Prepared for:
Municipality of Chatham-Kent

Waste-Based Energy Feasibility Study

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1. Introduction

The Municipality of Chatham-Kent, in consultation with representatives from the agricultural and academic sectors, has determined that the feasibility of generating alternative, “green” energy from the processing of an organics-based feedstock using anaerobic digestion (AD) technology should be investigated. There were a number of reasons for this decision. They are as follows:

• The Municipality had discussed the potential of including anaerobic digestion as a component of a livestock manure-management program with representatives from the University of Guelph’s Ridgetown College and a specific technology vendor. Municipal staff considered that it would be prudent to undertake a broad investigation of the capabilities of anaerobic digestion to provide a technically competent and economically feasible waste organics treatment option.

• The Nutrient Management Act (NMA) will set out comprehensive regulatory standards for all land-applied materials throughout the province. The agricultural importance of land-applying these nutrients is recognized, however, the purpose of the Act is to optimize the application, the crop requirements and the farm management techniques while minimizing their adverse environmental impacts. The intent of the Legislation and implementing regulations is to provide a science-based tool for standardizing the application of manure through the use of Nutrient Units (NU). The area’s pork producers will be required to comply with new provincial nutrients management protocols that are considered likely to place additional and ultimately more costly responsibilities on this sector of the agricultural industry. However, the NMA provides a means for the Ministries and industry stakeholders to develop specific standards and innovative technologies to manage nutrient containing materials. An anaerobic digestion-based manure processing system may represent an innovative, cost-effective alternative to current manure management practices.

• The Municipality, together with Chatham-Kent Energy, recognize that a market for alternative or “green” energy initiatives is emerging in the province of Ontario. Further, both the Municipality and Utility recognize the potential for generating and registering Greenhouse Gas Emission Reductions Credits associated with
the development of an alternative, renewable, fuel via the anaerobic processing of organics.

Determining whether anaerobic digestion represents a feasible component of a nutrient management system that meets standards for health protection and removes a potential “bottleneck” in the future development of the Municipality’s livestock industry represented an important objective for the subject Study. The advantages associated with the co-digestion of organics from other waste streams, including sewage sludge, septage and industrial processing materials and/or co-locating a facility so as to take advantage of other sources of carbon, without affecting the performance of the facility must also be assessed.

The Municipality has recognized a potential way in which it, together with the Utility and members of the area agricultural and industrial sectors, can address global environmental issues including greenhouse gas emissions reduction and climate change. In fact, the final report of the Select Committee of the Legislative Assembly on Alternative Fuel Sources, identifies the use of biomass as an energy source as an area of significant opportunity in Ontario. This finding is due, in part, to substantially fewer harmful emissions released through the combustion of biomass-derived fuels than through traditional power generation sources. The committee states in their Interim Report that anaerobic digestion must be classified as a source of ‘green’ or renewable energy in order to create demand. The environmental benefits must be balanced, however, with the need to ensure that local, community-based impacts, in terms of odour, noise, traffic, etc. are given primary consideration.

The viability of anaerobic digestion must be established on the basis of reasonable evidence that application of the technology can be financially sustainable within the Chatham-Kent context. This means that the revenue-generating potential of any facility should be sufficient to at least cover the capital, operating and maintenance costs required to sustain that facility. It is the recommendation of the Select Committee of the Legislative Assembly on Alternative Fuel Sources, to establish tax benefit incentive programs to producers who install and utilize biomass fuel and energy facilities. The Municipality may be willing to consider a financially marginal scenario if, in the broader sense, the technology relieves pressures
on important segments of the agricultural sector while offering an “environmentally friendly” means of processing waste organics.

The Municipality, by way of this Study, has set about to give decision makers the necessary basis upon which to proceed with a more detailed business planning process which should effectively position Chatham-Kent as a “player” in the emerging alternative energy market.

2. Work Plan

The following provides an outline of the steps that were completed by the Consulting Team in support of this Study. In short, the work plan consisted of a technology review and assessment; the financial assessment of the selected alternative anaerobic digestion technology; conclusions; and recommendations.

For the purposes of information collection and data analysis, the Municipality of Chatham-Kent was broken into ten (10) districts that generally follow former Township boundaries. Figure 2-1 illustrates how the study area has been delineated.

The work plan consisted of five (5) steps as follows:

*Step 1: Technology Assessment*

Anaerobic digestion is a process that has been widely used in municipal wastewater treatment for many years and, more recently, in other processes where organic solids are involved. Figure 2-2 provides a basic process flow illustration.

In this phase of the work program, the following technologies were assessed:

<table>
<thead>
<tr>
<th>Anaerobic Digestion Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Phase</td>
</tr>
<tr>
<td>Mesophilic</td>
</tr>
<tr>
<td>Thermophilic</td>
</tr>
<tr>
<td>Two Phase</td>
</tr>
<tr>
<td>Mesophilic/Mesophilic</td>
</tr>
<tr>
<td>Mesophilic/Thermophilic</td>
</tr>
<tr>
<td>Thermophilic/Mesophilic</td>
</tr>
</tbody>
</table>

The assessment consisted of a general description of the basic biological processes that takes place during the anaerobic digestion of waste.
Figure 2-1: Study Area Delineation

Figure 2-2: Process Illustration

- Biogas
- Electricity
- Heat
- Potential Use of Heat Energy (e.g., greenhouse)
- CO₂
- H₂S Removal
- Biogas
- Odour Control
- Anaerobic Digestion
- Animal Manure c/w pasteurize
- Residue
- Composting Process
- Solid/Liquid Separation
- Nutrient Redistribution
- Compost
- Liquid Fertilizer
Other technologies, including composting, can be used to stabilize organic wastes. The advantages associated with anaerobic digestion, such as methane conversion and alternative energy generation, however, make it particularly attractive for the management of a variety of organic waste streams.

Once the general review of the alternative technologies was completed, a qualitative assessment of the one and two phase technologies was conducted using the following criteria:

- Process flexibility;
- Operational track record;
- Environmental impacts;
- Space requirements;
- Pre- and post processing requirements;
- Energy generating potential;
- By-products; and
- Process complexity.

The result of this “Step 1” assessment was the selection of the technology type that provided a "benchmark" for the subsequent financial feasibility analysis.

**Step 2: Feedstock Availability and Siting**

Potential sources of organic waste materials, or feedstock, together with opportunity areas within which a prospective facility could be sited and potential biogas consumers were determined at this step of the work program. This information was in turn used to select an area within Chatham-Kent that has a comparatively high potential to support a prospective anaerobic digestion facility.

The specific components of Step 2 are as follows:

1. **Determine potential feedstock type(s) and distribution**
   - Pig Manure - Total quantities were calculated using American Society of Agricultural Engineers “manure production and characteristics” data along with Statistics Canada’s Agricultural Census data.
   - Sewage Sludge – Total quantities were compiled from individual waste water treatment facilities’ annual reports.
o Septage – Total quantities and storage/management locations were provided by Municipal Staff.

o Industrial Organics – Total quantities and facility locations were provided by industry and individual company representatives.

(2) **Identify potential consumers of biogas**.

(3) **Use feedstock and biogas consumer information to select the area(s) with the relatively highest apparent potential to support an anaerobic digestion facility.**

- Total quantity as well as the mix of feedstock sources were used, in part, to determine which area was selected for further analysis.

(4) **Identify and locate possible “opportunity sites” within the identified area(s).**

### Step 3: Energy Potential

Following Step 2, the alternative energy generation potential within each of the identified “opportunity areas”, defined in Step 2, was calculated. This included a more detailed analysis that further broke down the energy-generating potential into electrical and thermal components depending on the energy conversion technology assumed (i.e., gas engine, gas turbine or fuel cell).

### Step 4: Solid & Liquid By-Products Management

The management options available for the spent digestate, or by-products, generated from the anaerobic digestion of organic materials, largely dependent upon the specific characteristics of feedstock materials entering the system. For the purpose of this analysis, the potential feedstock type(s) determined to be available to a processing facility, at Step 2, were considered.

### Step 5: Financial Analysis

The success and/or failure of a proposed anaerobic digestion facility is contingent upon the following:

- a sound technological footing;
- the availability of suitable feedstock; and
- most importantly, net costs.
In this part of work program, capital and operating costs as well as revenues resulting from the sale of ‘green energy’ and other by-products including liquid fertilizer and/or compost were considered.

3. Findings

In the following section, the resultant findings from the five-step work plan are presented.

3.1 Technology Assessment

Anaerobic digestion is a process whereby a mixed culture of microbes degrades (digests) organic matter in the absence of oxygen. The resulting products include methane, carbon dioxide and a stabilized (non-putrescible) organic material. The methane biogas, which is similar to natural gas and, can be used to fuel gas-driven engines or boilers in order to produce electricity and heat in the form of hot water or steam. The organic residue, or by-products, can be used as a soil amendment in agriculture or horticulture.

Digestion takes place in a sealed tank, typically of concrete or steel, in the absence of oxygen. The temperature of the material is controlled to maintain optimum biological activity. Biogas production is maximized if the contents of the tank are mixed uniformly using mechanical or gas mixing systems.

Digesters are typically operated in two modes:

- A Mesophilic Digester operates at about 35 °C, with the material remaining in the digester for 15 days or more to achieve proper stabilization. Mesophilic processes tend to be more robust and stable than thermophilic ones (see below) but gas production is lower and larger tank volumes are required. As well, Mesophilic temperatures are not high enough to achieve high levels of pathogen reduction.

- A Thermophilic Digester operates at about 55 °C, with a residence time of 10-12 days. These systems feature higher gas production and better pathogen destruction but are somewhat less stable to operate, require more heat input and more operator attention.

The above processes have most commonly been operated as “One Phase” mixed culture systems. However, “two-phase” systems have gained some acceptance in the past 10 years. One example of a “two-phase” process is “temperature-phased anaerobic digestion” (TPAD) that consists of two tanks in series. The first tank provides approximately 5 days of detention time and is operated in the thermophilic temperature...
range. The second stage provides 10 days of detention time and operates in the mesophilic temperature range. Compared to a “one-phase” mesophilic process with an equal detention time, the TPAD process provides greater destruction of volatile solids, increased gas production and better process stability. A sludge-to-sludge heat exchanger is used between phases to maximize the thermal efficiency of the process.

At this time, “one-phase” installations predominate in waste water treatment as well as in the digestion of animal wastes and municipal organic wastes because of their relatively simple design and relatively lower capital and operating costs.

3.1.1 One Phase Thermophilic Digestion

Description

Organic material (e.g., pig manure) is delivered to the plant as a slurry in tanker trucks and stored in a receiving tank. The material is passed through a grinder to reduce the size of any particles in order to avoid plugging, jamming of equipment etc. downstream then pumped through a heat exchanger and into the thermophilic reactor (digester). This tank’s contents are held at 55°C for 15 days (lower times are possible), then may be passed through pasteurization tanks where the material is held for 1 hour at 70°C. Alternatively, pasteurization can precede digestion. The digested material is then available for further uses. The anaerobic digestion process results in the production of biogas (a mixture of about 65% methane, 34% carbon dioxide, traces of hydrogen sulphide and other gases).

The biogas can be used to fuel an internal combustion engine driving an electricity generator on-site, or can be transmitted by pipeline off-site for heating or other combustion purposes. Heat is recovered from the generator cooling water. A portion of the heat is required to maintain the digester temperature at 55°C. Excess heat is available for other uses such as building heating or third-party use, in commercial greenhouses, for example.

Process Flexibility

This anaerobic digestion process is adaptable to handle organic feedstocks from various sources. The amount of readily biodegradable organic matter determines the volume of gas generated and the mass of treated biosolids to be disposed off-site. The process is
somewhat more prone to instability due to fluctuations in input quality than mesophilic processes but one-phase thermophilic processes have successfully been applied to treat animal wastes, municipal wastewater sludges, source-separated municipal organic refuse, and combinations of these.

Operational Track Record

There are numerous installations using this technology to process animal wastes. The great majority are in Europe, some dating back to the 1980’s. Major vendors are as follows:

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Location</th>
<th>Year</th>
<th>Capacity</th>
<th>Gas Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entec (Germany)</td>
<td>Grossvoigtsberg (1993)</td>
<td>0.24 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krüger (Denmark)</td>
<td>Ribe (1990)</td>
<td>1.0 MW (11,000 m³ gas / day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECB Enviro Berlin (Germany)</td>
<td>Pastitz (1997)</td>
<td>0.99 MW (10,400 m³ gas / day)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Environmental Impacts

Odours are released during loading, storage and transfer of the feedstock and product. Although these odours are “agricultural” in character, they may be offensive to some. A well-designed plant includes containment, capture and treatment of odourous air using a biofilter or wet scrubber, both of which are capable of reducing odours to levels acceptable to the Ontario Ministry of the Environment (MOE).

External noise impacts are confined to those of delivery truck traffic. Noise generated by the engine-generator, pumps, etc., are dealt with through appropriate insulation and silencers.

Visual impacts in a rural setting resemble those of storage silos and barns.

Space Requirements

Depending on site arrangements, a typical 1 MW plant is expected to occupy approximately 1-2 ha of land. The land use is similar to light-industrial or farm buildings.

Pre- and Post- Processing

Pre-processing of the raw material consists of size reduction of material using a grinder upstream of transfer pumps.
Post-processing is not normally necessary, if the finished slurry is to be land-applied directly. If further processing is desired (e.g., composting), the material can be dewatered using, for example, a centrifuge to dry the product to about 25% dryness.

**Energy Potential**

Plants of this type typically produce between 20 and 30 m$^3$ of biogas per tonne of feedstock. Pig manure is generally at the lower end of the range. The quantity varies, however, depending on mixing efficiency, feed patterns, hydraulic retention time and, most importantly, volatile solids content of the feed material.

**By-Products**

The by-product of this digestion process is a stabilized organic material that can be used as a soil amendment or additive to inorganic fertilizer.

Because the process takes place at 55°C, pathogens are considerably reduced during digestion and the product is likely to qualify as a Class ‘A’ material as defined by United States Environmental Protection Agency (US EPA) Part 503 rule (<2000 coliform colonies/100 mL). Additional security in this regard is ensured by an optional pasteurization step in which the digested material is held at 70°C for one hour.

The digested product will contain low concentrations of macronutrients, 0.4% nitrogen (N), 0.1% phosphorus (P), and a variety of micronutrients. Heavy metals are not likely to be present in significant amounts owing to the source of the feedstock.

**Process Complexity**

This process is relatively simple and straightforward to operate and maintain, if equipment suitable for the application is used (e.g., pumps, grinders, heat exchangers and gas scrubbers). Such equipment is readily available commercially. Close control of digestion temperature is needed to optimize gas production. Since there are no recycle loops, apart from heat exchangers, process complexity is comparatively low and an operator can be readily trained.
3.1.2 One Phase Mesophilic Digestion

Description
The process operates identically to the thermophilic process, with the exception that the sludge is held in the digester at 35°C for 15 days. It may then be pasteurized at 70°C for 1 hour, or in some plants it is pre-pasteurized before mesophilic digestion.

Process Flexibility
This process exhibits similar flexibility with respect to feedstock as the thermophilic, one-phase, process and is used in similar applications. It is somewhat more stable and adaptable to fluctuations in feedstock quality than the thermophilic, digestion process.

Operational Track Record
There are numerous existing installations that process animal wastes. Most are located in Europe and many have been operating for over 10 years. Major vendors include Entec (Austria), Linde (German), Kompogas (Switzerland) and Valorga (France).

Environmental Impacts
The digested by-products may be slightly less odorous than those generated by thermophilic digestion. Odour treatment is similar to that required for thermophilic technologies.

Noise and visual impacts are similar to one-phase thermophilic digestion-based facilities.

Space Requirements
Similar to one-phase thermophilic digestion-based facilities.

Pre and Post-Processing
Similar to that required for one-phase thermophilic digestion-based facilities.

Energy Potential
Gas generation is generally in the same range or slightly lower than that achieved by one-phase thermophilic digestion.
**By-Products**

The digested slurry from mesophilic digestion is stabilized and can be used as a fertilizer, or soil amendment. However, it does have a much higher pathogen content and can be considered to be a Class ‘B’ material as defined under the US Part 503 Rule. As such, it needs to undergo additional pre- or post- pasteurization at 70°C before being acceptable for use as an inorganic fertilizer amendment or similar uses. Nutrient and metals content are likely to be similar to the thermophilic-based by-product.

**Process Complexity**

Because it is a one-phase process, the complexity of mesophilic digestion is similar to one-phase thermophilic technologies.

3.1.3 **Two-Phase Processes**

Two phase (acid/gas phases) processes include mesophilic/mesophilic, mesophilic/thermophilic, or thermophilic/mesophilic digestion. The intent is to separate the two biological activities making up the overall digestion process. These activities are carried out by two distinct groups of bacteria, one being the acid-formers, the second being the methane formers. In a one phase process, these groups co-exist in one mixed culture. Separating them in sequential tanks reduces interference between them and makes for a more efficient breakdown of organic matter and formation of methane gas. In other words, the overall hydraulic retention time for the process can be reduced. However, a greater degree of control is needed.

In the field of digestion of agricultural (animal) wastes, there are few, if any, documented installations of two-phase systems. This may be because of the additional complexity (two tanks instead of one), additional pumping and heat transfer facilities, and greater process control complexity. Similarly, there are few such facilities in the area of digestion of source-separated municipal organic refuse.

Various combinations/sequences of the two-phase systems have been built in the last 10 years or so in municipal wastewater treatment. Examples of these various combinations are included in the following Table.
Following is an outline of the relative “advantages” and “disadvantages” associated with the one and two-phase anaerobic digestion technology types.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Two Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Low capital investment</td>
<td>• Higher process stability</td>
</tr>
<tr>
<td>• Simple process control</td>
<td>• Adaptable for specific conditions</td>
</tr>
<tr>
<td>• Higher process stability</td>
<td>• More efficient</td>
</tr>
<tr>
<td>• Adaptable for specific conditions</td>
<td>• Better organics destruction</td>
</tr>
<tr>
<td>• More efficient</td>
<td>• More gas</td>
</tr>
<tr>
<td>• Better organics destruction</td>
<td>• Greater pathogen reduction through low pH during acid phase</td>
</tr>
<tr>
<td>• More gas</td>
<td>• Greater pathogen reduction through low pH during acid phase</td>
</tr>
<tr>
<td>• Greater pathogen reduction through low pH during acid phase</td>
<td>• More complex process control</td>
</tr>
<tr>
<td>• Greater pathogen reduction through low pH during acid phase</td>
<td>• More complex process control</td>
</tr>
</tbody>
</table>

Following is a summary of the relative “response” of each technology type to the evaluation criteria.

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Anaerobic Digestion Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One Phase</td>
</tr>
<tr>
<td></td>
<td>Mesophilic/Thermophilic/Mesophilic</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Good</td>
</tr>
<tr>
<td>Operational Track Record</td>
<td>Good</td>
</tr>
<tr>
<td>Environmental Impacts</td>
<td>Lowest</td>
</tr>
<tr>
<td>Space and Land Use Impacts</td>
<td>Low</td>
</tr>
<tr>
<td>Pre-processing/Post-processing</td>
<td>Greater</td>
</tr>
<tr>
<td>Energy Potential</td>
<td>Good</td>
</tr>
<tr>
<td>By Products</td>
<td>Good</td>
</tr>
<tr>
<td>Process Complexity</td>
<td>Less complex</td>
</tr>
</tbody>
</table>

Due to its comparatively better performance, the one-phase thermophilic process is selected as “representative” for the purposes of the subsequent feasibility assessments. Figure 3-2 is an illustration of the key components and sequencing of a ‘typical’ one-phase, thermophilic digestion process.
3.2 Feedstock Availability

Factors including the type, quantity and quality of waste material available as feedstock for an anaerobic digestion facility are all important considerations when determining the feasibility of using this technology for the purposes of generating alternative, “green” energy. Also, given the cost, time and resources required to haul feedstock to a facility, the location of feedstock sources is also an important consideration.

As part of this study, the characteristics and location of potential sources of feedstock including pig manure, sewage sludge, septage and industrial organics were determined.

3.2.1 Pig Manure

The availability of pig manure for use in a centralized anaerobic digestion facility is largely dependent upon the number, location and size of pig farms and, therefore, the total number of pigs within a given area.

In order to determine the total number of pork producers in Chatham-Kent, sources including Statistics Canada’s Agricultural Census (1996 and 2001) and Ontario Pork Producers Marketing Board’s (Ontario Pork) Statistics (2001), were reviewed. It was found that during the enumeration period for 2001, 181 pork producers in Chatham-Kent reported to the Agricultural Census. According to Ontario Pork’s information for the same year (Fiscal Year 2001 – December 8, 2000 – December 8, 2001), there were a total of 190 producers. It is understood that all producers may not necessarily ‘report’ to the Agricultural Census and may therefore not be represented in its producers counts. For the purpose of this study, therefore, Ontario Pork’s count of 190 producers is assumed to be correct and is used as the benchmark for subsequent data verification and analysis in this study. It is important to note that the number of producers in 2001 declined from 1996, when there were at least 236 producers in Chatham-Kent.\footnote{1 Statistics Canada, Census of Agriculture 1996.}
Figure 3-1: System Diagram

- **Organic Waste**: Received in Receiving Bin BI-1, then passed through Shredder/Conveyor.
- **Livestock & Septage Waste**: Received in TK-1 Receiving Tank.
- **10° - 20°C Mixing Tank TK-2**: Pumped to TK-3 Pasteurization Tank.
- **Pasteurization Tank TK-3**: 65° - 70°C.
- **5° - 10°C Receiving Tank TK-1**: Pumped to TK-2 Mixing Tank.
- **15-day Anaerobic Digester TK-4**: 55°C.
- **15-day Anaerobic Digester TK-5**: 55°C.
- **15-day Anaerobic Digester TK-6**: 55°C.
- **Dewatering**: TK-7 Effluent Storage Tank.
- **TK-7**: Pumped to D-1 Compost System.
- **Compost Shed**: Solid Fertilizer.
- **TK-8 Liquid Fertilizer Tank**: Liquid Fertilizer.
- **Dilution Liquid (if required)**
- **TK-8**: Pumped to TK-7.
- **TK-6**: Pumped to D-1.
- **TK-5**: Pumped to D-1.
- **TK-4**: Pumped to D-1.
- **TK-3**: Pumped to D-1.
- **TK-2**: Pumped to TK-3.
- **TK-1**: Pumped to TK-2.
- **Water Treatment Unit W-1**: Water.
- **Electricity**: Compressed Gas C-1.
- **Combined Generator**: Exhusted Steam/Hot Water.
- **Input of Industrial Organics (If available)**
The number of pigs per farm is also an important factor to consider when determining the availability of feedstock. For example, it might be advantageous to locate a potential centralized anaerobic digestion facility in the vicinity of a few medium-to-large sized farms, where sufficient manure quantities could be reliably sourced. In Chatham-Kent in the year 2001: small farms (i.e., < 500 pigs) accounted for 39%; medium sized operations (i.e., between 501 and 3000 pigs) accounted for 46%; and large farms (i.e., >3001) accounted for 15% of the producers\(^2\).

As was mentioned earlier, given the cost, time and resources required to haul feedstock, the location of feedstock sources (i.e., pig farms) is a very important consideration. Unfortunately, and due largely to concerns expressed by various stakeholder groups, information about the location of individual farms is not available for the purpose of this feasibility study. Some stakeholders were not, however, opposed to providing specific locational information as part of a more detailed business planning and facility siting exercise at a later date.

While the location of individual farms is not known, the gross distribution of farms by former township is known, as it was included as part of Statistics Canada’s 1996 Agricultural Census. Figure 3-2 presents the number and distribution of pigs in Chatham-Kent, in 1996 based on the Agricultural Census.

A similar break-down of the number of pigs by former County is not included in the latest census (i.e., 2001) and this level of information is therefore not available for the purposes of this Study.

The approach used to estimate the annual quantity of pig manure produced in Chatham-Kent, involved multiplying the number of ‘animal units’ (i.e., 1,000 kg live animal mass) by an accepted manure production rate. The American Society of Agricultural Engineers’ (ASAE) pig manure production rate (i.e., 84 kg manure per 1,000 kg live animal per day) and an average pig size of 52 kg were used to calculate annual quantity of pig manure produced.

\(^2\) Ontario Pork …
Figure 3-2: Total Number of Pigs

Statistics Canada. Census of Agriculture, 1996. (236 farms reporting; 188,352 total pigs)
Based on these calculations, approximately 810,386 kg (810 tonnes) of manure is produced from within the municipality per day. The following table includes a summary of annual manure produced in each of the former townships within Chatham-Kent.

Table 3-1: Manure Production: Total Quantity

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Pigs</th>
<th>Manure Production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1996</td>
<td>kg per day</td>
</tr>
<tr>
<td>Camden</td>
<td>31,472</td>
<td>137,470</td>
</tr>
<tr>
<td>Chatham</td>
<td>15,741</td>
<td>68,757</td>
</tr>
<tr>
<td>Dover</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Harwich</td>
<td>41,179</td>
<td>179,870</td>
</tr>
<tr>
<td>Howard</td>
<td>27,639</td>
<td>120,727</td>
</tr>
<tr>
<td>Orford</td>
<td>57,979</td>
<td>253,252</td>
</tr>
<tr>
<td>Raleigh</td>
<td>7,258</td>
<td>31,703</td>
</tr>
<tr>
<td>Romney</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tilbury East</td>
<td>1,306</td>
<td>5,705</td>
</tr>
<tr>
<td>Zone</td>
<td>2,954</td>
<td>12,903</td>
</tr>
<tr>
<td>Total</td>
<td>185,528</td>
<td>810,386</td>
</tr>
</tbody>
</table>

This total amount of manure (i.e., 810,386 kg) equates to approximately 16.2 “nutrient units” as per Ontario’s Regulations under the Nutrient Management Act. The following table provides the nutrient values, as specified by OMAFRA, used to calculate the nutrient units.

Table 3-2: Nutrient Values

<table>
<thead>
<tr>
<th>Manure</th>
<th>Nitrogen</th>
<th>Phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine Liquid</td>
<td>24 lb/1000 gal*</td>
<td>11 lb/1000 gal</td>
</tr>
</tbody>
</table>

* Imperial Gallons

It is understood that the total number of pigs and the resulting amount of manure produced in Chatham-Kent has changed from 1996 to 2001 and will continue to fluctuate over time. However, the concentration of pig production in certain areas has remained consistent over time and is expected to be maintained and perhaps increase. For the

---

4 Consultation Draft, Ontario Regulation made under the Nutrient Management Act, 2002, General, Part 1 Introduction, Definitions, “nutrient unit, means the amount of nutrients that give the fertilizer replacement value of the lower of 43 kilograms of nitrogen or 55 kilograms of phosphate as nutrient as established by reference to the Nutrient Management Protocol”.

5 OMAFRA, 10 Steps to Complete a Nutrient Management Plan for Livestock & Poultry Manure, 1996.
purposes of this feasibility study therefore, the 1996 pig data was used as the baseline for our manure production calculations.

As was stated earlier, the actual location of pig farms is not available. Although pig farms may in fact be concentrated in certain areas (i.e., along major highway corridors) it is assumed that pig production is equally distributed throughout the former townships. The following Table includes the daily rate of pig manure production, per acre in each of the former townships. These rates were calculated by dividing the total manure production quantities (Table 3-2) by the total area in each of the former.

<table>
<thead>
<tr>
<th>Name</th>
<th>Manure Production</th>
<th>Total Area</th>
<th>Production Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg per day</td>
<td>hectares</td>
<td>kg per hectare per day</td>
</tr>
<tr>
<td>Camden</td>
<td>137,470</td>
<td>17,976</td>
<td>7.65</td>
</tr>
<tr>
<td>Chatham</td>
<td>68,757</td>
<td>39,994</td>
<td>1.72</td>
</tr>
<tr>
<td>Dover</td>
<td>0</td>
<td>29,034</td>
<td>0.00</td>
</tr>
<tr>
<td>Harwich</td>
<td>179,870</td>
<td>40,045</td>
<td>4.49</td>
</tr>
<tr>
<td>Howard</td>
<td>120,727</td>
<td>25,474</td>
<td>4.74</td>
</tr>
<tr>
<td>Orford</td>
<td>253,252</td>
<td>22,520</td>
<td>11.25</td>
</tr>
<tr>
<td>Raleigh</td>
<td>31,703</td>
<td>29,425</td>
<td>1.08</td>
</tr>
<tr>
<td>Romney</td>
<td>0</td>
<td>12,022</td>
<td>0.00</td>
</tr>
<tr>
<td>Tilbury East</td>
<td>5,705</td>
<td>23,895</td>
<td>0.24</td>
</tr>
<tr>
<td>Zone</td>
<td>12,903</td>
<td>11,668</td>
<td>1.11</td>
</tr>
<tr>
<td>Total</td>
<td>810,386</td>
<td>252,053</td>
<td></td>
</tr>
</tbody>
</table>

Due to the relatively high manure availability in Orford, Howard and Harwich townships, the focus of the availability assessment is therefore concentrated in this part of the Municipality (i.e., southeastern quadrant). Camden also has a relatively high concentration of pig manure production. However the total ‘capture area’ of a facility located in Camden may be insufficient because adjacent (former) townships (i.e., Zone and Chatham) have relatively low manure production concentrations.

Figure 3-3 identifies two potential pig manure-based feedstock catchment “opportunity” areas (i.e., Area #1 Harwich and Area #2 Howard) where pig production is relatively more concentrated within the municipality. For simplicity, circular catchment areas were established each with a radius which was assumed to generally encompass an area with sufficient feedstock for a prospective processing facility. Catchment areas based on
10 km and 20 km radii were delineated for the purposes of potential feedstock availability calculations.

The manure generation densities (Table 3-3) and size of the catchment areas, in hectares, were used to calculate the amount of manure generated. The following tables present the results of these feedstock availability calculations.

### Table 3-4: Area #1 (Harwich)

<table>
<thead>
<tr>
<th>Former Township</th>
<th>10 km Radius</th>
<th>20 km Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Manure Density (kg/ha/day)</td>
</tr>
<tr>
<td>Chatham</td>
<td>39,994</td>
<td>1.72</td>
</tr>
<tr>
<td>Harwich</td>
<td>40,045</td>
<td>4.49</td>
</tr>
<tr>
<td>Howard</td>
<td>25,474</td>
<td>4.74</td>
</tr>
<tr>
<td>Raleigh</td>
<td>29,425</td>
<td>1.08</td>
</tr>
<tr>
<td>Tilbury East</td>
<td>23,895</td>
<td>0.24</td>
</tr>
<tr>
<td>Total</td>
<td>187,868</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3-5: Area #2 (Howard)

<table>
<thead>
<tr>
<th>Former Township</th>
<th>10 km Radius</th>
<th>20 km Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>Manure Density (kg/ha/day)</td>
</tr>
<tr>
<td>Camden</td>
<td>17,976</td>
<td>7.65</td>
</tr>
<tr>
<td>Chatham</td>
<td>39,994</td>
<td>1.72</td>
</tr>
<tr>
<td>Harwich</td>
<td>40,045</td>
<td>4.49</td>
</tr>
<tr>
<td>Howard</td>
<td>25,474</td>
<td>4.74</td>
</tr>
<tr>
<td>Orford</td>
<td>22,520</td>
<td>11.25</td>
</tr>
<tr>
<td>Raleigh</td>
<td>29,425</td>
<td>1.08</td>
</tr>
<tr>
<td>Zone</td>
<td>11,668</td>
<td>1.11</td>
</tr>
<tr>
<td>Total</td>
<td>187,103</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2.2 Sewage Sludge

The Study Team considered the possibility of utilizing an anaerobic digestion facility to process undigested solids from residential sewage. Chatham-Kent currently utilizes five
water pollution control plants (WPCP). The following Table outlines the location of these facilities, the waste material type and quantity of solids generated.

Table 3-6: Biosresidential Sewage Generation (Chatham-Kent 2001)

<table>
<thead>
<tr>
<th>Treatment Facility</th>
<th>Waste Material Description</th>
<th>Storage Site Location</th>
<th>Total Solids (mg/l)</th>
<th>Total Volume (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatham WPCP</td>
<td>Air dried sludge</td>
<td></td>
<td>2,697</td>
<td>2,697</td>
</tr>
<tr>
<td>Dresden WPCP</td>
<td>Aerobic digested sludge</td>
<td>WPCP - aerobic digester/storage lagoon</td>
<td>34,100</td>
<td>3,191</td>
</tr>
<tr>
<td>Thamesville WPCP</td>
<td>Aerobic digested sludge</td>
<td>WPCP - aerobic digester/storage cell</td>
<td>28,000</td>
<td>963</td>
</tr>
<tr>
<td>Wallaceburg WPCP</td>
<td>Air dried sludge</td>
<td></td>
<td>546,000</td>
<td>975</td>
</tr>
<tr>
<td>Wheatley WPCP</td>
<td>Digested biosolids</td>
<td></td>
<td>45,000</td>
<td>1,674</td>
</tr>
</tbody>
</table>

Figure 3-3: Opportunity Areas

Area #1: Harwich

Area #2: Howard
It is important to note that currently at all of the above noted facilities, sludges are
digested before being taken for land application. These digested "biosolids" from the
Dresden, Thamesville and Wheatley facilities are spread on agricultural fields. The
digested biosolids from the Chatham and Wallaceburg facilities are disposed at the
Ridge Landfill site.

The Study Team was interested in investigating the general effectiveness of processing
sewage sludges, or undigested biosolids, from area water pollution control plants
(WPCPs) as an alternative to expanding digester capacity at the identified plants.
Diversion of the raw sludge feed to a separate anaerobic digestion facility would require
the design of an oversized facility and would unnecessarily disrupt an existing service,
namely the anaerobic digestion of sewage sludge at the existing wastewater treatment
plants. Further, the transport of sewage sludge from a respective WPCP would be
costly given the location of the “opportunity areas” for facility siting within the southern
portions of the Municipality.

3.2.3 Septage

Currently, there are a number of communities that are not serviced by municipal sewage
treatment infrastructure and therefore use individual septic tanks that are pumped
periodically. The following Table includes a listing of those communities that are
unserviced and the associated estimated annual septage-generation quantities.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Households</th>
<th>Population</th>
<th>Generation Rate (225 litres /capita /year )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camden</td>
<td>806</td>
<td>2,142</td>
<td>481,950</td>
</tr>
<tr>
<td>Chatham</td>
<td>2,519</td>
<td>6,321</td>
<td>1,422,225</td>
</tr>
<tr>
<td>Dover</td>
<td>1,594</td>
<td>4,040</td>
<td>909,000</td>
</tr>
<tr>
<td>Erie Beach</td>
<td>125</td>
<td>251</td>
<td>56,475</td>
</tr>
<tr>
<td>Erieau</td>
<td>342</td>
<td>499</td>
<td>112,275</td>
</tr>
<tr>
<td>Harwich</td>
<td>2,793</td>
<td>6,594</td>
<td>1,483,650</td>
</tr>
<tr>
<td>Highgate</td>
<td>176</td>
<td>446</td>
<td>100,350</td>
</tr>
<tr>
<td>Howard</td>
<td>947</td>
<td>2,449</td>
<td>551,025</td>
</tr>
<tr>
<td>Merlin</td>
<td>267</td>
<td>267</td>
<td>60,075</td>
</tr>
<tr>
<td>Orford</td>
<td>501</td>
<td>1,359</td>
<td>305,775</td>
</tr>
<tr>
<td>Raleigh</td>
<td>1963</td>
<td>5,566</td>
<td>1,252,350</td>
</tr>
</tbody>
</table>

7Sources: Household and population data, Municipality of Chatham-Kent Planning Department; per capita septage generation rate, US EPA.
Due to the number of unserviced communities within the municipality, the amount of septage that must be managed annually is not insignificant. Currently within the Municipality, septage is managed through the practice of landspreading. The recently released Regulations under the provincial Nutrients Management Act will require that this practice be phased out and that alternative management techniques be employed. Given the quantities generated, and the characteristics of the waste material (i.e., very similar to manure from a per cent solids perspective), septage is included as a potential feedstock in the context of this study. The median septage discharge fees based on a survey of septage haulers and municipalities accepting hauled septage is $7.75 per 1000 litres, which is approximately equivalent to $7.75 per tonne.

### 3.2.4 Industrial Organics

Industrial organic materials were identified as a potential feedstock for an anaerobic digestion-based alternative energy generation facility. This potential waste stream includes organic residuals from the manufacture of food products and ethanol. It was determined that these materials would provide a good quality feedstock for the generation of alternative electricity. Further, access by this sector of the economy to a cost-competitive alternative for the management of waste materials was considered to be an effective “selling point” to respective manufacturers.

The following table includes a list of the companies contacted in order to determine the amount of potential organic feedstock generated from industrial processing facilities. Also included in the Table is information (where available) about the type of waste generated at each of the plants.

---

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Households</th>
<th>Population</th>
<th>Generation Rate (225 litres/capita/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Romney</td>
<td>823</td>
<td>2,176</td>
<td>489,600</td>
</tr>
<tr>
<td>Tilbury East</td>
<td>703</td>
<td>2,304</td>
<td>518,400</td>
</tr>
<tr>
<td>Zone</td>
<td>411</td>
<td>1,039</td>
<td>233,775</td>
</tr>
<tr>
<td>Total</td>
<td>13,970</td>
<td>35,453</td>
<td>7,976,925</td>
</tr>
</tbody>
</table>

---

8 Assumed density for septage – 1 tonne per cubic metre.
Only Family Traditions, King Milling and Omstead Foods Ltd. provided actual waste quantity information to the Consulting Team. These are approximately 29,000; 38,000; and 15,000 wet tonnes respectively. The company representatives interviewed indicated that existing waste materials handling protocol were operating satisfactorily. Companies would be ready to consider an alternative to these existing mechanisms if it proved to be cost competitive and equally effective. The Study Team concluded that this waste stream could not be considered to be available to an anaerobic digestion facility for the purposes of the subject feasibility study. There is potential, however, to engage respective companies in more detailed business-development discussions as the basis for gaining access to the Chatham-Kent based industrial organics waste stream.

### 3.3 Biogas, Steam and/or Heat Energy Consumption

The anaerobic digestion of organic waste materials results in the production of methane (biogas) as well as heat energy. In general, facilities are net energy producers (i.e., more energy is produced than can be used at a given facility). In these cases, the methane may be combusted in order to power engine/generators for the production and distribution of electricity. Alternatively, biogas, steam and/or heat energy may be piped off site to other users. Unlike electricity, for which the distribution network is already in
place in the form of the grid, the piping required to deliver biogas, steam and/or heat energy would have to be built to connect the facility to potential users.

**Figure 3-4: Location of Potential Biogas Energy Consumers**

During the course of the Study, the Consulting Team became aware of a greenhouse complex development being initiated within identified Opportunity Area #1 (Harwich). The complex is being constructed by DECLOET Building Systems south of Chatham and represents a potential consumer of process heat generated at an anaerobic digestion facility.
3.4 Facility Siting

The distances associated with transporting feedstock to a facility and hauling any fertilizer/soil amendments to users are both important factors to be considered when identifying potential locations for a facility. In the case of Chatham-Kent, although pig production takes place across the municipality, it tends to be concentrated in the south-eastern section of the municipality. The availability of septage, which is the other major feedstock source in the municipality, is also relatively significant in this area due to the proximity of unserviced municipalities.

As was mentioned in the previous section, the direct piping of excess biogas, steam and/or heat energy from an anaerobic digestion facility is a viable option within close proximity to potential consumers. As stated previously, the greenhouse complex development, under construction south of Chatham in Opportunity Area #1, represents a potential consumer of process heat and has been identified as a factor in the identification of a potential site for the facility. Figure 3-4 illustrates the location of the potential consumers for biogas and/or process heat. A majority are located within and in close proximity to the City of Chatham and in the north-western portion of the municipality. Currently, the above-mentioned greenhouse development represents the only potential consumer of process heat located within the area of highest feedstock availability (i.e., south eastern part of the Municipality). This potential consumer could also utilize the process CO₂, in addition to the process heat energy from an anaerobic digestion facility.

Selection of a specific site for an anaerobic digestion facility could prove to be a fairly involved process due to the potential for public opposition and government approvals. While the treatment process takes place in a “closed” environment, there is a definite need to give primary consideration to the local, community-based, impacts such as odour, noise, traffic, etc. As is the case when siting most waste management facilities, governmental approvals will be required at both the municipal and provincial level.

The Ministry of Environment Certificate of Approval for waste management systems requires all proposals to be carried out in accordance with the existing legislation. As a part of this process, each application is subject to the Environmental Bill of Rights (EBR) public participation process where the EBR proposal is placed on the Environmental Registry (ER) for a minimum 30-day public comment period. As part of the Ministry's
technical review, public comments will be considered. Consideration must be given to the local, community-based impacts such as odour, nuisance and noise which could potentially be the basis of public opposition.

At the municipal level, the site will require relief from compliance with existing and pending Municipal Official Plan policies and Zoning provisions. The Project Consulting Team understands that the Municipality is currently undertaking a review of its Official Plan policies. Siting will determine the necessity for amending one or both of these planning instruments. Placement on land already designated for this purpose, such as the Ridge landfill site would eliminate the need for municipal permitting.

### 3.5 Energy Potential

The terms "renewable energy" or "green power" are often used synonymously to define electric power generated from sources that have lower environmental impact than conventional energy technologies. Renewable energy technologies are generally accepted to include wind and solar power, geothermal power, small-scale hydropower and various forms of biomass. Generation of green power supplants the need for an equivalent amount of energy created from traditional fossil fuels such as coal and oil.

There is a growing recognition of the environmental benefits associated with renewable energy such as reducing overall emissions of greenhouse gasses. Surveys have identified a preference and willingness among some consumers to pay a premium, if necessary, to cover the additional incremental cost of generation of renewable energy.

Currently, the renewable energy market in Canada is fragmented and consumer access to the purchase of green power is limited to a small number of utilities that have chosen to participate in development of the emerging green power market. There are a number of reasons for this situation including the historical predominance of electricity monopolies in Canada, as well as the general perception that consumer demand for premium green power has been weak.

There is a growing interest in renewable energy with public focus on the environmental impacts electricity generation often associated with conventional methods. The Federal government has recently taken preliminary steps, in response to this, by making tax credits available to facilities that generate wind power. In some jurisdictions, there has also been an increase in the regulatory priority placed on limiting emissions from
electricity generation. In a similar manner, it is speculated that the increasing motivation to take action on key environmental issues such as climate change will contribute to the growth of both the demand and supply of green power.

Due to the concentration of potentially available feedstock (i.e., pig manure and septage) in the south eastern part of the Municipality, the detailed energy potential analysis was conducted for the two Opportunity Areas identified and described in Section 3.2 of this report.

The following Table summarizes the energy-generating potential of these two feedstock types from within Areas #1 and #2 for both the 10km and 20km radii.

**Table 3-9: Energy Potential Summary – Area #1 (Harwich)**

<table>
<thead>
<tr>
<th></th>
<th>10 km radius</th>
<th></th>
<th>20 km radius</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per day</td>
<td>per year</td>
<td>per day</td>
<td>per year</td>
</tr>
<tr>
<td>Pig manure (wet tonnes)</td>
<td>90</td>
<td>32,850</td>
<td>272</td>
<td>99,280</td>
</tr>
<tr>
<td>Septage (wet tonnes)</td>
<td>3.5</td>
<td>1,260</td>
<td>7.8</td>
<td>2,800</td>
</tr>
<tr>
<td>Biogas Production (m³)</td>
<td>1,870</td>
<td>681,600</td>
<td>5,002</td>
<td>1,824,920</td>
</tr>
<tr>
<td>Theoretical Power*</td>
<td>0.52 MW</td>
<td></td>
<td>1.56 MW</td>
<td></td>
</tr>
<tr>
<td>Electricity for Export*</td>
<td>0.17 MWe</td>
<td></td>
<td>0.50 MWe</td>
<td></td>
</tr>
<tr>
<td>Heat for Export*</td>
<td>0.24 MWt</td>
<td></td>
<td>0.62 MWt</td>
<td></td>
</tr>
<tr>
<td>Heat in MMBTU/year*</td>
<td>7,180</td>
<td></td>
<td>18,660</td>
<td></td>
</tr>
</tbody>
</table>

* megawatt (MW); megawatt electricity (MWe); megawatt thermal (MWt); million British Thermal Units (MMBTU)). The 0.5 MW of electricity available for export from a facility processing organics from within a 20 km. area would provide over 300 households with their annual energy needs.

**Table 3-10: Energy Potential Summary - Area #2 (Howard)**

<table>
<thead>
<tr>
<th></th>
<th>10 km radius</th>
<th></th>
<th>20 km radius</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per day</td>
<td>per year</td>
<td>per day</td>
<td>per year</td>
</tr>
<tr>
<td>Pig manure (wet tonnes)</td>
<td>170</td>
<td>62,050</td>
<td>606</td>
<td>221,190</td>
</tr>
<tr>
<td>Septage (wet tonnes)</td>
<td>2.4</td>
<td>864</td>
<td>8.4</td>
<td>3,066</td>
</tr>
<tr>
<td>Biogas (m³)</td>
<td>3,486</td>
<td>1,265,490</td>
<td>10,683</td>
<td>3,897,520</td>
</tr>
<tr>
<td>Theoretical Power</td>
<td>0.9 MW</td>
<td></td>
<td>2.8 MW</td>
<td></td>
</tr>
<tr>
<td>Electricity for Export</td>
<td>0.29 MWe</td>
<td></td>
<td>0.90 MWe</td>
<td></td>
</tr>
<tr>
<td>Heat for Export</td>
<td>0.43 MWt</td>
<td></td>
<td>1.34 MWt</td>
<td></td>
</tr>
<tr>
<td>Heat in MMBTU/year</td>
<td>12,920</td>
<td></td>
<td>40,190</td>
<td></td>
</tr>
</tbody>
</table>
The 0.9 MW of electricity available from a facility processing organics from within a 20 km. area would provide 600 households with their annual energy needs.

The assessed theoretical potential energy includes both the electrical power that is the MW of electricity to be produced by an electric generator and the thermal power, which is the waste heat from the combustion engine or turbine to be recovered as by-product. From these, the equipment inefficiency, process loss and all internal requirements of the plant would have to be satisfied before any surplus electricity and heat would be made available for export.

3.6 By-Product – Management

The liquid feedstock slurry introduced into an anaerobic digester, at approximately 6% solids content, contains both nutrients and organic matter. Once the digestion process is completed, a by-product comprised of “spent” material, referred to as digestate, has retained most of the same elements, providing an opportunity to recover these beneficial substances for use in soil building.

Dealing with the digested slurry, rather than the raw material, provides an opportunity to consider a wide range of alternative management options. For all options, any odour associated with raw manure slurry is substantially diminished by the anaerobic digestion process. In addition, depending on the time and temperature of the digestion process chosen, weed seeds and pathogens are effectively eliminated in the digester, markedly lowering environmental safety concerns that “raw” manure poses.

Generally, the nutrient composition of a “typical” digestate slurry is as follows:

- Kjeldahl N: 0.45%
- P: 0.16%
- K: 0.25%
- Cu: 10.4ppm
- Mo: 0.21ppm
- Zn: 43.3ppm

The spent anaerobic digestate can be separated into solid and liquid fractions or kept combined. Included in Appendix A is a summary of the advantages and disadvantages, as well as a cost benefit comparison associated with these two approaches. Depending on the chosen management approach, a variety of technical options are available.
Following are “typical” nutrient concentrations for liquid and solids phase components of a separated digestate slurry:

<table>
<thead>
<tr>
<th>Component</th>
<th>Liquid</th>
<th>Solid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kjeldahl N</td>
<td>0.45%</td>
<td>0.44%</td>
</tr>
<tr>
<td>P</td>
<td>0.01%</td>
<td>1.35%</td>
</tr>
<tr>
<td>K</td>
<td>0.25%</td>
<td>0.25%</td>
</tr>
<tr>
<td>Cu</td>
<td>7.75ppm</td>
<td>54.3ppm</td>
</tr>
<tr>
<td>Mo</td>
<td>0.10ppm</td>
<td>1.50ppm</td>
</tr>
<tr>
<td>Zn</td>
<td>40.4ppm</td>
<td>69.6ppm</td>
</tr>
</tbody>
</table>

The decision to compost will require further processing to produce a quality product, while some of the alternative uses, if feasible, may require a shorter time commitment. The following highlights of both the compost market and the wider organic inputs market provide an overview of the opportunities and challenges that may be part of particular choices.

### 3.6.1 The Canadian Market For Compost

Generally, markets are locally-based. Compost producers must know the local opportunities and understand the needs of their potential customers. Establishing a new product will depend on developing long-term clients who are able to trust your product. This can involve working with them on product testing, providing samples for their own trials and actively encouraging their feedback. The most successful compost producers in Canada have found that one needs to move beyond the environmental safety focus of the CCME Guidelines to develop a strong knowledge of your compost’s agronomic values. Resources dedicated to establishing your product can result in long-term success, though the first few years may show limited revenue.

Compost can be marketed in bagged or bulk form. Most producers are selling their product in bulk to large volume customers such as landscapers. Like many products, compost can be targeted for volume markets (high volume, lower price per unit) or dollar markets (higher prices, lower volumes sold).
Major players in each category include:

- Volume: agriculture; silviculture; transportation and natural resources agencies; sod markets; mine and oilfield reclamation; landfill cover.
- Dollar: nurseries; landscapers; topsoil blenders; retail garden centres; sports turf and golf courses; specialty markets.

According to a recent Composting Council of Canada survey, the price range for a Grade A compost in Canada ranges from $15-30/tonne at the facility site, with any shipping costs being deducted from that.

Any compost offered for sale in Canada is governed by the Canadian Food Inspection Agency’s (CFIA) quality and labelling requirements. Appendix B includes an outline of regulatory requirements in Canada.

The Canadian Market for Organic Inputs

The fertilizer industry as a whole relies on simple chemical processes to produce mineral fertilizers with no organic content. Most of these manufactures are not set up to manage materials like the by-product of an anaerobic digestion facility.

Individual manufactures seeking to capitalize on the “organic” fertilizer and amendment market may be interested in the by-products. Industry representatives have identified the lists of characteristics they would need to know about the material as including:

- comprehensive chemical analysis;
- consistency and handling/application considerations;
- behaviour of solids (e.g., temp sensitivity, settling, agitation needed);
- compatibility of material with other chemicals to be added; and
- agronomic benefits.

Chatham-Kent may find that the shipping costs of transporting a material that is 97% liquid prove prohibitive. Selling and shipping the separated solids to this industry may be possible, but the cost of separation and of managing the liquid fraction must be considered. The material would be considered an input to their process, and therefore subject to a relatively low offered price, depending on the cost of managing the material.
within their system and on the comparative market prices for the material’s components (e.g. nitrogen; organic matter).

At this time, 28% nitrogen liquid fertilizer is selling wholesale for $186/tonne, and 40% nitrogen granular fertilizer is selling for $270/tonne. These prices are market-driven.

Horticultural industries may be interested in anaerobic digestion by-products but will be keenly interested in the consistency of the material and in its agronomic performance before committing to accept large quantities of the material on an on-going basis.

If operators of a Chatham-Kent facility based on anaerobic digestion, decide to become compost producers, a variety of technical approaches are possible. An alternative would be to partner with the horticultural industry for the mutual benefit of both industries.

3.6.2 Possible Industry Partnerships

With regard to possible partnerships, a combination of strategies may prove the most effective in dealing with seasonal demands, weather considerations, storage requirements, and the needs of customers or industry partners. The following outlines a few industry sectors with whom potential partnerships may be viable.

Sod Production

Sod growers use a wide variety of inputs to supply nutrients including mineral fertilizers and biosolids. The digestate from an anaerobic digestion process may be used to add water, nutrients, and organic matter to sod crops where as compost may be used in establishing new crops or used as top-dressing.

As with other agricultural practices, sod production is seasonal (up to 4 months per year), and therefore storage capacity or a combination of alternative arrangements would be required. For example, in the “off-season”, digestate could be separated—the solids could be composted and used to establish the next sod crop, and liquid could be handled through the wastewater treatment plant where its lowered BOD will result in lower processing costs than treating the un-separated digestate. However, additional treatment capacity may have to be installed at a municipal treatment plant to accommodate this additional load from a manure treatment plant.
On the down side, sod produced strictly as a by-product of disposal procedures and sold at lower-than-industry prices, may be seen by local commercial sod producers as having an unfair competitive advantage.

**Nursery Stock Production (Containerized - Producing Trees and Shrubs)**

Similar to sod production, digestate may be used to add water, nutrients, and organic matter to established nursery stock crops. Also similar to sod production, the production of nursery stock is seasonal and therefore nutrient requirements are not constant throughout the year.

Unlike sod production, it may be more desirable if digestate were separated into solid/liquid components, as suspended solids will not work in many existing distribution systems. Once separated, the solid portion may be composted and be used in establishing new crops (as part of the growth media).

**Greenhouse Production**

In order to be used in a greenhouse environment, digestate would have to be separated into its liquid and solid components. The liquid portion could be used in watering and humidity control whereas the solids could be composted and used in growth media. It is important to note, however, that consistent, known agronomic quality would be critical for incorporation into the growth media. Similar to other potential partnerships, demand may fluctuate with the seasons.

**Agroforestry Productions (Production of Quick Growing Trees for Harvest)**

Digestate may be used to add water, nutrients, and organic matter to tree crops. Compost may be used in establishing new crops or top-dressing: Considerations include: may be able to use either separated or unseparated material. Absolute consistency of product is not as high a priority in this industry since the material is land-applied rather than containerized. This application is also subject to seasonal limitations and may involve longer transportation distances, if the grower cannot establish a crop near the digester site.
There are strong markets for high-quality composted products. However, the market for organic inputs in general, including anaerobic digestate and its separated components, is at present underdeveloped. In short, there is “space” for organic by-products in a variety of market niches.

It is critical to not underestimate the importance of marketing, as these products will not find their way to consumers on their own. In launching any new product or service, resources, time and effort need to be dedicated to establish the product in the marketplace, building consumer awareness and trust in the brand. In deciding to enter the organic product market, the Chatham-Kent team will need to count on in-house marketing expertise or partner with someone who has this experience.

Key elements to ensuring success in the compost market are:

- **Quality**: the product MUST meet the needs of the end user, and it is up to the compost producer to understand thoroughly what these needs are; and
- **Consistency**: reliability in both product quality and available supply.

### 3.7 Financial Analysis

Generally, economics of scale favour larger facilities with respect to capital costs measured on the per tonne design capacity of an anaerobic digestion plant. Results of the feedstock availability assessment has established that, for the purposes of this analysis, the processing of only pig manure and septage from farm operations and residences located within the south-eastern portions of the Municipality was possible. Further, the potential reduction in facility permitting costs as well as the opportunity to optimize energy-generating potential, by combining landfill gas with the biogas created at an anaerobic digestion facility, together with the relatively close proximity to a potential process heat consumer, revealed that a siting opportunity existed at the Ridge landfill site located within Opportunity Area #1.

Potential revenue from the use of the spent digestate “by-product” was not included in the subject financial analysis. The relative value of this potential revenue stream can only be reliably defined within the context of a more detailed business planning exercise associated with the development of a specific facility. Finally, the price that area pork producers would pay to utilize an anaerobic digestion facility, will also require a more specific understanding of the respective farming operations involved and their existing...
manure management systems. It is reasonable, however, to assume that the current septage disposal fees at wastewater treatment facilities could be applied to septage accepted at a dedicated anaerobic digestion facility generating revenue to offset treatment costs.

The subject financial analysis is, therefore, based on a potential facility located within Area #1 at the Ridge landfill site that is capable of processing up to 100,000 wet tonnes per annum, of a feedstock comprised of pig manure and septage.

The available feedstock within a 10 km radius of the site would not provide sufficient economies of scale for electrical power production based on the production capacity of the smallest commercially available reciprocating engine generating sets. For the purposes of determining net revenue for the proposed facility, it was, therefore, assumed that the facility would require a feedstock capture radius of 20km. Based on this 20 km capture area the facility could receive a throughput in excess of 100,000 tonnes per year, which corresponds to an average in the order of 300 tonnes per day or 68,700 pigs.

In terms of energy generation, this volume of throughput would provide approximately 0.50MW of electricity for sale. This generation rate is determined from the conversion of the energy content of the methane in the biogas produced from the anaerobic digestion process. A thermodynamic efficiency of 35% was used to calculate the energy output of the reciprocating engine electrical power plant. This rate is typical for the capture of the theoretical energy content of the gas using reciprocating engines (i.e., generators) to generate electrical power. Reciprocating engine or microturbine technologies are the only economically feasible and technically proven technologies at this relatively low rate of power production.

The following Table provides a listing of the capital cost items included in the financial analysis of the anaerobic digestion facility feasibility assessment.
Table 3-11: Summary of Capital and Operating Costs

<table>
<thead>
<tr>
<th>Capital Cost Items</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving/Weighing (1 scale)</td>
<td>$ 149,500</td>
</tr>
<tr>
<td>Digesters (2)</td>
<td>$ 1,058,500</td>
</tr>
<tr>
<td>Receiving Tank (1)</td>
<td>$ 241,700</td>
</tr>
<tr>
<td>Mixing Tank (1)</td>
<td>$ 241,900</td>
</tr>
<tr>
<td>Pasteurization Tank (2)</td>
<td>$ 228,600</td>
</tr>
<tr>
<td>Gas/Holder Storage (1)</td>
<td>$ 129,300</td>
</tr>
<tr>
<td>Storage Tanks (8)</td>
<td>$ 2,263,800</td>
</tr>
<tr>
<td>Pumps</td>
<td>$ 95,200</td>
</tr>
<tr>
<td>Heat Exchanger (1 system)</td>
<td>$ 311,300</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>$ 710,000</td>
</tr>
<tr>
<td>Piping Valves</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>HVAC, Fire Protection, Plumbing &amp; Drainage</td>
<td>$ 100,000</td>
</tr>
<tr>
<td>Electrical/Instrumentation</td>
<td>$ 649,300</td>
</tr>
<tr>
<td>Power production at common power plant (w/ Ridge LF)</td>
<td>$ 420,000</td>
</tr>
<tr>
<td>Engineering &amp; Start up Assistance</td>
<td>$ 820,400</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>$ 7,469,500</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual costs:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hauling (1-way)</td>
<td>$ 312,700</td>
</tr>
<tr>
<td>Operation &amp; Maintenance</td>
<td>$ 256,900</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>$ 569,600</strong></td>
</tr>
</tbody>
</table>

Note: All Costs include installation and facility housings. Specific Capital and Operating Costs for a biofilter and a post-digestion (aerobic) finishing component have not been included since need for and design of these components are subject to facility-specific investigations.

### 3.7.1 Capital Costs

Building and equipment cost calculations are based on a one phase, thermophilic anaerobic digestion facility. Capital costs include the cost of the building to house the processing plant, and the equipment required for the anaerobic digestion of the manure and septage, as well as the facilities for power generation. This includes the costs for the interface between the electrical power generation plant and the distribution network, or power grid.

Specific components of the processing facility are illustrated in Section 3.1.1 of this report and are based on the process depicted in Figure 3-1. Costs to construct and operate an aerobic composting component, to “finish” the process digestate, have not been included in this analysis. It is assumed that if a market for compost is identified and confirmed, at the next business-planning phase, these costs could be readily calculated and compared with the potential revenues from the sale of the compost to
local soil amendment operations. For the purposes of the subject financial analysis, it was assumed that a “conservative” approach for the alternative management of the available sources of organics (pig manure & septage) would be employed. This would include the anaerobic digestion of predominantly pig manure to stabilize the material and minimize pathogens so that the digestate could be land applied using current practices.

Facility component costs are based upon an industrial-type design including glass fired, steel tanks with less robustness and redundancy than that found in a typical municipal sewage treatment plant. Some design redundancy may be considered and costed accordingly at the next, more detailed, business planning step.

When calculating costs, it was assumed that the capital costs for the building are depreciated and amortized over 20 years and that the equipment cost is amortized and depreciated over 10 years, based on the projected useful life of these asset groups. Amortization was calculated using a rate of 6% as an inflation-free (i.e., “real”) rate. This corresponds to a nominal rate of approximately 8%. A real rate was used to eliminate the additional uncertainty introduced by forecasting inflation rates for nominal operating cost increased over the 20-year evaluation period.

Financial analysis periods longer than 20 to 25 years are generally considered to introduce excessive uncertainties and are not recommended even though the assets may remain serviceable for a longer period of time if they are well maintained.

3.7.2 Operations and Maintenance

Operating costs were estimated for each element of the thermophilic anaerobic digestion process described in Section 3 of this report. These costs represent typical operating costs for the type of equipment identified in wastewater treatment plant applications, and compared to actual costs at a European facility with a similar throughput and feedstock. Much of the maintenance cost for the plant will be in the form of labour, which is largely a fixed annual cost. The labour portion of the operating costs was included in the maintenance labour estimate, and reduced proportionally.

3.7.3 Manure Hauling

Pumping of manure slurry from a farm to a centralized treatment plant, instead of tanker truck transport, was evaluated. Slurries with a solids content greater than about 2% do not behave like water when being pumped, but become “Non-Newtonian” fluids that
exhibit thixotropic behaviour. Friction losses in the pipeline increase steeply as the solids concentration increases. For example, friction losses for a 6% slurry are about 8 times those of water. Pumping requires high-pressure pumps such as hydraulic piston units operating at a discharge pressure of say 60 bar or 870 psi, and heavy-duty steel pipe with special high-pressure couplings. A typical setup to pump 6% pig slurry over a distance of 3 km would cost in the order of $5 million, with significant annual power consumption. This feedstock transport method was not considered to be practical.

In assessing manure-hauling costs, actual cost information from a local pig manure management firm (Hodgins Custom Service Ltd.), was used in combination with information from various European operations assessed by the consulting team. Costs for collecting the feedstock from farms within the 20 km catchment area were estimated based on the use of dedicated tanker trucks at a rate of $100/hr, including fuel costs. The Study team assumed about 12 tanker truck loads delivered to the facility in day by commercial liquid manure tankers. This current market cost was used rather than developing a cost estimate based on acquiring rolling stock dedicated to the facility. Acquisition of dedicated vehicles and trailers for an enterprise of this scale would likely result in a lower utilization rate than a broker would likely be able to realize, potentially resulting in higher unit costs for manure and septage transport.

It is likely that restrictions on the application of municipal biosolids (i.e., separation distance from watercourse, wells, etc., and seasonal restriction) will be for the most part also applicable to the digestate from the processing facility, potentially reducing opportunities for tankers to take digestate for land application on a return trip after delivering manure or septage to the processing facility.

It is estimated that the reduction of the mass of the incoming waste stream relative related to the production of biogas from anaerobic digestion would be less than half of one tanker capacity (i.e., less than 16 tonnes) per day. The number of daily tanker trips would, therefore, likely remain unchanged as 12 vehicle trips per day to remove the unseparated process liquid/solids from the facility. A financial analysis of this process (i.e., handling costs versus revenue potential from process material utilization) was not completed. It was considered more appropriate to first confirm the most applicable utilization scenario, and to then complete the financial assessment of the scenario at the next business planning stage.

Costs and challenges associated with addressing pathogen contamination of digestate through decontamination procedures or investment in tanker trailers dedicated to digestate hauling, are such that the costs would approach those associated with one-way hauling costs. The results of the financial analysis detailed below indicate that these costs or the additional costs to accommodate decontamination of dedicated tankers
could not be covered by potential revenues from the facility and that these costs would have to be borne by the waste generators or through other revenue sources in any event.

Some of the detailed assumptions used to calculate transportation costs are listed in the table below:

**Table 3-12: Manure Hauling - Assumptions**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure capture rate (%)</td>
<td>100%</td>
</tr>
<tr>
<td>Maximum Truck Load Size (tonnes)</td>
<td>32</td>
</tr>
<tr>
<td>Working Days/yr</td>
<td>260</td>
</tr>
<tr>
<td>Truck Load/Unload Time (hr)</td>
<td>2</td>
</tr>
<tr>
<td>Available transporting time/truck (hr)</td>
<td>6</td>
</tr>
<tr>
<td>Avg. truck Travel speed (km/hr)</td>
<td>60</td>
</tr>
<tr>
<td>Distance travelled per truck per day</td>
<td>360</td>
</tr>
<tr>
<td>Travel distance to capture area radius (ratio)</td>
<td>1.5</td>
</tr>
<tr>
<td>Truck cost (broker rates $/hr)</td>
<td>$100</td>
</tr>
</tbody>
</table>

### 3.7.4 Cost Optimization

A potential location for an anaerobic digestion facility has been identified at the Ridge landfill site. This presents a potential opportunity to integrate power production facilities for the landfill to increase the economies of scale of electricity production from a combined feedstock of landfill gas and gas from the anaerobic digestion process. This prospective site also provides an opportunity to generate revenues from the sale of process heat to a nearby greenhouse development.

Based on the Environment Canada inventory of landfill sites and utilization of landfill gas, the Ridge landfill will generate significant quantities of methane given its capacity for disposal of 20 million tonnes of waste. The rate of potential landfill gas generation has been conservatively estimated to be more than 3,000,000 tonnes of methane between 2002 and 2025. This represents an energy content of approximately 15,000 gigajoules of energy. At a 35 percent thermodynamic conversion efficiency and a collection efficiency of 75 percent (typical for vertical gas extraction well systems), this would represent the potential for the generation of 4.3 million megawatt-hours of electrical power.

A joint facility for electrical power generation using both the landfill gas and the digester gas would significantly decrease the cost to produce power from the manure and septage in terms of costs per unit of power output. The cost of generating electricity
from the landfill gas is expected at the scale anticipated for the Ridge landfill site (i.e., greater than 5 MW peak production) would involve a capital expenditure of approximately $1 million per megawatt of generation capacity. The estimated capital costs for electricity generation for the anaerobic digestion plant are approximately $1.8 million for 420 kilowatts of generation capacity. Since the same technology and equipment for electricity generation from landfill gas can be used for electricity generation from the digester gas, significant savings in capital costs for electricity generation could be realized if both sources of gas are utilized at a common power production facility on the order of $3,300 per kw, or $1.4 million in capital cost. All of these costs include the capital cost of equipment and installation for the power interface between the engines and the distribution grid.

3.7.5 Revenues

Generally, anaerobic digestion plants generate the following marketable products that can generate revenue to offset facility capital and operating costs:

- The direct sale of process heat to off-site consumers such as greenhouse operations;
- Alternative energy, surplus to the plant’s demand, generated by burning process biogas;
- The “sale” of registered, greenhouse gas reduction credits;
- The direct sale of cleaned biogas as an alternative fuel;
- The sale of a finished digestate “by-product” as, for example, a blending agent for a soil conditioner; and
- A management fee for receipt and processing of feedstock from respective producers.

Process Heat Energy

As previously stated, potential revenues from the direct sale of biogas were not included in this financial analysis because of the lack of identified consumers within the vicinity of the opportunity site. Revenues from the sale of excess process heat were estimated and included in the subject financial analysis due to the location of a greenhouse complex development in close proximity to the prospective (Ridge landfill) site for the
facility. Discussion with greenhouse facility construction & operations representatives has revealed that if prospective operators could get 225,000 BTUs of heat per dollar from an alternative source to those currently being utilized by the industry, it would provide sufficient incentive to locate in proximity to the alternative heat source. Assuming this market value for process heat, an anaerobic digestion facility could generate about $83,000 in gross revenues per annum. Capital and operating costs for the boiler and piping system have not been considered at this stage. It is assumed that some cost-sharing agreement could be established with area greenhouse operator(s).

**Alternative Electrical Energy**

Revenues generated through the sale of electricity will depend upon specific market conditions. A value was selected as representative of what could be expected for the “green” energy generated at a facility through, for example, a power purchase agreement with local industrial and/or institutional consumers. This representative value was established at $0.075/kWh.

This price provides an approximate estimation of revenues that would be expected from the sale of alternative or green energy generated at the site. Projections of future pricing were not made, as these would be unreliable and extremely difficult to rationalize without a detailed economic analysis of global energy markets.

**Greenhouse Gas Emissions Reduction Credits**

Greenhouse gas emission reductions would result from processing the manure and septage and generation of electrical power from the methane in the digester gas. These would include both electricity production offsets as well as methane emission reductions.

*Electricity Production Offsets:* Production of electricity from the digester gas would offset production of greenhouse gases associated with generation of the electrical power that currently feeds into the provincial power grid. The mix of generation sources to the overall grid has a higher greenhouse gas emission rate per unit of power output than the emission rate from power production from the digester gas, since a significant portion of the power fed into the grid comes from coal-fired generation plants or other power generation processes with higher greenhouse gas emissions than would be produced from the digester gas.
This difference in unit greenhouse gas emissions is referred to as offsets. For the power produced from the digester gas to be marketed as green power, and to therefore realize a price premium relative to the price for conventional or “brown” power generated from fossil fuel sources these emission offsets cannot be converted into marketable credits for sale or trade. The financial analysis included here is based on revenues from sale of the electricity produced from the digester gas as green power. No additional revenue is available from the sale of emission offset credits, as these credits are attached to the sale of the green power.

*Methane Emission Reductions:* Greenhouse gas emissions will also be realized relative to the status quo through the reduction of the methane emissions from manure holding facilities at the pig farms and septage storage systems that would be providing feedstock to the plant. Given the length of storage of manure in on-site storage tanks, and that anaerobic processes that begin generating methane and carbon dioxide in these closed tanks, it is very likely that methane emissions from the storage facilities would be equivalent to the volume of digester gas generated through anaerobic digestion at the plant. It is anticipated that on-site storage times would be minimal if the manure could be removed to the treatment plant on a year-round basis. The need for on-site storage is currently driven by the seasonal restrictions on land application of manure (i.e., no spreading during the winter). These restrictions would not apply to the operation of the treatment plant.

It can therefore be assumed that the manure that is treated at the plant would result in the elimination of methane emissions from the storage facilities at the pig farms, and therefore the emission reduction relative to current practices would be equivalent to the quantity of methane in the digester gas generated through anaerobic digestion of the feedstock at the plant.

Based on the estimates presented in previous sections, a reduction of 822,568 cubic metres of methane per year would be realized. Because the global warming potential of methane of 21 times that of carbon, dioxide, this is equivalent to 17.3 million cubic metres of carbon dioxide emission annually. This in turn is equal to 10,600 tonnes of carbon dioxide equivalent impact per year.
A recent study of publicly disclosed trades of greenhouse gas emission reduction credits indicates an applicable range of values for these credits with a median value of $3.70 per tonne of carbon dioxide.

The greenhouse gas emission reduction credits associated with the net reduction in methane emissions could, therefore, contribute additional revenues on the order of $39,300 per year. This revenue is relatively insignificant in terms of an analysis of the economic feasibility of the anaerobic digestion facility.

**Analysis Results**

The preliminary financial analysis included the potential revenues from the sale of “green” energy; the sale of registered methane reduction credits; and the direct sale of process heat energy to area greenhouse facility operator(s). The potential revenues that may be generated from these sources on a per annum basis are as follows:

- The sale of process heat to an off-site consumer, such as a greenhouse complex = $83,000.
- The sale of “green” energy generated on-site by burning biogas generated at the facility supplemented by landfill gas assuming a market value of $0.075/kWhr = $275,940.
- The sale of registered greenhouse gas emission reductions credits = $39,300.

The capital and annual operating costs, presented in Section 3.7, have been annualized and are presented, graphically, as follows:
This includes capital costs for the plant (equipment and structure) but excluding a supplementary aerobic, digestate finishing component, the plant’s share of the combined landfill gas/digester gas power plant, operating costs and one-way haul costs. This total annual cost is $1,615,560. An annual operating deficit of about $1.2M would be experienced at the facility when potential revenues, generated from the sale of process heat, alternative electricity and GHG credits, are compared with this annualized cost. Additional revenue sources in the order of $12/tonne of material feedstock are necessary in order to make a facility economically self-sufficient. These would include:

- Potential revenues from sale of the plant digestate as marketable compost. The current national average for bulk sale of unrestricted use compost product ranges from $20-$40/tonne. This would require an additional investment in capital and operating costs for an aerobic “finishing” process stage at the facility. Capital costs for this stage are estimated to be about $2M.
An assumed nominal management fee charged to participating pork producers for the management of their manure.

While the application of a management fee on the largely manure-based feedstock would represent a cost to pork producers, it would be relatively modest when compared to alternative manure management processes to be required under the Nutrients Management Act. Further, more stringent nutrients management requirements will represent a real limit to the growth of the pig industry in Chatham-Kent. The value for a manure management fee would be established by agreement with prospective, participating pork producers.

There are also considerable intrinsic “upstream” and “downstream” economic benefits that would be realized with the development of an anaerobic digestion facility. A key “upstream” benefit, already mentioned, entails the reduction in restrictions to the growth of the area’s pig industry. Another is a marked reduction in the potential for the contamination of subsurface water supply sources from the land spreading of untreated manure and septage. Considerable “downstream” benefits would be realized including the production of organic soil amendment materials. More importantly, a facility of this type would attract potentially significant new investment in Chatham-Kent by greenhouse growers.

3.7.6 Alternative Business Development Models

There are several business development options available to the Municipality and Chatham-Kent Energy if the decision is made to proceed to the next step. Figure 3-5 illustrates some of these alternatives.
There are also a number of federal and provincial funding assistance programs which could be considered as part of a going-forward strategy. These are as follows:

- **Provincial**
  - Nutrients Management Act and Implementing Regulations
  - Select Committee of the Ontario Legislature on Alternative Fuel Sources
- **Federal**
  - Federal “Green Power” Procurement Program
  - Sustainable Development Technology Canada (SDTC)
  - Federation of Canadian Municipalities (Green Municipal Investment Fund)

### 4. Study Conclusions

- Anaerobic digestion is a process whereby a mixed culture of microbes degrades (digests) organic matter in the absence of oxygen. The digestion of organics occurs in an enclosed chamber, or reactor, where conditions critical to the
process, such as temperature, moisture content and pH levels can be monitored and controlled to maintain optimum biological activity. The resulting products include methane, carbon dioxide and a stabilized organic matter. For the purposes of the subject Study, anaerobic digestion technologies were classified on the basis of the operating temperature of the reactor and the staging or phasing of the process. These technology classifications were outlined previously in this summary. Based on the relative response of the technology classifications to the identified criteria (outlined above) it was determined that the single or one phase thermophilic digestion technology would be used as the representative “benchmark” for the purposes of the subsequent financial analysis. Generally, one-phase thermophilic digesters operate at about 55 degrees C with a residence time of 10 to 12 days. These systems feature relatively higher biogas production and good pathogen destruction. In these systems, the two stages of the digestion process (hydrolysis & acidification and fatty acid conversion to methane, referred to as methanogenesis) take place in the same reactor thereby reducing overall facility capital costs.

- Analysis of the quantity and distribution of the identified organic “feedstock” materials established that a Chatham-Kent based facility would have ready access to a sufficient volume of pig manure and septage-based feedstock if it were sited in the southeastern portion of the Municipality. Determination of the accessibility of other types of organic materials could only be undertaken as part of a more detailed, facility-specific business planning exercise. This would include access to industrial and source-separated, residential organics. The Study Team did not consider it practical to access undigested solids from residential sewage generated at existing waste water treatment plants since these materials are already being digested at the respective waste water treatment facility.

- A potential anaerobic digestion facility could be most effectively sited at the Ridge landfill site. This siting opportunity is located within one of the identified “opportunity areas” with ready access to a sufficient volume of feedstock, comprised of pig manure and septage. Siting a facility at this landfill site could reduce permitting costs and would also serve to optimize access to a supplementary source of biogas from the landfill itself.
• The preliminary financial analysis, undertaken in this Study, determined that net revenues, generated by the sale of “green” power together with excess process heat and GHG credits were not sufficient to completely off set the costs to build and operate an anaerobic facility located at the Ridge landfill site. Additional revenues would be required to establish at least a “break even” financial performance for the facility. These would include management fees from livestock and industrial organics operations, septage management fees and revenue from the sale of composted digestate to area soil amendment companies.

• Alternative business development models are available to the Municipality within which a specific facility may be established and operated. These range from the construction of a wholly public-sector owned and operated facility, using conventional engineering design and contracting protocol, through the use of design/build and construction-management-at-risk processes, to equity partnerships with private sector builders/operators. There are also an increasing number of federal and provincial funding programs focused upon assisting in the creation of sustainable development technologies.

5. Recommendations

• The Municipality, together with the Utility and Ridetown College should confirm the feasibility of developing “the first” anaerobic digestion facility in Chatham-Kent, on the basis of the following parameters:
  o the facility would be designed on the basis of current, one-phase thermophilic digestion technology and would be sited at the Ridge landfill;
  o access to additional sources of “feedstock” organics would be determined given the specific siting and design parameters established by the subject Study;
  o local pork producers would be directly engaged to discuss and determine the relative value associated with this alternative means of managing their manure as the basis for establishing a mutually-acceptable processing fee to be charged to producers by the facility operator;
  o The Municipality would discuss possible opportunities with representatives of a greenhouse complex development located in proximity to the recommended Ridge site;
- area soil amendment companies would be directly engaged to determine their interest in utilizing the spent digestate byproducts generated at the facility given more specific information pertaining to the quality of this material;
- the Municipality would determine whether and if so when it would establish a source-separated residential organics collection program in Chatham-Kent and would establish relative costs vs revenues generated by processing this type of feedstock at an anaerobic digestion facility;
- the Municipality, together the Utility and Ridgetown College would more fully investigate the business development models, summarized as part of the subject Study to decide the most effective means by which a facility could be designed and operated;
- the Municipality would, at the appropriate time, enter into preliminary discussions with the owners of the Ridge landfill to confirm whether it is possible to site the facility at this location; and
- a detailed business plan would be developed as the basis for the construction and operation of an anaerobic digestion facility in Chatham-Kent.

The subject Study has established a basis upon which the Municipality, in cooperation with Chatham Hydro and Ridgetown College can undertake the more detailed analyses necessary to complete the business planning for “the first” anaerobic digestion facility in Chatham-Kent.
APPENDIX A

BY-PRODUCT MANAGEMENT
### Managing Un-separated Digestate

<table>
<thead>
<tr>
<th>Option</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spread “as is”</strong></td>
<td>No new capital investment required to manage digestate—producers already possess both the equipment and experience to handle this type of material. Plant nutrients and organic matter remaining after the digestion process are returned to cropland. Water used in barn flushing is incorporated into crop management system.</td>
<td>Polymers added during the digestion process may have plant or soil structure effects when applied repeatedly over years to the same land. No possibility of revenue generation through sale of end-products.</td>
</tr>
<tr>
<td></td>
<td>This option requires the least amount of change from the current system. Producers who introduce their manure slurry into the anaerobic digestion process can reacquire the digestate at the end of the process and handle it as they would raw slurry.</td>
<td></td>
</tr>
<tr>
<td><strong>Compost “as is”</strong></td>
<td>Production of an excellent soil amendment which provides slow-release of plant nutrients and organic matter Material has easy to handle and spread May not be subject to the same seasonal spreading restrictions as raw manure Possibility of co-operative agreements with municipalities or industries producing high-carbon by-products—required amendment may be acquired free of charge or may even generate a tipping fee. Possibility of revenue generation through off-farm sale of finished product.</td>
<td>Capital investment required for turner and in-vessel system</td>
</tr>
<tr>
<td></td>
<td>Liquid manure from pig barns is being composted at Ridgetown College, in co-operation with Global Earth Products. The manure is sprayed onto a high-carbon material (e.g., straw, dry leaves, wood fibre or paper waste), and the mixture is composted using an in-vessel system.</td>
<td></td>
</tr>
<tr>
<td><strong>Process as wastewater</strong></td>
<td>No capital investment required Material is being reused in an environmentally positive way.</td>
<td>Operating cost of sludge management, payable to the Chatham wastewater facility. Cost of hauling or pumping sludge to Chatham facility. Water used for barn flushing is now “lost” to the producer with no advantage of reuse or crop benefit</td>
</tr>
<tr>
<td></td>
<td>The wastewater facility at Chatham, which is presently being expanded, has both the capacity and the capability to handle a 3% organic solids sludge. The cost for this service would be based on the biological oxygen demand (BOD) of the material and the cost associated with drying and processing the sludge. The facility currently dries and composites their biosolid sludge and uses the resulting material as landfill daily cover. The anaerobically digested sludge would be added to this existing process.</td>
<td></td>
</tr>
</tbody>
</table>
Managing Digestate Separated into Liquid and Solid Fractions

Specific separation technologies are not reviewed or referred to at this time unless the success of an application depends on a particular technology. Liquid and solid management options are listed separately, again starting with alternatives requiring least management or capital input.

<table>
<thead>
<tr>
<th>Option</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LIQUID MANAGEMENT OPTIONS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread “as is”</td>
<td>The separated liquid contains the majority of the water-soluble nutrients, including plant-available nitrogen.</td>
<td>Soluble nutrients and water are incorporated into crop management system. No new capital investment required to manage liquid fraction—producers already possess both the equipment and experience to handle this type of material. Low solids content and neutralized odour make an increased number of spreading options feasible, including irrigation. Cost of separation process must be balanced by advantages gained in separately managing the solid fraction.</td>
</tr>
<tr>
<td>Recycle to Barn for flushing, washing, and possibly drinking</td>
<td>Lowers barn’s total water consumption</td>
<td>May require advanced technology, depending on the level of reuse required; reverse osmosis or an equivalent technology would be required if the liquid must be fit for stock to drink. If a more basic separation process is used, solute content in the liquid will build up with repeated reuse, requiring management planning. Options might include treatment as waste water through a municipal system.</td>
</tr>
<tr>
<td>Process as wastewater</td>
<td>The wastewater facility at Chatham, which is presently being expanded, has both the capacity and the capability to handle a 1.6% organic solids sludge. The cost for this service would be based on the biological oxygen demand (BOD) of the material and the cost associated with drying and processing the sludge. The facility currently dries and composts their biosolid sludge and uses the resulting material as landfill daily cover. The anaerobically digested sludge would be added to this existing process.</td>
<td>No capital investment required Material is being reused in an environmentally positive way. Liquid will have a much lower BOD and lower solids content, and so will incur reduced processing costs from the Chatham facility. Solid fraction now available for further processing/benefit to digester operators and their co-operating producers.</td>
</tr>
<tr>
<td>Option</td>
<td>Advantages</td>
<td>Disadvantages</td>
</tr>
<tr>
<td>--------</td>
<td>------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Cleanse through <strong>engineered wetlands</strong>&lt;br&gt;Engineered, managed wetlands are proving very capable of purifying water containing organic contaminants, such as the water released from biosolids processing facilities.</td>
<td>A “natural” system capable of returning water to the environment without requiring further chemical processing. Holds potential as a purification alternative to reverse osmosis for cleansing water destined for reuse in the barn. Depending on design, project may be combined with local remediation efforts towards the re-establishment of natural habitats, providing a multi-use area for wildlife and limited recreational use.</td>
<td>Requires sufficient and appropriate land base.</td>
</tr>
<tr>
<td><strong>SEPARATED SOLIDS MANAGEMENT OPTIONS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send to an existing compost operation&lt;br&gt;The solids could be incorporated into the current management system at an established compost facility without requiring significant process changes on their site. The acceptability of the material may depend on its chemical analysis, particularly if the site is producing compost for use by organic growers (e.g. Kerr Farms in Chatham-Kent).</td>
<td>No capital outlay or management resources required. Nutrients are being effectively captured and processed for reintroduction into soils.</td>
<td>Operating costs include transportation of solids and possible tipping fee.</td>
</tr>
<tr>
<td>Spread “as-is”&lt;br&gt;Organic matter and remaining nutrients are returned to crop fields.</td>
<td></td>
<td>Material’s fine-grained texture may make it difficult to handle.</td>
</tr>
<tr>
<td><strong>Vermicompost</strong>&lt;br&gt;Separated pig manure solids are being successfully composted using red wriggler worms in a variety of different physical set-ups.</td>
<td>The highest potential revenue option: finished vermicompost is highly valued in all major segments of commercial horticulture and has high acceptance value in the residential sector. Operation itself can offer a high level of public acceptability as a very “green”, low-tech approach. Relatively small capital investment compared to aerobic composting systems that rely on a high level of mechanization.</td>
<td>Requires active, knowledgeable management.</td>
</tr>
<tr>
<td>Compost “as-is”&lt;br&gt;Separated pig manure solids have been successfully composted using in-vessel technology; a windrow system might also be an option. A source of appropriate bulking agent would have to be located. This would likely need to be a fairly dry, high-carbon material.</td>
<td>Production of an excellent soil amendment which provides slow-release of plant nutrients and organic matter. Material has easy to handle and spread. May not be subject to the same seasonal spreading restrictions as raw manure. Possibility of co-operative agreements with municipalities or industries producing high-carbon by-products—required amendment may be acquired free of charge or may even generate a tipping fee. Possibility of revenue generation through off-farm sale of finished product.</td>
<td>Capital investment required for turner and in-vessel system.</td>
</tr>
</tbody>
</table>
# Spent Digestate- Management Options, Cost/Benefit Comparison

<table>
<thead>
<tr>
<th>Cost/Benefit Comparison</th>
<th>Capital Costs</th>
<th>Operating Costs</th>
<th>Specialized expertise required</th>
<th>Mechanization</th>
<th>Established Technology</th>
<th>Marketability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Un-separated digestate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1. Spread &quot;as-is&quot;</td>
<td>Low</td>
<td>Low</td>
<td>None</td>
<td>Med</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td>A2. Compost &quot;as-is&quot;</td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
<td>Yes</td>
<td>Med</td>
</tr>
<tr>
<td>A3. Process as wastewater</td>
<td>Low</td>
<td>Med</td>
<td>None</td>
<td>Low</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td><strong>Separated liquids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1. Spread &quot;as-is&quot;</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
<td>Med</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td>B2. Recycle to Barn</td>
<td>Med-high</td>
<td>Med</td>
<td>Med-high</td>
<td>Med-high</td>
<td>In process</td>
<td>N/a</td>
</tr>
<tr>
<td>B3. Process as wastewater</td>
<td>Low</td>
<td>Med</td>
<td>None</td>
<td>Low</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td>B4. Engineered wetlands</td>
<td>Med-high</td>
<td>Med</td>
<td>High</td>
<td>Low to med</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td><strong>Separated solids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B5. Send to outside Composter</td>
<td>None</td>
<td>Med</td>
<td>None</td>
<td>None</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td>B6. Spread &quot;as-is&quot;</td>
<td>Low</td>
<td>Low</td>
<td>None</td>
<td>Med</td>
<td>Yes</td>
<td>N/a</td>
</tr>
<tr>
<td>B7. Vermicompost</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
<td>Low to med</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>B8. Compost &quot;as-is&quot;</td>
<td>High</td>
<td>Med</td>
<td>Med</td>
<td>Low to high</td>
<td>Yes</td>
<td>med</td>
</tr>
</tbody>
</table>
APPENDIX B

COMPOST REGULATORY REQUIREMENTS
Setting the Standard: A Summary of Compost Standards in Canada

The establishment of product quality standards supports the long-term growth of an industry. The Canadian composting industry and government have developed compost quality criteria which will ensure product satisfaction and maintain consumer confidence. This is fundamental to the continued expansion and strengthening of the composting industry in Canada.

In Canada, three organizations are responsible for the development of standards and regulations for compost and composting: Agriculture and Agri-Food Canada (AAFC), the provincial and territorial governments, and the Standards Council of Canada (SCC) (through the Bureau de normalisation du Québec (BNQ)). This collective responsibility reflects government regulatory requirements (of both the AAFC and the provinces and territories) as well as voluntary industry initiatives.

The scope of their responsibilities is as follows:

Agriculture and Agri-Food Canada (AAFC) regulates compost under the authority of the Fertilizers Act and Regulations. All compost that is sold in Canada must comply with the requirements of the Fertilizers Act. This includes provisions for product safety, benefit claims and labelling.

- the provinces and territories regulate the disposal and use of waste, including its production and use. Consequently, compost which is produced and used is regulated within this jurisdiction. The Canadian Council of Ministers of the Environment (CCME) assists to coordinate provincial and territorial initiatives wherever possible.

- the BNQ, acting on behalf of the Standards Council of Canada, establishes voluntary industry standards and endorses products which meet these standards.

The development of compost standards was coordinated by the three organizations to establish and maintain high standards for product quality and safety while maximizing uniformity thereby facilitating industry competitiveness. This innovative approach has resulted in the establishment of the following:

- a National Standard of Canada entitled: Organic Soil Conditioners - Composts (BNQ);
• Guidelines for Compost Quality (CCME); and
• future amendments to the Fertilizers Act and Regulations (AAFC).

These provide for a significant level of national consistency by containing virtually identical technical requirements while ensuring that the mandates and interests of the different organizations are realized.

The standards are based on four criteria for product safety and quality: maturity, foreign matter, trace elements and pathogens.

The purpose of this document is to provide a summary of the details of the 3 standards, identifying their similarities and areas of difference.

**Definition of Compost**

“Composting” and “compost” are two distinct terms. The former refers to the bio-oxidation process and the latter refers to the resulting product: stabilized organic matter.

As agreed upon by the CCME, BNQ and AAFC, compost is:

“A solid mature product resulting from composting, which is a managed process of bio-oxidation of a solid heterogeneous organic substrate including a thermophilic phase.”

**Classification of Compost**

The criteria for product safety is consistent across all the standards. The differences in compost types or categories reflect variances in product quality.

<table>
<thead>
<tr>
<th>Classification of Compost</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNQ</td>
<td>AA,A,B</td>
</tr>
<tr>
<td>CCME (provinces &amp; territories)</td>
<td>A,B</td>
</tr>
<tr>
<td>AAFC</td>
<td>one category based on trace element limits of B</td>
</tr>
</tbody>
</table>

**BNQ Standard**

Under the BNQ Standard, compost may be classified in three ways: Types AA, A and B.
The requirements for Type B compost are considered to be the minimum necessary to obtain a good compost. Compost classified as Types AA and A is of higher quality.

Foreign matter content is the distinguishing factor between the three types. Trace element content is the classification feature which differs Types AA, A compost from Type B compost.

**CCME Guideline**

Within the CCME Guideline, two compost categories have been established: Category A and B. This reflects differences in trace element concentrations. Category A compost can be used for all types of applications: on agricultural lands, in residential gardens, in horticultural operations, in nurseries or other enterprises. Category A criteria for trace elements are achievable using source separated municipal solid waste feedstock.

Category B compost has restricted use. Its use may be controlled under provincial or territorial regulations.

**AAFC Regulation**

The AAFC recognizes only one class of compost, reflective of product safety criteria. It is based on the limits of Category and Type B compost for trace elements and reflects the requirements of the standards on pathogenic organisms, maturity and the presence of sharp objects.

The Four Criteria: Maturity, Foreign Matter, Trace Elements and Pathogens

**I. Maturity**

Compost maturity is fundamental to the classification of the product. Several indicators are necessary to determine compost maturity. The BNQ/CCME/AAFC standards use the same compost maturity indicator tests. The CCME guidelines also have identified additional criteria which may be used instead, and which reflect criteria already in existence in certain provinces.

The compost maturity indicator tests which are recognized by all three organizations (BNQ, CCME, AAFC) are as follows:
Compost is deemed mature if it meets 2 of the following requirements:

- C/N ratio \( \leq 25 \);
- oxygen uptake rate \( \leq 150 \text{ mg O}_2/\text{kg volatile solids per hour} \); and
- germination of cress (Lepidium sativum) seeds and of radish (Raphanus sativus) seeds in compost must be greater than 90 percent of the germination rate of the control sample, and the growth rate of plants grown in a mixture of compost and soil must not differ more than 50 percent in comparison with the control sample.

The CCME guideline also identifies the following criteria which may be used instead of the above to confirm compost maturity:

- Compost must be cured for at least 21 days; and
- Compost will not reheat upon standing to greater than 20°C above ambient temperature.

OR

- Compost must be cured for at least 21 days; and
- Reduction of organic matter must be > 60 percent by weight.

OR

- If no other determination of maturity is made, the compost must be cured for a six month period. The state of the curing pile must be conducive to aerobic biological activity. The curing stage begins when the pathogenic reduction process is complete and the compost no longer reheats to thermophilic temperatures.

II. Foreign Matter

Foreign matter is defined as:

“Any matter over a 2 mm dimension that results from human intervention and having organic or inorganic constituents such as metal, glass and synthetic polymers (e.g. plastic and rubber) that may be present in the compost but excluding mineral soils, woody material and rocks.”
Safety and aesthetics constitute the key considerations in the development of foreign matter content standards in compost.

The safety criteria, relating to sharp foreign matter content, are similar across the BNQ, CCME and AAFC standards.

The BNQ standards establish three different foreign matter mass content limits for Types AA, A and B compost, reflective of product aesthetics. The CCME guidelines also identify a limit for foreign matter content which is the same as the maximum dimension allowed by BNQ (25 mm) (table b).

**Foreign Matter -- Safety Criteria**

Compost must not contain any sharp foreign matter measuring over a 3 mm dimension that may cause damage or injury to humans, animals and plants during or resulting from its intended use.

Compost must not contain any sharp foreign matter measuring over a 3 mm dimension that may cause damage or injury to humans, animals and plants during or resulting from its intended use.

**Foreign Matter -- Aesthetics**

**BNQ Standard**

<table>
<thead>
<tr>
<th></th>
<th>Type AA</th>
<th>Type A</th>
<th>Type B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign matter content as percentage of oven-dried mass</td>
<td>&lt;= 0.01</td>
<td>&lt;= 0.5</td>
<td>&lt;= 1.5</td>
</tr>
<tr>
<td>Foreign matter, maximum dimensions, in mm</td>
<td>12.5</td>
<td>12.5</td>
<td>25</td>
</tr>
</tbody>
</table>

**CCME Guideline**

The compost must not contain any foreign matter greater than 25 mm in any dimension.

**III. Trace Elements**

A “trace element” is defined as “a chemical element present in compost at a very low concentration.” The compost standards identify trace elements that are essential to plant growth in addition to identifying heavy metals which, depending
on their concentration in the soil, could be harmful to human health and the
environment.

The similarities across the BNQ, CCME and AAFC criteria for trace elements are
significant.

The BNQ Types AA and A are identical to the CCME Category A. The B
classification is similar across all 3 standards with the exception that maximum
permissible concentrations for chromium and copper are not identified by AAFC
and CCME, having yet to be established by AAFC under the Fertilizers Act.

The maximum cumulative additions to the soil are the same across the standards
although its not specifically referenced in the BNQ standards. This reflects the
fact that the BNQ standards deal with product-specifics only.

It is recognized that additional elements may be added to the list according to the
availability of new scientific data.

Table 2: Maximum Trace Element Concentration Limits for Compost

<table>
<thead>
<tr>
<th>Trace Elements*</th>
<th>BNQ CCME Types AA and A Category A</th>
<th>BNQ CCME, AAFC Type B** Category B² Maximum Acceptable Concentrations within Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>13</td>
<td>75</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>34</td>
<td>150</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>210</td>
<td>1,060 (BNQ only); not stated in CCME/AAFC</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>100</td>
<td>757 (BNQ only); not stated in CCME/AAFC</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.8</td>
<td>5</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>62</td>
<td>180</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>150</td>
<td>500</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>500</td>
<td>1,850</td>
</tr>
</tbody>
</table>
*Other elements, such as boron, manganese, aluminium and iron, may eventually be regulated in certain provinces to accommodate regional and national concerns.

**Type B limits for maximum trace element concentrations in compost are based on the standards enforced by AAFC under Trade Memorandum T-4-93 since 1979.

<table>
<thead>
<tr>
<th>Trace Elements* (kg/ha)</th>
<th>CCME AAFC Trace Elements* (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>15</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>4</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>**</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>**</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>1</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>4</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>36</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>100</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>2.8</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>370</td>
</tr>
</tbody>
</table>

*Other elements, such as boron, manganese, aluminium and iron, may eventually be regulated in certain provinces to accommodate regional and national concerns.

**Limits for copper and chromium are not established in the Fertilizers Act. Agriculture and Agri-Food Canada will be conducting a consultation process for adopting limits for chromium and copper. The CCME will re-evaluate these parameters when this process is complete.
IV. Pathogens

Pathogenic organisms are sometimes present in the feedstocks used to make compost. As a result, the compost may also contain pathogens. To reduce any potential health concerns, treatment processes as well as biological specifications have been identified.

All 3 standards (BNQ, CCME, AAFC) identify that the pathogenic organism content must not exceed the following limits:

- the quantity of faecal coliforms must be < 1,000 Most Probable Number (MPN)/g of total solids calculated on a dry weight basis; and
- there can be no salmonellae present (< 3 MPN/4g total solids).

Reflective of its ability to regulate and monitor process, the CCME has also identified additional process guidelines to be followed to meet pathogen limits. The process choice reflects both the feedstock in addition to the composting method being used.

Within the CCME guideline, if the compost does not originate from feedstock known to be high in human pathogens, either a test may be conducted to meet the limits identified above (similar to BNQ and AAFC) or the following process may be done:

Using the in-vessel composting method, the solid waste shall be maintained at operating conditions of 55°C or greater for three days.

Using the windrow composting method, the solid waste shall attain a temperature of 55°C or greater for at least 15 days during the composting period. Also, during the high temperature period, the windrow shall be turned at least five times.

Using the aerated static pile composting method, the solid waste will be maintained at operating conditions of 55°C or greater for three days. The preferable practice is to cover the pile with an insulating layer of material, such as cured compost or wood chips, to ensure that all areas of the feed material are exposed to the required temperature.

If the compost contains feedstock known to be high in human pathogens, it must not exceed the identified limits for faecal coliforms or be absent of salmonellae as
well as undergo the composting process identified above or other treatment as identified by the relevant province or territory.

The above summary has been designed to provide an overview of the three standards. Prior to embarking on a specific course of action, members of the composting industry should refer to the documentation produced by each of the three organizations (BNQ, CCME, AAFC).

BNQ: CAN/BNQ 0413-200-M95
Amendement organiques - Compost (Organic Soil Conditioners - Compost)
Contact: Bureau de normalisation du Québec
333, rue Franquet
Sainte-Foy, Québec G1P 4C7
Ph: (418) 652 2238
Fax: (418) 652 2292

CCME: Guidelines for Compost Quality
CCME-106E
Contact: CCME Documents
c/o Manitoba Statutory Publications
200 Vaughn Street
Winnipeg, Manitoba R3C 1T5
Ph: (204) 945 4664
Fax: (204) 945 7172

AAFC: A consultation process is underway at AAFC to amend the Fertilizers Regulations to reflect the identified compost standards. For further information, please contact:

Fertilizer Section, Plant Products Division
Agriculture and Agri-Food Canada
59 Camelot Drive, 3rd Floor, East
Ottawa, Ontario K1A 0Y9
Ph: (613) 952 8000
Fax: (613) 992 5219