CIF MONITORING AND MEASUREMENT PLAN

PROJECT 935 MRF UPGRADES

Region of Waterloo

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Executive Summary

The Material Recycling Centre (MRC) located at 925 Erb St. W., in Waterloo, Ontario is part of the Region of Waterloo's (Region's) Waste Management (WM) Division operations. The Region owns the facility and contracts out its operation to Green for Life (GFL). It opened in 1991 to help manage the municipality's four-stream recycling program. Fibre material is collected and consolidated at the MRC before it is transferred into highway trailers and hauled away and sorted by another facility. In addition to its transfer station operation for fibres, the MRC houses a container line approved to process up to 65,000 tonne per year (tpy). Currently 20,000 tonnes of containers are processed annually in the Waterloo facility.

Prior to 2012, Waterloo residents were required to sort their recyclables into 4-streams; one of which was glass. Residents set out their glass separate from their other containers for collection. As such glass did not need to enter the facility for further sorting and could be consolidated outside the MRC in dedicated piles before being transferred and hauled away. In 2012 residents were no longer asked to keep their glass separated. This meant it was comingled with all other containers and would be brought into the MRC to be sorted. The existing glass breaker was not designed to handle the volume of glass now entering the facility. At this time the volume of plastic containers also began to steadily increase. This gave rise to a second set of concerns related to equipment downtime and inefficiency. The container line did not appear to have the capacity to keep up with the growing volume of materials in the container stream.

The Region was granted funding from the Continuous Improvement Fund (CIF) for MRC upgrades that included the In-feed conveyor system, Programmable Logic Controller (PLC), optical sorter, and glass breaker. The project goals were to reduce operating costs and improve capture and diversion.

The Region explored options for replacements or upgrades. Improvements were evaluated by conducting feasibility studies, audits and a cost benefit analysis. The outcomes of these evaluations were used to inform decisions on how best to accomplish the upgrades in a cost effective manner.

In-feed Conveyor

The in-feed conveyor at the beginning of the container line is at a relatively steep incline due to space limitations. The steep incline created the following problems:

- Material roll back, which increased the amount of time needed to convey all the materials onto the container line (i.e., lengthened operating hours required). This became more problematic in the winter months when the containers were frozen and heavier.
- Material distribution (i.e., black belt) at the pre-sort, meaning there were moments of time when no materials were on the belts to be sorted, which is an inefficient use of equipment, utilities and labour.
- Material surges or piles of varying depth at the pre-sort, meaning manual sorters and equipment were unable to see buried materials, which resulted in missed capture and again inefficient use of the equipment utilities and labour.

The Region obtained proposals and quotes on a range of solutions. The least expensive option, which the staff implemented in 2015, involved extending the length of the cleats on the belt to help prevent the materials from rolling backwards. The incline continues to contribute to some material distribution and material surge issues; however, MRC studies in 2017 and again in 2018 show the cleat extensions successfully minimized the roll back problem.

Optical Sorter

Year over year inbound container tonnage were increasing, and staff were concerned the optical sorter did not have the capacity to keep up with the increased volume. Solutions contemplated included installation of a new, more robust optical sorter or upgrading the software for the existing optical sorter.

The Region elected to move forward with the upgrade of the software for the existing optical sorter along with improvements to the conveyor belts and associated air compressor. The 2017 and 2018 MRC process audits indicated that this solution was meeting the Region's needs and the optical sorter did not require replacement.

PLC

The PLC - the computer that runs the entire container processing line was not communicating well with the equipment on the container line. It was determined that an upgrade of the PLC hardware and software was needed to reduce the overall plant downtime. Downtime dropped by 95% once the PLC was upgraded in 2016. Subsequent studies in 2017 and 2018 showed that it did not require any further upgrades.

Glass Breaker

The glass breaker at the MRC was not able to keep up with the increased volume of glass that resulted from the switch to the 2-stream system. The glass breaker regularly jammed which caused downtime. Studies in 2017 and 2018 showed the amount of material it failed to capture grow from 15% to 33%. Missed glass was causing wear and tear on the conveyor belts and equipment downstream. Corrections contemplated included installing a drum feeder at the beginning of the container line along with a trommel type screen to better break the glass and screen it out of the system early in the process. The alternative was to install a new, more robust glass breaker. The drum feeder was not viable due to floor space restrictions, and so the Region elected to go forward with the new glass breaker, as the payback window was reasonable at less than two years. This yielded a decrease in maintenance costs, downtime and wear on the equipment downstream.

1. Introduction

The Material Recycling Centre (MRC) located at 925 Erb St. W., in Waterloo, Ontario is part of the Region of Waterloo's (Region's) Waste Management (WM) Division operations. The Region retains a third party contractor to operate the sorting and baling operations at the MRC and perform minor maintenance and general cleanup. Green For Life (GFL) were contracted to operate the MRF until 2020 with the option to renew two 1-year terms until 2022. The Region is responsible for maintaining the building envelope, undertaking major capital projects including equipment replacement and upgrades, and major repairs.

In 2015 Region staff observed the MRC was experiencing a significant amount of downtime. The container line did not appear to have the capacity to keep up with the increased volume of materials in the container stream. Region staff noted a number of issues, specifically:

- Increased cross-contamination on the three lines after the optical sorter (PET, HDPE and negative sort line);
- Materials sliding back from the C2 conveyor to the C1 feed conveyor and getting stuck between the belts; and
- The glass breaker at the MRC appeared to be undersized as it was installed when glass was not part of the sorting process. A switch from 4-stream collection to 2-stream collection resulted in all the glass being introduced to the sorting system.

The Region was granted funding from the Continuous Improvement Fund (CIF) for MRC upgrades that included the In-feed conveyor system, Optical Sorter, Programmable Logic Controller (PLC), and Glass Breaker. The project goals were to reduce operating costs and improve capture and thereby diversion.

This report presents a brief review of the project and provides data to show efficiencies achieved from the upgrades.

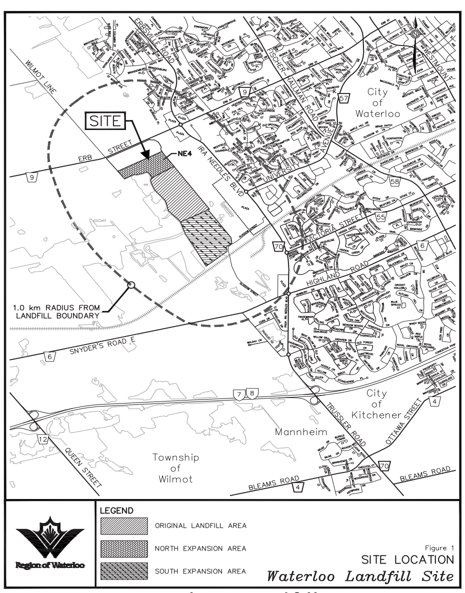


Figure 1. Waterloo Landfill

2. Background

The Region is located in Southern Ontario, and consists of seven local municipalities: the Cities of Cambridge, Kitchener and Waterloo and the townships of Wellesley, Woolwich, Wilmot, and North Dumfries. The Region has a population of 594,100 (2017). Based on data from the last 15 years, the Region's population is growing at a rate of 1.5% per year. The MRC is located on the boundary of the City of Waterloo and within the Waterloo Landfill Site that serves the Region (Figure 1). The MRC operates as a hub for Blue Box material collected within the Region with papers, film and fibre being transferred to another processing facility while the remaining Blue Box materials are sorted and baled at the MRC. The MRC handles approximately 38,000 tonnes of material from 213,220 households (66% single family and 34% multi-residential).

The MRC receives all Blue Box materials collected in the curbside and multi-residential programs as well as materials received at the small vehicle transfer stations. Each material received is sorted, baled or stockpiled at the MRC and then shipped to market. Materials are also received from a limited number of institutional sources, such as local municipal offices.

In the Region of Waterloo, recyclables are collected through the residential curbside collection program serving single family households, and the cart collection program servicing multi-residential dwellings, commercial businesses, institutions and industries. In general, the recyclable material is comprised of two streams:

1) **Mixed fibres:** boxboard (OBB), corrugated cardboard (OCC), newsprint (ONP), and film plastic bags; and

2) **Containers:** steel and aluminum containers, PET, HDPE, glass (clear, coloured and mixed coloured), gable tops and mixed rigid plastics.

The MRC has an existing Environmental Compliance Approval (ECA No. 5319-9QJQ3H) that specifies a Facility Production Limit of 65,000 tonnes per year, with the facility currently processes approximately 20,000 tonnes of containers per year. The MRC Operations Contractor is responsible for accepting all recyclables delivered for processing, except those materials, which are deemed by the Region to be unacceptable. The unsorted container materials undergo sorting and processing. Fibre and film materials are dropped off at in east side of the MRC. The mixed fibre and film are stockpiled and loaded on to trailers then shipped to market without processing.

Container Sorting System

On average the Waterloo Material Recycling Centre processes 4.7 to 5 tonnes of containers per hour. Since switching from 4-stream collection to 2-stream curbside collection in 2012, the volume of material being processed on the container line has increased due to glass being introduced to the system. A schematic of the container sorting system is provided in Attachment 1.

Incoming loads of containers are tipped inside the building and then loaded into the in-floor hopper, and conveyed up onto the pre-sort line within the pre-sort room. Recyclable fibres, aluminum pie plates and trays, large contaminants and bagged materials are hand-sorted from the conveyor line and thrown into separate moveable storage cages. All contamination is positively hand sorted and removed at the beginning of the sorting process to ensure it does not interfere with the sorting equipment and manual sort stations downstream. Also at this time, containers arriving to the MRC in small tied off plastic bags are manually opened and emptied onto the line.

The magnetic separator removes the steel cans from the end of the pre-sort belt which are then conveyed through a can flattener and then outside into 40 yard steel bins.

The material remaining on the belt drops off the end of the pre-sort belt then falls into a glass breaker/fines screen. The glass and fines are conveyed outside the building and dumped on the ground. Glass and fines are then picked up by the MRC Operations Contractor and dumped into a nearby transfer bin. The Region is responsible for transferring the bin contents to the outside mixed broken glass bunker.

The material passing over the glass breaker/ fines screen is processed through a plastics perforator before being conveyed up to a vibratory feeder for the optical sort line. The vibratory feeder also screens some small pieces (mainly small bottle lids and any remaining small glass) out of the material stream. The screenings are deposited into a transfer bin on the floor of the plant. The transfer bin contents are dumped into the residue bunker by the Contractor.

The optical sort line feeds material at a high speed to a Pellenc Mistral 1205T optical sorter. The optical sorter uses near infrared light to recognize PET and HDPE plastics and then uses compressed air to separate the PET and HDPE from the material stream. The three streams from the optical sorter are PET, HDPE and negative or remaining material. The remaining materials are sorted by hand in the main sort room which is located over the material bunkers.

The negative stream from the optical sorter contains all of the remaining materials including the PET and HDPE missed by the optical. PET plastic bottles and jars are hand sorted off the negative sort line along with mixed rigid plastic containers, HDPE plastic bottles and jars, gable top cartons, and any remaining steel containers. All hand sorted material in the main sort room is manually dropped into hoppers or into plastic totes beside the sort station. Plastic totes are either deposited in the appropriate bunker below or onto the appropriate sort line for further hand sorting.

The aluminum separator uses an eddy current to remove the aluminum cans from the end of the negative sort line. All other remaining materials on the negative sort line drop into the residue bunker.

The MRC began operation in 1991 and the building footprint was expanded in 2009 with the complete replacement of the original sort line at that time.

2.1 Project Description

Since the 2009 container line expansion, the Blue Box collection program has evolved. When the new container sort line was designed, the Region's Blue Box collection was a 4-stream system. Fibre, plastic containers, cans and glass were sorted by the residents and at the curb. Upon arrival at the MRC, glass was dumped in an outside bunker as it had been sorted by the residents and did not require further sorting inside the facility. As the glass was not anticipated to enter the MRC, the container sorting system was not designed to accommodate it. The small amount of glass that did find its way into the facility as a result of the residents improper sorting was considered cross-contamination, and was removed early in the MRC process and sent to the outside bunker. While not designed to manage glass, the system was able to tolerate the small amount entering as result of cross contamination.

In 2012, the Region switched to a 2-stream collection system, and residents were no longer required to set out glass separately from their other containers. All the glass collected was now introduced into the system and it was observed that the existing glass breaker could no longer keep up with the increased volume.

In March 2017, the Region collection contract underwent significant changes. Garbage collection went from weekly collection to every 2 weeks with a four bag limit imposed and recyclables and green bins being collected on a weekly basis. This resulted in an 8% increase by weight in recyclable materials being collected and processed at the MRC in 2017. In May 2017 the MRC added a second shift for processing of containers on the container line.

Those changes, coupled with the Region's continued population growth, have made it a challenge to manage the increased recyclable materials at the MRC.

2.2 Program Challenges

2.2.1 Rationale for C1 and C2 Conveyor Upgrades

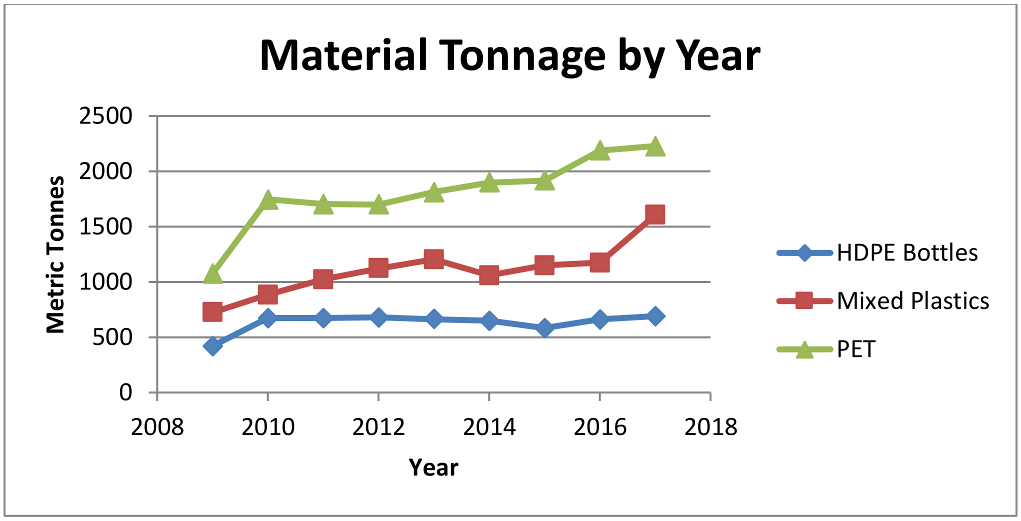
The combined C1 and C2 conveyor systems are located at the beginning of the processing operations, conveying comingled containers to the pre-sort room. The C2 conveyor is at a relatively steep incline due to space limitations in the MRC building. Materials were observed to be sliding back to the C1 feed conveyor and getting stuck between the belts. This slowed the rate at which the material was being brought forward for processing rendering this aspect of the operation inefficient. Conveyance appeared to rely on the jamming of one piece of material to another to move the material up the incline. The majority of the material that was cascading down the incline appeared to be plastic water bottles. The problem was exacerbated as the PET and HDPE became frozen in the winter and it became difficult to convey the material up the incline. MRC staff estimated that approximately one third of the plastic material was falling down the C2 conveyor. The proposed solution was to add cleats to the conveyor to help move the material up the incline.

2.2.2 Rationale for Optical Sorter Upgrades

The optical sorter was installed in 2009 when the entire container sort line was replaced and is a critical part of the MRC processing operations. Based on observations of the optical sorter performance Region staff decided that upgrades were needed to improve capture and efficiency. It was identified that the optical sorter did not have the capacity to keep up with the increased volume of materials in the container stream. Figure 2 below shows the increasing tonnages of plastics since 2009 when the new container line was installed.

Prior to the Optical sorter upgrades, Region staff noted increased cross-contamination on the three lines after the optical sorter (PET, HDPE and negative sort line). Region staff observed that hand sorters were missing commodities and not able to effectively sort resulting in increased plastics in the residue bin. At the time, it was common practice to re-run the residue to recover commodities that were missed. Region staff recognized that it made economical sense to upgrade the optical sorter earlier than planned, as it would reduce the frequency of re-running the residue and increase the amount of commodities captured. The Region considered if they could increase the bale counts for PET and HDPE by as little as five bales per month, it was estimated that revenue could increase by $56,000 per year.

Figure 2. Material Tonnage by Year



In June 2015, staff began to track equipment downtime. The data showed that the optical sorter was experiencing a significant amount of downtime compared to other equipment. Table 1 below shows the downtime ranking based on downtime minutes and downtime instances for the top four pieces of equipment at the MRC. The "Other" category of downtime is unrelated to a specific piece of equipment but related to other causes such as presence of sharps, alarm errors and power failures. The optical sorter was ranked number one (out of thirteen) for number of downtime minutes and number one downtime instances.

Table 1. Downtime

Equipment	Ranking[3] based on Total Downtime Minutes	Ranking[3] based on Downtime Instances
Optical sorter	1	1
Conveyors (combined total)[1]	2	2
Glass Breaker	3	4
Other[2]	4	3
PLC	5	6[1]

Notes:
[1] The C1 conveyor (not shown on the table) was ranked number 5 in terms of downtime instances
[2] Other is not related to a specific piece of equipment
[3] Downtime is ranked for 13 pieces of equipment/causes. Details of rankings can be found in RSE, 2017.

2.2.3 Rationale for PLC Upgrade

The PLC is the computer that runs the entire container processing line. As shown above in Table 1, the PLC was ranked number 5 out of 13 for downtime minutes. Investigation indicated that the plant processing PLC was not communicating well with the equipment on the container line. It was determined that an upgrade of the PLC hardware and software was needed to reduce the overall plant downtime.

2.2.4 Rationale for Glass Breaker Upgrade

The glass breaker at the MRC was sized for the 4-stream collection system where glass was sorted at the curb and dumped in a bunker outside the building. The glass breaker was meant to handle only the relatively small amount of glass that was intermixed with the other containers. Since the Region switched to the 2-stream collection, all the glass collected now enters the sort line with the other containers. The glass breaker installed in 2009 was not able to keep up with the increased volume of glass that resulted from the switch to the 2-stream system. The glass breaker was not able to capture all of the glass, and this created operations and maintenance issues in the downstream sorting operations.

The glass breaker was ranked number three on the list for downtime minutes. The glass breaker jammed periodically and had no ability to reverse when an object got stuck. A process audit (RSE, 2018) showed that 33% of glass was not captured by the existing glass screen and it continued past the screen causing increased wear on the conveyor belts and contaminating other commodities. Initially, following a 2016 audit (RSE, 2017), it had been recommended that adding new equipment would help solve the problem of excessive glass in the system. The Region contemplated adding a new drum feeder to help break the glass at the beginning of the line and a new trommel-type screen to remove the glass earlier on in the process. A subsequent cost benefit analysis (Archibald Engineering, 2018) concluded that the best option would be to install a new, more robust glass breaker to remove the glass and prevent jams. The cost benefit analysis showed that the glass breaker, installed in 2009, had excessive maintenance costs and the installation of a new glass breaker would have the quickest payback period. In 2009, the cost to install the glass breaker was $62,000. Records showed that over 2016 and 2017 alone, $120,000 was spent to maintain the existing glass breaker. The cost for installation of a new more robust glass breaker was estimated to be $150,000. Installation of a new glass breaker was expected to decrease maintenance costs; downtime and wear on the container sort line and achieve a payback in less than three years.

3. Approach

The Region uses an asset management approach for equipment replacement. When the new container sort line was installed, Region staff set timelines for equipment replacement based on design of the system, manufacturer’s specifications, MRC capacity and capital budgets. Staff continually evaluates the timelines based on equipment performance, quality of the materials and growth of the Blue Box program.

As described above in Section 2, Region staff observed a number of issues with the container sort line that needed to be addressed. In 2015 the Region applied and received CIF funding to upgrade the Optical Sorter, In-feed conveyors (C1 and C2), and Glass Breaker. The Region used different tools to explore options for replacements or upgrades. Improvement options were evaluated by conducting feasibility studies, audits and a cost benefit analysis. The outcomes of these evaluations were used to inform decisions on how best to accomplish the upgrades in a cost effective manner.

3.1 C1 and C2 Conveyor Upgrades

In September 2015, the Region undertook a study to investigate concept options for improving the C2 conveyance system (GRB Engineering, 2015). The study provided options and cost estimates to address the issue of the material cascading down the inclined belt. Of the possible solutions presented in the study, the decision was made to implements the lowest cost option first and evaluate the improvement following a winter season when the issue appeared to be worse. The cleats on the C2 conveyor were extended in October 2015.

3.2 Optical Sorter Upgrades

The optical sorter was slated for replacement in 2019, however, ongoing issues prompted staff to investigate options for improvement or early replacement. In 2015 Region staff became aware of an optical sorter upgrade package from Pellenc (2G Upgrade). Although the outer shell of the optical sorter remained, the entire inside of the machine, both hardware and software, was replaced in December 2015. Upgrades to the optical sorter infeed conveyor were also completed. These upgrades included switching from a rubber belt to a galvanized belt, upgrading the infeed motor from 3hp to 5hp and the addition of a variable frequency drive (VFD) to control belt speed. These upgrades were seen as a cost effective alternative to outright replacement of the optical sorter. The anticipated outcome was to improve the efficiency and reduce downtime.

3.3 PLC Upgrades

In June 2016, the plant PLC that controlled the container sort line was upgraded. The anticipated outcome of this major upgrade was to improve the overall efficiency of the sort line and reduce downtime.

3.4 Process Audits

Process audits were completed in November 2016 (RSE, 2017) and again in March 2018 (RSE, 2018). The process audit completed in November 2016 was partially funded by CIF (Project 952). Following the In-Feed Conveyor and Optical Sorter upgrades, which were initiated based on staff observations of specific issues, the process audits were completed to determine if further upgrades were needed. The process audits provided the data to confirm and prioritize what additional equipment should be targeted for upgrades. The process audits were used to establish a baseline and provide data for the monitoring and measurement plan. The March 2018 process audit was completed following the collection contract changes as recyclables increased 8% in 2017 and this established a new baseline.

3.5 Glass Breaker Upgrade

A new, more robust glass breaker was installed in July 2018. The new glass breaker is equipped with stronger motors, and has the ability to automatically reverse when a jam occurs.

3.6 Implementation Challenges and Solutions

When undertaking any capital upgrade – there are variety of problems and challenges to sort through before the most appropriate solution can be selected (i.e., the solution that best balances cost against the anticipated benefits). Table 2. Project Challenges and Solutions presents a consolidated summary of problems and challenges Waterloo Region staff studied before spending on capital upgrades. Also in the table are the lessons learned.

Table 2. Project Challenges and Solutions

Problems and Challenges	Solutions Implemented	Lessons Learned
Difficulty quantifying the extent and source of the problems (i.e., location of the inefficiency and extent of the financial impact to the Region's operation. Staff was aware that the line was not running efficiently, however it was a challenge to identify the causes.	Conduct a process flow audit to isolate the causes of poor performance and quantify their impacts (e.g. missed capture, high operating costs). This included careful evaluation of the various potential fixes before finally selecting a piece of equipment or process to be either replaced or upgraded.	This was invaluable to quantify the extent of the problems. It allowed for cost benefit analysis and prioritization of spending. Conducting a process flow audit allows baselines performance metrics to be established so that post upgrade changes can be measured to see if they achieved the forecasted improvements.
Collection program changes resulted in significant increased recyclables mid-project. Recyclables increased 8% in 2017 (from approximately 33,000 tonnes in 2016 to 36,000 tonnes in 2017)	A second process audit was completed to establish a new baseline and confirm that the correct piece of equipment was targeted for upgrading.	Similar to above. Establishing a baseline is key to measuring improvements and success of the project. The second process audit showed that the efficiency of the glass breaker decreased from 85% to 67%, thus providing a new baseline to evaluate the glass breaker upgrade.
Legislative changes that occurred mid-project. The timeline for continued operation of the MRC may or may not be affected.	Because the likelihood of full producer responsibility legislative changes taking hold are unknown, the number of years over which the Waterloo MRC will continue to operate are also unknown. A series of carefully constructed cost benefit evaluations were carried out prior to committing to large capital replacements of equipment to determine if the payback period was acceptable.	Cost benefit analysis was an important tool to inform decisions in an uncertain political climate. The cost benefit analysis helped prioritize which piece of equipment would be the most cost effective to add or replace. In our case, we had planned to add a new trommel screen and drum feeder and keep the old glass breaker but the cost benefit analysis showed that replacing our existing glass breaker would be the best option to decrease maintenance costs and downtime.

4. Monitoring and Measurement Methodology

The monitoring methodology used to assess the performance of the Optical Sorter, PLC and conveyor upgrades is outlined below. These three upgrades were completed within a close timeframe and the metrics used to evaluate the improvements are the same.

Baseline Conditions

1. **Downtime** was monitored for each piece of equipment in the MRC on a daily basis and tracked in units of minutes/day.
2. Number of **bales by material type** is documented on a monthly basis
3. **Total number of bales** are tracked on a monthly basis

Baseline conditions for the Glass Breaker replacement were determined as follows:

1. **Process flow audits** completed in 2017 and 2018
2. **Glass capture** measured in the weeks prior to glass breaker replacement
3. **Maintenance** cost

The baseline data were compared to post upgrade data to evaluate the improvements. The comparisons can be found in the following section.

4.1 Project Results and Analysis

Optical Sorter, PLC and C2 conveyor upgrades

Downtime minutes help Waterloo Region staff to monitor how efficiently their sorting facility is operating. A high number of downtime minutes are a warning sign that equipment may be in need of replacement or upgrading. It may also be a sign that operational procedures (e.g. maintenance, clean up or emptying bunkers) are not as efficient as they could be. Failure to address these factors can result in processing interruptions, which in turn can trigger the need for expensive overtime arrangements with the contractor to catch up for missed time. Figure 3 shows the downtime trends before and after significant changes in the facility.

Figure 3. Downtime before and after Optical Sorter, PLC and Conveyor upgrades

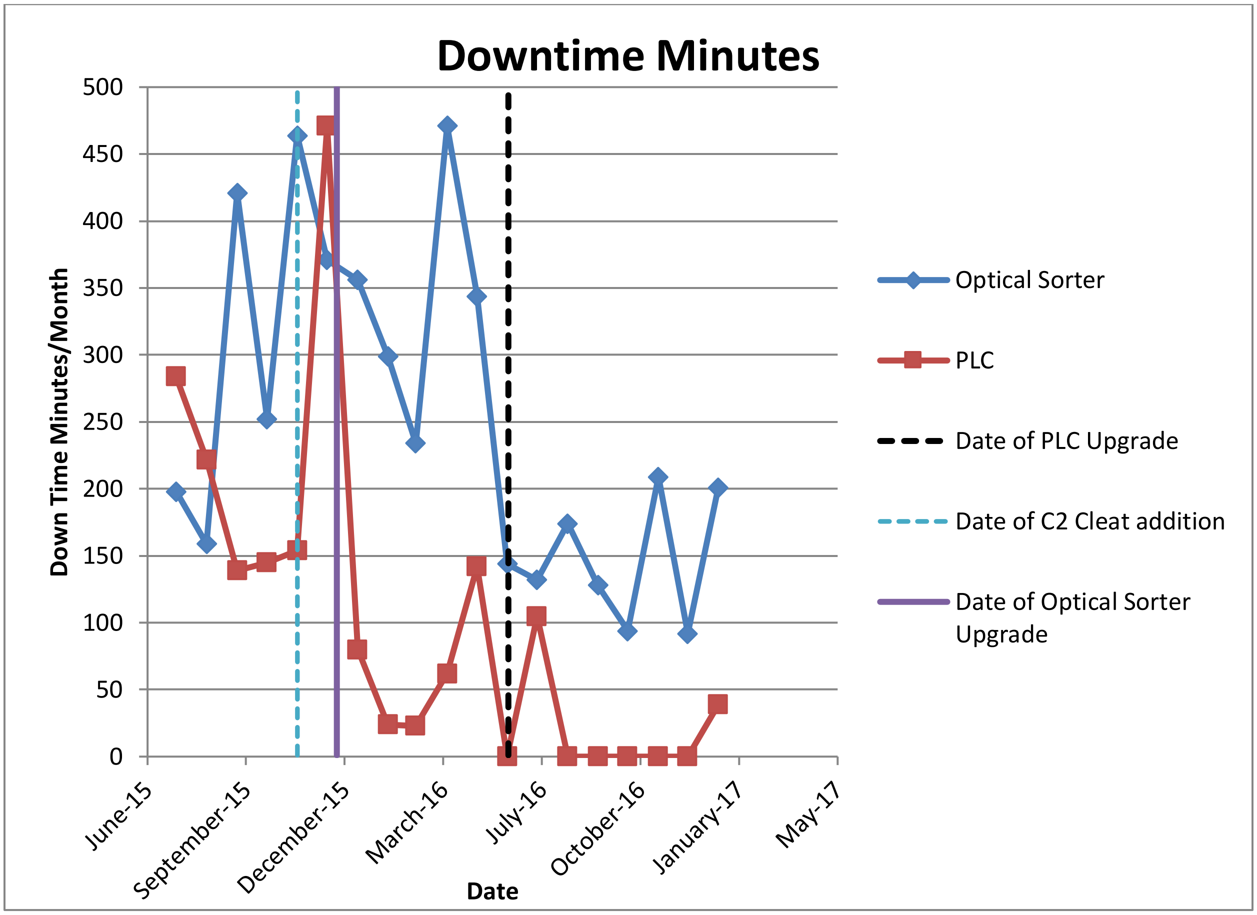


Figure 3 shows that downtime was significantly reduced following the Optical Sorter, PLC and C2 conveyor upgrades. Downtime related to the optical sorter decreased by 49% and downtime related to the PLC decreased by 95%. The decreased downtime resulted in more processing time and increased bales, as quantified further below.

Staff further evaluated the C2 conveyor upgrades based on observation of the changes. Throughout the winter season, staff periodically checked the conveyor and noted that the cleats prevented the material from sliding back down the belt and the burden depth was observed to be more consistent.

Figure 4 below shows the total monthly bale counts before and after the Optical Sorter, PLC and C2 conveyor upgrades. The 2016 total bale counts increased compared to the same time in 2015 for all months except December. The data displayed in Figure 4 shows bale count increased by up to 32%. The increased bales for PET and HDPE resulted in approximately $133,000 of increased revenue in 2016 based on average commodity prices over 2015 and 2016.

Figure 4. Total monthly bale counts before and after Optical Sorter, PLC and C2 conveyor upgrades

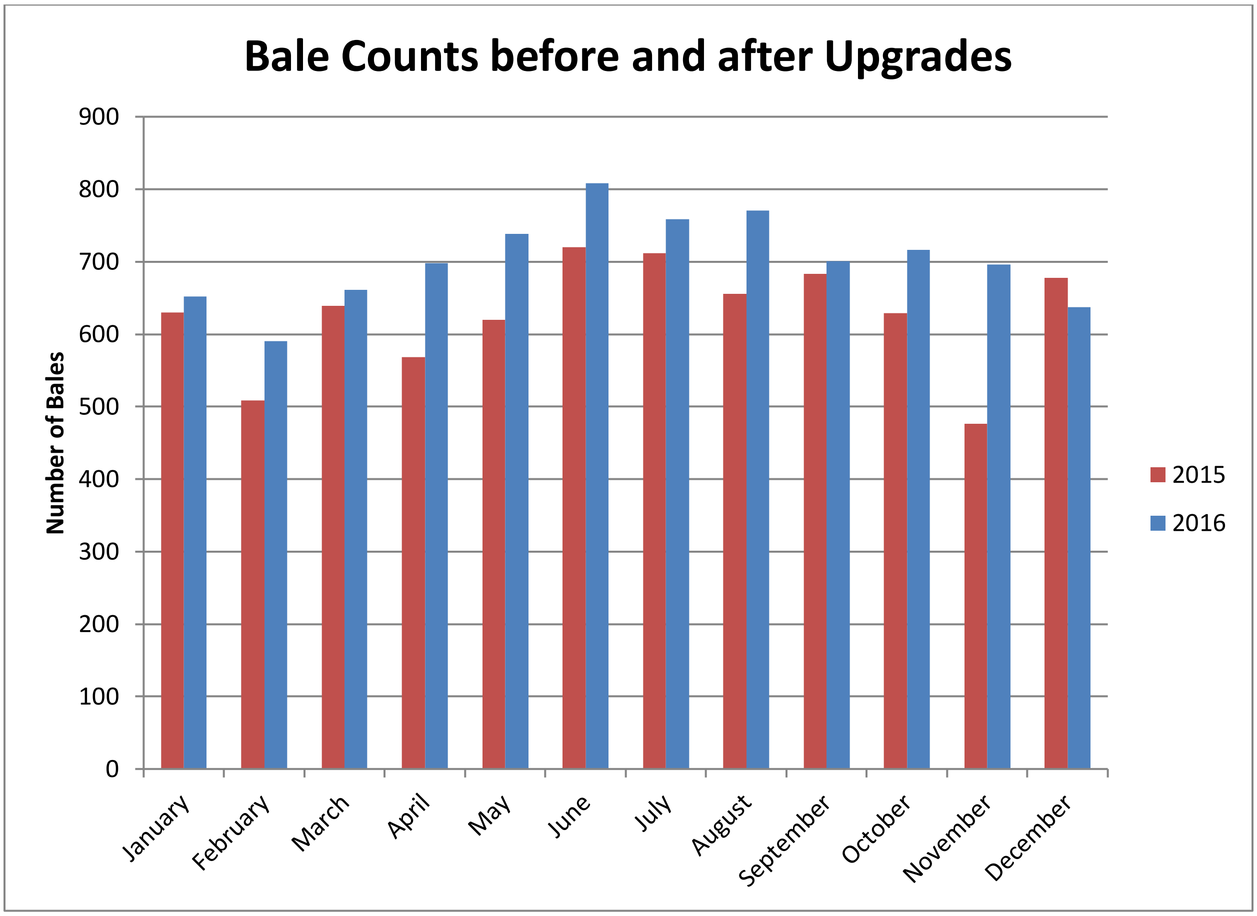
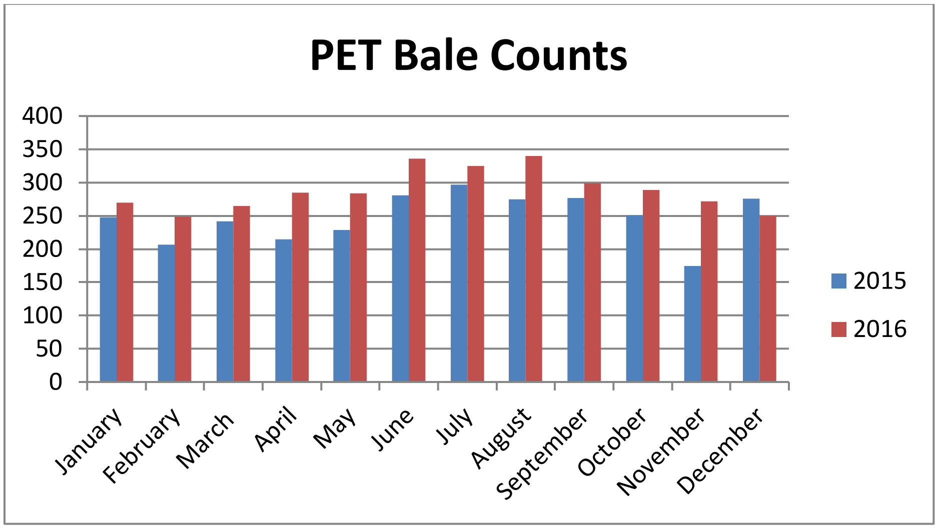
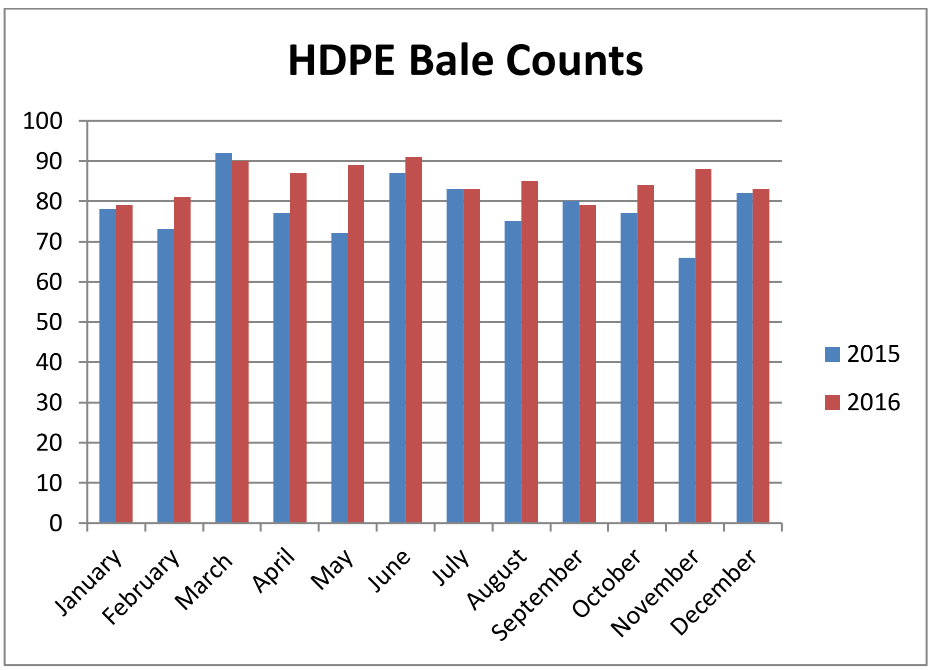


Figure 5. PET Bale Counts



The PET bale count increased by 492 from 2015 to 2016 representing increased revenue of $100,000.

Figure 6. HDPE Bale Counts



The HDPE bale count increased by 77 from 2015 to 2016 representing increased revenue of $33,000.

The results confirm the expected outcome of the upgrades, specifically increased bales of plastics resulting from more efficient, correct sorting by the optical sorter and from decreased downtime. Better quality sorting by the optical sorter would also have a positive effect on hand sorting improving the quality of material presented to manual sorting staff.

Figures 5 and 6 show graphs of bale counts by material type. Results show that the Optical Sorter and C2 conveyor upgrades resulted in increased number of PET and HDPE bales. Specifically, there was less variation in burden depth and a more consistent feed of plastics as they were no longer sliding back down the C2 conveyor. Material was moving more evenly through the system resulting in better presentation to the optical sorter and improved capture.

<u>Glass Breaker Replacement</u>

The expected outcome of the glass breaker replacement was:

- Decreased maintenance costs due to installing a more robust machine with more powerful motors and upgraded shafts
- Decreased downtime due to the new machine's ability to reverse in the case of jams
- Increased glass capture due to better breakage on a more powerful speed shaft

In anticipation of the glass breaker replacement project Region staff measured the tonnage of glass in the outside bunker in the two weeks prior to replacement and the two weeks after.

Table 3. Glass Bunker Tonnages

Date*	Glass Tonnage
July 9-14, 2018	68.9
July 16-21, 2018	70.8
July 30 – August 4, 2018	73.1
August 6-11, 2018	83.9

* The glass breaker was replaced from July 26-30, 2018

Table 3 indicates that the glass capture increased by 17.3 tonnes in the two weeks following the glass breaker replacement. Prior to the replacement, the extra tonnage of glass was making its way along the sort line causing premature wear on the equipment and contaminating commodities. Following the replacement there was improved glass capture.

The process flow audits completed in 2016 (RSC, 2017) and 2018 (RSC, 2018) showed that the glass breaker efficiency decreased from 85% to 67% from 2016 to 2018. Results from tests following the new glass breaker installation showed the efficiency had improved to 97% (Machinex, 2018). In general, it is anticipated that the overall maintenance of the sort line will decrease due to more glass being removed from the system early in the process thus decreasing wear and tear on the container sort line.

The Region's annual maintenance cost in 2016 and 2017 for the old glass breaker averaged $60,000 per year. Since the installation of the new glass breaker in July 2018 there have been no costs associated with maintenance of the new machine. In addition, there have been no recorded instances of downtime related to the new glass breaker. The automated reverse function has eliminated any downtime related to jamming of the screen.

The data collected following the glass breaker replacement confirms the success of the project as the improvements measured were as expected.

5. Project Budget

Upgrade	Project Budget Estimate*	Actual Cost*	% Change
Addition of C2 cleats	$129,000	$13,080	90% underspent
Optical sorter 2G	$170,000	$53,644	128% underspent
PLC	$96,472	$29,828	69% underspent
Glass Breaker	$69,480	$158,330	68% overspent
Measure & Monitor	$27,650	$ 9,900	
10% Contingency	57,565	$ -	
Total	$550,167	$264,782	

*includes labour and installation cost

6. References

Archibald Engineering, 2018. Proposed 2018 MRC Upgrades Cost Benefit Analysis. Regional Municipality of Waterloo. April 2018.

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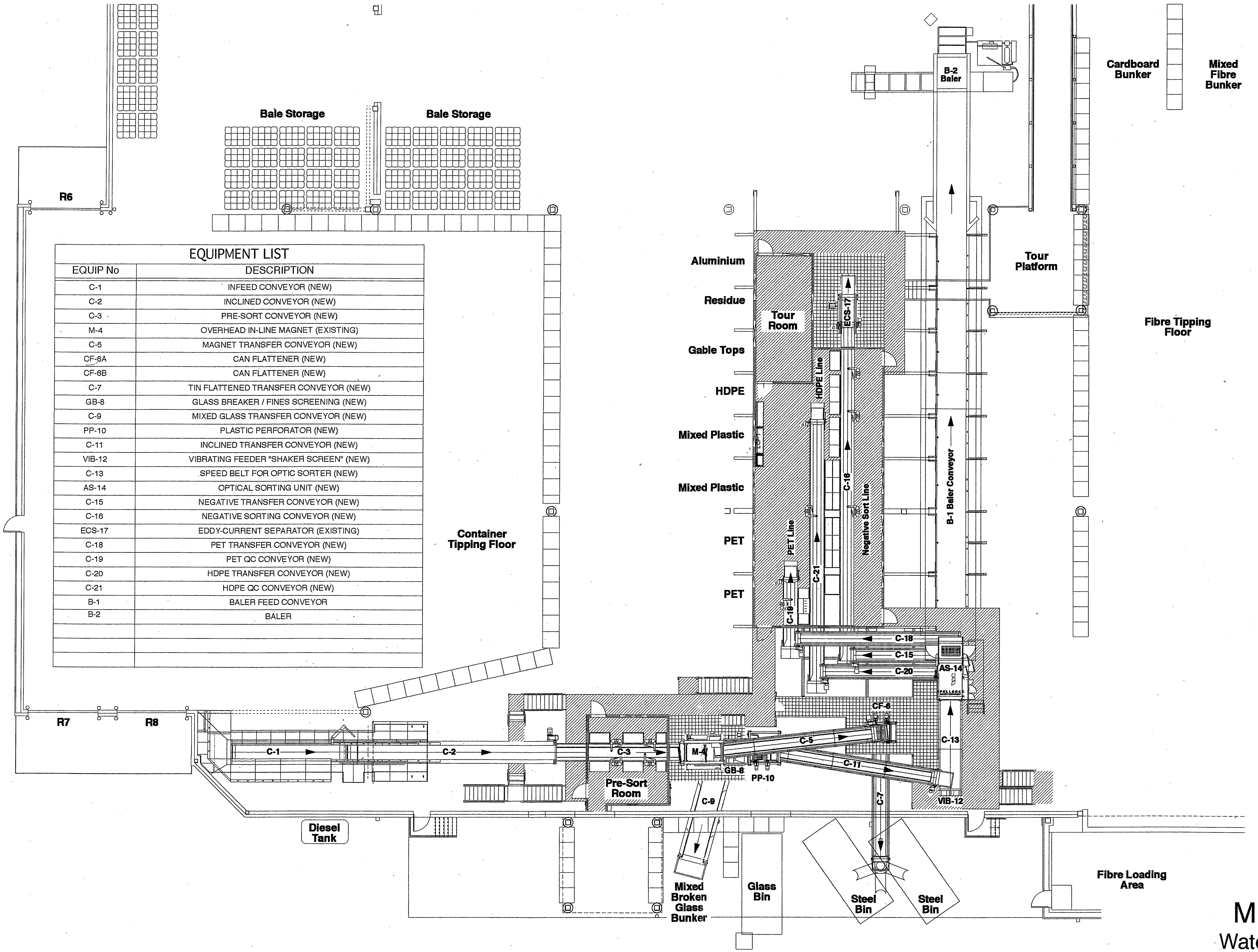
Attachment 1

MRC Sort Line Schematic

MRC Sort Line

Waterloo Landfill Site



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