

## Foreword

In 1991, the Environment and Plastics Institute of Canada (EPIC) and the Ontario Ministry of Environment and Energy (MOEE) co-sponsored the development of the Recycling Collection Cost Model (RCCM) to assist municipalities to:

1. calculate the impact of adding recyclable materials to a curbside collection program; and
2. increase the overall cost effectiveness of municipal recycling programs.

Subsequent to the release of the RCCM in 1992, EPIC and MOEE co-sponsored the development of the Materials Recovery Facility Processing Cost Model (MRF-PCM). This model, released in 1995, helps guide municipalities in the examination of the cost implications of processing recyclable materials in a MRF under different processing conditions.

To be fully compatible and interactive with the MRF-PCM and to address some of the shortcomings of the original version, the RCCM required an upgrade. To be fully compatible, an expanded materials list, a section on cost allocation, and the ability to easily link the output with the *Recycling Management Report* in the MRF-PCM had to be incorporated.

With the support of EPIC and the MOEE, the upgrade to the RCCM was completed. Compared to the first version of the RCCM, the new version now has the ability to undertake the following:

- Examine a greater number (up to 35) of recyclable materials;
- Apportion materials collected to dwelling type (i.e., single family dwellings vs. apartments) based on input capture rate data;
- Analyze and optimize individual compartment sizes within the truck;
- Assess the impact of material compaction within a compartment; and
- Allocate costs to individual materials by weight, volume, units or activity.

The ability to examine more than one scenario at the same time without having to run the model 'from scratch' twice was a key shortcoming of the first version, as expressed by its users. The new model is now capable of examining two scenarios at the same time allowing the model user to compare time allocations to tasks, fleet requirements and costs.

Version 2.0 retains all of the key functions of the first version including the provision of:

- a cost accounting method for recycling programs;
- total annual capital and operating collection costs;
- truck fleet and cost requirements of recycling programs;
- truck fleet and cost requirements as a result of adding new materials; and
- ability to examine program time efficiencies by outlining time requirements for the activities of loading the vehicle, driving on-route, driving off-route (haul time) and dump time.

With these changes which make the model a much more powerful planning and optimization tool, the RCCM will continue to be of interest to the following groups:

- municipalities and private sector firms examining the requirements and costs of establishing or expanding a curbside source separation program for recyclable materials;
- municipalities examining various collection factors of their existing program for the purpose of controlling or reducing costs and optimizing fleet utilization; and
- public interest groups and citizens that are interested in obtaining detailed information on the requirements and costs of establishing, maintaining or expanding a curbside collection program.

The RCCM is available in Microsoft Excel™ v.5.0. It is recommended that at a minimum the model be run on a 386/25 with 4MB of onboard memory. The manual and diskette of the RCCM can be obtained from either EPIC - Telephone: (905) 678-7748; Fax: (905) 678-0774 or MOEE - Telephone: (416) 325-4422; Fax (416) 325-4437. Questions on the use of the model can still be

addressed to Daniel Lantz, Proctor & Redfern Limited - Telephone: (416) 445-7022 x2466; Fax (416) 445-5276.

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## **Disclaimer**

The statements, opinions, summaries and conclusions expressed in this report are those of the Project Steering Committee, comprised of Proctor & Redfern Limited (the consultant for the project) and individuals from the EPIC and MOEE. The statements and opinions do not necessarily represent those of the full membership of EPIC or MOEE or all municipal or private sector representatives contacted for this study.

# Recycling Collection Cost Model - Version 2.0

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## **1.0 INTRODUCTION**

### **1.1 Purpose**

This report serves as a manual to describe the various steps and procedures required to use the Recycling Collection Cost Model Version 2.0 (RCCM) for the purpose of determining the cost implications of:

- establishing a residential curbside collection program for recyclable materials;
- expanding a residential curbside collection program for recyclable materials by adding:
  - new materials, or
  - new sources (e.g., institutions apartment buildings, commercial establishments, etc.)
- improving a curbside collection program for recyclables by increasing:
  - participation rates
  - material capture rates
- increasing the efficiency of a current program through:
  - the examination of time allocations to specific events,
  - the impact of material characteristics (e.g., compacted, non-compacted volume, material mixes) on compartment size and vehicle requirements, and

- the impact of time per setout on vehicle requirements.
- collecting individual material - through the use of user defined cost allocation.

## **1.2 Contents of the Report and Manual**

The report and manual that have been developed include:

- **Chapter 2.0** - identifies and discusses recycling program collection factors that will have an impact on program costs. This chapter includes an examination of recycling program and route characteristics. Sensitive factors which affect recycling program operations and costs are also outlined.
- **Chapter 3.0** - includes an introduction to the RCCM including the model structure and input and calculated variables within the model.
- **Chapter 4.0** - includes a step by step "operator's manual" that describes each line or column of the model. "Sampletown, Anyprovince" is used as an example municipality to show how the model works. The figures in Chapter 4.0 show the actual output of the model using the Sampletown example. Sampletown, Anyprovince represents no actual community, although the values used as inputs represent reasonable values which could be used by the *model user* until more accurate or appropriate data are compiled specific to the program in question. Also included is a brief trouble shooting section of items to examine when the model does not provide the user with "expected" output.
- **Chapter 5.0** - discusses cost allocation and the cost allocation worksheet which are included as part of the RCCM. Because of the potentially confrontation nature of the output of any cost allocation exercise, no absolute values are shown in the example. The cost allocation chosen is completely user defined although some algorithms are included should the *model user* wish to use a simple approach by weight, volume or units.

### 1.3 Potential Users of the Model

The information presented in this report and the "how to" manual will be of interest to the following groups:

- municipalities that are examining the requirements and costs of establishing a curbside source separation program for recyclable materials,
- municipalities that are examining the requirements and costs of expanding a curbside source separation program for recyclable materials,
- municipalities that are examining the various collection factors of their existing program for the purpose of controlling/reducing costs,
- private sector firms engaged in (or considering) the collection of recyclable materials, and
- public interest groups and citizens that are interested in obtaining detailed information on the requirements and costs of establishing, maintaining or expanding a curbside collection program.

The RCCM has been developed to be used either as a management tool or as a planning tool for expanding a program to include new houses/apartments/schools, etc. or new materials. The costs associated with pilot projects or initiating new mechanisms to increase material recovery rates through public education and promotion, mandatory recycling, award (incentive) systems, and charging households for service can be examined using the RCCM.

The RCCM can also be used for budgetary planning and for providing cost information to councillors, operators, etc.

## 1.4 Methodology

The following activities have been undertaken over the past five years since the development of the first collection cost model which subsequently have gone into completing this manual:

- reviewed or obtained file information for several operating recycling programs;
- met with representatives from several recycling programs; and
- conducted a literature survey to identify recycling program collection cost information.

**NOTE:** *In the example used in this manual, an increased level of efficiency has been built into the program (i.e., through the use of the RCCM) in an effort to reduce program costs. As programs are more closely examined to determine opportunities to increase efficiencies and to ensure that the collection system is compatible with the processing system, collection costs will ultimately decrease.*

## **2.0 IDENTIFICATION OF RECYCLING PROGRAM COLLECTION FACTORS**

The collection component of the recycling program has a direct impact on the processing of the material and is critical to the overall success, efficiency and overall cost of the entire program. Therefore, obtaining a comprehensive understanding of the numerous factors that will affect the collection program is critical. This chapter provides information that will assist you in identifying key factors that will influence collection activities and collection costs. These factors include, but are not limited to:

### **Recycling Program Characteristics**

- household demographics
- selection of materials
- recovery rates
- collection techniques, equipment and staff requirements

### **Route Characteristics**

- participation and setout frequency
- time per stop
- pick-up intervals
- on-route versus off-route time

Collection costs vary from municipality to municipality for two main reasons. First, the factors identified above will vary from municipality to municipality. Some will vary more than others.

The second main reason for the range of collection costs is associated with the 'accounting systems'. Municipalities and/or the private sector often use different methods to allocate collection costs. For example, a vehicle may be used to collect both garbage and recyclables (i.e., as occurs with co-collection programs which are more common in the United States than in Canada). However, capital costs associated with the use of the vehicle may not be included because they have been 'paid' by another department. Also, a private company will depreciate capital costs, possibly over the length of the contract, while a municipality may not.

Further complications arise when collection costs are merged with overall recycling program costs making direct comparisons very difficult. For example, what percentage of a route supervisor's time (labour costs) is actually devoted to collection versus public education and promotion?

## **2.1 Recycling Program Characteristics**

### **2.1.1 Household Demographics**

The number of households (single family or multi-unit) served (or to be served) by the recycling program can be obtained from the planning department. Obtaining an understanding of the population that lives within the municipality will assist with the expansion or establishment of the recycling program. Useful information to obtain would include:

- family size;
- owned versus rented households;
- income categories;
- preferred language(s); and
- housing density.

For example, current demographic information and recycling program impact can be used to approximate what may occur in a new subdivision that will be joining the recycling program.

### **2.1.2 Selection of Materials**

Three critical areas should be investigated to maximize opportunities to divert more recyclable materials through a recycling program:

- targetting new marketable materials (tubs, mixed household paper, polystyrene, etc.);
- targetting new sources (additional apartments, rural households, commercial establishments, institutions, etc.); and
- increasing existing material recovery rates (e.g., more public education and promotion).

The number of recyclable materials included in recycling collection programs has increased to the point that some programs now collect more than 20 different items. Expanded recycling programs are not restricted to large urban areas or those communities that have an end market in close proximity but rather are being undertaken by small and large communities alike. For all municipalities however, cost implications and availability of markets are two important factors that must be addressed prior to adding materials to the existing recycling program.

For a recyclable material to be included as a target material in curbside collection programs, it should:

- represent a significant portion of the waste (generally >2% by weight) or have other desirable attributes (e.g., high market value),
- be readily recognizable by householders for separation,
- have an acceptable cost of collection and sorting relative to its market value, and
- have an identified market with reasonable expectation of continuity.

### **2.1.3 Material Recovery Rates**

A review of numerous studies undertaken in Canada (and some in the United States) suggest that per capita generation rates for residential waste, including the quantity of materials available for recycling, vary based on several factors including:

- urban versus rural populations;
- socio-economic characteristics;
- ratio of population that live in multi-unit dwellings (i.e., apartments) versus single family households;
- weight of the newspapers in major urban areas (e.g. Toronto Star or Calgary Herald versus the North Bay Nugget), and
- average size of the house lot.

The amount of recyclable material that will actually be recovered by the recycling program is a function of quantity available, participation and capture rates. Participation and capture rates, when combined, become the material recovery rate. The process to determine the amount of a recyclable material that you will likely recover is illustrated on Tables 2.1 to 2.4.

### **Step 1: Estimate Quantity of Recyclable Material Available Per Capita (Table 2.1)**

The quantity of recyclable materials available refers to the quantity (kilograms or volume) of materials that are generated by consumers in the home. Quantity available will depend on how the source is defined (e.g., all households with access to depots, all households with curbside service, etc.). This information can be estimated for the community in a similar format to that identified on Table 2.1.

## **Step 2: Estimate Recycling Program Participation Rate (Table 2.2)**

Participation rate refers to the percentage of residents that use the curbside collection service on a regular basis (usually once a month as a minimum). Participation rates have been shown to vary in curbside collection programs and recycling depots directly with:

- the frequency of collection;
- the quality of service (e.g., collector's motivation and adherence to rules);
- household demographics;
- how well the program is promoted - both directly (information sent to the household) and indirectly (information displayed in shopping centres and newspapers);

Table 3.1

Table 3.2

- the level of convenience provided to the participants (e.g., container types, location of depots, etc.);
- whether or not the program is mandatory; and
- how it is enforced.

There has been a number rate studies undertaken. The results from these studies consistently indicate that participation rates generally average between 75% and 95% as shown on Table 2.2. Studies undertaken in the past three years also indicate that participation rates vary by type of recyclable material.

### **Step 3: Estimate Recycling Program Capture Rate by Material (Table 2.3)**

Capture rate refers to the percentage of the recyclable materials that are actually captured from the recyclable materials available (generated). Capture rates are likely to vary for each recyclable material based on:

- the ease of identification of a material;
- household demographics;
- in which room of the house the material was generated;
- the material type (e.g. glass, plastic - some materials are more convenient or easier to adapt to reuse in the home, e.g. margarine tubs for storage);
- the material preparation requirements in the household or other location (e.g. containers of solid foods typically have lower capture rates because they are harder to clean out); and
- program promotion and education.

Traditional recyclable materials typically have higher capture rates than recently added materials (Table 2.3). Many householders have been capturing traditional materials for more than five years. Therefore, this activity has become a daily routine for many residents. It is expected that over time and with increased public education and promotion, new materials will achieve similar capture rates.

Table 3.3

Table 3.4

#### **Step 4: Estimate Quantity of Recyclable Material Recovered Per Capita (Table 2.4)**

Recovery rate refers to the percentage of a specified recyclable material that may be recovered through a recycling program. The recovery rate is dependent on the participation rate and capture rate as is calculated as follows:

$$\text{Recovery Rate (\%)} = \text{Participation Rate (\%)} \times \text{Capture Rate (\%)}$$

The quantity of material recovered or recoverable refers to the quantity (weight in tonnes or volume in cubic metres) of recyclable materials recovered or potentially recoverable from households. It is a function of the recovery rate factors and quantity available:

$$\begin{aligned} &\text{Quantity Recovered or Recoverable (tonnes or cubic metres/capita/year)} \\ &= \text{Recovery Rate (\%)} \times \text{Quantity Available (tonnes or cubic metres/capita/year)} \end{aligned}$$

The quantity that is expected to be recovered for the recycling program is determined by using the value (or range) identified on Table 2.4 and multiplying by the total population that will be served by the recycling program. For example, in an urban community of 100,000 residents in the Greater Toronto Area (GTA) currently served with curbside collection, it is estimated that 190 to 540 tonnes of HDPE containers would be collected on annual basis.

The estimated quantity of recovered HDPE containers would be entered into the computer model in column 44x for Scenario #1 or column 57x for Scenario #2.

#### **2.1.4 Collection Techniques, Equipment and Staff Requirements**

As indicated previously, collection costs change from municipality to municipality. However, collection costs are generally minimized when:

- vehicles are loaded as quickly as possible;
- large vehicle capacities reduce the number of trips to unload; and
- the maximum use is made of the vehicle's capacity.

Collection techniques should complement activities of the Materials Recovery Facility (MRF) or transfer station. For example:

- a MRF that is capable of sorting commingled materials (e.g., mixed fibres from one compartment and commingled containers from another), either mechanically or manually, would not require intensive sorting at the curbside/depot;

- a MRF/transfer station that merely bulks homogeneous material would require intensive sorting at the curbside/depot to ensure that contamination levels are low, "double handling" of materials is not required and the material meets end market specifications; and
- a MRF that separates one material from another works more efficiently when the material mix is compatible (e.g., not mixing glass with fibres, commingled fibres, all containers (with or without glass depending on the MRF configuration)).

Because of the varying nature of one recycling program to another, the number of setouts each driver will pickup per workday varies with the collection frequency, number of materials in the program and the number of sorts that must be done at the curb. During a typical work day (nine hours), an operator will be able to pickup between 400 (multiple curbside sorts) and more than 1,000 (commingled collection) setouts.

*Ultimately the collection program should be established to be compatible with the MRF to maximize the efficiency of the overall program.*

## Frequency and Coordination of Collection

Adding new materials to a recycling program generally results in an increase in the frequency of collection as more containers are placed at the curb each week. By adding more materials to the recycling program, participants will find their containers are filled to capacity much sooner. Larger containers, multiple containers or a mixture of container types may accommodate the excess materials to some extent and help keep setout frequencies reduced. However, with some programs expanding the list of acceptable materials and decreasing the collection frequency to once every two weeks (or less), overall setout frequencies (i.e., the percentage of households that will have a container set at the curb for collection each period) is exceeding 80% in many programs. As participation rates increase to above 90% and more materials are continually added, overall setout frequencies and, potentially the number of vehicles required will also increase without examining other means of *improving overall recycling program efficiency opportunities*.

The frequency of collection plays an important role in the success of any curbside recycling program. Higher participation rates are generally reported in programs that provide weekly recyclables collection on the same day as garbage collection as residents need only to remember one day for putting out both. However, in order to reduce collection costs, many municipalities have moved to biweekly collection and are considering other collection schedules to minimize program costs (e.g., monthly fibre collection). As well, where biweekly collection has been in place for a long period of time (i.e., more than one year), participation and capture rates are meeting weekly rates.

Education is the key to successfully implementing changes in an existing program. Providing concise information to householders along with any changes required in the setting out of materials in the Blue Box will help reduce contamination problems and increase capture rates.

## 2.2 Route Characteristics

Route characteristics are variable factors that affect collection program effectiveness and efficiencies. These factors include, but are not limited to, the time spent at the curbside by the operator, the distances a truck travels between setouts, distances between the route and the off-load site(s), topography and street patterns (e.g., dead end, one-way streets).

In the following discussion, the major factors that affect a curbside collection program are highlighted and it is shown how they interact and can be manipulated to provide cost and impact estimates. Default values for a number of model characteristics are provided in Table 2.5.

### 2.2.1 Participation and Setout Frequency

Participation and setout frequency affect the model in slightly different ways. The **Participation Rate** is an indicator of the percentage of households that do recycle and put out their recyclables at some time interval, (i.e., every week or once per month). The **Setout Frequency** is an indicator of how often the containers are placed at the curb by a participating household.

These two factors are required to determine the volumes per stop and number of stops. They are then incorporated into the calculations of time and cost with the time per stop and other truck utilization calculations. These are factors that can be manipulated in the model to estimate potential impacts of promotion campaigns, user pay programs, etc.

Participation rates are determined primarily by monitoring collection programs over a specified period of time (a minimum of six weeks is required). The setout frequency can be determined while undertaking the participation rate study. There are a number of studies available and an estimate has been provided (Table 2.5).

Table 2.5

### **2.2.2 Time Per Setout**

The time per setout (also referred to as the time per stop) is one of the most sensitive factors affecting the costs of curbside collection programs. A setout requires the operator to get off, or out of the truck, pick up the curbside container(s), put the contents in the truck, replace the container and return to the truck. On occasion, inspection of the container contents, gathering of loose material, etc. are non-regular direct activities that also occur and add to the time required at each stop.

Considerable effort should be given to determining the **Time per Setout** value(s) for the model. Default values derived from other studies are provided, but program specific data should be used wherever possible.

During a review of operations or consideration for including additional material(s) to the program, the operator should consider different methods of containing and handling the material(s). The time at the stop is highly variable and impacted by:

- how the recyclable material is placed at the curb (e.g., bagged, in a Blue Box, a rollout cart, etc.);
- the quantity of material that is placed in the curbside container that requires curbside sorting;
- how the driver loads the recycling vehicle (e.g., by throwing material into compartments); and
- the type of recycling vehicle used (e.g., loading height and access of loading openings).

Numerous alternative approaches are available to an operator, but these may be classified into three basic methods outlined below (Table 2.6 provides an example of how these methods would be applied to arrive at a sorting time per stop for a Blue Box program):

- **Isolated**

Isolated refers to a material that is placed at the curb and handled completely separate from other materials. An example would be the bundling and handling of newspaper (ONP) separately from other materials. This methodology would require two to three seconds per stop for one material. If residents bundled their OCC, magazines, etc. as requested, the driver would have to simply grab

the bundle and place it in the side hopper. This would add only approximately one second to the stop time. However, if the OCC is not bundled and pieces have to be separated from the rest of the materials, then times as occur with “separated” items (below) would apply. Overall, in the example, approximately six seconds would be spent on isolated sorting activities.

## Tables 2.6

- **Separated**

Separated refers to a material (or materials) that is placed in the Blue Box by the householder and picked out separately by the operator for placement into a separate truck compartment. An example would be the handling of glass containers into a separate compartment. This would also apply to any fibres that had to be removed from the box (or if fibres are separated into two compartments). To sort clear and coloured glass into two separate compartments, and to manage the mixed and layered materials, in the example, would require approximately 20 seconds per stop, depending upon the number and volume of material.

- **Mixed**

Mixed refers to a mix of materials that require no specific sorting but are dumped, mixed, into one compartment. An example of this would be aluminum, steel and PET containers placed into one compartment. These materials would take approximately four seconds to handle.

Included in the times to sort is time to move between each of the compartments that contain the isolated, separated and mixed materials. Generally two seconds is spent moving each time the truck

compartment is changed and each of the sorting methods is used. Therefore, if three sorting methods is used, six seconds would be added to the sort time. This time is included in the explanations of the sorting methods outlined above.

**\*NOTE:** *Table 2.6 provides an estimate range for the time requirements for the **model user**, as an example only, for an expanded Blue Box program. The actual time per stop may vary from program to program even for the same items in the Blue Box. As many householders have the tendency to create, in the vernacular “lasagne” in their Blue Box (i.e., the layering of materials - fibres - containers - fibres - containers - glass - fibres, etc.), this can dramatically impact the time per setout.*

*It is recommended that those responsible for recycling operations should consider obtaining accurate and reliable information on time per stop impacts when considering additional materials and/or methods.*

### **2.2.3 Pick-up Intervals**

The pick-up interval refers to the distance between stops. It is another highly sensitive factor and is impacted greatly by collection frequency and setout. The reason for this is that the distance and speed of travel between pick-ups provides the time between stops. As in the discussion on time per stop, the time between stops has a high frequency and subsequently can influence the cost of the program.

The pick-up interval is dealt with in the model with the **Pass Spacing, Setout Frequency and Average Route Speed**. A user of the model can determine the average spacing by requesting route

drivers to measure the distance of a route (only once), and then dividing by the number of households on the routes (usually available from route supervisors). The setout frequency can be determined from route supervisor records or a sample study to determine the average number of pick-ups per route. Average route speeds for urban, semi-urban and rural (denoted low, medium and high) settings are shown in Table 2.5.

#### **2.2.4 On-Route Time Versus Off-Route Time**

The time spent by collection drivers can be classified as on-route, being direct costs, and off-route, being a mix of direct and in-direct costs. The on-route time is primarily covered by aggregating time per stops and intervals between stops. The off-route time is comprised of travel to and from route, to and from off-load site and the time to off-load materials.

The primary off-route factors accounted for in the model are **A.M. Truck Inspection, A.M. Drive to Route, and End of Day Dumping**. These activities do not have a high frequency of occurrence, relative to the previous two factors. They can however account for a reasonably high proportion of total work day and therefore should be estimated accurately. The route supervisors can likely provide the off-route information required by the model.

### **2.3 Other Cost Factors to Consider**

The amount of material in a setout is an indirect factor in program costs. The amount of material may or may not contribute to the time per stop. For example, the amount of glass containers in a standard

curbside sorting collection program may be directly proportional to time and cost if it is sorted from the other materials in the curbside container. Whereas the number of PET containers in the same program may not be proportional to time as it may be the last material, along with cans, dumped into a compartment.

The amount of material has significant implications when considering the methods and costs of adding additional materials to the program. Increases in material quantities can impact time per stop and will impact utilization of trucks. Both of these areas require the *model user* to consider collection methods, truck compartment allocations, material mixes on the truck, off-loading patterns, etc. in order to maximize program efficiency.

## **2.4 Sensitive Factors**

There are a number of factors that will affect the cost of the recycling program. Sensitive factors are those which, if they are changed even slightly, may affect the cost of the recycling program to a measurable extent. The degree of sensitivity of the factors will vary between recycling programs.

The RCCM can be used to determine degrees of sensitivity. Within the RCCM, there are more than twenty different, non-monetary variables that will affect the fleet and labour requirements and, consequently, the cost of the program. Five of these variables will be examined for their sensitivity in affecting costs of a collection program. They are as follows:

1. Time per setout

2. Pass spacing (Distance between houses/apartments)
3. Setout frequency
4. Length of workday
5. Weighted average density of the materials

### 2.4.1 Time Per Setout

Time per setout is one of the most sensitive factors in collecting recyclable materials. Time per setout relates to the efficiency of the recycling collection system. The change of a few seconds in the time per stop can mean the difference between adding or eliminating one truck and person. This is due to the high frequency of stops in most collection programs.

#### **Example: Time per setout sensitivity**

$$800 \text{ stops/route} \times 5 \text{ routes/day} \times 4.5 \text{ days/week} = 18,000 \text{ stops/week}$$

A change (e.g., due to the addition of a new material or changing the method of material handling), can add 5 seconds/stop, resulting in

$$\underline{18,000 \text{ stops} \times 5 \text{ seconds}} = 25 \text{ hours/week}$$

*3,600 seconds/hour*

This can be interpreted and managed in a number of ways including an additional 5 hours per day (one hour per route). Considering that in an average 8 hour workday that only about 60-70% of the actual day is available for collection (considering time for lunch, breaks, traffic, driving to and from the route, etc.), another truck (or permanent overtime) would be required to service the households not served because of the additional 5 seconds per stop.

Some programs may be able to absorb added seconds per stop because of time available is longer than the time it takes to complete the route. In an examination of other recycling programs undertaken over the past five years in Ontario, it was seen that, in almost all instances, adding any additional time per setout would lead to an increase in the cost of that program.

Generally, as more materials are added to the program, the time taken to sort the materials, and consequently the costs, will increase. Improving the method of collection to improve time efficiency at the curb (e.g., combining items to be picked up - commingled collection) can help decrease the time spent sorting materials at the curb, thereby decreasing the overall costs of the collection program. However, this may come at the expense of increased processing costs. *Again, the collection and processing systems should be complementary to decrease the overall costs of the program.*

#### **2.4.2 Pass Spacing (Distance between households/apartment buildings)**

The distance between houses is an important consideration when establishing or planning to expand a recycling program into rural areas (i.e. areas with a greater distance between houses). Ultimately the goal of the recycling program is to collect as much material as quickly and efficiently as possible. The time spent travelling between houses is inefficient in as much that no materials are being collected while

driving. As the distance between pick-ups increases, the costs increase. The relationship between distance and costs shows a step-linear pattern (See Figure 2.1).

The results of an examination of cost versus pass spacing can serve as a useful planning tool in helping define the limit of how far to extend curbside collection of recyclables and still maintain an acceptable operating cost per tonne of material collected.

### **Figure 2.1: Step Linear Relationship of Pass Spacing to Cost for Collection**

#### **2.4.3 Setout Frequency**

How often a container is set out at the curb affects the cost of the program. As the setout frequency increases, the operator has to stop more often. This can be costly if there is not a lot of material in the curbside container (i.e., the container is not full).

Much of the cost associated with the collection of recyclables relates to time spent driving between stops and to and from the route. To improve costs, the program should collect as much material per

stop for the time it is on the road. By having residents only setting out their Blue Boxes when they are full (i.e. decreasing the setout frequency) the cost of the program should decrease.

#### 2.4.4 Length of Workday

Generally, the length of the workday is a very critical factor in determining the costs of a recycling program. In an examination of any given workday, a number of events occur which do not involve the act of collecting recyclable materials.

Considering that the 80 - 195 minutes must be removed from the length of the workday before collection can begin, to improve time efficiency and potential collection, the length of the workday is a critical factor. Efficiency in collection increases with an increasing workday length because the amount of time lost to the events on Table 2.7, as a percentage of the total time available for work decreases.

**Table 2.7: Daily Off Route Events Which Result in Time Lost to Collection**

EVENT	DESCRIPTION	TIME "LOST"
A.M. Truck Inspection	The time taken by the generator to do a "walk around" inspection of the truck prior to heading out for the day.	10 - 30 minutes
A.M. Drive to Route	The time taken to get from the truck/recycling depot to the route.	5 - 45 minutes

Time for Lunch and Breaks	The time given to the operator for lunch and breaks.	60 - 90 minutes
P.M. Drive Back to the Depot	The time taken to take the truck from the route/recycling depot back to the truck storage depot (if applicable).	5 - 30 minutes
<b>TOTAL TIME LOST FROM COLLECTION</b>		<b>80 -195 MINUTES</b>

**Example: Comparison of number of day in the workweek on time efficiency**

Assume that the time lost to the events in Table 2.7 totals 2 hours for every day that the truck is on the road. Two "typical" workweeks are shown below in Table 2.8.

**Table 2.8: Length of Workday Time Efficiency**

<b>Factor</b>	<b>Workweek 1</b>	<b>Workweek 2</b>
Days of collection	5	4
Hours per day	8	10
Time per day not available for collection (hrs)	2	2

Total hours of work per week	40	40
Total hours lost per week	10	8
Time available for collection per week (hrs)	30	32
<b>Rate of time efficiency</b>	<b>75%</b>	<b>80%</b>

A five per cent increase in efficiency applies to each vehicle. Therefore, if the program employs 20 vehicles, a 100% cumulative savings (equivalent to one truck) could be realized.

#### 2.4.5 Material Densities

It is common knowledge that the recycling truck cubes out by volume before it reaches its axle weight limitation (i.e., recycling programs are volume dependent). To reduce costs of the collection program, it is better to keep the density of the materials as high as practically possible. For example, adding film plastic to newspapers (even if kept in one large bag before placing in the fibres compartment) increases the density of the film plastic more than ten times than if it was to be put into the truck in a separate compartment. This improves truck space utilization and decreases the cubing out rate.

How the materials are grouped onto the recycling truck is very important as the utilization factor of the truck will ultimately be decided by the weighted average density of the materials being collected.

### 3.0 INTRODUCTION TO THE RECYCLING COLLECTION COST MODEL

#### 3.1 Overview

The Recycling Collection Cost Model (RCCM) can be used in a number of applications. Six of the key applications are shown in Table 3.1. The model is not restricted to reviewing the costs of an entire recycling program, but as it can be applied to a single route, any number of routes, or to an entire program simply by altering the scale of the input (i.e., only input information for one route rather than the entire program). However, the drawback of applying the model to a single route is that most of the information on recycling programs is collected on a program basis. That is, generally, data are actually average values based on an entire municipality or program. Therefore, the average values may be representative of a single route. However, as a result of rising costs and tighter fiscal policies, recycling programs are now being examined more closely to determine opportunities to best utilize the financial resources available to the municipality or operator.

**Table 3.1: Applications of the Recycling Collection Cost Model**

- |  |
|--|
| <ol style="list-style-type: none"><li>1. Examining the costs associated with starting a program</li><li>2. Calculating the costs associated with expanding a program by:<ul style="list-style-type: none"><li>- adding new materials</li></ul></li></ol> |
|--|

- adding new sources

3. Calculating the costs associated with initiating programs/mechanisms to increase material recovery rates.
4. Managing a program or route
5. Reviewing costs associated with a pilot program
6. Budgetary planning

## 3.2 Model Structure

This section provides an overview introduction to the RCCM. The line by line manual of how to use the model is contained separately in Chapter 4. The model is capable of examining two scenarios simultaneously. The inputs for Scenario #2 are generally right beside those for Scenario #1. However, for two pages, because of the number of inputs (or outputs) the two pages for the two scenarios follow each other (i.e., they are consecutive).

When you open up the model on the computer you will find that it includes two worksheets (RECYCLING MODEL and COST ALLOCATION). “RECYCLING MODEL” covers twelve pages and COST ALLOCATION contains four pages. The model is structured so that the *model user* can proceed from top to bottom in a logical order filling in the necessary lines with information. The *model user* is not required to cursor between pages to find the next line. Each of the pages will be discussed briefly below.

### **PAGE 1: Community Demographics**

This page is setup for the *model user* to input information on household and apartment demographics (i.e. number of houses, apartments, population, etc.). Entered here are all aspects associated with participation, setout frequency and the frequency of collection (e.g., weekly, biweekly, monthly). If you are using the model to determine the impact of adding new households or apartment buildings to the existing (i.e., base) program, by entering the population, number of households/apartment buildings and units and participation characteristics, the model will recalculate the quantity to be collected and the fleet required to service all households and apartments now in the program.

## **PAGE 2: Materials Collected - Scenario #1**

The *model user* is required to input the quantity of each material collected, its compartment number and the estimated density of each material *as it sits at the curb*. The model is capable of determining optimal compartment sizes and can determine how many stops it will take to fill each compartment on the truck. In the upper righthand corner of the page, the *model user* is to input the estimated capture rate of recyclables for households and apartments. Although an estimate, this will help program operators determine the quantity of material they are receiving per household and per apartment and will provide the model with data necessary to determine the average weight and volume of material per household setout and per apartment setout.

## **PAGE 3: Materials Collected - Scenario #2**

This page is identical to Page 2 in its setup. The *model user* is required to input the quantity of each material collected, its compartment number and the estimated density of each material *as it sits at the curb*. The model is capable of determining optimal compartment sizes and can determine how many stops it will take to fill each compartment on the truck. In the upper righthand corner of the page, the *model user* is to input the estimated capture rate of recyclables for households and apartments. Although an estimate, this will help program operators determine the quantity of material they are receiving per household and per apartment and will provide the model with data necessary to determine the average weight and volume of material per household setout and per apartment setout.

## **PAGE 4: Truck Compartment Parameters and Utilization**

This page contains most of the information on the trucks used to collect the material. The *model user* is required to input the weight and volume capacity of the trucks in use, outline the size of each compartment, the compaction ratio used in each compartment (if any) and the utilization of each compartment. The model will subsequently determine the effective size of each compartment (taking into account the compaction and utilization of each compartment). Then the model will determine the number of setouts it will take to fill each compartment and then flag the *model user* with a note in column 79 and/or 89.

#### **PAGE 5: Collection Factors**

All of the route, fleet and personnel related information regarding the program is to be input on this page. Many of the most sensitive factors affecting the outputs in the model are contained on this page. If there is a discrepancy between the outputs of the model and the program being examined, the inputs on this page should be confirmed. The greater the accuracy of the information input here, the greater the accuracy of the output of the model.

#### **PAGE 6: Materials Collected: Total, Per Household/Apartment Unit, Per Capita**

This page acts as a summary section for the *model user*, as it shows information on the total population, participating population and the recovered quantity of recyclables for households separately from apartments, in total, per household/apartment unit, and per capita. The estimates per household and per apartment are based on the data provided on pages 1 through 3 of the model. The model also compares the base program household quantities per household/apartment unit and per capita with those households/apartment units in the additional program (from the righthandside of page 1).

This page would be useful to the program director, for example, when comparing two routes, to explain why one route may be taking longer than another. There may be more material per household along one route compared to another and therefore the driver has to spend more time sorting the materials.

### **PAGE 7: Route Calculations**

The variables entered on the previous pages are used to calculate a variety of program requirements. No inputs are required from the *model user*. Thirty-three different outputs provide detailed information on the number of households/apartments picked up per day per vehicle, time allocations to collection, hauling, driving on-route and dumping the truck are provided in addition to the key output of fleet size required to collect the materials from the estimates setouts per period.

### **PAGE 8: Collection Costs: Capital Costs - Fleet Purchase**

All of the costs associated with the purchase of the collection fleet are entered onto this page. The purchase of vehicles is designated as a capital cost whereas fleet rental or collection contracts are considered operating costs as they do not involve the direct purchase, ownership and ability to later sell any equipment. The *model user* is able to determine annual capital costs on the basis of three financing methods - straight line depreciation, capital replacement and taking a loan to purchase. Total capital annual costs are presented along with the cost per month and cost per tonne collected.

### **PAGE 9: Vehicle Contract, Operating and Maintenance Costs**

All of the fleet operating and maintenance costs for your fleet are input into the box on the lefthandside of the page. Although a default list of operating line items is provided, they can be changed to meet the needs (i.e., recording/reporting structure) of the individual program. The

model calculates the total annual operating and maintenance cost, average cost per vehicle, cost per month and cost per tonne collected.

All of the costs associated with the rental/lease or purchase of your fleet are entered into the righthandside box on this page. The costs are considered as an operating cost rather a capital purchase as there is no ownership of equipment. The model outputs the total annual fleet rental/collection contract cost and calculates the average cost per vehicle, cost per month and cost per tonne collected.

#### **PAGE 10: Operating Costs - Labour Costs - Crew Members and Support Staff**

All costs associated with the on-route labour (i.e., administrative staff costs are excluded) are input on this page. The costs for the route supervisors/foremen that spend time on-route are input separately from the truck drivers/crew members. Although a default list of labour cost line items is provided, they can be changed to meet the needs (i.e., recording/reporting structure) of the individual program. The model calculates the total annual operating and maintenance cost, average cost per vehicle, cost per month and cost per tonne collected.

#### **PAGE 11: Administration Costs**

Office and other costs associated with the recycling program should be input on this page. The costs of administering the program, including the costs for the recycling/program coordinator are input here. All costs that are allocated to the collection program (e.g., public education, advertising, household/apartment building containers, etc.) are input here. A default list of administration line items is provided although they can be changed to meet the needs (i.e., recording/reporting

structure) of the individual program. The model calculates the total annual administration costs, cost per month and cost per tonne collected.

## **PAGE 12: Collection Cost Summary and Comparison of Scenario Costs**

This page provides the *model user* with a one page summary of the key program components, (number of households/apartments, total tonnes collected, total cubic metres collected) and all of the costs associated with the recycling program. The costs are summarized by capital, operating and administration categories as well as by total cost, cost per tonne, cost per cubic metre and cost per household. If it decided to examine two scenarios by inputting “yes” into line 316x, the model will calculate the differences in costs for the two scenarios.

### **3.2.1 Input Variables**

Some of the sections require input from the *model user* while other sections are restricted to calculations done by the computer. Where the program does calculations, the *model user* is locked out (i.e., the *model user* will not be able to input any value). In those cases, the user will be shown a dialogue statement indicating that the line cannot accept any input. The lines that require (or can be) input are marked with an x (e.g. 1x, 2x, etc.) and are shown in blue. The line/column number is shown in magenta and each has a definition/explanation in Chapter 4. Each page of the model is shown separately in Figures 4.1 through 4.12 (A blank copy of the model is provided in Appendix A). An example has been provided to allow the user to better understand how values in certain lines affects the calculations later in the program.

The *model user* will need to know the following:

1. Total population by households and apartments served by the program
2. Number of houses and/or apartments and apartment units served
3. Number of apartment rollouts in the program
4. The quantities (at least approximately) that will/have been collected
5. The compartment into which each material is sorted
6. The total length of the route(s) or distance between houses
7. The size of the truck(s) to be/being used
8. The size of each compartment on the truck
9. The length of the workday
10. Time it takes to empty the recycling truck
11. All costs (fleet, labour, administration) associated with the program

A number of other variables are also required. Because some of the variables may not be readily known by the operator, default values for some variable are provided in Chapter 2. The greater the accuracy of the input data, the greater the quality of the resultant calculations. If default values are used in place of collecting data specific to your community, the model may not be able to approach the 'reality' of your program.

### **3.2.2 Calculated Variables**

Based on the values input into the model, the program will calculate a number of variables of interest.

Some of the key variables that the model can calculate include:

- cost per tonne or cubic metre of recyclables collected
- cost to collect each material (using a user defined methodology)
- incremental cost of adding one or more items to a recycling program (i.e., by running a second scenario simultaneously)
- cost per household/apartment
- costs of a current recycling program
- comparative cost of a second recycling program scenario
- number of trucks required for a program or route for one or two different scenarios
- number of setouts which can be picked up per day
- tonnes picked up per day
- time spent collecting material, compared to time spent driving on and off-route

All of the results of calculations based on route collection factors and demographics input variables are provided in the "Route Calculations" on page 7 of the model. All cost allocation output is provided separately in the COST ALLOCATION worksheet.

Once the original figures for the recycling program have been input into the model you will find that as you "play" with the model, testing different scenarios, the costs can be quickly compared on the summary page.

## **Waste Management**

## **Environmental Management**

## **Using the RECYCLING Collection Cost Model**

This chapter will proceed step-by-step through the collection cost model. Definitions of each line/column have been supplied to help the user understand exactly what is required in each input line/column and what information is provided in the output lines/columns. Where information is required by the user, the line/column number is followed by an (e.g., line 1x, 2x, etc.). Where the line/column is providing output no follows the number. If you try to type in information in a cell other than in an input cell, the computer will tell you that the cell is locked and cannot be changed. This ensures that you do not accidentally change one of the formulas. The text note boxes are to point out highlights of the model and will not be showing on the screen.

## **Discussion of Model Components**

This section will proceed through each of the sections of the model outlining what is included in the section and how it relates to the model. The user will also be provided with step-by-step instructions on how to "fill-in-the-blanks".

## **Introduction, Community Demographics and Adding More**

### **Households/Apartments to Your Program**

Figure 4.1 shows you what it will look like (there will be blanks in all of the lines instead of sample figures). Fill in the name of your community or program at the top. A complete copy of the blank model is provided in Appendix A. Input the year of the examination (e.g., for a current program or for a proposed future program).

A single scenario or two different scenarios can be run simultaneously. Description lines (3x and 4x) are provided.

## Community Demographics

In the first two boxes on the lefthandside of the page

## Community Demographics

, there are six lines of information required for households and eight lines for apartments\*.

\*NOTE: Industrial, Commercial and Institutional (IC&I) buildings can be added in as households if they are served by curbside box/bag service or they can be added in as apartments if rollout carts are used.

Households served (5x):

Indicate how many houses are included in the program (line 5x).

Household Population Served (6x):

Indicate the total household population served by the program (whether they are participating or not).

Occupancy (per household) (7):

Indicates the average number of people living in each household.

Participation Rate (%) (8x):

Indicate what percentage of the households are participating in the program (line 8x).

Setout Frequency (%) (9x):

Indicate how often those households that are participating set their containers out at the curb for pickup (e.g. 50% means every other week, 67% means two weeks out of every three, etc.).

Overall Setout Frequency (%) (10):

Indicates the percentage of households will have a container set out for collection each period (e.g. 50% means 50 households out of every 100, 80% means 80 out of every 100, etc.).

Total Number of Households Participating (11):

Based on the participation rate input in line 8x, indicates the number of households participating in the program.

Figure 4.1:

## Recycling Collection Cost Model Page 1:

Introduction, Household Demographics and  
Quantities of Household Materials Recycled  
Number of Collection Weeks (12x):

Indicate how many times per year collection service is provided in the municipality (not the number of pickups provided to each house) (See Note on page 4-4). For example, for a one year period this number is generally 52 although in some municipalities where service is missed due to a holiday and not replaced (e.g., for a Monday holiday service is provided on a Tuesday) this number could be lower (e.g., 48 - 50).

\*NOTE: The model can examine collection over any length of time - with the minimal length being one week. This may help determine fleet/overtime requirements for peak periods throughout the year. Ensure that the quantities collected (Pages 2 and/or 3) match the period of collection examined (e.g., if examining one month, the quantity input should be for the one month and the Number of Collection Weeks (Line 12) should be input as four).

Number of Pickup Periods Provided Per Year (13x):

Indicate how many times per year pickup service is provided to the household (e.g., weekly service is 52 times per year, biweekly service is 26 times, etc.).

Ratio of Household to Apartment Dweller Generation Rate (14x):

Generally program operators do not track the quantity of material collected from apartments separately from households. Three factors impact the quantity collected per household/ apartment unit:

people per household/apartment unit;  
waste generation rate; and  
recyclables capture rate.

The first bullet is addressed by inputting the number of households/apartment units and the population figures. This line addresses the second bullet. For example, if it is assumed that a person in a household generates 400 kg of material per year and a person in an apartment generates, on average, 300 kg of waste, the ratio of household dweller to apartment dweller generation rate is 1.33 (i.e., 400 kg/300 kg). 1.33 would be input into line 14. If it is assumed that the generation rate per capita is equal a ratio of 1.0 would be input. (Recyclables capture rate is addressed on pages 2 and 3 of the model.)

Apartment Buildings Served (15x):

Indicate how many apartment buildings are included in the program.

Apartment Units Served (16x):

Indicate the number of apartment units served by the program (whether they are participating or not).

Apartment Population Served (17x):

Indicate the total apartment population served by the program (whether they are participating or not).

Occupancy (Per Apartment Unit) (18):

Indicates the average number of people living in each apartment unit.

Participation Rate - Units (19x):

Indicate what percentage of the apartment units are participating in the program.

Total Number of Apartment Units Participating (20):

Based on the participation rate input in line 18x, indicates the number of apartment units participating in the program.

Total Number of Containers to Pickup Per Period (21x):

Indicate the number of containers to be picked up per collection for all buildings.

Number of Containers Per Building (22):

Outputs the average number of containers (e.g., rollout carts) to be collected per building per period.

Number of Collection Weeks Per Year (23x):

Indicate how many times per year collection service is provided in the municipality (not the number of pickups provided to each house per year). Generally this number is 52 although in some municipalities where service is missed due to a holiday and not replaced (e.g., for a Monday holiday service is provided on a Tuesday) this number could be lower (e.g., 48 - 50) (See Note on Page 5-4).

Number of Periods of Pickup/Building/Year Provided (24x):

Indicate how many times per year pickup service is provided to the household (e.g., weekly service is 52 times per year, biweekly service is 26 times, etc.)

## **Adding More Households/Apartments to Your Program**

This section is provided to help the user examine the impact on the collection parameters (including fleet size) on adding new households or apartments to the program. After filling in the information in one (or both) boxes, the model will automatically calculate the estimated tonnage that will be recovered from the new households/apartments and then recalculate the collection route characteristics and fleet size required.

Additional Households Served (25x):

Input the additional households that will be served by the program (e.g., from a new neighbourhood, new community, etc.) whether or not they will be participating in the program.

Additional Household Population Served (26x):

Input the population of all additional households to be served in the program (of both participating and non-participating households).

Occupancy (per household) (27):

Indicates the average number of people living in each household.

Participation Rate (%) (28x):

Input the estimated participation rate for the new households. For example, it may be reasonable to assume that a the new community will not have as high a participation rate as a community that has had a recycling program for a long period of time.

Setout Frequency (%) (29x):

Input the estimated setout frequency for the additional households in the program.

Overall Setout Frequency (%) (30):

Indicates the percentage of additional households will have a container set out for collection each period (e.g. 50% means 50 households out of every 100, 80% means 80 out of every 100, etc.).

Total Number of Additional Households Participating (31):

Based on the participation rate input in line 26x, indicates the number of new households participating in the program.

Estimated Capture Rate (%) (32x):

Generally new participants to a recycling program do not capture as much of their recyclables as those people who have been participating for a longer period of time. Input in this line the estimated capture rate compared to those households in the base program. For example, inputting 100% means that the new households will capture the same quantity per household as the base program households. Inputting 50% means that the new households will capture only one half that of the existing households, etc.

Additional Apartment Units Served (33x):

Input the additional apartment units that will be served by the program (e.g., from a new neighbourhood, new community, etc.) whether or not they will be participating in the program.

Additional Apartment Buildings Served (34x):

Input the additional apartment buildings that will be served by the program (e.g., from a new neighbourhood, new community, etc.).

Additional Apartment Population Served (35x):

Input the population of all additional apartment units to be served in the program (of both participating and non-participating units).

Occupancy (Per Apartment Unit) (36):

Indicates the average number of people living in each apartment unit.

Participation Rate (%) (37x):

Input the estimated participation rate for the new apartment units. For example, it may be reasonable to assume that a the new community will not have as high a participation rate as a community that has had a recycling program for a long period of time.

Total Number of Apartment Units Participating (38):

Based on the participation rate input in line 33x, indicates the number of apartment units participating in the program.

Additional Containers to Pickup Per Period (39x):

Indicates the number of containers to be picked up per collection for all buildings.

Number of Containers Per Building (40):

Outputs the average number of containers (e.g., rollout carts) to be collected per new building per period.

Estimated Capture Rate (%) (41x):

Generally new participants to a recycling program do not capture as much of their recyclables as those people who have been participating for a longer period of time. Input in this line the estimated capture rate compared to those apartment dwellers in the base program. For example, inputting 100% means that the new apartments will capture the same quantity per apartment as those in the base program. Inputting 50% means that the new apartments will capture only one half that of the existing program, etc.

### ***Pages 2 and 3: Materials Collected - Scenario #1; Materials Collected - Scenario #2***

Pages 2 and 3 are identical in setup with the only difference being that Page 2 (Figure 4.2) is for those materials collected in Scenario #1 and Page 3 is for those materials collected in Scenario #2 (Figure 4.3).

Capture Rate (Sc#1-42x; Sc#2-55x):

Recognizing that capture rates for recyclables tends to vary by dwelling type, indicate (by percentage) the estimated capture rate for recyclables from households and from apartments. In the example shown in Figure 4.2 and Figure 4.3, it has been assumed that the capture rate for recyclables from households is 60% and 50% from apartment units.

Material List (Sc.#1-43x; Sc.#2-56x):

A generic list of recyclable materials is provided on pages 2 and 3. The quantities of each of the materials can be listed next to the material as shown or you can input your own list in your own order as required.

Quantity Collected (tonnes) (Sc.#1-44x; Sc.#2-57x):

Across from each material, input the quantity collected. This information will be primarily based on the information on the quantity of material marketed from the Materials Recovery Facility (MRF). This quantity should, wherever possible, include the quantity of residue collected. Residues can be listed as separate materials (e.g., fibres residues, containers residues, etc.) which can then be allocated to a specific compartment.

The model can examine collection over any length of time.

Additional Households/Apartments Quantities Collected (Sc.#1-45x; Sc.#2-58x):

Based on the information provided in the two righthand side boxes on Page #1, the model will calculate the quantity of material that could be expected to be recovered from the additional households and apartments in the program.

Figure 4.2:

Recycling Collection Cost Model Page 2:

Materials Collected - Scenario #1

Figure 4.3:

Recycling Collection Cost Model Page 3:

## **Materials Collected - Scenario #2**

Total Quantity Collected (tonnes) (Sc.#1-46x; Sc.#2-59x):

This is a sum of the previous two columns and represents the total quantity of material collected from all households, apartments, IC&I establishments, etc. included in the program.

Percentage of the Total Quantity (by weight) (Sc.#1-47x; Sc.#2-60x):

This column outputs the percentage each material represents (by weight) of the total quantity (by weight) collected.

Compartment Number (Sc.#1-48x; Sc.#2-61x):

The model has the ability to determine which compartment of the truck will cube out first. Each material collected should be allocated to a specific compartment on the truck. The model is capable of handling up to ten compartments on a single truck (i.e., a number between 1 and 10 should be entered into this column).

Density of the Material at the Curb (kg/m<sup>3</sup>) (Sc.#1-49x; Sc.#2-62x):

Input the estimated density of each material as it sits at the curb prior to being collected. Even if a material is not collected, a number greater than zero must be present in each line of this column (If a material is not collected, the density input for that material is not important as it will not have an impact on the output). Because of the formula used to calculate weighted density, if a zero (or no value) is input, an error message will appear.

Average Volume of Material at the Curb (kg/m<sup>3</sup>) (Sc.#1-50x; Sc.#2-63x):

The model will output the average volume of material as it sits at the curb.

Percentage of the Total Quantity (by Volume) (Sc.#1-51x; Sc.#2-64x):

This column outputs the percentage each material represents (by volume) of the total quantity (by volume) collected based on the average density of material at the curb.

Density on the Truck (kg/m<sup>3</sup>) (Sc.#1-52x; Sc.#2-65x):

The model is capable of examining variable compartment sizes and compaction rates for individual compartments on the truck. Based on the information provided on Page 4 of the model (in Column 65 - Compaction Ratio), this column outputs the average density of each material as it sits in the truck.

Average Volume of Material on the Truck (kg/m<sup>3</sup>) (Sc.#1-53x; Sc.#2-66x):

The model will output the average volume of material as it sits in the truck.

Percentage of the Total Quantity (by Volume) (Sc.#1-54x; Sc.#2-67x):

This column outputs the percentage each material represents (by volume) of the total quantity (by volume) collected based on the average density of material in the truck.

## **Page 4: Truck Compartment Parameters and Utilization**

Page 4 examines the parameters for an average truck in use in the program, the parameters for each compartment within the truck and determines the number of setouts (by volume) that can be picked up before each compartment cubes out (Figure 4.4).

Vehicle Capacity (tonnes) (68x):

Input the capacity (in tonnes) of an average truck within the fleet being/to be used in the program.

Vehicle Capacity (cubic metres) (69x):

Input the capacity (in m<sup>3</sup>) of an average truck within the fleet being/to be used in the program.

The two lower boxes on the lefthandside of Page 4 are identical. The first box examines the collection vehicle compartment parameters for Scenario #1 and the second box is for Scenario #2.

Name (optional) (Sc.#1-70x; Sc.#2-80x):

Input the name of each compartment on the truck. For example, if one compartment is used just for clear glass, it would be named clear glass, etc.

Compartment Size (m<sup>3</sup>) (Sc.#1-71x; Sc.#2-81x):

Input the size of each compartment on the truck.

Compaction Ratio (Sc.#1-72x; Sc.#2-82x):

If a compaction device is used on the truck or if, as a result of a typical action on the truck (e.g., the breaking of glass) results in an increased density of material on the truck, input the compaction ratio achieved by the device or action.

Figure 4.4:

Recycling Collection Cost Model Page 4:

## **Truck Parameters**

Compartment Utilization (%) (Sc.#1-73x; Sc.#2-83x):

Some vehicle configurations do not necessarily allow for the complete utilization of each compartment. Input the utilization, as a percentage, of each compartment on the truck.

Effective Size (m<sup>3</sup>) (Sc.#1-74x; Sc.#2-84x):

As a result of the compaction being achieved in and the utilization of each compartment, the effective size of each compartment is output. For example a 10m<sup>3</sup> compartment that has a compaction device in it that will densify the material by 2 times (i.e., a ratio of 2.0) but takes up 10% of the compartment (i.e., utilizable space = 90%), the effective size is the product of those three numbers as follows:

Effective Size = Compartment Size x Compaction Ratio x Compartment Utilization

Effective Size = 10m<sup>3</sup> x 2.0 x 90% = 18m<sup>3</sup>

Weighted Density (kg/m<sup>3</sup>) (Sc.#1-75x; Sc.#2-85x):

Based on the materials allocated to each compartment (From Page 2 or 3), the density allocated to each material and the compaction ratio input for each compartment, the average weighted density of the materials in each compartment on the truck is output. These values are of interest as the lower the weighted density, the greater the space taken on the truck per kilogram of material.

The two boxes on the righthandside of Page 4 examine the number of setouts that can be picked up before each compartment cubes out. Across from the first compartment to cube out will be note

. The two boxes on the righthandside of the page (columns 76 to 79 and 86 to 89 respectively) are identical. The first box is for Scenario #1 and the second for Scenario #2.

Total Setouts (Sc.#1-76x; Sc.#2-86x):

Outlines the total number of setouts, per compartment, that could be picked up before the compartment cubes out. This calculation is based on the size, compaction ratio and utilization of each compartment divided by the volume of each material as set out at the curb as it has been allocated (according to Page 2 or 3 respectively) to each compartment.

Household Setouts in Total (Sc.#1-77x; Sc.#2-87x):

Shows what number of the total number of setouts is household setouts.

Apartment Setouts in Total (Sc.#1-78x; Sc.#2-88x):

Shows what number of the total number of setouts is apartment building setouts.

First Compartment to Cube Out (Sc.#1-79x; Sc.#2-89x):

Provides a note to the model user showing which compartment will cube out first.

\*NOTE: The model has been built to handle only metric input values. On the righthandside of Page 5 is an Imperial-Metric/Metric-Imperial Conversion Table.

## Collection Factors

Many of the computations done in the “Route Calculations” (Page 8) section depend on the input variables of this sec

tion. This section provides the data on the on-route and off-route characteristics and the time allocations to given activities (Refer to Figure 4.7). The elements of time, speed and distance input on this page combine to determine route characteristics and fleet requirements. Wherever possible supply accurate, known quantities.

\*NOTE: The accuracy of the inputs on this page is critical (i.e., very sensitive). If the results of running the model the first time do not closely match your existing program or if the results do not appear to be correct, check each of the inputs on this page first.

A.M. Truck Inspection Time (minutes) (90x):

Input, in minutes, how long the driver spends in the morning inspecting the truck for the day's run.

A.M. Time to Drive to Route (minutes) (91x):

Input, in minutes, how long it takes the driver to get to the first stop.

Pass Spacing (average distance between all houses/apartment buildings) (metres) (92x):

This is the average distance, in metres, between all (not just participating) households and/or apartments. When estimating this value, ensure that intersections and turn around points are included.

Housing Units On-route (93):

This line outputs the total number of houses and apartment buildings on the route(s).

Figure 4.5:

Recycling Collection Cost Model Page 5:

Recycling Program Collection Factors

Total of All Route Distances (km) (94):

This line outputs, in kilometres, the length of the route or total length of all routes. This distance is based on the total number of households/apartment buildings multiplied by the pass spacing input in line 92x.

Average Speed on the Route (km/hr) (95x):

Input the average speed the truck travels between pickups. Some average values for urban, semi-urban and rural settings are provided in Table 2.5.

Haul Distance (average distance from the facility to the route) (km) (96x):

Input the average distance between the route and the recycling facility (or transfer station, interim drop-off point, etc.).

Average Off-route Speed (km/hr) (97x):

Input the average speed of the truck while driving to (or from) the route from the recycling facility (transfer station, interim drop-off point, etc.). Some default values are provided in Table 2.5.

Interim Dumping Time (minutes) (98x):

Input, in minutes, the length of time it takes to unload the recycling truck in the middle of the day. This value may be less than for the end of the day dump

ing time if queuing times are shorter during the day than at day end or if, for example, only the fibres compartment and containers compartment are emptied and the glass compartment is left until the end of the day.

End of Day Dumping Time (minutes) (99x):

Input, in minutes, how long it takes to empty truck at the end of the day. Include any queuing time in the estimate.

Crew Size Per Collection Vehicle (100x):

Input the number of crew members per vehicle.

Time Per Setout - Curbside Households (seconds) (101x):

Input how long it takes for the crew member to empty each curbside container. (See Tables 2.6 and 2.7 for an explanation of how to calculate time per setout). The time per setout may be higher in inclement weather when the operator has to deal with cold, high winds, wet material, snow and snowbanks, etc.

Time Per Setout - Apartment Building Containers (seconds) (102x):

Input how long it takes for the crew member to empty each apartment building container. This includes stepping out of the truck, latching on the container(s), emptying each, placing it back in their proper location and getting back into the vehicle. Depending on the system in use, times per setout (assuming rollout carts) varies from approximately 10 seconds for a fully automated system to 90 seconds for semi-automated cart lifting systems. A higher time per setout may be experienced if the operator has to move the containers from a storage area or has to contend with snow, etc.

Day End Time Back to Truck Depot (minutes) (103x):

Input, in minutes, how long it takes to go from the recycling facility back to the truck depot at the end of the day. This line is only to be used when the trucks are not stored at the recycling facility but, after emptying, return to a works yard or similar storage facility.

Total Length of Working Day (including lunch and breaks) (hours) (104x):

Input, in hours, the total length of the workday including lunch and breaks.

Time Given for Lunch and Breaks (105x):

Input, in minutes, the time given for lunches and breaks.

Average Time Utilization Factor (%) (106):

Indicate what percentage of the workday is utilized for collection. Account for downtime and unforeseen circumstances (e.g. weather, slowdowns, etc.). For example, inputting 95% would indicate that approximately 5% of the time per day is lost to downtime and other circumstances, etc.

Time Available for Collection (hours) (107):

This indicates the time available per day (in hours) for travelling between households/ apartments and picking up recyclable materials. The average time utilization factor is multiplied by the workday length.

Collection Days Per Period (108x):

Input how many collection days that are utilized per period (e.g., 5 collection days are used per week; 2 collection days are used per month).

Spare Vehicles (109x):

Indicate (using whole numbers only) how many spare vehicles you have/would like available. This will depend on the size of the program. At least 10% spare capacity is recommended.

## **Materials Collected: Total, Per Household/Apartment Unit, Per Capita**

This page acts primarily as a program (i.e., not individual route) summary sheet of all of the demographic and material quantity inputs. Estimations of per household/apartment unit and per capita recovery rates are based on inputs from Pages 1 to 3). The outputs shown are the results of model calculations on input data. Scenario #1 output relates to the base program while Scenario #2 outputs show the incremental and/or combined results of adding more households.

Total Population Served (110):

This line sums the populations of the base program and the additional populations entered on Page 1.

Total Participating Population (111):

This line calculates, based on the participation rates input on Page 1, the number of people who are participating in the recycling program.

Total Households/Apartment Units Served (112):

This line sums the households and apartment units of the base program and the additional households/apartment units entered on Page 1.

Total Participating Households/Apartment Units (113):

This line calculates, based on the participation rates input on Page 1, the number of households/apartment units participating in the recycling program.

Total Quantity to Collect (tonnes) (114):

This information is transferred from Page 2 (Scenario #1) or Page 3 (Scenario #2).

Setouts Per Period (115):

Indicates how many household curbside containers and how many apartment building containers will be set out at the curb for collection each period.

Figure 4.6:

## **Summary of Total Recyclables Collected, Recyclables Per Capita**

Community Demographics Summary Information and  
Distribution of Recyclables Between Houses and Apartments  
Average Weight Per Setout (kilogram) (116):

Indicates the average weight of each household container and each apartment building container set out at the curb.

Average Volume Per Setout (cubic metres) (117):

The average volume of material per household container and per each apartment building container set out for collection. The average volume is calculated using densities of each material input on Page 2 (Scenario #1) or Page 3 (Scenario #2) .

Recovered Quantities From Participating Households and Apartments

Total Weight to Collect - All Households/Apartment Units (tonnes) (118):

Based on the relative populations, relative participation rates and relative capture rates of households to apartments (from Pages 1, 2 and 3), the model calculates how much material will come from all households and how much will come from all apartment buildings in the program.

\*NOTE: All base households/apartment units (lefthandside boxes on Page 1) are used in the calculations in lines 118 to 120 for Scenario #1, while the calculations for Scenario #2 also include all additional households (righthandside boxes on Page 1).

Weight Per Household/Apartment Unit - All Households/Apartment Units (kg) (119):

Based on the quantities calculated in line 118 and the number of participating households/apartment units, the model calculates the average quantity to collect/collected per household/apartment unit.

Weight Per Capita - All Households/Apartment Units (kg) (120):

Based on the quantities calculated in line 118 and the participating population, the model calculates the average quantity to collect/collected per capita.

Total Weight to Collect - Base Program Households/Apartment Units (tonnes) (121):

Based on the split between household and apartment populations, the differential household/apartment participation rates and differential capture rates of the base program (i.e., existing) households to apartments (from Pages 1, 2 and 3) and the estimated recovery rate comparison to additional households (Lines 32 and 41), the model calculates the combined result of how much material will come from the existing households, how much will come from the existing apartment buildings and how much will potentially be recovered from the additional households and apartments.

\*NOTE: Only those base program households/apartment units (lefthandside boxes on Page 1) are used in the calculations in lines 121 to 123.

Weight Per Household/Apartment Unit - Base Program Households/Apartment Units (kg) (122):

Based on the quantities calculated in line 118, the number of participating households/apartment units in the base program and the estimated recovery rate comparison to additional households (Lines 32 and 41), the model calculates the average quantity to collect/collected per base program household/apartment unit.

Weight Per Capita - Base Program Households/Apartment Units (kg) (123):

Based on the quantities calculated in line 118, the participating population and the estimated recovery rate comparison to additional households (Lines 32 and 41), the model calculates the average quantity to collect/collected per capita.

Total Weight to Collect - Additional Households/Apartment Units (tonnes) (124):

Based on the relative populations, relative participation rates and relative capture rates of the additional households to apartments (from Pages 1, 2 and 3) and the estimated recovery rate (relative to existing (i.e., base) households (Lines 32 and 41)), the model calculates how much material will come from the households and how much will come from the apartment buildings.

\*NOTE: All base households/apartment units (lefthandside boxes on Page 1) are used in the calculations in lines 125 to 126 for Scenario #1, while the calculations for Scenario #2 also include all additional households (righthandside boxes on Page 1). Line 124 examines only those additional households/apartments (righthandside boxes on Page 1).

Weight Per Household/Apartment Unit - All Households/Apartment Units (kg) (125):

Based on the quantities calculated in line 118, the number of participating households/apartment units and the estimated recovery rate (relative to existing (i.e., base) households (Lines 32 and 41)), the model calculates the average quantity to collect/collected per household/apartment unit.

Weight Per Capita - All Households/Apartment Units (kg) (126):

Based on the quantities calculated in line 118, the participating population and the estimated recovery rate (relative to existing (i.e., base) households (Lines 32 and 41)), the model calculates the average quantity to collect/collected per capita.

## **Route Calculation Results**

This section shows the summary of calculations incorporating all the inputs in Pages 1 through 5. If there are discrepancies between actual (i.e., known values) and outputs from the model, go back and check the input values relative to your own knowledge of your program.

Haul Time (one way) (minutes) (127):

Based on the inputs of haul distance and haul speed, this line calculates the time it takes to travel each way to the route and from the route.

Setouts Per Load (weight basis) (128):

Based on the average weight of a household curbside container setout and an apartment container setout it takes to reach the weight capacity of the recycling truck.

Setouts Per Load - Households (weight basis) (129):

Based on the average weight of a household setout, this calculation shows how many households are included in the total setouts (line 128) required to fill the truck.

Setouts Per Load - Apartment Building Containers (weight basis) (130):

Based on the average weight of an apartment building container setout, this calculation shows how many apartment building setouts are included in the total setouts (line 128) required to fill the truck.

Setouts Per Load (volume basis) (131):

Based on the average volume of a household curbside container setout and an apartment container setout it takes to reach the volume capacity of the recycling truck. This is based on the first compartment to cube out (from Page 4).

Figure 4.7:

Recycling Collection Cost Model Page 7:

Recycling Program Results of Model Route Calculations Including  
the Calculation of the Size of Fleet Required

Setouts Per Load - Households (volume basis) (132):

Based on the average volume of a household setout, this calculation shows how many households are included in the total setouts (line 131) required to fill the truck.

Setouts Per Load - Apartment Building Containers (volume basis) (133):

Based on the volume weight of an apartment building container setout, this calculation shows how many apartment building setouts are included in the total setouts (line 131) required to fill the truck.

Collection Time Per Full Load (not including haul and dumping time) (134):

Based on the inputs of the previous section, this calculation indicates how long it will take for the truck operator to fill the first compartment to cube out (from Page 4) to capacity.

Minimum Time for One Full Load Per Day (hours) (135):

This line indicates how much time it takes to collect one full load of material, travel on and off-route and empty the load (using the end of day dumping time). The model assumes that the actions of travelling on and off-route and dumping the truck (using the end of day dumping time) occur every day.

Time Available for Further Full Loads (hours) (136):

This line indicates how much time is available, after the first full load, for further full loads.

Full Loads Per Day (137):

Indicates how many times the truck (i.e., the first compartment to cube out) is filled to capacity in a day.

Time Available After Full Load(s) are Completed (hours) (138):

Indicates how much time is left for collection after the truck has completed its full load(s). This line is different than line 136 in that if the truck fills to capacity more than once per day the time left will be less than line 136. If the truck only completes one full load per day line 138 will equal line 136.

Time Available for Additional Collection (less haul and dump time) (139):

Indicates how much time is left to be spent on collection. This calculation subtracts the time it takes to go on and off-route and empty the truck and shows the time that is strictly available for further pickups.

Number of Loads Per Day (full + partial loads per day) (140):

Shows the number of full and partial loads each truck will, on average, collect per day.

Number of Setouts Picked Up Per Day (141):

Shows how many household containers and apartment building containers will be picked up by each truck each workday.

Number of Household Containers Picked Up Per Day:

Indicates how many household containers are represented (i.e., picked up) in the total number of setouts per day (line 141).

Number of Apartment Building Containers Picked Up Per Day (143):

Indicates how many apartment building containers are represented (i.e., picked up) in the total number of setouts picked up per day (line 141).

Actual Passes Per Day (households and apartment buildings) (144):

Indicates how many houses and/or apartments buildings are passed on a single day.

Setouts Per Route Hour (145):

The model calculates and outputs the number of household and/or apartment building setouts are picked up per hour.

Passes (total households + apartment buildings) Per Route Hour (146):

The actual number of houses and/or apartment buildings that the truck passes daily.

Tonnes of Recyclables Collected Per Route (147):

Indicates how many tonnes of material are picked up by each truck (on average) per day.

Route Distance (km) (148):

This line shows, based on route speed, pass spacing and the number of households/ apartment buildings passed per day, the length of the collection route. This distance does not include the distance travelled on or off-route.

Total Distance Travelled Per Route (includes hauling distances) (km) (149):

This calculation shows approximately how far the truck travels on and off-route and on the collection route each day.

Time Spent Driving on the Route (hours) (150):

This line shows how much time is spent each day on route travelling between pick-ups

Time Spent Loading Recyclables onto the Truck (hours) (151):

Indicates how much time is spent each day on-route picking up recyclables from household and/or apartment building containers.

Hauling Time (including to and from the route, no day end time back to the depot) (hours)

Indicates how much time is spent travelling on and off-route and from the truck depot (in the morning - if any to the route) each day.

Dumping Time (hours) (153):

This line indicates how much time is spent each day emptying the truck.

Total time on collection (route + loading + hauling + dumping time) (154):

Shows the sum of the time spent on route, loading, hauling and dumping.

Load + Route Time Per Lift (seconds) (155):

Indicates how much time (on average) it takes to pick-up one household and/or apartment setout and travel to the next pickup.

Fleet Size (no spare) (156):

Based on all of the information supplied, this line shows how many vehicles would be required to pick up the total number of setouts per period (line 115).

Fleet Size (with spare) (157):

The line adds in spare capacity as indicated in line 109 and rounds the number up to the nearest whole number.

Spare Capacity Factor (158):

This line shows what spare capacity there is available based on the fleet size (with spare) divided by the fleet size (no spare). To increase spare capacity increase the number of spare vehicles on hand (line 109).

Crew, Total (159):

Shows how many crew members would be required to staff the indicated fleet size.

## **Pages 8, 9, 10, 11 and 12: Collection Costs**

The collection costs have been divided into three sections:

### **Capital Costs - Fleet Purchase - Page 8**

Included are the purchase costs associate with the collection fleet.

### **Operating Costs - Pages 9 and 10**

Included are the employee/labour costs and fleet operating/maintenance costs. The employee/labour costs are restricted to the drivers, route supervisors, etc. (i.e., no administration staff).

## Administration and Overhead Costs - Page 11

Included are the costs associated with running the office and all other administration costs for the program.

Page 12 provides a summary of all collection costs.

### Capital Costs - Fleet Purchase

These boxes allow the user to input the cost of their vehicle purchases. Six separate columns are provided for different priced vehicles (or for vehicles of different ages). The two boxes on this page are identical. The top box (lines 160 - 176) is for Scenario #1 and the bottom box (lines 177 - 193) is for Scenario #2.

Truck Type (optional) (Sc.#1-160x; Sc.#2-177x):

Indicate the type of truck(s) in use (e.g., top-loading, stake truck, etc.).

Year of Purchase (Sc.#1-161x; Sc.#2-178x):

Input the year each truck(s) was purchased.

Figure 4.8:

Recycling Collection Cost Model Page 8:

Collection Costs:

## Capital Costs - Fleet Purchase Costs

Number of Trucks Purchased (Sc.#1-162x; Sc.#2-179x):

Indicate the number of each type of truck(s) purchased.

Vehicle Capital Cost (Sc.#1-163x; Sc.#2-180x):

For each vehicle (or all vehicles purchased at the same price) input the average cost per vehicle.

Interest Rate (Sc.#1-164x; Sc.#2-181x):

For each vehicle (or all vehicles purchased at the same price) input the average cost per vehicle.

Type of Financing (Sc.#1-165x; Sc.#2-182x):

For each vehicle (or all vehicles purchased at the same price) input the type of financing used for the purchase. There are three options:

**Straight Line Depreciation (enter SLD):** This assumes that no interest is being paid on a loan for the purchase of the vehicles or no interest is being accrued to savings set aside for the purchase of a vehicle at some point in time in the future. If an interest rate was input in line 164 or line 181 and

is entered into this line, the model will default the interest rate to zero.

**Capital Replacement (enter CR):** This assumes that interest is being accrued to savings set aside for the purchase of a vehicle at some point in time in the future. If an interest rate was input in line 164 or line 181 and

is entered into this line, the model will calculate the annual interest paid to an account and calculate the required principal required to allow the purchase of future vehicles at the capital cost input into line 163 (scenario #1) or line 180 (scenario #2).

Loan to Purchase (enter LP): This assumes that interest is being paid on a loan for the purchase of the vehicles. If an interest rate was input in line 164 or line 181 and

is entered into this line, the model will calculate the annual loan payment required to pay off the capital cost of the vehicle(s) input into line 163 (Scenario #1) or line 180 (Scenario #2).

Depreciation/Replacement/Amortization Period (years) (Sc.#1-166x; Sc.#2-183x):

Input the number of years the vehicle is being depreciated over, the replacement period of the vehicle or the loan is being amortized over.

Vehicle Life (Years) (Sc.#1-167x; Sc.#2-184x):

Input the expected life of each type of vehicle in the fleet.

Vehicle Replacement Year (Sc.#1-168; Sc.#2-185):

Based on the year of purchase and the expected vehicle life, the model outputs the vehicle replacement year.

Annualized Capital Cost (per purchased truck) (Sc.#1-169; Sc.#2-186):

The model outputs the annualized capital cost for each vehicle purchased for the program.

Total Annual Purchased Fleet Cost (by column) (Sc.#1-170; Sc.#2-187):

Based on the annualized capital cost per vehicle (line 169 or 186) and the number of trucks purchased at that rate (line 162 or 179), the model will output the total cost for the total number of vehicles purchased of that type (or price) of vehicle.

Total Annual Fleet Cost (Sc.#1-171; Sc.#2-188):

This line sums the total annual purchased fleet cost (line 170 or line 187) to provide the total annual cost for all trucks.

Total Number of Trucks in Fleet (Sc.#1-172; Sc.#2-189):

This line sums the total number of trucks purchased (from line 162 for Scenario #1 or 179 for Scenario #2).

Average Annual Cost Per Truck (Sc.#1-173; Sc.#2-190):

This line outputs the average annual cost per truck for all trucks in the fleet.

Tonnes Collected (Sc.#1-174; Sc.#2-191):

This line outputs the total tonnes collected for the scenario (from column 46 for scenario #1 and column 59 for Scenario #2).

Cost Per Tonne Collected (Sc.#1-175; Sc.#2-192):

This line outputs the average annual capital cost per tonne of material collected.

Cost Per Month (Sc.#1-176; Sc.#2-193):

The model divides the total annual cost to present a monthly capital cost.

\*NOTE: To allow the model user to quickly see the difference in cost between two scenarios, once is input into line 316x (see page 12 of the RCCM), the model will automatically show which of the two scenarios has a higher cost. There is a Scenario Cost Comparison Box for each of: Fleet Capital Costs; Fleet Operating and Maintenance Costs; Collection Contract Costs; Labour Costs; Administration Costs; and Total Program Costs.

#### Operating Costs

##### Fleet Maintenance Costs

All of your costs associated with fleet maintenance should be input in this box in the appropriate lines (lines 194 to 211) (See Figure 9). The lines provided are suggested default categories. However, as the input lines are in blue, they can be adjusted to suit the reporting method used by your program.

In line 213x input the total number of trucks in the fleet. The outputs are as follows:

Total Annual Fleet Operating and Maintenance Cost (All Trucks) (212):

This line sums the total annual fleet operating and maintenance costs.

Total Number of Trucks in Fleet (213x):

Input the total number of trucks in the collection fleet (Do not include maintenance or supervisor vehicles in the number).

Average Annual Cost Per Truck (214):

This line outputs the average annual operating and maintenance cost per truck for all trucks in the fleet.

Tonnes Collected (215):

This line outputs the total tonnes collected for the scenario (from column 46 for scenario #1 and column 59 for Scenario #2).

Cost Per Tonne Collected (216):

This line outputs the average annual operating and maintenance cost per tonne of material collected.

Figure 4.9: Page 9

Cost Per Month (217):

The model divides the total annual operating and maintenance cost to present the monthly cost.

## **Fleet Rental/Collection Contract**

This box (lines 218 to 225) allows the user to input the cost of their collection contract with a third party or the cost of renting/leasing their own collection fleet. As the vehicles are the property of a third party and/or the cost could change annually, it is considered an operating cost rather than a capital cost.

Collection Contract Cost (218x):

Input the cost of the collection contract for the program.

Total Annual Rental/Lease Fleet Cost (219x):

Input the annual cost for the rental/fleet in use in the program.

Total Annual Contract/Leased Fleet Cost (220):

This line sums the total annual contract/leased fleet cost (lines 218x plus 219x).

Total Number of Trucks in Fleet (221x):

Input the total number of trucks in the rental/collection contract fleet (Do not include maintenance or supervisor vehicles in the number).

Average Annual Cost Per Truck (222):

This line outputs the average annual cost per truck for all trucks in the fleet.

Tonnes Collected (223):

This line outputs the total tonnes collected for the scenario (from column 46 for scenario #1 and column 59 for Scenario #2).

Cost Per Tonne Collected (224):

This line outputs the average annual contract/fleet rental cost per tonne of material collected.

Cost Per Month (225):

The model divides the total annual fleet rental/collection contract cost to present the monthly cost.

## **Employee/Labour Costs**

All of your costs associated with your truck operators and route supervisor(s) should be input into this section (lines 226x to 241x) (See Figure 10). The Labour Costs box is subdivided into two sections: Employee Earnings and Employee Benefits/Taxes. The lines provided are suggested default categories. However, as the input lines are in blue, they can be adjusted to suit the reporting method used by your program. Input the earnings, taxes, required and additional benefits and additional costs. Input the costs separately for the driver/operators and for the supervisors/support staff/equipment operators (i.e., non-drivers). The total employee costs for each of these two subgroups is shown in line 243. Input the number of supervisors/foremen that are out on-route (do not include administration staff) in line 244x. Input the number of drivers/crew members that are out on-route in line 245x. The total staff complement is output in line 246. The total of all labour costs is shown in line 247 with the total costs allocated on a per employee basis in line 248, per tonne basis in line 250 and per month in line 251.

Figure 4.10:

Recycling Collection Cost Model Page 10:

Collection Costs: Labour Costs

Page 11: Administration and Overhead Costs

The administration costs include office and other costs (See Figure 4.11). The Administration Costs box is subdivided into three sections: Employee Earnings; Employee Benefits/Taxes; and Office Expenses.

Administration costs includes all costs associated with the office employees (e.g. coordinators, managers, secretaries, technical assistants), office materials, printing and advertising, purchase of collection containers and all other costs. All of your costs should be input into the appropriate lines (lines 252x through 284x). A default list of line items has been provided as a reference. However, as the list is in blue on your screen, it is totally flexible and can be adjusted to suit your program

s requirements. Subtotals for employee earnings, employee benefits/taxes and office expenses are shown in lines 256, 265 and 285 respectively. The total of all administration costs is shown in line 286 with the total costs allocated on a per tonne basis in line 288 and per month in line 289.

Figure 4.11:

Recycling Collection Cost Model Page 11:

Collection Costs: Administration and Overhead Costs

Page 12: Collection Cost Summary

This section summarizes all of the costs associated with the recycling program (See Figure 4.12). Lines 290 to 293 review the total number of households and apartment units in the program, the total tonnes collected and the total number of cubic metres of material collected.

The annual capital costs are summarized in lines 294 to 296, with the annual capital cost output in line 294.

The annual operating costs are summarized in lines 297 through 308, divided into three sections: annual lease/contract cost (lines 297 to 299); annual operating and maintenance costs (lines 300 to 302); and annual labour cost (line 303 to 305). The total annual operating cost is output in line 306.

The annual administration and overhead costs are summarized in lines 309 to 311 with the total annual cost output in line 309.

The total annual cost of the recycling program is shown on line 312. The total annual cost per tonne is output in line 313. The total annual cost per on-board (the vehicle) cubic metre is shown in line 314 and the cost per household/apartment unit is output in line 315.

## Comparing Scenarios

When using the model to compare different scenarios, a quick comparison of scenario costs can be undertaken by inputting

into line 316x (in the box in the upper righthand corner of page 12). The difference in cost between the two scenarios will be output in column 317. The costs for both scenarios must be input into the appropriate sections of the model for the model to calculate the differences.

Figure 4.12

Recycling Collection Cost Model Page 12

Collection Costs:

## Summary of All Collection Costs, Calculation of

Costs Per Tonne for Capital, Operating and Administration and  
Summary of Costs Per Tonne, Cubic Metre and  
Household or Apartment

\*NOTE: Once you have completed the model and have examined all of your costs, try running the second scenario, changing the parameters of the program, e.g., time per setout, and then based on the revised number of vehicles required, examine the adjusted capital and operating costs. To quickly input the costs for the revised program (i.e., Scenario #2) take the average costs per vehicle, employee, etc. output in Scenario #1, multiple the average by the new number of vehicles, people, etc., and enter the total as a lump sum into one line in the appropriate section.

### **Number of crew members in Scenario #1 = 10; Total labour cost = \$200,000**

Cost per crew member = \$20,000.

Number of crew members in Scenario #2 = 8

Input \$160,000 into the labour section (page 10) under any line item under drivers/crew members. Repeat this for each of the cost pages of the model.

Checking for Accuracy

When using the model to review an existing program, if you find that the model is not approaching the “reality” of your specific program reexamine your inputs to make sure that they are accurate. Also, examining the output cells on Page 6

Materials Collected: Total, Per Household/Apartment Unit, Per Capita and Page 7 “Route Calculations” (other than fleet size) can provide a good check to see if accurate information is being used in the model. Key lines which should be examined include:

Material Densities (Sc#1-49x; Sc#2-61x):

These densities are used to calculate the average weighted density in each compartment on the truck, which ultimately determines the number of setouts that can be picked up before each compartment cubes out. If the densities of each material being collected are known, ensure that the figures match the defaults provided. If the numbers do not match, input the values you have measured.

1<sup>st</sup> Compartment to Cube Out (Sc#1-79; Sc#2-89):

Based on the densities of the materials, the quantity per setout and the size of each of the compartments, the model calculates the number of setouts that each compartment can hold before cubing out.

Consequently, the first compartment to cube out is determined. This should be compared to what happens in the actual program to ensure consistency. If the model does not indicate the same compartment, revisit the densities of each of the materials and compartment sizes to ensure accuracy.

Number of Loads Per Day (140):

Operators/municipalities generally know how many full and partial loads and what percentage full the partial load is for each truck and route each day. Ensure that the numbers coincide with one another. If the number of loads does not match the known value, examine all time and speed variables as required

on the “collection factors” page (Page 5) to ensure they are accurate. Depending on the recycling program, under or overestimating time for daily activities (i.e. unloading the vehicle, driving to and from the route, etc.) can mean the difference between accurate and inaccurate outputs. Also check the average densities of the materials collected to ensure that the model is not “trying to fill up the truck” too quickly or too slowly based on volume.

#### Number of Setouts Picked Up Per Day (141):

The number of setouts picked up per day is often measured in each program to help determine efficiency, routing of vehicles, etc. Make sure that the number matches that shown on line 141. If the numbers do not match, check to ensure that all time estimates and vehicle velocities input into the “collection factors” section (Page 5) are accurate.

#### Actual Passes Per Day (Households and Apartment Buildings) (144):

It is generally known how many households that each truck passes on an average daily basis. Make sure that the number matches that shown on line 184. If the numbers do not match, check to ensure that all time estimates and vehicle velocities input into the “collection factors” section are accurate.

#### Setouts Per Route Hour (145):

Similar to line 144 only on an hourly basis. If the numbers do not match do the same check as outlined for line 144.

#### Fleet Size (156):

Ultimately, if all variables have been accurately input into the model for the recycling program, the fleet size required shown on line 156 will equal the known fleet size for the program. If the fleet size does not correspond with the known size examine all output lines above line 156 (i.e. examine lines outlined above first) to try and pinpoint the cause for the calculation of the difference in the number of vehicles required.

This chapter has gone through the Recycling Collection Cost Model on a line by line basis explaining how the model works, what inputs are required and what results might be expected to come from the model’s use. The model has been set up to allow the user to change variables easily and subsequently examine the effects the change(s) have on the model and the recycling program’s requirements (i.e., fleet and crew size).

With a number of the variables, the sensitivity is quite high, i.e., if they are changed slightly, the model’s outputs are changed markedly. For those variables where the values shown in the example are used in place of hard numbers, it is in the best interest of the recycling program and the model to go out and measure the values and then input the accurate information into the model. This will help the model approach the existing recycling program scenario.

In the next chapter, the allocation of costs to individual materials, collection streams and material streams (e.g., fibres, plastics, glass, metals, etc.), how to allocate the costs, and considerations which must be made when undertaking the cost allocation will be discussed.

## **5.0 COST ALLOCATION - ALLOCATION OF COSTS BY MATERIAL, BY WEIGHT, VOLUME, UNITS (PIECES) OR ACTIVITY**

This chapter outlines a method of cost allocation for all of the costs outlined on pages 8 through 11 of the model. Pages 1 and 2 are the cost allocation pages for Scenario #1 and Pages 3 and 4 are for Scenario #2. Page 1 and Page 3 are identical and page 2 and page 4 are identical in how they are set up. The cost allocation pages for Scenario #1 are shown in Figures 5.1 and 5.2. examines the costs for the collection program for each of four different “cost centres”:

1. Capital Costs - Equipment
2. Operating Costs - Labour/Employee
3. Operating Costs - Equipment Operating
4. Administration Costs

The costs calculated on pages 8 through 11 of the model for each of the cost sections must be, in whole or in part, depending on the allocation method chosen, input under the appropriate cost centre in the line marked “*Input costs to be allocated*”.

### **5.1 Cost Allocation Methodologies**

You *model user* must define how the costs for each of the cost centres (as defined on page 1), should be allocated to each of the **individual** materials. The *model user* can automatically allocate the costs in three ways - by weight, by volume, by units - using the built in formulae. The fourth allocation method - activity based costing - requires you to input the dollar values for each of the costs, directly across from the material that incurs the cost. This method can be used alone or in combination with one of the three automatically calculated approaches. The four allocation methods are explained in more detail below.

**By Weight (denoted by “w”):**

The costs are allocated to each material in the same proportion as that material represents, by weight, of the total amount of (all) material received. For example, if newspaper represents 47%, by weight of all material collected, then 47 of all costs (for the cost centre where weight is the basis for allocation) will be allocated against the newspaper.

**By Volume (denoted by “v”):**

The costs are allocated to each material in the same proportion as that material represents, by volume, of the total amount of (all) material received. For example, if PET represents 5.1%, by volume of the material on the truck, then 5.1% of all costs (for the cost centre where volume is the basis for allocation) will be allocated against the PET.

**By Units (pieces) (denoted by “u”):**

The costs are allocated to each material in the same proportion as that material represents, by the number of units (or pieces), of the total amount of (all) material received. This is dependent on the average weight for a “piece” of material as input by the *model user* in column 4x (Scenario #1) or column 30x (Scenario #2). If a material being picked represents 20% of all materials picked, then it would be allocated 20% of the costs for that category.

**By Activity (denoted by “a”):**

Under this method, costs are directly input, by you, against a material. This can be the most accurate method of allocating costs in a number of areas (e.g., R&D for plastics recovery, on-board equipment purchased explicitly for one material type, etc.). This could also be used if the you wish to allocate the costs to materials on a specific basis, other than weight, volume or units (e.g., the amount of time taken to manage a material). For example, if 15% of the time per setout (i.e., assuming it has been accurately measured) is spent by the operator sorting one specific material, then 15% of the labour cost of that person would be allocated to that one material, instead of being “spread out” over all materials through another allocation method.

## **5.2 Allocating Costs to Specific Materials**

To allocate costs on the basis of weight (w), volume (v) or units (u), input the appropriate letter under each of the cost centre column under the “Input appropriate letter” row. Alternatively, the actual cost can be input directly for each material under each cost centre under the “A” column for each cost centre. The input columns are summarized on the Table 5.1.

The total allocated costs will be shown, for each material, in column 14 for Scenario #1 and column 40 for Scenario #2. This summary cost takes the allocated costs for each cost centre, irrespective of the allocation method (i.e., by weight, volume, units or activity). The total tonnes of each material that are collected are shown in column 2 for Scenario #1 and column 28 for Scenario #2.. The arbitrary “cost per tonne” of material in Scenario #1 (i.e., Total Allocated Costs (column 14) divided by Quantity Collected (column 2)) is shown in column 15. For Scenario #2, the arbitrary “cost per tonne” of

material in Scenario #1 (i.e., Total Allocated Costs (column 40) divided by Quantity Marketed (column 28)) is shown in column 41.

At the bottom of Page 1 for Scenario #1 and Page 3 for Scenario #2 is three rows which outline the total costs allocated (Sc#1-16; Sc#2-42), the total annual costs (Sc#1-17; Sc#2-43) and the total costs still not allocated (Sc#1-18; Sc#2-44). This provides the *model user* with a method of quickly checking to ensure that all costs as input into the model are accounted for in the cost allocation section.

**Figure 5.1:**

**MRF-PCM Page 10:**

**Figure 5.2:**

**MRF-PCM Page 11:**

**Table 5.1: Column Designations for Cost Allocation**

Weight, Volume or Units* (Input “w”, “v” or “u”)	Activity** (Input Costs Directly)	
<u>Capital Costs</u>		
Fleet Purchase	Sc#1-6; Sc#2-32	Sc#1-7; Sc#2-33
<u>Operating Costs</u>		
Fleet Labour	Sc#1-8; Sc#2-34	Sc#1-9; Sc#2-35
Fleet Operating	Sc#1-10; Sc#2-36	Sc#1-11; Sc#2-37
<u>Administration Costs</u>		
Administration & Overhead	Sc#1-12; Sc#2-38	Sc#1-13; Sc#2-39

\*Costs will be allocated automatically by material upon input of a letter.

\*\*Costs must be input by the *model user*.

### 5.3 Cost Allocation by Material Groups or Collection Stream

#### Total Costs Allocated by Material Group

In addition to calculating allocated costs specifically for each material, on page 2 (Scenario #1) and page 4 (Scenario #2), the model can also calculate the cost for two “groups”. The first is by one of ten material groups as follows (designated shortform in brackets):

Fibres (F);	Other - 1 (O1);
Aluminum (Al);	Other - 2 (O2);
Ferrous (Fe);	Other - 3 (O3);
Plastics (Pl);	Other - 4 (O4);
Glass (Gl);	Other - 5 (O5).

You can define the “other” categories. Input the appropriate shortform in column 1 (Scenario #1) or 27 (Scenario #2).

For Scenario #1, the first box on page 2, lines 19 through 22, show the costs for each material category (e.g., fibres, aluminum, ferrous, plastics, glass, etc.) as defined by the *model user* in column 1. The model combines all of the “Total Allocated Costs” (column 14) for each material indicated as part of

the defined category of materials. Five “other” categories are provided should one of the preset categories not be sufficient. (See page 6-1 for a list of materials and their designated shortforms). These categories can be user defined and named in line 19. The model calculates the total costs allocated to each material category (line 20), the tonnage of material in each material category (line 21) and then provides, in line 22, the average material cost per tonne for all tonnes of material within that category (no matter what individual materials make up the category).

This exercise is repeated in lines 45 to 48 for Scenario #2, with the average material cost per tonne for all tonnes of material with the defined category being output in line 48.

### **Total Costs Allocated by Collection Stream Number**

The model will also allocate the costs on the basis of the collection streams, as input by the *model user* in columns 48 (Scenario #1 - page 2 of the model) or 61 (Scenario #2 - page 3 of the model). This method allows you to examine allocated costs for the collection of the streams of materials in the same manner as may be done for processing costs.

For Scenario #1, the second box on page 2, lines 23 through 26, show the costs for each processing stream (i.e., stream as the material is collected). For example, aluminum cans, ferrous cans, PET and container residue are all combined in the collection (and processing) stream as stream #2 (defined in column 48 on page 2 of the model).

The model combines all of the “Total Allocated Costs” (column 14) for each material indicated as part of the defined stream of materials. There are ten material streams to match the ten possible streams

from Page 2 of the model. These categories can be named in line 23. The model calculates the total costs allocated to each collection stream (line 24), the total tonnage of material in each collection stream (line 25), and then provides, in line 26, the average collection stream cost per tonne for all tonnes of material within that stream (no matter what individual materials make up the stream).

This exercise is repeated in lines 49 to 52 for Scenario #2, with the average collection stream cost per tonne for all tonnes of material with the defined collection streams being output in line 52.