Reclay StewardEdge

Product Stewardship Solutions

Bluewater Recycling Association

Material Recovery Facility Mass Balance and Efficiency Study

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1. Executive Summary

On behalf of Bluewater Recycling Association (BRA) and with the support of the Continuous Improvement Fund (CIF), Reclay StewardEdge (RSE) has carried out a performance assessment of BRA's Material Recovery Facility (MRF) and identified areas that could benefit from improvements.

The primary objective of this project was to evaluate the performance of the sorting equipment and manual stations, and to evaluate the maintenance and condition of the sorting line at the single-stream MRF. These assessments are intended to evaluate the MRF's current effectiveness to sort incoming recyclables, in order to inform recommendations that could result in increased recovery of materials, and potentially increased revenues.

RSE worked with BRA's staff to conduct a controlled test to measure performance. Efforts were made to ensure the test was reflective of normal operations. Prior to the test, the sorting line was shut down, and all belts and bunkers were emptied. A representative sample was collected from the tip floor (approximately 1.5 tonnes of single stream materials) and then introduced to the line to be sorted under normal conditions. Due to the complexity of the MRF, several shorter samples were taken (such as glass, PET, and HDPE processing) for shorter periods (10-minute samples for glass, and three-minute samples for PET and HDPE), and then "scaled up" to be on par with the other sample data.

Following the audit, RSE analyzed the results and summarized the key findings within this report:

- A significant amount (44%) of OCC ends up in the mixed fibre bunker, resulting in decreased revenues for that material. This is due primarily to the low efficiency rate (38%) of the OCC Screen (S4).
- A significant amount of ONP (88%) also ends up in the mixed fibre bunker, resulting in decreased revenues for that material. This is due primarily to the low efficiency rate (26%) of the Medium Disc Screen (S8).
- The mixed fibre bunker receives 19% of the residue that enters the facility, which could potentially devalue or jeopardize the marketability of the material.
- The Container Optical Sorter has an efficiency rate of 66% for PET and 77% for HDPE, and 26% for MRP.
- The efficiency rate of the eddy current magnet is only 70%. A typical efficiency rate for an eddy current magnet is 90%. Approximately 8% of the aluminum ends up in mixed fibre, and 10% in residue. This results in a loss of revenue.
- A significant amount of office paper (37%) winds up in the residue stream, resulting in a loss of revenue for that material.

Based on these observations, RSE recommends the following changes to BRA and CIF, in order to improve operations and boost the MRF's revenues:

- **Improve the capture of OCC:**
    - Replace the current OCC Screen as it currently has an operating efficiency rate of 38%. It is imperative that the OCC be removed more efficiently early in the sort process. This will ensure 1) the highest revenues for OCC, rather than being capture with mixed fibre (significantly lower commodity value); and 2) that OCC is not blocking material further down the line and overburdening equipment positioned further downstream.
    - Add a new fibre optical sorter to targets "browns". Nearly one third of the fibre entering the MRF is moving on to the container line. This results in overburdening sorters and equipment on the container line. Only 50% of the OCC is being marketed as OCC, as 44% ends up in mixed fibre. This results in decreased revenues.

With market specifications for mixed fibre becoming more stringent, lowering contamination rates and decreasing the portion of brown fibre in the mix will be critical. Currently 19% of the residue entering the facility ends up in mixed fibre.

- **Improve the capture of office paper:**
    - It is recommended that office paper be targeted for manual sort on the pre-sort line, to reduce the amount of office paper (37%) that is disposed as residue.
- **Improve the capture of aluminum:**
    - Ensure the eddy current magnet is adjusted and maintained properly to maximize the amount of aluminum removed. Currently the eddy current magnet has an efficiency rate of 70%, which is much lower than expected.
- **Improve the capture of PET, HDPE, and MRP:**
    - Make adjustments to the Container Optical Sorter so that it more successfully removes PET, HDPE, and MRP. Currently the Container Optical Sort line has an efficiency rate of 67% for PET and 61% for mixed fibre on the first pass. On the second pass, the efficiency rate for HDPE is 77% and 26% for MRP.
- Additionally, it is recommended that the BRA, as the entity that conducts education and outreach to its customers, provide specific outreach to customers to remind them to only place plastic film in the recycling cart if it is bundled with other film, not loose, and that only clean film should be included.

2. Objectives and Background

2.1. Study Objectives

The Bluewater Recycling Association (**BRA**) and the Continuous Improvement Fund (**CIF**) commissioned this study to evaluate sorting performance of its single-stream Material Recovery Facility (**MRF**). The BRA MRF interfaces automatic processing equipment with manual sorting activities in order to cost effectively sort commingled single stream materials into marketable products.

The MRF is somewhat unique in that, on the container line, a Container Optical Sorter with multiple channels and air classifying systems ejects the targeted materials in opposite directions. The Container Optical Sorter is then used in a batch processing function to conduct QC of previously sorted PET and HDPE. This study analyzes the efficiency and purity of the equipment performance, as well as the overall (including manual sorter) outcome of the operations.

In order to provide improvement options, detailed on-site and off-site analyses were undertaken. Evaluations conducted include:

1. Mass Balance: included an audit of the equipment and material flow, as well as a visual assessment to determine the capture of targeted materials and composition of the residue stream.

2. Off-Site Modelling and Analysis: included quantification of equipment efficiency and material purity rates, material capture rates and an associated financial analysis. Off-site analysis involved compilation of the data collected through the audit as well as an equipment and maintenance record review in order to determine the performance baseline of the system. The financial analysis also estimated opportunities for the MRF to increase revenue earning potential.

2.2. Background

BRA provides collection and processing/marketing of recyclables services (along with waste collection services) for Huron, Lambton, Middlesex, and Perth Counties. The MRF is capable of processing 50,000 tons per year, but currently processes between 17,000 and 18,000 tonnes annually.

BRA collects garbage and recyclables, in some locations, using a single multi-compartment vehicle to increase efficiency and minimize environmental impacts. The MRF is designed to receive single-stream recyclables.

2.3. Description of MRF Operations

Materials that arrive at the MRF are processed using a combination of mechanical equipment and manual sorters/QC operators. The material flow is as follows:

1) Pre-sort – Material goes through a drum feeder, then three sorters manually positively sort:
    - film plastic,
    - oversized rigid plastics,
    - bagged shredded paper, and scrap metal.
2) OCC screen – Material then moves over an OCC screen, where a manual sorter QC's to remove residue, film plastic and containers from the overs.
3) Small disc screen – Materials (the unders) that have fallen through the OCC screen passes over a small disc screen which removes glass and other fines;
4) Medium disc screen – Negatively sorts ONP, and manual QC sorters (2) remove film plastic, OCC, mixed fibre, residue, containers, and fibre/film composites.
5) 3D screen -- Material passes over a 3D screen which removes additional glass and other fines and containers are directed to the container sort line.
6) Fibre optical sorter --Fibre material moves through an optical sorter targeting mixed fibres. Two manual sorters QC for residue, scrap metal, fibre/film composites, and containers.
7) Container pre-sort – Remaining materials, containers, go through a manual QC (1) where the sorter removes residue, oversized rigid plastics, scrap metal and fibre.
8) Magnet -- steel cans are removed with a magnet.
9) A perforator perforates containers to empty containers of any liquid and to deflate them.
10) A 2-inch screen removes additional glass fines.
11) An optical sorter (first pass) separates PET (stored in an interim hopper) from mixed fibers/polycoat (first pass), with a QC sorter on the mixed fiber side removing aluminum, and residue.
12) The material that passes through the optical sorter (first pass) goes through an eddy current separator, which removes aluminum;
13) Containers remaining on the line pass through the optical sorter again (second pass), where HDPE (stored in an interim hopper) is separated from mixed rigid plastics (a QC sorter is on the mixed rigid plastics line to remove residue, HDPE, aluminum, PET and fibre).
14) Material passing through goes through a QC (1 sorter) where steel, PET, and HDPE are removed.
15) Sorted HDPE and PET from prior passes are alternatively processed through the Container Optical Sorter for a third pass, at which time any non-targeted material is ejected, and the PET or HDPE (depending on the material being processed), is negatively sorted. A manual QC sorter sorts HDPE (on the PET pass, or PET on the HDPE pass), MRP, residue and aluminum from the negatives of the Optical Sorter.

The process at the MRF is illustrated in the overall facility material flow presented in Figure 1. Additional Figures in Appendix A provide enlarged images of the material flow.

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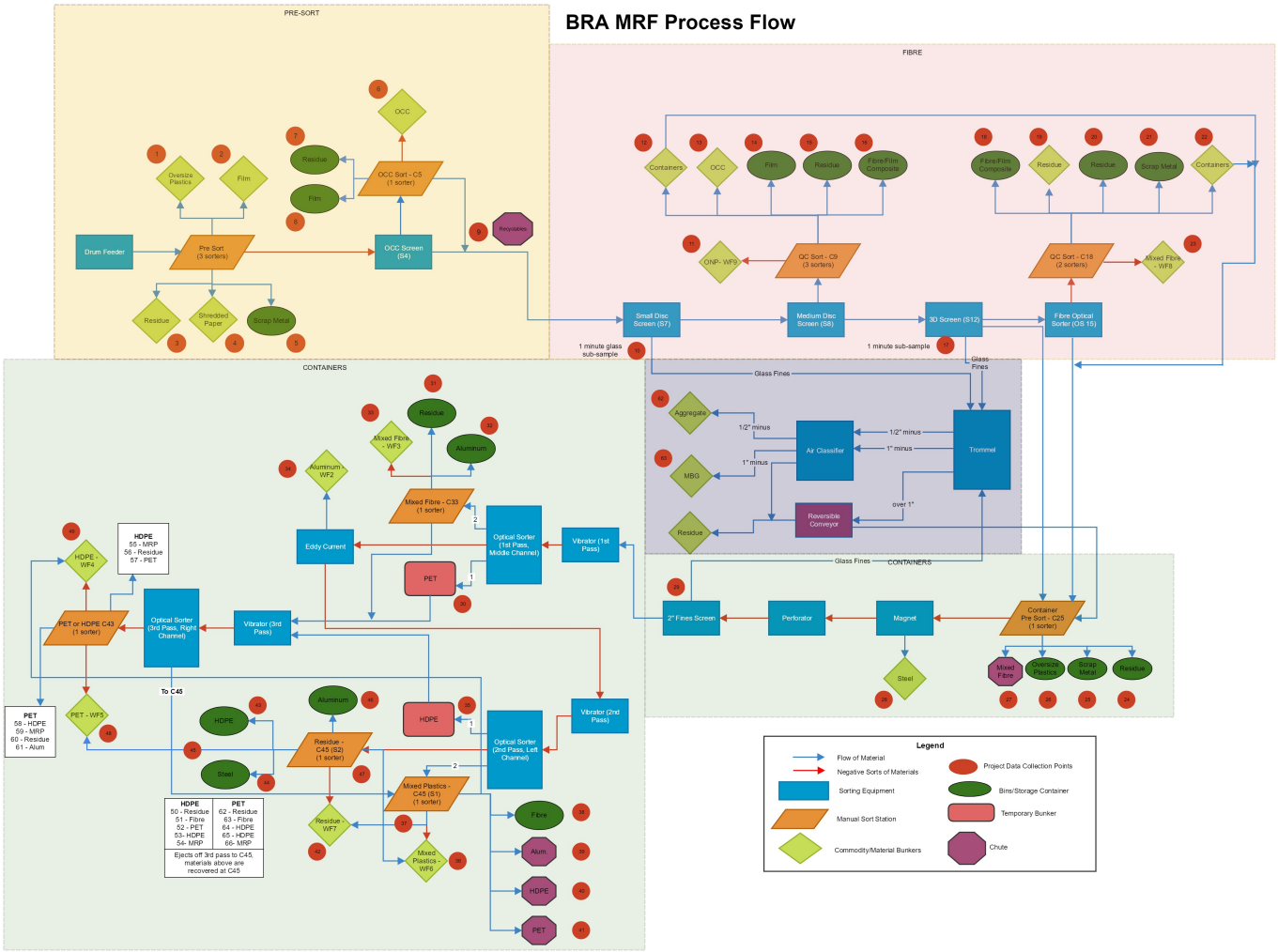
Figure 1: Overall BRA MRF Process Flow



2.4. Limitations of Results

The following limitations should be considered when interpreting the results of this review:

- Accuracy of Data: No investigation was conducted as to the completeness or accuracy of statements made or data obtained. Information on the BRA MRF was limited to data collected during the RSE tests and on-site observations and from publicly available sources (e.g., annual reports, studies, websites, etc.) as well as information willingly disclosed by BRA representatives.

- Unaudited Information: The data provided in this report has not been audited or otherwise verified. There have not been any independent audit activities performed or verification of the information contained in any of the materials or statements provided by the Region under consideration.

3. Methodology

At the start of this study, RSE conducted a walkthrough of the MRF to observe normal sorting operations and document the flow of materials. During this site visit, RSE also identified data collection points throughout the sorting operations which were then used to conduct the analysis of the outlined system (see Figure 1).

Following the site visit, and under normal sorting operations, RSE worked with MRF staff to conduct the mass balance audit. The mass balance audit involved emptying all bunkers and conveyor belts to conduct the audit without contending with previously sorted material. Additionally, temporary storage containers (e.g. bins) were used in sorting locations in place of bunkers where materials are normally deposited (e.g. OCC captured at the OCC QC stations) and QC return chutes were isolated or blocked to ensure material flow and sorting efficiency could be accurately tracked. Due to the complexity of the MRF operations, some shorter audits (e.g., 10-minutes for the glass sorting operation and three minutes for the Container Optical Sorter, third pass) were conducted to gain more complete knowledge of the effectiveness of this equipment, and the outcome of these processes.

Data from the MRF was then used to “scale up” the audit data to be representative of annual operations, and RSE staff analyzed the efficiency of the equipment, end results of the processes, synthesizing information to identify potential ways to improve operations, and potential revenues that could potentially be earned.

4. Observations and Results

During the field study, data was capture and tracked at 65 different points. The data collected was analyzed by the project team to identify the following MRF operational metrics:

Tip Floor Composition: The weight and composition of each materials received by the BRA MRF that is available for sorting.

Capture Rate: The portion of targeted material captured (correctly sorted) after the sorting process, including manual sort stations, equipment, and additional QC to recover previously missed items.

Efficiency Rate: The ability of an individual piece of equipment (or sorter/sort station) to capture the targeted material type that reaches it (e.g., excludes material loss that occurs prior).

Purity Rate: The amount of targeted materials sorted/ejected divided by the amount of total materials sorted/ejected by the equipment.

The results of these analyses are described below.

4.1. Tip Floor Composition

For the purposes of this study, the tip floor composition was determined after completing the material flow study. The cumulative weight of each material collected during the material flow study represents the total weight of the material introduced into the system (taken from the tip floor). The results of the tip floor composition are shown in Table 1. Note that materials are the description of the incoming material type, and the commodity type indicates the end product material would be marketed as after processing.

Table 1: Tip Floor Composition and Materials/Commodity

	Material Category	Commodity	Tip Floor Composition
Paper	Newspapers including Inserts and Flyers	ONP	12.3%
	Magazines, catalogues, phone directories	Mixed Paper	5.2%
	Office paper	Mixed Paper	8.3%
Paper Packaging	Corrugated cardboard & Kraft paper	OCC	16.8%
	Boxboard & molded pulp	Mixed Paper	9.3%
	Gable-top cartons	Mixed Paper	1.4%
	Aseptic cartons	Mixed Paper	0.2%
	Paper cups - hot	Mixed Paper	0.5%
	Paper cups - cold	Mixed Paper	0.1%
	Paper ice cream containers	Mixed Paper	0.1%
	Other laminated packaging	Residue	0.1%
	Composite cans	Steel	0.2%
Plastics **e.g.:** **- PET (#1) bottles** **- HDPE (#2) mixed** **- Mixed Plastics** **etc.**	Clear PET bottles, jugs and jars	PET	4.6%
	PET thermoforms	PET	1.4%
	Opaque PET	Mixed Plastics	0.1%
	HDPE bottles, jugs and jars	HDPE	2.7%
	PVC containers	Mixed Plastics	0.0%
	LDPE/HDPE film	Film	1.1%
	Plastic laminates	Residue	1.4%
	#4 LDPE - rigid	Mixed Plastics	0.3%
	#5 PP - bottles and jugs	Mixed Plastics	1.1%
	#6 PS - expanded polystyrene	Mixed Plastics	0.2%
	#6 PS - non-expanded	Mixed Plastics	0.4%
	Single-serve coffee pods (Keurig, Tassimo)	Mixed Plastics	0.1%
	Black plastic	Mixed Plastics	0.5%
	Other rigid plastic packaging	Bulky Plastics	2.6%
	Large HDPE & PP pails & lids	Bulky Plastics	0.0%
	Other plastics - non-packaging/durable	Residue	1.6%
Metals	Aluminum food and beverage cans	Aluminum	2.7%

	Material Category	Commodity	Tip Floor Composition
	Aluminum foil & aerosols	Aluminum	0.3%
	Steel food and beverage cans	Steel	5.0%
	Steel aerosol containers	Steel	0.1%
	Other metal containers	Scrap Metal	1.2%
Glass	Clear glass food and beverage containers	Glass	6.4%
	Colored/mixed glass food/bev. containers	Glass	1.4%
	Non-recognizable glass	Glass	7.4%
Organic Waste	Food or liquid waste (from containers)	Residue	0.1%
	Food or liquid waste (not from containers)	Residue	0.7%
Electronics	All waste electronics	E-Waste	0.0%
Household Waste	All household hazardous waste including propane tanks, needles, CFL bulbs, etc.	Residue	0.1%
Other	Other non-recyclables	Residue	2.2%
TOTAL			**100%**

4.2. Capture Rates

As described above, a capture rate is the portion of targeted material that is correctly sorted into the commodity listed in Table 1. This includes the sorting process conducted at all manual sort stations, equipment, and additional QC to recover previously missed items. In some cases a portion of a material type might not be captured as ideally destined (e.g., ONP into the ONP bunker), instead a portion of the material may end up in an acceptable bunker (e.g., ONP into a mixed paper bunker). The incorrect capture of materials may downgrade the quality of the commodity resulting in reduced revenues (marketing newsprint as mixed paper). Table 2 provides a summary of material capture rates observed at the Bluewater MRF, including such instances of acceptable mis-sorts, as well as where non-captured materials tend to be directed.

Table 2: Material Capture Rates at Bluewater MRF

Material Type	Capture Rates – Desired Commodity Bunker	Capture Rates- Secondary Commodity Bunker	Total Capture Rate	Primary Mis-Sort Locations
Newsprint, flyers and inserts	**26%**	**73% Mixed Fibre**	**99%**	• **1% Residue**
Telephone directories, magazines, and boxboard	**88% Mixed Fibre**	**4% ONP**	**92%**	• **7% Residue**
Office paper	**60%**	**NA**	**60%**	• **37% Residue**

Material Type	Capture Rates – Desired Commodity Bunker	Capture Rates- Secondary Commodity Bunker	Total Capture Rate	Primary Mis-Sort Locations
	Mixed Fibre			
Corrugated cardboard	**50%**	**44% Mixed Fibre**	**94%**	• **5% Residue**
Polycoat	**91% Mixed Fibre**	**NA**	**91%**	• **8% Residue**
PET	**76%**	**NA**	**76%**	• **14% Mixed Rigid Plastics** • **8% Residue**
Other plastics, opaque PET (mixed rigid plastics)	**42%**	**NA**	**42%**	• **42% Residue** • **14% Mixed Fibre**
HDPE	**77%**	**NA**	**77%**	• **11% Residue** • **7% Mixed Rigid Plastics**
Film	**62%**	**NA**	**62%**	• **33% Residue**
Bulky & durable plastics	**5%**	**22% Mixed Rigid Plastics**	**27%**	• **61% Residue**
Aluminum	**80%**	**NA**	**80%**	• **10% Residue** • **8% Mixed Fibre**
Steel	**96%**	**NA**	**96%**	• **3% Mixed Fibre** • **1% Residue**
Glass	**76% Mixed Broken Glass**	**20% Aggregate**	**96%**	• **4% Residue**
Scrap Metal	**58%**	**29% Steel**	**87%**	• **12% Residue**
Residue	**66%**	**NA**	**66%**	• **19% Mixed Fibre** • **8% Mixed Broken Glass**

As Table 2 indicates, there are opportunities to capture a higher percentage of some material types, or to capture them where they will earn higher revenues. For example, 37% of office paper ends up in residue. While 94% of corrugated cardboard is captured, 44% of it is in mixed paper, which is sold at a significantly lower price compared to OCC. Similarly, 73% of newsprint, flyers and inserts ends up in mixed paper, not sorted into ONP.

On the container side there may be opportunities to recover more PET as 14% ends up with mixed rigid plastics and 8% with residue. Similarly, 11% of HDPE ends up in residue, and 7% in mixed rigid plastics. Aluminum, a high-value material, is recovered at a rate of 80%; however, 10% goes to residue and 8% to mixed fibre. It is interesting to note that 12% of scrap metal goes to residue. Additionally, 19% of residue in the MRF ends up in the mixed fibre, which could potentially impact the quality (thus marketability and value) of market mixed fibre, and 8% to mixed broken glass.

4.3. Efficiency Rates

Efficiency rates describe the ability of an individual piece of equipment or sorter(s) to capture the targeted material type that reaches it. In other words, if material that would normally be targeted by the piece of equipment or sorter(s) has been mis-sorted earlier in the line, it does not "count against" the sorter or equipment. RSE calculated efficiency rates for sorters and equipment. The efficiency rates for the installed pieces of equipment are presented in Table 3, and the efficiency rate for sorters at each manual sort station is presented in Table 4.

Table 3: Efficiency Rates for Equipment

Equipment/Sort Station	Map Location/ Sorted Material Location	Targeted Commodity	Efficiency Rate
OCC Screen (S4)	6	OCC	38%
Small Disc Screen (S7)	10	Mixed Broken Glass (MBG)	51%
Medium Disc Screen (S8)	11	ONP	26%
3D Screen (S12)	17	MBG	61%
Fibre Optical (OS15)	23	Mixed Fibre	62%
Magnet	28	Steel	99%
2" Screen	29	MBG	82%
Container Optical – First Pass	30	PET	67%
	33	Mixed Fibre	56%
Eddy Current	34	Aluminum	70%
Container Optical – Second Pass	35	HDPE	77%
	36	Mixed Rigid Plastics (MRP)	26%

Some of the equipment with the highest efficiency rates include the steel magnet, with an efficiency rate of 99%, and the 2" Screen, with an efficiency rate of 82% for mixed broken glass, The second pass of the Container Optical Sorter has a relatively high efficiency rate for HDPE (77%),

Efficiency on the fibre line could be greatly improved. The fibre Optical sorter, targeting mixed fibre, has an efficiency rate of 62%, The OCC screen has an efficiency rate of 36%, which is a clear opportunity for improvement and, if improved, would likely improve efficiency rates for subsequent equipment. Additionally, the Medium Disc Screen, targeting ONP, has an efficiency rate of just 26%. Consequently, most of the ONP materials ends up in the mixed fibre bale

There are also opportunities for improvement, including the first pass of the Container Optical Sorter, which has an efficiency rate of 67% for PET. The efficiency rate for the eddy current, 70%, is relatively low and, as stated above, the second pass of the Container Optical Sorter has a low efficiency rate for mixed rigid plastics (26%).

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Table 4: Efficiency Rates for Sorters

Equipment/Sort Station	Map Location	Targeted Material	Estimated Efficiency Rate
Pre-Sort	1	Bulky Plastic	0%
	2	Film	36%
	3	Residue	5%
	5	Scrap	25%
OCC Sort (C5)	7	Residue	84%
	8	Film	99%
QC Sort (C9)	15	Residue	81%
	13	OCC	100%
	14	Film	88%
QC Sort (C18)	19	Residue	34%
Container Pre-Sort (C25)	27	Mixed Fibre	6%
	26	Bulky Plastic	4%
	24	Residue	32%
Mixed Fibre QC (C33)	31	Residue	51%
	32	Aluminum	48%
MRP QC (C45)	37	Residue	85%
	38	Mixed Fibre	71%
	39	Aluminum	87%
	40	HDPE	76%
	41	PET	57%
Residue QC (C45)	43	HDPE	19%
	48	PET	52%
	46	Aluminum	65%
	36	Mixed Rigid Plastics	20%

In terms of efficiency rates at manual sort stations, one significant opportunity for improvement is the Container Pre-Sort (C25) where the efficiency rate for mixed fibre is only 6%, and the efficiency rate for bulky plastic is only 4%. Therefore, a significant portion of these materials move further along the container sort line.

Another opportunity for improvement is the Mixed Fibre QC (C33) where only 48% of the aluminum cans available are sorted. Similarly, the Mixed Rigid Plastic QC (C 45) has an efficiency rate of only 57% for PET and 76% for HDPE.

Finally, the Residue QC (C45) achieves only a 19% efficiency rate for HDPE, a 20% efficiency rate for mixed rigid plastics, a 52% efficiency rate for PET, and a 65% efficiency rate for aluminum. This sorter appears to be overburdened.

4.4. Purity Rates

Purity rates describe the portion of targeted materials sorted/ejected by the equipment, relative to all of the material sorted/ejected by the equipment. In other words, a piece of equipment that only sorted the targeted type of material would have a purity rate of 100%. RSE analyzed the audit data to estimate purity rates for the equipment at the MRF. The results are presented in Table 5.

Table 5: Purity Rates for Sorting Equipment

Equipment	Targeted Material(s)	Purity Rate	Comments
OCC Screen (S4)	OCC	94%	Most significant non-targeted materials include film, plastic laminates, and other laminated packaging.
Small Disc Screen (S7)	Mixed Broken Glass (MBG)	76%	Most significant non-targeted materials include office paper, other rigid plastic packaging, other metal containers, and other non-recyclables.
Medium Disc Screen (S8)	ONP	49%	Most significant non-targeted materials captured by the screen include OCC, boxboard and molded pulp, and magazines, catalogues and telephone directories
3D Screen (S12)	Mixed Broken Glass (MBG)	36%	Most significant non-targeted materials include office paper, clear PET containers, other non recyclables, other rigid plastic packaging, steel food and aluminum food and beverage cans.
Fibre Optical (OS15)	Mixed Fibre	92%	Most significant non-targeted materials include plastics/non packaging/durable, other non recyclables, plastic laminates, and PET bottles.
Magnet	Steel	89%	Most significant non-targeted materials include “other metal containers” and corrugated cardboard and kraft paper.
Eddy Current Magnet	Aluminum	97%	Most significant non-targeted materials include other metal containers and boxboard/molded pulp.
Container Optical Sorter – First Pass	PET	75%	Most significant non-targeted material is corrugated cardboard/kraft paper, with some boxboard/molded pulp and mixed rigid plastics.
Container Optical	Mixed Fibre	94%	Most significant non-targeted material

Equipment	Targeted Material(s)	Purity Rate	Comments
Sorter – First Pass			includes other non recyclables, other rigid plastic containers, aluminum cans, and plastic laminates
Container Optical Sorter – Second Pass	HDPE	84%	Most significant non-targeted materials are PET and MRP
Container Optical Sorter – Second Pass	MRP	31%	Most significant non-targeted materials include aluminum, PET, and various fibre materials.
Container Optical Sorter – Third Pass	Non-PET	40%	Included a significant amount of PET
Container Optical Sorter – Third Pass	Non-HDPE	28%	Included a significant amount of HDPE

As Table 5 indicates, there is some equipment that captures a significant quantity of non-targeted material. This may be because the equipment is overburdened, or not properly adjusted. In some cases, complex packaging types pose an issue for equipment. In particular, the purity rates for the Medium Disc Screen (S8), 3D Screen (S12), and Container Optical Sorter (PET, first pass) eject non-targeted materials at a relatively high rate. For the Container Optical Sorter, the non-targeted material in commodities on the first eject consists of the material targeted on the second eject. For example, on the Container Optical Sorter – First Pass, where PET is targeted on the first eject has mixed fibre as the primary non-targeted material. Similarly, the Container Optical Sorter – Second Pass, where HDPE is targeted on the first eject has MRP and PET as the primary non-targeted material.

In addition, the third-pass for the Container Optical Sorter results in a 40% purity rate for positively sorting non-PET and 28% for positively sorting non-HDPE. Given that the Container Optical Sorter – Third Pass provides a QC role, the purity is based on the amount of non-PET or non-HDPE ejected relative to the total amount of materials ejected. Therefore, a low purity rate indicates the incorrect eject of PET and HDPE on the respective lines.

4.5. Mass Balance

To better understand the flow of materials within the MRF, Table 6 summarizes how each type of material is handled throughout the container line and fibre line. Specifically, it identifies the total amount of materials introduced into the system, the amount lost before reaching the intended sorting equipment, the amount captured by the designated sorting equipment, and the amount missed by the sorting stations/equipment.

Table 6: Material Flows and Losses – Percentages Indicate Percent of Material Type Received at MRF

Material	Equipment / Sort Station	Lost or Captured Before Sort Equipment / Station (%)	Captured (%)	Remaining in System/Not Captured (%)*
OCC	OCC Screen – S4	0%	**38%**	62%
	Medium Disc Screen – S8	38%	**13%**	49%
	Fibre Optical	51%	**28%**	21%
ONP	Medium Disc Screen -- S8	<1%	**26%**	74%
	Fibre Optical	26%	**65%**	9%
Mixed Fibre	Medium Disc Screen – S8	<1%	**11%**	81%
	Fibre Optical	11%	**55%**	34%
Steel	Magnet --	3%	**96%**	1%
Aluminum	Eddy Current	15%	**60%**	25%
MBG	Small Disc Screen – S7	0%	**51%**	49%
	3D Screen – S12	51%	**31%**	18%
	Fines Screen --	82%	**15%**	3%
PET	Container Optical Sorter – First Pass	2%	**66%**	32%
	Container Optical Sorter – Third Pass	66%	**16%**	18%
HDPE	Container Optical – Second Pass	6%	**72%**	22%
	Container Optical – Third Pass	78%	**6%**	16%
Mixed Rigid Plastics	Container Optical – Second Pass	22%	**21%**	57%

*Final Row percentages for each material may not sum to 100% exactly due to rounding.

4.6. Mass Balance and Bale Composition

Table 7 shows the mass balance for materials processed. This is a combination of the materials correctly sorted by each sorting station or sorting equipment, plus any additional QC sorts to recover missed materials. For example, the capture rate for ONP indicates that 26% of the available materials in the facility ended up in the ONP bunker, and 73% in the mixed fibre bunker. This is a combination of the materials correctly captured by the medium disc screen, the fibre optical sorter, and the missed materials recovered at manual sort stations. The remaining 1% ended up in the residue stream. In some cases material may end up in other commodity bunkers (and not residue), which means it is theoretically sold to an end market, however it may be considered contamination/out throws depending on the commodity and the contract details.

Table 7: Mass Balance – Allocation of Materials

Commodity	Bulky Plastic	Film	Scrap	OCC	ONP	Mixed Fibre	Al.	Steel	MRP	HDPE	PET	Residue	Aggr. Glass	MBG
Material														
Newspaper and inserts	0%	0%	0%	0%	26%	73%	0%	0%	0%	0%	0%	1%	0%	0%
Old telephone directors, old magazines, and boxboard	0%	0%	0%	1%	4%	88%	0%	0%	0%	0%	0%	7%	0%	0%
Office paper	0%	0%	0%	0%	1%	60%	0%	0%	0%	0%	0%	37%	0%	1%
Corrugated cardboard and Kraft paper	0%	0%	0%	50%	0%	44%	0%	0%	0%	0%	0%	5%	0%	0%
Cartons, paper cups and ice cream containers	0%	0%	0%	0%	0%	91%	0%	1%	0%	0%	0%	8%	0%	0%
PET	0%	0%	0%	0%	0%	2%	0%	0%	14%	0%	76%	8%	0%	0%
Other plastics, opaque PET	0%	0%	0%	0%	0%	14%	0%	1%	42%	1%	1%	42%	0%	0%
HDPE	3%	0%	0%	0%	0%	2%	0%	0%	6%	77%	0%	11%	0%	0%
Film plastic	0%	62%	0%	0%	0%	4%	0%	0%	0%	0%	1%	33%	0%	0%
Bulky plastics & durable plastics	5%	0%	0%	0%	0%	3%	0%	1%	22%	2%	1%	61%	0%	5%
Aluminum cans and foil	0%	0%	0%	0%	0%	8%	80%	0%	0%	0%	0%	10%	0%	0%
Steel cans	0%	0%	0%	0%	0%	3%	0%	96%	0%	0%	0%	1%	0%	0%
Glass containers	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	20%	76%
Residue	0%	0%	0%	0%	1%	19%	0%	1%	0%	2%	1%	66%	0%	8%
E-waste	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
Scrap metal	0%	0%	58%	0%	0%	0%	1%	29%	0%	0%	0%	12%	0%	0%

As Table 7 shows, the results of the mass balance allocation indicate that a considerable amount of newspaper (73%) and corrugated cardboard and kraft paper (44%) is marketed as lower-value mixed fibre. In addition, a high percentage (37%) of office paper ends up being disposed as residue. Additionally, 37% of film plastic winds up in residue.

On the container side, a significant portion of PET (14%) winds up in mixed rigid plastics, and another 8% in residue, and 11% of HDPE containers end up in residue and 6% in mixed rigid plastics. In addition, 10% of aluminum ends up in residue, and 8% in mixed fibre. With regards to mixed rigid plastics, 42% end up in residue. Also, 61% of bulky plastics and durable plastics end up in residue.

Table 8 highlights the composition of all targeted commodity bunkers. Each commodity is baled and sold to an end market with the exception of glass, which is marketed loose.

Table 8: Material Bunker Composition

Commodity Material	Bulky Plastics	Film	Scrap	OCC	Mixed Fibre	Al.	Steel	MRP	HDPE	PET	Residue
Newspapers including Inserts and flyers	0.0%	0.0%	0.0%	0.0%	23.3%	0.0%	0.3%	0.0%	0.0%	0.0%	0.7%
Magazines, catalogues, and telephone directories	0.0%	0.0%	0.0%	0.0%	12.3%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%
Office paper	0.0%	0.2%	0.1%	0.0%	12.8%	0.2%	0.3%	0.9%	0.5%	0.2%	21.6%
Corrugated cardboard & Kraft paper	0.0%	0.0%	0.0%	98.1%	19.1%	0.0%	1.3%	1.0%	0.1%	0.1%	6.3%
Boxboard & molded pulp	0.0%	0.0%	0.0%	1.8%	21.0%	0.3%	0.0%	0.0%	0.0%	0.1%	6.2%
Gable-top cartons	0.0%	0.0%	0.0%	0.0%	3.6%	0.0%	0.1%	0.0%	0.0%	0.0%	0.2%
Aseptic cartons	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Paper cups - hot	0.0%	0.0%	0.0%	0.0%	0.9%	0.1%	0.1%	0.0%	0.0%	0.0%	1.1%
Paper Cups - cold	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Paper ice cream containers	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other laminated packaging	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%
Composite cans	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	2.3%	0.0%	0.0%	0.0%	0.3%
Clear PET bottles, jugs and jars	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.2%	25.5%	0.0%	73.5%	2.6%
PET thermoforms	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	5.9%	0.1%	23.0%	0.6%
Opaque PET	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.3%	0.6%	0.0%	0.0%

Commodity Material	Bulky Plastics	Film	Scrap	OCC	Mixed Fibre	Al.	Steel	MRP	HDPE	PET	Residue
HDPE bottles, jugs and jars	40.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	6.0%	92.3%	0.0%	2.1%
PVC containers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LDPE/HDPE film	0.0%	95.8%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.2%	2.6%
Plastic laminates	0.0%	4.0%	0.0%	0.0%	0.5%	0.1%	0.1%	0.0%	0.0%	0.0%	7.8%
#4 LDPE - rigid	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.7%	0.1%	0.0%	1.0%
#5 PP - bottles and jugs	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	28.0%	0.0%	0.0%	1.6%
#6 PS - expanded polystyrene	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	0.0%	0.0%	0.0%	0.1%	0.8%
#6 PS - non-expanded	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.1%	1.6%	0.0%	0.0%	1.9%
Single-serve coffee pods (Keurig, Tassimo)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	0.0%	0.0%	0.0%
Black plastic	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.3%	3.1%	0.0%	0.2%	2.0%
Other rigid plastic packaging	60.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	21.0%	1.0%	0.4%	11.2%
Large HDPE & PP pails & lids	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%
Other plastics - non-packaging/durable	0.0%	0.0%	0.0%	0.0%	1.2%	0.0%	0.4%	0.9%	0.0%	0.0%	6.2%
Aluminum food and beverage cans	0.0%	0.0%	0.0%	0.0%	0.5%	95.9%	0.2%	0.1%	0.0%	0.1%	1.0%
Aluminum foil & aerosols	0.0%	0.0%	0.0%	0.0%	0.2%	2.0%	0.0%	0.3%	0.0%	0.1%	1.1%
Steel food and beverage cans	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	85.1%	0.0%	0.0%	0.0%	0.1%
Steel aerosol containers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%
Other metal containers	0.0%	0.0%	99.9%	0.0%	0.0%	0.4%	6.3%	0.0%	0.1%	0.0%	1.1%
Clear Glass food and beverage containers	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Colored/mixed glass food and beverage containers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Non-recognizable glass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.3%
Food or liquid waste (found within a container)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.8%	0.0%

Commodity Material	Bulky Plastics	Film	Scrap	OCC	Mixed Fibre	Al.	Steel	MRP	HDPE	PET	Residue
Food or liquid waste (not within a container)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.5%
All waste electronics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
All household hazardous waste including propane tanks, needles, CFL bulbs, etc.	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.1%	0.0%	0.0%
Other non recyclables	0.0%	0.0%	0.0%	0.0%	1.2%	0.1%	0.2%	0.0%	0.0%	0.1%	11.5%
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

As Table 8 indicates, a significant portion of residue is comprised of recyclable materials, - particularly office paper, which comprises 21.6% of the residue, by weight, corrugated cardboard and boxboard/molded pulp, which each comprise over 6% of residue. Other materials being disposed with residue include other rigid plastics, film, and PET. It is also comprised of non-recyclables, such as plastic laminates (nearly 8%).

In terms of mis-sorts, as has been described above, a significant portion of newspaper and cardboard are sent to the mixed fibre bunker. Combined these two materials comprise over 40 percent of the material in the mixed fibre bunker, by weight.

5. Opportunities for Improvement

RSE analyzed the information collected to identify potential opportunities to improve operations and/or equipment at the MRF with the goal being to direct commodities to their proper bunker more frequently and/or with more efficiency. Naturally, the balance at the MRF is to market material at the highest price possible, and to improve efficiency of the sorting operation, but only to the extent that it makes business sense to do so. Potential opportunities for improvement are described below by commodity type.

RSE noted that the processing of steel and glass are both excellent, with 96% of steel going to the steel bunker, and 96% of glass going to either the aggregate or Mixed Broken Glass bunker.

5.1. Capture Additional OCC

OCC is the first material type to be removed by equipment, the OCC Screen (S4). The efficiency rate of the OCC Screen is estimated to be 38%. This means that 62% of the OCC entering the facility is not being captured by the OCC Screen. The Medium Disc Screen (S8) captures another 13% of the OCC that enters the facility, and the Fibre Optical Sorter then removes an additional 28% of the OCC however, while the material is removed from the material stream, much of it (about 44%) winds up in the mixed fibre bales, and 5% ends up in residue. Thus, there is a potential opportunity to divert more OCC early on in the process, which would not only result in higher material revenues (as OCC is a higher-value commodity than mixed fibre), but would also keep OCC from blocking other materials and overburdening successive sorting equipment and sorters.

5.2. Capture of Additional ONP

ONP is removed by the Medium Disc Screen (S8), with a QC station of 3 sorters removing other material types. The efficiency rate for the Medium Disc Screen with respect to ONP is 26%. This means that approximately 74% of the ONP passes by this screen. Then, the optical sorter captures another 65% of the ONP. However, it then ends up with mixed fibre, not ONP. Based on the study observations, only 26% of the incoming ONP ends up in the ONP bunker, while 73% ends up in the mixed fibre bales, and 1% is in residue. As with OCC, there is a potential opportunity to divert additional ONP earlier in the fibre line to the ONP bunker, which is a higher-value commodity, and would reduce the burden on later sorting equipment and sorters

The Medium Disc Screen (S8) has a purity rate of 49%, with the most significant non-targeted materials being captured by the screen including OCC, boxboard and molded pulp, and magazines, catalogues and telephone directories.

5.3. Capture of Additional Office Paper

While office paper is not typically a large-volume material, and is not marketed as a separate commodity at the MRF, but is instead included with mixed fibre, the fact that 37% of the material ends up in residue is of concern. A significant quantity is moving on to the fibre line and ending up in the residue after the Container Optical Sorter Second Pass. Addressing some of the issues with ONP and OCC may help free up the optical sorter to more adequately sort out office paper into mixed fibre.

5.4. Improve Mixed Fibre Sorting

As is described above, many of the single-fiber commodities are being sorted, to some extent, into mixed fibre. Of the materials that should end up in mixed fiber, 88% ultimately are sorted to that bin, with 7% going to residue. About 11% of the mixed fibre is positively ejected by the Medium Disc Screen (S8), and another 55% is sorted by the Fibre Optical Sorter. The Fibre Optical Sorter has an efficiency rate of 66%, and a purity rate of 75%. The non-targeted materials it most frequently ejects include OCC (by far) as well as MRP, other rigid plastic packaging, steel cans and aluminum cans. Additionally, 19% of the residue entering the facility was in the mixed fibre bunker. This has the potential to devalue mixed fibre bales. Very small amounts were also observed in the PET, HDPE, and rigid mixed plastics bunkers. Most of the polycoat is removed by the Container Optical Sorter, first pass. A significant amount of polycoat was observed in the residue after the Container Optical Sorter, second pass.

5.5. Capture of Additional Aluminum

While 80% of the aluminum was properly sorted into the aluminum bunker, another 8% was observed in mixed fibre, and 10% in residue. Some of the aluminum in residue may be due to food contamination in foil and pans. Because aluminum is a high-value material, there may be an opportunity to improve the process to sort it out in order to enhance recovery rates. The eddy current magnet targets the aluminum and it has an efficiency rate of 70%, meaning 30% of the aluminum that reaches it passes it by. The purity rate of 97.2%, however, is acceptable. The non-targeted materials diverted by the eddy current magnet include other metal containers and boxboard/molded pulp.

5.6. Capture Additional PET

PET is primarily sorted by the Container Optical Sorter, which has an efficiency rate of 67% on the first pass. The efficiency rate on the third pass is to remove residue, with an efficiency rate of 48%. A QC is done in a batch process alternating between HDPE and PET. In this process an additional 16% of PET is sorted, however not necessarily into the proper bunker. Ultimately, 76% of PET was observed in the proper (PET) bunker, while 14% of PET was sorted into the MRP bunker, 2% into the Mixed Fibre bunker, and 8% wound up in residue – in particular the residue after the Container Optical Sorter, second pass (where a considerable amount of Polycoat was also identified). Therefore, there may be an opportunity to enhance the recovery of PET, and decrease the amount going to residue and MRP. The Container Optical Sorter has a purity rate of 75%, with respect to PET. Non-targeted materials that were positively sorted on this pass included OCC/kraft paper, with some boxboard/molded pulp and mixed rigid plastics. Again, ensuring more complete removal of OCC earlier in the process might help with recovery of other materials, including PET.

5.7. Capture Additional HDPE

HDPE had a similar outcome as PET, with the Second Pass of the Container Optical Sorter having an efficiency rate of 77% relative to HDPE. . Some HDPE, 11%, ended up in residue, and 6% was in MRP while 2% was in mixed fibre. The purity rate was estimated to be 84%, which is an acceptable rate, with the most significant non-targeted materials sorted with the HDPE including aluminum, PET, and various fibre materials.

5.8. Capture Additional Mixed Rigid Plastics

Mixed rigid plastics (MRP) are positively sorted by the Container Optical Sorter, second pass. For MRP the Optical Sorter had an efficiency rate of 26%, meaning 74% of the MRP available to the optical sorter pass by it. The purity rate for the Container Optical Sorter relative to MRP is 31%, with the most frequently sorted non-targeted materials being aluminum, PET and various fiber materials. While the purity rate for MRP is likely to be lower than that for PET and HDPE, this is still a potential opportunity for improvement.

5.9. Improve Film Plastic Collection and Handling

Plastic film is accepted in the BRA recycling program. Residents are asked to stuff all of their bags inside another bag. Because 33% of the film is ending up in residue, it is likely that much of this film is either not being captured at the pre-sort station, then "comes apart," or is not being bundled by residents to begin with. A significant portion of the film is being captured at the container pre-sort line. Smaller quantities were directed to various residue sort locations further along the system.

Because enhancements made to the front (fibre) end of the BRA MRF are likely to positively impact container line sorting (as fewer fibre materials will be on the container line, therefore less likely to block and trap containers and overburden manual sorters), it is suggested that the MRF address the fibre line opportunities first.

6. Financial Analysis

RSE conducted a financial analysis to estimate the revenue BRA could realistically expect to gain by implementing improvements at the MRF. Table 9 summarizes these results.

In particular, RSE focused on the fiber line impacts, as some of these impacts will also have positive impacts on the container line. For example, capturing more corrugated cardboard and sorting it into the OCC bunker will result in moving OCC from mixed fibre to OCC, a higher-grade commodity. If the MRF can achieve a capture rate of 90% (at the primary targeted material grade) then it stands to increase fibre revenues by $119,073 annually.

Table 9: Estimated Potential Annual Net Revenue Increases

Commodity Type	Current Capture Rate	Current Expected Annual Revenues	Potential Capture Rate	Potential Annual Revenues (Considering Expected Efficiency Rates)	Potential Increase (Decrease) in Annual Revenues	Impact on Mixed Fibre Revenues	Net Annual Increase (Decrease)
ONP	26%	$ 55,187	90%	$ 159,237	$ 104,050	$(91,841)	$12,209
OCC	50%	$ 208,084	90%	$ 364,795	$ 156,711	$(75,195)	$81,515
Office Paper	60%	$ 50,697	90%	$ 76,045	$ 25,348	$ 25,348	$ 25,348
Total Potential Increases in Annual Net Revenues							**$ 119,073**

In order to increase the capture rate of the fiber materials, additional sorting equipment would need to be installed on the fiber line, and pre-sort staff would also focus on removing office paper. Removal of more large cardboard early on in the process will help improve equipment and sorter efficiency for both subsequent fibre materials as well as containers, as less fiber will move on to the container line, where it can block items from the optical sorters and overburden manual sorters. Annual increased revenues due to increased capture of containers is not included in Table 9, as it is difficult to identify the portion of mis-sorted or uncaptured materials that will be captured and properly sorted due to the changes on the fibre line.

7. Recommendations

Based on the audit and analysis conducted, RSE suggests that the BRA MRF/CIF consider implementing the follow upgrades to the MRF's fibre line

1. **Replace the OCC Screen**

   The OCC Screen is only capturing 38% of the OCC. By replacing the OCC Screen, the MRF will be able to 1) direct a higher percentage of OCC to a higher-value commodity bunker (from mixed paper to OCC), thus earning higher revenues, and 2) remove a large item that can block other materials from sorters and sorting equipment further down the line, and overburden other equipment. It is anticipated, therefore, that removing a higher percentage of OCC from the sort line earlier in the sorting process will also allow the subsequent fiber sorting equipment to more accurately sort fiber and containers.

2. **Add a New Fibre Optical Sorter**

   A fair amount of containers are ending up in mixed fibre (14% of other plastics, 8% of aluminum, and a lesser amount, 2% each, of HDPE and PET). Adding an optical sorter on the fibre line will not only help keep containers out of the fibre line and therefore allowing these materials to be captured, but will also help BRA achieve some of the more stringent requirements on contamination for paper commodities. Currently, when all fibre categories are considered, 28% of incoming fibre moves on to the container line. Removing more fibre up front will facilitate more efficient and efficient processing (manual and mechanical) on the container sort line, which will aid in increasing the capture of containers, thus the revenues from container commodity sales. Additionally, with markets for mixed fibre becoming more stringent, it is imperative that mixed fibre bales be of high quality in order to remain marketable, and the ONP bales would enhance marketability with reduced brown fibers. Currently 19% of the residue entering the facility ends up in the mixed fibre materials. In addition, 19% of the OCC and boxboard entering the facility ends up in the mixed fibre bales.

The fibre line enhancements are of primary importance, as these will have a positive impact on the container line and mis-sort of containers on the fibre line. Additional enhancements the MRF might consider making to the container line include:

3. **Adjust the Container Optical Sorter**

   The Container Optical Sorter should be adjusted so that it more successfully targets PET on the first pass (the efficiency rate is 67%), and also so that it targets HDPE more successfully on the second pass (It has an efficiency rate of 77%). There may be an opportunity to adjust it to also more accurately identify mixed rigid plastics, as the efficiency rate for MRP is only 26%. It is possible that some of the mis-sorts with PET, HDPE, and MRP will be resolved with improvements to the fibre line, as is described above.

4. **Adjust the Eddy Current Magnet**

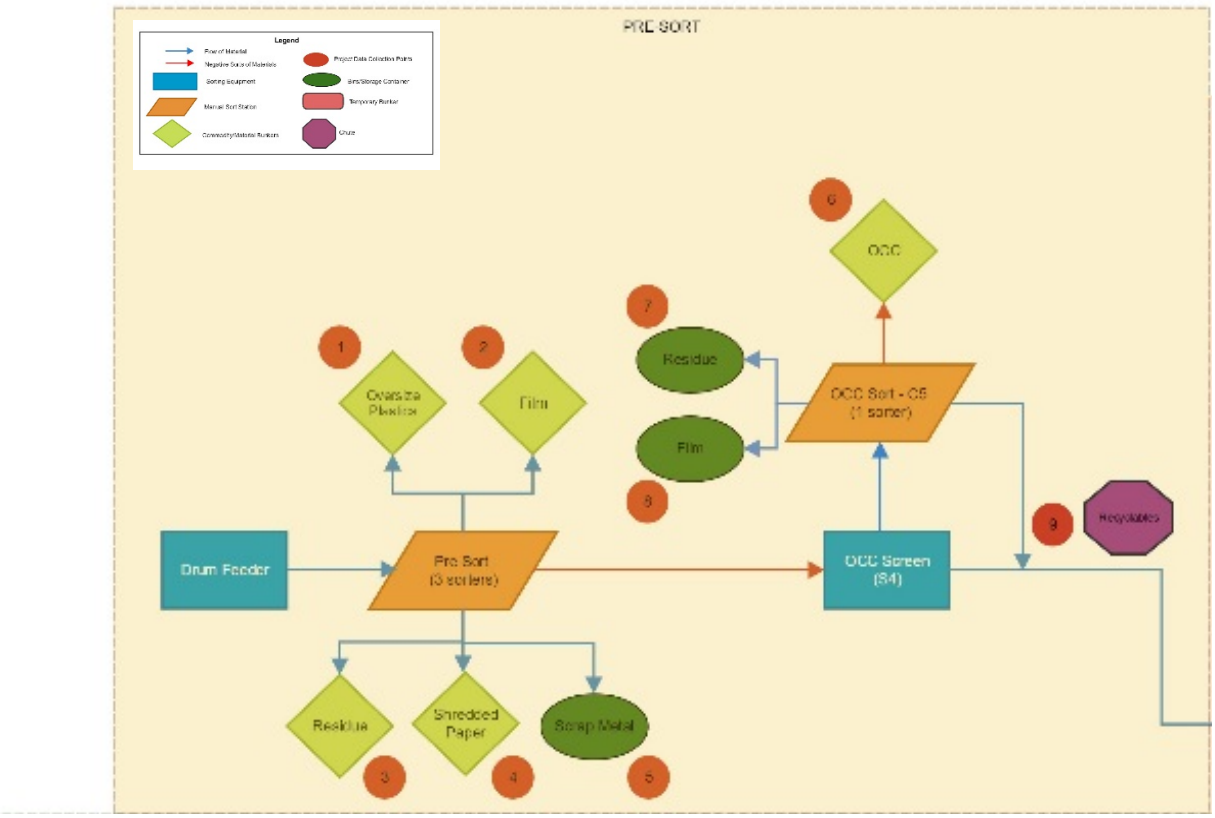
   The efficiency rate of the eddy current magnet is estimated to be 70%. While 15% of the material is "lost" before it reaches the eddy current magnet, another 25% passes by the eddy current magnet. Again, investing in the fibre sort equipment may alleviate this issue, as aluminum will be less likely to be covered with fibre material, it is also suggested that the eddy current magnet be adjusted to ensure it is operating properly. It uncommon for eddy current magnets to have efficiency rates of lower than 90 to 95%. Increasing the capture rate of aluminum cans from 80% to 90% at the MRF would increase annual revenues by an estimated $80,547.

5. Conduct Outreach about Film Plastic

RSE recommends that the BRA remind residents that they should not set loose or soiled film in their recycling carts, but should instead only place film inside another bag. Reminding them that plastic laminates are not recyclable would also decrease the amount of residue generated at the MRF, and reduce the burden on sorters and sort equipment, as well as improve the quality of commodity bales, particularly mixed fibre bales.

Appendix A – Additional MRF Flow Images

Figure 2: MRF Pre-Sort



Appendix A – Additional MRF Flow Images

Figure 3: MRF Fibre Line

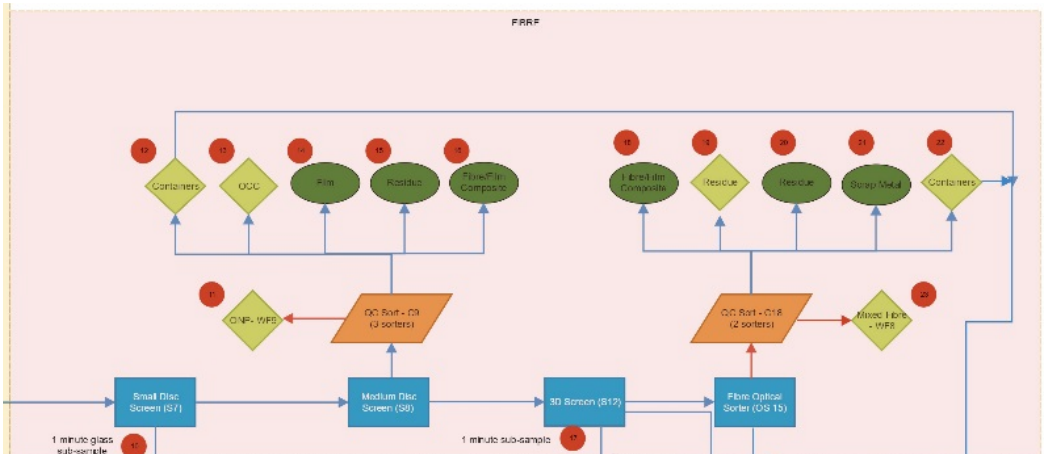
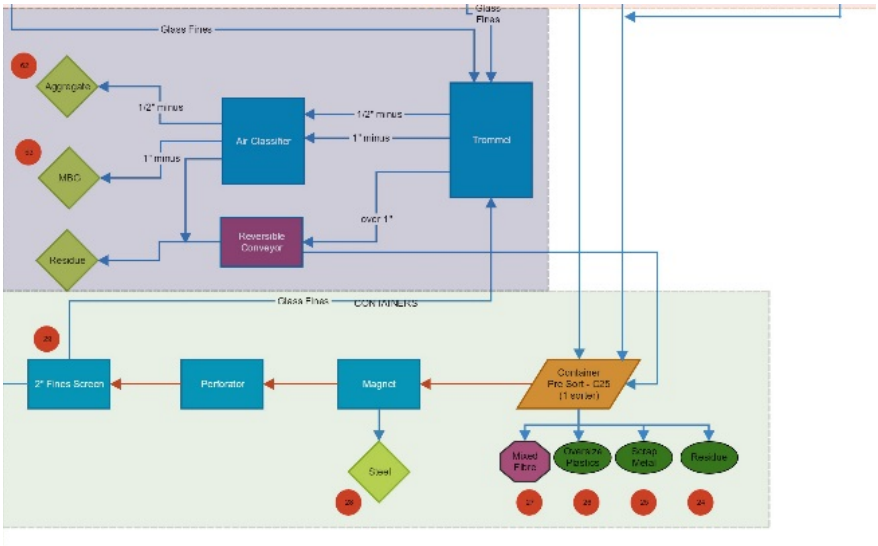
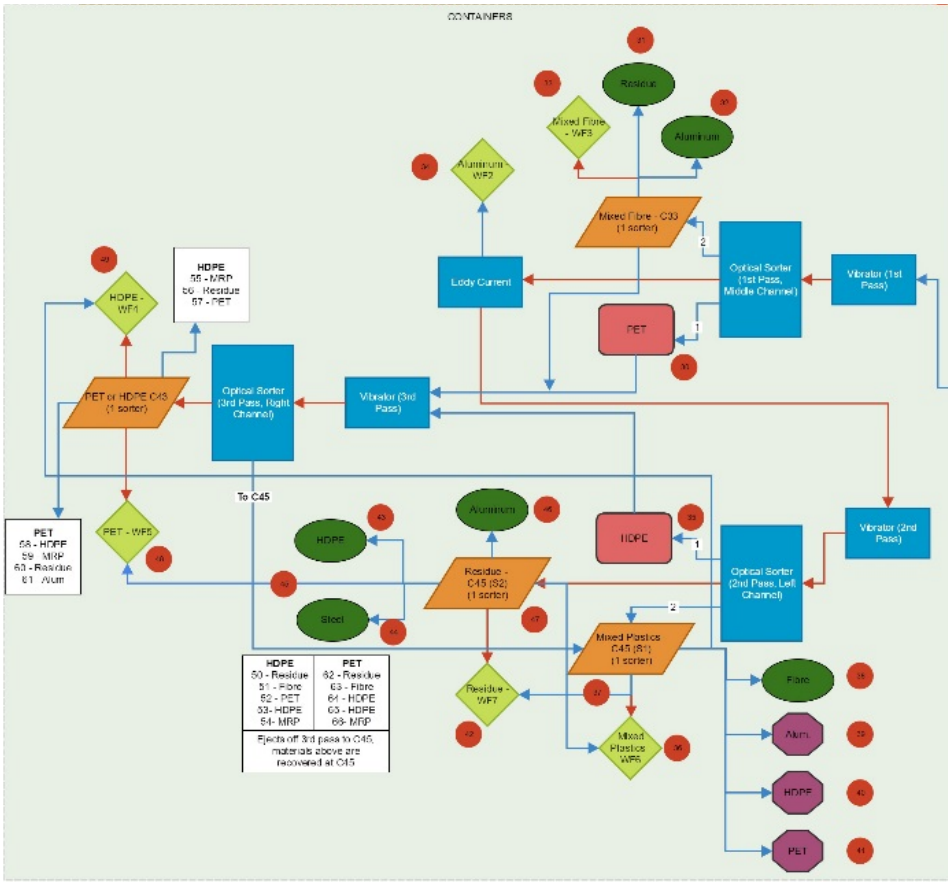


Figure 4: MRF Glass Line and Container Pre-Sort



Appendix A – Additional MRF Flow Images

Figure 5: MRF Container Line



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