AUSTRALIAN MEAT PROCESSOR CORPORATION

Pilot plant case study

Non-potable recycled water for refrigeration condensers

All Energy Pty Ltd
AMPC project 2021-1212
27 June 2024

Pilot plant results

Treatment train

Multimedia filter

>90% of TSS

Output **<1 mg/L**

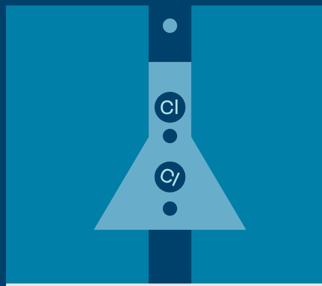
Ultrafiltration

0.04

micron aperture

Reverse osmosis

3 to ~50-100 µS/cm

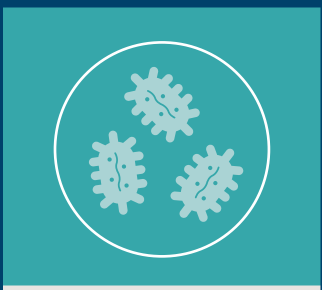


Control point

0.7 – 1.0 mg/L

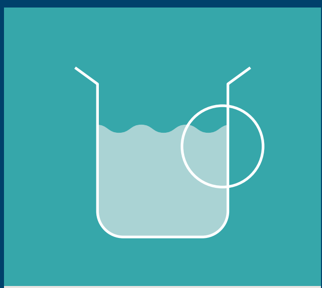
free chlorine concentration

Performance



E.coli content

<1 CFU/100 mL



Ultrafiltration turbidity

<0.1 NTU

Use cases

- Yard or truck wash
- Primary belly wash
- Palatable water for stock drinking
- Refrigeration condensers
- Rendering condensers
- Boiler makeup

Condenser trial results

Immediate savings

- ↓ Cooling tower water
- ↓ Sewer bleed off water
- ↓ Treatment chemicals
- ↓ Scale formation
- ↑ Heat transfer efficiency

Lower cost of water

$2.17 kL

(levelised cost of water)

$2.74 kL
Current rate for town water

Annual saving

>$32K

Simple payback

<5 years

Contents

Executive summary

A NSW red meat processing plant trialled a water recycling pilot unit as part of AMPC's R&D into advanced water recycling for non-potable uses. Wastewater recycling trials began in 2023 and involved treating several raw water streams through the unit for different end uses.

The NSW plant trialled recycled water for use within a plant cooling asset. The trial went through all the relevant government approvals. Part of compliance included the development of a detailed hazard identification and management plan for the trial design, which was informed by several months of water recycling and lab testing. This was the first time that a fit for purpose use of non-potable recycled water had been utilised in a red meat processing plant condenser. The wastewater was treated through the recycling unit to a standard fit for use in a condenser unit.

Prior to this project there had not been industry exploration of the possibilities of non-potable water recycling using a portable pilot unit. While many plants have ultra-filtration (**UF**) and reverse osmosis (**RO**) for treating river and bore water, the learnings from treating wastewater sources have helped deliver better design and management in areas such as clarification, and micro-filtration, prior to **UF**/**RO**. Other benefits from this project include more responsible water management and using less potable water with a lower over levelised cost of water.

AMPC engaged All Energy to assess whether recycled non-potable water sources could be identified and utilised at a large species facility which processes about 850 head per day. The goal was to pilot a program which would divert recyclable non-potable water for refrigeration condensers. The result was a system that could generate annual savings of over $30,000 across two condensers.

Finding the right source

An initial investigation of available raw streams assessed the volume, composition and proximity to a suitable location for a recycling plant.

Streams with an appreciable fat, oil, or blood content were ruled out as they are best suited for diverting back to the rendering or blood plant to recover as much saleable product, then sending to the CAL for recovery of biogas.

It was determined that the holding pond before discharge to sewer had the largest available volume of potential potable water with consistent composition and temperature. The daily inlet to this pond was approx. 1.4 ML during operational days, with sufficient buffering to ensure a non-potable water recycling plant could operate continuously.

Figure 1 Red and green streams sampled to assess viability in a water recycling plant.

Figure 2 Tank “clarifier” and screen filter.

Pilot plant treatment train

During the pilot it was noted that the suspended solids in the raw stream tended to settle to the bottom, so a settling vessel was made by repurposing a standard 10 kL poly tank and shifting the outlet up to approx. 1/3 the height of the tank. This would allow solids to settle out and be periodically drained from the tank by opening a ball valve at the bottom and flushing. A 100-micron screen filter was placed at the outlet of this tank to catch any suspended solids that did not have sufficient retention time to settle out.

Next in the treatment train was a glass sand and anthracite multimedia filter (**MMF**) to filter out any entrained, small diameter suspended solids from the feed stream. This worked very well, removing over 90 percent of TSS and delivering an output typically <1 mg/L. The greatest feature of the **MMF** is automated backflushing based on a timer setting into the head control. As the **MMF** is in service and solids accumulate, typically the operation of this unit can become a bottleneck.To maximise utilisation of a plant, it is recommended to install at least two **MMF** vessels in parallel to provide greater throughput and redundancy.

Figure 3 Ultrafiltration module.

Figure 4 Reverse osmosis module.

After coarse filtration in the MMF, an ultrafiltration (UF) system down to 0.04-micron aperture was chosen. This removed all residual TSS, turbidity, and microbial pathogens (microbes, viruses, and protozoa) and was an effective critical control point. The membrane that was installed was a basic hollow fibre polymer membrane, however a ceramic membrane is recommended to provide greater robustness against fouling, temperature sensitivity, and reduced need for cleaning, allowing greater uptime and throughput. Two UFs in parallel are recommended.

Reverse osmosis (RO) was the next unit operation, used to remove dissolved solids, viruses, and protozoa to produce an ultra-pure permeate that is typically many times "purer" than town water. With different input streams, the output of RO can range from as low as 3 μS/cm for carcase defrost up to around 50-100 μS/cm for pond water.

The output quality and quantity can also be controlled with the incoming pressure to the membrane, and the backpressure setting on the recirculation loop. RO is highly modular and increasing throughput or redundancy is as simple as bolting on another membrane housing vertically to the same support structure.

The final critical control point in the process was chlorine dosing to target a free chlorine concentration of 0.7 – 1.0 mg/L. This was achieved using a small peristaltic pump dosing liquid chlorine proportional to the RO permeate flow rate and verifying with test strips.

Figure 5 Pilot plant layout.

Pilot plant performance

Over a four-month period, the pilot was able to consistently deliver E.coli content less than the test sensitivity threshold of **1 CFU/100mL**. Although this level of sterilisation was achieved just by **UF** and **RO**, chlorine dosing was added as an extra critical control point to achieve a sufficient plant combined microbial log reduction value (LRV) for reuse.

UF turbidity was always under **0.1 NTU**, indicating that this critical control point was working correctly. There was a normal upward trend of **RO** permeate over time indicating fouling in the membrane. A CIP done on 24 January 2023 brought this back to within limits.

HACCP plan for reuse

Current regulations limit contact of non-potable water with meat or meat products regardless of treatment or quality specification, and recycled non-potable water may only be used for a purpose not connected with meat and meat products. In the context of a red meat processing plant, potential use cases may include:

- ✓ Yard or truck wash
- ✓ Primary belly wash
- ✓ Palatable water for stock drinking
- ✓ Refrigeration condensers
- ✓ Rendering condensers
- ✓ Boiler makeup

For the use case demonstration in this pilot project, refrigeration condensers were selected. A HACCP plan was developed with the assistance of Viridis Consultants. Once all HACCP requirements were satisfied, and the trial completed, using non-potable recycled water in a refrigeration condenser was added by the Federal Department of Agriculture, Fisheries, and Forestry as an approved arrangement in the site water standard operating procedure and quality management system.

Condenser trial

The system architecture for this trial was a reduced pressure zone (RPZ) non return valve on the potable inlet to the condenser, with a segregated and clearly marked non-potable recycled line into the condenser sump. By always ensuring a gap between the outlet of the potable line and the level of the sump (i.e. pipe not flooded) this would ensure no risk of backflow into the intra-plant potable network and risk of contact of non-potable recycled water with meat product.

During a one-week demonstration, the engineering controls were checked hourly along with monitoring of the sump conductivity, pH, temperature, ORP (indication of free chlorine disinfection potential), and refrigeration compressor pressure. There was also a minimum daily check of free chlorine in the non-potable recycled water supply tank to ensure maintenance within the 1.0 mg/L control limit.

This site had two refrigeration condensers running in parallel, so total refrigeration compressor work and the water draw of the other condenser was monitored to ensure it was not 'picking up the slack' of an insufficient non-potable water supply volume or quality. It was observed that there was no change to the potable condenser water draw, and the refrigeration compressor pressure setpoint remained unchanged.

A major observation was that over time, the condenser sump conductivity will normalise towards the bleed-off setpoint (**1,500 μS/cm** in this case) due to the accumulation of TDS from inlet water evaporating.

However, due to the differences in specific molar conductivity (µS/cm per mg/L) of the dissolved solutes in **RO** permeate compared to town water, there was a rapid drop in total sump conductivity when **RO** permeate was first introduced, down to a new equilibrium of approx. **1,100 µS/cm**. From there, the accumulation of conductivity was very slow, due to the high purity of supplied recycled water.

It was calculated that if running on 100% recycled water, it could potentially take days to accumulate enough TDS/conductivity to reach the current bleed off setpoint. This would become a problem regarding water stagnation and microbial growth, hence when using high purity recycled water in refrigeration condensers, the motivation for bleed off changes from preventing scale formation to preventing microbial formation in stagnant water. A general rule of thumb for cooling towers is that 10% is the minimum bleed off to prevent stagnation, hence for each cubic metre of supplied water, 100 L should be bled off. This can be achieved either with a new conductivity set point on the system controller at around **1,100 µS/cm**, or with a proportional control based on incoming flow rate. Compared to the current water use statistics where **17 – 35%** of total supplied town water was bled off, this is an immediate saving in:

- Reduced water sent to cooling tower
- Reduced water discharged as bleed off to sewer
- Reduced treatment chemicals lost in blowdown
- Reduced scale formation
- Improved heat transfer efficiency

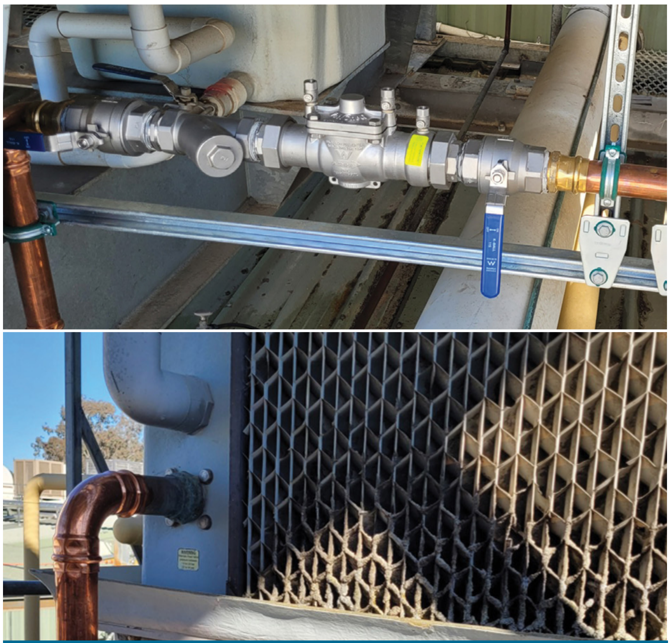


Figure 6 Engineering controls on condenser – RPZ and air gap.

The calculated levelised cost of water (LCoW) for this 100 kL/day pilot plant input/50 kL/day **RO** output was **$2.17/kL** compared to the current rate site paid for town water of $2.74 including buy-in and discharge. This equates to an annual saving for both condensers of over **$32,000** and a simple **payback of less than 5 years**. A major non-tangible benefit of investing in water recycling programs comes during drought periods, where red meat processing plants can show, they are dedicated to reducing water intensity to improve sustainability and building relationships with the local community, and hence social license to operate. Some red meat processing plants have water volume inlet and outlet costs >$6/kL, equating to a simple pay towards 2 years.

Glossary

CAL
Covered anaerobic lagoon.

Green streams
Water sources generated from manure and paunch wastes from the emptying of the animal stomach and internal organ processing.

HACCP
Hazard Analysis and Critical Control Points.

HACCP plan
A program designed to help businesses identify and manage hazards to food safety.

Raw streams
Wastewater that has not been treated.

Red streams
Water sources generated from the slaughter, evisceration and boning areas as well as any rendering processes. These streams contain fat and nitrogen from blood and urine and proteins from meat tissue.

TSS
Total suspended solids which are wholly or partially visible to the naked eye. Examples include paunch, dirt, sand or hair in the green streams, and fats and blood colloids in the red streams.

AMPC

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