



Organics Management Business Case

Halifax Regional Municipality, Nova Scotia

Halifax Regional Municipality

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Executive Summary

GHD has prepared this organics management business case to evaluate organic material management options available to Halifax Regional Municipality (Halifax) to meet processing capacities for the next 15 to 20 years, post 2019. As Halifax's organics management infrastructure has matured, investments are needed to sustain and expand the system to meet future needs. Through discussions with Halifax, options have been developed with regards to existing infrastructure and new facilities. The overall objective of the business plan is to evaluate these options in terms of cost, compatibility with feedstock, and risk as examples. The findings of the business plan will help Halifax understand the cost implications and advantages and disadvantages of each option.

In developing options, the following were identified as key considerations:

- Minimizing capital and operating costs, including reducing current processing costs.
- Meeting the 2010 Nova Scotia Environment (NSE) Composting Facility Guidelines (2010 NSE Guidelines) post 2019.
- Increasing organics processing capacity from 50,000 tonnes to 60,000 tonnes per year, with the option to increase to 75,000 tonnes per year in the future.

The following table summarizes the options evaluated.

Option No.	Facility 1	Facility 2	Facility 3
Option 1a	Existing Dartmouth Compost Facility	New Compost Facility	NA
Capacity	25,000 tonnes/year	35,000 tonnes/year (may be increased to 50,000 tonnes/year)	
Potential Sites		- Goodwood Compost Facility - New site	
Option 1b	Existing Dartmouth Compost Facility	New Anaerobic Digestion Facility	NA
Capacity	25,000 tonnes/year	35,000 tonnes/year (may be increased to 50,000 tonnes/year)	
Potential Sites		- Goodwood Compost Facility - Dartmouth Compost Facility - New site	
Option 2a	Existing Dartmouth Compost Facility	New Compost Facility	New Anaerobic Digestion Facility
Capacity	25,000 tonnes/year	10,000 tonnes/year (may be increased to 25,000 tonnes/year)	25,000 tonnes/year

Option No.	Facility 1	Facility 2	Facility 3
Potential Sites		- Goodwood Compost Facility - Waste Stabilization Facility (WSF) at Otter Lake Site (partially repurpose facility) - New site	- Goodwood Compost Facility - Dartmouth Compost Facility - New site
Option 2b	Existing Dartmouth Compost Facility	New On-Farm AD Facility	New On-Farm AD Facility
Capacity	20,000 tonnes/year	20,000 tonnes/year	20,000 tonnes/year
Potential Sites		- On-farm site	- On-farm site
Option's 3a	New Compost Facility	NA	NA
Capacity	60,000 tonnes/year (may be increased to 75,000 tonnes/year)		
Potential Sites	- Goodwood Compost Facility - New site		
Option's 3b	New Anaerobic Digestion Facility	NA	NA
Capacity	60,000 tonnes/year (may be increased to 75,000 tonnes/year)		
Potential Sites	- Goodwood Compost Facility - Dartmouth Compost Facility - New site		

The following list ranks the options in terms of overall Equivalent Annual Cost, based on 4 percent interest for 20 years, from lowest to highest:

- \$148/tonne: Option 2b (Dartmouth Facility, On-Farm Anaerobic Digestion).
- \$155/tonne: Option 3a (New 60,000 tonne/year Compost Facility).
- \$159/tonne: Option 1a (Dartmouth Facility, New Compost Facility).
- \$184/tonne: Option 2a (Dartmouth Facility, New Compost Facility, New Anaerobic Digestion Facility).
- \$191/tonne: Option 1b (Dartmouth Facility, New Anaerobic Digestion Facility).
- \$209/tonne: Option 3b (New 60,000 tonne/year Anaerobic Digestion Facility).

In addition to economic evaluation criteria, the following criteria were also scored in a decision matrix:

- Facility footprint
- Compatibility with Feedstock
- Planning and Approvals Risk
- Process and Technical Risk
- Odour and Noise

- Process Water and Stormwater
- End Products and Byproducts
- Phasing and Transition
- Overall Schedule
- Future Regulations (i.e. current regulations, guidelines or standards currently under review)

The decision matrix was created to compare the different siting configurations with each option, using criteria to rank the various options and a weighting factor to weight the significance of each criterion noted above. The decision matrix was used to develop a score for each option, with a maximum total possible score of 100.

The weighting values were determined in cooperation with Halifax staff. They represent the priorities of Halifax for developing a new organics processing facility based on the over 15 years of experience in managing two organics processing facilities. The primary priorities identified were:

- Cost (Weighting 20/100)
- Odour and Noise (Weighting 20/100)
- Compatibility with Feedstock (Weighting 15/100)
- Overall Schedule (Weighting 10/100)

Scores were tabulated in two different ways, namely:

- Total Score: sum of the weighted scores for each option, higher scores are better.
- Value for Money: calculated¹ as an adjusted total score divided by Equivalent Annual Cost and represents a relative points per dollar score.

The options are sorted by Equivalent Annual Cost (lowest to highest) in the table below to compare the results of the top scores. The top three options under each column in the below table are highlighted. The top scores all involved existing sites.

Evaluation Results Summary

	Option	Equivalent Annual Cost (\$/tonne) (Rank)	Total Score (Rank)	Value for Money (Rank)
2b	Existing Dartmouth Facility (25,000 tonne/year) & 2 New On-Farm Anaerobic Digestion Facilities (~20,000 tonne/year each)	\$148	67 (5)	31.4 (3)
3a	New 60,000 tonne/year Compost Facility at an Existing Site	\$155	56 (9)	23.5 (11)
1a	Existing Dartmouth Facility (25,000 tonne/year) & New Compost Facility (35,000 tonne/year) at an Existing Site	\$159	59 (8)	25.5 (7)

¹ Value for Money = 100 x (Total Score - Equivalent Annual Cost Score)/ Equivalent Annual Cost

	Option	Equivalent Annual Cost (\$/tonne) (Rank)	Total Score (Rank)	Value for Money (Rank)
2a	Existing Dartmouth Facility (25,000 tonne/year) & New Compost (10,000 tonne/year) and Anaerobic Digestion (25,000 tonne/year) Facilities at an Existing Site	\$184	62 (6)	25.3 (8)
1b	Existing Dartmouth Facility (25,000 tonne/year) & New Anaerobic Digestion Facility (35,000 tonne/year) at an Existing Site	\$191	72 (4)	30.1 (5)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at Goodwood Site	\$209	82 (1)	33.5 (1)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at Dartmouth Site	\$209	79 (2)	32.3 (2)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at New Site	\$209	77 (3)	31.1 (4)

The lowest cost option, based on an Equivalent Annual Cost basis, over a 20 year lifecycle, was determined to be the option that utilized the existing Dartmouth composting facility assets in combination with two new on-farm anaerobic digestion facilities (Option 2b). The on-farm anaerobic digestion facilities do not require significant additional capital expenditures for Halifax. This is based on the assumption that existing Nova Scotia Community Feed-In Tariff (COMFIT) revenues for renewable energy received by these farms will offset capital expenditures for the farms, savings which will in turn be passed on to Halifax (i.e., they will build the facilities regardless if Halifax supplies them with feedstock). This option also represents the third best value for money. However, it has a low score compared with some of the other options primarily due to the uncertainty of relying on on-farm third-party processors for the bulk of Halifax's organics processing needs; this resulted in Option 2b only scoring well in one of the four priority evaluation criteria. Establishing agreements with multiple farms can help mitigate this risk to an extent. Also, ensuring contractual arrangements that would provide Halifax with performance guarantees and penalties would be critical to ensuring reliability of processing capacity.

Options 1b and 3b, which involve the construction of a new anaerobic digestion facility generally scored the highest and represent the best value for money; but are the highest cost options as well. The options involving a new 60,000 tonnes per year facility at the Dartmouth or Goodwood sites (Option 3b) score high in three of the four priority evaluation criteria and high in all of the other evaluation criteria. Anaerobic digestion is better suited for the nature of the materials generated within Halifax given the mandatory inclusion of industrial, commercial, and institutional (IC&I) organics. Anaerobic digestion facilities offer many benefits over composting in large urban centers, as they are able to be sited closer to the areas where the organics are generated and have smaller footprints.

For the purposes of the business case, it was assumed that COMFIT revenues for renewable energy would not be available for new anaerobic digestion facilities due to a current program freeze in Nova Scotia. If a long term COMFIT contract could be secured for the Goodwood or Dartmouth sites, this could decrease the Equivalent Annual Cost by roughly \$25-40/tonne down to \$169-184/tonne; which would result in a more cost competitive option albeit still a higher cost over the long term as compared to composting.

Overall, based on the evaluation criteria and weighting utilized in this report, GHD is of the opinion that the development of anaerobic digestion capacity to process at a minimum part of Halifax's source separated organics (SSO) will offer many long-term benefits including addressing the processing of wetter IC&I organics. It will also allow existing composting capacity at the Dartmouth site, should Halifax elect to keep it operational past 2019, to operate more effectively by allowing Halifax to selectively divert only drier residential organics to it that are mixed with some leaf and yard waste materials.

Each of the above options has its advantages and disadvantages. An option for Halifax to consider as a next step, would be to move forward with a competitive bid process that is technology neutral to allow compost and anaerobic digestion technology centered bids to compete against each other. As well to allow bids that utilize on-farm infrastructure coupled with centralized transfer and pre-processing components; ensuring that proposals received adequately address all potential risks with partnering with one or more local farm businesses. This allows those firms with COMFIT agreements, for example or any other competitive advantage, to potentially offer the more expensive anaerobic digestion option at a more competitive price compared to composting.

However, in a public procurement process with pre-defined scoring, when the technology is not pre-determined prior to going out to tender, the owner must be willing to accept any technology that receives a passing score or cancel the procurement completely. One approach to mitigate this is a two stage procurement process where technology vendors and suppliers are pre-qualified based on technical merit first and then on their full business proposal second. This is similar to the approach currently being used by the City of Edmonton to find partners to provide a high-solids anaerobic digestion facility for their SSO.

Table of Contents

1.	Introduction.....	1
2.	Existing Halifax Organics Management Facilities	1
2.1	Goodwood Composting Facility	2
2.2	Dartmouth Composting Facility.....	2
2.3	Otter Lake Waste Processing & Disposal Facility	3
3.	Evaluation Considerations	4
3.1	Feedstock Considerations	4
3.2	Aerobic Versus Anaerobic Digestion	6
3.2.1	Aerobic Digestion/Composting	6
3.2.2	Anaerobic Digestion	7
3.3	Siting – Existing Versus New	8
3.3.1	On-Farm Anaerobic Digestion	9
3.4	Regulatory Considerations.....	11
3.4.1	Facility Development and Operations	11
3.4.2	End Product Quality.....	13
3.5	Cost Considerations.....	13
3.5.1	Nova Scotia Community Feed-In Tariff (COMFIT)	14
3.6	Wastewater Considerations	14
3.7	Assumptions	15
4.	Organic Material Management Options	16
5.	Evaluation of Options	18
6.	Closure	22

Table Index

Table 3.3	Preliminary Budget Estimate for New Composting and Anaerobic Digestion Facilities
Table 5.1	Budget Comparison of Options
Table 5.2	Scoring Matrix

1. Introduction

GHD has prepared this organics management business case to evaluate organic material management options available to Halifax Regional Municipality (Halifax) to meet processing capacities for the next 15 to 20 years, post 2019. As Halifax's organics management infrastructure has matured, investments are needed to sustain and expand the system to meet future needs. Through discussion with Halifax, options have been developed with regards to existing infrastructure and new facilities. The overall objective of the business plan is to evaluate these options in terms of cost, compatibility with feedstock, and risk as examples. The findings of the business plan will help Halifax understand the cost implications and advantages and disadvantages of each option.

In developing options, the following were identified as key considerations:

- Minimizing capital and operating costs, including reducing current processing costs
- Meeting the 2010 Nova Scotia Environment (NSE) Composting Facility Guidelines (2010 NSE Guidelines) post 2019
- Increasing organics processing capacity from 50,000 tonnes to 60,000 tonnes per year, with the option to increase to 75,000 tonnes per year in the future

Currently, source-separated organics (SSO) collected from residential and industrial, commercial and institutional (IC&I) haulers from within Nova Scotia are processed at either the New Era Technologies (New Era) composting facility, located at 61 Evergreen Place, Goodwood, Nova Scotia, or the Miller Waste Systems Inc. (Miller) Dartmouth composting facility, located at 80 Gloria McCluskey Avenue, Dartmouth, Nova Scotia. The 20-year long term design-build-operate contracts for both facilities will be completed in 2019, with Halifax taking ownership of the facilities, and terminating the lease of the properties. Each facility processes approximately 25,000 tonnes of organic materials per year. Although Halifax has established a number of policies and practices to reduce organic matter within the waste stream (e.g., green carts, clear bags), organic materials are still present within the residential and IC&I waste streams. This organic material is processed and disposed of at the Otter Lake Waste Processing & Disposal Facility (Otter Lake Site) through the Waste Stabilization Facility (WSF) located at exit 3 off Highway 103 in Halifax, Nova Scotia.

GHD considered the use of both existing organics processing sites under contract with Halifax, the Otter Lake Site, and the option of finding new sites for this evaluation. With respect to technology, in consultation with Halifax, GHD looked at proven organics treatment processes that have a demonstrated track record of being used to divert organics from landfills in Canada; namely composting and anaerobic digestion.

2. Existing Halifax Organics Management Facilities

As discussed in Section 1.0, organic material collected within Halifax is currently processed at three separate facilities on land owned by Halifax:

- Goodwood composting facility (SSO from residential and IC&I haulers).
- Dartmouth composting facility (SSO from residential and IC&I haulers).

- Otter Lake (organic material mixed with residential and IC&I waste).

GHD has considered how each of these sites could potentially contribute to Halifax's need for organics management post 2019. A brief description of each site and potential options for future organics processing is provided in the following subsections.

2.1 Goodwood Composting Facility

GHD completed a compliance and process review of the Goodwood composting facility (CRA², June 2015), and it was concluded that the facility is not ideal for considering further investment to upgrade operations to bring into compliance with the 2010 NSE Guidelines or to increase or decrease capacity. In 2019, when the 2010 NSE Guidelines will apply to the facility, it was recommended that Halifax replace the existing facility with alternate organics processing capacity to meet Halifax's organics processing needs for the subsequent 20-year period. With respect to process improvements or modifying the capacity of the facility, the primary constraints are:

- Age and condition of existing equipment and buildings.
- Characteristics of feedstock materials (e.g., porosity, moisture, and carbon to nitrogen ratios) and challenges in sourcing suitable bulking amendment to mix with the feedstock material to make more compatible with the processing technology.
- Incompatibility between the existing organics processing technology (static aerated floor/container) with Halifax SSO material (particularly IC&I materials). This is related to the feedstock issues identified above and the inability to easily address this incompatibility through changes to feedstock materials or composition.

In addition to the primary constraints, GHD estimated to continue operating the facility for the first 5 years of operation past 2019 would cost Halifax \$5-17 million of capital and operating costs as compared to more efficient organic processing capacity.

Therefore, it was recommended that the Goodwood composting facility be decommissioned by 2019. A new organics management facility with a different technology could be constructed at this site, as the land is owned by Halifax and the site already contains an Approval to Operate as a compost facility. There is also the potential to utilize some existing equipment or infrastructure as part of a new processing facility.

2.2 Dartmouth Composting Facility

GHD completed a compliance and process review of the Dartmouth compost facility (CRA, July 2015). Overall, the existing Ebara in-vessel composting process is generally effective at producing compost from Halifax's residential SSO and IC&I organics.

It was recommended that the Dartmouth compost facility continue operating at its current capacity beyond 2019 with some building repairs and equipment replacement and the implementation of one of the following options to meet the 2010 NSE Guidelines for compost maturity requirements as of 2019:

² Conestoga-Rovers and Associates (CRA) has since changed its name to GHD

- Option 1: Increased aeration during curing by forced aeration including the addition of a roof structure over screener bunkers and compost loading area, as piloted and proposed by Miller (\$1.5 - 2.2 million capital expenditure by 2019).
- Option 2: Increased aeration during curing with turning equipment (\$3.8 - 6.0 million capital expenditure by 2019).
- Option 3: Increased outdoor curing area (off-site) (\$0.4 – 1.5 million capital expenditure by 2019, excluding cost of land and does not consider annual operating costs with respect to trucking compost).
- Option 4: Partial implementation of Miller's proposal to implement forced aeration throughout the curing area and additional outdoor curing of materials at the site (0.5 – 1.0 million capital expenditure by 2019).

An increase in capacity would require a significant expansion to the facility, which may not be approved given the separation distance requirement of at least 500 metres from the nearest residential or institutional building in as per the 2010 NSE Guidelines. The separation distance between the existing composting building and the neighbouring Central Nova Scotia Correctional Facility is less than 250 metres.

This site may also be able to accommodate a new organics management facility with a technology other than composting (i.e., anaerobic digestion), as the land is owned by Halifax and the site already contains an Approval to Operate as a compost facility.

2.3 Otter Lake Waste Processing & Disposal Facility

The Otter Lake Site contains a Front End Processor (FEP) and WSF commissioned to remove recyclable materials and hazardous materials prior to landfill disposal, and stabilize any putrescible materials to reduce potential for landfill nuisance factors (e.g., odours, leachate, and vectors and vermin). Mirror Nova Scotia is the contractor operating the Otter Lake Site under a long-term 25-year design-build-operate contract. The majority of the solid waste taken to the Otter Lake Site is processed through the FEP. Approximately 27,000 tonnes per year of residential and IC&I residual solid waste materials less than 150 mm are processed through the WSF for stabilization with the intent of biodegrading organics, after being processed through the FEP. The WSF has the capacity to process approximately 49,000 tonnes per year of material. The facility contains 14 channels where materials are aerobically composted for 15-21 days, and then the resulting materials are sent to the landfill for disposal.

The WSF composting channels could potentially be transformed to allow for composting of residential SSO and IC&I organics. The following are examples of items that would require careful consideration to complete this:

- The indoor building air quality resulting from the positive aeration of the WSF channels is a significant concern that would need to be addressed. An option would be to implement negative aeration through the piles within the channels to improve indoor air quality.
- Creating a barrier over the channels to collect and treat the process air whether it be negative or positive aeration.
- Running a two-phased composting operation whereby half of the channels are used for primary composting and the other half are used for curing.

- The WSF is integral to the Otter Lake Site approval (i.e., approval was conditional on the WSF) and re-purposing it would involve a significant amendment to the Otter Lake Site approval.

There are a number of unknowns with this option that require further evaluation, such as building condition, other retrofit requirements, contractual constraints, approval conditions, and any impact this option may have on overall landfill operations. It is anticipated that amending permits for the Otter Lake Site would be much more onerous and expensive than for the development of a new site for an organics processing facility.

3. Evaluation Considerations

3.1 Feedstock Considerations

Based on discussions with Halifax, GHD developed organics processing options for an anticipated generation rate of 60,000 tonnes per year, with the option to expand to 75,000 tonnes per year if required to address current and future processing capacity requirements.

On August 1, 2015 Halifax implemented a clear bag program for residential garbage collection to improve the participation in their source separation programs for recyclables and organics. Halifax expects this program, based on results observed in other municipalities in Nova Scotia and Ontario, will significantly increase residential organics collection. Halifax also implemented a ban on grass clippings from residential collection, encouraging residents to "grasscycle", which will reduce the amount of organics collected as grass clippings as they were previously permitted in the green bins.

As of August 1, 2015 the following items were permitted in the green cart for collection:

- Fruit & vegetable peelings
- Table scraps, meat, fish, bones
- Dairy products
- Cooking oil & fat
- Bread, rice, pasta
- Coffee grounds, filters, tea bags
- Eggshells
- Food napkins
- Kitchen paper towels and soiled paper
- Excess leaves, brush and plants
- Sawdust and wood shavings

Plastic of any kind, including compostable bags or bin liners, was not permitted in the green carts. Boxboard is also permitted from the residential sector but is also allowed in the paper recycling stream effective August 1, 2015. The material accepted in Halifax's program is generally typical of SSO in other Canadian jurisdictions that do not permit plastic, pet waste or diapers. The relative quantities of residential and IC&I organics is summarized in Table 3.1 below.

Table 3.1 Organics Collected 2012 to 2014

Year	Leaf and Yard Waste ¹ (tonne)	Residential (tonne)	IC&I (tonne)	Total (tonne)	% IC&I	Precipitation ² (mm)
2012	2,210	33,349	16,233	49,581	32.7%	1,328
2013	2,348	33,365	16,453	49,818	33.0%	1,370
2014	3,559	33,002	17,353	50,355	34.5%	1,592
% Change		-1.0%	+6.9%	+1.6%	+5.3%	
Average		33,239	16,679	49,918	33.4%	1,388 ³

Notes:

1. Leaf and yard waste collected separately from residential organics, includes Christmas trees; shown for reference, not included in Total Organics as this material is not managed at the Goodwood or Dartmouth composting facilities
2. Source: <http://halifax.weatherstats.ca/charts/precipitation-25years.html>
3. Annual Historical Average from above-noted source.

The total amount of organics received at the two existing composting sites increased by 1.6 percent from 2012 to 2014. This is not a significant increase particularly when precipitation is factored in. IC&I tonnages increased by 6.9 percent from 2012 to 2014, however the operating staff at both the Goodwood and Dartmouth facilities commented that 2014 was a wet year and they noted the IC&I material specifically was coming in wetter than normal that year. Precipitation data over that time period confirms that 2014 was a wetter than average year; whereas 2012 and 2013 were both drier than normal years. IC&I collection containers are more exposed to the elements than residential green carts as they are more often stored outside and not always covered. Thus, it was assumed that the amount of organics collected over the three most recent years remained relatively constant at approximately 50,000 tonnes/year. The relative amount of IC&I organics is also assumed to be relatively stable at one third of the total.

A key challenge to future processing infrastructure is the ability to handle the wetter IC&I organics. Both the Goodwood and Dartmouth facilities have challenges to manage this material due to difficulty in sourcing reliable and cost effective bulking amendments (i.e., woodchips).

While the residential clear bag policy is expected to increase the total quantity of organics collected, the relative amounts of residential and IC&I organics is not expected to change significantly. A 15 percent (5,000 tonnes) increase in residential organics, with no change in IC&I quantities, would decrease the relative amount of IC&I organics from 33 to 30 percent. Thus, the feedstock porosity and moisture challenges currently experienced at both the Goodwood and Dartmouth facilities would remain an operational issue into the future. An external bulking amendment would still be required in greater quantities to effectively compost Halifax's co-mingled residential and IC&I organics. This is considered a significant obstacle to producing a quality compost product for sale under the 2010 NSE Guidelines. If an appropriate compost feedstock recipe cannot be achieved (i.e., C:N ratio, porosity, pH, etc) it will be difficult to produce a compost that can be marketed directly from the facility for a good price; and continued bulk sales to third-party landscaping companies, as an example, for low prices will likely continue to be the extent of the marketability of the product.

The moisture content and resulting lack of porosity or free air space of the SSO are generally conducive to creating anaerobic conditions in the material. One option is to work with the moisture in the material, not against it, and treat at least a portion of the organics in an anaerobic digestion facility. Halifax's residential and IC&I organics could be treated in an anaerobic digestion facility without the addition of external amendment materials.

3.2 Aerobic Versus Anaerobic Digestion

There are generally two processes utilized for organic material processing: aerobic composting and anaerobic digestion. Both are engineered biochemical conversion processes involving the decay of organic materials, but involve different conditions and produce different outputs, and have differing cost factors and revenue potential. Aerobic composting of SSO is the predominant means of processing SSO in Canada and the United States, while anaerobic digestion is relatively limited and may be dependent on energy pricing for biogas utilization as a revenue stream.

3.2.1 Aerobic Digestion/Composting

Aerobic composting occurs in the presence of oxygen, and uses naturally occurring microorganisms to break down complex organics into carbon dioxide, water, nitrates, and sulphates. In addition to these compounds, the aerobic process produces stable end-products (i.e., compost) and heat. Appropriate equipment selection and controlling process conditions such as moisture content and carbon to nitrogen ratio are key to minimizing odours and guaranteeing the quality of the end-product.

There are three main techniques used in aerobic composting: static piles, aerated static piles, and in-vessel systems. In its simplest form, composting is achieved using static piles called windrows, which are turned periodically using mobile equipment to aerate the material. These are simple outdoor piles that are exposed to the elements, and the level of overall process control is quite low.

Aerated static piles incorporate vented floors or perforated pipes into the windrows. Oxygen is introduced using pressure to push, or a vacuum to pull, air through the piles. There is a greater potential for odours using these techniques, so they are usually conducted indoors, or under a specially designed cover system. Introduction of controlled airflow accelerates the composting process and allows for more even and consistent distribution of oxygen within the organic mass, which is a prime consideration for composting.

More sophisticated systems include in-vessel composting plants which use mechanical means to introduce oxygen and aerate the material in enclosed, controlled environments. The most common systems include: beds or bays with mechanical agitation, horizontal basin reactors, modular tunnels/biocells with or without aeration, and vertical reactors. At this level of technology, process control is advanced, reducing composting times, environmental emissions, and producing high quality compost.

One of the key features of composting systems is the process air. In any composting regime, oxygenation of the material, either through mechanical turning or active aeration, is required. The air that has passed through and contacted the composting material thus contains odorous compounds that are then typically treated prior to release to the atmosphere. The treatment of process air in composting tends to be the single most challenging aspect of this type of operation.

The footprint required for an in-vessel composting facility is generally larger than an anaerobic digestion facility, mainly due to the size requirements for the processing vessels/tunnels and the area necessary for curing.

Composting is a proven technology for waste streams similar to Halifax's organics waste stream that includes residential and IC&I material. Generally, composting requires bulking amendment material to provide some structure within the compost piles during processing which allows air flow through the piles. Halifax's residential organic waste stream includes some leaf and yard waste that provides some bulking characteristics to the feedstock. The IC&I organic material does not contain leaf and yard waste and has a higher moisture content than the residential organic waste stream.

3.2.2 Anaerobic Digestion

Anaerobic digestion occurs in the absence of oxygen, and uses naturally occurring microorganisms to break down complex organics with the addition of heat. The outputs from this process include significant amounts of methane and carbon dioxide, other gases such as ammonia and hydrogen sulfide, and digestate which can be further composted using aerobic processes. A key advantage with anaerobic digestion is that a significant amount of energy can be recovered with the capture and utilization of the methane.

Anaerobic digestion processes are described as either wet or dry, or low vs. high solids, depending on the ratio of solids to moisture in the feedstock. Anaerobic digestion technologies are also distinguished by the number of stages (single or two-stage), operating temperature (mesophilic or thermophilic), process flow (continuous or batch), and the mixing regime (completely mixed, plug flow, or static). Anaerobic digestion facilities are more complex and capital intensive to operate than aerobic composting facilities, and require minimum tonnages and a continuous supply of material to make them feasible, in addition to some reasonable expectation of energy revenue over the long-term.

As opposed to composting, anaerobic digestion does not generate specific process air streams, as the odorous compounds are captured in the biogas produced in the unaerated environment. From an environmental emissions standpoint, this can be a significant benefit, especially when locating facilities in proximity to neighbours.

As noted, anaerobic digestion still produces an organic digestate that may be able to be directly land applied or it can be dewatered and composted. There may also be a wastewater/leachate end product that may require pre-treatment prior to discharge to the sewer or trucking off-site, and a residuals stream that is typically landfilled. The processing fees included in this business case account for some wastewater disposal/treatment or the hauling of digestate that is not dewatered for land application.

Water is a key consideration in planning an anaerobic digestion facility. The Dartmouth and Halifax sites are not connected to a sanitary sewer system and therefore wastewater generated would have to be trucked off-site for treatment or disposal. GHD recommends that Halifax carefully consider water and wastewater costs when evaluating anaerobic digestion options. High solids AD systems that minimize the amount of water required in the process should be included as part of the evaluation. High solids AD systems are less common in North America than wet AD systems but have been successfully implemented at a commercial scale at a number of locations, including in Richmond, British Columbia.

Anaerobic digestion is a proven technology for waste streams similar to Halifax's organics waste stream that includes residential and IC&I material. For example, the cities of Toronto, Richmond, and Orlando utilize anaerobic digestion to process a portion of their organic materials. Anaerobic digestion does not require the bulking amendment material that composting does, and as the IC&I organic material does not contain leaf and yard waste and has a higher moisture content than the residential organic waste stream, the IC&I material may be the most suitable organic waste stream for anaerobic digestion in Halifax.

The methane generated from the anaerobic digestion process can be captured and used to provide electricity and heat to the facility to offset electricity and propane requirements, or it can be exported from the facility and sold for additional revenues. Given that the Nova Scotia Community Feed-In Tariff (COMFIT) program is currently on hold, there are no incentive programs currently in Nova Scotia that offer premium prices and guaranteed long-term contracts for the generation and sale of renewable electricity or natural gas. As such, this business case assumes that no revenue will be realized from the sale of electricity from anaerobic digestion facilities; other than at third-party private on-farm anaerobic digestion facilities with existing COMFIT contracts. Revenues and on-farm anaerobic digestion facilities are discussed in detail below. COMFIT is further discussed in Section 3.5.1.

However, if a COMFIT or similar program does become available again in time for consideration, electricity revenue could be a significant source of revenue. The previous COMFIT price for combined heat and power was 17.5 cents per kWh. The amount of biogas and energy produced at anaerobic digestion facility varies depending on the feedstock and the process but at 17.5 cents per kWh, electricity sales could offset processing costs by approximately \$25-40 per tonne of SSO³.

If anaerobic digestion is selected as the preferred organics processing technology, a review of the inclusion of excess leaves, brush, and plants in the green carts should be reviewed with the technology provider. Certain leaf and yard materials can be digested under the right conditions but may not be compatible with all digestion technologies.

3.3 Siting – Existing Versus New

Halifax has the option to utilize existing organics management facility sites to develop new organics management facilities, to modify existing facilities, or to consider new sites in order to meet future processing capacity demands.

Siting criteria generally used to evaluate the suitability of a site for the purpose of constructing and operating an organics management facility are summarized below:

Location: in relation to waste-shed and other solid waste facilities.

Environmental: Air quality, noise, odour, terrestrial, aquatic, surface water, groundwater, agricultural.

Social: Sensitive receptors, land use/zoning, transportation, visual.

Cultural: Archaeological, heritage.

Technical: Permitting/approvals, safety, utility and services, suitability, flexibility.

³ Assumes: 2 kWh/m³ biogas, 90–130 m³ biogas/tonne SSO and 10-20 percent engine downtime

Economic: Land purchase price and development costs.

Legal: Land acquisition, agreement.

Existing waste processing or disposal sites owned by Halifax have already gone through a siting exercise to address a set of siting criteria similar to the list above. The existing two composting sites and the Otter Lake Site are currently permitted for waste processing and/or disposal. Utilizing existing sites to expand the organics program in Halifax is a significant benefit in terms of site development cost savings and project development timelines. Environmental permits will need to be amended but a zoning amendment process can be avoided.

Halifax will need the existing organics processing capacity to be unaffected during the construction of any new facility. In other words, an existing facility may not be demolished to make room for a new facility until after the new facility is operational. A new facility constructed at an existing site must be constructed alongside an existing facility. Depending on the size of the new facility, and the staging area required for its construction, this may be a constraint for an existing site that may prevent its use or increase the time and cost required for construction.

The Goodwood composting facility is approximately 14 hectares while the Dartmouth composting facility is approximately 6 hectares. Co-locating a new anaerobic digestion facility at the Dartmouth site may be a challenge depending on its size and the ability to share or repurpose portions of the existing facility like the receiving hall, scale, and administration offices. There is approximately 2 hectares of usable space (accounting for 30 m buffers along the property boundary) at the Dartmouth site if the existing facility continues to operate. The Dartmouth site would not be an option to implement a new composting technology (if selected) due to setback requirements from neighboring institution. The Goodwood site is a good size for either composting or anaerobic digestion at the scales contemplated in this business case, namely 10,000 to 60,000 tonnes per year of SSO.

This business case does not evaluate sites based on the above-noted criteria other than to:

1. Differentiate between an existing site permitted and zoned for organic waste processing and a new site without requisite zoning or permits; for the purposes of this study GHD assumed that development costs for new organics processing capacity at all existing sites would be similar to developing a new site. This is a conservative estimate with regards to the cost of implementing new organics processing capacity at existing sites.
2. Eliminate the Dartmouth site as a potential site for additional composting capacity due to setback distances from the neighbouring institution.

3.3.1 On-Farm Anaerobic Digestion

There is also the potential to take advantage of available on-farm anaerobic digestion capacity to provide additional processing capacity as part of Halifax's organics management future plan. A number of farms have successfully obtained 20-year COMFIT agreements (refer to Section 3.5.1 for details on the COMFIT program) to sell electricity to the grid at a premium price (17.5 cents per kWh) and are in the process of constructing anaerobic digestion facilities. The actual status of these projects could not be confirmed and would need to be explored further. There is no known on-farm anaerobic digester processing residential SSO in the vicinity of Halifax that GHD is aware of. GHD is aware of on-farm anaerobic digesters processing agricultural and IC&I organics in Nova Scotia.

Table 3.2 summarizes the pros and cons of partnering with local farms for organics processing, specifically anaerobic digestion of SSO.

Table 3.2 Evaluation of On-Farm Organics Processing

Pros	Cons
COMFIT revenues decrease reliance on tip fees to finance capital expenditures. Deals with farms would need to be negotiated but there is a potential that this could save on processing fees for Halifax.	Reliability: Will on-farm facilities provide reliable processing capacity with minimal downtime? This depends on a number of factors including: - Operator skills and experience - Capacity redundancy, contracting with multiple farms with spare capacity - Agreement with facilities, ensure contracts contain necessary performance guarantees, consider contracting directly with farms to ensure Halifax can address any contract issues directly
Digestate can be stored on-farm and directly land applied at the farm, minimizing dewatering and transportation costs of digestate management.	An agricultural operation is not a waste processing operation. While some organics pre-processing can be done well on-farm, for cleaner IC&I organics for example, Halifax should exercise due diligence to ensure that any contracted farm is able to reliably deal with any residues generated by their process, or any wastes generated during a process upset. This can be mitigated by pre-processing the organics at a central location and delivering a clean pulp to the farms. Note: pre-processing systems need to be compatible with the anaerobic digestions systems, for example some anaerobic digestion systems are more sensitive to grit in the digester.
Provide local farms with additional electricity and tip fee revenues by supplying organics to support their project and their farm business.	GHD is not aware of any municipality of a similar size to Halifax in Canada that relies on on-farm partners for their organics processing requirements.
Reduced permitting requirements, particularly in comparison to a new industrial site.	
Halifax currently pays to transport and treat additional leachate generated by the composting facilities. An on-farm anaerobic digestion facility could minimize or eliminate the need for leachate transport or further treatment if the pulp is not dewatered prior to sending to the farms.	

GHD recommends Halifax pre-process the organics and supply the farm facility with a clean pulp suitable for their anaerobic digestion system. This will allow Halifax to retain control of and properly manage any residues at their own facilities or at facilities run by professional waste management companies. This business case assumes a central pre-processing facility for the on-farm processing option.

Grit removal is a key consideration in organics pre-processing ahead of an anaerobic digestion system. If grit enters the digester, or any storage tanks prior to the digester, it will settle out and accumulate at the bottom of the digester. Eventually, that digester will need to be shutdown, emptied and cleaned of grit. One hundred percent grit removal is not realistic and some grit

accumulation is normal and anticipated, but it should be minimized to the extent possible; particularly for on-farm anaerobic digestion facilities. Most anaerobic digestion systems rely on pre-processing systems to remove grit, but some anaerobic digestion systems provide for grit and other contaminant removal within the digestion tank. Thus, a pre-processing system designed for an anaerobic digestion tank that includes built-in contaminant removal systems is not necessarily compatible with an anaerobic digestion system that does not include any built-in contaminant removal system.

Partnering with local farms would provide Halifax with a very unique model in Canada of returning food waste back to agricultural soils in a very local context. This could potentially be a very innovative and positive social benefit of this type of approach that could also provide Halifax with real economic benefits as well. That being said, this approach is untested and is considered risky from a processing capacity reliability perspective and should be considered carefully.

3.4 Regulatory Considerations

The regulatory framework for an organics processing facility in Nova Scotia can generally be thought of in two stages: facility development and operations, and end-product quality. The development and operation of the facility may require various approvals at the provincial and municipal level, while the quality requirements tied to the end-product govern its ability to be distributed into the marketplace.

A brief overview of the regulatory requirements for an organics facility is provided in the sections that follow. However, it is important to note that a number of different regulations and approvals may apply depending on the type of processing technology selected. In addition, if a site is selected that already has existing approvals in place, only amendments may be necessary. As a result, a review of the applicable regulatory requirements should be undertaken once the preferred processing approach and location have been selected.

3.4.1 Facility Development and Operations

As part of any siting process, it is important to highlight appropriate legislative framework that may apply to the development of the facility and ultimately, operations. Applicable Nova Scotia legislation includes:

1. Environment Act, administered by Nova Scotia Environment (NSE)
 - Solid Waste-Resource Management Regulations
 - NSE Compost Facility Guidelines (2010 NSE Guidelines)
 - Environmental Assessment Regulations
2. Fire Prevention Act, administered by the Department of Labour and Advanced Education
 - Fuel Safety Regulations

These Acts, along with the Regulations and Guidelines under it, are used to establish and detail the authority and responsibility of the province as well as the legal requirements for proponents of various proposals.

Environment Act

Solid Waste-Resource Management Regulations

Solid Waste-Resource Management Regulations (Section 27) made under Section 102 of the Environment Act states that a Municipal Waste Approval: Solid Waste from NSE is required prior to construction of a composting or anaerobic digestion facility.

NSE Compost Facility Guidelines

The 2010 NSE Guidelines state that applications to NSE to construct, operate, expand or modify a composting facility must be accompanied by a letter from the municipal unit where the facility is to be located stating that the facility meets zoning, planning restrictions and such other by-laws as may exist.

General information on facility design and operations is located within Part IV and Part VII of the Compost Facility Guidelines (i.e. receiving and tipping area, composting area, curing area, leachate management, surface water management, groundwater management, odour control systems, and separation distances).

Environmental Assessment Regulations

The Nova Scotia Environmental Assessment Regulations made under Section 49 of the Environment Act promote sustainable development by evaluating the potential environmental effects of major developments before they are constructed. The regulation applies to the following types of waste management facilities:

1. A facility for storing, processing, treating or disposing of waste dangerous goods that were not produced at that facility, other than facilities operated by, or on behalf of, a municipality or Provincial agency for waste dangerous goods collected only from residential premises (Class 1).
2. A facility for treating, processing or disposing of contaminated materials that is located at a site other than where the contaminated materials originated (Class 1).
3. A facility for the incineration of municipal solid waste (Class 2).

Based on the waste management facility categories above, a new composting or anaerobic digestion facility is not anticipated to be required to complete an Environmental Assessment, however, the Minister has the authority to apply an environmental assessment to any undertaking. In addition, elements of an environmental assessment (e.g., siting evaluation for items such as traffic, noise and odour; and some form of public consultation) will be required for significant amendments to existing Municipal Waste Approvals or in obtaining new approvals.

Fire Prevention Act

The Fuel Safety Regulations made under Section 3 of the Fire Prevention Act requires that any digester gas utilization project requires a Digester Gas/Landfill Gas Equipment Approval, issued by the Department of Labour and Advanced Education.

Other Approvals

Aside from the NSE, requirements under the following authorities and standards may also be applicable for the site works:

- Ministry of Natural Resources
- Ministry of Transportation
- Nova Scotia Building Code
- Occupational Health and Safety Act
- Nova Scotia Fire Code
- Standard municipal approvals (i.e. building permits and site plan approvals)

3.4.2 End Product Quality

The 2010 NSE Guidelines are used to identify whether compost may be categorized as Category A or B compost, and finished compost is classified in accordance with the criteria identified in the Canadian Council of Ministers of the Environment (CCME) document "Guidelines for Compost Quality" dated October 2005 as amended. Finished compost at both the existing Dartmouth and Goodwood composting facilities will be required to meet these criteria as of 2019 at the end of the current contracts. It has been well documented that the primary challenge for source-separated organic compost facilities, including the Dartmouth and the Goodwood compost facilities; to achieve compliance with the 2010 NSE Guidelines is the more stringent maturity requirement.

The sale and importation of compost products is regulated by the Canadian federal government under the Fertilizers Act and Regulations (T-4-120 - Regulation of Compost under the Fertilizers Act and Regulations), administered by the Canadian Food Inspection Agency (CFIA).

It should be noted that the end product might not necessarily be compost and that depending on the technology ultimately selected, other end products may be produced. Products may also be generated to be sold as a registered or regulated fertilizer under the federal Fertilizers Act. Any such fertilizer product would have a label with a guaranteed analysis and instructions for use that have been reviewed by the CFIA to ensure that the product, if used as directed, will not be detrimental to vegetation, domestic animals, public health or the environment.

3.5 Cost Considerations

Table 3.3, attached, and summarizes the capital and operating costs for a number of different sized organics processing facilities. The size and type of facility correspond with the options analysis presented in Section 4. These numbers were developed based on capacity factoring and professional judgement from existing facilities where capital and operating costs or processing fees were known. These costs are used in the options evaluation in Section 5. The facilities ranked from lowest to highest Equivalent Annual Cost⁴ are as follows:

1. \$135/tonne: 20,000 tonne/year on-farm anaerobic digestion facility
2. \$154/tonne: 60,000 tonne/year composting facility

⁴ Equivalent Annual Cost (EAC) = $NPV / At, r + \text{annual operating cost}$; where NPV is Net Present Value and At, r is the inverse of a loan repayment factor (PMT in Excel) for a period t (20 years) and a cost of capital r (4%).

3. \$175/tonne: 35,000 tonne/year composting facility
4. \$184/tonne: 10,000 tonne/year composting facility
5. \$209/tonne: 60,000 tonne/year anaerobic digestion facility
6. \$230/tonne: 25,000 – 35,000 tonne/year anaerobic digestion facility

Land purchase price was not included in the capital cost estimates and is therefore not included in the Equivalent Annual Cost numbers above.

3.5.1 Nova Scotia Community Feed-In Tariff (COMFIT)

The COMFIT program is part of Nova Scotia's 2010 Renewable Electricity Plan available through the Nova Scotia Department of Energy, and encourages community-based, local renewable energy projects by guaranteeing a rate per kilowatt-hour for the energy the project feeds into the province's electrical distribution grid. This program is currently on pause, but an announcement regarding an update to the program status is anticipated to be made in the fall of 2015. The majority of the programs currently receiving COMFIT or in the application process involve renewable energy produced from wind, biomass, tidal, hydro, and combined heat and power (CHP). Any COMFIT status announcement that includes changes to agricultural digester approvals and requirements for the acceptance of SSO at farms may have an effect on the outcome of this business case.

Miller is currently listed as having an approved COMFIT agreement as of February 25, 2015 for a biomass CHP facility located at the Dartmouth composting facility for 2 megawatts. There are also a number of farms in the vicinity of Halifax that have COMFIT agreements, which may be beneficial for on-farm anaerobic digestion projects.

As stated previously, as there is no current active COMFIT program or other renewable energy incentive program in-place at present in Nova Scotia, the sale of electricity was assumed to be negligible as part of this business case analysis. COMFIT, or similar, premium electricity prices are a significant source of additional revenue for an anaerobic digestion facility and would improve the overall economics of the project significantly; on the order of \$25–40 per tonne of SSO at a price of 17.5 cents per kWh.

3.6 Wastewater Considerations

The existing composting facilities generate a significant amount of process wastewater that is required to be hauled to an off-site wastewater treatment facility at significant expense. In 2014, the Dartmouth composting facility generated 3.7 million litres of leachate or 159 litres per tonne of organics processed. This material is a relatively high strength material and requires surcharges to be treated at third-party wastewater treatment facilities. Halifax Water can no longer accept this material into the sanitary sewer system, even with a surcharge agreement, due to its high strength.

A new composting facility could be designed to minimize leachate generation by utilizing covered biofilters for example. However, due to the wet nature of the organics in Halifax a certain amount of leachate is expected and will vary with the amount of precipitation in a year.

A SSO wet anaerobic digestion facility will also generate significant amounts of wastewater if solids are separated from the digestate for composting or land application. Wastewater volumes can vary from 500 litres of treated (to sewer use criteria) effluent per tonne of organics processed to over 1,100 litres of untreated effluent per tonne of organics process that would also require sewer use

surcharges or additional tipping fees to be applied to the effluent. The amount and strength of the wastewater varies by facility and can vary over time. Managing wastewater is a significant part of the cost of an anaerobic digestion facility.

Table 3.4 summarizes Toronto and Halifax sewer use bylaw limits compared to wastewater quality data taken from the City of Toronto's anaerobic digestion organics processing facilities. The Dufferin Organics Processing Facility material is generally a lower strength wastewater compared with the wastewater from the Disco Road Organics Processing Facility because the Dufferin facility utilized more fresh water than the Disco Road facility.

Table 3.4: Anaerobic Digestion Wastewater Quality

Parameter	Toronto Sewer Use ByLaw Limit (mg/L)	Halifax Sewer Use ByLaw Limit (mg/L)	Disco Road Organics Processing Facility (mg/L)	Dufferin Organics Processing Facility (mg/L)
TKN	100	100	3133	1829
TSS	350	300	1583	3366
TP	10	10	119	74
BOD	300	300	7649	3690

Provided the wastewater treatment facility is sized appropriately, there are a number of proven wastewater treatment options for treating organics processing facility wastewater to meet sewer use discharge criteria, including biological treatment systems such as Sequencing Batch Reactors (SBR) or Membrane BioReactor (MBR) systems; among others. GHD has completed a number of wastewater treatment studies for source separated organics wastewater treatment facilities and is confident that treating to sewer use surcharge limits is readily attainable. The type and size of wastewater treatment system can vary significantly depending on the volume and characteristics of the wastewater.

The capital and operating costs compiled for this study include a conservative amount for treating and hauling wastewater utilizing either an on-site treatment system or off-site treatment facility. GHD reviewed the wastewater management costs for a number of facilities, and included a conservative estimate for wastewater management for a new organics processing facility in Halifax.

Another option for addressing wastewater at an anaerobic digestion facility is to not separate out the digester solids from the digestate and manage the digestate as a liquid soil amendment or fertilizer directly. The liquid digestate would need to be stored between land application windows but could otherwise be directly land applied in a liquid form. This may require additional permits for the agricultural operation.

3.7 Assumptions

The following assumptions have been applied to this analysis:

1. The Goodwood composting facility will be shut down as of 2019, as per GHD's recommendation.
2. The Dartmouth compost facility cannot be expanded for additional compost-based capacity due to regulated setbacks (see Section 2.2) from neighbouring sensitive receptors.

3. The 2010 NSE Guidelines will be applied to all existing and new facilities as of 2019.
4. COMFIT will likely not provide funding for new projects and no incentivized pricing for electricity or renewable natural gas sales will be available as a conservative estimate. COMFIT pricing only considered where known COMFIT contracts have been awarded and will be constructed regardless of the availability of Halifax organics, such as in the instance of a number of on-farm sites in Nova Scotia⁵. GHD is aware that Miller has secured a COMFIT agreement for the Dartmouth site in anticipation of participating in a future biogas project (as noted in Section 3.5.1 above). As there is no agreement between Miller and Halifax regarding a future biogas project in the existing COMFIT agreement, it was assumed that Halifax would not be able to utilize the COMFIT agreement independently of Miller. Therefore COMFIT pricing was included with the on-farm anaerobic digestion options, but not in the options that include the development of a new anaerobic digestion facility.
5. The cost of acquiring new land has not been included in this assessment as it has been assumed that new land would serve as a new asset to Halifax and not a cost associated with a new organics processing facility.
6. The financial impact of increasing the total capacity from 60,000 tonnes to 75,000 tonnes has not been included in the analysis; however, it may be worthwhile to Halifax to complete a similar analysis when the total capacity increase is required to ensure that the most cost effective options are selected at that time.
7. Cost estimates include a conservative estimate for disposing of or treating process and waste water generated at an organics processing facility. The estimate provides for some combination of on-site wastewater treatment, potential off-site wastewater treatment, and haulage. One option for addressing excess process water for anaerobic digestions options may be to manage it with the digestate (i.e., not separate the solids from the digestate).

4. Organic Material Management Options

Table 4.1 summarizes the options that have been considered for this assessment. Note that all options provide for a total of 60,000 tonnes per year organics processing capacity with the option to increase to 75,000 tonnes per year in the future. The options are split into three basic categories:

- Option 1: utilize the Dartmouth Compost Facility with one new organics processing facility for 35,000 tonnes/year, scalable to 50,000 tonnes per year
- Option 2: utilize the Dartmouth Compost Facility with two new organics processing facilities for 10,000 – 25,000 tonnes per year each. This option was created to explore partially repurposing the WSF and utilizing on-farm anaerobic digestion facilities that have COMFIT agreements. The WSF and on-farm facilities have limited capacity to accept Halifax organics.
- Option 3: one new organics processing facility for the full 60,000 tonnes per year

The 'a' and 'b' sub-options under each main option generally differentiate between a compost-based process and an anaerobic digestion based process.

⁵ COMFIT Project Status Table (as of August 14, 2015)
<http://energy.novascotia.ca/sites/default/files/files/Comfit%20Status%20as%20of%20August%2015%2C%202015.pdf>

Table 4.1 Evaluated Organics Processing Options

Option No.	Facility 1	Facility 2	Facility 3
Option 1a	Existing Dartmouth Compost Facility	New Compost Facility	NA
Capacity	25,000 tonnes/year	35,000 tonnes/year (may be increased to 50,000 tonnes/year)	
Potential Sites		- Goodwood Compost Facility - New site	
Option 1b	Existing Dartmouth Compost Facility	New Anaerobic Digestion Facility	NA
Capacity	25,000 tonnes/year	35,000 tonnes/year (may be increased to 50,000 tonnes/year)	
Potential Sites		- Goodwood Compost Facility - Dartmouth Compost Facility - New site	
Option 2a	Existing Dartmouth Compost Facility	New Compost Facility	New Anaerobic Digestion Facility
Capacity	25,000 tonnes/year	10,000 tonnes/year (may be increased to 25,000 tonnes/year)	25,000 tonnes/year ¹
Potential Sites		- Goodwood Compost Facility - WSF at Otter Lake Site (partially repurpose facility) - New site	- Goodwood Compost Facility - Dartmouth Compost Facility - New site
Option 2b	Existing Dartmouth Compost Facility	New On-Farm AD Facility	New On-Farm AD Facility
Capacity	20,000 tonnes/year	20,000 tonnes/year	20,000 tonnes/year
Potential Sites		- On-farm site	- On-farm site
Option's 3a	New Compost Facility	NA	NA
Capacity	60,000 tonnes/year (may be increased to 75,000 tonnes/year)		
Potential Sites	- Goodwood Compost Facility - New site		
Option's 3b	New Anaerobic Digestion Facility	NA	NA
Capacity	60,000 tonnes/year (may be increased to 75,000 tonnes/year)		
Potential Sites	- Goodwood Compost Facility - Dartmouth Compost Facility - New site		

Notes:

1. The uneven split between Facility 2 and Facility 3 for Option 2a was to provide sufficient capacity in the anaerobic digestion facility for all or nearly all of the wetter IC&I organics and to also provide a minimum size to take advantage of economies of scale as anaerobic digestion facilities are generally more expensive than composting facilities

5. Evaluation of Options

The cost estimate for different sized organics processing facilities shown in Table 3.3 were utilized to calculate the estimated total capital and processing costs associated with new organics processing capacity for each option shown in Table 4.1. Table 5.1, attached, shows the budget comparison of each option, including an overall Equivalent Annual Cost, based on 4% interest for 20 years. The budget comparison includes forecasting all capital and operating costs to process 60,000 tonnes per year of SSO.

The following list ranks the options in terms of overall Equivalent Annual Cost (as shown in Table 5.1), from lowest to highest:

- \$148/tonne: Option 2b (Dartmouth Facility, On-Farm Anaerobic Digestion).
- \$155/tonne: Option 3a (New 60,000 tonne/year Compost Facility).
- \$159/tonne: Option 1a (Dartmouth Facility, New Compost Facility).
- \$184/tonne: Option 2a (Dartmouth Facility, New Compost Facility, New Anaerobic Digestion Facility).
- \$191/tonne: Option 1b (Dartmouth Facility, New Anaerobic Digestion Facility).
- \$209/tonne: Option 3b (New 60,000 tonne/year Anaerobic Digestion Facility).

In addition to economic evaluation criteria, the following criteria were also scored in a decision matrix summarized in Table 5.2:

- Facility Footprint: anaerobic digestion facilities have a smaller footprint than composting facilities.
- Compatibility with Feedstock: anaerobic digestion is generally more suitable for the nature of the Halifax materials, in particular with the wetter IC&I organics and does not require the addition of bulking amendment materials.
- Planning and Approvals Risk: Existing sites are already zoned and approved for solid waste activities. New sites will need to be sited, apply for a zoning amendment and apply for new approvals.
- Process and Technical Risk: Compost and anaerobic digestion of food waste are both proven technologies in Canada, throughout North America and throughout Europe. On-farm anaerobic digestion is not proven in Canada.
- Odour and Noise: given proximity of sites to developed areas of Halifax.
- Process Water and Stormwater: the existing Goodwood and Dartmouth composting facilities have known water management issues. It is assumed that a new site would be designed to better address water management issues.

- End Products and Byproducts: the existing Goodwood and Dartmouth compost facilities have struggled to generate quality compost from the available feedstock material. Anaerobic digestion would provide better treatment of the food waste which would result in a higher quality solid or liquid agricultural soil amendment.
- Phasing and Transition: Halifax requires the existing composting operations to remain in operation until one or more new facilities are constructed; this may impact suitability of the Dartmouth site for those options that require a large footprint and cannot be accommodated within the available space.
- Overall Schedule: with respect to permitting requirements, construction phasing, etc.
- Future Regulations: it is known that the 2010 NSE Guidelines are currently being reviewed and may be revised in the near future. In Ontario, compost quality standards have recently been created that are more onerous than the 2005 CCME Guidelines and this has resulted in a number of operations being unable to generate certified compost any more. There is a risk that the new Nova Scotia guidelines may mimic Ontario standards as jurisdictions typically look to other jurisdictions for examples.

The decision matrix was created to compare the different siting configurations with each option, using criteria to rank the various options and a weighting factor to weight the significance of each criterion in Table 5.2. The decision matrix was used to develop a score for each option, with a maximum total possible score of 100.

The weighting values were determined in cooperation with Halifax staff. They represent the priorities of Halifax for developing a new organics processing facility based on the over 15 years of experience in managing two organics processing facilities. The primary priorities identified were:

- Cost (Weighting 20/100): Fiscal responsibility is always a priority for public projects.
- Odour and Noise (Weighting 20/100): In order to locate the facilities as close as possible to the urban centres where the organic waste is generated, the facility may not generate nuisance odours or noise.
- Compatibility with Feedstock (Weighting 15/100): Halifax's SSO program has changed over time and the existing composting facilities have had difficulty composting a wetter organics feedstock.
- Overall Schedule (Weighting 10/100): Halifax must have the new organics process facility operational before the expiry of the current Goodwood and Dartmouth composting facilities operating agreements in 2019.

These four priority criteria represent nearly two-thirds of the Total Score. In order to score well overall, an option needed to score relatively well in 3-4 of these four priority items for Halifax.

Scores were tabulated in Table 5.2 in two different ways, namely:

- Total Score: sum of the weighted scores for each option, higher scores are better, top five scores are summarized in Table 5.3 below.
- Value for Money: calculated⁶ as an adjusted total score divided by Equivalent Annual Cost and represents a relative points per dollar score, top five scores are summarized in Table 5.3 below.

⁶ Value for Money = $100 \times (\text{Total Score} - \text{Equivalent Annual Cost Score}) / \text{Equivalent Annual Cost}$

The options are sorted by Equivalent Annual Cost (lowest to highest) in Table 5.3 below to compare the results of the top scores calculated in Table 5.2. The top three options under each column in Table 5.3 are highlighted. The top scores all involved existing sites.

Table 5.3 Evaluation Results Summary

	Option	Equivalent Annual Cost (\$/tonne) (Rank)	Total Score (Rank)	Value for Money (Rank)
2b	Existing Dartmouth Facility (25,000 tonne/year) & 2 New On-Farm Anaerobic Digestion Facilities (~20,000 tonne/year each)	\$148	67 (5)	31.4 (3)
3a	New 60,000 tonne/year Compost Facility at an Existing Site	\$155	56 (9)	23.5 (11)
1a	Existing Dartmouth Facility (25,000 tonne/year) & New Compost Facility (35,000 tonne/year) at an Existing Site	\$159	59 (8)	25.5 (7)
2a	Existing Dartmouth Facility (25,000 tonne/year) & New Compost (10,000 tonne/year) and Anaerobic Digestion (25,000 tonne/year) Facilities at an Existing Site	\$184	62 (6)	25.3 (8)
1b	Existing Dartmouth Facility (25,000 tonne/year) & New Anaerobic Digestion Facility (35,000 tonne/year) at an Existing Site	\$191	72 (4)	30.1 (5)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at Goodwood Site	\$209	82 (1)	33.5 (1)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at Dartmouth Site	\$209	79 (2)	32.3 (2)
3b	New 60,000 tonne/year Anaerobic Digestion Facility at New Site	\$209	77 (3)	31.1 (4)

Only two of the options, namely Option 2b and 1b are in the top five for all three columns in Table 5.3. None of the options are in the top three for all three columns. Three of the options, namely Option 2b, Option 3b (Goodwood Site), and Option 3b (Dartmouth Site), are in the top three for two of the three columns.

The lowest cost option, based on an Equivalent Annual Cost basis, over a 20 year lifecycle, was determined to be the option that utilized the existing Dartmouth composting facility assets in combination with two new on-farm anaerobic digestion facilities (Option 2b). The on-farm anaerobic digestion facilities do not require significant additional capital expenditures for Halifax. This is based on the assumption that existing COMFIT revenues for renewable energy received by these farms will offset capital expenditures for the farms, savings which will in turn be passed on to Halifax (i.e., they will build the facilities regardless if Halifax supplies them with feedstock). This option also represents the third best value for money. However, it has a low score compared with some of the other options primarily due to the uncertainty of relying on on-farm third-party processors for the bulk of Halifax's organics processing needs; this resulted in Option 2b only scoring well in one of the four priority evaluation criteria. Establishing agreements with multiple farms can help mitigate this risk to an extent. Also, ensuring contractual arrangements that would provide Halifax with performance guarantees and penalties would be critical to ensuring reliability of processing capacity.

Options involving new compost facilities at existing site(s) (e.g., Goodwood site; Options 1a and 3a) represent the next lowest cost option. These options have relatively low scores and represent poor value for money; in this case, primarily due to the issues surrounding the suitability of composting the feedstock material (i.e., wetter IC&I organics). An external bulking amendment would be required in greater quantities to effectively compost Halifax's co-mingled residential and IC&I organics. This is considered a significant obstacle to producing a quality compost product for sale under the 2010 NSE Guidelines. As such, it will be difficult to produce compost that can be marketed directly for a good price; and continued bulk sales to third-party landscaping companies, as an example, for low prices will likely continue to be the extent of the marketability of the product.

Options that involve the continued operation of the existing Dartmouth compost facility will also need to account for the replacement of major components over the 15-20 year planning horizon. Replacement costs for the existing Dartmouth facility are factored into Table 5.1 and assume replacement with an equivalent compost facility. Repair costs, based on separate inspection reports, for the Dartmouth facility required to keep the facility in service past the end of the current operations agreement are also included. The \$500,000 included in Table 5.1 for the Dartmouth facility for options that do not include its continued operation is to account for decommissioning costs.

Options 1b and 3b, which involve the construction of a new anaerobic digestion facility generally scored the highest and represent the best value for money; but are the highest cost options as well. The options involving a new 60,000 tonnes per year facility at the Dartmouth or Goodwood sites (Option 3b) score high in three of the four priority evaluation criteria and high in all of the other evaluation criteria. Anaerobic digestion is better suited for the nature of the materials generated within Halifax given the mandatory inclusion of IC&I organics. Anaerobic digestion facilities offer many benefits over composting in large urban centers, as they are able to be sited closer to the areas where the organics are generated and have smaller footprints.

For the purposes of the business case, it was assumed that COMFIT revenues for renewable energy would not be available for new anaerobic digestion facilities due to a current program freeze in Nova Scotia. If a long term COMFIT contract could be secured for the Goodwood or Dartmouth sites, this could decrease the Equivalent Annual Cost by roughly \$25-40/tonne down to \$169-184/tonne; which would result in a more cost competitive option albeit still a higher cost over the long term as compared to composting.

Overall, based on the evaluation criteria and weighting utilized in this report, GHD is of the opinion that the development of anaerobic digestion capacity to process at, a minimum, part of Halifax's SSO will offer many long-term benefits including addressing the processing of wetter IC&I organics. It will also allow existing composting capacity at the Dartmouth site, should Halifax elect to keep it operational past 2019, to operate more effectively by allowing Halifax to selectively divert only drier residential organics to it that are mixed with a portion of the leaf and yard waste materials.

Options involving new sites, with their potential permitting issues, scored lower overall for both Total Score and Value for Money when compared against the same option implemented at one of the existing Goodwood or Dartmouth sites.

Each of the above options has its advantages and disadvantages. An option for Halifax to consider as a next step would be to move forward with a competitive bid process that is technology neutral to allow compost and anaerobic digestion technology centered bids to compete against each other. As well to allow bids that utilize on-farm infrastructure coupled with centralized transfer and

pre-processing components; ensuring that proposals received adequately address all potential risks with partnering with one or more local farm businesses. This allows those firms with COMFIT agreements, for example or any other competitive advantage, to potentially offer the more expensive anaerobic digestion option at a more competitive price compared to composting.

However, in a public procurement process with pre-defined scoring, when the technology is not pre-determined prior to going out to tender, the owner must be willing to accept any technology that receives a passing score or cancel the procurement completely. One approach to mitigate this is a two stage procurement process where technology vendors and suppliers are pre-qualified based on technical merit first and then on their full business proposal second. This is similar to the approach currently being used by the City of Edmonton to find partners to provide a high-solids anaerobic digestion facility for their SSO.

6. Closure

The findings of the business plan include:

- The lowest cost option, based on an Equivalent Annual Cost basis, over a 20 year lifecycle, was determined to be the option that utilized the existing Dartmouth composting facility assets in combination with two new on-farm anaerobic digestion facilities (Option 2b) to provide a combined total of 60,000 tonnes per year of organics processing capacity. The lower cost is a result of the assumption that Halifax would not be required to contribute to the capital expenditures of the on-farm facilities (i.e., they will build the facilities regardless if Halifax supplies them with feedstock). This option is considered high risk as no other municipality in Canada has attempted to rely on an on-farm anaerobic digestion facility for the majority of its organics processing needs.
- Options which involve the construction of a new anaerobic digestion facility generally scored the highest and represent the best value for money; but are the highest cost options as well. The options involving a new 60,000 tonnes per year facility at the Dartmouth or Goodwood sites (Option 3b) score high in three of the four priority evaluation criteria and high in all of the other evaluation criteria.
- Overall, based on the evaluation criteria and weighting utilized in this report, GHD is of the opinion that the development of anaerobic digestion capacity to process at a minimum part of Halifax's SSO will offer many long-term benefits including addressing the processing of wetter IC&I organics. It will also allow existing composting capacity at the Dartmouth site, should Halifax elect to keep it operational past 2019, to operate more effectively by allowing Halifax to selectively divert only drier residential organics to it that are mixed with some leaf and yard waste materials.

All of Which is Respectfully Submitted,
GHD

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Preliminary Budget Estimate for New Composting and Anaerobic Digestion Facilities
Organics Management Business Case
Halifax Regional Municipality
Nova Scotia

New Facility Processing Capacity (1000 tonnes)	2015 Capital Expenditure Estimate per Tonne	2015 Capital Expenditure Estimate (millions)	2015 Processing Fee Estimate per Tonne SSO ²	2015 Processing Fee Estimate ² (millions)	Equivalent Annual Cost (EAC)³ (4%, 20yr)
New Composting Facility Costs					
10	\$1,200	\$12.0	\$95	\$1.0	\$184
35	\$1,150	\$40.3	\$90	\$3.2	\$175
60	\$1,000	\$60.0	\$80	\$4.8	\$154
New Anaerobic Digestion Facility Costs					
25	\$1,350	\$33.8	\$130	\$3.3	\$230
35	\$1,350	\$47.3	\$130	\$4.6	\$230
60	\$1,200	\$72.0	\$120	\$7.2	\$209
On-Farm Anaerobic Digestion Facility					
20	\$0	\$4.0	\$120	\$2.4	\$135

Notes:

1. This capital cost estimate is a Class 5 cost estimate developed as defined by recommended practices of the Association for the Advancement of Cost Engineering (AACE) and is to be used for concept screening or feasibility assessment only. The methodology used to develop this cost estimate was based on capacity factoring and judgment estimating methods and should be considered to have an accuracy range of -30 percent to +50 percent. All estimates in Canadian dollars. Effects of capital and operating costs based on potential sites have not been included in these estimates.

2. Revenue from electricity generation is factored into the processing fee estimate for the on-farm anaerobic digestion facility. Revenue from electricity generation is assumed to be negligible for other anaerobic digestion facilities.

3. Equivalent Annual Cost (EAC) = $NPV / A_{t,r}$ + annual operating cost; where NPV is Net Present Value and $A_{t,r}$ is the inverse of a loan repayment factor (PMT in Excel) for a period t (20 years) and a cost of capital r (4%).

4. The capital expenditure and processing fee estimate for the on-farm anaerobic digester accounts for revenues from electricity revenues and assumes they will be used to offset a portion of the capital expenditures. This was done in order to account for the potential benefit of the additional revenue and compare the on-farm option to the other options that do not include revenue from electricity generation as a conservative assumption. The capital expenditure estimate also accounts for a central processing facility located at a Halifax owned organics or waste processing site.

Table 5.1
Budget Comparison of Options
Organics Management Business Case
Halifax Regional Municipality
Nova Scotia

Technology /Facility	Existing Dartmouth Compost Facility ²			New Compost Facility			New Anaerobic Digestion Facility			Total for All Facilities					Equivalent Annual Cost (EAC) ⁵ (4%, 20yr)
Option ¹	Processing Capacity (thousand tonnes)	Capital Expenditure Estimate (millions)	Processing Fee Estimate ³ (millions)	Processing Capacity (thousand tonnes)	Capital Expenditure Estimate (millions)	Processing Fee Estimate (millions)	Processing Capacity (thousand tonnes)	Capital Expenditure Estimate (millions)	Processing Fee Estimate ⁴ (millions)	Processing Capacity (thousand tonnes)	Capital Expenditure Estimate (millions)	Capital Expenditure Estimate per Tonne	Processing Fee Estimate ⁴ (millions)	Processing Fee Estimate ⁴ per Tonne	
Option 1a	25	\$16.0	\$2.3	35 (option for expansion to 50)	\$40.3	\$3.2				60	\$56.2	\$937	\$5.4	\$90	\$159
Option 1b	25	\$16.0	\$2.3				35 (option for expansion to 50)	\$47.3	\$4.6	60	\$63.2	\$1,054	\$6.8	\$113	\$191
Option 2a	25	\$16.0	\$2.3	10 (option for expansion to 25)	\$12.0	\$1.0	25	\$33.8	\$3.3	60	\$61.7	\$1,029	\$6.5	\$108	\$184
Option 2b	20	\$16.0	\$2.4				40	\$6.4	\$4.8	60	\$22.4	\$373	\$7.2	\$120	\$148
Option 3a		\$0.5		60 (option for expansion to 75)	\$60.0	\$4.8				60	\$60.5	\$1,008	\$4.8	\$80	\$155
Option 3b		\$0.5					60 (option for expansion to 75)	\$72.0	\$7.2	60	\$72.5	\$1,208	\$7.2	\$120	\$209

Notes:

1. This capital cost estimate is a Class 5 cost estimate developed as defined by recommended practices of the Association for the Advancement of Cost Engineering (AACE) and is to be used for concept screening or feasibility assessment only. The methodology used to develop this cost estimate was based on capacity factoring and judgment estimating methods and should be considered to have an accuracy range of -30 percent to +50 percent. All estimates in Canadian dollars. Effects of capital and operating costs based on potential sites have not been included in these estimates.
2. Assumed partial completion of forced aeration throughout the curing area and additional outdoor curing of materials at the site, provided an amendment to permit curing outdoors can be obtained (\$0.5 – 1.0 million capital expenditure by 2019); with building repairs and equipment replacement costs of \$606,950.
3. Revenue from electricity generation is not considered other than for on-farm options.
4.

Equivalent Annual Cost (EAC) = NPV / A_{t,r} + annual operating cost; where NPV is Net Present Value and A_{t,r} is the inverse of a loan repayment factor (PMT in Excel) for a period t (20 years) and a cost of capital r (4%), in thousands.

Table 5.2

Evaluation Matrix
Organics Management Business Case
Halifax Regional Municipality
Nova Scotia

Option		Equivalent Annual Cost (EAC) (\$/tonne)	Equivalent Annual Cost (EAC) Score ¹	Facility Footprint ²	Compatibility with Feedstock ³	Planning and Approvals Risk ⁴	Process and Technical Risk ⁵	Odour and Noise ⁶	Process Water & Stormwater ⁷	End Products and Byproducts ⁸	Phasing and Transition ⁹	Overall schedule (approvals, infrastructure) ¹⁰	Future Regulations (ie. compost standards) ¹¹	Total Score	Value for Money ¹²	Rank - Total Score	Rank - Value for Money
	Weighting		20	5	15	5	5	20	5	5	5	10	5	100			
1a	Existing Dartmouth Compost Facility & New Compost Facility																
	Goodwood, or	\$159	19	0.5	3	4.5	4	14	0.5	2	3	8	1	59	25.5		
	New Site	\$159	19	0.5	3	1.5	4	14	2.5	2	5	4	1	56	23.6		
1b	Existing Dartmouth Compost Facility & New Anaerobic Digestion Facility																
	Goodwood, or	\$191	14	2.5	9	4.5	4	16	2.5	4	4	8	3	72	30.1	4	5
	New Site	\$191	14	2.5	9	1.5	4	16	3.5	4	5	4	3	67	27.5	5	
2a	Existing Dartmouth Compost Facility, New Compost Facility & New Anaerobic Digestion Facility																
	Goodwood and Dartmouth, or	\$184	15	2.5	7	3.5	4	14	0.5	3	2	8	2	62	25.3		
	Goodwood and New Site, or	\$184	15	2.5	7	2.5	4	14	2.5	3	4	4	2	61	24.7		
	New Site and	\$184	15	2.5	7	2.5	4	10	2.5	3	3	4	2	56	22.0		
	Goodwood/Dartmouth, or	\$184	15	2.5	7	1.5	4	10	3.5	3	5	2	2	56	22.0		
2b	Existing Dartmouth Compost Facility, 2 New On-Farm Anaerobic Digestion Facilities																
	New On-Farm Sites	\$148	20	2.5	9	2.0	1	10	5.0	3	4	6	4	67	31.4	5	3
3a	New Compost Facility																
	Goodwood, or	\$155	19	0.5	3	4.5	4	10	0.5	2	3	8	1	56	23.5		
	New Site	\$155	19	0.5	3	1.5	4	10	2.5	2	5	4	1	53	21.6		
3b	New Anaerobic Digestion Facility																
	Goodwood, or	\$209	12	5.0	15	4.5	4	18	2.5	4	4	8	5	82	33.5	1	1
	Dartmouth, or	\$209	12	5.0	15	4.0	4	18	2.5	4	2	8	5	79	32.3	2	2
	New Site	\$209	12	5.0	15	1.5	4	18	3.5	4	5	4	5	77	31.1	3	4

Notes

1. EAC Score calculated as: Weighting x (1 - (EAC - Lowest EAC)/Lowest EAC))

2. Smallest footprint (anaerobic digestion) assigned score of 5, largest footprint (composting) assigned score of 0.5, combination of anaerobic digestion and composting assigned score of 2.5

3. Anaerobic digestion is better suited to Halifax's wet SSO material which includes IC&I organics. Compost only options given the lowest score and options that involve a combination of anaerobic digestion and compost technologies given an intermediate score.

4. Existing sites with existing approvals scored highest, new sites (assumed to have no approvals) scored lowest. Options involving both existing and new sites score in the middle.

5. Anaerobic digestion and compost are both proven technologies in Canada, North America and globally. Anaerobic digestion of SSO in an on-farm anaerobic digestion system is less proven and more dependent on operators not experienced with food waste or wastewater treatment.

6. Odours at an anaerobic digestion facility are generally easier to mitigate and manage than at a composting facility. The on-farm option was scored low due to less stringent on-farm regulations for odour mitigation and unknown site location.

7. Anaerobic digestion and compost options assumed to have similar water issues. Existing sites have known issues. New sites assumed to be designed to address concerns better. Water from on-farm option can be directly land applied with no additional trucking.

8. Generating a quality compost has historically been challenging for existing compost facilities. Utilizing digestion is assumed to improve the treatment level of the SSO and the quality of the resulting end products, whether solid or liquid.

9. Halifax requires existing compost facilities remain operational during construciton of new facility. A new site will make this easier than phasing construction on an existing site. The larger Goodwood site offers more room for the phasing and transition than the Dartmouth site.

10. Existing sites provide significantly reduced development timelines compared with new sites. Additional time for phasing of construction on existing sites is incorporated into the scores.

11. It is known that the compost standards are currently being reviewed. Recent Ontario regulation changes have left many SSO compost facilities unable to produce certified compost.

12. Value for Money calculated as: (Total Score - EAC Score) / EAC * 100