the red meat sector. This innovative coagulant is explored as an alternative to conventional metal-based coagulants commonly used in the industry. A detailed breakdown of the project's objectives is presented in Figure 1 below.

Efficient removal of key contaminants to enhance the quality of treated wastewater
The project evaluates the removal efficiencies of key wastewater contaminants to achieve improvements over existing performance benchmarks. By optimising the coagulation process, Tanfloc enhances the quality of treated wastewater. This improvement supports environmental compliance, reduces the burden on downstream treatment processes, and increases opportunities for water reuse in industrial operations.

Mitigation of greenhouse gas (GHG) emissions and a lower carbon footprint
The project emphasises the environmentally sustainable characteristics of Tanfloc, including its carbon-negative production process, 100% biodegradability, and suitability when prioritising carbon-neutral and sustainable practices. Additionally, improved wastewater treatment efficiency minimises energy consumption and associated emissions, supporting decarbonisation efforts.

Operational efficiencies and reduced chemical dependency related to equipment corrosion and pH dosing, respectively
The project highlights Tanfloc's non-corrosive nature, unlike traditional metal-based coagulants, which helps extend equipment lifespan, reduce maintenance costs, and enhance operational reliability. Additionally, it emphasises the reduced need for pH adjustments, minimising chemical use and improving process efficiency.

Improved sludge recovery and management
The project explores the use of Tanfloc, which leads to lower sludge volumes and improved recovery of valuable by-products such as tallow. Additionally, it highlights Tanfloc's suitability for resource recovery applications, including anaerobic digestion for biogas production, as the heavy metal-free sludge it produces supports circular economy practices.

Financial positive benefits
The project includes a cost assessment of Tanfloc's use at Bindaree Food Group, evaluating potential operational savings such as aeration, and additional revenue generation through enhanced resource recovery, such as improved tallow extraction.

Assess the scalability and applicability of tannin-based coagulants across different red meat facilities
A key focus of this study is assessing Tanfloc's performance across various red meat processing plants. Through data-driven analysis, it aims to evaluate its effectiveness and adaptability across different facilities.

Establish a framework for transitioning to a sustainable wastewater treatment process, setting future sustainability initiatives in the red meat sector
The study aims to create a structured approach for integrating the use of Tanfloc as a sustainable, low-impact wastewater treatment solution in the red meat industry. This will serve as a foundation for future environmental initiatives, supporting industry-wide efforts toward carbon-neutral and resource-efficient operations.

Figure 1. Project objectives.

5.0 Methodology

To execute this project the following materials and methods were used:

5.1 Materials

5.1.1 Natural tannin-based coagulant – Tanfloc

A carbon-negative coagulant, produced in Brazil from acacia tree, composed of a brown powder that is non-toxic and non-corrosive. For this project, Tanfloc was supplied by Tanfloc Australia in its standard commercial form: 1,000L IBCs at 20% w/v concentration. Figure 2 shows the coagulant's IBCs delivered on-site.

Figure 2. Tanfloc's IBCs on Bindare's site.

5.1.2 Flocculation Polymer

To execute the 30-day full-scale trial at the Red Meat Processor, SNF's anionic emulsion polymer EM533 was used. The polymer dosage for the studied application was between 0.1% and 0.8% (1–8 g/L for the polymer solution). For jar testing, a 0.1% solution was used. However, for the trial, a higher concentration of 0.8% was prepared. Figure 3 shows a 20L SNF emulsified anionic polymer EM533 bottle used in the 30-day full-scale trial.

Figure 3. SNF's emulsified anionic polymer EM533 used in the 30-day full-scale trial.

5.1.3 Jar Test

The VELP FP4 portable flocculator and VELP portable turbidimeter were used for jar tests in the initial and second site visits at RMP's site. Figure 4 shows the equipment used in the jar tests.

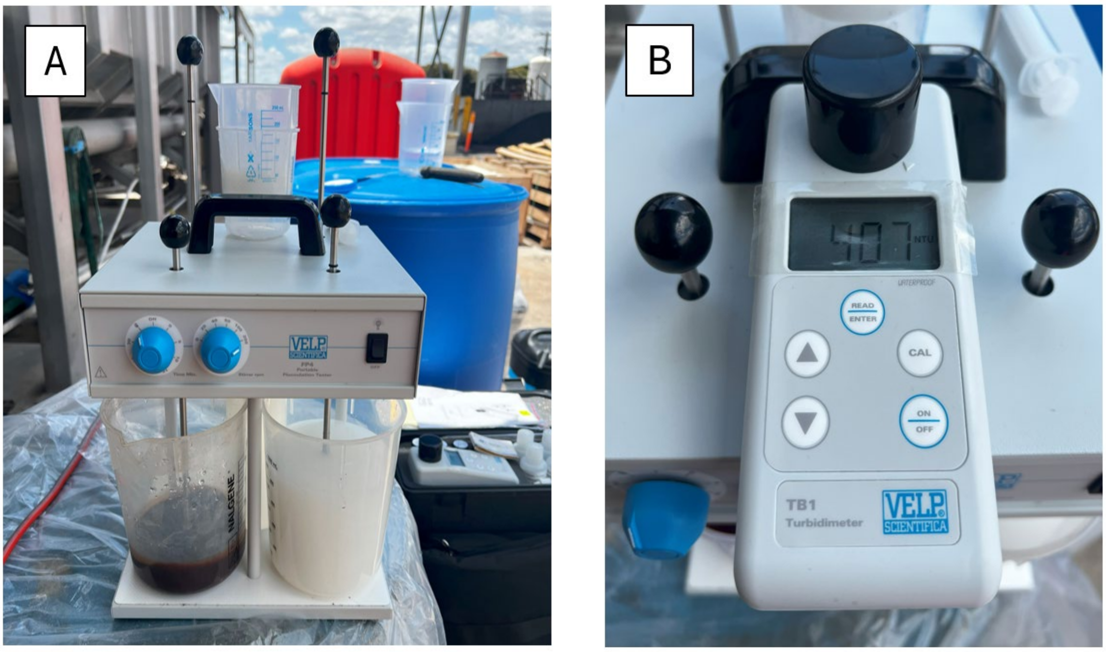

Figure 4. VELP FP4 portable flocculation tester (A); VELP TB1 portable turbidimeter (B).

5.1.4 Dosing System

A dedicated dosing system was designed and installed in collaboration between Tessele Consultants and RMP.

The coagulant dosing system consists of a signal-controllable dosing pump (120 L/h and 4 bar) connected to an Intermediate Bulk Container (IBC) for chemical storage, with secondary containment bunding provided to prevent spills. The dosing pump is configured to deliver coagulant in proportion to the DAF inflow rate, ensuring consistent chemical application.

The polymer dosing system includes a polymer make-down skid and an agitated tank. The make-down skid is used to prepare the polymer solution to the required concentration before dosing, while the agitated tank ensures uniform mixing and polymer inversion (500 rpm for 15 minutes). The system includes a signal-controllable polymer dosing pump, with a capacity of 200 litres per hour and a pressure rating of 4 bar. It is also equipped with level sensors to monitor chemical inventory and prevent interruptions in dosing.

Additional infrastructure was installed to support the system, including protective shading for the polymer skid, bunding for the polymer's IBC, and various adaptors and fittings to ensure compatibility with the existing infrastructure. The final configuration of the dosing system is shown in Figure 5.

It is important to note that RMP had no prior chemical dosing system in place and had not previously trialled any coagulants or flocculants. This trial is an innovative initiative to assess the effects of chemical dosing at the DAF. However, it does not explore all available market options, such as metal-based coagulants.

Figure 5. Dosing system configuration. From left to right: neat polymer IBC, polymer tank, make-down skid and Tanfloc IBC bunding. In the background, the pre-DAF tank appears on the left, followed by the DAF on the right-hand side.

5.2 Methods

5.2.1 Jar Test

Jar tests are essential for assessing the effectiveness of a treatment process on a small scale. The VELP FP4 portable flocculator and VELP portable turbidimeter were used for this purpose in this project. Tanafloc specialists conducted on-site tests during both site visits (May 2024 and November 2024).

A standard procedure was followed for each jar test:

1. Wastewater was collected from the pipe leaving the pre-DAF tank using four 500 mL plastic beakers.
2. pH and turbidity of the raw wastewater were measured.
3. The coagulant was dosed at varying rates (typically 0.1–1 mL/L).
4. The solution was mixed at 100 rpm for 2 minutes, then at 50 rpm for 10 minutes.
5. The polymer was added at a fixed dose (typically 0.5 or 1 mL/L for all beakers).
6. The solution was mixed again at 50 rpm for 10 minutes
7. The beakers were left without any agitation for a minimum of 5 minutes and then filtered using paper filters.
8. The filtrate was analysed for turbidity.

Treatment efficiency was assessed by measuring the reduction in wastewater turbidity before and after coagulation and flocculation since turbidity analysis is a cost-effective way to evaluate treatment performance.

5.2.2 Full-scale dosing and additional tests

Considering the chemical dosing system previously described, the coagulant injection point was set at the top of the pre-DAF tank, with a hose running from the dosing pump to the top of the tank (approximately 15 metres high).

Since the tank had an in-built mixing motor, it was assumed that the provided mixing gradient and hydraulic retention time (HRT) would be sufficient for proper coagulant dispersion.

It is known that polymer requires contact time with the coagulated wastewater, however injecting the polymer into the same tank as the coagulant is not recommended, as coagulation requires time to take effect, and premature polymer addition could interfere with this process. Thus, the polymer injection point was placed into the pipe connecting the pre-DAF tank to the DAF. This included several turning joints, which were assumed to function as a flocculation zone, provided by turbulence from the bends.

During critical phases of the project, as detailed in this report, samples were collected before and after the DAF and analysed in a certified laboratory to evaluate overall treatment efficiency in terms of FOG, TSS, TN, TP, and BOD removal. The "before DAF" samples were obtained by scooping wastewater from the pre-DAF tank, while the "after DAF" samples were collected from the DAF outlet pipe via an installed tap. To minimise variability, it was recommended that sampling be conducted at the same time each day (12:00 AM).

5.5 Project Stages and Schedule

During the initial site visit in May 2024, the focus was on understanding the system's operation, informing site personnel about the planned trial, and installing the preliminary dosing system using pre-procured materials for the project. This stage also included bench-scale tests that were conducted using facility wastewater, followed by replicated full-scale trials. The daily activities carried out during this visit are detailed in Figure 6 below.

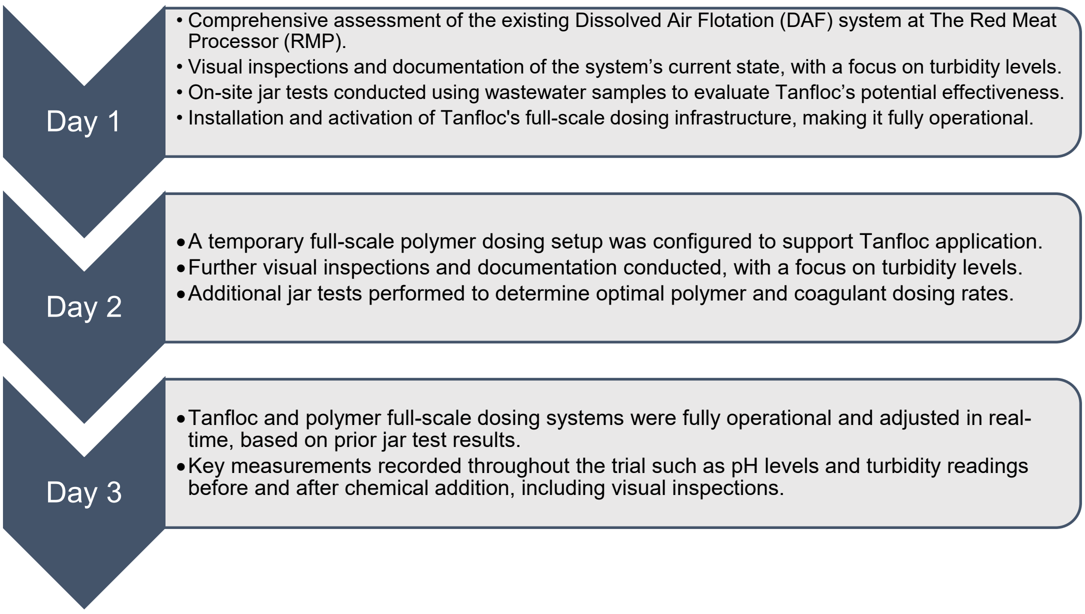

Figure 6. Initial site visit trial daily actions.

This phase also included the development of a DAF optimisation strategy, aimed at improving the system performance and enhancing the effectiveness of coagulant application in the subsequent trial.

Following the proposed DAF optimisation strategy, technical improvements were implemented by RMP's site personnel ensuring the procurement of recommended parts for their DAF. RMP's maintenance and operations teams contributed significantly by commissioning the additional infrastructure, including programming a supervisory system to follow the KPIs during the subsequent trial.

The second site visit, which occurred at the end of November 2024, was accomplished once the recommended infrastructure for RMP's DAF was commissioned on-site. The trial's daily actions are shown in Figure 7 below.

Day 1

- Inductions, safety briefing, and site walk through.
- Assessment of DAF performance: Dissolved saturation pressure (DAS), recycle rates, bubbles formation, flow rates.
- Definition of key performance indicators (KPIs) and expected outcomes.

Day 2

- Control and automation checks (Functional Control Descriptions).
- Tanfloc and polymer jar testing to determine optimal dosing rates.
- Equipment and material assessments (dosing pumps, polymer makeup skid, hoses, connections, and power/water supply).
- Checklist finalisation and preparation for automated testing.

Day 3

- Start of automated coagulant and polymer dosing.
- Monitoring, fine-tuning, and performance assessments (SCADA data, KPIs, and success measurements).
- Qualitative observations (foam, sludge thickness, third-grade tallow colour, clarification chamber).
- Preliminary documentation of results and challenges, including operator training and checklist creation.

Day 4

- Scheduling and planning for the subsequent three weeks of the trial.
- Coordination of coagulant manufacturing and supply.
- De-briefing and packing up.

Figure 7. Second site visit trial daily actions.

To assess the subsequent 30-day trial and evaluate the DAF performance under different conditions, samples were taken before and after the DAF, and analysed externally by a certified laboratory, during three periods: (1) before the equipment upgrades – January 2023 and April 2024, (2) post-upgrades without chemical dosing – August 2024 to November 2024 and (3) post-upgrades with chemical dosing – December 2024 to January 2025.

It is important to note that Tessele Consultants coordinated the supply of chemicals for both trials. Additionally, RMP's efforts in providing the recommended DAF infrastructure were instrumental in the success of the 30-day full-scale trial.

6 Results

6.1 Initial Site Visit (May 2024)

During the first site visit, jar tests were conducted at around 4 pm. It was observed that the wastewater had a pH above 10, significantly higher than the expected average of 7.8. Despite this high alkalinity, Tanfloc performed well. However, a higher dosage—1.5 mL/L of Tanfloc and 1 mL/L of anionic polymer (0.1% active)—was needed to achieve the same results as previous laboratory tests, where only 0.4 mL/L of Tanfloc was used. Figure 8 shows the liquid-solid separation achieved after dosing 1.5 mL/L of Tanfloc and 1 mL/L of anionic polymer.

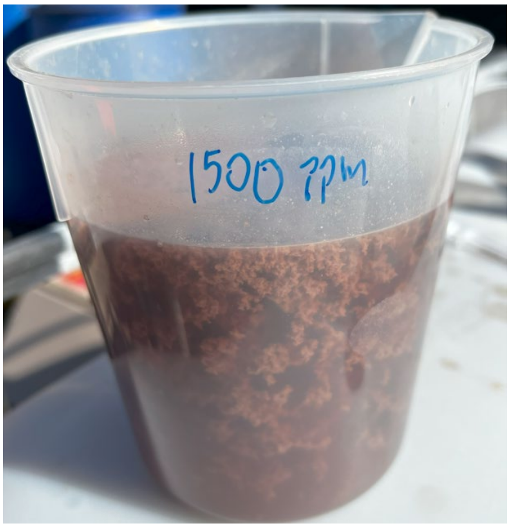

Figure 8. Liquid-solid separation after the chemical dosing of 1.5 mL/L of Tanfloc and 1 mL/L of anionic polymer (0.1% active).

At RMP, the killing process works in shifts, usually ending at 3 and 11 pm, each followed by a cleaning process, which uses 250L of a cleaning product to disinfect the processing floor. Thus, it was the main cause of the variation in pH in the test accomplished at 4 pm.

The existing 50 m³ tank pre-DAF is not sufficient to neutralise the wastewater load, which arrives at an average rate of 70 m³/h but peaking at over 115 m³/h from 5:30 am to 3 pm. A tank capable of holding at least 8 hours of effluent at a standard flow rate is recommended.

On the following days, when jar tests were conducted during the morning, the required chemical dosing was consistent with those accomplished in laboratory, requiring only 0.5 mL/L of Tanfloc and 0.5 mL/L of anionic polymer (0.1% active) to flocculate 1 L of wastewater, removing approximately 97% of its turbidity as shown in Table 1.

Table 1. Wastewater turbidity before and after the coagulation test.

Wastewater	Turbidity (NTU)
Pre-DAF Wastewater	1,964
Wastewater after chemical dosing of 0.5 mL/L of Tanfloc and 0.5 mL/L of anionic polymer (0.1% active)	63.6

Initially, polymer dosing was not included in the project scope. Its inclusion was based on site conditions, including wastewater characteristics and DAF operational efficiency. Notably, Tanfloc functions as both a coagulant and a flocculant. However, its effectiveness depends on optimal DAF operation, ensuring sufficient dissolved oxygen in the form of microbubbles to suspend particles. Since this condition was not met on-site, polymer dosing became necessary to enhance floc formation and improve particle suspension.

The Tanfloc and polymer dosing pumps on-site were capable of delivering the required dosing rates based on the positive outcomes of the jar test. However, for the 30-day trial, finely tuned, specially designed pumps were recommended to accommodate potential variations in dosing requirements based on the DAF inlet stream.

After 1 hour of combined natural coagulant and polymer dosing in the DAF by the preliminary dosing system, a clear improvement was observed in the suspended solids in the top layer. The flocs became larger and the emulsion was largely broken, as illustrated in Figure 9.

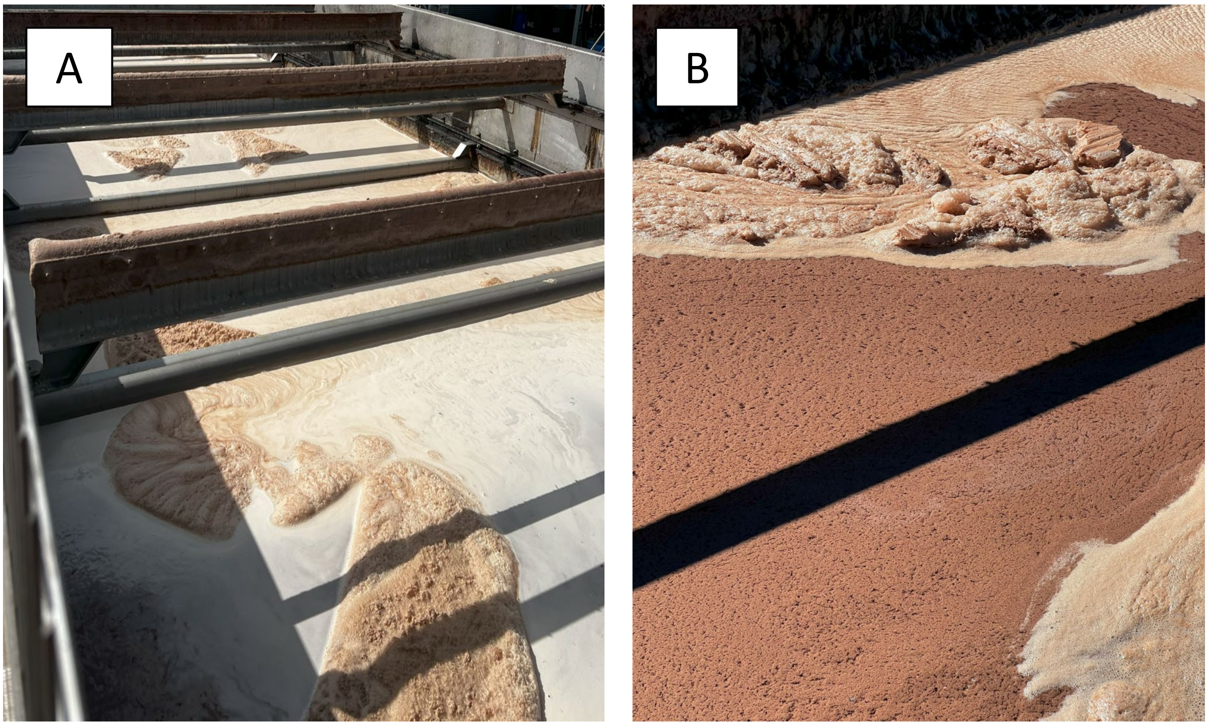

Figure 9. DAF top layer before (A) and after (B) Tanfloc and polymer dosing.

With the preliminary dosing functioning, the floated sludge exhibited improved consistency and captured a higher amount of solids, oils, and greases. As a result, the clarified stream from the DAF system showed greater purity and less turbidity (about 70% less, according to turbidimeter readings before and after DAF). Since the sludge is efficiently removed from the surface and directed to the sludge handling system for further processing or disposal, there was a notable improvement in sludge recovery. This was evident from the rapid increase in sludge tank levels compared to previous days without chemical dosing.

The enhanced removal of Total Suspended Solids (TSS) and Fats, Oils, and Greases (FOG) by Tanfloc effectively redirected these contaminants into the sludge, leading to greater sludge formation. Importantly, improved FOG capture in the sludge directly contributes to increased third-grade tallow production, further enhancing resource recovery. However, some flocs were still carried into the final clarified water stage of the DAF (Figure 10), indicating persistent aeration inefficiencies in the DAF.

Figure 10. Flocs were in the final clarified water stage of the DAF.

Overall, the preliminary dosing system exhibited strong performance. Additionally, site personnel reported a noticeable improvement in both the recovery and quality of third-grade tallow in RMP's tricanter. For instance, the third-grade tallow exhibited a more yellowish colour, suggesting improved capture of oils and grease.

The initial visit encompassed a DAF optimisation strategy, aimed at improving the system performance and enhancing the effectiveness of coagulant application in the subsequent trial. The DAF assessment and optimisation strategy is detailed described in Appendix 1. The technical improvements implemented in the DAF by RMP's site personnel are presented in Appendix 2.

6.2 Second Site Visit (November 2024) and following 30-day full-scale trial

6.2.1 Jar Test

Tests conducted during the second site visit indicated significant fluctuations in turbidity levels in the wastewater stream before the DAF. Turbidity ranged from approximately 400 NTU in the morning (around 8 AM) to 1,500 NTU in the afternoon (around 3 PM). This variation is attributed to different operational processes at RMP.

A cleaning cycle occurs after the second shift ends at 11 PM, leading to a more diluted effluent by morning, as the DAF remains idle until the next shift begins at 7 AM. Throughout the day, animal processing and deboning activities generate a substantial organic load, contributing to increased turbidity in the afternoon.

A jar test executed around noon 10 AM demonstrated a 99% turbidity reduction with coagulant and polymer dosages of 0.8 mL/L and 0.5 mL/L (0.8% active). Turbidity values before and after the jar test along with the visual assessment are presented in Table 2 and Figure 11, respectively.

Table 2. Turbidity levels before and after jar test.

Wastewater	Turbidity (NTU)
Pre-DAF Wastewater	974
Wastewater after chemical dosing of 0.8 mL/L of Tanfloc and 0.5 mL/L of anionic polymer (0.8% active)	3.20

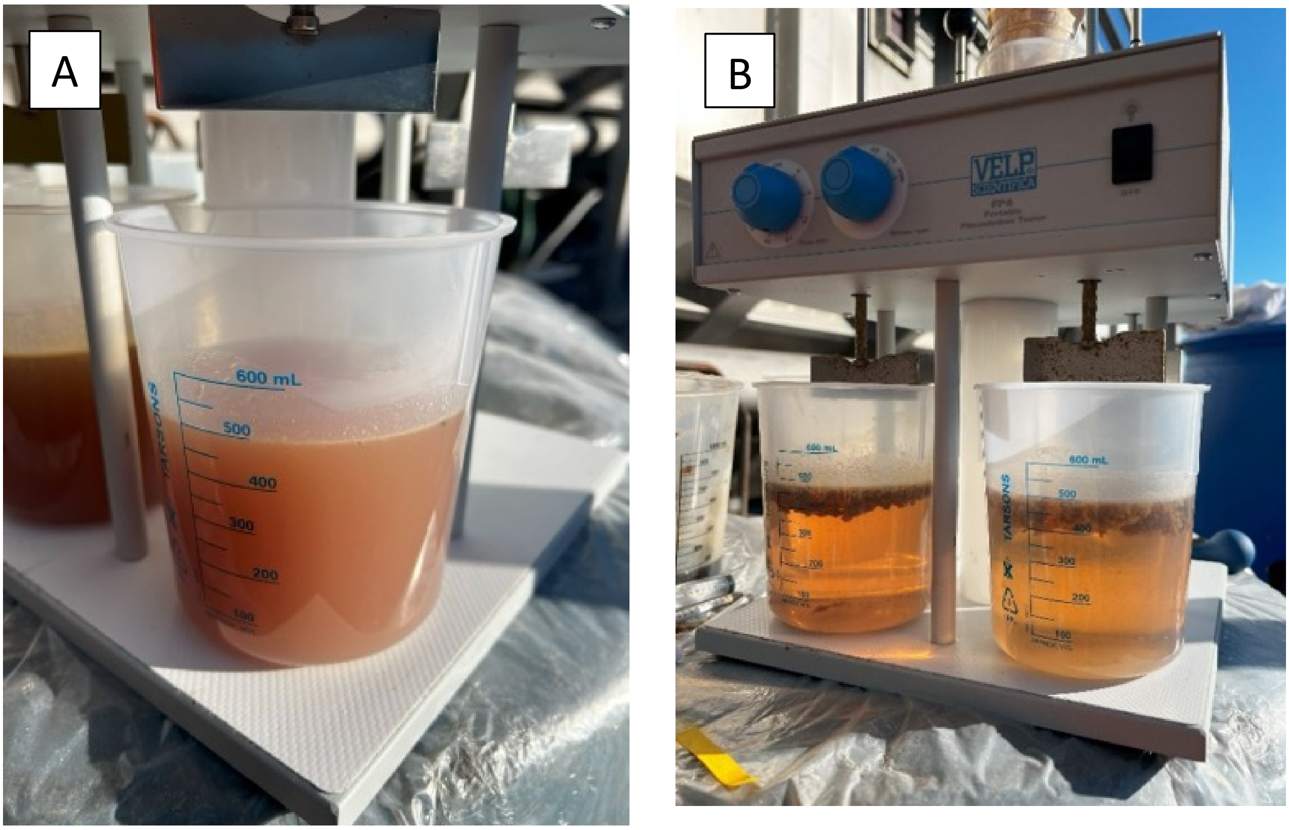

Figure 11. Visual assessment of the jar test. Before jar test (A). After jar test (B).

6.2.2 Removal Efficiencies of Key Contaminants

Based on the jar test analysis, a fixed dosing rate of 0.8 mL/L of coagulant and 0.5 mL/L of polymer (0.8% active) was applied in the full-scale dosing trial, which started on the 28th of November at 2 pm and finished on 20th of January, with a quick break between 20th of December to 5th of January 2025 due to plant maintenance shutdown and holidays.

Although the chemical dosing pumps operated proportionally to the DAF inlet flow rate, turbidity fluctuations require continuous monitoring and adjustment for optimal chemical application. To enhance process control and chemical efficiency, integrating in-line turbidity and Total Suspended Solids (TSS) meters with an advanced dosing control system—such as feed-forward or proportional-integral-derivative (PID) control—is recommended. This would enable real-time dosing adjustments based on influent characteristics, improving both chemical efficiency and overall treatment performance.

It is important to note that the optimal dosing rates identified during jar tests are based on achieving the highest removal efficiencies. However, in practical operating conditions, chemical dosing rates should be balanced to meet both treatment performance and economic targets.

Process performance improvements were observed during the first day of chemical dosing (Figure 12). The clarified water chamber showed no visible suspended particles, a significant improvement from observations in the initial site visit, where insufficient bubble formation in the DAF had caused particulate carryover into the treated wastewater. Additionally, the sludge produced was noticeably thicker, further indicating enhanced separation efficiency within the DAF system.

Figure 12. Clarification chamber before chemical dosing (A). Clarification chamber after chemical dosing (B). DAF reservoir before chemical dosing (C). DAF reservoir after chemical dosing (D).

To assess the 30-day trial and evaluate the DAF performance under different conditions, samples were taken before and after the DAF, and analysed externally by a certified laboratory, during three periods as shown in Figure 13.

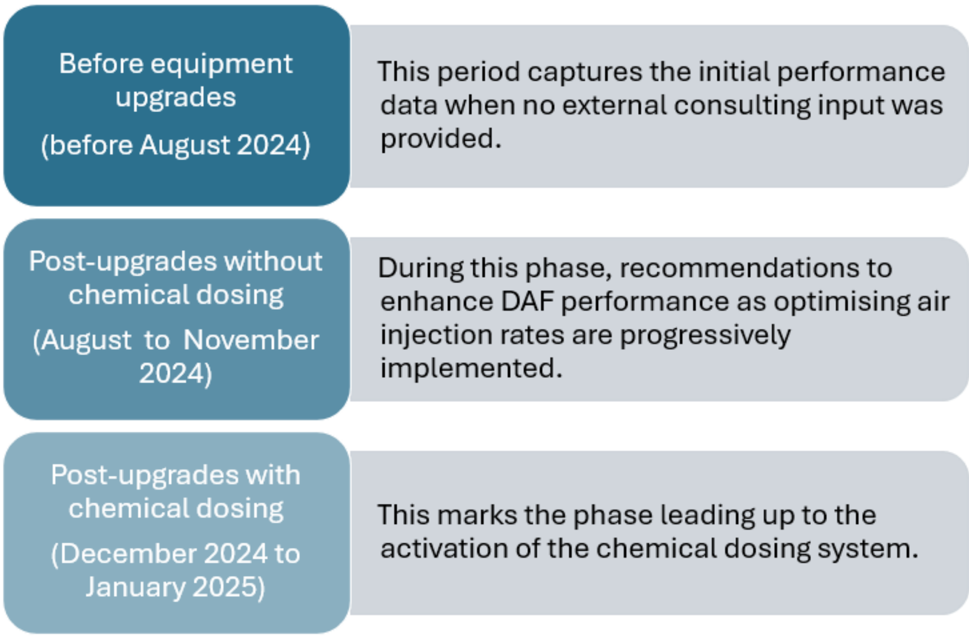

Figure 13. Analysis periods during the dosing trial.

By segmenting the data into these periods, it becomes possible to evaluate the incremental effects of each improvement step and observe the continuous optimisation of the system. RMP has proactively monitored wastewater quality before and after the DAF as part of its internal efficiency tracking process, collecting wastewater samples and sending them to external laboratories for analysis. This has been instrumental in tracking the equipment's performance over time.

The implementation of Dissolved Air Flotation system upgrades in August 2024, followed by the introduction of the chemical dosing in December 2024, resulted in quantifiable improvements in the removal efficiencies of Total Suspended Solids (TSS), Fats, Oils, and Greases (FOGs), and Biochemical Oxygen Demand (BOD). The initial DAF modifications enhanced flotation performance, while the addition of chemical dosing further improved the coagulation and flocculation processes, leading to higher contaminant separation rates, as shown in Figure 14.

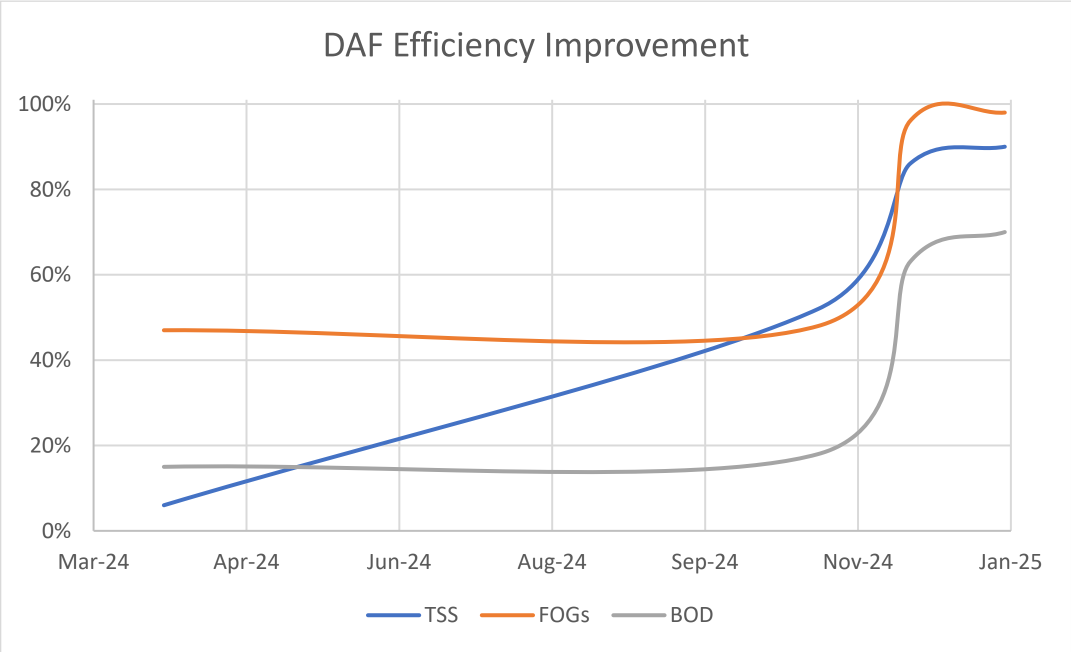

Figure 14. DAF efficiency improvement across periods (%).

Figure 15, Figure 16 and Figure 17 show the TSS, BOD and FOG average values in each analysis period, respectively.

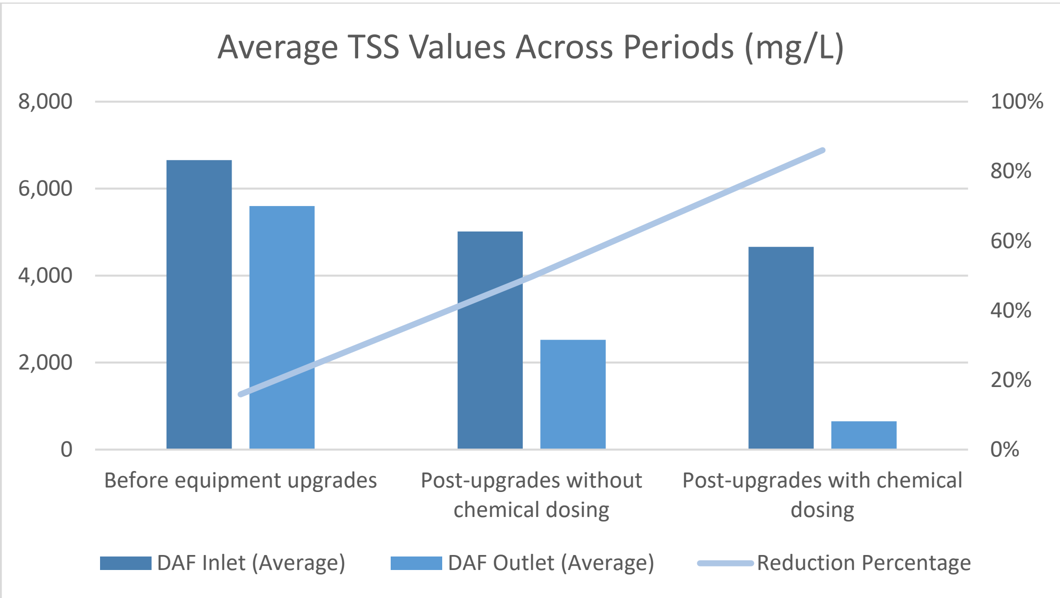

Figure 15. Average TSS values across periods (mg/L).

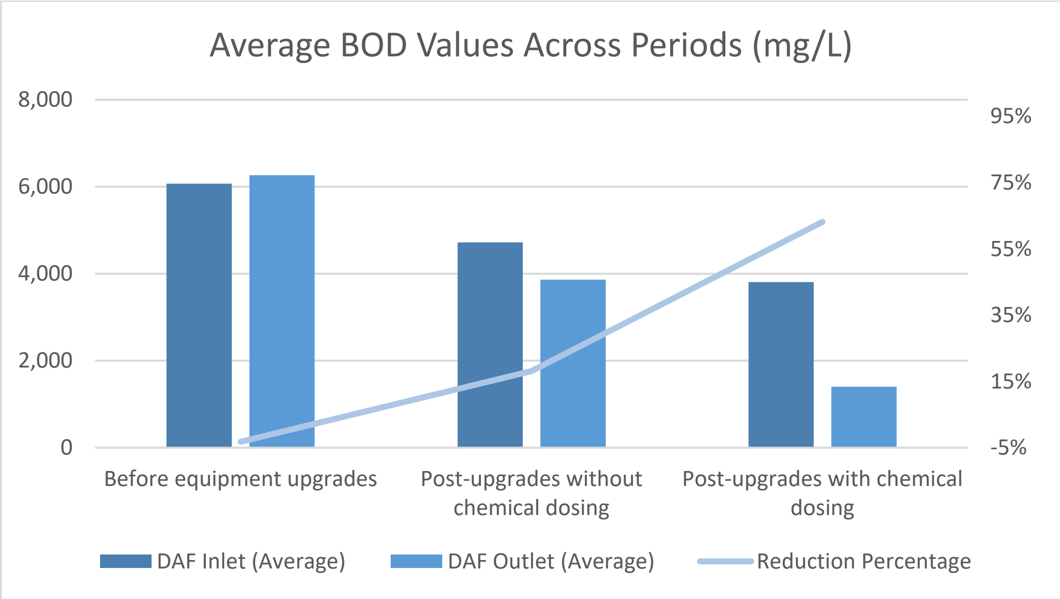

Figure 16. Average BOD values across periods (mg/L).

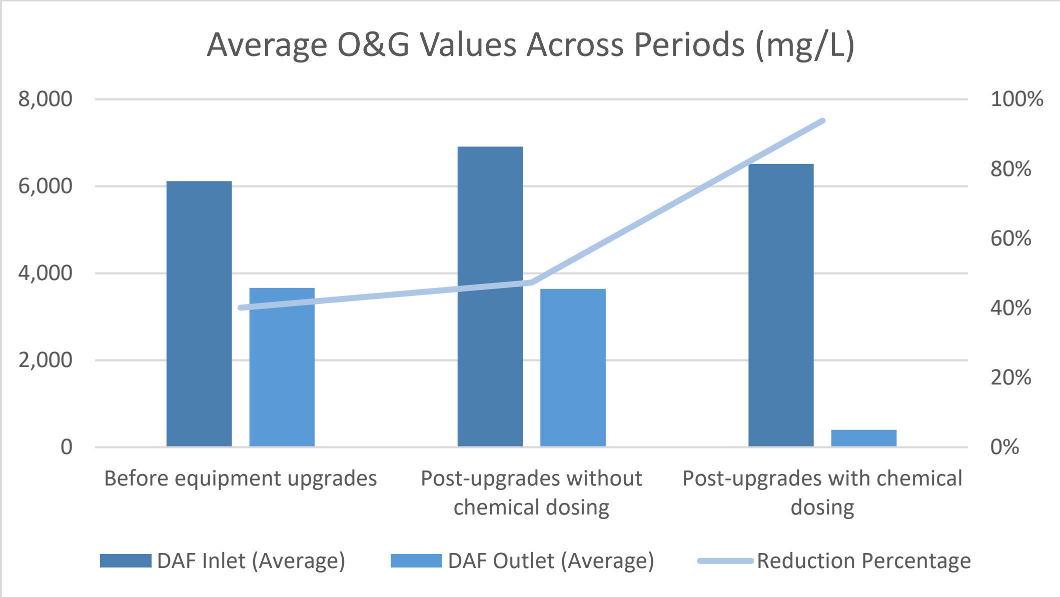

Figure 17. Average FOG values across periods (mg/L).

The upward trend in TSS, BOD and FOG removal rates from before equipment upgrades to post-upgrades with chemical dosing was notable, increasing from 16% to 86% for TSS, from -3% to 63% for BOD and from 40% to 94% for FOG.

Due to the high FOG value detected in the results—likely influenced by localised sampling near accumulation zones or poor mixing—the DAF inlet average for this period was calculated using data from both pre-upgrade and post-upgrade periods. This isolated measurement may not accurately reflect overall system conditions, as flow patterns cause FOG concentrations to fluctuate. Despite these measurements, variations in wastewater characteristics throughout the day can impact FOG levels, as illustrated in Figure 18, which shows fluctuations in the pre-DAF tank at RMP.

Figure 18. Pre-DAF tank surface at different times of the day (A) 11:25 am; (B) 7:00 am; (C) 2:00 pm; (D) 1:40 pm.

Despite this, the chemical dosing system effectively contributed to removing more than 90% of the measured FOG, demonstrating its efficiency in the treatment process.

Figure 19, Figure 20 and Figure 21 show the TN, TP and TDS average values before equipment upgrades and post-upgrades with chemical dosing.

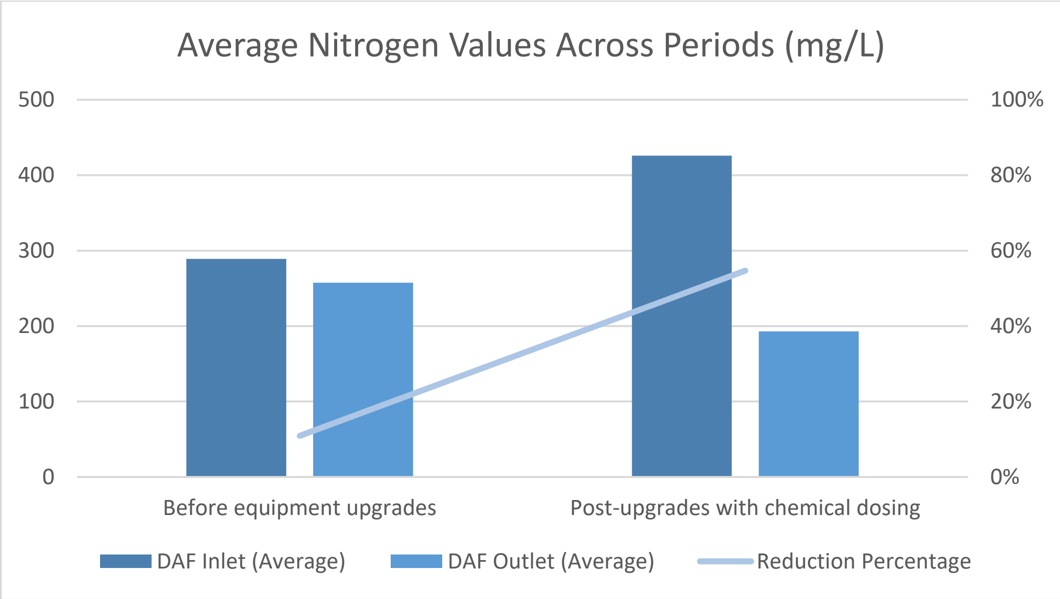

Figure 19. Average nitrogen values across periods (mg/L).

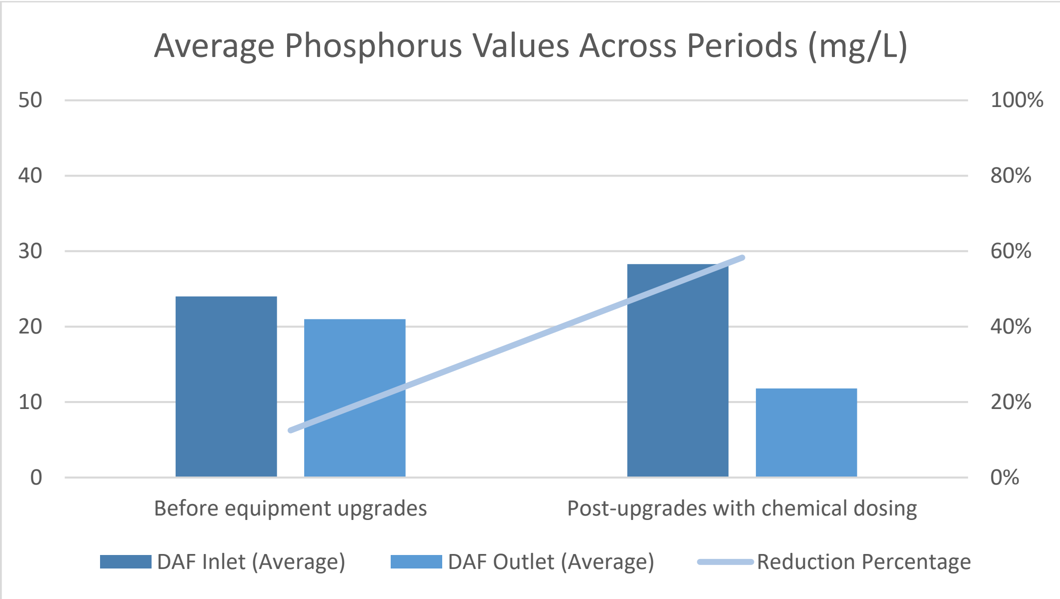

Figure 20. Average phosphorus values across periods (mg/L).

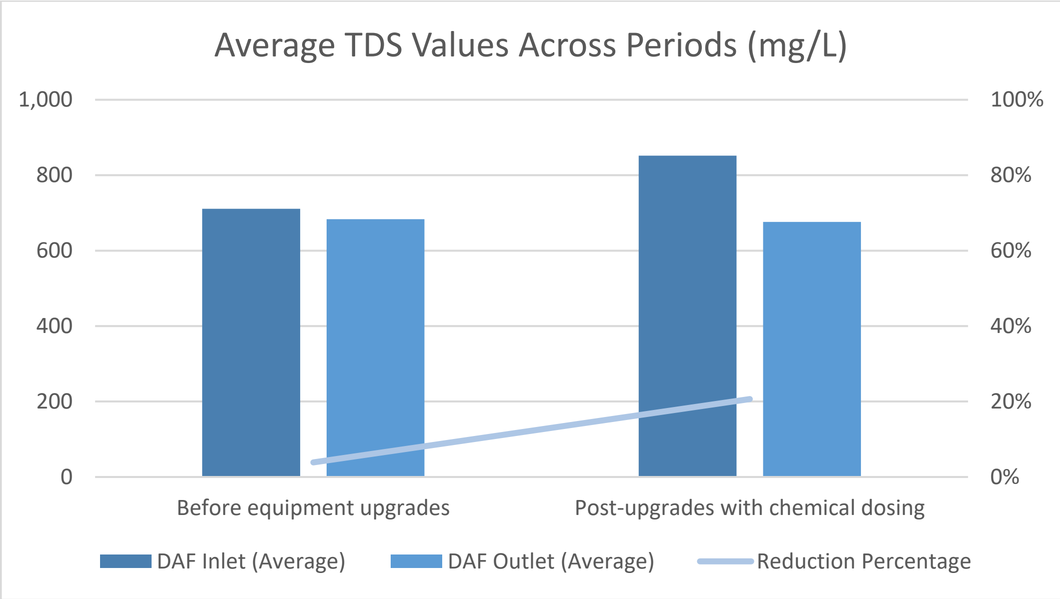

Figure 21. Average total dissolved solids values across periods (mg/L).

TN, TP and TDS measurements were taken only before equipment upgrades and post-upgrades with chemical dosing. However, the removal rates showed significant improvement. Nitrogen removal increased from 11% to 55%, while phosphorus removal increased from 13% to 58%. TDS removal showed a slight improvement, increasing from 4% to 21%.

In addition to analysing key contaminant removal, the sludge tank's filling time was evaluated (Table 3). The assessment estimated the average time required for the sludge tank level to increase by 20%, providing insight into how DAF upgrades and chemical dosing adjustments affected sludge capture.

Table 3. Sludge tank average filling time across periods.

Period	Sludge Tank Average Filling Time to reach 20% increase in level (hours)
Before equipment upgrades	16.6
Post-upgrades without chemical dosing	16.1
Post-upgrades with chemical dosing	9.6

*Rain events were not accounted for but may introduce minimum variability in this analysis.

6.3 Additional Studies

Besides the 30-day full-scale trial at RMP, additional studies has been done with Tanfloc in Australian facilities.

A case study in a red meat facility similar to RMP assessed Tanfloc dosing for effective coagulation and flocculation through jar testing and pilot-scale trials in different equipment. An optimal range of 0.8-1.0 mL/L was reported, aligning with industry benchmarks for high-strength wastewater treatment. The facility used ACH (Aluminum Chlorohydrate) as a coagulant, which required 1.6 mL/L of the chemical to achieve similar turbidity and FOG removal levels. Tanfloc's higher affinity for organic matter allows for improved destabilisation and aggregation of particles at lower dosing concentrations when compared to metal-based coagulants.

Due to their acidic nature and residual ions, metal-based coagulants increase water corrosivity. ACH, in particular, is known to reduce alkalinity, requiring additional chemicals to maintain system stability and prevent corrosion in downstream equipment and piping. On the contrary, Tanfloc does not contribute to excessive acidification of the wastewater, not requiring pH correction and reducing the need for supplementary chemical dosing such as caustic soda or lime, which are commonly required when using metal-based coagulants to stabilise pH fluctuations in wastewater. The operational benefits when using a non-metal-based coagulant are shown in Figure 22.

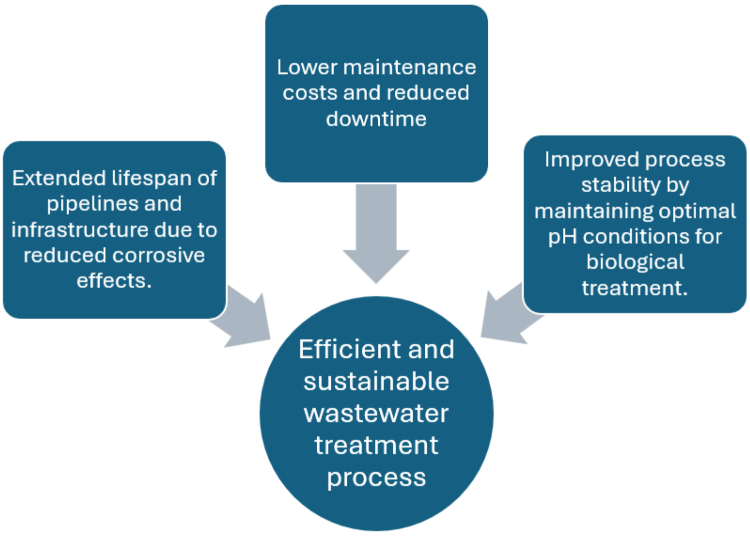

Figure 22. Operational benefits when using a non-metal-based coagulant.

This case study also included a cost comparison comparing Tanfloc to ACH, as shown in Table 4 below.

Table 4. Cost comparison between Tanfloc to ACH at the red meat facility in Melbourne.

Coagulant	Cost per 1000L (AU$)	Optimal dosage (mL/L)	Daily Usage (L)	Cost per day ($)
Tanfloc	3,300	0.8	184	608
ACH	2,215	1.6	368	815

While Tanfloc presents a slightly higher unit cost, its lower dosing requirements contribute to an overall economic advantage. Additional key financial benefits of Tanfloc, when compared to metal-based coagulants, are shown in Figure 23.

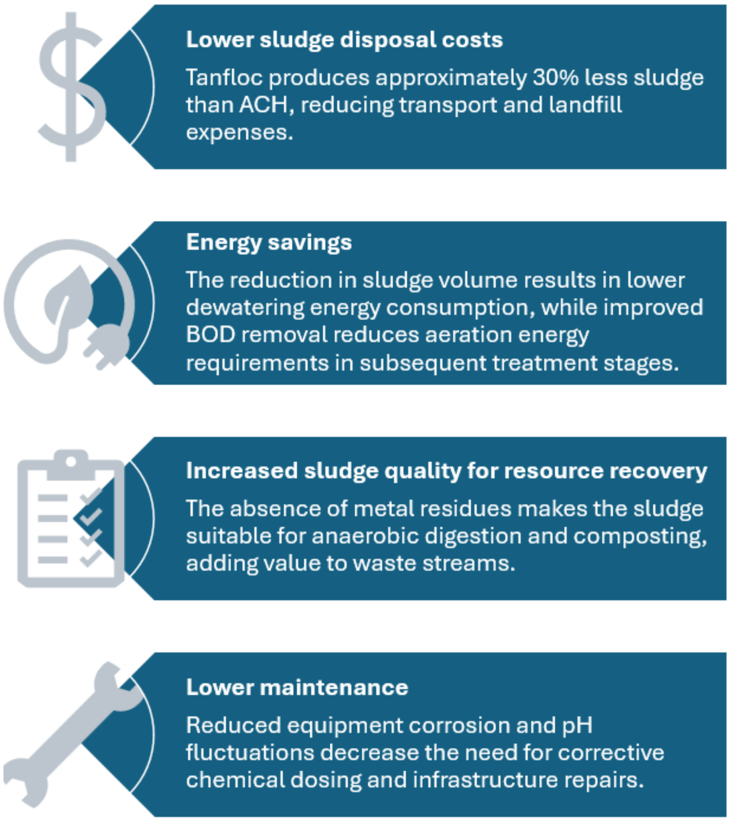

Figure 23. Key financial benefits of Tanfloc, when compared to metal-based coagulants.

Tanfloc offers both economic and operational advantages, particularly for facilities aiming to integrate resource recovery and sustainability initiatives into wastewater treatment processes. While ACH remains a widely used and effective coagulant, its drawbacks—including high sludge production, corrosion risk, and alkalinity reduction—present long-term challenges that Tanfloc can mitigate.

Additionally, while metal-based coagulants effectively precipitate phosphorus—a key nutrient that must be controlled in the final effluent—their use in pre-treatment (e.g., DAF or lamella clarifiers) can lead to excessive phosphorus depletion. This can pose challenges for downstream biological nutrient removal (BNR) processes, as anaerobic bacteria require phosphorus for metabolism. As a result, phosphorus depletion in early treatment stages may necessitate phosphoric acid supplementation to maintain treatment efficiency, increasing overall operational costs.

Figure 24 illustrates the removal rates of key contaminants, comparing the performance of Tanfloc and ACH in Lamella Clarifiers and DAF equipment in this case study.

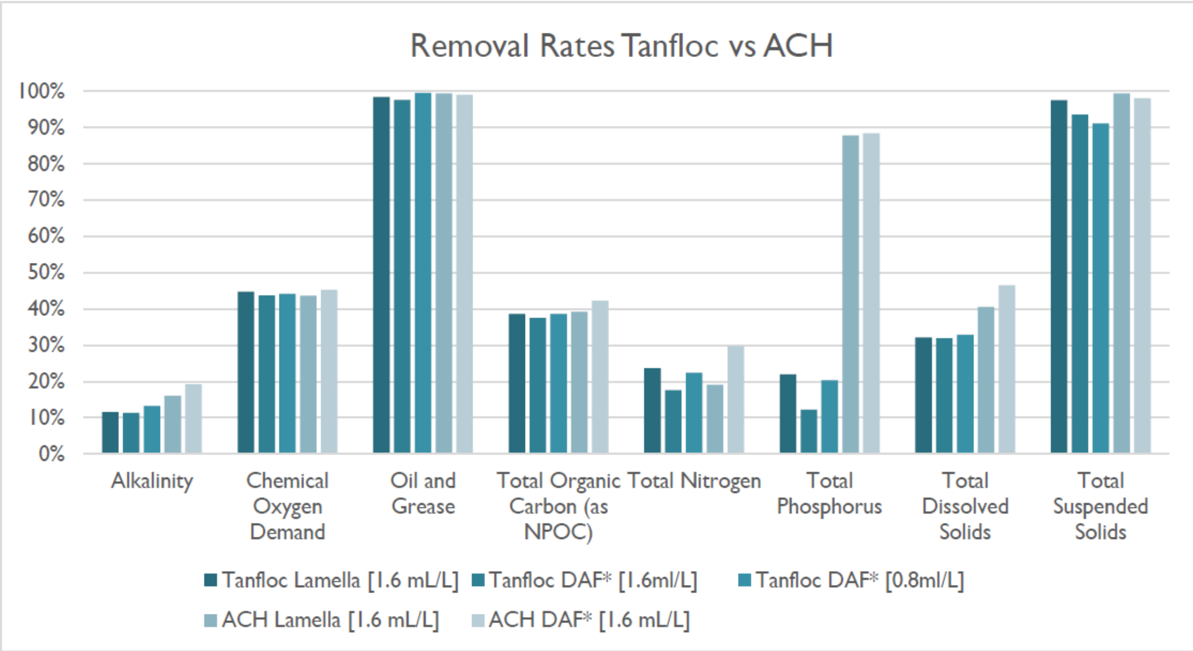

Figure 24. Removal rates of key contaminants, comparing the performance of Tanfloc and ACH in Lamella Clarifiers and DAF equipment.

Another case study examined sludge composition by comparing different coagulants, including Tanfloc and several metal-based options. The content in the sludge from all coagulant tests was analysed. The metal content in the sludge of all coagulant tests is presented in Table 5 and Figure 25 below.

Table 5. Metal content in the sludge of all coagulant tests.

Parameter	Tanfloc	PAC	Ferric Chloride	Alum	ACH
Aluminium	0.30	34	<0.60	24	89
Copper	0.016	0.035	<0.10	0.026	<0.10
Iron	0.16	<0.20	76	<0.20	<2.00
Manganese	0.034	0.042	0.15	0.032	<0.10

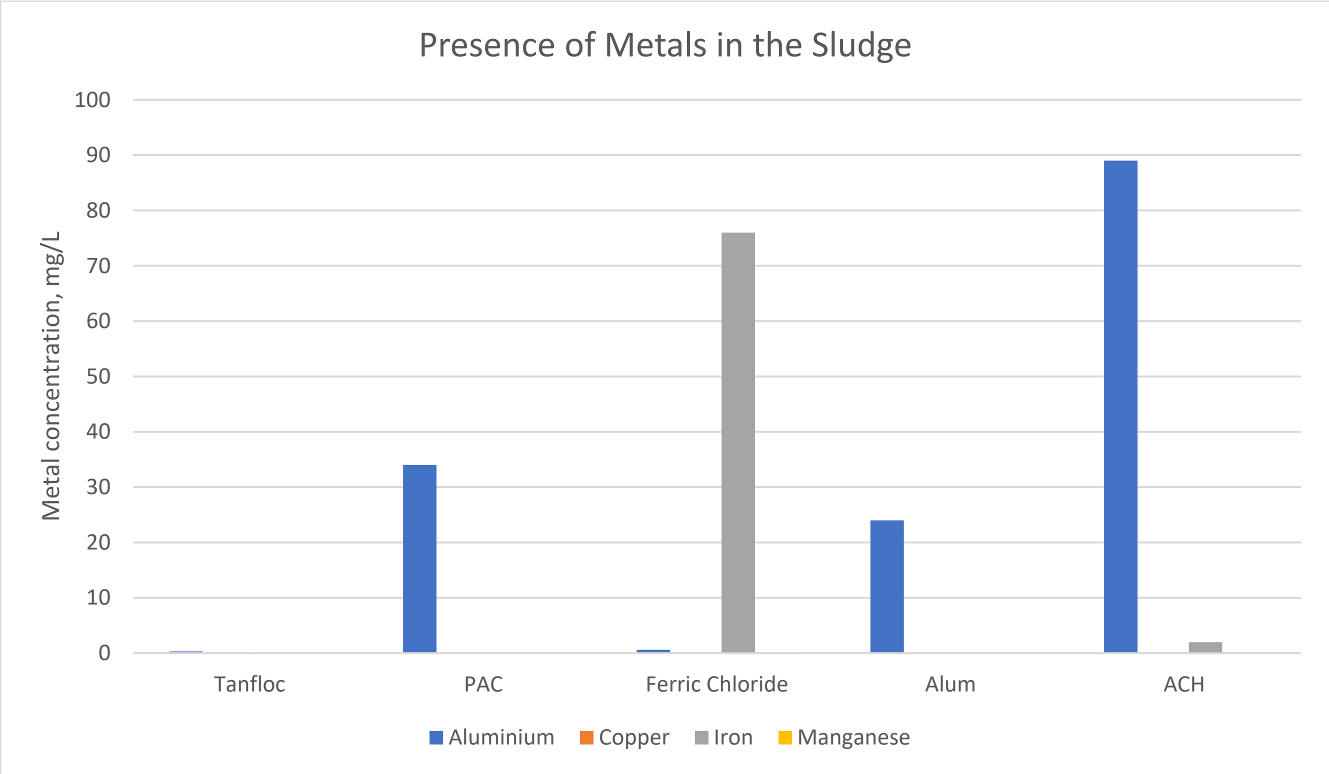

Figure 25.Metal content in the sludge of all coagulant tests.

Metal-based coagulants (PAC, ferric chloride, alum, and ACH) resulted in significant heavy metal accumulation in the sludge. ACH had the highest aluminium concentration (89 mg/L), followed by PAC (34 mg/L) and alum (24 mg/L). Ferric chloride produced sludge with the highest iron concentration (76 mg/L), consistent with its composition. In contrast, Tanfloc, as a natural coagulant, had negligible heavy metal accumulation (0.30 mg/L aluminium and 0.16 mg/L iron), making it more environmentally friendly and suitable for broader reuse applications.

Tanfloc sludge also exhibited the highest total organic carbon (TOC) at 28 mg/L in the sludge, reflecting its organic nature. Its biodegradability, indicated by 40% volatile solids, makes it a strong candidate for biogas production in an anaerobic digester, contributing to a circular economy. Metal-based coagulant sludges also showed volatile solids content, ranging from 33.3% (alum) to 50% (ACH), which suggests biogas production could be feasible. However, the feasibility of sludges with high metal content requires further analysis due to potential toxicity.

Besides being metal-free, the tannin-based coagulant has a lower carbon footprint compared to metal-based coagulants, which require energy-intensive processes such as high-temperature calcination, electrolysis, and acid treatments (Henze et al., 2008). Figure 26 illustrates Tanfloc's carbon footprint compared to metal-based coagulants. While Tanfloc is carbon-negative at the production stage, emissions from its supply chain—including transport from Brazil to Australia—were considered in the assessment.

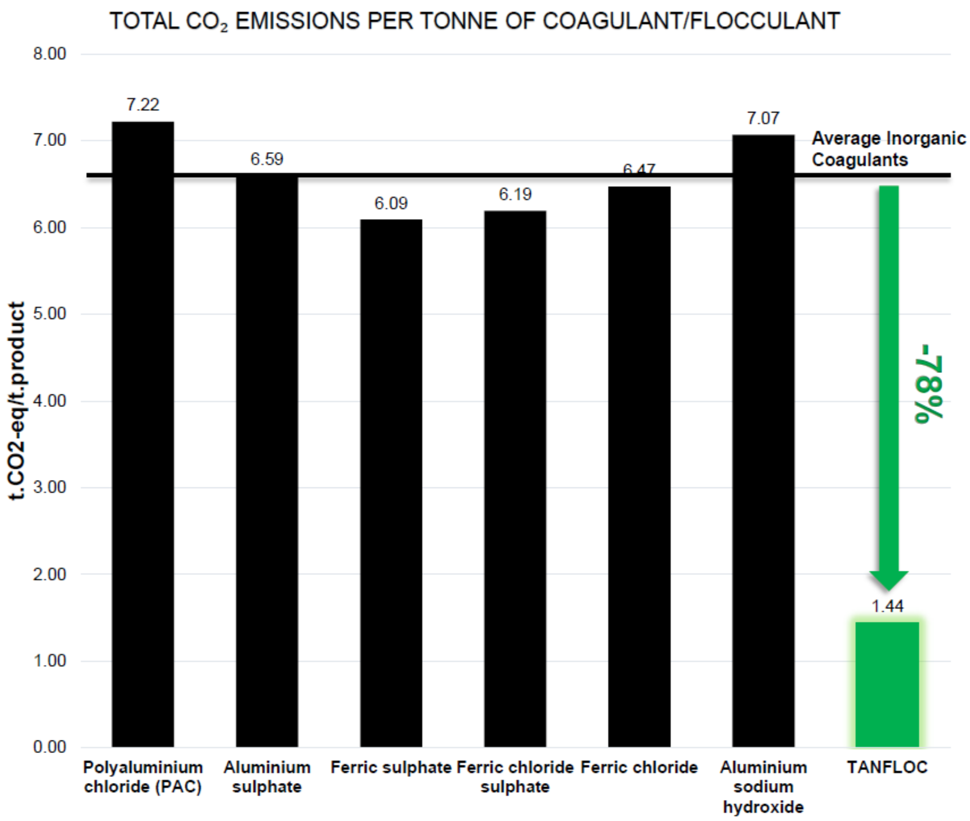

Figure 26. Tanfloc's carbon footprint compared to metal-based coagulants.

As a final consideration, a recent compilation of case studies evaluating Tanfloc's treatment efficiency in wastewater from three red meat processing facilities in NSW (RMP), VIC, and WA found similar dosing rates (0.6 mL/L) required to achieve over 90% TSS reduction. This reinforces the effectiveness and consistency of tannin-based coagulants in removing solids from high organic-load wastewater. Figure 27 and Figure 28 show the results of TSS reduction and key contaminants recovery rates obtained in the study, respectively.

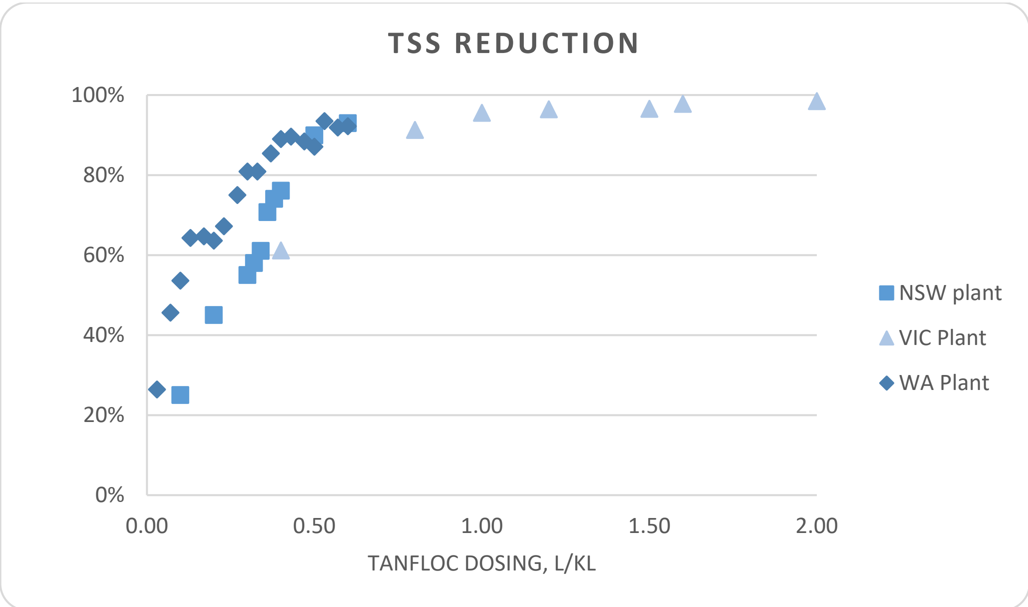

Figure 27. Total suspended solids reduction using Tanfloc in three different red meat processing plants in Australia.

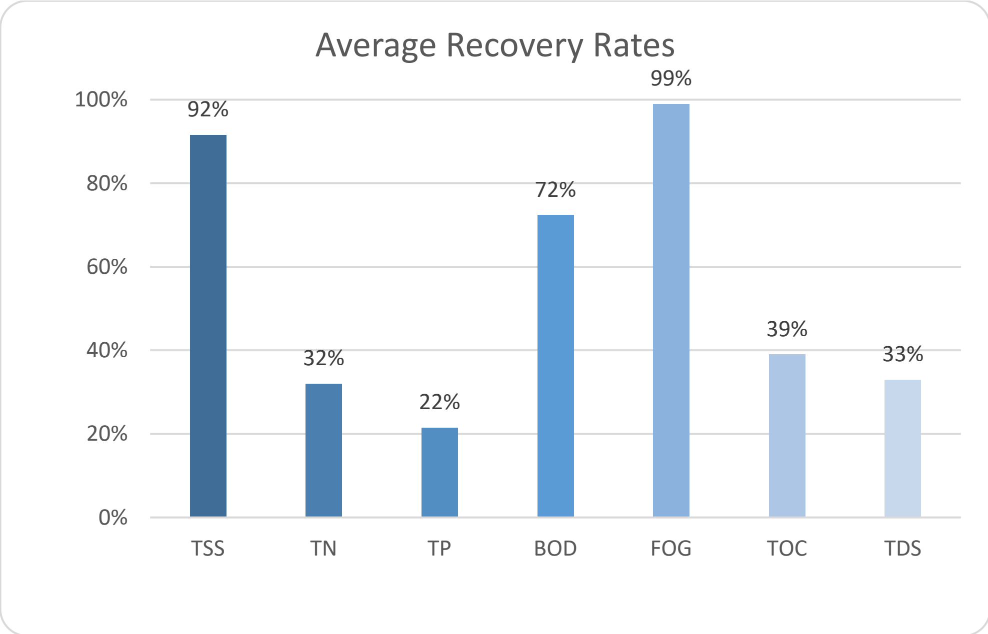

Figure 28. Average recovery rates using Tanfloc in three different red meat processing plants in Australia.

6.4 Detailed Economic Assessment

Given that the 30-day full-scale trial at RMP demonstrated improved BOD removal rates in the primary wastewater treatment stage (DAF system), the secondary (biological) treatment process— carried out in ponds at RMP—will require less aeration.

Additionally, the increased sludge production facilitated better FOG separation in the DAF, directing FOG-rich sludge to the RMP's tricanter. This, in turn, enhanced third-grade tallow production, a valuable byproduct that is commercialised by the facility, generating additional revenue.

Based on these findings, an economic assessment was conducted to evaluate the capital and operational costs of implementing Tanfloc dosing in RMP's DAF system. This assessment also considered potential financial benefits, including energy savings from reduced aeration requirements in the ponds and increased revenue from enhanced valued-based by-product production.

Table 6 below shows the estimated cost of implementing Tanfloc and Polymer dosing at RMP's DAF system.

Table 6. Estimated cost of implementing Tanfloc and Polymer dosing at RMP's DAF system.

Item	CAPEX (AU$)	OPEX (AU$)
Dosing System (CAPEX)	41,640	N/A
Polymer (Annual OPEX)	N/A	10,517
Tanfloc (Annual OPEX)	N/A	615,015
Total	**41,640**	**625,532**

This analysis considered a polymer concentration of 0.5 mL/L and Tanfloc at 0.8 mL/L, assuming a fixed flow rate of 80 kL/h at the DAF inlet. It is important to note that these costs may change according to the assumed IBCs' prices, which vary depending on the agreement between the red meat facility and suppliers.

Table 7 below presents the cost related to on site sludge management when dosing Tanfloc in RMP's DAF. To provide context, the Red Meat Processor operates a tricanter (three-way decanter) that separates DAF sludge into three streams: solids, tallow, and wastewater. The tricanter's inlet stream is pre-heated with steam, which enhances the separation of FOG, improving equipment performance. The solid outlet fraction is then sent for disposal on site. The tallow fraction is sold as third-grade tallow while the wastewater fraction is directed to the wastewater treatment on site.

It is known from the trials that Tanfloc generates more sludge at RMP's facility. It is essential to note that RMP does not use any metal-based coagulants. When comparing sludge production between Tanfloc and a metal-based coagulant, Tanfloc reduces sludge production by 30%. Regardless, Tanfloc produces higher-quality sludge, with increased FOG content and full biodegradability.

Based on the sludge tank filling time analysis discussed earlier in this report, biosolids production is estimated to increase by 73% with Tanfloc dosing. This leads to additional costs for steam to heat the increased inlet stream in the tricanter, as well as for coal to render the additional biosolids produced. For this approach, the tricanter's outlet stream ratios were assumed to be 4% tallow, 17% solids, and 79% wastewater. The steam cost was estimated at $0.78 per tonne based on industry references, while RMP's confidential coal cost was used for estimating the expenditure of rendering additional biosolids.

Table 7. Cost related to on site sludge management when dosing Tanfloc in RMP's DAF

Item	Cost (AU$)
Additional steam and rendering cost (Annual OPEX)	9,290

It is important to highlight that biosolids management practices vary across red meat facilities. Not all facilities utilise three-way decanters, nor do they send their biosolids for rendering. Therefore, while this economic analysis is based on RMP's operational model, it can be adjusted to simulate other facilities by incorporating relevant data for a more accurate economic assessment.

In terms of revenue, these were considered: energy savings through reduced aeration, additional revenue from third-grade tallow and meat meal production.

From the 30-day trial, it was observed that the use of Tanfloc resulted in approximately 70% BOD reduction (5,653 mg/L) between the inlet and clarified stream of the DAF. Given that approximately 1.25 mg/L of O_2 is required to reduce BOD in biological treatment, which facilitates the breakdown of organic matter, this reduction would translate to an oxygen savings of 13,567 kg/day, assuming an 80 kL/h flow rate at the DAF inlet. Considering a conservative energy consumption rate of 0.5 kWh/kg O_2 for mechanical surface aerators and RMP's confidential electricity price, it is possible to estimate the annual energy savings in aeration when using Tanfloc at RMP.

It is important to note that this assessment assumes an ideal scenario where mechanical surface aerators operate in aerobic ponds. However, aeration in the aerobic pond is subject to facility operations. For optimal biological wastewater treatment in ponds, aeration is strongly recommended to maintain effective treatment conditions.

As previously mentioned, with Tanfloc dosing, sludge production is estimated to increase by 73% at RMP. Assuming the tricanter outlet stream ratios are 4% tallow, 17% solids, and 79% wastewater, this financial analysis considers that 20% of the final solid stream is conservatively classified as meat meal, a valuable ingredient in pet food, with an estimated market price of $620 per tonne. Additionally, the tallow stream, categorised as third-grade due to its high Volatile Fatty Acid (VFA) content, was valued at $1,180 per tonne.

The considered revenue for the economic assessment is shown in Table 8 below.

Table 8. Considered revenue for the economic assessment.

Item	Revenue (AU$)
Energy savings in aeration (Annual)	129,909
Additional third-grade tallow (Annual)	391,490
Additional meat meal (Annual)	174,843

The key financial metrics of the economic assessment are shown in Table 9.

Table 9. Key financial metrics of the economic assessment.

Item	Value
Present Value of CAPEX	AU$41,639
Present Value of OPEX	AU$7.3 mi
Present Value of Income	AU$8.0 mi
NPV	AU$0.7 mi
ROI	1,702%*
Annualised ROI	34%
Payback time	1 year

*The high ROI value is explained by the low CAPEX required in the project.

For this economic assessment, information on the current sludge and tallow productions provided by RMP operations personnel was crucial. Additionally, it is important to note that this analysis assumes the facility operates 260 days per year, key parameters shown in Table 10 were also considered.

Table 10. Key parameters considered in the economic assessment.

Parameter	Value
Nominal Discount Rate	5%
Escalation Rate	6%
Tax Rate	0%
Effective Post Tax Cash Coefficient	100%
Period considered for present value calculations	10 years

This economic assessment could be replicated in other red meat facilities and adapted based on operational methodologies. For example, it could compare Tanfloc with a metal-based coagulant that requires additional pH adjustment, which would likely result in a positive return on investment as well.

7. Discussion

Focusing on the benefits of the carbon-negative coagulant dosing in the DAF system at the Red Meat Processor, the following paragraphs summarise the results of the full-scale trial conducted at RMP, aligned with the project's objectives.

Efficient removal of key contaminants to enhance the quality of treated wastewater

Chemical dosing in the optimised DAF system at the Red Meat Processor significantly improved the removal of TSS (86%), BOD (63%), FOG (94%), TN (55%), TP (58%), and TDS (21%). Pre-treatment plays a crucial role in wastewater management, directly influencing the performance of downstream treatment processes, overall wastewater quality, and opportunities for water reuse.

While dissolved contaminants such as nutrients and soluble organics are typically addressed in stabilisation ponds or biological treatment stages, optimising TSS and FOG removal at the pre-treatment stage is essential for enhancing wastewater treatment efficiency and minimising environmental impacts.

This improvement was visually evident in the 30-day full-scale trial at RMP, where the formed sludge was noticeably thicker than before DAF optimisation and chemical dosing. This observation, further confirmed by measured TSS and FOG removal rates, indicates more effective solid-liquid separation in the DAF system. Improved FOG removal also prevented excess fat accumulation in ponds, which, under anaerobic digestion, could generate pollutant gases such as methane - a gas with a global warming potential approximately 28 times higher than carbon dioxide.

From an economic perspective, the enhanced FOG removal with Tanfloc also supports greater third-grade tallow recovery. The dramatic improvement in FOG separation in December 2024 ensures that more third-grade tallow is captured within the DAF system and diverted from the waste stream. This allows for the recovery of third-grade tallow, which can be sold as a co-product, reinforcing the facility's circular economy approach and improving its overall resource efficiency.

Moreover, the improved BOD removal reduces the organic load on downstream biological treatment systems, lowering aeration demands and associated energy consumption. This not only reduces operational costs but also enhances the system’s capacity to handle higher inflows or seasonal variations in wastewater characteristics.

Although biological treatment of wastewater occurs in the secondary stage (ponds), enhanced TN, TP, and TDS removal through Tanfloc dosing improved overall wastewater quality. This improvement facilitates easier treatment in subsequent stages and increases the potential for reuse within the facility, including irrigation, internal washing, and cleaning.

In conclusion, the addition of Tanfloc dosing has provided quantifiable benefits, with substantial increases in removal efficiencies for key contaminants. These improvements translate into operational, environmental, and economic gains, making Tanfloc dosing a highly effective enhancement to the pre-treatment process

Mitigation of greenhouse gas (GHG) emissions and a lower carbon footprint

While RMP’s current wastewater treatment operations do not utilise coagulants or flocculants, metal-based alternatives are commonly used in the industry despite their significant environmental drawbacks. These coagulants have a high carbon footprint, generate excessive sludge, and leave heavy metal residues in the sludge, limiting its reuse potential.

In contrast, tannin-based coagulants offered a more sustainable solution by:

- Lowering embodied emissions – The extraction and refinement of tannins require significantly less energy than the industrial production of aluminium- and iron-based coagulants (Tessele, 2024).
- Reducing sludge volume – Unlike metal-based coagulants, Tanfloc does not precipitate metal hydroxides, resulting in a more compact sludge with lower moisture content, reducing dewatering energy consumption.
- Eliminating heavy metal residues in sludge – Metal-free sludge can be safely applied to land, composted, or used in anaerobic digestion without the risk of environmental contamination (Henze et al., 2008).

In particular, Tanfloc is made by TANAC, a Brazilian company with over 70 years of experience. TANAC manages the world's largest certified black acacia forest and focuses on acacia-based products, including wood, tannin-based coagulants, and animal nutrition. The company recently earned a greenhouse gas emissions certification, confirming that its forests absorb 21 tonnes of carbon dioxide for every tonne emitted during production—making Tanfloc a carbon-negative product. Committed to sustainability, TANAC also supports local communities in southern Brazil by employing over a thousand families and investing in responsible forestry practices.

Thus, Implementing Tanfloc coagulant dosing enhances the sustainability of wastewater treatment while simplifying waste management.

Operational efficiencies and reduced chemical dependency related to equipment corrosion and pH dosing, respectively

Tanfloc, a pH-neutral organic coagulant, minimises effluent acidification, reducing the need for pH adjustment and enhancing overall treatment efficiency. By preventing excessive acidity, it helps extend the lifespan of pipelines and treatment infrastructure, reducing corrosion-related damage. Additionally, it lowers maintenance requirements for pumps, valves, and distribution systems, leading to cost savings and improved reliability. Maintaining optimal pH conditions also enhances process stability, supporting more effective biological treatment. These benefits collectively contribute to lower operational costs, reduced downtime, and a more sustainable wastewater treatment process.

Improved sludge recovery and management

The implementation of Tanfloc has positively impacted sludge management by capturing and removing solids at the Dissolved Air Flotation (DAF) stage, rather than allowing them to accumulate in downstream anaerobic ponds.

The reduction in the sludge tank filling time in the 30-day full scale trial indicates that chemical dosing has improved particle precipitation, emulsification and capture efficiency, leading to the formation of denser and more compact sludge. The shorter filling time in the sludge tank implies that the DAF system is capturing a greater proportion of suspended solids and FOGs, reducing the load on downstream processes.

By optimising the removal of Total Suspended Solids (TSS) and Fats, Oils, and Greases (FOGs), the DAF system prevents solid material from entering the ponds. Representing a significant reduction in sludge accumulation, decreasing the need for frequent desludging and improving overall pond hydraulics. Additionally, improved sludge characteristics, particularly higher solids concentrations (5–12% total solids), enhance storage capacity and minimises excess water in the sludge stream, facilitating dewatering processes.

A key advantage of this enhanced solids separation is the ability to redirect DAF sludge to the tricanter for third-grade tallow recovery. With 94% FOG removal, the process efficiently extracts high-fat-content sludge, which is ideal for tricanter processing. This not only reduces the organic load on subsequent treatment stages but also generates valuable by-products such as third-grade tallow, supporting resource recovery and aligning with circular economy principles.

Beyond by-product extraction, the remaining sludge fraction is well-suited for anaerobic digestion (AD), playing a critical role in the facility's integrated resource recovery strategy. Processing sludge through AD enables biogas production, contributing to on-site renewable energy generation while further minimising waste. The high organic content and absence of metals in the remaining sludge make it an excellent feedstock for anaerobic digestion, allowing the facility to recover energy from residual solids rather than relying on disposal.

The shift from pond accumulation to controlled sludge recovery, including by-product separation and potential anaerobic digestion, enhances operational efficiency while reducing the environmental impact.

Financial positive benefits

The 30-day full-scale trial demonstrated improved BOD removal rates in the primary wastewater treatment stage (DAF system), reducing aeration requirements in the secondary (biological) treatment ponds at RMP. Additionally, increased sludge production facilitated better FOG separation in the DAF, directing FOG-rich sludge to RMP's tricanter, which enhanced third-grade tallow production—a valuable byproduct commercialised by the facility to generate additional revenue. Based on these findings, as previously shown in this report, an economic assessment was conducted to evaluate the capital and operational costs of implementing Tanfloc dosing in RMP's DAF system, considering potential financial benefits such as energy savings from reduced aeration and increased revenue from improved by-product production, resulting in a payback period of just one year. This demonstrates the economic viability of Tanfloc dosing at RMP's site. Moreover, the economic assessment can be extended to other red meat facilities and adapted to their specific operational processes. For example, it could compare Tanfloc with a metal-based coagulant requiring additional pH adjustment, which may also result in a strong return on investment.

Assess the scalability and applicability of tannin-based coagulants across different red meat facilities

The accomplished full-scale trial results confirm that integrating Tanfloc into the Dissolved Air Flotation (DAF) system is feasible for full-scale adoption in a red meat processing facility. The process has been validated by efficient removal of TSS, BOD, FOG, TN, TP and TDS while minimising environmental impacts such as improved metal-free sludge recovery.

With these proven results, no technical barriers prevent immediate large-scale implementation. The equipment, dosing strategies, and process control mechanisms tested during the trial can be seamlessly applied to full-scale operations without requiring modifications. Additionally, Tanfloc can be integrated into existing DAF systems without significant capital investment, as it is fully compatible with current infrastructure. The transition primarily involves adjusting chemical dosing and optimising process control parameters.

Establish a framework for transitioning to a sustainable wastewater treatment process, setting future sustainability initiatives in the red meat sector

The trial has confirmed that the chemical dosing including Tanfloc as coagulant has optimised RMP's DAF operation. With its proven performance, seamless integration, and environmental advantages, Tanfloc represents a best-practice solution for improving wastewater treatment efficiency, reducing carbon footprint, and optimising sludge management in the red meat sector.

For red meat processors looking to transition to a sustainable wastewater treatment process including Tanfloc as a coagulant, the following recommendations will support a smooth and efficient large-scale implementation:

- Optimised dosing strategies – Providing clear dosing guidelines to achieve optimal coagulation and flocculation through jar testing.
- Seamless integration with existing DAF systems – Tanfloc can be incorporated into current wastewater treatment processes without significant infrastructure modifications. Implementing automated dosing control with real-time flow rate monitoring, and additional analysers such as turbidity or TSS can further enhance process efficiency and minimise chemical consumption. Training operators on dosage adjustments and process monitoring is essential to ensure consistent performance and operational efficiency.
- Enhanced sludge management and resource recovery – Tanfloc produces metal-free, highly biodegradable sludge, creating opportunities for anaerobic digestion and composting. Red meat processors should explore sludge valorisation pathways, including its integration into biogas production systems or composting on site.
- Industry collaboration and knowledge sharing – The adoption of a natural-based efficient coagulant presents an opportunity for industry-wide collaboration to refine best practices, exchange operational insights, and continuously improve treatment performance. Establishing benchmarking frameworks will help processors maximise efficiency and environmental benefits.

8. Conclusions

The findings from this study show the potential of Tanfloc as a highly effective solution for wastewater treatment in the red meat processing industry, demonstrating substantial improvements in coagulation, flocculation, and resource recovery. Through site-specific jar tests and full-scale dosing trials, Tanfloc consistently reduced turbidity, Total Suspended Solids (TSS), Fats, Oils, and Greases (FOG), and other contaminants. Additionally, its lower dosing requirements and ability to operate efficiently at varying wastewater conditions make it a promising alternative to traditional metal-based coagulants, which often require higher dosages and contribute to increased sludge production and potential corrosion risks. The economic analysis demonstrates that Tanfloc is a cost-effective solution, considering its operational benefits and resource recovery potential. Based on an assessment of RMP's operations, the investment in Tanfloc dosing achieves a payback period of just one year.

The successful application of Tanfloc at the Red Meat Processor, giving the improvements in effluent quality and sludge management, supports the viability of scaling up Tanfloc use across other facilities in the industry, helping to achieve sustainability objectives related to water and energy conservation, waste minimisation, and carbon footprint reduction. There are no major technical barriers for red meat processors to adopt Tanfloc into their wastewater treatment systems, as it integrates seamlessly into existing DAF systems without significant capital investment.

This study presents the red meat processing industry with a proven, low-carbon wastewater treatment strategy that aligns with sustainability goals and best practices. The results offer clear opportunities for industry stakeholders to adopt Tanfloc, providing both environmental and operational benefits. The positive impact on improved sludge quality supports its potential for resource recovery and value creation. To optimise its full potential, further research and development are encouraged, particularly in refining dosing systems and integrating advanced monitoring technologies. Ultimately, the adoption of Tanfloc could lead to widespread improvements in wastewater management, sustainability, and economic performance across the industry.

9. Recommendations

Based on the findings of this study, the following recommendations are provided to the Red Meat Processor (RMP) and the broader red meat processing industry aiming to enhance wastewater treatment efficiency, resource recovery, and environmental performance. These recommendations are grounded in technical feasibility, operational practicality, and sustainability objectives, supporting the long-term optimisation of wastewater management strategies.

9.1 Practical Application of Project Findings

Full-Scale Implementation of Tanfloc: RMP should transition to full-scale Tanfloc dosing at the optimised rate identified during the trials. Automation of dosing control using real-time turbidity or TSS monitoring should be implemented to further optimise treatment performance and reduce chemical usage. RMP should also monitor coagulant performance regularly to ensure optimal operation and refine dosing strategies as necessary.

Sludge Management and Resource Recovery: RMP should monitor improved sludge quality and production on site. As well as evaluate future initiatives regarding biogas production including sludge as a feedstock. Regular monitoring of sludge characteristics will be important to ensure feedstock consistency and stable biogas yields.

Optimisation of Wastewater Treatment Performance: RMP should regularly assess DAF system performance and standardise its chemical dosing and operations. Additionally, expanding water quality monitoring to include real-time indicators may optimise treatment processes.

Water Reuse and Sustainability: RMP should continue to expand its water reuse initiatives, focusing on irrigation and cleaning operations such as yard and truck washing, to reduce reliance on potable water. Evaluation of potential water storage infrastructure is recommended to ensure flexibility in wastewater reuse, especially during peak demand periods.

Energy and Carbon Footprint Reduction Strategies: RMP should make use of Tanfloc's benefits in decarbonisation, such as reducing methane emissions, minimising sludge disposal, and lowering aeration energy demand. Methane reduction emissions should be quantified and incorporated into sustainability reporting. Additionally, exploring carbon credits or sustainability certifications will further enhance the facility's circular economy goals.

9.2 Future Research, Development, and Extension (RD&E)

Advanced Technologies: Emerging technologies and innovations in wastewater treatment should be explored, with a proactive approach to adopting new advancements that align with sustainability goals. Research into novel methods for further enhancing resource recovery from wastewater may complement the findings of this study. Additionally, further research should be conducted to enhance on-site resource recovery, such as exploring biogas production using sludge as a feedstock.

Action for Broader Industry Adoption: Building on the successful adoption of Tanfloc at RMP and another red meat processing facility, there is a significant opportunity to expand its use across the wider industry. Future research, development, and extension efforts should aim to apply the findings of this study to other facilities, adapting the framework used in this study, including jar testing and dosing system optimisation for broader use. Additionally, the industry should explore the widespread adoption of sustainable wastewater management practices, such as energy and carbon footprint reduction, advanced sludge management, and water reuse. By implementing these approaches across more facilities, the industry can standardise best practices, improve wastewater management, and scale up resource recovery, leading to greater environmental and operational benefits.

9.3 Adoption and Extension Activities

Industry Collaboration and Knowledge Sharing: RMP should continue to engage with key industry stakeholders, including the Australian Meat Processing Corporation (AMPC), and regulatory agencies, to share the success of Tanfloc adoption. Participation in industry working groups and hosting technical site visits will help disseminate best practices and promote innovation across the red meat processing sector.

Engagement in water reuse initiatives: RMP should engage with regulatory bodies and industry stakeholders to explore further expansion of water reuse initiatives. This collaboration will help shape future policies that support sustainability in the red meat processing industry.

Long-Term Monitoring and Continuous Improvement: RMP should implement a structured long-term monitoring framework to track wastewater quality, sludge composition, and overall treatment performance on site. Periodic process audits should be conducted to identify potential areas for further optimisation in coagulant dosing, sludge handling, and energy consumption. This will ensure that the facility remains compliant with evolving environmental regulations and that the process continues to improve over time.

In summary, adopting these recommendations will support RMP in enhancing wastewater treatment efficiency, reducing environmental impact, and achieving its sustainability objectives, while ensuring regulatory compliance, operational resilience, and industry leadership in low-carbon, resource-efficient wastewater management. Additionally, it will foster the development of best practices that can be applied industry-wide, driving long-term improvements in wastewater management and resource recovery.

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11. Appendices

Appendix 1 – DAF Assessment and Optimisation Strategy

Given that the on site DAF (RENDERTECH model) has presented operational inefficiencies during the dosing tests including coagulant (Tanfloc SG) and flocculant (SNF AN943SH) in the initial visit, a detailed assessment was taken.

The solid loading of flocculated material in the clarified stream of the DAF is caused by inadequate operation of the saturated water system and the generation of microbubbles. The current system is operating at a very low saturation pressure, around 20 psi (or 1.4 bar) as shown in Figure 29. The ideal saturation pressure for this system ranges between 4 and 6 bar.

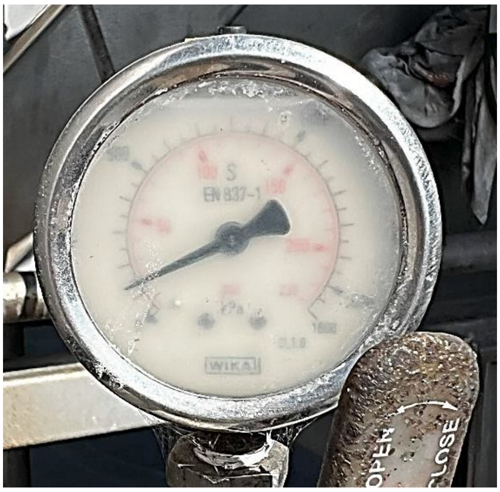


Figure 29. V512 pressure gauge installed in the saturated water line, after the EDUR pump.

It was identified that the low saturation pressure is caused by the V517 valve used to pressurise the saturated water flow (Figure 30). This valve, besides operating completely open, is not the appropriate model for this function. The installed valve is a ball valve, primarily designed for quick opening/closing operations and low-pressure loss. For precise flow control and pressurisation operations, required for the formation of microbubbles, needle valves or globe valves are recommended.

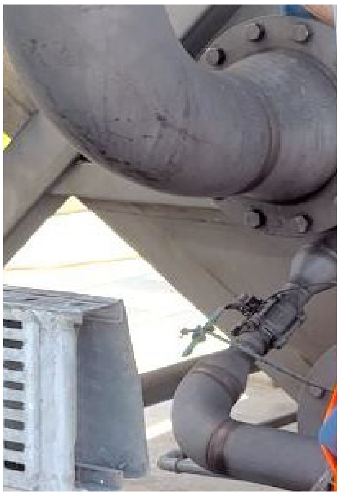


Figure 30. V517 ball valve installed at the end of the saturated water pipe.

Moreover, the saturated water and generation of microbubbles system lacks a flowmeter to monitor the air suction flow in the EDUR pump. This absence hinders the control of the saturation system, ultimately affecting the proper generation of microbubbles.

Based on the detailed DAF assessment, a priority list to optimise the system was created (Table 11).

Table 11. DAF optimisation strategy list, ranked by priority.

Strategy	Description	Priority
1	Replacement of the ball valve with a globe valve, to allow control of the saturated water flow, which is recommended to be maintained at 40 m³/h, with a saturation pressure of 6.0 bar (or ~90 psi).	HIGH
2	After replacing the ball valve, a test must be carried out with the EDUR pump, to assess the need for some maintenance on its rotors, as it is operating with a large quantity of solids in the feed flow (which should be a clarified effluent).	HIGH
3	Installation of a flowmeter to monitor and control the air suction flow in the EDUR pump, which must be maintained at approximately 15% of the saturated water flow, that is, at 6.0 m³/h (or 100 LPM). A rotameter type meter with a measuring range of 15 to 150 LPM is recommended.	HIGH
4	According to the DAF-RENDERTECH operating manual, the air purge valve must be constantly open to allow any undissolved air to be discharged from the saturation tank, and a mixture of air and water must be discharged into this line. This valve should ideally be a suction cup type to allow adequate purging of excess air from the saturation tank without requiring the operator to do it manually.	MEDIUM

In addition to the recommendations suggested above, it is important to highlight the need for the DAF supply system to be operated continuously, with a constant flow rate or within a narrow range of variation.

It was observed that the DAF’s inlet pump operated in a cyclic pattern, running for approximately 20 minutes at 150 m³/h, followed by 20 minutes off. Its activation was controlled by the balance tank level, turning on at 80 and off at 60%. Additionally, a gravimetric flow was noticed, reaching 45 m³/h when the balance tank level approached 80% and dropping to approximately 5 m³/h at 60%. This indicates an absence of a backflow valve, which could hinder this flow rate if it is linked to the DAF’s inlet pump signal.Continuous operation allows for a lower feed rate, avoids sudden changes in the solids' load, and maintains a constant air/solid ratio in the DAF tank.

Further efficiency improvements include installing a 10 – 15 m³ (HRT 5 minutes) stirred tank at the DAF system inlet, ensuring both rapid and slow mixing for proper reagents conditioning and adequate flocculation of suspended solids (Figure 31).

Figure 31.Example of a stirred tank to provide better contact time with the polymer and the wastewater as usually occurs in wastewater plants.

Additionally, optimising the distribution of the saturated water flow across the flotation tank would allow microbubble generation at multiple points, rather than being concentrated solely at the tank inlet, as is currently the case. However, implementing this modification would require structural changes to the DAF, making it a last option.

Appendix 2 – DAF Technical Improvements

The modifications made to the Dissolved Air Flotation (DAF) system were outside the original scope of the AMPC-funded study. However, because effective phase separation is critical to the success of any coagulant in wastewater treatment, these improvements were documented to provide valuable insights for broader industry applications. The modifications and upgrades to the DAF system were independently funded by the Red Meat Processor (RMP). These modifications were implemented by RMP’s maintenance team between May and October 2024 to enhance system performance, ensuring that the flotation process achieved more effective solid-liquid separation.

Instrumentation

The improvements in the DAF instrumentation were observed to directly enhance the stability and efficiency of the treatment process. They are illustrated in Figure 32.

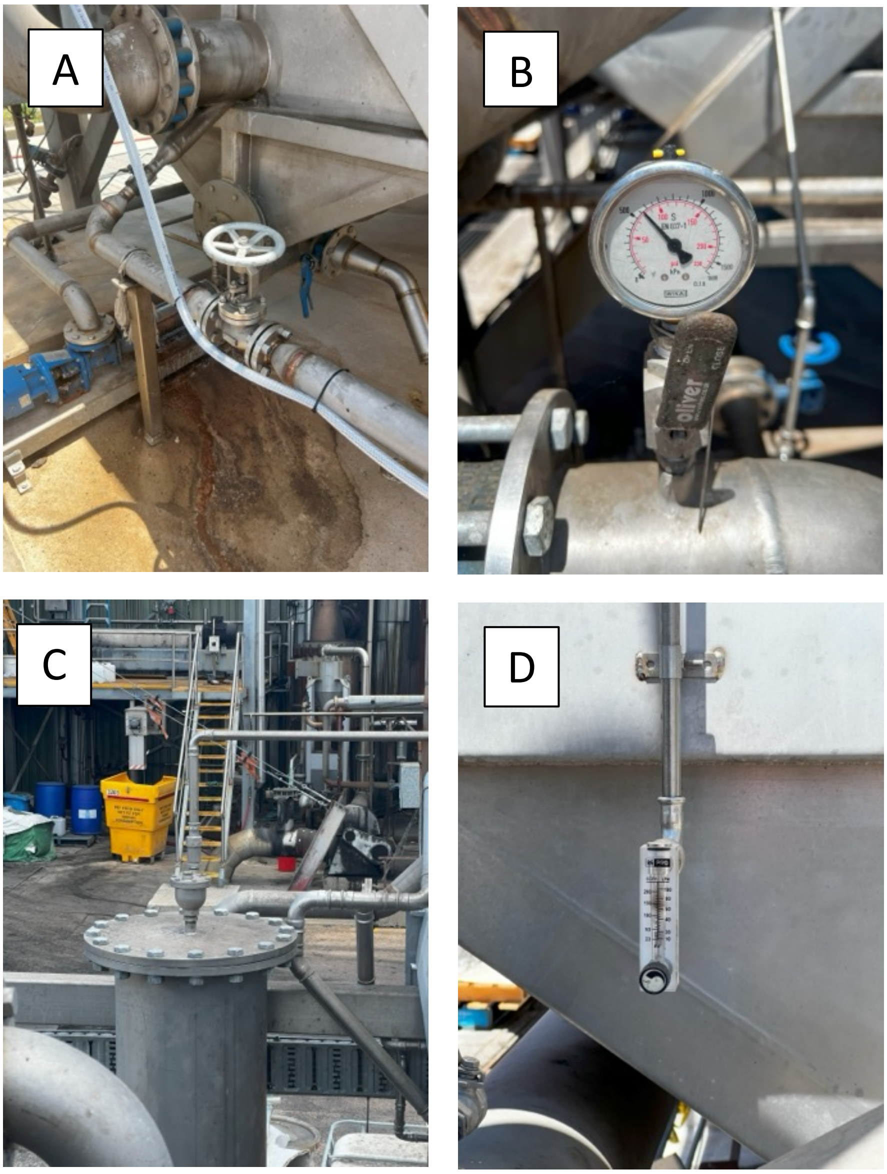


Figure 32. Modifications in the DAF following the first site visit. Globe valve (A). Pressure gauge (B). Automatic air purge (C). Airflow meter (D).

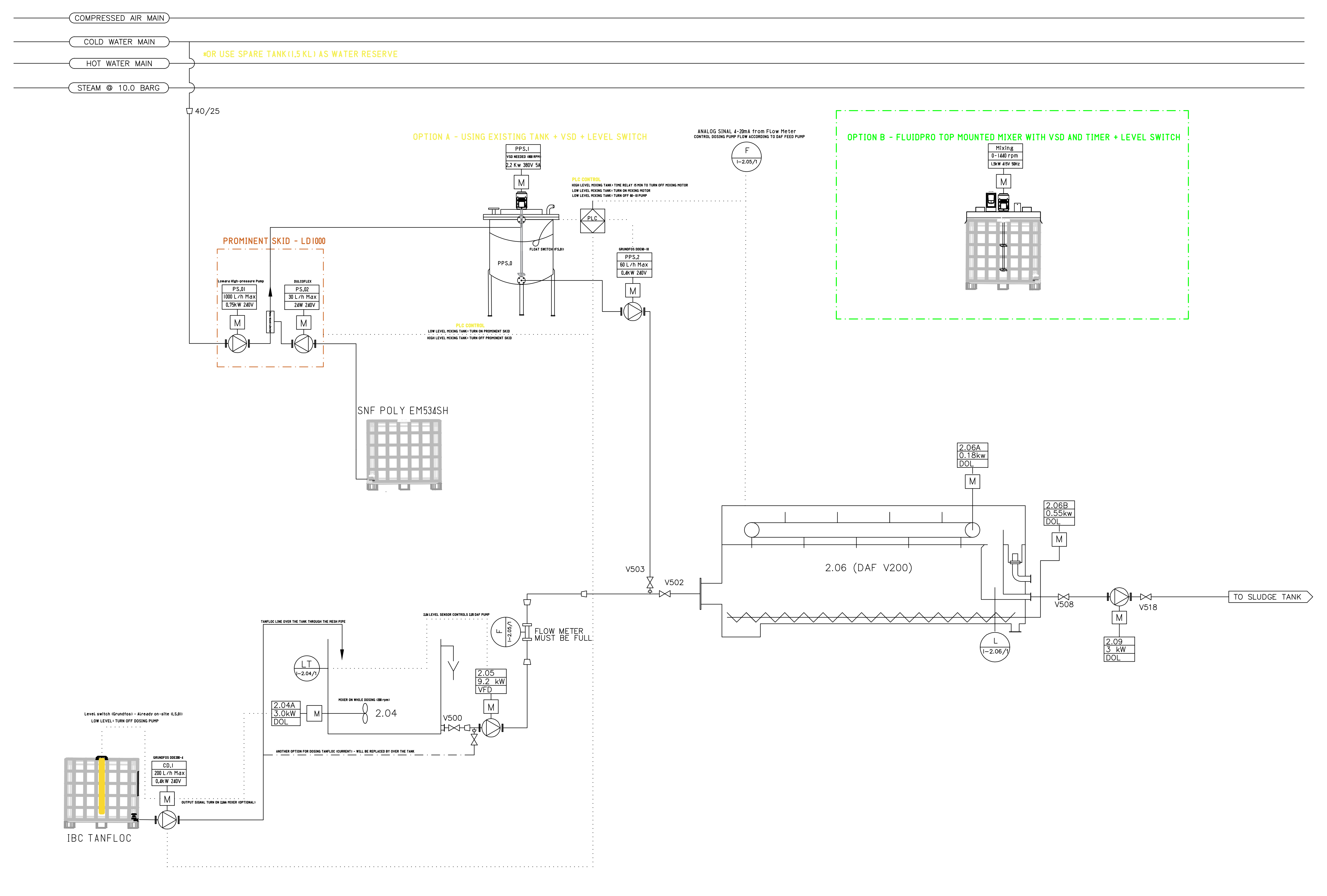
One of the key modifications was the replacement of the existing ball valve in the saturated water stream with a globe valve. The ball valve previously used in the system hindered precise control of pressure, leading to fluctuations in saturation conditions. The newly installed globe valve provides more accurate pressure adjustments, enabling the system to maintain optimal saturation pressure between 4 and 6 bar, typically at a setting of 40% to 50% open. The stability of this pressure is crucial for microbubble formation, which directly impacts the efficiency of solids flotation and removal.

Another critical upgrade was installing a new pressure gauge to replace the existing one, which had become difficult to read due to wear and aging. The inability to accurately monitor pressure levels in the dissolved air system had been a challenge, as maintaining correct operating pressure is essential for ensuring proper bubble formation and solids separation. The new high-visibility pressure gauge has significantly improved operators' ability to monitor and maintain the system's parameters within the required range, contributing to overall process stability.

The air intake system was also upgraded to enhance air-to-water mass transfer efficiency. The manual air purge valve, located at the top of the saturator, was replaced with an automatic purge valve to facilitate continuous removal of excess air. This modification prevents air accumulation, which can disrupt saturation efficiency and affect flotation performance. Additionally, an airflow meter was installed at the air intake to provide real-time monitoring of airflow rates, ensuring that air injection remains at the recommended 100 litres per minute for optimal system operation.

As a result of these modifications, the operational parameters of the DAF system—saturation pressure, airflow, and water flow—are now more accurately controlled and aligned with the supplier's recommended conditions. Observations from site visits confirm that bubble formation has significantly improved, with a more uniform and stable white froth layer forming on the surface of the effluent. Operators have reported noticeable improvements in effluent clarity and a higher rate of sludge recovery, with sludge tank filling times decreasing as a direct result of enhanced solids separation efficiency.

Appendix 3 – Dosing System PFD



TANFLOC AUSTRALIA

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DATE	7/8/2024
SCALE	NTS
SIZE	A1

WASTEWATER TREATMENT PLANT
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