CIF Project 731
Processing of Expanded Polystyrene in Accordance with CPIA Recommendations

Final Report
July 2014

Prepared for:
Waste Diversion Ontario
Continuous Improvement Fund Office
Barrie, Ontario

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This Project has been delivered with the assistance of Waste Diversion Ontario's Continuous Improvement Fund, a fund financed by Ontario municipalities and stewards of blue box waste in Ontario.

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Appendices

1. INTRODUCTION

In September 2013, the Canadian Plastics Industry Association (CPIA) released a study which suggested that Expanded Polystyrene (EPS) should not be baled in Material Recovery Facilities (MRFs). CPIA conducted field studies in MRFs located in Waterloo Region, the City of Ottawa and the City of Kingston to support findings which demonstrated that management of EPS in MRFs, and in particular contact with conveyors and balers, was largely responsible for the introduction of contaminants to municipally-collected EPS. The report recommended that the material should instead be shipped loose or separated and densified prior to shipment to the processor or end market.

The purpose of this report was to estimate, to the best possible extent, potential cost ranges associated with the management of EPS and, more specifically, management of EPS based on operating parameters recommended by CPIA, namely that the material is not baled and instead either densified or shipped loose to the processor or end market, and that the material be collected in transparent plastic bags to reduce contamination of the EPS at curbside or depot.

There are a number of variables and operating approaches influencing cost, however twelve main collection and processing scenarios were defined and modeled to determine relative operating costs. The general approach was similar to cost modelling in which the cost elements are identified, such as material handling labour, capital equipment and transportation, and the costs attributable to a single material are allocated to the specific material. Activity-based models already exist in which this is done, and this approach was used to identify scenarios applicable to EPS and apply the data.

The scenarios used to develop the cost ranges are attached in Appendix A. EPS for the purposes of this report was considered to consist solely of expanded polystyrene foam and food packaging.

2. SCENARIO DEVELOPMENT

A number of variables were used to develop different scenarios for handling EPS in Ontario. The variables used to differentiate each scenario are as follows:

1. Where EPS is collected
   The major variable differentiating EPS material is how it is collected from the source – Ontario households. In Ontario, recyclables can be collected in a depot or curbside.

2. How EPS is collected
   In addition, consideration was given to how the EPS itself would be collected. It could be comingled and loose with all other materials, which is the current method most municipalities are using. EPS could also be collected along with other materials, but separated in a transparent bag. Finally, it could be collected segregated from other materials, either in a bag or loose.

3. Densification
   Once EPS has been collected, municipal operators have the option of densifying it prior to shipping it to the end market or processor. As noted above, for the purposes of this study densification was limited to common compaction technologies such as densifiers and not other technologies such as heat application to melt the EPS.

Figure 1 shows an example of a purpose-build foam densifier and the resulting bricks. This machine would only be used to densify EPS, which limits the amount of contamination of the final product.

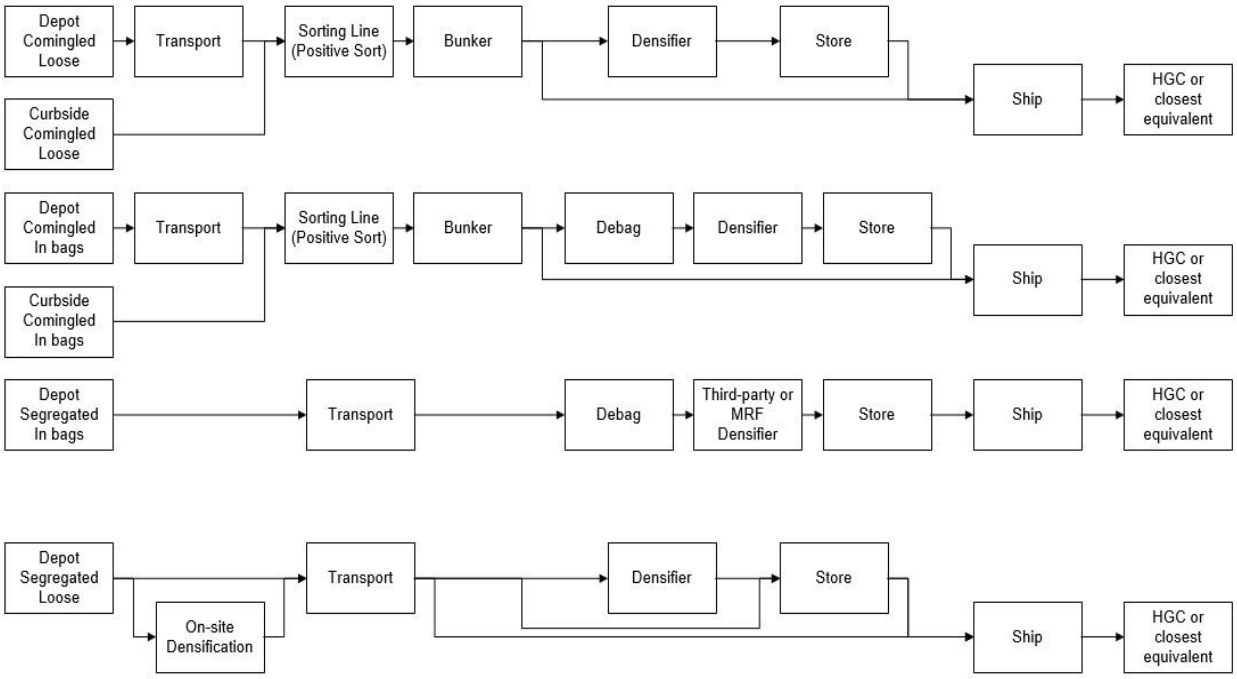
Figure 1. Dedicated EPS Densifier.

These variables were combined to produce the scenarios detailed in Appendix A, and were the basis for modeling cost ranges. The combination of these three variables produced twelve unique scenarios shown below in Table 1. More detail is shown in Figure 2.

Table 1. Scenarios for How and Where EPS is Collected, with or without Densification.

Where EPS is Collected	How EPS is Collected	Densification
Curbside	Comingled Loose	No densification
		Densification
	Comingled in Bags	Shipped in bags
		Debag, Densification
Depot	Comingled Loose	No densification
		Densification
	Comingled in Bags	Shipped in bags
		Debag, Densification
	Segregated in Bags	Shipped in bags
		Debag, Densification
	Segregated Loose	Shipped loose
		Densification

Figure 2. Scenario Detailed for EPS Options.



3. COST MODELING

The Ontario Blue Box Program Plan supports the various municipal recycling programs that operate across the Province. There is significant diversity among municipalities across the Province, as well as in the recycling programs provided by those municipalities. Recognizing this diversity but also recognizing the need to evaluate and compare program effectiveness and efficiency, municipalities and associations participating in the Municipal Datacall have been placed into municipal groups.

In order to develop a generic cost per tonne for handling EPS in each of the scenarios shown in Section 2, consideration was given to the area of Ontario in which the scenario will be implemented as this can affect operating costs. Programs in more densely populated parts of the Province tend to be less costly to operate due to the economies of scale and even local factors such as labour rates and transportation costs to market vary considerably. As such, all cost modeling was been done utilizing the Ontario Waste Diversion Ontario recognized groupings.

Municipal groups are based on two primary and two secondary criteria, which are shown below in Table 2 for each group

Table 2. Municipal Groups in Ontario.

Municipal Group	Primary Criteria		Secondary Criteria	
	Population	Population Density (residents per km^2)	Location (O. Reg. 101/94)	Type of Service
Large Urban	> 250,000	>4		
Urban Regional	> 250,000	<4		
Medium Urban	50,000-250,000	>3		
Rural Regional	50,000-250,000	<3		
Small Urban	<50,000	>4		
Rural Collection - North	<50,000	<4	North	Curbside >30% of households
Rural Collection - South	<50,000	<4	South	Curbside >30% of households
Rural Depot - North	<50,000	<4	North	Depot only or curbside <30% of households
Rural Depot - South	<50,000	<4	South	Depot only or curbside <30% of households

The use and accuracy of cost model data is highly dependent on a number of variables including labour rates, capital costs, and transportation costs. The numbers in the cost model should be considered as planning estimates. It is necessary to understand that local conditions associated with any given recycling program will impact the actual costs of implementing or changing EPS collection and processing. Further comments on cost assumptions are described in the following sections where they apply to the components of the EPS management scenario.

3.1 COLLECTION

To estimate collection costs for each option, 2012 WDO Datacall information was examined as this information includes all reported operating and capital costs associated with collecting material in either a depot or at the curb. To determine the amount of this cost that should be assigned to EPS only, Stewardship Ontario's Activity-Based Costing Principles for collection were referenced. For collection costs, high level allocation is based on the relative volumes of the material collected.

The amount of collection costs allocated to EPS was determined as follows. The results of this calculation are shown below in Table 3.

1. For each municipality, determine the volume of EPS they collected in 2012.
   An estimate of 2 kg/hhld was applied to the total households served for each program that indicated they were targeting EPS as part of their recycling program (CIF 711 Curbside Single Family Audits, MRF Commodity Bale and Residue Audits and MRF Composite Paper or Packaging Observations (CPP)). The volume of this material was calculated by applying the EPS density of 14.59 kg/m^3 from the 2013 Stewardship Ontario Fee-Setting Model.
2. For each municipality, the EPS volume was calculated as a percentage of total volume.
   A basket-of-goods density of 102.81 kg/m^3 was applied to all remaining marketed tonnes. EPS volume divided by this volume gives the percentage of total volume that EPS represents.
3. For each municipality, this percentage was applied to the total collection cost or depot cost to determine how much should be assigned to EPS.
4. For each municipal group, the average cost per tonne was determined to collect EPS at either the curb or in a depot.
   The total collection costs assigned to EPS for all programs in the group was summed up. This amount was divided by the total EPS tonnes collected by the group. The average cost to collect EPS at a depot was calculated using the same approach..
5. The results were compared among municipal groups and rounded for more conservative estimates due to the limited accuracy of the underlying data.

Table 3. Depot and Curbside Collection Costs per Tonne by Municipal Group.

Municipal Group	Depot Collection	Curbside Collection
	($/tonne)	($/tonne)
Large Urban	200	1,400
Urban Regional	200	1,400
Medium Urban	200	1,400
Rural Regional	200	1,650
Small Urban	200	1,400
Rural Collection - North	700	3,000
Rural Collection - South	450	2,500
Rural Depot – North	6,500	-
Rural Depot – South	3,600	-

For costs associated with collection, the cost per tonne shown in Table 3 was based on the range of reported costs within each municipal group. The information reported in the Datacall includes a number of operating conditions, including municipal collection and contracted operations. Programs may have combined collection and processing contracts, or separate contracts for each part of their recycling system. Generally, all combined contracts are reported

under collection. While care was taken to limit the inclusion of cost data from programs with combined contracts, additional analysis would be useful to ensure that this is the case. Information on the density of EPS at various stages through the collection process has been collected in the past, but additional field data would improve the data set.

3.2 PROCESSING

To estimate processing costs for each option, 2012 WDO Datacall information was examined as this information includes all operating and capital costs associated with handling EPS in a MRF. To determine the amount of this cost that should be assigned to EPS only, Stewardship Ontario's Activity-Based Costing Principles for processing costs were referenced. For processing costs, high level allocation is based on the relative volumes of the material handled. There is little observed difference between the collected or processed density of EPS prior to baling based on audits of facilities in Ontario, so the same calculation described in section 3.1 was used.

In addition, the cost of a sorter to pull EPS (either in bags or loose) out of comingled material was added to scenarios requiring this activity. For a sorter, a portion of an existing person's time was included. In those scenarios where debagging is required, a dedicated debagging sorter was included. For both operators, the additional sorting activities were estimated to increase the assigned processing costs by 5%. The amount of processing costs allocated to EPS for each municipal group is shown below in Table 4.

As with collection costs, the processing cost per tonne reflect an examination of all reported costs in each municipal group.

Table 4. Processing Costs per Tonne by Municipal Group.

Municipal Group	MRF Operation, Capital, Storage	Sorter	Dedicated Debagging Operator
	($/tonne)	($/tonne)	($/tonne)
Large Urban	200	50	50
Urban Regional	200	40	40
Medium Urban	200	15	15
Rural Regional	200	40	40
Small Urban	200	10	10
Rural Collection - North	700	20	20
Rural Collection - South	450	30	30
Rural Depot - North	6,500	20	20
Rural Depot - South	3,600	30	30

3.3 OTHER ACTIVITIES

In scenarios where densification is required, capital and operating costs for a densifier were included. Data from an experienced densifier operator was used to estimate the cost of this operation, set at $67/tonne. Additional information from other markets could be used to provide a range for what this cost.

It should be noted that densified loads of 18 tonnes of EPS can be achieved, but we have used baled loads as a surrogate since shipping destinations and costs vary. For example, it may cost

$2,200 to send a container to China or $800 to ship to a local market. The figures shown in Table 5 are representative of densified loads.

Two shipping options were included in the scenarios: shipping loose material, or shipping baled material. Shipping costs for loose material were based on selected municipal costs of trailer rental ($350/month) and load costs ($200/load at 800 kg/load, 4-6 loads per month) with relative shipping distances to market were estimated. Similarly, shipping of densified material was based on selected municipal costs of $700-$800 per load, load size of 5-9 tonnes with relative shipping distances estimated and number of tonnes per load based on higher compaction rates at larger facilities.

If programs have further data on an intended market or a densifier that would provide different densified block sizes, this information could be used when undertaking planning estimates.

Costs for shipping and densification are shown below in Table 5.

Table 5. Costs of Shipping and Densification per Tonne by Municipal Group.

Municipal Group	Shipping Loose	Shipping Densified
	($/tonne)	($/tonne)
Large Urban	323	161
Urban Regional	323	161
Medium Urban	338	192
Rural Regional	359	217
Small Urban	359	217
Rural Collection – North	718.75	367
Rural Collection – South	539.06	292
Rural Depot – North	718.75	367
Rural Depot – South	539.06	292

4. RESULTS

Looking at the results of handling EPS in the modeled scenarios for the different demographics reflected by the nine municipal groups gives a range of costs for each option.

Table 6 shows the estimated cost range for each option. Clearly options where there is more manipulation of EPS required will be more costly. At the same time, if this improves the quality of the material, higher revenues may offset this cost.

Where options have the same or similar ranges of costs, these options reflect the same or similar handling of the EPS from collection to the end market. For example, material collected at the curb and then shipped either loose or in bags without densification both involve curbside collection, a dedicated sorter and loose shipping.

By examining the requirements of end markets that offer higher revenues, and looking at which processing steps will provide a positive return on investment, recyclers can determine what EPS options best suit their operation.

Table 6. Cost Range for EPS Handing Scenarios.

Urban Collection

Collection Location	Collection Method	Densification	Estimated Cost Range ($/tonne)	
			Low	High
Curbside	Comingled Loose	No densification	1,653	2,849
		Densification	1,507	2,707
	Comingled in Bags	Shipped in bags	1,653	2,849
		Debag, Densification	1,522	2,747
Depot	Comingled Loose	No densification	769	1,573
		Densification	627	1,411
	Comingled in Bags	Shipped in bags	769	1,573
		Debag, Densification	637	1,461
	Segregated in Bags	Shipped in bags	523	559
		Debag, Densification	401	457
	Segregated Loose	Shipped loose	523	559
		Densification	361	417

Rural and Depot Collection

Collection Location	Collection Method	Densification	Estimated Cost Range ($/tonne)	
			Low	High
Curbside	Comingled Loose	No densification	1,139	4,139
		Densification	787	3,787
	Comingled in Bags	Shipped in bags	1,139	4,139
		Debag, Densification	807	3,807
Depot	Comingled Loose	No densification	1,593	7,639
		Densification	1,346	7,287
	Comingled in Bags	Shipped in bags	1,593	7,639
		Debag, Densification	1,375	7,307
	Segregated in Bags	Shipped in bags	989	7,219
		Debag, Densification	771	6,887
	Segregated Loose	Shipped loose	989	7,219
		Densification	742	6,867

5. FURTHER WORK

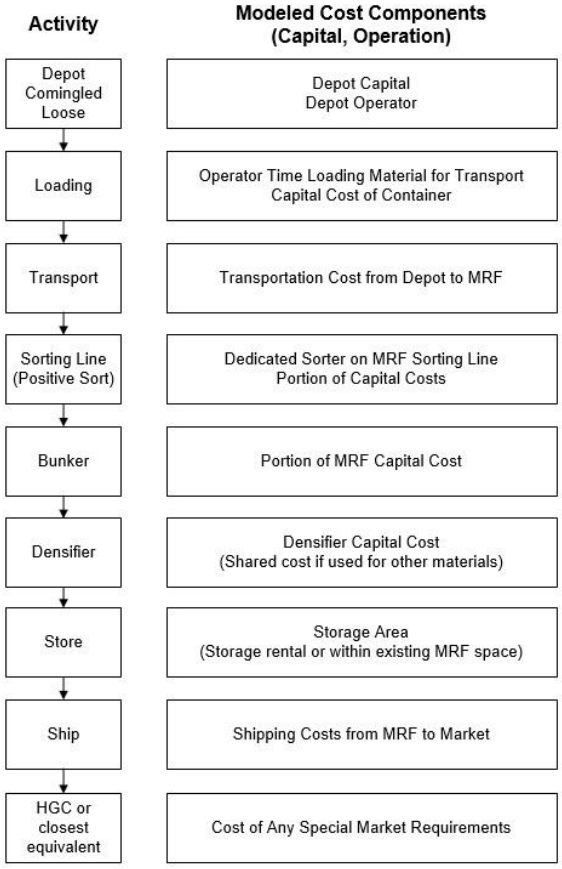
As discussed in the methodology above, additional activities will improve the quality and accuracy of this approach. It is suggested that future work could include the following items:

1. Additional analysis of collection and processing costs to develop a collection cost and a processing cost for each municipal group. This information could be as a basis for planning estimates for a number of activities. An analogue or "model program" approach may be preferred. The conditions associated with the model program could be noted, so other municipalities can determine how they differ and make any modifications to the assumptions as needed. Transfer of material from the point of collection to a transfer station or MRF will vary greatly by distance, so breaking down reported information into depot operation and capital versus transport would be helpful.
2. Further field work to collect density information on EPS and other printed paper and packaging at each stage in the recycling process. Volume is considered the major cost driver for both collection and processing activities. Density is used to calculate the volume of each material based on the tonnage reported. As such, the density information must reflect current operating conditions and the mass and volume of current printed paper and packaging being handled.
3. A review of the possible markets to develop more accurate shipping costs and revenue estimates, and the relationship between the two for finished material. Some buyers may quote revenue that includes collection from a MRF, while others are for delivered material. Distance to market and further processing steps that will be required to meet quality standards will ultimately affect the cost estimates for each scenario.

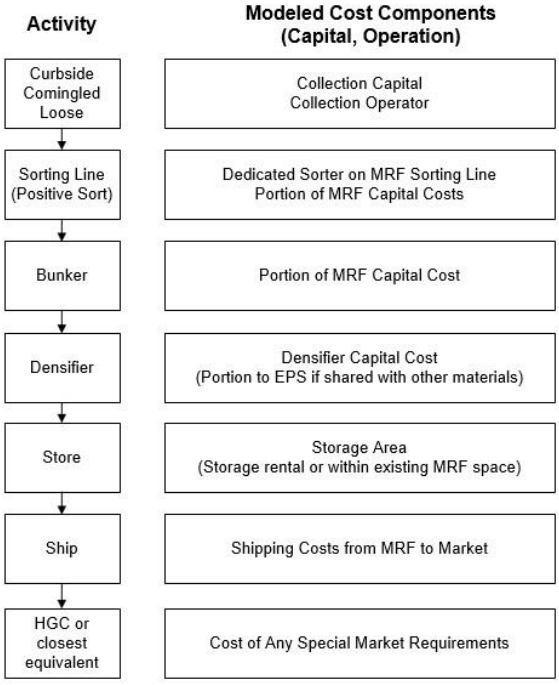
Appendix A

Flowcharts for EPS Options

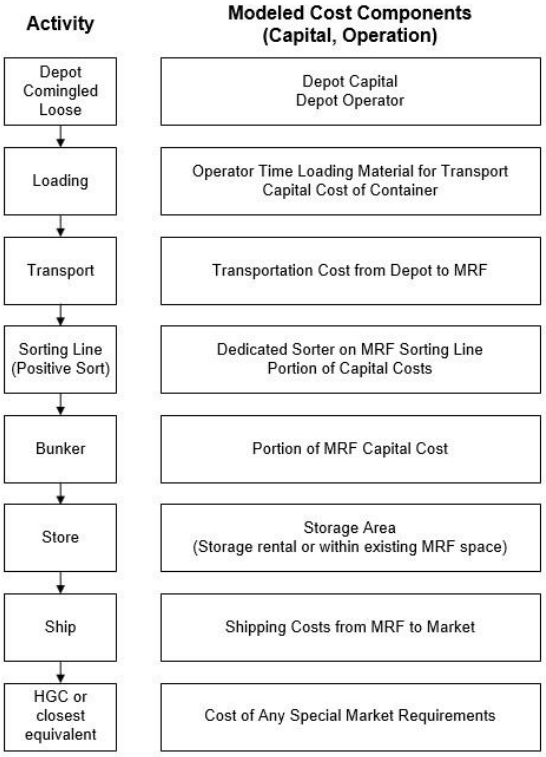
Option 1: Depot Comingled Loose with Densification



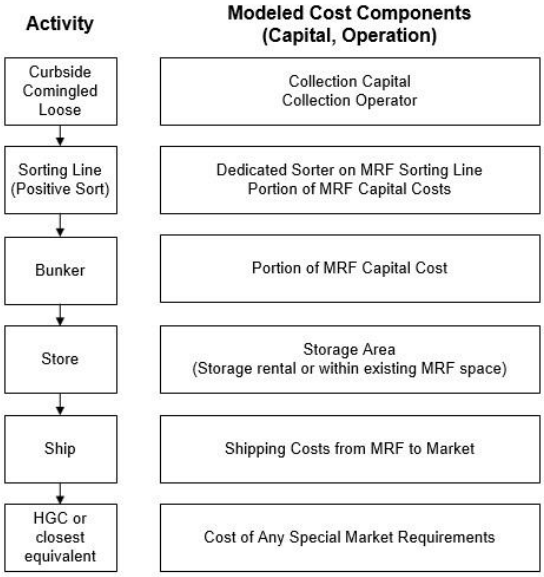
Option 2: Curbside Comingled Loose with Densification



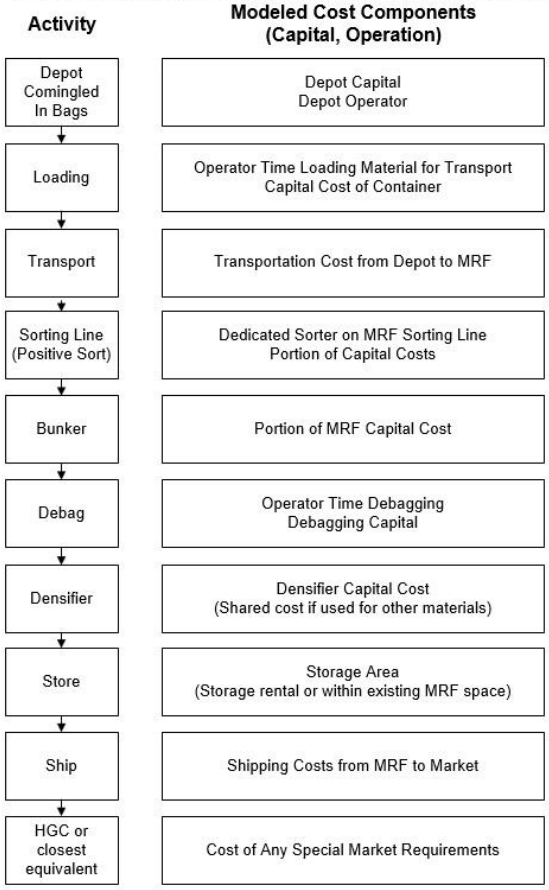
Option 3: Depot Comingled Loose without Densification



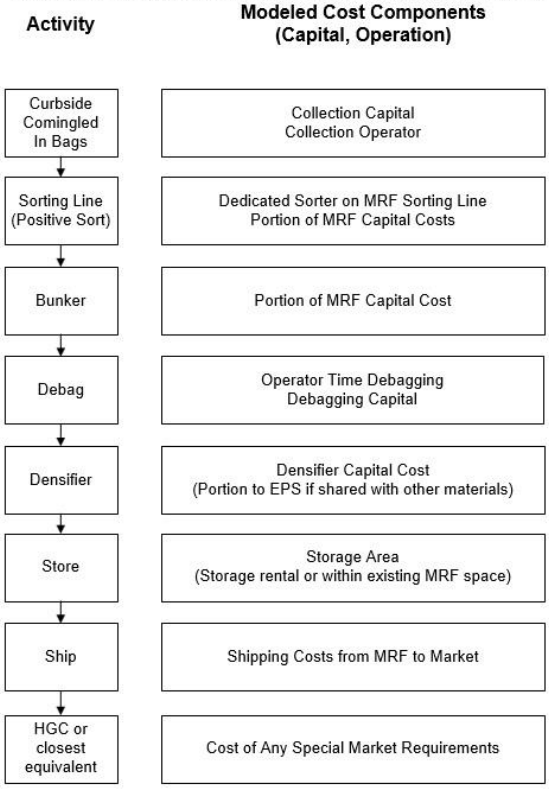
Option 4: Curbside Comingled Loose without Densification



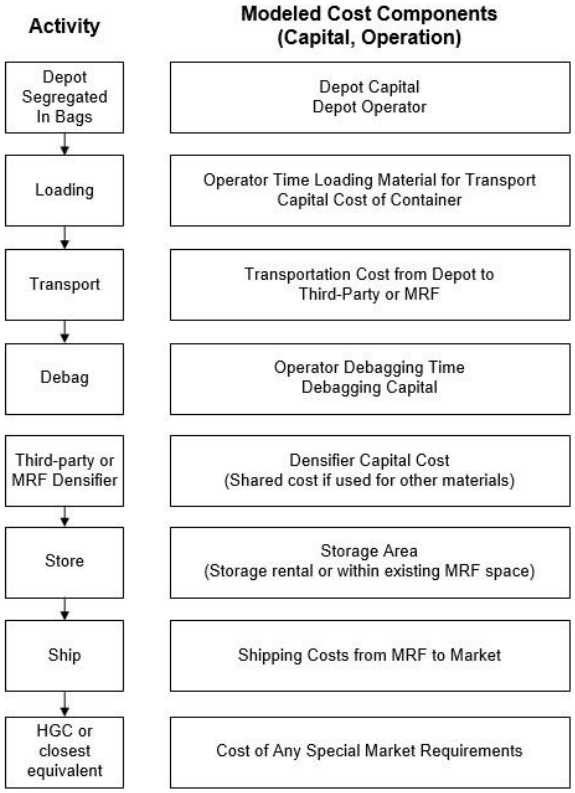
Option 5: Depot Comingled in Bags with Densification



Option 6: Curbside Comingled in Bags with Densification



Option 7: Depot Segregated in Bags with Densification



Option 8: Depot Segregated Loose with Densification