Snapshot Report

Techno-economic Feasibility of Water Recycling

Technical and economic feasibility of water recycling for red meat processing operations in abattoirs

Project Code	Prepared by	Date Submitted
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Project Description

The Australian red meat processing industry uses large quantities of water and energy to meet food safety requirements. Processors in regional areas are often perceived as over-users of water, which could result in tensions between red meat processors and the local community for the consumption of water, especially in times of water stress.

Therefore, Project 2018-1030 aimed to provide engineering solutions and technical recommendations to reduce water consumption of modern abattoirs via a technical and economic feasibility study to identify waste streams paired with technologies capable of water recycling from meat processing waste.

Project Content

The objectives of this project were achieved via the following four milestones.

- **Milestone1 – Abattoir Operational Data Collection:**

  Operational data was used to identify sources of meat processing wastewaters and their quality and quantity. The current water and energy consumption in Australian red meat abattoir was mapped, and specific processes where significant water and energy savings can be achieved were identified.

- **Milestone 2 – Selection of Waste Streams Feasible for Reuse/Recycling:**

  Selected wastewater streams were paired with treatment technologies to produce water that met quality standards for specific reuse or recycling applications. Waste streams were ranked and selected based on their contaminant loads and volumes.

- **Milestone 3 – Treatment Train Selection and Operating Conditions:**

  The operating conditions of the treatment process trains for the proposed water reuse/recycling options were evaluated and optimized. BioWin and WAVE Reverse Osmosis (RO) modelling tools were used to determine the operating parameters required to meet the recycled water's quality whilst minimising capital and operational expenditures.

- **Milestone 4 – Life-Cycle and Economic Cost-Benefit Assessments:**

  It was advised that to achieve significant water savings, meat processor need to consider potable water recycling. MS4 further evaluated the environmental impacts arising from adoption of these treatment trains, via a Life-Cycle Assessment (LCA), and also assessed its economic feasibility through Net Present Value (NPV) and Return on Investment (ROI) calculations. Two potable water recycling options were compared against the base case scenario of not recycling water, to contrast the environmental and financial cost-benefits.

Project Outcome

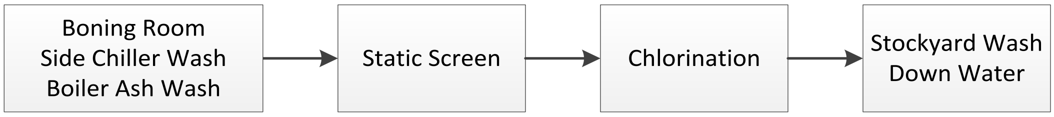
Findings from Milestone 1: Abattoir Operational Data Collection

- Processors had concerns regarding the growing uncertainty of the cost of potable water, which was exacerbated by risks on water availability due to drought conditions and increasing demand.
- The total normalised potable water consumption for red meat processing ranged from 3.10 to 12.18 kL/t.HSCW with sheep/lamb and cattle processors using an average 6.55 and 8.94 kL/t.HSCW respectively.
- Cost of potable water and tradewaste disposal were highly variant and dependent on processor's geographical location. Potable water costs ranged from as low as $1.46 to as high as $4.50 AUD/kL. Trade waste disposal costs also fluctuated significantly with prices ranging from $0.25 to $2.54 AUD/kL.

- ➢ The current legislation and perceived risks were the barriers that hindered the adoption of direct planned potable recycled water for red meat processing. This limits red meat processors to only specific AQIS-approved reuse options and minimal water savings.

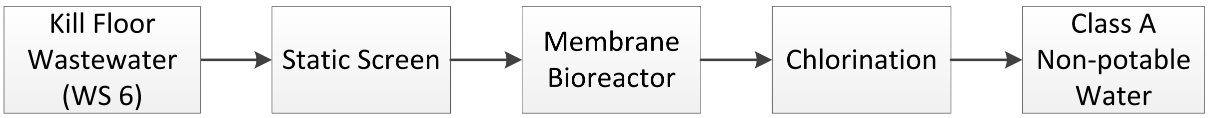
Findings from Milestone 2 and 3: Direct Reuse/Recycling Options for Selected Waste Streams

- ➢ Wastewater from cattleyard wash, boning room, kill floor, side chiller wash, boiler ash wash, and rendering condensates were the most feasible waste streams for reuse or recycling.
- ➢ **Option 1**: Direct reuse of wastewater from the boning room, side chiller wash, and boiler ash wash for stockyard wash down



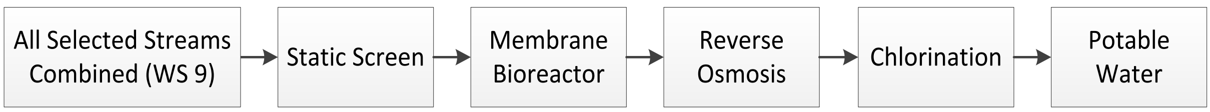
- ❖ Minimal treatment of screening followed by chlorination was required to achieve the 2 Log-removal for *Escherichia coli* and maintain a residual chlorine concentration of 0.2 - 2.0 mg/L.
- ❖ Reuse option has the potential to yield water savings of 204 m^3/day.

- ➢ **Option 2**: Producing Non-potable Class A water from treatment of kill floor wastewater



- ❖ For non-potable Class A water production, a Membrane Bioreactor (MBR) was required for pathogen and nutrient removal. MBR technology was selected for its small footprint, performance consistency, and lower CAPEX/OPEX compared to conventional nutrient removal technologies. It also met the pathogen Log Removal Values (LRV) required for non-potable Class A water.
- ❖ The MBR operating at a Recycle Ratio (RR) of 450% and a sludge production rate of 25.4 m^3/day, resulting in an estimated specific energy consumption rate of 0.15 kWh/m^3 producing 719 m^3/day of non-potable Class A water.

- ➢ **Option 3**: Direct Planned Potable Water Recycling of the Six Selected Waste Streams



- ❖ Similar to Option 2, Option 3 also employed a MBR for pathogen and nutrient removal with a Reverse Osmosis (RO) system for further treatment to produce potable water.
- ❖ The MBR operating at a RR of 300% and a sludge production rate of 40.6 m^3/day, resulting in an estimated specific energy consumption rate of 0.10 kWh/m^3.
- ❖ Effluent from the MBR was then further treated via a two-stage RO system producing 1023 m^3/day of potable water at a recovery rate of 88.1% with a specific energy consumption of 0.30 kWh/m^3.

Findings from Milestone 4: Life Cycle and Economic Cost-Benefit Assessments

- Notwithstanding the limitations of the current legislation and market access barriers, the previous milestones established that recycling abattoir wastewater to potable standards was the most ideal way for meat processors to achieve significant water savings.
- The Life-cycle and Economic Cost-Benefit Assessments compared two potable water recycling scenarios and a base case scenario, where no recycling is performed.
- The two potable water recycling scenarios were internal recycling, utilising the proposed treatment train (Option 3), and End-of-Pipe (EoP) recycling, which involves recycling water using an Ultrafiltration (UF) membrane unit and a RO unit from conventionally treated abattoir wastewater.

- **Life-cycle Assessment Findings**

LCA Impact Indicator	Unit/L Potable Water	Base Case	Internal Recycling	End-of-Pipe Recycling
Global Warming Potential	kg CO_2 eq	1.09E-02	1.16E-02 (+6.4%)	1.12E-02 (+2.8%)
Stratospheric Ozone Depletion	kg CFC-11 eq	6.69E-08	6.76E-08 (+1.0%)	6.74E-08 (+0.7%)
Fine Particulate Matter Formation	kg PM2.5 eq	7.69E-06	8.28E-06 (+7.7%)	7.89E-06 (2.6%)
Photochemical Ozone Formation	kg NO_x eq	4.13E-05	4.26E-05 (+3.1%)	4.20E-05 (+1.7%)
Terrestrial Acidification	kg SO_2 eq	2.29E-05	2.51E-05 (+9.6%)	2.38E-05 (+3.9%)
Freshwater Eutrophication	kg P eq	4.79E-06	6.05E-06 (+26.3%)	5.26E-06 (+9.8%)
Freshwater Ecotoxicity	kg 1,4-DCB	1.24E-04	1.56E-04 (+25.8%)	1.36E-04 (+9.7%)
Mineral Resource Scarcity	kg Cu eq	7.42E-07	4.99E-07 (-32.7%)	5.08E-07 (-31.5%)
Fossil Resource scarcity	kg oil eq	7.83E-04	9.57E-04 (+22.2%)	8.51E-04 (+8.7%)
Freshwater Consumption	m^3	1.01E-03	6.43E-04 (-36.3%)	6.44E-04 (-36.2%)

Blue indicates environmental benefit
Red indicates environmental burden

- A decrease in normalised impact scores indicated an environmental benefit while an increase indicated an environmental burden. Changes in LCA indicators were deemed to be significant when the final impact score experienced +/- 10% changes.
- Regardless of recycling configuration, potable water recycling generated an environmental benefit from the reduction in the mineral resource scarcity and freshwater consumption.
- Potable water recycling did increase the overall environmental burden compared to EoP recycling due to the increased energy consumption associated with the use of the MBR for nutrient removal.

- **Economic Cost-Benefit Assessment Findings**

	Potable Water Cost Price (AUD/kL)	1.45	2.98	4.50
Internal Recycling (MBR-RO)	NPV (AUD)	$-1,622,400	$2,910,544	$7,443,489
	ROI Rate (%)	-2.7%	10.2%	23.1%
	Capital Recover Point	Not Reached	8 Years	5 Years
End-of-Pipe Recycling (UF-RO)	NPV (AUD)	$-4,896,127	$-363,182	$4,169,763
	ROI Rate (%)	-22.6%	0.07%	22.8%
	Capital Recovery Point	Not Reached	Not Reached	5 Years

- At the current average potable water cost price of $2.98 AUD/kL, internal recycling was more economically feasible, attaining a ROI of 10.2%, a positive NPV of $2,910,544 AUD after 15 years, and full capital recovery after 8 years. EoP was unable to achieve capital recovery with a low ROI of 0.072% and negative NPV of $-363,182 AUD after 15 years.
- Economic feasibility was dependent on potable water price with both recycling options being not economically feasible at a low cost price of $1.45 AUD/kL. However, at a higher cost price of $4.50 AUD/kL, both options were able to recover their initial capital in 5 years.

Recommendations and Future Work

- Water recovery can be achieved via three options with direct planned potable water recycling yielding red meat processors the most significant water savings.
- Currently, red meat processors do not segregate their waste streams which reduces opportunities to recycle specific streams and, in turn, makes it difficult to implement proposed water reuse/recycling options.
- It is recommended that current abattoirs consider additional investment to retrofit plumbing for waste segregation while greenfield abattoirs should conduct hydraulic planning to allow for access to individual waste streams and minimise cross-contamination between streams.
- Although this study has demonstrated the technical and economic feasibility of potable water recycling, the main barrier limiting the implementation of this scheme is the food safety and market access legislations.
- Consultation with relevant industry stakeholders and health regulators will allow for potable water recycling validation guidelines to be established.
- Pilot testing of the proposed potable water recycling treatment trains is recommended to allow for technical validation of treatment processes and final product water quality compliance monitoring.