Reclay StewardEdge
Product Stewardship Solutions

Holliday Recycling Technologies

Region of Peel

Material Recovery Facility Efficiency Assessment and Improvement Recommendations

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WITH SUPPORT FROM: Holliday Recycling Technologies

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Contents

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Tables

Figures

1. Executive Summary

On behalf of Region of Peel (Region) and the Continuous Improvement Fund (CIF), Reclay StewardEdge (RSE), with support from Holliday Recycling Technologies (HRT), has carried out a performance assessment of the Region's Material Recovery Facility (MRF) and identified areas of improvement.

The primary objective of this project was to evaluate the performance of the sorting equipment and manual stations, and 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, and inform the recommendations as well as the feasibility assessment related to the potential installation of new equipment and process modifications to improve sorting operations.

RSE worked with the Region's staff and their service provider (Canada Fibers Ltd.) 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 (6.7 tonnes of single stream materials) and then introduced to the line to be sorted under normal conditions. The team also conducted a time and motion test to determine the effort of manual sorters to sort targeted materials and its downstream impact relative to the results of the mass balance.

Following the mass balance, and time and motion tests, RSE analyzed the results and summarized the key findings within this report:

- At the pre-sort for both shifts combined, sorters spend 33% of their time recovering plastic film, 25% handling residue and 27% handling bagged recyclables (to bag breaker, residue, or ripping open).
- Bagged recyclables, originating from both lines, that are broken by the bag breaker are returned to only line A creating a burden depth issue. As a result of a burden depth issue, sorters on line A perform 61% of all of the picks at the pre-sort.
- The OCC screens have a combined efficiency of 52%. Two manual sorters in the OCC rooms spend 96% of their sorting time only capturing an additional 9% OCC.
- A significant amount of valuable containers (1,538 tonnes) are lost in the mixed fibre stream annually. The revenue impact of the lost recyclables is valued at $465,223. Sorters in the upper and lower fibre rooms spend approximately 50% of their time capturing container recyclables.
- The capture rate for aluminum is 72%. Approximately 14% of the inbound aluminum is lost within the mixed fibre stream.
- The existing dual eject optical on the container side has an efficiency rate of 60% for polycoat cartons and 32% for mixed plastics.
- Also on the container side, the capture of PET, mixed plastics, polycoat cartons and HDPE is rated at 79%, 25%, 51% and 81% respectively.
- Approximately 30% of the end of the line residue is comprised of fibre materials, 19% mixed plastics, and 12% valuable recyclables (polycoat cartons, PET, HDPE, aluminum and steel).

These material losses are a result of increased inbound contamination and equipment/sorter inefficiency. To overcome these issues, the RSE team has made a series of recommendations to improve the MRFs performance and consequently boost related revenue.

RSE has provided the Region and the CIF with the following recommendations to address the issues identified in this report:

- Retrofit of the bag breaker to return ripped open bags to both lines;

- Retrofit the existing OCC screens to improve capture efficiency;
- Installation of optical sorters for the recovery of containers in the mixed fibre stream; and
- Installation of an optical sorter at the residue QC station to recover lost recyclables.

2. Objectives & Background

2.1. Project Objectives

The Region of Peel (Region) and the Continuous Improvement Fund (CIF) commissioned this study to evaluate sorting performance of its single-stream MRF. The Region's MRF interfaces automatic processing equipment with manual sorting activities in order to cost effectively sort commingled single stream materials into marketable products. This study analyzes each component of the processing system, equipment and manual.

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. Time and Motion Study: observed each manual sorter on the sorting lines to determine how much time each sorting station spends picking targeted materials.
3. Off-Site Modelling and Analysis: quantify equipment and material efficiency and purity rates, material capture rates and carry out a financial analysis.

Off-site analysis involved compilation of the data collected through the audit, and an equipment and maintenance record review in order to determine the performance baseline of the system. With performance baselines established, cost and improvement options to enhance the efficiency and effectiveness of the MRF line were developed.

2.2. Background

The Region is an upper-tier municipality that includes the City of Mississauga, City of Brampton, and the Town of Caledon; serving approximately 1.4 million residents. The Region's Integrated Waste Management Facility (IWMF) processes 300,000 tonnes of garbage, organics and recyclables annually. Within the IWMF, the MRF processes over 100,000 tonnes of single stream blue cart recyclables on an annual basis.

The Region utilizes a cart-based system to collect garbage and recycling on a bi-weekly basis and organics on a weekly basis. Residents are provided with a gray cart for garbage, a blue cart for recyclable materials and a green cart for organic material.

2.3. Description of Existing MRF Operations

Materials collected from the Region's curbside recycling program are received on the tip floor and then loaded into two metering drums which feed the pre-sort station using two different belts, A and B lines. Fourteen sorters (8 on line A, 6 on line B) positively sort bagged recyclables (conveyed to the bag breaker), plastic film (conveyed to a dedicated film baler), residue, oversize plastics, coloured HDPE and scrap metal. Bagged recyclables from both lines are conveyed to a single bag breaker that rips the bags and deposits the contents on to line A only.

After the pre-sort, materials from both lines are then fed through two parallel OCC screens separating the OCC from the other materials and transferring it directly into a dedicated bunker. The unders from the OCC screens are conveyed to two quality control OCC stations. One sorter in each room positively removes missed OCC, residue and scrap metal.

The material that passes through the OCC QC stations enters two parallel ONP screens that separate ONP, glass fines, and containers. The ONP from both screens are kept separate, and conveyed to dedicated fibre sort rooms (upper fibre room for line A, and lower fibre room for line B). The glass that has been screened is transferred to the glass cleanup system. The container unders from both ONP screens are combined and conveyed to a v-screen for further clean-up. Container unders from the V-screen are conveyed to a newly installed glass fines screen. Fibre overs from the V-screen are split and conveyed to the upper and lower fibre sort rooms.

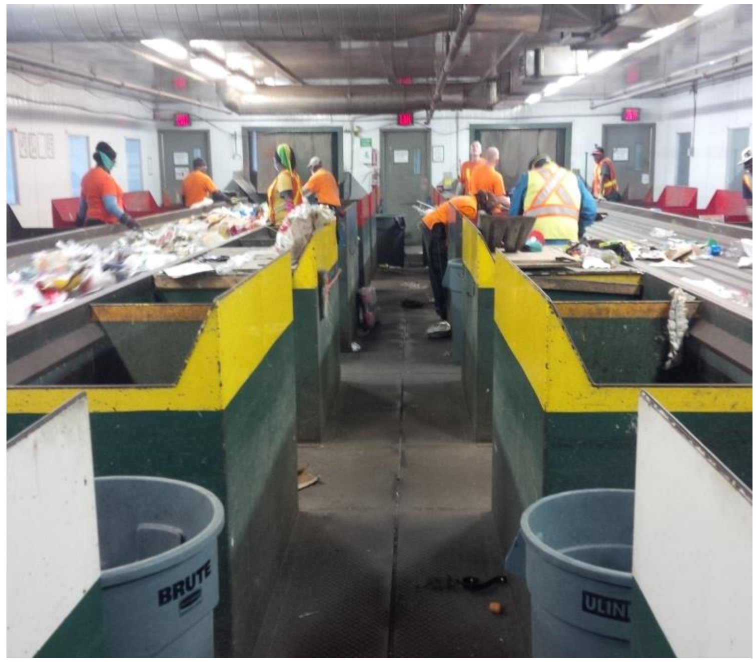


Figure 1 - Pre-Sort

The ONP materials from both lines are split onto two lines before entering the upper or lower sort rooms. Sorters in both rooms positively sort plastic film, containers and residue. Containers are conveyed to the container line and negative fibres from both rooms are conveyed to a single bunker. V-screen fibres are conveyed to a third line in each of the fibre sort rooms, where sorters positively remove containers, residue and plastic film. The negative fibres from the v-screen line in both fibre sort rooms are conveyed to the same bunker.

Figure 2 - Upper Fibre Room

Mixed containers from the v-screen are conveyed to the new glass fines screen. Materials that are 2.5 inches and less are then directed to the glass cleanup system. The new glass cleanup system utilizes an organic-separator screen to remove light fraction material from the glass cullet.

The remaining containers are conveyed towards the newly installed ballistic separator. The ballistic separator uses a series of stepping paddles to separate flat items (fibres and plastic film) from 3D materials (containers). Flat items are transferred to the v-screen line in the lower fibre sort room, while 3D materials are transferred to a QC sort station, where sorters remove rejects or any remaining flat items.

The container stream after the ballistic separator and QC station passes under an overhead magnetic separator where ferrous containers are conveyed to a storage bunker. The remaining container material then continues to a newly installed eddy current for aluminum recovery. The recovered aluminum passes through a QC station where aluminum foil, scrap metal and rejects are positively separated from aluminum cans. Aluminum cans are then transferred to a bunker via a blower and pipe run.

Container material, now free of metals, continues toward a newly installed single eject PET optical sorter. The ejected PET is directed to a QC station where residue is removed, and PET is directed to a bunker. The remaining container material is then conveyed to a newly installed dual eject optical sorter. Mixed plastics are ejected downwards to a QC station, where one sorter is positively removing residue, HDPE and PET (directed to PET QC station). The second valve (upward) ejects polycoat cartons (gable top and aseptic) to a QC station, where one sorter is positively removing fibres, and rejects.

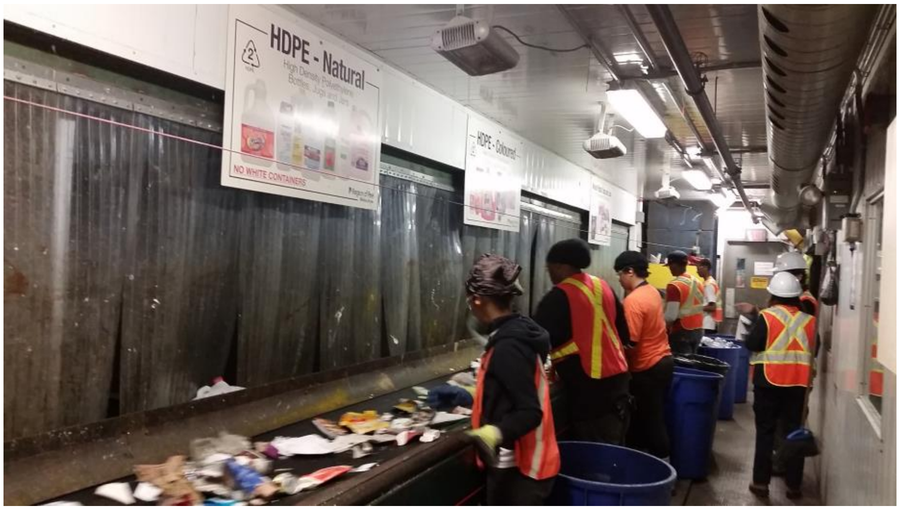
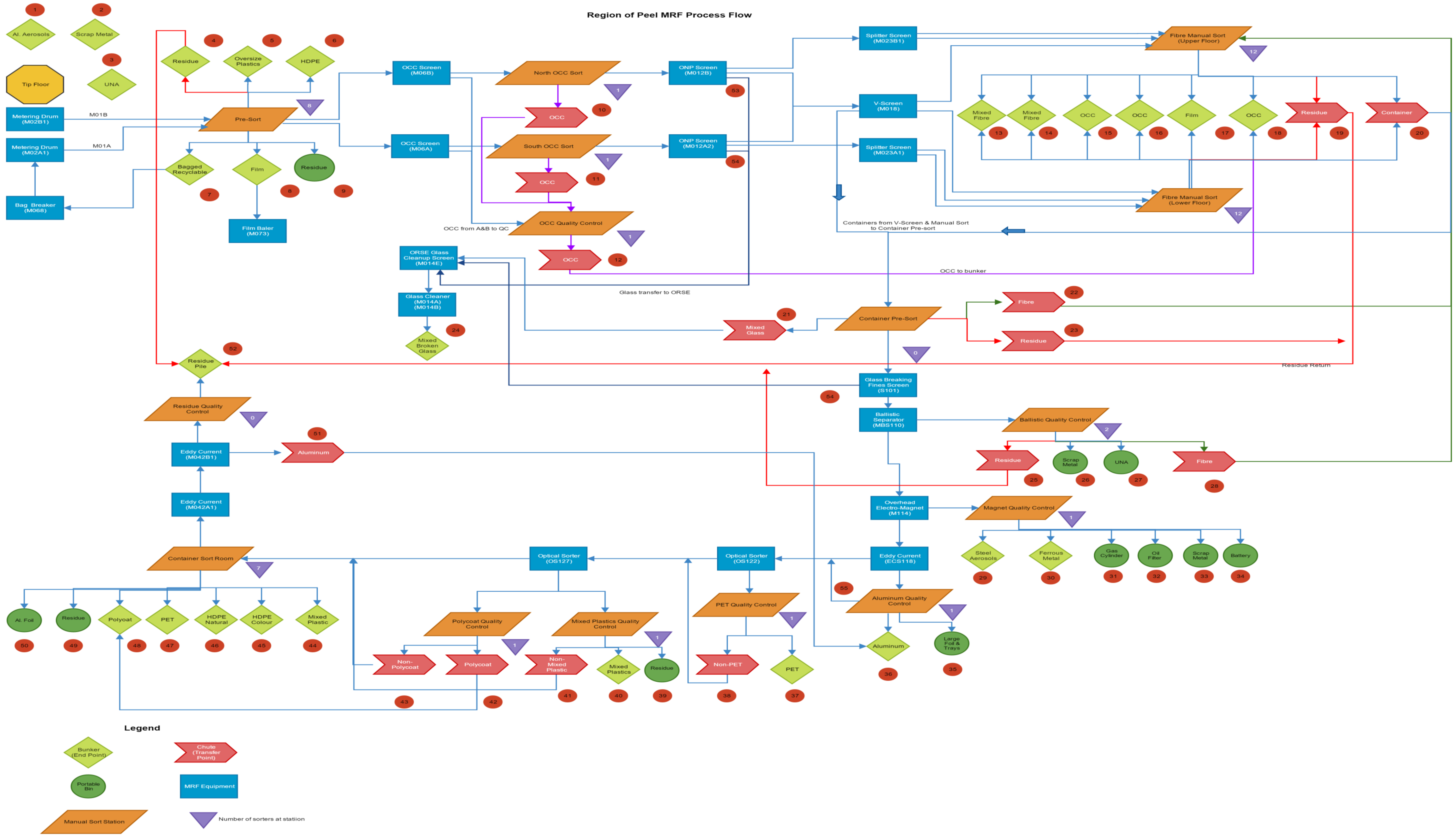


Figure 3 - Container Sort Room

Non-ejected containers from the dual eject sorter are conveyed to the manual container sort room where sorters are positively removing PET, mixed plastics and polycoat cartons missed by the optical sorters. Sorters also separate HDPE into a colour and natural sort. The remaining materials after the manual container sort room go through one last QC sort, whereby one sorter is positively removing plastic film, missed containers and fibre, before letting the remaining materials end up as residue.

Figure 4 - Process Flow of the Sorting Line



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 Region's MRF was limited to data collected during the RSE tests and on-site observations and from publically available sources (e.g., annual reports, studies, websites, etc.) as well as information willingly disclosed by Regional 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

Three aspects of the MRF's operation were evaluated as part of this study:

1. The material flow and performance of the sorting equipment
2. The efficiency of the manual sort stations
3. The upkeep of regular maintenance and service of the equipment

3.1. Material Performance & Sorting Equipment Performance

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 4).

Following the site visit, RSE worked with MRF staff to conduct the mass balance audit, and time and motion study under normal sorting operations. 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.

3.2. Sorting Efficiency & Accuracy

With the assistance of MRF staff, RSE obtained a representative sample from the container line tip floor totaling 6,700 kgs. This material was introduced at the beginning of the test. Manual sorters were instructed to follow regular sorting procedures during the test. To ensure materials were sampled at their correct points, auditors were also positioned at key locations to observe the flow during the tests. At the conclusion of the test, all equipment was stopped to allow for bunkers and storage containers to be emptied and material containers at the various collection points were brought to a staging area to be audited. Materials at each data point were sorted into the categories identified in Table 1. It should be noted that the mass balance was carried out during the AM shift.

Table 1 - List of material categories sorted during audits

Commodity	Material Category
Fibre	Newspapers including Inserts and Flyers
	Magazines, Catalogues, and Telephone Directories
	Office Paper
	Corrugated Cardboard & Kraft Paper
	Boxboard & Molded Pulp
Paper Packaging	Gable top cartons
	Aseptic cartons
	Paper cups
	Paper ice cream containers
	Other laminated packaging
	Composite cans
Plastics e.g.: - (#1) bottles - HDPE (#2) mixed - Mixed Plastics etc.	PET bottles, jugs and jars & Thermoforms
	HDPE bottles, jugs and jars (colour and natural)
	PVC Containers
	LDPE/HDPE Film
	Plastic laminates
	#4 LDPE – Rigid
	#5 PP - bottles and jugs
	#6 PS - Expanded polystyrene
	#6 PS - Non-expanded
	Other Rigid Plastic Packaging
	Large HDPE & PP Pails & Lids
	Other Plastics - non-packaging/durable
Metals	Aluminum food and beverage cans
	Aluminum foil & Aerosols
	Steel food and beverage cans
	Steel aerosol containers
	Other metal containers
Glass	Clear Glass food and beverage containers
	Colored/Mixed Glass food and beverage containers
	Non-recognizable glass
Organics	Food or liquid waste (found within a container)
	Food or liquid waste (not within a container)
Electronics	All waste electronics
Household Waste	All household hazardous waste including propane tanks, needles, CFL bulbs, etc.
Other	Other Non-Recyclables

A time and motion study was then performed. RSE began by observing the first set of sorters individually and then progressed to each consecutive station until all sorters on the line were assessed. RSE, with assistance from MRF staff tracked the number of times targeted materials were picked. This process was performed for the morning (7:00 am to 3:30 pm) and afternoon (3:30 pm to 11:00 pm) shifts to improve the statistical validity of the findings (i.e. reduce the margin of error due to the different material composition that could flow at different times).

3.3. Equipment Maintenance & Upkeep

Manufacturers' performance specifications and maintenance records were gathered and used as part of the equipment assessment along with visual observations of the equipment both in and out of operation (see section 4.7).

4. Observations & Results

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 2.

Table 2 - Tip Floor Composition

Commodity	Material Category	Tip Floor Composition (%)
Paper	Newspapers including Inserts and Flyers	20%
	Magazines, Catalogues, and Telephone Directories	4%
	Office Paper	5%
Paper Packaging	Corrugated Cardboard & Kraft Paper	18%
	Boxboard & Molded Pulp	10%
	Gable top cartons	1%
	Aseptic cartons	0%
	Paper cups	0%
	Paper ice cream containers	0%
	Other laminated packaging	1%
	Composite cans	0%
Plastics e.g.: - PET (#1) bottles - HDPE (#2) mixed - Mixed Plastics etc.	PET bottles, jugs and jars & Thermoforms	6%
	HDPE bottles, jugs and jars	2%
	PVC Containers	0%
	LDPE/HDPE Film	2%
	Plastic laminates	2%
	#4 LDPE - Rigid	1%
	#5 PP - bottles and jugs	0%
	#6 PS - Expanded polystyrene	1%
	#6 PS - Non-expanded	0%
	Other Rigid Plastic Packaging	1%
	Large HDPE & PP Pails & Lids	1%
	Other Plastics - non-packaging/durable	2%

Commodity	Material Category	Tip Floor Composition (%)
Metals	Aluminum food and beverage cans	1%
	Aluminum foil & Aerosols	0%
	Steel food and beverage cans	2%
	Steel aerosol containers	0%
	Other metal containers	1%
Glass	Clear Glass food and beverage containers	5%
	Colored/Mixed Glass food and beverage containers	2%
	Non-recognizable glass	2%
Organic Waste	Food or liquid waste (found within a container)	1%
	Food or liquid waste (not within a container)	1%
Household Waste	All household hazardous waste including propane tanks, needles, CFL bulbs, etc.	1%
Other	Other Non Recyclables	6%
Total		**100%**[1]

4.2. Efficiency & Purity Rates

This section outlines the methodology utilized to calculate equipment and sort station efficiency and purity rates and the subsequent analysis. For each piece of equipment, RSE identified the expected efficiency rate based on manufacturers' specification. The expected rate was evaluated against the study calculated efficiency and purity rate of the materials sorted. RSE also measured the efficiency of the manual sort stations throughout the line[2].

The efficiency rate is defined as the ability for each piece of equipment and sorter to correctly identify and sort the material it is intended to sort. For example, the eddy current is intended to target non-ferrous materials (e.g. aluminum). Therefore, the efficiency rate of the eddy current is calculated by dividing the total aluminum found in the aluminum bunker by the sum of all aluminum containers found within the bunker and all subsequent bunkers downstream. It is important to note that the efficiency rate is not calculated by dividing the total target materials captured by the total introduced to the system as there are some material losses prior to reaching the appropriate sorting station. For example, steel lost before even reaching the magnet is not considered in the efficiency calculation, as the magnet never had the opportunity to sort that material.

In addition to listing the efficiency rates of equipment and manual sorters, Table 3 details the purity rates. Purity rates are defined as the amount of targeted materials sorted/ejected divided by the total amount of materials sorted/ejected by the equipment. For example, the purity rate for the eddy current is the total number of aluminum containers ejected by the eddy current divided by the total number of containers (including non-aluminum materials) ejected by the eddy current. Figure 5 illustrates how the efficiency and purity rates are calculated.

[1] Individual figures in the tables may not add up to 100% or the total due to rounding.
[2] Purity rates for manual sort stations are not typically calculated.

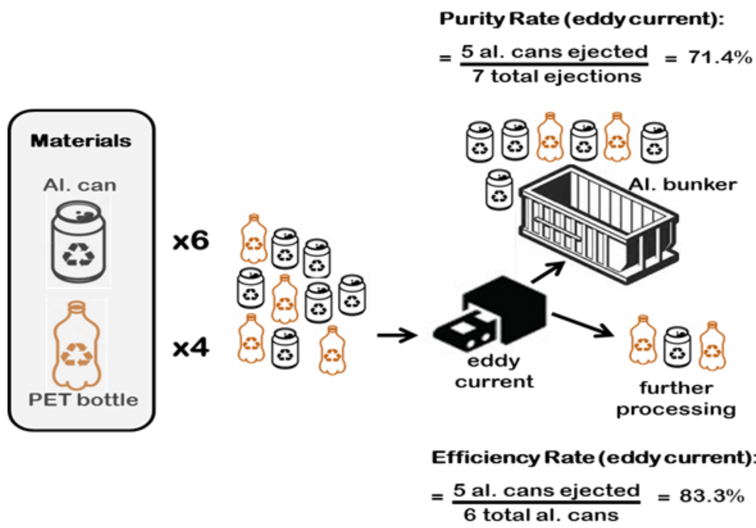


Figure 5 - Illustration of Efficiency & Purity Rate Calculation

Equipment with sufficiently high purity rates to meet market specifications need little to no QC before being conveyed to a bunker. However, material sorted by equipment with a low purity rate will require additional QC to meet market specifications prior to being baled and sent to market.

Table 3 - Efficiency & Purity Rates

Equipment	Description/Purpose	Expected Efficiency (%)	Actual Efficiency (%)	Actual Purity (%)
OCC Screens	Separates old corrugated cardboard	NA	52%[3]	85%
ONP Screens	Separates mixed fibres from containers and glass	NA	84%[4]	76%
V-Screen	Separates fibres from containers	NA	75%	59%
Fibre Manual Sort Rooms (Upper & Lower)	Targeted materials includes plastic film			
Plastic Film		-	56%	-
Fines Screen/ORSE	Separates glass from lightweight materials	95%	93%	93%
Magnet	Removes steel	95%	98%	92%
Eddy Current	Removes non-ferrous aluminum containers	90%	83%	91%
PET Optical	Detects and separates PET	90%	88%	95%
Dual Optical	Detects and ejects polycoat cartons and mixed plastics	90%	-	-
Mixed Plastics		-	32%	85%
Polycoat Cartons		-	61%	92%
Container Sort Room	Positive manual sorts of targeted materials			
Polycoat Cartons		-	43%	-
Mixed Plastics		-	41%	-
PET		-	63%	-
HDPE		-	88%	-
Second Eddy Current	Removes non-ferrous aluminum containers	90%	12%	100%
Residue QC	Positive manual sorts of targeted materials			
Fibres		-	12%	-
Containers		-	14%	-

While all quantitative results of the MRF flow analysis are provided in the results tables, several qualitative observations of critical note were made regarding existing equipment and material flow through the MRF in Table 4.

[3] Combined efficiency rate for OCC screens due to data access limitations.
[4] Combined efficiency rate for ONP screens due to data access limitations.

Table 4 - Equipment & Manual Sort Observations

Equipment/ Sort Station	Observations
Pre-Sort	• Deeper burden depth on line A (result of ripped open bags from bag breaker returned to line A only) • Numerous stoppages for breakdown/jams and removal of special/medical waste • Sorters spend significant amount of time ripping open bagged recyclables (beyond first set of sorters)
OCC Screens & QC Sort Rooms	• High amount (48%) of OCC passed through the screen • Sorters in QC rooms not able to capture most of missed OCC
ONP Screens and V-Screen	• High amount of containers found within mixed fibres • Combined efficiency rated for the ONP screens is 84%, purity rate is 76%
Fibre Sort Rooms	• Significant amount of manual sorting time used to capture containers and film • Sorters not able to keep up with amount of containers and film
Glass Capture & Cleanup System (Fines Screen/ORSE)	• Effective at capturing and cleaning-up mixed broken glass; purity rate is 93% • No changes recommended
Ballistic	• Significant amount of time spent picking mixed fibres at the QC station • Mixed fibres recovered include smaller pieces of OCC/OBB, rolled newspaper, and soft/hard cover books
Eddy Current	• The QC sorter dedicates (79%) most of their time removing ejected contamination
PET Optical Sorter	• PET optical sorter displayed a high efficiency and purity rate • QC sorter dedicated to removing contamination only
Dual-Eject Optical Sorter	• Low efficiency rates for both mixed plastics and polycoat cartons that require additional attention in the form of a preventative maintenance program
Container Sort Room	• Main sort station for HDPE containers, sorted into a colour and natural grades • Significant presence of other recyclables such as PET and mixed plastics
Residue QC Station	• Sorter at the residue QC station is not able to keep up with volume of container and fibre recyclables • No sorter present during the PM shift

4.3. Mass Balance Results

To better understand the flow of materials within the MRF, Table 5 summarizes how each type of material is handled throughout the line. Specifically, it identifies the percentage of the material lost before reaching the intended sorting station/equipment, the percentage captured by the designated sorting stations/equipment, and the percentage missed by the sorting stations/equipment.

Using film as an example, 100% of the film in stream is available for capture at the pre-sort. However, sorters at the pre-sort were only able to capture 20% of the available material, while the remaining 80% progressed downstream. In between the pre-sort and fibre sort rooms, an additional 17% of film was lost at other sort stations and no longer available for capture at the fibre sort rooms. This is similar to HDPE lost in between the pre-sort and container sort room capture points.

Table 5 - Mass Balance of Materials Sampled

Material	Equipment/ Sort Station	Lost/Captured Prior to Equipment/ Sort Station	Captured by Equipment/ Sort Station	Missed by Equipment/ Sort Station	Total
Film	Pre-Sort	0%	20%	80%	100%
HDPE	Pre-Sort	0%	24%	76%	100%
Film	Fibre Rooms	37%	35%	28%	100%
OCC	OCC and QC	0%	61%	39%	100%
Fibre	ONP and V-Screen	6%	89%	6%	100%
Glass	Fines Screen/ ORSE	1%	92%	8%	100%
Steel	Magnet	11%	87%	2%	100%
Aluminum	Eddy Current	12%	84%	4%	100%
PET	PET Optical	17%	73%	10%	100%
Mixed Plastics	Dual Optical	62%	12%	26%	100%
Polycoat Cartons	Dual Optical	36%	39%	26%	100%
HDPE	Container Sort Room	36%	56%	8%	100%
Mixed Plastics	Container Sort Room	76%	10%	14%	100%
PET	Container Sort Room	93%	4%	3%	100%
Polycoat Cartons	Container Sort Room	75%	10%	15%	100%

4.4. Material Capture Rates

Table 6 below outlines the capture rates for various materials on the sorting line. The capture rates presented are based on where the material will end up after the sorting process. This is a combination of 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 PET indicates that 79% of the available PET in the facility ended up in the appropriate bunker. This is a combination of the materials correctly captured by the optical sorter and the missed materials recovered downstream at the container manual sort. The remaining 21% was distributed in other commodity bunkers, either upstream of the PET Optical (12% in mixed fibre) or ended up in other commodities downstream (mixed plastics and residue). With regards to material ending up in other commodity bunkers (and not residue), although it is theoretically sold to an end market it may be considered contamination/out throws depending on the commodity and the contract details.[5] Material capture rate highlights include:

- For film, only 56% of the inbound film is captured for recycling (combination at the pre-sort and fibre rooms), 16% is lost in the mixed fibre stream and 9% is captured with the fibre stream residue. However, of the amount not captured only 5% makes it downstream to the container line past the ballistic sorter minimizing potential sortation issues caused by excessive film at manual sort stations, optical sorters and eddy currents.
- For OCC, only 61% of the inbound OCC is captured at the OCC screens and quality sort stations. The majority of the missed OCC, is found in the mixed fibre stream.
- For mixed broken glass, the glass breaking and recovery system at the MRF is performing fairly well with 92% of the inbound glass captured.
- For mixed fibre, approximately 88% of the inbound mixed fibre was captured[6]. Further downstream, 5% of the inbound mixed fibre was found in the end of line residue and past the residue QC sorter.
- For aluminum, only 72% of the inbound aluminum was captured. Approximately, 19% of the inbound aluminum was lost prior to the eddy current with a majority found in mixed fibre bales. An additional 7% of the inbound aluminum can be found in the end of line residue.
- For mixed plastics, the capture rate is poor at 25%. The majority (52%) of inbound mixed plastics was lost prior to the dual eject optical sorter tasked with sorting mixed plastics and polycoat cartons. After the dual optical sorter, 23% of the lost mixed plastics can be found in the end of line residue.
- For polycoat cartons, approximately 51% of the material stream is captured., The bulk of the lost polycoat cartons can be found in mixed fibre bales (28%) and end of line residue (16%).
- For HDPE, approximately 81% of the material stream is captured. This is a fairly positive capture rate considering HDPE is primarily sorted at the end of the system. However, 8% of the available HDPE can be found in the end of line residue.

[5] Materials sorted in the wrong commodity/bale are not considered as captured material.
[6] Captured utilizing the ONP screens and V-screen.

Table 6 - Material Capture Rates

Commodity	Residue - Pre-Sort	Scrap Metal	Film	OCC	Glass	Mixed Fibre	Residue - Fibre Line	Steel	Aluminum	PET	Mixed Plastics	Polycoat Cartons	HDPE	Residue - End of Line	Total
Scrap Metal	6%	**77%**	0%	3%	1%	2%	1%	5%	0%	0%	0%	0%	0%	5%	100%
Film	13%	0%	**56%**	1%	0%	16%	9%	0%	0%	0%	0%	0%	0%	5%	100%
OCC	0%	0%	0%	**61%**	0%	37%	1%	0%	0%	0%	0%	0%	0%	1%	100%
Glass	1%	0%	0%	0%	**92%**	3%	0%	0%	0%	0%	0%	0%	0%	4%	100%
Mixed Fibre	2%	0%	0%	3%	0%	**88%**	1%	0%	0%	0%	0%	0%	0%	5%	100%
Steel	2%	0%	0%	0%	0%	9%	0%	**82%**	0%	0%	0%	0%	0%	6%	100%
Aluminum	2%	0%	0%	1%	0%	14%	2%	0%	**72%**	0%	0%	0%	0%	7%	100%
PET	2%	0%	0%	1%	0%	12%	1%	0%	0%	**79%**	2%	0%	0%	4%	100%
Mixed Plastics	15%	1%	0%	6%	0%	24%	5%	0%	0%	1%	**25**%	0%	0%	23%	100%
Polycoat Cartons	1%	0%	0%	0%	0%	28%	1%	0%	3%	1%	0%	**51%**	0%	16%	100%
HDPE	1%	0%	0%	2%	0%	2%	1%	0%	0%	1%	4%	0%	**81%**	8%	100%
Residue	**21%**	1%	6%	1%	5%	27%	**12%**	0%	0%	2%	0%	0%	0%	**24%**	100%

4.5. Bunker Composition

Table 7 below 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. The highlights include:

- With the exception of mixed plastics, all container material bunkers have the lowest amount of contamination; less than 10%.
- The mixed fibre grade is comprised of 40% newsprint, 17% OBB, 13% OCC, 16% magazines/office paper, and 7% containers.
- The OCC bunker is comprised of 85% OCC, 7% OBB, 3% newsprint and 3% mixed plastics.
- The film grade is comprised of 68% polyethylene film and 30% multi-layer laminate film, which is considered a contaminant.
- The mixed plastics bunker is comprised of 84% mixed plastics, 6% PET, 6% HDPE and 3% residue (3%).
- The residue material generated at the pre-sort is comprised of 45% contamination, 21% fibre materials, and 21% mixed plastics.
- The residue material generated at the fibre sort rooms is comprised of 51% contamination, 17% fibre materials, 14% mixed plastics, 9% plastic film, and, and 6% recyclable containers (polycoat cartons, PET, HDPE, aluminum, steel).
- The residue bunker at the end of the line includes a high percentage, 19.3% of mixed plastics (followed by 12.9% of OBB and 8.8% of office paper.

Table 7 - Bunker Composition Results

	Bunker/Material Grade												
Commodity	**Residue - Pre-Sort**	**Film**	**OCC**	**Glass**	**Mixed Fibre**	**Residue - Fibre**	**Steel**	**Aluminum**	**PET**	**Mixed Plastics**	**Polycoat Cartons**	**HDPE**	**Residue - EoL**
Residue	**44.5%**	30%[7]	1.0%	6.5%	5.7%	**51.2%**	0.8%	4.2%	4.4%	2.5%	1.1%	0.3%	**32.1%**
Film	6.2%	**67.9%**	0.2%	0.0%	0.7%	9.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.1%	1.4%
OCC	1.6%	0.0%	**84.7%**	0.0%	13.3%	4.8%	0.0%	0.0%	0.0%	0.3%	0.0%	0.1%	2.3%
Glass	1.3%	0.0%	0.0%	**93.1%**	0.5%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%
Newsprint	1.5%	0.2%	3.0%	0.0%	**39.5%**	2.6%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	4.4%
Magazines	0.0%	0.0%	0.0%	0.0%	**8.3%**	0.6%	0.0%	0.0%	0.5%	0.0%	0.0%	0.0%	1.3%
Office Paper	9.8%	0.0%	0.1%	0.0%	**8.4%**	2.8%	0.0%	0.1%	0.0%	0.3%	0.2%	0.1%	8.8%
OBB	8.4%	0.3%	7.2%	0.0%	**17.2%**	6.4%	0.2%	0.0%	0.0%	0.7%	3.7%	0.1%	12.9%
Steel	2.7%	0.0%	0.2%	0.1%	0.5%	1.2%	**97.9%**	0.2%	0.0%	0.1%	0.3%	0.3%	2.8%
Aluminum	0.7%	0.1%	0.1%	0.0%	0.4%	1.5%	0.1%	**91.9%**	0.1%	0.1%	0.0%	0.0%	1.4%
PET	1.9%	0.9%	0.4%	0.0%	1.4%	2.3%	0.2%	0.1%	**93.3%**	5.7%	0.0%	0.5%	3.4%
Mixed Plastics	20.9%	0.4%	2.8%	0.2%	3.1%	14.4%	0.5%	0.2%	1.2%	**84.0%**	0.3%	0.4%	19.3%
Polycoat Cartons	0.2%	0.1%	0.0%	0.0%	0.7%	0.6%	0.1%	3.2%	0.2%	0.2%	**93.4%**	0.1%	2.7%
HDPE	0.4%	0.0%	0.3%	0.0%	0.1%	0.7%	0.0%	0.0%	0.3%	5.5%	0.8%	**97.9%**	2.5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

[7] Primarily comprised of plastic multi-laminate film (30%), which is considered a contaminant.

4.6. Time & Motion Study

In addition to the mass balance audit, RSE also conducted a time and motion analysis to determine the time spent by manuals sorters for both shifts to sort targeted materials. The primary goals associated with the time and motion tests were to determine of the number of picks per minute per sorter for each particular material, and how this varies by position and shift on the sorting line. Table 8 and 9 highlight the time share results of materials picked by each manual sorter.

- During the AM shift, sorters in the pre-sort room spend 35% of their time sorting plastic film, 25% residue and 27% handling bagged recyclables[8]. Similarly, sorters from the PM shift spend 45% of their time picking plastic film, residue at 20% and 27% handling bagged recyclables.
- From the AM shift, sorters in the OCC rooms spend 68% of their time picking large OCC (>30 cm) and 28% capturing small OCC (<30 cm). Similar results are found for the PM shift with 70% of the time spent on large OCC and 25% on small OCC.
- Sorters in the upper and lower fibre sort rooms are instructed to capture containers, residue and plastic film. Sorters in both rooms and shifts and for all lines spend the majority (54%) of their time capturing containers. Sorters on the v-screen lines encounter and handle more containers than sorters on lines A and B.
- From the AM shift, sorters at the ballistic QC station spend 55% of their time picking mixed fibre and 42% handling OCC. However, sorters from the PM shift sorters spend less time picking mixed fibre (39%), but more time picking OCC (49%) than that of the AM shift.
- From the AM shift, the sorter at the eddy current QC station spends the majority of their picking ejected contamination (77%) such as PET bottles and polycoat cartons, and 20% of their time on foil/pie plates. From the PM shift, the sorter spends 81% of their time picking contamination and 15% on foil/pie plates.
- From the AM shift, the sorter at the mixed plastics QC station spends 85% of their time handling residue and 14% capturing PET. From the PM shift, the sorter dedicates 59% of their time on residue, 24% on PET and 18% on other containers.
- From the AM shift, sorters in the container sort room spend 46% of their time capturing mixed plastics, 34% and 9% on HDPE colour and natural. Likewise, sorters from the PM shift spend 45% of their time on mixed plastics, 37% and 8% on HDPE colour and natural.
- From the AM shift, the sorter at the residue QC station spends 59% of their time capturing containers and 38% on fibres. During the sample periods, there was no sorter present during from the PM shift.

[8] This is a combination of sorters picking large and small bagged recyclables and manually ripping open bagged recyclables.

Table 8 - Percentage of Total Time Spent per Material in the AM Shift

Positively Sorted Materials	Pre-Sort	OCC QC	Upper Fibre ONP	Upper Fibre Vscreen	Lower Fibre ONP	Lower Fibre Vscreen	Ballistic QC	Magnet QC	Eddy Current QC	PET Optical	MRP Dual Optical	Cartons Dual Optical	Container Sort Room	Residue QC
Polycoat Cartons	-	-	-	-	-	-	-	-	-	-	-	-	5%	-
Fibre	-	-	-	-	-	-	-	-	-	-	-	8%	-	38%
Mixed Fibre	-	-	-	-	-	-	55%	-	-	-	-	-	-	-
OCC < 30cm	-	28%	-	-	-	-	-	-	-	-	-	-	-	-
OCC > 30cm	-	68%	-	-	-	-	-	-	-	-	-	-	-	-
OCC/OBB	-	-	-	-	-	-	42%	-	-	-	-	-	-	-
Small Bagged Recyclables[9]	8%	-	-	-	-	-	-	-	-	-	-	-	-	-
Large Bagged Recyclables	10%	-	-	-	-	-	-	-	-	-	-	-	-	-
Ripped Open Bags	9%	-	1%	-	1%	-	-	-	-	-	-	-	-	1%
Scrap Metal	1%	1%	-	-	-	-	2%	40%	3%	-	-	-	-	-
Containers	-	-	50%	60%	43%	63%	-	-	-	-	18%	-	-	59%
Aluminum Foil/Food Plate[10]	-	-	-	-	-	-	-	-	20%	-	-	-	-	-
Aerosol - Steel	-	-	-	-	-	-	-	60%	-	-	-	-	-	-
PET	-	-	-	-	-	-	-	-	-	-	14%	-	5%	-
HDPE Mixed	6%	-	-	-	-	-	-	-	-	-	1%	-	-	-
HDPE Natural	-	-	-	-	-	-	-	-	-	-	-	-	9%	-
HDPE Colour	-	-	-	-	-	-	-	-	-	-	-	-	34%	-
Plastic Film	35%	-	33%	27%	39%	24%	-	-	-	-	-	-	-	2%
Mixed Plastics	-	-	-	-	-	-	-	-	-	-	-	-	46%	-
Oversize Plastics	4%	-	-	-	-	-	-	-	-	-	-	-	-	-
Residue	25%	3%	15%	12%	16%	13%	1%	-	-	-	85%	-	-	-
Residue - UNA	1%	-	-	-	-	-	-	-	-	-	-	-	-	-
Ejected Contamination	-	-	-	-	-	-	-	-	77%	100%	-	92%	-	-
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

[9] Equivalent to grocery size bags
[10] Includes foil, pie plates, food trays

Table 9 - Percentage of Total Time Spent per Material in the PM Shift

Positively Sorted Materials	Pre-Sort	OCC QC	Upper Fibre ONP	Upper Fibre Vscreen	Lower Fibre ONP	Lower Fibre Vscreen	Ballistic QC	Magnet QC	Eddy Current QC	PET Optical	MRP Dual Optical	Cartons Dual Optical	Container Sort Room	Residue QC
Polycoat Cartons	-	-	-	-	-	-	-	-	-	-	-	-	3%	-
Fibre	-	-	-	-	-	-	-	-	-	-	-	10%	-	-
Mixed Fibre	-	-	-	-	-	-	39%	-	-	-	-	-	-	-
OCC < 30cm	-	25%	-	-	-	-	-	-	-	-	-	-	-	-
OCC > 30cm	-	70%	-	-	-	-	-	-	-	-	-	-	-	-
OCC/OBB	-	-	-	-	-	-	49%	-	-	-	-	-	-	-
Small Bagged Recyclables[11]	5%	-	-	-	-	-	-	-	-	-	-	-	-	-
Large Bagged Recyclables	10%	-	-	-	-	-	-	-	-	-	-	-	-	-
Ripped Open Bags	12%	-	2%	1%	3%	1%	-	-	-	-	-	-	-	-
Scrap Metal	1%	-	-	-	-	-	3%	29%	4%	-	-	-	-	-
Containers	-	-	51%	62%	45%	57%	-	-	-	-	18%	-	-	-
Aluminum Foil/Food Plate[12]	-	-	-	-	-	-	-	-	15%	-	-	-	-	-
Aerosol - Steel	-	-	-	-	-	-	-	27%	-	-	-	-	-	-
PET	-	-	-	-	-	-	-	-	-	-	24%	-	7%	-
HDPE Mixed	6%	-	-	-	-	-	-	-	-	-	-	-	-	-
HDPE Natural	-	-	-	-	-	-	-	-	-	-	-	-	8%	-
HDPE Colour	-	-	-	-	-	-	-	-	-	-	-	-	37%	-
Plastic Film	45%	2%	31%	25%	38%	23%	-	-	-	-	-	-	-	-
Mixed Plastics	-	-	-	-	-	-	-	-	-	-	-	-	45%	-
Oversize Plastics	1%	-	-	-	-	-	-	-	-	-	-	-	-	-
Residue	20%	2%	16%	12%	13%	19%	7%	-	-	-	59%	-	-	-
Residue - UNA	-	-	-	-	-	-	1%	-	-	-	-	-	-	-
Ejected Contamination	-	-	-	-	-	-	-	43%	81%	100%	-	90%	-	-
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

[11] Equivalent to grocery size bags
[12] Includes foil, pie plates, food trays

4.7. Equipment Maintenance Assessment

HRT assessed the maintenance and value of the sorting equipment (Appendix A). Key observations and recommendations identified from the assessment are highlighted in Table 10 and were made based on visual observations, discussions with MRF staff and other equipment experts.

General comments concerning sorting line:

- HRT's equipment maintenance observations was performed over several visits to the MRF.
- During the site visits, the MRF experienced significant downtime periods. However, the downtime was typically not associated with equipment breakdowns.
- High maintenance costs associated with the maintenance of the ONP screens, V-screen and balers.

Table 10 - Observations & Recommendations made from the Equipment Maintenance Assessment

Equipment	Peel Observations/Recommendations
Bag Breaker	• The bag breaker is in good shape and operating well. The bag breaker's technology is still considered to be the best available in the market. Maintenance costs will continue to increase as the equipment ages. When feeding the bag breaker both large and small bags, it only opens the large ones.
OCC Screens	• The screens are performing at a combined 52% efficiency rate. The steel discs will rarely need to be replaced. However, the Region should consider the possibility of tightening the disc spacing in accordance with consumer shift towards smaller OCC packaging.
ONP Screens	• Weekly inspections for disc wear are required. It is estimated that entry point axles will require disc replacement every 3 months. The balance of discs will require replacement on a revolving schedule. The Region's ONP screens are considered to be older technology in light of material composition change from decreasing newspaper readership.
V-Screen	• As a result of a weakness in the overall screen engineering design, the V-screen is sorting containers with the paper fraction. Weekly inspections for disc wear are required and frequent disc replacement will help to maintain improved paper/container separation. As this screen is considered to be out-of-date technology, deficient commodity separation is not a surprising result.
Fines Screen	• The fines screen encounters a high volume of glass, and therefore incurs very high disc and shaft wear. The shafts in this screen will wear differently in each zone. Entry point shafts wear more quickly than the rest, so will need replacement every 3 - 9 months. The balance of shafts/discs will require replacement on a revolving schedule. Also, due to the complexity of proper maintenance of this

	screen – weekly inspections for disc wear are recommended.
ORSE	• The ORSE requires monthly maintenance inspection with focus on the springs and bearings on the vibratory table.
Ballistic Separator	• Monthly or more frequent inspections are required to ensure minimal downtime on the ballistic separator. The items to predominately focus on are paddle bushing/bearings. Daily cleaning of wrapped film plastic from the paddles is mandatory. Plan on replacing the unit at 15 years of ownership.
Magnet	• Magnets historically require little maintenance. Bearings and belts are the most common maintenance items. Plan on replacing electro-magnets at around 15 years of ownership. Permanent Magnets will continue to perform indefinitely.
Eddy Current	• Eddy Currents in general will be severely damaged when ferrous metals are left in contact with the rotor (head pulley). The fiberglass sleeve which is covering the rotor will need inspection when metals are seen melted into the conveyor belt. Plan on replacing/rebuilding the rotor at 6 -7 years of ownership.
PET Optical Sorter	• All optical sorters require daily cleaning with special attention being paid to the glass protecting the lights and the space between the conveyor and the valve block. The return rollers on the acceleration conveyor also need more attention to cleaning. A buildup of any colored materials (paint etc.) on the conveyor belt will cause a misreading for sorting tasks. Pellenc Optical sorters have self-calibrating software which is known to become confused over the course of 1 or 2 shifts. Frequent re-calibration is required. Electronics will need replacing at year 6 of ownership.
Dual Optical Sorter	• Same comment as above. However, as a result of low sorting efficiencies, the dual optical sorter should be placed on a regular PM schedule with the installer or equipment manufacturer.
Balers	• Due to the age of the balers, the maintenance costs and type of maintenance that is being done, HRT and RSE recommend that the balers be replaced.
Atlas Air Compressor	• This compressor is experiencing a high level of maintenance. Consider replacement.
Boge Air Compressor	• Continue to follow manufacturer's maintenance requirements.

5. Areas for Improvement

5.1. Burden Depth on Sort Line A

Under the current sorting process, bagged recyclables recovered at the pre-sort from lines A and B are sent to the bag breaker. Broken bags and contents are then conveyed to only line A. This added material has created a burden depth issue on line A. It is important to note that the key to effective and efficient manual and automated sorting is the avoidance of overloading. If material on the sort line is too deep as it passes by manual sort stations or equipment, it will not be sorted properly or at a lower efficiency.

To manage the burden depth issue at the pre-sort, an additional two sorters are utilized on line A, and this accordingly results in an increase in the number of picks on that line (Table 11).

Table 11 - Combined Sorter Picks per Minute at the Pre-Sort for Both Shifts

	Line A	Line B
AM	74.1	42.7
PM	75.7	54.4

5.2. Containers in Mixed Fibre Bales

Table 12 below illustrates the fraction of the material type found in the mixed fibre stream. For example, 28% of all inbound polycoat cartons ended up in the mixed fibre stream; 12% of PET; 14% of aluminum; and 10% of steel. Although the presence of these containers in the mixed fibre stream generates some revenue, it is lower than what would have been realized if they were marketed based on their grade. The inverse is true for mixed plastics which typically yield a lower market price than mixed fibres. The financial implications of these recyclables lost in the mixed fibre stream is analyzed below in section 6.1.2.

Table 12 - Fraction of Material Stream Found in Mixed Fibre Category

Material Type	Materials Found in Mixed Fibre Bales
Scrap Metal	2%
Film	16%
OCC	37%
Glass	3%
Mixed Fibre	88%
Steel	9%
Aluminum	14%
PET	12%
Mixed Plastics	24%
Polycoat	28%
HDPE	2%
Residue	27%

5.3. Low Efficiencies of the Dual Eject Optical Sorter

As noted in Table 3, RSE identified lower than expected efficiency rate at the dual eject optical sorter, for mixed plastics (32%) and polycoat cartons (61%). As highlighted in the time and motion study results (Table 9 and 10), the low efficiencies found at the optical sorter results in manual sorters downstream, in the container sort room, spending a significant amount of time sorting mixed plastics (46% at the AM shift; 45% at the PM shift), on top of other targeted recyclables. The reduced efficiency for the equipment is in part due to the fact 30% of the material that the optical sorter sees is comprised of residue materials and fibre.

As a result of the abundance of loose materials such as fibre and residue still on the line once the conveyor approaches the dual eject optical sorter, the efficiency of the optical is lowered, as this contamination can interfere with the materials being targeted. For example, if a newspaper sheet is covering a milk carton, the optical sorter will be unable to “read” the carton and treat it as contamination rather than ejecting the carton to its correct bunker.

5.4. Fibre & Container Recyclables in the Residue Streams

Throughout the sorting line, three separate residue streams were independently tracked and analyzed. The first residue stream is generated at the pre-sort station; the second stream is generated in the upper and lower fibre rooms; and, third stream is the negative sort for residue at the end of the line after the residue QC station. For the purpose of this study, the end of line residue does not include the residue generated at the pre-sort and fibre rooms.

As illustrated in Table 13, less than half (45%) of the pre-sort residue is comprised of actual residue materials; fibre materials and mixed plastics each comprise 21%. For the residue generated in the fibre rooms, approximately half (51%) is comprised of residue materials, followed by 17% fibre materials, 14% mixed plastics, 9% film, and 7% valuable recyclables[13]. Residue generated at the end of the line and after the QC station, is comprised of 32% residue, 30% fibre, 19% mixed plastics, and 12% valuable recyclables.

Table 13 - Residue Streams Composition

Material	Residue - Pre-Sort	Residue - Fibre	Residue - End of Line
Fibre[14]	21%	17%	30%
Polycoat Cartons	0%	1%	3%
PET	2%	2%	3%
HDPE	0%	1%	3%
Mixed Plastics	21%	14%	19%
Aluminum	1%	2%	1%
Steel	1%	1%	2%
Glass	1%	2%	5%
Film	6%	9%	1%
Scrap Metal	1%	1%	1%
Residue	45%	51%	32%
Total	**100%**	**100%**	**100%**

6. Financial Analysis

6.1. Financial Impact of Missed Materials

In addition to the material flow model, RSE also developed a financial model to highlight the missed revenue opportunity of improperly sorted or missed materials (see Table 14). The following analysis used 2015/2016 inbound/outbound tonnage data and average commodity pricing.

Using the tip floor composition and the average commodity prices provided by the Region, it was estimated that an additional $1,400,000 in revenues could be generated annually if all of the materials entering the facility were sorted to their appropriate commodity types based on the expected efficiency rates of each sorting system. The greatest benefit lies by improving the capture of aluminum, PET, mixed plastics, polycoat cartons and HDPE for a return of $1,300,000. However, it should be noted that due to the age of some of the equipment and ever changing single-stream mix it is unlikely that all equipment will operate at rated efficiencies.

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[13] Valuable recyclables include polycoat cartons, PET, HDPE, aluminum, and steel.
[14] Includes mixed fibre, ONP, OCC, OBB.

Table 14 - Revenue Generation & Potential Estimates

Materials	Available Tonnes (MT)	Capture Rate (%)	Amount Captured (MT)	Actual Revenue ($)	Expected Revenue ($) *Expected Efficiency*	Net Benefit (Loss) ($)
Film	2,384	56%	1,332	$79,000	$127,000	-$48,000
Glass	8,853	92%	8,111	-$284,000	-$279,000	$5,000
Fibre	60,486	94.8%	57,334	$4,863,000	$4,874,000	-$11,000
Steel	2,577	80%	2,072	$358,000	$400,000	-$43,000
Aluminum	1,475	72%	1,056	$1,568,000	$1,971,000	-$403,000
PET	6,240	79%	4,903	$1,281,000	$1,467,000	-$186,000
Mixed Plastics	6,639	25%	1,659	$191,000	$687,000	-$497,000
Polycoat Cartons	1,362	51%	691	$96,000	$170,000	-$74,000
HDPE - Natural	652	81%	531	$463,000	$512,000	-$49,000
HDPE - Colour	1,790	81%	1,457	$890,000	$984,000	-$94,000
Scrap Metal	1,222	77%	865	-	-	-
Steel Aerosol	202	93%	187	-	-	-
Residue	10,542	-	-	-	-	-
Total	**104,324**	**-**	**80,198**	**$9,505,000**	**$10,915,000**	**-$1,410,000**

6.1.1. Potential Revenue from Increased Capture Rates

The system improvement recommendations outlined by RSE and HRT in Section 7 are expected to reduce the burden of sorting on all sort stations (manual and mechanical) starting at the pre-sort to the residue QC station. For example, at the pre-sort, the theory behind the recommendations is that they would enable sorters to be repurposed to increase the capture of material(s) (such as HDPE and film) and further remove residue that may inhibit downstream sorting efficiency. As these benefits cannot be accurately quantified, the revenue benefit from an arbitrarily selected minimum increase of 5% and 10% in capture rates for all materials downstream is presented in Tables 15 and 16.

If current material capture rates were to increase by 5%, approximately $600,000 in additional revenues could be realized. With a 10% increase in capture rates, an additional $1,170,000 in revenues could be realized.

Table 15 - Revenue Generation If Capture Rates Increased by 5%

Materials	Available Tonnes (MT)	Increased Capture Rate (%)	Amount Captured (MT)	Additional Amount Capture (MT) *5% Increase in Capture Rates*	Additional Revenue Potential *5% Increase in Capture Rates*
Film	2,384	61%	1,452	119	$7,000
Glass	8,853	97%	8,553	443	-$15,000
Fibre	60,486	99.8%	60,359	3,024	$257,000
Steel	2,577	85%	2,201	129	$22,000
Aluminum	1,475	77%	1,130	74	$110,000
PET	6,240	84%	5,215	312	$82,000
Mixed Plastics	6,639	30%	1,991	332	$38,000
Polycoat Cartons	1,362	56%	759	68	$9,000
HDPE - Natural	652	86%	563	33	$28,000
HDPE - Colour	1,790	86%	1,547	89	$55,000
Scrap Metal	1,122	82%	921	56	-
Steel Aerosol	202	98%	197	10	-
Residue	10,542	-	-	-	-
Total	**104,324**	**-**	**84,887**	**4,570**	**$592,000**

Table 16 - Revenue Generation If Capture Rates Increased by 10%

Materials	Available Tonnes (MT)	Increased Capture Rate (%)	Amount Captured (MT)	Additional Capture (MT) *10% Increase in Capture Rates*	Additional Revenue Potential *10% Increase in Capture Rates*
Film	2,384	66%	1,571	238	$14,000
Glass	8,853	100%	8,853	885	-$31,000
Fibre	60,486	100%	60,486	6,049	$513,000
Steel	2,577	90%	2,330	258	$44,000
Aluminum	1,475	82%	1,203	147	$219,000
PET	6,240	89%	5,527	624	$163,000
Mixed Plastics	6,639	35%	2,323	664	$76,000
Polycoat Cartons	1,362	61%	827	136	$19,000
HDPE - Natural	652	91%	596	65	$57,000
HDPE - Colour	1,790	91%	1,636	178	$109,000
Scrap Metal	1,122	87%	977	112	-
Steel Aerosol	202	100%	202	20	-
Residue	10,542	-	-	-	-
Total	**104,324**	**-**	**86,532**	**9,140**	**$1,170,000**

6.1.2. Value of Container Recyclables in Fibre Bales

The MRF is currently experiencing material recovery loss in the form of containers lost in the fibre stream which has negatively impacted revenue generation. Table 17 below illustrates the total annual amount of valuable containers lost in the mixed fibre stream. RSE estimates a total of 1,538 tonnes of high value container recyclables can be found in the mixed fibre stream, with an estimated value of $465,000. Using polycoat cartons as an example, an estimated 28% are lost in fibre bales, this amounts to 377 tonnes annually which has an approximate value of $20,000. For aluminum containers an estimated 10% can be found in the mixed fibre stream. This amounts to 212 tonnes with an approximate value of $300,000.

Table 17 - Container Recyclables in Fibre Bales

Materials	Tonnage Available (MT)	Lost in Mixed Fibre Stream (%)	Lost in Mixed Fibre Stream (MT)	Potential Revenue ($)
Polycoat Cartons	1,362	28%	377	$20,000
PET	6,240	12%	726	$128,000
Aluminum	1,475	14%	212	$297,000
Steel	2,282	10%	223	$20,000
Total	**11,358**		**1,538**	**$465,000**

6.1.3. Value of Residue QC Material

Another finding from the study was the high amount of recyclables not captured at the residue QC station (end of sorting process). Based on audit results and inbound tonnages, RSE estimates that on an annual basis 3,331 tonnes of valuable recyclables are not captured at the residue QC station. The value of the landfilled recyclables is an estimated $577,000 (see Table 18). As an example, mixed fibre lost at the end of line residue has an estimated value of $138,000.

Table 18 - Annual Value of Missed Recyclables at the End of Line Residue QC

	Material Loss (MT)	Lost Revenue
Fibre	1,621	$138,000
Polycoat Cartons	148	$21,000
PET	186	$49,000
HDPE	137	$120,000
Mixed Plastics	1,054	$121,000
Aluminum	75	$111,000
Steel	110	$19,000
Total	**3,331**	**$577,000**

7. Recommended Improvements

7.1. Retrofit of Bag Breaker

In order to alleviate burden depth issues on line A, it is recommended that the bag breaker be retrofitted in order to allow for the discharge of broken bags to both infeed lines, A and B. The retrofit should utilize a timed reverse mechanism on conveyor BO-3. Broken bags and their contents will then be discharged onto both lines on a yet to be determined alternating sequence (e.g.: 30 seconds of discharge on line A and then 30 seconds on the other line).

In addition, in the event that single stream loads consisting primarily of bagged recyclables[15] are received on a regular and long-term basis at the MRF, the retrofit should allow for the feed of these loads from the tip floor directly into the bag breaker thus bypassing the pre-sort station return conveyor. The broken bags would be conveyed to the pre-sort utilizing the above noted alternating sequence. The estimated cost to retrofit the bag breaker to allow for alternating discharge is $200,000.

7.2. Retrofit OCC Screens

The existing OCC screens should be modified to improve the efficiency and effectiveness of the screening process, which is currently calculated to be at 52%. Specifically, the current shaft setup would be improved by removing the first three shafts on the second deck and replacing them with upgraded shafts. These new components will result in tighter spacing and a more aggressive design that is intended to reduce the amount of OCC and OBB that is currently falling through. The retrofit of the OCC screens is a cost efficient approach that enhances the capture of materials upstream (at the OCC screens) and prevents downstream impacts on the manual sorters and equipment. Cost to retrofit the screens is $50,000[16].

7.3. Optical Sorters to Recover Containers in Mixed Fibre Stream

The RSE team recommends the installation of three optical sorters to improve the efficiency and capture of containers[17] found in the mixed fibre stream. Three optical sorters are recommended in order to process current tonnages from the ONP screens, V-screen and ballistic. The sorted fibres would then be transferred to the existing fibre sort rooms.

The ejected containers would be conveyed to the existing ballistic sorter. It should be noted that a potential consequence of using optical sorters to eject containers from the mixed fibre stream, is that some fibres will be ejected with the containers. However, the benefit of ejecting containers to the ballistic is that it will have the ability to remove incidental fibres. Cost and installation of the three optical sorters is estimated at $3,000,000.

7.4. Installation of Residue Quality Control Optical Sorter

As a consequence of upstream sorting inefficiencies and the inability of the manual sorter at the residue QC station to capture valuable container and fibre materials, the team recommends the installation of an optical sorter at the station to capture missed recyclables at the end of the line. The optical should be programmed to sort all containers (including metals) and automatically return ejected containers back into the system for an additional opportunity for capture. Cost and installation of the residue QC station optical sorter is estimated at $1,000,000.

The following payback analysis (Table 19) illustrates the return on investment under the integrated approach (bag breaker and OCC screens retrofit, installation of optical sorters for the mixed fibre stream and residue QC station) and varying capture rates. As capture rates improve with the addition

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[15] Although the Region utilizes an automated cart collection program, the MRF on regular basis receives loads that are comprised of 100% bagged recyclables which are derived from unique collection points where carts are not utilized.
[16] $25,000 per screen.
[17] Optical Sorter would target all plastic (1-7), metal and polycoat carton containers.

and retrofit of equipment, payback time period will improve. The payback analysis is based on the purchase of new equipment, however, when appropriate, refurbished-used equipment should be considered as an option to lower costs.

Table 19 - Payback Analysis of Recommended Improvements

	80% Capture of Lost Recyclables	**85% Capture of Lost Recyclables**	**90% Capture of Lost Recyclables**	**100% Capture of Lost Recyclables**
Capital Costs	**$4,250,000**	**$4,250,000**	**$4,250,000**	**$4,250,000**
Bag Breaker Retrofit	$200,000	$200,000	$200,000	$200,000
OCC Screens Retrofit	$50,000	$50,000	$50,000	$50,000
Fibre Side Optical Sorters	$3,000,000	$3,000,000	$3,000,000	$3,000,000
Residue QC Station Optical Sorter	$1,000,000	$1,000,000	$1,000,000	$1,000,000
O&M costs ($/yr)	$40,000	$40,000	$40,000	$40,000
Amortization (yrs)	10	10	10	10
Total cost	**$4,650,000**	**$4,650,000**	**$4,650,000**	**$4,650,000**
Revenue (est.) *(containers in fibre stream; recyclables in residue stream)*	$859,000	$912,000	$966,000	$1,073,000
Capital Payback period (yrs)	4.95	4.66	4.40	3.96
Capital & O&M Payback period (yrs)	5.42	5.10	4.81	4.33

Appendix

Region of Peel - Appendix A - HRT Equipment Analysis

Equipment	Initial Cost	Repair Cost to July 2016	Current Value	Replacement Cost	Current Condition	Estimated Total Lifespan	Estimated Remaining Lifespan	Inspection / Repair / Replace / Continue Preventative Maintenance	Maintenance Timing	Operating Expenses YR 1	Capial Cost YR 1	Operating Expenses YR 2 - 5	Capital Costs YR 2 - 5	Operating Expenses YR 6 - 10	Capital Costs 6 - 10 yr	Notes/Recommendations
BHS Bag Breaker	$ 610,326.00	$ 74,932.77	$ 50,000.00	$ 400,000.00	good	15 years	5 years	CPM	ongoing	$ 9,500.00	$0.00	$ 38,000.00		$47,500.00	n/a	Still in good shape and operating well. Technology is still considered to be the best available in the market. Maintenance costs will continue to increase as the equipment ages,
Film Baler Ambaco Model #5042CD-830R	$ 103,200.00	$ 27,953.93	$ 17,500.00	$ 175,000.00	good	20 years	10 years	CPM	ongoing	$4,000.00	$0.00	$ 16,000.00	$0.00	$20,000.00	$189,000.00	Baler only bales film plastic, will require regular maintenance.
OCC 1	$ 126,400.00	$ 68,403.55	$ 12,500.00	$ 175,000.00	good	15 years	5 years	CPM	ongoing	$7,000.00	$0.00	$ 28,000.00	$175,000.00	$35,000.00	n/a	steel stars rarely need replacing, possible tightening of star spacing needed to accommodate smaller occ
OCC 2	$ 126,400.00	$ 50,245.10	$ 12,500.00	$ 175,000.00	good	15 years	5 years	CPM	ongoing	$2,600.00	$0.00	$ 10,400.00	$175,000.00	$13,000.00		steel stars rarely need replacing, possible tightening of star spacing needed to accommodate smaller occ
Newscreen 1	$ 240,100.00	$ 328,872.53	scrap	$ 425,000.00	fair	15 years	5 years	Inspection	3 months	$ 98,300.00	$0.00	$ 393,200.00	$425,000.00	$491,500.00	N/A	3 month inspection, entry axles replaced more frequently + balance of screen stars replaced on a revolving schedule. Old technology, offering unacceptable commodity separation.
Newscreen 2	$ 240,100.00	$ 250,147.00	scrap	$ 425,000.00	fair	15 years	5 years	Inspection	3 months	$ 88,250.00	$0.00	$ 353,000.00	$425,000.00	$441,250.00		
Splitter Screen 1	$ 35,500.00	$ 64,204.07	$ 3,550.00	$ 45,000.00	good	15 years	5 years	Inspection	3 months	$10,400.00	$0.00	$ 41,600.00	$45,000.00	$52,000.00	N/A	3 month inspection. Replace stars as required.
Splitter Screen 2	$ 35,500.00	$ 35,205.14	$ 3,550.00	$ 45,000.00	good	15 years	5 years	Inspection	3 months	$8,200.00	$0.00	$ 32,800.00	$45,000.00	$41,000.00	N/A	3 month inspection. Replace stars as required.
V-Screen	$ 307,900.00	$ 311,629.54	scrap	$ 315,000.00	good	15 years	5 years	Inspection	3 months	$105,400.00	$0.00	$ 421,600.00	$315,000.00	$527,000.00	N/A	3 month inspection, entry axles replaced more frequently + balance of screen stars replaced on a revolving schedule. Old technology, offering unacceptable commodity separation.
2014 Glass Breaking Fines Screen (2" Minus)	$ 77,334.00	$ 1,541.22	$ 35,000.00	$ 85,000.00	good	15 years	12 years	CPM	ongoing	$515.00	$0.00	$ 2,060.00	$0.00	$2,575.00	$129,000.00	will require shaft/star replacement every 6 years of ownership.
2014 Ballistic Separator Screen	$ 168,080.00	$ 13,552.82	$ 85,000.00	$ 175,000.00	good	15 years	12 years	CPM	ongoing	$4,520.00	$0.00	$ 18,080.00	$0.00	$22,600.00	$105,000.00	plan on replacing the unit at 15 years of ownership.
2014 Electro-Magnet Separator	$ 55,782.00	$ 6,327.50	$ 12,500.00	$ 60,000.00	good	15 years	12 years	CPM	ongoing	$1,275.00	$0.00	$ 5,100.00	$0.00	$6,375.00	$72,000.00	plan on replacing the unit at 15 years of ownership.
2014 Eddy Current Separator	$ 158,525.00	$ 2,648.27	$ 40,000.00	$ 175,000.00	good	15 years	12 years	CPM	ongoing	$1,350.00	$0.00	$ 5,400.00	$0.00	$6,750.00	$10,000.00	plan on replacing/rebuilding the rotor at 6 -7 years of ownership.
2014 PET Optical Sorting Unit	$ 214,919.00	$ 4,090.13	$ 50,000.00	$ 250,000.00	good	15 years	12 years	CPM	ongoing	$1,375.00	$0.00	$ 5,500.00	$0.00	$6,875.00	$266,000.00	electroincs will need replacing year 6 of ownership
2014 Polycoat/MRP Optical Sorting Unit	$ 235,877.00	$ 5,969.39	$ 55,000.00	$ 250,000.00	good	15 years	12 years	CPM	ongoing	$2,000.00	$0.00	$ 8,000.00	$0.00	$10,000.00	$266,000.00	electroincs will need replacing year 6 of ownership. Consider a PM program with installer/manufacturer
Atlas Air Compressor		$ 49,193.74	$ 2,500.00	$ 75,000.00	poor	10 years	2 years	Replace	1-2 years	$9,750.00	$0.00	$ 39,000.00	$75,000.00	$48,750.00		will need a complete rebuild or replacement within 2 years
2014 BOGE Air Compressor	$ 35,000.00	$ 11,169.78	$ 10,000.00	$ 50,000.00	good	10 years	7 years	CPM	ongoing	$2,250.00	$0.00	$ 9,000.00	$0.00	$50,000.00	$72,000.00	Compressor and dryer will need major overhall at year 7 of ownership.
Aluminum Eddy Current 1	$ 94,600.00	$ 104,168.47	$ 20,000.00	$ 120,000.00	under repair	15 years	10 years	out for rebuild		$16,800.00	$0.00	$ 67,200.00	$0.00	$84,000.00	$166,000.00	currently down for rebuild, after startup go to 3 month inspection.
Aluminum Eddy Current 2	$ 94,600.00	$ 66,006.37	$ 20,000.00	$ 120,000.00	excellent	15 years	10 years	CPM	ongoing	$2,400.00	$0.00	$ 9,600.00	$0.00	$12,000.00	$150,000.00	3 month inspection
ORSE		$ 35,000.00	$ 75,000.00	$ 160,000.00	excellent	15 years	10 years	CPM	3 months	$4,050.00	$0.00	$ 16,200.00	$0.00	$20,250.00	$400,000.00	3 month inspection, consider newer technlogy after 2021
40yd Trash Compactor (replaces Trash Up - 3000)	$ 274,755.00	$ 6,925.49	$ 25,000.00	$ 325,000.00	Fair	15 years	2 years	CPM	2018	$450.00	$0.00	$ 1,800.00	$325,000.00	$2,250.00		repair/replace main cylinder within 2 years
Container Baler Harris Centurion Model #150	$ 526,000.00	$ 875,123.39	scrap	$ 700,000.00	poor	15 years	1 year	Replace	2017	$143,000.00	$700,000.00	$ 572,000.00		$715,000.00		baler needs replacing
Fibre Baler Ambaco Model #8043-10-150	$ 395,800.00	$ 464,350.47	$ 15,000.00	$ 400,000.00	poor	15 years	1 year	Replace	2017	$56,400.00	$400,000.00	$ 225,600.00		$282,000.00		Baler needs replacing
TOTALS										**$579,785.00**	**$1,100,000.00**	**$2,319,140.00**	**$2,005,000.00**	**$2,937,675.00**	**$1,825,000.00**	

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