Attachment 1: Technical Memorandum #1: Executive Summary: Waste Forecasting and Characterization

Waste Projections and Composition Analysis
Mixed Waste Processing Study
Executive Summary
City of Toronto
December 9, 2019

Contents

Tables

Figures

This page is intentionally left blank.

1 Introduction

The City of Toronto continues to exhibit environmental awareness and leadership through its ongoing pursuit to maximize waste diversion and move towards fully supporting a circular economy. This includes implementation of the City's Long Term Solid Waste Management Strategy with an aspirational goal of zero waste and recommendations to further this goal through the exploration of the feasibility of Mixed Waste Processing (MWP).

Ultimately, the goal of this Mixed Waste Processing Study is to assist the City in determining whether mixed waste processing with organics recovery can support the achievement of a 70 per cent residential waste diversion target, by recovering resources that can be successfully marketed within the circular economy framework.

This document provides key findings from the first technical memorandum which documents the results of the waste characterization study, waste projections, lab testing, projections on the tonnes of waste diverted through MWP, and the impact on the City's processing and disposal facilities. Findings from all sections are not included.

2 Waste Projections Methodology

Waste projections are a key element in any City planning process as it allows decision makers and planners to identify the long-term needs of the system and effectively plan their City's waste management programs. By understanding how the City's waste management needs may change in the short to long-term, the City can make effective and efficient decisions about waste management programs and services and allow the proper supporting infrastructure to be developed and/or maintained.

Waste projections forecasting to 2021 was undertaken as part of the Long Term Waste Management Strategy (Waste Strategy) using data from 2001 to 2014. The same techniques used in the Waste Strategy were applied to develop waste generation projections for this Study for the planning period of 2019 to 2039. The models used in this Study were updated based on changing demographics and the availability of an additional four years of recent waste tonnage data that reflect current trends in waste quantities and composition, consumer behaviour and changes in the City's customer base.
In short, the waste projections were developed as follows:

1. Statistical models were developed based on historical quarterly waste generation data[1] spanning from 2001 to 2018 to forecast total quarterly quantities of waste to 2039.
    a. A multiple linear regression model was developed by statistically relating trends from 2001 to 2018 in quarterly waste generation to comparable trends in two key economic indicators from the Toronto census metropolitan area, labour force unemployment rate and median family income. Of all the available economic and demographic information available for modelling, these two variables proved to be the most effective. Appropriate statistical approaches were used to control for the effects of seasonality (i.e., winter, spring, summer, and fall), and policy changes (i.e., volume based rate system) on trends and to provide the best fit to the data.
    b. The resulting multiple regression model for the purpose of this study is referred to as the "Full Data Series" model and is used to forecast long-term trends from 2019 to 2039. The full data series model is a formula which takes values of the economic, policy and time of season indicators and multiplies them with coefficients. The weighted sum of the model's inputs yields forecasted waste tonnes for a particular year and quarter of interest. In this manner, as economic indicators are forecasted and seasons are tracked, waste tonnage can be forecasted.
    c. A shorter term model using time series regression methodology was also developed based on the most recent tonnage data (2009 to 2018). This model is referred to as the "Recent Data Series" model and is used to forecast quarterly waste tonnes from 2019 to 2023. The

[1] In this context waste generation refers to the quantity of waste generated in the City that is directly managed by the City. It does not refer to all waste generated in the City (e.g. industrial waste, some Multi-residential buildings) which would include materials that are managed outside the City's system by private contractors.

reasoning behind the second model was to leverage the momentum of the most recent trends to forecast the short-term trends in waste tonnage.

2. The quarterly predictions were then consolidated to provide annual quantities of waste.
3. The forecasted annual and quarterly quantities of total waste were allocated by waste stream (Garbage, Blue Bin Recyclables, Green Bin Organics, Yard Waste and Other Material) and sector (Single family, Multi-residential, Non-residential) using assumptions derived from review of the City's waste and household data.

2.1 Tonnage Data Utilized

In addition to the fourteen years (2001 – 2014) of monthly data that was utilized to develop the Waste Strategy, four years (2015 – 2018) of monthly inbound and outbound tonnage data at the City's transfer stations categorized by waste stream and customer type was used to develop the tonnage forecast. The detailed monthly data over this 18 year period was grouped into the five following waste streams:

1. Garbage: including, garbage from residential (Single family and Multi-residential) and a portion of the Non-residential sector (Commercial, Charities, Institutions, and Religious Organizations (CIROs), School Boards, Divisions, Agencies & Corporations (DACs)); and residue from both Blue Bin Recyclables and Green Bin Organics
2. Blue Bin Recyclables
3. Green Bin Organics
4. Yard Waste
5. Other Material: including non-recyclable and recyclable durable goods (e.g., couches, mattresses); street sweepings, IC&I (industrial, commercial and institutional) garbage dropped off at City transfer stations, old corrugated cardboard, electronic waste, drywall, scrap metal, logs/branches, Christmas trees, woodchips and tires.

The customer type data was used to determine the allocation of tonnages from the five streams to the Single family residential, Multi-residential, and Non-residential sectors.

2.2 Economic Indicators Utilized

The City maintains a large data repository of economic indicators covering the Census Metropolitan Area (CMA), Greater Toronto Area (GTA), provincial and national levels. Annual and quarterly values for key economic indicators from the Conference Board of Canada (CBoC) and Moody's were analyzed to determine which would be appropriate for forecasting. Two key economic indicators from the Toronto census metropolitan area, labour force unemployment rate and median family income, were selected for use in the model. Of all the available economic and demographic information available for modelling, these two variables proved to correlate more strongly with the tonnage data and were found to be the most effective for application in the model.

2.3 Housing Information Utilized

Projections for housing type from 2016 to 2041 were developed by the Research & Information and Strategic Initiatives & Analysis units of City Planning Division using the actual values from the 2011 Statistics Canada Census. These projections provide population and households for Toronto split by ground-related units up to four storeys and apartments in buildings of five or more storeys. This information was used to determine the change in housing density over the next 20 years between Single family and Multi-residential households and the allocation of the residential waste stream between the two types of households over the 20-year period addressed in the projections.

3 Waste Generation Trends

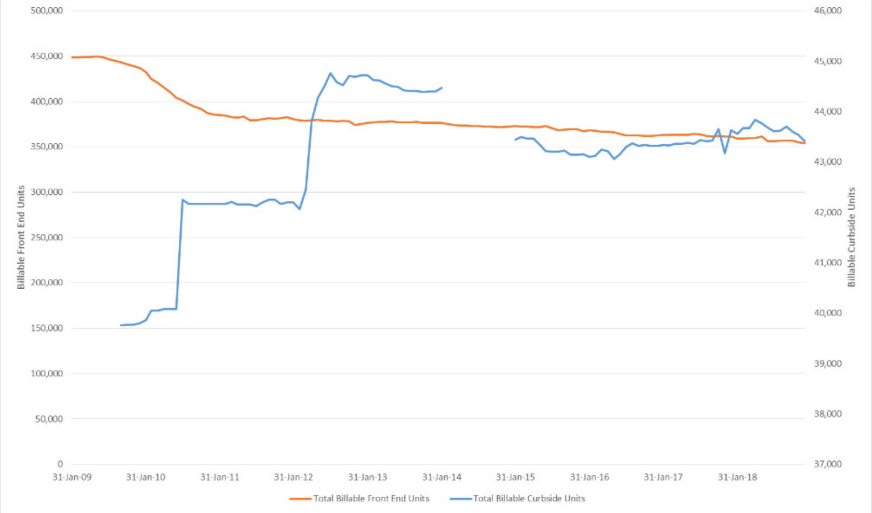
The City of Toronto has experienced a change in waste generation and composition consistent with what has been found in other cities across Canada and the U.S. Some changes are related to changing lifestyles and other trends that have been ongoing in the economy and in residential waste generation. Quantities and composition of materials managed by the City have been directly impacted by global trends, Provincial programs and policies, and City programs and policies. With respect to the impact of Provincial programs, it is not possible to predict the actual effect that these programs would have on future waste generation.

Overall, global trends in EPR will likely have an effect on producers and the products that enter the marketplace, but there is no statistical basis or data upon which to predict what that effect may be. The City should continue to monitor the impact of the National Sword program, as well as changing demographics, packaging and other trends that could have an impact on the amount of waste managed by the City. The City should continue to monitor trends in the tonnes of materials marketed and the value of marketed materials to support decision making on the types of recyclables that should be the focus for recovery through MWP.

3.1 Trends in Service Provision to the Multi-residential Sector

The following Figure **3-1** presents the number of Multi-residential households served by the City from 2009 to 2018 and illustrates the trends in customers over time. A downward trend has persisted since 2009 for Multi-residential buildings served with front end collection, which is reflected in the total residential tonnages received at City facilities, based on some buildings choosing to not use the City's VBRS based approach for service.

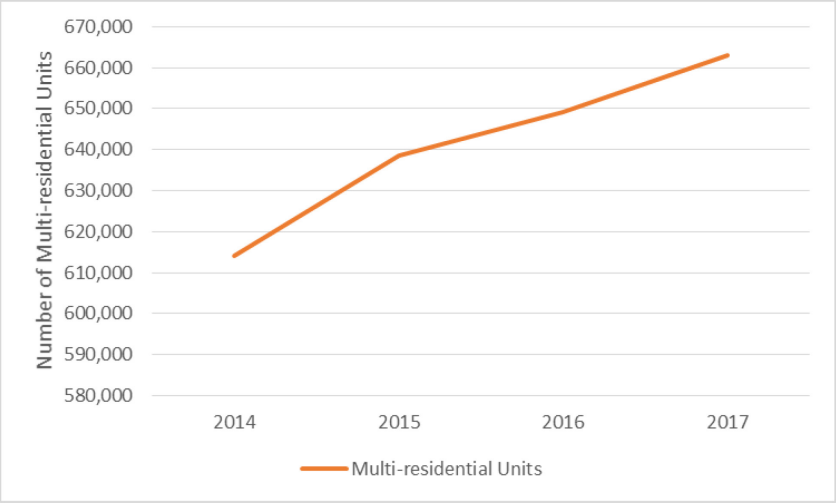
Figure 3-1: Multi-residential Customer Trends



Source: City of Toronto, Multi-res Unit Counts.

Figure 3-2 presents the upward trend in Multi-residential units over the past four years. With the downward trend in Multi-residential buildings served by the City's front end collection service, it would appear that growth in provision of Multi-residential services (and associated tonnes) is not keeping pace and may not keep pace with the increase in the number of buildings being developed. This is a concern for the viability of a MWP system if it is solely designed to process materials from the Multi-residential sector.

Figure 3-2: Total Multi-residential Units in the City

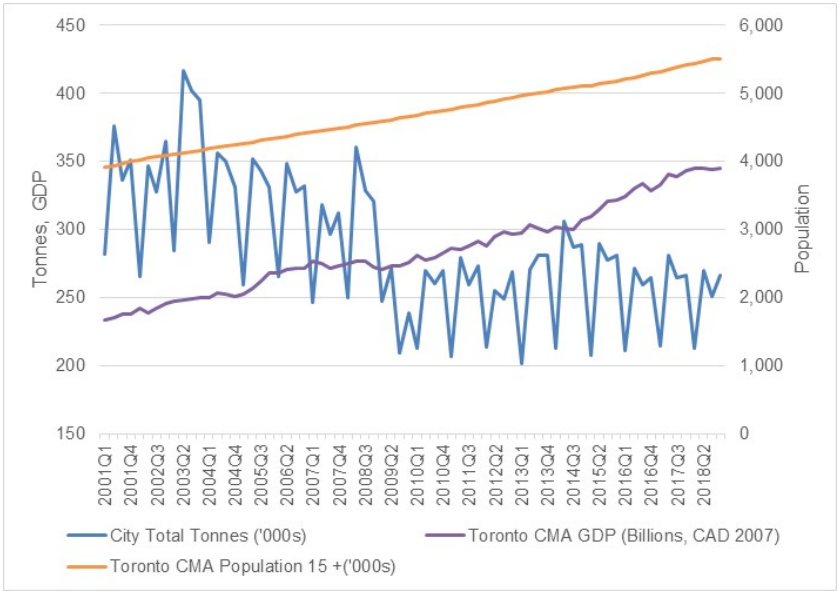


Source: City of Toronto, calculated from property tax for 2017 RPRA Datacall.

3.2 Trends in Quarterly Waste Generation

Figure 3-3 presents the trend in overall quarterly waste generation from 2001 to 2018, plotted against Gross Domestic Product (GDP) and population. It shows a steep decline in waste generation starting in 2001 and ending in 2009, with waste generation levelling off over the period from 2009 onwards. The 2001 to 2009 period represents the period during which many major Single family residential programs were rolled out across the City including Green Bin Organics collection, bi-weekly Garbage collection and culminating with implementation of the Volume Based Rate System (VBRS) for the Single family and Multi-residential sectors.

Figure 3-3: Trends for Waste Generation, GDP and Population by Quarter, 2001 – 2018



Sources: Waste data from City of Toronto. GDP and Population extracted excel file Moodys' - All Indicators_Quarterly & Annual_Dec 17, 2018.xlsx.

3.3 Impact of Trends in Population, Economic Activity, and Housing Densities on Total Waste Generation Trends

No statistically significant relationship was found in the trends of GDP, population, and quarterly waste generation when accounting for seasonality and the impact of the City's programs, including the VBRS in the waste generation trends. The impact of population growth to total waste generation cannot be modelled as population growth is not directly related to the observed trends in waste generation.

The historical trends in waste generation indicated in Figure 3-3 demonstrate that implementation of program changes by the City has had a greater effect on changes in waste generation then other factors such as population growth. This explains the clear difference in waste trends pre and post 2009. These changes have affected the tonnages used to develop the waste projections and thus are factored into the projections to the extent that they have affected the tonnages to-date. There is no data available that can be used to predict any additional effects from future policies, regulations or changes in purchasing behaviour on the waste projections.

A number of factors have been assumed to affect the quantity and composition of waste managed by the City over the period from 2001 to 2018. This includes global trends in waste generation, Provincial programs and policies, City programs and policies and changes in the City's customer base. The implementation of program changes by the City (Green Bin Organics Collection, Bi-weekly Garbage Collection, VBRS) has had a greater effect on changes in the overall tonnes of waste generated then other factors. Changes in the City's customer base such as the decline in front-end Multi-residential customers will have also affected the quantity and composition of waste managed by the City. These changes have affected the tonnages used to develop the waste projections, particularly the tonnes generated over the past nine years (2009 to 2018). These changes are factored into the updated waste projections to the extent that they have affected the tonnages to-date.

4 Waste Projections

Updated waste generation projections were required to reflect the changes in the tonnes of waste managed by the City over the past four years since completion of the Waste Strategy projections; and to estimate the potential quantity of material that could be directed to MWP over the planning period for this Project.

Waste generation projections were developed using two statistical models:

- Full Data Series Model - a long-term model that describes the relationship between waste generation and the economic indicators of unemployment rate and median family income. It was used to develop waste generation projections for the years 2019 to 2039. Analysis of the 18 years of data provided for this study indicates that changes in waste generation correlate to the unemployment rate and median family income.
- Recent Data Series Model - intended for short-term forecasts as it makes predictions solely on historical waste quantities. It was used to develop waste generation projections for the years 2019 to 2023.

The Full Data Series model provides a reasonable prediction of waste generation in the long term. The Recent Data Series estimates for waste generation are more conservative than those from the Full Data Series. This is because the recent data series model relies completely on past waste tonnage values from 2009 onwards, which show a slight downward trend in tonnes of waste generated in recent years. No statistically significant relationships relating quarterly recent series observations to that of quarterly economic indicators were identified. Eventually, with the collection of more observations, a causal relationship may be found to establish a long-term model based on the recent tonnage data series as the sole model for forecasting waste generation.

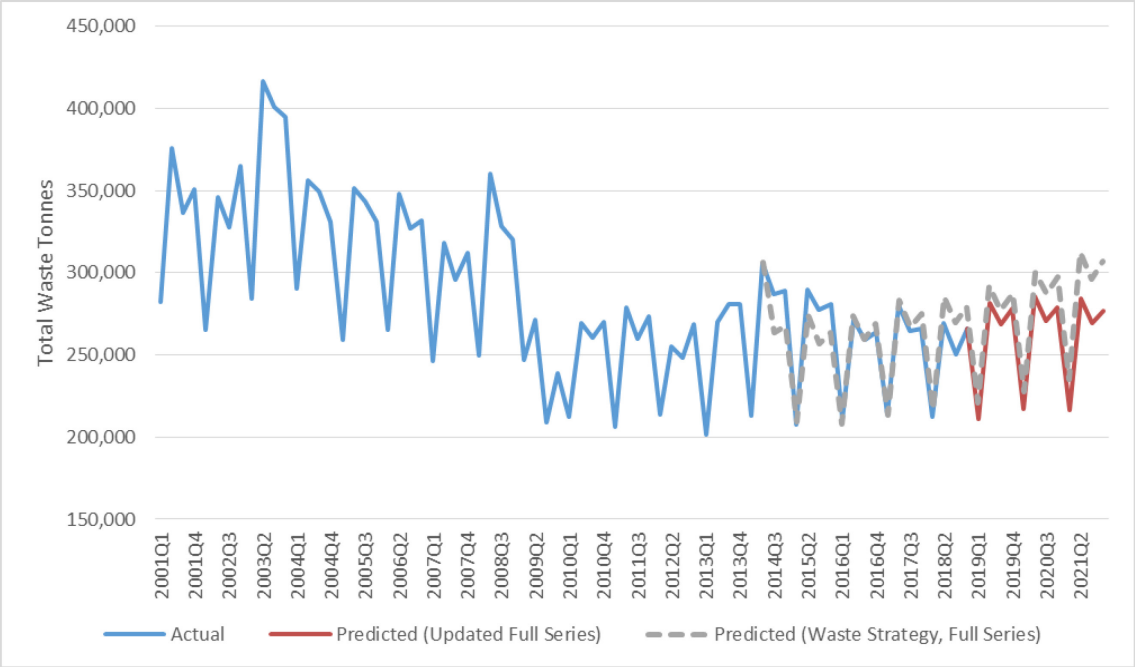
Projections developed using the two statistical models predict that waste generation will remain relatively stable for the next five years, at around 1 million tonnes (using the Recent Data Series) to around 1.05 million tonnes (using the Full Data Series).The updated Full Data Series and Recent Data Series models

from this Study, should replace the modelled waste tonnes from the previous Waste Strategy, until the City is ready to undertake another update. The updated projections, as presented in Figure 4-1, fit more closely to the forecasted waste generation, compared to those estimated for the Waste Strategy, as presented in **Figure 4-2**. Some explanations for the difference in tonnes projected in this Study compared to the Waste Strategy include:

- Household projections are more up-to-date
- There is a larger data set (18 years) which improves the reliability of forecasting
- The tonnes managed by the City may have shifted, in part due to the City not retaining as much of the Multi-residential sector as anticipated
- Policy changes on a local and international level (e.g. EPR)
- Shifts in packaging and consumer purchasing habits.

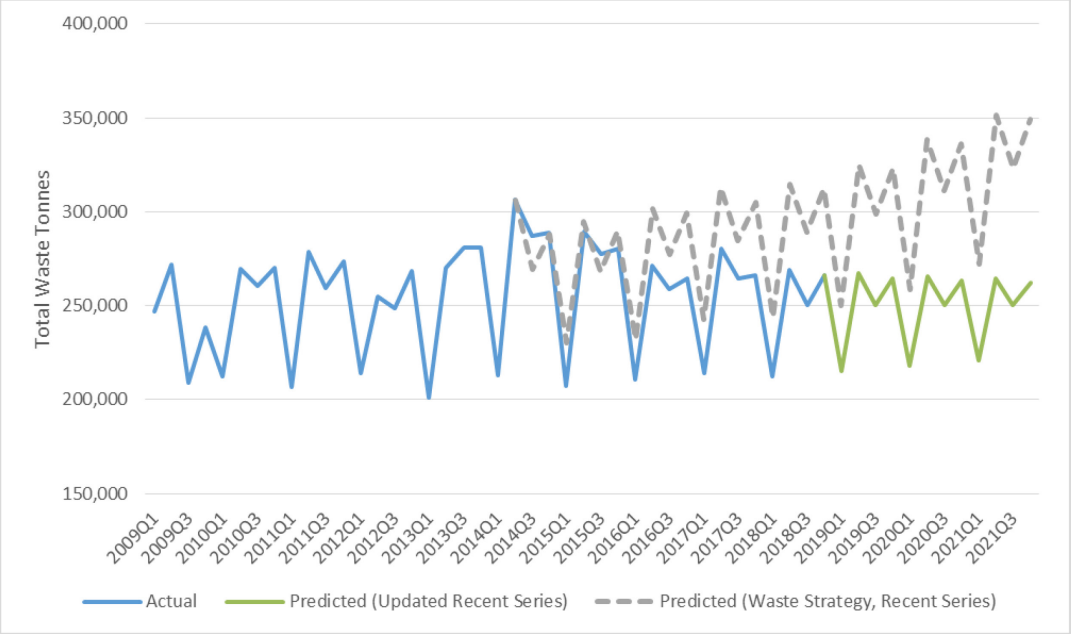
These issues will continue to impact projections going forward, and future updates of the Waste Strategy will need to acknowledge impacts to tonnes which are both within the City's control and not within the City's control. More frequent updates of the City's waste projections would allow for adjustments to the projects to reflect of future changes in the City's programs, policies and other factors that influence waste generation.

Figure 4-1: Comparison of Waste Strategy Projections with Actual and Forecasted City of Toronto Quarterly Total Waste Generation (Full Data Series)



Sources: Actual Waste Values: from City of Toronto. Quarterly Total Waste data was extracted from aggregating monthly inbound tonnage data at the City's transfer stations for 2001 to 2018; Updated predicted values: Table 7 in Appendix A. Predicted Waste Strategy Values: Table A - 10 of the Long Term Waste Management Strategy Report (2015).

Figure 4-2: Comparison of Waste Strategy Projections with Actual and Forecasted City of Toronto Quarterly Total Waste Generation

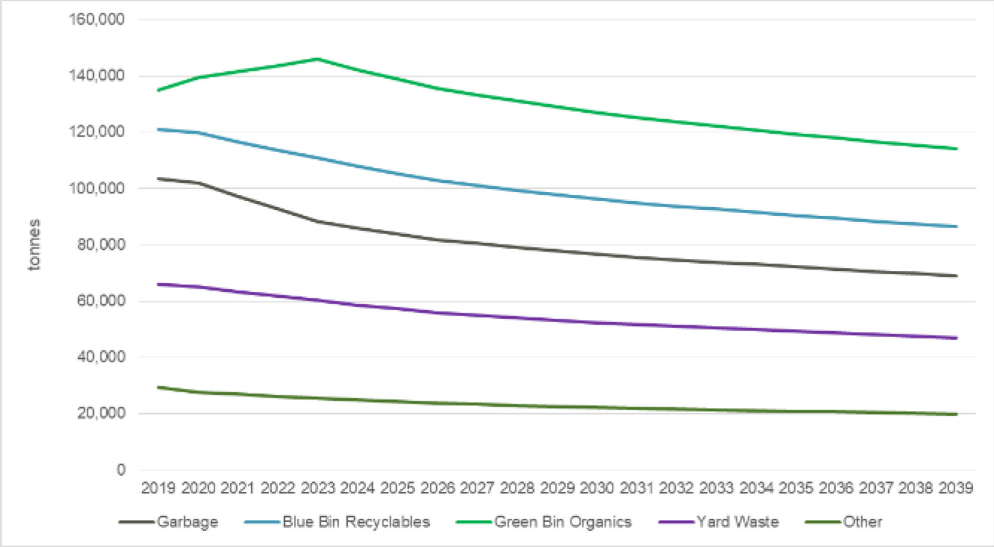


Sources: Actual Waste Values: from City of Toronto. Quarterly Total Waste data was extracted from aggregating monthly inbound tonnage data at the City's transfer stations for 2001 to 2018; Updated predicted values: Table 7 in Appendix A. Predicted Waste Strategy Values: Table A - 10 of the Long Term Waste Management Strategy Report (2015).

The following figures present the projected annual tonnes of waste (all types) generated by the Single family residential sector and the Multi-residential sector by material type.

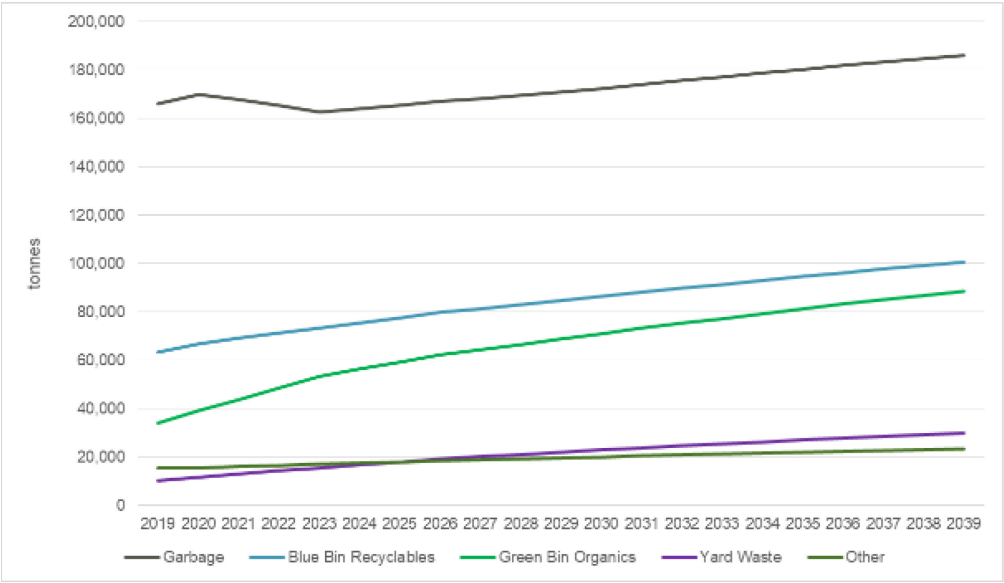
Considering the Single family and Multi-residential garbage streams, the allocation of the waste projections based on housing ratios over time results in there being higher estimated garbage quantities from the Multi-residential sector over time. While there could be a difference in reality between the projected housing ratios, and the actual proportion of Single family to Multi-residential households in the City's customer base each year, this is partially out of the City's control since Multi-residential buildings are able to opt in or out of the City's service. However, the overall forecasted total tonnes of garbage managed by the City as determined by the models indicates that overall there could be a relatively steady stream of garbage from residential sources (between 255,000 and 270,000 tonnes per year) available for MWP.

Figure 4-3: Projected Annual Waste Tonnes for the Single family Residential Sector



Source: Full Series Model Projections. Table 4-2.

Figure 4-4: Projected Annual Waste Tonnes for the Multi-residential Sector



Source: Full Series Model Projections, Table 4-3.

5 Waste Characterization Study

A waste characterization study was undertaken over a four week sampling period in November/December 2018. Just over six tonnes of material were sampled in this period from Single family residential (Garbage), Multi-residential (Garbage, Blue Bin Recyclables, Green Bin Organics) and Street Litter Bins (Combined Garbage and Blue Bin Recyclables).

Trommels as pictured in **Figure 5-1**, were used to sort materials into the following streams:

- Overs which included materials >100mm.
- Unders which included Large Fines (25mm-100mm) and Small Fines (<25mm).

Figure 5-1: Trommel Operation

Material was sorted into non-divertible material, non-acceptable Green Bin Organics, acceptable Green Bin Organics, non-acceptable Blue Bin Recyclables and acceptable Blue Bin Recyclable material. Acceptable Blue Bin Recyclable material was further broken down into clean and contaminated Blue Bin Recyclables to better analyze the condition of potentially marketable materials. City operations staff validated that the sort aligned with the City's current end market requirements.

Results of the study indicated:

- For all categories, paper and paper packaging formed the major component of contaminated Blue Bin Recyclables.
- Plastics comprised the largest portion of clean recycling for all streams but Multi-residential recycling, where paper packaging comprised the largest portion of clean Blue Bin Recyclables.
- For acceptable Green Bin Organics, tissue/toweling was found in slightly greater quantities than food waste in Single family residential Garbage and Multi-residential Blue Bin Recyclables. Food waste comprised the majority of acceptable organics in Multi-residential Garbage and Green Bin Organics.
- Pet waste comprised over half of the organic content of Street Litter Bin Garbage.

5.1 Laboratory Testing Methodology and Results

A composite sample of the fine material from each stream was sent for laboratory testing to better understand if the material is a suitable feedstock for organics processing. Samples were tested for organics and inorganics quality parameters, pathogens, trace metals, and biomethane potential which are typical tests performed for organic materials directed to aerobic and/or anaerobic processing.

In general, it appears that the Large and Small Fines that were tested have reasonable potential for processing through anaerobic digestion (AD). No significant issues related to AD processing were apparent in the laboratory tests. The more significant issue will be the degree of pre-processing that will be required to remove inorganic contaminants from the Unders (combined Large and Small Fines) pre (or

post) AD. Paper fibre in the Unders can be anticipated to become contaminated and would generally be treated as an organic material in further stages of organics processing.

Aerobic composting of the Large Fines (with the possible exception of the Large Fines from the Multi-residential Green Bin Organics) could be somewhat more problematic, due to the inorganic material content and presence of pathogens in higher concentrations in some of these materials. This would require additional front end and back end processing to remove inorganic contaminants and rigorous operational practices to address pathogens.

6 Projected Quantities of Waste Available

The composition of the audited waste streams was applied to the projected tonnes of material estimated for Single family residential Garbage, Multi-residential Garbage, Blue Bin Recyclables and Green Bin Organics.

Table 6-1 presents a summary of the estimated tonnes of acceptable Blue Bin Recyclables (clean and contaminated Recyclable material) and Green Bin Organics available from the Single family residential and Multi-residential sectors. Note that this is the total amount available in the source material streams and does not reflect the potential amount of material that could be recovered by any MWP technology. Generally most MWP technologies are capable of recovering only a fraction of the available material streams.

Table 6-1: Summary of Estimated Tonnes of Acceptable Blue Bin Recyclables and Green Bin Organics Available for Diversion in Source Material Streams

Source Material Stream	2019	2024	2029	2034	2039
Single family residential Garbage (2019 estimate - 103,400 tonnes)	54,700	45,500	41,200	38,600	36,500
Multi-residential Garbage (2019 estimate – 166,300 tonnes)	97,000	95,600	99,700	104,300	108,700
Subtotal Acceptable Blue Bin Recyclables and Green Bin Organics Available in Garbage	**151,700**	**141,100**	**140,900**	**142,900**	**145,200**
Multi-residential Blue Bin Recyclables (2019 estimate – 63,400 tonnes)	47,000	55,900	62,800	69,000	74,600
Multi-residential Green Bin Organics (2019 estimate – 34,100 tonnes)	28,700	47,500	58,000	66,900	74,800
Subtotal Acceptable Blue Bin Recyclables and Green Bin Organics Available in Source Separated Multi-residential materials	**75,700**	**103,400**	**120,800**	**135,900**	**149,400**
Grand Total of Acceptable Blue Bin Recyclables and Green Bin Organics Available for Diversion	**227,400**	**244,500**	**261,700**	**278,800**	**294,600**

Estimates for potential material recovery were developed for three scenarios, considering how mixed waste is initially sorted in a MWP facility (i.e. into Overs and Unders):

- Scenario 1 – Recovery of Green Bin Organics (including paper and paper packaging) in the Unders, and all clean paper, paper packaging, plastic and metal recyclables in the Overs.
- Scenario 2 – Recovery of Green Bin Organics (including paper and paper packaging) in the Unders, and all clean plastic and metal recyclables in the Overs.
- Scenario 3 – Recovery of Green Bin Organics (including paper and paper packaging) in the Unders, and clean PET, HDPE, metal recyclables in the Overs.

The following table presents the estimated tonnes of materials that could be recovered by sector and by the above scenarios, based on 2019 tonnes, assuming a theoretical 100 per cent capture rate.

Table 6-2: Estimated Tonnes of Materials that could be Recovered by Sector and Stream (2019) assuming 100 per cent Recovery

	Scenario 1 - Organics + all Clean Metal, Plastics, Paper Diversion	Scenario 2 - Organics + Metals, Plastic only Diversion	Scenario 3 - Organics + PET, HDPE, Metals Diversion
Single family residential Garbage (2019 estimated tonnes - 103,400)			
Organics (unders)	23,600	23,600	23,600
Recyclables (overs)	11,700	7,500	1,700
Total Available for Recovery	**35,300**	**31,100**	**25,300**
Multi-residential Garbage (2019 estimated tonnes – 166,300)			
Organics (unders)	40,700	40,700	40,700
Recyclables (overs)	16,900	10,300	2,500
Total Available for Recovery	**57,600**	**51,000**	**43,200**
Multi-residential Blue Bin Recyclables (2019 estimated tonnes – 63,400)			
Organics (unders)	4,900	4,900	4,900
Recyclables (overs)	26,800	4,500	2,300
Total Available for Recovery	**31,700**	**9,400**	**7,200**
Multi-residential Green Bin Organics (2019 estimated tonnes – 34,100)			
Organics (unders)	17,100	17,100	17,100
Recyclables (overs)	1,700	1,300	200
Total Available for Recovery	**18,800**	**18,400**	**17,300**

*Overs are materials >100 mm, Unders are materials <100 mm.

Based on the results of the waste characterization study, the quality of the Multi-residential Green Bin Organics was generally quite good. The proportion of acceptable organics is quite high in this stream (75 per cent) and the amount of Blue Bin Recyclables and non-acceptable materials (25 per cent) is substantially lower compared to Single family and Multi-residential Garbage. This material is suitable for source separated organics processing, and there is likely to be minimal benefit to overall diversion rates by directing this to MWP as only a small quantity of recyclables and possible some incremental change in organics recovery may be possible. It is recommended (as discussed further in Section 11) that Multi-residential Green Bin Organics not be directed to MWP in general, with exception being more highly contaminated materials which would be less suitable to source separated organics processing.

Based on the results of the waste characterization study, it does not appear that there would be a benefit from directing the Multi-residential Blue Bin Recyclables stream to MWP. The organics fraction in this material is very low (less than 8 per cent), resulting in little benefit from organics recovery. The proportion of clean Blue Bin Recyclables in this stream is significantly higher than in the other material streams, nearly 50 per cent compared to 16 per cent for the Single family Garbage stream and 15 per cent for the Multi-residential Garbage stream. It would likely reduce the ability to capture these clean Blue Bin Recyclables if they were co-mingled with other mixed waste streams with higher organic content.
For each of the potential residential garbage feedstock (Single family and Multi-residential garbage), and the three recovery scenarios, estimates of the potential tonnes of recovered materials[2] have been developed for:

- High range: +25 per cent Green Bin Organics recovery and 100 per cent recovery of targeted Blue Bin Recyclables.
- Mid-range: typical Green Bin Organics recovery and 75 per cent recovery of targeted Blue Bin Recyclables.
- Low range: -25 per cent Green Bin Organics recovery and 50 per cent recovery of targeted Blue Bin Recyclables.

[2] The apportionment of organics to the Overs and Unders can vary based on the organic composition and MWP facility design, and so a +/- 25 per cent variation in tonnage was applied to the organics projections.

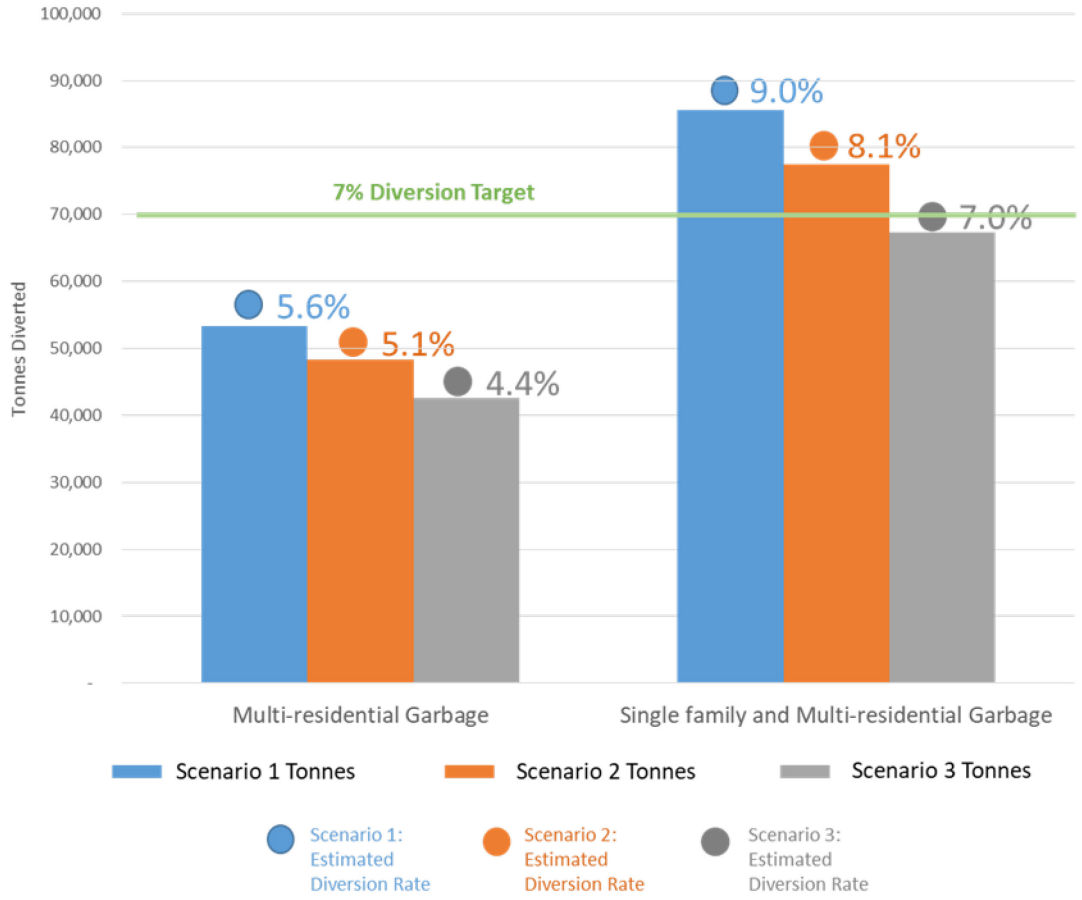
Figure 6-1 below presents the mid-range recovery estimates for the three recovery scenarios in the previous table for Multi-residential garbage alone, and the combination of Multi-residential and Single family residential garbage. These estimates represent reasonable recovery rates and indicate that:

- In order to achieve 7 per cent diversion from MWP, both Single family residential and Multi-residential garbage would have to be directed to MWP.
- While the majority of the diversion achieved relates to recovery of Green Bin Organics material, the ability to recover a broader range of recyclable materials including paper fibre and lower value recyclables (Scenario 1 and 2) would be required to meet or exceed 7 per cent diversion.

Overall, it would be difficult to achieve an additional 7 per cent diversion through MWP processing of Multi-residential Garbage alone. Both Single family residential and Multi-residential Garbage would have to be directed to MWP to achieve close to this amount of additional diversion.
Recovery of Green Bin Organics is the primary driver to achieve an additional 7 per cent diversion through MWP, with a small contribution from Blue Bin Recyclables recovery. The recovery of Green Bin Organics suitable for processing into marketable products will be the most critical component for any MWP technology considered by the City.

During the next steps in this Study, attention should be focused on the organics recovery components of the MWP systems, and the quality of the recovered organics stream. Testing of recovered organic material related to organics quality parameters (similar to those conducted as part of this study) will be necessary to determine the suitability of recovered organics streams for anaerobic digestion.

Figure 6-1: Estimates of Tonnes Diverted and Impact on Diversion Rates with Mid-range Recovery



Scenario 1 – Green Bin Organics (including paper and paper packaging) and all clean paper, paper packaging, plastic and metal recyclables.

Scenario 2 - Green Bin Organics (including paper and paper packaging) and all clean plastic and metal recyclables.

Scenario 3 - Green Bin Organics (including paper and paper packaging) and clean PET, HDPE, metals (recyclables).

7 Potential Recovery of Blue Bin Recyclables and Processing Approaches

Lower thresholds for contamination in recovered materials have been in effect since the enforcement of China's National Sword policy in 2018 with similar policies and programs being implemented in other nations. This has resulted in a decrease in the availability of end markets. It is anticipated that markets will continue to be more stringent in regards to contamination rates for the foreseeable future.

The available Blue Bin recyclable materials in the audited waste streams that currently have functioning and sustainable end markets primarily include clean PET, HDPE, metals and possibly polypropylene. Additional tonnes of plastics (e.g. polystyrene, polyethylene etc.) could be recovered, but it is uncertain if sustainable markets exist for these materials. The decisions made regarding plastics recovery through MWP will need to take into consideration the availability of these materials in the incoming waste stream, the level of investment and effort to recover them, and the market value of the material.

The majority of paper fibres in the garbage consisted of contaminated or non-recyclable materials. It will be necessary to examine each MWP technology's ability to separate out a clean and marketable paper stream and to determine if it would be worthwhile to recover paper materials from mixed waste through MWP. It may be viable to recover some clean cardboard materials for example. It will also be necessary to take a close look at the recycled paper fibre market, to determine the potential value of any recovered paper stream and how stringent the market specifications could be as part of MWP implementation.
As noted previously and below, it is not recommended that this material be included in MWP feedstock. If the MWP facility recovers some Blue Bin Recyclables from the Single family residential and Multi-residential garbage, there could be some value in co-marketing recyclables, depending on the quantity and quality of materials recovered. This would be a contractual issue the City would need to negotiate with their current Blue Bin Recyclables processing service provider. It is possible that the City would need to identify new markets for marketing materials that are more contaminated.

A MWP facility could provide some form of contingency recycling processing capacity depending on the facility design, in the event that the City's contracted processing capacity is unavailable. This would likely require integration of a by-pass in the MWP facility design to avoid co-mingling of the cleaner Blue Bin Recyclables with mixed garbage.

It would not be in the City's best interest to direct Multi-residential Blue Bin Recyclables to MWP as the City has invested considerable time and effort in developing and encouraging source separated diversion programs for the Multi-residential sector. The City has seen a gradual increase in diversion from the Multi-residential sector reflecting positive behavioural changes and results of the City's promotion and education campaigns.

8 Potential Recovery of Organic Material Streams and Processing Approaches

Additional Green Bin Organics processing capacity would be required to manage the organics fraction recovered through MWP. Additional Green Bin Organics processing capacity requirements would likely be in the range of 60,000 to 80,000 tonnes per year or more annually over the planning period depending on which materials are directed to MWP.

In general, the Large and Small Fines streams that were tested as part of this Study (where the majority of the Green Bin Organic materials were concentrated following the trommel separation) had reasonable potential for processing through anaerobic digestion (AD). The Small and Large Fines recovered in this Study did have higher inorganic contamination than the City's source separated Green Bin organics, which will require careful AD pre-processing design. These materials also had high pathogen content. These qualities make these materials less viable for aerobic composting.

With the City's existing Green Bin Organics capacity and the capacity procured at a private facility, the City has sufficient processing capacity for the Green Bin Organics it currently collects. The City currently does not have sufficient capacity to process the additional organic material recovered through MWP and the front-end processing systems at the existing City AD facilities may not be capable/or could be overwhelmed by the inorganic contamination present in the organic material recovered through MWP.

It may be reasonable to consider processing a portion of the Multi-residential Green Bin Organics through a future MWP facility depending on the level of contamination in the material:

- A MWP facility should be able to handle a more contaminated Multi-residential Green Bin Organics stream effectively and remove some of the inorganic contaminants pre organics processing.
- The Multi-residential Green Bin Organics would generally still be a cleaner material stream than the organics fraction recovered from mixed waste and would provide a cleaner organic fraction for secondary organics processing.
- Pre-processing through MWP should reduce the amount of inbound material sent to the City's AD facilities which could relieve capacity issues in the system.

9 Potential to Recover RDF or SRF from Residual Waste Streams

There are a number of MWP facilities operating across Europe and North America that recover solid recovered fuel (SRF) or refuse derived fuel (RDF) as one of their primary products. Higher heat value materials could be recovered from the Overs stream through MWP as an RDF. However, there is currently no broad market for RDF in Ontario. Most MWP facilities that produce an RDF in North America are associated with a thermal treatment facility which use the RDF as fuel. RDF markets in Ontario would be limited to the one operating waste to energy facility in the province which can accept waste from other municipalities and certain heavy manufacturing facilities (e.g. cement kilns) that are permitted to accept alternative fuels. Fuel analysis of the Overs streams was not undertaken as part of the waste audits. It is recommended that during the MWP pilot undertaken as part of this project, that solid fuel analysis be undertaken of the Overs fraction, to determine the potential fuel quality of this material. This will be necessary to determine the potential marketability of this material as a fuel.

10 Potential Impact on Disposal Capacity

It is estimated that, based on the mid-range recovery scenario modelled (see Section 6), an additional four years of capacity at Green Lane Landfill could be gained through the recovery of Blue Bin Recyclables and Green Bin Organics, if all Single family residential and Multi-residential Garbage is processed through MWP prior to landfilling. If additional tonnes are recovered as RDF, it is estimated up to an additional eight years of capacity would be gained.

This calculation demonstrates the impact of implementing MWP immediately (2019) to the City of Toronto's existing waste stream. It does not factor in the planning and implementation time that would be required to develop a new MWP facility.

11 Recommended MWP Feedstock

In summary, based on the preceding analysis, it is recommended that Single family residential and Multi-residential Garbage be considered as the primary MWP feedstock. More contaminated streams of Multi-residential Green Bin Organics could also be directed to MWP as appropriate. Based on the waste projections discussed in Section 4, between 269,700 and 255,200 tonnes of residential garbage could be directed to MWP. Based on the most conservative scenario presented and discussed in Section 6 (Scenario 3), in the order of 50,200 to 84,400 tonnes of Green Bin Organics and higher value Blue Bin Recyclables could be recovered from Single family and Multi-residential Garbage and diverted from landfill disposal. An additional 56,100 to 88,100 tonnes of RDF may be recovered if a market is available for this material.

12 Identification of Data Gaps

A number of data gaps were identified as part of this task which should be considered as the project progresses:

- Additional waste composition studies should be carried out over four seasons to provide a more robust data set. Material collected in different seasons is anticipated to have different levels of compaction, wetness, particle size, material composition and contamination levels. Additionally, the waste composition study examined only a few key material streams. Additional studies could include auditing non-residential sources (as this material is collected along with residential waste and there was no separate non-residential waste stream). It is also recommended that the liquid content, particularly for Street Litter Bins, be captured and weighed as part of the auditing process.
- It would be beneficial to be able to compare the detailed laboratory results for the Large and Small Fines of the audited material, to similar lab results for the Single family residential Green Bin Organics. This would assist in determining the suitability of the City's existing organics processing facilities (and AD processing approach) for the organic fractions that could be recovered through MWP.

13 Conclusions

The City should consider the following as this project progresses:

- Single family residential and Multi-residential garbage should be considered as the primary MWP feedstock. More contaminated streams of Multi-residential Green Bin Organics could also be directed to MWP as appropriate.
- The recovery of Green Bin Organics suitable for processing into marketable products will be the most critical component for any MWP technology considered by the City.
- Based on the waste projections, up to 269,700 tonnes of residential garbage could be directed to MWP over the planning period. Based on the most conservative scenario (Scenario 3), in the order of 50,200 to 84,400 tonnes of Green Bin Organics and higher value Blue Bin Recyclables could be recovered and diverted from landfill disposal. An additional 56,100 to 88,100 tonnes of RDF may be recovered if a market is available for this material.
- The contribution to diversion from recovering recyclables will depend on the ability to recover marketable paper fibres. The majority of paper fibres in the garbage stream consisted of contaminated or non-recyclable materials. It will be necessary to examine each MWP technology's ability to separate out a clean and marketable paper stream and to determine if it would be worthwhile to recover paper materials from mixed waste through MWP. It will also be necessary to take a close look at the recycled paper fibre market, to determine the potential value of any recovered paper stream and how stringent the market specifications are, as part of MWP implementation.
- Trends in Multi-residential service provision will need to be assessed, with or without any City policy changes, as this could significantly affect the quantity of Multi-residential material that could be directed to MWP.
- Considering the Single family and Multi-residential garbage streams, the allocation of the waste projections based on housing ratios over time results in there being higher estimated garbage quantities from the Multi-residential sector over time. While there could be a difference in reality between the projected housing ratios, and the actual proportion of Single family to Multi-residential households in the City's customer base each year, this is partially out of the City's control since Multi-residential buildings are able to opt in or out of the City's service. However, the overall forecasted total tonnes of garbage managed by the City as determined by the models indicates that overall there could be a relatively steady stream of garbage available from all residential sources (between 255,000 and 270,000 tonnes per year) available for MWP. As a result, direction of both the Single family and Multi-residential garbage streams to MWP should be considered.
- Attention should be focused on the organics recovery components of the MWP systems, and the quality of the recovered organics stream. Testing of recovered organic material related to organics quality parameters (similar to those conducted as part of this study) will be necessary to determine the suitability of recovered organics streams for anaerobic digestion. AD pre-processing design will need to consider the high levels of inorganic contamination in organics recovered through MWP.

- Fuel analysis of the Overs streams was not undertaken as part of the waste audits. It is recommended that during the MWP pilot undertaken as part of this project, that solid fuel analysis be undertaken of the Overs fraction, to determine the potential fuel quality of this material. This will be necessary to determine the potential marketability of this material as a fuel.
- Certain data gaps have been identified as of this point in the Project as indicated in Section 12 above. These gaps should be addressed to the extent possible as work proceeds on this project.