Durham/York
Residual Waste Study

Background Document 2-2
Consideration of "Alternatives To" the Undertaking

Development of Environmental Assessment Terms of Reference (EA Terms of Reference)

December 16, 2005

Residual Waste Disposal Planning Study

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Development of Environmental Assessment Terms of Reference

TASK 2

BACKGROUND DOCUMENTATION

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1. Introduction

This introduction provides an overview of waste management within the two Regions, the Environmental Assessment Act (EAA), the Background Documents supporting the Environmental Assessment (EA) Terms of Reference and the purpose of this particular Background Document.

1.1 Background

Durham and York Regions (the Regions) have agreed to undertake a joint Residual Waste Planning Study. Both municipalities are in need of a solution to manage the remaining solid waste after diversion (residual or post-diversion waste). The Regions are working to address the social, economic, and environmental concerns of residents through an Environmental Assessment (EA) Study process to examine potential waste management alternatives.

The Region of Durham (Durham) has programs in place for the source separation and diversion of both “Blue Box” recyclables and household organics. The Blue Box program is being expanded over the next few years to collect a wider range of materials and the source separated organics collection/composting program is being expanded to service all of Durham. In its December 1999 Solid Waste Master Plan, Durham adopted a diversion target for residential waste of at least 50% by 2007 or earlier. On April 14, 2004, Durham Regional Council adopted the position to increase waste diversion beyond 50%. In light of the province’s recently-announced policy initiative of “60% diversion by 2008” Durham will likely refine its diversion target to align with that established by the province.

York Region (York) has programs in place for the source separation and diversion of “Blue Box” recyclables and household organics. In July 2005, York opened a single-stream Blue Box materials recycling facility located in East Gwillimbury. This facility enables residents to put all recyclables into one blue box, eliminating the need for separating containers and fibres. The facility also allows residents to recycle approximately 25 items, including #1 to #7 rigid plastics containers, empty paint cans, and milk cartons. Household collection of food waste began, as a pilot project, in September of 2004 and is currently provided to approximately 67,000 households. Full implementation of household organics programs is expected to be completed by 2008.

Even with the expanded source separated diversion efforts, Durham and York continue to face the challenges of managing residual waste. Both Regions face a shortage of available landfill capacity over the long term. In response to the closing of existing landfill sites in the Greater Toronto Area (GTA) and the inability to develop new landfill capacity, Durham and York, along with other GTA municipalities, chose to enter into contracts for the “export disposal” of their residential waste primarily in Michigan. In response to this situation, the Regions want to implement, as quickly as possible, a Durham/York based solution that is socially and politically acceptable to both communities, that maximizes environmental protection and that fosters the wise management of potential resources) which are currently lost by way of landfill in Michigan.

During the later half of 2005, the United States government initiated the process of passing legislation that, if successful, would prevent or severely inhibit Durham and York's current disposal arrangements with sites in the State of Michigan. There is a reasonable likelihood that this legislation will be passed and in effect during 2006.

Durham and York, recognize that Ontario does not have sufficient energy to meet its growing needs. Both Regions recognize that there is significant opportunity associated with the utilization of the waste stream as a source of energy and have identified this opportunity as a key part of the subject EA Study.

1.2 Environmental Assessment Act (EAA)

Since the adoption of the EAA in the 1970s, the EA process has evolved into the completion of a study or decision-making process, in consultation with the public and interested parties, that evaluates alternatives considering potential effects on the environment, the availability of mitigative measures that address, in whole or in part, these effects and the comparison of the advantages and disadvantages of the remaining or "net" effects. The result of this process is to provide the planning rationale and support for a preferred solution.

The EA Study provides a planning approach where environmental constraints or opportunities are considered in the context of the broadly defined environment (i.e. the natural environment as well as the social, economic and heritage "environments") and potential effects are understood and addressed before development occurs.

All public sector (i.e. provincial or municipal) undertakings that have the potential for significant effects in terms of their scope are generally subject to the EAA and must apply for approval from Ontario's Minister of the Environment. With respect to waste management, certain types of waste management undertakings require compliance with the EAA. In general, approval under the EAA is required for the establishment or the expansion of a waste disposal facility, such as a landfill or energy from waste facility as well as some waste processing and transfer facilities.

Under the EAA, an EA Terms of Reference must be prepared and submitted to the Minister of the Environment for approval before an EA Study can be undertaken.

1.3 Overview of Task 2 – Background Documentation

A series of documents are being prepared to provide the necessary background and rationale in support of the EA Terms of Reference. These documents describe:

- underlying assumptions and commitments on the part of the Regions with respect to completing the EA Study in accordance with the approved EA Terms of Reference;
- public and agency consultation undertaken by the Regions in developing the EA Terms of Reference; and
- the manner in which that consultation influenced the document submitted to the Minister of the Environment for approval.

These documents have been provided to support the development of the EA Terms of Reference, but do not form part of the Terms that will be submitted for approval by the Minister of the Environment. The subject background documents contain information that may be referenced to obtain a better understanding of how the Regions established the steps, methods and criteria included in the EA Terms of Reference. Following is a list of the background documents prepared for the Durham/York Residual Waste Study:

- 2-1 – *Purpose and Need for Undertaking;*
- 2-2 – *Consideration of "Alternatives To" the Undertaking;*
- 2-3 – *Consideration of "Alternative Methods" of Implementing the Undertaking;*
- 2-4 – *Description of the Environment Potentially Affected; and*
- 2-5 – *Identification of Approvals Required for the Undertaking and Applicable Policy, Guidelines and Practices of the Approvals Authority.*

1.4 Purpose of this Background Document

The purpose of this Background Document is to describe the alternative disposal approaches and technologies being considered for managing the residual municipal solid waste (RMSW) from Durham and York.

The EAA requires for any study being completed that "Alternatives To" the undertaking be considered as part of the study. The EEA itself does not provide a definition of what constitutes an "Alternative To". However, practice and application of the EAA have defined these types of alternatives as fundamentally different ways or approaches to achieving the purpose of an undertaking. Furthermore, practice and application of the EAA have defined the range of "Alternatives To" to be considered during an EA Study as a reasonable range of those available to address the purpose of the undertaking.

Accordingly, an example of a reasonable range of "Alternatives To" address an undertaking intended to manage a municipal waste stream could include: waste reduction, reuse, recycling, composting, landfill and alternative disposal facilities.

This report defines and assesses each of the "Alternatives To" being considered in this study. Each alternative is considered in the following context:

- Process description;
- Diversion from Landfill;
- Environmental Impact;
- Commercial Status; and
- Cost Factors.

Once described, this document then considers the potential range of "Alternatives To" in terms of what is reasonably available for addressing the purpose of the undertaking and consideration in the Durham/York Residual Waste Study. The screening process, in this regard, is described and a recommended set of alternatives is identified at the end of the document.

2. Overview of Potential Alternative Disposal Approaches and Technologies

Numerous municipalities throughout Southern Ontario have recognized the need for a long-term disposal alternative. Limited locally available landfill capacity and the uncertainty and lack of sustainability associated with depending on American landfill sites have resulted in a significant level of study and analysis of alternative disposal technologies. The Durham/York Residual Waste Study is being undertaken to establish a long-term disposal plan for the waste remaining after increased source separated waste diversion.

As part of this initiative, a long-list of both "new & emerging" technologies for residual waste treatment, as well as more traditional disposal alternatives, are being considered and evaluated. There are six main categories of residual waste management alternatives potentially available for consideration in the Durham/York Residual Waste Study:

1. Additional Diversion at Source (3Rs),
2. Mechanical treatment,
3. Biological treatment,
4. Thermal treatment,
5. Chemical/other treatment, and
6. Landfilling of residuals.

Until now and continuing into the future, the emphasis of each Region's waste management system have centred around maximized waste diversion and disposal of only those materials that cannot be diverted. Durham and York have spent the last several years reviewing alternatives and arriving at plans to maximize waste diversion. Based on assessment of the effectiveness of these plans (see Background Report 2-1), an initial 60% waste diversion target is being established as well as a plan for future disposal capacity to manage the waste remaining after diversion. In the longer term society may generate less waste and it may become possible to recycle even more material. In response to these possible changes, consideration is given to ultimately achieving a 75% diversion target by the end of the 35-year study period.

An overview of each of the proposed alternatives to be evaluated as part of the EA is provided below. The technologies being considered for managing residual waste can be classified as follows.

- **Additional Diversion at Source**
- **Mechanical Treatment**
  - Mechanical treatment to create an Alternative Fuel
  - Mechanical treatment for material recovery
  - Steam treatment for material recovery
- **Biological Treatment**
  - Aerobic composting

- Anaerobic digestion

- **Thermal Treatment**
  - Advanced Thermal Technologies
    - Fixed-bed gasification
    - Fluidized-bed gasification
    - High temperature gasification
    - Plasma arc gasification
    - Pyrolysis
  - Conventional Combustion Treatment
    - Single Stage Mass Burn
    - Two Stage Incineration
- **Chemical/Other Treatment**
  - Chemical Treatment
  - Treatment requiring special feedstocks
  - Other
- **Landfilling of Residuals**

Each of these approaches and associated technologies will be further examined in the following sections.

2.1 Additional Diversion At-Source

Based on examination of the diversion plans of both Durham and York an initial at-source waste diversion target of 60 percent (60%) has been assumed for the first 20 years of the planning period of this Study. This target reflects the optimal performance of source separated recycling and organics management programs that are currently offered or planned in both the Regions. An increase to a 75% diversion target in the final year of the planning period is also considered. Adopting these diversion targets necessitates a review of program participation and material capture rates. This review would consider the availability of other new and emerging policies, practices and technologies potentially affecting the types and quantities of materials separated at source. Additional at-source diversion represents an alternative that could affect the quantity of residual wastes requiring disposal. Examples of at-source options that could increase diversion include:

- Development and Implementation of municipal "At Home" reduction initiatives enabling a municipality to decrease the quantity of waste they must manage (collect, process/dispose) with minimal cost. These types of programs typically include: backyard composting initiatives and grass cycling initiatives. Durham and York have a number of "At Home" reduction initiatives that are included in their diversion programs and which have been or are in the process of being implemented within the municipalities.
- Promotion of waste-wise purchasing ideals, encouraging the consumer to purchase materials with the least amount of packaging possible. This in-turn would, provided strong consumer participation, force industries to reduce the amount of packaging used when distributing their product. Municipalities have begun to increase pressure on industrial and commercial

operations that manufacture the products, packaging, etc. that the municipality is eventually responsible for managing as waste materials. The Waste Diversion Ontario (WDO) stewardship program for recyclables and proposed programs for tires, oil and electronics, are expected to help financially support the cost of some diversion programs but are not expected to have much of a direct impact on diversion rates as they are simply ways of ensuring producer responsibility for programs that largely already exist in some form. These programs potentially provide municipalities the opportunity to reallocate the municipal funding towards increased promotional and educational programs and/or development of other diversion programs. Other extended producer pay (EPR) initiatives may encourage industrial and commercial operations to develop new ways of manufacturing and packaging their products that generate less waste overall.

- Implementation of diversion programs that encourage waste generators to donate unwanted items to local charities or give away to others. York, for example, hosts special events to collect reusable goods for local charities.

A 60% Diversion target has been discussed publicly, but has yet to be formally adopted by the Province. A Discussion paper was released by the Ministry of the Environment (MOE) in 2004 and the development of an action plan is under consideration. It is unknown at this time how the Provincial target and action plan will impact on increased diversion or enhanced product stewardship programs.

2.1.1 Additional Capture and Participation At-Source

Durham and York intend to divert as much waste away from disposal as possible. However, in order to achieve aggressive source separated diversion objectives, significant increases in capture and participation rates in all waste diversion programs will be required. It is also recognized that based on the current composition of residential wastes managed by each municipality, a portion of material generated can neither be recycled nor composted (based on current technological limitations) and must be managed as a residual waste material.

2.1.2 A “Zero Waste” Society

There are currently no “Zero Waste” systems operating in the world that divert 100% of waste through the 3R’s (reduce, reuse, and recycle) initiatives. The concept of “Zero Waste” is really a philosophical goal and to date there is no evidence to support the premise that “Zero Waste” is achievable. “Zero Waste” is more of an overarching objective to support policies and programs to get everyone: residents, businesses, and institutions to reduce the quantities of waste being generated, to support the recycling industry by buying recycled content materials and to fully participate in waste diversion initiatives. One of the key elements stressed by all “Zero Waste” programs is that there has to be buy in from all levels of government: federal, provincial and municipal, if the program is truly going to have a chance of success. Even with government intervention on packaging, and their active participation in waste diversion programs and policy development, much of the waste that is generated is a result of the way of life for the general population. Without a change in the general populace’s attitudes from a consumer society to a conserver society, all the policy and program development that can be put forward will still not allow the “Zero Waste” goal to be achieved.

Currently in Ontario, based on the types of products, packaging, etc. being consumed and discarded by residents, it is not possible to divert from disposal all wastes being generated. As discussed above, additional diversion will remain a priority in waste management for Durham and York and the extent to which additional diversion could manage the projected residual waste stream could be included as a viable alternative.

2.2 Mechanical Treatment

Mechanical treatment has been applied for a long time in different contexts to increase the capture rate of recyclable materials. Mechanical treatment could be considered to pre-process wastes; capturing recyclable content and improving the consistency of the mixture of waste material for biological and thermal processing. It can also be used for the management of respective process residues to capture recyclable content (e.g. metal) flowing through the different processes. The three mechanical treatment options being considered are:

- Mechanical treatment to create an alternative fuel;
- Mechanical treatment for material recovery alone, and
- Steam treatment for waste sterilization and material recovery.

2.2.1 Mechanical Treatment to Create an Alternative Fuel

Treatment to produce an alternative fuel involves shredding, optional drying and automated separation of recyclable materials and a fuel product from the waste stream. Typically, the output from this system is over 50% fuel by weight, which can be marketed as a coal replacement to cement kilns, coal power plants, paper mills, biomass power plants, district heating plants and chipboard factories. The remaining outputs include ferrous (iron-containing) and non-ferrous metals, glass and potentially certain high value plastics much of which can be recycled. The complexity of the front-end processing system will directly impact the quality and quantity of recyclables recovered from the system. Assuming a market is available for the alternative fuel and the facilities accepting it obtain the necessary approvals, the potential for diversion from landfill using mechanical treatment is quite high.

Process

Mechanical treatment to create an alternative fuel involves several processes utilizing various sorting and processing equipment. These may include the following:

- Initial removal of contaminants by hand or an automated crane and grapple system;
- Mechanical screens (i.e. trommel, star, or vibratory screens) to sort material by size;
- Shredding of waste to a homogenous particle size for the alternative fuel;
- Magnetic removal of coarse ferrous metals;
- Removal of non-ferrous metals by eddy current separation;
- Sorting a light fraction from a heavy fraction by a float/sink separator;
- Separation of light combustible material by air classification and sieving processes;

- Automated separation of different types of plastic and fibre containers by Near Infrared (NIR) Detector technology;
- Optional drying of particulate waste; and/or,
- Balers to compress and tie-off captured recyclables such as plastics, ferrous, and aluminum.

Typically, an alternative fuel facility receives waste in a deep bunker or a receiving pit with storage capacity for a number of days. The bunker is outfitted with an automated crane and grapple system used for the initial removal of large contaminants for the received waste. From the feeding bunker, material is fed to shredders by the automatic grapple. The shredders are slow speed rotary shredders that reduce the material to a particle size of less than 200 mm. At this stage of the process, magnets are employed to remove coarse ferrous metals. It is also at this point in the process when biological treatment can be used to 'bio-dry' the shredded waste, or it can be dried by applying an external heat source. The purpose of drying the shredded waste is to decrease the moisture content to typically less than 12%, thus, creating a more stable material that is easier to separate by mechanical treatment.

After drying, the waste is moved to another bunker and then transferred in batches to the separation machinery. Separation is done with air classifiers and sieves while ferrous and non-ferrous metals are removed with magnets and eddy currents, respectively. The remaining material is primarily wood, paper, plastics, textiles and organics that are not captured through the blue box, green bin and other diversion programs equalling approximately 50% of the input mass and which is suitable for use as a fuel. Depending on the characteristics of the remaining output, pre-recycling steps can be applied to the system maximizing the recovery of these materials.

Diversion from Landfill

The availability of a market for an alternative fuel (i.e. a facility approved to receive the fuel and use it) will significantly impact the diversion rate achievable by this process. If a market is found, there is potential for 65% (by weight) of the RMSW stream to be diverted from landfill. The 35% of waste that would still require landfilling constitutes materials for which there is no viable recycling market. However, if there is no market for the alternative fuel produced from this process, it is estimated that approximately 80% of the input RMSW stream would require landfilling.

Environmental Impact

The major air quality concern with mechanical treatment for the production of an alternative fuel is odour and dust, in the waste receipt areas and during the drying process. Keeping the process within an enclosed building, closing truck doors as quickly as possible, and containing the process air through negative pressure on the tipping floor has proven to resolve odour issues at existing similar facilities. Mitigation of dust and particulate released from the facility is typically achieved using ventilation and at times water spraying.

Condensate from the drying boxes is expected to be the only wastewater generated from this mechanical treatment. While liquid will not be a major issue due to the nature of waste being received at this facility, the condensate will likely exceed the sewer use by-law standards and will therefore, require management.

The more significant impacts on the air environment occur at the alternative fuel utilization (i.e., combustion or gasification) site.

Commercial Status

This technology has been fully commercialized for some time and is operational in a variety of different countries with different climates. European mechanical treatment facilities are treating in the range of 85,000 – 150,000 tonnes per year of waste.

Cost Factors

In addition to impacting the diversion potential of this technology, the marketability and value of the alternative fuel produced by this technology will have a significant impact on net costs. While there is clearly a demand for alternative power feedstock sources in Ontario, information on the marketability of an alternative fuel is limited.

In order for a combustion facility to accept an alternative fuel, it requires provincial approval and is likely to involve an EA. Therefore, it is necessary to take into consideration the permitting and approvals costs that may be associated with this technology.

A third cost consideration is the value of the recyclables. Prevailing rates for metals and plastics will dictate revenues from this source and the availability of markets for recyclables will determine if disposal costs will be incurred for unmarketable materials.

2.2.2 Mechanical Treatment for Material Recovery

Mechanical treatment for material recovery involves mixed waste sorting for the purpose of recovering recyclables and organics recovery and treatment. It is essentially the same as a Material Recovery Facility (MRF) however instead of accepting and treating source separated recyclables, the input material is mixed waste. As a result, this technology is sometimes referred to as a 'dirty MRF'. This system combines manual and automated sorting of recyclable materials from the waste feedstock.

Process

The key components of mechanical treatment for material recovery are:

- Initial removal of large, bulky items;
- Pre-processing of bulky items;
- Manual and automated sorting of remaining recyclables and organics;
- Magnetic removal of coarse ferrous metals;
- Removal of non-ferrous metals by eddy current separation;
- Organics screening;
- Organics treatment – on or off site (as discussed in Section 2.3).

Mechanical treatment for material recovery begins with the removal and categorization of large, bulky items including construction and demolition materials. The remaining materials are pre-processed as required and sent for treatment or to end markets.

After bag breaking, manual sorting is used to remove all plastic film. Standard MRF equipment including a magnet and an eddy current separator are used to sort the ferrous and non-ferrous materials, respectively, and the organics and glass fines are screened out of the remaining waste materials. The organics can be treated either in combination with source separated organics or on-site through digesters. Plastics and marketable fibres are removed manually. Unmarketable fibres and other organics can be sent for further biological treatment (discussed in Section 2.3) or simply landfilled.

Diversion from Landfill

The amount of materials that can be diverted from landfill via mechanical treatment for material recovery is heavily dependent on the waste stream being treated. Typically, the recyclables from a ‘dirty MRF’ are of lower quality than those from a traditional MRF and are therefore, more difficult to market and of lower value.

Given the planning assumption that 60% of the generated material will be diverted at-source, only a small amount of potentially recyclable material will remain in the waste stream. Mechanical treatment alone is likely only to divert approximately an additional 5% of the RMSW. If mechanical treatment is combined with biological treatment, as discussed in Section 2.3, then more diversion may be achieved.

Environmental Impact

Environmental impacts of a mechanical treatment material recovery facility are similar to those for an alternative fuel producing facility and are relatively minimal. However, due to the nature of materials received at these facilities, and the subsequent treatment of the separated organics, odour as well as other health and safety concerns can be significant issues with these types of facilities.

Commercial Status

This technology is not new and emerging, but has been in existence at a commercial scale for a number of years.

Cost Factors

The factors impacting the cost of this system are similar to a material recovery facility for the production of an alternative fuel in that the cost of both systems is significantly influenced by the marketability of the output products. In the mechanical treatment for material recovery system, the marketability of the compost and recyclables is a significant cost factor. The methods and efficiency of material recovery operations and technologies employed at the facility will impact the marketability of these materials as well as the cost of the system as a whole.

Cost factors for these facilities are highly interdependent. For example, the type of composting technology employed will directly impact the quality and potential marketability of the output materials, the facility cost, size requirement, number of facilities and site location(s) which will dictate the transportation cost for carrying feedstock to the facility.

2.2.3 Steam Treatment for Material Recovery

Process

An emerging technology uses steam pressure to treat waste to recover the fibrous materials and to clean and sterilize the recyclables for recovery. The system uses a steam pressure pulverization (SPP) vessel, steam production system, steam recovery system and, separation trommel. The feedstock is taken from the tipping floor and placed into a low-pressure rotary vessel where the SPP breaks down all cellulose materials and cleans and sterilizes both the biomass and non-cellulose materials. The time in the vessel varies depending on the input materials. The output materials from the vessel are passed through a trommel screen then sorted into separate, potentially marketable materials.

Diversion from Landfill

The newness of this technology and the differences in reported diversion by the technology vendors makes it difficult to determine the potential diversion from this technology. It is known that steam treatment for material recovery can accept a mixed MSW feedstock and requires minimal pre-processing. Markets for the resultant output materials, cellulose as feedstock for paper manufacturing and low-grade plastics for the composite lumber industry, have been proposed but are not established.

While the biomass production technology has no restriction on the feedstock, it is likely that 20% or more of the in-feed will require disposal. This result is due to the development stage of both the biomass and mixed plastics output product markets.

Environmental Impact

As this technology is in early development, there are information gaps in the known environmental impacts however, cellulose processing technology is known. Contaminants from cellulose technology that require consideration include:

- Volatile organic compounds. Volatile compounds and fumes liberated from the materials combined with the steam are captured and cleaned with either vamp tanks and charcoal filters or a Thermal Oxidizer.
- Odours. In theory, odours should be minimal however curbside RMSW feedstock generally requires some odour management. Odour management is usually accomplished by containing the process air and removing odours by biological (biofilter) or chemical (scrubber) means.
- In addition to the management of contaminants, the steam vessel rotation used by this technology requires fuel to generate steam and electricity to turn the vessel. Emissions from this process will require further consideration. Further examination of wastewater discharge and solid residue is also required for this technology.
- As is the case with all of the mechanical treatment technologies, it is assumed that the waste will be received inside the facility. Therefore, it is unlikely that dust emissions will result. As well, due to the nature of the waste and the re-absorption of the liquid into the waste pile, liquid is not considered to be an issue.

Commercial Status

While cellulose-producing steam treatment technology has been around for many years, the commercial status of steam treatment for material recovery technologies is relatively new. Commercial units have been built, however none are in operation today.

The biomass steam treatment technology is in the early stages of commercialization with a three year old pilot unit and a newly constructed 100 tonnes per day (tpd) system is about to become operational.

Cost Factors

The factors that influence the cost of this technology are:

- Marketability of output products. Though paper manufacturers and the composite lumber market have shown interest in cellulose and low-grade plastics, respectively, they are still in the development stages. No developed markets currently exist for the use of biomass as a soil enhancer or engineered fuel.
- Recyclables. Revenues from recyclables will be dictated by the rates for metals.
- Technology. Large, centralized technologies may have high capital and operational & maintenance (O&M) costs.
- Energy costs.

2.3 Biological Treatment

Biological treatment involves the use of microorganisms such as bacteria to change the properties of the organic constituents of the waste stream. Essentially, biological treatment breaks down and stabilizes organic matter such as food waste and waste paper. This approach is being applied elsewhere including other parts of Canada for a mixed waste stream. This approach offers the potential for a relatively stable landfill with reduced odours and other nuisance impacts. Considering the proportion of organics remaining in residual waste stream this alternative may be applicable to addressing the purpose of the undertaking.

There are two main biological treatment technology approaches: aerobic composting and anaerobic digestion. These technologies are further examined below.

2.3.1 Aerobic Composting

Aerobic composting is a biological process in which aerobic microorganisms use oxygen in the breakdown of organic materials to form a stabilized material known as compost. The two main phases of composting are the initial high-rate phase, during which biological activity is at its highest, and the low-rate curing/finishing phase, when biological activity is lower. The two main methods of composting, in-vessel and windrow, differ primarily in whether the high-rate phase of composting is contained inside a vessel (or building) or not. Each method presents unique advantages and disadvantages, which generally translate to different siting implications and requirements.

In-Vessel Composting (with Windrow Curing)

With in-vessel composting, the active composting phase occurs in a closed container or building. The size of the container or building varies with the technology and can range in size from a small bunker to a large building with one or many concrete channels. During active composting, the material is either mechanically turned on a daily basis or air is injected or drawn through the material to ensure optimal operating conditions. Both air and moisture levels are actively controlled during the process. After the active composting phase, the resulting materials still need to be stabilized during a curing period. Curing takes place in open windrows for most in-vessel composting operations because the costs of carrying out the entire composting and curing process in a vessel are much higher than composting in a vessel followed by curing in open windrows. A vessel is generally not necessary for the curing stage.

Windrow Composting

Windrow composting does not involve enclosure of the composting material at any stage of the process. Instead, material is piled into rows on an open pad, and turned periodically to provide aeration throughout the pile. There may also be an initial static pile stage, during which the material is piled into rows but not turned. If air is blown into the pile from beneath or drawn through the pile by a vacuum, the pile is referred to as an aerated static pile.

Windrow composting is generally cheaper than in-vessel composting as no containers are required for the active composting phase. It is generally a simpler process as air and moisture levels are controlled mainly by turning the materials and not through highly mechanized processes. However, outdoor windrow composting usually takes longer than in-vessel processes. Less staff time is generally required to operate these facilities. As the composting material is not enclosed, windrow composting facilities may be subject to more odour problems during the active composting phase than in-vessel facilities. Also, since windrow composting is less space-efficient than in-vessel composting, it has greater land requirements.

Compost produced from residual mixed waste contains contaminants (primarily heavy metals) and therefore cannot be marketed as a product in Ontario (i.e. the compost is classified as a waste and must be managed accordingly) under current regulations (see below).

Diversion from Landfill

Due to the biological nature of the aerobic composting process, it can only process the biodegradable components of the waste stream, which includes: organics (including food and yard waste), paper fibres and portions of diapers and sanitary products. The composition of the feedstock determines the suitability of composting as an alternative for processing residual waste. A high biodegradable component and low non-biodegradable component are most suitable for composting. Feedstocks with a high non-biodegradable proportion are less suited for composting because it is difficult to maintain proper composting parameters and ensure complete decomposition.

The capability of aerobic composting technology to divert waste from landfill is highly dependent on the quantity and quality of recyclables that can be removed during the pre-processing phase. Capturing marketable recyclables from a mixed waste stream can be difficult and result in poor quality recyclables that require landfilling.

The difficulty with creating compost from mixed waste is meeting the MOE "Interim Guidelines for the Production and Use of Aerobic Compost in Ontario" and the CCME Class 'A' standards for foreign matter and metals. Since this compost is not likely to meet these requirements, it is classified as a 'waste' in Ontario and can only be land applied with a site-specific Certificate of Approval from the MOE. Obtaining this approval for each application of the material is very costly and time consuming therefore, it is likely that this material will be landfilled.

If a market is found for the compost, biological treatment combined with mechanical treatment (as discussed in Section 2.2) to recover recyclables has the potential to divert up to 50% of the RMSW stream from landfill. However, if no market is found, diversion from landfill is likely to be in the order of 30% (5% recyclables, 25% moisture loss and carbon conversion to CO_2).

Environmental Impact

There are a number of contaminants that require consideration in regards to aerobic composting; these include heavy metals, volatile organic compounds, ammonia, odour and biological emissions such as fungi spores.

Heavy metals do not volatilize in the composting process, but instead stay in the composting material. Highly soluble metals may be found in the wastewater stream, but composting does not have a large wastewater stream because the majority of water is retained in the process, or evaporates during composting. Most metals will exit the system in the compost solids. It should be noted that because of the mass loss during the composting process metals present in the waste could be concentrated in the compost product.

Volatile organic compounds (VOC) are so named due to their tendency to volatilize into the gas phase. Therefore, any VOCs that are present in the composted waste will volatilize from the compost and must be contained. Various biological and chemical treatments are available to neutralize VOCs.

Most compost systems produce ammonia, which is not removable using biofilters. Ammonia must be chemically scrubbed from the process air before it is sent to biofilters for odour reduction. Theoretically, odours should not form during aerobic composting. In practice, however, odours have been a major source of air contamination. Containing the process air and using chemical (scrubbers) and/or biological (biofilters) are often employed for odour management.

Unlike landfilling, where anaerobic decomposition results in the emission of methane, the aerobic composting process produces the less potent GHG, carbon dioxide. The energy required for aeration and material handling will also result in greenhouse gas emissions.

Wastewater is a relatively minor consideration for aerobic composting, especially in comparison to anaerobic digestion. It has been shown that a mature windrow or static pile will generally either absorb all precipitation, or lose moisture in the form of evaporation.

As previously mentioned, the compost produced from a mixed waste feedstock will likely not meet MOE and CCME standards and the difficulty of obtaining approval to land apply the material may result in landfilling the compost. Generally this somewhat stabilized material would consist largely of materials that cannot or cannot easily be decomposed, such as non-recyclable plastics, non-recovered recyclables and inert materials such as grit and broken glass.

In either case, the material being somewhat stabilized will theoretically lead to less odour and landfill gas generation at the landfill site, and potentially a shorter contaminating lifespan and post-closure monitoring period.

Commercial Status

Composting of mixed waste is well established both in Canada and abroad. There are currently three large facilities operating in Edmonton, Tracy (PQ) and Halifax. Both Alberta and Quebec Regulations allow for the marketing of a low grade Class "B" compost. The compost produced by these facilities would be classified as a waste in Ontario. The compost produced from residual waste in Halifax is landfilled.

Cost Factors

In comparison to anaerobic digestion and thermal treatment, aerobic composting has a lower cost. The main factors influencing the cost of this technology are:

- Marketability of compost. If the compost does not meet Ontario guidelines for compost, which is expected, there will be a cost associated with landfilling the material and a loss of potential revenue from the compost.
- Technology. Some large-scale composting facilities particularly in-vessel facilities have high capital, operating and maintenance costs due to the technologies required to process larger volumes of material.

2.3.2 Anaerobic Digestion

Anaerobic digestion (AD) is the biological breakdown of organic materials in the absence of oxygen. The process is carried out by anaerobic microorganisms that convert carbon-containing compounds to biogas, which is a gas primarily consisting of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of other gases. The material remaining is a partially stabilized organic material that can be used as a soil amendment, or separated into solid and liquid fractions. The solid fraction may be stablized/cured via aerobic composting, and the liquid fraction is disposed as wastewater.

Although the basic biological process is the same, there are different AD technologies for achieving the conversion of organic carbon to methane. They differ primarily by providing environments that are favourable to different populations of micro organisms. They can be grouped into general categories according to three variables including process temperature, moisture content of the material being digested, and the number of stages in the process. The main temperature categories are thermophilic and mesophilic digestion. The moisture categories are wet (low solids) and dry (high solids) digestion. The number-of-stages categories consist of single-stage and dual-stage digestion. Each of these variables is described briefly below.

Mesophilic Vs. Thermophilic Digestion

Mesophilic refers to the bacteria that prefer a "medium" temperature range (meso = medium, philic = loving). These bacteria have an optimal temperature range of 35-40°C. Mesophilic digestion was the first to be used on a commercial scale, and is generally stated to be more stable than thermophilic digestion (i.e., it is less susceptible to upset in the biological process). However, it has a lower gas yield per tonne of material digested than thermophilic digestion. Gas production from mesophilic processes is generally in the range of 75-125 m³/tonne of waste digested (assuming food waste is included in the mixed waste stream).

Thermophilic, or "heat-loving" bacteria have an optimal temperature range from 50-55°C. Thermophilic processes are generally considered to be less stable than mesophilic processes, but give greater gas yields. Gas production from thermophilic processes is usually in the range of 100-150 m³/tonne, and can be up to 200 m³/ tonne of waste digested depending on the proportion of food waste in the feedstock.

Wet Vs. Dry Digestion

The second level of categorization for digestion is by the solids content of the feedstock. "Wet" and "Dry" digestion terms refer to the level of solids in the feedstock, although all processes have some moisture, which is essential to the biological process. Process water is added to incoming material for "wet" digestion. In "dry" digestion, no water is added. The two digestion methods have different materials handling requirements.

Wet digestion processes are carried out at a Total Solids (TS) content of no more than 15% by weight, most commonly within the range of 7-12%. Usually, water must be added to the feedstock during a slurrying stage to dilute the solids (organic materials tend to range from 10-30% TS). The slurry can be pumped using positive displacement or rotary lobe pumps. Mixing in process tanks can be achieved by mechanical mixers within the tanks, or by gas mixing using recirculated biogas if TS in the digester is below 10%. Most wet digestion processes use a completely mixed reactor.

Dry digestion processes are carried out at a TS content of over 15%, with 25-40% being the most common TS range. This material is too thick for liquid-handling pumps, and therefore dry digestion technologies use concrete pumps and screw conveyors. Mechanical and gas mixing equipment cannot usually handle the high solids concentrations of dry digestion, and therefore mixing is achieved by the configuration of the digester and recirculation of waste through the digester. The tank is usually a plug flow reactor, rather than a completely mixed reactor as normally used in wet digestion.

Single-Stage Vs. Dual-Stage Digestion

Anaerobic digestion occurs in two phases, by two different populations of bacteria. In the first phase (acid-forming phase), the first set of bacteria break down complex organic molecules into simpler, short-chained molecules called Volatile Fatty Acids (VFAs). These VFAs are converted by methanogenic bacteria to methane and carbon dioxide in the second phase (methane-forming phase).

Single-stage digestion uses one digestion tank in which both phases of anaerobic digestion take place. Single-stage digestion is the most common type of process available commercially, with 90% of AD capacity in Europe (where AD is more prevalent) using single-stage digestion. For larger plants, more than one tank may be used to handle all the material processed, but the tanks are arranged in parallel rather than in series.

One example of dual-stage digestion is to separate the two phases of digestion in two different digestion tanks, so as to optimise each one. A second example of dual-stage digestion is the separation of solids and liquids into separate digestion stages. This makes the easily degraded dissolved organics more quickly available to bacteria, and the liquid can then be recirculated through the solids to assist in dissolving more organics. These are only two possible types of dual-stage digestion systems, but it should be noted that there are many different ways to operate a multi-stage digestion system.

Dual-stage digestive processes are intended to have higher gas yields, although the increase in gas production is small and there is an increase in capital and operating costs in comparison with single-stage digestion. The gas increase is in the order of 5% for dual-stage vs. single-stage digestion.

Anaerobic digestion produces a “digestate” which must subsequently be mixed with a bulking agent and aerobically composted to produce a potentially viable compost.

Compost produced from anaerobic digestion of residual mixed waste contains contaminants (primarily heavy metals) and therefore cannot be marketed as a product (i.e. the compost is classified as a waste and must be managed accordingly) under current Ontario regulations.

Diversion from Landfill

As is the case with aerobic composting, the diversion potential for AD is largely dependent on the composition of the feedstock. Greatest diversion will be achieved from a waste stream with a high biodegradable component. There is potential to recover the non-biodegradable portion of the waste with a front-end treatment system however, due to quality issues it can be difficult to market recyclables recovered from a mixed waste stream.

The compost produced from anaerobic digestion is of similar quality to that produced by aerobic composting and is also not likely to meet MOE “Interim Guidelines for the Production and Use of Aerobic Compost in Ontario” or the CCME Class ‘A’ standards for foreign matter and metals. Therefore, it is classified as a ‘waste’ and will require management as such. Accordingly, the diversion potential for AD is the same as that for aerobic composting. If a market is found for the recyclables and compostable digestate, this technology in combination with mechanical treatment has the potential to divert up to 50% of the residual municipal waste stream. However, if no market is found for the compost and it is landfilled, diversion of 30% or less can be expected.

Environmental Impact

The contaminants that require consideration from this process include: heavy metals, volatile organic compounds (VOC), acid gases, oxides of Nitrogen (NOx) and Carbon monoxide (CO).

Heavy metals are not converted to biogas and therefore, depending on their solubility, stay in the liquid or solid faction of the waste. Volatile compounds are defined by their tendency to volatilize into the gas phase. Therefore, some VOCs may go into the biogas and some may be released as fugitive emissions during the composting of the digestate. For VOCs released during composting, scrubbers and biofilters may be required for containment.

Anaerobic digestion converts sulphur from the waste material into hydrogen sulphide which is then a trace constituent of the biogas. As a result, sulphur dioxide (SOx) and other acid gases will be produced during combustion. SOx levels could be controlled either by scrubbing the gas before combustion or by adjusting the biogas utilization equipment to control SOx. Similar to sulphur, nitrogen is also volatilized as ammonia in the biogas resulting in the production of NOx during the biogas combustion. There is also some production of NOx during combustion as a result of atmospheric nitrogen. Carbon monoxide is not generally produced during anaerobic digestion due to the biochemistry of AD. CO^2 may, however, be formed if combustion is incomplete.

Biogas produced by AD consists primarily of methane and carbon dioxide, with some water vapour, hydrogen sulfide (H_2S) and ammonia (NH_3). Typically the biogas is burned to convert the methane into energy. Biogas thermal oxidation in a boiler or engine for energy recovery would give low levels of SOx and NOx due to the sulphur and nitrogen in the biogas. However, metals and chlorinated compounds do not volatilize in biogas, so levels of parameters such as heavy metals and dioxins in air emissions would not be expected.

With regards to greenhouse gas emissions, while both AD and landfilling produce methane, the methane from AD is captured and converted to CO^2 which is approximately 20 times less potent a form of green house gas emission. While some landfills do have methane capture systems, in practice only a portion is collected.

Due to the liquid by-product of AD, wastewater emissions are of concern. Unlike aerobic composting and thermal technologies, AD does not result in the evaporation of water from the waste therefore, most of the moisture must be disposed of as wastewater. The quantity of wastewater equates to approximately 20-30% of the incoming mixed waste to the plant.

The wastewater from an AD facility is expected to exceed the local sewer by-law standards for nutrients (phosphorus, nitrogen) and suspended solids. Ontario AD facilities have dealt with this issue by including the payment of a municipal sewer surcharge in their operating costs. In Europe, some plants have installed wastewater treatment components such as clarifiers and aeration tanks.

Commercial Status

Aerobic digestion facilities are at various stages of commercialization from demonstration scale to full commercialization**.** Currently there is one full scale and one demonstration scale facility operating in Ontario.

Cost Factors

In general, the cost of anaerobic digestion facilities tend to be more than aerobic composting and comparable to thermal technologies.

Overall cost is influenced by the following factors:

- Value of energy product. Power generated by the AD process is considered to be "green" which allows for it to be sold at a premium via the public grid and potentially available for greenhouse gas credits. The market value for "green" electricity is up to three times as high in Europe than in Ontario. As well, starting in 2005, European AD facilities are also supported by legislation requiring organic waste to be treated before disposal. The absence of these economic and policy drivers in North America make AD a less viable alternative.
- Cogeneration. Additional revenue may be possible if markets for low-grade heat are nearby and there is sufficient excess heat for sale.

- Marketability of compost. The compost generated from this process is not expected to meet Ontario guidelines. If no market is found for this output material, a disposal cost will be incurred.
- Recyclables. The revenue potential of recyclables will be largely dependent on the metals market.

2.4 Thermal Treatment

Thermal treatment includes approaches such as combustion and gasification where the hydrocarbons in the waste stream are converted to thermal energy, carbon dioxide (CO_2) and water. Based on recent industry activity in Ontario (e.g. responses to requests for expressions of interest) and facilities operating in other jurisdictions it is evident that this alternative is reasonably available to address the purpose of the undertaking from both a commercial and technical perspective. Aside from the realization of a "zero waste" society, this alternative offers the best potential for a minimal landfill system. Current thermal technologies can be broadly categorized as follows:

- Gasification;
- Pyrolysis; and
- Conventional Combustion (or incineration).

Both gasification and pyrolysis technologies are considered advanced thermal technologies and are normally followed by thermal oxidation of the synthetic gas. While there are different technological options within each of the three categories, the systems are further described within two groups: advanced thermal technologies and conventional combustion.

2.4.1 Advanced Thermal Technologies

Process

Gasification and/or pyrolysis processes involve the thermal breakdown of solid materials into a gaseous constituent (syngas), a solid char residue, and in the case of pyrolysis, possibly a liquid fuel constituent. The processes differ from combustion in that they operate under a limited oxygen, reducing environment (as opposed to an excess air, oxidizing environment) and they are endothermic (i.e., require external energy). This external energy is either provided by allowing a very limited amount of the volatiles in the feedstock to combust in a reactor (gasification), or heat is added from external sources in the absence of oxygen (pyrolysis). The effect is the same: volatiles in the feedstock are converted to syngas, which may be used for a variety of purposes, such as fuel or chemical feedstock.

Syngas consists primarily of hydrogen, carbon monoxide, carbon dioxide and nitrogen, and has a heating value of about one third that of natural gas. Generally, syngas must be subjected to a cleaning process before it is utilized for the generation of heat. After cleaning, syngas can be used as fuel for reciprocating engines or gas turbines, or it can be combusted in a steam boiler to generate steam under utility conditions (with good combustion control) the same way that natural gas is used. Syngas can also be used as a feedstock for the synthesis of chemical compounds.

Before gasification or pyrolysis can occur, the solid waste input is generally subjected to some pre-processing (mechanical treatment). Depending on individual thermal process requirements, this can range from coarse shredding and sorting, to elaborate front-end processing involving recyclable material recovery, fine shredding, drying and mechanical sorting to produce a homogenous alternative fuel product.

There are a variety of new and emerging gasification and pyrolysis technologies available, many of these at the pilot or demonstration scale of commercialization. In addition there are several fully commercialized technologies currently operating, primarily in Japan. Some of these specific technologies include:

- Fixed bed gasifiers;
- Fluidized bed gasifiers;
- High temperature gasifiers;
- Plasma gasifiers; and
- Pyrolysis units.

The solid residue exiting an advanced thermal treatment requires management. Portions can be recycled (e.g., metals) but the majority of this material generally requires landfilling. Some technologies offer a process that melts the remaining inerts into a glass-like slag, which, if accepted by the marketplace and permitted under Ontario regulations, could be used as construction aggregate.

Diversion from Landfill

The syngas produced by advanced thermal treatment technology generally requires a clean, homogeneous feedstock. Metals and inerts are removed to the greatest extent possible and recycled, landfilled or vitrified. It is usually suggested that the syngas be utilized on site for the generation of heat or electricity.

The residuals from this system that require landfilling generally include:

- Contaminants pulled out in front-end processing;
- Byproducts from the syngas and/or flue gas cleaning process; and
- Process inerts (if not vitrified).

If all of the above materials are landfilled, advanced thermal treatment has the capability to divert in the order of 70% of the RMSW stream from landfill. If the majority of inerts are utilized and included in the vitrified slag, this technology has the potential to divert over 90% of the incoming RMSW. Residue from thermal treatment generally has a higher density than untreated RMSW, therefore, depending on whether diversion is calculated based on volume or weight this will impact the calculated diversion percentage. Regardless, the landfill space capacity requirements for this residue would be considerably less than the original residual waste.

Environmental Impact

The contaminants from advanced thermal treatment technology are dependent on a number of factors including the input materials, the treatment temperature and the type of pollution control equipment. The following are common contaminants of concern:

- Heavy metals. Depending on the temperature of the gasification process, low boiling point metal compounds will vapourize and become entrained in the syngas. These metals typically include: mercury, lead and cadmium and must be removed by gas scrubbing equipment, either before or after syngas combustion. The technologies for removing heavy metals from gases are well established and proven.
- Volatile organic compounds. Contained in the syngas, these contaminants will be broken down during the syngas combustion process. Through this process the volatile organic contaminants combine with oxygen to produce carbon dioxide and water. During the gasification stage, some ultra-high temperature thermal treatment processes will destroy these contaminants.
- Dioxins and Furans. The reducing conditions of the gasification process will minimize the formation of dioxins and furans. If any dioxins and furans do form, conventional air pollution control equipment can be employed downstream for removal.
- Acidic gases. Acidic gases may form during the gasification process and require management during the syngas cleaning process. A neutralizing chemistry needs to be applied.
- Oxides of Nitrogen (NOx). The reducing condition of gasification causes the likelihood of NOx formation to be minimal. NOx may result from the combustion of syngas but can be abated in the same way as in the combustion of other fuels.
- Carbon Monoxide (CO). Carbon monoxide is an essential burnable component of syngas therefore, its formation during gasification is desired. During the syngas combustion, the CO must be fully converted to Carbon Dioxide (CO_2). This conversion is common in any good combustion process.

A single air emission stream results from the production and use of syngas. In general, syngas contains a number of contaminants and treatment is dependent on the final application. If the syngas is combusted in reciprocating engines or turbines, then cleaning is necessary to remove particulates, tars and other contaminants that would damage the engines or turbines. In the case of syngas clean-up, the syngas is quenched and washed using scrubbers prior to combustion, and wastewater from the scrubbers may require treatment prior to discharge. If the syngas is directly combusted in a boiler for steam production, then minimal pre-combustion cleaning of the syngas is needed, but air pollution control is required for the exhaust gases.

Solid residues from advanced thermal treatment are produced at various stages of the process. Pre-processing is required to remove recyclables, hazardous materials and inerts prior to gasification. Each of these material streams will require suitable management that would include landfilling of the inerts. A second residual stream resulting from the gasification and pyrolysis process is char. In most instances the char is landfilled. If however, the char and inerts are vitrified, the resulting slag may be suitable for use as an aggregate substitute. The final residual stream requiring landfill is the gas treatment by-products. These by-products are likely to require some stabilization to allow for landfill disposal.

Commercial Status

The level of commercialization for advanced thermal treatment is dependent on the technology. Currently there are no technologies of this kind operating on a commercial scale in North America. Vendors claim however, that there are a number of full-scale facilities in Japan and possibly Europe.

Cost Factors

As is the case with most large-scale, centralized facilities, gasification and pyrolysis facilities for municipal solid wastes are known to have high capital and operating costs. These costs tend to be comparable or slightly higher than more traditional mass burn energy from waste systems. The following factors will influence cost:

- System complexity. Gasification and pyrolysis differ from a traditional mass burn system in that they consist of several separate treatments (i.e. materials pre-processing and preparation, gasification/pyrolysis, syngas cleaning, syngas utilization) and therefore, increased cost.
- Process efficiency. The potential cooling or quenching of the syngas before utilization in a boiler may impact the thermal efficiency of the system.
- Residuals. The disposal of carbon bearing char is a loss of energy to landfill. However, if the char is used, the system complexity increases.
- Front-end processing. While the front-end process will differ depending on the technology, it is required by all advanced thermal technologies. This process will increase the capital and operating costs of the system.
- Value of the product. If the energy produced from this technology is considered to be 'green' there is potential for it to be sold at a premium rate.
- Cogeneration. Local markets for low-grade heat can provide an additional revenue source.
- Recyclables. The rates for metals will dictate the revenue from recyclables.

2.4.2 Conventional Combustion Treatment

Process

Combustion, also referred to as incineration, is a process whereby the hydrocarbons in the waste stream are converted to thermal energy, carbon dioxide (CO_2) and water in either a single stage or multi-stage process, and the exhaust gases from combustion are cleaned prior to being emitted to the atmosphere. Combustion processes operate in an excess air, oxidizing environment and they are exothermic requiring little to no external energy once combustion has been initiated.

The main difference between advanced thermal technology and conventional combustion technology is that with conventional combustion technologies, exhaust gases are cleaned up after combustion while with gasification technologies, the syngas is often cleaned up prior to its combustion.

Single-Stage Mass Burn

Single-stage combustion technology is well established. Waste is typically received in an enclosed tipping area and dumped into a receiving pit. The feed crane operator inspects waste in the pit and any visible unacceptable materials are removed. The waste is then fed via a grapple crane into the combustion chamber.

The combustion chamber is usually equipped with an inclined moving grate system where the material passes through the stages of drying, ignition, combustion and burn out as it travels down the grate. Air is added at various points in the chamber to optimise combustion in each stage of the process. Ash is discharged from the bottom of the grate and is quenched (i.e. cooled with water). Generally, each mass burn combustion chamber can process in the order of 500 tonnes of waste per day based on the design.

Flue gases generated inside the combustion chamber pass upward into a burnout zone, where the temperature is maintained at approximately 1,000 degrees Celsius. The flue gases then pass through a boiler and economizer. Steam is generated and used to produce heat and/or electricity via a steam turbine. Modern incineration facilities employ air pollution control (APC) equipment to mitigate the plant emissions in the flue gases (see discussion below under Air Emissions).

Two-Stage Incineration

Two-stage units are generally modular units that are much smaller than single-stage mass burn units processing up to 100 tonnes per day of material. Facilities are constructed by assembling a number of modules on-site and plants often consist of a number of modular gasification/ combustion units operating in parallel. (Note: In Ontario, this technology is typically referred to as two-stage incineration although elsewhere it has been referred to as gasification.)

As these plants are smaller, waste may be received on a flat tipping floor, rather than in a pit. Waste is often loaded into the primary combustion chamber with a front-end loader. The waste is usually gasified in a starved-air condition, which leads to the formation of a combustible gas mixture (primarily hydrogen and carbon monoxide) and ash. The combustible gas mixture passes into a secondary chamber where it is fired with auxiliary fuel (if required) to complete combustion and to raise the temperature to approximately 1,000 degrees Celsius. As with all combustion technologies, steam produced in the boilers can be used for electricity production and/or heating.

Diversion from Landfill

Unlike most advanced thermal technology, conventional combustion does not require the same degree of pre-processing of the waste. However, the technology does allow for a pre-processing system to be implemented to capture recyclables, and post-processing systems to recover recyclable metals from bottom ash. Thermal treatment of mixed waste can divert approximately 70% of the RMSW stream from landfill and can achieve a diversion of 75% if metals are recovered from ash. If bottom ash is recovered and marketed as a recycled granular construction material (as in the case in some jurisdictions), this technology has the potential to divert over 90% (by weight) of the incoming RMSW.

Environmental Impact

Due in part to older combustion technologies, air emissions are always a major consideration. In recent years, conventional combustion facilities have been enhanced with new pollution control technologies in order to meet stringent air emission regulations.

The Ontario Ministry of the Environment (MOE) has addressed air emissions from thermal facilities in Ontario Guideline A-7. Guideline A-7 sets air emission limits for particulate matter, acid gases, metals and dioxins/furans and establishes requirements for their control, monitoring and air pollution control system performance testing. The emissions criteria specified in Guideline A-7 are very stringent, comparable with the latest regulations governing emissions from facilities in both the United States and Europe.

Flue gases typically contain mercury, dioxins/furans, particulate matter, acid gases and oxides of nitrogen (NOx). The gas is usually maintained at a very high temperature before reducing the NOx component of the gas. The exhaust gases pass through an air pollution control system before being discharged to the atmosphere (the air emissions from these plants, as with those from the Advanced Thermal Technologies, can meet the requirements of MOE Guideline A-7).

Emissions from combustion/incineration technologies are controlled by directing the exhaust gases through an air pollution control system that generally includes:

- Lime slurry scrubber or dry lime scrubber, to control acid gases such as oxides of sulphur (Sox), and hydrochlorides (HCl);
- Urea injection in the post-combustion flue gases commonly known as a Selective Non-Catalytic Reduction (SNCR) process or a Selective Catalytic Reactor (SCR) process, for reduction of nitrogen oxide (NO_x) emissions;
- Powdered activated carbon (PAC) system to control mercury and dioxins/furans;
- A high-efficiency fabric filter or bag house to remove particulate matter; and
- The cleaned exhaust gases are then discharged to the atmosphere via a stack.

The fly ash removed from the air pollution control system is a solid hazardous waste and must be managed accordingly. A two–stage combustion unit generally requires a slightly different set of pollution control technologies than a single stage unit due to their size and facility configuration. However, both technologies remove air contaminants and achieve emissions that meet regulatory requirements.

The bottom ash from two-stage combustion units may contain more unburned carbon than single-stage combustion units. In other respects, the bottom ash and air pollution control system residues from this technology are similar to those produced by larger single-stage incinerators. Bottom ash can be disposed in landfills with other MSW or in ash monofills.

Commercial Status

Conventional incineration technologies have been well established for many years. Currently, there are several incineration facilities operating in Canada. The only operational incinerator in Ontario is located in the Region of Peel.

Cost Factors

The costs associated with a traditional mass burn energy-from-waste systems tend to be slightly lower than advanced thermal treatment, however, they are still high. Cost will be influenced by the following:

- Value of the product. If the energy produced from this technology is considered to be 'green' there is potential for it to be sold at a premium rate.
- Technology. Even smaller scale two-stage combustion facilities have high capital, operating and maintenance costs due to the technologies required.
- Siting costs. Siting an incinerator can be an extremely long and costly process. Developing a new site and obtaining the necessary approvals can also be expensive.
- Tipping fees. High tipping fees at an incinerator could divert non-municipal waste to neighbouring areas where waste disposal is cheaper. Fees would consequently have to rise, or taxes would need to be increased to pay for it.
- Residuals. While the quantity of waste that requires landfill is substantially reduced in volume and weight, incineration still requires a landfill for disposal of bottom ash and other wastes that cannot be burned. Depending on the level of pollutants, ash may have to be treated somewhere other than a local landfill, at higher cost.

2.5 Chemical Treatment

The chemical treatment of waste generally involves a combination of physical, chemical and/or thermal treatments to convert the input waste into saleable energy or other products such as construction products. As a result, chemical treatments can be extremely varied and differ greatly in regards to acceptable feedstock, process type, process complexity and output products.

Chemical treatment involves the chemical preparation of solid waste materials into a gas, liquid and/or new solid. The gas and liquid product enters into a second chemical process to create a final usable output product.

The key components of chemical treatment, are: sorting and sizing (in most cases); recyclable materials recovery; creation of gas, liquid and/or solid to be treated; sterilization or cleaning of output product; and residue disposal.

Examples of chemical treatments include:

- The conversion of organic materials in the residual waste stream into ethanol through the initial chemical conversion of the organic materials to sugars. This is followed by the fermentation of the sugars into alcohol (ethanol) and the final concentration of the alcohol by distillation. The ethanol can then be subsequently used to enhance the octane rating of gasoline.
- Hydrogen reforming and catalytic conversion to produce ethanol. This technology is a reformer/catalytic converter that produces syngas by entering shredded, screened waste into a hydrogen reformer. The syngas is cleaned of sulphur and heavy metals and entered into a catalytic converter to produce ethanol.
- Advanced thermal treatment process to produce industrial chemical and fuels. This process involves creating and heating a liquid slurry from which industrial chemical and fuel is extracted. Organic feedstock is first pulped and slurried with water, then heated under pressure. The slurry is then flashed to a lower pressure to release the gaseous products. The flashed liquids are separated by density in a liquid separator and the high value oil is extracted. At this stage of the process, the high value oil is sent for further refinement and the

remaining slurry is reheated to separate the water and light oils from the solids. Finally, the light oil is separated from the water and sent to a high temperature cooker. The cooker cracks the oil into high value industrial chemicals and fuels.

- Advanced thermal treatment to produce construction materials. This technology is designed to be a component of a full waste management system that treats organic materials. The system would begin with a dirty Material Recovery Facility (MRF) for the purpose of removing recyclables from mixed waste. The pre-processed waste would then be reduced in size and mixed with recycled process water and other liquid waste to form a slurry. The slurry is fed into a thermal process where it undergoes a two-stage oxidation process. The first stage of the process creates a liquid suitable for anaerobic digestion and therefore, produces methane gas. The objective of the second stage of the process is to fully oxidize any remaining suspended organics and to minimize the remaining solids in order to produce a fully sterile and chemically inert ash cake. This product has the potential to be used as a construction material.
- Combined physical and chemical treatment to produce construction panels. In this treatment, pre-sorted waste is dried, sterilized and milled to form a filler for the panel manufacturing process. The treated waste fill is encapsulated in construction panels by combining it with raw materials and proprietary chemical binders.

Many of these technologies are at a pre-commercial stage of development in terms of their application to treatment of municipal waste. Their lack of an established track record makes it difficult to comment on their diversion potential, environmental impact and cost factors.

2.6 Landfill

2.6.1 Conventional Landfill

The conventional approach of disposing of residual wastes in a sanitary landfill site represents the approach currently used by Durham and York to dispose of RMSW and has been established in Ontario as a viable approach to manage wastes that are not or cannot be diverted.

Landfill sites are generally large areas of land upon which waste is deposited and buried. At landfill sites the waste is hauled to the 'tipping face' of the landfill where it is deposited and then spread, compacted and covered (with soil or other approved materials) in layers on a daily basis by heavy machines such as compactors and bulldozers. There are a few variations on landfill site design.

Conventional landfills are generally designed to control the rate of decomposition of waste within the site at a fairly low level by restricting the amount of moisture available within the site. This reduces the overall annual quantities of leachate and landfill gas generated by the landfill, but results in a relatively long contaminating lifespan.

It is important to note that all of the alternative disposal approaches and technologies described above will require landfill disposal for the purpose of managing process residues. There are currently no operational Alternative Disposal Technologies (ADT) facilities that are achieving a zero landfill disposal system. The landfilling needs of the various technologies will vary and will need to be accounted for in the evaluation of these technologies.

Diversion from Landfill

If all residual waste is taken directly to a landfill site, there will be minimal potential for additional diversion. If waste is bulked at decentralized transfer stations before final landfill disposal, there is some potential for the removal of large recyclables such as metal and cardboard, however, this diversion is typically minimal.

Environmental Impact

Landfill sites generate over a quarter of the methane emissions caused by human activity in Canada, sending 1.2 million tonnes of this potent greenhouse gas into the atmosphere each year. Although the composition of landfill gas can vary, typically it is 50% methane and 50% carbon dioxide, with trace levels of sulphur compounds and volatile organic compounds. Landfills typically start producing methane in their first year of existence and can continue for up to half a century.[1] However, over the past decade innovative technologies have been developed for the capture and use of landfill gas. Captured gas is either flared off or piped to nearby facilities for use as fuel in heating buildings or generating electricity. Ontario currently regulates that a capture system be put in place for some landfills, based on landfill fill rates and the volume of gas measured at the sites. As of 1998, all new and expanding landfill sites require a gas management plan in their MOE Operations and Maintenance report. In addition, the landfill operation procedure requires the implementation of gas monitoring wells to ensure the Landfill Gas (LFG) does not migrate from the site.

Trace amounts of sulphur compounds and VOCs found in landfill gas may create nuisance odours and affect air quality while high truck volumes can cause noise and dust issues. As a result, these impacts require consideration and minimization through good operational procedures.

All landfill sites are required to meet provincial regulations for storm water management. Sites are required to minimize, mitigate and monitor disturbance to existing surface water features. All precipitation that comes into contact with active areas of landfill site is automatically considered leachate and must be managed and treated as such through on-site treatment or discharge to municipal wastewater treatment facilities. Precipitate that comes into contract with closed areas of a landfill is regarded as stormwater. Landfill storm water management is usually accomplished with berms and swales guiding surface water to a collection pond(s). As is the case with anaerobic digestion facilities, if leachate from the landfill site exceeds the local sewer by-law standards for nutrients and suspended solids, they are generally required to pay a sewer surcharge to the municipality.

Landfill sites are also required to protect groundwater by monitoring and managing the leachate. Monitoring is usually done with the use of groundwater monitoring wells. Sampling and measurements are taken and compared to MOE standards and site-specific historical data.

Commercial Status

Landfill disposal is one of the oldest alternatives for residual waste disposal under consideration. Landfill gas systems for the production of energy are in existence at a commercial scale throughout Canada.

[1] Environment Canada S & E Bulletin, "Harnessing the Power of Landfill Gas", Environment Canada, May 1999.

Cost Factors

The following factors impact the cost of the landfill disposal alternative:

- Tipping fees. The ownership of a landfill site and who is permitted to dispose at the site will determine whether a municipality is collecting or paying tipping fees. If, for example, the site is municipally owned and local private haulers use the facility, there is potential for revenue generation. If, however, the municipality is reliant on a privately owned landfill or is in a public-private partnership, the cost of tipping fees or a decreased revenue stream, respectively, may be incurred.
- Value of energy product. Landfill gas systems where the methane gas is burned in boilers or industrial-scale internal combustion engines to produce electrical energy are becoming increasing common. The electrical energy produced by LFG is considered to be "green" which allows for it to be sold at a premium via the public grid.
- System complexity and technology. The LFG can be managed by collection and burning in flares either in the open air or in enclosed stacks or it can be burned in boilers or industrial-scale internal combustion engines. The complexity of the gas collection system will directly influence its capital, operational and maintenance costs.
- Siting costs. Siting a new landfill can be an extremely long and costly process. Developing a new site and obtaining the necessary approvals can also be expensive.
- Regulatory compliance. Capital, operational and maintenance costs required to monitor, mitigate and manage the integrity of the site, comply with MOE requirements and protect the surrounding environment can be high.

2.6.2 Bioreactor Treatment

Anaerobic bioreactor waste treatment technology ("the bioreactor") is a new and emerging technology for organic or mixed waste management. Bioreactor treatment of municipal solid wastes involves design and construction of a landfill cell that is specifically engineered to enhance the decomposition of wastes through careful manipulation of conditions within the site. Bioreactor treatment is similar to anaerobic digestion, however, unlike AD, it has the advantage of not being limited by the size, cost and time constraints of a treatment vessel.

Many of the elements of a bioreactor are similar to the components of a modern, engineered sanitary landfill site. The primary difference lies in the increased level of process control that is inherent in the bioreactor landfill system of waste treatment. One of the key components of a bioreactor landfill is the introduction of moisture to optimize the biological decomposition environment. The moisture must contain landfill leachate to provide the microbiological and nutrient input that is required to increase biological activity. At most landfills, leachate alone will not provide sufficient quantities of liquid to adequately boost biological degradation of the wastes. Additional moisture must also be provided. Typically, horizontal liquid injection pipe galleries are installed within the wastes as filling progresses. Extensive in-situ monitoring instrumentation and control systems are employed to allow for operational management of moisture injection and to optimize waste treatment within the bioreactor. As a direct result of enhancing the rate of waste decomposition, landfill gas generation rates are also increased.

Benefits of bioreactor treatment of municipal solid waste compared to other alternatives include:

- Faster stabilization of organic wastes;
- Rapid waste settlement leading to increased effective site capacity;
- Increased gas and energy recovery opportunities;
- Reduced overall emissions to air compared to a traditional landfill.

It should also be noted that enhanced rates of landfill settlement also provide an opportunity to increase the effective utilization of landfill space thereby reducing the need to expand the site or locate, approve and construct replacement landfills.

Diversion from Landfill

If all residual waste is disposed directly in a bioreactor landfill, there will be minimal potential for additional diversion. If waste is bulked at decentralized transfer stations before final landfill disposal, there is some potential for the removal of large recyclables such as metal and cardboard, however, this diversion is typically negligible.

Environmental Impact

Odour at bioreactor landfills is consistent with traditional landfilling operations. Material is placed and kept in the cell for the necessary amount of time for full stabilization while new material is being continuously added.

The operation of a bioreactor requires the installation of gas monitoring wells to ensure the landfill gas does not migrate from the site.

Large centralized facilities can have high truck volumes resulting in noise and dust issues. As a result, these impacts require consideration and minimization through good operational procedures.

Similar to a conventional landfill site, a bioreactor site is required to meet provincial regulations for storm water management. All precipitation that comes into contact with the active areas of the site is also considered leachate. While the surface water collection system employed at a bioreactor site is similar to a landfill system, the water is usually reused in the bioreactor to supplement its moisture requirement.

Bioreactor sites are also required to protect groundwater by monitoring and managing the leachate. Monitoring is usually done with the use of groundwater monitoring wells. Sampling and measurements are taken and compared to MOE standards.

Commercial Status

Bioreactor applications are in the early stages of commercialization. Currently, there is one full-scale facility in operation in Canada.

Cost Factors

In general, the cost factors for bioreactor landfills are similar to conventional landfills.

- Tipping fees. The tipping fee at a bioreactor is more expensive than a traditional landfill. However, it is less expensive than an anaerobic digester. As a general rule, per tonne of waste, a bioreactor is approximately double the cost of a landfill and half the cost of an AD facility. The ownership of a landfill site and who is permitted to dispose at the site will determine whether a municipality is collecting or paying tip fees.

- Value of energy product. The increased rate of waste decomposition achieved by a bioreactor will increase the landfill gas (LFG) generation rate. This "green" energy can be sold at a premium via the public grid.
- System complexity and technology. The extensive monitoring instrumentation and control systems necessary to allow for optimal management of the moisture injection and waste treatment can have significantly higher capital, operational and maintenance costs than a traditional landfill.
- Siting costs. Siting a bioreactor would be comparable to siting a landfill and therefore, can be expected to be time and cost intensive. While the necessary Ministry approvals for a bioreactor are the same as those needed for a landfill site, greater scrutiny can be expected resulting a more time intensive and costly process.
- Regulatory compliance. Capital, operational and maintenance costs required to monitor, mitigate and manage the integrity of the site, comply with MOE requirements and protect the surrounding environment can be high.

3. Identification of "Alternatives To" for EA Evaluation

3.1 Approach to Defining a Reasonable Range of Alternatives

3.1.1 The role of Additional At-Source Diversion and Landfill

Durham and York Regions propose to base their EA Terms of Reference on the following purpose which focuses on addressing their residual waste management problem while, at the same time, pursues the opportunity for an alternate source of electrical (and possibly other power) generation:

The purpose of the undertaking is to process – physically, biologically and/or thermally – the waste that remains after the application of both Regions' at-source waste diversion programs in order to recover resources – both material and energy – and to minimize the amount of material requiring landfill disposal.

In proceeding with this undertaking only those approaches that will meet or exceed all regulatory requirements will be considered.

At-Source Diversion

The role of at-source diversion is explicitly established in this statement of purpose. For the purpose of estimating future waste quantities it will be assumed that at-source diversion measures will initially continue to manage at 60% of the waste stream in Durham and York's integrated waste management systems over the first 20 years of the planning period for this study. Sixty percent diversion is considered reasonable in the context of this study based on the performance of existing diversion programs, the performance of planned programs in similar municipalities and major urban centers that share similar demographic conditions such as a high proportion of multi-residential unit dwellings. Additional at-source diversion measures as identified in the examination of "Alternatives To" within the EA study will be applied consistently to the integrated waste management systems that are developed for analysis.

Landfill Disposal

The role of landfill disposal is also explicitly established in this statement of purpose, which clearly expresses the intention of Durham and York to minimize the amount of material requiring landfill disposal. Landfill facilities will be assumed to continue to play a role for the disposal of certain materials that cannot be otherwise treated or diverted. Development of a landfill only system capable of managing all waste that remains after at-source diversion would not meet the proposed purpose of the undertaking, and therefore is not being considered. Rationale for the exclusion of this option is provided in Background Document 2-1. Furthermore, the results of consultation in both Durham and York (see Consultation Record, Summary of Consultation on "Alternatives To") indicate public support for minimizing the role of landfill in future disposal systems, and the need or preference to recover resources that remain in the residual waste stream.[2]

For the purpose of comparison and evaluation of the "Alternatives To", a "Do Nothing" system is required as a component of the EA process. For this study the "Do Nothing" system would be the continuation of the current method of disposal of the residual waste that remains after diversion, namely, the continued export of waste from Durham and York to landfill facilities outside of the study area.

3.1.2 Integrated Waste Management System Planning

The "Alternatives To" that would be evaluated in the Durham York Residual Waste Management Study, will be developed in the context of Integrated Waste Management System Planning. Essentially, alternative systems that are capable of managing the residual waste that remains after at-source diversion will be developed and evaluated. These integrated systems would be developed based on the combination of at-source diversion assumptions, reasonable alternatives for the treatment of the remaining residual municipal solid waste (RMSW) and landfill disposal of materials that remain after treatment.

3.1.3 Alternatives for the Treatment of Residual Waste

The approach used to define a reasonable range of alternatives for the treatment of residual waste, developed in consultation with the public and stakeholders, involved the application of a set of screening criteria to the treatment approaches described in Section 2 of this document. The screening criteria developed are outlined below:

Proven Technology. The technology or approach must have a proven operating history at a capacity similar to that required by Durham and York Regions. A proven operating history is defined as operating for at least 2 years following the successful commissioning of the facility in North America (or anywhere with similar waste management requirements).

[2] Workshop #1 "Alternatives To" Summary Report (Durham), and Workshop #1 "Alternatives To" Summary Report (York)

Environmental Suitability. It must be demonstrated that the technology or approach will not have unacceptable effects on the environment and public health and safety (as defined by current regulatory requirements) and that all applicable environmental approvals can be secured.

Applicability to Subject Waste Stream. The technology will process the post diversion waste stream and the residuals, requiring further treatment or landfill disposal, from the technology or approach must be minimal (i.e. less than 25% by volume input).

If the technology or approach can meet these minimum screening criteria requirements, it is recommended that it be considered in the evaluation of "Alternatives To" as part of the EA Study.

3.2 Screening of Potentially Available Alternatives

Table 3-1 outlines the application of the screening criteria and their impact on the potential alternatives.

Table 3-1 Impact of Application of Preliminary Screening Criteria

Alternatives to be Considered	Proven Technology	Environmental Suitability	Applicability to Subject Waste Stream	To be Considered in EA Evaluation Process
Mechanical Treatment	**YES** – Technology used throughout Southern Ontario on Source Separated Recyclable Streams. Limited use on Mixed Waste Streams.	**YES** – Any technology being considered at this stage must be able to comply with all regulated limits for emissions to the environment.	**MINIMAL** – Based on planned source separated diversion objectives, mechanical treatment could contribute to the diversion rate of the two municipalities and will decrease the volume of residual requiring landfill disposal. It represents a viable alternative in combination with another alternative.	✓

Alternatives to be Considered	Proven Technology	Environmental Suitability	Applicability to Subject Waste Stream	To be Considered in EA Evaluation Process
Biological Treatment	**YES** – Technology used in Southern Ontario on Source Separated Organic Waste Streams. Limited use on Mixed Waste Streams.	**YES** – Any technology being considered at this stage must be able to comply with all regulated limits for emissions to the environment.	**MINIMAL** – Based on planned source separated diversion objectives, biological treatment could contribute to the diversion rate of the two municipalities and will decrease the volume of residual requiring landfill disposal. It represents a viable alternative in combination with another alternative.	✓
Chemical Treatment	**NO** – Limited use throughout North America. Minimal large-scale experience managing MSW.	**YES** – Any technology being considered at this stage must be able to comply with all regulated limits for emissions to the environment.	**NO** –Available information indicates that chemical treatment cannot be used to process the full RMSW stream. It is possible that components of the RMSW recovered through mechanical treatment could be further processed chemically.	✗
Thermal Treatment	**YES** – Technology used throughout North America on MSW waste streams.	**YES** – Any technology being considered at this stage must be able to comply with all regulated limits for emissions to the environment.	**YES** – Facility currently operating in Ontario managing waste stream similar to that managed by Durham and York Regions.	✓

3.3 Proposed Alternatives for EA Evaluation

Based on the application of the above preliminary screening criteria, the following alternative treatment technologies and approaches are considered "reasonable" and will be carried forward into the EA Evaluation Process:

- Physical Treatment;
- Biological Treatment; and
- Thermal Treatment.

As noted in section 3.1.3, these component alternatives will be assembled into a range of alternative disposal systems with each system capable of managing the entire residual waste stream. Each system would include the application of additional at-source diversion measures and landfill disposal of residuals remaining after treatment, as required.

4. Evaluation Methodology and Criteria for "Alternatives To" the Undertaking

4.1 Proposed Evaluation Methodology

The evaluation of the "Alternatives To" the undertaking will be a comparison of the advantages and disadvantages associated with each which, in turn, will be defined using a net effects analysis. The step-by-step methodology for use of a net effects analysis of "Alternatives To" in the Durham/York Residual Waste Study is described as follows:

Step 1

The proposed methodology and criteria developed for the evaluation of "Alternatives To" has been based on similar methods used in other studies and on the feedback provided through consultation sessions held in Durham and York. Only a small proportion of the population participated in these consultation sessions, and consultation in both communities identified some issues and priorities that were not held in common. This initial review step would provide the potential opportunity for additional review and feedback from the public and agencies prior to proceeding with the evaluation of "Alternatives To". Based on this review the methodology, criteria and indicators will be finalized.

Step 2

The component alternatives will be assembled into a range of alternative disposal systems with each system capable of managing the entire residual waste stream;

Step 3

Data collection is undertaken for the purpose of applying each of the comparative evaluation criteria to each of the alternative disposal systems. The proposed disposal system comparative evaluation criteria are listed in the following Section 4.2 and are also included in Appendix "E" of the proposed EA Terms of Reference. Suggested indicators and data sources may be adjusted at the initiation of this EA evaluation based on input received from agencies and the public.

Step 4

The comparative evaluation criteria are applied to each of the alternative disposal systems and potential effects identified.

Step 5

Each of the potential effects identified at Step 3 will be considered with respect to the availability of mitigative (i.e. measures that may be applied to reduce or eliminate a negative potential effect) or enhancement (measures that may be applied to improve or increase the magnitude of a benefit or positive effect) measures and identify the residual or 'net effects'.

Step 6

Compare1son of the net effects associated with each disposal system under each comparative criterion will be undertaken and a list of relative advantages and disadvantages associated with each system will be developed; and,

Step 7

The relative advantages and disadvantages of each system will be compared in the context of priorities established in consultation with the public as the basis for selecting the preferred system. The preferred system will be the one exhibiting the preferred balance of advantages and disadvantages accounting for the significance of environmental categories and criteria established through public consultation.

The process described above is a comparative evaluation of alternative disposal systems, utilizing criterion and indicators to measure potential effects. The proposed criteria and indicators are outlined in Table 4-1. There are different methods (qualitative or quantitative or a combination of both) that can be used to evaluate the systems. There is no requirement to apply any specific methodology except that the process must be rational, traceable and replicable and must consider advantages and disadvantages based on a net effects analysis of alternatives. This methodology is commonly applied to address the approval requirements of the EAA and promotes the selection of alternative systems considering relative advantages and disadvantages based on net effects after the application of reasonably available mitigative measures.

4.2 Proposed Comparative Evaluation Criteria

The following table contains a set of proposed draft criteria that would be applied to the alternative disposal systems for the purpose of selecting a preferred "Alternative To". The criteria are organized under four categories. Beside each criterion are sets of indicators, which are the specific considerations, measures or data sources that are proposed to be applied to identify potential effects related to the respective criterion.

Table 4-1 Proposed Comparative Evaluation Criteria and Indicators

Criterion	Indicators
Environmental Considerations	
Environmental burden at a global or macro-environmental scale	• Predicted emissions released to atmosphere by alternative. • Predicted pollutants released to water resources by alternative. • Need to manage residues, classified as hazardous waste associated with alternative.
Consumption /preservation of non-renewable environmental resources	• Potential of system to displace non-renewable fossil fuel consumption for energy generation considering energy balance of waste management facilities
Potential for destruction or disruption of sensitive terrestrial and/or aquatic habitats at an eventual site	• Total area of land required for the siting of alternative facilities. • Land use setting typically associated with establishment of waste management facilities in system.
Potential to increase disposal diversion rate and/or make best use of residual (post-diversion) waste materials.	• Potential of system facilities to remove any remaining materials in the post-diversion waste stream for use in a non-disposal manner. • Potential of system facilities to manage and make beneficial use of materials in the post-diversion waste stream including those materials for which diversion markets may decline or disappear in the future.
Social / Cultural Considerations	
Potential for land use conflicts from siting of facilities required for alternative.	• Number of waste management facilities associated with approach. • Potential for land use conflicts considering location requirements of waste management facilities. • Types and degree of nuisance impacts associated with waste management facilities based on operational experience.

Criterion	Indicators
Economic / Financial Considerations	
Net system costs per tonne of waste managed – in a systems context.	• Capital and operating costs over operational period of system (2011 to 2045). • Estimated costs associated with perpetual care of component facilities in accordance with current environmental and municipal accounting requirements. • Estimated revenues associated with operations of system once fully implemented and operational. • Potential subsidies and revenues that may be realized during establishment and future operation of system.
Sensitivity of system costs and affordability to external financial influences.	• Types of revenues and subsidies currently available to offset system costs and predicted sustainability of these sources into the future. • Degree to which system affordability relies on revenues and subsidies during long-term operation of the system.
Legal / Technical Considerations	
Legal/Contractual risks associated with waste management alternative.	• Types and complexity of approvals required to implement components of system. • Degree to which system relies on private or public sector partnerships.
Technical risks associated with waste management alternative.	• Flexibility of alternative to changes in waste quantities, composition and availability of system diversion and disposal components. • Reliability of alternative and component technologies and need for contingency landfill capacity.

5. Consultation During Evaluation of "Alternatives To"

During the initial steps of the process of evaluating "Alternatives To", the public, stakeholders and agencies will be involved in the review of the proposed methodology, criteria and priorities to be utilized in the evaluation process. Input from this consultation will be used to finalize the evaluation process.

The specific consultation activities will be undertaken during the evaluation of "Alternatives To" to inform the public, stakeholders and agencies regarding the outcome of the various steps in the evaluation process.

All public and agency consultation processes and events will be communicated to interested parties in accordance with the consultation plan outlined in the Proposed Terms of Reference.

The results of all consultation will be documented including specific input received and the impact of that input on the study outcomes. This input will be made available to all interested parties upon request.