



An Assessment of Single and Dual Stream Recycling

Including Current Program Performance in Large Ontario Municipalities

November 1, 2012 (Update March 4, 2013)

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Section 1: INTRODUCTION

In the past ten or more years, many municipalities in North America have implemented single stream recycling systems, either replacing existing recycling programs or implementing new initiatives where recycling programs had not previously been in effect. The cited reasons for the selection of dual or single stream programs are varied, but usually the primary factors cited by those jurisdictions that have chosen single stream recycling include potential cost savings (largely related to curbside collection efficiencies as discussed below) and the potential for higher diversion. In Ontario, single stream recycling has been implemented by four of the largest municipal jurisdictions.

There is some debate documented through various studies in regards to whether dual or single stream systems offer better performance. The benefits of implementing one approach versus another, appears to be largely based on the status of the existing municipal waste management system. In the absence of an existing recycling program, or in circumstances where the existing system may include multi-sort approaches, inefficient collection performance and/or old infrastructure that requires replacement, transition to single stream may offer some benefits. In other circumstances, where a relatively efficient dual stream collection approach is currently in effect, and where existing dual stream processing infrastructure is adequate and cost effective, there may be little benefit associated with such a change.

The purpose of this report is to:

- Review and discuss the current performance of single and dual stream recycling in North America, based on documentation and study findings in other jurisdictions. This discussion focuses on the key functional areas in which single and dual stream recycling differ, examining implications regarding collection, processing, end market material quality and diversion potential.
- Review and discuss current single and dual stream recycling performance in Ontario based on reported information including the WDO data call results.



Section 2: PERFORMANCE OF SINGLE AND DUAL STREAM RECYCLING PROGRAMS – RESEARCH AND STUDY FINDINGS

A scan has been completed of available studies comparing single and dual stream systems, along with data reported by municipalities that have examined changes to their existing programs and/or have reported on actual system costs. Wherever feasible, the focus has been on reports issued within the past ten years or so, representing the period in which single stream recycling programs have been on the rise. For example, a survey completed by R.W. Beck and released in 2005, indicated that access of the population in the U.S. to single stream collection programs had increased from 11% in 2000 to 27% as of 2005.¹ In 2008 alone, forty new single stream recycling programs were implemented across the U.S.²

Much of the information that is readily available comparing or reporting on dual and single stream programs, has reflected either local circumstances that can differ substantially from one area to the next and/or has reflected a particular focus or interest of the author, rather than providing a broader dialogue regarding the overall performance of both approaches (e.g. focusing just on collection efficiency, rather than total system costs). As a result, an attempt was made to broaden the research to the greatest extent possible to include system performance documented both inside and outside Ontario, and to identify the specific rationale supporting the findings regarding system performance.

The following sections discuss particular facets of single and dual stream recycling system performance. This is followed by discussion regarding a few case studies both inside and outside Ontario, that provide an indication of the overall findings when all facets of the systems are considered and discussion of the key factors that should be considered when making decisions regarding either recycling approach.

2.1 Collection

Various studies have indicated that single stream recycling offers potential for more efficient collection, and reduced collection costs as compared to dual stream collection. The extent of the potential savings ranges based on the collection approach that it is replacing, and depends on key decisions regarding the collection container and approach used (e.g. automated collection, co-collection, collection frequency etc.).

Generally, collection costs for single stream programs tend to be reduced through a combination of factors including automated collection, use of larger bins/carts, eliminating manual curbside sorting and use of single compartment compaction trucks. Some of these cost savings can also be obtained through modification of two stream programs such as consideration of automated collection, co-collection and use of larger recycling bins.

A summary of findings from various studies is presented below.

- In 2007, a presentation given by the Solid Waste Association of North America (SWANA) noted the collection savings from a single-stream system ranged from \$10 to \$20/per ton (\$9 to \$18 per tonne). These savings vary from municipality to municipality as variables such as population density and types of materials collected are considered, but the main cost savings are realized in reduced labor and transportation.³ A fully automated truck can be operated by only one worker, reducing labor costs. Injury insurance and compensation costs are also lowered, since the operator does not need to manually lift loads onto the truck. Single-Stream systems that use fully automated trucks generally have reduced time per stop, allowing for larger route sizing and more efficient use of the collection fleet.
- Examination of collection costs in another study conducted by Cascades/Metro in 2008 concluded that the savings from single stream collection as compared to dual stream could be much lower, with estimates ranging from \$0 to \$3 per tonne.⁴
- The Solid and Hazardous Waste Education Centre at the University of Wisconsin has reported that potential savings associated with single stream collection, can vary from 5 to 25%.⁵

¹ *AF&PA Community Survey*, R.W. Beck, 2005.

² *Resource Recycling*

³ *Understanding economic and environmental impacts of single-stream collection systems*, CRI (Container Recycling Institute), 2009.

⁴ *Metro Waste Paper Recovery Study*, Dan Lantz, 2008.

⁵ Solid and Hazardous Waste Education Centre, University of Wisconsin, United States Department of Agriculture and Wisconsin Counties Cooperating, 2005.



- The collection time per stop for dual stream recycling programs vary depending on: the number of containers collected at the curb, number of material types included in the program (which expand the volume of materials and often the need for multiple containers), contract requirements related to acceptable ‘contamination’ rates with non-recyclable material, collection truck configurations, householder compliance with set-out instructions, and choice of collection container (film plastic bag, blue box and size of blue box). Reported values for manual dual stream curbside collection can be in the order of 18 to 36 seconds per stop and for fully automated single stream collection can vary from 10 to 26 seconds per stop, considering just the activity of picking up, emptying and returning the recycling container.^{6 7}
- In dual stream or multi-sort programs, one truck compartment will ‘top-out’ prior to another. This is not an issue with single stream collection, and significant savings in transportation costs can result (depending on the configuration of the collection and transfer system) as the collection truck is no longer forced to leave the route and go to the processing facility to unload while at less than capacity.⁸ Depending on the system, the processing facility or transfer stations receiving material can be some distance from residential areas, making fuel usage even less efficient.

Many of the performance improvements associated with single stream systems can be attributed to automation rather than commingling recyclable materials. It has been documented that automation decreases injuries and improves collection efficiency along with other benefits, including⁹:

- An assessment of impacts on productivity undertaken by the US EPA, examining programs that switched from manual to semi or fully automated garbage collection, found significant increases in the percentage of households served per scheduled crew hour. This would be applicable to the switch from manual to semi or fully automated recycling collection.¹⁰
- The use of lidded carts can reduce potential litter and keep recyclable materials dry, reducing losses due to climactic conditions. The ability of lidded carts to prevent loss due to wind and impacts related to wet weather has been cited in some studies as part of the rationale for considering use of lidded carts.¹¹ Losses during processing can occur as a result of receipt of wet paper materials, which reduces the tendency of paper materials to behave as ‘flats’ and or ‘light’ material and rather to behave as ‘chunks’ or ‘heavy’ material. Wet paper can also shred easily, such that it may pass through material screens and wind up in the MRF residue stream or such that it can become a residue material in another paper grade.¹² Roll out carts have been identified as resulting in drier recyclables, which allows a star screen to effectively sort year-long with minimal adjustments associated with local climactic conditions.¹³
- Losses can also occur in the manufacturing process using recovered paper fibre as a result of excess moisture. Printed paper materials that are in a ‘wet condition’ do not lose the ink in the pulping process at the same rate as dry paper, due to development of microorganisms and chemical reactions between the paper fibres and the printing ink.¹⁴
- In regards to effects on litter, it is difficult to find any empirical studies indicating the impacts of the use of lidded carts for recyclables or garbage collection on litter. Anecdotally, some municipalities have noted a decrease in litter when lidded automated carts were used.¹⁵ A significant portion of residents (47 to 58%) participating in a recycling container pilot study in two municipalities within York Region in 2008 claimed they noted a reduction in recycling related litter during the pilot study.¹⁶
- However, losses can also result from the lack of ability to sort materials at the curb, associated with the use of automated carts. The collector cannot easily scan for and remove contaminants in the cart, in the fashion that they can from a blue box. Blue bags don’t facilitate removal of contaminants, but it is somewhat easier to visually screen

⁶ *To Single Stream or Not to Single Stream? Presentation by SWANA at US EPA Meeting, Philadelphia, PA, 2007*

⁷ *Recycling Collection Operations Review, CIF Project 176, Stantec Ltd. September, 2009.*

⁸ *CRI, 2009.*

⁹ Kinsella and Gertman. 2007. *Single Stream Best Practices Implementation Guide.*

¹⁰ *US EPA, Getting More for Less, Improving Collection Efficiency.*

¹¹ *Clark County, Recycling Feasibility Study, Green Solutions Team, April 2007.*

¹² *Resource Recycling, April 2006.*

¹³ *Resource Recycling, April 2006*

¹⁴ *Waste Paper Quality and Seasonal Impact on Deinking Process and Remedial Measures, Emami Paper Mills, July-Sept 2012*

¹⁵ *Benefits and Challenges Associated with Pay As You Throw and Automated Garbage Collection Programs, RW Beck, December 2007*

¹⁶ *A Joint Report on the Alternative Container Pilot Study, Summary of Findings, reported to York Regional Council Meeting, September 2008.*

and reject contaminated bags.¹⁷ Analysis of curbside collection data gathered from Ontario municipal recycling programs from 2007 and 2009 reveal a difference in average residue rate for dual stream MRFs of 7%, compared to single stream MRFs of 14%. This residue included both production losses (as discussed below under processing) and unsolicited contamination.¹⁸ A comprehensive study of incoming material streams at MRFs in the U.S.A. found that single stream programs had an increased level of rejects (unsolicited material) in the incoming material stream that was 2% higher than the materials received by two-stream MRFs.¹⁹

- The use of 96-gallon carts in automated systems allows residents to save more materials before setting the cart out at the curb for collection. Collecting more materials from fewer stops increases efficiency. The concept of a larger size container facilitating additional recycling can also be addressed through the use of larger blue boxes. The use of larger lidded containers has been cited as supporting increased capture of recyclable materials. Findings resulting from a 2002 study in St. Paul, Minnesota that compared various dual stream and single stream collection methods, found that the determining factor in increased resident participation and increase in materials set out at the curb, was the recycling container capacity not whether it was dual or single stream.²⁰
- A wider range of applicants (e.g. age, physical ability, etc.) may be suited as drivers of a fully-automated truck, since it does not require heavy lifting. Use of automated collection can also reduce lost-time claim costs associated with musculoskeletal impacts associated with collection workers, which is an ‘hot’ issue with the Ontario Ministry of Labour.²¹ A study completed in Rochester New York in 2006 compared physical stresses on collection workers before and after switching to semi-automatic collection. It found that approximately 4.5 percent fewer days were lost due to injury per employee in the year following semi-automated waste collection, and that Workers’ compensation costs were reduced by 52 percent over the same period.²² Transition to single stream collection and processing in Madison Wisconsin was associated with a 25% decrease in worker’s compensation costs when collection was automated.²³
- With both semi-automated and fully-automated collection, recycling carts can be larger and are usually on wheels, encouraging residents to separate more materials for recovery and making it easier for residents to get them to the curb.

Additional costs associated with a switch to automated single stream recycling collection include the costs for purchase and delivery of bins/carts, higher capital costs for automated trucks, and the costs of educating residents on how to use an automated collection system. Automated collection is not required for single stream programs, and there are numerous examples of single stream programs that use traditional blue boxes (e.g. Region of Halton, Region of Peel). Some of the additional costs associated with automated collection include:

- Investing in the purchase and delivery of automated carts. The cost to purchase and deliver costs can vary. For the recent roll out of automated carts across the City of Winnipeg, the cost per container was just under \$50/cart.²⁴ This can require a substantive up-front investment for many municipal programs, which for Winnipeg was estimated as in the order of \$9.35 million for roll-out across the City.²⁵
- The capital cost for the purchase of automated collection trucks suitable for single stream systems, tends to run from \$50,000 to \$100,000 higher than those used for manual collection. Depending on the amortization period and interest rate applied, the annual cost to service the debt to purchase trucks tends to run around 1/5 of the annual operating costs. Any program change requires promotion and education support. Depending on the extent of the changes (i.e. is recycling ‘new’ or are the changes adjustments to an existing system), comprehensive education campaigns tend to run around \$1 to \$2 per household to develop and deliver the ‘message’ about recycling. Given however, that continuous and frequent promotion and education is regarded as a best practice for recycling, this is not a cost unique to single or dual stream programs, but rather more the cost of doing business.²⁶

¹⁷ *A Joint Report on the Alternative Container Pilot Study, Summary of Findings, reported to York Regional Council Meeting, September 2008.*

¹⁸ *Resource Recycling, April 2011*

¹⁹ *Pennsylvania Recovered Material Study, RW Beck, February 2005.*

²⁰ *Resource Recycling, November 2002*

²¹ *Bluewater Recycling Association, 2011 Annual Report.*

²² *US EPA, Getting More for Less, Improving Collection Efficiency,*

²³ *EPA, RCC Web Academy Presentation, Study for Waste Management Inc. by Columbia University.*

²⁴ *Personal Communication, D. Drohmerski, City of Winnipeg, August 2011.*

²⁵ *City of Winnipeg, Comprehensive Integrated Waste Management Plan, Stantec, September 2011.*

²⁶ *Blue Box Program Enhancement and Best Practices Assessment Report, KPMG, RW Beck, July 31, 2007.*



2.2 Processing

It is generally accepted and demonstrated that the capital and operating costs for single stream processing are higher than those incurred for processing dual stream materials. It requires more effort to separate co-mingled paper and container materials. Greater capital investment is required for the equipment used at the front end of the plant, to separate the paper fibre materials from the container (glass, metals, plastic) stream and for the mechanical and optical sorters and other equipment required to separate materials on the processing lines. Higher operational costs are incurred to run this equipment and for additional labour required to facilitate separation of materials. Single stream processing is associated with higher production loss, with loss of containers to the paper fibre stream and vice versa, which can affect revenues. While research indicates that single stream processing continues to require greater investment and has a higher per tonne cost to generate material of the same market value as dual stream processing, the design and equipment used for single stream processing continues to improve which is reducing past problems with production loss. As noted in a relatively recent study undertaken on best practices in single stream recycling, single stream programs were introduced by collection companies where the efficiencies and cost savings are concentrated. Processors are still working to determine the best approach to take apart the mix of materials that single stream collection puts together.²⁷ Several single stream programs in Ontario have implemented modifications to recover aluminum and paper fibre lost to the residue stream during processing.²⁸

In some respects, it is difficult to disassociate the level of effort for processing single stream materials from the effect of material compaction during collection, which may happen in both single and dual stream programs. Some of the studies on single stream processing, have cited compaction as a significant contributor to impaired performance.

The following summarizes some of the more recent research regarding processing efficiencies and costs.

- Single stream processing facilities have been found to have increased internal costs because poorly sorted materials demand new and upgraded feedstock cleaning systems, increased maintenance, and more frequent equipment repair and replacement.²⁹ The reported or calculated ranges in operating costs vary, but in most cases studies have found when single and dual stream systems were compared, that the operating costs for single stream facilities were reported or calculated as being higher than for dual stream facilities of a similar size, processing materials from a similar population. As noted in Section 3, the gross processing cost per tonne marketed for large Ontario blue box programs reported from 2008 to 2010, indicate that the cost of dual stream processing is in the order of 14 to 15% lower than the cost of single stream processing. A study undertaken for Waukesha County found that the range of operating costs for a dual stream MRF would run from \$43 to \$32 per ton (processing from 25,000 to 66,000 tons per year), and for a single stream MRF would run between \$44 and \$37 per ton (processing from 31,000 to 76,000 tons per year).³⁰
- However, there have been some cost analyses that have determined that the annual operating cost for single stream facilities (including amortized capital) could be lower for a single stream facility operating at the same throughput as a dual stream facility. The study undertaken of the blue box system optimization in Ontario by Resource Recycling estimated that for a Greenfield facility with an operating throughput of 14 tonnes per hour, operating on a dual shift (and not accounting for the cost of managing EPS, film plastic and plastic laminates) would be in the order of \$107/tonne for single stream and \$116/tonne for dual stream.³¹
- Inefficiencies related to single-stream versus dual-stream or curbside sorting are in-part related to the lost revenue associated with recyclables ending up in the wrong separated stream (containers in the fiber stream, and fiber in the container stream). It has been suggested that the efficiency of a typical single-stream processing line is about 85% meaning that roughly 15% of the container stream sent to market has unwanted fibers, and roughly 15% of the fiber stream has unwanted containers.³² Plastic manufacturers estimate that in one year alone, in the order of 39 million pounds of plastic may be inadvertently included in the recovered paper sent to paper mills, increasing the costs incurred by the paper mills in order to remove and dispose of the plastic and decreasing the plastic resin available to the market.³³ A 2009 study of MRFs in the UK indicated that the material quality for single stream MRFs was similar to that of dual stream MRFs for commodities such as ferrous metal and aluminum, however, material quality

²⁷ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

²⁸ *Resource Recycling*, April 2011

²⁹ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

³⁰ *Waukesha County Recycling System and Capacity Study*, RRT, GBB. September 2007.

³¹ *A Study of Optimization of the Blue Box Material Processing System in Ontario, Cost Modeling*, Resource Recycling Systems, June 2012.

³² Resource Recycling, December 2008.

³³ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

for paper and card (boxboard) tended to be worse for card and mixed paper coming out of single stream MRFs but better for newsprint. In regards to plastic, the dual stream MRFs had a much higher percent of the targeted plastic stream (PET, HDPE etc.) than the single stream MRF which had a higher degree of contamination.³⁴

- Single stream processing facilities tend to incur higher annual disposal costs as a result of higher residue rates. Reported residue rates range widely from in the order of 2 to 4% for dual stream programs, while those for single stream systems can range from 3 to 10%, with higher residue rates being reported by some programs.^{35,36} Other sources have reported residue rates for single stream systems in the range of 14.2 to 27.2% with the highest rates representing programs where the majority of mixed broken glass is included in the MRF residues.³⁷ As noted in Section 3, the reported average residue rates for large municipal recycling programs in Ontario, indicate that dual stream MRF residues are in the order of ½ that (6.91%) of single stream MRFs (14.41%).
- MRF residues reported for single stream and dual stream MRFs consist of both unsolicited materials that are not permitted in the program and lost recyclables that were not recovered through processing. Study results vary in regards to reporting of recyclable material loss to the residue stream for single and dual stream MRFs. One UK study undertaken by WRAP of 18 operating MRFs in 2009 indicated that the single stream MRFs had a higher percent of paper and card (boxboard) in the MRF residual stream, while the dual stream MRFs surveyed, had a higher percentage of plastic bottles and cans.³⁸ Reasons cited for the residual stream including input stream contamination which was found to be moderately lower for dual stream programs, and differences in processing approach. The authors of this study however, cautioned that a range of factors contribute to material quantity that cannot be accounted for in the same analysis, and also noted concern with the size of the dataset.
- The residue rates for four MRFs in the Minneapolis Minnesota area were reported as ranging from 2 to 17% of total throughput, largely it appears based on the design of the facility and method of collection (with or without compaction) as it relates to glass breakage, and less related to whether dual or single stream materials were being processed.³⁹ Glass is reported as a problematic material that reduces the life of MRF equipment and equipment at the mills and processing facilities to which recyclable material is marketed.⁴⁰ The trend for glass processing is to facilitate removal earlier in the process, through use of glass breakers. Preliminary data suggests that this can save up to 10 percent of the projected wear on conveyor belts and balers. This generally results in marketing of a mixed broken glass stream to glass reprocessors that clean this stream to generate marketable products.⁴¹
- Glass is not the only problematic material managed at recycling facilities. While glass is often cited as the number one issue for both single stream and dual stream MRFs, shredded paper and non-recyclable plastics also contribute to decreased processing efficiency and processing residues.⁴²
- The Solid and Hazardous Waste Education Centre at the University of Wisconsin has reported that additional costs associated with single stream processing, can be in the order of 10%.⁴³
- Separation and sorting equipment is available that can be very effective at mechanically sorting fibres from containers, fibres from fibres and containers from containers, with efficiency ratings that run from 80 to 95%, depending on the equipment, material mix and targeted material streams. Optical sorting equipment is available that report achieving purity rates (cleanliness of the ejected material) is the range of 90 to 98% for plastic, 70% for paper and 95 to 98% for glass.⁴⁴
- Berenyi (2008) compared the capital costs of different MRF designs, based on data collected through an annual survey of U.S. MRFs. The average capital cost was determined to be in the order of \$7.55 million for single stream MRFs, and \$4.9 million for dual-stream facilities.⁴⁵ Other studies indicate similar differences in MRF capital costs, with single stream capital costs being estimated or reported as higher than dual stream capital costs. A study

³⁴ WRAP, *MRF Quality Assessment Study*, *Enviros*, 2009.

³⁵ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

³⁶ *Waste Monitoring Program, 2006 MRF Assessment (King County)*, Cascadia, WIH Resource Group, November 2006.

³⁷ *Solid and Hazardous Waste Education Centre, University of Wisconsin, United States Department of Agriculture and Wisconsin Counties Cooperating*, 2005.

³⁸ WRAP, *MRF Quality Assessment Study*, *Enviros*, 2009

³⁹ *Single-stream and Dual-stream Recycling, Comparative Impacts of Comingled Recyclables Processing*, Minnesota Pollution Control Agency, Tim Goodman & Associates, 2006.

⁴⁰ *Waste Monitoring Program, 2006 MRF Assessment (King County)*, Cascadia, WIH Resource Group, November 2006.

⁴¹ *Resource Recycling*, November 2011

⁴² *Waste Monitoring Program, 2006 MRF Assessment (King County)*, Cascadia, WIH Resource Group, November 2006.

⁴³ *Solid and Hazardous Waste Education Centre, University of Wisconsin, United States Department of Agriculture and Wisconsin Counties Cooperating*, 2005.

⁴⁴ *Single-stream and Dual-stream Recycling, Comparative Impacts of Comingled Recyclables Processing*, Minnesota Pollution Control Agency, Tim Goodman & Associates, 2006.

⁴⁵ *Escambia County, Single Stream Report*, SCS Engineers, 2008.



undertaken for Waukesha County indicated that the capital cost of developing a new Greenfield single stream MRF capable of processing up to 80,000 tons/year were in the range of \$8.25 million (2007\$ USD), while the capital cost for a similar scale of dual stream MRF were in the order of \$7.75 million (2007\$ USD).⁴⁶ The cost modeling recently completed for the WDO, indicates that for the same design throughput (14tph) the capital investment for a dual stream MRF would be in the order of \$8.7 million compared to \$9.4 million for single stream. Caution should be used in comparing and estimating capital costs, as different assumptions may be made regarding the ways in which problematic materials are managed and certain costs (e.g. land purchase) may not be included in all cost estimates. Furthermore, under DBO or DBOM project delivery scenarios, municipalities may include specifications specific to their needs that may fall outside those included by the private sector in their facility designs (e.g. architectural elements, education centres). It is not the actual reported or projected capital investment that should be taken away from most studies, just the understanding of the relationship between the capital costs for both processing facility options.

2.3 End-Markets and Material Quality

As single stream recycling programs have become more prevalent, end markets have expressed concern regarding the quality of recovered material streams from these programs. It is often assumed that the commodities recovered from single stream programs are of lower quality than those recovered from dual sort systems and that this results in decreased value and/or difficulties in finding end-markets. Reported results from recent studies regarding end market quality are noted below:

- One study estimated that for paper pulpers, single-stream material has eight times the yield loss of curbside-sorted material. Plastics processors report material from single-stream MRFs has a yield rate of about 68 percent to 70 percent, compared to dual-stream systems that usually yield about 75 percent to 78 percent⁴⁷.
- Interviews conducted with end markets associated with recycling materials recovered in the Minnesota and the Upper Midwest in 2006, indicated that 70% of the end-markets were seeing more contamination in their recycled feedstock compared to 2000/2001. The most noticeable and problematic contaminants were plastic bags/film, glass and unacceptable paper grades (paper mills), glass and metal (plastic recyclers) and ceramics/mixed glass (glass manufacturer). Most of the mills and all of the plastic recyclers cited single stream recycling as a contributing factor to the decline in quality. However, over 85% of the end-markets interviewed stated that making blanket statements regarding feedstock quality coming from single-stream and dual-stream MRFs is inaccurate. Both have the ability to provide exceptionally clean or dirty loads of material. The factors cited for increased contamination also included completing with lower standards for export markets, reductions in public education efforts, MRF emphasis on quantity over quality, transient MRF workforces, and weather conditions.⁴⁸
- Glass breakage and co-mingling/cross contamination with other materials is a commonly reported issue for single stream programs. A recent study indicated that only about 40 percent (a range of 20 percent to 60 percent) of glass recovered from single stream programs is of suitable quality to be recycled into containers and fiberglass. In contrast, performance of dual-stream systems indicate that in the order of 90 percent of the glass collected is of suitable quality to be recycled⁴⁹.
- In 2005 the impacts of residuals on a NORPAC paper mill in Longview, Washington were examined. Prior to 2001, all of the mill's incoming feedstock came from 100% source-separated programs. The mill's yield loss was only 1% and the mill purchased an extra 2,500 tons of fiber to replace the rejects. However, between 2003 and 2005, the study reported a dramatic change to the mill's input finding that roughly 42% of incoming secondary newsprint came from commingled (single or dual stream) programs. The yield loss at the pulper increased to 9%, and the need for replacement fiber increased to 20,000 tons. At the same time, the mill's annual cost base for replacement fiber and disposal of residues increased to \$2 million a year.⁵⁰
- The quality of the marketed recyclable stream produced by a MRF, whether single or dual stream is often a function of the commodity market that is available. Prior to the economic downturn of 2008, many Asian countries that purchased recyclable materials were not concerned with the quality of the materials because cheap available labor allowed cost effective final sorting. However, after 2008, markets demanded higher quality feedstock squeezing out


⁴⁶ *Waukesha County Recycling System and Capacity Study, RRT, GBB. September 2007.*

⁴⁷ *Single Stream Uncovered, Clarissa Morawski, February 2010.*

⁴⁸ *Single-stream and Dual-stream Recycling, Comparative Impacts of Comingled Recyclables Processing, Minnesota Pollution Control Agency, Tim Goodman & Associates, 2006.*

⁴⁹ *Single Stream Uncovered, Clarissa Morawski, February 2010.*

⁵⁰ CRI, 2009.



many suppliers⁵¹. The MRF quality assessment study undertaken for WRAP in the UK in 2008/2009 concluded that there was significant variability in the quality of the same outputs between the single stream and dual stream MRFs studied, based due to local operational and economic factors, including the available markets.⁵²

- Poor incoming material quality has implications for the market, as the facilities accepting materials often incur increased costs from land filling unusable materials included in the bales bought to make recycled products⁵³.
- The Solid and Hazardous Waste Education Centre at the University of Wisconsin has reported that potential additional costs to paper mills associated with processing single stream materials can be in the order of 8%.⁵⁴
- There are some divergent views of the ability of MRFs to generate product that meets market specifications between MRF operators and material reprocessors. A UK study regarding MRF Output quality thresholds applicable to both single and dual stream facilities found that most facility operators claimed that their material “always” or “usually” met material quality standards that were set by the end market. However, the majority of reprocessors stated that MRF output only “sometimes” met their standards.⁵⁵
- In general, it was difficult to find any studies that undertook a comprehensive assessment of the effects on material markets and market value of recyclable commodities when comparing the outputs of single stream and dual stream systems. Minimal information was available to document the differences in the levels of contamination and potential market value, when comparing state-of-the-art systems for processing single or dual stream materials. Comparison of the reported revenue streams for recyclable commodities for the largest Ontario recycling programs (see section 3 below), indicates that the average revenues per tonne reported for single stream programs were higher for some recyclable streams and were lower for others. There is minimal evidence in Ontario of lower market values for the full range of recyclable commodities generated by large single stream programs compared to dual stream programs.

2.4 Program Participation and Diversion Rates

Varying opinions have been expressed regarding the performance of dual and single stream programs in regards to program participation and diversion rates. The simplicity of single stream programs is perceived to encourage greater participation and capture of recyclable materials; however, that very simplicity is also implicated in some of the higher reported residue rates as there is some indication that the householder may err on the side of placing all plastics for example, regardless of recyclability, in their single stream container. Both dual stream and single stream programs report poor to excellent recovery rates, with the ranges reflecting the material types included in the program, the frequency and quality of promotion and education programs, and whether incentive/disincentive programs are in effect. Implications regarding diversion rates also vary. Increases in the amount of material per household that is captured at the point of collection do not necessarily result in higher quantities being marketed if the processing facility cannot effectively separate the materials into marketable streams.

It is very difficult to separate the effect of implementing single stream recycling on program participation and diversion rates, from other factors that also improve participation and material capture rates such as increased promotion, container limits or other disincentives for garbage (user pay, bi-weekly collection). Examining performance in large Ontario programs (serving over 150,000 single family households) indicates a range of program performance within both the dual and single stream programs. From 2008 to 2010, dual stream programs reported kg per household of materials marketed that ranged from 162 kg/hhd for the program with the poorest performance to 228 kg/hhd for the program with the best performance, a 40% difference that could be ascribed to the differences between these communities as it relates to a combination of promotion, differences in recycling container types and implementation of bi-weekly garbage collection and restrictions on garbage volume in the best performing program. In that same period, the range in reported performance for single stream programs varied just as widely and within the same overall range. Reported program performance ranged over those three years from an average in one community of 164 kg/hhd to a high of 253 kg/hhd, a 50% difference in performance which does not correlate to disincentives for garbage collection as each program had both volume restrictions and bi-weekly garbage collection in effect. There is only one large single stream program without bi-weekly garbage collection in effect, and that program markets around 10% less material on average per household than the best performing program.

⁵¹ Morawski, 2010

⁵² WRAP, *MRF Quality Assessment Study*, *Enviros*, 2009.

⁵³ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

⁵⁴ *Single Stream Recycling*, SHWEC = UW Extension

⁵⁵ WRAP, *MRF Output Material Quality Thresholds*, *Resource Futures* November 2009



The assessment of performance is also complicated by the lack of consistent terminology used in reporting. Some jurisdictions report on the increase of materials collected at the curb, others report on changes in the quantities of specific recyclables captured and marketed for recycling which takes into account the loss of materials to the processing residue streams but not the actual amount of material processed into new products by the manufacturer.

A summary of findings in a number of recent studies is provided below:

- A study published by Resource Recycling in 2008, reviewed program performance and recovery rates in seven large Ontario municipalities. For the three municipalities that employed single-stream recycling it was found that the quantity of recyclables recovered (i.e. tonnes sent to market) increased by an average of seven percent, per household, between 2003 and 2007. Over the same period, the four municipalities that employed dual stream programs also increased their recovery rates by an average of seven percent⁵⁶. The range in values reported by each municipality appeared generally unrelated to whether the programs were single or dual stream. For the single stream programs, two of the three experienced a reduction in recovery rates over the period from 2003 to 2007, while the third experienced a 46.6% increase that appeared to be associated with the transition to bi-weekly garbage collection. For the four dual stream programs, the change in recovery rates from 2003 to 2007 ranged from a decrease of 14.2% to an increase of 56.2%.
- The Solid and Hazardous Waste Education Centre in Wisconsin notes that single stream is often considered “simplified recycling” as all recyclable materials are collected in one container, making collection easy and convenient for participants. This typically increases the number of participants, tonnage collected, and material diverted from landfills⁵⁷.
- The Kinsella and Gertman Best Practices Guide, reports that single-stream recycling in most cases results in increased participation by residents as recycling is perceived as being easier if people do not have to “think” about sorting before they recycle.⁵⁸ Using this same theory, it was concluded that single-stream recycling also increased participation by small businesses and multi-family apartment complexes. It was noted that accommodating multiple bins for sorted recyclables is a challenge in areas with high density or space constraints, especially in older downtown buildings or congested neighborhoods. Single stream reduces collection to one container and consolidates what previously may have been small amounts in each of several bins.
- These findings would also be applicable to other areas with space constraints and requirements to haul larger volumes of material off-site, such as rural depots and services to condominium developments. Of particular interest is the concept that single stream recycling could prove beneficial to programs with rural depots, as cross-contamination of container and paper fibre material streams is common with the unstaffed depots that are used by many programs and as co-mingling may allow for some efficiencies in haul costs through consolidation of loads, assuming that the program has access to single stream processing capacity. The Quinte Waste Solutions, evaluation of best practices for rural recycling depot programs found that compacting and comingling materials in rural recycling depots, reduced the frequency of collection from the depot site and increased the potential for the municipality to haul materials a greater distance for processing at a lower cost.⁵⁹ Programs elsewhere in Canada (e.g. Abbotsford B.C.) operate single stream depots.
- Single stream recycling appears to offer more benefits to communities with a higher concentration of multi-family households. There is a general trend in Ontario to increased population density and a shift in housing such that in many municipalities the projected proportion of multi-family to single family housing is expected to increase. Single stream programs are generally found to be simple and convenient, and residents are more likely to participate in a recycling program if it is more convenient.⁶⁰ The higher turnover rate in multi-family residential dwellings makes it difficult to get out a common message, as people move into the area from other municipalities where the waste management system may not be the same. Also, as multi-residential dwellers often have to go outside to the rollout carts for recyclables, single-stream makes it more convenient as no sorting is required in the cold (or wet). The City of Ottawa service level review determined that moving from the current dual stream system to a single stream would likely increase recyclable capture rates by 10% for Single-Family Households, but potentially even higher for Multi-Family households⁶¹.

⁵⁶ Mixed Results. Resource Recycling. Daniel Lantz, December 2008.

⁵⁷ Solid and Hazardous Waste Education Centre, University of Wisconsin, United States Department of Agriculture and Wisconsin Counties Cooperating, 2005.

⁵⁸ *Single Stream Recycling Best Practices Implementation Guide*, Kinsella and Gertman, 2007.

⁵⁹ *Evaluation of Best Practices for Rural Recycling Depot Programs*, SGS Lakefield Research Ltd. April 2006.

⁶⁰ Container Recycling Institute. 2009. Understanding the Economic and Environmental Impacts of Single-Stream Collection Systems.

⁶¹ City of Ottawa Service Level Review. Prepared by Stantec Consulting, 2011, p. 70.

2.5 Integrated Recycling Systems – General Findings

There are methods to improve the efficiencies of both single and dual stream programs, and neither appears to hold a general advantage when the local context is not taken into consideration. There are challenges for both approaches in regards to recovering materials for market, whether that challenge is experienced at the curb or at the processing plant. When the local context and existing system performance is taken into consideration some municipalities have chosen to shift to single stream programs, whereas others have chosen to implement other best practices in order to improve system performance.

Some case studies are presented below, that examine the system costs and implications considered by both large and small municipal jurisdictions in the U.S. and Canada that have considered or chosen to adjust their recycling systems. Each of these case studies compared the benefits of dual and single stream recycling, considering their existing baseline recycling system and the local context.

2.5.1 Case Study #1 – Madison, Wisconsin

A cost-benefit analysis was completed in 2006 by researchers with the University of Wisconsin and Colorado State University, to compare the potential performance of the previous dual stream system and new single stream system implemented in 2005 in Madison, Wisconsin.⁶² The cost savings identified in this study were largely associated with collection, with cost increases associated with the processing of materials. The tonnage of recyclables collected was expected to increase, and some additional savings were factored in to reflect the reduction of the tonnes of garbage landfilled. As highlighted in Table 1, assessing overall system costs, it was determined that generally if the municipality switched to single stream automated collection the net annual municipal cost per household would increase. However, this increase would be more than offset by potential savings per household associated with avoiding purchase of recycling bags that had been previously used in that community for dual stream collection.

The authors also considered the potential ‘downstream’ effect on the markets for recyclables, factoring in an additional cost of \$8 per ton for manufacturers, which was the equivalent of \$1.88 per HHD. With this factored in, the single stream program would exhibit a ‘net loss’ compared to dual stream collection.

2006 was the first full year of implementation of the single stream program. The City of Madison has reported cost savings of over \$1 million annually and an increase in overall recycling by 25% from 2005 levels.⁶³

Table 1: Madison Wisconsin: Recycling System Cost Comparison

<i>Category</i>	<i>Current System Manual Dual Stream</i>	<i>Proposed System Automated Single Stream</i>
Wages and Benefits	\$600,744	\$529,344
Worker's Compensation	\$88,000	\$61,600
Time Lost	\$85,821	\$60,074
Equipment Debt Service	\$341,712	\$292,287
Equipment Maintenance	\$478,656	\$430,764
Cart Debt Service	\$0	\$305,784
Net MRF Revenue	(\$20,164)	\$0
Net MRF Cost	\$0	\$108,905
Tip Fee Savings	\$0	(\$62,048)
Total Annual Cost	\$1,574,769	\$1,726,710
Annual Cost Per Household	\$25.52	\$27.98
Recycling Bag Cost Per Household	\$3.40	\$0
Net Annual Cost Per Household	\$28.92	\$27.98

⁶² Eric Jemelske and Gorm Kipperberg. 2006. A contingent valuation study and Benefit-cost analysis of the switch to automated collection of solid waste with single stream recycling in Madison, Wisconsin. Public Works Management and Policy, 11, 2, 89-103.

⁶³ SWANA Recycling Technical Assistance Study: Feasibility of Implementing a Single Stream Recycling Program. Gannett Fleming Inc, 2010.



2.5.2 Case Study #2 – Cheltenham Township

A SWANA Recycling Technical Assistance Study was undertaken in 2010 for Cheltenham Township (population around 37,000) in Pennsylvania, which currently employs a public sector dual stream collection system recovering in the order of 2,700 tons/year at a 21% curbside recycling rate. The current material streams include a limited container stream (#1 and #2 plastic bottles, glass, steel and aluminum cans) and paper fibre. This study determined that although their current dual-stream program is successful and operates effectively (e.g. public forces collect from between 800 and 1,100 households per route), its potential to maximize recovery of Township-generated recyclables is limited by the current collection format, collection equipment and the curbside containers.

The study found some key areas for improvement that could be addressed through a transition to single stream recycling:⁶⁴

- The current side-loading recyclers do not maximize collection efficiency. The side-loading recyclers collect 5 to 6 tons of recyclables, while a 25-cubic yard single-stream packer can collect 10 tons per load.
- The inability of the current side-loading recyclers to accept larger pieces of cardboard leads to disposal of this valued recyclable commodity.
- The 14-gallon recycling bins used by the program did not have sufficient capacity for recyclables generated by the average home. Small recycling containers are inconvenient and proven to discourage recycling. Many residents must use multiple containers which is inconvenient, but also slows the time per stop during collection.
- Worker injuries associated with the existing curbside trash and recycling collection program are excessive (worker compensation claims in 2008 exceeded \$375,000).

The study found that total system costs were expected to be reduced through switching to a Single Stream program as:

- Increased collection and routing efficiency could be realized through the proposed 25-cubic-yard recyclable packer that will dramatically reduce the total number of trips to the recyclables transfer station each year and overall operational costs;
- Improved collection efficiency could be realized by collecting more recyclable material (weight) per collection stop;
- Reduction in waste disposal and associated tip fees, saving \$30,000 to \$50,000 annually
- A 20 to 30% increase in curbside diversion was estimated, based on the experience of a local hauler/processor, and review of performance of the City of Madison and the City of Philadelphia;
- An increase in total income from recyclables recovered and marketed can be achieved through additional diversion (at current commodity rates); and,
- Improved safety and reduced worker compensation claims.

2.5.3 Case Study #3 City of Hamilton

In 2010/2011 Stantec Consulting completed a Service Level Review of the City of Hamilton's collection system.⁶⁵ The intent of the review was to examine options for curbside collection of garbage, organics and recyclables that could improve overall waste management system performance, and to narrow the focus of their most recent collection RFP process to those options that could offer the most benefit to the City. The Service Level Review offered an opportunity to revisit the recycling program, to determine if the current dual stream system should be continued or if procurement for collection and processing services beginning in 2013 should seek submissions for a single stream system.

Various integrated collection systems were modeled and compared to the status quo collection system (weekly co-collection of garbage and organics, weekly collection of dual stream recyclables).

Processing cost estimates were based on a review of the City's existing costs and municipal costs for two stream and single stream processes, including both operational costs and capital upgrades/costs. The existing dual stream MRF equipment was found to have a remaining useful life of between 5 and 10 years, and was found to be functioning at around 60% capacity. Review of MRF operations indicated that some upgrades to the front end of the container and fibre lines, could improve the

⁶⁴ SWANA Recycling Technical Assistance Study: Feasibility of Implementing a Single Stream Recycling Program. Gannett Fleming Inc, 2010.

⁶⁵ City of Hamilton, Public Works Committee, Report PW11030, April 2011.

recovery of higher value commodities. Single stream recycling offered an alternative approach, and was found to offer greater opportunity to market capacity to other municipalities. The Service Level Review recommended that should the City issue an RFP for processing, bidders could be invited to price both single and dual stream processing, with and without capital improvements. The outcome of the Service Level Review indicated that three (3) options could offer increased collection efficiencies and cost effectiveness. One option involved single stream recycling and two involved continuation of the existing dual stream program. The top ranked single stream scenario ranked behind the best two stream recycling scenarios following evaluation. The single stream approach however, ranked better in regards to collection costs and diversion potential. Table 2 summarizes the outcome of evaluation of the short-listed systems, specific to recycling collection and processing.

Table 2 Hamilton Service Level Review - Summary of Evaluation of Short-Listed Systems (Specific to Recycling)

	System 1: Bi-weekly garbage, Weekly Single Stream and Green Cart Co-collection, Bi-weekly seasonal collection of Leaf and Yard	System 2: Bi-weekly Garbage, Weekly Dual Stream recycling collection, Weekly co-collection of Green Cart and Leaf and Yard	System 3 (Status Quo): Weekly Co-collection of Garbage and Green Cart, Weekly Dual Stream Recycling collection, Bi-weekly seasonal collection of Leaf and Yard
Public Acceptability	Was found more likely to be convenient to residents, particularly residents of multi-family unit dwellings	-	-
Potential Effects on Diversion	Would contribute to increase in diversion of recyclables (estimated 14% increase in curbside capture rates). Estimated 5,300 tpy of additional recyclables	Some potential (lower) for increased diversion of recyclables (estimated 7% increase in curbside capture rates associated with bi-weekly collection alone). Estimated 2,600 tpy of additional recyclables	No potential for increased diversion of recyclables
Effect on Collection Costs	Smallest overall fleet (53 to 58 trucks), annual collection cost (all materials) of \$20 to \$21.2 million	Smaller fleet (69 to 76 trucks), annual collection cost (all materials) of \$25 to \$26.5 million	Largest fleet (73 to 80 trucks), annual cost collection cost (all materials) of \$26.2 to \$27.8 million
Effect on Recycling Processing	Largest investment in capital. \$18.2 million for new MRF. Estimated annual operating cost of \$74/tonne (based on 2008 RFP process). Estimated revenue of \$110 per tonne (3% lower than dual stream)	Minimal investment in new MRF Capital. Estimated annual operating cost of \$50.2/tonne (based on current contract prices). Estimated revenue of \$113/tonne.	Minimal investment in new MRF Capital. Estimated annual operating cost of \$49.7/tonne (based on current contract prices). Estimated revenue of \$113/tonne.
Net System Financial Implications	Net annual cost of \$20.6 to \$21.8 million	Net annual cost of \$22 to \$24 million	Net annual cost of \$23.7 to \$25.3 million
Environmental Impacts	Highest potential to reduce direct air emissions based on smallest fleet. Highest	Some potential to reduce direct air emissions based on smaller fleet. Some potential	Highest potential for direct air emissions based on largest fleet. No potential to



	potential to decrease indirect GHG emissions related in increased diversion.	to decrease indirect GHG emissions related in increased diversion.	decrease indirect GHG emissions as no projected increase in diversion.
Implementation Requirements	<p>Could accommodate regional MRF concept. May have required extension in current processing contracts to allow for new capacity to be developed. Less flexible to changes in WDA as requires capital investment.</p> <p>System cost estimates did not include the purchase and delivery of automated recycling carts. It was estimated that the purchase and delivery of carts could cost in the order of \$50/unit, or \$8 to \$9 million for city-wide roll out.</p>	<p>Unlikely to accommodate regional MRF concept. No requirement to extend current processing contracts to allow for new capacity to be developed. Somewhat flexible to changes in WDA.</p>	<p>Unlikely to accommodate regional MRF concept. No requirement to extend current processing contracts to allow for new capacity to be developed. Somewhat flexible to changes in WDA.</p>

Hamilton Committee and Council requested more information when considering the results and recommendations of the service level review. Additional reports were prepared to respond to these information requests including a report (PW11030a) which discussed the outcome of the current MRF assessment and further refinement of processing costs. The option for single stream recycling was not carried forward in the short-term. While it offered the potential to lower collection costs, it was found to require a higher capital investment of \$20 million, as compared to \$5 million in capital costs to invest in improvements to the current dual stream processing facility.⁶⁶

City Council directed staff to enter into negotiations with Canada Fibres Ltd. to extend the current dual stream recycling contract. Following these negotiations, City Council approved the extension of the current contract for seven years, with no net increase to the operating budget for recycling. This included the installation and operation of new front end equipment for the container line at a cost of \$1.91 million, to improve the capture of various container streams from the facility.⁶⁷ In regards to collection, City Council awarded the new collection contract to GFL, including city-wide weekly dual stream collection services. A break-out of the new contract costs from the total collection services package approved by Council, is not publicly available.

2.5.4 Case Study #4 County of Simcoe

The County of Simcoe retained Stantec in 2009 to develop a Solid Waste Management Strategy (SWMS)⁶⁸. The purpose of the SWMS was to assist the County in establishing a long-term approach to manage the municipal waste stream. Located in South-Central Ontario and comprised of 16 municipalities. Simcoe County is home to roughly 123,000 households and a population of 322,120. As a part of the SWMS the current system was reviewed and was determined there are several key areas that reflect ‘problems’ with the current solid waste management system.

The problems related to recycling included:

⁶⁶ City of Hamilton, Public Works Committee, Report PW11030a, June 2011.

⁶⁷ City of Hamilton, Public Works Committee, Report PW11030b), November 2011.

⁶⁸ County of Simcoe, Solid Waste Management Strategy. Stantec, June 2012.

- Lack of secure long-term processing capacity for recyclable materials. As of 2009, the County was contracting combined collection and processing services for the majority of the municipalities within the County, and processing capacity was only secured for the term of each collection contract.
- Need for improvements to the effectiveness and efficiency of the County’s overall waste diversion system, in order to sustain diversion performance. The County consistently reports higher net costs per household and per tonne for their blue box program.

Both short and long term recycling approaches and technologies were identified during the Simcoe County SWMS. The Strategy considered the options of processing recyclables within and outside the County in the short and long-term, the feasibility of including additional recycling streams and the potential for a move to single-stream recycling. Implications related to transfer requirements for recyclables were also reviewed. Although the review determined that the construction of a new MRF was more advantageous than exporting recyclable materials, it was recommended that for the short-term (the next 5 or 6 years) the County should focus on export of recyclables to an out of County MRF for the recyclables generated in the East, West and South Simcoe contract areas. This mitigates the immediate risk and need for immediate capital investment as there is significant uncertainty in regards to how the Blue Box Program Plan (BBPP) will evolve over the next five years, and uncertainty related to negotiations regarding a larger MRF.

Implications regarding MRF processing capacity were examined. Five of the MRFs canvassed during the Study were able to process single stream recyclables, while three processed dual stream recyclables. It was noted that a single stream MRF is also capable of processing recyclables collected in two-streams (fibre and containers). The form of processing will also impact how recyclables would be transferred to these MRFs, with additional resources (i.e., multiple bays) being required to transfer dual stream materials.

The potential for a shift to single stream recycling in the short-term, if export capacity for this approach was available, also considered the following:

- As long as the County continues to collect recyclables curbside using a two box system (i.e., not using carts or bags), recyclables could be sent to a single stream MRF out of County for processing in the short term. If required, the County could then easily “move back” to a dual stream system in the longer term without requiring the residents to make any changes to their behaviour; and,
- Supporting a single stream processing option at the North Simcoe MRF would be very difficult, and thus in the short-term all of the materials from North Simcoe would have to be exported.

A collection model was developed, and various collection approaches (including single stream recycling) were compared. The outcome of the review identified that there was no definitive benefit in regards to collection costs if the County were to move from its current dual stream recycling program to single stream recycling. A decision to ship recyclables to an out of County single stream MRF in the short-term should be made primarily on the associated net processing costs. A stable contract with an out of County MRF should lead to reduced net recycling costs compared to the current system. While the focus in the Strategy was export of recyclables in the short-term, the SWMS noted it was possible that stable longer term options may be available and could potentially pose a reasonable option for the longer term processing of the County’s recyclables.

Table 3 provides a summary of the implications of the recommended approach for processing recyclables in the short-term.

Table 3 Short-Term: Processing Recyclables Outside of Simcoe County

Table 3 Short-Term: Processing Recyclables Outside of Simcoe County	
Short-term or Long-term Option	<ul style="list-style-type: none"> • Implement in short-term • May sustain this arrangement over the long-term if stable long-term arrangements are available and if it appears unreasonable for the County to develop its own MRF.
Interaction with other System Components	<ul style="list-style-type: none"> • Potential effect on collection system if single stream processing option available. • Requires upgrading of transfer facilities or development of a new facility.
Potential Cost Implications	<ul style="list-style-type: none"> • Estimated average gross cost of \$88/tonne, not including potential for revenue sharing



Table 3 Short-Term: Processing Recyclables Outside of Simcoe County	
Potential Change in Diversion	<ul style="list-style-type: none"> Minimal in regards to actual processing option. May see increase in diversion performance if collection is shifted to a single stream system.
Potential for System Efficiencies and Improvements in Level of Service	<ul style="list-style-type: none"> Could reduce recycling system costs. Should address issues related to variable capture rates and marketed tonnages of materials such as aluminum.
Potential Processing or Disposal Capacity Requirements	<ul style="list-style-type: none"> County requires at minimum 25,000 tonnes of processing capacity (short-term) and longer term capacity ranging up to 35,000 to 40,000 tonnes.
General Implementation Requirements	<ul style="list-style-type: none"> Will require potential improvements to transfer system. New collection tender/contracts. Processing tender/RFP/contracts.
Ability to Adjust Option to Changes to the WDA	<ul style="list-style-type: none"> Flexibility to adjust to potential changes to the WDA and the Blue Box Program Plan (BBPB) would have to be addressed in contractual arrangements made by the County Generally a more flexible option (i.e. less capital investment) than development of processing capacity within the County

For the long-term, there was no rationale found in the SWMS for moving to a single stream recycling system as:

- A review of collection costs and collection modeling showed no single stream collection advantages. There was no significant cost advantage through single stream based on the projected fleet requirements. The additional cost of providing automated single stream recycling carts to all households served would be substantial.
- Although there could be some cost advantage in transferring single stream recyclables over dual stream recyclables, processing costs for a single stream MRF are considerably higher than an equivalent dual stream MRF.
- Single stream MRF capital costs were estimated to be in the order of 35% higher and operating costs were estimated to be in the order of 8% higher than for a comparable dual stream MRF.
- Single stream recycling systems typically result in higher contamination levels and therefore higher residue rates (thereby increasing disposal costs).
- There is a greater possibility of cross contamination and lower revenues in marketing products from a single stream MRF.

Therefore, the SWMS identified that a dual stream MRF would be preferred over a single stream MRF for development of a new long term in-County processing facility. Table 4 provides a summary of the implications of the potential approach for processing recyclables in the longer-term, should it be reasonable to develop an in-County MRF.

Table 4 Longer-Term: Develop Recyclables Processing Capacity within the County (new MRF)

Table 4 Longer-Term: Develop Recyclables Processing Capacity within the County (new MRF)	
Short-term or Long-term Option	<ul style="list-style-type: none"> Implement in short-term, sustain over long-term.
Interaction with other System Components	<ul style="list-style-type: none"> Potential effect on collection system if single stream processing option available. May require changes to municipal transfer system.
Potential Cost Implications	<ul style="list-style-type: none"> Potential for lower unit processing costs under arrangements made directly by the County. Potential for economies of scale if processing capacity is also provided for Barrie and Orillia
Potential Change in Diversion	<ul style="list-style-type: none"> Minimal in regards to actual processing option. May see increase in diversion performance if move to single stream system, and/or if new collection contracts include higher level of enforcement on waste.



Table 4 Longer-Term: Develop Recyclables Processing Capacity within the County (new MRF)

Potential for System Efficiencies and Improvements in Level of Service	<ul style="list-style-type: none"> • Development of a new MRF in the County could reduce recycling system costs. • Should address issues related to variable capture rates and marketed tonnages of materials such as aluminum.
Potential Processing or Disposal Capacity Requirements	<ul style="list-style-type: none"> • County requires at minimum 25,000 tonnes of processing capacity (short-term) and longer term capacity ranging from 35,000 to 40,000 tonnes. • The possibility of a larger MRF to accommodate Barrie and Orillia’s recyclables will be reviewed.
General Implementation Requirements	<ul style="list-style-type: none"> • Would likely require improvements to the County transfer system. • New collection tender/contracts. • Design/ build/operate RFP and contracts.
Ability to Adjust Option to Changes to the WDA	<ul style="list-style-type: none"> • Recyclables collected under an updated/amended BBPP in accordance with proposed WDA changes will still require processing. Potential role for new processing facility under changed system to be determined. • Generally a less flexible option (i.e. more capital investment) than the use of processing capacity outside the County, should the changes to the WDA and BBPP remove responsibility for managing recyclables from the municipal sector. This option does have more flexibility in regards to adding new materials.

Single stream recycling could be a viable option for the County in the future, but would need to be assessed based on a full-system cost assessment arising out of the evaluation of future bids for both collection and processing services. Collection modeling undertaken as part of the SWMS indicated little to no benefit in the form of reduced collection costs for single stream collection. This conclusion was expected given that the majority of the County is rural in nature and thus the cost for collection is driven more by the time required to move from stop to stop rather than the time required to collect material at the stop itself.

The County issued an RFP for short-term collection services in accordance with the recommendations in the SWMS in regards to consolidation of collection services for garbage, organics and recycling within a single contract and separation of collection and processing requirements for recyclables. This contract was awarded to Progressive Waste Solutions (BFI) at an annual cost of \$10.6 million, 21% (\$2.6 million) less than the budgeted cost for service in 2012. A detailed assessment of the shift in recycling costs has yet to be made publicly available.

2.5.5 Case Study #5 City of Ottawa

In July 2010, the City of Ottawa (the City) retained Stantec Consulting Ltd. (Stantec) to undertake a service level review of its residential waste collection program⁶⁹. The focus of the residential service level review was to determine the level or type of waste collection service that would be provided to residents in the immediate short-term (being the term of the next collection contract which would begin as of 2012).

The City of Ottawa is the second largest municipality within the province of Ontario. It is located in the Ottawa Valley in the eastern portion of Southern Ontario. As of 2009 it was reported that there were approximately 369,771 households in the City (251,219 single family and 117,552 multi-unit), with a total population of approximately 908,389. Based upon a study completed by the Ministry of Finance in 2009, the population of Ottawa is expected to increase to 1,265,700 by the year 2036.

As of 2011, the City delivered the following curbside collection services to the residents of Ottawa:

- Weekly pick up of residual waste;
- Weekly pick up of Green Bin in spring, summer and fall; bi-weekly pick up in winter;
- No Green Bin service for remote rural residents; and
- Bi-weekly pick up of Blue and Black boxes on alternating weeks.

⁶⁹ City of Ottawa, Solid Waste Collection Service Level Review. Report to Environment Committee March 30, 2011.



As of 2009, a total of 67,462 tonnes of residential blue and black box material was collected from residents. Of this material, 61,561 tonnes was marketed and 4,297 tonnes was considered residue and shipped for disposal, for a recyclables processing residue rate of 6.4%.

As a part of the Collection Service Level review the following potential changes to the City's collection system were reviewed:

- Weekly and bi-weekly collection of residual waste;
- Collection of recyclables (Blue and Black box materials) together (single stream) and in separate containers;
- Weekly, bi-weekly and monthly pick up of Blue and Black boxes;
- Weekly pick up of Green Bin on a year-round basis;
- Weekly pick up of Green Bin in spring, summer and fall, with bi-weekly pick up in winter;
- Expanding the Green Bin program to remote rural residents;
- Co-collection of materials (separated collection of two different material streams e.g. organics and residual waste on the same truck); and
- Incentives to improve diversion, such as a reduction in bag limits, enforcement of bag limits and implementing a "pay as you throw" system.

Public surveys were undertaken to ascertain the level of public interest in changes to the collection system. In regards to recycling, residents indicated that they were satisfied with the current level of service and when asked for their preference regarding collection frequency, expressed a preference to retain the alternating week two-stream recycling collection approach.

Technical and financial analysis was carried out using the following criteria:

- Public acceptability;
- Potential effects on diversion;
- Environmental impacts;
- Financial implications; and
- General implementation requirements and/or barriers.

While the range of systems initially considered, included a system with single stream recycling collection, it was not carried through the study based on public acceptability of the current system as noted above, and as there was a lack of available cost effective single stream processing capacity that would be available for the short-term. The recommended collection system that was carried through to tender included the following:

- Weekly collection of Green Bin year round;
- Bi-weekly collection of residual waste; and
- Bi-weekly collection of Blue and Black box on alternating weeks.

This system offered the best combination of social, environmental and financial advantages as follows:

- It offers the greatest cost savings;
- It maximizes diversion;
- It preserves a critical/irreplaceable asset—the Trail Road Landfill, through reduced disposal demand/requirements;
- It allows the City to move closer to provincial waste diversion targets;
- It requires the fewest trucks on the road and the least number of trips;
- It reduces environmental and health-related impacts from collection vehicles, through a reduction in air emissions associated with a smaller vehicle fleet; and
- It provides a consistent, city-wide service level.

When compared to the status quo, implementation of the recommended program changes were anticipated to result in:

- Up to \$54 million in estimated savings over a 6-year period, which equates to a savings in the average residential curb side household tax bill for solid waste collection and disposal of up to 10 per cent for the solid waste collection and disposal component of the residential curb side tax bill;
- Up to 9 per cent increase in waste diversion, moving the residential curb side diversion rate to between 48 and 53 per cent; and
- Up to 5,200 tonnes of recyclables and 20,100 tonnes of organics per year diverted from landfill.

Actual savings were subject to the competitive bidding process for the new collection contract(s). The new collection contracts, starting October 30, 2012, were awarded to Waste Management (collection zone C1), Miller Waste Systems (collection zones C2 and C4) and the City's In-House Group (collection zones C3 and C5). Cost avoidance savings will be achieved similar to those predicted during the service level review. In fact, an additional savings of \$1.14M beyond what was identified in the service level review has been realized as a result of the tendering process for an overall annual savings of \$10.14M over status quo.⁷⁰

The potential increase in diversion will depend on the degree to which Ottawa residents heed the diversion messaging that accompanies the new service levels along with the impact of bi-weekly garbage collection. Information regarding changes in program performance will not be available until 2013.

2.5.6 Case Study #6 Bluewater Recycling Association

The Bluewater Recycling Association (BRA) is a non-profit municipal organization that serves 19 municipalities located within Perth, Huron, Lambton and Middlesex Counties in Southwest Ontario. As of 2008, the municipalities participating in the Association's programs had a population of just under 160,000 and were home to 72,383 residential households. The municipalities currently generate approximately 28,169 tonnes of residential solid waste per year, approximately 42% of which is diverted through the blue box program. Within the WDO program groupings the BRA falls within the 'Rural - Regional' group.

The BRA currently offers single stream processing services, and is the primary provider of recycling collection services for its member municipalities. Collection of regular waste is provided using a variety of methods including services offered by the BRA, contractors, municipal forces or are not provided at all. There are a range of recycling incentives and garbage disincentives currently in effect.

The Continuous Improvement Fund, provided funding assistance (50% of costs) for the conversion of the existing BRA MRF in 2009, and assistance for the purchase of automated carts for the first municipalities converted to automated collection. It has been publicly reported that implementation of single stream processing in early 2010 (including the addition of mixed plastics) reduced MRF operating hours by 25%, increased MRF capacity by approximately 100%, resulted in a 34% reduction in collection costs while collecting 17% more material, and decreased the MRF residue rates to around 4%.⁷¹

The following table presents a comparison of the performance of the BRA recycling programs in comparison to the average performance within the 'Rural Regional' municipal grouping as of 2010 when for the large majority of the year the BRA program was operated as a single stream system. This table also presents data regarding performance of the BRA recycling programs as of 2008, prior to implementation of single stream processing and collection.

Table 5 Comparison of Ontario Municipal Rural Regional Average Program Performance 2010 (Derived from the WDO Tonnage and Financial Datacalls)

Rural Regional Program Comparison	Avg. HHDs Served 2010	Kg Marketed / HHD	Net Cost / HHD	Net Cost / Tonnes Marketed	Revenue / Tonnes Marketed	Collection Cost / HHD	Gross Processing Cost / Tonne Marketed
Average Rural Regional Program Performance (2010)	40,686	149.59	\$42.61	\$283.96	\$111.38	\$34.54	\$107.69
Bluewater Recycling Association Performance (2010)	68,449	162.35	\$56.88	\$350.34	\$137.53	\$45.93	\$158.83
Bluewater Recycling Association Performance (2008)	68,669	168.99	\$50.35	\$297.93	\$160.68	\$49.98	\$111.21

⁷⁰ City of Ottawa. Solid Waste Curbside Collection and Services, Report to Environment Committee, November 15, 2011.

⁷¹ *Innovation in Ontario's Blue Box Program, CIF, Andy Campbell*



The BRA is one of two municipal programs within the Rural Regional program group that provide single stream recycling service, the other being the City of Greater Sudbury. Both programs report marketing considerably higher quantities of recyclables on a per household basis. Both programs report net costs per household that are higher than the average for the other Rural Regional programs, although Sudbury reports a lower than average net cost per tonne marketed. Both programs report collection costs per household and gross processing costs per tonne that are above the average for the Rural Regional programs.

From a processing performance perspective, although the BRA reports higher gross processing costs per tonne than the other Rural Regional programs, it also reports higher average revenue per tonne marketed and generally has lower residue rates, as compared to the majority of dual stream Rural Regional programs.

Comparing the reported BRA program costs for 2008 to 2010 indicates that there was a 4% decrease in the kg of material marketed per household, a 13% increase in the net costs per household and an 18% increase in the net costs per tonne marketed. Examining the individual program elements indicated that although collection costs per household decreased by 8%, processing costs per tonne marketed increased by 43% and revenues per tonne marketed declined by 14%. Comparison to 2009 reported program costs was not provided in Table 5 above, as just like most programs in Ontario, 2009 was an anomalous year in which program revenues had a steep decline and net program costs were much higher than in 2008 or 2010.

Currently, the collection service provided in the BRA is still largely provided through manual blue box collection. Therefore the shift in program costs reported from 2008 to 2010 for the BRA, represents the changes in materials processing and some shift in curbside collection efficiencies associated with the transition to single stream programs, that are expected to improve as automated collection is fully implemented.

The BRA has determined that implementation of automated collection is a priority initiative and began automated cart collection in two member municipalities in 2008.

The BRA estimates that implementing automated collection could cost in the order of \$4,299,500 to convert the majority of municipalities served by the BRA to automated collection, with annual savings of up to \$1,000,000 per year.⁷² Currently, the BRA is undertaking a phased roll-out of automated recycling and garbage co-collection across the member municipalities.

The Town of St. Marys and the Municipality of Strathroy-Caradoc, will have full implementation of automated cart collection as of January 2013. Other municipalities (e.g. Lambton Shores) expect implementation by 2014. Residents can choose to use varying sizes of garbage carts for an annual fee that varies per cart size and per municipality. The cost of recycling collection via 65 or 95 gallon recycling carts is absorbed within the overall fee.

⁷² *A Waste Recycling Strategy for the Bluewater Recycling Association, November 2010.*

Section 3: ANALYSIS OF RECYCLING SYSTEM PERFORMANCE IN ONTARIO

The annual Waste Diversion Ontario datacall (financial and tonnage) provides a fairly robust dataset to compare dual stream and single stream system performance. Table 6 below, presents a comparison of the annual data call results for the eight largest municipalities that offer dual-stream programs and the four largest municipalities that offer single-stream programs. These municipalities include all of the communities in the Large Urban and Urban Regional program categories.

The information presented in Tables 6, 7 and 8 represent the average results of the three most recent years (2008 to 2010) for which data is currently available. The three year averages are presented, rather than a single ‘snap-shot’ in time, as this dataset provides a more robust overview of program performance.

Table 6 Comparison of Ontario Large Municipal Dual and Single Stream Average Program Performance 2008-2010 (Derived from the WDO Tonnage and Financial Datacalls)

	Average HHDs per Program (2010)	Kg Marketed / HHD	Net Cost / HHD	Net Cost / Tonnes Marketed	Revenue / Tonnes Marketed	P&E Cost / HHD	Collection Cost / HHD	Gross Processing Cost / Tonne Marketed	Residue Rates
Dual Stream (8 Programs)	198,722	189	\$34.20	\$182.00	\$105.62	\$0.94	\$32.47	\$94.13	6.91%
Single Stream (4 Programs)	447,366	224	\$45.17	\$206.41	\$90.81	\$1.25	\$32.27	\$108.08	14.41%
Comparative Performance of Single Stream		35	\$10.97	\$24.41	\$(14.81)	\$0.31	\$(0.20)	\$13.94	7.49%
Percentage Difference		18.50%	32.09%	13.41%	-14.02%	33.10%	-0.60%	14.81%	108.42%

In some respects, the analysis presented in Table 6 is consistent with findings reported in other studies, while in others these results are inconsistent.

- On average, the single stream programs recovered and marketed more recyclable material than the dual stream programs, although at least two of the eight dual stream programs had comparable results to the single stream programs averaging at around 225 kg/HHD. Three of the four single stream municipalities had bi-weekly garbage collection in effect, while at the time of reporting, only one of the dual stream municipalities had bi-weekly garbage collection in effect and reported comparable kg/HHD marketed. Disincentives for garbage collection and incentives for recycling varied between the seven other dual stream communities. It was not possible to isolate the effect of bi-weekly garbage collection and other disincentives from the effects of single stream recycling. There was little difference between single and dual stream programs in regards to the types of materials collected, with the range for dual stream programs varying between 14 and 17 material types and single stream programs varying between 12 to 17 material types over the period from 2008 to 2010.
- Reported collection costs per household indicated very little difference on average between dual and single stream collection programs, inconsistent with the generally reported assumption regarding lower collection costs for single stream programs. Automated collection was in effect for only one of the four single stream programs, however, that program reported higher than average collection costs for the single stream group. The collection costs reported for manual collection in the dual stream programs was relatively consistent with variability from year to year between 12 to 20%. Collection costs for single stream programs exhibited greater variability between 26 and 31%. These results are particularly interesting given that in general the dual stream programs were offered in jurisdictions with greater geographic area and lower population density. These values indicate that the current dual stream collection programs in large Ontario municipalities appear to be relatively efficient.
- Reported processing costs for single stream programs were around 15% more than those for dual stream programs, consistent with the range of reported processing costs elsewhere in North America. One of the single stream programs and one of the dual stream programs reported gross processing costs for the use of merchant processing capacity that was significantly lower (\$50 to \$60 per tonne lower) than the other programs, while those same programs reported lower revenues per tonne of material marketed reflecting that their reported program costs appeared to be ‘adjusted’ to reflect some degree of revenue sharing. When adjusted to remove these programs as



outliers, the reported processing costs for single stream programs were over 20% higher on average than for dual stream programs.

- Dual stream programs reported revenues that were on average just over 14% more than single stream programs, however, as noted above for at least two communities, reported revenues appeared to reflect some degree of pricing adjustment related to processing. With those outliers removed, the remaining dual stream programs reported revenues that were on average just over 5% higher than single stream programs.
- Overall, net system costs were around 32% lower for dual stream programs on a per household basis, and around 13% lower on a per tonne marketed basis. This is a greater differential than reported elsewhere in North America, which is reasonable given that Ontario's single stream programs do not currently appear to exhibit significant cost savings for collection, but do exhibit higher processing costs and lower revenues.
- Residue rates reported by the single stream programs were over double those reported for dual stream programs. This is consistent with other studies. Both dual stream and single stream programs have been actively seeking solutions to reduce material loss to residues.

Table 7 below, compares the material recovery in these same programs. While the total recovery of marketable materials was generally higher for the single stream programs, there are some notable differences on an individual material stream basis. Single stream programs relatively consistently recovered more paper fibre materials than the dual stream programs, which could be reflective of higher curbside capture rates for paper fibre and/or differences in the generation rates for paper fibre considering that all of the single stream programs examined are located in highly urban areas within the Greater Toronto Area. An examination of publicly reported waste audit data for single stream and dual stream programs available on the Stewardship Ontario web site, reveals that the large single stream programs that completed curbside residential audits between 2005 and 2007 reported an average generation rate for printed paper of 3.12 kg/hhd/week (for single family households), whereas the large dual stream programs reported an average generation rate of 2.7 kg/hhd/week (for single family households).

Recovery of glass from single stream programs was remarkably high considering the difficulty associated with sorting this material. However review of the revenues earned per tonne of material recycled (see Table 8 below), indicates that these materials were marketed at a much lower value, which is more representative of marketing a mixed broken glass stream.

Dual stream programs recovered more aluminum and steel as well as consistently capturing more recycled plastic, with the exception of HDPE. In regards to the kg marketed per household, current program performance appears to be consistent with studies elsewhere. The overall quantity marketed is higher for single stream programs, however, the quantity marketed for the various container streams is lower, which is generally representative of the capability of single stream systems to sort and recover the container stream.

Table 7 Comparison of Ontario Large Municipal Dual Stream and Single Stream Performance - Average Kg of Materials Marketed per Household (2008-2010)

	Total Kg Marketed / HHD	Printed Paper	OCC/OBB	Polycoat	Aluminum	Steel	Total Glass
Dual Stream (8 Programs)	189	100.43	42.07	1.35	2.48	7.41	18.62
Single Stream (4 Programs)	224	132.97	43.44	1.72	2.02	6.39	23.90
Comparative Performance of Single Stream	34.92	32.53	1.37	0.38	(0.46)	(1.02)	5.27
Percentage Difference	18.50%	32.39%	3.26%	27.88%	-18.69%	-13.75%	28.33%
	PET	HDPE	Plastic Film	Tubs & Lids	Polystyrene	Mixed Plastic	Other Plastic
Dual Stream (8 Programs)	6.37	3.21	1.13	1.60	0.17	1.82	4.72
Single Stream (4 Programs)	5.64	3.43	0.52	0.56	0.05	0.42	1.55
Comparative Performance of Single Stream	(0.73)	0.22	(0.61)	(1.04)	(0.12)	(1.40)	(3.17)
Percentage Difference	-11.48%	6.92%	-54.18%	-65.14%	-69.17%	-76.96%	-67.22%

Table 8 below, presents a comparison of the reported revenues per tonne per material stream averaged over the period from 2008 to 2010. The values noted for dual stream programs, have been adjusted to remove the anomalous data from one municipality which consistently fell outside the reported values for the group.

Single stream programs consistently reported average revenues for paper fibres streams that were higher than those for dual stream programs. If there was any impact regarding paper fibre material quality from Ontario single stream programs on paper mills, this does not appear to be passed down through the market price to these municipal programs.

The average revenue per tonne for some plastics (PET, HDPE) were higher for single stream programs. The revenue per tonne for metals was relatively the same for both program types. Dual stream programs reported significantly higher average revenues for glass, plastic tubs and lids, mixed and other plastics.

Table 8 Comparison of Ontario Large Municipal Dual Stream and Single Stream Performance - Average Revenue Per Tonne for Key Material Streams (average 2008-2010)

	Printed Paper	OCC/OBB	Polycoat	Aluminum	Steel	Total Glass	
Dual Stream (7 of 8 Programs)	\$114.26	\$87.51	\$70.32	\$2,020.94	\$191.73	\$16.61	
Single Stream (4 Programs)	\$131.09	\$105.93	\$73.87	\$2,006.28	\$188.96	\$1.27	
Comparative Performance of Single Stream	\$ 16.83	\$ 18.42	\$ 3.55	\$ (14.67)	\$ (2.77)	\$(15.34)	
Percentage Difference	14.73%	21.05%	5.05%	-0.73%	-1.44%	-92.37%	
	PET	HDPE	Plastic Film	Tubs & Lids	Polystyrene	Mixed Plastic	Other Plastic
Dual Stream (7 of 8 Programs)	\$320.20	\$477.88	\$40.39	\$170.04	\$45.05	\$41.85	\$113.71
Single Stream (4 Programs)	\$393.43	\$599.02	\$67.17	\$141.83	\$67.21	\$0.00	\$103.81
Comparative Performance of Single Stream	\$ 73.23	\$ 121.13	\$ 26.78	\$(28.21)	\$ 22.16	\$ (41.85)	\$ (9.91)
Percentage Difference	22.87%	25.35%	66.32%	-16.59%	49.19%	-100.00%	-8.71%



Summary of Findings

Review of current dual and single stream program performance for large Ontario jurisdictions does not indicate many distinct benefits for single stream recycling compared to dual stream recycling. In summary:

- The kg/HHD marketed for single stream programs from 2008 to 2010 was in the order of 18.5% higher than for dual stream programs. However, it was not possible to distinguish the impact of bi-weekly garbage from that of single stream recycling collection in the 2008 to 2010 dataset.
- Over the period from 2008 to 2010, the dual stream programs in large Ontario municipalities reported comparable collection costs, lower processing costs and higher overall revenues per total tonnes marketed than single stream programs. Overall, dual stream programs reported lower net recycling program costs per household served and per tonne marketed.
- Over the period from 2008 to 2010, the single stream recycling programs in the larger Ontario municipalities did not appear to exhibit the economies of scale, particularly for materials processing that would be anticipated. In 2010, the four municipalities with single stream recycling served in the order of 1.8 million households collecting almost 450,000 tonnes of material, compared to 1.6 million households in the eight municipalities with dual stream programs collecting just over 300,000 tonnes of material.

Section 4: CONCLUSIONS

There is no consistent body of research that demonstrates clearly that either dual or single stream recycling is a specific best practice. There is no clear answer regarding which recycling system offers the most benefits when examining recycling program performance in North America. Rather, current information indicates that there are best practices that could be applied to both single and dual stream recycling approaches in order to increase public participation, improve material capture rates for reprocessing, increase diversion and control program costs. When making choices in regards to system changes, municipalities should assess options for both program configurations considering local conditions and the potential effects of other best practices that could improve program performance such as increasing the size of the curbside recycling container, more efficient collection system configurations (e.g. co-collection) and disincentives for garbage, all of which could apply to either approach. Further research (as discussed below) could provide useful information to assist municipalities in making decisions regarding program changes.

The following provides an overall summary of the benefits and issues associated with single stream recycling, as documented in the studies discussed above. The significance of the benefits and issues will vary according to the municipal context. One jurisdiction may place a higher degree of significance on costs, while another may place a higher significance on diversion. A jurisdiction that provides collection through public forces is likely to be more interested in ergonomics and the potential to reduce lost time incidents, than one where all collection services are contracted. Considering the balance of the benefits and issues within the municipal context is the key to good decision making.

Single Stream Recycling	
Benefits	Issues
<ul style="list-style-type: none"> • Some potential for increased program participation (particularly for multi-family residential households) • Increases convenience to customers • Some potential to collect more materials and increase diversion from disposal, although other program changes also contribute to this • Increases collection efficiency and reduces collection costs through vehicle payload optimization and reduced collection times per stop (particularly with automated collection) 	<ul style="list-style-type: none"> • Reduces quality control during collection (particularly for automated cart collection) • Can contribute to increases in contamination by unsolicited materials • Higher collection system implementation costs for purchase of containers and vehicles (for automated cart collection) • May reduce value of recovered materials if quality control not maintained • Increased MRF capital and operating costs • Potential for higher net recycling system costs on a per



<ul style="list-style-type: none"> • Reduces scavenging, litter and protects recyclable materials from precipitation and other climactic effects (associated with automated cart collection) • Reduces worker injury and compensation costs (associated with automated cart collection) • Facilitates co-collection with other material streams 	<p>household and per tonne marketed basis, based on reported Ontario system costs for large municipal programs</p> <ul style="list-style-type: none"> • Potential operational and cost impacts to manufacturers, reprocessors if market specifications are not met • Reduces glass recovery • Potential for higher percentage of processing residue, revenue losses from the loss of recyclable materials to the residue stream and higher residue disposal costs
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Dual Stream Recycling	
Benefits	Issues
<ul style="list-style-type: none"> • Greater potential for quality control during collection (blue box collection) • Potential for less contamination by unsolicited materials • Lower collection system implementation costs for purchase of containers and vehicles (for manual blue box or blue bag collection) • Lower MRF capital and operating costs • Potential for lower net recycling system costs on a per household and per tonne marketed basis, based on reported Ontario system costs for large municipal programs. • Potential for higher material market revenues through marketing of higher quality material and/or more effective material recovery during processing • Higher glass recovery rates, however, glass recovery and management can still be an issue for dual stream MRFs • Potential for lower percentage of processing residue, reduced loss of recyclable materials to the residue stream and lower residue disposal costs 	<ul style="list-style-type: none"> • Potential for lower program participation, particularly for multi-family residential households and other customers affected by space constraints • May be regarded as less convenient to customers • Some potential to collect less materials (e.g. kg/household) resulting in lower rates of diversion from disposal, however other program changes such as garbage disincentives can result in achieving similar material capture and diversion rates as single stream programs • Potential for lower collection efficiency and higher collection costs as multi-compartment collection can reduce vehicle payload optimization and as manual collection of multiple blue boxes increases collection times per stop (particularly as compared to automated collection) • Difficult to control scavenging, litter and protects recyclable materials from precipitation and other climactic effects for blue box programs • Potential for higher worker injury and compensation costs for manual blue box collection • More difficult to structure the collection system to allow for co-collection with other material streams

The research undertaken for this project indicates that there are gaps and issues in the way that single and dual stream programs have been studied, which can influence the analysis and understanding of the potential implications of both systems:

1. Many studies or analysis of the potential benefits of one system over another undertaken for municipal clients, have relied on anecdotal evidence and/or a small set of data sources. This was particularly the case when examining potential system effects that are difficult to empirically measure (e.g. 'convenience', litter). For example, there are few to no studies that have undertaken a reasonable comparison of single stream and dual stream recycling services to the multi-family sector, to determine how significant the 'convenience' factor could be in improving recycling program performance for that sector.
2. Many studies examining the potential differences in collection costs associated with transitioning from a multi-sort or dual stream collection to single stream compared a new single stream to the existing baseline system in those communities. Rarely were the range of various options and system configurations modeled and assessed to look at the full range of options and improvements that could be considered for both single and dual stream system configurations.



The completion of modeling exercises to examine the full collection system design (for garbage, recycling and organics) can assist the decision making process for municipalities.

3. There is an insufficient body of research regarding the impacts of various container types on recycling system performance. Few studies provided any quantification or detailed assessment of the potential differences in litter associated with open or closed containers. Little information was available regarding the actual impacts of climate on material quality and the impacts of managing 'wet' materials at dual or single stream MRFs.
4. Many of the existing studies regarding single stream and/or dual stream performance could become dated as the residential waste stream has changed. Recent municipal curbside audits in some Ontario municipalities indicate that the percentage of fibre materials generated by residential customers is decreasing and the percentage of plastics is increasing. Analysis of general trends for Ontario blue box programs indicates a decrease in the proportion of paper fibre (excluding polycoat), a significant increase in polycoat and plastics and a significant decrease in glass associated with the impact of the management of LCBO glass outside of the curbside system. There could be a significant benefit from undertaking empirical studies of MRF performance in Ontario to bring together data from the curbside material audits, MRF residue audits and marketed material audits, to examine the mass balance of the current system and to project the potential changes and implications for dual and single stream processing systems as the generated material stream continues to change.
5. There has been little comparative analysis regarding the potential impacts on diversion and material capture rates associated with single stream programs, where the effects of 'single stream' have been isolated from other effects such as garbage disincentives and increased promotion and education. In the Ontario context, it would be useful to undertake a detailed comparative analysis of single stream and dual stream programs with relatively similar demographics and waste program delivery, to better determine the differences in material capture rates and program performance. Current data available through the WDO datacall is insufficient for this purpose, as it addresses only differences in kg marketed per household, and this cannot be isolated from the potential differences in overall generation rates by material type.