Comparison of Current Systems Costs & Alternative Scenarios for Managing Plastic Film in the City of Hamilton

PREPARED BY: Reclay StewardEdge Inc.

May 2016

1. Executive Summary

1.1. Introduction

In 2014, Reclay StewardEdge (RSE) conducted a detailed audit and analysis for the City of Hamilton (City) to evaluate the sorting efficiency on the container line at the City's Material Recovery Facility (MRF). The results of the analysis identified opportunities to improve sorting efficiency which included a business case for the procurement of new sorting equipment to achieve this objective. The study also concluded that the current management of flexible plastic film within the MRF was problematic, as it encumbered both sorting equipment and manual sorters resulting in decreased overall sorting efficiency. Currently, the City collects plastic film through the containers stream within its curbside program and is sorted at the MRF primarily by manual sorters.

RSE conducted a follow-up study and analysis to refine the initial estimates provided to the City on the current costs to manage plastic film through its curbside program. Included in the follow-up study is an evaluation of alternative scenarios for collecting plastic film. Findings and associated evaluations of this effort are summarized in this report.

1.2. Methodology

RSE performed a time-and-motion study to understand how much time each sorter spends sorting plastic film on the fibre and container line at the City's MRF, and the impact on the capture of other recyclables. For this study, RSE obtained measurements from each sorter on the both the fibre and container line to determine the number of picks made per material targeted for sorting.

1.3. Key Findings

It is estimated that 4,328 tonnes of residential plastic film is generated annually in the City. Of the total generated, 1,195 tonnes (28%) is collected through the curbside and depot recycling programs. From the total collected for recycling, only 560 tonnes (47%) is captured at the MRF and marketed as plastic film grade. The remaining plastic film collected, 635 tonnes (53%), is disposed as MRF residue. The current annual net cost to manage residential postconsumer plastic film at the City MRF is estimated to be $680,000 per year ($570 per tonne collected or $1,214 per tonne marketed).

From the time-and-motion analysis, all but one of the sorters on the container line spend 45% to 84% of their time handling film. As all container line sorters positively sort other materials, the burden plastic film poses on the sort staff is significant, as it results in sorters missing valuable targeted materials. In addition, film not captured by the initial set of manual sorters will interfere with the downstream sorting equipment leading to materials being missed by the eddy current and optical sorter.

In order to reduce the burden of film at the MRF, six alternative collection scenarios have been identified and evaluated by RSE to help the City consider an alternative approach to managing the plastic film generated. The evaluated six scenarios are:

- **Scenario 1 – Return to Municipal Sites:** Establish film collection bins at municipal sites such as community centers, arenas, and libraries, where recycling collection already exists. Residents will return their plastic film to these sites and place them in dedicated bins for plastic film which are lined with thicker-gauge branded (distinct colour) bags. These branded bags are then collected with the City's current curbside collection system and delivered to the MRF. The annual net cost of this scenario is $194,000.
- **Scenario 2 – Return to Municipal Sites Using a Milk-Run Model:** Similar to Scenario 1, this scenario will collect film at municipal sites with dedicated bins for plastic film; however, it will utilize a dedicated collection vehicle to collect plastic film from municipal sites. Thinner-gauge bags are used at the municipal sites to consolidate plastic film, and to differentiate it from other types of materials collected at the sites. Film is then collected and delivered to the MRF to be baled directly. The annual net cost of this scenario is $380,000.

- **Scenario 3 – Return to Retail:** This scenario requires residents to return their plastic film to retail stores. The postconsumer film is then blended with back-of-store film by retail store staff. The film would then be recycled through the retailer's existing recycling system. The annual net cost of this scenario is $231,000.
- **Scenario 4 – Collecting Film through Fibre Stream:** This scenario is similar to the City's current collection method except plastic film is collected with fibre materials at the curb and then processed on the fibre line, as opposed to through the containers stream. The annual net cost of this scenario is $421,000.
- **Scenario 5 – Collecting Film with the Use of Branded Bags:** Under this scenario the City provides residents with thicker-gauge branded bags which are used to consolidate plastic film before placing it in the blue box. Bags of plastic film are then collected with containers and processed on the container line at the MRF. The annual net cost of this scenario is $290,000.
- **Scenario 6 – Return to Municipal Sites and Return to Retail:** This scenario combines the first and third scenarios. This scenario results in less postconsumer film being handled by each site and provides residents with a wider range of drop-off options. The annual net cost of this scenario is $306,000.

1.4. Scenario Evaluation

In order for the City to evaluate the six scenarios, an impact assessment matrix was developed. The impact assessment focuses on four criteria, with evaluations noted below.

Impact on Access: How accessible is the scenario for the residents and what is the impact compared to the current collection method. A low impact assessment indicates the residents face minimal changes by the new system, and a high impact assessment indicates a more dramatic change to residents.

Impact on Recovery: This criteria focuses on the anticipated recovery rate (diversion from landfill) of the scenario in comparison to the current recovery rate of residential plastic film. A low impact assessment indicates the method is expected to cause a positive change to the recovery of plastic film while a high impact assessment indicates an expected negative change to the recovery rate.

Net Costs: Net cost assessment is directly linked to estimated changes (increase or a decrease) in net costs when compared to current net costs. A low impact assessment indicates a much lower cost and a high impact assessment indicates much higher costs under the alternative scenario.

Challenge to Implementation: This is an assessment of how easily the City would be able to implement and transition to the alternative methods. A low impact assessment indicates the least amount of anticipated challenges to implement and/or resistance from affected parties, and a high impact assessment indicates more significant anticipated challenges to implement and/or resistance by affected parties.

Scenario Evaluation						
	1	2	3	4	5	6
Impact on Access	Medium	Medium	Medium	Low	Medium	Medium
Impact (Negative) on Recovery	Medium - High	Medium – High	Medium	Low	Medium	Medium
Net Cost	Low	High	Low - Medium	High	Medium	Medium
Challenge to Implementation	Medium	Medium	Medium - High	Medium - High	Low	Medium - High

2. Background and Objectives

2.1. Background

The City of Hamilton (City), which has a dual-stream recycling program, currently collects plastic film through the container stream within their curbside program. Residents are asked to place loose plastic film inside larger bags (bag-in-bag), tie it off, and place the bundle in the "containers" stream.

In 2014, Reclay StewardEdge (RSE) conducted a study for the City and the Continuous Improvement Fund (CIF) to evaluate the efficiency of sorting operations on the Material Recycling Facility's (MRF) container line. The study provided recommendations to reduce operating costs and achieve higher diversion rates at the MRF. One of the recommendations was to consider alternative methods for collecting and managing plastic film. Plastic film posed a significant burden on manual sort staff and equipment due to the effort it required to remove it from the container stream, and because this effort hindered staff and MRF equipment from sorting other more valuable recyclable materials as optimally as they otherwise would have.

2.2. Project Objectives

The City, in partnership with the Canadian Plastics Industry Association (CPIA), CIF, and Stewardship Ontario (SO), retained RSE to quantify the impacts of recycling plastic film in the municipality. Specifically, RSE was tasked with evaluating the current costs and impacts of managing plastic film through the City's curbside program, as well as assist the City to objectively evaluate six alternative collection scenarios for managing plastic film.

In order to assess the impact on capture and cost, RSE developed a methodology to measure the level of effort required to sort plastic film at the MRF, and the potential impact to other commodities. This methodology considered the amount of plastic film received at the MRF, the time required by sorters to sort plastic film, and the tonnage marketed or disposed.

For the purposes of this study, plastic film was defined as any polyethylene film/wrap, where polyethylene film comprises at least 95% of the material, by weight. Polyethylene film is typically stretchy and lightweight relative to other types of film. Examples include frozen vegetable bags, milk bags, shrink wrap for unitizing multi-packs, sandwich bags, produce bags, and retail/grocery shopping bags.

Additionally, the RSE team reviewed and modelled six alternative collection scenarios for managing plastic film based on programs and initiatives implemented across Canada and the U.S. The six scenarios, reviewed in Section 4.6, were identified based on the recommendations of the Project Team.

2.3. Description of Existing System

At the City's MRF, plastic film is separated using both mechanical (Bollegraaf film grabber) and manual separation on the container line, and only manual separation on the fibre line. Process flow diagrams of the container and fibre lines are provided in Appendices A and B respectively.

Container Line Process Flow

The container stream materials, including plastic film, received through the curbside program are loaded from the tip floor via a front-end loader into the drum feeder. The drum feeder meters the materials to an inclined conveyor, which deposits the material onto a fines screen, which separates glass and other materials 2.4 inches or less in size from the balance of the container stream.

The screen overs are fed to a pre-sorting platform where two sorters (manual sorters 1 and 2) remove large oversized plastics, residue (items not in the program), film and HDPE bottles. In addition, these sorters remove bagged recyclables and place them on a conveyor belt to the bag breaker.[1] The remaining materials are conveyed under a mechanical film grabber, which captures loose and bagged film by snagging it off the belt and releasing it into a vacuum hood. Air then conveys it to a storage bunker.

Remaining materials are then conveyed across to the second manual sorting station where six (6) sorters (manual sorters 3, 4, 5, 6, 7 and 8) positively sort HDPE, oversized PET (15-litre water bottles), film, mixed

paper, and residue. The film sorted by manual sorters 1-6 is placed into vacuum hoods located above the conveyor. Any film that makes it beyond these sorters (e.g., to manual sorters 7 and 8) are removed and placed into the residue bunker.

The materials that remain on the conveyor belt after the second manual sorting station pass under an overhead magnet that removes ferrous materials (primarily steel cans). Next, an eddy current is used to separate non-ferrous materials (primarily aluminum packaging) from the rest of the stream. A manual sorter (manual sorter 9) further separates the aluminum stream into (1) aluminum beverage cans and (2) aluminum food cans, foil and aerosols. This sorter also removes any non-aluminum items that may have been mistakenly sorted into the aluminum stream and places it onto a conveyor belt leading to the optical sorter.

The remaining materials then pass through a dual-eject optical sorter which separates PET onto one line (first eject), and mixed plastics and polycoat on to another line (second eject). The sorter on the PET line (manual sorter 10) positively removes mixed plastics, polycoat, residue and aluminum cans; while the sorter on the mixed plastics/polycoat line (manual sorter 11) positively sorts polycoat into a bunker, and removes remaining residue and aluminum cans. Materials that pass through the optical sorter without being ejected are disposed as residue.

Fibre Line Process Flow

The fibre line (Appendix B) can consist of three (3) to five (5) manual sorters[2] assisted by one fibre screen. Materials that are fed onto the line are first sorted by an old corrugated cardboard (OCC) screen. The screen is designed to separate OCC materials from other fibre materials. OCC flows on top of the screen to a manual sorter who positively removes non-OCC materials (typically printed paper and bagged recyclables), and places them onto a conveyor to be sorted further downstream. Fibre materials that fall through the OCC screen are conveyed to a manual sorting station with up to 4 sorters (manual sorters 2, 3, 4 and 5) who positively sort out containers and residue. All film that is removed by these sorters is deposited into residue. Film found on the fibre line typically consists of newspaper sleeves and bagged recyclables.

3. Methodology

Although the City encourages residents to only use blue boxes for their recyclables, they still accept recyclables that are set out in clear plastic bags. For this reason, plastic film was separated into two categories:

1. Loose film – All polyethylene film/wrap as defined in section 2.2, excluding large clear bags used for the set out of recyclables.
2. Container film – Large clear bags used as containers for setting out recyclables at the curb.

RSE performed a time-and-motion study to determine how much time each sorter spent sorting the above types of plastic film compared to other materials sorted on the fibre and container lines at the City's MRF. RSE also interviewed the plant manager to determine the sort instructions provided to sorter(s) to determine their sorting priorities.

Additionally, the analysis compared the average number of picks per minute for film to that of other materials in order to evaluate productivity differences for sorting different materials. This was done to test the assumption that a sorter's efficiency is based primarily on the number of picks, and not the shape, volume or weight of a material.

4. Observations and Results

4.1. Generation and Recovery of Residential Film in Hamilton

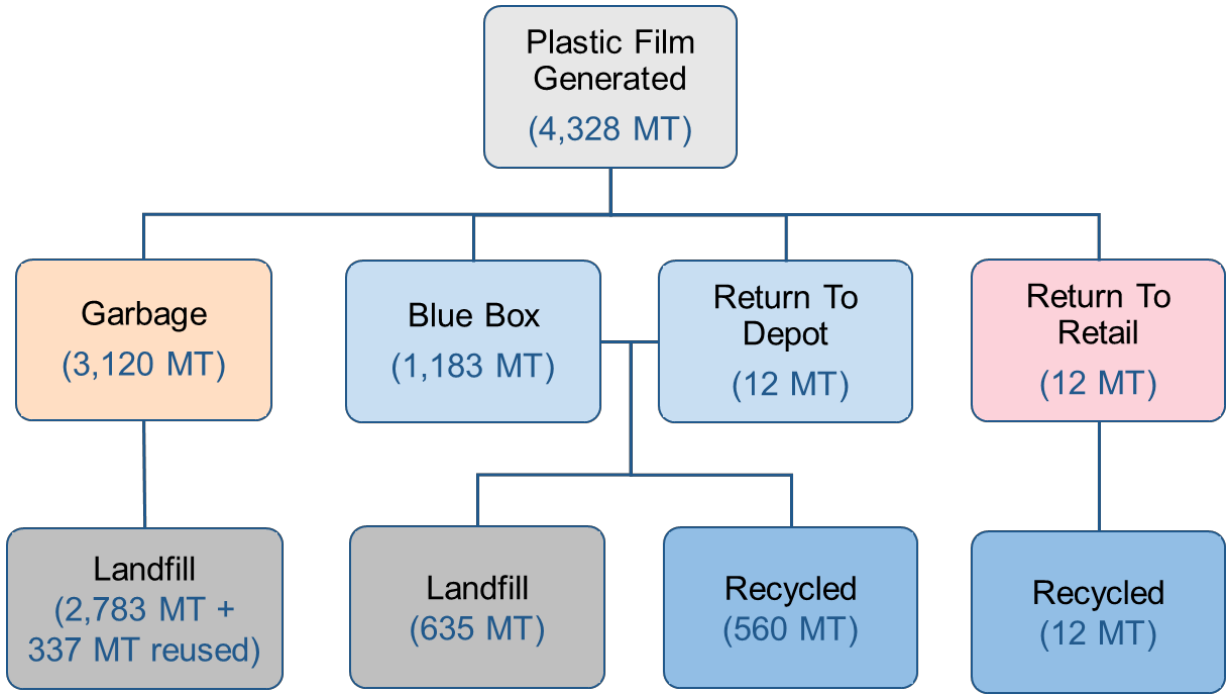
Using 2014 City waste composition study data,[3] it was estimated that 4,328[4] tonnes of residential plastic film is generated annually in the City. Of the total generated, 3,120 tonnes is disposed by residents within their garbage, 1,183 tonnes is collected through the curbside recycling program, 12 tonnes is returned to depot,[5] and 12 tonnes is returned to retail stores.[6]

Of the 3,120 tonnes of film sent to the garbage from households, it is believed that a portion of film is reused by the residents as liners for smaller garbage bins, for pet waste or retail shopping bags. Based on estimates provided by project partners, it is estimated that 50% of grocery carry-out bags in the garbage stream are reused for these purposes which represents 337 tonnes of plastic film (13% of the garbage disposed).

Additionally, of the 1,195 tonnes of recycling film that is received by the MRF (curbside plus depot), only 560 tonnes (47%) is captured and marketed as plastic film grade. The remaining plastic film, 635 tonnes (53%) is disposed as residue.

Overall, it is estimated that Hamilton residents recycle 560 tonnes of plastic film annually, either through their municipal program or through return-to-retail locations; this represents 13% of the total film generated (excluding reused bags). The overall diversion would increase to 897 tonnes, or 21%, if reused bags were considered as diverted for other uses and not available for recycling.

Figure 1: Generation and Flow of Residential Plastic Film in the City of Hamilton



Note: Of the 3,120 tonnes of plastic film residents set out in their garbage, RSE has estimated only 2,783 tonnes are directly disposed, and an estimated 337 tonnes are eventually reused as liners for smaller garbage bins, or for pet waste. It was also assumed that all 12 tonnes received at retail stores were recycled.

4.2. Time-and-Motion Study Analysis

Beginning at the first manual sort station for both sort lines, each sorter was tracked in sequence through the end of the line as activity was observed and counts taken to determine the number of picks made per material type manually sorted.

Based on the analysis of the data collected, the 11 container line sorters appear to have an average of 56 picks per minute (see Table 1). On the fibre line, the 3 assigned sorters have an average of 18 picks per minute (see Table 2). As the sorters on the fibre line are tasked with removing residue and/or containers from the line (quality control), which comprise a small portion of the fibre stream; the average number of picks per minute is far lower than that of the sorters on the container line who are positively sorting recyclable material.

Table 1: Average Number of Picks per Station – Container Line

	Position Pairs	Picks per Minute
Manual Sort Station #1 (Film, HDPE, Oversize Plastics, Residue, Bagged Recyclables)	Positions 1 & 2	36
Manual Sort Station #2 (Film, HDPE, PET, Fibre, Residue)	Positions 3 & 4	64
	Positions 5 & 6	54
	Positions 7 & 8	41
Aluminum QC	Position 9 Alum QC	45
PET QC	Position 10 PET QC	67
Mixed Plastic/Polycoat QC	Position 11 MP/P QC	88
Average Number of Picks		**56**

Table 2: Average Number of Picks per Station – Fibre Line

	Position Pairs	Picks per Minute
Manual Sort OCC	Position 1	16
Manual Sort Fibre	Position 2	25
	Position 5	12
Average Number of Picks		**18**

4.2.1. Time Share Analysis

To gain a clear understanding of the direct effect the presence of plastic film has on each of the manual sorters, a time share analysis was conducted to determine the time spent removing the sorters' targeted materials. From the data collected, the team was able to calculate the percentage of time a sorter spent handling a particular material, specifically plastic film.

On the container line, the first 3 pairs of sorters (positions 1 & 2, 3 & 4, and 5 & 6) spent an average of 61% to 84% of their time picking plastic film. These 3 pairs of sorters, plus the mechanical film grabber represent the only opportunity to capture plastic film that can be marketed as a plastic film grade. Once it passes sort stations 5 & 6, plastic film removed by the remaining sorters is considered residue. Even with the first six sorters and the film grabber targeting plastic film, manual sorters in positions 7 & 8 still spend approximately 50% of their time picking plastic film.

Film missed by the first eight manual sorters and the film grabber continues its way downstream to the overhead magnet, eddy current[7] and to the optical sorter. The manual sorter at position 10 (PET QC) spends 51% of their time removing plastic film missed upstream and incorrectly ejected by the optical sorter. Similarly, manual sorter 11 (mixed plastics and polycoat QC) spends 45% of their time removing plastic film. Not only is the level of effort to remove plastic film at these stations similar to that of sort staff much

further upstream, but the number of picks made by these sorters is greater than all of the previous sorters (66.7 picks per minute at position 10 and 88 picks per minute at position 11) (see Table 3).

As all container line sorters positively sort multiple materials, the burden plastic film poses on the sort staff is significant, as it results in sorters missing targeted valuable materials. It also interferes with downstream equipment sorting operations leading to materials being missed by the eddy current and the optical sorter.

Table 3: Percentage of Total Time Spent per Material - Container Line

Material Handled	Sorter Positions						
	1 & 2 Film, Residue, Oversized Plastic, HDPE	3 & 4 Film, HDPE, PET	5 & 6 Film, Fibre, PET	7 & 8 Fibre Residue	9 Alum QC	10 PET QC	11 MRP/Poly QC
Film	61%	80%	84%	-	-	-	-
Loose Film	*48%*	*71%*	*78%*	-	-	-	-
Container Film	*13%*	*9%*	*6%*	-	-	-	-
Bagged Recyclables	10%	-	-	-	-	-	-
Residue	6%	-	-	-	-	-	-
HDPE	23%	20%	-	-	-	-	-
Residue – Film only	-	-	-	53%	4%	51%	45%
Residue - Loose Film	-	-	-	*49%*	*4%*	*50%*	*43%*
Residue - Container Film	-	-	-	*4%*	-	*1%*	*2%*
Residue – Non-Film	-	-	-	28%	-	20%	13%
Aluminum – B Grade	-	-	-	-	59%	-	-
Containers	-	-	-	-	36%	-	-
Aluminium – Prime	-	-	-	-	-	8%	7%
Fibre	-	-	16%	19%	-	-	-
Polycoat	-	-	-	-	-	2%	34%
Mixed Plastic	-	-	-	-	-	19%	-
Total	100%	100%	100%	100%	100%	100%	100%

On the fibre line, the level of effort to sort film is far less intensive compared to the sorters on the container line (see Table 4). The sorters in positions 2 and 5 spend 35% and 21% of their time, respectively, picking loose film. All film sorted on Hamilton's fibre line goes to residue.

Aside from fibre, for the sorter in position 1, bagged recyclables consume most of the sorter's time. The sorter in position 2 spends 64% of their time picking bagged recyclables and the sorter in position 5 spends 40%. This is due to the fact that bagged recyclables have to be ripped and emptied manually, which takes more time compared to other materials that only have to be picked.

Table 4: Percentage of Total Time Spent per Material Type - Fibre Line

Material Handled	Sorter Positions		
	1 OCC	2 Fibre	5 Fibre
Loose Film	-	35%	21%
Containers	-	-	24%
Bagged Recyclables	-	64%	40%
Residue	2%	1%	15%
Fibre	98%	-	-
Total	100%	100%	100%

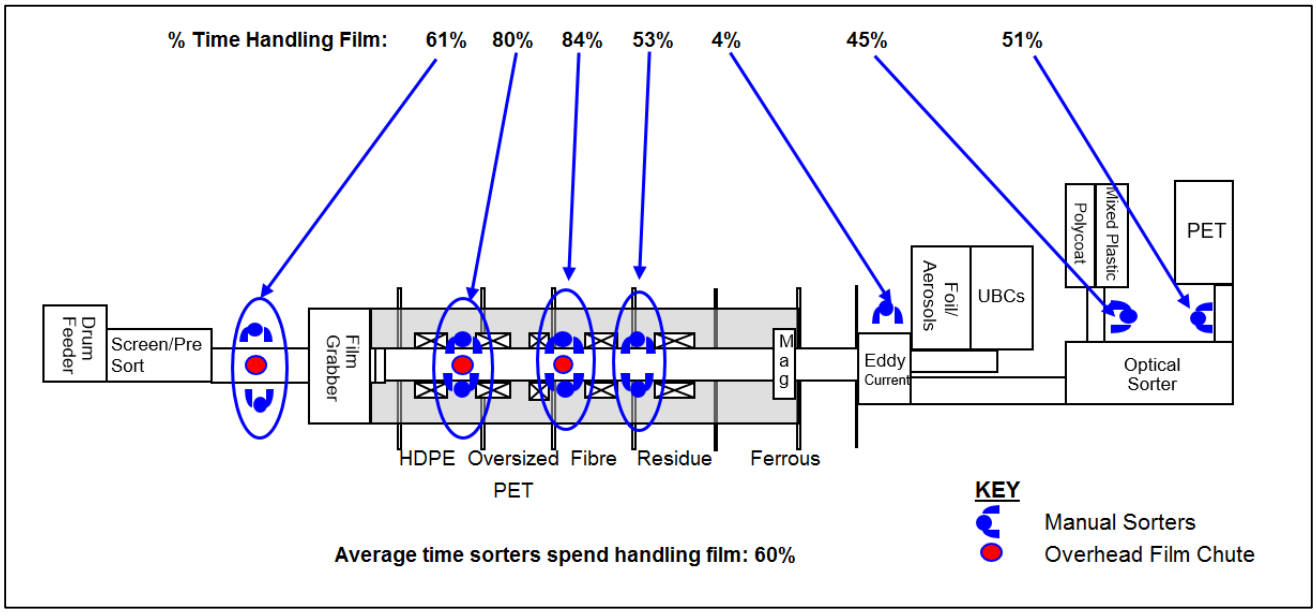
To understand the overall level of effort to handle film, further analysis of the number of picks each sorter dedicates to film is needed. A total of 81,534,000 picks of film is estimated to be carried out annually[8] by the sorters in the MRF based on the field data obtained (see Table 5). This amounts to a total of 15,000 hours annually spent picking film, 14,000 on the container line and 1,000 on the fibre line.

Table 5: Time and Effort Spent Picking Film by Sorters

	Film Picks per Minute	Annual Picks	Percent of Time	Annual Hours Spent
Positions 1 & 2	36	9,175,000	61%	2,583
Positions 3 & 4	64	16,153,000	80%	3,367
Positions 5 & 6	54	13,722,000	84%	3,544
Positions 7 & 8	41	10,391,000	53%	2,239
Position 9 -- Alum QC	45	5,694,000	4%	94
Position 10 -- PET QC	67	8,448,000	51%	1,081
Position 11 -- MP/P QC	88	11,151,000	46%	966
Total on Container Line		**74,733,000**		**14,000**
Fibre Line Sorter 1	16	2,070,000	-	-
Fibre Line Sorter 2	25	3,227,000	35%	741
Fibre Line Sorter 5	12	1,504,000	21%	451
Total on Fibre Line		**6,801,000**		**1,000**
Total		**81,534,000**		**15,000**

Figure 2 below depicts the position of the sorters on the container line as well as the portion of time each sorter spends manually sorting plastic film. The first 2 manual sorters (sorters at positions 1 and 2) spend 61% of their time manually sorting out plastic film while the next 4 sorters spend 80% and 84%, respectively. The film grabber is located between the first and second pair of sorters. The plastic film picked out by either of the first six sorters 6 sorters (pairs 1 2 and 3) are sent to the overhead chute while any plastic film missed by them ends up as residue further downstream. Based on this field data obtained, the RSE has estimated that the overall average time sorters spend handling film is 60%.

Figure 2: Percentage of Time Sorters Spend Picking Film on Container Line



4.3. Current Net Costs of Managing Film in Hamilton

In estimating the current annual net cost impact of managing plastic film in Hamilton, RSE reviewed the following cost and revenue parameters:

- Tonnes of film disposed in Hamilton
- Tonnes of film collected through the recycling program
- Estimated collection costs
- Estimated processing/sorting costs
- Disposal cost of non-marketable film

The total annual net cost of managing residential postconsumer plastic film at the Hamilton MRF is estimated to be $680,000 per year, under the current method of collecting, sorting, and marketing the material (see Table 6).

Table 6: Current Annual Net Costs of Managing Postconsumer Plastic Film in the City

Tonnes of Film Generated in Hamilton (Disposed, reused and recycled)	**4,328 tonnes**
Total Tonnes Entering MRF	1,195 tonnes
Total Collection Cost (@240/tonne)[9]	$287,000
Processing Cost (Excludes capital cost allocation)[10, 17]	$281,000
Gross Cost to Collect and Process Film	**$568,000**
Disposal Cost ($120/tonne)[11]	$76,000
Baling Cost ($30/tonne)[12]	$36,000
ANNUAL NET COST	**$680,000**
Net Cost per Tonne Marketed[13]	**$1,214**

4.4. Impacts on Other Recyclables

As the materials flow through the container line, a greater burden to sorters and equipment further downstream is presented if manual sorters 1 to 6 are unable to remove all of the plastic film.

As part of the 2014 efficiency study, RSE concluded that valuable recoverable materials were being missed in the sorting process. For this analysis, "missed" refers to materials found in the wrong bunkers after they have been sorted at the MRF, e.g. PET bottles found among residue. In the 2014 Study, it was noted that a share of aluminum, polycoat, HDPE and PET containers were found within the mixed plastics and post-optical residue despite efforts to remove them upstream.

It is expected that sorting efficiency will improve if the amount of inbound film is reduced. For example, reducing the amount of film by 25% on the container line would result in savings of 3,500 hours of manual labour or the equivalent of 11.7 million picks. This reduction in the number of picks for film would allow sorters and sorting equipment to capture additional higher-value materials resulting in higher efficiency rates and increased revenues from the sale of these materials. A range of estimated impacts to the capture rates for other material types is provided, if the quantity of film plastic entering the MRF were reduced. The low case assumes that capture rate of each material will be increased by 5%, and the high scenario assumes that each material type is recovered at the industry average for the equipment utilized to sort the material (see Table 7).

Table 7: Current Capture Rates and Estimated Capture Rates of High-Value Materials if Handling of Plastic Film Reduced

Materials	Current Capture Rate	Low Scenario	High Scenario
HDPE	81%	86%	90%
Aluminum (Prime)	84%	89%	98%
Aluminum (B-Grade)	63%	68%	98%
PET	73%	78%	90%
Mixed Plastics	43%	48%	90%
Cartons	74%	79%	90%

Using these estimated capture rates (low and high), the additional quantity of total recovered materials that could be recovered ranges from 215 to 699 tonnes with an expected minimum increase in revenue of $115,000, when estimated using the 2015 average resale market prices of each material type (see Table 8).

Table 8: Estimated Increased Revenues from High-Value Recyclables if Handling of Plastic Film Reduced

	Available Tonnes	Current Marketed Tonnes	Additional Tonnes to be Captured (Low Scenario)	Additional Tonnes to be Captured (High Scenario)	Increase in Revenue (Low Scenario)	Increase in Revenue (High Scenario)
Aluminum (Prime)	524	422	26	91	$40,000	$141,000
Aluminum (B-Grade)	77	58	4	17	$1,000	$5,000
Cartons	393	127	20	226	$2,000	$19,000
HDPE	834	614	42	136	$27,000	$89,000
PET	2,467	1,993	123	228	$44,000	$82,000
Total			**215**	**699**	**$115,000**	**$337,000**

4.5. Reduction of Inbound Film via Current Collection Method

There is currently an ongoing promotion and education campaign to encourage City residents to bag their film before placing it at the curb. This is to help increase sorting efficiency at the MRF. However, alternative

options to manage plastic film have to be explored and one such option is to reduce the amount of plastic film entering the MRF as it currently does – curbside collection with containers.

The analysis of plastic film reduction below considers three reduction scenarios (25%, 50% and 75% reduction) and focuses on the reduction of only loose film. No reduction in container film is assumed, as the City will continue to accept recyclables set out in clear bags in the various scenarios described below. Furthermore, data indicates that 88% of the film received at the MRF is loose film.

Of the estimated 1,195 tonnes of plastic film received at the MRF annually, 560 tonnes is recovered and 635 tonnes is sent to the landfill. RSE has assumed that the quantity of film recovered (sold to an end market) at the MRF would only be reduced when the total tonnes entering the MRF is reduced by 75% relative to current levels. This is because there is ample plastic film coming into the MRF under the 25% and 50% reduction that is marketable, but not currently being captured. In the 75% reduction of incoming film scenario, the amount of entering the MRF would drop to 406 tonnes annually, which is less than the current amount of film captured and marketed.

It is assumed that collection and MRF labour costs will remain constant even with the reduction of plastic film. Collection costs are primarily driven by the number of households served and the volume of materials collected (greater the volume, the fewer the households that can be served per collection vehicle). The current amount of plastic film is estimated to make up only 12% of curbside material (by volume) and therefore will result in an insignificant savings on collection costs. For MRF labour costs, it was assumed that the reduction of film will reduce the amount of labour time required to manage film. However, it is assumed sorters will be repurposed to focus on other recyclable materials that are currently being missed. The primary benefit of having less loose plastic film enter the MRF would be improved mechanical and manual separation which would result in enhanced recovery of higher-value containers and therefore increased revenues from the sale of these materials. In addition, it is expected that less plastic film would be disposed.

When reviewing the costs associated with collecting, processing and landfilling plastic film (film ending up in residue), the cost/revenue analysis indicates that opportunities for cost savings exist when the amount of inbound plastic film is reduced. Using a conservative assumption for revenues for missed high-value materials, (i.e., using the lower end of the range estimated in section 4.4), the annual net benefit (net cost reduction) is estimated to be $154,000, $194,000 and $210,000 for the 25%, 50% and 75% film reduction levels, respectively (see Table 9). Cost savings are due to decreased collection, bailing, and disposal costs of landfilled film. Revenues from the sale of plastic film are not included in the analysis, as the City does not receive these revenues. However, the MRF would receive increased revenues from the sale of other materials that had been missed, but are positively sorted through the enhanced function of sorting equipment (optical sorters, eddy current separator) as a result of less film being on the container sort line.

Table 9: Estimated City Costs and Revenues Associated with Reduction of Inbound Film

		Film Reduction Scenarios		
	Current	**25%**	**50%**	**75%**
Total Tonnes Entering MRF	1,195	932	669	406
Loose Film	1,052	789	526	263
Container Film	143	143	143	143
Total Tonnes of Film Recovered	560	560	560	406
Total Landfilled (Residue from MRF)	**635**	**372**	**109**	**0**[14]
Revenue from Missed Materials (Low range)		$115,000	$115,000	$115,000
Revenue from Missed Materials (High range)		$337,000	$337,000	$337,000
Savings - Low estimate		$154,000	$194,000	$210,000
Savings - High estimate		$376,000	$416,000	$432,000

4.6. Alternative Collection Scenarios

As identified previously, the City collects plastic film curbside (through the container stream) which, as from the previous study,[15] creates sorting inefficiencies at the MRF. Six alternative collection scenarios have been identified by RSE to help the City consider alternative methods for handling the plastic film generated. The assumptions for the six scenarios are noted in Table 10.

Table 10: Assumptions and Parameters for Estimating Costs Associated with Alternative Collection Scenarios

	Scenario 1 Municipal Sites	**Scenario 2 Municipal Sites/Milk Run**	**Scenario 3 Return to Retail**	**Scenario 4 Curbside/ Fibre Stream**	**Scenario 5 Curbside/ Branded Bag/ Container Line**	**Scenario 6 Municipal Sites and Retail**
Total Collection Sites/Homes	62	62	49	226,230	226,230	62 + 49
Assumed Bag Usage per Site/Hhld	One per day	Once per day	Once per day	NA	One per month	One per day
Time to Empty Container	5 Minutes	10 Minutes	20 Minutes	1 Minute	1 Minute	5-20 Minutes
Cost per Branded/Clear Bags[16]	$0.50/bag	$0.20/bag	$0.20/bag	N/A	$0.10/bag[17]	$0.50 & $0.20/bag[18]
Party Assumed to Bear Cost of Bags	City	City	Retailers	N/A	City	City/ Retailers
Branded Bins	$200/bin	$200/bin	$200/bin	N/A	N/A	$200/bin
Signage for Bins	$10/sign	$10/sign	$10/sign	N/A	N/A	$10/sign
Collection Staff/On-Site Staff(Fully loaded)	$30/hr.	$30/hr.	$20/hr.	N/A	N/A	$20-$30/hr.
Hauling/Transportation Cost	$0	$275/tonne	$0	$0	$0	$0
Revenue for Clean Film[19]	$323/tonne[20]	$323/tonne	$323/tonne	$323/tonne	$323/tonne	$323/tonne
Party Assumed to Receive Revenues from Sale of Film	MRF Contractor	City, if Bypasses MRF; Contractor if delivered to MRF	Retailers	MRF Contractor	MRF Contractor	MRF Contractor/ Retailers

These six alternative scenarios are briefly described directly below and in more detail in the sections that follow. Table 11 presents the costs associated with each of the scenarios.

- **Scenario 1 – Return to Municipal Sites:** Establish film collection bins at municipal sites such as community centers, arenas, and libraries, where recycling collection already exists. Residents will return their plastic film to these sites and place them in dedicated bins for plastic film which are lined with thicker-gauge branded (distinct colour) bags. These branded bags are then collected with the City's current curbside collection system and delivered to the MRF. The annual net cost of this scenario is $194,000.
- **Scenario 2 – Return to Municipal Sites Using a Milk-Run Model:** Similar to Scenario 1, this scenario will collect film at municipal sites with dedicated bins for plastic film; however, it will utilize a dedicated collection vehicle to collect plastic film from municipal sites. Thinner-gauge bags are used at the municipal sites to consolidate plastic film, and to differentiate it from other types of materials collected at the sites. Film is then collected and delivered to the MRF to be baled directly. The annual net cost of this scenario is $380,000.
- **Scenario 3 – Return to Retail:** This scenario requires residents to return their plastic film to retail stores. The postconsumer film is then blended with back-of-store film by retail store staff. The film would then be recycled through the retailer's existing recycling system. The annual net cost of this scenario is $231,000.

- **Scenario 4 – Collecting Film through Fibre Stream:** This scenario is similar to the City's current collection method except plastic film is collected with fibre materials at the curb and then processed on the fibre line, as opposed to through the containers stream. The annual net cost of this scenario is $421,000.
- **Scenario 5 – Collecting Film with the Use of Branded Bags:** Under this scenario the City provides residents with thicker-gauge branded bags which are used to consolidate plastic film before placing it in the blue box. Bags of plastic film are then collected with containers and processed on the container line at the MRF. The annual net cost of this scenario is $290,000.
- **Scenario 6 – Return to Municipal Sites and Return to Retail:** This scenario combines the first and third scenarios. This scenario results in less postconsumer film being handled by each site and provides residents with a wider range of drop-off options. The annual net cost of this scenario is $306,000.

Table 11: Financial Analysis of the Six Scenarios Based on 50% Film Reduction

	1 Return to Municipal Site	2 Return to Municipal Site-Milk Run	3 Return to Retail	4 Fibre Stream	5 Containers Stream-Branded Bags	6 Combination of 1 & 3	
Annual Capital & Operating Costs							
Bags	$56,000	$23,000	$25,000	$0	$271,000	$34,000	$11,000
Bins	$62,000	$62,000	$69,000	$0	$0	$37,000	$29,000
Signage	$620	$620	$490	$0	$0	$620	$490
Labour (Non-MRF)	$56,000	$113,000	$119,000	NA	NA	$56,000	$119,000
Annual Transportation Costs							
Collection	$0	$164,000	$0	$0	$0	$0	$0
MRF Costs							
MRF Labour Cost of Sorting ($20/hr fully loaded)	<$1,000	$0[21]	$0	$288,000[22]	<$1,000[23]	<$1,000	$0
Baling for End Markets	$18,000	$18,000	$18,000	$18,000	$18,000	$10,000	$8,000
Equipment (Amortized Costs)	$0	$0	$0	$115,000[24]	$0	$0	$0
Annual Revenues							
Revenue from Sale of Film	$193,000	$193,000	$193,000	$193,000	$193,000	$108,000	$85,000
Annual Net Cost						**$139,000**	**$167,000**
	$194,000	**$380,000**	**$231,000**	**$421,000**	**$290,000**	**$306,000**	
Total Tonnes	598	598	598	598	598	334[25]	264
Net Cost per Tonne ($/tonne)	**$325**	**$636**	**$386**	**$704**	**$485**	**$513**	

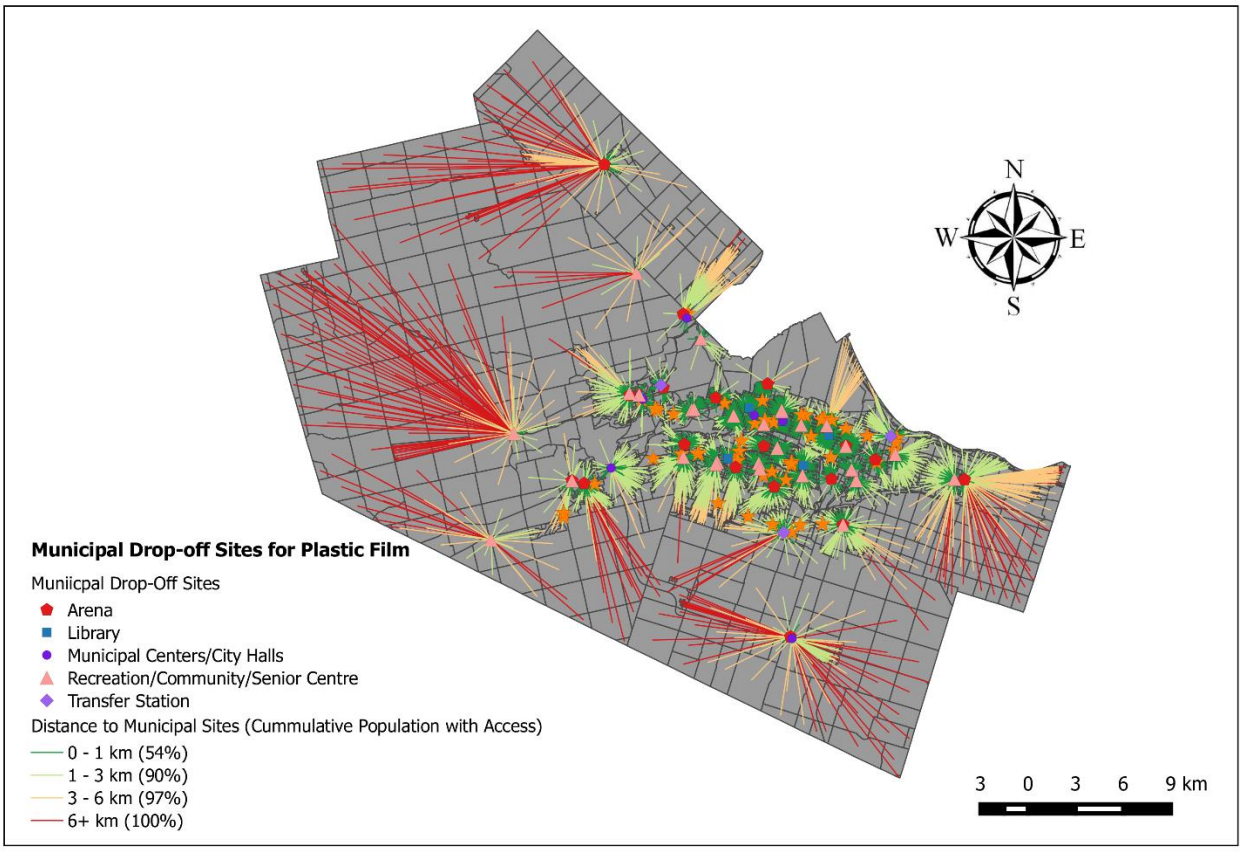
4.6.1. Scenario 1: Return to Municipal Sites

In this scenario, plastic film is returned by residents to municipally owned sites (e.g. arenas, libraries, community centres) and collected by the existing curbside collection system for these sites. Residents place their plastic film in bags which they then drop off in the sites' dedicated plastic film bins. These bins are lined with thicker gauge-branded bags which are more durable to withstand the cycling within a collection truck and are easier to sort (more visible) when received at the MRF. Once the bins are full, the staff secure them and place them alongside other recyclables (containers) that are also collected regularly from these locations.

Due to the high visibility of branded bags at the MRF and the increased consolidation of plastic film, it is anticipated that sorters 1 and 2 could sort the plastic film positively with minimal effort and there should be no need for sorters downstream to have to handle film.

The figure below displays the distance between dissemination blocks[26] within the City to the municipal sites with existing recycling services. It is estimated that 54% of the population lives within 1 km of a municipal site, 90% lives within 3 km of a site and 97% lives within 6 km of a site. A majority (90%) of the population would have a drop off site for their plastic film within 3 km.

Figure 3: Municipal Sites in the City



Assuming that 50% of the residential plastic film currently diverted is diverted using this alternative collection scenario, this scenario's total annual estimated net cost would be $194,000 ($325/tonne). This scenario results in the lowest annual net cost among all six alternative scenarios examined, due to the fact that there are no additional collection and hauling costs, and that capital costs are relatively low. The annual net costs of Scenario 1 are described in Table 11 above.

4.6.2. Scenario 2: Return to Municipal Sites Using Milk Run Model

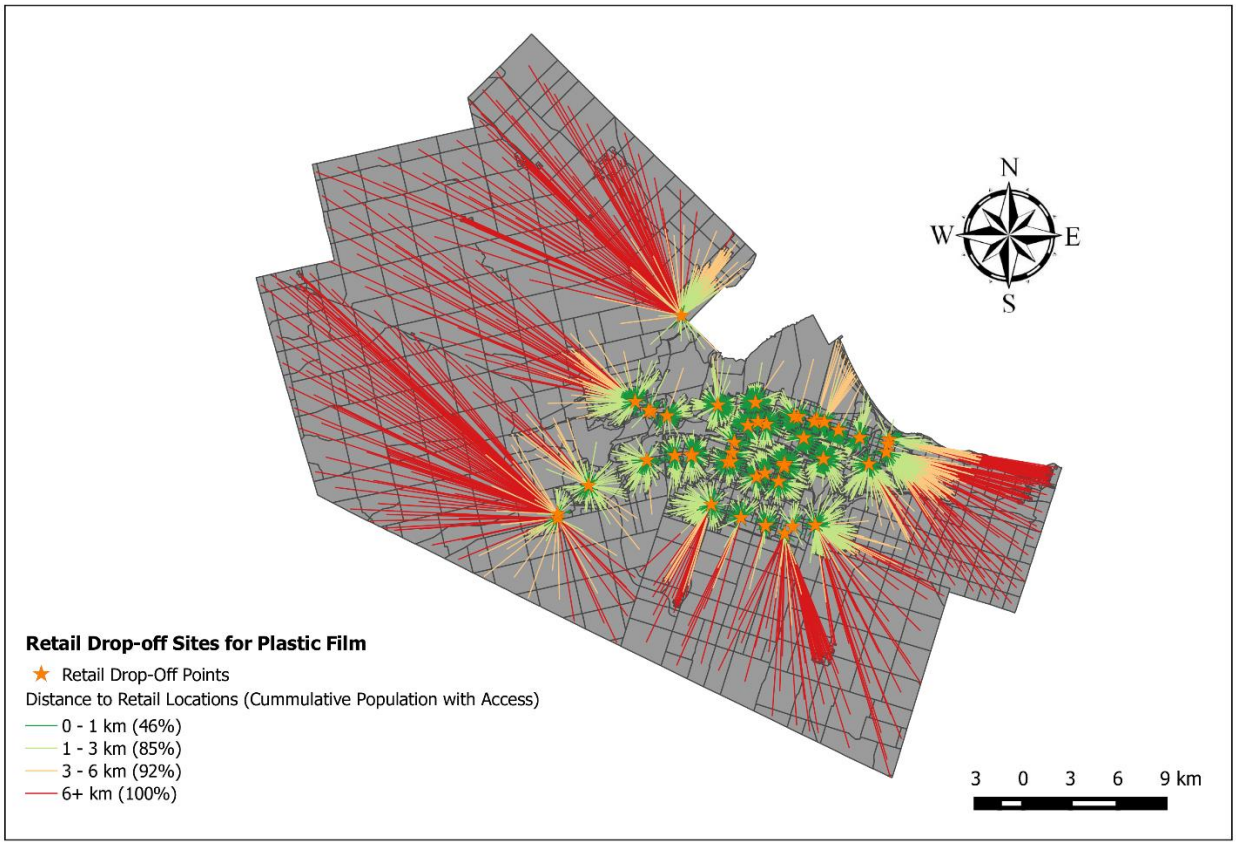
A milk-run model involves using a dedicated collection vehicle to collect from different locations until the truck is filled to capacity and then emptied before it makes further rounds. Scenario 2 is similar to Scenario1, as plastic film is dropped off by the residents at municipal collection sites, with standard clear bags (less costly) used at these sites to line bins. Collection is done by a dedicated collection vehicle instead of being mixed with other recyclables in one of the City's current collection vehicles. It is assumed under this scenario that the City would be able to perform this function with existing vehicles.

Assuming use of the same 62 municipal sites described in Scenario 1, if 50% of the quantity of residential postconsumer plastic film currently collected with containers in the curbside blue boxes is diverted through this scenario, the estimated annual net cost is estimated to be approximately $380,000 ($636/tonne). This appears to be one of the highest-cost scenarios considered, due to the high transportation costs involved with the milk-run collection model (see Table 11 above).

4.6.3. Scenario 3: Return to Retail

It is estimated that there are 49 return-to-retail locations available in the City. There are fewer of these sites than municipal sites, and they are not as conveniently located for some residents. It is estimated that 46% of Hamilton's residents live within 1km of a retail drop-off site, 85% within 3km of retail drop-off site and 92% within 6km. However, retail stores are more frequently visited by residents than municipal locations, which may contribute to higher capture rates of plastic film. Access to these sites is presented in the figure below.

Figure 4: Retail Drop-off Sites in the City



Using the return-to-retail collection scenario requires the residents to return their plastic film to the retail stores. This scenario would use standard gauge bags, where the collected post-consumer film is blended with back-of-store film that is already being managed and backhauled to a market. This material bypasses

the MRF, so there are no increased costs due to baling at the MRF. Revenues for the sale of the recovered film are earned by the retailer.

Assuming that 50% of the plastic film that Hamilton's curbside blue box program currently collects is collected through using retail collection sites, total annual net costs of such a collection program are estimated to be $231,000 ($386/tonne), which would be borne by the retail stores. The cost is relatively lower compared to scenarios 1 and 2 due to the fact that it is assumed to utilize existing waste management infrastructure and backhaul available to the retailers (see Table 11 above).

4.6.4. Scenario 4: Curbside Collection with Fibre Materials

Another option RSE considered for the collection of postconsumer plastic film from residents is continuing to include plastic film in curbside recycling programs, but collecting film and processing it with fibre stream rather than with containers. Collecting film with fibres and processing it on the fibre line works in a similar manner to Hamilton's current method, except the residents would be instructed to place the plastic film in the fibre blue box. Currently, residents place their plastic film in the container box.

RSE has identified four communities currently managing plastic film through the fibre stream. These communities are:

- City of Peterborough
- County of Peterborough
- Region of Niagara
- City of Orillia

RSE surveyed these communities to gain a better understanding of their experiences and costs of managing plastic film. With the exception of the Region of Niagara, these communities are significantly smaller in size and their reported costs and diversion rates suggest they are processing plastic film cost-effectively, and achieving a higher recovery rate. Based on the responses received from the municipalities, it was suggested that collecting film through the fibre stream as opposed to the containers stream does result in cleaner plastic film, as there is significantly less contamination on the fibre stream.

Estimated net annual costs of this scenario in Hamilton is estimated to be $421,000 ($704/tonne). Although this method does not result in increased collection and on-site labour costs like Scenario 2 does, it requires the purchase of equipment – four hoods, an associated air conveyance system and additional bunker spaces – to manage the film. Total cost of the equipment is estimated to be $850,000 plus ancillary fees. In addition, four additional sorters would be required on the fibre line to remove plastic in this scenario (see Table 11 above). This scenario would not require the purchase of branded bags.

4.6.5. Scenario 5: Collecting Film Curbside Using Branded Bags

The bag-in-bag method Hamilton is currently using, simply means that residents are instructed to place all their loose plastic film (plastic bags and overwrap) in a larger plastic film bag or loose film and set it in the blue box with the containers. This scenario would entail residents using branded bags purchased and provided by the City for consolidation of recovered plastic film before setting it out at the curb. These branded bags are the same bags used by the municipal sites for lining their bins. They are usually clear or a distinctive color and larger in capacity and much stronger than plastic grocery bags.

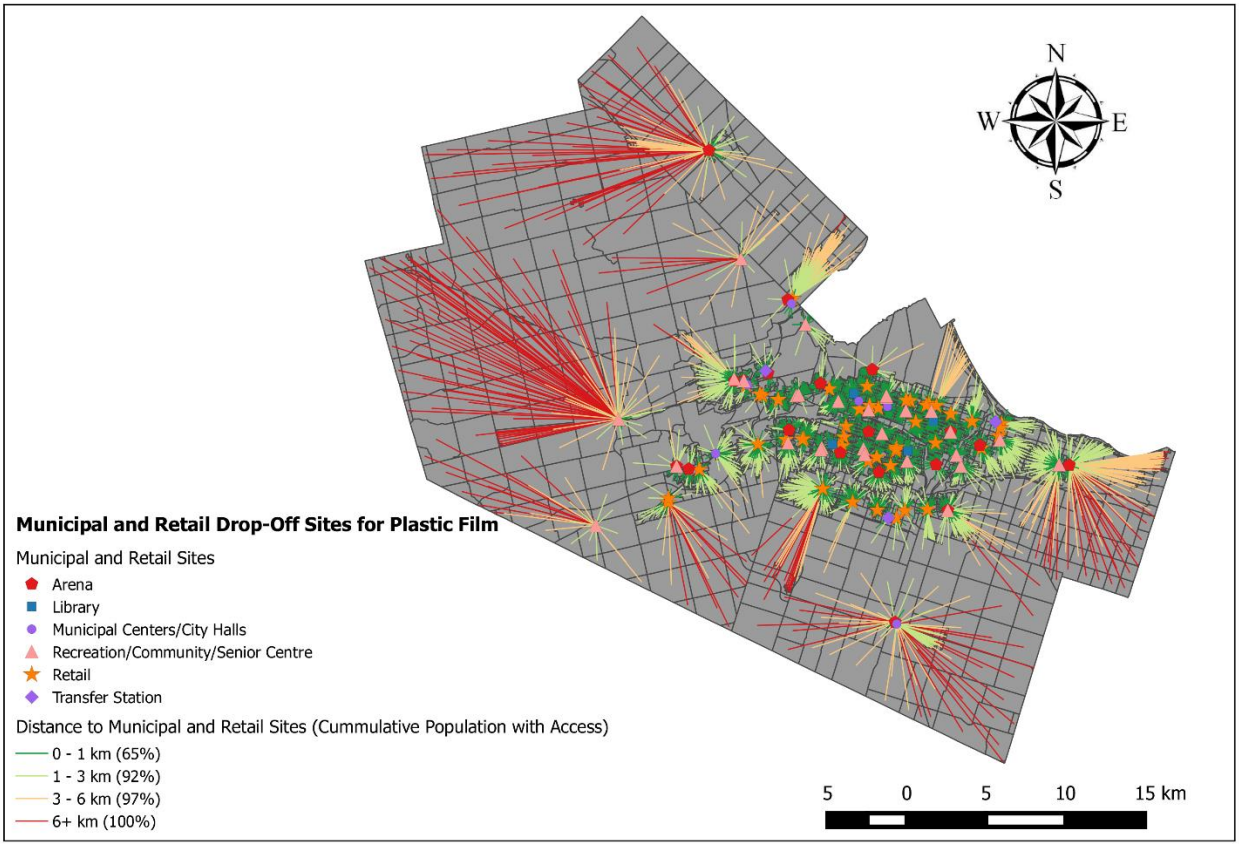
Use of branded bags would decrease the incidence of tearing and breakage (an existing issue at the MRF with bagged film), leading to reduced levels of contamination. It would also enhance the visibility of plastic film and keep it better contained, which improves sorting efficiency. As plastic film would still be collected and processed with containers, this scenario would not require the capital investment for new equipment. However, the use of branded bags would impose an additional cost that would likely be borne by the City in order to encourage participation. It is estimated that each of the 226,230 households in Hamilton would set out one bag ($0.10/bag) of plastic film, on average, per month.

If 50% of the residential plastic film received at the MRF currently were collected under this scenario, it is estimated that the total annual net cost of the program would be $290,000, and the net cost per tonne is estimated to be $485 (see Table 11 above).

4.6.6. Scenario 6: Return to Municipal Sites and Retail Stores

Under scenario 6, residents are able to return plastic film to municipal sites and retail locations. This scenario provides the residents with more options, enhancing the convenience of the program which is expected to increase the participation. It is estimated that 65% of the City's population lives within 1 km of a site, 92% lives within 3 km of a site, and 97% lives within 6 km of a site when both municipal and retail sites are considered. Therefore, a majority (92%) of the population would have access to a plastic film recycling site within 3 km.

Figure 5: Municipal and Retail Drop-off Sites in the City



The increase in the number of locations available for plastic film collection under this scenario would most likely result in a reduced tonnage handled per site. Assuming that 50% of the plastic film currently diverted would be collected under this scenario, combined total annual net costs are estimated to be $306,000 ($513/tonne) (see Table 11 above).

4.6.7. Annual Net Cost Comparison of Alternative Scenarios

In this section, the annual net cost of each alternative collection scenario is presented and compared to current annual net costs of plastic film collection and recycling. For each method, RSE presents net costs assuming that 25%, 50% and 75% of plastic film delivered to the MRF is received through the alternative scenario, with the remaining share of plastic film still handled through the current collection and processing scenario. Thus, these costs are expected to be representative of the net costs incurred as residents gradually change their behaviours to adopt to the new system.

The annual net costs are presented in ranges due to the inclusion of the "missed materials revenue" ranges described in section 4.4. Annual net costs take into consideration additional costs that would be incurred under each scenario, as well as additional revenues from the marketing of increased quantities of plastic film.

Annual net costs for all scenarios are the lowest when 75% of the film is received via one of the alternative methods described above, relative to when only 25% and 50% are being received by one of the alternative scenarios. The highest annual net costs per scenario are incurred when only 25% of plastic film is collected via the alternative scenario being considered, with the highest annual net costs via scenario 4, collection of film through the fibre stream. At both low and high point missed revenue estimates and across all diversion rates, the return to municipal sites scenario (#1) has the lowest annual net cost among the alternative scenarios.

The estimated annual net cost of each scenario using the high and low estimates of additional revenues (as described in section 4.4) from the capture and sale of other commodities ($337,000 and $115,000 per year) is presented in Table 12.

Table 12: Annual Net Cost of Alternative Methods (Including High and Low Estimates of additional Revenues)

Annual Net Cost of Handling Plastic Film Using Alternative Methods[27]			
	25%[28] **of Total Plastic Film Received Via Scenario**	**50%**[29] **of Total Plastic Film Received via Scenario**	**75%**[30] **of Total Plastic Film Received via Scenario**
Scenario 1: Return to Municipal Sites	$375,000- $597,000	$248,000-$470,000	$145,000-$366,000
Scenario 2: Return to Municipal Sites - Milk Run	$479,000-$701,000	$434,000-$656,000	$413,000-$634,000
Scenario 3: Return To Retail	$412,000-$634,000	$285,000-$507,000	$181,000-$403,000
Scenario 4: Collection via Fibre Stream	$602,000-$823,000	$474,705-$696,000	$371,000-$592,000
Scenario 5: Collection with Branded Bags	$470,000-$692,000	$344,000-$566,000	$240,000-$462,000
Scenario 6: Municipal Sites + Return to Retail	$487,000-$709,000	$360,000-$582,00	$257,000-$478,000
Current Scenario Costs	$680,000		

Under all scenarios considered, there is a decrease in annual net costs as the portion of plastic film received through the scenario being considered increases from 25% to 75%. Scenario 4, collection with via the fibre stream results in a greater annual net cost when compared with the current scenario. However, net costs decline as the portion of plastic film collected through that scenario is increased. Return to municipal sites consistently has the highest reduction in net costs across all diversion rates and under both low and high additional revenues estimates.

Table 13 highlights the estimated reduction in annual net costs of each alternative scenario with both the low and high estimates for additional revenues ($115,000 and $337,000 per year). These costs represent total estimated program costs and revenues, not just those borne by the City.

Table 13: Annual Net Cost Reductions (Increases) Associated with Alternative Scenarios

Annual Net Cost Reductions Achieved from Handling Plastic Film Using Alternative Methods						
Scenarios	**25% of Total Plastic Film Collected via Alternative Scenario**		**50% of Total Plastic Film Collected via Alternative Scenario**		**75% of Total Plastic Film Collected Via Alternative Scenario**	
Revenues from High-Value Materials	Low	High	Low	High	Low	High
Scenario 1: Return to Municipal Sites	$66,000	$288,000	$193,000	$415,000	$297,000	$518,000

Scenarios	25% of Total Plastic Film Collected via Alternative Scenario		50% of Total Plastic Film Collected via Alternative Scenario		75% of Total Plastic Film Collected Via Alternative Scenario	
Scenario 2: Return to Municipal Sites - Milk Run	-$38,000	$184,000	$7,000	$228,000	$29,000	$250,000
Scenario 3: Return To Retail	$29,000	$251,000	$156,000	$378,000	$260,000	$482,000
Scenario 4: Collection via Fibre Stream	-$161,000	$61,000	-$33,000	$188,000	$70,000	$292,000
Scenario 5: Collection with Branded Bags	-$30,000	$192,000	$97,000	$319,000	$201,000	$423,000
Scenario 6: Combination Method - Municipal Sites + Return to Retail	-$46,000	$176,000	$81,000	$302,000	$184,000	$406,000

4.7. Costs Borne by the City

The annual net costs presented above in Tables 12 and 13, outline the estimated overall costs and revenues associated with managing residential plastic film in the City. However, not all costs would be incurred by the City, nor would the City benefit from all increases in revenues. Scenarios involving return to retail (scenarios 3 and 6), some of the costs would be realized by the retail stores and not by the City.

When 50% of the plastic film currently being collected through the blue box method (598 tonnes) is collected via Scenario 3 (return to retail), there is an estimated total net cost of $507,000 (see Table 14). This total estimated cost is incurred both by the City ($469,000) and the retail stores ($38,000). Similarly, when 50% of the plastic film currently being collected is collected via Scenario 6 (return to retail and municipal sites), there is an estimated total annual net cost of $582,000. This total estimated cost is incurred both by the City (annual estimated cost of $500,000) and the retail stores (annual estimated cost of $82,000).

The costs borne by the retail stores decrease significantly as the diversion rates increase. The retail stores have an opportunity to make a profit of $50,000 when 75% of plastic film is collected via Scenario 3.

Table 14: Share of Net Costs between Hamilton and Retail Stores

Net Costs Shared between the City and Retail Stores when Handling Plastic Film						
	25% of Total Plastic Film Collected Via Scenario [31]		50% of Total Plastic Film Collected Via Scenario [32]		75% of Total Plastic Film Collected Via Scenario [33]	
	Net Cost Borne by Hamilton	**Net Cost Borne by Retail Stores**	**Net Cost Borne by Hamilton**	**Net Cost Borne by Retail Stores**	**Net Cost Borne by Hamilton**	**Net Cost Borne by Retail Stores**
Return To Retail (Scenario 3)	$508,000	$125,000	$469,000	$38,000	$453,000	-$50,000
Combination Method: Muni Centre + Retail (Scenario 6)	$588,000	$121,000	$500,000	$82,000	$435,000	$43,000

5. Impact Assessment of Alternative Scenarios

In order for the City of Hamilton to further evaluate the 6 scenarios, an impact assessment matrix was developed. The impact assessment focuses on four criteria:

Impact on Access: How accessible is the scenario for the residents and what is the impact compared to the current collection method. A low impact assessment indicates the residents face minimal changes by the new system, and a high impact assessment indicates a more dramatic change to residents.

Impact (Negative) on Recovery: This criteria focuses on the anticipated recovery rate (diversion from landfill) of the scenario in comparison to the current recovery rate of residential plastic film. A low impact assessment indicates the method is expected to cause a positive change to the recovery of plastic film while a high impact assessment indicates an expected negative change to the recovery rate.

Net Costs: Net cost assessment is directly linked to estimated changes (increase or a decrease) in net costs when compared to current net costs. A low impact assessment indicates a much lower cost and a high impact assessment indicates much higher costs under the alternative scenario.

Challenge to Implementation: This is an assessment of how easily the City would be able to implement and transition to the alternative methods. A low impact assessment indicates the least amount of anticipated challenges to implement and/or resistance from affected parties, and a high impact assessment indicates more significant anticipated challenges to implement and/or resistance by affected parties.

Table 15: Impact Assessment of Collection Scenarios

Scenario	Criteria	Anticipated Impact	Comment
Scenario 1: Return to Municipal Sites	Impact on Access	Medium	Less convenient than curbside, but with 62 locations, 90% of residents are within 3km and 97% of residents are within 6km of a municipal site.
	Impact (Negative) on Recovery	Medium - High	Although recovery may be reduced slightly due to decreased convenience/accessibility, all plastic film recovered through this method is expected to be recycled due to low levels of contamination.
	Net Cost	Low	Under the low increased revenues assumption, and with 50% of plastic film collected via this scenario, the total annual net cost decreases from $680,000 to $470,000.
	Challenge to Implementation	Medium	Implementation requires significant cooperation from current municipal maintenance staff.
Scenario 2: Return to Municipal Site (Milk Run Collection)	Impact on Access	Medium	Less convenient than curbside, but with 62 locations, 90% of residents are within 3km and 97% of residents are within 6 km of a site.
	Impact (Negative) on Recovery	Medium - High	Although access may be reduced slightly, all plastic film recovered through this method is expected to be recycled due to low levels of contamination with the use of dedicated collection vehicles.
	Net Cost	High	Under the low increased revenues assumption, and with 50% of plastic film collected via this scenario, the total annual net cost decreases from $680,000 to $656,000.
	Challenge to Implementation	Medium	Implementation requires significant cooperation with current municipal maintenance staff. This method would also require additional collection staff.

Scenario	Criteria	Anticipated Impact	Comment
Scenario 3: Return to Retail	Impact on Access	Medium	Less convenient than curbside, but with 49 retail sites 92% of residents are within 6km of a site. Most residents visit retail stores more frequently than municipal sites.
	Impact (Negative) on Recovery	Medium	Although access may be less convenient for some residents, all plastic film recovered through this method is expected to be recycled due to low levels of contamination.
	Net Cost	Low - Medium	Under the low increased revenues assumption and with a 50% of plastic film collected via this scenario, the total annual net cost decreases from $680,000 to $507,000.
	Challenge to Implementation	Medium – High	Implementation expected to be fairly challenging as only
Scenario 4: Curbside, with Fibres/No Branded Bags	Impact on Access	Low	Collection curbside, does not require branded bags.
	Impact (Negative) on Recovery	Low	Recovery impact dependent upon degree to which residents adopt new behaviour. All plastic film recovered using this method is expected to be recycled.
	Net Cost	High	Under the low increased revenues assumption and with 50% of plastic film collected via this scenario, the total annual net cost increases from $680,000 to $696,000.
	Challenge to Implementation	Medium – High	The City is in the third year of a seven-year contract with the MRF operator. A renegotiation of the contract would be required.

Scenario	Criteria	Anticipated Impact	Comment
Scenario 5: Curbside with Containers/Branded Bags	Impact on Access	Medium	While still curbside, requirement to use branded bags could hinder access for some residents.
	Impact (Negative) on Recovery	Medium	Dependent upon access to bags, perceived convenience/no cost to residents. However, all film collected through this method is assumed to be recovered.
	Net Cost	Medium	Under the low increased revenues assumption and with 50% of plastic film collected via this scenario, the total annual net cost decreases from $680,000 to $566,000.
	Challenge to Implementation	Low	It is expected this method will be the easiest method to implement as it does not require a significant change in residents' behaviour. The impacts are further minimized if the municipality provides the bags to residents (current assumption in the analysis above).
Scenario 6: Return to Municipal Sites and Retail Stores	Impact on Access	Medium	Less convenient than curbside, but with 111 total sites 97% of residents are within 6km of a site.
	Impact (Negative) on Recovery	Medium	Although accessibility may be reduced slightly due to decreased convenience/accessibility relative to curbside, using both types of sites enhances access relative to municipal or retail. The majority of plastic film collected via this scenario is expected to be recycled due to relatively low levels of contamination.
	Net Cost	Medium	Under the low increases revenues assumption, and assuming 50% of plastic film collected via this scenario, the total annual net cost decreases from $680,000 to $582,000.
	Challenge to Implementation	Medium - High	Implementation in retail stores may be challenging due to concerns about space and contamination. Requires cooperation of municipal maintenance staff.

5.1. Limitations of Results

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

- **Accuracy of Data:** This report contains data that RSE gathered from field trips to the City's MRF. However, the team also relied on information retrieved from publically available sources (e.g., annual reports, studies, websites, etc.) as well as information willingly disclosed by City representatives. Similarly, MRF observational data was from a discrete timeframe at the MRF, and is assumed to be reflective of average annual operations.
- **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 City and other stakeholders under consideration.
- **Assumptions:** By necessity, RSE had to make certain assumptions when estimating costs and revenues, and anticipated behaviours. In some cases, such as when examining revenues from the sale of additional high-value commodities, RSE analyzed the net cost data using a high and low scenario, to indicate the types of revenue swings that occur in the marketplace.

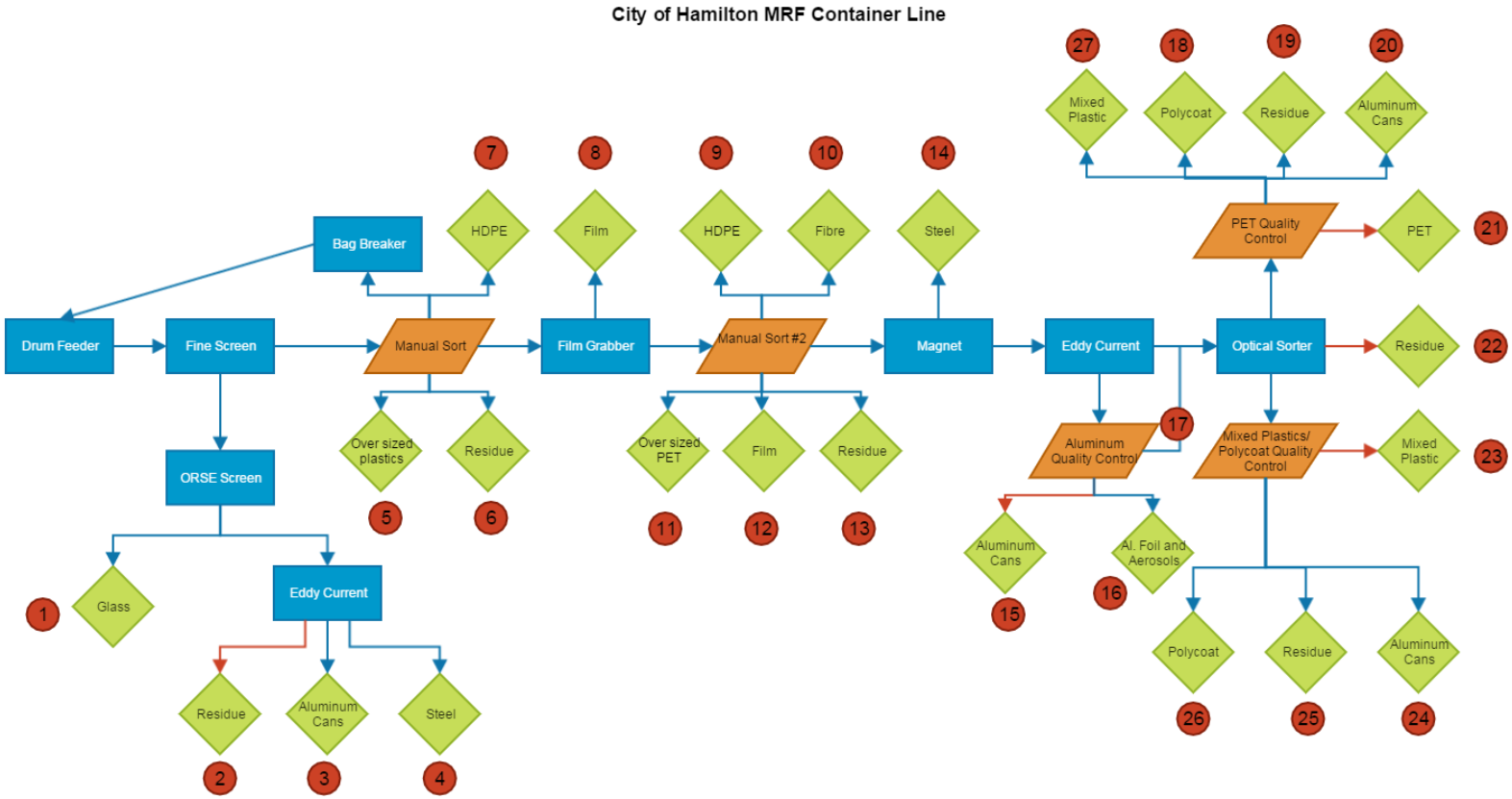
Endnotes

[1] The bag breaker is designed to rip open bagged recyclables and feed them back to the drum feeder for reintroduction to the container line.
[2] During the audit conducted at the facility, only three (3) staff were present on the fibre line.
[3] 2014 and 2015 waste composition studies single and multi family residences.
[4] Weight per household per year from the WDO Datacall was used along with data from the waste composition studies to estimate tonnes per household per year in Hamilton.
[5] The quantity of film returned to depots was estimated using Hamilton inbound data as well as the share based on RSE's previous report (The City Container Line Performance Audits and Improvement Recommendations).
[6] It was assumed that the amount of film through return-to-retail programs would be similar to film returned through Hamilton's depot program.
[7] Any non-aluminum containers including plastic film that is accidentally ejected by the eddy current is placed back on the conveyor to be introduced to the optical sorter. As shown in Table 3 above at Position 9, there are small amounts of plastic film that are ejected by the eddy current (typically stuck to an aluminum container or ejected with an aluminum container).
[8] It has been assumed that each sorter spends 2112 hours a year working at the MRF (8 working hours a day and 264 working days in a year).
[9] 2014 WDO Datacall (latest publically available data).
[10] Processing costs solely reflect the labour cost associated with sorting film. It doesn't include the capital cost for equipment, storage or the building; allocation of cost for utilities, or maintenance, all of which are sunk costs that would continue to be incurred even if film were excluded from the MRF. In addition, for a more conservative estimate, it has been assumed that the sorters on the container line remain unchanged in all scenarios as these sorters have other responsibilities even as film is reduced in the system. Also, estimates were based on a $20/hr wage, 8 hour working days, 264 working days a year and 60% time spent picking film. Under the film reduction scenarios, it is expected that the level of effort to remove film will decrease. However, it is assumed sort staff positions will not be eliminated but rather their time will shift to sorting other materials.
[11] Disposal costs includes the full cost to haul and dispose waste at the landfill. It has been estimated at $120/tonne.
[12] Baling costs includes the full cost to haul materials to the end market. It has been estimated at $30/tonne.
[13] Based on a capture of 560 tonnes of film (548 tonnes curbside and 12 tonnes through depots).
[14] Disposal tonnage and therefore cost would be nonexistent at this point with 75% reduction. It has been assumed that the remaining film entering the MRF is being recovered based using existing capabilities.
[15] The City Container Line Performance Audits and Improvement Recommendations, 2014.
[16] Branded bags have been assumed at $0.50/bag, $0.20/bag, and $0.10/bag, depending on the gauge and amount to be procured for the scenario.
[17] With economies of scale, thicker-gauge branded bags for the residents of the City have been assumed at a discounted price of $0.10 each.
[18] Bags for the municipal sites have been estimated at $0.50 each while bags for the retail stores have been estimated at $0.20 each.
[19] Assumed all 5 alternatives produce clean film instead of MRF grade film due to film arriving in bags (bag-in-bag collection) as well as absence of contamination usually from the containers on the container line.
[20] Resource Recycling, What's in Store for Plastic Bags - June 2007 – pg. 3, reports a $0.20 premium on MRF Grade film for Clean Film. RSE has used a more conservative estimate of $0.13/lb. premium on the current price of MRF grade film (~$30/tonne).
[21] Labour cost has been estimated as $0 as the plastic film received through this model (dedicated trucks) does not need to be sorted at the MRF.
[22] Labour cost has been estimated quoted at $6.40/tonne by the MRF manager which was used for this sorting cost estimation. This includes 4 additional sorters.
[23] Labour cost has been estimated based on the premise that the plastic film is received in bag-in-bag and/or with branded bags will reduce drastically the amount of time spent sorting. A $20/hr wage and the reduced time spent have been used for sorting cost estimation.
[24] Capital Investment required for collecting through the fibre line (4 hoods, an associated air conveyance system and additional bunker spaces) has been quoted by the MRF manager at $850,000 which has been amortized at 10 years and 3%.
[25] Distribution of tonnes between the municipal centers and retail stores have been based on the fact that each site will receive the same amount of film. However, it should be noted that it is likely retail locations will achieve higher recovery rates than municipal centers.
[26] Dissemination blocks are areas equivalent to one city block. Data was obtained from the 2011 Statistics Canada Census
[27] Net costs have been estimated using total costs (including cost of baling/disposal) and revenues received from clean film resale and missed revenues. Ranges are used to account for the missed revenue ranges given in section 4.4.

[28] 25% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 75% continues to be handled by Hamilton's current method.
[29] 50% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 50% continues to be handled by Hamilton's current method.
[30] 75% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 25% continues to be handled by Hamilton's current method.
[31] Where 25% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 75% continues to be handled by Hamilton's current method
[32] Where 50% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 50% continues to be handled by Hamilton's current method.
[33] Where 75% of total film (1195 tonnes) is being handled by the alternative methods while the remaining 25% continues to be handled by Hamilton's current method.

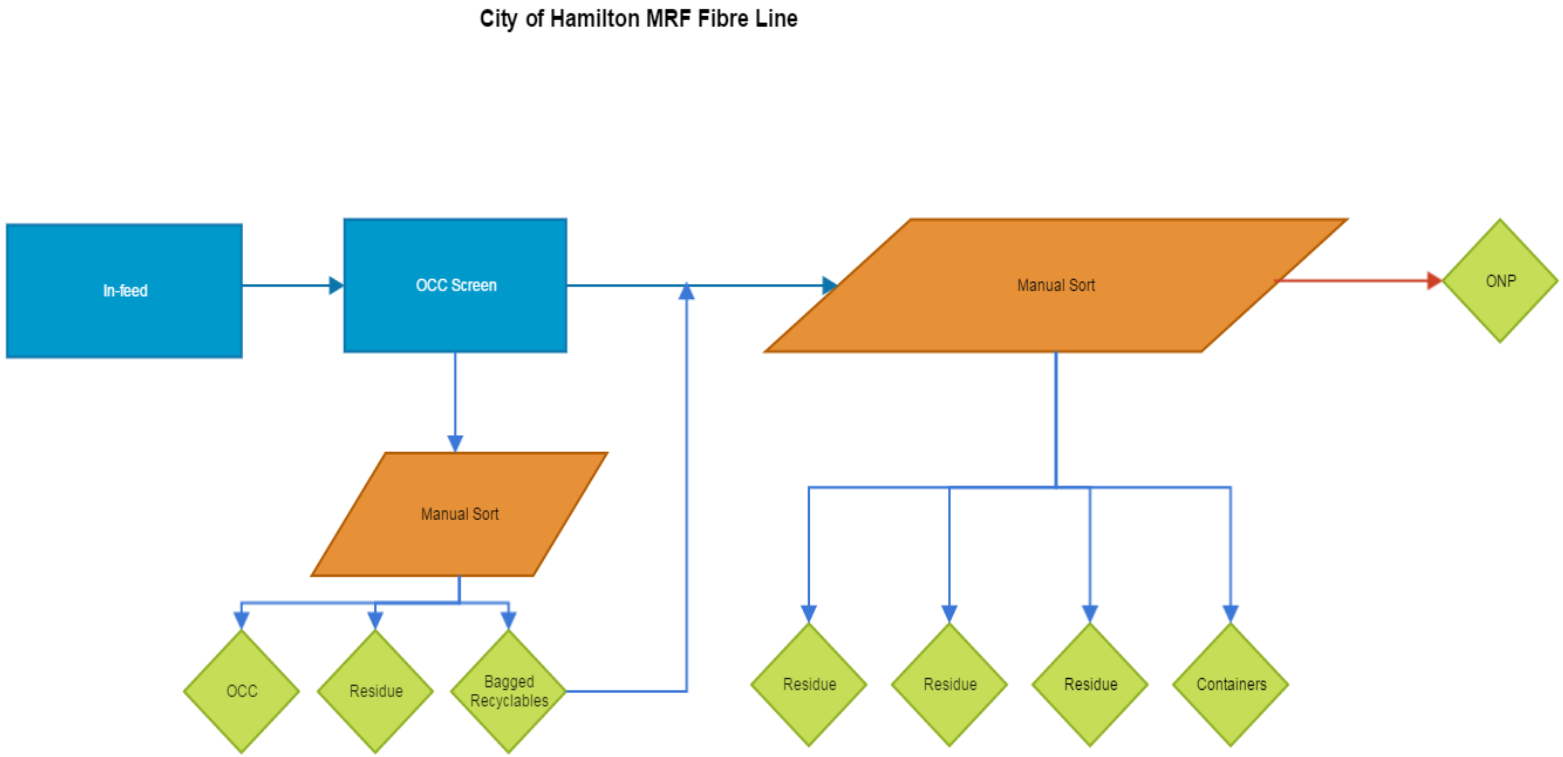
APPENDICES

5.2. Appendix A: City MRF Container Line Flow



- Blue arrows indicate flow of materials
- Red arrows indicate negative sorts of materials
- Blue rectangles indicate sorting equipment
- Orange indicates a manual sorting station or manual quality control station
- Green indicates commodity/material bunkers
- Numbers indicate the project data collection points

5.3. Appendix B: City MRF Fibre Line Flow



- Blue arrows indicate flow of materials
- Red arrows indicate negative sorts of materials
- Blue rectangles indicate sorting equipment
- Orange indicates a manual sorting station or manual quality control station
- Green indicates commodity/material bunkers