Mixed Broken Glass Clean Up System

CIF Project #: 928

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Background:

In 2011, the Regional Municipality of York (the "Region") completed a significant upgrade that increased the York Region Waste Management Centre's blue box processing capacity from 90,000 tonnes per year to 140,000 tonnes per year. The upgrade included wider newspaper and mixed paper disc screens, two optical sorting systems, a new baler and a new mixed paper sort line. In 2014, the Region installed a mixed paper clean up system with the assistance of CIF funding to remove misdirected containers and contaminants from the mixed paper stream – this system comprised of a ballistic separator followed by an optical sorter and a series of transfer conveyors.

The Region's Mixed Broken Glass (MBG) stream was the undersize material from the original finishing screens installed in 2005. This stream had a contamination rate of over between 30 and 40% and therefore was not suitable feedstock for glass recycling facilities. For this reason, the material was used as road base at a local landfill at a cost to the Region. In addition to non-recyclables, the contamination included misdirected recyclables including metals, plastics and fibre which also resulted in a loss of revenue for the Region.

To improve the quality of the MBG stream and recover the misdirected recyclables the Region worked with the MRF Operator, Miller Waste Systems Inc. (Miller Waste), to look for a solution. Miller was responsible for all contract management of the tender with technical and costing oversight by Region staff. The design specifications for the Mixed Broken Glass Clean up System (by weight) are summarized below:

- Recovery of 90% of glass
- Recovered glass stream with below 20% contamination
- Recovery of 50% of fibres
- Recovery of 80% of containers
- Recovery of 80% of metals

Through the tender process, the project was awarded to Machinex Industries Inc. (Machinex).

System Description:

A summary of the Machinex MBG clean-up system is presented in Figure 1 below.

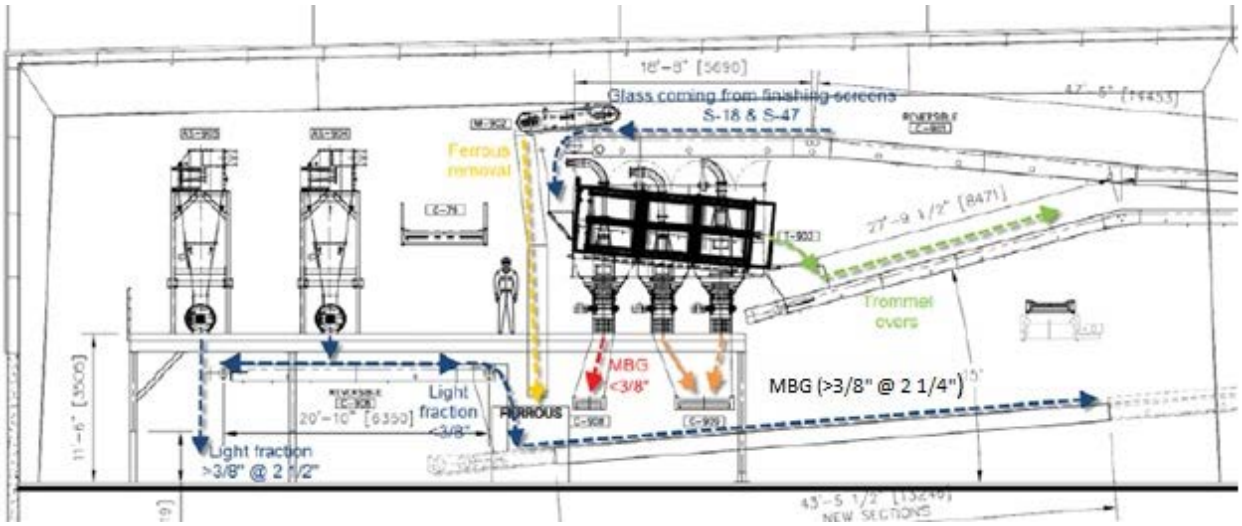


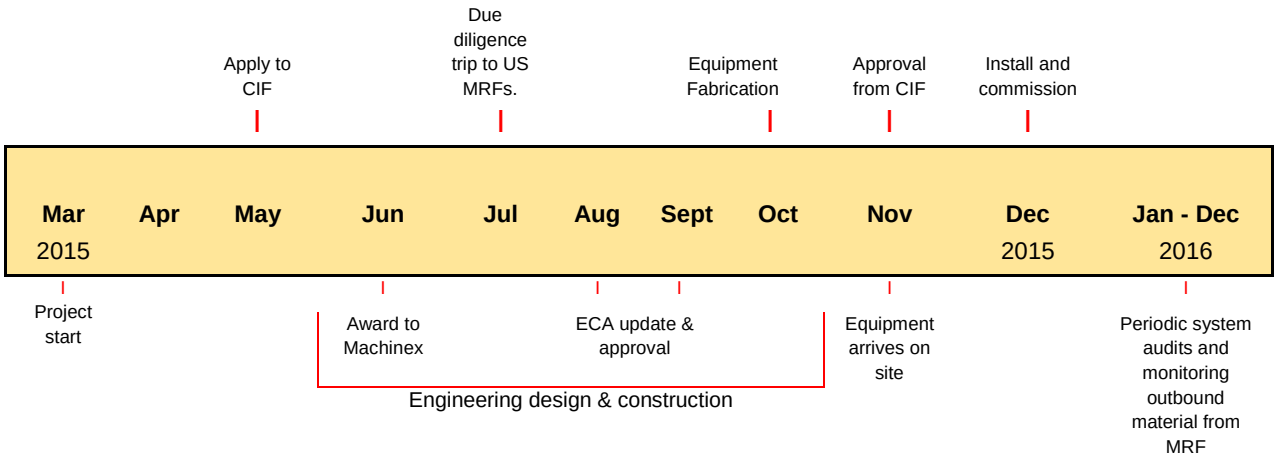
Figure 1 - Mixed Broken Glass Cleanup System overview

The Machinex MBG cleanup system consists of a ferrous magnet, trommel screen, a fines disc screen, rotary separator equipment and a series of transfer conveyor. The MBG coming off the finishing screens are conveyed towards the ferrous magnet to remove all ferrous material from the glass stream. The remaining material then flow through a rotating trommel screen with three opening sizes to separate material into different fractions:

- Material $\frac{3}{8}$" and smaller,
- Materials between $\frac{3}{8}$" and 2 $\frac{1}{4}$"
- Materials greater than 2 $\frac{1}{4}$"

The 2 $\frac{1}{4}$" or 'oversize' material would pass through a fines disc screen where misdirected fibre/residue (1 $\frac{1}{2}$"minus) is removed and managed as residue. The remaining oversized material is returned to the mixed paper clean up system where fibre, aluminum and containers are separated and sent to the appropriate end markets. Materials between $\frac{3}{8}$" and 2 $\frac{1}{4}$" and materials smaller than $\frac{3}{8}$" would be further processed through rotary separators operating under a cyclone to separate the light material (i.e., paper fines) while the heavy material (i.e., broken glass) falls into bunkers as the new glass streams. The MBG cleanup system was designed such that the light materials recovered by the rotary separators could be blended with newsprint bales (if feasible) or managed as residue based on material quality.

Project Timeline



In July 2015 the Region, along with staff from Miller Waste and Machinex, visited MRFs in Chicago and Cincinnati where similar glass clean up systems had been installed. These locations were selected for their technology and the fact their climates are similar to York Region's – specifically dealing with high moisture content in the material in winter. Based on feedback from the site staff, modifications were made to the initial proposed design. The site visit also allowed the Region to engage in discussions with the MRF's operators about any operational and maintenance challenges associated with equipment. Both sites spoke favourably regarding the effectiveness of the equipment.

The Region was required to obtain an amendment to the MRF's waste Environmental Compliance Approval to include the MBG cleanup system.

Additional Equipment

Additional equipment that was added to Machinex's original proposal:

Return (Fines) Screen

After the site visit, it was agreed to add a fines disc screen to manage the oversized fraction coming out of the trommel screen. The fines disc screen would remove any small fractions (mainly $1\frac{1}{2}$"minus) that can still be in the stream. The $1\frac{1}{2}$"minus fraction would be re-directed to the light material removed by the rotary separators for disposal as residue while the remaining fraction is conveyed to the mixed paper clean up system for further separation.

Touch Screen

The MRF's central control panel is not in the vicinity of the MBG cleanup system – as such a local control panel was added to allow for quick adjustments to system as required.

Trommel Brushes

Miller Waste staff noticed that increased moisture in the feedstock resulted in blinding of the trommel screen. Machinex suggested the addition of hydraulic brushes to scrape the screen as it rotates as seen in Figure 2 below.

Figure 2 -Trommel brush

Installation Process

The equipment arrived onsite in November 2015 and was installed over a 4 day period. Prior to equipment arrival, Miller Waste had obtained all necessary permitting and had prepared necessary tie in points to the designated area. The MRF typically processes materials Monday – Thursday so by scheduling a weekend installation, service disruption was minimized.

Figure 3 shows the installed trommel screen. The ferrous discharge bin can be seen to the right of the staircase.

Figure 3 - Mixed Broken Glass Trommel

Figure 4 shows both cyclones installed with the discharge bin for the cyclone light material beneath it. The conveyor below the cyclone is reversible which allows for the cyclone discharge to either discharge into the bin or be sent to residue.

Figure 4 - Installed cyclones

Figure 5 shows the fines disc screen, which removes fine material (as unders) prior to returning recyclables (via the conveyor shown in Figure 6) to the mixed paper clean up system for further separation.

Figure 5 - Recycle return disc screen

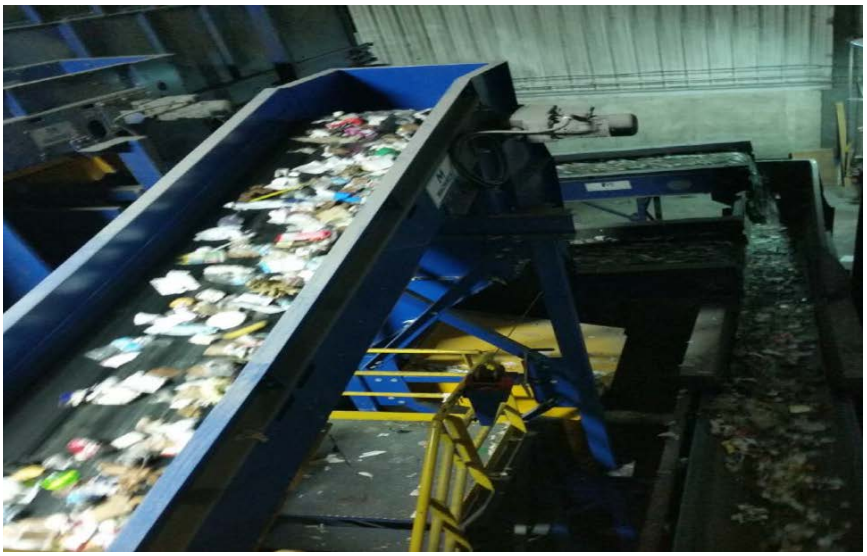


Figure 6 - Recycle return conveyor

Noise

Due to the noise emitted by the cyclones, Miller Waste made hearing protection mandatory for all areas surrounding the MBG cleanup system. The Region's audit office is adjacent to the glass load out area and a consultant was retained to conduct a noise assessment of the space. The noise map of the area is presented in Figure 7 below. Inside the audit office, the noise generated by the glass system during operation was within the acceptable threshold of 85dBA as prescribed by the Ministry of Labour.

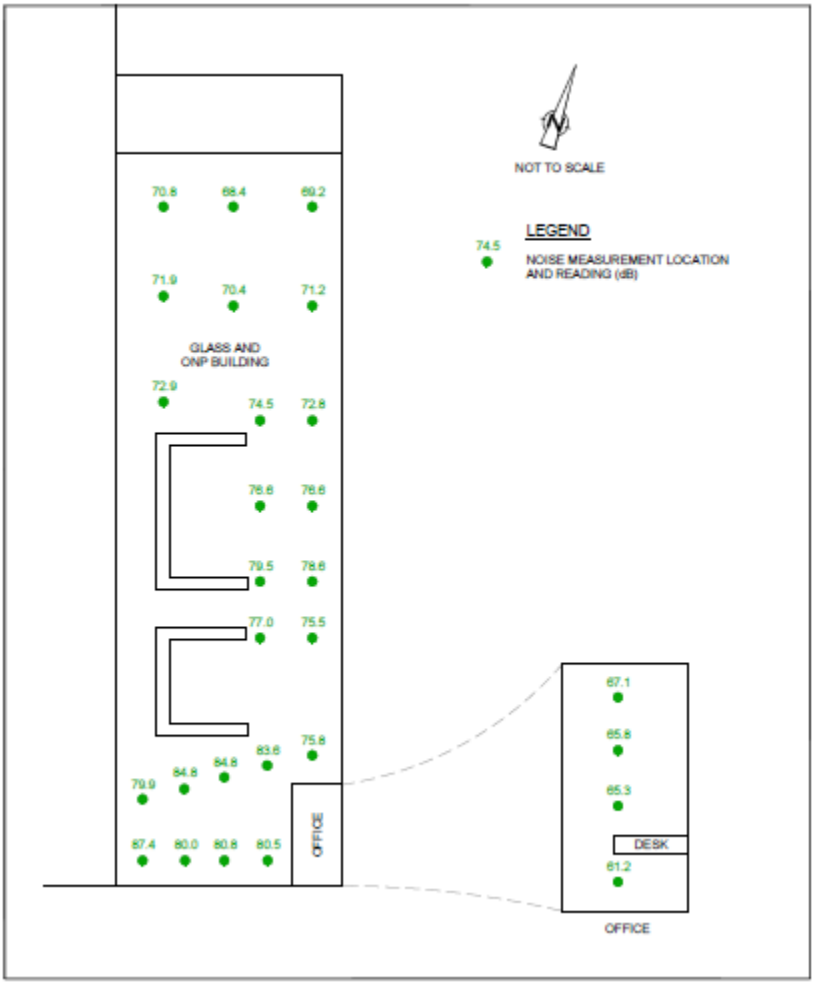


Figure 7 - Noise map of glass loadout area

Challenges

The reason for the reversible conveyor shown in Figure 4 was in hopes that the light fraction material captured by the cyclone are predominantly fibre and could be added to the paper bales. However, once installed it was observed that this material had high grit content and would not pass quality control for the Region's paper bales. As such, the light fraction from both cyclones was managed as MRF residue.

System Audits

In compliance with the CIF grant, seasonal audits were completed to evaluate system performance. A third party audit company, AET Group Inc., was retained to conduct seasonal audits during the first year of operation of the system to monitor system performance.

In addition, audit data was provided by the Region's glass end market, Nexcycle, as a condition to accepting the Region's material. Independent grab sample audits of each inbound load of material shipped were conducted at Nexcycle's facility. The agreement gave Nexcycle the authority to refuse any loads with contamination exceeding 20%. In 2016, no glass loads from the Region was rejected.

AET Audits

Each audit included running the system until approximately 1,400 kg of material was collected from all discharge points over a 2 day period (700 kg each day). Samples were collected from the following points:

- Glass discharge below 3/8"
- Glass discharge between 3/8" and 2 ¼"
- Magnet discharge bin
- Cyclone discharge
- Recyclable return screen oversize and undersize

Audits were conducted on the following dates;

- December 2nd – December 3rd, 2015
- February 23rd – February 24th , 2016
- June 7th – June 8th, 2016

Audit challenges

After the first audit, Region, Miller Waste and AET staff decided that the undersize material from the recyclables return screen would not be sampled as there was no safe and efficient manner to collect the material. In addition, the material that had been collected during the first implementation audit accounted for less than 1% of the total material sample and was predominantly small pieces of paper.

Audit results

Complete Audit results are presented in Appendix A

Glass Recovery

The project design criteria stipulated a recovery rate of 90% for glass entering into the MBG cleanup system. Also, the recovered glass streams should not exceed 20% contamination.

Based on the audit results presented in Table 1, it was evident that the system met its quality objective and was close to meeting its recovery targets even in high moisture conditions (February 2016 audit):

Table 1 - Glass Content by Stream

Sampling Point	December 2015 Audit		February 2016 Audit***		June 2016 Audit		Average
	Audit #1	Audit #2	Audit #1	Audit #2	Audit #1	Audit #2	
Glass Capture Rate							
Total Glass going into System (kg)	489.46	486.12	943.69	634.55	424.76	405.74	
Total Glass captured by System (kgs)	476.34	466.02	817.66	530.89	421.19	402.91	
Glass Capture rate (%)	**97.3%**	**95.9%**	**86.7%**	**83.7%**	**99.2%**	**99.3%**	**93.7%**
Glass Purity Rate							
<3/8" glass Stream Glass fraction **(Total materials)**	80.29 **(80.3)**	104.51 **(104.52)**	128.76 **(129.57)**	90.83 **(91.65)**	86.96 **(87.16)**	89.57 **(89.77)**	
<3/8" glass Stream purity rate (%)	**99.9%**	**99.9%**	**99.4%**	**99.1%**	**99.8%**	**99.8%**	**99.7%**
3/8" and 2 ¼" stream Glass fraction **(Total materials)**	396.05 **(426.12)**	361.51 **(393.62)**	688.90 **(738.80)**	440.06 **(486.84)**	334.23 **(357.77)**	313.34 **(339.20)**	
3/8" and 2 ¼" Stream purity rate (%)	**92.9%**	**91.8%**	**93.2%**	**90.4%**	**93.4%**	**92.4%**	**92.4%**

Note: * ** In February the material was extremely wet, causing it to stick together and affecting the System's glass capture rate. Consequently, the System recovered 86.7% and 83.7% during the February audits, slightly below the 90% glass capture rate requirement,

Plastic Container Recovery

The project design criteria stipulated recovery of 80% of containers (plastics). For a plastic item to be considered "recovered" after passing through the system, it must be in the fines disc screen over stream where the materials is then returned to the mixed paper clean up system where the plastic can be recovered by the ballistic separator and optical sorter. Table 2 indicates that this goal was achieved.

Table 2 - Plastic contents by stream

	December 2015 Audit		February 2016 Audit		June 2016 Audit		Average
	Audit #1	Audit #2	Audit #1	Audit #2	Audit #1	Audit #2	
Total plastic going into the System (kg)	24.95	31.69	47.67	45.23	16.91	20.28	
Total plastic in the Disc Screen Over Stream (kg)	21.49	27.86	29.78	23.16	14.12	19.76	
Capture Rate	**86.1%**	**87.9%**	**62.5%**	**51.2%**	**83.5%**	**97.4%**	**78%**

*In February the material was extremely wet, causing it to stick together and affecting the System's container capture rate.

Fibre Recovery

The project design criteria stipulated recovery of 50% of fibre. For fibre to be considered "recovered" after passing through the system, it must be in the fines disc screen over stream. Fibre that end up in the Disc Screen under stream and cyclone are not included in the fibre capture rate calculation since these materials are managed as residue and not sent to fibre markets.

Table 3 - Fibre contents by stream

	December 2015 Audit		February 2016 Audit		June 2016 Audit		Average
	Audit #1	Audit #2	Audit #1	Audit #2	Audit #1	Audit #2	
Total fbre going into the System (kg)	27.60	53.50	44.64	53.50	20.87	31.22	
Total fibre recovered by System (kg)	21.65	53.43	44.56	53.43	20.85	31.18	
Capture Rate	**78.4%**	**99.9%**	**99.8%**	**99.9%**	**99.9%**	**99.9%**	**96.3%**

Metals Recovery

The project design criteria stipulated recovery of 80% of metals. For a metal item to be considered "recovered" after passing through the system, it must either be in the ferrous stream or in the Disc Screen over stream where the material is returned to the plant where magnets and eddy current separators further downstream can recover the ferrous material and aluminum respectively. Table 3 indicates that this goal was achieved.

Table 4 - Metal contents by stream

	December 2015 Audit		February 2016 Audit		June 2016 Audit		Average
	Audit #1	Audit #2	Audit #1	Audit #2	Audit #1	Audit #2	
Total metal going into the System (kg)	30.36	30.59	40.53	28.07	22.69	21.10	
Total metal recovered by System (kg)	27.87	28.92	34.54	23.84	20.66	20.58	
Capture Rate	**91.8%**	**94.5%**	**85.2%**	**84.9%**	**91.1%**	**97.5%**	**90.9%**

Overall System Performance

In addition to audits, performance of the system was measured by monitoring all outbound streams from the facility and analyzing the data for any significant changes. A 2016 projected tonnage for each outbound material type was calculated using actual outbound material distribution recorded in 2015 and assuming there were no significant changes to inbound material composition. The 2016 projected tonnages were then compared with actual 2016 tonnages to determine the impact of the MBG cleanup system. Because the MBG cleanup system is intended to remove recyclables from MBG stream and not add to it, tonnage reduction recorded between 2016 and 2015 was not accounted for or attributed to System impact.

Initially, the Region had proposed comparing monthly outbound material tonnage to measure system performance however this report has done it on an annual basis for the following reasons:

1. Inventory is shipped when there is sufficient quantity and not scheduled monthly, therefore there is carry-over between months.
2. The tonnage recovered by the glass system on a monthly basis was not significant enough to show a significant monthly impact in most streams, however increased recovery was observed in 2016 overall.

Table 5 provides a breakdown on total material marketed based on actual 2015 tonnage, projected 2016 tonnage and actual 2016 tonnage. The 12 months period was between December 2015 and November 2016. The far right column outlines the estimated impact made by the MBG cleanup system between 2015 and 2016.

Table 5 -Total outbound tonnes by material type and impact due to MBG Cleanup System

Material Type	2015 Outbound Tonnage	2015 Outbound Composition	2016 Projected tonnage (without MBGCUS operation)	2016 Actual Tonnage (include MBGCUS operation)	Impact due to MBGCUS***
Fibre	2,107	2.48%	2,087	2,122	36
Glass					
GLASS ROAD BASE	13,041	15.36%	12,913	2,543	(10,371)
MIXED BROKEN GLASS				5,877	5,877
Metal					
FERROUS LOOSE				327	327
ALUMINUM	596	0.70%	590	702	112
STEEL CANS	1,818	2.14%	1,800	1,874	74
ALUMINUM FOIL	96	0.11%	95	96	
MHSW	13	0.02%	13	11	
Paper	50,985	60.07%	50,488	50,543	
Plastics					
PET	3,089	3.64%	3,059	3,462	403
HDPE	1,375	1.62%	1,362	1,278	
MIXED PLASTICS	672	0.79%	665	590	
BULKY MIXED PLASTICS	50	0.06%	49	27	
Polycoat	420	0.50%	416	384	
Residue	10,614	12.51%	10,510	14,211	3,483
Grand Total	**84,874**	**100.00%**	**84,047**	**84,047**	

Note: ***impact calculated as year over year difference

Fibre

Initially it was anticipated that the fibre recovery would be higher if the paper fines recovered by the rotary separator were blended with paper bales. However, the fibre recovered through the rotary separator was unsalvageable (too contaminated with grits) and was managed as residue. Only large pieces of fibre that returned to the mixed paper clean up system were recovered and marketed.

Glass

The focus of the system was to upgrade the quality of the Region's glass stream. Based on Nexcycle (the Region's end market) requirements, the glass stream was classified by size – above and below $\frac{3}{8}$", with Nextcycle only accepting material $\frac{3}{8}$" or higher. The minus $\frac{3}{8}$" glass fraction recovered was used as road base at a local landfill. The amount of glass used as road

base decreased from 13,041 tonnes in 2015 to 2,543 tonnes in 2016. On the other hand, the Region sent 5,877 tonnes of clean glass to Nexcycle in 2016.

Ferrous Material & Steel Cans

The ferrous material recovered by the magnet in the MBG cleanup system was predominantly small metal fragments, metal bolts, nuts, screws. These materials are not suitable for the baler and were not added to the steel can bales. Instead, a roll-off bin was used to store this material. The material is shipped out loose to its end market. All 327 tonnes of loose ferrous material shipped out in 2016 can be attributed to the MBG cleanup system as the material was previously blended in with the MBG stream.

In addition to loose ferrous materials, the MBG cleanup system also recovered other forms of ferrous material as part of the oversize fraction. These materials were returned to the mixed paper cleanup system and recovered by magnets further downstream. Based on the projection methodology presented in Table 5, the additional 74 tonnes of baled steel cans marketed in 2016 can be attributed to the MBG cleanup system.

Aluminum

112 tonnes of additional aluminum was recovered in 2016 by the MBG system. Previously crushed aluminum cans fell through the disc screens and was shipped out as MBG. While the MBG cleanup system itself does not directly recover aluminum, the material is returned to the mixed paper line where it will be recovered by the two eddy current units downstream in the plant.

Type 1 Plastic (PET)

403 tonnes of additional Polyethylene terephthalate (PET) was recovered due to the MBG cleanup system in 2016. The primary source of PET is single use plastic water bottles. Previously, bottles that were not completely emptied or crushed would often end up in the glass stream. The MBG cleanup system directs these bottles to the mixed paper clean up system where downstream optical sorter and sort staff would recover these materials.

Residue

The system generated 3,481 tonnes of residue in 2016 which was managed through the transfer station on site.

Cost & Payback

The system was initially estimated to cost $1,668,107. The Region has spent $1,580,212.65 on the system.

The Region has realized savings through the following:

- Overall cost to process MBG at Nexcycle ($37/tonne) is lower than the cost to manage the material as road base at a local landfill ($69/tonne).
- Increased revenue from recovered materials (plastics, aluminum, ferrous, fibre).

Table 6 -Cost/Revenue Analysis for 2016

Material Type	Impact due to MBG	(Revenue) or Cost/Tonne ***	Financial Impact
Fibre	36	$ (74)	$ (2,612)
Glass			
GLASS ROAD BASE	(10,371)	$ 69	$ (717,145)
MIXED BROKEN GLASS	5,877	$ 37	$ 217,200
Metal			
FERROUS LOOSE	327	$ (168)	$ (55,018)
ALUMINUM	112	$ (1,788)	$ (200,986)
STEEL CANS	74	$ (307)	$ (22,759)
ALUMINUM FOIL		$ (976)	
Plastics			
PET	403	$ (358)	$ (144,130)
MIXED PLASTICS	60	$ (45)	$ (2,713)
Residue	3,483	$ 88	$ 304,739
Total Savings per year			**$ (623,425)**

Note: *** Based on commodity prices outlined in the initial CIF application in March 2015

System Payback

Based on the annual saving noted in Table 6 and the total system cost, the estimated payback period is 2.5 years as shown in Table 7 below.

Table 7- Payback Period

Total System Cost	$ 1,580,212.65
Annual Saving	$ 623,425
Payback Period (Year)	2.5

Lessons Learned

Overall the Mixed Broken Glass Clean Up system was a success. The increased glass quality has allowed the Region to send its glass to Nexcycle for processing at a cost than managing the material as road base. Furthermore, the Region has also been able to generate additional revenue from the sale of previously misdirected recyclables.

Appendix A: Audit Results

December 2015 Audit #1 Summary

Audit #1 (Dec 2015)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	80.29	396.05	0.00	10.42	2.68	0.12	**489.56**
Paper going into system	0.00	5.84	0.11	0.12	21.65	1.18	**28.90**
Plastic going into system	0.01	3.45	0.00	0.00	21.49	0.00	**24.95**
Metal going into system	0.00	1.58	20.11	0.36	7.76	0.56	**30.36**
Other Mat'ls going into system	0.01	19.20	0.22	20.48	48.49	53.80	**142.20**
TOTAL (kgs)	**80.31**	**426.12**	**20.44**	**31.37**	**102.07**	**55.67**	**715.98**

December 2015 Audit #2 Summary

Audit #2 (Dec 2015)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	104.51	361.51	0.00	15.39	4.71	Not audited	**486.12**
Paper going into system	0.00	0.01	0.06	0.00	53.43	Not audited	**53.50**
Plastic going into system	0.01	3.00	0.00	0.82	27.86	Not audited	**31.69**
Metal going into system	0.00	1.20	21.43	0.47	7.49	Not audited	**30.59**
Other Mat'ls going into system	0.00	27.90	0.63	25.57	42.68	Not audited	**96.78**
TOTAL (kgs)	104.52	393.62	22.12	42.26	136.17	**Not audited**	**698.69**

February 2016Audit #1 Summary

Audit #1 (Feb 2016)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	128.76	688.90	0.00	46.50	7.88	71.59	**943.63**
Paper going into system	0.00	0.02	0.06	14.8395	44.56	5.51	**44.64**
Plastic going into system	0.11	4.55	0.02	4.9465	29.78	8.26	**47.67**
Metal going into system	0.08	1.57	25.40	2.9679	9.14	1.38	**40.53**
Other Mat'ls going into system	0.62	43.76	3.45	29.679	55.69	50.94	**184.14**
TOTAL (kgs)	**129.57**	**738.80**	**28.93**	**98.93**	**147.05**	**137.68**	**1280.96**

February 2016 Audit #2 Summary

Audit #2 (Feb 2016)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	90.83	440.06	0.00	39.57	4.72	59.36	**634.55**
Paper going into system	0.01	0.16	0.21	14.85	42.14	3.77	**42.52**
Plastic going into system	0.11	4.26	0.02	14.85	23.16	2.83	**45.23**
Metal going into system	0.08	1.18	18.12	2.97	5.72	0.00	**28.07**
Other Mat'ls going into system	0.62	41.18	2.51	26.73	40.40	28.27	**139.71**
TOTAL (kgs)	**91.65**	**486.84**	**20.86**	**98.97**	**116.14**	**94.23**	**908.69**

June 2016 Audit #1 Summary

Audit #1 (June 2016)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	86.96	334.23	0.00	not audited	3.57	0.00	**424.76**
Paper going into system	0.00	0.00	0.02	not audited	20.85	0.00	**20.87**
Plastic going into system	0.01	0.55	0.00	not audited	14.12	2.23	**16.91**
Metal going into system	0.03	1.44	15.33	not audited	5.33	0.56	**22.69**
Other Mat'ls going into system	0.16	21.55	0.96	not audited	45.19	60.88	**128.74**
TOTAL (kgs)	87.16	357.77	16.31	**not audited**	89.06	63.67	**613.97**

June 2016 Audit #2 Summary

Audit #2 (June 2016)							
	Small Glass	**Med Glass**	**Ferrous**	**Disc Under**	**Disc Over**	**Cyclone**	**TOTAL**
Glass going into system	89.57	313.34	0.00	not audited	2.83	0.00	**405.74**
Paper going into system	0.01	0.00	0.03	not audited	31.18	0.00	**31.22**
Plastic going into system	0.00	0.50	0.02	not audited	19.76	2.07	**22.35**
Metal going into system	0.02	0.50	15.18	not audited	5.40	0.00	**21.10**
Other Mat'ls going into system	0.17	24.86	2.61	not audited	51.44	75.37	**154.45**
TOTAL (kgs)	**89.77**	**339.20**	**17.84**	**not audited**	**110.61**	**77.44**	**634.86**