

CIF 201: CONTAINER DENSITY FACTORS



CIF 201

Density factors for use in multi-residential recycling



Abstract: Average density of recyclables collected from multi-residential buildings is calculated. The data was collected from buildings in the City of London and Peel Region. The average density for recyclables in carts is 0.05 kg/litre. The average weight of recyclables in a 360-litre cart is 20 kg. For front-end bins, density is 0.045 kg/l and the weight of recyclables in a 4-yard bin is 140 kg.

More information on Best Practices in Multi-residential Recycling can be found on the CIF website.

CIF 201: Container Density Factors

DENSITY FACTORS FOR USE IN MULTI-RESIDENTIAL RECYCLING

PROJECT DESCRIPTION

This objective of this project was to establish average density factors for use in measuring and benchmarking recycling performance in multi-residential programs. This information is of used in estimating the quantity of recyclables captured in multi-residential buildings. The goal was to provide a reliable measure in the absence of weight scale data. Estimates of capture rate (tonnes/year or kg/unit/year) based on density factors are of particular value for municipalities that do have weight data for multi-residential collection routes. It is also useful for any municipality to be able to estimate individual building recycling quantities. At the time of the project completion there were no programs that were collecting weight-based data for individual buildings. Peel Region will be the first municipality to have this capability (with the use of on-board weight scales to be implemented on each collection vehicle under CIF 328: RFID Integration & On-Board Weigh Scales). As most municipalities do not have this level of detail about their buildings, the estimates provided by this project will be a useful tool for most.

For the purposes of this report, recycling capture is defined as the quantity (estimated weight) of materials placed in recycling containers at multi-residential buildings. It is expressed in terms of tonnes or kilograms per unit per year. Density factors were determined for paper and container streams in a two-stream program (London) and for a single stream program (Peel). Density factors for bundles of cardboard and cardboard carts were also determined.

Data was collected in the fall of 2009 the report was completed in 2011.

PURPOSE

Benchmarking recycling performance at a multi-residential building is a best practice. It is a key step in setting targets, implementing program enhancements and measuring improvements. Benchmarking by completing visual inspections at individual building serves two main functions:

1. For individual buildings it provides an effective measure of how much is recycled and kg/unit/year can be estimated for the building. The information from each building is instructive for identifying both low and high performing buildings. Low performers should be identified for follow-up strategies and top performers are useful as 'model' buildings and to understand strategies for successful recycling.
2. Total program capture rate estimates (tonnes per year) based on these visual inspections can provide reliable data (when completed at all buildings) in the absence of weigh scale records for multi-residential. This is often the case for smaller and mid-size municipalities that collect multi-residential with curbside households and do not have designated multi-residential collection routes.

PROJECT DELIVERABLES

The project determined density factors for the purpose of estimating individual building and overall recycling program performance. Density factors will be determined for the following:

1. 360 litre cart (95 gallon) – fibre carts in a two stream program
2. 360 litre cart – container carts in a two stream program
3. 360 litre cart – fully comingled carts in a single stream program
4. Bulk bin (3 or 4 cubic yard) – fully comingled in a single stream program
5. OCC (old corrugated cardboard) in carts
6. OCC bundles

PROJECT METHODOLOGY

The following is an overview of the methodology used. Density factors were based on multi-residential collection routes in London and Peel Region. 2cg Waste Management Consulting Services collected data under the direction of CIF staff.

1. Cart densities: 2cg staff recorded the number and fullness of each cart ($\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, full) at each building on multi-residential collection routes in London and Peel Region. Weigh scale tickets were obtained for the collection routes, and in London's case for each of the two streams (fibres & containers). The weight divided by the number of full carts provided the density factors for each stream. (Total kg collected on route \div total number of full 360 litre cart collected \rightarrow Density = kg/litre)
2. Front End Bin density: the procedure noted above was repeated in Peel Region for a bulk bin collection route.
3. OCC density: in the City of London, 2cg staff weighed samples of OCC in typical bundle sizes. The average was determined and the resultant factor provided the estimated weight of OCC bundles. Carts filled with OCC were also weighted and an average density determined.

ASSUMPTIONS & LIMITATIONS

The estimated Capture Rates noted are based on weekly collection.

The purpose of obtaining density factors is to determine estimated quantity of materials set out for recycling collection. Density factors will not provide tonnes or kg/unit net of residual.

Recycling material composition will vary based on season and municipal and building attributes such as size of daily paper and building population demographics. The project scope does not include the impact of these factors.

FINDINGS

The key results of this project are summarized in the Table 1 and further illustrated in Figures 1 to 6. These findings can be used as a general 'rule of thumb' for estimating quantities of recyclables. Detailed results are included in the Appendices.

Table 1: Key Findings

Container	Density	Annual Capture Rate of Container	Report Reference
360 Litre Cart	<ul style="list-style-type: none"> 0.07 kg/litre (fibres) 0.04 kg/litre (containers) 0.05 comingled 	1 tonne per cart Average cart both single & two-stream	Figure 1, Table 2, Appendix A & B
Front end bin	34 kg per cubic yard (.045 kg/l)	1.8 tonne per cubic yard	Figure 2, Table 2, Appendix C
Stacked OCC (flattened)	5 kg per 20 cm pile of 1 metre x 1 metre size (e.g. a stack of OCC that is 80 cm high x 1 m x 1 m = 20 kg)		Figure 3, Appendix D
OCC additional observations (in carts & loose)	30 kg per cubic yard	1.5 tonne per cubic yard	Figures 4, 5, 6 Appendix D

FIGURE 1: 360 LITRE CART (95 GALLON)



Capture: 1 Tonne/year

Density:

Two- Stream:

- Fibres: $D = 0.7 \text{ kg/l}$
- Containers: $D = 0.4 \text{ kg/l}$
- Average of all carts $D = 0.05 \text{ kg/l}$

Single Stream

- Comingled: $D = 0.5 \text{ kg/l}$

Approximate values

FIGURE 2. 4 YD³ BIN (3060 LITRES)



Capture: 7 Tonne/year

Density:

- Comingled: $D = 35 \text{ kg/yd}^3$
($D = 0.4 \text{ kg/litre}$)

Approximate values

FIGURE 3: OCC - FLATTEN & BUNDLED



Stacks of OCC
1 meter x 1
meter

5 kg for every
20 cm

At left:

20 cm = 5 kg

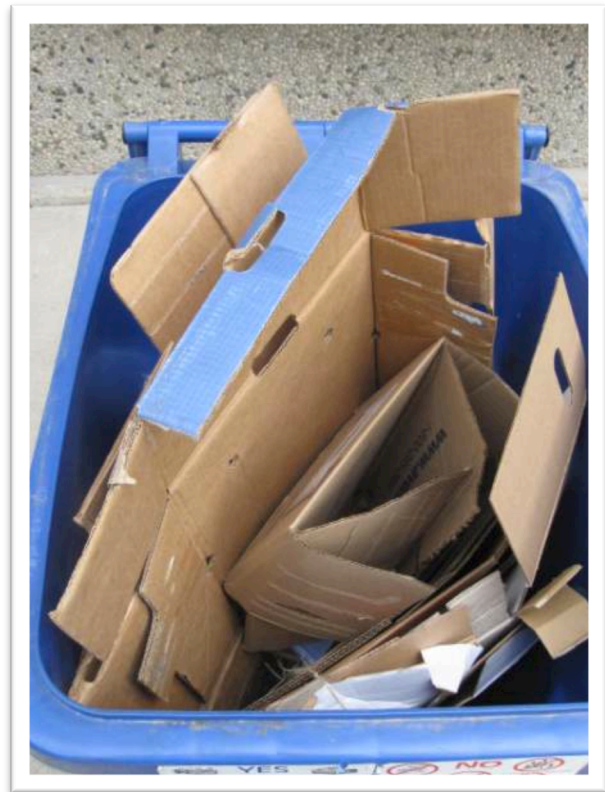


At left:

80 cm = 20 kg

Approximate values

FIGURE 4: 360 L CART – FLATTENED OCC



Capture: 0.8 tonne per year (when averaged within a cart based program can be rounded to 1 te per year)

Density:

- $D = 15 \text{ kg per cart}$ (0.4 kg/l)

Approximate values

FIGURE 5: 1 YD³ OCC CART (765 LITRES)



Capture: 2 Tonne/year

Density:

- OCC: $D = 30 \text{ kg/yd}^3$
($D = 0.4 \text{ kg/litre}$)

Approximate values

FIGURE 6: OCC – UNFLATTENED & LOOSE



OCC boxes,
piled, not
flattened

Weight = 5 kg



OCC boxes,
scattered, not
flattened (same
boxes as above,
shown scattered
for illustrative
purposes)

Weight = 5kg

Approximate values

Further to the key findings presented in Table 1 and illustrated in Figures 1 through 6, the summary data of the audits completed in London and Peel Region is presented below in Table 2.

Table 2: Summary Data - Densities in London and Peel Region

		London 1 Two- stream	London 1 Two- stream	London 1&2	Peel 1 Single- stream	London/ Peel Cart Average		Peel Front End
	Stops	21	22		21			33
Fibre	Full Carts	55.5	70					
	Kilograms	1400	1600					
	Kg/litre	0.07	0.06	0.07				
Co- mingled	Full Carts	32.75	41					
	Kilograms	430	570					
	litre/kg	0.04	0.04	0.04				
							Cubic Yds	190.25
All Carts	Full Carts	88.25	111	199.25	126.75		Kg	6500
	Kilograms	1830	2170	4000	2410			
	litre/kg	0.058	0.054	0.056	0.053	0.054	Kg/l	0.045
	Te/yr/cart	1.1	1.0	1.0	1.0	1.0	Te/cu yd/yr	1.8
	Average weight of Contents for Cart					20 kg	For 4 cu yd bin:	140 kg

PROJECT DATA COMPARED WITH OTHER DATA

This data supports previous estimates of density factors based on the Stewardship Ontario Waste Audits of Multi-residential buildings in Ontario municipalities between 2004 and 2008, and on container densities used in Peel Region.

- Stewardship Ontario Waste Audit data found that the average cart densities were 0.058 kg/litre (compared to 0.054 in this project) and capture of 1.1 tonnes per cart per year (compared to 1.0 in this project).
- Peel Region density data based on their weigh scale records found the density for 360 litre carts was 0.056 (compared to 0.054 in this project). The density for front-end bins (3,4,5 yard containers) was reported as .050 kg/litre (compared to 0.045 for this project), or 38 kg per cubic yard (compared to 34 for this project). See Appendix E for Peel's data completed independent of this project.

APPENDIX A: LONDON - CARTS

ROUTE 1: THURSDAY, SEPT 17, 2009

#	Street Name	Total Carts at Building	Fibre Stream Full	Fibre Stream litres	Container Stream Full	Container Stream litres
744	Fanshawe Park Rd E	8	4.00	1,440	3.50	1260
724	Fanshawe Park Rd E	7	4.00	1,440	3.00	1080
640	Fanshawe Park Rd E	5	1.50	540	1.75	630
746	Fanshawe Park Rd E	5	3.00	1,080	1.50	540
1549	Trossacks Ave	2	1.00	360	1.00	360
1558	Trossacks Ave	5	3.00	1,080	1.00	360
1554	Trossacks Ave	4	1.00	360	0.75	270
1562	Trossacks Ave	3	1.00	360	1.00	360
1560	Trossacks Ave	3	1.75	630	0.50	180
1550	Trossacks Ave	5	1.00	360	0.75	270
1566	Trossacks Ave		-	-	0.00	0
1265	Bentley Dr	6	2.75	990	1.50	540
1275	Bentley Dr		-	-	0.00	0
1270	Webster St	11	5.25	1,890	4.00	1440
1280	Webster St		-	-	0.00	0
1260	Webster St	4	1.75	630	0.75	270
1230	Sanford St	2	1.00	360	0.75	270
1240	Sanford St	4	2.50	900	0.75	270
1250	Sanford St		-	-	0.00	0
1550	Beckworth	11	6.00	2,160	2.00	720
1420	Huron St	3	2.00	720	1.00	360
1426	Huron St	2	1.00	360	1.00	360
202	McNay St	8	4.25	1,530	1.50	540
1203	Huron St	9	4.75	1,710	2.75	990
1229-1237	Huron St	5	3.00	1,080	2.00	720
	Total	112	55.50	19,980	32.75	11,790
	Truck Weight - kilograms			1400		430
	Density kg/litre			0.07		0.04
	Kg per year			1312		683
	All carts te/year (average)			1.1		

APPENDIX A: LONDON - CARTS

ROUTE 2: FRIDAY, SEPT 18, 2009

#	Street Name	Total Carts at Building	Fibre Stream Full	Fibre Stream litres	Container Stream Full	Container Stream litres
279	Horton St	6	4.00	1,440	1.25	450
300	Wellington	2	0.25	90	0.50	180
1	Beaufort Street	8	4.50	1,620	2.25	810
190	Sarnia Rd	4	2.50	900	1.00	360
200	Sarnia Rd		-	-	-	-
217	Sarnia Rd	7	4.50	1,620	2.00	720
1083	Western Road	5	3.00	1,080	2.00	720
1095	Western Road		-	-	-	-
305	Wharnccliffe Rd NORTH	2	1.00	360	0.75	270
345	Wharnccliffe Rd	7	3.75	1,350	2.00	720
349	Wharnccliffe Rd	9	3.75	1,350	3.00	1,080
939	Western Rd	11	5.50	1,980	3.00	1,080
310	Wharnccliffe Rd	2	1.00	360	1.00	360
118	Wharnccliffe Rd	2	1.00	360	0.75	270
85	Walnut St	8	2.75	990	1.75	630
201	Riverside Dr	4	1.75	630	1.50	540
284	Wonderland Rd S	15	6.50	2,340	6.00	2,160
620	Springbank Dr	5	3.00	1,080	2.00	720
630	Springbank Dr	12	8.00	2,880	3.50	1,260
1	Andover Dr	4	1.50	540	1.00	360
240	Commissioners Rd W	2	0.75	270	0.25	90
70	Huxley St	6	3.50	1,260	2.00	720
80	Huxley St	6	4.00	1,440	1.50	540
90	Huxley St	6	3.50	1,260	2.00	720
	Total	133	70.00	25,200	41.00	14,760
	Truck Weight - kilograms			1600		570
	Density kg/litre			0.06		0.04
	Kg per year			1189		723
	All carts te/year			1.0		

APPENDIX B: PEEL - CARTS

#	Street Name	Total Carts	Full Carts	Litres
2757	Battleford Rd	18	17.50	6,300
2866	Battleford Rd	14	10.50	3,780
210	Steeles Ave	3	3.00	1,080
220	Steeles Ave	15	15.00	5,400
3420	Trelawney Circle	3	3.00	1,080
3345	Escada	6	5.50	1,980
5605	Freshwater Dr	8	6.50	2,340
5800	Montevideo Rd	5	5.00	1,800
5940	Montevideo Rd	3	3.00	1,080
6234	Osprey Blvd	6	5.75	2,070
6325	Millers Grove	2	1.50	540
6700	Edenwood Dr	2	1.75	630
6770	Edenwood Dr	2	2.00	720
1780	Meadowvale Blvd	7	6.25	2,250
6630	Turner Valley	5	5.00	1,800
3600	Thomas St	2	0.50	180
3061	Battleford Rd	7	6.25	2,250
6509	Glen Erin Dr	16	15.00	5,400
6521	Glen Erin Dr	11	11.00	3,960
444	Steeles Ave	2	1.75	630
6975	Meadowvale Town Centre	1	1.00	360
	Total	138	126.75	45,630
	Truck Weight - kilograms			2410
	Density kg/litre			0.05
	Kg/cart/year			989
	Te/cart/year			1.0

APPENDIX C: PEEL - FRONT END

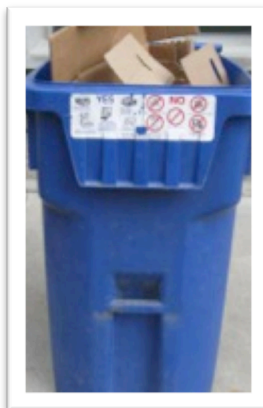
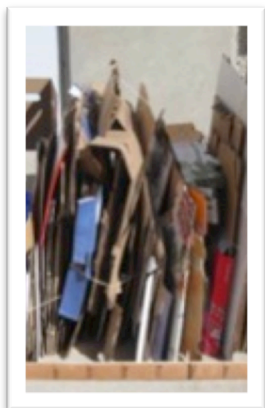
#	Street Name	Total Bins	Bin Size (cu. yd.)	full bins	Litres	Cubic Yards
370	Steeles Ave	2	4	2.00	6,120	8.0
365	Kennedy Rd	2	4	2.00	6,120	8.0
34	Rambler Dr	1	6	1.00	4,590	6.0
25	Rambler Dr	2	4	2.00	6,120	8.0
195	Kennedy Rd	2	4	2.00	6,120	8.0
165	Kennedy Rd	2	4	2.00	6,120	8.0
80	Orenda Cres	2	4	2.00	6,120	8.0
33	Kennedy Rd	2	4	2.00	6,120	8.0
161	Church St	1	4	1.00	3,060	4.0
171	Church St	1	4	1.00	3,060	4.0
182	Church St	2	4	1.25	3,825	5.0
22	Beech St	2	4	1.00	3,060	4.0
99	Kennedy Rd	2	4	1.75	5,355	7.0
525	Main St	1	6	1.00	4,590	6.0
525	Main St	2	4	1.50	4,590	6.0
10250	Kennedy Rd	1	4	0.75	2,295	3.0
11	Church St	2	4	1.75	5,355	7.0
100	Ken Whillans Dr	1	6	1.00	4,590	6.0
3	Wellington St	1	6	-	0	0.0
80	Scott St	3	4	1.50	4,590	6.0
47	McMurphy Ave	1	4	1.00	3,060	4.0
49	McMurphy Ave	1	4	1.00	3,060	4.0
51	McMurphy Ave	1	4	1.00	3,060	4.0
53	McMurphy Ave	1	4	1.00	3,060	4.0
55	McMurphy Ave	1	4	1.00	3,060	4.0
123	Railroad St	2	4	0.75	2,295	3.0
125	Railroad St	1	4	1.00	3,060	4.0
143	Main St	2	4	1.75	5,355	7.0
53	Church St	2	4	1.25	3,825	5.0
71	Mary St	2	4	1.25	3,825	5.0
141	Main St	2	4	1.50	4,590	6.0
320	Mill St	3	4	3.00	9,180	12.0
310	Mill St	3	3	2.75	6,311	8.25
	Total	56	139	46.75	145,541	190
	Truck Weight - kilograms				6500	0.04
	Density kg/litre				0.04	
	Kg/4 yard bin/year				7106	
	Te/cubic yard/year (assume full bins collected weekly)				1.8	

APPENDIX D: OCC WEIGHTS & VOLUMES

Flattened & bundled OCC

Bundle Height 1 meter x 1 meter (39 inch x 39 inch)	Weight	Density
20 cm (8 inch)	5 kg	
40 cm (8 inch)	10 kg	
60 cm (8 inch)	15 kg	
80 cm (8 inch)	20 kg	
1 meter (39 inch) = 1 cubic meter	25 kg	25 kg/cubic meter (0.025 kg/l)

Flattened OCC in Carts	Weight	Density
360 litre cart	15 kg	0.04 kg/litre
Techstar Cart (520 litre) (100 x 80 x 65 cm)	30 kg	0.06 kg/litre



APPENDIX E: INDEPENDENT PEEL DATA

Cart Recycling			
Total Average Carts Collected on Route	Total Average Kg per Route	Kg/Cart	Kg/yd ³
334	6681	20	40

Calculated from Peel data above:

Number of 360 litre Carts	Total Litres	Kg collected	Kg/litre	Capture: kg/cart/yr (weekly collection)
334	120,240	6,681	0.056	1.04
CIF 201 Project Findings			0.054	1.0

Front -End Recycling		
Bin Size/Type	Kg/Bin	(Kg/yd ³)
FL 6.00	255	42
FL 4.00	140	35
FL 3.00	110	37
Average kg/yd		38

Calculated from Peel data above:

Bin Size Yd ³	Litres	Kg/bin	Kg/litre	Kg/Yd ³
6	4590	255	0.056	42
4	3060	140	0.046	35
3	2295	110	0.048	37
Average			0.050	38.0
CIF 201 Project Findings			0.045	34.0