Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Diverting plastics from landfill – Final report

Business Scenario Study for Red Meat Processors

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1. Executive Summary

This project explored the consumption of single-use plastics at Australian red-meat processing facilities. It further investigated opportunities to implement circular economy principles to minimise plastic waste in the production process. The project scope included all single-use plastics consumed on-site and collected by waste recovery services for disposal as landfill. The project also investigated sustainable packaging product development for red meat, packaging policies and regulations coming into effect in Australia and internationally, noting that this is currently a rapidly evolving space.

The red meat supply-chain is progressing towards more sustainable solutions, particularly regarding retail-ready packaging. International initiatives, such as the Circular Economy for Flexible Packaging (CEFLEX) and Australia's National Packaging Targets 2025, are driving changes to reduce waste and improve the circularity of materials. In Australia, the Australian Packaging Covenant Organisation (APCO) is driving the transformation towards improved packaging sustainability and circularity, including a strong focus on plastics. This project complements APCO's focus on plastics in whole-sale and retail packaging by addressing the current data-gap of single-use on-site plastic waste arising in the production process at facilities. Therefore, the principal focus for this project was to develop strategies that might reduce on-site single-use plastic waste for landfill disposal at Australian red-meat processing facilities.

Initially, APMC members were engaged through a survey and a webinar to gain a whole-of-industry view of current awareness and action regarding plastic use, raise awareness of the rapidly evolving regulatory and policy environment relating to plastic waste, and invite members to participate in a detailed site assessment. Interested facilities submitted an expression of interest to participate in the study. Eight processing sites were selected to participate in the study, located across four states covering beef, veal, sheep and lamb production. The throughput volume of the chosen sites represented 16.2% of all red meat production in Australia and provided coverage of single/multiple brands, including export, domestic and retail markets.

The study identified a significant diversity of single-use on-site plastic products used in red-meat processing. A total of 44 plastic item types were identified that are commonly used by facilities and are included in the Plastics Inventory (Appendix A). The inventory presents a diverse array of polymer types and operational applications. This included polyethylene terephthalate (PET), polypropylene (PP), polyethylene (PE), polyurethane (PU), low- and high-density polyethylene (LDPE, HDPE), polyvinyl chloride (PVC), polyvinylidene chloride (PVDC), polyester and combinations of other plastics that were not easily identifiable. Process maps were developed that demonstrated the application of these plastics across all meat processing departments/rooms. Ten application categories were identified during the process mapping stage. These included plastics used in:

- Cross-contamination management
- Personal protective equipment (PPE)
- Production ID
- Site cleaning and hygiene
- Transport and logistics -inbound
- Transport and logistics -outbound
- Temporary inhouse packaging/Storage
- Product packaging (Business to Business - B2B, Business to Consumer - B2C).

In addition, two process-related categories were identified as:

- Leakers/Repacks
- Off-cuts.

A plastics data collection tool was developed using the plastics inventory as a basis. Using this tool, detailed production and plastic consumption data was then collected from each participating facility. Based on the supplied data, seven high-priority items were identified by the amount of usage and/or weight of plastic waste created (Table 1).

For each of the priority items, waste-reduction scenarios were then generated by applying the waste management hierarchy and currently available alternatives. These scenarios were then validated through consultation with sites and relevant stakeholders. Identified scenarios included a broad range of interventions (Table 1) that might enable nearly 60% of single-use on-site plastic to be diverted from landfill.

Table 1: High-priority single-use plastic items and their key alternatives to landfill disposal.

Plastic Item (consumable)	Sustainability strategies
Disposable plastic gloves	Biodegradable products
Disposable aprons	Reusable and compostable products
Disposable arm sleeves	Downcycling
Pallet wrap	Reusable products and recycling
Carton/pallet strapping	Reusable products and recycling
Bin liners/garbage bags	Biodegradable products
Weasand clips	Downcycling options

Based on the reported sample from the participating sites, the Australian red-meat processing sector was estimated to generate 4511 metric tonnes of on-site plastic consumables waste in the 2021/2022 financial year. While there was some evidence of diverting vacuum shrink packaging off-cuts and used pallet wrap to re-processors, most single-use on-site plastic make their way directly to landfill each year.

This project provides the first comprehensive examination of single-use on-site plastics in Australian red-meat processing facilities. Developing a comprehensive plastics inventory and an associated data collection and evaluation tool has established an important platform for facilities to identify and monitor their use of single-use plastics. The extensive list of items highlights the many opportunities for facilities to readily reduce their plastic waste stream and minimise plastics going to landfill. There are immediate opportunities for plastic avoidance, such as by switching to readily available reuse system alternatives to pallet wrap (e.g. closed-loop systems of pallet netting and strapping). Furthermore, investigation of biodegradable and compostable alternatives for personal protective equipment (PPE) and cross-contamination management may reduce the volume of plastic waste and potential plastic contamination of secondary production processes. Finally, there are largely still untapped currently available recycling opportunities for clean, uncontaminated plastics such as pallet wrap, bags and films that can be collected and baled on site.

This project represents a starting point for the transition to a more circular red meat processing economy. It comes at a time of major disruption of the make-use-dispose approach to production. Around the globe, the concepts of circular economy and Extended Producer Responsibility (EPR) are taking hold. This is facilitating a shift towards more circular approaches as regulatory and other mechanisms encourage producers to take whole-of-life responsibility for their products, including associated packaging and production waste. Shelf-life, food safety and customer appeal remain key priorities and challenges for the meat industry. Plastic products made from virgin material remain readily available, comparatively cheap and meet regulatory hurdles with regard to food safety. Complex multilayer plastics outperform mono-plastics with regard to shelf-life but are far more difficult to recycle. The low costs of waste disposal provide little incentives for waste reduction initiatives. Recycling of contaminated plastics (meat, blood, fat) remains problematic. However, the regulatory as well as technological landscape is evolving rapidly and has the potential to quickly disrupt current cost structures. Compostable and biodegradable bioplastics and plastic alternatives provide opportunities with the potential for concurrent process improvements. For example, a compostable slap sheet used in cross

contamination management would eliminate the risk of plastic contamination in processing by-products. Regulations are starting to allow and demand recycled plastics, even in food-grade applications, while at the same time, recycling technologies are diversifying and improving in their capacity to deal with contamination.

The project makes the following recommendations for all AMPC members to consider:

- Red meat processing organisation and sites to develop a circular roadmap for plastics using the waste hierarchy principles.
- Conduct baseline audits of single-use plastic consumption and target high-volume plastic with key diversion strategies.
- Engage with plastic producers, manufacturers and suppliers to explore alternative solutions such as reusable, compostable, recycled and recyclable products.
- Collaborate with co-located industries, waste services and re-processors to develop waste recovery streams in regional areas and take advantage of clustering and scale/volume.
- Develop sufficient systems to capture internal plastics data and put targets in place that align with evolving government policy, regulations and targets.

In addition, red meat processors should also explore their obligations in packaging:

- Continue to invest in sustainable packaging and closely monitor the regulatory environment

2. Introduction

Modern society has benefited greatly from advances in plastic technologies and the application of plastic products. Plastic is lightweight, durable and versatile and can be produced cheaply. Its versatility allows for the production of a wide array of products, from simple containers and clothing to complex medical devices. Plastics are corrosion-resistant and have excellent insulation properties. These properties have enabled innovation across many industries, such as efficiencies in packaging and transportation, hygiene and safety, durability of products and improvements to people's lives. While plastics offer multiple benefits to society, there are concerns related to their production, use, and disposal, such as micro plastic pollution and their contribution to greenhouse gas emissions. Without strategies to address increasing plastics production, consumption and disposal, there will continue to be severe and potentially irreversible environmental impacts (Thompson et al. 2009). To meet its commitments as global leaders in environmental stewardship, the Australian red meat industry is focusing on plastic as part of the solid waste to landfill reduction strategy (AMPC, 2020).

Australia consumed 3.4Mt of plastics in 2020, which is estimated to rise to 8.6Mt by 2025 (National Waste Report, 2022). Approximately, 2.4Mt of plastic reached its end-of-life with 2.1Mt sent to landfill. It is estimated there is currently 50Mt of plastic sitting in landfills across Australia. Unfortunately, due to plastic products' complex and diverse nature, only around 15% of plastic is recycled each year (Hossain et al. 2022). Even PET plastics that have the potential to be fully circular only achieved a 21% recycling rates in 2020. To further exacerbate this, Australia's infrastructure to collect, sort and recycle plastic is also limited. It is a problem on a global scale as the production, consumption and disposal of plastic have devastating impacts on the environment. The entire lifecycle of plastic, from production to disposal, contributes to greenhouse gas emissions. Plastic production is energy-intensive, and plastic waste in landfills release methane, a potent greenhouse gas (Lui et al. 2021). As plastics degrade, microplastics are found throughout the environment, including in soil, water, and the air, entering the food chain potentially affecting organisms at various levels (Lehel and Murphy, 2021). Harmful chemicals from plastics are leaching into the environment, contaminating soil and water and posing a risk to ecological systems and human health (Waring et al. 2018).

Various parts of society, including governments, businesses, non-governmental organizations (NGOs), and individuals, are taking active steps to address the problem of plastics and plastic pollution. Efforts to address plastic pollution in Australia are diverse and collaborative, involving a combination of government policies, business initiatives, community engagement, and individual actions. These initiatives fall under the paradigm of the circular economy - an economic system that aims to minimise waste and make the most of resources by keeping products, materials, and resources in use for as long as possible (Stahel, 2016). These efforts aim to reduce plastic consumption, improve recycling and waste management, and promote the development of more sustainable alternatives. However, the circular plastics ecosystem in Australia is in its infancy with a lack of market structure and technology to support large-scale implementation of circular solutions (Caceres and Zaman, 2022). On the positive side, considerable progress has been made with the introduction of the Australian Packaging Covenant to advance sustainable retail packaging. Reprocessing and recycling capacity is building, especially for PET and other clean LDPE and HDPE plastics. New plastic consumable products are emerging in biodegradables and compostable. Closed-loop systems and reverse logistics systems are being developed to reuse products. Plastic waste is yet to become a tradable resource, and various ecosystem elements (e.g., collection schemes) are resource-intensive and open to high business risk (McKinnon et al. 2018). Furthermore, many circular activities are siloed and require greater levels of collaboration and investment to stabilise business activity (Tapaninaho &Heikkinen, 2022). Scientific advancements also hold the key (e.g. advanced recycling) but research and development are still needed to develop a fully commercialised pathway.

Aligning with global and national policies, the Australian Meat Processor Corporation and its members have committed to achieving zero waste operations by 2030 through their 'zero waste to landfill' policy (AMPC, 2020). This continues to drive investigations into waste reduction, reuse and recycling. Finding viable alternatives that facilitate meaningful diversion of plastic waste from landfill is thus imperative and provides a genuine opportunity not only to strengthen the

social and environmental credibility of red meat processors but also to achieve cost savings and/or alternative revenue streams. Individual meat processors have already attempted to reduce their waste outputs, look for alternative methods, or find ways to reuse or recycle waste materials (McCabe et al. 2018). However, sector-wide solutions are needed to address waste management to minimise costs, sustain business operations, and protect the environment for future generations.

Single-use and problematic plastics are used in red meat supply chains, systems and processes. This is not only true of packaging but also essential across meat processing operations. Like other food processing industries, the dependency on plastic to maintain food safety & quality standards, and production outputs, makes it extremely challenging to implement circular solutions. This project explores ways red-meat processors can divert on-site plastic waste from landfills. It seeks to establish a rigorous understanding of plastic application points along the waste supply chain for the entire meat processing sector. The research provides measurable baseline data against which alternative production pathway scenarios can be assessed and evaluated to achieve the AMPC's sustainability goals while maintaining or improving production standards. The project also seeks to understand the shifting regulatory environment, especially concerning sustainable packaging targets. Through this, the project directly contributes to achieving AMPC's aspiration of Australian meat processors being recognised as global leaders in environmental stewardship and acknowledged as responsible businesses with positive economic and social impacts on their communities by 2030.

3. Project Objectives

The first principle of the project was to explore opportunities for Australian red meat processing facilities to divert on-site single-use plastic from landfill. To meet this objective, several deliverables were established to guide the project toward achieving its purpose (Table 3.1). The project undertook a scan of the policy and industry environment to develop an understanding of regulatory and market conditions in relation to circular economy strategies and waste streams for single-use plastic products. The project also explored the existing evidence-base to build knowledge of the scientific and technological advancement in plastics circularity. Through selected case studies the project identified and analysed the types and amounts of single-use plastic waste generated by Australian red meat processors annually. From this, the project evaluated the environmental impact of diverting single-use plastics from landfill, and developed scenarios that red meat processors across the sector can consider. The project objectives where monitored through milestone reports between March 2022 and July 2023.

Table 3.1 - The overall project comprises four main steps as follows.

Phase 1:	**Industry Overview**	> Review of academic/industry best practices literature > Online survey of AMPC member facilities > Selection of case study facilities for detailed analysis
Phase 2:	**Detailed Process Analysis**	> Detailed analysis of on-site plastic use and waste at selected case study facilities
Phase 3:	**Scenario Modelling**	> Developing scenarios that outline a viable pathway to reduce on-site plastic use and waste

Phase 4:	**Verification & Dissemination**	> Testing and validation of preferred scenarios > Dissemination of findings

4. Methodology

Phase 1. Business process mapping and analysis

- Collect comprehensive operating data from several plants nominated by AMPC through document reviews, interviews with key operational and management staff and observations;
- Detailed documentation of business processes using relevant visualisation software, identifying single-use plastics application points with a primary focus on on-site packaging wastes, and a secondary focus on other packaging;
- Analysis of application point data, including single-use on-site plastic types, purposes, volumes, costs, post-use condition (e. g. level of contamination);
- Evaluation of current/proposed packaging regulation & compliance impacts on processor plastic use, and historic (pre- plastics use) meat processing approaches and rationale for change to plastics use
- Develop academic best practices on:
    - Single-use on-site plastic waste use reduction strategies of relevance to red meat processors
    - Re-use and recycling approaches, technologies and waste value chains
- Evaluation of contextual drivers including health regulations, market requirements and business process and related waste streams

Phase 2. Scenario and simulations developed for current single-use on-site plastics application points

- Detailed analysis of existing plastics use points within business processes, including capturing of process purpose, rationale for using plastics and costs - follow-up interviews/ on-going consultation with operational and management staff;
- Development of potential alternative production pathways, considering options to reduce use of single-use on-site plastics;
- Development of reuse and recycling options in consideration of available plastics technology, science and potential recycling pathways and end-markets (Literature reviews and Market consultation);
- Based on data and accessing stakeholder knowledge co- design scenarios;
- Validate scenarios through benchmarking and stakeholder focus groups. Interaction with a range of stakeholders within the plastics supply chain this will include suppliers/providers;
- Stakeholder focus groups to identify financial, social, environmental assessment criteria, followed by workshop to determine their relative weightings for evaluation of scenarios.

Phase 3. Review of potential business pathways

- Select validated scenarios that target high-impact on-site plastic products and develop diversion strategies that model potential impact across the sector.

- Evaluate alternative diversion strategies against AMPC criteria and weightings to prioritise future business pathways.
- Establish preliminary KPIs that assist red meat processing facilities in monitoring progress toward circularity goals.

Phase 4. Acceptance and verification

- Report and presentation of business pathways to process experts and stakeholders for verification and feedback;
- Consideration of feedback and recommendation of preferred pathways for implementation;
- Develop supporting discussion for the most viable options.

5. Project Outcomes

This project took a holistic approach to single-use plastic waste, built on circular economy principles and the priorities of reduce, reuse, and recycle. A comprehensive investigation of the current business processes of eight representative red meat processors was conducted to explore opportunities for AMPC members to meet their stated sustainability goals concerning solid waste to landfill. Business process analysis identified potential intervention points (plastics application points) to which scenario development and analysis were applied. Through this, the project facilitated co-design with the scientific, technological, operational and business expertise of circular economy scenarios that sought to ultimately divert on-site single-use plastic waste from red meat processing away from landfill. This new knowledge and understanding provides wide-ranging guidance for the Australian red meat processing sector in achieving its aspiration of zero plastic waste to landfill.

5.1 Strategies and initiatives for sustainable plastic management

5.1.1 Global action on single-use and problematic plastic

The Sustainable Development Goals (SDG) and their associated targets emphasise the need to reduce plastic waste, prevent pollution, promote sustainable consumption and production patterns, and protect marine and terrestrial ecosystems from the harmful effects of single-use plastics and plastic pollution (de Sousa, 2021). Achieving progress on these goals requires concerted efforts at the global, national, and local levels. SDG 12 - Responsible Consumption and Production aims to promote sustainable and efficient use of resources, reduce waste generation, and encourage environmentally friendly practices in manufacturing and consumption to ensure a more sustainable and responsible global economy. An associated SDG 12 target is - 12.5: “By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse” (UN General Assembly, 2015, p 22). The Ellen MacArthur Foundation is a pioneer in the circular economy and works to accelerate the transition toward a circular economy by engaging businesses, governments, and academia through research, education, and collaborative projects (Ellen MacArthur Foundation, 2021). The World Economic Forum has launched initiatives such as the Circular Economy Initiative, which focuses on promoting circular economic models, innovation, and collaboration among businesses, governments, and civil society. The United Nations Environment Programme plays a key role in promoting sustainable consumption and production, including circular economy principles, through various programs and partnerships.

The European (EU) Strategy for Plastics is influencing global actions to address plastics production and use. The objective of the EU strategy is to protect the environment and reduce marine litter, greenhouse gas emissions and dependence on imported fossil fuels (European Commission, 2018). It will support more sustainable and safer consumption and production patterns for plastics. The plastics strategy also aims to transform how plastic products are designed, produced, used and recycled in the EU. The suggested actions in the EU strategy are making recycling profitable, curbing plastic waste, driving innovation and investment and spurring global change. The Circular Economy for Flexible Packaging (CEFLEX) initiative is a collaboration of over 180 European companies, associations and organisations representing the entire flexible packaging value chain. CEFLEX works to make all flexible packaging in Europe circular by committing to the collection of all flexible packaging and over 80% of the recycled materials channelled into valuable new markets and applications to substitute virgin materials. CEFLEX is an example of the need for whole supply chains to work together for sustainable packaging solutions to work effectively.

5.1.2 National strategies to address single-use plastic

Australia has implemented a comprehensive National Plastics Plan to combat plastic waste. This plan outlines the country’s approach to increasing plastic recycling, finding alternatives to unnecessary plastics, and reducing plastic's impact on the environment (DCCEEW, 2021). The plan focuses on five fronts: prevention, recycling, consumer education, oceans and waterways, and research. For instance, Australia is working with industry to phase-out

particularly problematic plastic materials and has introduced new laws to ensure all stakeholders take responsibility for plastic waste.

In addition to the *National Plastics Plan*, Australia has also established the *National Waste Policy Action Plan*. This policy includes targets and actions that guide Australia's investment and national efforts up to 2030 and beyond. Some of the key actions include banning the export of waste plastic, paper, glass, and tyres, commencing in the second half of 2020, reducing the total waste generated in Australia by 10% per person by 2030, achieving an 80% average recovery rate from all waste streams by 2030, significantly increasing the use of recycled content and phasing out problematic and unnecessary plastics by 2025.

In addition, the Australian Government launched the *Recycling Modernization Fund* (RMF) to boost local waste processing (DCCEEW, 2023). The RMF supports new infrastructure investments to sort, recycle, and remanufacture waste materials, including mixed plastics. This is part of a broader effort to stop the export of unprocessed plastic waste and promote product stewardship through the Recycling and Waste Reduction Act 2020. These initiatives demonstrate Australia's commitment to reducing plastic waste and promoting sustainable practices at both the national and state levels.

5.1.3 Packaging regulations and compliance requirements

In Australia, major policy shifts have occurred and continue to occur in relation to plastic waste over the last few years. Since 1999, the Australian Packaging Covenant (APC) has been the principal national instrument to reduce the environmental impacts of consumer packaging, supporting waste reduction approaches at state and territory level. The APC is agreed between the Australian Packaging Covenant Organisation Ltd. (APCO), representing industry participants in the packaging supply chain, and commonwealth, state and territory governments, and endorsed by environment ministers. The APC takes a supply-chain-approach to reduce the environmental impacts of packaging by optimising resource recovery, minimising leakage from the waste system to the broader environment and preventing waste through innovative design and material choice. The APC supports an industry-led component of a co-regulatory arrangement underpinned by the *National Environment Protection (Used Packaging Materials) Measure 2011* (NEPM).

Recent external pressures on Australia's approach to waste have dramatically changed and accelerated policy and action regarding the treatment and prevention of waste. The Chinese restrictions on the import of foreign waste through the *Prohibition of Foreign Garbage Imports: The Reform Plan on Solid Waste Import Management* in 2017, in particular, massively disrupted a policy approach of waste export that had been embraced by Australia, particularly for plastics. This abrupt ban prompted changes in Australia's policy approach and forced a focus on opportunities for domestic processing and waste reduction. It also shed light on a geographically piecemeal approach with often confusing (to a consumer) variation of waste treatment and recycling strategies right down to local government level.

In response, the *2025 National Packaging Targets* were first established in 2018. The targets promote circular economy principles and require a complete and systemic change to how Australia creates, collects, and recovers product packaging across whole supply chains. Following industry and government consultation, they were developed and contributed to global sustainable packaging initiatives. APCO is the organisation charged by the government to facilitate the delivery of the 2025 Targets.

The 2025 Targets are:

- 100% reusable, recyclable or compostable packaging;
- 70% of plastic packaging being recycled or composted;
- 50% of average recycled content included in packaging (revised from 30% in 2020); and

- The phase-out of problematic and unnecessary single-use plastics packaging.

The 2025 Targets are supported by the federal and all Australian state and territory governments and were included in the 2019 *National Waste Policy Action Plan* and the 2021 *National Plastics Plan*. In addition, individual states and territories have also taken legislative steps to restrict problematic and unnecessary single-use plastic packaging items identified by APCO for phase-out.

It is anticipated that most Australian red-meat processors are subject to the *2025 National Packaging Targets* and have to report either to APCO directly or each EPA of the jurisdictions they engage in. The industry survey conducted as part of this project (see 4.3 and 5.3) thus sought to ascertain the status of current engagement by the industry with the targets. Nonetheless, it is important to note that this project is interested in reducing single-use on-site plastics across the meat-processing process, which are different in nature to consumer packaging on which the targets are focussed.

5.1.4 Shift from Take-Make-Dispose Economies to Circular Economies

A rapidly accelerating shift is underway from a *take-make-dispose approach* to a *circular approach* to economies (Lazarevic and Valve, 2017). Drivers of this shift are varied and include government policy, legislation and regulation at state, federal and supranational levels; international agreements; materials and packaging innovations; retailer and industry body initiatives; increasing consumer awareness and preference; and pressure from consumer advocates and lobby groups. The shift towards circular economies applies to all types of waste, though plastics are a major focus due to their long-life and increasingly documented environmental prevalence and harm.

Currently, the focus regarding plastics in Australia is on single-use plastic consumables and on single-use packaging for retail goods (Bering and Karasik, 2022). For consumables such as single-use plastic bags, straws, plates and cutlery, a state-based approach has been evident (e.g. Qld Government ban on single-use plastic straws, plates and cutlery; NSW Government ban on single-use plastics), with approaches and implementation timelines varying between States and Territories. For single-use packaging, however, an Australia-wide approach is being implemented with a cross-jurisdictional and cross-industry goal of the National Packaging Targets 2025. The Australian Packaging Covenant Organisation (APCO) has been established to implement the national regulatory framework of the Australian Packaging Covenant under the National Environment Protection (Used Packaging Materials) Measure 2011 (NEPM). The Sustainable Packaging Guidelines are the guiding document for Australian organisations to help them integrate the ten Sustainable Packaging Principles (figure below) into their operations.

Figure 5.1.4 - Overview of the ten Sustainable Packaging Principles underpinning the Sustainable Packaging Guidelines (source: Sustainable Packaging Guidelines - APCO)

These Principles have been designed to 'optimise outcomes for packaging functionality and sustainability' (APCO 2022) with a view to achieving Australia's 2025 National Packaging Targets. Through the provision of guidelines and tools, APCO actively supports industry members in the transition towards a circular approach to packaging and helps them achieve the National Packaging Targets 2025. The timeline for transitioning is very tight, and data indicates that Australian red-meat processors as a whole are still in the very early stages of engagement with that transition, particularly regarding the capture and monitoring of detailed data on packaging. The Sustainable Packaging Guidelines outline a six-step process for organisations that are supported through APCO resources such as the Sustainable Packaging Checklist and tools such as the Packaging Recyclability Evaluation Portal (PREP).

1: Understand your position and opportunities
2: Work with the right people (internal knowledge holders and decision makers; external contacts)
3: Review existing packaging
4: Implement the Sustainable Packaging Principles
5: Track and report progress

6: Seek opportunities for continual improvement

Concurrent initiatives such as the Australasian Recycling Label (ARL) and associated tools such as the Packaging Recyclability Evaluation Portal (PREP) yield useful synergies with impending data reporting requirements to APCO or state-based environmental protection agencies. PREP, for example, helps users establish detailed inventories of all components of their packaging to facilitate simple and clear labelling of packaging waste for post-consumer recovery. The model under development in this project will also support red-meat processors in making viable and evidence-based business decisions to help the transition.

In addition to product packaging, however, initial data highlights that there is also scope for significant reduction in plastics use and improved circularity in areas of manufacturing (e.g. capture and recycling of clean packaging offcuts; scraps; and in-house short-term uses) and the transportation of goods (e.g. alternatives to single-use plastic pallet wrap). As such, this project seeks to examine and evaluate single-use on-site plastics applications across the meat-processing process.

5.1.5 Applying the Waste Hierarchy in decision making

The premise underpinning current policy, legislative and regulatory shifts is a desire to shift towards a more circular economy. Accordingly, the issue of waste creation and how society deals with waste is central to the transition. The Waste Hierarchy (Figure 5.1.5) provides an overview of priorities, with the most preferred option being prevention (avoiding through rethinking or redesigning of process or product) to the least preferred disposal option. In terms of this research, each plastic application point will be examined through the lens of this hierarchy. From an operational perspective regarding plastics in red-meat processing, avoiding plastics should be the highest priority.

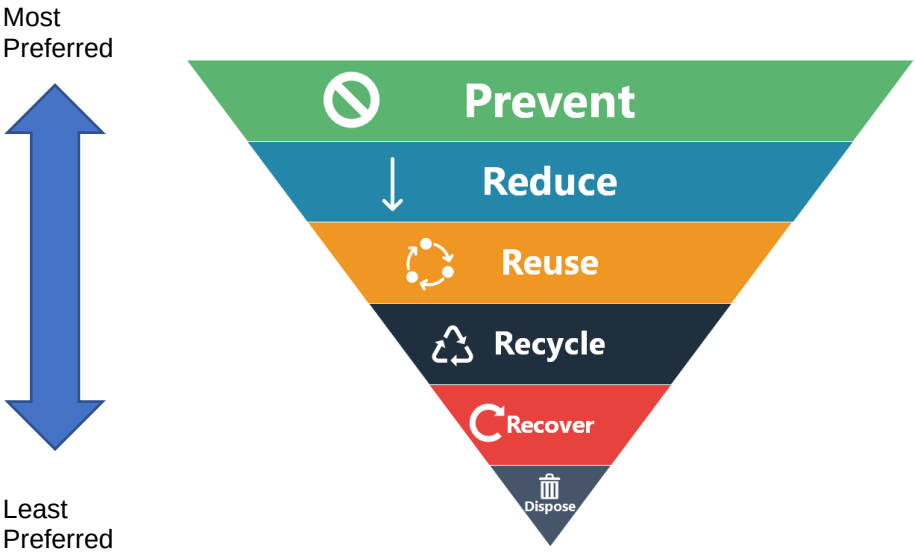


Figure 5.1.5: The waste management hierarchy.

Plastics are not fully replaceable. However, there are moves in jurisdictions around the globe towards establishing a new plastics economy similar to the aspirations of APCO and the Australian National Packaging Targets 2025. For example, the EU recently developed a strategy for plastics with a circular economy focus. Key targets frame the EU plastics economy and seek by 2030 to achieve full reusability or recyclability of all plastic packaging materials, for at least 50% of plastic waste generated in Europe to be recycled, and for plastics sorting and recycling capacity to be quadrupled. Supporting the transition in the EU, the Circular Economy for Flexible Packaging (CEFLEX) initiative is a collaboration of over 180 European companies, associations and organisations representing the entire value chain of flexible packaging. CEFLEX provides a range of guidelines to make flexible packaging circular and through these, supports relevant industry members akin to the efforts of APCO in Australia. Japan provides another example of a jurisdiction with key waste and recovery targets and a Resource Circulation Strategy for Plastics. This strategy also promotes the development and use of substitutes for petroleum-based plastics and the introduction of biomass plastics.

5.1.6 Circular economy strategies

Circular economy strategies refer to a set of practices and approaches aimed at achieving sustainability and reducing the environmental impact of production and consumption systems. These strategies involve maximizing resource use, minimizing waste generation, and promoting the reuse, recycling, and reduction of materials (Yang et al. 2022). Actions to achieve circularity include:

Redesign: Redesign is a strategy in the circular economy and waste hierarchy that aims to prevent waste by designing products, processes, and systems that are more sustainable, durable, and can be easily repaired or recycled. By taking a holistic approach to product design, companies can reduce waste, improve resource efficiency, and create more sustainable products and systems.

Replace: Replace is a strategy in the waste hierarchy that involves replacing a product or material with a more sustainable or environmentally friendly alternative. For example, replacing single-use plastic bags with reusable bags or replacing incandescent light bulbs with energy-efficient LED bulbs.

Reuse: Reuse is a strategy in the waste hierarchy that involves using a product or material again for the same or a different purpose. This strategy extends a product's or material's life cycle and reduces the need for new resources. Examples include refilling a water bottle or repairing and reusing a broken electronic device.

Recycle: Recycling is a strategy in the waste hierarchy that involves converting waste materials into new products or materials. This strategy reduces the amount of waste sent to landfills and conserves resources. Examples include recycling paper, plastic, glass, and metal. This is further separated into two categories: recycling for the same item or higher value material (circular) or recycling for a lower quality/value product (downcycling, linear).

Recover as energy: Recovering energy is a strategy in the waste hierarchy that involves extracting energy from waste materials, such as through incineration, gasification, or anaerobic digestion. This strategy reduces the amount of waste sent to landfills and generates renewable energy.

Dispose: Disposal is the least desirable option in the waste hierarchy and involves sending waste to landfills or other forms of disposal. This strategy should only be used for waste that cannot be prevented, minimised, reused, recycled, or recovered as energy. The goal of the circular economy and waste hierarchy is to eliminate or minimise waste disposal as much as possible.

5.1.7 Re-use and recycling approaches, technologies and waste value chains

The plastics circular economy and ecosystem is an evolving space with rapidly advancing new technologies, processes, chemicals, and business models in reusing and recycling.

Reuse approaches – Along with designing products that are durable, closed-loop supply chains, also known as closed-loop logistics or reverse supply chains, are systems designed to efficiently manage the return and recovery of products, materials, and components from the end of their life cycle or from customers (MahmoumGonbadi et al. 2021). These supply chains are in contrast to traditional, open-loop supply chains, which primarily focus on the flow of products from manufacturers to consumers. These approaches include systems that facilitate collection and return, remanufacturing or refurbishment, and recycling and material recovery. Closed-loop supply chains are increasingly important in industries where products have a significant environmental impact and where there is a growing emphasis on sustainability. They offer both environmental and economic benefits through improved resource utilization and reduced waste.

Chemical recycling of plastic waste exploits a chemical transformation to either recapture virgin monomer (closed-loop) or directly convert it into other useful synthetic chemicals/feedstocks (open-loop). Closed-loop chemical recycling involves reprocessing plastic and using the recyclate produced to manufacture another product in the same category, e.g. recycling PET bottles and HDPE milk bottles and non-packaging applications, such as PVC windows. The study on dual closed-loop chemical recycling of synthetic polymers by intrinsically reconfigurable poly(disulphides) by Zhang et al. (2021) highlights the efficiency of completing the depolymerization process in basic aqueous solutions. Closed-loop chemical recycling promotes the concept of producing new products with recycled content before they are recycled and made back into new products. Therefore, closed-loop chemical recycling can be used as a solution to plastic waste management in the meat processing industry.

In open-loop chemical recycling, products are reprocessed, and the recyclate is used in a different application. Several studies suggest open-loop chemical recycling as a method of plastic recycling, including catalytic chemical recycling of commercial polyesters and upgrading various aromatic plastics waste to arenes. In the first method chemical transformation of poly lactic acid (PLA) and polyethylene terephthalate (PET) is done using metal-based catalysts. It allows to convert polymers into their original monomers, fuels or chemical precursors for value-added products. The second method involves upgrading various aromatic plastics waste to arenes. An arene is an aromatic hydrocarbon such as benzene or naphthalene. The conversion is done via catalytic hydrogenolysis over a Ru/Nb2O5 catalyst. This catalyst allows the selective conversion of single-component aromatic plastic and, more importantly, enables the

simultaneous conversion of a mixture of aromatic plastic to arenes. This method reduces the volume of waste that must be treated and disposed of and reduces the usage of raw materials. Therefore, this method is useful in considering waste management in the meat processing industry.

Mechanical recycling involves shredding the waste in order to obtain recyclate or regranulate that meets specific quality requirements. More often, plastic bottles and packaging films are subjected to mechanical recycling. The mechanical recycling of plastics involves the following steps:

- Cutting and shredding
- Contaminant separation
- Floating
- Milling
- Water washing, chemical washing, drying
- Agglutination
- Extrusion
- Pelletising, quenching, and selling as a final product

The advantages of this method over chemical recycling are that this method does not use toxic chemicals in the recycling process and is less energy intensive. Therefore, this method can be considered an efficient method for plastic waste management in the meat processing industry.

Studies on alternative food packaging to single-use plastic packaging suggest bioplastics as an alternative to conventional plastic used in the packaging. Due to the biodegradability of the bio-plastic reinforced with natural fibres, it has gained much attention in preventing plastic waste disposal. For example, sweet potato by-products packaging was developed to create bio composites used for food packaging from the sweet potato residue after industrial extraction of starch from sweet potatoes. Furthermore, active Packaging using agro-industrial residues promotes the use of biodegradable packaging options that minimize the waste in the food packaging. T9hese packages are created using agro-industrial residues as a source of added value to produce bioplastics, and these packages intentionally interact with food, aiming to improve some of its characteristics.

5.1.8 Plastics-related trends for red-meat processors

Australia's main supermarket chains (Coles, Woolworths and ALDI) have all committed to sustainable packaging strategies. This is driving innovation within the supply chain between packaging producers, meat processors and retail markets. Several examples were found where meat processing sites are collaborating with their supply chains to develop sustainable packaging solutions (Table 2.4).

Packaging outcome	Red Meat application	Case Study
93% renewable & recyclable	Skin Pack - fillet	http://aipack.com.au/wp-content/uploads/AIP_Case_Study_Plantic_RV_skin_pack_2019.pdf
50% energy saving in the production of a bioplastic	PET Tray - mince	http://aipack.com.au/wp-content/uploads/AIP_Case_Study_Plantic_R_Packaging_Material_2017.pdf
100% recyclable tray	PET Tray - cutlets	http://aipack.com.au/wp-content/uploads/AIP_Case_Study_Pact_Group_Moisture_Lock_2017.pdf
75% less plastic in tray	Skin Pack and paper tray - fillet	http://aipack.com.au/wp-content/uploads/AIP_Case_Study_Woolworths_Paper_Seal_Meat_Tray_2021.pdf

REDcycle Recyclable	Non-leak, Vacuum shrink with bone guard - lamb ribs	http://aipack.com.au/wp-content/uploads/2021_AIP_SFP_Case_Study_Junee_Lamb_and_Sealed_Air.pdf
70% less plastic waste	Flow wrap - mince packet	https://bindareefoodgroup.com.au/striving-for-sustainability/

Table 5.1.8 Selected examples of sustainable packaging in red meat processing (Source: Australian Institute of Packaging, and Bindaree Food Group)

Extended producer responsibility (EPR)

Globally, there is a clear trend towards increasing responsibility for waste prevention and circularity on the producer to facilitate waste avoidance. It is no longer good enough to pass responsibility of packaging waste onto the consumer or local authorities, as has been the approach in jurisdictions like Australia until recently. The concept of extended producer responsibility (EPR) and take-back/deposit systems has already played a major role in leading countries such as Switzerland. For example, the Swiss Ordinance on Beverage Containers implemented in 2001 for refillable and one-way containers that are recycled at levels below 75% imposed a mandatory minimum deposit amount. By 2017, recycling rates of 94% for glass, 83% for PET and 92% for aluminium were achieved. Making producers responsible for the end-of-life phase also provides incentives for more recycling-friendly plastic packaging. Over the past year or two, this transition has begun to rapidly accelerate in Australia, supported by APCO, the National Packaging Targets 2025, major retailers and plastics suppliers.

Shift to plastic alternatives and compostable plastics

In line with the waste hierarchy priority of plastic avoidance, there are evident efforts of process and product rethink and redesign, such as bring-your-own or deposit scheme containers for meat counter services. The availability of compostable packaging options is also rapidly increasing, including compostable (biomass/non-petrochemical) plastics. For example, recent MLA-funded trials of plastic free meat trays and film made from upcycled food waste showed strong consumer approval and manufacturer interest. MLA also recently completed research into identifying the retail packaging materials at risk in the Australian market and providing an unbiased baseline evaluation to support innovation and progression towards the future of sustainable meat packaging (MLA, 2023). A key finding was that there has been good progress towards achieving APCO sustainability guidelines for red meat retail packaging. Alternatively, a recent review of sustainable red meat packaging stated that “complete elimination of non-compostable plastics in red-meat retail packaging appears not yet feasible under the current consumption model which requires a robust shelf-life performance”, such as Australian products going to the EU and US markets.

The pathway of compostable/biodegradable polymers provides an alternative where plastic that does end up in composting facilities or landfill can breakdown into ideally water and carbon dioxide and not bear a burden of unreacted petroleum-based plastic that can last in landfills for up to decades. The ability to have these composting facilities enhanced for faster degradation can be achieved through control of the aerobic and anaerobic atmosphere of the compost. Temperature settings are also essential. An example of a collection of plastic types, biodegradability and composting temperature and conditions has been reviewed (Idris et al. 2023). An unfortunate side effect of long-term inert polymers that sit in landfills or worse become fugitive in the environment is that they can breakdown to become troublesome micro plastics. And the harmful challenges of micro plastics are still being discovered and studied to this day (Shilpa et al. 2022)

Compostable/biodegradable polymers are made from natural often plant, animal or insect-based sources. They include but are not limited to biopolymers such as polysaccharides (for example, starch, chitin, cellulose, lignin), proteins (for example gelatin, soy proteins) and fatty acids (Polyhydroxyalkanoates) are probably the most well-known of this class). However the manufacturing of these plastics at commercial scales and in quantitates for large scale packaging manufacturing is challenging and economically deficient at present. Interestingly, a possible path forward to ensure the properties of these types of polymers are compatible with the area of packaging lies in the field of bio

nanocomposites where natural polymers are blended with inorganic substances that enhance properties such as clarity, UV resistance and gas barrier effects. (Zhang et al. 2023).

A further improvement to degradable food packaging incorporates starch-gelatine blend films that demonstrate enhanced food preservation and film performance properties. This is achieved through addition of cross linkers, plasticizers and nanoparticles.

Focus on plastic content, types and circularity

Where the continuing use of plastics remains necessary for now, design changes may achieve a reduction in retail plastic content. For example, material savings in plastic content of meat trays has been achieved through refining the ribbed design of the tray base to achieve strength despite thinner material. Other retail plastic-saving design strategies include vacuum skin packed (VSP) on-board retail-ready packaging of meat. This approach has achieved substantial savings in the amount of retail level plastics used in packaging and though fairly new to Australia, has been widely adopted in some European countries.

For the continued use of plastic to be sustainable, however, a well-functioning system is required to recover and recycle the plastics still in circulation. In Australia, efforts to develop this capacity are underway but at present, remain highly limited. The choice of plastic types and clear identification thereof play an important element in facilitating recovery and improved circularity. There is a growing push for mono plastics packaging – packaging that is made of a single type of plastic (as opposed to mixed plastics whereby a lid may be made of different material from the bottle it seals; or a plastic film may be made of different material from the meat-tray it covers; or a film may contain layers of different types of plastics). Mono plastics simplify material recovery both in the collection and recycling phase. Combined with detailed labelling such as supported by ALR and PREP (see earlier), mono plastics are seen to improve waste separation and recovery. On the other hand, facility or wholesale-level plastics are currently made from mixed plastics to provide strength and toughness that makes them fit for purpose.

There is also a trend towards preferred plastic types, with some outright banned. For example, multi-material laminate soft plastics, opaque or coloured polyethylene terephthalate (PET), expanded polystyrene (EPS) and rigid polyvinyl chloride (PVC) packaging has already been identified by APCO as problematic and unnecessary and, therefore is likely to be subject to restrictions in the near future. This has been recognised by some plastic suppliers/manufacturers for the red-meat processing industry. These suppliers are in the process of adjusting their products and phasing out certain materials.

Recycled content plastics are another important element to plastics circularity that relies upon the whole supply chain for success. Targets in Australia, as well as in the EU, South Korea and Japan all stipulate increasing recycled plastics content in plastic packaging. This is an essential component towards true circularity and has been successfully achieved in PET drink bottles. It is, nonetheless, only in its infancy for other plastic packaging and there are apparent incidences of maladaptation occurring. For example, it appears that plastic trays appearing on the Australian market with reported recycled content are diverting recovered material from an otherwise closed-loop plastic-waste stream (PET bottles being made into PET bottles) and shifting it into an open waste stream (PET bottles into plastic trays into landfill and/or garden benches).

Obligations to monitor and report

With the development and implementation of waste targets, the obligation to monitor and report data relating in particular to packaging, is rapidly arising in jurisdictions around the globe. In many instances, this may require industry to develop or adapt their systems to facilitate easy capture and reporting of data such as plastic types and volumes associated with all their products and particularly packaging thereof. It is suggested that AMPC could play a key role in facilitating the efficient development and implementation of data capture and reporting amongst its members.

5.1.9 Current and anticipated challenges

There are still many challenges related to plastic waste and most current systems are far from circular. Extended producer responsibility is a key initiative to increase recycling rates, reduce collection costs and minimise littering. Bassia et al. (2020) suggest that recyclers are also a weak link in the value chain and recycling of soft plastic and mixed polyolefin is often not profitable. This weak link in the Australian plastics economy was dramatically exposed in 2022 with the suspension of the soft-plastics recovery program REDcycle.

With regards to red-meat processing, shelf-life remains one of the key challenges particularly for Australian export markets such as the US and EU. Other aspects identified in the Australian context include potential supply bottlenecks for packaging materials, as retailers are forcing a rapid pace for the transformation by including packaging requirements in their supplier contracts. Some red-meat processors have raised concerns regarding the capability and capacity of packaging suppliers to match this pace across a broader range of packaging purposes.

An arguably overrated solution to the plastics problem has been a shift to biodegradable plastics. These non-petroleum-based plastics appear to present an 'easy' technological solution that is less-reliant on behaviour-based solutions of moving away from plastics use. Recent research has highlighted that biodegradable plastics may not break down as easily into biological components as desired (Lambert and Wagner, 2017). This has led to some compostable bioplastics being banned in NSW as they break into micro- or nano-plastics. Regulatory responses such as this highlight the dynamic environment that plastic waste management currently is.

Contamination of the recovery stream is a further challenge that requires further attention. Few recyclers can currently deal with plastics contaminated by substances such as blood, fat and meat. Accordingly, plastics recycling efforts have been predominately focussed on comparatively clean and easily washable mono-plastic items such as PET drink bottles. Indeed, PET bottle recycling is where the whole supply chain has helped realise the potential for true circularity (PET bottles recycled into new PET bottles). With tight timelines for achieving 'recycled content' targets, examples of mal-adaptation are starting to occur whereby recovered PET is diverted from an otherwise circular process to be used in recycled-content food packaging for which recovery streams are not yet circular. This is not a desirable response and should be avoided.

A further source of plastic contamination is the labelling, with potential use of toxic inks continuing in product labelling practices, leading to toxin accumulation in the recovered plastic waste, leading to recycled plastic that is unsuitable for food-based applications. Work on food packaging is making progress on detoxifying plastic of the common toxins found and is on the verge of producing food contactable recyclate again (Kapinga & Chung, 2020). Currently, plastic is classified in terms of colour coding for recycle status: Clear is food contactable, opaque is clean but often not food contactable due to appearance only (grey is in this category also), but grey is starting to be acceptable as packaging with labels bearing the colours of the manufacturer's brands. Finally, black plastic is considered non-food contact as it has been in contact with toxins or has had the potential to be in contact with toxins.

Overall, any amount of whole of supply chain recycling will result in an overall improvement for the red meat industry both from a landfill mitigation strategy, a moral and ethical stance on resource recirculation (including a push away from a linear resource and waste generation strategy) and finally from a client good will standpoint. This is in addition to opportunities for economic benefits and meeting increasingly tighter regulatory requirements around plastic use. Research published in 2020 calculated that a shift towards recycling all (currently) possible plastics on the planet would result in a global reduction of about 40 Mt/year of plastic (Winnie et al. 2020). This project contributes to identifying viable opportunities for the Australian red-meat industry to participate in this reduction.

5.2 Webinar and survey

To create awareness for the project a webinar entitled 'Diverting Plastic from Landfill' was facilitated by AMPC and the project team. The project team presented to 26 participants representing 13 red-meat processors and two other organisations. The webinar first addressed the context of the 2025 National Packaging Targets. It explained the concept and principles of a circular economy before introducing the research project, demonstrating the online industry survey and inviting expressions of interest in participating as detailed case study sites.

Surveys were completed for twelve facilities representing ten organisations (Appendix B). This represents 8.8% of the 135 AMPC member facilities and 9.5% of AMPC member organisations. Participants were spread across four states: New South Wales, Queensland, South Australia and Victoria. Participating operations ranged in size from 250 to 1200 staff with an average of 600 staff. Turnover at all but one facility exceeded AUD 5 million in the 2020/2021 financial year.

Ten participants reported being aware of all four National Packaging Targets, while two were aware of 'some' but not 'all'. The average of the reported percentage of plastic packaging used in operations that is reusable, recyclable or compostable at 41% was well below the target of 100%, ranging from 3% to a facility reporting 93% (Table 5.1.1). Similarly, the reported percentage of plastic packaging that is recycled or composted ranged from 0% to 90%, averaging 22% against the target of 70%. Finally, the recycled content in plastic packaging was still well below the 50% target, averaging 12% (across only 5 respondents) and ranging from 0 to 30%.

Table 5.1.1: Awareness of reusable, recyclable or compostable plastic in packaging

Item	Average	Median	Max	Min	n	2025 NPT
The percentage of plastic packaging in our operations that is reusable, recyclable or compostable is:	41%	50%	93%	3%	11	100%
The percentage of plastic packaging in our operations that is recycled or composted is:	22%	10%	90%	0%	11	70%
The recycled content in plastic packaging used in our operations is:	12%	0%	30%	0%	5	50%

Confidence of being on track to halve the 2020 volume of plastic waste going to landfill by 2030 (a KPI by AMPC), was very low, with eight respondents responding 'no' while four answered don't know. Five of the participants are current members of APCO.

When asked about the measures on plastic waste that facilities at current collected at their facility, 6 participants reported that they didn't collect any of the suggested data, while the others collect data on some measures only.

When asked about their views regarding a circular economy, participants agreed strongly that a circular economy is necessary now (Table 3). Confidence regarding the readiness of their facility, however, was considerably lower as illustrated by items two and three below, noting a strong variation in the spread across respondents (min. 2; max. 7). Respondents tended slightly to agree that barriers currently outweighed the incentives to transitioning (Table 5.1.2).

Table 5.1.2: Views on circular economy

	(1 = strongly disagree; 7 = strongly agree)				
Item	Average	Median	Max	Min	n
I think a circular economy is necessary right now	6.25	6.5	7	5	12
Our facility has a clear plan about how to transition to a circular economy	4.25	4	7	2	12
Our facility is well on track to transition to a circular economy	4.3	4	7	2	12
The barriers of transitioning towards a circular economy outweigh the incentives	4.4	4	7	3	12

Reported barriers to participation in the circular economy ranged from drivers such as technological (usable with existing infrastructure; lack of quality alternatives that meet food safety, product integrity and shelf life requirements); operational (cost; financial performance dominates decision making); and structural (lack of local recycling capabilities; availability of alternatives; cost neutral or positive recycling; country import regulations).

Reported incentives to participation in the circular economy ranged from drivers such as risk (compliance; meeting customer expectations; climate action; improving resilience; alignment with organisational goals) to cost (cost savings; waste reduction) and competitive advantage (reputation; market access) to transformation (sustainability, social responsibility, good corporate citizenship).

5.3 Site visits

Eight sites were selected for the project (Table 5.2.1), and site visits were conducted from May 2022 – September 2022. The average throughput across the sites was 59,701 tonnes HSCW of beef/veal and 38,857 tonnes HSCW of sheep/lamb representing 16.2% of the entire red meat processing sector.

Table 5.2.1 Overview of meat processor site operations

Site	State	Products	Processing	Branding/Distribution
A103	VIC	Lamb, mutton – primal, sub-primal, retail ready	Slaughter, boning, offal, rendering, value-added, cold store	Several brands, domestic retail, wholesale export
B106	NSW	Beef, veal – primal, sub-primal, retail ready	Slaughter, boning, offal, rendering, pet food, value-added, cold store	Multiple brands, wholesale domestic and export, domestic and supermarket retail
C105	NSW	Beef – primal, sub-primal	Farming and feedlot, stockyards, slaughter, boning, offal, tripe, rendering, cold store	Single brand, wholesale export
D104	NSW	Lamb, mutton – primal, sub-primal	Slaughter, boning, offal, pet food, rendering, cold store, transportation	Single brand, wholesale export
F107	QLD	Beef – primal sub primal	Slaughter, boning, offal, rendering, pet food, value-added, cold store	Multiple brands, wholesale domestic and export, domestic retail
G102	VIC	Beef, veal, lamb mutton- full carcase, primal/sub-primal cuts	Slaughter, boning, offal, rendering, pet food, cold store	Single brand, wholesale domestic and export, manufacturing
H101	QLD	Beef – primal, sub-primal, retail ready	Slaughter, boning, offal, rendering, value-added, cold store	Several brands, domestic and supermarket retail, wholesale domestic and export
I108	SA[1]	Lamb, mutton – primal, sub-primal, retail and consumer-ready	Farming and feedlot, slaughter, boning, offal, rendering, pet food, cold store	Multiple brands, wholesale, food services, butchers, B2C, wholesale domestic and export

5.4 Single-use on-site plastic application

The following single-use on-site plastic application diagrams demonstrate generic plastic applications and where they occur in the meat processing sites observed. These diagrams were constructed using field site observations, consultations with sites and existing process maps. In some cases, names have been used to describe plastic types that may differ between sites. The diagrams also indicate the three plastic mitigation streams: packaging, general

[1] Site was only able to provide limited data due to operational constraints

waste and recovery that are present in red meat processing. The following legend is provided along with the below diagrams for the slaughter room, boning and value add room, offal room and cold store.

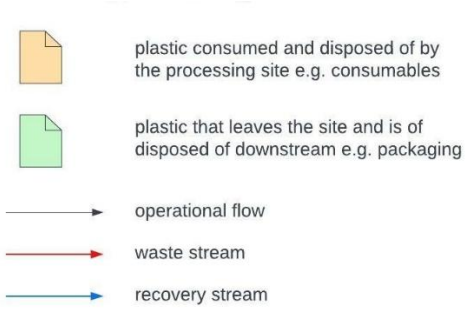


Figure 5.3.1: Plastics application legend

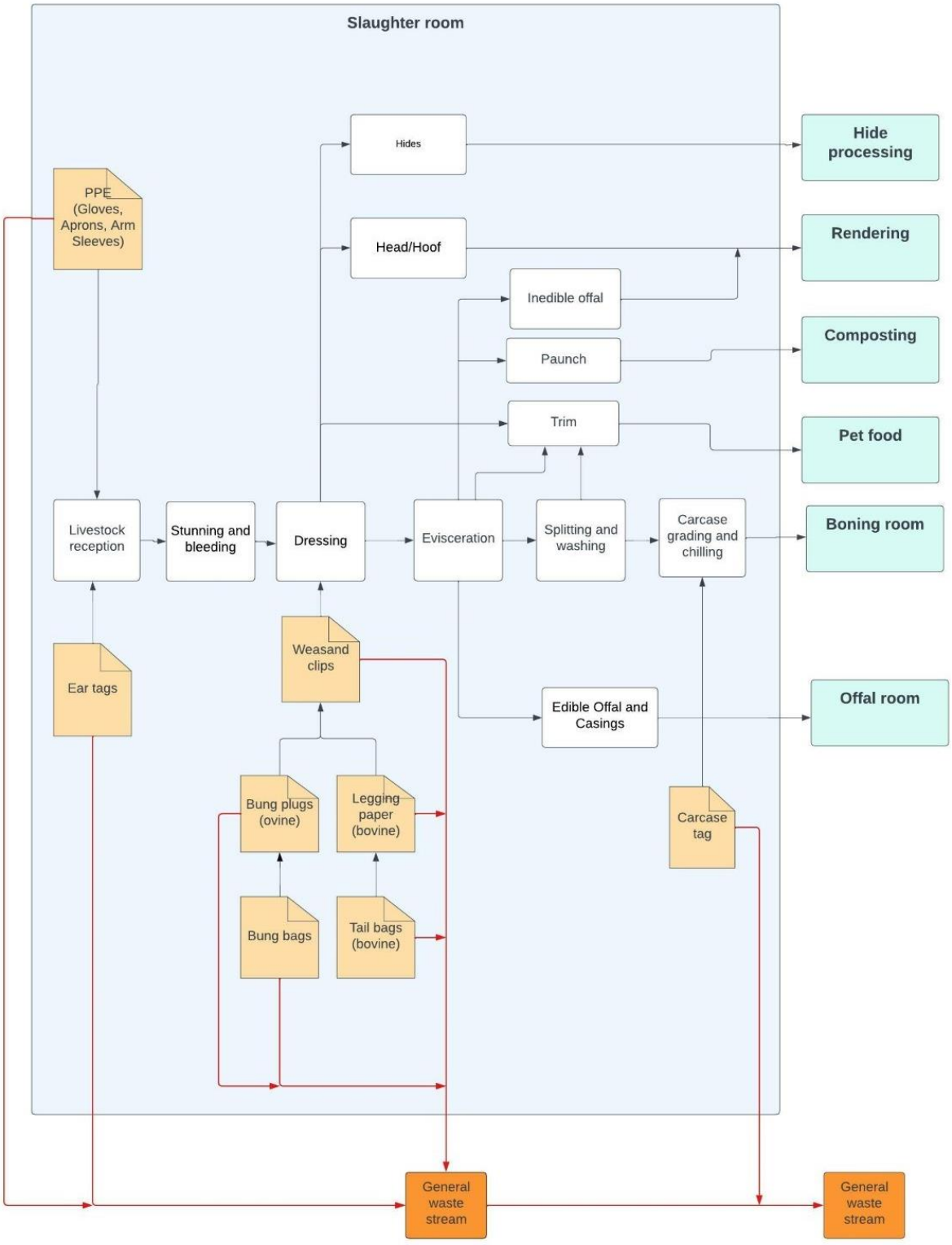


Figure 5.3.2: Plastics application – Slaughter room

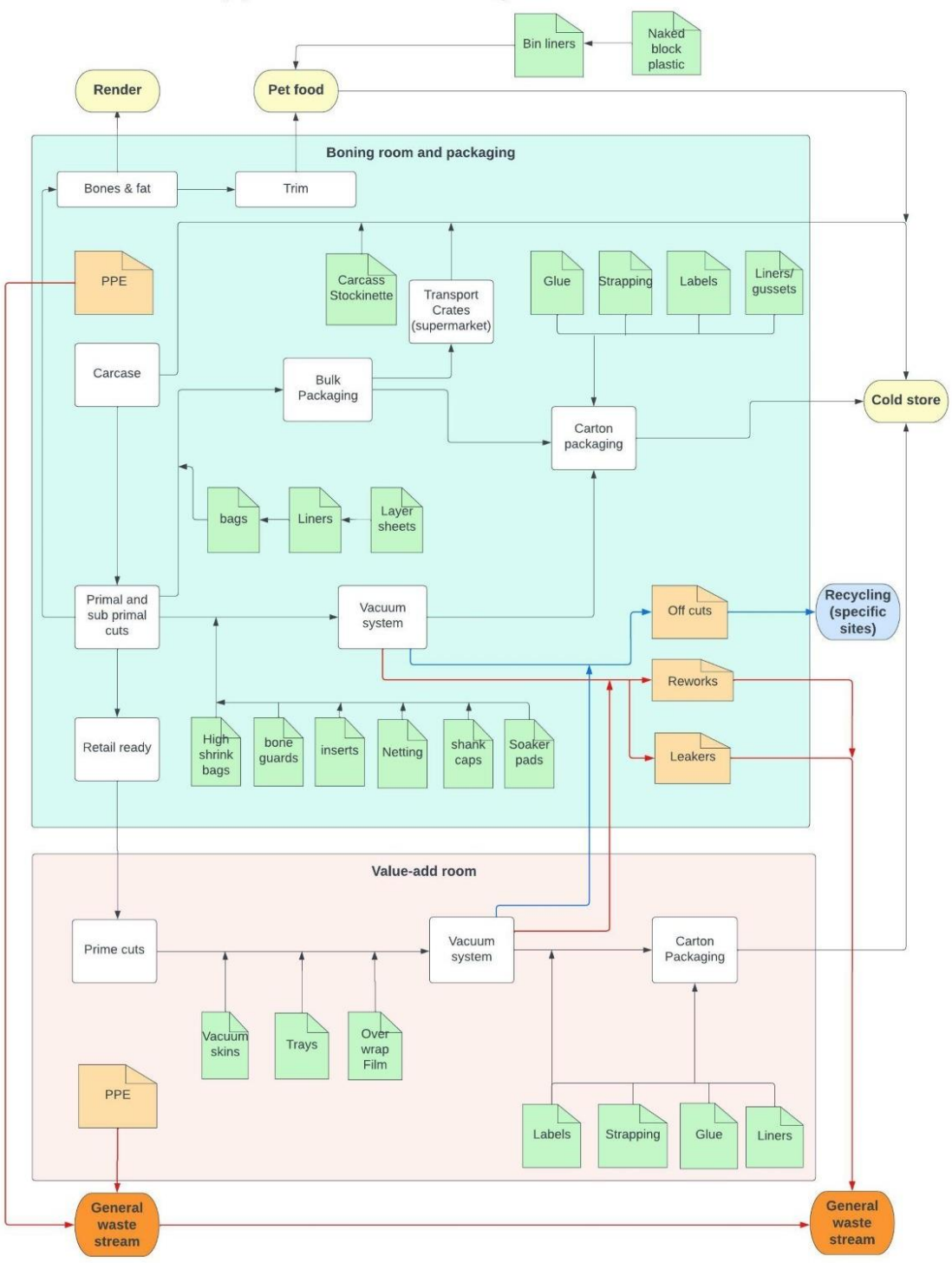


Figure 5.3.3: Plastics application – boning room and value add

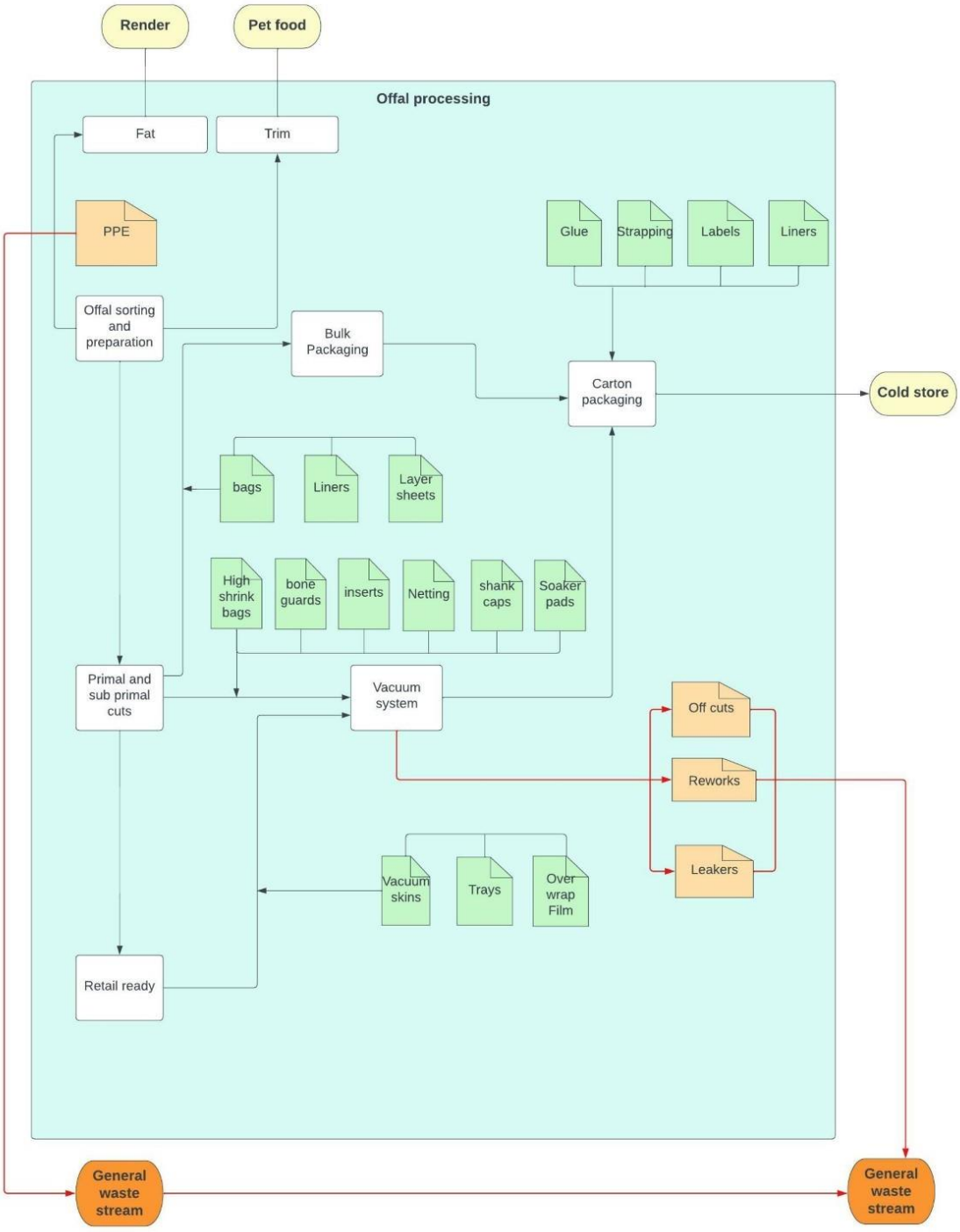


Figure 5.3.4: Plastics application – Offal processing

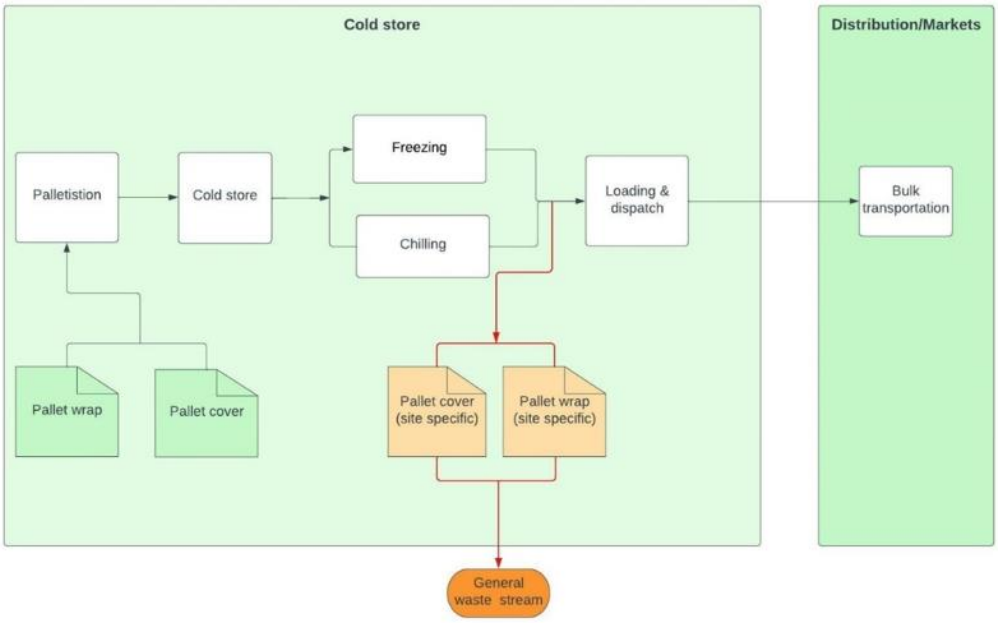


Figure 5.3.5: Plastics Application – Cold store

5.3.1 Miscellaneous single-use on-site plastic applications

Various single-use on-site plastic items are not indicated on the plastics application diagrams. However, they have a quantum volume that requires noting. In all site observations, these materials are disposed of via the general waste stream and ultimately go into landfills. These plastic items represent a cost to processing sites and the environment.

Packaging materials that transport and secure consumables and meat packaging products to processing sites:

- Pallet wrap, pallet covers and strapping, e.g., bulk cartons and packaging product
- Bags, films, layer sheets and inserts to keep packaging products and consumables from being damaged or contaminated
- Labels/stickers associated with packaging material

Site dependant applications of single-use on-site plastics used in processing:

- Waste bin liners for on-site waste collection
- Films for surfaces to preserve the meat product and prevent contamination
- Bags/liners for transferring product between rooms e.g. slaughter to offal room

5.3.2 Single-use on-site plastic application analysis

As indicated in the application diagrams, the use of plastics in Australian red meat processing is widespread. Due to food safety, work hygiene, durability, flexibility, low cost and barrier properties, plastic has become a critical resource for Australian red meat processing. This includes applications during the processing/manufacturing of meat products and when product packaging is for the market. Three plastic migration streams have been identified across the sites. These include:

Packaging stream - identifies an extensive range of packaging products destined for domestic and international markets. Except for reworks, leakers and off-cuts, these items leave the processing facility and are disposed of downstream in the supply chain by wholesalers, food services, manufacturers, retailers or consumers.

General waste stream - represents on-site plastic consumables and discarded plastic products that flow to on-site waste collection points. In most cases, these plastic items are contaminated with biomass. They may also be damaged and can no longer be used. Furthermore, there may not be any existing sorting or collection point that would enable it to be recycled. General waste is collected under contract by waste collection services and makes its way to local government landfill sites, or in the instance of paper and carboard to recycling facilities.

Recovery stream - The recovery stream diverts waste single-use plastic to recycling collection points on site. Local recycling services then collects this waste. It should be noted that this stream was observed in only two sites, where business process and waste supply chain arrangements are established. These sites were diverting high shrink vacuum bag offcuts to collection points for recovery.

From processing observations, site consultations and analysis, there may be several opportunities to explore to further divert single-use plastic away from landfills.

5.5 Plastic inventory

A wide range of single-use plastics were identified across the case study sites. Plastic on-site consumables and packaging are present across all departments and processes. There are eight application factors that drive the consumption of single-use on-site plastic across sites (Table 5.4.1).

Table 5.5.1: Single-use plastic application factors in red meat processing

Category	Application Category	Description	Items
I - CCM	Cross contamination management	Single-use plastics that provide a protective layer when processing red meat	Bung bags Bung rings Bung plugs (foam) Hindquarter slap sheets Tail bags Weasand clips Rubber bands
II - PPE	Personal protective equipment (PPE)	Plastics that provide a protective layer from human contact and harmful environmental exposure (e.g., bacteria)	Disposable aprons Disposable ponchos Disposable arm sleeves Disposable ear plugs Disposable hair net Disposable plastic gloves Disposable face masks Gum boots
III - PID	Production ID	Various plastic items that contribute to tracking and identification of beasts through process	Anti-mortem card bag Carcase number tickets Carcase tag Bags Carcase tags Ear tags
IV - SCH	Site cleaning and hygiene	Plastic containers that hold cleaning liquids or bags for collection of waste	200L plastic drums 5-20L plastic drums Bin liners/garbage bags
V – TL (in)	Transport and logistics - inbound	Various plastic packaging to enclose/protect materials as they are transported and	Disposable pallet covers/caps Carton/pallet strapping Pallet wrap

		delivered to the site by the suppliers	Shrink wrapping for storage/transport Slip sheets Cable ties
VI – TL (out)	Transport and logistics - outbound	Various plastic packaging to enclose/protect materials as they are transported from the facility to the customers	Disposable pallet covers/caps Carton/pallet strapping Pallet wrap Shrink wrapping for storage/transport Carton glue Slip sheets Cable ties Packing tape
VII - TIP	Temporary inhouse packaging/Storage	Various plastics temporarily used within the manufacturing process before further processing	Lashing Twine Films Liners/gussets/sheets Plastic tubes from rollstock Plastic bags
VIII - PP	Product packaging (B2B, B2C)	Various plastic packaging solutions to maintain food safety and shelf life as meat products are distributed within the market	Vacuum bags Heat shrink bags Loose bags Trays Pouches Lid films Box gussets/liners
IX - Rep	Leakers/Repacks	Soiled packaging waste that occurs due to faults or problems in packing.	As above
X - OC	Off-cuts	Clean packaging waste due to machinery limitations (off-cuts)	Off-cuts from shrink bags

Appendix A provides an inventory of commonly applied single-use on-site plastics in Australian red meat processing. The plastics inventory is catalogued by an image of the plastic item, its name, application factor, department where it is applied and current mitigation. Currently, 44 single-use plastic items have been included in the inventory. This consists of both on-site consumables and packaging items.

As indicated in the inventory, the common mitigation of single-use on-site plastics across sites is to general waste collection points on-site and eventually landfill managed by local councils. Packaging products are distributed to wholesale, retail and consumer markets, where it is assumed that most domestic packaging (i.e. other than recycled paper and cardboard) ends up in landfills. The exception also being that some packaging may divert to supermarket-based collection points. Site visit observations uncovered that two sites redirect vacuum bag off-cuts and some used pallet wrap to recycling services for reprocessing.

5.6 Plastics data collection and scenario validation

To quantify the problem concerning Australian red meat processing, single-use plastic data (via the plastics inventory) were classified into two main streams viz.

(1) Plastic on-site consumables used in the meat manufacturing process, and

(2) Plastic packaging used for meat products sent to the customer.

Each plastic consumable has an application point and purpose of use so that a consolidated view on plastic application can be developed by analysing the data in eight sites selected in this study. This helps to develop a common plastic

item catalogue across the industry along with a generic plastic application point in the meat manufacturing process to facilitate developing alternative strategies to divert them from land filling.

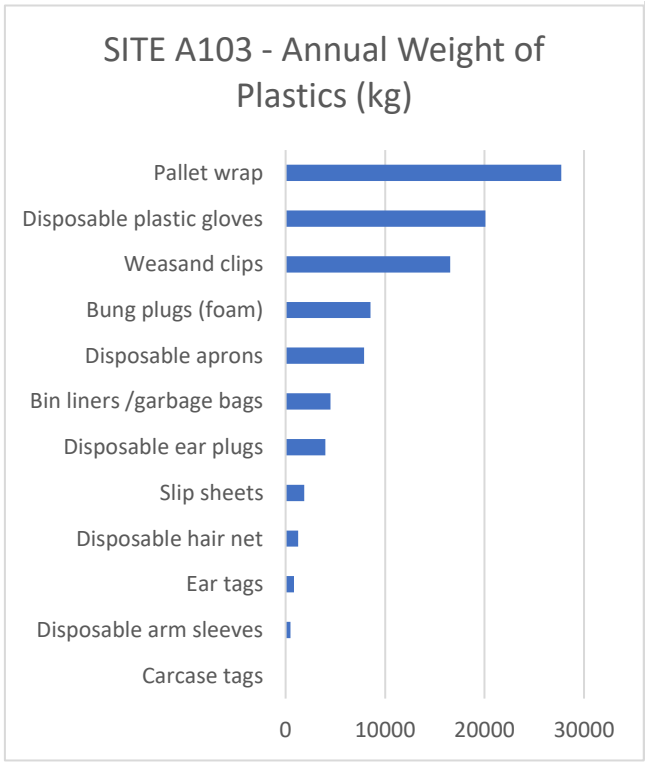
Plastic items used in packaging are more diversified compared to on-site consumables and hence are consolidated based on generic meat product categories for sense-making in developing alternative strategies to divert from land filling. Data collection from each of the eight sites considered consumables and packaging data separately (Table 5.5.1).

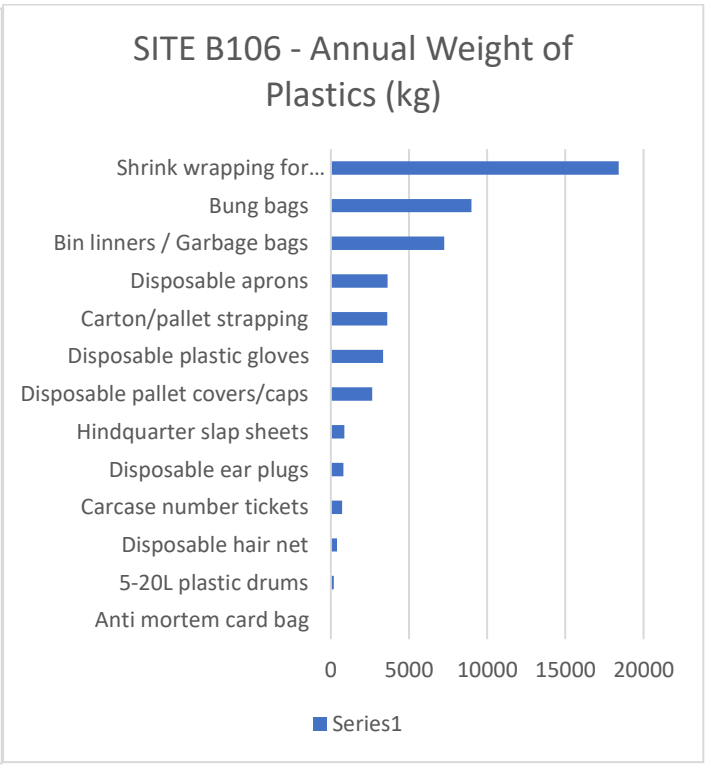
Table 5.6.1: Reported plastics volumes by site - 2021/2022

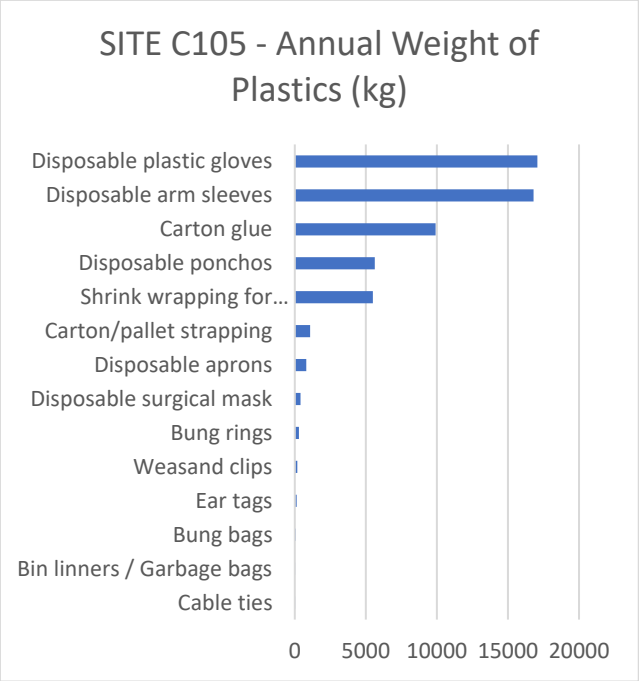
Site	Plastic on-site consumables (kg)	Plastic packaging (kg)
A103	126,002	201,884
B106	70,176	n/a
C105	52,883	173,157
D104	8,250	n/a
F107	86,389	486,434
G102	40,226	270,434
H101	91,835	285,978
Total	**475,761**	**1,042,846**

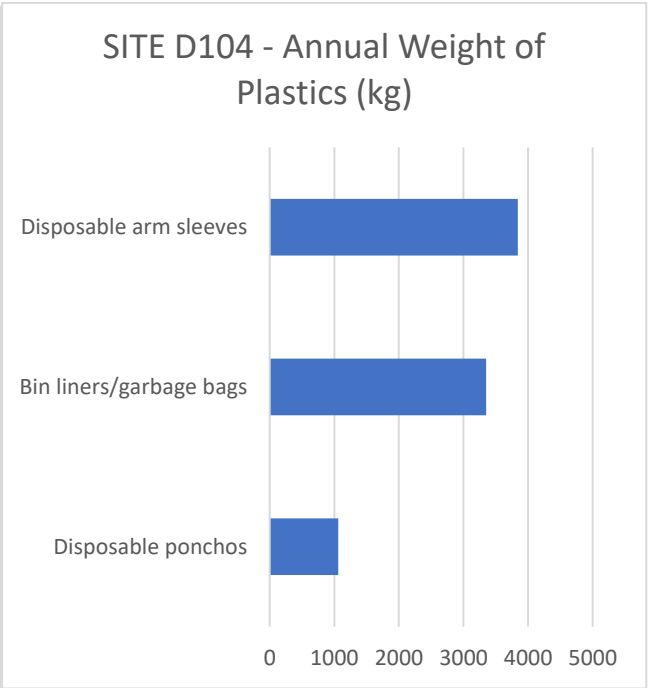
The data collection process identified several high-volume single-use on-site plastic items that were discussed in scenario validation workshops. The highest volume of plastic items (on-site consumables) varies considerably across sites (Figure 5.5.1a-h.

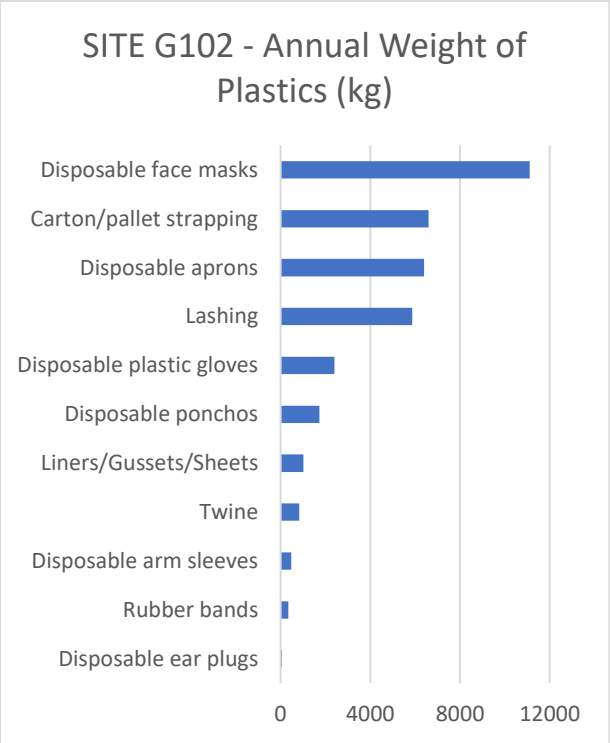
Figures 5.6.1a-d: Charts indicating high-volume plastic items per site (kg per item)

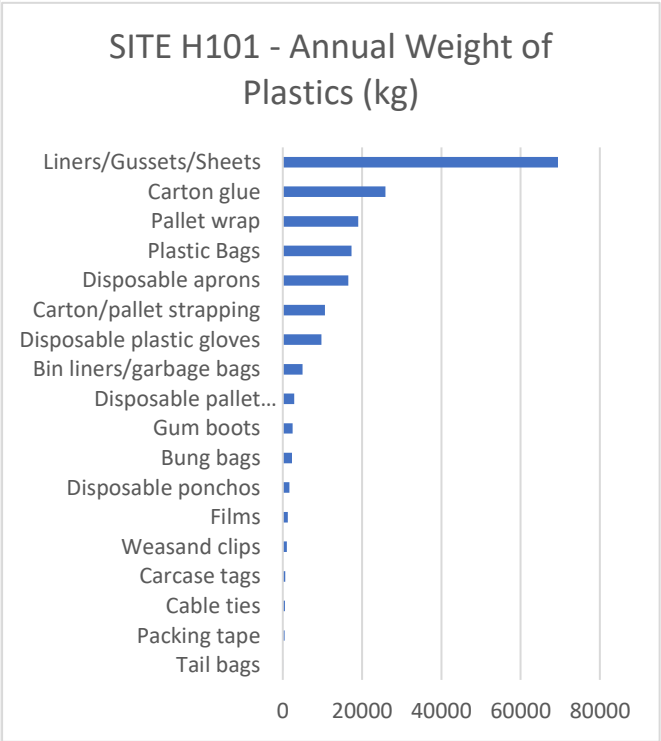





SITE C105 - Annual Weight of Plastics (kg)
Disposable plastic gloves
Disposable arm sleeves
Carton glue
Disposable ponchos
Shrink wrapping for...
Carton/pallet strapping
Disposable aprons
Disposable surgical mask
Bung rings
Weasand clips
Ear tags
Bung bags
Bin linners / Garbage bags
Cable ties
0
5000
10000
15000
20000


SITE D104 - Annual Weight of Plastics (kg)
Disposable arm sleeves
Bin liners/garbage bags
Disposable ponchos
0
1000
2000
3000
4000
5000


SITE G102 - Annual Weight of Plastics (kg)
Disposable face masks
Carton/pallet strapping
Disposable aprons
Lashing
Disposable plastic gloves
Disposable ponchos
Liners/Gussets/Sheets
Twine
Disposable arm sleeves
Rubber bands
Disposable ear plugs
0
4000
8000
12000


SITE H101 - Annual Weight of Plastics (kg)
Liners/Gussets/Sheets
Carton glue
Pallet wrap
Plastic Bags
Disposable aprons
Carton/pallet strapping
Disposable plastic gloves
Bin liners/garbage bags
Disposable pallet...
Gum boots
Bung bags
Disposable ponchos
Films
Weasand clips
Carcase tags
Cable ties
Packing tape
Tail bags
0
20000
40000
60000
80000

5.7 Scenarios for a circular economy

5.6.1 Redesign

Examples of redesign involve completing the task using a different method or tool. In the case of Pallet wrap or Carton / Pallet strapping, a redesigned process would utilise reusable Pallet Netting (Figure 5.6.1). During the consultation process with the industry members, it was identified, for example, that the use of reusable pallet netting could replace pallet wrap travelling from the factory to the port facility as approximately a 60 km round trip. This route was identified because it seemed easy to recover the pallet net to be used back at the factory again.

Figure 5.6.1 - Pallet netting being installed by an operator (Source: https://palletnets.com/)

A further example of a redesigned process would be to use self-locking cardboard boxes to do away with the need for Carton Glue. It was argued that one facility needed the glue in order to make cardboard boxes strong enough for export handling. However, another facility is currently using self-locking cardboard boxes for export successfully, therefore, doing away with the need for carton glue. Other solutions include applying tacks of glue externally to cartons to allow them to stuck together on the pallet (similar to how beer is transported). Pre-stretch pallet wrap is also an option where plastic film has been pre-stretched with some remaining elasticity, allowing it to be stretched to its limit when applied by hand or machine. This can result in around 50% less film needed both a saving to a processing site and the environment.

5.6.2 Replacement (Non-plastic item)

Non-plastic alternatives largely fall into the category of compostable/biodegradable replacement items. These polymers, designed to biodegrade in typically commercial/industrial composting facilities, enable contaminated plastic garments such as aprons and gloves to be collated and composted back to nutrients for microorganisms and plant life.

However, the biodegradable space, albeit better, is still a challenging space to determine what is compostable/biodegradable and at a rate that is compatible with current industrial systems, such as compost facilities but also usage life span within a meat handling industry, not to mention the logistical handling of this separate waste stream which would likely go into a green bin / composting organic waste stream. Most industries around Australia lack this as a main waste stream with landfill and commercial recycling mostly in use. Biodegradable/compostable examples were found for all the high-priority items above. However, the surrounding industry/post-usage handling and complete life cycle of biodegradation detail is highly illusive.

5.6.3 Replacement with Multi-use Item

Here, items were identified to replace the single-use approach for a number of the high-priority items above. Indeed, some of these are already being used, such as reusable/washable aprons and plastic gloves. There is a bacterial standard that exists as a pressure against the use of reusable. The risk of contamination and voiding of the quality of the meat bears heavily on the producers whose strict export quality measures lend themselves to single-use items with a much lower risk of cross-contamination, and furthermore, the reusable items require a rigorous, highly maintained cleaning procedure to ensure against contamination.

5.6.4 Recycled in the same or higher-value product

No progress was made on this specific category. An important end goal of recycling, especially in the goal of circularity, it is challenging in the modern day as current recycling methods lend themselves to diluting or producing lower-quality items when virgin polymers are not added. Notable exceptions are water bottles (PET) and shipping crates/pallets.

5.6.5 Recycled into lower-value products

This is largely the capture-all recycling system that exists currently with numerous industries across Australia that can accept plastic items and down-cycle or turn this into lower-grade/value products. Notable examples include park benches, fencing, furniture, construction grade plastics, crates and pallets. However, recent disruptions to this recycling supply chain, such as a halt to REDcycle operations, have proved to be troublesome, particularly for one of the industry members who revealed this during the scenario interview process. Despite not being in the spirit of circularity, perhaps identifying a number of recycling options for each industry member could re-route plastic waste from landfills and buy time to identify the higher-value recycling supply chains.

Recycling options available to industry members were largely determined by local recycling/council services available to these members. As a future action for this project, these local recycling/waste handling facilities were encouraged to be explored, as well as emerging online databases such as websites like https://businessrecycling.com.au/recycle/strapping as an example of looking into recycling options for specific items.

5.6.6 Recover as energy

An emerging area in Australia that is coupled with depolymerisation processes where similar recovery infrastructure and processes have one of the greatest potentials to provide a pathway back to recycling into the same or greater value as it enables reversal of the polymerisation process. There are organisations such as ResourceCo that provide waste-to-energy services. Refer to https://resourceco.com.au/what-we-do/energy/

The overarching variables of the *waste hierarchy*, *plastic-type* and *timeframe* provide the parameters for the exploration of scenarios ultimately at the fine-grained scale of individual plastics application points. Based on-site observations and preliminary data exchanges with participating red-meat processing facilities, a course-grained overview of the current situation (AS-IS scenario) can be provided as follows.

5.6.7 As-Is scenario (current situation)

The overarching variables of the *waste hierarchy*, *plastic type* and *timeframe* provide the parameters for the exploration of scenarios ultimately at the fine-grained scale of individual plastics application points. Based on-site observations and preliminary data exchanges with participating red-meat processing facilities, a course-grained overview of the current situation (As-Is scenario) can be provided as follows.

Waste hierarchy

Almost the entire on-site plastic waste stream from participating facilities is going to landfill (i.e., the least preferred option of Dispose under the Waste Hierarchy)

There was evidence at two participating facilities of some soft plastics (pallet wrap) being collected for Recycle *into other use.* However, it is possible that this option is currently active despite suspension of the REDcycle program since 9 November 2022.

There are no examples of initiatives to Prevent, while there is evidence that participants who recently joined APCO have started and/or have buyer-imposed packaging requirements have started engaging with processes and practices to Reduce plastics use. It is important to note there has been few options and little incentive for red-meat processors to reduce on-site plastic use and curb plastic waste production. However, the regulatory and technology landscapes are developing and will likely increasingly incentivise/reward such efforts.

Plastic type

It was observed that plastic packaging suppliers are actively working on adjusting their product catalogues to better align with the increasing focus on plastic circularity. There are efforts to remove currently identified problematic resins from their palette while seeking to maintain important product characteristics to suit intended uses (e.g., shelf-life; bone vs no-bone). There is also increasing awareness of the preference for mono-plastics over mixed and multilayer plastics due to the impact of those characteristics on material recoverability.

Contamination currently appears the biggest challenge for plastics recovery arising during the meat-processing process. It appears to be the driver for the dominant current option being disposal to landfill. The dominant application purpose being food products currently seems to severely limit the implementation of recycled content plastics.

Timeframe

This project has the potential to substantially value-add to APCO's efforts. While APCO is focussed exclusively on packaging and is providing useful tools and mechanisms for facilities to meet their rapidly evolving regulatory requirements, this project complements and extends these efforts by capturing the substantial non-packaging plastics waste stream. This will provide realistic options for immediate actions that may be implemented in the short-term.

There is evidence of developing collaborations between parties such as plastics suppliers, red-meat processors, supermarket chains, industry bodies such as MLA and AMPC and researchers on exploration of plastic avoidance and reduction efforts that may provide medium-term outcomes.

The State/Territory and Federal governments are increasingly getting involved and are implementing policy targets and timelines. This is a rapidly evolving space that involves longer-term actions related to recycling and manufacturing infrastructure.

5.6.8 To-Be scenarios (potential future situations)

Waste hierarchy

Avoidance and reduction of plastics in the process should be the foremost priority as it minimises the risk arising from failures in the highly challenged Australian plastics economy as well as the rapidly changing policy and regulatory environment in relation to plastics. The current Australian plastics ecosystem is not yet capable of full circularity for plastics associated with red-meat processing.

Plastic type

Where the use of plastics is currently unavoidable, a focus on plastics content, type and circularity will facilitate processor readiness to engage with plastic circularity as local recycling processing capacity is established with the increasing government and private-sector investment.

Timeframe

Development of detailed monitoring, reporting and evaluation capacity for plastic items along the entire process at facilities should be a priority in the short-term. Such information will allow rapid and targeted action to respond to technological innovations and regulatory changes.

Broad solutions currently

Currently there are three major scenarios for the on-site plastic waste that can be identified so far from member manufacturing facilities.

1. Clean uncontaminated hard plastic:
    - Cable ties, cardboard box strapping for example can be recycled into current post consumer recycling collection schemes
2. Clean uncontaminated soft plastic:
    - Clean LDPE pallet wrap scenario (several current options including: Cleanaway, NationwideWaste both of which operate across Australia). Contingent on finding a collection solution.
3. Contaminated plastic hard and soft
    - Currently, this waste is being landfilled in almost every practice where a site visit was conducted. However, two companies in Australia: CRDC Global and Repeat Plastics Australia Pty Ltd (Replas) can down-cycle this waste into a plastic recyclate material that can enhance infrastructure manufacturing. Resin8 and Polyrok from each of these respective companies is the result of a comingled food contaminated waste stream that then becomes a concrete aggregate substitute. Interestingly Replas claim REDcycle to be one of their collaborating partners, hence the cessation of soft plastic collection by REDcycle is yet to be realised on its effect of partner organisations such as Replas.

5.8 Circular economy strategies

In order to determine which consumable plastics require the highest priority for scenario generation and validation, sites and associated service experts validated high-volume plastic items and potential scenario pathways. Table 5.8.1 indicates high-priority items by sites, and as such, a waste scenario hierarchy was conducted to find solutions/alternatives/substitutes for the current on-site plastic usage.

Table 5.8.1: Circular scenarios for high-volume plastic items

Single-use item	Scenarios	Potential sector impact annually
Disposable aprons	Reusable aprons Compostable aprons	380.7 tonnes
Disposable plastic gloves	Biodegradable nitrile gloves	996.9 tonnes
Bin liners/garbage bags	Biodegradable options	203.7 tonnes
Pallet wrap and strapping	Reusable pallet netting system, recycling and conversion to feedstock oil.	651.3 tonnes
Disposable ponchos and arm sleeves Weasand clips	Downcycling of contaminated product	427.1 tonnes

5.7.1 Compostable products

A number of compostable and plastic-free products are entering the market that are suitable for use in food processing. These products are approved for composting, breaking down safely in landfill. Reported site data suggests that processing sites pay 10 -18 cents per unit which is sent to directly to landfill. Compostable plastic-free aprons are available at 21 cents per unit (see, for example: https://www.growise.com.au). Polymers typically used in compostable applications such as compostable aprons include: Polylactic Acid (PLA), Polybutylene Succinate (PBS), Polyhydroxyalkanoates (PHA), starch-based polymers, Polycaprolactone (PCL) and more recently a biodegradable version of PET known as (Bio-Polyethylene Terephthalate). The word compostable is broadly used and the specific physical and chemical properties of the polymer must be considered when choosing the composting environment, for example some PLAs require industrial grade composting facilities to produce the high enough temperatures for complete composting.

5.7.2 Biodegradable products

Biodegradable nitrile gloves are also made from nitrile rubber, but they are formulated to break down more easily in the environment compared to traditional nitrile gloves. The biodegradability is typically achieved by incorporating additives that accelerate the degradation process, making them less harmful to the environment over time. Regular nitrile gloves range in price from 6 – 11 cents per unit. Biodegradable options are available for 12c per unit (see for example: https://glovesnow.com/). Often the polymers suitable for a compostable product are regarded as biodegradable also. In addition to the polymers defined as compostable, cellulose acetate is also capable of behaving as a biodegradable polymer.

5.7.3 Reusable Products

Reusable products generally require the implementation of a closed-loop system that can be costly and resource intensive. For example, the use of reusable pallet netting and strapping that is transported offsite requires a collection and return system. e.g. Green Spider, Max Pack or Cary Company. An effective alternative is the giant rubber bands

by Aero Rubber. Both netting and strapping need to be manually installed but handling time is comparable to pallet wrap application. The existing investment in automated pallet wrapping machinery may lead to a loss in appetite towards this change for reuse.

Reusable aprons are is used throughout the food processing sector and were indicated to be in use in all but one of the case study sites. While damaged or used aprons require disposal, these PVC-based materials tend to extend the lifecycle of an apron to over 12 months. Furthermore, there are options for recycling PVC material in Australia.

5.7.4 Recycling/downcycling of single-use plastic

Mechanical recycling of clean and uncontaminated products such as pallet wrap is highly possible in Australia with a number of re-processors situated throughout more populated metropolitan and more populated regional areas. There also now exists a potential pathway to chemical recycling of clean and uncontaminated plastics since the VIVA Energy Geelong-based refinery is coming online (VIVA, 2023). This facility will be able to turn plastics into feedstock oil that can act as virgin material for new plastic. Recycling of highly contaminated products in Australia is severely limited and generally prohibited from collection services due to a need for an effective cleaning system. As such, this waste is sent to prescribed landfill. Downcycling is the best option for contaminated products but is still in the testing phase. The downcycling of contaminated products into aggregate made from mixed plastic waste is possible, e.g. Resin8 (CRDC product). This has the potential to eliminate large quantities of single-use plastics from landfill including gloves, arm sleeves, ponchos, aprons, masks, beard covers and hair nets.

5.7.5 Current recycling efforts by case study sites

Two sites demonstrated progress in developing plastic waste recovery streams. In both cases, off-cuts from vacuum shrink bags are directed to external bins that are collected by waste recovery services. Vacuum shrink bags typically contain PVDC and EVOH barriers, making them difficult to recycle. However, in most cases, lower volumes of barrier material can be used (e.g. <10%) in the mechanical recycling process alongside other plastic waste and virgin material to downcycle into garbage bags and bin liners. Offcut recycling form these two sites divert a total of 52.1 tonnes from landfill. One of the sites also reported the collection used pallet wrap (20.2 tonnes) by local waste recovery services. This pallet wrap is consumed on-site to secure pallets in cold storage. The pallet wrap is removed before transportation.

Five sites reported vacuum shrink bag off-cut volumes (Table 5.7.1). The total reported off-cuts volume was 79.1t. The total potential across the red meat processing sector for recycling offcuts is estimated at 715 tonnes.

Table 5.7.5: Reported volumes of offcuts per site

Site	Offcuts (kg)
G102	4,410
A103	32,240
B106	19,340
C105	3,247
F107	19,775
Total	**79,012**

5.9 Indicators for plastic use

From the site data reported, it was possible to prepare preliminary indicators of plastic consumption for meat processing (Table 5.8.1).

Table 5.9.1: Mass Indicators for plastic consumption and packaging based on reported data

Indicator	Beef	Sheep/Lamb
Plastic (on-site consumables) per HSCW* (Kg)	1.4 g	2.5 g
Plastic (on-site consumables) per Head	322.5 g	61.1 g
Plastic packaging per HSCW (kg)	4.4 g	9.9 g
Plastic packaging per Head	1167.5 g	235 g

*Hot Standard Carcase Weight

As indicated above these results are derived from baseline data reported from the case study sites. Therefore, indicators may vary based on operational model, supplier arrangements and market destinations.

6. Discussion

Plastic has proven to be an extremely valuable resource for the Australian red meat industry for on-site processing and packaging. When it reaches its end-of-life, plastic has proven to be harmful to the environment, leading governments, industries, advocacy groups and research organisations worldwide to step up efforts to reduce its impact on our ecological systems. All three levels of government in Australia have moved to implement circular economy policies and initiatives to address plastics in the coming years. Evidence of a circular plastics ecosystem is already appearing across city and regional centres. Biodegradable and compostable products are gaining traction in the marketplace, closed-loop systems for reusable products are being trialled, mechanical recycling for clean plastic waste has been established, downcycling of clean and part-contaminated plastics is in extension phases, and development into chemical recycling capacity is gaining ground. Regulation around sustainable packaging is having positive impacts in retail markets, with many red meat brand owners working with packaging suppliers and retailers to meet the 2025 national targets. The circular plastics ecosystem is still in its early stages holistically, displaying market fragility and a lack of clarity within the waste value chain. For example, it is difficult to trace the lifecycle of some used plastics and the involvement of the various actors as waste is transferred from collection and recovery through to recycling. Furthermore as new ventures (e.g. collection schemes) seek investment, it is challenging to understand the viability of their circular strategies. Unfortunately, a few suppliers are engaged in deceptive marketing practices (i.e., greenwashing) in relation to the claims made about the circularity or sustainability of their products. Unfortunately, it is sometimes difficult for customers or users to discern for themselves. Terms such as biodegradable, compostable and recyclable without clear details are misleading as are packaging or marketing materials containing green imagery (e.g., images of nature, use of green colours) or vague terms (e.g., eco-friendly or natural).

The diversion of single-use on-site plastic away from landfill is a complex and challenging problem for Australian red meat processors. A significant number and volume of single-use on-site plastics are used in the sector, and much of the focus on plastic has been on post-consumer waste and packaging as opposed to post-industrial waste. Single-use on-site plastic items range in their application use, volumes, constituency and final condition (i.e. contamination) once they have been consumed. In 2021/2022, the selected sites reported 475.8 tonnes of on-site single-use plastic consumables sent to landfills. This suggests that the sector may be contributing 4511.6 tonnes of onsite plastic to landfill each year[2] (i.e. ~0.20% of national plastics to landfill p.a.). The most significant on-site contribution comes from eight items. Disposable aprons, gloves and arm sleeves, pallet wrap and strapping, bin liners, garbage bags and weasand clips accounting for 59.9% of sectoral onsite plastic waste to landfill.

This project also uncovered disincentives to sustainable plastic solutions in Australia that are based on “end of life” issues. For example, the red meat industry supply chain is a complex and widely geographically disbursed group of businesses, which makes transportation a major disincentive to recycling where long distances and complex collection systems are offered for the treatment of relatively small volumes of on-site plastic waste. In some cases, sending on-site plastic waste to landfill may be the smallest emissions footprint available to processors. While this is discouraging it does not preclude red meat processors and plastics product suppliers from addressing the long term impacts of plastic waste to landfill.

Like many industries, red meat processors are reliant of plastic products across their processes. The 44 items on the plastics inventory demonstrate a large complexity in solving the single-use on-site plastics issue. The volumes and the range of polymer types and application points demonstrate how entrenched single-use plastics are in red meat processing. In effect, plastics have become essential for ensuring production quality, and it therefore becomes enormously challenging to disentangle production processes from their essential application. Unfortunately, the options are also limited when considering technological and economic variables. The industry will be required to discover and invest in new products and processes to meet sustainability objectives. Initial engagement with AMPC

[2] Calculated using a multiplier that based on reported site data.

members through the webinar and survey indicated a strong awareness of the circular economy and sustainability principles. Many have recognised the advantage of becoming APCO members and reporting through one co-regulated point rather than separate state-based EPAs. This will support progress toward the 2025 National Packaging Targete and also help brand owners build knowledge on plastic product varieties, use and disposal. Site visits were revealing for service experts as observers noted plastic types and application points throughout the operations. There was a strong acknowledgement by processing sites of the large qualities of plastic being placed in general waste streams and the opportunity to investigate alternative products and processes. For example, all sites have a degree of capacity to sort clean, uncontaminated plastics for immediate recycling. These processes can be resource intensive and depended on volumes and the availability of recovery services within the region.

Several single-use plastics in meat processing could be substituted with biodegradable, compostable or recyclable options, e.g., aprons and gloves. Competitive single-use plastic alternatives are starting to appear in the marketplace. These developments will pressure red meat processors' operating costs in the short to medium term. However, they will see gains in the long term as products become more competitive with existing unsustainable offerings. Biodegradable products are part of the arsenal when it comes to circular strategies. However, these products generally end up in landfills and do not generally reduce waste. Furthermore, no standards determine biodegradability (i.e., the rate of decomposition), and the additives used to create biodegradable options can often leave toxic residue and microplastics behind. Compostable products that meet AS 4736-2006[3] provide a compelling case for the red meat processing industry. Contaminated plastic products can potentially make their way to commercial composting or soil-enhancing facilities. Industrial composting facilities are able to process organic waste at high temperatures (50°C or higher), thus accelerating the rate at which the waste decomposes. Red meat processing sites either operate their own composters or have established relationships with commercial services. Therefore, sending contaminated compostable plastic products with other organic waste is potentially feasible. Compostable products are generally considered of greater benefit to the environment than biodegradable products, so this could hold great promise for contaminated on-site material.

Innovation in sustainable packaging for retail is quite advanced, and all sites reported working with packaging suppliers to work towards the National Packaging Targets. A large quantum of packaging material is non-recyclable or requires chemical recycling. Furthermore, products must contain recycled material as a constituency to achieve the packaging targets. Therefore, packaging must include not only recyclable material but also be able to be recycled again, i.e. implementing circular principles. A significant boost to this capability will be the progress of chemical recycling, of which Australia has limited infrastructure. For example, options for the recycling of thermoform plastics are inadequate. Meat processing brand owners are positioned to work with packaging suppliers to remain compliant and operate or meet the objectives of domestic wholesalers, retailers and international trade partners.

The plastics collection, sorting and recycling services network is limited in Australia. The recycling of materials also requires available collection and recycling services. Recycling or collection organisations are not prolific, and meat processing sites may be inhibited by their region's lack of recycling services, the high contamination of their waste product and the diversity of plastic types being used. The lack of capacity for sites to collect and sort their plastic waste and the lack of available local waste recovery services present significant challenges. Moreover, there are the high costs of transportation and, ironically, the need for high volumes of specific polymer types to generate enough scale to sustain the value stream. Collection schemes can be quite selective about what polymer types they accept. Clean and uncontaminated PET, LDPE or HDPE is the minimum standard. As indicated in Figure 6.1, some regions might present as an opportunity. Most capital cities have reprocessing and recycling services available, with enough economies of scale to sustain collection services. Other regional areas (e.g. central and mid-west Victoria) may also potentially have enough existing infrastructure to create a sustainable waste recovery supply chain. At present, several organisations are investing in recycling technology. The most significant of these is the Cleanaway recycling plant in

[3] In Australia, for a plastic material to be certified as commercially compostable, it must comply with the AS 4736-2006 standard

Albury-Wodonga. The success of this facility is in recycling polyethylene Terephthalate (PET), although PET is not a resin of most packaging or consumables in meat processing. Viva Energy is building infrastructure to enable it's Geelong refinery to process feedstock oil made from waste plastics to create new PP products. Several smaller regional-based services are developing recycling capacity in HDPE, LDPE and PVC. The meat processing sector could consider developing downstream linkages within the plastics supply chain between meat processors, waste collection services and recyclers. Importantly this could be achieved for clean, uncontaminated plastics but potentially for the diversion of contaminated and problematic plastics through chemical recycling. Furthermore, forming relationships with other industries co-located within regions is possible. For example, Dairy Australia is currently investigating recycling plastic silo (heavy HDPE material) waste in South-West Victoria (Dairy Australia, n.d.). This project is not currently amassing enough volume that support targeted recycling infrastructure therefore industries that accumulate similar HDPE waste could contribute to larger volumes and create more viable services.

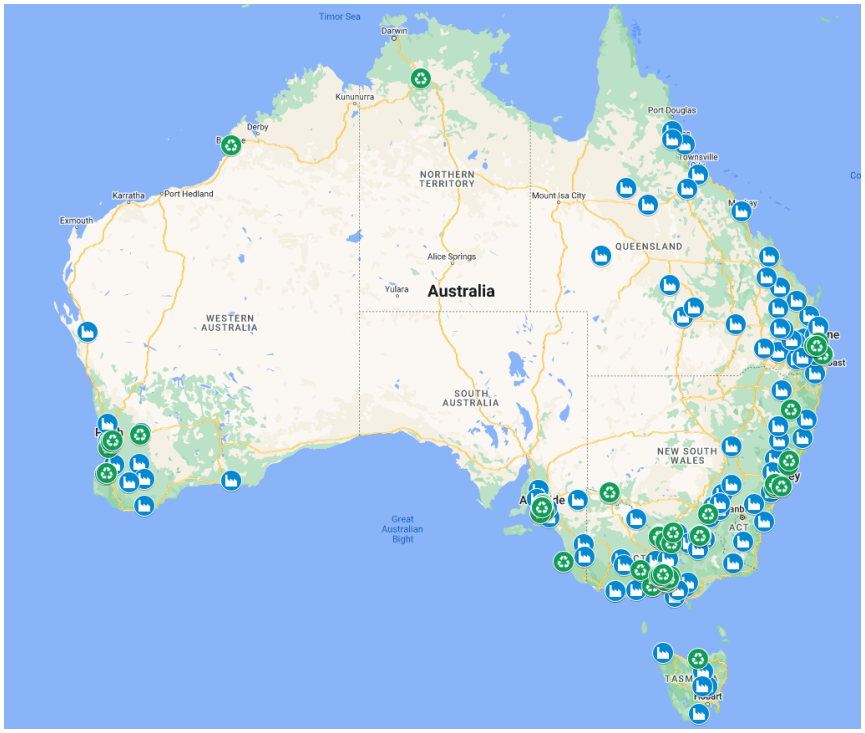


Figure 6.1: Map of meat processing facilities and plastic resource recovery services

Overall, the project results demonstrate a strong awareness by meat processors about the environmental impact of plastics. Furthermore, there is a willingness to act, particularly on more immediate sustainable packaging targets. For the diversion of on-site plastic products away from landfill, the options are limited. Due to their polymer types and application, each plastic product can require a separate strategy. The uptake of compostable products is a promising strategy for greater diversion from landfill, especially if they can be diverted to commercial composting or soil enhancers via the organic waste stream. Reusable, closed-loop systems can also be important solutions for keeping products in circulation longer. Recycling appears problematic as waste material is often far too contaminated and, therefore, unacceptable to current reprocessors. Downcycling appears to be the most likely future scenario here. However, research is ongoing in this space.

The readiness of meat processors to implement circular economy strategies is in the early stages. Certainly, activity has ramped up around sustainable packaging, but most other plastics are currently sent to landfill. Participant sites reported that information systems and resources constrained appropriate data gathering. Furthermore, plastic was not 'front of mind' when developing sustainability objectives. As state-based EPAs turn their attention to plastics going to landfills over the coming years, post-industrial plastic waste will be a significant priority. Red meat processors now have an opportunity to develop the capacity to implement diversion strategies.

7. Conclusions / Recommendations

This has been an extremely timely project for Australian red meat processors, not only because of compliance pressures for retail packaging but because plastics production and consumption are a significant global issue. The pathway to plastics circularity is complex and challenging. In reality, it will take years to achieve sustainability goals and will require diverse and collaborative actions by multiple stakeholders within the supply chain. There is evidence that red meat processors who choose to implement circular economy strategies can already make short-term gains, with the red meat supply chain development of sustainable plastic packaging retail solutions making good progress. This project makes recommendations and provides examples across strategic and operational levels to combat the growing challenges of on-site single-use plastic in the Australian red meat processing industry.

7.1 Red meat processing organisation and sites to develop a circular roadmap for plastics using the waste hierarchy principles.

This overarching recommendation ensures that organisations and processing sites place a particular focus on single-use plastics being used across their operations. Therefore, as a part of broader sustainability strategies (i.e. ESG), read meat processing organisations and processing sites should clearly identify objectives that aim to divert single-use on-site plastics away from landfills. They should then seek to minimise plastic use throughout their operation through redesign, reduction strategies, and reuse systems. Furthermore, sites should identify priority plastic items for focussed waste-reduction and/or recovery strategies, developing targets and KPIs that measure the results of circular actions. A systems approach is recommended that applies the waste management hierarchy across all aspects of the operation, prioritising waste avoidance over waste recovery, and where the use of plastic items remains necessary, co-develop a circular roadmap to facilitate supply chain material recovery, ensuring adherence to government / regulatory body targets and guidelines.

7.2 Conduct baseline audits of single-use plastic consumption and target high-volume plastic with key diversion strategies.

Processing sites can take the practical step to conduct a baseline audit of all single-use plastics being used in their facilities. As part of the sustainability focus, sites can utilise service experts, inventory and supply data to identify single-use on-site plastics and their applications. The plastics inventory (Appendix A) can be used as a resource to identify plastics and develop a site-specific inventory. This will identify high-volume or high-priority items that can be analysed against the waste hierarchy, leading to circular strategies to divert plastics away from landfill. It should also develop a thorough understanding of what plastics are being applied and the accompanying decision rules or policies for their application (e.g. cost, export regulation, hygiene standards, convenience, and application history). Where plastics remain essential, processing sites should seek simplicity and circularity (e.g. clear mono-plastics) and help facilitate waste capture and reuse/recycling.

7.3 Engage with plastic producers, manufacturers and suppliers to explore alternative solutions such as reusable, compostable, recycled and recyclable products.

Like many industries, Australian red meat processors are engaged in long and complex value chains. Plastic ensures the quality and safety of meat processing and product packaging. It is, therefore, necessary to engage more deeply with supply chains to solve the plastics problem and understand the lifecycle of each plastic product in use. Red meat processors have the opportunity to collaborate with a range of stakeholders to enable the ongoing investment in technology, systems and processes that will drive a circular economy. It is recommended that meat processors

investigate and actively scan the product landscape for alternatives to current plastic applications (i.e. examples provided in this report). Engage with plastic producers, manufacturers, suppliers, and waste collectors to explore alternative solutions and new technologies such as reusable, compostable, recycled and recyclable products.

7.4 Collaborate with co-located industries, waste services and re-processors to develop waste recovery streams in regional areas and take advantage of clustering and scale/volume.

Many industries face exactly the same challenges when it comes to single-use plastic. There are opportunities for processing sites to collaborate across sectors to strengthen waste recovery streams for recycling and composting. This is especially pertinent for regionally located sites with limited waste recovery infrastructure. Meat processors can develop their knowledge of plastic waste recovery streams within their regions. This includes collection services and recycling options, understanding what plastic waste (type and volumes needed) is in demand and whether cooperative approaches with other organisations might support a stronger ecosystem.

7.5 Develop sufficient systems to capture internal plastics data and put targets in place that align with evolving government policy, regulations and targets.

To develop circular strategies, sites need access to data. Red meat processing organisations should invest in information systems that allow them to easily capture single-use on-site plastics data. This will support the development of strategies and reachable targets for improvement. It will also provide data that can be more readily supplied to government regulators. Sites should seek to establish efficient data reporting mechanisms that facilitate ongoing monitoring across the application of on-site plastic items, their amounts used and current costs involved. This would also enable the capacity to quickly model changes: i.e., knowing the comprehensive cost of the current approach (e.g., cost of plastic item, amount used, cost of disposal) to calculate the cost-benefit of the alternative approach quickly. In short, be shovel-ready to test whatever changes/opportunities arise.

7.6 Continue to invest in sustainable packaging and monitor the regulatory environment

Good progress has been made across supply chain solutions for sustainable packaging at the retail level (i.e. examples provided in this report). This final recommendation signals brand owners to continue the work to adopt sustainable packaging strategies. Red meat processing brand owners have a responsibility to monitor policy development for sustainable packaging and take urgent action to ensure compliance with regulatory requirements. This project encourages brand owners to consider participating in the enabling work by APCO, as it is vital to determine if and how brand owners report and act in this co-regulated space for used packaging materials. For example, sites that choose to become members of APCO can report directly to them as opposed to individual state-based EPAs. APCO also provide a large volume of resources to support building knowledge for action and establishing reporting.

7.7 Limitations of the Study

Limitations to the study must be acknowledged. Eight case study sites participated in the study. However, due to operational and time constraints, not all sites were able to complete every data collection and validation phase. It is also recognised that the eight selected case study sites might not be an exact representation of the sector. Indeed, all sites were classified as medium to large and, therefore, not necessarily representative of small red meat processing. However, enough coverage across locations, operating and distribution models was achieved. Case study sites were

responsible for self-reporting, and it was discovered that reporting systems were, at times very limited. This may have resulted in some inaccuracies in the reporting of data or data gaps. For example, case study sites found extracting information on plastic item volumes, weights, and waste management data difficult. Therefore, there was inconsistency in reporting against the plastics inventory where a site was unable to obtain data on individual on-site plastic items. This may have resulted in missing data points and some under reporting. Each site's contribution is warmly appreciated, and all data and consultation supplied benefited the project overall.

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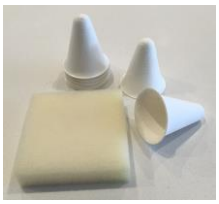
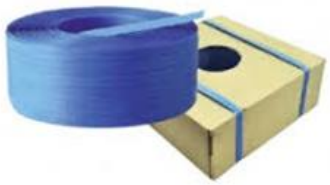
9. Appendices

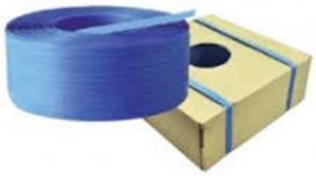
Appendix A – Plastics Inventory

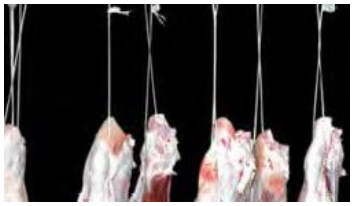
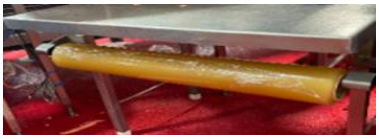
Cat	Application Category	Plastic Item	Image	Packaging type (Soft/Rigid)	Plastic Types
I - CCM	Cross-contamination management	Bung bags		soft	High Density Polyethylene (HPDE)
I - CCM	Cross-contamination management	Bung rings		n/a	Natural latex
I - CCM	Cross-contamination management	Bung plug (foam)		n/a	Other Plastics
I - CCM	Cross-contamination management	Hindquarter slap sheets	 	soft	High Density Polyethylene (HPDE)
I - CCM	Cross-contamination management	Tail bags		soft	High Density Polyethylene (HPDE) Low Density Polyethylene (LDPE)
I - CCM	Cross-contamination management	Weasand clips		rigid	Polypropylene (PP)

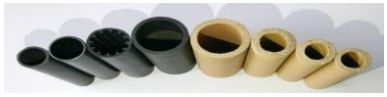
I - CCM	Cross-contamination management	Rubber bands		soft	Other Plastics
II - PPE	Personal protective equipment	Disposable aprons		soft	Low-Density Polyethylene (LDPE)
II - PPE	Personal protective equipment	Disposable ponchos		soft	Low-Density Polyethylene (LDPE)
II - PPE	Personal protective equipment	Disposable arm sleeves		soft hard	Low-Density Polyethylene (LDPE) Polyvinyl Chloride (PVC)
II - PPE	Personal protective equipment	Disposable ear plugs		soft	Polyvinyl Chloride (PVC)
II - PPE	Personal protective equipment	Disposable hair net		soft	Polypropylene (PP)
II - PPE	Personal protective equipment	Disposable beard covers		soft	Polypropylene (PP)

II - PPE	Personal protective equipment	Disposable plastic gloves		soft	Other Plastics
II - PPE	Personal protective equipment	Disposable face masks	 		PP, PE, PS, polyurethane, polyacrylonitrile, polycarbonate, or polyester
II - PPE	Personal protective equipment	Gum boots			PE / PVC/ PU
III - PID	Production ID	Anti-mortem card bag		soft hard	Polyethylene Terephthalate (PET)
III - PID	Production ID	Carcase number tickets			Polyethylene Terephthalate (PET)
III - PID	Production ID	Carcase tag Bags	No image available		Polyethylene Terephthalate (PET)
III - PID	Production ID	Carcase tags		soft hard	Polyethylene Terephthalate (PET)
III - PID	Production ID	Ear tags	 	rigid	Other Plastics

IV - SCH	Site cleaning & hygiene	Chemical drums		rigid	High Density Polyethylene (HPDE)
IV - SCH	Site cleaning & hygiene	Bin liners/garbage bags	 	soft	Low-Density Polyethylene (LDPE)
IV - SCH	Site cleaning & hygiene; Production waste	5-20L plastic drums		rigid	High Density Polyethylene (HPDE)
V - TL(in)	Transport & logistics (inbound)	Disposable pallet covers/caps	 	soft	Low-Density Polyethylene (LDPE)
V - TL(in)	Transport & logistics (inbound)	Carton/pallet strapping		rigid	Polypropylene (PP)
V - TL(in)	Transport & logistics (inbound)	Pallet wrap		soft	Low-Density Polyethylene (LDPE)
V - TL(in)	Transport & logistics (inbound)	Shrink wrapping for storage/transport		soft	Low-Density Polyethylene (LDPE)

V - TL(in)	Transport & logistics (inbound)	Slip sheets		rigid	High Density Polyethylene (HPDE)
V - TL(in)	Transport & logistics (inbound)	Cable ties		rigid	Other Plastics
VI - TL(out)	Transport & logistics (outbound)	Disposable pallet covers/caps	 	soft	Low-Density Polyethylene (LDPE)
VI - TL(out)	Transport & logistics (outbound)	Carton/pallet strapping		rigid	Polypropylene (PP)
VI - TL(out)	Transport & logistics (outbound)	Pallet wrap		soft	Low-Density Polyethylene (LDPE)
VI - TL(out)	Transport & logistics (outbound)	Shrink wrapping for storage/transport		soft	Low-Density Polyethylene (LDPE)
VI - TL(out)	Transport & logistics (outbound)	Carton glue			Other Plastics

V - TL(out)	Transport & logistics (inbound)	Slip sheets		rigid	High Density Polyethylene (HPDE)
VI - TL(out)	Transport & logistics (outbound)	Cable ties		rigid	Other Plastics
VI - TL(out)	Transport & logistics (outbound)	Packing tape		soft	Polypropylene (PP)
VII - TIP	Temporary in-house packaging/storage	Lashing		soft	Polypropylene (PP)
VII - TIP	Temporary in-house packaging/storage	Films		soft	Low-Density Polyethylene (LDPE)
VII - TIP	Temporary in-house packaging/storage	Twine		soft	Polypropylene (PP)
VII - TIP	Temporary in-house packaging/storage	Liners/gussets/sheets	 	soft	High Density Polyethylene (HPDE) Low Density Polyethylene (LDPE)

VII - TIP	Temporary in-house packaging/storage	Plastic tubes from rollstock		hard	High Density Polyethylene (HPDE)
VII - TIP	Temporary in-house packaging/storage	Plastic bags	 	soft	High Density Polyethylene (HPDE) Low Density Polyethylene (LDPE)

Appendix B – AMPC Member Survey

Diverting Plastic Waste from Landfill - Red-Meat Processors (Released 27 April 2022)

Start of Block: Welcome

Q1 **Dear AMPC Member,**

The **2025 National Packaging Targets** will have major ramifications for most red-meat processing facilities. The targets aim to eliminate non-recoverable packaging waste, i.e. packaging waste to landfill. **If your facility is required to comply with the targets by 2025 and doesn't, it might incur additional costs or penalties.**

To help member facilities understand the nature and impact of these targets, AMPC has engaged Southern Cross University **to investigate the use and disposal of plastic packaging by red-meat processing facilities**.

This 15 minute confidential survey will capture initial baseline data across member facilities, determine if you would like to participate further, and ultimately help identify relevant plastic waste-management options. Data will be de-identified upon collection and dissemination of data will be in an aggregated form to ensure confidentiality.

This research has received approval from the Southern Cross University Ethics Committee (Approval #2022/032).

○ I agree to participate and wish to continue

Skip To: End of Block If Dear AMPC Member, The 2025 National Packaging Targets will have major ramifications for most re... = I agree to participate and wish to continue

End of Block: Welcome

Start of Block: Site Details

Q2
Site information
Note: Data will be de-identified upon collection.

- ○ Business name _____
- ○ Postcode where processing facility is located _____

End of Block: Site Details

Start of Block: Study Context: Waste Reduction Targets

Q3 **First, a question regarding the Australian Packaging Covenant and the National Packaging Targets:**

The **Australian Packaging Covenant** is a national regulatory framework aiming to reduce the environmental impacts of consumer packaging by: 1) optimising resource recovery of consumer packaging through the supply chain; and 2) preventing packaging waste from entering the environment and supporting innovation in packaging approaches.

The **Australian Packaging Covenant Organisation (APCO)** is the entity administering the covenant to achieve four **National Packaging Targets for consumer packaging by 2025**:

1) 100% of packaging to be reusable, recyclable or compostable;
2) 70% of plastic packaging recycled or composted;
3) 50% average recycled content across all packaging (revised from 30% in 2020);
4) Phase out problematic and unnecessary single-use plastic packaging through redesign, innovation or alternative delivery methods.

Q4 Is your processing facility aware of the National Packaging Targets?

- ○ Yes, all four
- ○ Yes, but not all of them
- ○ No

Q5 Feel free to comment on the above:

_____

_____

_____

_____

_____

End of Block: Study Context: Waste Reduction Targets

Start of Block: A Baseline of Current Plastic Packaging Waste Management

Q6
Now some questions about plastic waste at your facility:

The National Packaging Targets use the term 'consumer packaging'. **'Consumer packaging'** includes **distribution & wholesale packaging** and is **packaging** made of any material, or combination of materials, **for the containment, protection, marketing, or handling of consumer products**. This includes primary (container directly holding the product), secondary (materials used to contain single or multiple primary packed products) and tertiary packaging (materials used to distribute packaged and unpackaged products, including pallets, wrapping stretch film, shippers, shrink film, strapping, and cartons).

Page Break

Q7 **Considering plastic consumer packaging in the operations of your facility, where would you place your facility currently on the following scale?**

Percent of total plastics We don't know

0 10 20 30 40 50 60 70 80 90 100

The percentage of **plastic packaging** in our operations that is **reusable, recyclable or compostable** is: ()	
The percentage of **plastic packaging** in our operations that is **recycled or composted** is: ()	
The **recycled content in plastic packaging used** in our operations is: ()	

Page Break

Q8
Considering plastic consumer packaging in the operations of your facility, are you on track to halve the 2020 volume of plastic waste going to landfill by 2030?

- ○ Yes
- ○ No
- ○ Don't know

Q9 Please comment on your response above:

_____

_____

_____

_____

_____

Page Break

Q10

We use single-use plastic packaging in the following steps of our meat processing operation *(please describe)*:

Note: Single-use plastics are plastics that are used once, or for a short period of time, before being thrown away.

_____

_____

_____

_____

_____

Q11 What steps, if any, is your facility currently undertaking to address **single-use plastic** usage and **plastic waste**? *(select all that apply)*
Note: Single-use plastics are plastics that are used once, or for a short period of time, before being thrown away.

- ☐ Developing organisational **policy** or **strategy** that includes a specific focus on single-use plastic usage and plastic waste.
- ☐ Setting **targets/KPIs** around plastic use and plastic waste.
- ☐ **Monitoring** and **collecting data** on plastic usage and plastic waste volumes within our facility.
- ☐ **Investigating plastics usage** and plastic **waste** within our facility.
- ☐ Dedicating specific **resources** (e.g. physical, human, financial) to address plastic usage and plastic waste.
- ☐ Developing or implementing specific **technologies** to address plastic use or plastic waste.
- ☐ Discussions or **arrangements with plastics suppliers** around design, usage, and waste of plastics.
- ☐ Discussions or **third-party arrangements with downstream plastics value chain** (e.g. recovery operators, waste specialists, re-processors).
- ☐ Other, please specify: _____
- ☐ ⊗ None of the above.

End of Block: A Baseline of Current Plastic Packaging Waste Management

Start of Block: Current plastic input/output

Q12
You're doing fantastic!
Now just a few questions about your current waste monitoring and reporting:

Q13 Is your facility a current signatory to the Australian Packaging Covenant Organisation (APCO)?

- ○ Yes
- ○ No

Skip To: Q14 If Is your facility a current signatory to the Australian Packaging Covenant Organisation (APCO)? = Yes

Skip To: Q15 If Is your facility a current signatory to the Australian Packaging Covenant Organisation (APCO)? = No

Page Break

Q14 **Considering plastics only, which of the following information do you currently report to APCO?** *(select all that apply)*

- ☐ ⊗ I have not yet reported any data to APCO.
- ☐ Total weight of plastics used.
- ☐ Number of units of plastics packaging by unit type.
- ☐ Total weight of plastic material recovered.
- ☐ Total weight of recovered plastic material re-used and recycled in Australia.
- ☐ Total weight of recovered plastic material re-used and recycled by material type through export.
- ☐ Total weight of recovered plastic material disposed of to landfill.
- ☐ How consumers have been advised as to how packaging is to be recovered.

Skip To: End of Block If Condition: Selected Count Is Greater Than or Equal to 1. Skip To: End of Block.

Page Break

Q15 **Instead of reporting to APCO, which of the following state or territory-based Environmental Protection Authorities (EPAs) do you report to?** *(select all that apply)*

- ☒ None
- ☐ NSW EPA
- ☐ QLD EPA
- ☐ WA EPA
- ☐ NT EPA
- ☐ ACT EPA
- ☐ VIC EPA
- ☐ TAS EPA

Display This Question:

If Instead of reporting to APCO, which of the following state or territory-based Environmental Prote... != None

Q16 **Considering plastics only, which of the following information do you currently report to a State/Territory-based Environmental Protection Authority (EPA)?** *(select all that apply)*

- ☐ ⊗ I have not yet reported any data to an EPA.
- ☐ Total weight of plastics used.
- ☐ Number of units of plastics packaging by unit type.
- ☐ Total weight of plastic material recovered.
- ☐ Total weight of recovered plastic material re-used and recycled in Australia.
- ☐ Total weight of recovered plastic material re-used and recycled by material type through export.
- ☐ Total weight of recovered plastic material disposed of to landfill.
- ☐ How consumers have been advised as to how packaging is to be recovered.

End of Block: Current plastic input/output

Start of Block: Block 8

Q17 Which of the following data do you **NOT** currently collect at your facility? *(select all that apply)*

- ☐ Total weight of plastics used.
- ☐ Number of units of plastics packaging by unit type.
- ☐ Total weight of plastic material recovered.
- ☐ Total weight of recovered plastic material re-used and recycled in Australia.
- ☐ Total weight of recovered plastic material re-used and recycled by material type through export.
- ☐ Total weight of recovered plastic material disposed of to landfill.
- ☐ How consumers have been advised as to how packaging is to be recovered.
- ☒ We don't collect any of the above data as yet.

End of Block: Block 8

Start of Block: Operating Model

Q18 **Almost there! To finish off, some questions about your facility to provide context:**

Q19 **Staffing:**

○ Total number of staff at the facility _____

Page Break

Q20 **The annual turnover** (gross revenue in AUD) **of our facility in the 2020/2021 financial year was:**

- ○ less than AU$ 5 million
- ○ AU$ 5 million or more

Page Break

Q21 **Type of species** and **throughput** processed at the facility *(select all that apply & nominate annual throughput as heads/year)*:

- ☐ Cattle (please nominate annual throughput as **heads/year**) _____
- ☐ Sheep (please nominate annual throughput as **heads/year**) _____
- ☐ Goats (please nominate annual throughput as **heads/year**) _____
- ☐ Other (please specify): _____

Page Break

Q22 **Finishing level of packaged product** *(select all that apply)*:

- ☐ Retail ready - domestic (1)
- ☐ Retail ready - export (2)
- ☐ Distribution centre - domestic (3)
- ☐ Distribution centre - export (4)
- ☐ Wholesale - domestic (5)
- ☐ Wholesale - export (6)
- ☐ For in-plant use only (7)

End of Block: Operating Model

Start of Block: Block 7

Q23
And **finally:**

The **circular economy** concept is based on three principles: 1) the **elimination of waste** and pollution; 2) the **circulation of materials** and products; and 3) the **regeneration of nature**. A circular economy stops waste being produced in the first place.

Q24 **Considering <u>your facility</u> in relation to the concept of a circular economy, to what extent do you agree or disagree with the following?**

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I think a circular economy is necessary right now (1)	○	○	○	○	○	○	○
Our facility has a clear plan about how to transition to a circular economy (2)	○	○	○	○	○	○	○
Our facility is well on track to transition to a circular economy (4)	○	○	○	○	○	○	○
The barriers of transitioning towards a circular economy outweigh the incentives. (5)	○	○	○	○	○	○	○

Page Break

Q25 What are the main **incentives** for your facility to transition towards a circular economy?

_____

_____

_____

_____

_____

Q26 What are the main **barriers** for your facility to transition towards a circular economy?

_____

_____

_____

_____

_____

End of Block: Block 7

Start of Block: Further Interest

Q27
Well done, you've made it to the end. Before you go:

Phase 2 of this research involves an **in-depth analysis of single-use plastics at three facilities**, including business modelling to viably reduce plastic waste.

Would your facility be **interested in participating in Phase 2**?

- ○ Yes, we're interested (1)
- ○ No, we don't have the capacity to participate at the moment (2)
- ○ Maybe, we'd like to find out more (3)

Display This Question:

If Well done, you've made it to the end. Before you go: Phase 2 of this research involves an in-de... = Yes, we're interested

Q28 Thank you for your **interest in participating in Phase 2**. Please provide your contact details so we can get in touch:

- ○ Name of Facility (1) _____
- ○ Contact Name (2) _____
- ○ Contact Email (3) _____
- ○ Contact Phone (4) _____

Display This Question:

If Well done, you've made it to the end. Before you go: Phase 2 of this research involves an in-de... = Maybe, we'd like to find out more

Q29 Thank you for your interest in **finding out more about Phase 2**. Please provide your contact details so we can get in touch:

- Name of Facility (1) _____
- Contact Name (2) _____
- Contact Email (3) _____
- Contact Phone (4) _____

End of Block: Further Interest