DESCRIPTIONS OF WASTE TECHNOLOGIES –

MATERIALS RECOVERY FACILITIES

WA Waste Authority - Strategic Waste Infrastructure Planning

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WA WASTE AUTHORITY

STRATEGIC WASTE INFRASTRUCTURE PLANNING

Concise Descriptions of Modern Waste Technologies

Materials Recovery Facility FINAL REPORT

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1 SUMMARY

Hyder Consulting was commissioned by the Western Australia Department of Environment Regulation (DER) on behalf of the Waste Authority to provide a concise description of best practice Materials Recovery Facility (MRF) technologies as a means of modern waste treatment and resource recovery.

This report summarises a number of key parameters relating to this technology, as requested by the DER. It is one of a series of reports reviewing various waste treatment and disposal technologies that may be applied in the Perth Metro and Peel Region. The information is presented in a concise, standardised table format in Section 7 and Section 8 that, when merged with the information on other waste technologies, will allow a comparison of key parameters across the technology types and inform the development of the *Waste and Recycling infrastructure Plan for the Perth and Metropolitan and Peel Region*.

The purpose of the project is to provide sufficient information on each technology type to allow a comparison with other waste technologies and help to assess the potential for each option to play a role in the future Perth and Peel waste infrastructure mix. The project is intended to inform Government planning and strategic decisions.

A variety of well-established and proven waste technologies can be used in MRFs, in order to potentially make a significant contribution to resource recovery and landfill diversion objectives. A MRF is not a total waste solution in itself and will not result in zero waste to landfill. MRFs should be considered as part of a broader integrated waste management system and should complement future and existing waste management systems.

A MRF is a facility where components of a mixed waste stream are separated into their constituent materials. This is achieved through the use of mechanical separation techniques including a combination of automated equipment and machinery and/or use of physical labour (handpicking). After sorting, materials are bulked and stored prior to being sold to reprocessors or commodity markets for eventual reprocessing. MRFs can be designed to separate a variety of materials, with target materials - and financial viability of the operation - often depending heavily on the availability of sustainable markets for the outputs.

Although there are different variations and system configurations for MRFs, in this report Hyder has focussed on ‘clean’ MRFs which sort commingled recyclables.

The information presented in this report is a combination of details gained through consultation with the operators of the case study facilities, and information arising from a review of relevant available literature. Additional general information has been included based on Hyder’s industry knowledge and experience.

On the basis of selection criteria agreed with the DER, Hyder selected the following MRF facilities to use as case studies:

Type	Location
MRF (‘Clean’ comingled recyclables)	Sydney, NSW
MRF (‘Clean’ comingled recyclables)	Canberra, ACT

This report presents key details of each reference facility, based on information provided by the operators. In some cases, information was not provided due to commercial concerns. The facility information has been summarised in a table as requested by the DER to enable quick comparison with other waste management technologies. Section 8 contains a ‘Study Synopsis’ table for MRF technologies which summarises the parameters for MRFs in general.

2 INTRODUCTION

Following release of the *Western Australian Waste Strategy*, the Western Australia Waste Authority (WAWA) and the Department of Environment Regulation (DER) have established the Strategic Waste infrastructure Planning Working Group, with the aim of developing a plan for the future waste disposal and recycling infrastructure needs of the Perth metropolitan and Peel regions. The Working Group will guide the development of a *Waste and Recycling infrastructure Plan for the Perth and Metropolitan and Peel Region*.

The WA Waste Strategy sets out challenging recovery targets for each of the major waste streams: municipal solid waste (MSW), commercial and industrial waste (C&I) and construction and demolition waste (C&D), for both the Perth Metro and Peel regions. One of the key objectives of the Waste and Recycling infrastructure Plan for the Perth and Metropolitan and Peel Region is to identify the waste technology options and infrastructure mix that will help Western Australia to achieve those targets.

Hyder was commissioned by the DER on behalf of the Waste Authority to provide a concise description of best practice MRFs within a modern waste management system. This report summarises a number of key parameters, as specified by DER, relating to this technology. It is one of a series of reports reviewing various waste treatment and disposal technologies that may be applied in the Perth Metro and Peel Region. The information is presented in a concise, standardised table format that, when merged with the information on other waste technologies will allow a comparison of key parameters across the technology types and inform the development of the Waste and Recycling infrastructure Plan for the Perth and Metropolitan and Peel Region.

In the current project, Hyder has focussed on ‘clean’ MRFs processing commingled (mixed) recyclables.

2.1 PURPOSE

The purpose of the project is to provide sufficient information on each technology type to allow a comparison with other waste technologies and help to assess the potential for each option to play a role in the future Perth and Peel waste infrastructure mix. The project is intended to inform Government planning and strategic decisions.

3 PROJECT METHODOLOGY

The information presented in this report is a combination of

- **a** Details gained through case studies of representative reference facilities identified by Hyder in consultation with DER; and
- **b** Information arising from a review of relevant and available literature on the topic.

Additional general information has been included based on Hyder’s industry knowledge and experience.

3.1 CASE STUDIES

For the case studies, information was gathered through direct interviews and consultations with the current operators of the selected facilities, and Hyder acknowledges their valuable contribution to the project.

To identify appropriate reference sites to use as case studies in the current project, Hyder considered the parameters described below. These generic criteria have been applied across all waste technologies described by Hyder, including the present study:

- Use proven, mature and best practice technology;
- Have been operational for at least 12 months;
- Have been operating successfully to a high standard with no known major issues or fundamental failures;
- Are generally of a capacity that would be appropriate for the Perth Metro and Peel regions;
- Have established sustainable markets for any outputs and products from the process; and
- The operators have agreed to take part in the project and provide information.

Hyder has selected Australian facilities, so that the costs, regulatory drivers and environmental standards are likely to be consistent with the Western Australian context.

To facilitate the provision of information by operators, the DER wrote an introductory letter to each selected operator to introduce the project, explain Hyder's role, and provide assurance as to the protection of commercially sensitive information.

3.2 LITERATURE REVIEW

To supplement the information obtained through the case studies and provide a broader view of typical facilities, Hyder conducted a limited review of available literature on MRFs and representative reference facilities and sites. Literature in this case includes:

- Published books;
- Published industry reports;
- Journal articles;
- Company websites;
- Waste and recycling survey and data reports.

Information obtained from published literature sources has been identified as such and references provided (see Section 9).

3.3 KEY PARAMETERS AND INFORMATION

The table below summarises the key parameters and information specified by the DER. The same parameter list will be applied to each waste technology category in order to allow information to be presented in a standardised table format, and therefore allow comparison across technologies.

Where relevant and representative information was obtained for the case study facilities, this is presented in the summary table (see Sections 7 and 8). Where information was not available or there was a benefit in providing additional background, the table has been supplemented with information obtained through the literature review.

Table 3-1 Technology Parameters

Ref	Information Parameter	Description
1	Process description	A high level description of the process (or technology type) for managing or treating waste including its purpose, conversion processes, stages of treatment and key inputs and outputs (including energy and waste residues)
2	Feedstock	Types of suitable feedstock, pre-treatment requirements, broad physical and chemical characteristics, key exclusions
3	Capacity	Processing or disposal capacity (in tonnes per annum) including typical values and ranges
4	Waste Hierarchy	How and where does the technology fit into the established waste hierarchy?
5	Landfill Diversion Potential	Potential to divert waste from landfill (for example, waste recycled/recovered and waste to landfill expressed as a percentage of total waste sent to facility)
6	Products and Residuals	Identify all products, outputs and residuals from the facility / process (including any potentially beneficial outputs and energy)
7	Capital Cost	Expressed as a total cost and $ per tonne of annual capacity
8	Operational Cost	Expressed as $ per tonne of waste processed / disposed
9	Gate fees	Typical gate fees charged to customers. Note gate fees do not necessarily correlate directly with running costs and may include a profit margin and be driven by market forces (i.e., prices of alternatives)
10	Set-up Timeframe	Typical timeframe to establish the technology including planning, approvals, procurement, design, construction and commissioning
11	Lifespan	Typical lifespan of the technology taking into account standard maintenance and replacement practices
12	Footprint	Typical land footprint for a facility including for the core technology and any surrounding ancillary requirements (access roads, waste and product storage, buffers, etc.)
13	Buffer zones	Extent of buffers required around the plant, including typical existing facilities and any requirements in regulation
14	Emissions Performance	Typical pollutants arising from the process (solid, liquid and gaseous) – key substances and approximate quantities / concentrations. Also high level estimates of carbon impact including direct carbon emissions and indirect emissions from electricity use.

Ref	Information Parameter	Description
15	Environmental Performance	Compliance with regulations / permits, key environmental impacts including air, water, groundwater, noise, odour, dust, and waste arisings.
16	Social impacts / costs	Impacts on local community and neighbours, employment, local economy impacts,
17	Compatibility with existing systems / technologies and supporting systems	To what extent is the technology compatible with the existing waste management system and facilities (sorting, collection, processing, disposal), what broad changes would be required and which other technologies are required to complement the technology
18	Risks	Identification of potential risks including technical, commercial, environmental, operational and market risks
19	Local Application	Most appropriate application of the technology to the local context (metro or non-metro, medium to high density)
20	Maturity of the technology	How long has the technology been in operation, it considered proven and how many reference facilities exist in Australia and overseas
21	Availability	Typical annual maintenance shutdown requirements, plant availability as a proportion of the name-plate capacity
22	Penetration	Extent of existing penetration of the technology in the Perth Metro and Peel regions and within Australia (such as number / total capacities of existing facilities)
23	Benefits	Benefits of the technology (financial, environmental, social) compared with alternatives including landfill diversion performance, flexibility, future-proofing, etc.
24	Barriers / constraints	Barriers to implementation including markets for outputs, policy and regulatory constraints, availability of technology and support in Australia, etc.
25	Other relevant information	Any other relevant information which becomes apparent during investigations

4 BACKGROUND

A MRF is a facility where a mixed waste stream is separated into its constituent materials. This may be achieved using mechanical separation techniques through a combination of automated equipment and machinery and/or use of manual labour (hand-sorting / handpicking). Some MRFs use highly technical equipment, while some are based predominantly on the use of manual labour, and others use a combination of both.

MRFs may serve social objectives, such as creating local employment, however their primary function is the provision of cost-effective sorting, which necessitates efficient operation in order to achieve product streams that meet market specifications, with minimal residues. An efficient MRF will maximise economic and environmental advantages.

MRF processing has changed dramatically from early sorting practices, which either relied very heavily on manual labour or used equipment designed for use in other industries. Today, there is a plethora of automatic sorting equipment that has been designed specifically to enable different recyclable materials to be sorted from each other. Although the efficiency of MRF technologies and techniques has greatly improved as a result, there is still scope for further advancements to be achieved.[ii]

MRFs usually employ a system of conveyors that carry the waste materials over sorting screens or other sorting mechanisms (such as inclined tables, or air classifiers) which separate the materials based on physical properties such as shape and density. Advanced systems employing optical, near-infrared or laser sensor technology, capable of recognising and separating different materials are sometimes employed. For example, this advanced equipment is able to sort glass by colour, or separate different types of plastics. There will typically be a significant element of hand-sorting of materials in addition to the automatic extraction of materials as part of the separation process.

After sorting, materials are prepared for market using bulking and storage equipment. For example, balers may be used to compress recyclable material such as cardboard or PET plastic into dense bales for transport to material reprocessors.

There usually be a reject stream of materials passing through the plant which cannot be easily recovered and recycled, with the level of residual waste depending on the level of contamination in the incoming feedstock, and the efficiency of the MRF. This residual waste will typically go to landfill, or other suitable residual waste treatment facility.

MRFs can generally be categorised into two types, a clean MRF or a dirty MRF. A ‘clean’ MRF is designed to process source separated/comingled dry recyclables, while a ‘dirty MRF’ handles a mixed waste stream that may include putrescible materials. The product quality and recovery rate tends to be lower a “dirty” MRF.

4.1 BRIEF PROCESS OVERVIEW

A MRF separates out designated recyclable and non-recyclable materials through a combination of manual and mechanical sorting. The waste streams that are processed at a “dirty” MRF can include a mixed Municipal Solid Waste (MSW) or Commercial and Industrial (C&I) waste. Kerbside collected mixed recyclables are usually processed through a “clean” MRF, which may also be suitable for processing mixed recyclable materials collected from commercial premises.

The type of separation process used at a MRF depends on the incoming feedstock, and the target market for the separated materials. Some product streams from a MRF may undergo further processing to meet technical specifications for the end markets. For example, some MRFs will not attempt to sort plastics by polymer type, and instead export ‘mixed plastics’ for further separation into constitute materials, such as PET, PVC and HDPE.

Materials separated at a MRF are bulked and transported for further processing, or sale. The remaining residual material is sent to an appropriate disposal or processing facility.

Paper and card separation

One of the first processing steps in a MRF is the separation of fibre streams (i.e. paper, newspaper, cardboard) from container streams (i.e. cans, plastic bottles). In an automated system, screens are typically used to undertake this step.

To meet market specifications, fibre will often be sorted into various grades. Commonly, MRFs are developed to separate paper and card into:

- Corrugated cardboard,
- Newspapers, periodicals and magazines, and
- Mixed paper.

Sorting can be done manually, using screens or using advanced optical scanners. Smaller MRFs tend to rely on manual sorting, while larger facilities may use more advanced screens. The grades of paper to be sorted will depend on the available markets.

Sorting metal containers

There is MRF technology capable of separating ferrous (i.e. steel) and non-ferrous (i.e. aluminium) materials from other containers.

Overband magnets and magnetic head pulleys on conveyors are commonly used to separate ferrous items, such as steel cans, while eddy current separators are used to sort non-ferrous materials such as aluminium cans. While most MRFs will employ automated technologies for separating metals, the specifications for the high value materials such as aluminium may necessitate further manual inspection and sorting to be undertaken. Any manual quality control of this nature will be performed following sorting and before baling, to ensure the final product meets market requirements.

Sorting glass containers

A variety of approaches can be used for sorting glass containers, depending on the availability of end markets and quality of feedstock. When a MRF is located within viable transporting distance of a glass reprocessor, it may be economically viable to sort glass by colour (i.e. clear, amber or green glass) through either manual hand picking or automatic systems (such as optical sorting systems). A portion of glass in a MRF feedstock is likely to be broken into fragments too small to sort by colour; such ‘glass fines’ may be crushed and screened to create a sand-replacement product.

Sorting plastic containers

In a MRF, plastics (polymers) are sorted by resin using either manual or automated techniques. Optical systems can be used to sort multiple grades of plastic, but the capital cost of this equipment will usually mean that a relatively high volume of feedstock will be required in order to justify investment.

The efficiency of an automated system is typically better than a manual sorting system, and the value of fully sorted plastics is high compared to the value of mixed plastics.

Post-sorting

MRFs often have a post-sort station that will allow for negative sorting at the end of the process to deliver quality control and efficiency benefits. This post-sorting can assist in the removal of contaminants and allow for any missed material that was not sorted by the MRF to be recycled. Residual material will be collected and stored for end disposal.

Baling and transport

A baler can be one of the most important pieces of equipment at a MRF. The baler must have sufficient capacity and produce bales that meet market requirements in terms of size and density. Decisions on whether or not to bale materials processed at a MRF are dependent on:

- Market requirements;
- Market prices; and
- Differences in cost of transporting materials baled or loose.

Managing residues

Residues from a MRF consist of non-recyclables (i.e. contaminants) that are mixed in with the targeted recyclables delivered to the MRF, as well as some recyclables that are not recovered during processing.

The rejects derived from the sorting process will be sent to a residual waste treatment facility, such as a landfill for disposal, or sometimes to an energy from waste facility.

5 CASE STUDY DETAILS

On the basis of the selection criteria set out in 3.1 above, Hyder selected the following MRF sites to use as case studies.

Type	Site Name	Location
MRF ('Clean' comingled recyclables)	Site A	Sydney, NSW
MRF ('Clean' comingled recyclables)	Site B	Canberra, ACT

In Australia, dirty MRFs are less common compared to clean MRFs. Examples of dirty MRF facilities currently in operation are the SITA ResourceCo facility in Adelaide and the SITA Spring Farm ARRT in Sydney. It is useful to note a dirty MRF process is generally the same as the 'mechanical' part of the Mechanical Biological Treatment (also known commonly as Advanced Waste Treatment) process, in terms of targeting recyclables for separation from mixed waste feedstock.

This section provides a brief description of each reference facility, including the key features that make them representative case studies of best practice MRF sites, and how they satisfy the criteria set out in section 3.1.

Case Study 1 – Material Recovery Facility A, NSW

The MRF is sited in an industrial zone of the Sydney metropolitan area, close to other waste management facilities. The facility is privately owned and operated on behalf of a local government authority. The facility is a clean MRF, accepting and processing domestic kerbside commingled recyclables, and recyclable waste streams from the general public (through the drop-off facility located close to the facility). The recyclables are sorted and sold into the relevant commodity markets. Any non-recyclable materials that are suitable are sent for processing into a refuse derived fuel, while all unsuitable residuals are disposed at landfill.

Although the facility's design capacity is up to 250,000 tpa of recyclable waste, the current throughput is 85,000 tpa. The facility began operating in 1995, following a three year period of approvals, design and construction. The footprint of the facility building is 0.4ha.

Case Study 2 – Material Recovery Facility B, ACT

The MRF is sited in a light industrial precinct, close to the edge of the Canberra metropolitan area. The facility is privately owned and operated on behalf of the ACT Government. The facility is a clean MRF and accepts domestic kerbside commingled recyclables as its core operation, together with recyclable cardboard waste from commercial businesses. The recyclables are sorted and then sold to the commodity markets. Any non-recyclable materials are disposed at landfill.

The facility began operating at the end of 2003, following a three year period of approvals, design and construction, has an operating life of 15-20 years. The site footprint is 1-1.5 ha, with a building footprint of 0.3 ha. It processes 75,000 tonnes of waste per annum.

6 LITERATURE REVIEW

6.1 PROCESS DESCRIPTION

The MRF process has three distinct phases in its sorting process:

1. Receiving and preparation of materials for the sorting process;
2. Sorting materials into individual material streams; and
3. Inspecting, baling, storing and transporting sorted materials.

The sorting process is undertaken by a series of ‘unit operations’. There are various proven components available that can be designed into a MRF. The unit operations are chosen by the operator to fulfil the sorting requirements. Table 6-2 outlines the different unit operations. Typical MRF process flows are provided in Appendix A.

Table 6-2 Unit operations that may be used at a MRF[i] (Integrated Solid Waste Management, Tchobanoglous, G, Theisen, H & Vigil,S.A 1993)

Unit Operations	Function
Shredding - Hammer Mill, Flail Mill, Shear shredder	Shredding operations are used to reduce the size of waste materials
Glass crusher	Used to crush glass containers
Wood grinder	Used to shred large pieces of wood (also known as wood chippers).
Screening – Vibrating screens, rotary screens, disc screens	Screens are used to separate mixtures of materials of different sizes into fractions. Vibrating screens remove undersized materials. Rotary screens, also known as rotary drum screens or trommel screens are used to separate materials into several sized fractions. As the material tumbles down the length of the screen, undersized material is separated by passing through groups of differently sized holes. With disc screens, oversized materials ride over the top of the rotating discs whilst undersized materials fall between them.
Density separator (air classification)	Air classification separates light materials, such as paper and plastic, from heavier materials such as metals or glass fines based on the weight difference in the material in the air stream.
Magnetic Separation	Ferrous metals are separated using magnets
Eddie currents	Aluminium cans are separated using electromagnet currents. An eddy current has a slight electrical charge which passes through other materials but is resisted by aluminium, causing the cans to lift or bounce off the conveyor.
Balers	Balers reduce the volume of waste for storage, prepare the waste for market and increase the density of the materials, therefore reducing transporting costs. Common materials baled include paper, card, plastic, aluminium and ferrous cans.
Can crushers	Can crushers, crush aluminium and ferrous cans and tins, therefore increasing their densities and reducing handling and transporting costs.

Unit Operations	Function
Conveyor belts	Conveyors transfer wastes from one location to another. There are a number of types including hinged, apron, bucket, belt drag, screw, vibrating and pneumatic. The commonly used conveyors for waste are horizontal or inclined drag conveyors.
Picking belts	The manual separation operation of waste at a MRF is usually undertaken by manually removing, or 'picking', individual waste components from the waste as it passes by on a conveyor belt (picking belt) in front of the operators.
Mobile waste handling equipment	Front end loaders and forklifts are universal material handling equipment used at MRFs. Front end loaders are used to lift waste from the tipping floor onto the conveyor belt, and to load materials after sorting. Forklifts are used for transporting baled materials from the balers to the storage areas.

6.1.1 RECEIVING AND PREPARATION OF MATERIALS

Preparation and storage of incoming materials

It is common for all incoming waste materials to be stored prior to processing on a large space called the "tipping floor" which is protected from the weather, i.e. to prevent windblown litter, or protect from rainwater ingress. Rain can significantly reduce the value of some of the output material streams, especially paper and card.

There should usually be sufficient capacity to store at least two days volume of incoming materials. This will enable delivery of the materials to the MRF to continue during downtime and at times of high demand, such as after public holidays[ii].

Receiving incoming materials

Incoming loads of waste materials are off-loaded onto the tipping floor. They then may be transferred from the tipping floor onto a conveyor belt system, such as via a front end loader, loading shovel, or other similar equipment.

The conveyor belt moves the materials towards the sorting stations. Conveyor belt systems can be designed, either to be at the bottom of a pit in the floor, where equipment (loader or shovel) is used to push the materials onto the conveyor, or as a floor-level conveyor, where mobile equipment is used to lift the materials onto the conveyor.[ii]

Regulating the flow of material

The consistent flow of materials is important in the MRF process. Having an uneven flow on the conveyor reduces the efficiency the sorting process[ii].

There are four basic methods employed at MRFs for metering the flow of material:

- **Slowly feed materials onto the conveyor** – A simple approach is to require the operator of the loader to control the speed of tipping, by slowly feeding the materials onto the conveyor belt, thus spreading them out.
- **Series of conveyor belts of progressively increasing speeds** – This system utilises a series of belts, each operating faster than the previous one. The progressively increasing speed causes materials to spread more evenly over the conveyor belt.
- **Metering drum** – A large steel drum rotates in the opposite direction of the materials to level them out on the conveyor system.

- **Gates or curtains** – As materials move up a steep incline, they pass under a steel gate or curtain placed at a specified height. Those materials unable to fit under the gate/curtain fall back down the belt and occupy a space that has fewer materials before being able to pass through.

Pre-sorting materials

Typically all MRFs have an initial pre-sort stage, where staff spot and manually remove materials or contaminants that cannot be sorted at the facility.

This pre-sorting stage is critical to the efficiency of the entire system. Removing contaminants early avoids unnecessary costs being incurred as a result of these materials passing through the various sorting stations, and allows the sorting technology to operate at optimal efficiency. It can also help to avoid wear and tear on the equipment, such as may be caused through contamination materials such as a garden hose wrapping around equipment.

Bag Splitter

A bag splitter may be required if feedstock materials delivered to the MRF are collected in bags. This would be employed as an automatic process to release the contents of the bag, and avoid the health and safety implications of undertaking it manually.

6.1.2 SORTING INTO INDIVIDUAL MATERIAL STREAMS

A primary sorting operation is the separation of fibre (newsprint, magazines, office paper, and cardboard) from containers. Advanced sorting steps may then be used to separate paper by fibre grade and containers by material type.

There are a variety of mechanical techniques to separate different container types based on the size, shape, density and conductivity of the material. Technologies commonly used to sort by type using conductivity include eddy currents for aluminium and overband magnets for ferrous metals.

Screens and discs are also used to sort containers based on physical properties including weight and density (for example, plastic from glass).

There are different schools of thought on the optimal sequence for sorting containers. Some prefer to remove the plastic early in the process, while others find it more efficient to remove metals early so as to optimise the efficiency of sorting later in the process. Although the sorting sequences can differ, the sorting techniques and technologies are similar.

Some large-capacity MRFs install a crusher that breaks glass and flattens plastic, aluminium and metal. Screening systems may then be used to sort the various fractions.[ii]

Sorting paper from containers

Separating paper from containers early in the sorting process allows easier access to the materials for further sorting. With automated sorting, this initial sorting is done using screens. Common screens used at modern MRFs include trommel screens and disc screens.

A trommel screen is a large rotating cylinder with holes of various sizes through which materials fall through, thereby sorting according to size. Materials are sorted as the holes become progressively smaller down the length of the trommel.

Disc screens are another technology often employed at MRFs. They may be used to:

- Perform an initial separation of fibre and container materials;
- Separate cardboard or newspaper and magazines from other fibre grades; and

- Remove fines and debris from the larger materials as an alternative to vibrating or trommel screens.

The disc screen has several inclined rows of rectangular steel discs which spin in the direction of the material flow. Larger surface size materials move up the incline of rotating discs. There is sufficient space between the conveyor belt and the disc screen, as well as space between the rows of discs to allow the smaller surface size materials to fall below onto another conveyor system.

Advance grading of paper and cardboard is undertaken using disc screens where paper is sorted into various market grade specifications.

Optical scanning

Optical scanners may be capable of identifying fibre grades and sorting targeted grades using reflective near infrared (NIR) sensors. The sensor module can be placed on top of the sorting conveyor and, once target material is sensed, air jets at the end of this conveyor sequentially eject the target material, separating it from the remainder of the materials.

Optical scanners can be configured in a variety of ways, and for example used to identify and sort various grades of paper and plastics, as well as to separate paper from other materials.

Sorted material streams normally pass through one final inspection station where staff manually remove any remaining contamination before the materials are prepared for market. This final inspection is important to ensure the sorted materials meet the specifications or quality standards required by the reprocessors[ii].

Sorting plastic containers

Plastic containers are often removed early in the sorting process due to their volume and size. Sorting plastic containers is done either manually or by means of an automated screening/scanning process.

Optical scanning technologies may be used to sort plastics into specific resins for the commodities markets. NIR technologies can identify each resin and colour, and an air jet is used to lift the sorted containers into the appropriate storage bunker.

In determining whether to carry out advanced sorting on site, MRF operators would compare the market price for mixed vs. resin-sorted plastic containers.[ii]

Sorting steel or ferrous metals

Metal sorting is undertaken by magnets. Usually either overband magnets or magnetic head pulleys are employed to pull steel cans from the conveyor belt and drop them into the storage bunker ready to be baled. This is a relatively inexpensive and accurate way to recover steel and ferrous metal.

Sorting non-ferrous metals

Eddy current separators are used to separate aluminium cans from other materials. Normally eddy current separators are placed at the end of the sorting process to sort aluminium from a plastic mix. This is so that the eddy current separator can be operated at a maximum efficiency, and prevent cans getting buried under other containers or minimising other materials from being pulled off with the cans.

An eddy current has a slight electrical charge which passes through other materials (paper, plastic, metals, and glass) but is resisted by aluminium, causing the cans to lift or bounce off the conveyor.

Due to the high value of aluminium, manual quality control is employed to ensure any contamination is removed before the sorted aluminium falls into the storage bunker.[ii]

Sorting glass

Manual and automatic systems can be used at MRFs to sort glass from other containers. Generally, manual sorting of glass occurs early in the sorting process to avoid interference with the eddy current and overband magnet from efficiently removing aluminium and steel containers.

Automated sorting of glass can be undertaken using disc or trommel screens. Normally after fibre separation, materials pass through a crushing system that flattens plastics, metals and breaks the glass containers. A trommel screen can then be used to sort the glass cullet from other materials.

Broken glass is often sorted into size categories. The larger size glass particles can be sorted by means of an optical scanner. The smaller size cullet tends to be sold to the sand blasting or aggregates markets.

Optical scanning technology can also be used to sort glass by colour. However, to achieve optimal efficiency, glass cullet must be at least 0.95cm in size to be identified by the scanner.

MRF operators would evaluate the market value for mixed and colour separated cullet, to determine if there is sufficient price margin to justify the advanced colour sorting of glass.

6.1.3 INSPECTING, BALING, STORING AND TRANSPORTING

Inspection and quality control

The sorted materials have to meet set specifications to receive optimum value in the commodities markets. Operators need to employ quality control processes to control the quality of the materials. Techniques used include:[ii]

- Quality control or inspection stations at the end of each sorting line;
- Visual inspection of the materials at various levels in the storage bunkers;
- Random sampling of bales prior to shipment;
- Quality control feedback systems between the market and the supplier.

Baling and storing

Materials that have been sorted are transferred from their respective storage bunkers to a baling system using conveyors or loaders.

Baled materials, particularly paper and cardboard should be stored in a weather protected area prior to being shipped to market.

6.1.4 RESIDUE MANAGEMENT

Residues are those materials remaining at the end of the sorting process, which require disposal. Residues can include both non-targeted materials which are deposited into the waste stream (i.e. contamination) and recyclable materials missed in the sorting process.

MRFs are designed to maximise resource recovery, refine process outputs, and remove inappropriate materials from the waste input. The amount of reject materials from a MRF process will depend on the quality of the input material, the sorting equipment used, and the degree the input waste is sorted and separated. The range for reject material from a clean MRF is between 3-20% and 30-70% for a dirty MRF.

Dirty MRFs produce a larger residual stream due to the mixed waste feedstock containing a range of materials that do not have a market value. Dirty MRFs can process a large proportion of this residual stream into a Refuse Derived Fuel (RDF). The high calorific value of the residual material makes it suitable for used as a fuel in thermal treatment (incineration, gasification, pyrolysis) plants, or as a substitute for coal in other industrial processes (e.g. cement kilns).

Non-recyclable plastics as well as the organic components of MSW and C&I wastes, together with textiles, carpets etc, may be suitable materials for RDF production. The process for producing RDF will include stages to remove inert materials as well as moisture so as to maximise the calorific value of the final product.

The final RDF product should have good combustion characteristics and be stable so that it can be easily stored and handled. RDF is generally produced in pellet form, but has also been produced in looser fibre form known as 'fluff' or 'floc'.

Residue management at a clean MRF incurs additional costs through the sorting, transportation and disposal of the residual material.

MRF operations are reliant on minimising the percentage of residues in their systems to reduce their costs as far as practical. To improve recovery rates some MRFs will process residues a second time by recycling them back through the sorting system.

Managing residues can be achieved by:[ii]

- Auditing incoming recyclables to identify levels and types of contamination and providing regular feedback to the collection operator to take action;
- Conducting residue audits to identify quantities of missed recyclables, and then working to improve processing efficiencies; and
- Putting residues into the sorting system for a second time to ensure that all recyclable materials are taken out.

6.1.5 OPERATIONAL FACTORS

Manual versus automated sorting techniques

Most commonly, a MRF will use a combination of manual and automated, mechanical sorting techniques. Some steps in the sorting process are best handled manually, while other steps will be more accurate and less costly if automated.

The following summarises the preferred techniques at various sorting stages[ii]:

- **Pre-sort** – Manual sorting tends to be the preferred option to remove non-recyclables and any recyclable materials the system is not designed to process,
- **Metals** – Automated sorting technologies with high degrees of accuracy are available that are relatively inexpensive.
- **Other materials** –the choice of employing manual sorting versus investing in automated mechanical technologies is less clear and often dependent on the throughput of the facility.

The benefits of manual sorting include[ii]:

- Less capital investment required in automated equipment;

- Greater flexibility in changing the sorting techniques (future proofing); and
- Local jobs are created.

Flexibility

The fluctuation in material commodity prices requires consideration. Flexibility in the operation is essential for when prices for any particular material drops, rendering its separation no longer financially viable. Conversely, if the price for a material rises, additional separation and preparation steps may become viable.

Maintenance

Maintenance and regular care of equipment at a MRF is crucial to its effective operation. MRFs have a lot of wear and tear due to the nature of the mechanical processes involved. On-site engineers need to be available to clean and maintain equipment during down-time, and to respond immediately to mechanical failure which would otherwise result in significant costs through lost production.

6.1.6 DIRTY MRF VS CLEAN MRF

The core differences between a 'dirty' and 'clean' MRF are the feedstock that they sort and process. Other key differences between the two operations are highlighted in Table 6-3

Table 6-3 Key differences between a clean and dirty MRFiv

Clean MRF	Dirty MRF
Potential for revenues from sale of materials. Residue requiring disposal is 8-10% of the feed.	Unless there is a high level of separation in the plant, there is likely to be a major component of the waste entering the plant requiring final disposal (30-70% of the feed).
Recyclables generally of relatively high quality.	Low quality of recyclables output can render material of low value.
Can significantly contribute to meeting high recycling targets.	Extracts additional recyclables from residual waste stream.
Can attract material from both drop-off facilities and kerbside collection systems, including some commercial / industrial waste.	Can be used as part of an integrated system to gain energy (as RDF) and materials value (recyclables) out of the residual waste stream.

6.2 ENGINEERING CONSIDERATIONS IN THE DESIGN OF MRFS

The engineering considerations for a MRF include[ii]:

- Defining the functions of the MRF, in terms of:
  1. The role of the MRF in the waste management system;
  2. The types of materials to be recovered;
  3. The form in which the materials to be recovered will be delivered to the MRF; and
  4. The storage and containerisation of processed materials for the market.
- Selecting the materials to be separated (and consideration for materials that may need separation in the future);
- Identification of the material specifications that must be met (including for materials that may be handled in the future);
- Development of the separation process flow diagrams;
- Determination of the process loading rates;
- Layout and design of the physical facilities;
- Selection of the equipment and facilities that will be used;
- Environmental controls;
- Aesthetic considerations; and
- The adaptability of the facility to potential changes in characteristic or quantities of the waste.

6.2.1 CAPACITY AND FOOTPRINT

MRF capacities can range from a few thousand tonnes per year, to hundreds of thousands of tonnes per annum. A MRF may be able to operate on a single, double or triple shift system, which allows for flexibility in managing the quantity of feedstock materials.

MRFs can be designed to operate at various capacities. They can be designed as modular systems to allow for future expansion. They can be adapted to the end markets by accounting for space at the design stage for additional sorting equipment, if and when required.

Fully automated MRFs are less flexible than those operated with a degree of manual separation. The flexibility of staff to recognise and separate different materials may be superior to automated equipment, which only has the capability to recognise and separate pre-defined materials.

MRF capacity is often designed to accommodate a specific throughput, however they are flexible and have a potential to increase capacity through running extra shifts.

MRFs must allow for sufficient storage capacity for the recyclables allowing them to be stored before onward transport at an efficient tonnage, i.e. using bulk carriers.

The site footprint of a clean MRF can vary depending on the land available and the equipment being employed, however it is typically[iii] between 2-3 Ha. The site footprint of a dirty MRF is generally between 2-4 Ha.

This must include a building and storage bunkers. There must be an area in front of the building to allow a bulk carried to turn so that it can be loaded with separated recyclables for transfer to reprocessors.

6.3 COSTS AND INCOMES

The estimated capital cost for a MRF is between $500,000 and $60 million, depending on the complexity of the process and equipment employed[iv]. This cost would include the civil constructions, buildings, plant and equipment costs.

The capital cost is increased if a fully automated system is employed. It can be reduced by implementing a manual sorting system, however, as this will necessitate a larger number of operators, the operating costs will be higher.

The operating costs for a MRF is dependent upon the throughput and technology employed and has been estimated to be typically around $60-$120[iv] per tonne of waste handled. This figure includes the costs for energy use, labour, maintenance of equipment, fuel use, the treatment cost for residues and on-site utilities. Sorting costs are heavily influenced by the quantity and variety of materials to be sorted, as well as the market specifications for the quality of the recyclate recovered. Operating costs can be offset through the sale of recovered process, and the gate-fee charged for use of a MRF will be determined as a function of net operating costs.

There is a lot of variation in the income from recyclables. Income is dependent on the quality of materials recovered and the demand for them in the market. For example, in the UK and Australia, there have been examples where some local governments are paid for their recyclables, rather than paying a gate fee to the MRF operators, on the basis of the high value of recovered commodities.[v]

6.4 RISKS

Commercial risks for MRF operators are largely associated with security of feedstock, and operators generally seek to manage these risks by securing long-term contracts – at predictable gate-fees – for a significant portion of the feedstock.

The financial viability of a MRF will usually depend on either the agreed processing gate-fee, commodity markets for recovered products, or both. Viability is usually improved where there are established local recyclate markets available. Nevertheless, the value of recyclables can vary dramatically over short periods of time, and this results in the main commercial risk associated with MRF operation: income streams can vary at a greater rate than the gate fee/service charged for managing the waste materials.

Technical risks associated with MRFs can generally be considered quite low, considering such facilities are operating and proven worldwide. Some components may have more than operating history than others, although in general there is a lot of international and local experience in recovering materials from the waste stream for the purpose of recycling.

Other risks for MRFs may be associated with fire arising within materials stored on site, potential dust emissions, and occupational health and safety issues for workers.

6.5 ENVIRONMENTAL CONSIDERATIONS

Environmental factors to be taken into account when evaluating the site for a MRF include:

Traffic

Traffic management measures should incorporate planning for traffic entering and leaving the facility, and safe traffic flows within the site.

Litter

The generation of litter in and around a MRF is likely during operation of the facility, and measures must be taken to minimise its impact.

The design of the MRF infrastructure should take into account the direction of prevailing winds. Regular litter clearing and ensuring all loads entering and leaving the site are covered are other measures that can be used[vi].

Odour

Municipal waste streams, particularly packaging materials that contained food, has a potential for odour. Good facility design can significantly reduce odour problems. The careful positioning the building and its doorways with respect to neighbours is a good measure to mitigate odour complaints. At the MRF building itself, exhaust fans with air filters and rooftop exhaust vents can further reduce off-site odour impacts.

Some of the operating procedures that can help reduce odours include:

- "First-in, first-out" waste handling practices that keep waste on site only for short periods of time;
- Removing all waste from the tipping floor or pit by the end of each operating day so that these surfaces can be swept clean and washed down;
- "Good housekeeping" measures, including regular cleaning and disinfecting of surfaces and equipment that come into contact with waste; and
- Water misting and/or deodorising systems.[vi]

Vermin

Rodents and birds can be a nuisance and a potential health concern at any waste facility. There are a number of basic design and operational elements that can control vermin infestation. For instance, good housekeeping practices are a simple and effective means of minimising their presence. These practices may include removing all waste delivered to the facility by the end of each day, and cleaning the receiving floor daily.[vi]

Noise

Heavy vehicle traffic and the operation of facility equipment (e.g. conveyors and front-end loaders) will be the primary sources of noise from a MRF. The design and operation of MRFs should incorporate measures that help reduce noise such as:

- Confining noisy activities within buildings or other enclosures as much as possible
- Arranging the site so traffic flows are not adjacent to properties that are sensitive to noise
- Conducting activities that generate the most amount of noise during the day.[vi]

Fire

MRFs must have fire response procedures which address fires that may occur at the facility themselves, in incoming loads, temporary storage areas, equipment and vehicles.

Facilities should have fire hoses or other fire fighting equipment in the area, in addition to ceiling mounted sprinklers.[vii]

Hazardous Materials

Hazardous materials procedures should include methods to identify and isolate hazardous materials, temporary storage and quarantine locations and methods, and emergency phone numbers.[vii]

6.6 APPLICATION OF MRFS

6.6.1 SET-UP TIMEFRAME

A newly procured fully automated system would have a lead of time (construction, delivery and installation of equipment) of approximately 6-18 months. At the other end of the scale, the MRF could be of a much simpler design i.e. a portal frame building with bunkers, picking stations and little automated equipment, in which case delivery could be in the region of four months, depending on market availability of the equipment and timeframes for development approval.

6.6.2 PLANNING AND DESIGN PROCESS FOR MRFS

There are three basic steps involved with the planning and design of MRFs[ii]:

1. Feasibility analysis;
2. Preliminary design; and
3. Final design.

Feasibility analysis

The feasibility analysis provides the decision makers with clear recommendations on the technical and economic merits of the planned MRF.

It will address the following topics:

The integrated waste management plan – The role of the MRF in achieving landfill diversion and meeting recycling goals;

Conceptual design – The type of MRF to be built, which materials are to be processed now and in the future, the design capacity;

Economics – Capital and operating costs, incomes from gate fees and sales of recyclables, their markets, and revenues for financing;

Ownership and operation – For example Build Own Operate or Build Own Operate Transfer model, contracting of operations; and

Procurement – Architect, engineer design, and contractor process, turnkey contracting or full service contract.

Preliminary design

The preliminary design includes developing the materials flow diagram for the MRF, the mass balances and loading rates for the unit operations (for example conveyors, screens, shredders) that make up the MRF. It also includes the layout of the facilities. The cost estimate developed in the feasibility stage is refined using actual price quotations from vendors.

Final Design

The final design stage is the preparation of final plans and specifications that will be used for construction. A detailed engineering cost estimate is developed. This can be used for the evaluation of contractor bids if a traditional procurement process is used.

6.7 BENEFITS AND BARRIERS OF TECHNOLOGY

There are many potential benefits of the MRF technology that can assist in the recovery of resources from the waste stream and therefore contribute to sustainability and recycling targets.

MRFs generally have a high processing efficiency to recover recyclables and prepare them for transport to reprocessors. MRFs can be flexible and designed to adapt to different sorting operations. They also have a positive impact on the community through the creation of employment opportunities, compared with disposal of material to landfill.

The main barriers to the uptake of MRF technology are associated with residual waste management operations, which are costly, and even more importantly with the risk associated with fluctuations in commodities markets. The fluctuation in the commodities markets can mean that a lower income than expected is received for the sorted materials.

7 SUMMARY OF WASTE TECHNOLOGY FEATURES

In the project brief, the DER identified a number of key features and parameters to be identified for each technology type and case study. This information has been collated in the following summary table. By collating information in this standardised and summary format, a comparison of different waste technologies should be simplified.

Table 4 - Summary Features – MRF Technology

Technology	1	2	3	4	5	6
	Process	Feedstock (type and tonnes)	Annual processing capacity (t/yr)	Place in waste hierarchy	Landfill diversion potential (%)	Products and residuals
Literature Review	A MRF uses a combination of manual and automated mechanical separation to recover recyclable products from either a fully mixed waste stream (usually Municipal Solid Waste (MSW) or mixed recyclables collected from the kerbside. The automated mechanical processes may comprise a combination of different unit operations to separate recyclables from the mixed waste, including air classification, screening, magnets, eddy current systems and near infrared optical technologies. At a dirty MRF, recovered recyclables will be of a lower quality and more contaminated than those from a clean MRF (which sorts a mixed recyclables waste stream) due to the putrescible content of the waste. Once sorted, the materials are baled to prepare them for transportation to the commodity markets.	Dirty MRF feedstock: A fully mixed waste stream (usually Municipal Solid Waste (MSW) or Commercial and Industrial (C&I) Clean MRF feedstock: Mixed recyclables collected from the kerbside	Typical throughputs at commercial facilities range from around 40,000 tpa - >200,000 tpa.	Recycling.	The overall landfill diversion is typically 40-60%.for a dirty MRF and 90% for a clean MRF	At a dirty MRF, around 10-20% of MSW feedstock is recovered as recyclables. These recyclables are typically: paper, cardboard, metals (aluminium, steel), plastics and glass. An RDF can also be produced from the biodegradable residue depending on the process, which may be 20-50% of the feed. A clean MRF will process 90% of the feedstock into paper, cardboard, metals (aluminium, steel), plastics and glass.

Technology	1 Process	2 Feedstock (type and tonnes)	3 Annual processing capacity (t/yr)	4 Place in waste hierarchy	5 Landfill diversion potential (%)	6 Products and residuals
Site A	The facility takes mixed recyclables from Local government kerbside collections and sorts them into material types using manual and mechanical systems. The operations include conveyors, screens, trommels, air classification, eddy current, magnets (metals) and NIR optical sorting for polymers. Manual picking consists of negative sorting to remove non-recyclable materials from the process, and post sort paper (the largest material stream). The materials are then sold as commodities to onshore and offshore markets.	Mixed recyclables from the yellow lidded kerbside bin: paper, cardboard, plastics, glass, steel and aluminium.	The facility processes 85,000tpa (1 shift over 5 days). The maximum processing capacity is 170,000-250,000tpa.	Recycling.	95% of the materials received at the facility are diverted from landfill.	The products at the facility include: paper (55%), glass (30%), plastics (4%), steel (3%), aluminium (0.5%), The residue makes up 7.5% which is disposed to landfill.

Technology	1 Process	2 Feedstock (type and tonnes)	3 Annual processing capacity (t/yr)	4 Place in waste hierarchy	5 Landfill diversion potential (%)	6 Products and residuals
Site B	There are two parts to the process of this MRF. One is the baling of cardboard, which consolidates source separated cardboard delivered to the MRF from C&I businesses. The sorting and separation section of the facility sorts separately collected kerbside recyclables. Screening is used to separate paper from containers. Paper and card is further separated by air classification, glass is hand-sorted into colours. Magnets and eddy currents separate steel and aluminium, and plastics are further sorted into three categories using near infra-red optical sorting processes. Glass fines are consolidated as a separate fraction. Any oversized materials or contaminants which are non-conforming are landfilled as residual waste	The feedstock is source separated C&I cardboard waste. Mixed recyclables from the kerbside: metals, glass, plastic containers, paper and card.	The maximum processing capacity of the facility is 75,000 tonnes per annum. This is based on an 18 tonnes per hour throughput within scheduled operating hours.	Recycling.	The overall landfill diversion from both C&I and kerbside collected recyclables is 90%	The products are: glass separated into colours (brown, green and colourless), glass fines, plastics (PET, HDPE and Mixed plastics), mixed paper, cardboard, steel, aluminium and a residue stream consisting of feed contaminants.

Technology	7	8	9	10	11	12	13
	Capital cost	Operational cost	Gate fees	Set-up timeframe	Lifespan	Technology/ facility footprint	Buffer
Literature Review	$500,000- $40M depending on the complexity of the process and equipment employed.	Estimated at $45-90 per tonne	No literature information available.	The set up timeframe is similar to other waste facilities (up to 3 years for planning consent and 6-18 months for construction)	Lifespan of a MRF is between 10-20 years depending on the operations, technology upgrades and maintenance.	For a 50,000 tonne facility, 1-2 ha site footprint with a 2000-3000 m^2 facility footprint	Buffers will be required to restrict on noise and hygiene impacts.
Site A	The operator advised that a high technology MRF facility (mostly automated sorting) would have an equipment cost of $12m-$15m. A low technology system (combination of manual and automated sorting) would cost $7m. (This does not take into account the cost of the land or building construction.)	$70-85 per tonne	The gate fee is negative (the facility pays the local government a fee) due to the price of commodities being high.	The timeframe to set up the MRF was three years, which included development approval and construction.	The lifespan is up to fifteen years. Advances in technology impact the feasibility of the MRF. Glass sorting equipment is subject to high wear and tear and will eventually require replacement.	The footprint of the MRF facility is 0.4Ha.	There is no buffer in place. The site is located in an industrial area.

Technology	7	8	9	10	11	12	13
	Capital cost	Operational cost	Gate fees	Set-up timeframe	Lifespan	Technology/ facility footprint	Buffer
Site B	The capital costs do not include the acquisition of the land. The cost was $4.5m for equipment. The building construction cost was $2.5m.	No information was provided.	$0-50 per tonne.	The general set-up timeframe is between 12-18 months for development approval, (providing there is no resistance) and 12-18 months for construction.	The lifespan is approximately 20 years due to advances in technology and to be cost competitive.	1-1.5 ha in total for full site.	The immediate boundary is the buffer. The site is located in a light industrial area.

Technology	14	15	16	17	18
	Emissions	Environmental impacts	Social impacts	Supporting technology required	Risks
Literature Review	n/a MRFs do not directly generate emissions.	Environmental impacts can include: traffic, litter, odour, vermin, noise, and fire.	The social impacts would be associated with employment and resource recovery.	MRF can work in conjunction with other waste operations such as transfer stations, MBT facilities to extract recyclables.	The main risks include: risk of fire, risk to health and safety of staff, risk of redundancy of technology and breakdown of facility and fluctuations in commodities market.
Site A	n/a	The largest impact is noise.	Provides employment and promotes landfill diversion.	MRFs divert waste from landfill, recycle materials and save virgin resources.	Technical risk includes the breakdown of equipment. Financial risk involves the fluctuations in the commodities markets. The risk of fire is also significant.
Site B	n/a	Impacts to consider are dust and noise.	The MRF has an educational facility and provides employment.	MRFs are a key component of the integrated waste system and are very compatible. They are required as part of the overall waste strategy for the community.	Financial risks from the recovery of the commodity materials as prices can fluctuate. Health and Safety risks from the MRF process due to confined closed working areas. Risk of redundancy of the process over the lifetime of the facility as technology advances changes. Contractual risk from breakdown of facility.

Technology	19	20	21	22	23	24	25
	Applicability to local context	Technology maturity	Availability rate	Regional penetration	Benefits	Barriers	Other
Literature Review	When siting a MRF, the location needs to consider the proximity of the facility to end markets and waste generation.	MRF technologies are proven globally.	MRFs can be available as required. Maintenance can be planned to be undertaken during periods of downtime (weekends, holidays).	There are many MRFs operating within Australia and worldwide.	The benefits of MRFs are: resource recovery and diversion from landfill.	The barriers of MRFs are: securing feedstock and fluctuating commodities markets.	
Site A	A MRF must be located in the city (metropolitan area). In order to be viable, the facility should be close to where the feedstock is generated and close to end markets.	The MRF technology is well proven.	The facility has no shutdowns. Planned works are undertaken on weekends or after hours. This could be a problem if the facility was operating 24/7.	There are a number of MRFs operating in the states of NSW and Victoria as well as Perth.	The benefit s of MRFs are: reduced environmental impact from landfilling of waste and resource recovery.	Commercial barriers include: feedstock providers having an unrealistic expectation of the commodities market; many players in the market and export markets not giving a return. The commodities prices have halved within the last three years.	

Technology	19	20	21	22	23	24	25
	Applicability to local context	Technology maturity	Availability rate	Regional penetration	Benefits	Barriers	Other
Site B	The facility must be in proximity to the waste generation (populated areas) and end-use of recyclables. If markets are for export, there should be a reasonable distance to outlets for export.	The facility has been in operation since 2003. MRF Technology has been operating since the late 90s and is proven.	The MRF is available every day. Maintenance is undertaken during non-operational hours.	There are approximately 30 MRFs operating in Australia.	The benefits of MRFs are: diversion from landfill, resource recovery, proving employment opportunities.	The major barriers are capital cost and the approval process. Other barriers are obtaining a continuous feedstock of materials and available markets for the end products.	

8 STUDY SYNOPSIS

Technology	1	2	3
	Process	Feedstock (type and tonnes)	Annual processing capacity (t/yr.)
MRF Study Synopsis	A MRF uses a combination of manual and automated mechanical separation to recover recyclable products from either a fully mixed waste stream (usually Municipal Solid Waste) or mixed recyclables collected from the kerbside. The automated mechanical processes may consist of a combination of different unit operations to separate recyclables from the mixed waste including, air classification, screening, magnets, eddy current systems and near infrared optical technologies. At a dirty MRF, recyclables recovered will be of lower quality and more contaminated than those from a clean MRF (which sorts a mixed recyclables waste stream) due to the putrescible content of the waste. Once sorted, the materials are baled to prepare them for transportation to the commodity markets.	Feedstock at a dirty MRF is a mixed waste stream (usually Municipal Solid Waste (MSW) or Commercial and Industrial (C&I) The feedstock at a clean MRF consists of mixed recyclables collected form the kerbside. Typical recyclables are: paper, cardboard, plastics, glass, steel and aluminium.	Typical throughputs at commercial facilities range from around 40,000tpa up to >200,000tpa. The two facilities involved in the study processed 85,000tpa and 75,000tpa.

Technology	4	5	6
	Place in waste hierarchy	Landfill diversion potential (%)	Products and residuals
MRF Study Synopsis	Recycling.	The overall landfill diversion is typically 40-60%.for a dirty MRF and 90% for a clean MRF. The two clean MRFs involved in the study reported landfill diversion figures of 90% and 95%.	At a dirty MRF, around 10-20% of MSW feedstock is recovered as recyclables. These recyclables are typically: paper, cardboard, metals (aluminium, steel), plastics and glass. An RDF can also be produced form the biodegradable residue depending on the process, which may be 20-50% of the feed. A clean MRF will recover 90% of the feedstock into paper, cardboard, metals (aluminium, steel), plastics and glass. The remaining residue will require disposal.
Technology	**7**	**8**	**9**
	Capital cost	**Operational cost**	**Gate fees**
MRF Study Synopsis	The capital cost for a MRF will be between $500,000 - $40M depending on the complexity of the process and equipment employed. A high technology MRF (mostly automated sorting) would have an equipment cost of $12m-$15m. A low technology system (combination of manual and automated sorting) would cost $4.5-$7m.	The operating cost for a clean MRF is typically around $45-90 per tonne, however this will depend upon the facility capacity and the level of automation employed.	No literature information was available for gate fees, however one of the facilities indicated that the gate fee was negative (i.e. the facility pays the local government a fee) due to the price of commodities being high. The other facility reported a gate fee of $0-$50 per tonne.

Technology	10 Set up Timeframe	11 Lifespan	12 Technology Footprint
MRF Study Synopsis	The set up timeframe for a MRF is between 12- 36 months for planning consent and 6-18 months for construction. One of the facilities interviewed had a total set up time frame of three years, which included development approval and construction.	The lifespan of a MRF is between 10-20 years depending on the operations, technology upgrades and maintenance. Advances in technology impact the feasibility of the MRF. If glass sorting is undertaken, more wear and tear occurs on the equipment.	The footprint at a MRF varies between MRF types. A dirty MRF will typically require 2-4ha, whereas a clean MRF requires only1-2ha.
Technology	**13 Buffer**	**14 Emissions**	**15 Environmental impacts**
MRF Study Synopsis	Buffers will be in reference to restriction on noise and site hygiene where neighbours are present. If he MRF is sited in an industrial area, it is unlikely to have a buffer requirement.	n/a - MRFs do not directly generate emissions.	Environmental impacts can include: traffic, litter, odour, vermin, noise, and fire. The largest impact is noise.
Technology	**16 Social impacts**	**17 Supporting technology Required**	**18 Risks**
MRF Study Synopsis	The social impacts would be associated with providing resource recovery, employment opportunities and education where there is an educational centre provided.	MRF work in conjunction with other waste operations such as transfer stations and MBT facilities to extract recyclables.	The main risks include: risk of fire, risk to health and safety of staff, risk of redundancy of technology and breakdown of facility and fluctuations in commodities market.

Technology	19	20	21
	Applicability to local context	Technology maturity	Availability rate
MRF Study Synopsis	When siting a MRF, the location should be in a metropolitan area and needs to consider the proximity of the facility to end markets and waste generation (where the feedstock is generated). If markets are for export, there should be a reasonable distance to outlets for export.	MRF technology is well proven globally.	MRFs can be available as required. Maintenance can be planned to be undertaken during periods of downtime (weekends, holidays). Maintenance requirements generally preclude MRF continuous MRF operation on a 24/7 basis.
Technology	22	23	24
	Regional penetration	Benefits	Barriers
MRF Study Synopsis	There are approximately 30 MRFs operating within Australia.	MRF technology reduces the environmental impact of landfilling waste through the recovery of resources and the avoidance of virgin resource use. They also provide employment opportunities.	The commercial barriers to MRF include: securing feedstock at a reasonable gate fee and the fluctuating commodities markets where returns may not be made if prices of materials decrease drastically. Competition is a risk, there are many players in the market. The other major barriers are capital cost and the approval process.
Technology	25		
	Other		
MRF Study Synopsis			

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APPENDIX A

MRF PROCESS FLOWS

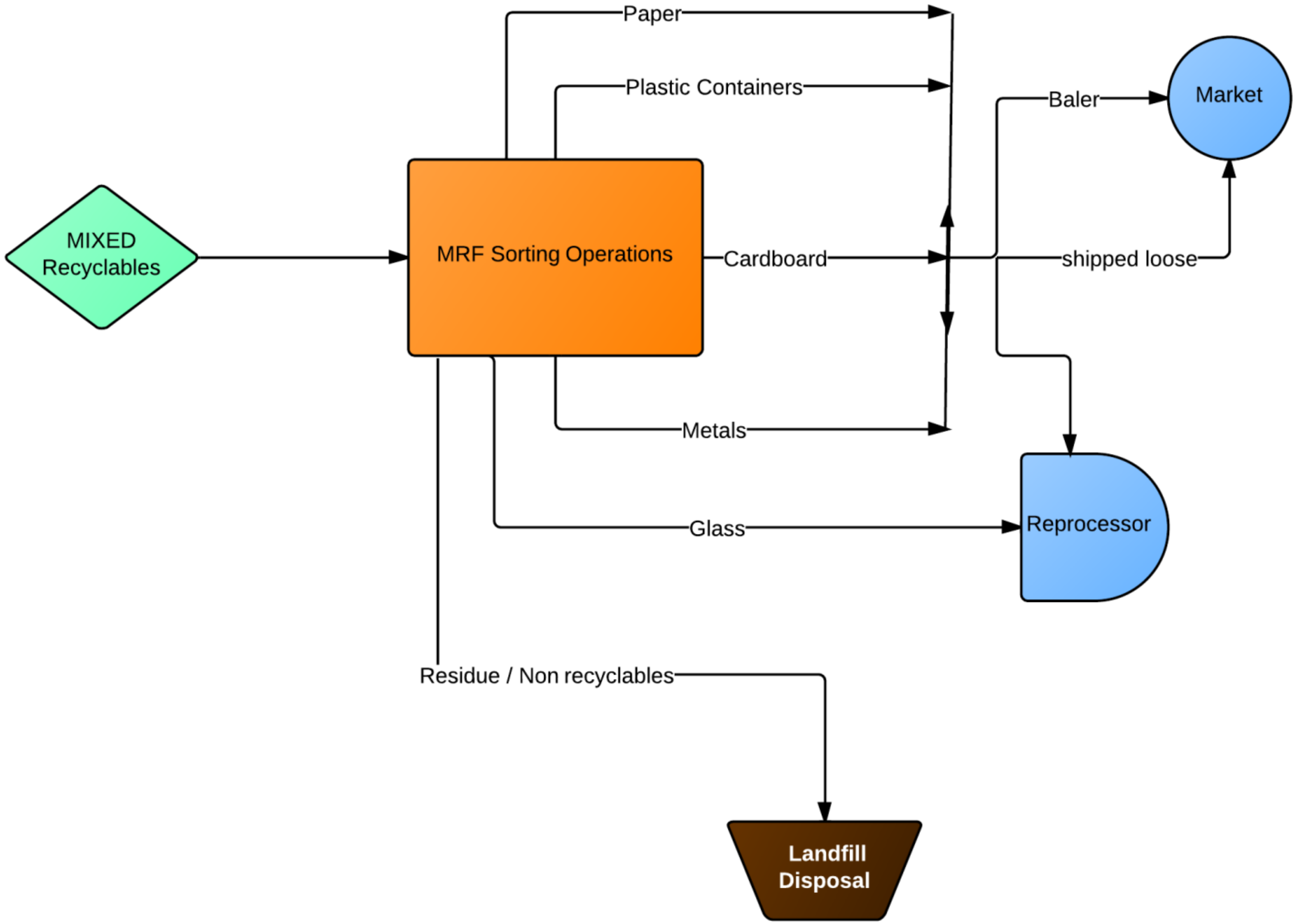

Figure 0-1 Clean MRF Process Flow

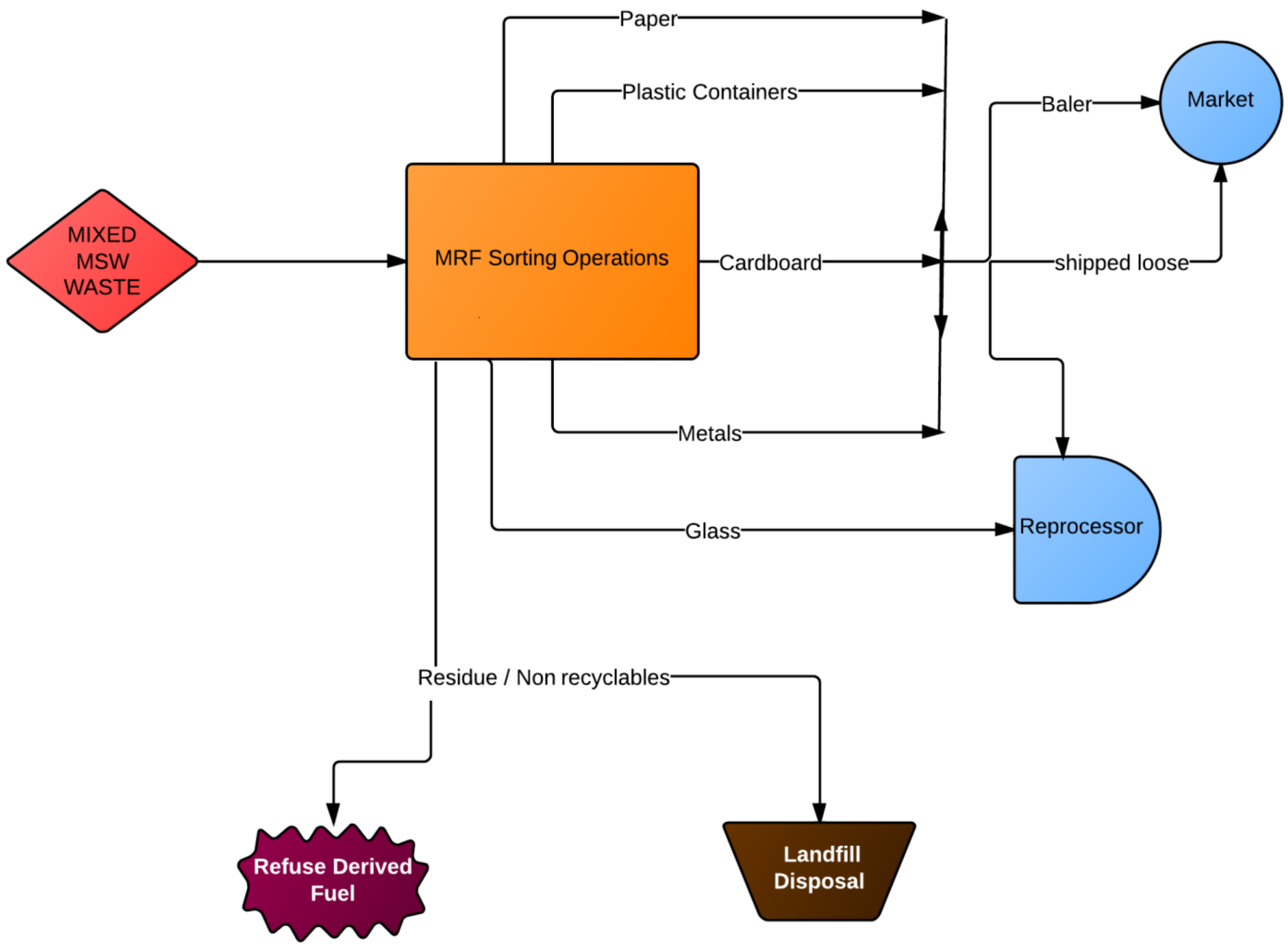

Figure 0-2 Dirty MRF – Typical Process Flow Block Diagram