Continuous Improvement Fund

Report on Transfer of Blue Box Recyclable Materials: Factors Affecting Decision Making

July 2009

Prepared for:
The Continuous Improvement Fund
92 Caplan Avenue
Suite 511
Barrie, Ontario L4N 1Z7

Prepared by:
GENIVAR Ontario Inc.
600 Cochrane Drive, 5th Floor
Markham, Ontario L3R 5K3

Project No. MA-09-028-00-MA

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1. Introduction

Ontario's Blue Box program involves collection of primarily residential, recyclable materials from communities across the Province and subsequent processing of these materials for sale to relevant commodity markets. The processing, which involves sorting and baling of the recyclable materials, typically occurs at Material Recovery Facilities (MRFs). There are approximately 54 MRFs operating in Ontario and, because of significant differences in; individual community sizes, the recyclable materials collected in each community, the development history of each community's MRF and other factors, there is substantial variation amongst Ontario's MRFs in terms of capacity, processing capability, effectiveness and efficiency.

The Continuous Improvement Fund (CIF) is a committee of Waste Diversion Ontario, a non-crown corporation created under the Waste Diversion Act on June 27, 2002. The CIF provides grants and loans to municipalities to execute projects that are intended to increase the efficiency of municipal Blue Box recycling and help boost system effectiveness. As part of this mandate, the CIF is exploring how to build out and upgrade the existing MRF infrastructure in the Province to maximize efficiencies while still creating capacity for future needs.

Optimization of existing MRF infrastructure includes, among other things, examining the trade-off between processing at numerous MRFs around the Province versus transfer/hauling to fewer MRFs, which process more efficiently due to factors such as economies of scale. This report has been developed to assist decision makers in determining whether it is more efficient to develop transfer and hauling capacity in place of MRFs. Specifically, the report examines only the transfer and haul aspects of this larger analysis, and identifies the primary factors that must be considered in determining transfer station types/costs and haul costs.

"Critical" factors are those factors affecting transfer station types/costs and haul costs that are felt to be both *significant* in their overall contribution to facility sizing and/or costs and *sensitive* to variability. Sections 3 and 4 of this report identify the factors, including critical factors, to be considered while Section 6 provides a summary of these factors.

Appended to this report are a number of tables showing examples of transfer station sizing/costs and haul costs. The examples are generic in that "typical" costs/factors, rather than unique site-specific costs/factors, are employed. Therefore the applicable costs for a particular community are not necessarily to be obtained directly from this document. Rather, this document can be used to provide an overall framework and the building blocks necessary to formulate the scope of a project-specific analysis that would be necessary to make decisions regarding transfer of recyclable materials.

Transfer of recyclables can be achieved through either:

- "direct" haul, where the trucks used to collect the recyclable materials at curbside haul directly to the processing facility; or
- "transfer" haul, where a transfer station is utilized to consolidate curbside materials into trucks designed for long haul that then haul to the processing facility.

When faced with the need to haul materials some distance, a fundamental analysis that should be conducted to determine the most economical means of hauling the material is a direct haul versus transfer haul comparison. Section 5 of this report provides this comparison.

Finally, it should be noted that the analyses in this report are provided in the context of transfer of recyclable materials. The principles behind the analyses presented herein may also be used to assess the transfer of municipal solid waste but the reader is cautioned that municipal solid waste and recyclable materials have very different characteristics (notably; density, compactability and odour potential), all of which can significantly affect transfer economics.

2. Scope of Analysis

When considering the transfer and haul of recyclable materials there are three (3) key or fundamental variables that must be defined and which can then form the basis for the analyses conducted. These variables include:

- The nature of the recyclable materials to be transferred/hauled;
- The quantity of recyclable materials to be transferred/hauled; and
- The type of transfer station that would be used.

Each of these variables is further explained below.

2.1 Nature of the Recyclable Materials to be Transferred/Hauled

Blue Box recyclable materials are typically categorized into two basic streams; containers (such as plastic bottles, plastic tubs and lids, aluminum and steel cans, glass bottles/jars) and fibres (such as newspaper, boxboard, cardboard, office paper, etc.). In Ontario, containers and fibres are most often collected and processed in one of two forms:

- "Single-Stream", where all of the container materials and the fibres materials are mixed together; or
- "2-Stream", where the containers stream and the fibres stream are kept separate from each other.

There are some jurisdictions that collect and process their recyclable materials in more than two streams (for example, when glass is separated out from the remaining materials). This is typically a result of the lack of appropriate separation equipment in the MRF and for the purposes of this report, only the more common single-stream and 2-stream collection/processing approaches are considered. It is important that the analyses herein consider *both* single-stream and 2-stream since each has different storage requirements, densities, hauling requirements and thus different costs.

It is beyond the scope of this report to identify which collection/processing approach a community should adopt or change to. Such decisions would stem from a more comprehensive analysis that includes factors such as the current collection practice, opportunities to upgrade or expand the existing processing facility and, where a community's MRF is contemplated to be closed, what processing approach is utilized at the MRF to be hauled to.

2.2 Quantity of Recyclable Materials to be Transferred/Hauled

It is anticipated that where it is deemed more efficient to develop transfer and hauling capacity in place of MRFs, such MRFs would generally have capacities of less than 10,000 tonnes per year (tpy). Thus, the transfer station capacities potentially required would also be less than 10,000 tpy. For the purposes of the analyses in this report, transfer station sizing/costs and haul costs are developed for the following quantities:

- 2,500 tpy of single-stream materials and 2,500 tpy of 2-stream materials;
- 5,000 tpy of single-stream materials and 5,000 tpy of 2-stream materials; and
- 10,000 tpy of single-stream materials and 10,000 tpy of 2-stream materials.

2.3 Transfer Station Type

At the scale of facility as discussed above, there are two common types of transfer stations available:

- Transtor transfer station; and
- Traditional transfer station.

Transtor transfer stations involve proprietary material storage containers (called “Transtor” containers by the container manufacturer/vendor; Haul-All Equipment Systems – see Figure 1) that are hydraulically pivoted to discharge their contents into open top transfer trailers or transfer trailers with integral compacting ram. A grade separation is required so that delivery vehicles can access the container loading door at the top of the container. The Transtor containers are available in 40 yd^3 and 53 yd^3 storage volumes.

Figure 1 – Transtor Containers (Photo from Haul-All Website)

A traditional transfer station involves a fully enclosed building with overhead doors and a (normally but not always) clear span tip floor/storage area. Delivery vehicles enter the building via the overhead doors and discharge their contents onto the floor and then a front-end loader pushes the material into storage piles. These facilities normally utilize heavy concrete pushwalls to allow the material being stored to be pushed into high piles to minimize the storage area for the piles. The loader takes material from the storage piles and dumps it into transfer trailers, which are usually accommodated in separate trailer bays that are at a lower grade to enable top loading into the trailer. In some cases the use of a stationary compactor and feed hopper (to increase the payload in the transfer trailer) are provided, generally when the added capital cost can be recovered through haul cost savings. Figure 2 shows a typical traditional transfer station, in this case an open-style facility without overhead doors.

Figure 2 – Traditional Transfer Station

Facility sizing as well as capital and operating costs are developed in this report for both of these styles of transfer station.

3. Factors to Consider in the Sizing and Design of Transfer and Haul Infrastructure

Factors to consider in the sizing and design of transfer and haul infrastructure are discussed below. Critical factors (i.e., those factors affecting transfer station types/costs and haul costs that are felt to be both *significant* in their overall contribution to facility sizing and/or costs and *sensitive* to variability) are identified.

3.1 Nature of the Recyclable Materials to be Transferred/Hauled

As indicated earlier this report considers two fundamental recyclable material streams:

- "Single-Stream", where all of the container materials and the fibres materials are mixed together; and
- "2-Stream", where the containers stream and the fibres stream are kept separate from each other.

Factors that differentiate these two streams and that impact the sizing and design of transfer and haul infrastructure include:

- *Material Composition* – For the purposes of the analyses in this report a 25%/75% by weight containers/fibres split is assumed. Thus for single-stream applications, the blend of the containers and fibres is estimated to be in the 25%/75% split. For 2-stream, the separate containers stream would represent 25% of the total tonnage to be transferred/hauled while the separate fibres stream would represent 75% of the total tonnage to be transferred/hauled. This approximate material stream split is consistent with many municipalities in Ontario (the author's experience suggests most programs in southern Ontario range from 20%/80% to 30%/70%), however a community-specific analysis should utilize actual audit data to establish this material stream split.
- *Material Stream Densities* – Based on the author's experience, it is estimated that the containers stream has an "on-floor" (i.e., piled but not intentionally compacted) density of approximately 50 kg/m^3. It is estimated that the fibres stream has an "on-floor" density of approximately 150 kg/m^3. In a single-stream mix, the blended materials would have an "on-floor" density of approximately 100 kg/m^3. It is worth noting that with the same 3:1 ratio for material composition split and material stream densities (i.e., there is 3x as much fibres as containers by weight and fibres have 3x the density as containers), the two streams will occupy approximately the same volume.
- *Compaction Ratios* – In the context of haulage, compaction of the containers and fibres is desirable as this increases the payload on the transfer trailer thus reducing the per-tonne haul cost.

  The containers stream has the ability to be greatly compacted owing to its low density and the nature of the materials making up the containers stream (i.e., highly compactable bottles and cans). However, high compaction of this stream is discouraged because this substantially hinders typical MRF containers processing operations such as sorting and screening. A maximum compaction ratio for the containers stream of 1.5 – 2 is recommended based on the results of a compaction and MRF processing impacts analysis conducted by York Region (the York Region analysis is available via the following link: http://www.stewardshipontario.ca/bluebox/eefund/projects.htm#207). In this report the lower compaction ratio of 1.5 is used to be conservative (in the sense that it leads to higher costs). Had the higher compaction ratio been used the calculated unit haul costs (on a $/tonne basis) would be lower, however in the ultimate Direct Haul vs Transfer Haul analysis (see section 5 below) the difference caused by the higher compaction ratio is relatively minor and thus is not considered a critical factor.

  The fibres stream cannot be compacted substantially owing to its higher density and the nature of the materials making up the fibres stream (i.e., less compactable paper, boxboard, etc.). Somewhat higher compaction of this stream can be tolerated at a MRF than for the containers stream because this does not substantially hinder typical MRF fibres processing operations. A typically achievable

(and tolerable at the MRF) compaction ratio for the fibres stream of 2.7 is assumed, again based on the results of the above-noted York Region report).

The above compaction ratios are applicable for trailers outfitted with a compaction ram (as can be used in the Transtor style transfer stations) or at a traditional transfer station outfitted with a stationary compactor. A traditional transfer station that relies only on tamping into a top-loading trailer is expected to achieve lower compaction ratios for containers and fibres (estimated at 1.2 and 2 respectively).

In the case of single-stream material, the limiting factor for compaction is the need to avoid over compacting the containers within the single-stream mix (to avoid MRF processing issues). As above for containers in a 2-stream system, a compaction ratio of 1.5 is recommended under a single-stream system.

3.2 Quantity of Materials to be Transferred/Hauled

For the purposes of the analyses in this report, transfer station sizing/costs and haul costs are developed for the following quantities:

- 2,500 tpy of single-stream materials and 2,500 tpy of 2-stream materials;
- 5,000 tpy of single-stream materials and 5,000 tpy of 2-stream materials; and
- 10,000 tpy of single-stream materials and 10,000 tpy of 2-stream materials.

Factors that differentiate these three quantity scenarios and that therefore impact the analyses in this report include:

- *Economies of Scale* – Capital and operating costs presented on a per-tonne basis can appear disproportionately high when low tonnages are involved. In the case of the three quantity scenarios analyzed in this report, this is particularly evident at the 2,500 tpy level.

  For example, a traditional transfer station sized for 2,500 tpy results in a building that has most of its footprint required just to get the collection and transfer vehicles inside the building, with very little building floor space required for the actual tonnage to be stored. Indeed the transfer station requirements at the 2,500 tpy level lead to per-tonne costs ranging from about $170/tonne to almost $240/tonnes, depending on the transfer station type.

  It is not the intent within this report to directly compare transfer and haul costs between the different quantity scenarios. Rather, it is intended to present transfer and haul costs for a range of quantities to capture the material transfer and haul requirements in a broad range of community sizes. The economies of scale factor is nevertheless identified as a critical factor because, as the tonnage becomes smaller, the cost estimates developed herein become increasingly sensitive to the elements making up the cost estimate and the accuracy of the element unit costs.

3.3 Need for a Transfer Station

Conducting the direct haul versus transfer haul comparison, as described in Section 5, may lead to the determination that transfer haul is more economical than direct haul and therefore consideration should be given to constructing a new transfer station. However, there are several factors that should be considered before making the final determination that a new transfer station is required. These factors include:

- *Availability of Another Transfer Station* – Construction of a new transfer station might be avoided if there is an existing transfer station in the local community or in a nearby community that could be used.

- *Availability of a Building That Could be Used as a Transfer Station* – Construction of a new transfer station might be avoided if there is an existing building in or near your community that could be

converted to a transfer station. A MRF that is proposed to be closed would be a good candidate. It should be noted that transfer station operations are characterized by heavy trucks and loaders causing substantial impacts and vibrations to building structures (particularly when materials are piled into storage piles against pushwalls). As well, transfer stations typically require high clearances for trucks to unload their contents (in excess of 10m) and ideally have clear span tip floors to allow unimpeded loader movement. These characteristics may render many buildings unsuited for conversion to a transfer station.

Either of the above items is considered a critical factor in that availability of another transfer station or of a building that could be converted to a transfer station could dramatically alter the transfer haul costs.

3.4 Type of Transfer Station

As discussed in Section 2 there are two common types of transfer stations considered in this report:

- Transtor transfer station; and
- Traditional transfer station.

Factors that differentiate these two types of transfer station and that impact the sizing and design of transfer and haul infrastructure include:

- *Need For Building Enclosure* – Transtor transfer stations can be operated either indoors or outdoors, the latter offering a benefit over a traditional style transfer station in that the cost of a building enclosure for delivery vehicles and/or transfer trailers is avoided. In some settings where harsh weather and large quantities of snow are common it may be preferable to utilize an enclosure at a Transtor transfer station.

  The enclosure capital cost can be relatively significant (see cost estimates in Appendix B) and thus is considered a critical factor. For example, with inclusion of the capital costs for an enclosure, the cost per tonne of the Transtor system increases by 10-15% depending on the scale of the facility.

- *Storage Capability* – A disadvantage to the Transtor approach is that the overall operation of receiving material, storage and discharge into trailers can be subject to delays if the storage containers are full and a transfer trailer is not immediately available. This issue can be mitigated with more Transtor storage containers or purchase of an extra trailer, but this comes at a relatively high marginal cost. A traditional transfer station by comparison can typically accommodate extra days of storage at a very low marginal cost.

  Transtor containers are available in 40 yd^3 and 53 yd^3 storage volumes and have no ability to compact within the container. When a delivery truck arrives to discharge its contents into the Transtor, the truck driver will open the container and will then judge whether the entire truck contents can be accommodated in the remaining container volume. Since it is often impractical to discharge only a portion of a truck's contents, if the driver feels the remaining container volume cannot accommodate the truck contents, another Transtor container will be used. The effect of this is that the *usable* storage volume of the Transtor containers is less than the actual volumes noted above. A 90% average capacity is assumed in this report.

- *Need for Front End Loader* – Loaders are required at traditional transfer stations to move material into storage piles and to load trailers and/or compactor hoppers. Transtor systems due to their self-loading and self-tipping nature do not require loaders.

3.5 Haul Vehicles

Factors related to haul vehicles that impact system costs include:

- *Trailer Size and Payload* – To reduce unit haul costs (on a $/tonne basis for example) the largest haul vehicles by volume are typically used to transport materials long distances so as to maximize payloads. The payloads are however limited by allowable Provincial and State road weight limits. In Ontario, weight limits vary depending on the number of trailer axels but in general long haul vehicles do not carry more than about 35 tonnes. New York State for example has lower weight limits (28 tonnes) while Quebec imposes lower weight limits seasonally.

  The analyses herein are based on commonly available transfer trailers having volume of 100 yd^3 and 140 yd^3, with the larger trailers proposed unless Ontario road weight limits will be exceeded.

- *Trailer Construction and Weight* – To allow for increased payloads and/or to realize better fuel consumption, trailers can be constructed of aluminum to reduce their tare weight. The down side to this approach is that these "light weighted" trailers are more prone to wear and damage, increasing maintenance costs. In this report use of conventional, steel trailer construction is assumed.

3.6 Examples of Transfer Station Sizing and Design Basis

Table A1 in Appendix A develops the sizing and design basis for a Transtor transfer station. Tables A2 and A3 develop the sizing and design basis for a traditional transfer station, without and with stationary compactors respectively. These tables form the basis for the corresponding cost estimates provided in Appendix B. The various factors for consideration in the sizing and design of transfer and haul infrastructure discussed above are incorporated into the tables.

4. Transfer and Haul Costs and Factors Affecting These Costs

4.1 Cost Estimates

In this section, cost estimates for the transfer and haul components discussed in the previous sections are developed. The estimates, although utilizing recent cost data for similar applications, are nevertheless generic in that "typical" costs, rather than unique site-specific costs, are employed.

Appendix B provides the following transfer station cost estimates:

- Table B1(a) – Transtor Transfer Station Capital Cost (2-Stream)
- Table B1(b) – Transtor Transfer Station Capital Cost (Single-Stream)
- Table B2 – Transtor Transfer Station Operating & Maintenance Cost
- Table B3(a) – Traditional Transfer Station (without compactor) Capital Cost (2-Stream)
- Table B3(b) – Traditional Transfer Station (with compactor) Capital Cost (2-Stream)
- Table B4(a) – Traditional Transfer Station (without compactor) Capital Cost (Single-Stream)
- Table B4(b) – Traditional Transfer Station (with compactor) Capital Cost (Single-Stream)
- Table B5 – Traditional Transfer Station Operating & Maintenance Cost

Table 1 provides a summary of the costs developed in the above Appendix B tables.

Appendix C provides the following haul unit cost estimates:

- Table C1 – Direct Haul Unit Costs
- Table C2 – Transfer Haul Unit Costs

Table 1 - Transfer Station Capital and O&M Cost Estimate Summary

Transfer Station System	2-Stream or Single-Stream	Cost Component	2,500 tonnes/yr	5,000 tonnes/yr	10,000 tonnes/yr
Transtor	2-Stream	Capital Cost ($)	2,449,200	3,112,900	4,858,800
		Annualized Capital Cost ($/yr)	252,200	320,500	500,300
		Annual O&M Cost ($/yr)	189,600	274,800	400,800
		Total Annual Cost ($/yr)	441,800	595,300	901,100
		Cost per Tonne ($/tonne)	177	119	90
	Single-Stream	Capital Cost ($)	2,321,000	3,170,200	4,742,300
		Annualized Capital Cost ($/yr)	239,000	326,400	488,300
		Annual O&M Cost ($/yr)	189,600	274,800	400,800
		Total Annual Cost ($/yr)	428,600	601,200	889,100
		Cost per Tonne ($/tonne)	171	120	89
Traditional (without compactor)	2-Stream	Capital Cost ($)	2,732,600	2,965,100	3,197,500
		Annualized Capital Cost ($/yr)	281,400	305,300	329,200
		Annual O&M Cost ($/yr)	259,800	313,300	375,600
		Total Annual Cost ($/yr)	541,200	618,600	704,800
		Cost per Tonne ($/tonne)	216	124	70
	Single-Stream	Capital Cost ($)	2,342,600	2,575,100	3,002,500
		Annualized Capital Cost ($/yr)	241,200	265,100	309,100
		Annual O&M Cost ($/yr)	259,800	313,300	375,600
		Total Annual Cost ($/yr)	501,000	578,400	684,700
		Cost per Tonne ($/tonne)	200	116	68
Traditional (with compactor)	2-Stream	Capital Cost ($)	3,226,600	3,459,100	3,691,500
		Annualized Capital Cost ($/yr)	332,200	356,200	380,100
		Annual O&M Cost ($/yr)	259,800	313,300	375,600
		Total Annual Cost ($/yr)	592,000	669,500	755,700
		Cost per Tonne ($/tonne)	237	134	76
	Single-Stream	Capital Cost ($)	2,589,600	2,822,100	3,496,500
		Annualized Capital Cost ($/yr)	266,600	290,600	360,000
		Annual O&M Cost ($/yr)	259,800	313,300	375,600
		Total Annual Cost ($/yr)	526,400	603,900	735,600
		Cost per Tonne ($/tonne)	211	121	74

4.2 Cost Factors for Consideration

In the previous section several factors for consideration in the sizing and design of transfer and haul infrastructure were presented. These factors are considered in the cost estimates presented in Appendix B and Appendix C.

For all intents and purposes, each of the line entries in the cost estimate tables (i.e., each component making up the total estimated cost) is also a factor for consideration and decision makers should consider the relevance and applicability of each component when developing site-specific cost estimates. To assist decision makers in understanding which cost items (or factors) are considered "critical" factors (i.e., factors considered to be both *significant* in their overall contribution to the costs and *sensitive* to variability), critical factors are identified in the cost estimate tables.

Regarding costs, a less quantifiable factor that is considered critical is the competitive conditions that prevail. Prices can vary significantly for the infrastructure and services discussed in this report especially where bidders are able to offer marginal rather than full cost pricing (yielding lower costs than expected) or where there is limited competition (yielding higher costs than expected).

Another factor for consideration is whether the annualization of transfer station or haul cost capital components is based on public sector or private sector financing assumptions. In this report a cost of capital financing rate typical for a public sector of 6% is assumed. A private sector financing rate of 10% or more could apply. This is identified in the cost estimate tables as a critical factor due to the significant difference in annual costs depending on the financing assumptions used.

5. Direct Haul versus Transfer Haul Comparison

5.1 Overview

Transfer of recyclables can be achieved through either:

- "direct" haul, where the trucks used to collect the recyclable materials at curbside also haul to the processing facility; or
- "transfer" haul, where a transfer station is utilized to transfer materials into trucks designed for long haul that then haul to the processing facility.

When faced with the need to haul materials some distance, a fundamental analysis that should be conducted to determine the most economical means of hauling the material is a direct haul versus transfer haul comparison.

In a direct haul versus transfer haul comparison the unit cost of direct haul (collection truck and driver, developed on a $/tonne-km basis) is plotted on a graph with total cost ($/tonne) on the vertical axis and round-trip haul distance (km) on the horizontal axis. This graph will thus show the total cost of direct haul as a function of round-trip haul distance.

Similarly the unit costs of transfer haul (transfer trailer and driver, developed on a $/tonne-km basis) *combined with* the cost of a transfer station (amortized capital plus operating, expressed on a $/tonne basis) can be plotted on the same graph.

Where the two systems' cost curves intersect on the graph represents the "break even" point (i.e., the round trip haul distance at which the costs of direct haul and transfer haul are the same). If the actual haul distance is shorter than the break even point then direct haul will be more economical and if the actual haul distance is greater than the break even point then transfer haul will be more economical.

Implicit to the direct and transfer haul costs derivation is the assumption that the driver can complete their normal activities and complete the haul trip in one day, thus not requiring overtime or accommodation costs, which would increase the cost estimates. In the case of direct haul, this means that the truck must first collect from sufficient homes to fill the truck before making the haul to the MRF.

5.2 Comparison

Figures 3 through 8 present Direct Haul versus Transfer Haul graphs for the various scenarios discussed in this report, namely:

- Figure 3: Transtor Transfer Station (2-Stream)
- Figure 4: Transtor Transfer Station (Single-Stream)
- Figure 5: Traditional Transfer Station, no compactor (2-Stream)
- Figure 6: Traditional Transfer Station, no compactor (Single-Stream)
- Figure 7: Traditional Transfer Station, with compactor (2-Stream)
- Figure 8: Traditional Transfer Station, with compactor (Single-Stream)

When looking at the above Figures, several conclusions can be drawn as follows.

First, the direct haul costs (expressed on a $/tonne basis) are not influenced by the tonnages hauled since there are no economies of scale. Thus the graphed direct haul costs are a straight line. Similarly, the transfer haul costs (expressed on a $/tonne basis and *not* including the costs of the transfer station) are not influenced by the tonnages hauled. Thus the graphed transfer haul costs are also a straight line. The transfer haul line has a less steep slope than the direct haul line, reflecting the lower per-tonne cost of transfer haul.

The direct haul unit costs for single-stream are lower than for 2-stream. Capital and O&M costs are also lower for single-stream than 2-stream. The combined effect results in the “break even” round trip haul distance being greater for single-stream than for 2-stream. Notwithstanding this conclusion, the decision as to whether a community should adopt (or change to) single-stream or 2-stream will likely be made on the basis of other factors.

The “break even” round trip haul distance is progressively shorter as the tonnage managed (tonnes/yr) increases. This is because of the economies of scale realized at larger transfer stations, which in turn means transfer haul becomes more economical than direct haul as the tonnage increases.

The capital and O&M costs for traditional transfer stations with compactor(s) are higher than without compactor(s). However, the transfer haul unit costs (per tonne) are lower when a compactor is used (as a result of higher payloads due to greater compaction). The net effect is that these two aspects tend to offset each other, suggesting that there is not a particular advantage to either approach. If the analysis were looking at haulage of more compactable material or material that could tolerate higher compaction rates than used in this report (municipal solid waste for example), there would definitely be an advantage to using a compactor as unit haul costs (per tonne) would be much lower.

6. Summary of Factors Affecting Transfer and Haul Costs

Factors affecting transfer and haul costs have been identified in several sections of this report. To assist the reader, the factors are summarized herein in Table 2. Table 2 also identifies those factors considered “critical” (i.e., factors considered to be both *significant* in their overall contribution to the costs and *sensitive* to variability).

Figure 3: Direct Haul vs. Transfer Haul
Transtor Transfer Station, 2-Stream

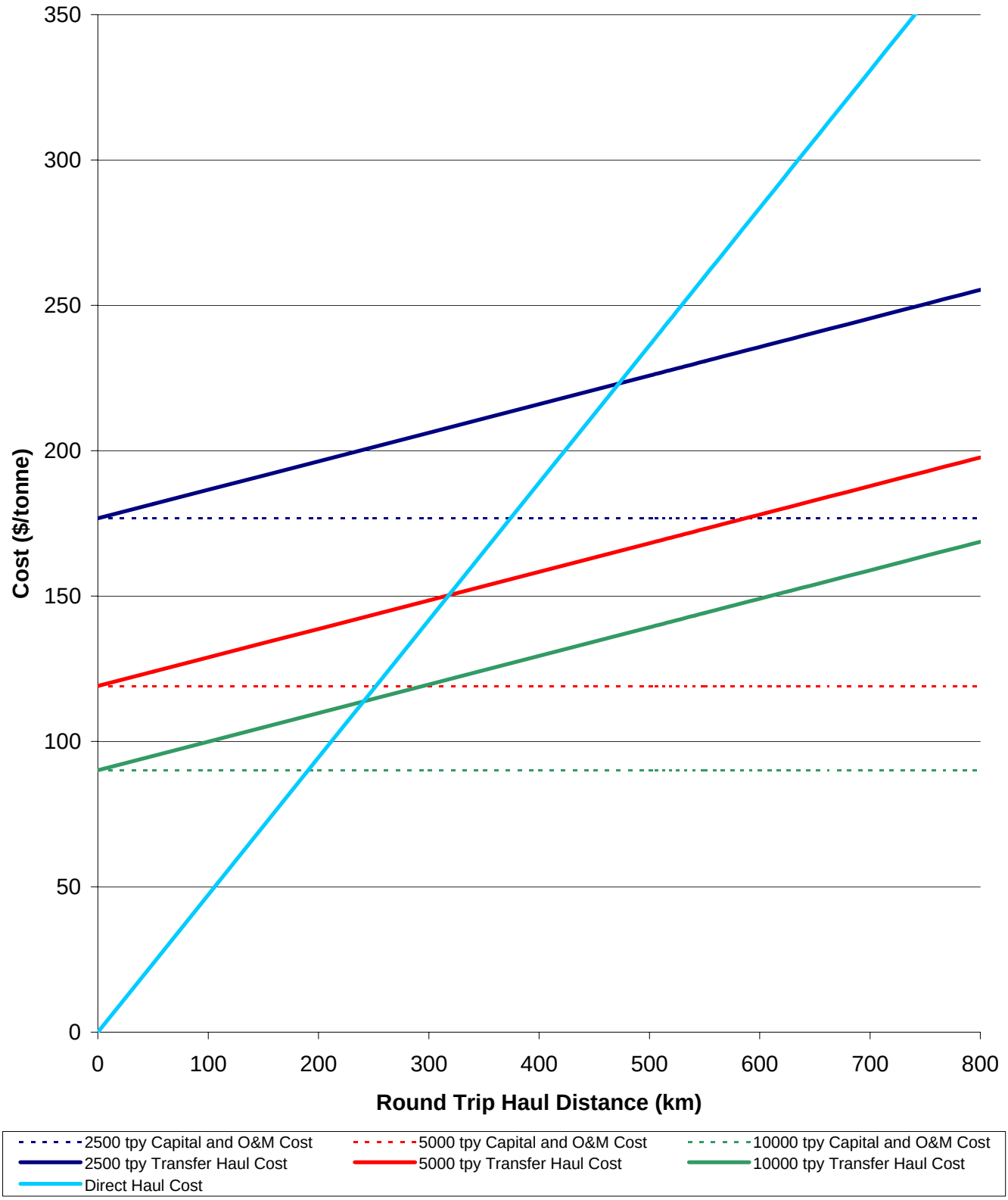

Figure 4 Direct Haul vs. Transfer Haul
Transtor Transfer Station, Single-Stream

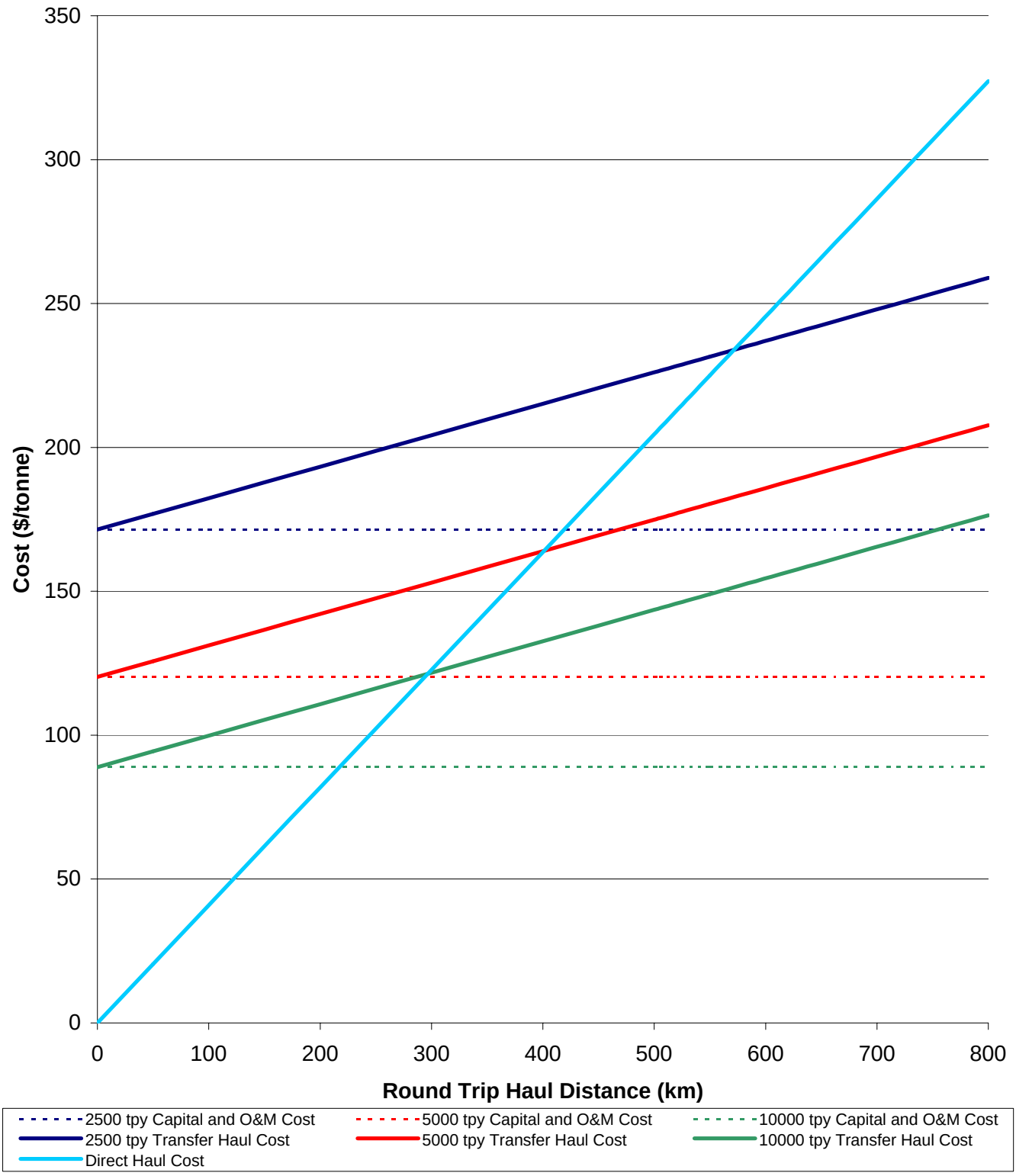

Figure 5: Direct Haul vs. Transfer Haul
Traditional Transfer Station (no compactor), 2-Stream

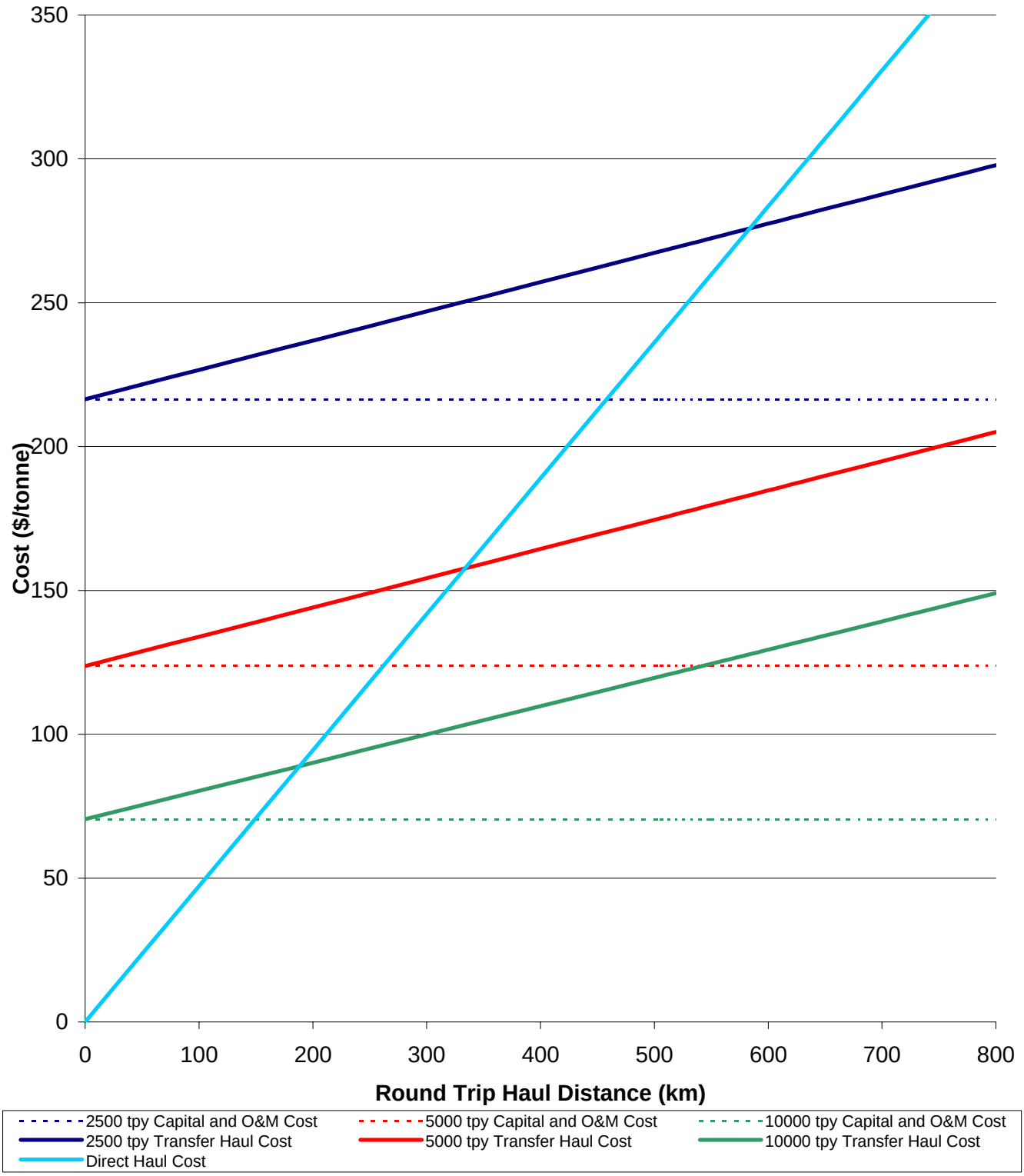

Figure 6 Direct Haul vs. Transfer Haul
Traditional Transfer Station (no compactor), Single-Stream

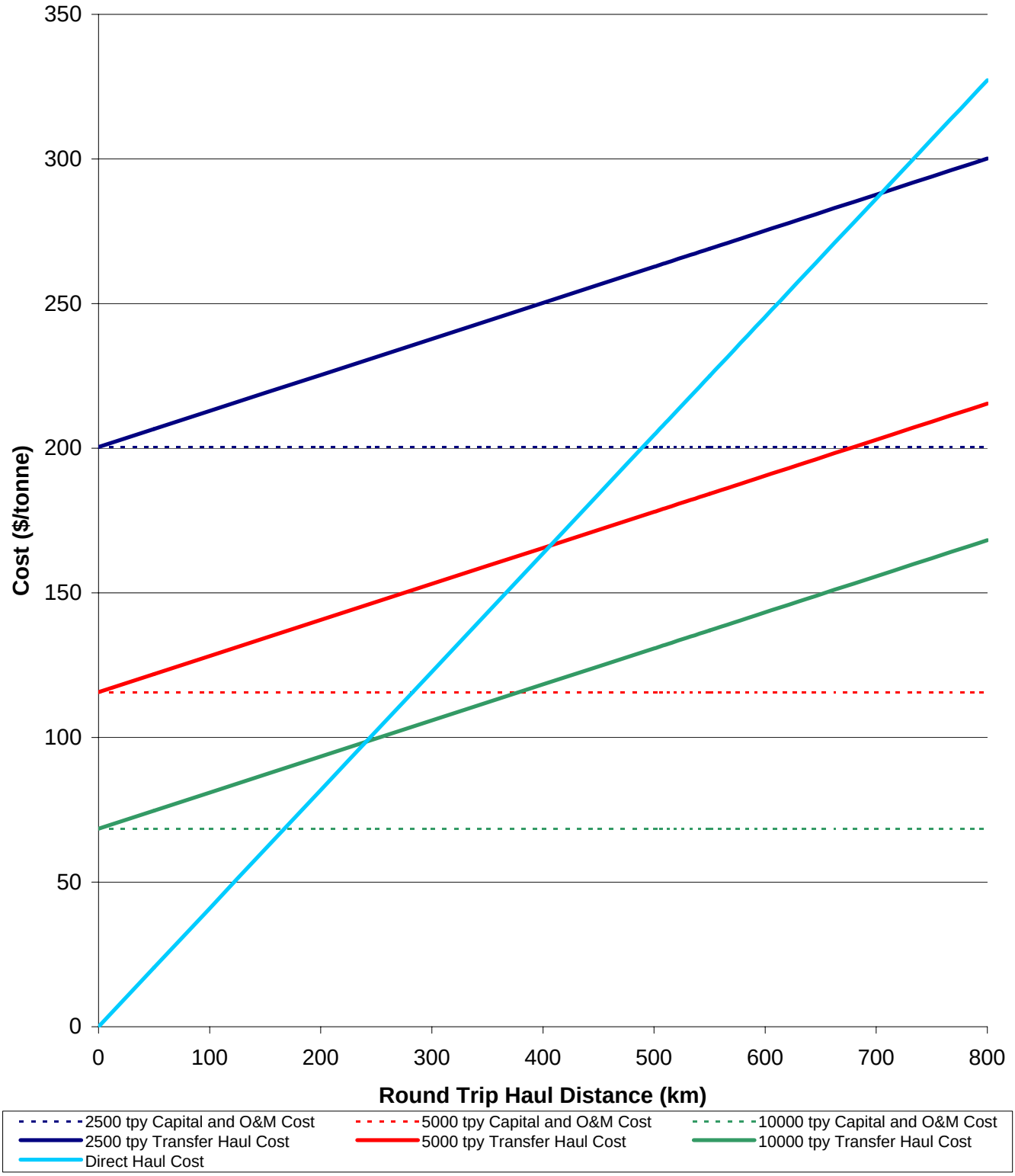

Figure 7 Direct Haul vs. Transfer Haul
Traditional Transfer Station (with compactor) , 2-Stream

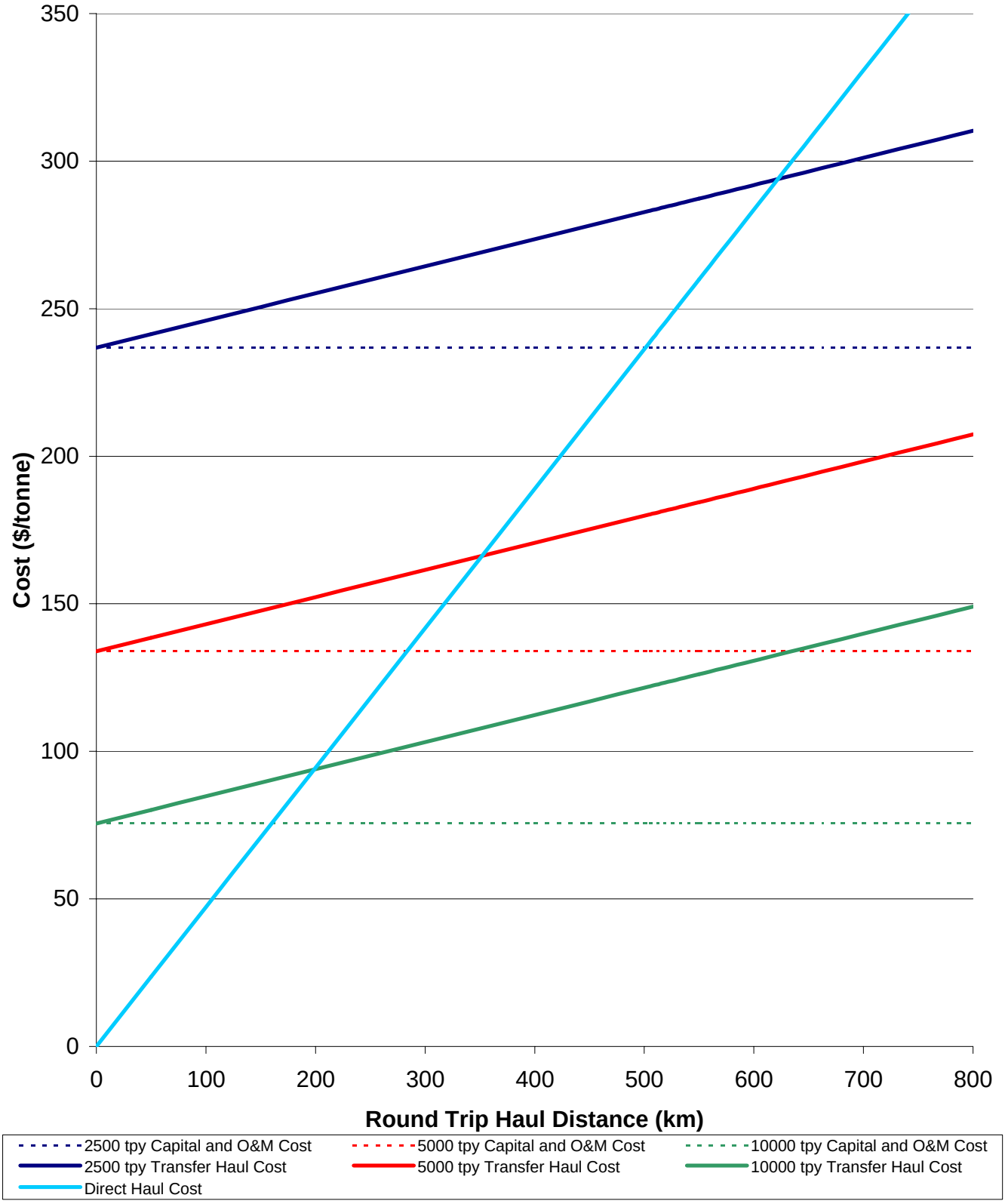

Figure 8: Direct Haul vs. Transfer Haul
Traditional Transfer Station (with compactor), 1-Stream

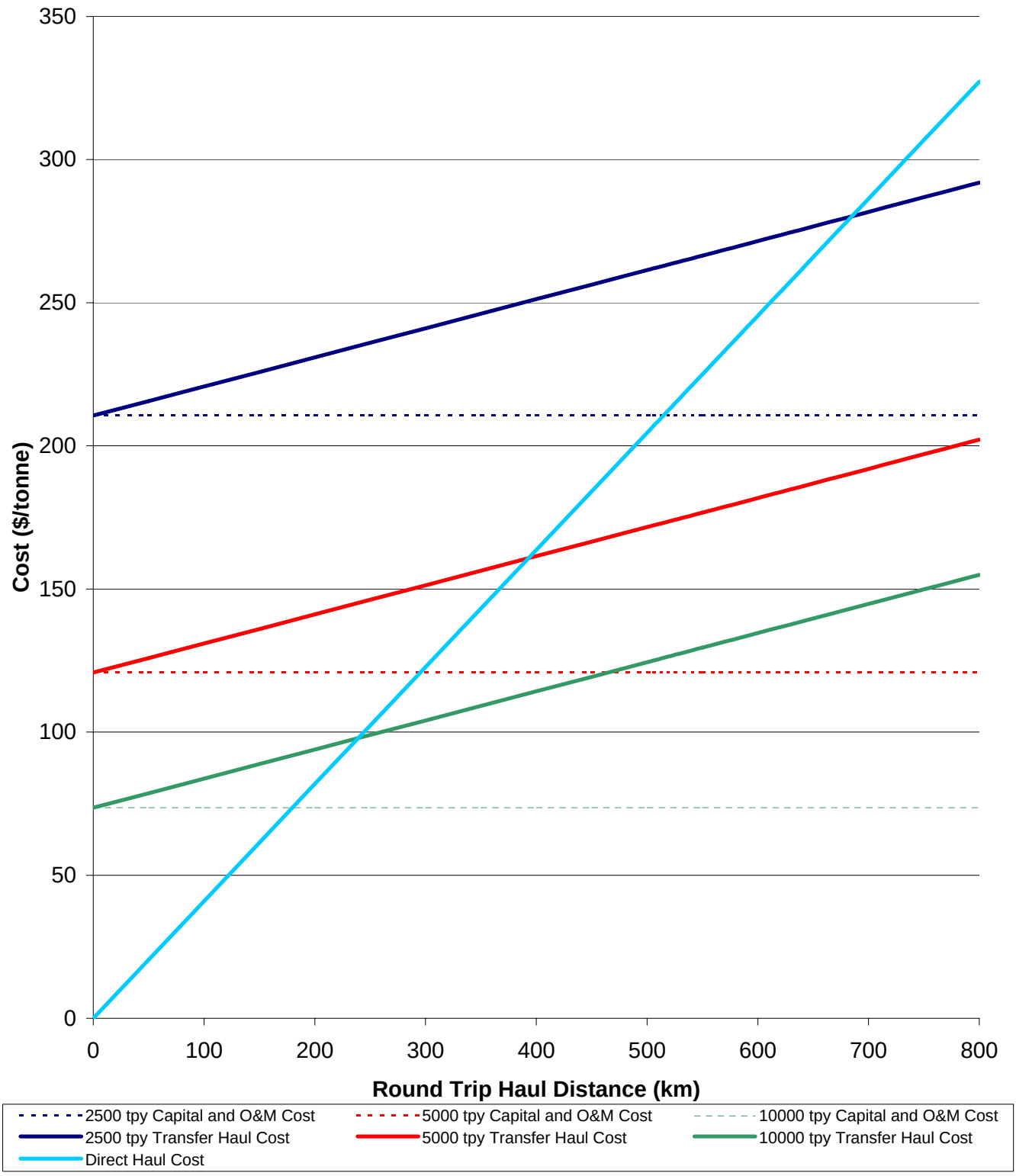

Table 2 - Summary of Factors Affecting Transfer and Haul Costs

Factor	Assumptions Used or Comments Stated in Report	Critical Factor	Page
Material composition	25% / 75% containers/fibers split by weight		4
Material stream density	50 kg/m3 (containers); 150 kg/m3 (fibers); 100 kg/m3 (single-stream)		4
Compaction ratio (with compactor)	1.5 (containers); 2.7 (fibers); 1.5 (single-stream)		4
Compaction ratio (top loading, tamping)	1.2 (containers); 2.0 (fibers); 1.2 (single-stream)		4
Availability of another transfer station	Facility development costs potentially not required if another transfer station is available.	Yes	5
Availability of another building	Facility development costs potentially not required if another building is available that can be used as a transfer station. Many buildings not suited for this application though.	Yes	5
Storage capability	Transtor containers typically hold only 90% of their design capacity.		6
Need for front end loader	Transtor transfer stations can operate without front end loader.		6
Haul vehicle trailer size and payload	100 yd3 and 140 yd3 trailers assumed; largest trailer used unless road weight limits exceeded.		7
Haul vehicle trailer construction/weight	Steel trailer construction assumed.		7
Transfer Station Cost estimate components (general)	Generic cost estimates provided, based on lengthy list of components. Consider the relevance and applicability of each cost estimate component when developing site-specific estimates.	Yes	8
Cost estimate components (land purchase)	Cost estimates do not include for purchase or lease of land. Site specific.	Yes	App B
Cost estimate components (off-site costs)	Cost estimates do not include for off-site development costs (eg, approach road upgrades, municipal services to site, electrical utility upgrades, etc.). Site specific.	Yes	App B
Cost estimate components (roads/paving)	Cost estimates assume on-site roads required (i.e., site with existing roads would reduce cost).	Yes	App B
Cost estimate components (weighscales)	Cost estimates assume weighscales and scalehouse required (i.e., site with existing weighscales and scalehouse would reduce cost).	Yes	App B
Cost estimate components (enclosure)	Transtor transfer stations can operate without enclosure over transtors and trailer.	Yes	6
Direct Haul and Transfer Haul Cost estimate components (fuel)	$1/litre assumed. Subject to high variability.	Yes	App C
Economies of scale	Cost estimates (expressed in $/tonne) become increasingly sensitive to components and unit cost accuracy with smaller scale facilities.	Yes	5
Competitive forces	Actual/prevailing competitive forces may substantially increase or decrease cost estimates.	Yes	8
Public sector vs private sector development	Public sector financing assumptions (interest rates and financing period) used. Private sector financing assumptions will alter cost estimates (will typically yield higher annualized cost and thus higher $/tonne).	Yes	8

Appendix A

Transfer Station Sizing and Design Basis

Table A1 - Transtor Transfer Station Design Basis

	2,500 tonnes/yr Facility			5,000 tonnes/yr Facility			10,000 tonnes/yr Facility		
	2-stream		single-stream	2-stream		single-stream	2-stream		single-stream
	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix
Annual capacity (kg/yr)	625,000	1,875,000	2,500,000	1,250,000	3,750,000	5,000,000	2,500,000	7,500,000	10,000,000
Daily capacity at 250 delivery days/yr (kg/day)	2,500	7,500	10,000	5,000	15,000	20,000	10,000	30,000	40,000
Density in transtor container (kg/m3)	50	150	100	50	150	100	50	150	100
Daily storage volume required (m3/day)	50	50	100	100	100	200	200	200	400
Useable transtor container storage volume based on 40 m3 container at 90% full on average (m3)	36	36	36	36	36	36	36	36	36
Number of transtor containers required to manage volume of daily deliveries	1.4	1.4	2.8	2.8	2.8	5.6	5.6	5.6	11.1
Number of transtor containers recommended to provide at least 1 day storage (while transfer trailer is hauling)	2	2	3	3	3	6	6	6	11
Actual number of days of storage in recommended number of transtor containers	1.4	1.4	1.1	1.1	1.1	1.1	1.1	1.1	1.0
Compacting transfer trailer compaction ratio (as appropriate for the recyclable material)	1.5	2.7	1.5	1.5	2.7	1.5	1.5	2.7	1.5
Effective transfer trailer volume based on above compaction ratios and 100 cu yd trailer (m3)	115	207	115	115	207	115	115	207	115
Payload in 100 cu yd transfer trailer based on above effective volumes and material densities	5,700	31,000	11,500	5,700	31,000	11,500	5,700	31,000	11,500
Effective transfer trailer volume based on above compaction ratios and 140 cu yd trailer (m3)	161	289	161	161	289	161	161	289	161
Payload in 140 cu yd transfer trailer based on above effective volumes and material densities	8,000	43,400	16,100	8,000	43,400	16,100	8,000	43,400	16,100
Recommended trailer size to maximize payload without exceeding road weight limits (cu yd)	140	100	140	140	100	140	140	100	140
Typical haul cycle (ie, number of days before transfer trailer is full and hauling is required)	3.2	4.1	1.6	1.6	2.1	0.8	0.8	1.0	0.4
Number of transfer trailers required (assuming only 1 haul trip per day per vehicle)	1	1	1	1	1	1-2	1-2	1	2-3
Typical number of transfer trailer hauling trips per month	7	5	13	13	10	26	26	20	52

Table A2 - Traditional Transfer Station Design Basis (use of top-loading transfer trailers, no compactor)

	2,500 tonnes/yr Facility			5,000 tonnes/yr Facility			10,000 tonnes/yr Facility		
	2-stream		single-stream	2-stream		single-stream	2-stream		single-stream
	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix
Annual capacity (kg/yr)	625,000	1,875,000	2,500,000	1,250,000	3,750,000	5,000,000	2,500,000	7,500,000	10,000,000
Daily capacity at 250 delivery days/yr (kg/day)	2,500	7,500	10,000	5,000	15,000	20,000	10,000	30,000	40,000
Storage capacity required based on 2-days storage recommended (kg)	5,000	15,000	20,000	10,000	30,000	40,000	20,000	60,000	80,000
On-floor density, piled to max 3m height (kg/m3)	50	150	100	50	150	100	50	150	100
Total volume of storage required (m3)	100	100	200	200	200	400	400	400	800
Storage area required based on material piled max 3m hight, 45 degree angle of repose (m2)	55	55	95	95	95	175	175	175	325
Transfer station length to accommodate transfer trailer bay(s) and future compactor/hopper (m)	30		30	30		30	30		30
Transfer station width to accommodate storage area(s) and area for loader movement (m)	20		15	25		20	30		25
Number of transfer trailer bays based on number of transfer trailers required (developed below)	1	1	1	1	1	1	1	1	2
Total transfer station width including 5m wide transfer trailer bays	30		20	35		25	40		35
Compaction ratio in top-loading trailers	1.2	2.0	1.2	1.2	2.0	1.2	1.2	2.0	1.2
Effective transfer trailer volume based on above compaction ratios and 100 cu yd trailer (m3)	92	153	92	92	153	92	92	153	92
Payload in 100 cu yd transfer trailer based on above effective volumes and material densities	4,600	22,900	9,200	4,600	22,900	9,200	4,600	22,900	9,200
Effective transfer trailer volume based on above compaction ratios and 140 cu yd trailer (m3)	128	214	128	128	214	128	128	214	128
Payload in 140 cu yd transfer trailer based on above effective volumes and material densities	6,400	32,100	12,800	6,400	32,100	12,800	6,400	32,100	12,800
Recommended trailer size to maximize payload without exceeding road weight limits (cu yd)	140	140	140	140	140	140	140	140	140
Typical haul cycle (ie, number of days before transfer trailer is full and hauling is required)	2.6	4.3	1.3	1.3	2.1	0.6	0.6	1.1	0.3
Number of transfer trailers required (assuming only 1 haul trip per day per vehicle)	1	1	1	1	1	2	2	1	3-4
Typical number of transfer trailer hauling trips per month	8	5	16	16	10	33	33	19	65

Table A3 - Traditional Transfer Station Design Basis (use of rear-loading transfer trailers and stationary compactor)

	2,500 tonnes/yr Facility			5,000 tonnes/yr Facility			10,000 tonnes/yr Facility		
	2-stream		single-stream	2-stream		single-stream	2-stream		single-stream
	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix
Annual capacity (kg/yr)	625,000	1,875,000	2,500,000	1,250,000	3,750,000	5,000,000	2,500,000	7,500,000	10,000,000
Daily capacity at 250 delivery days/yr (kg/day)	2,500	7,500	10,000	5,000	15,000	20,000	10,000	30,000	40,000
Storage capacity required based on 2-days storage recommended (kg)	5,000	15,000	20,000	10,000	30,000	40,000	20,000	60,000	80,000
On-floor density, piled to max 3m height (kg/m3)	50	150	100	50	150	100	50	150	100
Total volume of storage required (m3)	100	100	200	200	200	400	400	400	800
Storage area required based on material piled max 3m hight, 45 degree angle of repose (m2)	55	55	95	95	95	175	175	175	325
Transfer station length to accommodate transfer trailer bay(s) and compactor/hopper (m)	30		30	30		30	30		30
Transfer station width to accommodate storage area(s) and area for loader movement (m)	20		15	25		20	30		25
Number of transfer trailer bays based on number of transfer trailers required (developed below)	1	1	1	1	1	1	1	1	2
Total transfer station width including 5m wide transfer trailer bays	30		20	35		25	40		35
Compaction ratio in rear-loading trailers using hopper-fed stationary compactor	1.5	2.7	1.5	1.5	2.7	1.5	1.5	2.7	1.5
Effective transfer trailer volume based on above compaction ratios and 100 cu yd trailer (m3)	115	207	115	115	207	115	115	207	115
Payload in 100 cu yd transfer trailer based on above effective volumes and material densities	5,700	31,000	11,500	5,700	31,000	11,500	5,700	31,000	11,500
Effective transfer trailer volume based on above compaction ratios and 140 cu yd trailer (m3)	161	289	161	161	289	161	161	289	161
Payload in 140 cu yd transfer trailer based on above effective volumes and material densities	8,000	43,400	16,100	8,000	43,400	16,100	8,000	43,400	16,100
Recommended trailer size to maximize payload without exceeding road weight limits (cu yd)	140	100	140	140	100	140	140	100	140
Typical haul cycle (ie, number of days before transfer trailer is full and hauling is required)	3.2	4.1	1.6	1.6	2.1	0.8	0.8	1.0	0.4
Number of transfer trailers required (assuming only 1 haul trip per day per vehicle)	1	1	1	1	1	1-2	1-2	1	2-3
Typical number of transfer trailer hauling trips per month	7	5	13	13	10	26	26	20	52

Appendix B

Transfer Station Capital and O&M Cost Estimates

Table B1(a) - Transtor Transfer Station Capital Cost Estimate (2-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	140m x 90m	-	155m x 90m	-	190m x 90m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	140m x 90m	88,200	155m x 90m	97,700	190m x 90m	119,700		
Perimeter fencing and gates (at $100/m)	460m	4,600	490m	4,900	560m	5,600		
Roadworks and paving (at $50/m2)	2,700m2	135,000	3,300m2	165,000	4,700m2	235,000	✓	Actual site may have suitable on-site road (15-30% of cost estimate).
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	9 poles	54,000	10 poles	60,000		
Stormwater management (at $2/m2)	140m x 90m	25,200	155m x 90m	27,900	190m x 90m	34,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	140m x 90m	126,000	155m x 90m	139,500	190m x 90m	171,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		55,000		60,000		
Platform and Transtor Containers								
Bin walls at transtors (4m high at $6,000/m)	30m	180,000	45m	270,000	80m	480,000		
Retaining wall elsewhere (2.5m high at $3,000/m)	90m	270,000	105m	315,000	140m	420,000		
Transtor containers package (at $140,000 each)	4 units	560,000	6 units	840,000	12 units	1,680,000		
Import/place engineered fill (at $10/m3)	30m x 30m x 3m	27,000	45m x 30m x 3m	40,500	80m x 30m x 3m	72,000		
Allowance for railings, stairs, additional lighting		25,000		35,000		45,000		
Enclosure over transtors and trailer (at $400/m2)	30m x 30m	360,000	45m x 30m	540,000	80m x 30m	960,000	✓	Many sites operate without enclosure. Subtotal **excludes** this item.
Compacting Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$1,884,000		$2,394,500		$3,737,500	✓	This subtotal line excludes the optional transtor and trailer enclosure.
Unforseen and Estimating Allowance (20%)		376,800		478,900		747,500		
Engineering and Contract Administration (10%+/-)		188,400		239,500		373,800		
Total		$2,449,200		$3,112,900		$4,858,800		
Annualized capital (15 years at 6% int rate)		$252,200		$320,500		$500,300	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$101	5,000 tonnes/yr	$64	10,000 tonnes/yr	$50		

Table B1(b) - Transtor Transfer Station Capital Cost Estimate (Single-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	140m x 90m	-	155m x 90m	-	190m x 90m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	140m x 90m	88,200	155m x 90m	97,700	190m x 90m	119,700		
Perimeter fencing and gates (at $100/m)	460m	46,000	490m	49,000	560m	56,000		
Roadworks and paving (at $50/m2)	2,700m2	135,000	3,300m2	165,000	4,700m2	235,000	✓	Actual site may have suitable on-site road (15-30% of cost estimate).
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	9 poles	54,000	10 poles	60,000		
Stormwater management (at $2/m2)	140m x 90m	25,200	155m x 90m	27,900	190m x 90m	34,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	140m x 90m	126,000	155m x 90m	139,500	190m x 90m	171,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		55,000		60,000		
Platform and Transtor Containers								
Bin walls at transtors (4m high at $6,000/m)	30m	180,000	45m	270,000	80m	480,000		
Retaining wall elsewhere (2.5m high at $3,000/m)	90m	270,000	105m	315,000	140m	420,000		
Transtor containers package (at $140,000 each)	3 units	420,000	6 units	840,000	11 units	1,540,000		
Import/place engineered fill (at $10/m3)	30m x 30m x 3m	27,000	45m x 30m x 3m	40,500	80m x 30m x 3m	72,000		
Allowance for railings, stairs, additional lighting		25,000		35,000		45,000		
Enclosure over transtors and trailer (at $400/m2)	30m x 30m	360,000	45m x 30m	540,000	80m x 30m	960,000	✓	Many sites operate without enclosure. Subtotal **excludes** this item.
Compacting Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$1,785,400		$2,438,600		$3,647,900	✓	This subtotal line excludes the optional transtor and trailer enclosure.
Unforseen and Estimating Allowance (20%)		357,100		487,700		729,600		
Engineering and Contract Administration (10%+/-)		178,500		243,900		364,800		
Total		$2,321,000		$3,170,200		$4,742,300		
Annualized capital (15 years at 6% int rate)		$239,000		$326,400		$488,300	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$96	5,000 tonnes/yr	$65	10,000 tonnes/yr	$49		

Table B2 - Transtor Transfer Station Operating & Maintenance Cost Estimate

Item	2,500 tonnes/yr $/yr	5,000 tonnes/yr $/yr	10,000 tonnes/yr $/yr
Staffing Requirements			
Plant Manager (1 x $80,000/yr x 1.4 O'Head/Benefits)	not required	not required	not required
Site Supervisor (0.1-0.2 x $60,000/yr x 1.4 O'Head/Benefits)	8,400	12,600	16,800
Scalehouse Operator (1 x $35,000/yr x 1.4 O'Head/Benefits)	49,000	49,000	49,000
Maintenance Staff (0.3-0.5 x $50,000/yr x 1.4 O'Head/Benefits)	21,000	28,000	35,000
Platform Attendant (0-1 x $25,000/yr x 1.4 O'Head/Benefits)	not required	17,500	35,000
Labourer / Trailer Jockey (0-1 x $25,000/yr x 1.4 O'Head/Benefits)	not required	17,500	35,000
Administration staff (0.1-0.2 x $40,000/yr x 1.4 O'Head/Benefits)	5,600	8,400	11,200
Utilities and Fuel			
Fuel	not required	not required	not required
Water	1,000	1,000	1,000
Electricity	3,000	4,000	5,000
Natural Gas/propane	2,000	2,000	2,000
Maintenance and Operations			
Buildings, roads, site works (at 0.5% of capital cost)	7,000	9,000	12,000
Mechanical and electrical equipment (at 5% of capital cost)	33,000	50,000	100,000
Rolling equipment lease (estimated at $3,000/month)	not required	not required	not required
Service contracts (estimated at $1,000/month)	12,000	12,000	12,000
Other			
Administration, legal, accounting costs	6,000	8,000	10,000
MOE fees/reporting, consulting fees	10,000	10,000	10,000
Subtotal	$158,000	$229,000	$334,000
Unforseen and Estimating Allowance (20%)	31,600	45,800	66,800
Total	$189,600	$274,800	$400,800
O&M cost per tonne	$76	$55	$40

Table B3(a) - Traditional Transfer Station Capital Cost Estimate (2-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	150m x 110m	-	155m x 110m	-	160m x 110m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	150m x 110m	115,500	155m x 110m	119,350	160m x 110m	123,200		
Perimeter fencing and gates (at $100/m)	520m	52,000	530m	53,000	540m	54,000		
Roadworks and paving (at $50/m2)	1,800m2	90,000	1,800m2	90,000	1,800m2	90,000	✓	Actual site may have suitable on-site road (60-70% of cost estimate).
Concrete ramps, pads at truck doors (at $100/m2)	350m2	35,000	350m2	35,000	350m2	35,000		
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	8 poles	48,000	8 poles	48,000		
Stormwater management (at $2/m2)	150m x 110m	33,000	155m x 110m	34,100	160m x 110m	35,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	150m x 110m	165,000	155m x 110m	170,500	160m x 110m	176,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		50,000		50,000		
Building and Ancillaries								
Building tip floor, storage area (at $1,000/m2)	30m x 20m	600,000	30m x 25m	750,000	30m x 30m	900,000		
Pushwalls (3.5m high x 0.3m th. at $1,400/m3)	50m	73,500	55m	80,850	60m	88,200		
Transfer trailer bays (at $1,000/m2)	30m x 5m x 2	300,000	30m x 5m x 2	300,000	30m x 5m x 2	300,000		
Administration/amenity areas (at $1,200/m2)	100m2	120,000	100m2	120,000	100m2	120,000		
Allowance for HVAC		50,000		55,000		60,000		
Truck doors (at $25,000 each)	1	25,000	1	25,000	1	25,000		
Stationary compactors (at $175,000 each)	0	0	0	0	0	0		
Compactor feed hopper, related steel works		0		0		0		
Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$2,102,000		$2,280,800		$2,459,600		
Unforseen and Estimating Allowance (20%)		420,400		456,200		491,900		
Engineering and Contract Administration (10%+/-)		210,200		228,100		246,000		
Total		$2,732,600		$2,965,100		$3,197,500		
Annualized capital (15 years at 6% int rate)		$281,400		$305,300		$329,200	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$113	5,000 tonnes/yr	$61	10,000 tonnes/yr	$33		

Table B3(b) - Traditional Transfer Station with Compactor Capital Cost Estimate (2-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	150m x 110m	-	155m x 110m	-	160m x 110m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	150m x 110m	115,500	155m x 110m	119,350	160m x 110m	123,200		
Perimeter fencing and gates (at $100/m)	520m	52,000	530m	53,000	540m	54,000		
Roadworks and paving (at $50/m2)	1,800m2	90,000	1,800m2	90,000	1,800m2	90,000	✓	Actual site may have suitable on-site road (60-70% of cost estimate).
Concrete ramps, pads at truck doors (at $100/m2)	350m2	35,000	350m2	35,000	350m2	35,000		
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	8 poles	48,000	8 poles	48,000		
Stormwater management (at $2/m2)	150m x 110m	33,000	155m x 110m	34,100	160m x 110m	35,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	150m x 110m	165,000	155m x 110m	170,500	160m x 110m	176,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		50,000		50,000		
Building and Ancillaries								
Building tip floor, storage area (at $1,000/m2)	30m x 20m	600,000	30m x 25m	750,000	30m x 30m	900,000		
Pushwalls (3.5m high x 0.3m th. at $1,400/m3)	50m	73,500	55m	80,850	60m	88,200		
Transfer trailer bays (at $1,000/m2)	30m x 5m x 2	300,000	30m x 5m x 2	300,000	30m x 5m x 2	300,000		
Administration/amenity areas (at $1,200/m2)	100m2	120,000	100m2	120,000	100m2	120,000		
Allowance for HVAC		50,000		55,000		60,000		
Truck doors (at $25,000 each)	1	25,000	1	25,000	1	25,000		
Stationary compactors (at $175,000 each)	2	350,000	2	350,000	2	350,000		
Compactor feed hopper, related steel works		30,000		30,000		30,000		
Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$2,482,000		$2,660,800		$2,839,600		
Unforseen and Estimating Allowance (20%)		496,400		532,200		567,900		
Engineering and Contract Administration (10%+/-)		248,200		266,100		284,000		
Total		$3,226,600		$3,459,100		$3,691,500		
Annualized capital (15 years at 6% int rate)		$332,200		$356,200		$380,100	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$133	5,000 tonnes/yr	$71	10,000 tonnes/yr	$38		

Table B4(a) - Traditional Transfer Station Capital Cost Estimate (Single-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	150m x 110m	-	155m x 110m	-	160m x 110m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	150m x 110m	115,500	155m x 110m	119,350	160m x 110m	123,200		
Perimeter fencing and gates (at $100/m)	520m	52,000	530m	53,000	540m	54,000		
Roadworks and paving (at $50/m2)	1,800m2	90,000	1,800m2	90,000	1,800m2	90,000	✓	Actual site may have suitable on-site road (60-70% of cost estimate).
Concrete ramps, pads at truck doors (at $100/m2)	350m2	35,000	350m2	35,000	350m2	35,000		
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	8 poles	48,000	8 poles	48,000		
Stormwater management (at $2/m2)	150m x 110m	33,000	155m x 110m	34,100	160m x 110m	35,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	150m x 110m	165,000	155m x 110m	170,500	160m x 110m	176,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		50,000		50,000		
Building and Ancillaries								
Building tip floor, storage area (at $1,000/m2)	30m x 15m	450,000	30m x 20m	600,000	30m x 25m	750,000		
Pushwalls (3.5m high x 0.3m th. at $1,400/m3)	50m	73,500	55m	80,850	60m	88,200		
Transfer trailer bays (at $1,000/m2)	30m x 5m x 1	150,000	30m x 5m x 1	150,000	30m x 5m x 2	300,000		
Administration/amenity areas (at $1,200/m2)	100m2	120,000	100m2	120,000	100m2	120,000		
Allowance for HVAC		50,000		55,000		60,000		
Truck doors (at $25,000 each)	1	25,000	1	25,000	1	25,000		
Stationary compactors (at $175,000 each)	0	0	0	0	0	0		
Compactor feed hopper, related steel works		0		0		0		
Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$1,802,000		$1,980,800		$2,309,600		
Unforseen and Estimating Allowance (20%)		360,400		396,200		461,900		
Engineering and Contract Administration (10%+/-)		180,200		198,100		231,000		
Total		$2,342,600		$2,575,100		$3,002,500		
Annualized capital (15 years at 6% int rate)		$241,200		$265,100		$309,100	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$96	5,000 tonnes/yr	$53	10,000 tonnes/yr	$31		

Table B4(b) - Traditional Transfer Station with Compactor Capital Cost Estimate (Single-Stream)

Item	2,500 tonnes/yr		5,000 tonnes/yr		10,000 tonnes/yr		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)	
	Description	$	Description	$	Description	$		
Pre-Construction								
Planning, approvals, RFP/tender and evaluation		80,000		80,000		80,000		
Land purchase	150m x 110m	-	155m x 110m	-	160m x 110m	-	✓	Purchase or lease of land not included in estimate. Site specific.
Site development costs		-		-		-	✓	Site specific. Example, upgrade of approach roads for anticipated loads.
Survey, geotechnical investigations		10,000		15,000		20,000		
Allowance for Phase I & II ESAs		40,000		40,000		40,000		
Site Works								
Mobilization / demobilization		10,000		10,000		10,000		
Clearing and grubbing, grading (at $7/m2)	150m x 110m	115,500	155m x 110m	119,350	160m x 110m	123,200		
Perimeter fencing and gates (at $100/m)	520m	52,000	530m	53,000	540m	54,000		
Roadworks and paving (at $50/m2)	1,800m2	90,000	1,800m2	90,000	1,800m2	90,000	✓	Actual site may have suitable on-site road (60-70% of cost estimate).
Concrete ramps, pads at truck doors (at $100/m2)	350m2	35,000	350m2	35,000	350m2	35,000		
Roadway lighting (25m spacing at $6,000/pole)	8 poles	48,000	8 poles	48,000	8 poles	48,000		
Stormwater management (at $2/m2)	150m x 110m	33,000	155m x 110m	34,100	160m x 110m	35,200		
Weighscale (1) and scalehouse		200,000		200,000		200,000	✓	Actual site may have weighscale and scalehouse (landfill for example).
Site services, utilities (at $10/m2 of site area)	150m x 110m	165,000	155m x 110m	170,500	160m x 110m	176,000	✓	Actual site may not have services to the site. Additional allowance req'd.
Site signage		5,000		5,000		5,000		
Landscaping		50,000		50,000		50,000		
Building and Ancillaries								
Building tip floor, storage area (at $1,000/m2)	30m x 15m	450,000	30m x 20m	600,000	30m x 25m	750,000		
Pushwalls (3.5m high x 0.3m th. at $1,400/m3)	50m	73,500	55m	80,850	60m	88,200		
Transfer trailer bays (at $1,000/m2)	30m x 5m x 1	150,000	30m x 5m x 1	150,000	30m x 5m x 2	300,000		
Administration/amenity areas (at $1,200/m2)	100m2	120,000	100m2	120,000	100m2	120,000		
Allowance for HVAC		50,000		55,000		60,000		
Truck doors (at $25,000 each)	1	25,000	1	25,000	1	25,000		
Stationary compactors (at $175,000 each)	1	175,000	1	175,000	2	350,000		
Compactor feed hopper, related steel works		15,000		15,000		30,000		
Transfer Trailer	incl. in haul cost	-	incl. in haul cost	-	incl. in haul cost	-		
Subtotal		$1,992,000		$2,170,800		$2,689,600		
Unforseen and Estimating Allowance (20%)		398,400		434,200		537,900		
Engineering and Contract Administration (10%+/-)		199,200		217,100		269,000		
Total		$2,589,600		$2,822,100		$3,496,500		
Annualized capital (15 years at 6% int rate)		$266,600		$290,600		$360,000	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annualized capital cost per tonne	2,500 tonnes/yr	$107	5,000 tonnes/yr	$58	10,000 tonnes/yr	$36		

Table B5 - Traditional Transfer Station Operating & Maintenance Cost Estimate

Item	2,500 tonnes/yr $/yr	5,000 tonnes/yr $/yr	10,000 tonnes/yr $/yr
Staffing Requirements			
Plant Manager (1 x $80,000/yr x 1.4 O'Head/Benefits)	not required	not required	not required
Site Supervisor (0.1-0.2 x $60,000/yr x 1.4 O'Head/Benefits)	8,400	12,600	16,800
Scalehouse Operator (1 x $35,000/yr x 1.4 O'Head/Benefits)	49,000	49,000	49,000
Maintenance Staff (0.3-0.5 x $50,000/yr x 1.4 O'Head/Benefits)	21,000	28,000	35,000
Loader Operator (0.5-1 x $45,000/yr x 1.4 O'Head/Benefits)	31,500	44,100	63,000
Administration staff (0.1-0.2 x $40,000/yr x 1.4 O'Head/Benefits)	5,600	8,400	11,200
Utilities and Fuel			
Fuel (1 vehicle x 10 L/hr x $1/L x 4 to 8 hrs/day x 250 days/yr)	10,000	15,000	20,000
Water	1,000	1,000	1,000
Electricity	4,000	5,000	6,000
Natural Gas/propane	4,000	4,000	4,000
Maintenance and Operations			
Buildings, roads, site works (at 0.5% of capital cost)	11,000	12,000	13,000
Mechanical and electrical equipment (at 5% of capital cost)	25,000	25,000	26,000
Loader lease (0.5-1 loaders, estimated at $3,000/month)	18,000	27,000	36,000
Service contracts (estimated at $1,000/month)	12,000	12,000	12,000
Other			
Administration, legal, accounting costs	6,000	8,000	10,000
MOE fees/reporting, consulting fees	10,000	10,000	10,000
Subtotal	$216,500	$261,100	$313,000
Unforseen and Estimating Allowance (20%)	43,300	52,200	62,600
Total	$259,800	$313,300	$375,600
O&M cost per tonne	$104	$63	$38

Appendix C

Direct Haul and Transfer Haul Unit Cost Estimates

Table C1 - Direct Haul Unit Costs Estimate

Collection Scenario --->	2-Stream	Single-Stream		Cost Estimate Critical Factors (i.e., Significant Cost Items Subject to Considerable Variability)
Assumed collection truck type	Dual Compartment	Single Compartment		
Typical payload in collection truck (kg)	3,100	3,500		
Estimated fuel consumption at above payloads (L/100km)	24	24		
Estimated capital cost of collection truck	$225,000	$210,000		
Item	**Unit Haul Cost**			
Labour ($45/hr including benefits)	45.0	45.0		
Fuel (above fuel consumption rates x 70km/hr avg haul speed x $1/L)	16.8	16.8	✓	Price of fuel subject to high variability.
Amortized capital (6% over 7 years)	20.2	18.8	✓	Annualized capital can vary significantly depending on cost of capital. 6% public sector interest rate used. Private sector could exceed 10%.
Annual maintenance (10% of capital cost)	11.3	10.5		
Administration and profit allowance (10% of above)	9.3	9.1		
Total Cost per Truck-Hour of Haul ($/hr)	$102.5	$100.2		
Total Cost per Tonne-Hour of Haul ($/tonne-hr)	$33.1	$28.6		
Estimated average speed while hauling including allowance for loading/unloading (km/hr)	70	70		
Total Cost per Tonne-km of haul ($/tonne-km)	$0.47	$0.41		

Notes:

1. Dual compartment truck assumed to have lower payload due to one of the two compartments topping out before the other as a result of weekly variations in materials collected.

Table C2 - Transfer Haul Unit Costs Estimate

Transfer Station Type --->	Transtor			Traditional Transfer Station (top-loading trailers, no compactor)			Traditional Transfer Station (rear-loading trailers, compactor)			Critical Factors
	2-stream		single-stream	2-stream		single-stream	2-stream		single-stream	
	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix	25% containers	75% fibres	cont/fibres mix	
Recommended trailer (see Tables A1/A2)	140 yd^3 compacting	100 yd^3 compacting	140 yd^3 compacting	140 yd^3 open top	140 yd^3 open top	140 yd^3 open top	140 yd^3 closed top	100 yd^3 closed top	140 yd^3 closed top	
Typical payload in trailer (see Tables A1/A2) (kg)	8,000	31,000	16,100	6,400	32,100	12,800	8,000	31,000	16,100	
Estimated fuel consumption at above payloads (L/100km)	26	34	26	26	34	26	26	34	26	
Estimated capital cost of trailer	$180,000	$150,000	$180,000	$100,000	$100,000	$100,000	$120,000	$100,000	$120,000	
Estimated capital cost of tractor for trailer	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	
Item	**Unit Haul Cost**			**Unit Haul Cost**			**Unit Haul Cost**			
Labour ($45/hr including benefits)	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	
Fuel (above fuel consumption rates x 70km/hr avg haul speed x $1/L)	18.2	23.8	18.2	18.2	23.8	18.2	18.2	23.8	18.2	✓
Amortized trailer (6% over 8 years)	14.5	12.1	14.5	8.1	8.1	8.1	9.7	8.1	9.7	✓
Amortized tractor (6% over 5 years)	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8	✓
Annual maintenance (10% of capital cost)	16.5	15.0	16.5	12.5	12.5	12.5	13.5	12.5	13.5	
Administration and profit allowance (10% of above)	11.2	11.4	11.2	10.2	10.7	10.2	10.4	10.7	10.4	
Total Cost per Truck-Hour of Haul ($/hr)	$123.2	$125.1	$123.2	$111.7	$117.9	$111.7	$114.6	$117.9	$114.6	
Total Cost per Tonne-Hour of Haul ($/tonne-hr)	$15.4	$4.0	$7.7	$17.5	$3.7	$8.7	$14.3	$3.8	$7.1	
Estimated average speed while hauling including allowance for loading/unloading (km/hr)	70	70	70	70	70	70	70	70	70	
Total Cost per Tonne-km of haul ($/tonne-km)	$0.22	$0.06	$0.11	$0.25	$0.05	$0.12	$0.20	$0.05	$0.10	
Blended Cost per Tonne-km (25%/75% containers/fibres)	$0.10		$0.11	$0.10		$0.12	$0.09		$0.10	