Final Report

Water Reference Group

Assisting industry in adopting Direct Planned Potable Recycled Water for use in abattoirs

Project Code
2021-1048

Prepared by
Jessica Jolley
Andreas Kiermeier
John Sumner

Published by
AMPC

Date Submitted
June 2021

Date Published
July 2021

Acknowledgements

We acknowledge the inputs of the members of the Water Reference Group:

- Peter Day, NSW Department of Primary Industries
- Matthew Deegan, Australian Meat Processor Corporation
- Claire House, Australian Meat Industry Council
- Michael Lang, JBS Australia
- John Langbridge, Teys Australia
- Pierre le Clech, University of NSW
- Stewart Lowden, Department of Agriculture, Water and the Environment
- Trevor Moore, Northern Cooperative Meat Company
- Gabrielle Ryan, Fletcher International Exports

Thanks also to staff at a number of establishments who provided SARDI with information throughout this project.

Contents

Acronyms

AMIC	Australian Meat Industry Council
AMPC	Australian Meat Processor Corporation
AMRG	Australian Meat Regulators Group
AQIS	Australian Quarantine and Inspection Service
ATM	Area Technical Manager
AWRG	Australian Water Recycling Guidelines
AWS	Alliance for Water Stewardship
CAC	Codex Alimentarius Commission
cfu	Colony Forming Units
CSIRO	Commonwealth Science and Industrial Research Organisation
DALYs	Disability Adjusted Life Years
DAWE	Department of Agriculture, Water and the Environment
DPPRW	Direct Planned Potable Recycled Water
D-R	Dose-response
EoP	End-of-Pipe
EU	European Union
HACCP	Hazard Analysis Critical Control Point
IPPRW	Indirect Planned Potable Recycled Water
MBR	Membrane Bioreactors
MLA	Meat and Livestock Australia
MN	Meat Notice
QRA	Quantitative Risk Assessment
RA	Risk Assessment
RCP	Recommended International Code of Practice
RO	Reverse Osmosis
ROI	Return on investment
SARDI	South Australian Research and Development Institute

STEC	Shiga toxin-producing *Escherichia coli*
UF	Ultrafiltration
UNSW	University of New South Wales
US or USA	United States of America
USDA FSIS	United States Department of Agriculture Food Safety Inspection Service
WRG	Water Reference Group
YLL	Years of life lost
YLD	Years lived with a disability or illness

Executive Summary

Stimulus for the study

To determine why the meat industry has not taken up the large-scale water savings seen in other industries, the Australian Meat Processor Corporation (AMPC) commissioned the South Australian Research and Development Institute (SARDI) to identify barriers to the uptake of Direct Planned Potable Recycled Water (DPPRW) with the objectives to:

1. Form a Water Reference Group (WRG) comprising industry and government representatives to inform and advise the project.
2. Consult industry on water reuse/recycling and identify barriers to adoption.
3. Facilitate discussions with the WRG to design trial projects for possible implementation at a later stage of the project.
4. Deliver a position paper on future pilot trial designs related to DPPRW and other reuse/recycling initiatives.

Conduct of the study

The objectives were met during the project by:

1. Gathering information contained in around thirty industry reuse/recycling projects funded by AMPC/Meat and Livestock Australia (MLA).
2. Consulting industry via a survey of practices regarding reuse/recycling.
3. Establishing a Water Reference Group from the Australian Meat Industry Council (AMIC), meat processors, Australian Meat Regulators Group (AMRG), Department of Agriculture, Water and the Environment (DAWE) and AMPC to oversee the project and disseminate information to their stakeholders during the project.
4. Online meetings with the WRG to identify, discuss and plan how to resolve barriers to adoption of DPPRW in abattoirs and to design potential future trials on water reuse/recycling.
5. Developing position papers on ways to overcome identified barriers, such as the design of future pilot trials.

Findings of the study

Discussions with industry personnel identified four major impediments to implementing reuse/recycling initiatives:

1. Regulatory requirements were both stringent and involved several authorities.
2. The risk assessment required by regulatory authorities was onerous and complicated.
3. The business case needed for initiatives, particularly DPPRW, was difficult to justify.
4. The negative public perception of using recycled water as DPPRW.

Accordingly, each of the impediments was considered by the WRG.

Impediment 1: Regulatory requirements

The study established that a four-stage process is required for an export establishment to install infrastructure to reuse/recycle water on-site:

1. Local authority: planning and development permission.
2. State health/environment department: validation that the reuse/recycle process delivers water with the proposed microbiological, chemical and physical parameters.
3. State meat authority: verification of the installation.
4. DAWE: sign-off on the decision of the state meat authority.

DAWE acknowledged that the above process does not align with AQIS Meat Notice 2008/6 *Efficient use of water in export meat establishments* and minor rewriting is required.

Accordingly, the WRG recommends that AMPC and the industry initiate the process of revising the Meat Notice and AMPC and the industry request DAWE to formally review market access requirements in relation to use of recycled water.

Impediment 2: Risk assessment

As part of AQIS Meat Notice 2008/6, a guide for businesses wishing to recycle or reuse water identifies five stages to be followed chronologically, including Stage 2: *Risk assessment through to formal submission to (AQIS) the principal regulator*.

The approach to risk assessment (RA) and recycled water has been moulded by three reports commissioned by MLA and/or AMPC in which Quantitative Risk Assessment (QRA) has been used: Jain *et al*. (2003) *A quantitative risk assessment of microbial emissions from abattoirs*; Warnecke *et al.* (2008) *Review of abattoir wastewater usage reduction, recycling and reuse* and Pither (2017) *Wastewater risk assessment*.

The QRA approach to risk assessment of recycled water installations follows the Australian Water Recycling Guidelines (AWRG) (Anonymous, 2006), which is complicated to undertake and measures risk in terms of Disability Adjusted Life Years (DALYs), an estimate of limited usefulness to establishment personnel.

An alternative approach is to use a qualitative tool such as developed by CSIRO for initial screening or a semi-quantitative risk tool such as Risk Ranger, both of which were used for the national meat industry risk assessment (Pointon *et al.*, 2006).

However, Risk Ranger is designed to estimate risks of pathogen:product pairings and in the present context, serves merely to illustrate that a similar tool designed specifically to estimate risk incurred by recycling technologies would be fit for purpose.

Accordingly, the WRG recommends that AMPC consider funding development of a suitable risk assessment tool for water recycling in the meat industry.

Impediment 3: Potential pilot projects and their business case

The WRG considered potential projects and recommended consideration of the following, which are presented in outline in three categories:

1. High technology production of DPPRW
2. Water reuse/recycling projects
3. Reconsideration of projects completed by AMPC/MLA over the past two decades.

For Category 1 (High technology production of DPPRW), it was concluded that a demonstration plant should be installed that begins with recycling to a non-potable stage and then progresses to providing DPPRW; the elements of such a project are presented later as *Pilot project 1: Demonstration of DPPRW plant for red meat processors*.

For Category 2, four projects are identified as Water reuse/recycling projects: Reuse of hot water wash on beef floor; Reuse of steriliser water; Reuse of final smallstock wash water and Alternative knife sanitising.

For Category 3, nine projects undertaken successfully in various locations in the abattoir are recommended for reconsideration.

Impediment 4: Changing perception of using recycled water as DPPRW – need for progress

The AWRG outline the importance of stakeholder consultation/communication and the WRG gained insights on how a major poultry processor (Ingham's) won public approval for recycling of its waste treatment streams to DPPRW at their Queensland, Victorian and South Australian plants.

The journey undertaken by Ingham's represents a template for any meat processor intending to generate DPPRW.

The demonstration plant proposed as a Category 1 pilot project (see Impediment 3) may also provide a useful framework for engaging with customers of processing establishments and the broader community and for promoting the benefits of water recycling in the meat processing sector and the food safety controls that are put in place to do so safely.

Introduction

At the beginning of the 21st century, Australia encountered protracted drought – known as the Millennial Drought – which had great consequences for abattoir operations, some of which use more than 4 million litres of water every day (4 ML/d).

In an endeavour to minimise water use, over the past twenty years, more than thirty projects have been undertaken on reuse and recycling of water used in abattoirs, a summary of which is presented in 0. A number of projects have focused on production of *Direct Planned Potable Recycled Water* (DPPRW) which is defined in the AQIS Meat Notice 2008/06 (AQIS, 2008) as:

> *Water produced by an establishment using a controlled process where processing waste-water is fully regenerated to make it of potable standard as defined in the regulations and is used solely within that establishment.*

These projects have developed combinations of primary and secondary treatments of abattoir effluents using ponding, screens, ultrafiltration (UF), membrane bioreactors (MBR) and reverse osmosis (RO) which are able to render significant proportions of effluent to water of potable quality.

In contrast to other industries, to date, no red meat establishment has implemented the infrastructure needed to achieve significant water savings via DPPRW. For example, a large poultry processor typically recovers the vast majority of the 4.5 ML of incoming water used each day via a train of treatments.

Dairy operations also reuse/recycle water, e.g. a milk powder plant may take in 1 ML of milk each day and recover 0.7 ML during evaporation (so-called “cow water”) which although nominally potable, is used for non-potable operations such as plant cleaning. A typical cheese plant will convert 1 ML/day of milk to curd (10%) and whey (90%). If the plant has a UF/RO whey treatment plant, it will separate lactose, whey protein and other constituents and release water for other on-plant uses.

For the red meat industry, next to reducing emissions intensity, reducing water intensity is one of the biggest environmental challenges. While processors have steadily improved their water efficiency over the long term, leading to a 9% improvement in water intensity since 2009, this improvement has largely been through water efficiency interventions, and water recycling rates have not improved over the same period. As evidenced in the 2020 Environmental Performance Review for red meat processors, water reuse/recycling in plants has stalled at just 11% of intake for a decade (All Energy Pty Ltd, 2021). Establishing a pathway for the transition to advanced water recycling for red meat processors will play an important role in continuing the red meat industry’s downward trend in water intensity.

Accordingly, to elucidate the reasons why, despite concentrated project support, the industry has not taken up the large-scale water savings seen in other industries, the Australian Meat Processor Corporation (AMPC) commissioned the South Australian Research and Development Institute (SARDI) to identify barriers to the uptake of DPPRW.

Project Objectives

The present project addresses the need for agreement between industry and regulators on any barriers to the use of DPPRW with the objectives to:

1. Form the Water Reference Group (WRG) – industry and government representatives.
2. Consult industry on the topic of DPPRW, barriers to adoption and trial projects.
3. Facilitate discussions between the WRG on the topic of DPPRW and trial projects, through workshops/meetings.
4. Deliver a position paper on future pilot trial design related to DPPRW (actual design of the pilot trials is not costed in proposed budget as the number and scope of pilot trials are currently unknown and will be determined by the WRG (points 2 and 3 above)).

Conduct of the study

The study began in November 2020, concluded in May 2021 and was conducted via the following:

1. Information gathering and industry consultation
    a. Review of recent literature and reports.
    b. Industry survey on in-house practices regarding reuse/recycling.
    c. Online and telephone discussions with individual companies to support survey findings.
2. Establishing a Water Reference Group (WRG)
    a. Recruit representatives from the Australian Meat Industry Council (AMIC), meat processors, Australian Meat Regulators Group (AMRG), Department of Agriculture, Water and the Environment (DAWE) and AMPC to have oversight of the project and to disseminate information to their stakeholders during the project.
    b. Include the University of New South Wales (UNSW) as an advisor in water recycling and treatment, and on environmental impacts related to abattoirs.
3. Meetings with the WRG
    a. Online meetings to identify, discuss and plan how to resolve barriers to adoption of DPPRW in abattoirs.
    b. Design potential future trials on water reuse/recycling.
4. Developing position papers on ways to overcome identified barriers, such as the design of future pilot trials
    a. As identified by AMPC or the WRG, there may be data gaps or the need for pilot trials on-plant to address any concerns about food safety, quality assurance and market access.
    b. The number, scope and complexity of the pilot trials are currently unknown and so the design and costing of pilot trials, as well as assisting abattoirs in achieving funding, will be costed and covered under a separate project – Stage 2.

Findings of the study

Industry survey

Industry personnel considered a questionnaire (see Appendix 2) that asked about any current water reuse/recycling processes at their establishments and their experience with their regulator in implementing these water saving processes. SARDI staff followed up the survey findings by:

- Discussions with staff associated with 29 establishments by phone
- Collating information received on existing and prospective water reuse/recycling activities
- Identifying impediments to extending the scope of water reuse/recycling.

The extent to which establishments reuse or recycle water can be summarised into several categories:

- Establishment does minimal recycling – puts all water through the treatment system and then recycles it for cleaning stock yards and pens.
- Establishment reuses water for potable purposes e.g. hot water carcase wash is reused after minimal treatment.
- Establishment recycles water for non-potable purposes e.g. "white" water from sterilisers, handwash, viscera table or hot water cabinet water used for:
    - Opening paunches and bibles
    - Primary wash of cattle (always followed by a second wash with potable water)
    - Cleaning yards
    - Irrigation of paddocks
- A small number of establishments indicated they were planning to recycle up to 600,000 L/day of treated effluent water for reuse through the site. Advanced water will be produced through a series of steps including ultrafiltration, nanofiltration and possibly reverse osmosis aimed at producing high quality water for various uses on-site. The Advanced water stream will be further improved with anti-microbial treatment and calcite filtration as required. It is proposed to use non-direct potable water in both the refrigeration condensers and make-up water for the boilers. Preliminary investigation indicates a 2-3 year return on investment.
- It is planned to set up the plant to allow for eventual recycling to DPPRW and its use in processing areas on meat and meat contact surfaces via two-step sterilisation with chlorination, ultraviolet and/or ozone and continuous quality monitoring instrumentation.

Identification of impediments to recycling

Discussions with industry personnel identified four major impediments to implementing reuse/recycling initiatives:

1. Regulatory requirements
2. Onerous/complicated risk assessment
3. Business case needed for initiatives, particularly DPPRW
4. Public perception of using recycled water as DPPRW.

These impediments are addressed in more detail in the following sections.

Impediment 1: Regulatory requirements

Background

The overarching requirements for water quality are laid out in Chapter 21 of the Australian Standard 4696:2007 "Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption" (Anonymous, 2007). The standard reflects the requirements of the CAC/RCP 58 Codex Code of Hygienic Practice for Meat (CAC, 2005) and the CAC/RCP 1 Codex Recommended International Code of Practice General Principles of Food Hygiene (CAC, 1969). RCP 58 refers to RCP 1 in relation to water and neither of these explicitly prohibits the use of recycled water.

For export meat establishments, AQIS Meat Notice 2008/06: *Efficient use of water in export meat establishments* (AQIS, 2008) sets out requirements for reuse/recycling of water.

The Meat Notice defines four types of recycled water:

1. **Indirect planned potable recycled water (IPPRW):** Water produced by a local water authority using a controlled process where general waste-water is fully recycled to make it of potable standard as defined in the regulations. The recycled water is then introduced back into the raw supply which in turn is subject to all the normal treatment procedures that this supply is subject to, to make it potable.
2. **Direct planned potable recycled water (DPPRW):** Water produced by an establishment using a controlled process where processing waste-water is fully regenerated to make it of potable standard as defined in the regulations and is used solely within that establishment.
3. **Reused water**: Water that has been used previously for an approved purpose that is reclaimed and used again, with or without further treatment, for the same or other purposes that it is fit for the purpose. Reused water is different to potable in that it is not for general use within an establishment and its use must be controlled using Hazard Analysis Critical Control Point (HACCP) principles.
4. **Non-potable recycled water**: Recycled non-potable water provided for restricted purposes such as irrigation, watering gardens, flushing toilets, washing down external areas which it is fit for the purpose.

The Australian national guidelines for water recycling consist of three documents:

1. National Guidelines for Water Recycling, Doc. #21, November 2006
2. Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies, Doc. #22, May 2008
3. Australian Guidelines for Water Recycling: Managed Aquifer Recharge, Doc. #24, July 2009.

All are based on the principles outlined in the first document and while they state that they: *"are intended to be used by anyone involved in the supply, use and regulation of recycled water schemes, including government and local government agencies, regulatory agencies, health and environment agencies, operators of water and wastewater schemes, water suppliers, consultants, industry, private developers, body corporates and property managers",* it appears that they are primarily aimed at local government water suppliers.

A more detailed presentation of each of the above standards and guidelines is presented in Annex 1.1 and 1.2 related to this impediment.

Market access implications

An important consideration for the use of DPPRW in an export registered meat establishment is the potential implications for market access and historically, development of AQIS Meat Notice 2008/06 was preceded by a full review of market access requirements in relation to use of recycled water (pers. comm. J. Langbridge, Teys Australia).

In preparation for WRG meeting 2 (29 January 2021), S. Louden (DAWE) was able to provide that Export Standards Branch did not find any importing country requirements for the EU or the USA[1] related to use of recycled water. Nevertheless, *"the US required DAWE certification that Australian US-export establishments will need to operate an on-site advanced wastewater treatment facility resulting in compliance with the requirements set out in 'Water Recycling Methodology in Australia' and any other requirements set by DAWE to ensure the safety and wholesomeness of meat product exported to the US."*

While this provides some comfort to exporters, there was unanimous agreement at the WRG meeting that a review of market access requirements in relation to use of recycled water (for all relevant markets) should be undertaken. This would provide industry with more confidence in continued market access given the considerable investment needed for water recycling infrastructure.

Recommendation: AMPC and the industry request DAWE to formally review market access requirements in relation to use of recycled water.

Regulatory requirements for export meat establishments

The conduct of the present project has established that a four-stage process is required for an export establishment to install infrastructure to reuse/recycle water on-site:

1. Local authority: planning and development permission.
2. State health/environment department: validation that the reuse/recycle process delivers water with the proposed microbiological, chemical and physical parameters.
3. State meat authority: verification of the installation.
4. DAWE: sign-off on the decision of the state meat authority.

The above follows confirmation by DAWE that the Department is not the principal regulator for approving the on-site recovery of water by meat establishments but will accept, in principle, the decision of an Approved Arrangement between an establishment and their relevant authority.

Alignment with AQIS Meat Notice 2008/6

The current DAWE position contradicts key elements of Meat Notice (MN) 2008/6 (AQIS, 2008), which will require amendment, including:

[1] Confirmed by an USDA Food Safety Inspection Service (FSIS) communique.

1. The Notice makes clear that the Department is the principal regulator: *"To assist the meat industry the process of obtaining approval to undertake the on-site recovery of water has been broken down into five stages. These stages being:*
    - *Stage 1: Self-assessment prior to preliminary meeting with regulators;*
    - *Stage 2: Risk assessment through to formal submission to (AQIS)* ***the principal regulator****;* (emphasis added)
    - *Stage 3: Approval process undertaken by (AQIS)* ***the principal regulator****;* (emphasis added)
    - *Stage 4: Commissioning, validation and verification; and*
    - *Stage 5: Approval to use water in production processes."*
2. At several points, MN 2008/6 makes clear that the Department is the principal regulator e.g. under 6.1.2 *"Establishments wishing to use direct planned recycled potable water as part of their production process must provide full details as per the attachment, to the responsible AQIS Area Technical Manager (ATM) who will consult with Central Office for initial in principle approval prior to construction of the facility, and then final approval once validated, prior to using this recycled water in production.* ***AQIS will inform the relevant state food safety authority of the proposal to ensure any concerns of the local authority is identified and addressed."*** (emphasis added)

Can recycled water be used on meat?

Clause 5.6.7 of MN 2008/6 states that DPPRW: *"must not use the water as a direct ingredient in meat products or use it for drinking water at the establishment"*.

It was established by the WRG that "ingredient" is intended to cover use of DPPRW in brines and marinades that are injected or massaged into meat cuts and under 6.1(d) MN 2008/6, it is stated that recycled water can be used on meat and meat contact surfaces providing:

- *The validation has been completed.*
- *The variation to the Approved Arrangement is approved.*

Conclusions

Discussion during the WRG meetings of the inconsistencies in the Meat Notice resulted in general consensus that the Meat Notice requires revision.

Recommendation: AMPC and the industry initiate the process of revising Meat Notice 2008/6.

Annex 1.1. Water recycling requirements

The overarching requirements for water quality are laid out in Chapter 21 of the Australian Standard 4696:2007 "Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption" (Anonymous, 2007). The standard defines potable as *"when used in relation to water, means water that is acceptable for human consumption*" and subclause 21.6 states:

21.6 Only potable water is used for the production of meat and meat products unless:

(a) the water is only used:

i. for steam production (other than steam used or to be used in direct or indirect contact with meat and meat products), fire control, the cleaning of yards, the washing of animals (other than the final wash) and other similar purposes not connected with meat and meat products: or

ii. in other circumstances where there is no risk of the water coming into contact with or contaminating meat and meat products; and

(b) the approved arrangements expressly provides for the use of the non-potable water in the circumstances in which it is used.

As such, the standard reflects the requirements of the CAC/RCP 58 Codex Code of Hygienic Practice for Meat (CAC, 2005) and the CAC/RCP 1 Codex Recommended International Code of Practice General Principles of Food Hygiene (CAC, 1969). RCP 58 refers to RCP 1 in relation to water and neither of these explicitly prohibit the use of recycled water. In particular, RCP 58 Principle 6 of meat hygiene applying to establishments, facilities and equipment (CAC, 2005) states that "*water should be potable except where water of a different standard can be used without leading to contamination of meat."* In addition, RCP 58 states that *"Where non-potable water is supplied for various uses e.g. firefighting, steam production, refrigeration, reticulation systems should be designed and identified so that cross-contamination of the potable water supply is prevented"* and *"water for cleaning and sanitising of a standard that is appropriate for the specific purpose and used in a manner that does not directly or indirectly contaminate meat."*

More broadly, RCP 1 states in Section 5.5.1 "In contact with food":

Only potable water, should be used in food handling and processing, with the following exceptions:

- *for steam production, fire control and other similar purposes not connected with food; and*
- *in certain food processes, e.g. chilling, and in food handling areas, provided this does not constitute a hazard to the safety and suitability of food (e.g. the use of clean sea water).*

Water recirculated for reuse should be treated and maintained in such a condition that no risk to the safety and suitability of food results from its use. The treatment process should be effectively monitored. Recirculated water which has received no further treatment and water recovered from processing of food by evaporation or drying may be used, provided its use does not constitute a risk to the safety and suitability of food.

Clearly, both codes of practice implicitly appear to allow the use of risk assessment to determine appropriate water treatment to ensure public health.

Subsequently, AQIS Meat Notice 2008/06 (AQIS, 2008) recognised the increasing need for more efficient use of water, including recycling of water, and set out requirements for export meat establishments.

The Meat Notice defines four types of recycled water:

1. **Indirect planned potable recycled water:** Water produced by a local water authority using a controlled process where general waste-water is fully recycled to make it of potable standard as defined in the regulations. The recycled water is then introduced back into the raw supply which in turn is subject to all the normal treatment procedures that this supply is subject to, to make it potable.
2. **Direct planned potable recycled water:** Water produced by an establishment using a controlled process where processing waste-water is fully regenerated to make it of potable standard as defined in the regulations and is used solely within that establishment.
3. **Reused water**: Water that has been used previously for an approved purpose that is reclaimed and used again, with or without further treatment, for the same or other purposes that it is fit for the purpose. Reused water is different to potable in that it is not for general use within an establishment and its use must be controlled using HACCP principles.
4. **Non-potable recycled water**: Recycled non-potable water provided for restricted purposes such as irrigation, watering gardens, flushing toilets, washing down external areas which it is fit for the purpose.

In addition, the Meat Notice defined potable water as *"Water from any source that is acceptable for human consumption."*

The Meat Notice also outlines a 5-stage process for obtaining approval to undertake on-site recovery of water.

- Stage 1: Self-assessment prior to preliminary meeting with regulators;
- Stage 2: Risk assessment through to formal submission to (AQIS) the principal regulator;
- Stage 3: Approval process undertaken by (AQIS) the principal regulator;
- Stage 4: Commissioning, validation and verification; and
- Stage 5: Approval to use water in production processes.

In particular, Stage 2 requires that a risk assessment be undertaken, where it is noted: "*The risk assessment process is not a full risk assessment of the health impact of reused water; rather it is an assessment of the risk of hazards getting through the treatment system in sufficient amounts to pose a risk to human health*." The document also provides an example of a qualitative approach to risk assessment that could be undertaken by an establishment, based on qualitative descriptors of consequence (severity) and likelihood. Unfortunately, no further information is provided as to how these two aspects are to be combined to determine the level of risk – this is usually done in the form of a risk matrix. In addition, no particular requirements are provided that indicate what level of risk would be deemed unacceptable. In this aspect, the Meat Notice differs slightly from the National Australian Guidelines for Water Recycling.

Annex 1.2. National Australian Guidelines for Water Recycling

The Australian national guidelines for water recycling consist of three documents:

1. National Guidelines for Water Recycling, Doc. #21, November 2006
2. Australian Guidelines for Water Recycling: Augmentation of Drinking Water Supplies, Doc. #22, May 2008
3. Australian Guidelines for Water Recycling: Managed Aquifer Recharge, Doc. #24, July 2009.

These are all based on the basic principles outlined in the first document. While these documents state that they *"are intended to be used by anyone involved in the supply, use and regulation of recycled water schemes, including government and local government agencies, regulatory agencies, health and environment agencies, operators of water and wastewater schemes, water suppliers, consultants, industry, private developers, body corporates and property managers",* it appears that they are primarily aimed at local government water suppliers.

The guidelines consider and define the following three water sources (Box 1.3, Anonymous, 2006):

- **Greywater** refers to water sourced from kitchen, laundry and bathroom drains, but not from toilets (note: some guidelines exclude water from the kitchen because it can contain high levels of food scraps and other undesirable particles and wastes). Greywater may contain urine and faeces from nappy washing and showering, as well as kitchen scraps, soil, hair, detergents, cleaning products, personal-care products, sunscreens, fats and oils. Cleaning products discharged in greywater can contain boron and phosphates, and the water is often alkaline and saline — all of which pose potential risks to the receiving environment. Greywater quality can be affected by inappropriate disposal of domestic wastes.
- **Sewage** refers to material collected from all internal household drains; it contains all the contaminants of greywater and urine, in addition to high concentrations of faecal material from toilets. Sewage can therefore contain a range of human infectious enteric pathogens, plus wastes from industrial and commercial premises. Discharge of trade wastes to sewer can introduce a range of contaminants, particularly chemicals. Sewage also contains high levels of nutrients, particularly phosphorus and nitrogen, which have been identified as key environmental hazards. Groundwater infiltrating into sewers can cause substantial increases in chloride, salinity and sodicity (high sodium concentrations relative to calcium and magnesium), which have also been identified as key environmental hazards.
- **Stormwater** refers to the water resulting from rain draining into the stormwater system from roofs (rainwater), roads, footpaths and other ground surfaces. It is usually channelled into local waterways. Stormwater carries rubbish, animal faeces, human faecal waste (in some areas), motor oil, petrol, tyre rubber, soil and debris. Initial runoff associated with storms can contain very high concentrations of enteric pathogens (disease-causing organisms) and contaminants (both chemical and physical).

The national guidelines spell out the requirements for undertaking risk assessment in relation to water recycling to determine the level of treatment required to make the end use safe. The guidelines include information about qualitative risk assessment, similar to that included in AQIS Meat Notice 2008/06, with the addition of how severity and likelihood can be combined (Tables 2.5 and 2.6). The aim should be to reduce all risks to low, addressing high and very-high risks first through implementing appropriate control measures.

However, while the guidelines *"are not prescriptive and do not represent mandatory standards",* they focus on quantitative risk assessment. In particular, the use of Disability Adjusted Life Years (DALY; see Appendix 2) seems to be strongly encouraged and the guidelines specify that the health-based target for water recycling equals 10^{-6} DALY per person per year. This target is the same as that for drinking water (NHMRC, 2011; WHO, 2006).

There are several potential problems with such a quantitative approach using DALYs:

1. The number of hazards (microbial and chemical) are likely to be large, requiring many risk assessments to be undertaken. This has led to the use of reference pathogens.
2. Dose-response (D-R) relationships are difficult and data intensive to establish and only relatively few have been quantified. The uncertainty in these D-R models is often large.
3. Data requirements are large, e.g. to quantify the levels and variability in levels of various hazard in source water over time.
4. Quantifying exposure levels (and variability in levels) is difficult, if not impossible, to ascertain. For this reason, gross assumptions about exposure volumes and frequencies are sometimes made, e.g. stock wash personnel compared with fire-fighters.

Guidelines for Fresh Produce Food Safety

Section 7 of the Guidelines for Fresh Produce Food Safety (FPSCANZ, 2019) details the microbiological and chemical hazards associated with water. It states that water may be used during growing, harvesting, packing and distribution and that microbial contamination of water presents different degrees of risk depending on the timing and context of application. The guidelines recommend that for produce with edible skin or inedible skin that may be consumed uncooked (p28, Table 5), a pathogen reduction step is required, such as:

- Significant time between harvest and consumption
- Wash step that can achieve minimum 3 log reduction of human pathogens, water treated to achieve *E. coli* <1 colony forming units (cfu)/100mL[2].

Growers of fresh produce utilise various sources of water include dams, bores, rain tanks, waterways (rivers and creeks), agricultural water schemes (channels and pipes) and domestic water supply. The guidelines state that reclaimed water (water derived from sewage systems and industrial processes) may generally be used during production but should not be used during harvesting and packing, even if treated. This suggestion seems to ignore the National Guidelines for Water Recycling.

In addition, Table 8 of the Produce Guidelines indicates exclusion periods (hours) between irrigation or spray application and crop harvest if water contains *E. coli* >100 cfu/100mL. Only when the water contacts the harvestable part during irrigation or spray application is an exclusion period of 48 hours required. In addition, it is noted in the document that *"Water potentially containing human pathogens that is applied more than 48 hours before harvest poses minimal food safety risk."*

[2] This limit is also used in the Australian Drinking Water Guidelines as part of monitoring water supplies.

Water used for hand washing by workers must contain *E. coli* levels of less than 1 cfu/100mL.

Given the large variety of potential water sources, the guidelines recommend the following restrictions in relation to water use:

- Water that contains *E. coli* <1 cfu/100mL can be used without restriction on any crop anytime.
- Water that contains *E. coli* <100 cfu/100mL can be used without restriction on any crop before harvest and for some purposes after harvest (Table 10).
- Water that contains *E. coli* >100 cfu/100mL can be used before harvest in accordance with the exclusion periods (Table 8).
- Water that contains *E. coli* >1,000 cfu/100mL should not be used for irrigation or crop spraying on produce that may be eaten uncooked, if the water contacts the edible part.

However, these limits do not apply to reclaimed water, which cannot be used postharvest.

Impediment 2: Risk assessments

Background

As part of AQIS Meat Notice 2008/6 (AQIS, 2008), the guide for businesses wishing to recycle or reuse water identifies five stages to be followed chronologically, including

> Stage 2: *Risk assessment through to formal submission to (AQIS) the principal regulator*.

The Meat Notice includes a Risk Consequence Assessment that focuses on business and reputational risk as a result of injuries incurred by operators and a Risk Likelihood Assessment that tries to equate a description of likelihood with a numerical probability. Both matrices are subjective and do not take into account the processes involved in making and using the water source.

Current approaches to risk assessment of recycled water in abattoirs

The approach to RA and recycled water has been moulded by three reports commissioned by MLA and/or AMPC in which Quantitative Risk Assessment (QRA) has been used:

1. Jain *et al*. (2003) *A quantitative risk assessment of microbial emissions from abattoirs*: a rigorous Hazard Identification phase was undertaken to reduce a list of 52 possible pathogens to six of importance to the meat industry: *Campylobacter jejuni*, *Coxiella burnetii*, *E. coli* (certain serotypes), *Salmonella*, *Cryptosporidium parvum* and *Listeria monocytogenes*. Based on a QRA, the researchers ranked *C. burnetii* as the highest risk via inhalation (including spray drift) and *C. parvum* and *C. jejuni* as the highest from waterborne sources.
2. Warnecke *et al.* (2008) *Review of abattoir wastewater usage reduction, recycling and reuse* cites the national approach to recycled water RA as the quantitative approach used in the AWRG (Anonymous, 2006), based on measuring Disability Adjusted Life Years (DALYs). In Annex 2.1 is presented background information on elements that comprise a risk assessment and in Annex 2.2, background information on the calculation of DALYs.
3. Pither (2017) *Wastewater risk assessment* embraces the AWRG, providing a quantitative risk assessment for *Cryptosporidium*, Shiga toxin-producing *E. coli* (STEC) and *Campylobacter* and estimating the disease burden for staff using recycled water in cattle yards, truck wash, cleaning the plant and by ingesting potable drinking water; DALYs and log reductions are calculated as required by the AWRG for different treatment options. A risk management program is proposed that includes sampling waters for faecal coliforms/*E. coli*, *Cryptosporidium/Giardia* and *C. burnetii* at five locations within an establishment (including an initial indication based on 85 samples).

In some of the above, there are significant errors in calculations and a lack of transparency in calculations that negate the estimates for DALYs, and some of the assumptions that underpin the risk assessment are questionable. In addition, one of the basics of a RA has not been done: to carry out a "reality check" to satisfy whether the estimates align with actual disease records.

Which type of RA is appropriate?

The quantitative approach is onerous to undertake and often lacks risk estimates that are useful in the meat context. Warnecke *et al*. (2008) consider that qualitative risk assessment may be more appropriate in certain situations stating: *Guidance for the meat industry could be provided by a generic qualitative risk assessment of the use of recycled water for particular applications. For example, the risk of human pathogen transmission to meat products resulting from cleaning of stockyards could be regarded as being of "Rare" likelihood and resulting in "Minor" consequences (due to subsequent handling), giving a qualitative risk estimation of "Low".* This suggestion fits well with the qualitative risk assessment discussion in the National Australian Guidelines for Water Recycling (Anonymous, 2006).

Warnecke *et al*. (2008) also note that the national risk assessment undertaken by the meat industry used a software tool called Risk Ranger to estimate risks and believe it could be adapted to assess risks associated with the reuse and recycling of water. The tool was effective in the national meat RA (Pointon *et al.*, 2006) as a primary screen to identify hazards in meat products that might require a quantitative risk assessment (e.g. *Listeria* in ready-to-eat meats) and Warnecke *et al*. (2008) suggest a similar approach could be used for the present work.

Qualitative CSIRO tool

A risk assessment tool was developed by Food Science Australia (FSA, 2000) in which answers to seven questions provide the basis for a qualitative risk assessment (QualRA). It was used for the national meat industry risk assessment as a preliminary screen for eliminating pathogen:product pairings that were obviously very low risk and could be used by establishments to identify recycled/reused water streams that may present a significant risk to either product or personnel.

The tool has seven elements and the rigour with which each of these is populated gives the output (risk ranking) credibility.

1. **Severity** of the hazard is obtained from a ranking of the International Commission on Microbiological Specifications for Foods (ICMSF, 2002).
2. **Effect of processing** Screening, filtering, heating, chlorination to eliminate target pathogens.
3. **Likelihood** that the hazard will be present in the recycled water in the form it is used.
4. **Possibility of recontamination:** Are the recycled lines secure from non-potable water and town water?
5. **Growth required to cause illness:** Yes/no, plus an estimate of the increase needed for the target population to become ill.
6. **Consumer cooking step** – is the pathogen eliminated by preparation of food contacted by recycled potable water?
7. **Epidemiological links** – has the pathogen:product pairing caused outbreaks of illness in Australia and overseas? If it has not, then there are no epidemiological links.

The tool could be used to assess the effect of the target pathogen in recycled/reused water on meat products and on operators.

In the example below, a qualitative risk is made of the likelihood that STEC in reused water from sterilisers and hot water cabinets will contact meat and cause illness among consumers.

If the process is validated to achieve a defined inactivation of STEC (e.g. 6 log reduction), then the likelihood that the pathogen will be in the reuse water when it is added to the usual water stream is disappearingly small.

Product	Reused water blended with potable 82°C water
Hazard	Shiga toxic *E. coli*
Severity	Severe
Effect of processing	Screened, filtered, chlorinated, heated to 82°C
Likelihood that the hazard is still present	No likelihood
Possibility of recontamination	Nil? Separate, identified lines
Growth required to reach infective dose	Yes
Consumer cooking step	Yes
Epidemiological links	None
Rating	Extremely low

When this tool was presented to the WRG, the members were in general agreement that the CSIRO tool could be useful as a screening tool.

Semi-quantitative tool (Risk Ranger)

Risk Ranger is a risk ranking tool developed by University of Tasmania (see Annex 2.3). It is designed to quickly separate low-risk from high-risk product:pathogen pairings so that resources can be prioritised to the latter. It is also useful in exploring "what-if" scenarios by illustrating weak and strong points in a product's history from formulation in the food plant to consumption.

It has been widely used by researchers around the world and, together with other risk tools, was evaluated recently by an United Nations expert panel (FAO, 2020).

It is presented here to illustrate that a semi-quantitative tool could provide satisfactory risk estimates to enable an establishment's reuse/recycling technology to be assessed by the state authority. It must be emphasised that Risk Ranger has been developed to assess food product:pathogen pairs, a superior tool could be developed specific for water reuse/recycling.

In the example below, the risk is of owner/operators of livestock trucks contracting salmonellosis when they wash down the vehicle, some of which are B-doubles, four storeys high using water that has been processed through a high technology train including ultrafiltration and reverse osmosis.

Enquiries indicate that operators typically wear wet-weather gear but no protection for inhalation of droplets or aerosol. Inputs to Risk Ranger are used only in an illustrative sense, with assumptions being made.

- **Hazard severity** Select MODERATE, *Salmonella* causes hospitalisation in some cases.
- **How susceptible is the population of interest?** Select GENERAL, all members of the population of livestock truck drivers.
- **Frequency of consumption** It is assumed that the operator washes down DAILY (an intended overestimate).

- **Proportion of consuming population** Select ALL.
- **Size of consuming population** Select 10,000 operators of livestock trucks (an assumption).
- **Probability of Contamination of Raw Product per Serving** In Risk Ranger, this is designed to apply to raw foods prior to processing. In this case, we assume *Salmonella* is a RARE contaminant of the effluent water entering the recycling treatment plant.
- **Effect of processing** If the water recycling system is effective, then select RELIABLY ELIMINATES hazards, which would result in zero risk from the water being used. However, if it is assumed that the recycling technology is only 99% effective and the recycled water is not of potable quality, select USUALLY ELIMINATES hazards.
- **Is there potential for recontamination after processing?** There is no recontamination of the recycled water in the pipe system (an assumption).
- **How effective is post-processing control system?** In Risk Ranger, this is designed to assess whether food can be recontaminated, e.g. milk that has been pasteurised during bottling. In this case, we assume there are no leaks that would allow recontamination of recycled water.
- **Post-processing contamination increase level** denotes the increase in post-process contamination level that would cause illness in the average consumer. Assume there is no increase in the level of *Salmonella* in the water needed to cause illness (an assumption that is likely a gross overestimate).
- **Effect of preparation before eating** In Risk Ranger, this is designed to take into account whether the food is cooked before consumption or eaten cold. In this case, we assume that there is no change in *Salmonella* level in the water the operator is using.
- **Risk Rating:** Based on the above inputs, the rating is 60, which is high.
- **Annual illnesses in operators:** The tool predicts that 36 livestock operators from a population of 10,000 will contract salmonellosis each year.
- **Reality check:** The key question is whether, every year, 36 operators around Australia become ill with salmonellosis, an illness that will probably prevent them working for some days and may even result in some becoming hospitalised?

  It is a question that is difficult to answer as the 36 cases will be spread sporadically among the more than 10,000 reported cases of salmonellosis annually across Australia.

  The result is that the risk assessors may need to re-examine their assumptions.

When presented to the WRG, the members agreed that such a tool, especially if it could be tailored to meat processing, could be very useful to allow broader uptake and application of the risk assessment framework outlined in the AWRG. The tool would require documentation to guide the user, including justification of assumptions and utilisation of plant-specific data and potential water treatments. This way, the risk assessment will be transparent and can be fully documented, in line with international best practice.

Recommendation: AMPC consider funding a suitable risk assessment tool for water recycling in the meat industry.

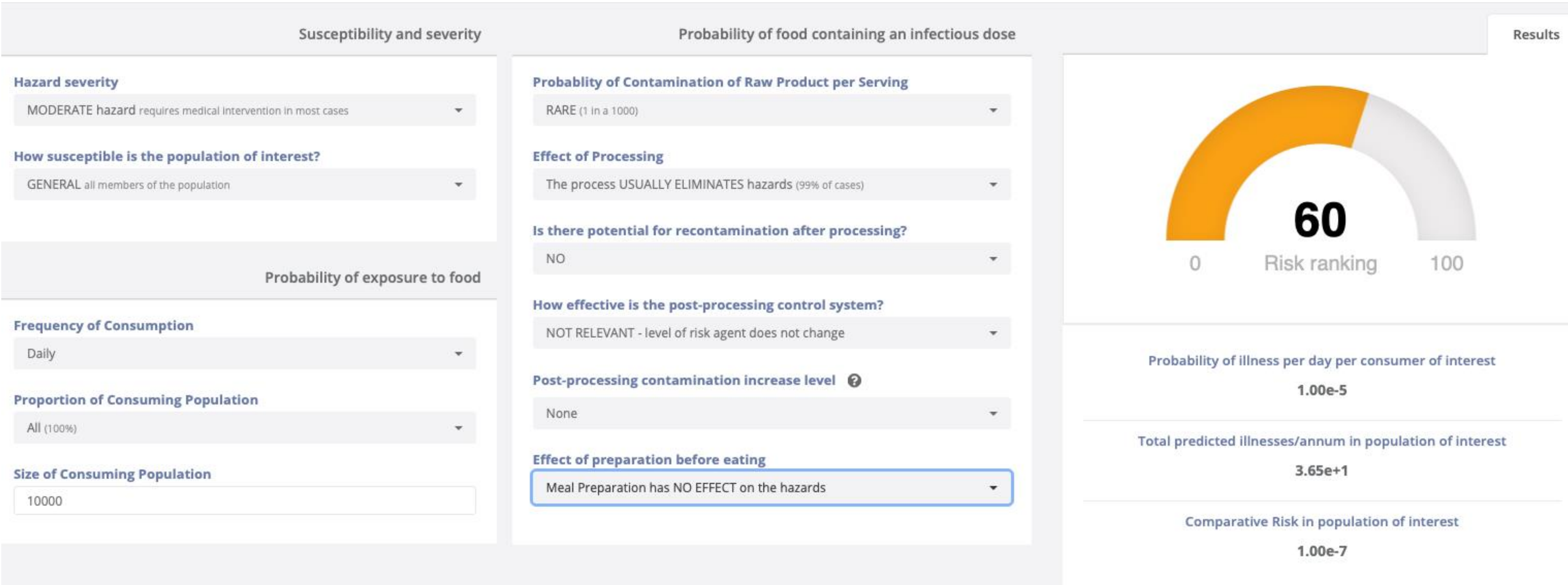

Figure 1: A screen shot of Risk Ranger

Annex 2.1. Elements of a risk assessment tool to evaluate water recycling technology

The AWRG stipulate that a risk assessment for any water recycling process must be completed (Anonymous, 2006). While qualitative risk assessment may be acceptable, at least for initial screening, the focus of the AWRG clearly focus on quantitative risk assessment (QRA), including the use of Disability Adjusted Life Years (DALY). As a result, the risk assessment process becomes quite complicated and onerous.

An example of a quantitative risk assessment was undertaken by Pither (2017) for an Australian beef abattoir. This work, which follows the AWRG approach, could form the basis for an Excel-based tool, similar to Risk Ranger (Ross and Sumner, 2002), that could be used to perform the QRA necessary for evaluating water recycling by meat abattoirs.

The key steps of any risk assessment are Hazard Identification, Exposure Assessment, Hazard Characterisation and Risk Characterisation. These components can be incorporated in the tool(s) as follows:

Hazard Identification

Jain et al. (2003) reviewed 52 potential pathogens and selected six for further consideration due to the potential risk they pose in the Australian abattoir context. These are *C. jejuni*, *C. burnetii*, *E. coli* (certain serotypes), *Salmonella* spp., *C. parvum* and *L. monocytogenes*.

A subset of these hazards, namely *C. jejuni* (and *C. coli*), *E. coli* (certain serotypes) and *C. parvum*, were used by Pither (2017). The authors provided a rationale for including these hazards but did not provide any rationale for excluding the others.

Consequently, it appears sensible to use the organisms identified by Jain et al. (2003) as the base hazards considered in the model, depending on availability of dose-response models (see below).

Exposure Assessment

The exposure assessment will incorporate the two main exposure routes – (accidental) ingestion of the hazard by workers (via aerosol) and consumption of the final meat product by consumers. In relation to *C. burnetii,* inhalation of aerosols will need to be considered.

The inputs for the exposure assessment will be the concentrations of each hazard in the effluent stream considered for recycling. In the first instance, these values can be based on generic industry information (e.g. as obtained by Pither, 2017), with the option for the user to input establishment specific inputs.

A range of water treatment options are available and many have been identified in the AWRG. Again, generic values for each treatment will be suitable starting values, unless the user can enter site-specific data. The tool should provide the option to incorporate a train of treatment options, with the user selecting which treatments are used at each stage.

These two components will then be combined with water volumes and microbial concentrations relevant to each exposure pathway, e.g. truck washing or consumption of meat.

Hazard Characterisation

A dose-response (D-R) model is required for each hazard that is considered in the risk assessment. Pither (2017) indicated that D-R models were obtained from the QMRA Wiki/CARMA project. However, not all D-R models used are available on the noted sources. Hence, a review of available D-R models is required, including those organisms that were not considered by Pither (2017).

Risk Characterisation

Using the outputs from the previous steps, namely the Exposure Assessment and Hazard Characterisation, a risk characterisation can be undertaken. In the first instance, the probability of infection/illness per exposure can be calculated and this can be extended to the number of infections/illnesses per 100,000 exposures, for example.

DALYs are usually calculated on a per infection/illness basis, and hence multiplying the number of infections/illnesses by the corresponding DALY factor for each hazard will result in the expected disease burden from using recycled water. The difficulty will be to determine suitable DALYs for all identified hazards. In addition, DALYs may need to be adjusted to the population at risk e.g. exclude children for workplace exposure.

Annex 2.2. Disability Adjusted Life Years (DALYs)

The following sections are reproduced for reference from the National Guidelines for Water Recycling (Anonymous, 2006).

Tolerable risk

The traditional approach to identifying tolerable risk has been to define maximum levels of infection or disease, such as one infection per 10,000 people per year (Macier and Regli, 1992). However, this approach fails to consider the varying severity of outcomes associated with different hazards; for example, the differences between mild diarrhoea, typhoid, haemolytic uraemic syndrome and cancer. This shortcoming can be overcome by measuring severity in terms of Disability Adjusted Life Years (DALYs).

The basic principle of the DALY is to weigh each health impact in terms of severity within the range of zero for good health to one for death. The weighting is then multiplied by duration of the effect and the number of people affected by the effect. In the case of death, duration is regarded as the years lost in relation to normal life expectancy. [Hence 1 DALY is the equivalent of 1 year of life lost]

Hence, DALYs = YLL (years of life lost) + YLD (years lived with a disability or illness).

In this context, disability refers to conditions that detract from good health. In these guidelines, it generally relates to illness, but in other arenas, it can relate to physical or mental impairment.

Using this approach, a mild diarrhoea with a severity weighting of 0.1 and lasting for 7 days results in a DALY of 0.002, whereas death of a 1-year old resulting in a loss of 80 years of life equates to a DALY of 80.

DALYs per case is based on (Havelaar and Melse, 2003), with a modification using Australian data for rotavirus, as described by Deere & Davison (2004).

[Note: Havelaar and Melse provided DALY calculations for *C. parvum*, thermophilic *Campylobacter* spp., Shiga-toxin producing *E. coli* O157 (STEC O157), rotavirus, hepatitis A virus, bromate and arsenic.

While DALYs appear complicated at the surface, once established for a hazard (and country), they are simply multipliers of cases/infections. For example, in Box 3.1 of the guidelines, the DALY per case of campylobacteriosis is calculated as 0.0046.]

Health-based targets

Health-based targets are the 'goal-posts' or 'benchmarks' that have to be met by each recycled water scheme to ensure that the risk of 10^{-6} DALYs per person per year is not exceeded.

Note the different units related to the two underlined words. A risk assessment in which the number of cases in an exposed population are calculated can usually also be expressed as a *"probability of infection/illness per consumption event (per person per year)"* and this can then be converted to the required health-based risk measure i.e. DALY per person per year. Example calculations are provided in Appendix 2 of the guidelines (#21).

Preventive measures to achieve performance targets

Unrestricted exposure to hazards contained in untreated sources of recycled water (maximum risks) will inevitably represent unacceptable risks (i.e. DALYs above 10^{-6} per person per year). Safe use of recycled water requires strategies (i.e. preventive measures) to reduce exposure to hazards by:

- preventing hazards from entering recycled water (Section 3.4.1)
- removing them using treatment processes (Section 3.4.2)
- reducing exposure, either by using preventive measures at the site of use or by restricting uses (Section 3.4.3).

The guidelines provide indicative efficacies of various treatment processes, i.e. range of log-reductions that are achievable. These can then be used to evaluate whether a particular treatment train can achieve the required health-based target.

Annex 2.3. Risk Ranger

FAO (2020) summarises Risk Ranger as follows:

> *"Risk Ranger is a spreadsheet-based risk ranking tool, developed using Microsoft Excel. Users can select from qualitative statements or can provide quantitative data concerning 11 factors that affect the food safety risk of a specific population for selected product-hazard combinations. It is a bottom-up approach, evaluating risk from harvest to consumption. A total of 11 inputs are grouped into three general categories (susceptibility and severity, probability of exposure to food, and probability of food containing an infectious dose). The spreadsheet converts the qualitative inputs to numerical scores, and using three different multiplicative algorithms, provides a risk ranking score (scaled logarithmically from 0 to 100) that approximates probabilities of disease or death. Risk estimates include predicted annual illnesses or probability of illness per day in the target population. Risk Ranger is simple to use and publicly available as a free download. However, it only ranks microbial risks. Uncertainty is also not addressed, but users could run different scenarios to explore the different results. The tool was carefully developed and maintains the theoretical model of risk as defined by Codex, being an excellent choice if the goal is to focus on microbial hazards and the number of food categories is manageable (Sumner & Ross, 2002)."*

Lammerding (2006) comments that:

> *"Not all food safety problems require intensive scrutiny, nor is it always feasible to undertake a quantitative risk assessment and that there is room for development of alternative strategies for risk-based assessments of food safety issues. For example, Ross and Sumner (2002) developed a semi-quantitative risk-ranking method using a spreadsheet program called Risk Ranger. It is a simplified approach but based on the scientific principles of food safety risk assessment. This semi-quantitative method was used as part of a study to provide a risk profile of the Australian red meat industry and to risk-rate specific hazard:product combinations (Pointon et al. 2005). The semi-quantitative analysis was found to be a useful approach to screen foodborne risks, identify high-risk pairings, and prioritize these for further detailed assessment or mitigation action (Sumner et al. 2005)".*

Risk assessments in which Risk Ranger was used include:

- Australian seafoods (Sumner and Ross, 2002)
- Australian egg industry (Daughtry *et al.*, 2005)
- Australian meat industry (Pointon *et al.*, 2006)
- Pork and poultry in Greece (Mataragas, Skandamis and Drosinos, 2008)
- Histamine in seafoods in France (Guillier *et al.*, 2011).

Impediment 3: Potential pilot projects and their business case

One of the project's Terms of Reference is to identify pilot projects that might lend themselves to more stringent evaluation (including economic analysis) in Stage 2 of the project.

The WRG considered potential projects and recommended consideration of the following, which are presented in outline in three categories:

1. High technology production of DPPRW
2. Water reuse/recycling projects
3. Reconsideration of projects completed by AMPC/MLA over the past two decades.

Direct Planned Potable Recycled Water

DPPRW is the priority for the present project but since the UF/RO trains are expensive to install, they do not lend themselves to a pilot study *per se* and any potential study should be evaluated after consideration of the requirements of each State's principal regulator. As an example, such requirements are described in *"Water reuse guideline for food businesses in NSW considering reusing water"* (NSW Food Authority, May 2008) and are presented verbatim:

Clause 3.2 Direct reuse of water

Direct reuse involves treating or reconditioning wastewater for direct reuse within a premises. Food businesses considering this form of reuse must, at a minimum, meet the following requirements:

- *Exclude human sewage (blackwater) from the wastewater to be treated,*
- *No physical connection between the potable and non-potable water supply,*
- *Follow HACCP principles for identifying hazards, implementing control measures and validating and verification of Critical Control Points (CCPs),*
- *Use a multiple barrier approach (i.e. utilise more than one treatment process to ensure that if one step fails at least one other treatment step will control the identified hazard),*
- *Have access to a potable water supply in case of failure with the wastewater treatment system, Treated water must be suitable for its intended use, according to the three basic types of direct water reuse:*
- *in direct contact with food (e.g. washing of fresh produce),*
- *on food contact surfaces (e.g. cleaning of conveyors), and*
- *on non-food contact areas, (e.g. cleaning outside areas and in cooling towers).*

Clause 3.3 Reuse of water in direct contact with food

Where a food business is considering reusing water in direct contact with food, the food safety requirements will be stringent. The water must be of potable quality, to ensure the safety and suitability of the food is not jeopardised and the risk of contamination is minimal.

This does not restrict the possibility of a food business implementing technology to recondition their industrial wastewater. All water used in direct contact with food (whether reconditioned or not) must be *potable (drinking quality) water as defined in the Australian Drinking Water Guidelines (NHMRC & NRMMC, 2004) for microbiological, chemical and physical properties (see Appendix 2).*

Clause 3.4 Reuse of water on food contact surfaces

The same stringent standards will be applied to the reuse of water on food contact surfaces.

The use of non-potable water could potentially contaminate the surface, which in turn could lead to cross contamination of the food which comes into contact with the surface. Therefore, all reused water must be of potable quality, as defined in the Australian Drinking Water Guidelines (NHMRC & NRMMC, 2004) for microbiological, chemical and physical properties (see Appendix 2), before it can be used on food contact surfaces.

Clause 3.5 Reuse of water in non-food contact areas

Where water will be reused on non-food contact areas, there is less risk for this practice to lead to contamination of food. The Food Standards Code allows for the use of non-potable water in a food business, in situations where it will not jeopardise the safety and suitability of the food.

Examples where non-potable water could be used include:

- *Cleaning of non-food contact surfaces (e.g. outside environment, loading docks, transport vehicles, animal holding yards etc.),*
- *Water for flushing toilets,*
- *Cooling towers and evaporative coolers.*

Pilot study 1: Demonstration of DPPRW plant for red meat processors

Purpose

- Demonstrate the technical and economic feasibility (i.e. inclusive of upfront and ongoing costs), as well as compliance requirements, for a DPPRW plant located at a Red Meat Processing facility
- Plant will aim to achieve DPPRW standard (sub-process source/s TBA), and may use permeate output for non-potable use until the following are resolved:
    - Performance (technical & biological)
    - Compliance with framework
    - Perception (domestic and export)
    - Host will need to enable third party access, inspections/testing and regular reporting/media.

Outputs

- Literature review – water reuse/recycling projects “stock take” with illustrative guidance on purposes and outcomes
- Methodology for selection of a host plant
- Expression of interest and selection of a host plant
- Risk assessment and design
- Approvals and final design
- Procurement, installation and certification/s

- Commissioning and validation
- Periodic reviews/reports for performance, compliance, maintenance, management and perception (i.e. over say 3 years)
- Consider market/marketing aspects (e.g. "product processed using 50% recycled water").

The University of NSW have researched the technology required and made an economic evaluation as follows:

> *Within the current Australian regulations, recycling abattoir wastewater to potable standards is the best strategy for meat processors to achieve significant water savings by either:*
>
> 1. *Internal recycling utilising a Membrane Bioreactor (MBR) and a Reverse Osmosis (RO) unit to treat selected waste streams*
>
>   *or*
>
> 2. *End-of-Pipe (EoP) recycling which involves using an Ultrafiltration (UF) membrane unit and a RO unit to produce 1023 m^3/day of potable water*
>
>   *It's possible to reduce the abattoir's potable water consumption by 37%, though only #1 provides a return on investment within the lifetime of the project.*
>
> *Internal recycling of selected waste streams treated to potable water standards would incur CAPEX of approx. $3 million with an OPEX of approx. $400K/year (indicative).*
>
> *These estimates are based on production of 300 t.HSCW/day (0.3t.HSCW/head, 1000 heads/day) for 300 days of operation/year.*
>
> *This option achieved a positive NPV after 8 years at a moderate potable water cost price of $2.98AUD/kL.*
>
> *The meat industry seems to only want to focus on projects that would ROI in <12 months but most water recycling infrastructure/processes would take longer to break even. Projections of future increases in water prices (MS4 economic analysis) highlighted the impact of higher potable water prices on capital recovery periods, reducing 8 years to 5 years at a high water price of $4.50/kL.*

Water reuse and recycling projects

A number of pilot studies were considered worthy of consideration by the WRG.

Pilot study 2: Reuse of hot water wash on beef floor

During recent years, the incorporation of a hot water wash cabinet has become commonplace in beef abattoirs that export manufacturing meat to USA for grinding and/or that seek to negate higher carcase counts that may result from spray chilling.

It is believed only one abattoir reuses water from the hot water intervention cabinet by:

- Collecting water from the bottom of the cabinet, pumping through screens and returning to a catchment tank.
- Reheating it to approximately 90°C and measuring turbidity before recycling to the wash cabinet.

What would a good pilot study look like?

1. Review literature and international requirements
2. Assess water use and savings in one or more participating abattoirs
3. Turbidity is a cost factor – assess effect of increasing turbidity on microbiological and sensory impacts on beef carcases
4. Stipulate validation requirements for critical control point(s)
5. Outline infrastructure, engineering and monitoring requirements.

Pilot study 3: Reuse of steriliser water

On large slaughter floors, there are >50 steriliser units that overflow approximately 3 L/min (9000 L/h). If overflow water could be collected, cleaned, reheated and returned, the savings in water and energy use might be significant.

What would a good pilot study look like?

1. Review literature and international requirements
2. Assess water use and savings in one or more participating abattoirs
3. Turbidity may be a cost factor – assess effect of increasing turbidity on microbiological load of steriliser water
4. Undertake an industry validation
5. Outline infrastructure, engineering and monitoring requirements.

Pilot study 4: Reuse of final smallstock wash water

Daily use of water at the final carcase wash for smallstock may approximate 350,000 L and is typically passed to the effluent stream.

If it is possible to collect and clean the stream for reuse, there are obvious savings.

What would a good pilot study look like?

1. Review literature and international requirements
2. Assess water use and savings in one or more participating abattoirs
3. Turbidity may be a cost factor – assess effect of increasing turbidity on microbiological load of returned water
4. Undertake an industry validation using various screens.

Pilot study 5: Econoliser knife sanitising

The Econoliser is designed to sanitise knives in a chamber by activating sprays that can remove residues such as fat and protein, and also bacteria associated with them from the knife blade at the same temperature as the current system.

In 2019, trials were carried out at an abattoir in Melbourne where operators used both the current and the Econoliser systems on the beef floor.

Microbiological monitoring of knives using sterilisers or Econoliser units indicated that the Econoliser unit with 4-second or 6-second spray can decontaminate the knife at legging and bunging to an extent that is at least equivalent to the current method used in Australian abattoirs.

It is believed that the Department accepted the data as validation of the Econoliser system.

The project has been accepted as a core project by AMPC.

Reconsideration of projects undertaken

Following are summaries of nine projects funded by MLA/AMPC over the past two decades, some of which have been taken up by some abattoirs, indicating that they are feasible economically.

These studies should be reprised and publicised.

Project Code/Funder/Date	**P.PIP.0355/AMPC/MLA/2013**
Company/Author	Mark Collen, Nalco Australia
Title	Bore Water Purification for Abattoir Use, done at Grantham
Purpose	To evaluate effectiveness of a UF-RO plant to provide potable water to the plant and utilities
Outcome	Water treated successfully but discharge rich in salt

Project Code/Funder/Date	**A.ENV.0137/MLA/2014**
Company/Author	JBS/Graham Treffone
Title	Tripe wash water reuse in beef processing
Purpose	Recycle water in processing of beef tripe and omasum. Reclaim hot, white water stream from Stage 2 and reuse it in Stage 1 dirty wash in the tripe washer/cooker.
Outcome	Process non-viable because insufficient water available to run the tripe washer/cooker.

Project Code/Funder/Date	**PIP.010/MLA/2004**
Company/Author	NCMC/Todd Westgate
Title	Potential for Reuse of Low Contamination Abattoir Effluent
Purpose	Determine the appropriate technology to enable the reuse of white water in a nearby industry and/or within the abattoir itself
Outcome	Diverted 100kL/d to tannery, saving town water.

Project Code/Funder/Date	**MLA/2014**
Company/Author	Oakey/?
Title	The environmental, social and economic benefits of water use, reuse and effluent management projects.
Purpose 1	Reuse steriliser water to wash down cattle and yards
Outcome	Saving 2-4 Mega L/week.
Purpose 2	Improve extraction of fat from primary effluent using a Dissolved Air Flotation (DAF) system.
Outcome	Reduced nutrient load and saving 3t fat/d

Project Code/Funder/Date	P.PIP.0141/AMPC/MLA/2006
Company/Author	Churchill Abattoir/Mike Spence
Title	Churchill Abattoir (CA) large scale demonstration wastewater recycling plant
Purpose	To replace potable water with recycled water from the aerobic treatment lagoon for use in non-food sensitive areas.
Outcome	Company achieved a reduction in potable water use of about 11 ML/annum between January 2006 and June 2007 that can be attributed to replacing potable water with recycled water.

Project Code/Funder/Date	**A.ENV.0078/MLA/2011**
Company/Author	Tatiara/Wade Phillips
Title	Re-use of steriliser water for contra-shear and hose down outside rendering
Purpose	Capture the steriliser water from the boning room and use it for the Contra-shears and to hose down outside the rendering plant (the Contra shears screens solids). Both processes used potable hot water.
Outcome	Steriliser water is captured, injected with steam and reused in sterilisers. Saved up to 100kL/d of hot water being sent through the contra shears and hoses.

Project Code/Funder/Date	**A.ENV.0081/MLA/2011**
Company/Author	Teys/?
Title	Viscera table water reuse
Purpose	Collect and filter water from the viscera table for re-use in the cattle yards.
Outcome	High *E. coli* counts in water posed hazard to staff; too much water generated for use in yards.

Project Code/Funder/Date	**A.ENV.0066/AMPC/MLA/2008**
Company/Author	Ross Nicol
Title	Waterless cleaning of meat processing plants
Purpose	To identify emerging waterless, or water-reduced, cleaning technologies suitable for adoption by meat processing plants
Outcome	Identified the need to adopt a strategic approach to achieve change in water use

Project Code/Funder/Date	**A.ENV.0138/AMPC/MLA/2103**
Company/Author	Richard Ford
Title	Water saving in the cleaning of chillers
Purpose	Assess an alternative dry manual cleaning program in beef chillers to the intensive cleaning procedures commonly used
Outcome	Efficiencies within chiller cleaning regimes: 74% reduction in total water consumption (mostly at 82°C or hotter) 93% reduction in detergent concentrate; 60% reduction in labour input; Replacement of all 82°C hot water with 30°C water. Commensurate reductions of water and cleaning chemical in waste discharge.

Impediment 4: Changing perception of using recycled water as DPPRW – Need for progress

Background

The AWRG (Anonymous, 2006) outline the importance of stakeholder consultation and communication. While the discussion in the AWRG appears focussed on water recycling schemes that affect the general community, similar importance needs to be placed on industry water recycling, such as by the Australian meat industry. The AWRG list factors that may affect the general community's acceptance, though these factors appear to be also relevant in the meat context. The AWRG also outline essential features for successful communication, including key messages for stakeholders. Finally, the AWRG provide a list of Frequently Asked Questions, which again are focussed on those that may be asked by the general community in relation to receiving recycled water. A similar, general list of questions may be useful for the meat industry, which could be tailored by individual establishments to suit their specific water recycling approach.

A major poultry processor (Ingham's) has worked to win public approval for waste treatment systems at their Queensland, Victorian and South Australian plants by:

- Achieving certification under the Alliance for Water Stewardship (AWS), a global organisation that advocates "*the use of water that is socially equitable, environmentally sustainable and economically beneficial, achieved through a stakeholder-inclusive process that involves both site and catchment level actions.*"
- Achieving the Platinum Level of AWS certification.
- Removing nitrogen from waste streams and obtaining carbon credits.
- Working closely with the local authority and community by encouraging group inspections of the treatment facilities.
- Contributing to traditional owners' culture and values by introducing Yellow Belly Bass into ponds.

The demonstration plant proposed as a Category 1 pilot project (see Impediment 3) may provide a useful framework for engaging with customers of processing establishments and the broader community and for promoting the benefits of water recycling in the meat processing sector and the food safety controls that are put in place to do so safely.

Going forward

When surveyed on recycling all their waste streams to DPPRW, establishments emphasised the need for a quick return of investment and the University of NSW has provided some indicative numbers (see Impediment 3 – Pilot study 1). It may be, that for those establishments where housing encroaches ever closer, a more pressing need to institute treatment strategies will be encountered.

The Ingham's initiative is lauded as the gold standard in wastewater recycling, not only for the technology used but for the way they have brought the community with them.

In Annex 4.1 is presented a summary (from the Ingham's website) of what the company has done with their Advanced Water initiatives. The left-hand column (Water Stewardship Plan Objective) indicates the staged approach to a range of initiatives not only involving recycling technology but embracing local communities.

Annex 4.1: Summary of Water Stewardship Plan Progress and Effort to Address Shared Water Challenges – Ingham's Murarrie 2018-20

Water Stewardship Plan Objective	SMART Target	Metric(s)	Action	Progress Status
Improve water intensity	Improve water recycling to minimise water consumption and trade waste production	Maximise Advanced Water (AW) performance exceeding 65% recovery of incoming site wastewater	De-sludge anaerobic pond to increase retention time and available volume. Monitor and report performance	De-sludge completed - now regular maintenance required.
	Improve water recycling to minimise mains water consumption and trade waste production	Daily target of AW to Tanks >3.5ML	Improve water quality in SBR (Biological Reactor) to allow quicker throughput to AW. Monitor and report performance	80%
	Use less water per bird processed.	Achieve site KPI of 16-17.5 L/bird for average of 6 months.	Modify controls of pipe work for Mains and AW in ceiling for better control. Refer Recommendations in Gemms (modelling) report.	Completed achieved 15.3 L/bird average for FY19- 20.
	Amendments to site Environmental and Trade Waste Licence.	Meet with Regulator and submit changes.	Gain approval to treat RO wastewater through site ponds 3-8.	Completed. AW wash water going to site ponds.
Minimise impacts to Brisbane River and Moreton Bay	Reduce Nitrogen levels in trade waste to Gibson Island AW.	Decrease levels from average quarterly load of 5000kg to < 2000kg/ quarter	De-sludge anaerobic pond and implement "Single Cell Protein from purple Phototrophic bacteria" project in wastewater line of site.	BOD in trade waste reduced by 80%. UQ Field Project increased to large reactor
Maintain a healthy grass and wetland environment on lease.	Improve the health of vegetation and fauna	Improvements in water quality and volume of each pond	Connect ponds 3-8 on the pond system project the allow water flow of 4ML/w. Review site vegetation management plans in consultation with B4C	Completed, all ponds now connected and maintaining capacity
Improve water security for site	Secure portable water for hygiene and sanitary needs during mains outage.	Ensure potable water available for site usage for 48h.	Install 3ML tank between QUU meter and site factory inlet. (Not approved this FY). Installing pipe work to be able to redirect AW water to amenities in time of outage.	10%

Water Stewardship Plan Objective	SMART Target	Metric(s)	Action	Progress Status
Contribute to improved catchment governance	Cooperate with local stakeholder groups to improve Bulimba creek and Lower Brisbane Catchment	Proactive involvement to assist with achievements of Bulimba Creek (B4C) and Lower Brisbane catchment.	Meet with B4C, Port of Brisbane and other local groups to share site's WSP.	Reported actions completed at B4C Annual General meeting 13/11/20.
Contribute to traditional owners' culture and values	Introduction of Yellow Belly Bass	Sustain water quality to introduce Yellow Belly Bass	Improve water quality in pond 8 using floating grass islands. Test water and introduce bass.	Feeder fish have been introduced to ponds July 2020. Jan 21 hoping to place Bass in ponds.
Reuse AW Wastewater	Redirect all AW Trade Waste	0 litres going to QUU	Redirect 4ML/w to the pond system 3-8. Pump clean water to site for use in truck wash, Red area create wash, amenities, SBR, AW.	Completed with redirection. Next capital project instal reuse tank.
Contribute to traditional owners' culture and values	Meet with representatives of traditional owners' families.	Further understand the culture and spiritual values of the Site IWRA.	Meet with, discuss and agree on the Indigenous water related challenges. Develop actions to include in this plan.	100%

References

All Energy Pty Ltd. 2021. 2020 Environmental Performance Review (EPR) for the Red Meat Processing (RMP) Industry. No. V.MFS.0448. AMPC & MLA.

Anonymous. 2006. *National guidelines for water recycling: managing health and environmental risks (Phase 1)*. Adelaide, Environment Protection and Heritage Council/Natural Resource Management Ministerial Council/Australian Health Ministers' Conference/. (also available at http://www.ephc.gov.au/pdf/water/WaterRecyclingGuidelines-02_Nov06_.pdf).

Anonymous. 2007. AS4696:2007—Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption. No. 3 (FRSC Technical Report). 150 Oxford Street (PO Box1139), Collingwood, VIC 3066, CSIRO Publishing.

AQIS. 2008. *Meat Notice Number 2008/06: Efficient use of water in export meat establishments*. Department of Agriculture, Fisheries and Forestry.

CAC. 1969. *CAC/RCP 1-1969: General Principles of Food Hygiene (2020 Revision)*. Codex Alimantarius Commission.

CAC. 2005. *CAC/RCP 58-2005: Code of Hygienic Practice for Meat*. Codex Alimantarius Commission.

Daughtry, B.J., Sumner, J., Hooper, G., Thomas, C.J., Grimes, T., Horn, R., Moses, A. & Pointon, A.M. 2005. National food safety risk profile of eggs and egg products. Australian Egg Corporation Limited.

Deere, D. & Davison, A. 2004. Health Risk Assessment of Fire Fighting from Recycled Water Mains. No. 11. Water Services Association of Australia.

FAO. 2020. *FAO Guide to Ranking Food Safety Risks at the National Level*. FAO. (also available at http://www.fao.org/documents/card/en/c/cb0887en).

FPSCANZ. 2019. *Guidelines for Fresh Produce Food Safety*. Sydney, Australia, Fresh Produce Safety Centre Australia & New Zealand. (also available at https://fpsc-anz.com/).

FSA. 2000. Scoping study on the risk of plant products. Homebush, NSW, Australia, Food Science Australia.

Guillier, L., Thébault, A., Gauchard, F., Pommepuy, M., Guignard, A. & Malle, P. 2011. A risk-based sampling plan for monitoring of histamine in fish products. *Journal of Food Protection*, 74(2): 302–310. https://doi.org/10.4315/0362-028X.JFP-10-234

Havelaar, A.H. & Melse, J.M. 2003. Quantifying public health risk in the WHO Guidelines for Drinking-Water Quality: a burden of disease approach. No. 734301022. Bilthoven, The Netherlands, RIVM [Rijksinstituut voor Volksgezondheid en Milieu]. (also available at http://hdl.handle.net/10029/9098).

ICMSF. 2002. *Microorganisms in Foods 7: Microbiological testing in food safety management*. Kluwer Academic / Plenum Publishers.

Jain, P., Cunningham, D., Chesson, J. & Fabiansson, S. 2003. A quantitative risk assessment of microbial emissions from abattoirs (PRMS.036 Final Report). Meat and Livestock Australia.

Lammerding, A.M. 2006. Modeling and risk assessment for *Salmonella* in meat and poultry. *Journal of AOAC International*, 89(2): 543–552.

Macier, B.A. & Regli, S. 1992. Use of microbial risk assessment in setting US drinking water standards. No. PB-93-134930/XAB; EPA-811/S-92/001. Environmental Protection Agency, Washington, DC (United States). Office of the Assistant Administrator for Water. (also available at https://www.osti.gov/biblio/6735845).

Mataragas, M., Skandamis, P. & Drosinos, E. 2008. Risk profiles of pork and poultry meat and risk ratings of various pathogen/product combinations. *International Journal of Food Microbiology*, 126(1–2): 1–12. https://doi.org/10.1016/j.ijfoodmicro.2008.05.014

NHMRC. 2011. *Australian drinking water guidelines 6 (Update 2019)*. National Health and Medical Research Council. (also available at https://nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines).

Pither, K. 2017. Wastewater Recycling Risk Assessment - Final Report. Viridis Consultants Pty Ltd.

Pointon, A., Jenson, I., Jordan, D., Vanderlinde, P., Slade, J. & Sumner, J. 2006. A risk profile of the Australian red meat industry: Approach and management. *Food Control*, 17(9): 712–718. https://doi.org/10.1016/j.foodcont.2005.04.008

Ross, T. & Sumner, J. 2002. A simple, spreadsheet-based, food safety risk assessment tool. *International Journal of Food Microbiology*, 77(1): 39–53. https://doi.org/10.1016/S0168-1605(02)00061-2

Sumner, J. & Ross, T. 2002. A semi-quantitative seafood safety risk assessment. *International Journal of Food Microbiology*, 77(1): 55–59.

Warnecke, M., Farrugia, T. & Ferguson, C. 2008. Final Report A.PIA.0086: Review of abattoir water usage reduction, recycling and reuse. Meat and Livestock Australia.

WHO, ed. 2006. *WHO guidelines for the safe use of wastewater, excreta and greywater*. 3. ed edition. Guidelines for the safe use of wastewater, excreta and greywater. Geneva, World Health Organization.

Appendix 1. Water reuse/recycling projects in Australian abattoirs

Abattoirs use significant volumes of water each day, e.g. one large beef abattoir uses approximately 870,000 L/day on the slaughter floor; 500,000 L in cleaning; 280,000 L in the tripe room and approximately 350,000 L across all other elements of the process.

Since the early 2000s, AMPC and MLA have invested in more than thirty projects concerned with reuse of water at abattoirs; a summary of each is presented below and its alignment to a specific category in the table below.

Area covered by the project	Number of projects
General	13
Effluent treatment	4
Chiller cleaning	4
Slaughter floor	3
Risk assessment	2
Stock wash	1
Offal room	1
Boning room	1

- The investment indicates a large number of general projects (13) aimed at measuring wastewater streams and identifying technologies available for removing solids, chemicals and micro-organisms from them.
- Two risk assessment projects estimated the prevalence and concentration of pathogenic viruses, bacteria and protozoans in wastewater streams and the log reduction of each needed to align treated water with the Australian Guidelines for Water Recycling (Anonymous, 2006).
- Four projects focused on effluent treatment; four on waterless cleaning of chillers; five on slaughter, offal and boning operations and one on stock wash.

In total, the above investment provides the industry with the background information on how to reuse water streams ranging from simple screening of solids to multi-system treatment involving technologies such as ultrafiltration and reverse osmosis.

General reviews

Project Code/Funder/Date	CN 210520/MLA/2008
Company/Author	Ecowise (Victoria)
Title	Review of abattoir water usage reduction, recycling and reuse.
Purpose	A large review, including several PIPs already completed.
Outcome	Definitions of waters and regulatory requirements (p17); treatments available from simple screens to bioreactors (p20-25); examples of reuse systems (p32-35); case studies (p36-38); risk assessments (p40-42).

Project Code/Funder/Date	P.PIP.0538/AMPC/MLA/2019
Company/Author	Oakey/USQ
Title	Oakey Beef Exports Water Resource Sustainability
Purpose	Risks associated with the OBEX water supply and potential mitigation strategies. Identify, develop and evaluate water savings initiatives for the facility. Clarify options for sustainable and beneficial reuse of final treated effluent via a new irrigation/cropping management tool.
Outcome	Identified a number of reuse systems implemented at Oakey and potential further systems.

Project Code/Funder/Date	AMPC 2016.1021
Company/Author	Various, no attribution
Title	Strategic evaluation of RD&E opportunities for water reuse and recycling at Australian abattoirs
Purpose	The objective of the project was to identify the needs and opportunities to achieve water efficiency gains at Australian meat processers through reuse/recycling, while adhering to the highest food safety and product quality standards
Outcome	Strategies identified to minimise external water supplies by 65%

Project Code/Funder/Date	P.PIP.0172/AMPC/MLA/2011
Company/Author	Johns Environmental, done at Teys Beenleigh
Title	Water collection and data analysis
Purpose	To obtain sufficient information on waste stream flows and composition inform the development of a site strategy for improved efficiencies and sustainability
Outcome	Streams, columns and contamination status identified

Project Code/Funder/Date	A.ENV.0131/AMPC/MLA/2012
Company/Author	UQ, Advanced Water Management Sector
Title	Energy and Nutrient analysis on Individual Waste Streams, data collected at 3 sites
Purpose	Identify key contributors to waste stream loads and resources, including thermal, energetic, and chemical
Outcome	Major sources of wastewater were: Cattle Yard Wash, Slaughter Floor, Paunch Handling, Boning Room and Rendering Operations

Project Code/Funder/Date	A.ENV.0103 Part 1/AMPC/MLA/2011
Company/Author	Tracey Colley
Title	Energy efficiency opportunities program report (Federal Government)
Purpose	Identify company use of energy
Outcome	Industry benchmarked against other industries

Project Code/Funder/Date	P.PIP.0355/AMPC/MLA/2013
Company/Author	Mark Collen, Nalco Australia
Title	Bore Water Purification for Abattoir Use, done at Grantham
Purpose	To evaluate effectiveness of a UF-RO plant to provide potable water to the plant and utilities
Outcome	Water treated successfully but discharge rich in salt

Project Code/Funder/Date	A.ENV.0139/AMPC/MLA/2013
Company/Author	Craig Andrew-Kabilafkas
Title	Improved Abattoir Hygiene through Simplified and Improved Practices using Hygienic Design Guidelines and Water Management for Better Red Meat Processing
Purpose	To examine current developments and strategies in abattoir water efficiency and hygienic design
Outcome	Large review satisfying the stated purpose

Project Code/Funder/Date	MLA/2007
Company/Author	Several authors
Title	Environmental Best Practice Guidelines for the Red Meat Processing Industry
Purpose	Brings together: Module 1 - Meat Processing Module 2 - Energy Module 3 - Wastewater Module 4 - Waste solids Module 5 - Odour Module 6 - Effluent irrigation
Outcome	All background information collated up to 2006

Project Code/Funder/Date	PRENV.033/MLA/2005
Company/Author	URS Australia
Title	Industry environmental performance review: Integrated meat processing plants
Purpose	Benchmark against 1998 KPIs.
Outcome	Trends identified: Average energy usage per tonne of HSCW has remained relatively steady since the 1998 study Average raw water use per tonne of HSCW has decreased by approximately 11% since the 1998 study Average wastewater generation per tonne of HSCW has reduced since the 1998 study Average wastewater nutrient loads per tonne of HSCW have increased slightly since the 1998 study Average complaints (noise and odour) per kiloton of HSCW has reduced since the 1998 study Average overall environmental performance has increased since the 1998 study

Risk assessment

Project Code/Funder/Date	PRMS.036/MLA/2003
Company/Author	Dept Rural Sciences
Title	A quantitative risk assessment of microbial emissions from abattoirs.
Purpose	Identify pathogens of interest to the red meat industry and establish the routes by which they might be transmitted to the environment. Quantitatively estimate the risk to human health for each selected pathogen. Produce an overall ranking of risk for the selected pathogens.
Outcome	A series of recommendations for further work.

Project Code/Funder/Date	P.PIP.0516/AMPC/MLA/2017
Company/Author	Teys/Viridis Consultants
Title	Wastewater recycling risk assessment
Purpose	Quantify risk associated with options for the reuse of abattoir process water by applying the principles of quantitative microbial risk assessment (QMRA) to a range of theoretical scenarios to identify actions required to meet health-based targets
Outcome	QMRA is huge but this is a start.

Project Code/Funder/Date	2017.1042/AMPC/2017
Company/Author	Pype et al.
Title	Investigating water and wastewater reuse and recycling opportunities: identification and segregation of various waste streams
Purpose	To develop tools to analyse and assess costs and benefits of wastewater treatment and recycling options, based on data from the literature.
Outcome	Report describes how to use CBA spreadsheets and also reports on a workshop attended by some Queensland abattoirs

Offal room

Project Code/Funder/Date	A.ENV.0137/MLA/2014
Company/Author	JBS/Graham Treffone
Title	Tripe wash water reuse in beef processing
Purpose	Recycle water in processing of beef tripe and omasum. Reclaim hot, white water stream from Stage 2 and reuse it in Stage 1 dirty wash in the tripe washer/cooker.
Outcome	Process non-viable because insufficient water available to run the tripe washer/cooker.

Abattoir effluent

Project Code/Funder/Date	PIP.010/MLA/2004
Company/Author	NCMC/Todd Westgate
Title	Potential for Reuse of Low Contamination Abattoir Effluent
Purpose	Determine the appropriate technology to enable the reuse of white water in a nearby industry and/or within the abattoir itself
Outcome	Diverted 100kL/d to tannery, saving town water.

Project Code/Funder/Date	MLA/2014
Company/Author	Oakey/?
Title	The environmental, social and economic benefits of water use, reuse and effluent management projects.
Purpose 1	Reuse steriliser water to wash down cattle and yards
Outcome	Saving 2-4 Mega L/week.
Purpose 2	Improve extraction of fat from primary effluent using a Dissolved Air Flotation (DAF) system.
Outcome	Reduced nutrient load and saving 3t fat/d

Project Code/Funder/Date	P.PIP.0058/MLA/2011
Company/Author	Midfield/Chris Sentance
Title	Optimising integrated water reuse and waste heat recovery in rendering plants and abattoirs
Purpose	To validate the effectiveness of the Distech Vapour Compression Vacuum Distillation (VCVD) process.
Outcome	The equipment was not cost effective in reducing the effluent load.

Project Code/Funder/Date	P.PIP.0141/AMPC/MLA/2006
Company/Author	Churchill Abattoir/Mike Spence
Title	Churchill Abattoir (CA) large scale demonstration wastewater recycling plant
Purpose	To replace potable water with recycled water from the aerobic treatment lagoon for use in non-food sensitive areas.
Outcome	Company achieved a reduction in potable water use of about 11 ML/annum between January 2006 and June 2007 that can be attributed to replacing potable water with recycled water.

Boning room

Project Code/Funder/Date	A.ENV.0078/MLA/2011
Company/Author	Tatiara/Wade Phillips
Title	Re-use of steriliser water for contra-shear and hose down outside rendering
Purpose	Capture the steriliser water from the boning room and use it for the Contra-shears and to hose down outside the rendering plant (the Contra shears screens solids). Both processes used potable hot water.
Outcome	Steriliser water is captured, injected with steam and reused in sterilisers. Saved up to 100kL/d of hot water being sent through the contra shears and hoses.

Slaughter floor

Project Code/Funder/Date	A.ENV.0081/MLA/2011
Company/Author	Teys/?
Title	Viscera table water reuse
Purpose	Collect and filter water from the viscera table for re-use in the cattle yards.
Outcome	High *E. coli* counts in water posed hazard to staff; too much water generated for use in yards.

Project Code/Funder/Date	MLA/2014
Company/Author	Oakey/?
Title	The environmental, social and economic benefits of water use, reuse and effluent management projects.
Purpose 1	Reuse steriliser water to wash down cattle and yards
Outcome	Saving 2-4 Mega L/week.
Purpose 2	Improve extraction of fat from primary effluent using a Dissolved Air Flotation (DAF) system.
Outcome	Reduced nutrient load and saving 3t fat/d

Project Code/Funder/Date	PRENV.040/AMPC/MLA/2006
Company/Author	UNESCO Centre of Membrane Science and Technology
Title	Feasibility study of the microfiltration of steriliser water for reuse
Purpose	Trial microfiltration systems to clean steriliser water.
Outcome	Ceramic and polymeric systems were trialled and further work recommended.

Chiller cleaning

Project Code/Funder/Date	A.ENV.0141/MLA/AMPC/2013
Company/Author	Richard Ford
Title	Facilitation of Water Reuse Projects
Purpose	Assess effectiveness of: Steam used for the continuous sanitation of moving viscera tables in lieu of hot water. A water reuse system for the processing of tripe. A cleaning program for chillers.
Outcome	Only element 3 was concluded and showed 74% reduction in water use (mostly hot water).

Project Code/Funder/Date	A.ENV.0066/AMPC/MLA/2008
Company/Author	Ross Nicol
Title	Waterless cleaning of meat processing plants
Purpose	To identify emerging waterless, or water-reduced, cleaning technologies suitable for adoption by meat processing plants
Outcome	Identified the need to adopt a strategic approach to achieve change in water use

Project Code/Funder/Date	A.ENV.0108/AMPC/MLA/2011
Company/Author	Mike Johns and Ross Nicol
Title	First waterless cleaning workshop
Purpose	One day seminar to disperse findings of previous project
Outcome	Ideas developed and documented

Project Code/Funder/Date	A.ENV.0138/AMPC/MLA/2103
Company/Author	Richard Ford
Title	Water saving in the cleaning of chillers
Purpose	Assess an alternative dry manual cleaning program in beef chillers to the intensive cleaning procedures commonly used
Outcome	Efficiencies within chiller cleaning regimes: 74% reduction in total water consumption (mostly at 82°C or hotter) 93% reduction in detergent concentrate; 60% reduction in labour input; Replacement of all 82°C hot water with 30°C water. Commensurate reductions of water and cleaning chemical in waste discharge.

Hydrocyclone technology

Project Code/Funder/Date	PRENV.022/AMPC/MLA/2003
Company/Author	GHD Limited
Title	Assessment of Hydrocyclones for Fat Removal from Meat Processing Wastewater Streams
Purpose	Assess effectiveness of hydrocyclones at three establishments
Outcome	Survey demonstrated that the single stage hydrocyclone is an effective oil and gas removal technology for the meat processing industry

Stock cleaning

Project Code/Funder/Date	P.PIP.0143/AMPC/MLA/2008
Company/Author	Rowland Cobbold, UQ Veterinary School
Title	Innovative stock washing system to control cattle cleanliness
Purpose	Test the effectiveness of the Klenzion Stock Washing system
Outcome	Major conclusions are: 1. Heavily dagged cattle continue to be a problem for beef processors. 2. Following analysis of current trials, the participating plant has decided not to proceed with a commercial installation of the Klenzion system at the site. The reasons are: a) on the basis of the time saved in cattle washing in the trial, this would not extrapolate to labour savings at the site b) while water savings were recorded these did not alone justify commercial installation of the system (in this regard it is noted that for cattle destined to all markets other than the European Union the majority of cattle washing is currently undertaken using tertiary recycled water) c) the application as installed did not adequately address heavily tagged animals. In this regard it is acknowledged that Klenzion does not claim that its current product is suitable to treat heavily contaminated feedlot cattle. However, grain-fed cattle represent a substantial proportion of intake at the trial site. 3. A significant inhibiting issue in executing this project was the lack of an objective assessment system which determined the level of stock cleanliness that was commonly understood by AQIS and industry. Furthermore, should such a system ever be agreed, interventions such as the Klenzion system may make a valuable addition to the food safety/ quality assurance controls implemented by meat processors, in that they may assist in achieving objective measures which determine acceptability for slaughter.

Membrane technology

Project Code/Funder/Date	PRENV.028/MLA/2005
Company/Author	UNESCO Centre for membrane Science and Technology, UNSW
Title	Membrane technologies for meat processing waste streams
Purpose	Evaluate the potential application of membrane technologies to various aqueous waste streams in the meat processing industry
Outcome	Three wastewater scenarios were evaluated: (i) Stickwater treatment (ii) Sterilizer/handwash remediation (iii) Effluent reclamation

Appendix 2. AMPC project Assisting industry in adopting Direct Planned Potable Recycled Water for use in abattoirs: a call-out for feedback

AMPC is funding the SA Research and Development Institute (SARDI) to work with industry, regulators and researchers to stimulate the recycling and reuse of water streams in abattoir operations.

A large number of projects have been funded by AMPC and MLA over the years and we get feedback from industry that they see barriers to water recycling.

We need your help in defining what these barriers are, and how we can make it easier for companies to recycle and reuse abattoir water streams.

SARDI has gathered some information – they've summarised almost all the water projects that have been funded and they've identified potential barriers that exist in two regulatory documents: AQIS Notice (2008/06: efficient use of water in export meat establishments) and the Australian Guidelines for Water Recycling.

When you've looked over the backgrounder, we'd like you to answer a few key questions that will help SARDI to work with a Water Reference Group (WRG) of industry, regulatory and researchers to reduce barriers and impediments seen by the industry (we list the questions below).

One of the SARDI researchers (Jess Jolley, Andreas Kiermeier or John Sumner) will phone you, go through the questions and jot down your answers, which will then be made anonymous.

The project will run to mid-2021 and we plan to set up pilot studies to begin soon after.

Thanks in advance

Matthew Deegan
AMPC

Questions to help this project along the way

1. Do you currently recycle or re-use water? If you do:
    a. What is the source of the water you recycle?
    b. How do you treat it?
    c. What do you use it for?
2. How did you go about getting water recycling into your Approved Arrangement?
3. Did you undertake a risk assessment and, if so, can you talk us through the hazards you identified and the likelihood that they would occur?
4. Was the AA process straightforward or did you face hurdles?
    a. What were the hurdles?
    b. How did you overcome them?
5. Are you thinking about further water recycling options? In particular, have you considered Direct Planned Potable Recycled Water as defined in the AQIS Notice 2008/06?
6. Are there any other options that just seem too difficult or not cost effective?