Reclay StewardEdge
Product Stewardship Solutions

Holliday Recycling Technologies

Regional Municipality of Waterloo,

Process/Equipment Review, Material Recycling Centre (MRC)

PREPARED BY: Reclay StewardEdge Inc.

WITH SUPPORT FROM: Holliday Recycling Technologies

May 2017

This page has been intentionally left blank.

Contents

Tables

Figures

Appendix

Reclay StewardEdge

1. Executive Summary

On behalf of Region of Waterloo (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 Recycling Centre (MRC) 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 container line at the MRC. The assessment was intended to evaluate the MRCs current effectiveness to sort incoming recyclables. Data collected were used to outline recommendations related to equipment and process modifications to improve sorting operations.

For this analysis RSE considered the new Waste Free Ontario Act (WFOA) and the implications for municipal equipment purchases. Although the payback period was not formally calculated, recommendations were made based on the overall benefit within a five-year timeframe. That is the anticipated timeframe after which regulations under the WFOA are expected to be implemented which may impact the operation of the MRC.

RSE worked with the Region's staff and their service provider, Green For Life (GFL), 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 from the inbound stream was collected (1.3 tonnes of container stream materials) and then introduced to the line to be sorted under normal conditions.

Following the controlled test, RSE analyzed the results and summarized the key findings within this report.

Subject	Analysis and Findings
Material Infeed	Limited mechanism in place to properly distribute inbound materials into the container line. Material infeed is highly dependent on the loader operator to ensure that materials are loaded evenly and properly. This dependence on manual input leads to instances of black belt and mounding. The Region has recently moved to a new collection contract that will allow the service providers to compact collected materials. Compacted materials will pose a problem at the MRC as it currently does not have the capability to declump materials.
Glass Capture	The glass breaker (GB-8) is only able to capture 85% of the inbound glass. The majority of what is not captured is found downstream in the residue stream.
Fibre/Film Capture	Only 63% of the available fibre and film is captured. Significant manual sorter effort is utilized to capture the 63%. Majority of what is not captured ends up in the residue stream.

Optical Sorting Efficiency	The dual eject optical sorter (AS-14) on the first eject is 79% efficient in sorting PET, and 57% efficient in sorting mixed plastics on the second eject.
Aluminum Sorting	The eddy current (ECS-17) is 98% efficient in sorting aluminum containers. However, secondary aluminum materials such as foil and pie plates/trays are currently captured with scrap metal, this represents lower marketing potential for the aluminum material.
Polycoat Ice Cream Containers	Polycoat ice cream containers, a recyclable material type, is currently captured in the residue stream.
Commodity Capture Rates	Excellent capture rates for valuable recyclables (PET 91%; HDPE 92%; steel 95%; aluminum containers 89%). This is a combination of material capture from sorting equipment and manual sorters.
Baler Operation	From a brief test, there was limited energy efficiency realized when operating on one motor instead of two.
Baler Maintenance	Baler maintenance currently carried out is less than what is prescribed by the manufacturer's operation and maintenance manual.
Downtime	Downtime at the MRC is currently at 6%. However, this does not include downtime associated with issues from baler. There is also significant downtime associated with the daily cleaning of the optical sorter and emptying of sort station bins.

To overcome the identified issues, the RSE team has made a series of recommendations to improve the MRCs overall performance.

Issues	Recommendations
Material Infeed	The installation of a drum feeder is recommended at the C1 conveyor. The drum feeder will automatically meter inbound materials into the system and will declump any compacted inbound materials. The drum feeder will also assist in some glass breakage.
Glass Capture	The replacement of the glass breaker (GB-8) with a glass culvert screen. The glass culvert screen will improve the capture of glass at the front end of the system, minimizing downstream impacts.
Aluminum Sorting	Capture and marketing of aluminum materials such as foil and pie plates/trays as a secondary aluminum grade.
Polycoat Ice Cream Containers	Polycoat ice cream containers currently landfilled should be recovered with the polycoat grade.
Fibre/Film	Fibre mesh conveyor/separator is recommended to recover inbound fibre and film

Capture	materials. This material should then be automatically conveyed to the MRCs fibre side.
Baler Operation	Continue to investigate the efficiency of operating the baler on one motor through a more extensive trial period.
Baler Maintenance	Maintenance of the baler should follow the manufacturers operating and maintenance manual, which would include documented daily and weekly checks.
Downtime - Tracking	MRC downtime associated with a baler breakdown should be recorded.
Downtime – Process Review	A review of the process utilized to carry out cleaning of the optical sorter and emptying of bins should be performed.

2. Objectives & Background

2.1. Project Objectives

The Region of Waterloo (Region) commissioned Reclay StewardEdge (RSE) to complete a process review of the Region's Material Recycling Centre (MRC), and is intended to provide a range of alternative solutions and will allow the Region to make more informed decisions and prioritize projects. Project objectives are:

- Asses existing and future equipment requirements including options for upgrades, repair or retirement and evaluate comparative costs for equipment acquisitions; and
- Rank options to improve the overall effectiveness to achieve optimal performance of the container sort line.

The Region's container sort line combines automatic processing equipment with manual sorting activities in order to cost effectively sort commingled container stream materials into marketable products. This study evaluates the performance of the container sort line at this dual stream (MRC) and analyzes both the automated equipment and manual processing component of the sorting system.

In order to provide ranked improvement options, the following detailed analyses were undertaken:

1. Mass Balance: included an on-site 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. Modelling and Analysis: to quantify equipment and material efficiency and purity rates, material capture rates and carry out a financial analysis.

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 were developed to enhance the efficiency and effectiveness of the MRC sort line.

2.2. Background

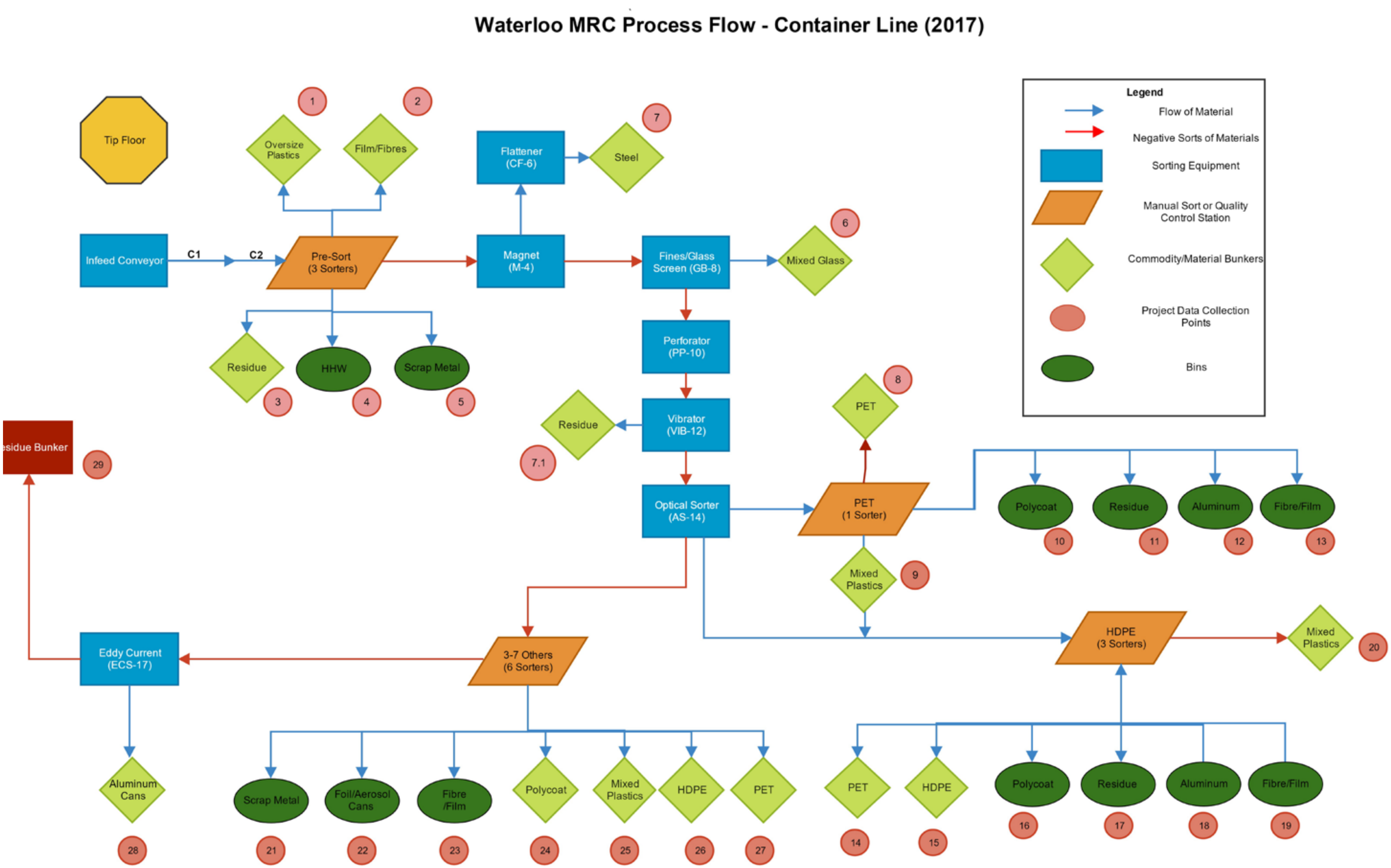
The Region consists of the cities of Kitchener, Waterloo and Cambridge and the townships of Wellesley, Woolwich, Wilmot, and North Dumfries. Annually, the MRC receives approximately 35,000 tonnes of dual stream blue box recyclables from the Region's curbside program and multi-residential programs.

The MRC only has a container sorting line and accordingly only containers (aluminum containers, PET, HDPE, gable tops and mixed rigid plastics) are processed and baled at the facility along with loose steel and mixed broken glass. The MRC does not process the inbound mixed fibres. That material is top loaded into trailers and transferred to the Region of Niagara's material recycling facility for sorting. However, the mixed fibre received at the MRC is still reported in the WDO Datacall as the Region of Waterloo's material.

2.3. Description of Container Line

The MRCs material process flow is shown in Figure 1.

Figure 1: Process Flow of the Container Line



Mixed containers collected are received on the container tip floor and then loaded using a front-end loader onto the C1 and C2 conveyor belts which feed the materials to the pre-sort station (C-3) (Figure 1). Sorters positively pick film, fibres, oversized containers, scrap metal and residue and are deposited into dedicated bins and cages. Bagged recyclables are also manually ripped opened to extract the recyclable material. The remaining material on the pre-sort conveyor (C-3) enters a magnetic separator (M-4) where ferrous metals are separated.

Recovered ferrous metals are transferred to a tin flattener before being conveyed to a roll-off container located outside the building. The non-ferrous material coming out of the magnet (M-4) enters a glass breaker (GB-8) system that recovers glass recyclables. The glass breaker (GB-8) is made out of steel shafts and steel discs that break the glass bottles into mixed broken glass (MBG). The MBG then falls through the spaces between the steel discs and is conveyed to the MBG bunker located outside of the building. MBG is transferred to the Region's landfill and used in the construction of road beds.

Figure 2: HDPE QC Sort Line

The remaining material riding on top of the glass breaker system (mostly containers and small size residue) goes into a plastic perforator (PP-10). The purpose of the perforator (PP-10) is to perforate and flatten all containers removing liquids and preventing bottles from rolling so the optical sorter (AS-14) can effectively scan and recognize the material. The perforator (PP-10) is also used to take out the air inside the containers to achieve better compaction at baling stage. Following the perforator (PP-10), materials are conveyed to a vibrating feeder/shaker screen (VIB-12) where the containers are spread evenly on a conveyor before entering the optical sorter (AS-14). The optical sorter (AS-14) is programmed to sort and eject PET containers onto one QC line ("PET") (C-19) and mixed rigid plastics onto another QC line ("HDPE") (C-21). Neutral materials are transferred to a third QC line ("3-7 Others") (C-16). These three conveyors pass through the manual container sort room where the following activities are undertaken.

At the PET QC conveyor (C-19), one sorter is responsible for the removal of non-PET containers off the conveyor. Mixed plastic and HDPE containers are directed to the HDPE line. Polycoat cartons, residue, aluminum and fibre/film materials are placed in sort station bins. The remaining PET material on the conveyor falls directly into the storage bunker underneath the platform.

At the HDPE QC conveyor (C-21), three sorters are responsible for the removal of HDPE, PET, polycoat cartons, and residue from the conveyor and placed in dedicated station platform bins. The remaining materials on the conveyor which are now comprised primarily of mixed plastics, fall directly in the storage bunker underneath the platform.

At the 3-7 Others QC conveyor (C-16), six sorters are responsible for the removal of PET, HDPE, mixed plastics, paper, film and polycoat cartons from the conveyor and place the material in the dedicated storage bunker underneath the sort room. The remaining material on the QC conveyor (C-16) enters an eddy current (ECS-17) separator where aluminum containers are ejected into a dedicated bunker. The remaining material, now considered residue, falls directly in the storage bunker underneath the platform.

All storage bunkers are equipped with a mechanically operated door. When the door is opened, the recyclables inside the storage bunker are pushed (using a skid steer) onto the baler infeed conveyor (B-1).

2.4. Issues Identified by the Region

Prior to carrying out the process review of the MRC, the Region identified the following equipment issues which RSE needed to consider in our evaluation:

Parallel Conveyor System (C1 & C2): The combined C1 and C2 conveyor systems are located at the beginning of the processing operations, conveying comingled containers to the presort room. A 2015 review[1] of the C2 conveying system found that due to space limitations the C2 conveyor was installed at a relatively steep incline of 35º. The MRC is an unheated building and in winter the comingled containers become frozen and conveyance up the incline may be problematic. The material slides down the conveyor and gets stuck between the C1 and C2 belts. RSE was asked to assess concept options for improvement based on the 2015 review.

Glass Breaker (GB-8): The current glass breaker at the MRC was sized for the 4-stream collection system when glass was sorted at the curb and removed before entering the sort line. The glass breaker is not able to keep up with the increased volume of glass going through the system that has resulted from the change to 2-stream collection. The net result is that not all of the glass is captured by the glass crusher and ends up creating operations and maintenance issues in the downstream sorting process. RSE was asked to review a 2015 proposal by Eurotech Systems as part of this project.

Perforator (PP-10): The existing perforator does not appear to be keeping up with the volume of material.

Shaker Table/Vibrator (VIB-12): The shaker table that feeds the optical sorter (AS-14) cannot keep up with the volume of material.

Optical Sorter (AS-14): The optical sorter is used to separate PET, mixed rigid plastics (MRP) and other material streams before these enter the sort room. RSE was asked to evaluate if the optical sorter has the capacity to keep up with the increased volume of material.

Eddy Current Separator (ECS-17): The eddy current (ECS-17) cannot keep up with the volume of material and the efficiency may be affected by changes in material composition (overall reduction in material thickness). As part of the project RSE assessed if a larger ceramic drum on the eddy current separator would be more effective for sorting the increased volume of material.

Baler: The baler currently runs on two motors. Our scope of work entailed evaluating the feasibility of operating the baler on one motor.

---

[1] GRB Engineering (2015). C2 Conveying System Review and Concept Options for Improvement. September 21, 2015. DOCS# 2080288.

3. Methodology

Two aspects of the MRC's operation were evaluated as part of this study:

1. An assessment of existing and future equipment requirements including options for upgrades, repair or retirement; assessment of comparative costs of potential equipment acquisitions (purchase or lease) or repair.
2. Ranking of options to improve the overall effectiveness to achieve optimal performance.

3.1. Material Performance & Sorting Equipment Performance

At the start of this study, RSE conducted a tour of the MRC 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 MRC staff to conduct a controlled test on October 24, 2016. This involved emptying all conveyor belts and bunkers of previously sorted material. Additionally, all bins/containers used in manual sorting and deposit locations were labelled for categorization and a mass balance audit was completed.

3.2. Manual Sorting Efficiency & Accuracy

With the assistance of MRC staff, RSE obtained representative samples from the container line tip floor totaling 1,287kgs. This material was introduced at the beginning of the controlled 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.

Table 1: Audit Material Categories List

Material Group	Material Sub-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	PET bottles, jugs and jars & Thermoforms
	HDPE bottles, jugs and jars
	PVC Containers
	LDPE/HDPE Film

Material Group	Material Sub-Category
- Mixed Plastics etc.	Plastic laminates
	LDPE – Rigid
	PP - bottles and jugs
	PS - Expanded polystyrene
	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

3.3. Equipment Assessment

Manufacturers' performance specifications and maintenance and downtime 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). The combination of the material flow mapping, the results from the audits, and the equipment expected efficiency rating have provided the basis for the data analysis.

4. Observations & Results

4.1. 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 MRC was limited to data collected during the RSE controlled test 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.

4.2. Tip Floor Composition

For the purposes of this study, the tip floor composition was determined after conducting the controlled test. The cumulative weight of each material collected during the controlled test 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

Material Group	Material Sub-Category	Tip Floor Composition (%)
Paper	Newspapers including Inserts and Flyers	1.5%
	Magazines, Catalogues, and Telephone Directories	0.6%
	Office Paper	0.9%
Paper Packaging	Corrugated Cardboard & Kraft Paper	1.2%
	Boxboard & Molded Pulp	2.8%
	Gable top cartons	2.7%
	Aseptic cartons	1.1%
	Paper cups	1.0%
	Paper ice cream containers	0.3%
	Other laminated packaging	0.1%
	Composite cans	0.8%
Plastics e.g.: - PET (#1) bottles - HDPE (#2) mixed - Mixed Plastics etc.	PET bottles, jugs and jars	14.8%
	PET Thermoforms	4.3%
	HDPE bottles, jugs and jars	5.8%
	PVC Containers	0.0%
	LDPE/HDPE Film	0.7%
	Plastic laminates	0.9%
	LDPE – Rigid	0.2%
	PP - bottles and jugs	3.2%
	PS - Expanded polystyrene	0.1%
	PS - Non-expanded	1.4%
	Other Rigid Plastic Packaging	2.2%
	Large HDPE & PP Pails & Lids	1.0%
	Other Plastics - non-packaging/durable	1.9%
Metals	Aluminum food and beverage cans	5.0%
	Aluminum foil & Aerosols	1.0%
	Steel food and beverage cans	11.0%
	Steel aerosol containers	0.3%
	Other metal containers	1.1%

Material Group	Material Sub-Category	Tip Floor Composition (%)
Glass	Clear Glass food and beverage containers	0.1%
	Colored/Mixed Glass food and beverage containers	0.1%
	Non-recognizable glass	30.5%
Organic Waste	Food or liquid waste (found within a container)	0.5%
	Food or liquid waste (not within a container)	0.1%
Electronics	All waste electronics	0.3%
Household Waste	All household hazardous waste including propane tanks, needles, CFL bulbs, etc.	0.0%
Other	Other Non Recyclables	0.5%
TOTAL		100%[2]

4.3. 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. For manual sort stations, RSE also measured efficiency throughout the line. Purity rates for manual sort stations are not typically calculated.

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 (ECS-17) is intended to target non-ferrous materials (e.g. aluminum). Therefore, the efficiency rate of the eddy current (ECS-17) 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 (M-4) is not considered in the efficiency calculation, as the magnet (M-4) never had the opportunity to sort that material.

[2] Individual figures in the tables may not add up to 100% or the total due to rounding.

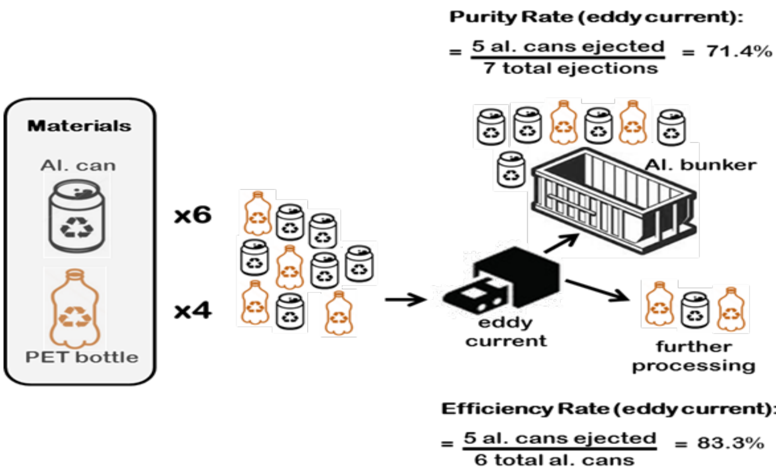


Figure 3: Illustration of Efficiency & Purity Rate Calculation

Table 3 provides the efficiency rates of equipment and manual sorters. Table 3 also 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 (ECS-17) is the total number of aluminum containers ejected by the eddy current (ECS-17) divided by the total number of containers (including non-aluminum materials) ejected by the eddy current (ECS-17). Figure 3 illustrates how the efficiency and purity rates are calculated.

Equipment with sufficiently high purity rate to meet market specifications need little to no QC before sorted material is conveyed to a bunker in preparation for baling and sale. However, equipment with a low purity rate requires additional QC to meet market specifications prior to material being baled and sent to market.

Table 3: Efficiency & Purity Rates

Equipment/Sort Station	Description/Purpose	Expected Efficiency (%)	Actual Efficiency (%)	Actual Purity (%)
Pre-sort Room (C-3)	Positive manual sorts of targeted materials			
Fibre/Film		-	35%	-
Oversized Plastics		-	20%	-
Scrap Metal		-	31%	-
Glass Breaker (GB-8)	Separates glass from lightweight materials	95%	85%	96%
Magnet (M-4)	Removes steel			
Steel		95%	98%	87%
Optical Sorter (AS-14)	Detects and ejects PET and mixed plastics			
PET		90%	79%	96%
Mixed Plastics		90%	57%	87%

HDPE Line (C-21)	Positive manual sort of HDPE			
HDPE		-	71%	-
3-7 Others Line (C-16)	Positive manual sorts of targeted materials			
Polycoat Cartons		-	84%	-
Fibre/Film		-	39%	-
PET		-	56%	-
Mixed Plastics		-	66%	-
HDPE		-	87%	-
Eddy Current (ECS-17)	Removes non-ferrous, containers from the sort line	90%	98%	98%

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

Table 4: Equipment & Manual Sort Observations

Equipment/ Sort Area	Observations
Pre-Sort Room (C-3)	• Sorters are manually sorting materials into different bins located at the sorting platform. • Sorters have to stop the line multiple times to even out the material by physically spreading out piles. • Bagged recyclables appears to be at a minimum in the inbound stream.
Magnet (M-4)	• Combination of magnet and flattener are functioning well.
Glass Breaker (GB-8)	• Glass ends up on the ground outside the MRC building. • Glass capture needs to be improved.
Perforator (PP-10)	• Perforator did not appear to be perforating plastic containers, only aluminum aerosols.
Optical Sorter (AS-14)	• As a result of the material coming out of the optical sorter in three parallel directions (PET line, HDPE line and MRP line) it was observed that because the belts were beside each other, the material that was correctly sorted by the optical sorter could bounce around and jump to nearby belts and end up in the incorrect line with a high volume of material.
HDPE Line (C-21)	• Role of sorters on this line is to positively pick materials and deposit into the proper bins or bunkers.
3-7 Others Line (C-16)	• Sorters are manually picking materials and classifying the materials in different bins or bunkers. • Polycoat ice cream tub containers are currently captured with residue materials. This material type can be recovered with polycoat cartons without impact to the grade.

Eddy Current (ECS-17)	• Located at the very end of the system and is highly effective in sorting available aluminum.

4.4. Mass Balance Results

To better understand the flow of materials within the MRC, Table 5 summarizes how each type of material is handled throughout the line. Specifically, it identifies the percentage of the material previously lost or captured 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 fibre/film as an example, 100% of the fibre/film stream is available for capture at the pre-sort. Sorters at the pre-sort were only able to capture 39% of the available material, while the remaining 61% progressed downstream. However, in between the pre-sort room and the next fibre/film capture point at the 3-7 Others QC sort line (C-16), an additional 15% of fibre/film was lost at other sort stations and no longer available for capture. At the 3-7 Others QC sort line (C-16), an additional 23% was captured.

Using PET as an additional example, 3% of the available PET in the system was not available for capture at the optical sorter (AS-14). The optical sorter (AS-14) was able to sort and capture 77% of the PET in the system, leaving 20% uncaptured by the optical sorter (AS-14) and sent downstream.

Table 5: Mass Balance of Materials Sampled

Material	Equipment/ Sort Station	Lost/Captured Prior to Sort Station	Captured by Equipment/ Sort Station	Missed by Equipment/ Sort Station	Total
Fibre/Film	Manual Sort - Pre-Sort (C-3)	0%	39%	61%	100%
Fibre/Film	Manual Sort - 3-7 Others Line (C-16)	54%	23%	24%	100%
Steel	Magnet (M-4)	3%	94%	3%	100%
Glass	Glass Breaker (GB-10)	0%	85%	15%	100%
PET	Optical Sorter (AS-14) - PET Line	3%	77%	20%	100%
HDPE	Manual Sort - HDPE Line	26%	70%	3%	100%
MRP	Optical Sorter (AS-14) - HDPE Line	28%	38%	34%	100%
Polycoat Cartons	Manual Sort - 3-7 Others Line (C-16)	10%	81%	8%	100%
Aluminum	Eddy current (ECS-17)	30%	68%	2%	100%

4.5. Material Capture Rates

Table 6 outlines the capture rates for various materials on each line. The capture rates presented are based on where the material will end up after the sorting process. 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 HDPE indicates 92% of the available materials in the facility ended up in the HDPE bunker. This is a combination of the materials correctly captured on the HDPE sort line (C-21) and the missed materials recovered at the 3-7 Others manual sort line (C-16). The remaining 8% was distributed in other commodity bunkers or ended up in the residue stream. 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.[3]

Material capture rate highlights include:

- Of the inbound fibre and film, 63% is captured and transferred to the fibre side. A significant amount of the lost fibre/film is found in the residue stream (25%).
- Primarily as a result of the magnet (M-4), steel is captured at a 95% rate.
- Only 85% of the mixed broken glass stream is captured. The missed mixed broken glass can be found downstream in the residue.
- PET has a 91% capture rate. The majority (6%) of what is missed can be found in the mixed plastics stream.
- HDPE also has a high capture rate of 92%. Of the missed HDPE containers, the majority (7%) can be found in the mixed plastics stream.
- For mixed plastics, approximately 77% of the material stream was captured. Of what is lost, 5% can be found in the mixed broken glass stream, 4% in PET, 4% in HDPE and 8% in residue.
- Polycoat cartons have an 87% capture rate. The majority of what is lost can be found in the residue stream (9%).
- For aluminum cans, approximately 89% of what is available is captured. From what is lost, 4% can be found in the scrap metal material category, 3% in mixed plastics, and the rest scattered in other material categories.
- For aluminum foil and pie plates, 44% can be found in scrap metal and 41% in the aluminum bunker. The aluminum material found in scrap metal represents downgraded market revenues.

[3] Materials sorted in the wrong commodity/bale were not considered as captured material.

Table 6: Material Capture Rates

Material Type	Fibre/Film	Scrap Metal	Steel	Glass	PET	HDPE	Mixed Plastics	Polycoat Cartons	Aluminum	Residue	Total
Fibre/Film	**63%**	0%	2%	6%	2%	0%	2%	0%	0%	25%	**100%**
Scrap Metal	0%	**33%**	49%	4%	0%	0%	2%	0%	0%	12%	**100%**
Aluminum Foil & Pie Plates	0%	**44%**	5%	1%	0%	0%	3%	0%	41%	5%	**100%**
Steel	0%	1%	**95%**	0%	0%	0%	1%	0%	0%	3%	**100%**
Glass	0%	0%	0%	**85%**	0%	0%	0%	0%	0%	15%	**100%**
PET	0%	0%	1%	0%	**91%**	1%	6%	0%	0%	1%	**100%**
HDPE	0%	0%	0%	0%	0%	**92%**	7%	0%	0%	0%	**100%**
Mixed Plastics	1%	0%	1%	5%	4%	4%	**77%**	0%	0%	8%	**100%**
Polycoat Cartons	1%	0%	0%	0%	1%	0%	1%	**87%**	0%	9%	**100%**
Aluminum Cans	0%	4%	1%	1%	1%	0%	3%	0%	**89%**	1%	**100%**
Residue	29%	0%	3%	1%	20%	1%	7%	0%	1%	**38%**	**100%**

4.6. Bunker Composition

Table 7 highlights the composition of all targeted commodity bunkers. Each commodity is baled and sold to an end market with the exception of steel and glass, which are marketed loose. Residue is disposed at the regional landfill. The highlights include:

- Steel (95%), glass (96%), PET (94%) and aluminum (98%) bunkers/material grades have the lowest amount of contamination. This is followed by HDPE (89%), mixed plastics (78%) and polycoat cartons (82%).
- The fibre/film grade is comprised of 75% fibre and 8% film. Main contaminant in the grade is primarily residue at 12%.
- The scrap metal grade is comprised of 42% steel materials (e.g. pots and pans) and 56% aluminum materials (e.g. pie plates, foil, aerosols). For added revenues, the aluminum component could be marketed separately from steel scrap.

Table 7: Bunker Composition Results

	Bunker/Material Grade									
Material Type	**Fibre/ Film**	**Scrap Metal**	**Steel**	**Glass**	**PET**	**HDPE**	**Mixed Plastics**	**Polycoat Cartons**	**Aluminum**	**Residue**
Fibre	**75%**	1%	1%	2%	1%	0%	1%	18%	0%	22%
Film	**8%**	0%	0%	0%	0%	0%	1%	0%	0%	1%
Steel	1%	**42%**	**95%**	0%	0%	0%	1%	0%	0%	6%
Glass	1%	0%	0%	**96%**	0%	0%	0%	0%	0%	**47%**
PET	1%	0%	1%	0%	**94%**	4%	11%	0%	0%	2%
HDPE	0%	0%	0%	0%	0%	**89%**	4%	0%	0%	0%
Mixed Plastics	1%	0%	1%	2%	2%	7%	**78%**	0%	0%	9%
Polycoat Cartons	1%	0%	0%	0%	0%	0%	0%	**82%**	0%	3%
Aluminum	0%	**56%**	1%	0%	0%	0%	2%	0%	**98%**	1%
Residue	12%	0%	1%	0%	3%	0%	2%	0%	0%	10%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

4.7. Equipment Assessment

This section outlines an assessment of the maintenance of the sorting equipment and associated downtime. Key observations and recommendations identified from the assessment are presented in Table 8 and were made based on review of maintenance and downtime records, visual observations and from discussions with other industry experts and MRC staff.

The equipment in Table 8 are listed in order of process flow and ranked in two ways; according to downtime minutes and downtime instances. Colour coding relates to ranking with red indicating high number of downtime minutes or instances, green indicating the least amount of downtime minutes or instances and orange indicating downtime within the mid-range.

General comments concerning the maintenance of the container line:

- All equipment maintenance on-site assessments and observations were performed over the course of several site visits by Holliday Recycling Technologies (HRT).
- During the site visits to the MRC, the site experienced little to no breakdowns during the assessments and observations. However, records for maintenance and downtime provided by the Region, outline the MRCs downtime for 2016.
- High maintenance costs and incidence of downtime is associated with specific sorting equipment.

The following comments relate to specific equipment initial issues identified by the Region as outlined in Section 2.4:

Parallel Conveyor System (C1 & C2): Following review of the concept options for improvement (GRB Engineering, 2015), no action is needed with respect to the options presented. The recent installation of taller cleats on C2 and a leveler to even out material entering on to C2 appears to have resolved the issues.

Eddy Current Separator (ECS-17): Ahead of the audit the Region expressed concern that the eddy current could not keep up with the volume of material and changing mix of materials and there was a need to increase the size of the ceramic drum. However, our analysis has shown that the eddy current to be 98% effective in efficiency and purity. In terms of the rotor size, there is no industry standard. Effectiveness of an eddy current is directly related to whether the magnets are eccentric or centric. It is also notable that the effectiveness of a piece of magnetic equipment is determined by the quality of the magnets, not necessarily the size of the rotor. At this time, there would be no benefit to increasing the size of the ceramic drum.

Glass Breaker (GB-8): In 2015, Eurotech Process Systems Inc. presented the Region with an option to improve the quality of glass by separating out lightweight contaminants such as straws and caps. This would be achieved through the installation double deck cleaning screen. However, glass clean-up for the Region is not a priority as the current stream is utilized at the landfill as road base material. There would be no benefit to installing this type of screen.

Baler: Currently the baler runs on two motors but has a reduced electrical option through one motor operation. In order to evaluate the feasibility of running the baler on motor for the benefit of energy savings and still be able to maintain baling operations and capacity (i.e. being able to bale the same amount of material at the same current duration), RSE and HRT recommend that MRC operator carry out the following procedural test:

1. With the baler set on two motors - track the time and number of bales produced from each bunker. Also track the time it takes to switch over from one material bunker to another. Do not add in the waiting time if the baler is sitting idle as this is considered wasted baling time.
2. Based on shipping records, calculate an average bale weight for each material type that is baled.
3. Using your “shipped to market data”, extrapolate how long it will take to bale each material including the switch-over time. Keep in mind that each bunker only holds so much material when adding in the switch-over time for the calculation. Add 10% for a cushion.
4. You should be able to calculate how long the baler needs to run per month to keep up with materials sorted.
5. Although the baler manual is said to explain the difference between running on one motor versus two, a review of manual did not find that information.
6. In its absence, do a quick test using one motor, timing how long it will take to make two or three bales and then use that baling time to recalculate the overall effect of the one motor baling sequence. The switch over time will remain the same for either one or two motors.”

Based on the baler rated capacity, it is possible that utilizing the “reduced electrical option” of running on one motor will result in some energy savings. From data provided by the Region for a short term test in February and March 2017, annual energy savings are estimated at $12,100. This is based on running the baler on one motor for an eight-hour shift.

Table 8: Equipment Maintenance and Assessment Observations and Recommendations

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
C-1: Conveyor	182	9	8	11	• Minimal downtime. • Inability to reduce the speed (i.e. slow down the line) of this conveyor without the motor tripping out.	• First recommendation is to install a drum feeder, which will help meter and de-clump material. • If drum feeder is not installed, it is recommended that the C1 conveyor gearbox is modified in order to be able to reduce the speed of the conveyor without the motor tripping out.
C-2: Conveyor	29	13	5	13	• Although the angle of this conveyor has caused feed problems for large containers (materials rolling backwards) in the past, this issue seems to be reduced by the addition of a leveler and taller cleats on the belt.	• Continue maintenance of conveyor as per manufacturer specifications.
M-4: Magnet	78	11	10	10	• In 2016 and in terms of downtime, the magnet ranked 11th in total minutes experienced, and 10th in downtime instances experienced. • The electro-magnet was installed in 1990. In spite of age, the sorting performance of the magnet, as determined by the controlled test, is fairly efficient.	• Magnets historically require little maintenance. Bearings and belts are the most common maintenance items. • Magnets typically lose magnetic abilities requiring replacement around 15 - 20 years of ownership. However, this magnet does not yet need replacing. Maintenance as per manufacturers specifications and minor modifications should continue.

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
GB-8:Glass Breaker	1,008	3	55	4.5	• A consistent source of significant downtime in 2016. The glass breaker ranked 3rd in total minutes experienced, and 4.5 in downtime instances experienced. • The main downtime documented at the glass breaker is a result of the screen jamming. The glass breaker installed during the 4-stream collection phase has not been able to keep up with the increase of glass in the stream. • In 2016, maintenance and repair work included the replacement of the gear box, shafts and bearings. • It also appears as though “cushioning” is occurring. “Cushioning” is when all of the material is mixed together going into the glass breaker. Non-glass materials cushioned with glass prevent the glass from making direct contact with the shafts thus diminishing the discs ability to actually break the glass itself.	• The operational and maintenance issues occurring downstream are caused by the ineffective removal of glass upstream. The issues can be greatly reduced with the installation of a drum feeder at the beginning of the line and replacement of the glass breaker with a culvert screen. However, if the glass breaker remains in operation and a drum feeder and culvert screen are not installed, our secondary recommendation is to adjust C-1 to a speed of 12 feet/minute resulting in a reduced depth of material on pre-sort conveyor. This will allow for greater capture of objectionable materials thus alleviating some of the pressure on the glass breaker. • Running the rotation speeds of the glass breaker at higher revolutions would help in reducing jams and increasing breakage. In general, glass breakers have a higher wear factor than other MRC equipment. • The recent addition of the blower to the glass breaker should also help to separate the lighter cushioned materials from the heavier glass increasing breakage. However, in order to maximize glass recovery a culvert screen is recommended, which is also less costly to maintain.

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
PP-10: Perforator	315	7	6	12	• In 2016, the perforator ranked 7th in total downtime minutes experienced, and 12th in downtime instances. However, the duration of breakdowns were prolonged. They included gear box and teeth replacement. • Inspection of HDPE and PET bottles was carried out after the perforator, and it was observed that there is little perforation occurring. It was also notable that the perforator was crushing material. While this can help to settle the material on the acceleration conveyor, ultimately helping the effectiveness of the optical sorter (AS-14).	• Changing the location of the perforator is not recommended to help with the issue of it being overburdened. Suggested equipment changes outlined above, along with the removal of the perforator will do a much better job of maintaining material flow at the desired levels. If the preference is to keep the perforator on the line, then it is recommended to reduce the frequency of teeth replacement by 75-100%. Use this as a test to see if a reduction in maintenance expenses can be achieved and still maintain crushing ability. • If possible under a redesign, keep the perforator as an aid to settle material before the optical sorter. Stop changing teeth in order to avoid the expense. The perforator should still be able maintain crushing ability with dull teeth.
CF-6A: Can Flattener	425	6	24	8	• Little maintenance and downtime is recorded as result of the can flattener.	• it is recommended that the Region continue to maintain this equipment as per the manufacturer's recommendations.

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
VIB-12: Vibrator/ Shaker Table	144	10	18	9	• In 2016 and in terms of downtime, the vibrator ranked 10th in total minutes experienced, and 9th in downtime instances experienced. • Concerns were outlined by the Region in the RFP regarding the vibratory feeder's ability to keep up with the current volume of material flowing over the system. Overburdening the vibratory feeder is direct result of overfeeding the line at C1.	• It is our recommendation that neither the replacement of this unit with a larger one, nor the addition of a secondary unit will fix an overfeeding issue. Adding a drum feeder or a reduction of C-1's speed to 12 feet per minute will prevent the overloading of the vibratory feeder, thus reducing downtime. If the changes outlined above are completed, this feeder is capable of meeting the volume requirements of the MRC.
AS-14: Dual Eject Optical Sorter	3,122	1	235	1	• For 2016 and in terms of downtime, the optical sorter ranked 1st in total minutes experienced, and 1st in downtime instances experienced. • The optical sorter was the cause of significant downtime in 2016. Repairs to the optical sorter included control unit and compressor repairs. However, the main cause of repeated downtime is the twice-daily need to clean the optical sorter to ensure optimal performance.	• The procedures undertaken to clean the optical sorter should undergo a process review for optimization. • Although questions have been raised about the optical sorter's ability to keep up with the current rate of flow through the plant, we believe it is capable of operating acceptably if the material is properly presented to it. The material should be in a single layer on the belt with space visible all around it. • Consideration should be given to reviewing the plant cleaning procedure for this piece of equipment. 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 but still require twice year detailed calibrations by the manufacturer.

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
ECS-17: Eddy Current	61	12	27	7	• For 2016 and in terms of downtime, the eddy current ranked 12th in total minutes experienced, and 7th in downtime instances experienced.	• Preventative maintenance of the eddy current should continue but also keep in mind they can 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 5 -7 years of ownership and the fiberglass sleeve every 3 - 5 years.
Conveyors	1,976	2	92	2	• The total downtime minutes and count represents an aggregate total of all conveyors (except C1 and C2) on the container line. The high ranking for minutes and count is to be expected as this represents a total of 14 individual conveyor belts. • Maintenance work includes bearings replacement.	• Continue maintenance of conveyors as per manufacturer specifications.
Empty Bins	262	8	55	4.5	• Significant downtime from the need to stop the sorting line to empty bins and containers located on the line.	• Similar to the optical sorter (AS-14), the procedures undertaken to empty bins should undergo a process review for optimization.

Equipment/ Downtime Cause	Total Minutes	Ranking (Minutes)	Downtime Instances Count	Ranking (Count)	Observations	Recommendations
PLC	545	5	46	6	• The PLC went through a major retrofit in June 2016. Prior to then there was consistent downtime associated with PLC. From January to June 2016, the MRC experienced 506 minutes of downtime as a result of a PLC malfunction. Since the install, there were only 39 minutes of downtime associated with the PLC.	• Continue maintenance of PLC as per manufacturers specifications.
Other	648	4	79	3	• Other causes of downtime are not attributed to sorting equipment. They include the presence of sharps, alarm errors, and power failure.	• Include additional detail in downtime log for other causes. • Downtime sources such as sharps should continue to be tracked to determine true impact. If impact is significant, a promotion and education campaign may be warranted.
B-2: Baler	NA	NA	NA	NA	• The Harris baler does not have a downtime rating. When the baler goes down, staff are sent home and no record of the time or cause is recorded.	• Consideration should be given to recording baler downtime instances and reviewing the preventative maintenance procedures to reduce overall maintenance costs and associated downtime. • Also, consideration should be given to running the baler on one motor to achieve energy savings. This will need to be confirmed through a long-term test.

5. Financial Analysis

5.1. Financial Impacts of Missed Materials

In addition to a material flow model, RSE also developed a financial model to highlight the missed revenue opportunity of improperly sorted or missed materials. The financial analysis utilized RSE audit data and 2015/2016 inbound/outbound tonnages and average commodity pricing provided by the Region. Table 9 outlines that average commodity pricing obtained by the Region in the sale of the MRCs recyclables.

Table 9: Average MRC Commodity Prices in a 12 Month Period (2015-2016)

Material	Average Price
Mixed Fibre	$60.33
Cartons	$128.84
PET	$288.07
HDPE	$580.75
Mixed Plastics	$99.63
Aluminum	$1,690.85
Steel	$157.59

Using the tip floor composition from the mass balance audit and the average commodity prices provided by the Region, it is estimated that the Region could obtain an additional $51,105 in revenues if the materials entering the facility were sorted to their appropriate commodity types and based on the expected and enhanced efficiency rates of each sorting system (see Table 10). For fibre/film as an example, it is estimated that a total of 915 tonnes is available for capture on an annual basis. Based on a 56% capture rate, identified through the mass balance, a total of 511 tonnes is actually captured, which equates to an approximate revenue of $30,843. The capture of fibre/film at an expected efficiency of 90% would yield a total of $49,673.

Table 10: Revenue Generation & Potential

Materials	Tonnes Available (MT)	Capture Rates	Amount Captured (MT)	Expected Revenue ($)[4]	Actual Revenue ($)	Net Benefit/ Loss ($)
Fibre/Film	915	56%	511	$49,673	$30,843	$18,831
Cartons	420	87%	363	$48,645	$46,753	$1,892
PET	2,001	91%	1,828	$518,796	$526,468	$(7,672)
HDPE	607	92%	559	$317,254	$324,372	$(7,118)
Mixed Plastics	1,052	77%	810	$94,370	$80,711	$13,660
Aluminum	628	89%	556	$955,411	$939,620	$15,792
Steel	1,270	95%	1,201	$190,177	$189,246	$931
Glass	3,210	85%	2,724	-	-	-
Total	**10,475**	**-**	**8,501**	**$2,121,015**	**$2,138,012**	**$51,105[5]**

[4] Expected revenue for has been calculated using the manufacturer efficiencies noted in Table 3. The expected efficiency of manual sorters is assumed at 90%.
[5] Capture rates for PET, HDPE and steel are already higher than expected rates. The material totals from those commodities are not included in the overall total.

A net loss is shown when the actual operating efficiency is better than the rated expected efficiency. While it is unlikely for all material capture rates to reach their rated expected efficiencies, our analysis and results suggests that a hypothetical 5% increase in material capture rates may be achieved with the implementation of our recommended system improvements. In cases when a net loss is shown, no net benefit will be achieved for a 5% increase as the equipment is already performing better than expected. The 5% increase in material capture rates would translate into an additional 524 tonnes of recyclable captured and $120,240 in additional revenues (see Table 11).

Table 11: Revenue Generation If Capture Rates Increased by 5%

Materials	Tonnes Available (MT)	Enhanced Capture Rates	Potential Amount Captured (MT)	Potential Additional Revenue ($)	Total Amount Captured (MT)	Total Actual Revenue ($)
Fibre/Film	915	61%	46	$2,760	557	$33,602
Cartons	420	92%	21	$2,702	384	$49,456
PET	2,001	96%	100	$28,822	1,928	$555,290
HDPE	607	97%	30	$17,625	589	$341,997
Mixed Plastics	1,052	82%	53	$5,243	863	$85,953
Aluminum	628	94%	31	$53,078	587	$992,698
Steel	1,270	99.5%	64	$10,009	1,264	$199,255
Glass	3,210	90%	161	-	2,884	-
Total	**10,475**	**-**	**524**	**$120,240**	**9,113**	**$2,258,252**

6. Areas of Improvement and Recommendations

For this analysis, RSE considered the new Waste Free Ontario Act (WFOA) and the implications for equipment purchases. Although the payback period was not formally calculated, the recommendations below are made based on the overall benefit within a five-year timeframe. That is the anticipated timeframe after which regulations under the WFOA are expected to be implemented.

In addition, the Region expressed that any new equipment should not be integral to the operation of the sort line. The desire is for the configuration of the sort line to remain the same so if any new piece of equipment failed, the sort line could continue to operate without impact on production.

6.1. Inbound Material Presentation

Effective inbound material infeed provides a consistent flow of materials and eliminates mounding and uneven distribution of materials (i.e. black belt) on the sorting line. At the MRC, inbound materials are fed onto C1 using a front-end loader. The materials are then automatically transferred to the C2 conveyor, which as a result of space limitations, is at a relatively steep incline of 35 degrees. The absence of material adjustment at C1 and the steep incline at C2 has created the following conditions:

- Some material roll back from C2 to C1
- Presence of black belt at the pre-sort
- Piles of varying depth at the pre-sort

Figure 4: C2 Incline Conveyor

Additionally, the Region moved to a new collection contract and system in March 2017. Previously, the inbound blue box recyclables were not compacted during collection. Under the collection system change, a minimum of 25% of inbound blue box recyclables may be compacted at a 2:1 ratio (150 kg/m^3). Based on a pilot test of compacted materials, the added compaction to container recyclables may pose sorting challenges at the MRC. Other dual stream municipalities such as the City of Hamilton and Region of Niagara outline a similar compaction ratio in their contracts with the blue box collection service provider. However, both Hamilton and Niagara material recycling facilities are equipped with a de-clumping mechanism at the front end of the container lines.

A primary recommendation is the installation of drum feeder at the front-end of C1 to provide an effective mechanism for material presentation and declump compacted recyclables collected as part of the impending collection changes in the Region. Without a declumping mechanism, material capture rates and sorting efficiencies will be greatly reduced.

The drum feeder will also be utilized to:

- Provide a consistent material feed rate into the system. This will allow the Region to no longer rely on the loader operator to provide the proper feed potentially allowing this staff person to help with other duties.
- Increase throughput and prevent surges of material.
- Provide some glass breakage.
- Allow for more efficient downstream equipment and manual sorting.

In the event that the drum feeder is not operational, the loader operator will still be able to load C1 with tip floor material without impacting production. The cost of a standard and new drum feeder is estimated at $125,000. Above ground installation cost is estimated at $50,000.

However, if the drum feeder is not installed, the Region should modify the C1 conveyor gear box in order to be able to reduce the speed of this conveyor without the motor tripping out. The gearbox would be modified to allow a setting of 40 Hz which equates to a speed of 12 feet/minute. This will provide the Region with the ability to slow down the line in order to maximize sorting capabilities downstream.

Equipment Cost	$125,000
Installation Cost	$50,000
Total	**$175,000**

6.2. Mixed Broken Glass Recovery

Clear and coloured glass bottles and containers were previously sorted from other mixed containers at the curb by the collection vehicle operator. These materials were subsequently tipped and removed before entering the sort line at the MRC. The minimal amount of glass bottles and containers missed by the collection vehicle operator that ended up in mixed containers stream were easily captured utilizing the glass breaker (GB-8). However, in 2012, the Region moved to two stream collection (containers and fibres), increasing the amount of glass in the mixed containers stream. The glass breaker (GB-8) initially meant to capture the incidental amount of glass bottles and containers has not been able to keep up with the increase. This highlighted by a high percentage of glass (15%) not captured at the front end by the glass breaker (GB-8) and found downstream in the residue stream. Accordingly, only 85% of the glass is recovered.

The inability to capture a high percentage of the glass at the front end has resulted in operational and maintenance issues downstream of the glass breaker (GB-8).

An additional primary recommendation is the installation of a glass culvert screen to capture the majority of the inbound glass, positioned after the pre-sort (C-3) and before the optical sorter (AS-14). Equipment and installation cost of a culvert screen is estimated at $80,000. The glass breaker (GB-8) will no longer be required and should be removed.

Equipment and Installation Cost	$80,000

6.3. Fibre and Plastic Film Recovery

Approximately 9% of the inbound mixed container stream is comprised of fibre and plastic film materials. Fibre and film captured on the sorting line is returned to the fibre side of the MRC for transport to the Region of Niagara for sorting. A total of five manual sorters positioned at the pre-sort (C-3), PET QC line (C-19), and 3-7 Others line (C-16) currently recover 63% of the inbound fibre and plastic film. The majority of what is not captured is found downstream in the residue stream (25%).

Although a time and motion study (to calculate the level of effort of sorters handling a specific material type) was not conducted for this project, it is clear that a significant amount of effort is expended on the capture of fibre and plastic film. Plastic film and fibre if not recovered early on a container line may pose a significant burden downstream on manual sort staff and equipment due to its tendency to wrap around and cover other materials and equipment. For example, the presence of fibre and plastic film may also create sorting inefficiency at the optical sorter (AS-14) which is currently rated at 79% for PET and 57% for MRP.

The purpose of installing an air mesh conveyor is to ensure that the inbound fibre and film on the container line (see Table 2) are sorted out of the line prior to the optical sorter (AS-14) and containers being sorted. This is critical as fibre and film on the line significantly impacts the sorting efficiency of sorting equipment and the ability for sorters to identify targeted containers. In addition, residential and collector promotion and education on reducing the amount of improperly sorted fibres and film in the containers blue box is also recommended.

The cost of a new air mesh conveyor is estimated at $100,000. Installation cost is estimated at $50,000.

Equipment Cost	$100,000
Installation Cost	$50,000
Total	**$150,000**

6.4. Baler Operation

In terms of maintenance of the baler, consideration should be given to following the preventative maintenance plan outlined in the operations manual. The manual currently recommends daily, weekly and monthly checks, all of which should be performed and documented.

In addition, short term tests for running the baler on one motor indicate cost savings could be achieved. The baler was run on one motor in February and March 2017. The metered energy data indicated that $12,100 savings annually may be possible. The data were based on a typical eight-hour day and five-day sorting week. It is recommended that the baler operate on one motor for a longer test period to confirm energy savings and identify impacts to bailing operations (if any). It should also be noted that operating the baler on one motor is not expected to result in added wear and tear.

6.5. Other Areas of Improvement and Recommendations

The following is a list of minor areas of improvement that could be implemented for the benefit of MRC operations and the Region:

- **Capture of aluminum foil and pie plates as a secondary aluminum grade:** As per Table 6, approximately 44% of available aluminum foil and pie plates are captured with scrap metal, while 41% are captured with aluminum beverage and food cans. For additional revenues, it is recommended that aluminum foil and pie plates normally recovered with scrap steel be captured as a secondary grade aluminum material and marketed as such. Market price for scrap metal is currently at $150/MT, while secondary aluminum prices are approximately $800/MT. Based on the tip floor composition and inbound tonnages on the container line, it is estimated that 47 tonnes of aluminum foil and pie plates could be diverted as a secondary grade for an additional $31,000 in revenues.

Aluminum in Scrap Metal Grade (annually)	47 tonnes
Secondary Aluminum Market Price	$800/MT
Additional Revenues	$31,000

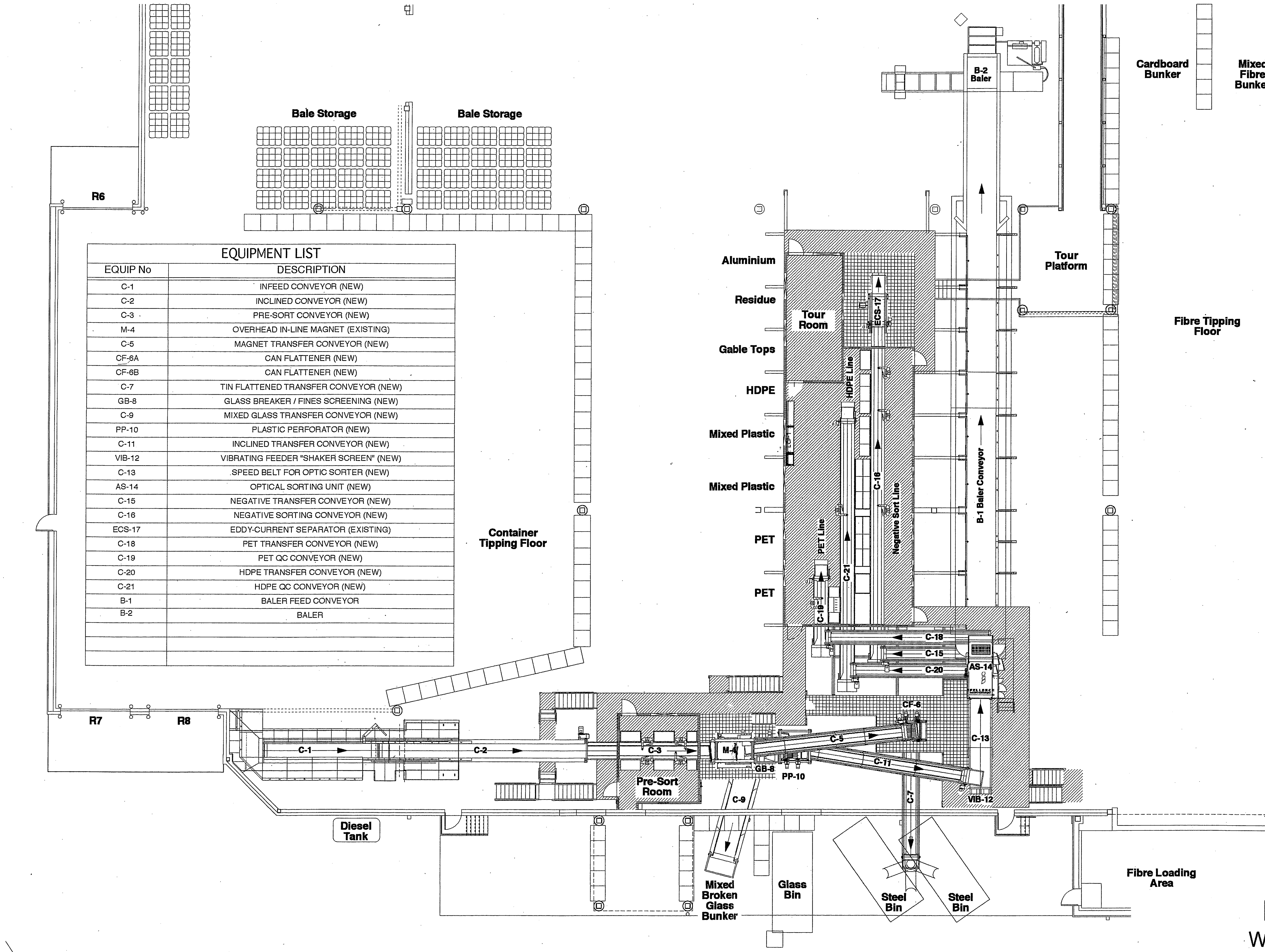
- **Capture of polycoat ice cream tub containers:** Currently, this material type is positively captured with residue materials. However, it can be recovered with polycoat cartons (aseptic and gable top) without causing a marketing impact to the polycoat grade. Based on our audits, capturing this material with polycoat cartons will divert 30 tonnes from landfill per year. Additional revenues are estimated at approximately $3,900 per year.

Polycoat Ice Cream Containers Collected (annually)	30 tonnes
Polycoat Market Price	$128.84/MT
Additional Revenues	$3,900

- **Process review of optical sorter cleaning and empty bins procedure:** All optical sorters require at a minimum daily cleaning with special attention focused on the glass protecting the lights and the space between the conveyor and the valve blocks. Stopping the sort line to clean the optical sorter resulted in 2,522 downtime minutes in 2016. In addition, stopping the line to empty sorter bins resulted in 262 downtime minutes in 2016. A process review of the procedures involved in the cleaning of the optical sorter and emptying of bins should be undertaken in order to prevent or lessen the impact the MRCs uptime.

- **Time and motion analysis of manual sorter stations:** A time and motion analysis is recommended in order to quantify and evaluate the amount of sort effort certain material types on manual sorting efficiency.

Appendix A: As-Built Container Line Drawing



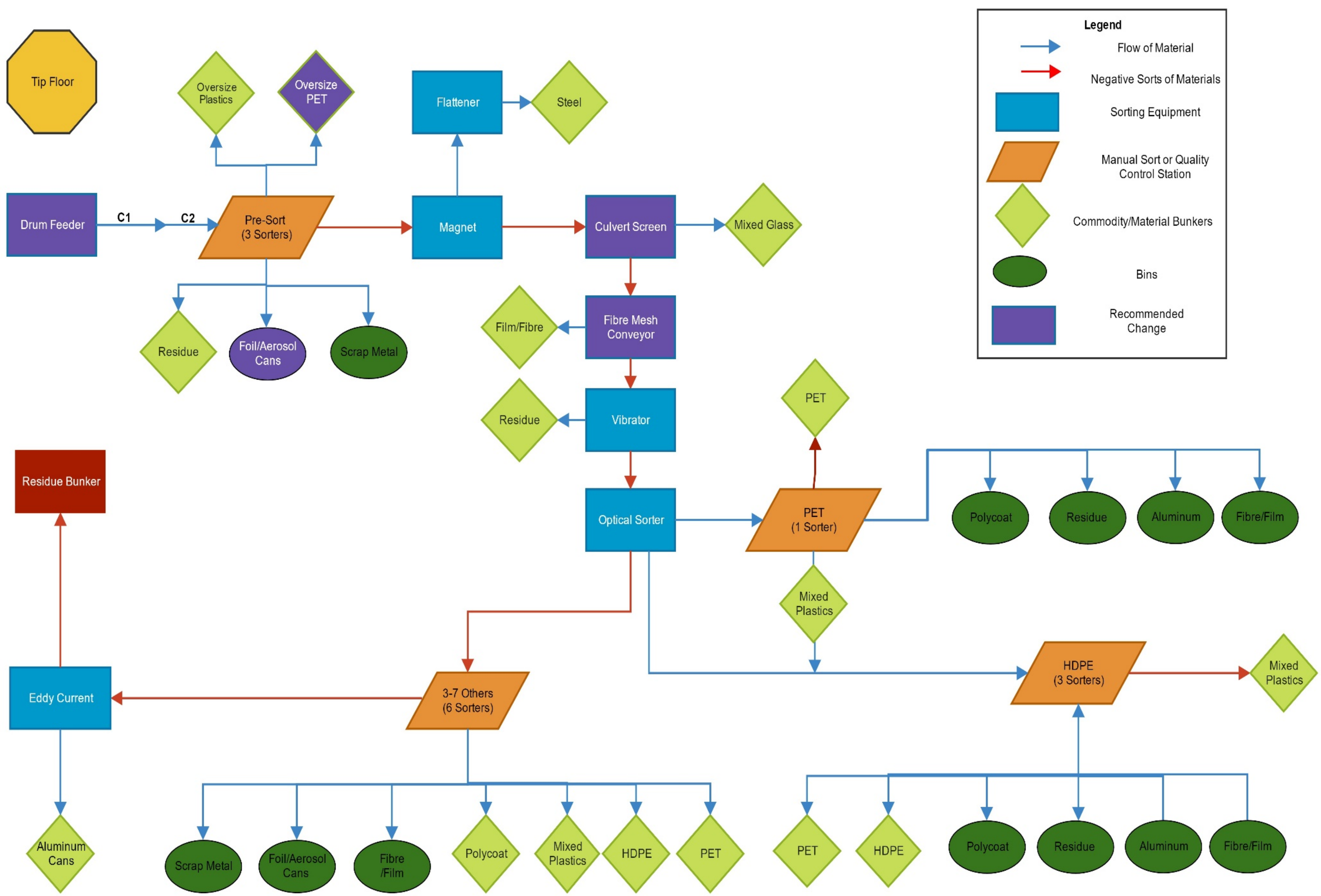
EQUIPMENT LIST

EQUIP No	DESCRIPTION
C-1	INFEED CONVEYOR (NEW)
C-2	INCLINED CONVEYOR (NEW)
C-3	PRE-SORT CONVEYOR (NEW)
M-4	OVERHEAD IN-LINE MAGNET (EXISTING)
C-5	MAGNET TRANSFER CONVEYOR (NEW)
CF-6A	CAN FLATTENER (NEW)
CF-6B	CAN FLATTENER (NEW)
C-7	TIN FLATTENED TRANSFER CONVEYOR (NEW)
GB-8	GLASS BREAKER / FINES SCREENING (NEW)
C-9	MIXED GLASS TRANSFER CONVEYOR (NEW)
PP-10	PLASTIC PERFORATOR (NEW)
C-11	INCLINED TRANSFER CONVEYOR (NEW)
VIB-12	VIBRATING FEEDER "SHAKER SCREEN" (NEW)
C-13	SPEED BELT FOR OPTIC SORTER (NEW)
AS-14	OPTICAL SORTING UNIT (NEW)
C-15	NEGATIVE TRANSFER CONVEYOR (NEW)
C-16	NEGATIVE SORTING CONVEYOR (NEW)
ECS-17	EDDY-CURRENT SEPARATOR (EXISTING)
C-18	PET TRANSFER CONVEYOR (NEW)
C-19	PET QC CONVEYOR (NEW)
C-20	HDPE TRANSFER CONVEYOR (NEW)
C-21	HDPE QC CONVEYOR (NEW)
B-1	BALER FEED CONVEYOR
B-2	BALER

MRC Sort Line
Waterloo Landfill Site

Appendix B: Conceptual Material Flow Drawing Based on Recommendations

Waterloo MRC Process Flow - Revised Container Line (2017)



Appendix C: MRF Site Visits

MRF Site Visits

MRF	Date	Meeting Details
City of Peterborough	**November 23, 2016**	- Met with Herb Lambacher, president of HGC Management - MRF primarily sorts City and County material - Two-stream, 1200 MT/month, 4 MT/hour, 5 am to 11 pm operation - Triple sort/run of materials (e.g. 1st run optical PET eject, 2nd run optical fibre eject) - Equipment of Interest: o Culvert Screen: used for glass capture and recycling positioned after the pre-sort. Produce a MBG material for aggregate use. Whole bottles recovered are sent to Nexcycle
County of Northumberland	**November 23, 2016**	- Met with Terry Preston, plant manager for the County - MRF sorts County (single stream) and City of Kawartha Lakes (dual stream) material - Single stream facility but capable of sorting two stream material. County and facility is transitioning to dual stream collection and processing in 2018 - 40-50 MT/day, 6 MT/hour, 22 sorters - High amount of coffee cups in polycoat bale, no issues with marketing - Equipment of Interest: o Trommel Screen: for glass capture and recycling. Glass quality – 22% NGR, 16% fines, 62% cullet o Fibre Mesh Conveyor: positioned ahead of PET optical, used in the recovery of 2D flat materials (fibre and film). Appears to be capturing most fibre and film, with some lids and flattened thermoforms

Bluewater (BRA)	**November 24, 2016**	- Met with Terry Erb, plant manager
		- MRF sorts recyclables of BRA member municipalities
		- Single stream, 18,000 MT/year, 15 MT/hour
		- Equipment of Interest:
		  o Drum Feeder: used for de-clumping of inbound materials and for an even flow
		  o Trommel Screen: produces ½” minus aggregate material; 1” minus MBG; over 1” material re-circulated; and light fraction fines
		  o Triple Pass Optical:
		    ▪ First Pass: PET up to a holding bunker, fibre/polycoat down, negatives to eddy current, to second pass
		    ▪ Second Pass: HDPE up to a holding bunker, MRP down, negatives to residue QC
		    ▪ Third Pass: PET or HDPE when ready to be baled

Region of Niagara	**December 6, 2016**	- Met with Norm Kraft, plant manager with Niagara Recycling
		- MRF sorts dual stream material from Region, plus ICI recyclables
		- Container line – 8 MT/hour, 24 sorters. Fibre line – 30 MT/hour
		- Currently processing Region of Waterloo fibre/film stream of material. Niagara noted that a significant amount of containers are finding their way into the fibre/film stream
		- Equipment of Interest:
		  o Trommel Screen: for glass capture and recycling. In conjunction, an air suction system is used to remove lightweight fraction materials as MBG is cascading down.
		  o Air suction system is also utilized in the glass processing system – suction is positioned above the conveyor belt

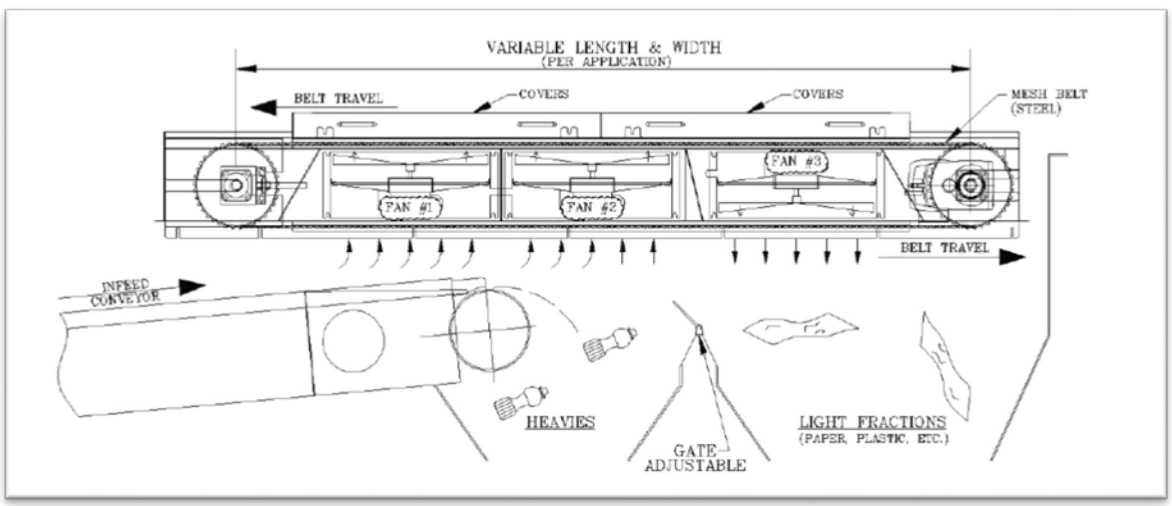
City of Guelph	**December 6, 2016**	- Met with Catherine McCausland, operations manager
		- MRF sorts single stream, blue cart recyclables from the City. Capable of sorting dual stream material
		- Approximately 30,000 MT/year
		- Part of the MRF was down during visit
		- Equipment of Interest:
		  o Drum feeder: used for de-clumping of inbound materials and for an even flow
		  o Spaleck Waste Screen: used for the sortation of MBG. Produces oversize materials to be recirculated; fines and light fraction materials for disposal; and glass cullet with 5-8% NGR. Screen utilizes vibration and multiple screen decks, in conjunction with a cyclone
		  o Auger: No longer in use

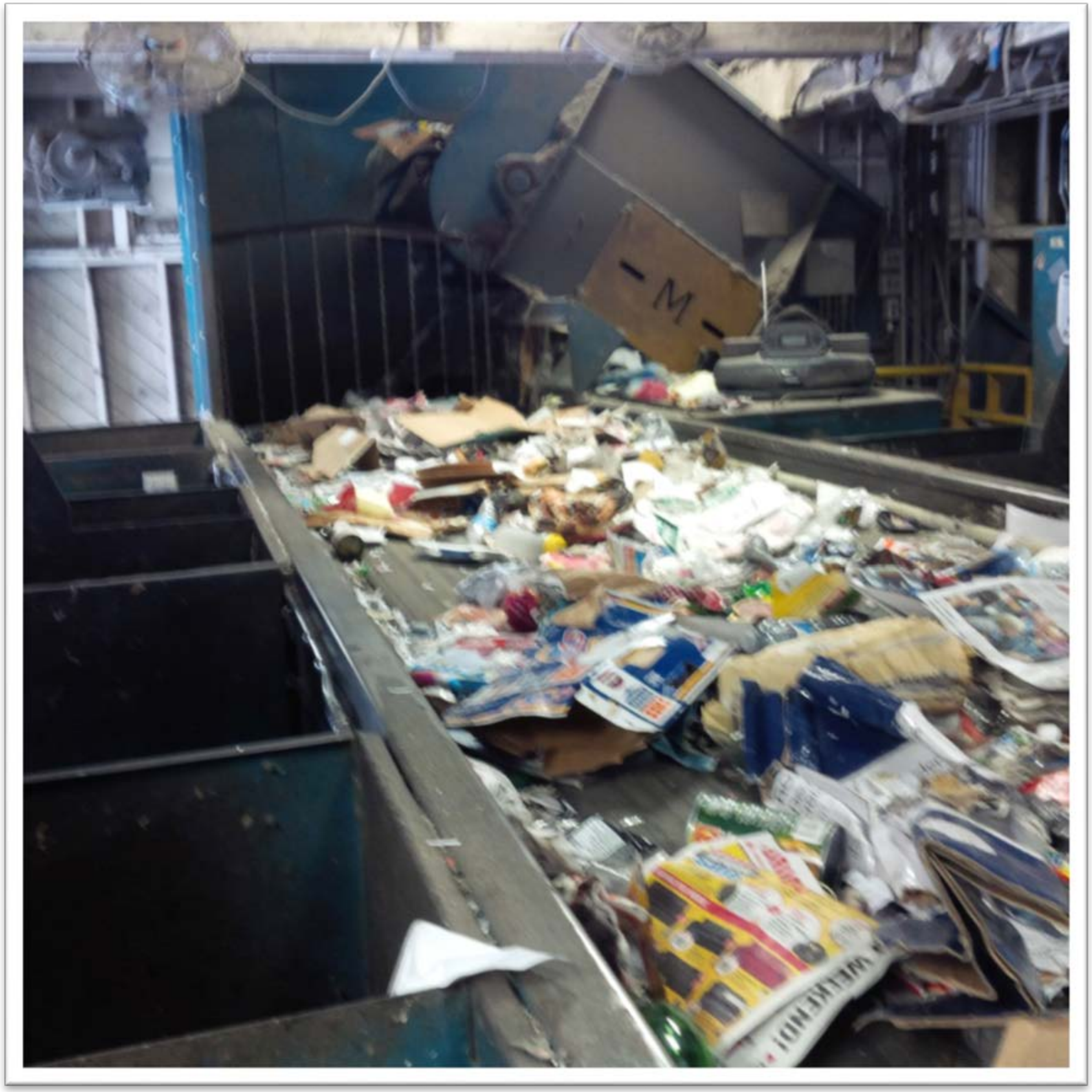
City of Hamilton	**February 2, 2017**	- Met with Jen Addison, MRF project manger
		- MRF sorts dual stream, blue box recyclables from the City.
		- Approximately 45,000 MT/year
		- New container line front end installed in 2013: drum feeder, glass breaker, organic separator (glass clean up) and bag breaker
		- New PET optical sorter and residue QA/QC line installed December 2016
		- Equipment of Interest:
		  o Drum feeder: Bollegraaf equipment, used for de-clumping of inbound materials and for an even flow
		  o Glass breaker: Lubo Systems equipment, used to break and sort glass

Photos

Peterborough – November 23, 2016 – Culvert Screen	

Northumberland – November 23, 2016 – Fibre Mesh Conveyor



Bluewater – November 24, 2016 – Drum Feeder	

Niagara – December 6, 2016 – Glass Cleanup Air Suction	

Reclay StewardEdge
Product Stewardship Solutions

Guelph – December 9, 2016 – Spaleck Glass Screen