Stantec

County of Brant Solid Waste Disposal Future Needs Study

FINAL STUDY REPORT

May 6, 2011

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Table of Contents

List of Figures

List of Tables

List of Appendices

GLOSSARY

ANSIs	Areas of Natural and Scientific Interest
ASR	Automotive Shredder Residue
BGS	Below Ground Surface
Bottom Ash	Comprises heterogeneous material discharged from the burning grate of the incinerator (grate ash) and material that falls through the burning grate to be collected in hoppers below the furnace (grate riddlings).
C of A	Certificate of Approval
CN	Canadian National Railway
DOMP	Design, Operation and Maintenance Plan
EFW	Energy from Waste, also known as waste to energy (WTE), is the conversion of waste into a useable form of energy, e.g. heat or electricity. A common conversion process is waste combustion.
Feedstock	The raw material that is required for some industrial process.
Fly Ash	Finely divided particles of ash which are normally entrained in the combustion gases. Fly ash is recovered from the gas stream by a combination of precipitators and cyclones.
GD1	Generic Design 1 specified in O. Reg.232/98
GD2	Generic Design 2 specified in O. Reg.232/98
GEM	Graveson Energy Management
GHG	Greenhouse Gases
Golder	Golder Associates
GRCA	Grand River Conservation Authority
IPZ	Intake Protection Zone
ISI	Intrinsic Susceptibility Index
KW	Kilowatts (10^3 W) is a unit of power equal to one thousand watts.

KWh	Kilowatt Hour
m	Metres
m^3	Cubic metres
mAMSL	Metres Above Mean Sea Level
MOE	Ministry of the Environment
MNR	Ministry of Natural Resources
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste is waste which is collected for treatment and disposal by a local authority. MSW generally comprise waste from households, civic amenity sites, street-sweepings, local authority collected commercial waste, and some non-hazardous industrial waste.
MW	Megawatts (10^6 W) is a unit of power equal to one million watts.
MWh	Megawatt Hour
OGS	Ontario Geological Survey
OP	Official Plan
O. Reg.232/98	Ontario Regulation 232/98, Landfilling Sites
O.Reg.287/07	Ontario Regulation 287/07, Terms of Reference
O. Reg.347	Ontario Regulation 347, General — Waste Management
PVC	Polyvinyl Chloride
RDF	Refuse Derived Fuel (interchangeable with SRF) is a fuel product recovered from the combustible fraction of household waste.
REOI	Request for Expressions of Interest
RFP	Request for Proposals
RFQ	Request for Qualifications
RUC	Reasonable Use Concept
SAAT	Surface to Aquifer Advection Time

SRF	Solid Recovered Fuel (interchangeable with RDF) being a fuel product recovered from the combustible fraction of household waste.
SSO	Source Separated Organics
Syngas	The name given to a gas mixture synthesized from waste materials that contains varying amounts of carbon monoxide and hydrogen (but may contain smaller amounts of other gases).
tpy	Tonnes per year
TSS	Ministry of the Environment’s Technical Support Section
UEM	Urban & Environmental Management Inc.
WHPA	Well Head Protection Area

1.0 Introduction and Background

In June 2010, the County of Brant (the County) retained Stantec Consulting Ltd. (Stantec) in association with Watson & Associates Economists Ltd. (W&A) to complete a Solid Waste Disposal Future Needs Study. This Study is necessary because the remaining capacity at the Biggars Lane Landfill Site (the County's only operating waste disposal facility) is estimated to be approximately 10 years, and currently, the County does not have any in-County disposal capacity available after Biggars Lane Landfill reaches its current Certificate of Approval (C of A) limits.

The overall purpose of this Study was to identify solid waste disposal options that will enable the County to dispose of solid waste generated within the County after Biggars Lane Landfill reaches its current C of A limits.

The study included three (3) parts and eleven (11) tasks:

- Part A: Review of Background Information and Data Collection
  - Task A – Project Initiation Meeting
  - Task B – Information Gathering
- Part B: Identify the Issues
  - Task C – Key Questions
- Part C: Identification and Evaluation of Alternatives
  - Task D – Identification of County of Brant Landfill Options
  - Task E – Identification of Existing Disposal Facilities Outside County of Brant
  - Task F – Identification of Waste Processing Options
  - Task G – Evaluation of Disposal Options
  - Task H – Managing Vendor Submissions
  - Task I – Recommendation of Preferred Disposal Option
  - Task J – Preparation of Draft Study Report
  - Task K – Preparation of Final Study Report

Part A of the study consisted of initiating the project (*Task A*) and reviewing background information regarding the County's current solid waste management system (*Task B*). Various data sources obtained during Part A are referenced throughout this report. Part B of the study indentified the key issues that the County is facing and how these issues are to be addressed during the study (*Task C*). The information gathered during Parts A and B of the study were consulted during the completion of *Tasks D, E* and *F* of Part C. During the completion of Parts A and B it was determined that the study planning period will be from 2010 to 2050 (40 years).

Tasks D, E and *F* of Part C identified and investigated various disposal opportunities available to the County over the planning period. Specifically, *Task D* identified landfill options within the County, *Task E* identified existing disposal facilities outside of the County, and *Task F* identified waste processing options (identified as “alternative disposal” options from here forward) that could be considered by the County. *Task G* evaluated the waste disposal options and recommended a preferred approach to disposing the County’s waste during the study period. *Task H* proposed a process for how the County could handle potential vendor inquiries. *Task I* recommended a preferred disposal alternative based on the results of the evaluation completed in *Task G*. And finally *Task H* and *I* included the completion of the draft and final version of the Solid Waste Disposal Future Needs Study report.

In addition, this report also presents waste disposal projections which were developed to determine the estimated remaining lifespan of Biggars Lane Landfill and to ensure that appropriate disposal options will be considered over the longer term.

2.0 Waste Disposal Projections

Waste disposal projections for the County were developed to estimate the amount of residual solid waste that will need to be managed by the County's solid waste management system year-by-year over the 40 year planning period (2010-2050). Waste disposal projections for the planning period were determined based on the per capita waste disposal rate at Biggars Lane Landfill and population growth projections for the County.

2.1 METHODOLOGY

The per capita waste disposal rate refers to the amount of waste generated per person within a defined time period (usually one year) within a defined jurisdiction (ex: a municipality). For this Study, an annual per capita waste generation rate was calculated for the County and used to generate waste disposal projections for the study period. See Section 2.3 for more information.

To determine the approximate volume of waste being disposed in a given year, the estimated tonnage of waste requiring disposal was multiplied by the average density being achieved at Biggars Lane Landfill. In this way, the approximate lifespan remaining at Biggars Lane Landfill (according to its current C of A) was also determined. See Section 2.4 for more information.

When developing waste disposal projections, it was assumed that the per capita waste disposal rate would remain constant over the entire planning period. Although the County may increase its residential waste diversion rate by following the recommendations outlined in the Solid Waste Diversion Plan developed in 2007, residential waste only accounts for approximately 60% of the waste disposed by the County (the other 40% consists of institutional, commercial and industrial (IC&I) waste). By assuming a constant per capita waste disposal rate throughout the planning period, the County is taking a conservative approach in an attempt to ensure that it will have sufficient disposal capacity available over the long term. In addition, over the past number of years, trends in Ontario show that waste generation rates continue to increase, which would potentially offset the impact of any increases in waste diversion.[1]

The following sections describe how population growth projections, per capita waste disposal rates, and waste disposal projections were developed.

2.2 POPULATION GROWTH PROJECTIONS

Population growth projections for years 2010 to 2031 were adapted from a report completed by W&A in 2008 entitled *Brant County Official Plan Review Growth Analysis Study, 2006 to 2031.*[2] The population growth projections developed by W&A are in conformity with Schedule 3 of Places to Grow: Growth Plan for the Greater Golden Horseshoe as required by the Province of

1 From 2004-2006, per capita waste generation in Ontario increased by 2.74%. Statistics Canada, 2006.

2 Watson and Associates Economists Ltd. 2008. Brant County Official Plan Review Growth Analysis Study, 2006 to 2031.

Ontario.[3] As the County does not manage waste produced by the Six Nations of the Grand River First Nations Reserve, which is located adjacent to the County, this population was discounted from W&A's population projections (approximately 6% was discounted).

In order to determine population growth projections from 2031 to 2050, the population growth projected by W&A for 2026-2031 were averaged (2,735 person increase divided by 5 years = 547 persons/year) to determine the approximate growth rate year-by-year for future years. Table 1 provides a summary of population growth projections for the County. As the data shows, over the 40 year planning period, the population of the County is projected to increase from 37,812 in the year 2010 to 57,657 in the year 2050. Appendix A provides a table showing the annual population projections to the end of the study period.

Table 1 Population Projections Summary

Year	Population	Year	Population
2006 (W&A Study)	36,226	2031 (W&A Study)	47,264
2011 (W&A Study)	38,208	2035 (extrapolated)	49,453
2016 (W&A Study)	40,283	2040 (extrapolated)	52,189
2021 (W&A Study)	41,981	2045 (extrapolated)	54,925
2026 (W&A Study)	44,528	2050 (extrapolated)	57,660

2.3 PER CAPITA WASTE DISPOSAL RATES

In 2009, a total of 17,762 tonnes of residual solid waste was disposed at Biggars Lane Landfill. These waste materials came from various sources including the residential, municipal, commercial and industrial sectors.

Table 2 identifies the quantities of waste from various sectors disposed at Biggars Lane Landfill in 2009.[4]

Table 2 Waste Quantities Disposed at Biggars Lane Landfill in 2009

Year	Commercial	Residential (Curbside Collection)	Residential (Drop-Off)	Industrial (Non-Hazardous)	Municipal Works Operations	Total
2009	2,087	7,482	3,082	2,720	2,391	17,762

From 2007 to 2009, the amount of waste disposed at Biggars Lane Landfill ranged from 16,823 tonnes to 17,822 tonnes, and averaged 17,469 tonnes. Therefore, 17,762 tonnes represents a good estimate of the amount of waste being disposed at Biggars Lane Landfill on an annual basis and was used to develop per capita waste disposal projections for the planning period.

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[3] Ontario Ministry of Public Infrastructure Renewal. 2006. Places to Grow: Growth Plan for the Greater Golden Horseshoe 2006.

[4] Stantec Consulting Ltd. 2010. 2009 Annual Report, Biggars Lane Landfill Site, County of Brant, Ontario.

Waste generation for the industrial and commercial sectors and municipal works operations are not directly linked to population changes (i.e. per capita waste generation) and may fluctuate from year to year. However, since the waste quantities for these generators do not typically vary significantly from one year to the next, it is common, for waste management planning exercises, to estimate changes in these waste streams by using a per capita waste generation rate.

The County's per capita waste disposal rate for the year 2009 was calculated in the following way: the total amount of waste disposed at Biggars Lane Landfill in 2009 was divided by the County's population in 2009. The following box shows the results of the calculation.

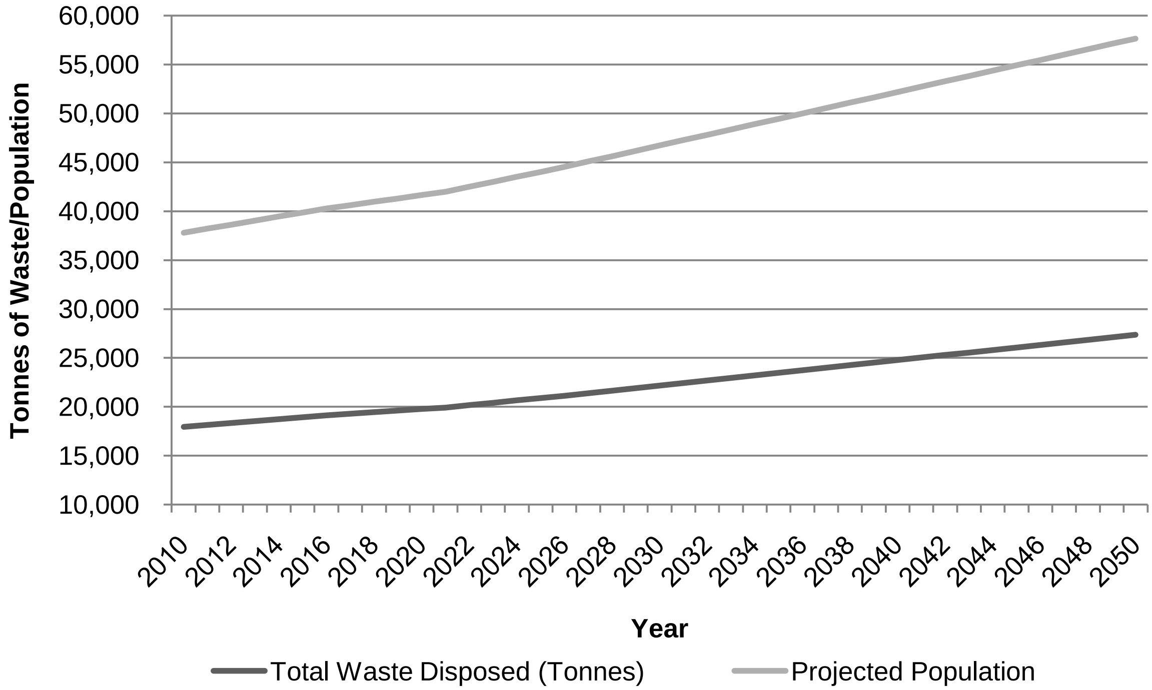
$$\frac{\textbf{Total Waste Disposed in 2009}}{\textbf{Population in 2009}} = \frac{\textbf{17,762}}{\textbf{37,415}} = \textbf{0.474 tonnes/person/year}$$

The calculated per capita waste disposal rate was used throughout the planning period to determine the amount of waste requiring disposal in the County.

2.4 WASTE DISPOSAL PROJECTIONS

By multiplying the per capita waste disposal rate (0.474 tonnes/person/year) by the predicted population in a given year during the planning period, the amount of waste requiring disposal for that year was estimated. Over the 40 year planning period it is estimated that a total of 916,289 tonnes of waste will require disposal. The estimated amount of waste requiring disposal ranges from approximately 18,000 tonnes in the year 2010 to approximately 27,000 tonnes in the year 2050. The following figure illustrates the waste disposal and populations projections over the planning period.

Figure 1 Waste Disposal Projections over the Planning Period (2010-2050)

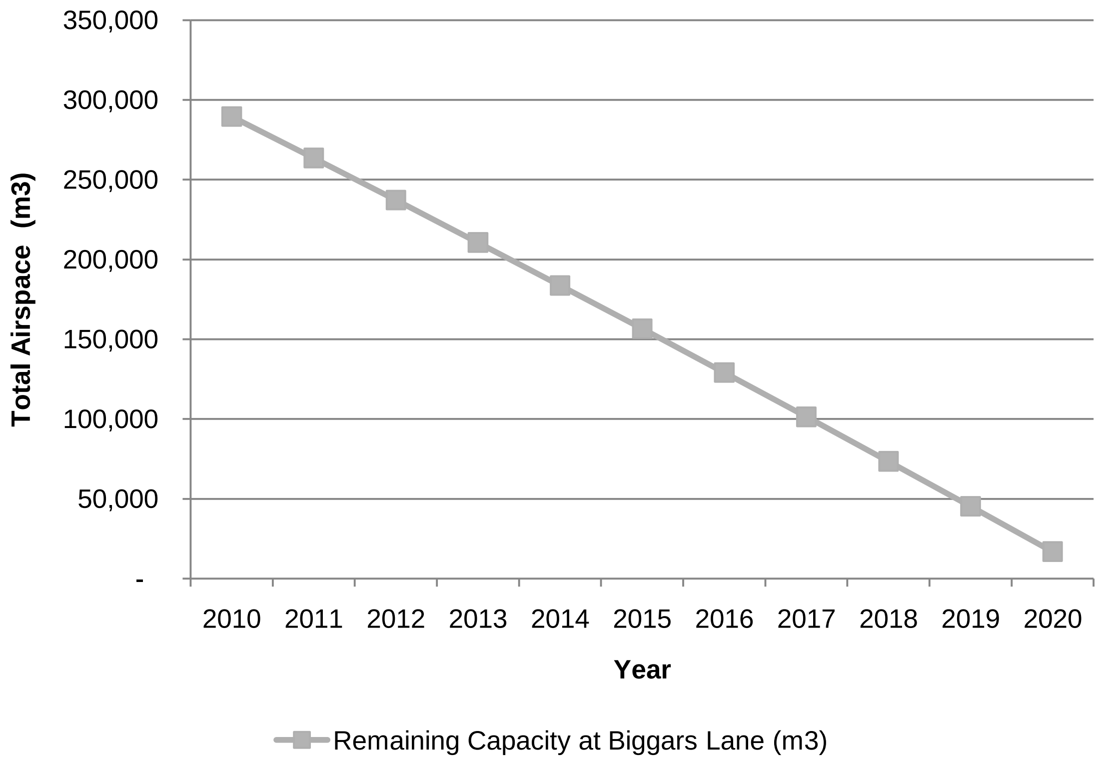


In order to estimate the volume of waste being disposed in a given year, the tonnage of waste was multiplied by the average waste density being achieved at Biggars Lane Landfill from 2006 to 2009 (696 kg/m^3).[5] Over the 40 year planning period it is estimated that approximately 1,316,078 m^3 of waste will require disposal. Appendix A provides a table with the calculations.

Based upon the waste disposal and waste volume projections developed and the measured airspace remaining at Biggars Lane Landfill at the end of 2009 (315,405 m^3), it is estimated that Biggars Lane Landfill will reach capacity (according to its current C of A requirements) sometime in the year 2020. The following figure illustrates the projected usage of Biggars Lane Landfill over the planning period.

[5] Although this number seems high, it includes daily cover which increases the calculated density of the waste material.

Figure 2 Biggars Lane Landfill Remaining Airspace over the Planning Period



The remaining timeframe (10 years) for the operation of the current approved landfill capacity at Biggars Lane should be placed in perspective with the potential timeframes required in order for the County to secure and develop additional approved disposal capacity. Depending on the approvals required and the type of landfill to be developed, it can take between 7 to 10 years for new landfill disposal capacity to be approved and developed in Ontario.

3.0 Identification of Alternative Disposal Options

3.1 INTRODUCTION

In order to address the County's future disposal needs over the long term there may be an opportunity for the County to develop an alternative disposal facility either on its own or in partnership with a private or municipal entity, especially those municipalities contiguous to the County. The development of an alternative disposal facility would not be considered a short term option due to the time required to develop partnerships, acquire necessary approvals, and construct and commission a facility.

A solid waste alternative disposal facility would be more viable if pursued jointly with other municipalities or with the private sector, given that the tonnage of residual solid waste produced by the County is fairly small and would not be of sufficient quantity to economically supply any type of alternative disposal facility.

Alternative disposal approaches that can be considered include:

- Thermal treatment technologies, including:
  - Existing and new thermal treatment technologies (i.e. conventional combustion and advanced thermal treatment); and,
  - Emerging thermal treatment technologies.
- Mechanical treatment technologies; and,
- Biological treatment technologies.

Note: It should be noted that all alternative disposal options produce some amount of residue after treatment which requires disposal. Therefore, the need for some type of landfill is still required even if an alternative disposal technology is developed.

The following subsections present the results of a literature review conducted by Stantec which investigated and assessed various alternative disposal technologies currently available.

3.2 METHODOLOGY

A comprehensive literature review was conducted by Stantec to determine candidate technologies and vendors for the treatment of residual solid waste, resulting in the development of a database of over 100 vendors and technologies. The literature review retrieved reports from various government and vendor websites as well as sources held by Stantec.

It is important to note that much of the information that was generally available is vendor information provided through "Requests for Expressions of Interest" (REOIs) and therefore it has not necessarily been verified through a third party and/or the verification is not publicly available. Some of the technology information has also been derived from proposals by respondents through Requests for Qualifications (RFQ) processes, Requests for Proposals

(RFP) processes and studies for other municipal jurisdictions undertaken by Stantec staff. Generally, the information derived from official procurement processes has a higher degree of veracity.

3.3 THERMAL TREATMENT TECHNOLOGIES

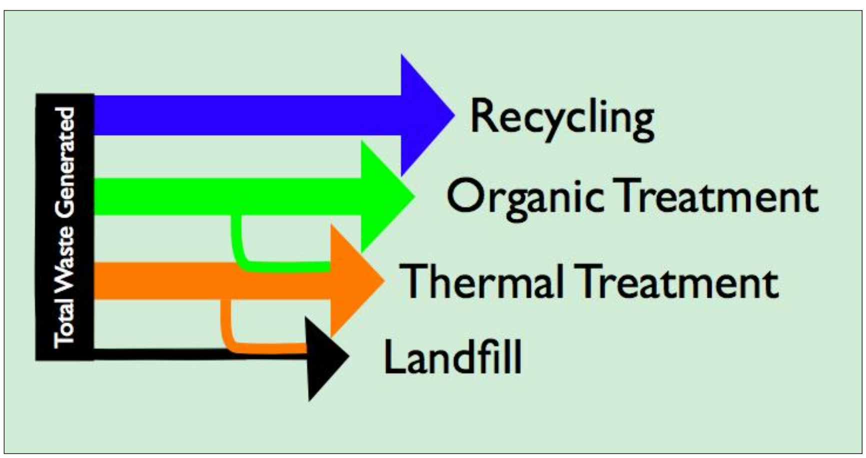
3.3.1 Introduction

Although thermal treatment of solid waste is uncommon in Canada, it is utilized regularly as part of waste management systems in Europe and the United States. Thermal treatment can play a number of important roles in waste management systems. Thermal treatment can:

- Reduce the volume of waste, therefore preserving landfill space (thermal treatment does not replace the need for landfills as various residuals such as ash still require disposal).
- Allow for the recovery of energy from the solid waste stream (energy-from-waste or EFW).
- Allow for the recovery of minerals and chemicals from the solid waste stream which can then be reused or recycled.
- Destroy a number of contaminants that may be present in the waste stream.
- Often, reduce the need for the “long-hauling” of waste.

In most jurisdictions, thermal treatment technologies are used to treat the remaining waste stream after source-separated diversion of recyclables and organics. Figure 4 presents a schematic diagram illustrating how thermal treatment fits into a conventional “mature” waste management system that includes source-separated recycling and organics diversion components.

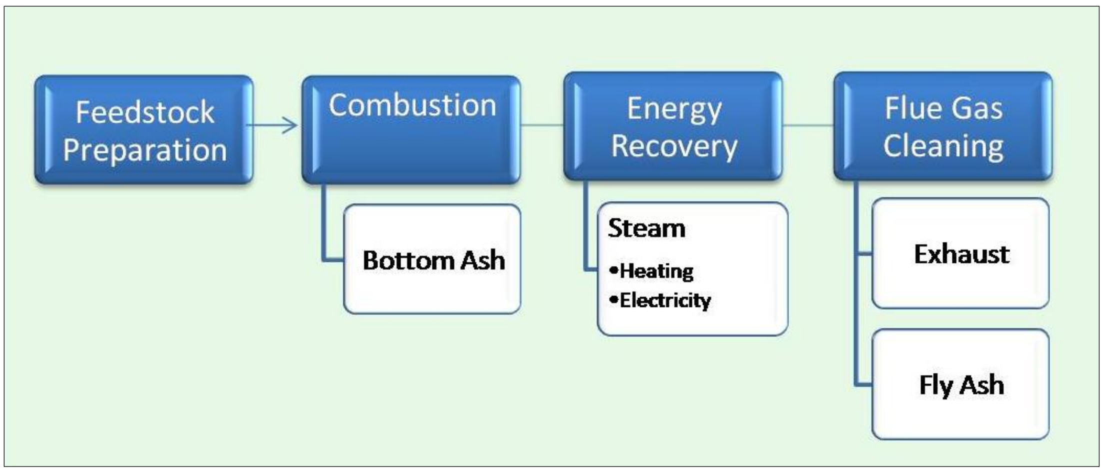
Figure 3 Schematic Overview of the Role of Thermal Treatment in Waste Management



3.3.2 Existing Thermal Treatment Technologies

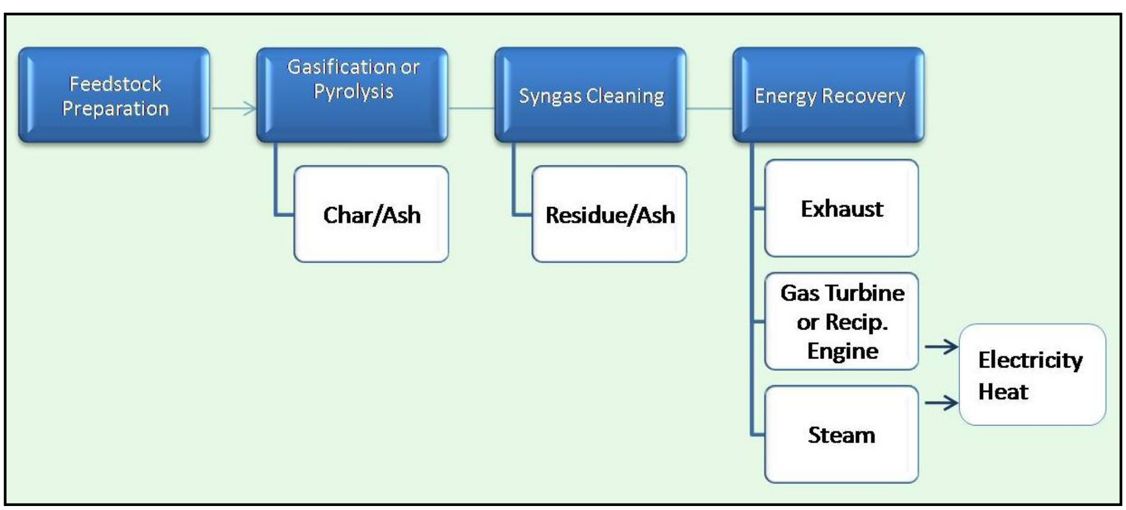
Current thermal treatment technologies can generally be grouped into two main categories: conventional combustion technologies and advanced thermal treatment technologies. Conventional combustion technologies include mass burn incineration and fluidized bed incineration among others. Mass burn incineration is the most common type of thermal treatment technology used worldwide. Figure 5 provides a flow diagram of a conventional thermal treatment approach.

Figure 4 Overview of Conventional Thermal Treatment



Advanced thermal treatment technologies include gasification, pyrolysis and plasma arc gasification. These technologies tend to be less proven on a commercial scale and involve more complex technological processes. Figure 5 provides a flow diagram of an advanced thermal treatment approach.

Figure 5 Overview of Advanced Thermal Treatment



The four most prevalent existing thermal treatment technologies used to treat residual solid waste are described below, namely, conventional combustion, gasification, plasma arc gasification, and pyrolysis. Of the four technologies mentioned, conventional combustion and gasification are the most common methods of converting waste into energy.

It should be noted that mass burn incineration (a type of conventional combustion) is the most well established and commercially proven thermal treatment technology. There are over 900 mass burn facilities currently in operation worldwide.

3.3.2.1 Conventional Combustion

Conventional combustion is a well-established technology developed over 100 years ago for energy generation from solid waste. The first attempts to dispose of solid waste using a furnace are thought to have taken place in England in the 1870s. Since that time, vast technology improvements have been made making conventional combustion the most common EFW technology currently being used to treat municipal solid waste (MSW) worldwide. The most prevalent conventional combustion approach is called single-stage combustion or mass burn incineration. Over 90% of EFW facilities in Europe utilize mass burn incineration technology.[6]

At a mass burn facility, minimal pre-processing of waste is required. Normally, trucks carrying refuse enter a building where they discharge their waste into a pit or bunker. From the pit, the waste is transferred into a hopper by an overhead crane. The crane is also used to remove large and non-combustible materials from the waste stream. The crane transfers the waste into a waste feed hopper which feeds the waste onto a moving grate where combustion begins.

Most of the energy produced during combustion is transferred to the flue gases which are cooled as they pass through the plant allowing for the capture of energy via a heat recovery boiler (which transfers the heat energy to water causing the production of steam or hot water). Newer facilities have greatly improved energy efficiency and usually recover and export energy as either steam and/or electricity.

Mass burn facilities can be scaled in capacity anywhere from approximately 36,500 to 365,000 tonnes per year (tpy) per operating unit.[7],[8] Most mass burn facilities are designed to combust waste continuously, 24 hours a day, seven days a week with the exception of scheduled or unscheduled shut downs. Some small scale facilities are designed for batch combustion, and are operated only when sufficient volumes of waste have been accumulated. Small batch facilities are often used in isolated locations where there is limited access to landfill disposal.

Mass burn facilities are generally designed to have multiple modules or furnaces, with the potential to add additional units to increase the capacity of the facility as required. This allows

[6] Thomas Malkow. 2004. Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal. In Waste Management 24 (2004) 53-79.

[7] GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. *Municipal Solid Waste Thermal Treatment in Canada.*

[8] AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*.

for individual modules to be shut down for maintenance or if there is inadequate feedstock, allowing for some continued operation.[9] Multiple modules can be accommodated on a single site with some sharing of infrastructure (e.g. access roads, administration buildings, tipping floors, ash handling facilities).

Two other conventional combustion approaches are also commonly used to manage MSW, but are less common. These two other conventional approaches are modular, two stage combustion and fluidized bed combustion.

In modular, two-stage combustion, waste fuel is combusted in a controlled starved air environment in the first chamber. Off-gases are moved into a second chamber where they are combusted in an oxygen rich environment. The heat generated in the second stage is fed into a heat recovery boiler. Ash is generated in the first stage and is managed in a similar manner as that from moving-grate systems (mass burn incineration).

In fluidized bed combustion waste fuel is shredded, sorted and metals are separated in order to generate a more homogeneous solid fuel. This fuel is then fed into a lined combustion chamber, in which there is a bed of inert material (usually sand) on a grate or distribution plate which is fluidized by air blowing under the grate. Waste fuel is fed into or above the bed through ports located on the combustion chamber wall. Drying and combustion of the fuel takes place within the fluidized bed, while combustion gases are retained in a combustion zone above the bed (the freeboard). The heat from combustion is recovered by devices located either in the bed or at the point at which combustion gases exit the chamber or a combination. Surplus ash is removed at the bottom of the chamber and is generally managed in a similar fashion as bottom ash from a moving grate system (mass burn incineration).

Conventional Combustion in Canada

In Canada there are currently seven operational conventional combustion incinerators that treat MSW (greater than 25 tonnes per day (tpd)). These seven (7) facilities are location in British Columbia (1), Alberta (1), Ontario (1), Quebec (3), and Prince Edward Island (PEI) (1).

Of these seven facilities, two (2) are larger mass burn incinerators (L'incinérateur de la Ville de Québec, Quebec and Greater Vancouver Regional District Waste to Energy Facility, British Columbia), one (1) is a smaller mass burn incinerator (MRC des Iles de la Madelaine, Quebec), two (2) are defined as two-stage starved air modular incinerators (PEI Energy Systems EFW Facility, PEI and Algonquin Power Peel Energy-From-Waste Facility, Ontario), and one (1) is defined as a three-stage incinerator (Wainwright Energy From Waste Facility, Alberta).

Table 3 provides an overview of each of these facilities.[10]

[9] AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*.

[10] GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. Municipal Solid Waste Thermal Treatment in Canada

Table 3 Overview of Conventional Combustion Facilities in Canada that Treat MSW

Facility Name	Thermal Treatment Units	Number of Units	Approved/ Licensed Capacity (tpd)	Air Pollution Control System
Metro Vancouver Waste to Energy Facility (1988 start-up)	Mass-burn – Martin grates	3 x 240 tonnes per day	720 (approx. 273,318 tpy)	Selective non-catalytic reduction – NH_4 injection, spray humidifier, dry lime injection, carbon injection and fabric filter
L'incinérateur de la Ville de Québec	Mass-burn – Von Roll grates	4 x 230 tonnes per day	920 (approx. 293,300 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter, electrostatic precipitator
L'incinérateur de la Ville de Lévis	Primary combustion chamber with afterburner	1 x 80 tonnes per day	80 (approx. 24,768 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter
MRC des Iles de la Madelaine	Mass-burn – step grate	1 x 31 tonnes per day	31 (approx. 4,500 tpy)	Spray humidifier, dry lime injection, fabric filter
Algonquin Power Peel Energy-From-Waste Facility, Brampton Ontario (1992 start-up)	2-stage modular Consumat units	5 x 91 tonnes per day – 5th line added in 2002	455 (permitted to operate at 118% of rated capacity) (approx. 147,700 tpy)	Spray humidifier, selective catalytic reduction, dry lime injection, powdered activated carbon addition, fabric filter
PEI Energy Systems EFW Facility, Charlottetown PEI	2-stage Starved Air Modular Consumat CS-1600 units	3x 33 tonnes per day	99 (approx. 25,623 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter
Wainwright Energy From Waste Facility	3-stage Starved Air Modular System	1 x 29 tonnes per day	27 (approx. 3,681 tpy)	Dry lime injection, powdered activated carbon addition, fabric filter

Summary

Table 4 provides a summary of conventional combustion processes, costs, scalability and reliability.

Table 4 Conventional Combustion – Summary of Information

Conventional Combustion Summary
Traditional mass burn incineration is a well-established technology developed over 100 years ago for energy generation from municipal solid waste.
There are hundreds of plants in operation, including approximately 450 in Europe (420 mass burn, 30 fluidized bed), 87 in the United States and over 400 in Asia. There are seven (7) conventional combustion facilities in Canada.
Conventional combustion facilities have reasonably good energy efficiency (up to 30% for electricity only and 60% or more for combined heat and power or just heat recovery systems) and usually export their energy as either steam and/or electricity.

Conventional Combustion Summary	
The largest facility in Canada is a mass burn facility, processing approximately 300,000 tpy of waste. (Quebec City). There are several mass burn facilities in Europe that treat over 300,000 tpy.	
At least 20 companies offer mass burn incineration technology or components of this technology, or services to develop such facilities in North America and elsewhere. There are four primary suppliers of the combustion (grate) systems active in the EU and North America.	
Other Summary Points:	
Median Reported Capital Cost (Facility Sized at 200,000 tonnes/year)	▪ $775/annual design tonne +/- 50% (2009$ CDN)
Median Reported Operating Cost (Facility Sized at 200,000 tonnes/year)	▪ $65/tonne +/- 30% (2009$ CDN)
Estimated County Capital Cost (27,000 tonnes/year)	▪ $31.4 million ($1,200/tonne +/- 50% (2009$ CDN)
Estimated County Operating Cost (18,000 to 27,000 tonnes/year)	▪ $1.8 to $2.7 million ($100/tonne +/- 30% (2009$ CDN) annually ▪ Does not include revenues from the sale of recovered energy or materials
Feedstock	▪ MSW, biomass ▪ Minimal waste preparation/pre-processing required by technology ▪ Designed to process variable waste streams
Residual to Disposal	▪ 5% (by weight) if the majority of bottom ash can be marketed for other applications ▪ Up to 20 to 25% by weight if there is no market for recovered materials from the ash (0.2 to 0.25 tonnes per input tonne) ▪ Landfill capacity consumption reduced by 90 to 95%
Potential Energy and Revenue Streams	▪ Revenue potential for: electricity, heat (steam and/or hot water), recovered recyclable metals, construction aggregate ▪ Electricity production, 0.5 to 0.6 MWh/annual tonne of MSW for older facilities[11] ▪ Electricity production rates of between 0.75 to 0.85 MWh/annual tonne for newer facilities
Scalability	▪ Various sizes of mass burn units; use of multiple units also possible
Reliability	▪ Numerous facilities operating worldwide with proven operational success. ▪ Less complex than other EFW approaches ▪ Scheduled and unscheduled downtime reported as <10%.[12]

3.3.2.2 Gasification of MSW

Gasification is the heating of organic waste (MSW) to produce a burnable gas which is composed of a mix of approximately 85% hydrogen and carbon monoxide (syngas). This gas can then be used off-site or on-site in a second thermal combustion stage to generate heat and/or electricity. There are three (3) primary types of gasification technologies used to treat waste materials, namely fixed bed, fluidized bed and high temperature gasification. Of the three (3) types of gasification technologies, the high temperature method is the most widely employed

[11] Juniper Consultancy Services. 2007. a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

[12] AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

at a commercial scale. The following paragraph briefly illustrates the high temperature gasification process.

In high temperature gasification, the heating process begins by feeding waste into a gasification chamber/reactor. Oxygen is injected into the reactor where heat is generated at a temperature of over 3,000°F. The amount of oxygen required is just enough to maintain the heat that is necessary for the process to proceed. The high temperature causes organic material in the MSW to dissociate into hydrogen, methane, carbon dioxide, water vapor, etc. The syngas is processed to remove water vapor and other trace contaminants, so that it can be used for power generation, heating or for other purposes.

Gasification is only used at a few facilities, worldwide, to treat MSW. This is primarily due to operational issues that arise due to the heterogeneous nature of MSW as the gasification process generally requires a fairly homogeneous feedstock. In addition, gasification tends to have much higher range of operating and capital costs in comparison with conventional combustion facilities, given the requirement for waste pre-processing and the added complexity of the technology. Gasification also tends to have higher net costs, given that generally less energy (and thus less revenue) is recovered from the waste stream.[13]

In the United States and Europe, there are currently no commercially operating gasification facilities that treat MSW as the technology is considered too expensive and unproven. The only larger scale commercial gasifier using MSW as feedstock was a Thermoselect gasification plant that was operated in Karlsruhe, Germany for a few years, but it was shut down in 2004 due to technical and financial difficulties.[14]

Summary

Table 5 provides a summary of gasification processes, costs, scalability and reliability.

Note: the costing information that is publicly available for gasification technologies is generally provided voluntarily, and not on the basis of any contractual commitments to the parties involved. It is not clear that reported capital costs address all capital and construction cost elements. Nor is it clear that reported operating costs address all real costs associated with such facilities.

Table 5 Gasification – Summary of Information

Gasification Summary
▪ Gasification combusts fuel to create syngas.
▪ The technology has been in use for over a century, but only recently has MSW been used as a feedstock.
▪ At least 42 companies offer gasification technologies or components of this technology that are capable (or claim to be capable) of treating mixed MSW in North America and elsewhere.
▪ The earliest example of this technology being used for MSW was in 1991 in Taiwan.

13 Fichtner Consulting Engineers. 2004. The Viability of Advanced Thermal Treatment of MSW in the UK. Published by ESTET, London

14 AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*

Gasification Summary	
Other Summary Points:	
Median Reported Capital Cost (Facility Sized at 200,000 tonnes/year)	▪ $850/annual design tonne +/- 40% (2009$ CDN)
Median Reported Operating Cost (Facility Sized at 200,000 tonnes/year)	▪ $65/tonne +/- 45% (2009$ CDN) (this reported cost by vendors seems well below the range of expected operating costs based on performance of gasification in the EU and Japan)
Estimated County Capital Cost (27,000 tonnes/year)	▪ $34.4 million ($1,275/tonne +/- 50% (2009$ CDN)
Estimated County Operating Cost (18,000 to 27,000 tonnes/year)	▪ $1.8 to $2.7 million ($100/tonne +/- 30% (2009$ CDN) annually ▪ Does not include revenues from the sale of recovered energy or materials
Feedstock	▪ Automobile shredder residue (ASR), biomass, black liquor, coal, hospital waste, MSW, organic waste streams, plastics, poly vinyl chloride (PVC), refinery residues, sludge, tires ▪ Waste preparation/pre-processing required by technology ▪ Difficulties in accepting variable (heterogeneous) waste streams
Residual to Disposal	▪ <1 % if bottom ash can be marketed for other applications ▪ 10 to 20% if it is not marketable (0.1 to 0.2 tonnes of residue per 1 tonne of input waste)[15] ▪ Landfill capacity consumption reduced by 90 to 95%
Potential Energy and Revenue Streams	▪ Revenue potential for: electricity, syngas, aggregate recovered from ash ▪ Electricity production, 0.4 to 0.8 MWh/annual tonne of MSW[16]
Scalability	▪ Usually built with a fixed capacity; modular ▪ Individual modules range in size from approximately 40,000 to 100,000 tpy[17]
Reliability	▪ At least seven (7) plants in operation in Japan at a large scale with over two (2) years of operating experience [18]. ▪ Limited data available in other jurisdictions to assess operational success with MSW feedstock in regards to technical reliability ▪ Complex operation ▪ Scheduled and unscheduled downtime reported as approximately 20% [19]. However other reports indicate potential for up to 45% downtime.

3.3.2.3 Plasma Arc Gasification

Plasma arc gasification uses an electric current that passes through a gas (air) to create plasma which gasifies waste into simple molecules. Plasma is a collection of free-moving electrons and ions that is formed by applying a large voltage across a gas volume at reduced or atmospheric pressure. The high voltage and a low gas pressure, causes electrons in the gas molecules to

15 Juniper, 2007 a) and b), *Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW*

16 Juniper, 2007 a) and b), *Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW*

17 AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*

18 AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*

19 AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*

break away and flow towards the positive side of the applied voltage. When losing one or more electrons, the gas molecules become positively charged ions that transport an electric current and generate heat when the electrons drop to a stable state and release energy.

When plasma gas passes over waste, it causes rapid decomposition of the waste into its primary chemical constituents which is normally a mixture of predominantly carbon monoxide and hydrogen gas, known as syngas. The extreme heat causes the inorganic portion of the waste to become a liquefied slag. The slag is cooled and forms a vitrified solid upon exiting the reaction chamber. This substance is a potentially inert glassy solid. The syngas is generally combusted in a second stage in order to produce heat and electricity for use by local markets. In some cases, alternative use of the syngas as an input to industrial processes has been proposed.

Currently, plasma arc gasification is not commercially proven to treat MSW. There are no large scale operating commercial plants in North America or Europe but there are a number of plasma arc systems being proposed to treat MSW. Two (2) technologies which are currently being tested in Canada are the Alter NRG process and the Plasco process..

In the Alter NRG plasma gasification process, a plasma torch heats the feedstock to high temperatures in the presence of controlled amounts of steam, air and oxygen. The waste reacts with these constituents to produce syngas and slag.

Plasco Energy Corp. (Plasco) has also developed a plasma arc gasification technology capable of treating MSW. In April 2006 Plasco entered into an agreement with the City of Ottawa to develop a demonstration facility on City-owned property next to the City's Trail Road Landfill. Construction began in June 2007, and the first waste was received at the facility in January 2008. In the first year of operations (2008), the plant processed approximately 2,000 tonnes of MSW (6% of the permitted annual quantity of MSW), operating for 890 hours,[20] or approximately 37 days (10% plant availability). Commissioning has indicated the need for improvements to the front end of the plant, including pre-processing of the curbside MSW to ensure that the waste received is suitable for the conversion chamber. Plasco has not been in regular operation (24/7) as of mid-2010.

Summary

Table 6 provides a summary of the plasma arc gasification process, costs, scalability and reliability.

Table 6 Plasma Arc Gasification – Summary of Information

Plasma Arc Gasification Summary
▪ Plasma gasification uses an electric current that passes through a gas to create plasma.

[20] Plasco Energy Group. 2010. *Environmental Performance*. Accessed February 10, 2010 http://www.plascoenergygroup.com/?Environmental_Performance

Plasma Arc Gasification Summary	
▪ Plasma arc is not a new technology; it has industrial applications and has been used for treating hazardous waste.	
▪ The earliest facility found to use plasma arc gasification was a test facility which operated from 1987 – 1988.	
▪ The largest facility currently operating in the world is located in Japan (Eco-Valley Utashinai Plant) and processes over 90,000 tpy of MSW and automobile shredder residue (ASR).	
▪ 24 companies supplying Plasma Arc gasification technologies and/or services have been identified that indicate use of MSW as a portion of their feedstock.	
Other Summary Points:	
Median Reported Capital Cost (Facility Sized at 200,000 tonnes/year)	▪ $1,300/annual design tonne +/- 40% (2009$ CDN)
Median Reported Operating Cost (Facility Sized at 200,000 tonnes/year)	▪ $120/tonne +/- 50% (2009$ CDN)
Estimated County Capital Cost (27,000 tonnes/year)	▪ $49 million ($1,820/tonne +/- 40% (2009$ CDN)
Estimated County Operating Cost(18,000 to 27,000 tonnes/year)	▪ $3.2 to $4.9 million ($180/tonne +/- 50% (2009$ CDN) annually ▪ Does not include revenues from the sale of recovered energy or materials
Feedstock	▪ MSW, ASR, hazardous waste, hospital waste, organic waste streams, shipboard waste, tires ▪ Waste preparation/pre-processing required by technology ▪ Difficulties in accepting variable waste streams
Residual to Disposal	▪ Estimated at >1 to 10% (0.1 tonne of residue per 1 tonne of input waste), varying due to the nature of the waste and efficiency of the conversion process.[21] ▪ Inert Slag, APC residue ▪ Landfill capacity consumption reduced by up to 99%
Potential Energy and Revenue Streams	▪ Revenue potential for: electricity, syngas, aggregate substitute ▪ Electricity production, 0.3 to 0.6 MWh/annual tonne of MSW[22] ▪ Note: Plasma arc facilities tend to consume more energy to operate than other types of facilities
Scalability	▪ Modular facilities; multiple modules can be accommodated on a single site with some sharing of infrastructure.
Reliability	▪ Limited data available to assess operational success with MSW feedstock in regards to technical reliability ▪ Eco-Valley Utashinai Plant, Japan processes over 90,000 tpy but feedstock is not 100% MSW ▪ Only two (2) plants (Japan) with two (2) or more years of operations ▪ Canadian facility (Plasco in Ottawa) has not been in regular (24/7) operation as of mid-2010 ▪ Complex Operation, scheduled and unscheduled downtime, unknown[23].

21 Juniper, 2007 a) and b), *Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW*
22 Juniper, 2007 a) and b), *Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW*

3.3.2.4 Pyrolysis

The concept of pyrolysis of MSW gained popularity in the 1960s as it was assumed that since MSW is typically about 60% organic matter, it would be well suited to pyrolytic treatment. By the mid-1970s studies in Europe and the United States concerning the pyrolysis of MSW were completed and some of these studies involved the construction and operation of demonstration plants. By the late 1970s, however, both technical and economic difficulties surrounding the pyrolysis of MSW arose which resulted in the lowering of interest and expectations for the technology. Since that time, the pyrolysis of MSW has been investigated but continues to face technical limitations.

Pyrolysis is the thermal decomposition of feedstock at moderately high temperatures in the absence of oxygen. The end product is a mixture of solids (char), liquids (oxygenated oils), and gases (methane, carbon monoxide, and carbon dioxide). The solid residue is a combination of non-combustible inorganic materials and carbon. Gases produced can be utilized in a separate reaction chamber to produce thermal energy which can then be used to produce steam for electricity production.

Pyrolysis generally takes place at lower temperatures than used for gasification which results in less volatilization of carbon and certain other pollutants, such as heavy metals and dioxin precursors, into the gaseous stream.

Issues identified in relation to the pyrolysis process include:

- Low energy outputs.
- The requirement for a properly sealed reaction chamber for safe operations. The pyrolysis process is highly sensitive to the presence of air. Accidental incursions of air can result in process upsets and increase the risk of explosive reactions.
- The requirement for pre-treatment of the MSW.

Summary

Table 7 provides a general summary of pyrolysis process, costs, scalability and reliability. This cost data is less reliable than the costs presented in this report for other technologies since:

- It is unclear if the reported capital costs address all capital and construction cost elements.
- It is not clear that reported operating costs address all costs associated with such facilities.
- It was also noted that the values were consistently reported to be lower than other similar WTE technologies, but without supporting rationale for these differences.

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[23] AECOM Canada Ltd. 2009. *Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling*

Table 7 Pyrolysis – Summary of Information

Pyrolysis Summary	
▪ Pyrolysis is the thermal decomposition of feedstock at moderately high temperatures in the absence of oxygen.	
▪ The longest operating pyrolysis facility is located in Burgau, Germany. It has been operating since 1987, but it does not treat MSW.	
▪ The largest facility (located in Japan) processes approximately 150,000 tpy of SRF.	
▪ Over 20 companies market pyrolysis technologies or approaches for treating MSW.	
Other Summary Points:	
Median Reported Capital Cost	▪ No reliable data
Median Reported Operating Cost	▪ No reliable data
Estimated County Capital Cost	▪ No reliable data
Estimated County Operating Cost	▪ No reliable data
Feedstock	▪ Biomass, ASR, coal, hospital waste, MSW, plastics, PVC, sludge, tires, wastewater ▪ Waste preparation/pre-processing required by technology ▪ Difficulties in accepting variable waste streams
Residual to Disposal	▪ If treated, residues reduced to 0.1 to 0.3 tonnes per input tonne ▪ >30%, if residue not treated ▪ Landfill capacity consumption reduced by up to 90%
Potential Energy and Revenue Streams	▪ Revenue potential for: electricity, syngas, pyrolysis oil ▪ Electricity production, 0.5 to 0.8 MWh/annual tonne of MSW[24]

3.3.2.5 Summary of Existing Thermal Treatment Technologies

Table 8 presents an overview of the four major types of thermal treatment technologies used worldwide and a number of their key characteristics.

Table 8 Overview of the Four Major Types of Thermal Treatment Technologies Used Worldwide

Characteristic	Conventional Combustion			Gasification	Plasma Gasification	Pyrolysis
	Mass Burn	Fluidized Bed	Two-Stage			
Applicable to unprocessed MSW, with variable composition	YES	NO	YES	NO	NO	NO
Commercially Proven System, with relatively simple operation and high degree of reliability	YES	YES	YES	Commercially proven to limited degree, more complex than combustion and less reliable, very costly	NO	NO

[24] Juniper, 2007 a) and b), *Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW*

Characteristic	Conventional Combustion			Gasification	Plasma Gasification	Pyrolysis
	Mass Burn	**Fluidized Bed**	**Two-Stage**			
Reasonably Reliable set of Performance Data	YES	NO	YES	Limited data. Operational problems have been documented.	Limited data. Operational problems have been documented.	NO
Estimated County Capital Cost – Small Scale Facility (27,000 tonnes)	$31.4 million			$34.4 million	$49 million	No reliable data
Estimated County Operating Cost – Small Scale Facility (27,000 tonnes)	$2.7 million (annually)			$2.7 million (annually)	$4.9 million (annually)	No reliable data

As the table shows, the only commercially proven thermal processing technology capable of treating unprocessed MSW with variable composition with a reasonable level of reliability and are mass burn incineration and two-stage (modular) incineration (both conventional combustion techniques). The table also indicates that significant capital and operating costs could be incurred with developing a small-scale thermal treatment facility, in part as there would be no economies of scale.

3.3.3 Emerging Thermal Treatment Technologies

There is a great deal of flux in the thermal treatment marketplace with regard to new and emerging technologies. The following is a selected list of some emerging combustion and thermal treatment technologies. While there are other emerging technologies, the following represents technologies that are in development (preliminary development, test facilities or commercial scale proposals) in North America. The information is available from technology vendors and generally is yet to be verified by any independent parties.

3.3.3.1 Gasplasma

The gasplasma process is used by Advanced Plasma Power, a United Kingdom-based company. They currently have one (1) small-scale demonstration plant in operation. The gasplasma process uses waste feedstock to produce clean hydrogen-rich syngas and Plasmarok™, a vitrified recyclate, which reportedly can be used as a building material replacement or replacement aggregate.

The gasplasma process is designed for post-diversion materials (i.e., those materials that cannot be recycled or composted). Although it can operate with a variety of feedstock, it operates most efficiently when treating a prepared Solid Recovery Fuel (SRF). Advanced Plasma Power utilizes three (3) different technologies in their process: fluidized bed gasification, plasma arc treatment and a power island (which consists of gas engines for highly efficient power generation). The gasifier operates at a temperature of approximately 900°C. At this temperature, the material is thermally broken down into syngas. The plasma arc treatment "cracks" the dirty syngas coming out of the gasifier. The cracking process breaks the molecular structure of the syngas and reforms it into a simpler structure, thereby producing a hydrogen-rich fuel gas. The hydrogen-rich fuel gas is cooled and further cleaned before being fed into the gas engines at the power island. It is claimed that the electrical generating efficiency reaches 35 – 40%.

The fluidized bed gasifier used in the gasplasma process produces char and ash (approximately 10 – 15% of the feedstock), this material is recovered in Plasmarok™. Plasmarok™ is stated as being an environmentally stable material that can be re-used as a building aggregate (in the UK). The vendor claims Plasmarok™ significantly reduces the amount of residue requiring landfilling; from 60,000 tonnes of SRF, 450 tonnes of activated carbon from the gas scrubbers requires landfilling (over 99% reduction).[25]

3.3.3.2 Thermal Cracking Technology

Graveson Energy Management (GEM) uses a technology traditionally used by the petrochemical industry to convert MSW into clean synthetic gas. The resulting synthetic gas can be used to heat boilers, produce energy, or be converted into methanol. A GEM facility employing thermal cracking technology has been operating in Romsey, England since 1998. It can process up to 1,680 tonnes per day of unsorted MSW.

In thermal cracking, prepared waste material is fed into the oxygen-free chamber. The chamber has stainless steel walls that are heated to 850°C. The waste material is instantly heated and thermally cracks to syngas in a matter of seconds. Syngas entering the Gas Filtration system is further filtered to remove finer particles and is cooled rapidly from 1500°C to less than 400°C to prevent the formation of dioxins and furans. A small portion of the clean syngas is used to heat the GEM Converter, which reduces the need for fossil fuels. The remainder of the syngas can be used in boilers, engines, or turbines for generation into energy. Mineral solids are produced as a residual, typically in the amount of 8 – 10% for domestic waste.[26]

3.3.3.3 Thermal Oxidation

Zeros Technology Holdings uses an Energy Recycling Oxidation System that can reportedly dispose of all classifications of waste. Zeros claims no emissions are produced in the process and other effluents can be sold as products or reintroduced into the system, however to our knowledge, these claims have not been supported by independent verification. The system is closed and uses pure oxygen for the oxidation process, as opposed to ambient air. The oxidation process used by this technology was originally developed for oil spill remediation. Several projects are in various stages of development, however there is currently no Zeros facility in operation.

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[25] Advanced Plasma Power. 2010. *What is Gasplasma – The Process.* Accessed February 10, 2010 http://www.advancedplasmapower.com/index.php?action=PublicTheProcessDisplay

[26] GEM Canada Waste to Energy Corp. 2009. *Process Description and Gas Production.* Accessed February 10, 2010. http://www.gemcanadawaste.com/53257.html

Zeros combines six (6) different technologies in their process: rotary kiln; gasification (Oxy-Fuel Technology); Rankine Cycle Technology; Fischer-Tropsch Fuels Technology; Gas Capture Technology; and Clean Water Technology. The gasification-oxidation process is a two (2) stage process using limited oxygen and high temperature. The system gasifies the fuel source to produce primarily Carbon Monoxide and Hydrogen. This synthetic gas forms the building blocks for the transformation to liquid fuels such as diesel using the Fischer-Tropsch technology.[27]

3.3.3.4 Waste-to-Fuels

Approaches to transform waste into fuels are generally based on the concept that rather than using the syngas produced through gasification as a direct energy source, the syngas can be used as a feedstock to generate various liquid fuels that could then be used off-site.

Enerkem intends to construct the world's first facility intended to produce biofuels from MSW. Construction of the Edmonton facility was set to begin in summer of 2010 (although there have been significant delays in construction already) and operations are currently planned to begin in 2011.[28] Enerkem indicates Alberta will reduce its carbon dioxide footprint by more than six (6) million tons over a 25 year period, while producing 36 million liters of ethanol annually through the use of this facility.

Enerkem converts urban biomass, agricultural residues and/or forest residues into biofuels by means of a four (4) step process:

- Pre-treatment of the feedstock which involves drying, sorting and shredding of the materials.
- Feedstock is fed into the gasifier. The bubbling fluidized bed gasifier converts the residues into synthetic gas and operates at a temperature of approximately 700°C.
- Synthetic gas cleaning and conditioning, which includes the cyclonic removal of inerts, secondary carbon/tar conversion, heat recovery units, and reinjection of tar/fines into the reactor.
- Conversion of syngas into biofuels.

Enerkem intends to produce approximately 360 litres of ethanol from one tonne of waste (dry base).[29]

Changing World Technologies employs a Thermal Conversion Process which converts waste into oil. They state: "The Thermal Conversion Process, or TCP, mimics the earth's natural geothermal process by using water, heat and pressure to transform organic and inorganic wastes into oils, gases, carbons, metals and ash. Even heavy metals are transformed into

[27] Zeroes Technology. 2008. Accessed May 10, 2010 http://www.zerosinfo.com/technology.php
[28] Enerkem. 2010. Edmonton Biofuels Project Status and Schedule. http://www.edmontonbiofuels.ca/status.htm?yams_lang=en
[29] Enerkem. 2010. *Technology Overview.* Accessed February 10, 2010 http://www.enerkem.com/index.php?module=CMS&id=6&newlang=eng

harmless oxides". Changing World Technologies does not have a commercial facility at this time; however, they do have a test centre in Philadelphia, PA.[30]

3.3.3.5 Kearns Disintegration System

The Kearns Disintegration System (KDS) uses thermal disintegration to reportedly combust 100% of waste materials and produce energy. The remaining ash is inert and can be disposed of or used in the construction industry. Promotional material for KDS states no additional fuel or water is used in the combustion process and the emissions from the facility are able to meet environmental standards and guidelines. Proponents of KDS report emissions can be reduced by 90-99% and the volume of waste can be reduced by 84%. The System accepts all types of waste (with the exception of radioactive waste). A prototype has been tested in Nova Scotia and KDS is not entering into commercial development.

3.3.3.6 Steam Reformation

The steam reformation process is utilized by the Elementa Group in their commercial pilot plant located in Sault Ste. Marie. The pilot plant has been operating for over three (3) years. Recently the City of Sault Ste. Marie has decided to move forward with Elementa's technology, and has agreed to be the first in Canada to have a fully operational commercial demonstration plant. The demonstration plant is set to begin operations in the fall of 2011 and is slated to accept 35,000 tonnes of MSW per year and convert it into approximately 6 megawatts of electricity. [31]

The Elementa Process uses steam in an oxygen deprived environment to re-arrange the carbon and hydrogen atoms in waste materials to produce fuels such as ethanol, methanol and other hydrocarbons. Proponents' state 98% of the volume of MSW put through the Elementa Process is reformed into syngas. The majority of the remaining 2% is metals which are separated and recycled and a small amount of inert solids which can be used to manufacture aggregate and cement.

3.3.3.7 Summary of Emerging Thermal Treatment Technologies

Many of the emerging thermal treatment technologies have yet to be proven and the financial capacity of many of the new technology vendors is limited. The technologies offered by many vendors are promising but they cannot be considered commercially proven technologies in Ontario for the management of exclusively MSW. More time is required for various approaches to become more commercially proven. For these reasons, emerging thermal treatment technologies will not be carried forward to the evaluation phase of the project (*Task G*).

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[30] Changing World Technologies. 2010. *What Solutions Does CWT Offer? What is Thermal Conversion Process (TCP)?*. Accessed February 10, 2010. http://www.changingworldtech.com/what/index.asp

[31] The Elementa Group. 2008. *Elementa Power to change the world*. Accessed August 18, 2010 at http://www.elementagroup.com.

3.4 MECHANICAL AND BIOLOGICAL TREATMENT TECHNOLOGIES[32]

3.4.1 Introduction

Mechanical treatment technologies are those that use mechanical means to sort input materials into different fractions based on the physical characteristics of the material. Biological treatment technologies are those that use biological means (the use of microorganisms) to treat input materials for the purpose of stabilizing the biological fraction of the input material waste stream.

Typically, mechanical and biological treatment technologies are combined at a single facility known as a mechanical biological treatment (MBT) plant which processes MSW. MBT plants function to capture recyclable materials from the waste stream and stabilize the biodegradable fraction of the input materials prior to being disposed at a landfill or further processed at a thermal treatment facility. At an MBT plant, waste is either biologically treated and then mechanically separated or mechanically separated and then biologically treated. It should be noted that MBT compliments, but does not replace, other waste management technologies such as recycling and composting as part of a waste management system.

Although mechanical and biological treatment technologies are normally combined at an MBT plant, there are instances when only mechanical treatment or biological treatment alone is used to process MSW. Due to their independence, the two technologies are discussed separately in this section of the report. Mechanical treatment technologies are discussed in more detail in Section 3.4.2, while biological treatment technologies are discussed in more detail in Section 3.4.3.

3.4.2 Mechanical Treatment Technologies

3.4.2.1 Introduction

Mechanical treatment involves some form or forms of physical sorting to isolate and capture individual components (recyclable products) from the input waste stream based on unique physical characteristics of the component such as size, weight or material type. Mechanical treatment can be used to:

- Process “raw” MSW to capture recyclables prior to landfilling;
- Process “raw” MSW to capture recyclables and improve the consistency of the waste prior to further biological or thermal processing; and
- Process the residues resulting from biological and thermal processing facilities to capture recyclable material which would otherwise be disposed.

Depending on the specific nature of the mechanical treatment technology, typical input materials into the process can include:

- MSW from curbside collection;

[32] Much of this information came from Department for Environmental Food and Rural Affairs. 2007. Mechanical Biological Treatment of Municipal Solid Waste.

- Organic materials from a biological treatment process; and
- Ash or char from a thermal treatment process.

Each of these materials has different characteristics and the mechanical treatment process equipment and facility would be designed to accommodate the unique characteristics of each material stream.

3.4.2.2 Process Overview

The input materials are typically received either on a flat concrete floor (tip floor) or in a concrete pit depending on the nature of the input materials and the type of processing equipment employed downstream. The tip floor or the pit is located inside a building with vehicle loading doors to permit delivery of materials. The receiving building is usually enclosed and may be under negative pressure, to control the release of dust, debris, noise and/or odour emissions.

Upon being received, input material is inspected and unacceptable material found is set aside. Unacceptable material typically includes any items that can cause damage to the process equipment or items that can adversely affect the process in terms of output product quality.

A bag breaker may be installed upstream of the process feed conveyor, if the input materials are collected in bags and if subsequent processing equipment does not perform effectively as a result of the presence of plastic bags. A bag breaker is a mechanical device that uses sharp edges or spikes to tear open plastic bags, releasing their contents. Some plastic bags will stay on the bag breaker's spikes, but the majority of plastic must be removed by a subsequent separation step.

After being prepared, the waste is ready for mechanical treatment and is fed into the system via a process feed conveyor. The following bullet list provides a summary of the various waste separation techniques currently being used at mechanical treatment facilities:

- Manual separation (hand sorting) is sometimes employed, whereby people pull or push off recyclables from a moving conveyor belt based on visual inspection.
- Mechanical screens and trommels are often utilized to separate materials based on size. This results in the separation of oversize items (plastic, paper, etc.) from small items (organics, glass, fines).
- The recovery of ferrous metals from the waste stream can be achieved by means of a strong magnet suspended above a conveyor belt.
- The recovery of aluminum can be achieved using an eddy-current separator. These units introduce eddy currents into the waste stream on a conveyor belt and the eddy currents cause a strong repelling force between the separator and aluminum. Aluminum is thus repelled off the conveyor to a storage bin while all other materials continue along the conveyor.
- Near Infrared (NIR) Detector technology can be used to detect and control the automated separation of various types of plastic and fibre containers.

- Sorting of lightweight materials such as plastics from heavier materials can be achieved using an air classifier.
- Wet separation can be used to separate materials based upon differential density (e.g. plastic and organics separated from stones and glass).
- Ballistic separators can be used to sort materials based on density and elasticity (e.g. plastic and paper from stones and glass).

Any solid material remaining after the desired products have been extracted from the facility input material becomes solid residue, which must be disposed. In addition, facility operation and maintenance will also generate solid residue such as damaged equipment components, baghouse residue, odour control device spent media, cleaning materials, etc. which must also be disposed.

3.4.2.3 Outputs from Mechanical Treatment

The products and in-feeds to other components from a mechanical treatment process, depend on the input materials to the process, but typically include:

- Recyclable products (e.g., ferrous metals, aluminium, HDPE and PET plastics).
- Organic materials that have had recyclable products removed and/or have been pre-conditioned for biological treatment.
- Combustible materials that have had recyclable products removed and/or have been preconditioned for thermal treatment.

3.4.3 Biological Treatment Technologies

3.4.3.1 Introduction

Biological treatment involves using microorganisms such as bacteria or fungi to break down the organic constituents (such as food waste and waste paper) of the waste stream. As the microorganisms decompose the organic materials much of the waste is converted into heat, carbon gases and water resulting is large losses in mass and an overall stabilization of the organic fraction of the waste stream.

Biological treatment technologies can be used to treat either source separated organic materials (e.g. those from a green bin/source separated organics program) or a mixed waste stream (i.e. garbage). Although it is much less common, for the purposes of this report, we will discuss the biological treatment of the mixed waste stream only.

Usually, when treating a mixed waste stream, biological treatment is combined with some form of mechanical treatment at a mechanical biological treatment (MBT) facility. At such a facility, the biological treatment component can take place prior to or after mechanical sorting of the waste. In some processes, however, the entire mixed waste stream is biologically treated to produce a stabilized output for disposal to landfill and no sorting is required. Biological treatment of the mixed waste stream offers the potential for a relatively stable landfill (e.g. less production of methane gas etc.) with reduced odours and other nuisance impacts.

There are two main types of biological treatment technologies which can be used to process mixed waste, namely aerobic and anaerobic processes. These processes are described at a high level below.

3.4.3.2 Aerobic Treatment (Composting)

During aerobic decomposition, biodegradable material present in the waste is decomposed into carbon dioxide, water, and heat through microbial respiration in the presence of oxygen. The two (2) 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. After treatment, what remains of the mixed waste are non-biodegradable materials, microbes and microbial remains, and a complex of decomposition by-products called humus.

Aerobic treatment options for mixed wastes can be broken into two (2) subgroups. These two (2) subgroups are in-vessel composting and bio-drying/bio-stabilization. The main difference between the two (2) processes is the degree to which decomposition occurs: in in-vessel composting decomposition is complete while in bio-drying/bio-stabilization, decomposition is only partial.

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 or tunnels. 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. There are various technologies which use the in-vessel approach including tunnel, vertical tower/silo, rotating drum, and house bays, piles or extended beds technologies. The main difference between each specific technology is the method by which the supply of oxygen is applied to the waste material (e.g. mechanical agitation or forced aeration).

Aerobic bio-drying/bio-stabilization is a form of in-vessel composting which is specifically used to reduce the moisture content of the waste material. Drying is achieved by forcing air through the hot biologically active waste to dry it quickly resulting in a partially decomposed end-product. Drying makes the waste more amenable to mechanical separation and increases its calorific value if it is to be used as a fuel at a thermal treatment facility.

3.4.3.3 Anaerobic Treatment (Digestion)

Anaerobic digestion 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 consisting primarily of methane and carbon dioxide, with trace amounts of other compounds. The biogas produced can be stored in large vessels prior to its used on or off site. Normally, biogas is burned to produce heat and electricity using some form of generator.

Although the basic biological process is the same, there are different anaerobic digestion technologies for achieving the conversion of organic carbon to methane. They differ primarily by providing environments that are favourable to different populations of microorganisms. They can be grouped into general categories according to three (3) 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.

3.4.3.4 Outputs from Biological Treatment

The products and in-feeds to other components from biological treatment of MSW, depend on the input materials to the process, and typically include:

- Low grade compost;
- Stabilized biological materials for landfilling;
- Dried material for mechanical processing or thermal processing; and
- Energy such as heat and/or electricity produced from biogas.

Any solid material remaining after the products have been extracted from the plant input material becomes solid residue, which must be landfilled. In biological treatment processes, common residue includes heavy weight materials such as grit and glass and light materials such as plastic film from hydropulping processes and plastic fragments and oversized materials from finished compost screening processes.

3.4.4 Summary of Mechanical and Biological Treatment Technologies

Either mechanical and biological treatment technologies (or some combination of the two technologies) were considered to assist in managing the solid waste produced within the County. That being said, both mechanical and biological treatment technologies do not eliminate the need for other disposal or treatment facilities. Both technologies produce a residue which must be managed at the end of the process. Potential cost to the County to develop a mechanical and biological treatment facility are listed below.

Mechanical and Biological Treatment Summary – Potential County Costs	
Estimated County Capital Cost (27,000 tonnes/year)	▪ $17 million ($620/tonne +/- 40% (2009$ CDN)
Estimated County Operating Cost (18,000 to 27,000 tonnes/year)	▪ $1.4 to $2 million ($77/tonne +/- 50% (2009$ CDN) annually

3.5 SUMMARY OF ALTERNATIVE DISPOSAL OPTIONS

Several alternative disposal options were considered over the longer term including thermal treatment technologies, mechanical treatment technologies and biological treatment technologies. The following table (Table 9) provides an overall summary of the alternative disposal options.

Table 9 Summary of Alternative Disposal Technologies

Option: Consideration of Alternative Disposal Technologies	
Short term or Long term Option	▪ Long term option.
Interaction with other System Components	▪ None.
Potential Cost Implications	▪ Generally greater than landfill disposal however, partnership approach could increase cost-effectiveness. The potential net cost for alternative disposal technologies depends upon economies of scale, the complexity of the processing technologies (the more complex generally cost more) and the revenues that can be recovered from the sale of material and/or energy. For example, in the Niagara Hamilton Long-term Waste Disposal Study, the potential net cost for thermal treatment was estimated between \$100 and \$160 per tonne, as compared to landfill that was estimated as being between \$50 and \$75 per tonne.
Potential Change in Diversion	▪ Some technologies (e.g. mechanical/biological treatment, many thermal approaches) allow for recovery of additional materials from the residual garbage stream.
Potential for System Efficiencies and Improvements in Level of Service	▪ Could create additional disposal capacity with a shared risk and cost with other(s).
Potential Processing or Disposal Capacity Requirements	▪ 1,000,000 m^3 of capacity (equivalent tonnage) or more would be sought, to secure 30 years or more capacity with some contingency.
General Implementation Requirements	▪ Research waste disposal technology(s). ▪ Select partner(s). ▪ Determine cost/risk sharing formula and develop agreement with partner(s). ▪ Determine site location. ▪ Acquire applicable approvals to develop facility.
General Implementation Timeframe	▪ Depending on required approvals to develop facility and the type of facility to be developed, it could be between 4 and 7 years. ▪ 4 years is the estimated time required to obtain approvals and construct a mechanical/biological treatment (MBT) facility. An MBT facility would require approvals and permits under the Environmental Protection Act. ▪ 7 years or more is the estimated time required to obtain approvals and construct a thermal treatment facility depending on the technology. Thermal treatment plants require Environmental Screening under the Environmental Assessment Act and permits under the Environmental Protection Act.
Ability to Adjust Option to Changes to the Waste Diversion Act (WDA)	▪ This could be a less-flexible waste disposal option, depending on the type of waste supply agreements involved. ▪ Disposal levy may be imposed under WDA, which may also apply to processing facilities.

At this time, alternative disposal technologies (ADTs) such as thermal, mechanical and biological treatment are not considered viable alternatives for the County to pursue independently to manage County generated waste during the study period.

It is not anticipated that the County will generate a sufficient quantity of waste at any time during the study period to make an ADT approach to waste disposal economically viable. For example the capital cost to construct a conventional combustion facility capable of processing 27,000 tonnes per year (the approximate amount of waste the County generates per year) would be approximately $32,000,000, with operating costs approaching $3,000,000 per year, for a total cost in the order of $218 per tonne.[33] This does not include revenues that could arise from the sale of energy and/or materials like recovered metals, but these tend to offset only a portion of the gross costs for such a facility. These costs are significantly higher than the costs associated with any landfill disposal option.

ADTs could be utilized by the County at some future time but should only be pursued in partnership with another party such as another municipality(ies) and/or a private sector vendor, which could offer the potential to develop an ADT facility with some economies of scale. It is recommended that the County remain open to pursuing ADT technologies outside this study based on opportunities that become available in the future (e.g. approaches from other municipalities or ADT vendors). Such opportunities would offer the potential to reduce costs, and share risks (such as financing) of proceeding with an ADT. Under such circumstances, the County could offer to host a facility within industrial lands that are appropriate for such a land use and could facilitate the marketing of any energy generated.

In May 2010, the County agreed to work with other local municipalities, Six Nations of the Grand River, Mississaugas of the New Credit, and institutions to promote and develop the local area as a Green Energy Hub within the Province of Ontario. The group is working together through a Green Energy Task Force, led by the Chamber of Commerce, to develop an area of industrial land with green businesses and industries who are devoted to development and production of sustainable development technologies and products. There may be an opportunity to include an ADT facility within the proposed Green Energy Hub lands, should the right partnership opportunity arise.

It is anticipated that technology vendors will approach the County to encourage development of partnership arrangements or permits to build facilities on County lands. Therefore, it is recommended that the County develop a vendor engagement strategy for handling vendor inquiries. Appendix B includes a cover letter and questionnaire that we recommend the County provide to all inquiring vendors. The questionnaire requires interested vendors to supply the County with detailed information about their technology. Vendors who represent proven and reliable ADTs should be able to complete the questionnaire, while vendors who do not have a viable technology will not. This will assist the County in determining if it should proceed with further discussions with any vendors. The County should maintain a record of all completed

[33] Stantec Consulting Ltd. 2010. Waste to Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices.

questionnaires, and take the lead on any future communications with vendors. This approach will ensure that County staff and Council members have a defined and controlled approach for handling vendor inquiries.

ADTs will not be carried forward for further evaluation in this study based on the facts noted above.

4.0 Identification of Existing Disposal Facilities Outside the County of Brant

4.1 INTRODUCTION

The use of available capacity at existing disposal facilities located outside of the County could play a role in addressing both short and long term future solid waste disposal needs. For example, if the recommended disposal option were to develop in-County landfill capacity or a alternative disposal facility, it may be necessary for the County to export waste in the short term to provide sufficient time to secure necessary regulatory approvals and construct new in-County landfill capacity or a alternative disposal facility. On the other hand, exporting waste may also be identified as a preferred option for the longer term.

The Ministry of the Environment (MOE) and Statistics Canada estimate that on an annual basis Ontario produces approximately 10 million tonnes of solid waste that requires disposal. It is estimated that 45 to 50 % of this waste is exported to American waste disposal sites (primarily in Michigan and New York) and the remainder is directed to waste disposal facilities in Ontario.[34][35]

In the last 3.5 years the MOE has approved over 50 million tonnes of additional landfill capacity at Ontario landfills. Landfills that have recently been granted approval for additional landfill capacity include Greenlane Landfill in St. Thomas (owned by the City of Toronto), Warwick Landfill in Watford (owned by Waste Management of Canada), Walker Landfill in Thorold (owned by Walker Industries Holdings Ltd.) and Navan Landfill in Ottawa (owned by Waste Services Canada Inc.). Several of these landfills have capacity available which could potentially be utilized by the County.

4.2 REVIEW OF EXISTING DISPOSAL FACILITIES OUTSIDE THE COUNTY OF BRANT

The County, at this time, is not interested in pursuing waste export as a long-term[36] waste disposal option. There are two main reasons for this decision. First, there are many uncertainties surrounding establishing economically reasonable pricing for disposal outside of the County over the long-term, and second, the availability of long-term disposal capacity outside of the County is nearly impossible to guarantee. Both of these issues pose significant risks to the County which must ensure that the County's waste is managed responsibly throughout the study period.

[34] Ontario Ministry of the Environment. 2008. Retrieved August 18, 2010 from http://www.ene.gov.on.ca/en/land/wastedisposal/index.php

[35] Statistics Canada. 2006. Waste Management Industry Survey: Business and Government Sectors. Retrieved August 18, 2010 from http://www.statcan.gc.ca/pub/16f0023x/16f0023x2006001-eng.pdf

[36] Long-term is considered more than half of the study period (i.e., beyond 2030)

The County is aware, however, that there may be some benefits to exporting its waste outside of its boundaries for disposal over the short-term. By doing so, the County will ensure that the life of the Biggars Lane Landfill Site is maximized until a suitable in-County guaranteed long-term waste disposal solution can be established.

Although the County, at this time, is willing to consider exporting its waste over the short-term, it is not interested in exporting its waste outside of the Ontario. Exporting waste outside of the province subjects the County to additional risks. For example, recent discussions indicate that the Federal government is proceeding with changes to the regulatory environment that would increase the complexity associated with the transboundary shipment of waste to the United States. These types of regulatory changes could lead to increased difficulties and complexities for shipment of waste across the Canadian border, even over the short-term.

For the above noted reasons, waste export will be considered only as a short-term option and only to facilities that are located within Ontario.

4.2.1 Survey of Disposal Facilities Outside The County of Brant

In January 2010, Stantec completed a comprehensive Solid Waste Management Strategy on behalf of the County of Simcoe. As part of the project, Stantec surveyed existing disposal facilities located in Ontario and New York State to determine if there is disposal capacity available at these facilities that could be utilized both over the short and long term. The disposal opportunities survey was sent to 11 existing waste disposal facilities requesting an expression of interest in providing residual garbage capacity. Six facilities are landfill sites and 5 are ADTs (i.e. thermal treatment or plasma arc gasification). Of the 11 facilities, 5 are either located within the Province of Ontario, or final disposal of the material they process is located in the Province of Ontario.

The results of the survey are summarized below (Table 10), including only landfill facilities that dispose of their material within the Province of Ontario. They are not listed in any order of preference.

Table 10 Short-Term Waste Export Options – Identified During Survey

Location
City of Toronto, Greenlane Landfill, London, Southwestern Ontario
Essex Windsor Waste Management Authority, Essex County, Southwestern Ontario
Lafleche Environmental Inc., Landfill, Moose Creek, Eastern Ontario
Walkers Landfill, Niagara Falls, Greater Golden Horseshoe, Ontario
Twin Creeks Landfill, Watford, Southwestern Ontario

Over the short term, the two municipally owned waste disposal sites in Ontario, Greenlane Landfill and the Essex Windsor Landfill, may have capacity available to accept the County's residual solid waste. There are also privately owned landfills in the province which could accept the County's residual solid waste including the Lafleche Landfill site in Moose Creek owned by

Lafleche Environmental Inc., a number of sites owned by Waste Management of Canada and the Walker Landfill located in Niagara Falls.

The list of facilities may be considered as viable options for waste export over the short-term. Waste export will be carried forward to the evaluation phase of the project (*Task G*).

4.2.2 Building Partnership with Neighbouring Municipalities

During the completion of the study, neighbouring municipalities to the County were sent a letter to notify them of the project, inform them that the County was reviewing opportunities to secure short and long term disposal capacity outside of the County's jurisdiction, to inquire if they were undertaking their own Solid Waste Disposal Study or are considering such a study, and if there would be an interest in discussing potential partnership opportunities with the County for disposal of solid waste.

The City of Brantford (the City) responded that they would be interested in discussing potential partnership opportunities with the County. County staff and Stantec met with the City on November 5, 2010. During the meeting the City of Brantford identified that they have capacity available at their Mohawk Street Landfill Site and would be interested in discussing whether they could accept waste materials from the County. Based on these discussions it is reasonable to include this option for analysis. It is recommended that the County carry forward the option to export material to the Mohawk Street Landfill Site in the short or long term.

4.3 SUMMARY OF EXISTING DISPOSAL FACILITIES OUTSIDE COUNTY OF BRANT

The following table (Table 11) summarizes the results of the identification of existing disposal facilities outside the County. Overall, the option of exporting residual solid waste for disposal outside of the County would be a viable option for the County in the short and long term. By exporting waste over the short term, the life of Biggars Lane Landfill could be extended. Exporting waste over the long term would also be a viable option for the County. The option to export the County's waste will be carried forward to the evaluation phase (*Task G*) of the project.

Table 11 Summary of Residual Disposal Facilities Outside County of Brant

Option: Use of Residual Disposal Facilities Outside County of Brant	
Short term or Long term Option	▪ Potential short and/or long term option.
Interaction with other System Components	▪ Would require development of transfer station(s) to consolidate and direct waste if hauled to facilities located outside the boundaries of the County. Transfer would not be required for use of the City of Brantford Mohawk Street Landfill site.
Potential Cost Implications	▪ Capital and operating costs for transfer station(s) to be determined based on volume of materials managed. ▪ Tipping fees for use of external disposal capacity that may be higher than current fees/costs incurred by the County. ▪ Potential to increase overall disposal costs for the County.
Potential Change in Diversion	▪ No change anticipated.
Potential for System Efficiencies and Improvements in Level of Service	▪ Lessen waste being disposed in County landfill.
Potential Processing or Disposal Capacity Requirements	▪ Could reduce consumption of landfill disposal capacity in the County depending on the quantity of residual garbage exported.
General Implementation Requirements	▪ Approvals, design and development of transfer facility (ies) should current transfer capacity be insufficient. ▪ Conduct due diligence of waste disposal facility(s) to be used. ▪ Negotiate a contract for waste disposal capacity provider(s).
General Implementation Timeframe	▪ 12 or more months.
Ability to Adjust Option to Changes to the Waste Diversion Act (WDA)	▪ This is a flexible waste disposal option. ▪ Should changes to the WDA reduce quantities of residual garbage disposed it would simply reduce quantities of waste transferred out of the County. ▪ May result in increased cost for disposal if disposal levy imposed under WDA.

5.0 Identification of County of Brant Landfill Options

5.1 INTRODUCTION

Even with increases in residential waste diversion and the pursuit of alternatives to landfill disposal such as new or emerging alternative disposal technologies the County will still need to secure long term landfill capacity to manage its residual solid waste.

Currently, the County has only one operating landfill, Biggars Lane Landfill, which has approximately 10 years of capacity remaining under its current C of A. The County also manages two other landfills which are currently closed: Burford Landfill and Paris Landfill. Operations at Burford Landfill ceased in 1998. In 2000, Paris Landfill stopped accepting waste for disposal, but the County has additional approved landfill capacity at the Paris Landfill which could be utilized at a future date.

In order to ensure long term disposal capacity, the County may consider expansion of one or more of the County's existing landfills or identify a potential location to site a new landfill within the County's boundaries.

One option that was reviewed but identified to not increase long term disposal capacity is landfill mining. Landfill mining has limited application, being most successful in areas where a landfill facility requires immediate remediation of a significant groundwater contamination issue, where the profile and nature of the waste disposed is clearly understood and where there is a lack of available cover material providing a use for the 'unders' that are recovered through the mining activities.

Another option that was reviewed but was considered too risky to be a viable long term solution was the privatization or sale of the County's solid waste disposal facilities. This option poses a risk to the County, as it would be nearly impossible to guarantee landfill capacity over the long-term and there would be uncertainties surrounding establishing economically reasonable pricing for tipping fees.

This section of the report provides an overview and high level evaluation of landfill disposal options located within the County.

The evaluation has focused on four (4) key areas:

1. Evaluation of the potential to expand the existing (but now closed) Burford Landfill;
2. Evaluation of the viability of developing the approved additional landfill capacity at the Paris Landfill (Site C-1);
3. Evaluation of the potential to expand the existing Biggars Lane Landfill; and
4. Identification of other potential areas within the County where establishment of a new landfill may be viable.

At this stage, a high level review of each option has been completed. Locations that can immediately be identified as not viable are dismissed within the following discussion, with options identified as potentially viable carried forward for additional evaluation under *Task G - Evaluation of Disposal Options*.

5.2 GENERAL CONDITIONS FOR SITING OF A LANDFILL

Ontario Regulation 232/98 (O. Reg.232/98) made under Part V of the *Environmental Protection Act* came into force August 1, 1998 and contains detailed requirements for the design, operation, closure and post-closure of municipal non-hazardous waste landfill sites. The requirements of O.Reg.232/98 are outlined in the companion MOE Landfill Standards[37] document. O.Reg.232/98 applies to new or expanding landfill sites where the total waste disposal volume of the landfill site is greater than 40,000 m^3. For small landfill sites (i.e. less than or equal to 40,000 m^3) and existing landfill sites that are not being expanded, the requirements of O.Reg.347 made under Part V of the *Environmental Protection Act* remain in effect. O.Reg.232/98 outlines specific design specifications that include two generic design options and procedures for development of a site-specific design.

The site-specific design approach included in O.Reg.232/98 gives the site owner flexibility to design the landfill site to suit the local environmental setting, provided groundwater protection is maintained. The acceptability of a design is judged on its ability to meet the requirements of the Reasonable Use Concept (RUC)[38][39] at the property boundary. The MOE sets out how these limits are determined, on the basis that groundwater is used for drinking purposes, but allows for the setting of limits for other circumstances. A site which has been properly designed using these criteria will fully protect groundwater quality. The site-specific design can be either a natural attenuation site or an engineered site. A natural attenuation site relies solely on contaminant attenuation in the landfill buffer area to meet the requirements of the RUC. An engineered site is designed to suit the local conditions and may incorporate a combination of different engineered controls such as a leachate collection system (drainage layer beneath the waste, or a well purge system, or a toe drain) and/or liner with or without reliance on contaminant attenuation in the landfill buffer area.

O.Reg.232/98 includes two generic design options which incorporate specific liner and leachate collection system designs. The Landfill Standards outline that to ensure the generic designs can be used within a broad range of hydrogeologic settings, the designs have been developed such that groundwater protection will be maintained without reliance on contaminant attenuation in the landfill buffer area. The first generic design (GD1) consists of a single liner below the waste, with a natural or constructed 3 m thick low permeability layer below the liner, and leachate collected above the liner. The second generic design (GD2) consists of a double liner,

[37] Ministry of the Environment (MOE). 1998. Landfill Standards, A Guide on the Regulatory and Approval Requirements for New or Expanding Landfilling Sites.
[38] Ministry of Environment and Energy (MOE). 1994. The Incorporation of the Reasonable Use Concept into the MOE Groundwater Management Activities. Guideline B 7.
[39] Ministry of Environment and Energy (MOE). 1994. Determination of Contaminant Limits and Attenuation Zones. Procedure B 7 1.

with a natural or constructed 1 m thick low permeability layer below the lower liner, and two leachate collection systems with the first located above the upper liner, and the second located between the upper and lower liners.

For all proposed new or expanding landfills, a hydrogeological assessment is required. Typically, for proposals using a site-specific design rather than one of the two generic designs, the level of detail in the hydrogeologic assessment will be greater. For landfill sites where an expansion is recommended, the hydrogeologic assessment must account for inputs to groundwater from both the existing waste footprint and the proposed expansion area. This is an important consideration, meaning that even if the expansion were proposed using one of the generic designs, the required level of detail for the hydrogeologic assessment would equal that of a site-specific design.

5.3 IDENTIFICATION OF DEVELOPMENT CONSTRAINTS

The first step in determining if the opportunity exists for identifying potential candidate sites for development of a new landfill site, or expanding one of the existing landfill sites within the County, is to identify and rule out areas that are immediately unsuitable based on developmental constraints. To complete this, a number of data sources have been consulted, including:

- County of Brant Official Plan (OP) and associated Schedules and Appendices (2010).[40] The County provided digital versions of mapping contained in the OP;
- Draft Assessment Report for the Grand River Source Protection Area[41] prepared as part of on-going work on Source Water Protection under Ontario Regulation 287/07 (O.Reg.287/07) made under the Clean Water Act, 2006. The Grand River Conservation Authority (GRCA) provided digital versions of applicable mapping from the Draft Assessment Report;
- Geological, hydrogeological, and natural resource mapping available in GIS format from the Ontario Geological Survey (OGS) and Ministry of Natural Resources (MNR); and
- Available consultant reports from which pertinent information could be gathered.

Appendix C provides a series of figures illustrating the development constraints.

5.3.1 Constraints Related to Land Use

Figure C.1 illustrates the land use designations throughout the County, based on *Schedule A: Land Use Plan* of the OP. A review of Figure C.1 shows that the majority of land within the County has been designated as agricultural, with that area intersected by large portions of lands identified as natural heritage systems (wetlands, woodlots, etc.). The remaining lands have been designated for specific development purposes, including residential (Urban, Suburban,

[40] County of Brant. 2010. County of Brant Official Plan, Adopted by Council September 7, 2010.

[41] Lake Erie Region Source Protection Committee. 2010. Grand River Source Protection Area, Draft Assessment Report. Report prepared under the Clean Water Act, 2006 (Ontario Regulation 287/07). August 12, 2010.

Rural, Hamlets/Villages), commercial, employment (industrial, offices), institutional (medical, education, government etc), parks and recreation, and resource development.

The OP outlines permitted land uses within each of the land use classifications. Waste disposal is not listed as a permitted use within any classification, although it is also not expressly excluded from any land use either. However, establishment of a landfill is inherently incompatible with numerous land uses, particularly lands that have been identified for development of specific purposes to support the long term growth of the County, including:

- Urban Residential;
- Suburban Residential;
- Hamlets and Villages;
- Rural Residential;
- Core Area;
- General Commercial;
- Shopping Centre Commercial;
- Mixed Use;
- Employment;
- Institutional; and
- Parks and Recreation.

Therefore, lands with these designations have been considered unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.2 Constraints Related to Official Plan Special Policy Areas

The County's OP identifies areas of the County where site specific conditions for land development beyond the general frameworks provided in the OP are required. These are referred to as Site Specific Policy Areas (SSPA). For each SSPA, the OP outlines specific policies for development, some of which contain site-specific constraints. The SSPAs are either associated with the land use designations identified above in Section 5.3.1 or as lands designated as Resource Development (See Section 5.3.8). Therefore, they are located in areas which are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.3 Constraints Related to Source Water Protection (Groundwater)

The MOE introduced the *Clean Water Act (2006)* as a means of ensuring the protection of drinking water sources within the Province. A requirement of the *Clean Water Act* is the definition of Well Head Protection Areas (WHPA) for groundwater drinking water sources, as follows:

- WHPA-A represents the surface and subsurface area within a 100 m radius of a production well;
- WHPA-B represents the surface and subsurface area within which the time of travel to the well is less than or equal to 2 years, excluding the area within WHPA-A;
- WHPA-C represents the surface and subsurface area within which the time of travel to the well is less than or equal to 5 years but greater than 2 years; and
- WHPA-D represents the surface and subsurface area within which the time of travel to the well is less than or equal to 25 years but greater than 5 years.
- The WHPA represent areas where practices and policies to protect the drinking water sources from potential contamination will be implemented.

The County currently operates four (4) groundwater supply systems: North Paris (consisting of the Gilbert, Telfer and Fairview Heights Well Fields), Airport, Mt. Pleasant and St. George. In addition, a fifth system in South Paris (Bethel Well Field) has been secured and is scheduled for commissioning in September 2012. A Draft Assessment Report[42] presents WHPA mapping for each of the five (5) systems, which are illustrated on Figure C.2. For each system, For Airport, Mt. Pleasant, St. George and South Paris, the WHPA are relatively small, with the 25 year time of travel extending approximately 4 km from the production wells. For the North Paris system; however, the WHPA are much larger, with the 25 year time of travel extending approximately 20 km to the north.

The County of Brant OP also illustrates WHPAs on *Schedule A: Land Use Plan*; although these WHPAs differ from those identified in the Draft Assessment Report, as the documents were prepared concurrently. Section 2.3.3.2 of the County's OP makes allowances for modifications of the OP based on the outcome of on-going work in relation to the *Clean Water Act.* Therefore, for the purposes of this evaluation, the WHPAs defined in the Draft Assessment Report shall be assumed to take precedence.

In addition to the WHPAs, *Schedule C: Natural Heritage System Features and Development Constraints* of the OP identifies a number of areas that have been designated as groundwater recharge areas by the County. The OP clearly outlines development constraints for the identified WHPAs and groundwater recharge areas to ensure protection of the County's source water. As such, certain land uses and activities are not permitted within an identified WHPA and groundwater recharge area, including landfills. Therefore, lands within an identified groundwater recharge area or a WHPA are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.4 Constraints Related to Source Water Protection (Surface Water)

In addition to the municipal groundwater supply systems operated by the County, the Grand River serves as a source of municipal drinking water for the City of Brantford, located centrally

[42] Lake Erie Region Source Protection Committee. 2010. Grand River Source Protection Area, Draft Assessment Report. Report prepared under the Clean Water Act, 2006 (Ontario Regulation 287/07). August 12, 2010.

to and surrounded by the County, and the Six Nations of the Grand River Reserve located in the southeast corner of the County. A requirement of the *Clean Water Act* is definition of Intake Protection Zones (IPZ) for surface water drinking water sources. The IPZ represent areas where practices and policies to protect the drinking water sources from potential contamination will be implemented.

The Draft Assessment Report presents IPZ mapping for each of the two (2) systems, as follows:

- IPZ-1 is the area in the immediate vicinity of the surface water intake, generally defined as a 200 m radius semi-circle upstream from the intake and a rectangle with a length of 400 m and width of 10 m downstream from the intake;
- IPZ-2 is the area within the surface water body, where there is a 2 hour time of travel to the intake, although this travel time may be refined to meet locale conditions. For the City of Brantford intake a 6-hour travel time was used and for the Six Nations of the Grand River Reserve an 8-hour travel time was used. Also included in the IPZ-2 are lands on either side of the water body; and
- IPZ-3 for both surface water systems represents the area within the surface water body that may contribute water to the intake, and for both systems extends to the head of the watershed.

Figure C.2 illustrates the IPZ-1 and IPZ-2 for both the City of Brantford surface water intake and the Six Nations of the Grand River Reserve surface water intake. A review of Figure C.2 shows that the IPZ-2 for both of these surface water sources cross political boundaries onto lands within the County. The IPZ-3 has been excluded from the current evaluation, due to the large area (essentially all upstream tributaries within the Grand River watershed) represented by the IPZ-3. As such best management practices dictate that land uses and activities not permitted by the OP within an identified WHPA, including landfills, should also be applied to the IPZ-1 and IPZ-2 for these two drinking water sources. Therefore, lands within an identified IPZ-1 and IPZ-2 are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.5 Constraints Related to Geologic Conditions

Figure C.3 provides a map of the surficial geology within the County prepared from GIS mapping published by the OGS. A review of the mapping shows that the County can be split into two distinct zones. The eastern half is characterized by massive, fine-grained, laminated glaciolacustrine sediments. The western half is characterized by coarser grained materials, consisting of glaciofluvial and glaciolacustrine deposits of sand/gravel and a series of moraines (Galt, Paris, Norwich, Tillsonburg).

Figure C.4 provides a map of overburden thickness within the County prepared from GIS mapping published by the MNR. A review of that map shows that thicknesses in excess of 101 m are observed in the central portion of the County, associated with the moraines. In contrast, the overburden thickness near the eastern and western boundaries of the County is significantly thinner, with bedrock exposed at surface in some locations. As outlined in Section 5.2, use of the Landfill Standards GD1 requires a minimum 3 m thickness of low permeability soils in design of a landfill to meet the requirements. Therefore, for the purposes of identifying constraints, areas with an overburden thickness less than 5 m have been identified as constituting a constraint, and these lands are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.6 Constraints Related to Hydrogeologic Conditions

Aquifer vulnerability aquifer refers to the level of protection provided by the geological materials overlying the aquifer to contaminants introduced at ground surface. It is independent of the potential contaminant. A number of means exist by which the vulnerability of an aquifer can be determined, including intrinsic susceptibility index (ISI) mapping and surface to aquifer advection time (SAAT) determination. The Draft Assessment Report presents aquifer vulnerability mapping for the Grand River watershed; within the Region of Waterloo the aquifer vulnerability assessment was completed using the ISI method, with SAAT used for the remainder of the watershed, including the County. Figure C.5 illustrates the aquifer vulnerability within the County. Although the intended purpose of this mapping was for use in identifying threats within the WHPA and IPZ as part of the on-going source water protection work, the mapping is valuable in identifying areas of the County where groundwater is vulnerable to contaminants from the surface. This is particularly important for the County, as municipal water supply is limited to the settlements of Paris, St. George, Mt. Pleasant, Cainsville (via water purchased by the County from the City of Brantford) and in the vicinity of the Airport, with many residents both in rural areas and in settlements such as Burford relying on groundwater for private water supplies.

A review of Figure C.5 shows that the western portion of the County is characterized by aquifers determined to have vulnerability ratings of high to medium, whereas in contrast the eastern portion of the County the aquifer vulnerability is low. A comparison to Figure C.2 shows that the groundwater recharge areas the County has previously identified within the OP fall within the zone of high to medium aquifer vulnerability. Therefore, for the purposes of identifying constraints, it has been assumed that areas with high to medium aquifer vulnerability are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.7 Constraints Related to Natural Heritage System Features

Figure C.6 illustrates the lands identified on *Schedule C: Natural Heritage System Features and Development Constraints* of the OP as wetlands, woodlands, vegetation, natural hazards and areas of natural & scientific interest (ANSIs). Also included on Figure C.6 are lands mapped as Provincially significant wetlands and other significant wetlands based on mapping available from the MNR. The OP does not allow development or site alteration of land that has been designated as Natural Heritage System. Additionally, the OP makes allowances for set-back distances from some Natural Heritage System features. Therefore, for the purposes of identifying constraints, it has been assumed that all areas designated as Natural Heritage within the OP are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.8 Constraints Related to Aggregate Resources

Figure C.7 illustrates the areas identified on *Schedule E: Aggregate and Petroleum Resources* of the OP as containing deposits having aggregate resource potential or containing petroleum pools. A comparison of the surficial geology mapping (Figure C.3), to the aggregate resource mapping shows that the majority of the western half of the County has been identified as having aggregate resource potential, reflecting the coarse-grained nature of the materials in the moraines. These are in addition to the lands within the County that are currently designated as Resource Development, per *Schedule A: Land Use Plan* of the Brant OP, shown on Figure C.1.

A review of the OP indicates that the County actively supports the mining of aggregate resources within its boundaries to ensure that the economic opportunity associated with these deposits is realised. The OP places some constraints to development on lands currently zoned as Resource Development, many through designation of these lands as a SSPA (See Section 5.3.2). Due to the value set by the County on aggregate development, and the inherent nature of aggregate lands as potential groundwater recharge areas, for the purposes of identifying constraints, it has been assumed that all areas designated as having resource potential (i.e. aggregate and petroleum resources, petroleum pool, and resource development area) are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

5.3.9 Constraints Related to Potential Archaeological Resources

Figure C.8 illustrates the areas identified on *Appendix 1: Areas of Potential Archaeological Resources* of the OP. The OP outlines that all development applications within the County require an archaeological assessment to be undertaken. While the identification of an area as having the potential to contain archaeological resources does not preclude development on the lands, it does represent a significant concern that should be taken into consideration for any development application.

5.4 IDENTIFICATION OF POTENTIAL AREAS FOR CANDIDATE SITES

Figure C.9 provides an overlay of the various potential developmental constraints discussed above. Individual constraints are not identified, with the exception of WHPAs, IPZs and groundwater recharge areas, as these areas are of prime importance with respect to drinking water protection. It is important to note that some of the identified constraints (i.e. aggregate resource potential) do not preclude the establishment of a landfill; however, they do indicate that the potential for approval of a development application may be diminished or would require more stringent pre-development assessments. Therefore, for the purpose of this evaluation it has been considered that these lands also represent firm constraints and are unavailable for consideration as potential candidate sites to meet the County's long term waste disposal needs.

A review of Figure C.9 shows that there are only a few small areas of the County that are located outside of any of the development constraints discussed in the proceeding sub-sections. These can generally be described as located:

- A small area in the northwest portion of the County, immediately west of the defined WHPA for the North Paris water supply system adjacent to the boundary with the Township of Blandford-Blenheim;
- Several small pockets of land in the western portion of the County, near the boundary with the Township of Norwich;
- Several areas in the northeast portion of the County, adjacent to the boundary with the City of Hamilton;
- A small area south of St. George;
- An area in the south-central portion of the County, near the existing Biggars Lane landfill and the boundary with Norfolk County; and
- A large area in the southeast corner of the County, between the boundary with the City of Hamilton and the Six Nations of the Grand River Reserve.

It is recommended that the areas marked on Figure C.9 as Area A - the small area south of St. George; and Area B - the lands in the southeast corner of the County, be carried forward for further evaluation. These two areas are identified as preferred over the remaining areas shown on Figure C.9 as they are located at distance from sensitive groundwater features (WHPAs, recharge areas), from sensitive surface water features (IPZs, wetlands, ANSIs), and are underlain by fine-grained, laminated glaciolacustrine sediments.

It is important to note that it is beyond the scope of the current study to complete a full in-depth evaluation of Area A and Area B i.e. detailed evaluation of these areas with respect to site-specific hydrogeologic and natural environment conditions. Rather, the evaluation of these areas will be a high-level review only, focusing for example on the identification of any County owned lands within these areas and establishing if pursuing a new landfill site will meet the County's overall needs.

5.5 BURFORD LANDFILL SITE

The Burford Landfill Site is located approximately 500 m to the southwest of the intersection of 7th Concession Road and East Quarter Townline Road, on Lot 7, Concession 7. Figure C.10 provides a map of the Burford Landfill Site. The Site is approximately 1.5 km west of the Burford Urban Area. The landfill footprint is positioned within a clearing of a forested area, and is relatively small, although the exact dimensions of the landfill footprint are not known with certainty.

5.5.1 Site History

Landfill operations at the Burford Landfill reportedly began in the 1970's, under C of A No. A100402 issued to the Township of Burford. The landfill was permitted to accept non-putrescible domestic waste and 5% other waste limited to construction and demolition debris. A Site inspection conducted by the MOE in 1998 found the Site was out of compliance with the C of A. On September 10, 1998, following the Site inspection, the Township closed the facility. The MOE Site inspection recommended that the Township should undertake a methane gas monitoring program, monitor groundwater for leachate impact, and develop a site closure plan. Due to lower-tier municipal restructuring, the Township did not undertake the recommended work. With its formation in 1999, the County took over responsibility for the Burford Landfill Site.

In 2004, the County retained Urban & Environmental Management Inc. (UEM) to prepare a site closure plan and to address outstanding issues related to the Site. Lotowater Geoscience Consultants Ltd. (Lotowater) conducted a hydrogeologic investigation[43] on behalf of UEM, which included the installation of four (4) monitoring well nests (MW1/04 to MW4/04; Figure C.10) and the establishment of two (2) surface water sampling stations (East Stream and SW2; Figure C.10) on Shaver Drain, south and east of the Site. The report concluded that, while there was evidence of landfill impacts within the fill area, the likelihood of a significant impact occurring downgradient of the landfill in the future appeared to be small. Based on the results of the hydrogeologic investigation, the Closure Plan recommended that continued monitoring of the Site was not required.

In 2006, the County received review comments from the MOE on the Closure Plan and Hydrogeologic Investigation. The County retained Stantec to complete a supplemental hydrogeologic investigation[44] to address the MOE review comments. As part of the investigation, two (2) additional monitoring well nests (MW5/06 and MW6/06; Figure C.10) were established as well as a background and downgradient surface water monitoring stations (SW1 and SW3; Figure C.10). The report provided recommendations for a long term monitoring program.

In October 2007, UEM provided a status update to the MOE on the Closure Plan for the Burford Landfill Site, and in 2008 an amended Closure Plan was prepared by UEM and submitted to the MOE. On May 6, 2009, the MOE issued an amendment to C of A No.A100402, which incorporates the requirement for a long term monitoring program and reporting.

5.5.2 Physical Setting

The hydrostratigraphic conditions in the Burford area have been investigated in detail by Lotowater.[45],[46] The hydrostratigraphic conditions at the landfill have been further investigated

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43 Lotowater Geoscience Consultants Ltd. (Lotowater). 2004. Hydrogeologic Investigation at the Burford Landfill Site, Summary Report. Prepared for: County of Brant and UEM Inc. Lotowater Reference 229-004.

44 Stantec Consulting Ltd. (Stantec). 2008. Supplemental Hydrogeologic Investigation, Burford Landfill Site, County of Brant, Ontario. Prepared for: County of Brant.

45 Lotowater Ltd. (Lotowater). 1997. Groundwater Quality Investigation in the Burford Urban Area. Prepared for: Township of Burford.

46 Lotowater Ltd. (Lotowater). 2002. Development of a Groundwater Protection Strategy, Burford Urban Area. Prepared for: County of Brant, February 2002. Lotowater Reference 213 006.

by Stantec as part of the hydrogeologic investigations noted above, and can be described as follows:

- An upper unconfined aquifer, comprised of sand and gravel, with occasional lenses of silt and/or clay. The water table within the upper unconfined aquifer at the landfill ranges from approximately 0.4 to 1.5 m below ground surface (BGS). The thickness of the upper aquifer below the landfill has not been determined. However, the base of the aquifer (top of underlying aquitard) is estimated to be on the order of 240 m above mean sea level (mAMSL) immediately to the east of the landfill in the Burford Urban Area. Assuming that the top of the aquitard is not marked by significant relief, based on the known ground surface elevation at the landfill of approximately 253 mAMSL, an upper aquifer thickness of 13 m is estimated in the vicinity of the Burford Landfill Site. Recharge to the upper aquifer is interpreted to occur in areas where urbanization has not occurred and precipitation can readily infiltrate;
- An aquitard comprised of silt, clay and/or till, ranging in thickness from 10 to 25 m in the Burford Area. The aquitard serves to limit the downward infiltration of water from the upper aquifer; and
- A bedrock aquifer comprised of the Salina Formation of the Paleozoic Era, consisting of interbedded brown dolostone and grey to green shale with lenses of gypsum and anhydrite. The bedrock aquifer receives recharge via leakage through the overlying aquitard.

The land immediately surrounding the Site is characteristically wet, although the closest defined surface water channel is Shaver Drain, located approximately 150 m to the southeast. Shaver Drain originates to the southwest of the Site and generally runs from west to east, before turning north immediately to the south of the Site, from where it runs in an approximate northeasterly direction until it joins Whitemans Creek, a tributary of the Grand River. Groundwater flow at the Site is generally east to west towards Shaver Drain.

The results of environmental monitoring at the Burford Landfill Site indicate that while groundwater at the Site was in compliance with respect to the MOE's RUC, there was some evidence of minor landfill-derived impacts to Shaver Drain.[47]

5.5.3 Developmental Constraints

A review of the location of the Burford Landfill Site in relation to the developmental constraints outlined in Section 5.3 was completed:

- Figure C. 2 shows that to the south and east of the Burford Landfill Site, lands have been designated as a groundwater recharge area. The County's OP specifically prohibits development of landfills within lands designated as groundwater recharge areas. Although the landfill is outside this area, it demonstrates that the hydrogeologic

[47] Stantec Consulting Ltd. (Stantec). 2010. 2009 Annual Monitoring Report, Burford Landfill Site, County of Brant, Ontario. Prepared for: County of Brant.

conditions at the Burford Landfill Site are not inherently suitable for construction of a landfill. This is confirmed by Figure C.5, which shows that the Burford Landfill Site is located in an area of high aquifer vulnerability;

- Figures A.6 and A.10 show that the Burford Landfill Site is surrounded entirely by lands designated as Natural Heritage Systems. To the east and south woodlands and significant wetlands are mapped, in keeping with the description of the landfills physical setting above. To the west and north, woodlands and natural hazard lands are mapped. In fact, the landfill footprint represents an "island" of lands not mapped as a Natural Heritage System in the immediate vicinity. Therefore, there would not be any buffer between a landfill expansion and the identified Natural Heritage System lands. The County's OP requires a buffer of at least 120 m between developments and wetlands;
- Figure C.7 shows that the Burford Landfill Site is located in an area that has been identified as having aggregate potential; and
- Figure C.8 shows that the Burford Landfill Site is located just outside an area that has been identified as having the potential to contain archaeological resources.

5.5.4 Potential for Development of Future Landfill Capacity

Based on the above-noted development constraints, Stantec's preliminary evaluation indicates that expansion of the Burford Landfill Site to meet the future waste disposal needs of the County is not feasible, and should not be carried forward for further consideration.

5.6 PARIS LANDFILL SITE

The Paris Landfill Site is located in the southwest corner of the Paris Urban Area, at the west end of Railway Street. Figure C.11 provides a map of the Paris Landfill Site. The Paris Landfill Site is bounded by the Nith River and its flood plain to the east, west and south and by Canadian National (CN) rail tracks to the north. The Paris Landfill Site occupies a total of 61 hectares, 11 hectares of which are covered by the existing landfill and 6 hectares of which are licensed for construction of a new landfill (Site C-1). The remainder of the land is designated as buffer area.

5.6.1 Site History

The Paris Landfill began operations in 1948 as a private disposal site. In 1972 the site was purchased by the former Town of Paris, who then operated it as a municipal landfill under C of A No. A100201. In the early 1990's, the former Town of Paris began a search to identify a new landfill for the municipality, as the Paris Landfill was approaching capacity. In 1996, a new landfill, identified as Site C-1, located on the same property as the existing landfill site, was selected as the preferred option and approval was secured under both the *Environmental Assessment Act* and the *Environmental Protection Act*. At that time, the MOE re-issued C of A No. A100201 for the Paris Landfill to reflect both the existing and proposed new landfill areas. To date, the new landfill site has not been constructed.

The existing Paris Landfill reached capacity in September 2000 and ceased accepting waste for disposal. In August 2000, the MOE amended the C of A for the Paris Landfill Site from No. A100201 to No. 7755-4MKJC3, to reflect an internal MOE re-numbering. In November 2000 the County received an amendment to the C of A approving a waste transfer station on the Paris Landfill Site.

The County retained Earth Tech Canada to prepare a draft Closure Plan for the existing landfill site based on the requirements of O.Reg.232/98. The draft Closure Plan was used as a guide for implementing initial closure activities at the existing landfill site. In 2004, the County retained UEM to prepare a final Closure Plan for the existing landfill site. The Final Closure Plan documented activities that had already been completed as part of closure, and outlined additional closure activities, such as placement of final cover, site security measures and post closure maintenance and inspection.

From 1996 to 2004, the annual monitoring program for the Paris Landfill Site was conducted according to the program specified in the 1996 issue of the C of A. The final Closure Plan presented a recommended post closure monitoring program for the existing landfill site, which recognized the significant database of historical data and allowed for continued care of the Paris Landfill in its post-closure state. The County implemented the post-closure monitoring program in 2005.

Reviewers from the MOE's Technical Support Section (TSS) provided comments on the monitoring program recommended in the final Closure Plan. These included comments from both a hydrogeologist and a surface water specialist, and were received by the County in Spring 2005. Over the course of 2005 and 2006, the County and the MOE worked to reach an agreement with respect to the post-closure monitoring program, and on January 10, 2007 received final approval for the program from the MOE.[48]

The County and UEM continued to work with the MOE to finalize the Closure Plan for the Paris Landfill Site. In June 2010, the MOE issued an Amended C of A for the closed Paris Landfill Site, proposed new landfill and the waste transfer facility. The amended C of A governs the post-closure care of the existing landfill and outlines the MOE's requirements for construction of the proposed new landfill (Site C-1) at the Paris Landfill Site.

5.6.2 Physical Setting

The hydrogeologic conditions at the Paris Landfill Site have been studied in detail as part of the on-going monitoring program for the existing landfill site, and as part of the Environmental Assessment completed for the proposed new landfill. The hydrogeologic conditions are controlled by three main physiographic features identified at the Paris Landfill Site[49]:

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48 Stantec Consulting Ltd. (Stantec). 2008. Review of File regarding Groundwater and Surface Water Monitoring Requirements, Paris Landfill Site. Letter to Ed Sharp, County of Brant from Clare Stewart, Stantec Consulting Ltd. dated March 13, 2008.

49 Lotowater Geoscience Consultants Ltd. (Lotowater). 2005. Paris Municipal Landfill Site Report on the Annual Monitoring Program (2004). Lotowater Reference 213-068.

- A plateau/terrace originally covered by sand and gravel deposits but modified by excavation and fill. Stratigraphic conditions below the fill/sand and gravel deposits consist of a clayey silt interbedded with sand and silt, underlain by a stoney till, and subsequently bedrock of the Salina Formation;
- The Nith River alluvial flood plain. The alluvial deposits are underlain by the stoney till and bedrock; and,
- A steep scarp that separates the plateau from the floodplain.

The Paris Landfill Site is situated between two meanders of the Nith River, approximately 2.5 km upstream of the point where the Nith joins the Grand River. To the north of CN tracks passing north of the Paris Landfill Site, several large on-line ponds connected to a series of drainage ditches are located. These ditches eventually join a main ditch flowing through the Paris landfill property to the Nith River.

Groundwater flow in the Paris area is generally from the northwest to the southeast, although shallow groundwater flow is locally influenced by topographic and physiographic features, with shallow groundwater flow directed towards the Nith and Grand Rivers. At the Paris Landfill Site, groundwater is mounded within the existing landfill area, resulting in components of radial flow from the fill area but the overall flow pattern is to the south and the Nith River.

The results of environmental monitoring at the Paris Landfill Site indicated that while groundwater at the Site was in compliance with respect to the MOE's RUC based on chloride, a plume of leachate impacted groundwater is identified to the north and west/northwest for the existing fill area, and in seepage areas to the east.[50] Within the Nith River, concentrations of key indicator parameters upstream and downstream of the landfill are comparable to each other, indicating no impairment of water quality in the Nith River due to the landfill.

The proposed expansion at Site C-1 includes the design of a leachate collection system. Leachate would be collected at the Site and transported to the Paris Water Pollution Control Plant.

5.6.3 Developmental Constraints

A review of the location of the Paris Landfill Site in relation to the developmental constraints outlined in Section 5.3 was completed:

- Figures C.1 and C.11 shows that that the lands for the existing Paris Landfill and the proposed expansion at Site C-1 are zoned as Resource Development in the County's OP. As indicated on Figure C.11, Schedule A-1: Land Use Plan Paris of the County's OP designate these lands as part of SSPA-4 Paris West Resource Lands – County Road 36. The County's OP indicates that for SSPA-4 prior to redevelopment, an Area Study shall be prepared to ensure land use compatibility for both the new and existing uses (i.e. aggregate development). It is unclear if the studies completed in the early

[50] Stantec Consulting Ltd. (Stantec). 2010. 2009 Annual Monitoring Report, Paris Landfill Site, County of Brant, Ontario.

1990's culminating in approval of Site C-1 for landfilling would meet the County's OP requirements in this regard;

- Figure C.5 shows that the Paris Landfill Site is located in an area of high to medium aquifer vulnerability;
- Figures C.6 and C.11 show that the Paris Landfill is adjacent to lands designated as Natural Heritage Systems. The lands immediately surrounding the Nith River, to the west, east and south of the Paris Landfill, are designed as an ANSI with a combination of woodlands, significant wetlands and natural hazard lands. The County's OP requires a buffer of at least 50 m between developments and lands mapped as an ANSI. Provincially Significant Wetlands are also located in this area. A review of the design drawings for Site C-1 indicates that the waste footprint, at its closest point, is approximately 110 m from the ANSI. Although this is beyond the buffer limits established within the OP, it is a factor bearing consideration when determining the potential for future development of Site C-1;
- Figure C.7 shows that the Paris Landfill Site is located in an area that has been identified as having aggregate potential; and
- Figure C.8 shows that the Paris Landfill Site is located just outside an area that has been identified as having the potential to contain archaeological resources.

5.6.4 Potential Landfill Capacity

Stantec has reviewed the Design and Operations Document[51] and design drawings for the approved Site C-1, and determined that the proposed new landfill has an approved air space of approximately 703,000 m^3. Using the population and waste generation projections outlined in Section 2, it is estimated that once the Biggars Lane Landfill reaches capacity, the Paris Landfill Site C-1 could provide disposal capacity for the County until 2042.

5.6.5 Potential for Development of Future Landfill Capacity

At the Paris Landfill Site, the approved additional landfill capacity from the 1996 Environmental Assessment represents a viable alternative that should be carried forward for more detailed evaluation to determine if it can meet the future waste disposal needs of the County. The key in the detailed evaluation will be a review of the developmental constraints identified above.

5.7 BIGGARS LANE LANDFILL SITE

The Biggars Lane Landfill is located in the south part of Lot 1, 2nd Range East of Mount Pleasant Road in the County of Brant (formerly Township of Brantford) at 128 Biggars Lane Road, south of Burtch Road. Figure C.12 provides a map of the Biggars Lane Landfill Site. Surrounding land use is primarily agricultural, although a golf course is located to the south. A few farm residences are located along Biggars Lane Road. Six Nations of the Grand River First

[51] SENES Consultants Limited, 1996. Environmental Protection Act, Design and Operations Document for the Proposed Landfill Site (C-1). Prepared for: Town of Paris.

Nations has a land holding located adjacent to the Biggars Lane Landfill Site. The land was the location of the former Birch Correctional Facility.

5.7.1 Site History

The Biggars Lane Landfill began operations in 1966 as a municipal landfill receiving waste from a portion of the former Township of Brantford. C of A No. A100301 was originally issued in 1971, and has been updated and revised numerous times over the years. This included expansion of the service area to now include the entire County of Brant. The current version of C of A No. A100301 was issued February 15, 2005, with three amendments to the C of A issued on May 2, 2005, August 2, 2005 and May 18, 2006. The Biggars Lane Landfill currently services all of the waste disposal needs of the County.

A new Design, Operation and Maintenance Plan[52] (DOMP) for the Biggars Lane Landfill was prepared by UEM in 2005 on behalf of the County, and was submitted to the MOE in October 2005. The new DOMP proposed an amended disposal footprint, which was approved by the MOE on May 18, 2006. The total area of County owned lands at the Biggars Lane Landfill is 91.18 ha, with the approved landfill footprint comprising 11.1 ha.

The County also holds C of A No. 9792-6T8K7A for Sewage Works related to stormwater management at the Biggars Lane Landfill.

5.7.2 Physical Setting

The hydrostratigraphic conditions at the Biggars Lane Landfill have been defined through a series of hydrogeologic investigations that have been undertaken since 1986, summarized by Lotowater as[53]:

- Unit A – An upper discontinuous sand/silty sand, 1 to 6 m thick. This unit is interpreted to have a moderately good hydraulic connection with the fill material in the landfill, and is considered to be the most significant potential pathway for leachate migration in groundwater. The water table at the Site is generally found within this unit;
- Unit B – A silt/sandy silt/clayey silt, 2 to 15 m thick, which while finer grained material than Unit A, contains lenses of sandy material. Given the discontinuous nature of Unit A, where it is absent Unit B represents the upper hydrostratigraphic unit at the Site. Therefore, while Unit B has historically been interpreted as an aquitard, in places it may actually be a poor aquitard unit and contain the water table;
- Unit C – A clayey silt/silty clay, 20 to 30 m thick, which is continuous in the vicinity of the landfill. Unit C is interpreted as having a much lower hydraulic conductivity than Units A and B, due to the higher fraction of finer grained soils (silts and clays) and horizontal

[52] Urban & Environmental Management Inc. (UEM). 2005. Biggars Lane Landfill Site, Certificate of Approval A100301, Design, Operations & Maintenance Plan. Prepared for: County of Brant.
[53] Lotowater Technical Services Inc. (Lotowater). 2006. Biggars Lane Landfill Annual Hydrogeological Monitoring Report (2005). Prepared for: County of Brant. Reference 213 093.

layering. This unit is thus interpreted to be an aquitard, restricting the movement of groundwater and reducing its potential as a leachate migration pathway; and

- Unit D – Bedrock of the Salina formation, known to be used for domestic groundwater supply purposes, typically characterized by naturally poor water quality.

The main surface water feature in the vicinity of the Site is an un-named creek located approximately 200 to 250 m southwest of the landfill, flowing from west to east through the south landfill buffer area. The creek is a tributary of the Grand River, discharging approximately 9 km to the northeast of the landfill. Horizontal groundwater flow at the Biggars Lane Landfill is to the south-southwest towards the un-named creek.

The results of environmental monitoring at the Biggars Lane Landfill indicated that while groundwater at the Site was in compliance with respect to the MOE's Reasonable Use Policy and the Trigger Values outlined in the DOMP, the results at some monitoring wells in the south buffer area indicate they need to be closely monitored to ensure they remain in compliance.[54] Water quality within the un-named creek is generally comparable at the upstream location SW-C and the downstream location SW-D; however, chloride, total phosphorous and iron are often slightly elevated at the downstream location, and may suggest minimal leachate impacts.

5.7.3 Developmental Constraints

A review of the location of the Biggars Lane Landfill Site in relation to the developmental constraints outlined in Section 3.3 was completed:

- Figure C.5 shows that the far western portion of the Biggars Lane Landfill Site is located in an area of medium aquifer vulnerability. The majority of the land at the Biggars Lane Landfill Site is mapped as having low aquifer vulnerability; and
- Figures A.6 and A.12 show that some pockets of wetland are mapped along the unnamed creek, with a Provincially Significant Wetland noted just to the southwest of the County owned lands.

5.7.4 Potential Landfill Capacity

As outlined in Section 2.2 and on Figure 1-3 of the DOMP[55] for the Biggars Lane Landfill, the total area of County owned lands at the Biggars Lane Landfill Site is 91.2 ha. Of that, 18.4 ha are within the licensed landfill boundary which contains an 11.1 ha approved waste footprint. The remaining 72.8 ha form the landfill buffer area. Much of the buffer area is located upgradient from the licensed landfill area. Therefore, conceptually there are sufficient land resources at the Biggars Lane Landfill to construct a landfill expansion capable of meeting the County's long term waste disposal needs for the planning period ending in 2050.

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54 Stantec Consulting Ltd., (Stantec). 2010. 2009 Annual Report, Biggars Lane Landfill Site, County of Brant, Ontario. Prepared for: County of Brant.

55 Urban & Environmental Management Inc. (UEM). 2005. Biggars Lane Landfill Site, Certificate of Approval A100301, Design, Operations & Maintenance Plan. Prepared for: County of Brant.

5.7.5 Potential for Development of Future Landfill Capacity

Stantec's preliminary evaluation indicates that expansion of the Biggars Lane Landfill or development of a new landfill adjacent to the existing Biggars Lane Landfill (on County owned lands) may represent a viable alternative to meet the future waste disposal needs of the County, and should be carried forward for additional evaluation. This is based on a number of factors, including:

- The hydrogeologic conditions and results of the environmental monitoring program, which suggest that only a small plume of leachate impacted groundwater has developed downgradient of the landfill footprint;
- The County has significant land holdings at the Site, with a large buffer zone located to the north of, and therefore upgradient from, the existing waste footprint. Therefore, the potential exists for expansion of the landfill without the need to acquire additional land holdings; and
- All of the County's current infrastructure related to waste management is located at the Biggars Lane Landfill. This includes scale houses, equipment and transportation routes to and from the landfill. Therefore expansion of this location as opposed to siting of a new landfill allows for seamless continuation of operations.

5.8 SUMMARY OF COUNTY OF BRANT LANDFILL OPTIONS

Based on the evaluation provided herein, the following table (Table 12) presents the list of the landfill disposal options that will be carried forward to the evaluation phase of the project (*Task G*). They are not listed in order of preference. Each of these options are assumed to provide sufficient disposal capacity over the entire study period. For that reason, the options that involve use of the approved additional landfill capacity at the Paris Landfill Site also include additional approaches (short-term export or development of long-term in-County disposal capacity) that would provide the total quantity of disposal capacity needed until 2050. In all cases it is assumed that the remaining approved capacity of the Biggars Lane Landfill site will be utilized prior to the use or development of one of the proposed waste disposal options.

Table 12 In-County Disposal Options to be Carried Forward for Evaluation

Waste Disposal Option
• New Greenfield Site - Area A (south of St. George)
• New Greenfield Site - Area B (southeast corner of the County)
• Short-term export (outside the County) + Paris Landfill Site (approved capacity)
• Paris Landfill Site (approved capacity) + long-term in-County disposal capacity
• Biggars Lane Landfill Site Expansion
• Site new landfill adjacent to Biggars Lane Landfill Site on County owned lands

6.0 Evaluation of Disposal Options

The following disposal and processing options will be carried forward for evaluation in the next step of the Study which is *Task G – Evaluation of Disposal Options*. They are not listed in any order of preference.

Table 13 Summary of Waste Disposal Options Carried Forward for Further Evaluation

Waste Disposal Option
• New Greenfield Site - Area A (south of St. George)
• New Greenfield Site - Area B (southeast corner of the County)
• Short-term export (outside the County) + Paris Landfill Site (approved capacity)
• Short-term export to City of Brantford Mohawk Street Landfill Site + Paris Landfill Site (approved capacity)
• Paris Landfill Site (approved capacity) + long-term in-County disposal capacity
• Export to City of Brantford Mohawk Street Landfill Site
• Biggars Lane Landfill Site Expansion
• Site new landfill adjacent to Biggars Lane Landfill Site on County owned lands
• Short-term export to City of Brantford Mohawk Street Landfill Site + Site new landfill adjacent to Biggars Lane Landfill Site on County owned lands

Task G – Evaluation of Disposal Options involved a comparative evaluation of the identified waste disposal options utilizing criteria and indicators to measure potential effects. Based on the outcome of the evaluation, the study recommends which disposal option(s) are the most viable for the County to pursue for disposal of its non-hazardous solid waste. The evaluation was completed with the appropriate degree of vigor to ensure it meets the pre-planning requirements for the scoping of alternatives for an Environmental Assessment. The recommended disposal alternative(s) identified as part of this study could be used to define the alternative(s) to be assessed in a future Environmental Assessment process and would be used to refine which *Environmental Assessment Act* and *Environmental Protection Act* approval requirements would need to be met.

There are different methods (qualitative, quantitative or a combination of both) that can be used to evaluate the options. A qualitative methodology is commonly applied to address the approval requirements of the *Environmental Assessment Act* and promotes the selection of a preferred alternative considering relative advantages and disadvantages.

The evaluation criteria applied during *Task G* were organized under the following 5 categories:

- Natural Environment
- Social and Cultural Environment

- Economic/Financial
- Technical
- Legal

Table 14 below provides a more detailed explanation of the evaluation criteria, indicators as well as the rationale for considering and applying each indicator.

Table 14 Evaluation Criteria

Criterion	Indicators	Rationale
Natural Environment		
Air Quality Impacts	Distance travelled from main source(s) of waste generated (the centroid of waste generation) to the site(s).	Air impacts from transportation of waste to the site(s) are related to the distance travelled from the area of waste generation to the waste disposal site. Air impacts associated with the site(s) are addressed under other criteria related to sensitive uses (i.e. residential areas, institutions etc.)
	Potential impacts related to emissions of landfill gas, effects on local air quality, exposure to emissions and particulate matter in the direct vicinity of the waste disposal site(s).	Gases produced by landfill facilities can enter the atmosphere and impact air quality. In addition, particulate matter can be released through construction and operations of landfill facilities. The preferred alternative would have to comply with O.Reg. 419/05 (air emission thresholds based on human health effects from airborne air emissions) and the provisions of O.Reg. 232/98 (Landfilling Sites). Note: the project does not include the capacity for an air impact assessment.
Water Quality Impacts (Surface Water and Groundwater)	Relative distance to and type of watercourses (aquatic habitat) present within close proximity of the landfill footprint.	Close proximity of the landfill footprint to sensitive watercourses could result in negative impacts to the aquatic environment due to potential discharges from the site(s).
	Receiving body for wastewater and/or surface water discharge from the site(s).	Depending on the location of the site(s) and nature of the receiving body for wastewater discharge, negative impacts could result to the natural environment and/or social cultural environment due to potential discharges from the site(s). Note: the project does not include the capacity for a water impact assessment.
	Potential impacts to groundwater quality at the property limits, considering local groundwater characteristics.	Compliance with MOE Guideline B-7 (Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities) and O. Reg. 232/98 (Landfilling Sites) in regards to protection of groundwater resources. Application of this criteria and indicator will have to address the difference between the expansion areas for existing sites, with monitoring networks for which there are more ‘known’ site conditions, and for the new landfill areas where there is less data upon which to assess background conditions and thus more risk. Note: the project did not include the capacity for a water impact assessment.

Criterion	Indicators	Rationale
Environmentally Sensitive Areas and Species Impacts	Species of special concern, threatened, and/or endangered species identified by Ministry of Natural Resources (MNR) within 500 m of the site(s).	Proximity of site(s) to sensitive species could result in impacts during construction and operation). Note: the project did not include the capacity for field studies to collect natural environment data.
	Distance from landfill footprint to areas that are designated Natural Heritage Features and Areas including: Significant Wildlife and Fish Habitat; Significant Areas of Natural and Scientific Interest; Significant Wetlands, Woodlands, etc.; Designated Hazard Lands; and, Conservation Areas.	Proximity of landfill footprint to sensitive environmental features could result in impacts during construction and operation).
Terrestrial Ecology Impacts	Amount of woodlands, hedgerows, etc., removed at the site(s) and the degree of impact on the edge of a woodlot/hedgerow.	Negative impacts to the natural environment could result from removal of woodlands or hedgerows on a site(s), including edge impacts on a woodlot/hedgerow.
Social and Cultural Environment		
Compatibility with Existing and/or Proposed Land Uses	Consistency with existing land use designations, approved development plans, and proposed land use changes.	Fewer impacts to mitigate if current and future land use plans are consistent with a waste disposal facility (i.e., avoid sites with an adjacent land use such as proposed residential development). Minimize impact on social environment with sites that are compatible with existing land use designations and would not require re-zoning.
	Compatibility with existing and surrounding land uses.	Fewer impacts to mitigate if existing land uses are consistent with a waste disposal facility. Note: the project does not include the capacity for field studies to collect social and cultural data.
	Size of buffer zone available on the site(s).	Sites larger than the minimum site size would be easier to accommodate the landfill (including design opportunities) and potential impacts could be mitigated with greater distance between the site(s) and surrounding land uses.
Residential Areas	Distance from site(s) to designated residential areas within an appropriate separation distance of the site(s).	A greater distance between the site(s) and residential areas is preferred to reduce the potential impacts of the facility (including visual, noise, dust, litter and odour impacts).
	Number and distribution of residences within 500 m of the site(s) and the density of residential dwellings on the road network within 1 km of the site(s).	Impacts on, and the need for, mitigation measures (for visual, noise, dust, litter and odour impacts) are reduced for site(s) that are located farther away from residents, so rural or lower density residential areas are preferred surrounding the site(s). Note: the project did not include the capacity for field studies to collect social and cultural data.

Criterion	Indicators	Rationale
Parks and Recreational Areas	Number and type of recreational areas (i.e., parkland) within 500 m of the site(s) and the number of recreational areas on the road network within 1 km of the site(s).	Potential nuisance impacts (visual, noise, dust , litter and odour) may effects park and recreational areas. Greater distances to the site(s) would minimize potential impacts and the need for mitigation measures.
Institutional Facilities or Areas	Number and type of institutions within 500m of the site(s) or area and the number of institutional facility on the road network within 1 km of the site(s).	The type of institutions in close proximity should be considered to determine if the waste disposal facility is an incompatible land use. If the institution(s) represents an incompatible land use, then a greater distance to the site(s) would minimize potential impacts and the need for mitigation measures. Note: the project does not include the capacity for field studies to collect social and cultural data.
Traffic Impacts	Type of roadway accessing the site(s) (i.e., paved, gravel) and proximity of site(s) to major arterial roads or highways.	Convenient access to the site(s) will reduce impacts on traffic and to residents/commuters and would ease development of the site(s) as a County facility. Note: the project does not include the capacity for a traffic impact assessment.
Agricultural Impacts	Classification of agricultural lands removed through construction of the facility, and classification of prime agricultural lands and agricultural businesses within 500m of the site(s).	Provincial Policy Statement (2005) requires an evaluation to identify impacts to specialty crops and to agricultural operations.
Archaeological and Cultural Resources	Area of previously undisturbed land that would be used for landfill development at any of the sites, for which there may be archaeological or cultural resources present.	The potential for archaeological resources to be present increases with the amount of undisturbed land that could be used for landfill development. Note: the project does not include the capacity for Stage 1 or Stage 2 archaeological and cultural assessments.
Distance to Federally Regulated or Unregulated Airports	Distance from the site(s) to the closest Federally Regulated or unregulated airports.	Birds are attracted to waste disposal facilities which can pose a risk of bird strikes with aircraft. Consider 8 km radius zone of concern based on the Transport Canada Guideline.
Employment	Number of direct jobs created.	Employment during the construction and operations of waste management facilities is of direct economic benefit to the community.
Economic/Financial		
Capital Costs	Site development costs, including: infrastructure required, upgrades to existing infrastructure (roads, sewers, etc.), property acquisition and possible site remediation.	Sites with lower development costs would be more economically feasible.

Criterion	Indicators	Rationale
Operation, Monitoring and Maintenance Costs	Annual operating, monitoring and maintenance costs. Potential impacts to waste collection and transfer costs based on the location of the site(s).	Impact of facility on the County's financial resources including waste collection costs must be assessed and deemed affordable.
Technical		
Compatibility with Existing Infrastructure	Distance from required infrastructure (i.e., sewers, hydro, road access, water).	Construction may take additional time and extend beyond site(s) location if site(s) does not have existing access to required utilities.
Design/Operational Flexibility Provided by Site	Area surplus to minimum requirement provided by site(s).	Surplus lands will enhance the potential to design a facility capable of managing additional sources of residual wastes (e.g. IC&I wastes or other municipalities) or may be used to enhance the on-site(s) buffer area.
Legal		
Complexity of Required Approvals	Nature of approvals required, considering all potential Federal, Provincial and local municipal planning approvals.	The need for complex approvals and possibly a public hearing present a legal risk to the successful implementation on a particular site. These risks should be considered in the selection of a preferred disposal site.
Complexity of Required Agreements	Nature of property acquisition (related to the need for expropriation, County owned or willing seller site).	Sites that have fewer property acquisition issues associated with them would be less costly from the perspective of time and money. The order of preference based on property acquisition timing would be County owned sites, willing seller sites and sites requiring expropriation.

The evaluation of waste disposal options consisted of the following steps:

- Data collection and application of the comparative evaluation criteria to each of the waste disposal options. Potential effects to the environment were identified based on the application of the comparative evaluation criteria.
- Comparison of the potential effects associated with each option to establish the relative advantages and disadvantages of each option. Under each criterion, options received a ranking based on comparison with the other options, ranging as follows:
  - Major Advantage
  - Advantage
  - Neutral
  - Disadvantage
  - Major Disadvantage.

  The waste disposal option that best met the objective of the criterion was identified as having a major advantage and the option that least met the objective of the criterion would have a major disadvantage. It is not intended that specific ranges would be predetermined for the ranking; instead they will be developed based on a comparison between the potential options. For this study, a qualitative evaluation methodology was applied that uses professional judgment of the Consultant Team.

Advantages and disadvantages were applied as follows:

Table 15 Summary of Advantages and Disadvantages

Ranking	Description
MAJOR ADVANTAGE	**Description**: Use/Development of the waste disposal option would have minimal impact based on the criteria/indicator being applied and in most cases a net benefit would result from facility use/development. **Example**: A waste disposal option that would not require the development of additional infrastructure would be considered to have a major advantage when compared to a waste disposal option that does require additional infrastructure development.
ADVANTAGE	**Description**: Use/Development of the waste disposal option would have manageable impact based on the criteria/indicator being applied and in most cases a net benefit would result from facility use/development **Example**: A waste disposal option that would require the development of limited additional infrastructure would be considered to have an advantage when compared to a waste disposal option that requires more significant additional infrastructure
NEUTRAL	**Description**: Use/Development of the waste disposal option would have no potential benefits or impacts based on the criteria/indicator being applied. **Example**: All waste disposal options being considered have similar infrastructure requirements.

Table 15 Summary of Advantages and Disadvantages

Ranking	Description
DISADVANTAGE	**Description**: Use/Development of the waste disposal option would have some impacts based on the criteria/indicator being applied. **Example**: A waste disposal option that would require the development of additional infrastructure would be considered to have advantage when compared to a waste disposal option that requires less additional infrastructure.
MAJOR DISADVANTAGE	**Description**: Use/Development of the waste disposal option would have a significant impact based on the criteria/indicator being applied and would require extensive mitigative measures to reduce potential impact. **Example**: A waste disposal option would require the development of significant additional infrastructure (i.e. Sewer, water, roads, natural gas, etc.) that in themselves, may have potential negative environmental impact would be considered to have a major disadvantage when compared to a waste disposal option that is already sufficiently serviced and does not require additional infrastructure development.

The rankings are recorded in a summary table and overall rankings for each of the five categories of criteria will be established based on the advantages and disadvantages of the options. The preferred option will be the one with the preferred balance of advantages and disadvantages. This decision will be based on the professional judgment exercised by the Consultant Team and in consideration of the technical database and advice from County staff.

Identification of the preferred option involves the consideration of the options advantages and disadvantages. The comparison was undertaken using a methodology that compared each of the alternative waste disposal options, based on their relative advantages and disadvantages, for each of the five (5) categories of the environment. This comparison of advantages and disadvantages was completed at three-levels as follows:

- **Level 1**, which involved the comparison of all waste disposal options with respect to each of the indicators within a particular criterion of the environment (See Table 14). At this level, each system was assigned a relative Major Advantage, Advantage, Neutral (where the potential effect is neither an advantage nor a disadvantage), Disadvantage or Major Disadvantage;
- **Level 2**, which involved the summation of the advantages and disadvantages identified at Level 1 for each indicator within a particular criterion of the environment to determine the overall advantage or disadvantage of each waste disposal option at the criteria level. (See Table 14). At this level, each waste disposal options was assigned a relative Major Advantage, Advantage, Neutral (where the potential effect is neither an advantage nor a disadvantage), Disadvantage or Major Disadvantage; and,
- **Level 3**, which involved the summation of the advantages and disadvantages identified for each criteria at Level 2 within a particular category of the environment to determine the overall advantage or disadvantage of each waste disposal option at the category level (See Table 14). At this level, each waste disposal option was assigned a relative

Major Advantage, Advantage, Neutral (where the potential effect is neither an advantage nor a disadvantage), Disadvantage or Major Disadvantage.

The purpose of this exercise was to give an indication of the relative strengths and weaknesses of the nine (9) waste disposal options being evaluated. Accordingly, an option with a longer list of significant advantages or disadvantages under a particular category was considered to be an outlier (i.e. significantly advantaged or disadvantaged) in that regard whereas, an option with no or few advantages or disadvantages under a particular category was considered to reside somewhere in the midrange of effects for that consideration.

6.1 COMPARATIVE EVALUATION

The results of the comparative evaluation and identification of waste disposal option advantages and disadvantages are summarized in Appendix D, Table D.1. Supporting documentation for the evaluation is provided in Appendix E.

Where possible, the following decision making guidelines were applied in the summation of advantages and disadvantages to determine the overall Category rankings:

- An advantaged indicator would offset a disadvantaged indicator within the same criteria;
- An advantaged criteria would offset a disadvantaged criteria within the same category;
- The combining of a major disadvantage with an advantage typically results in an overall disadvantage; and,
- Multiple advantages or disadvantages within a category do not constitute an overall major advantage or major disadvantage for the category.

In certain circumstances, professional judgement was applied by the Consultant Team to ensure the degree of advantage or disadvantage of a particular impact or benefit was taken into account.

6.2 SUMMARY OF RELATIVE ADVANTAGES AND DISADVANTAGES

Appendix D, Table D.2 and Table D.3 provide a summary of how the individual criteria rankings were combined to determine the overall advantages and disadvantages of each of the categories of the environment.

Based on the consideration of the advantages and disadvantages noted above in Table 15, the recommended preferred waste disposal option for the County is the development of new disposal capacity at the Biggars Lane Landfill Site, through either an expansion of the existing footprint of the landfill or through the development of a new landfill area immediately adjacent to the existing site. The option for an expansion of the current landfill footprint is moderately more preferred however, the difference in the ranking of the two waste disposal options at this level of analysis is extremely small.

The following table (Table 16) lists the results of the evaluation, presenting the nine (9) waste disposal options in order of the preferred to least preferred.

Table 16 Waste Disposal Options – Evaluation Results

Ranking	Waste Disposal Option
1 (recommended preferred options)	Biggars Lane Landfill Site Expansion
	Site new landfill adjacent to Biggars Lane Landfill Site on County owned lands
2	Export to City of Brantford Mohawk Street Landfill Site
3	New Greenfield Site - Area A (south of St. George)
	New Greenfield Site - Area B (southeast corner of the County)
	Short-term export to City of Brantford Mohawk Street Landfill Site + Paris Landfill Site (approved capacity)
	Paris Landfill Site (approved capacity) + long-term in-County disposal capacity
	Short-term export to City of Brantford Mohawk Street Landfill Site + Site new landfill adjacent to Biggars Lane Landfill Site on County owned lands
4	Short-term export (outside the County) + Paris Landfill Site (approved capacity)

6.3 SUMMARY OF RECOMMENDED PREFERRED OPTIONS – BIGGARS LANE SITE EXPANSION OR NEW SITE DEVELOPMENT

This section provides a summary of advantages and disadvantages of the recommended preferred options and information the County should consider prior to implementation of the preferred.

Table 17 provides an overall summary of the preferred option.

Table 17 Summary of Recommended Preferred Options

Consideration of Preferred Options	
Short term or Long term Option	▪ Long term option.
Interaction with other System Components	▪ None.
Potential Cost Implications	▪ Net Annual Operating Costs should remain close to current operating cost for Biggars Lane, at around $300,000 annually ▪ Approvals (EAA and EPA) would be in the order of $1.1 to $1.23 million. ▪ Construction of the new landfill area at Biggars would cost around $3 to $3.3 million initially, and $2.8 million every 8 years or so to construct new landfill cells. ▪ Overall the total net capital and operation cost for the Biggars landfill option over the 40 year planning period would be around $30.4 to $31.3 million, or around $785,000 annually. The net present value for the recommended option is between $16.9 and $17.6 million.
Potential Change in Diversion	▪ None.
Potential for System Efficiencies and Improvements in Level of Service	▪ Creates additional County owned and operated disposal capacity.
Potential Processing or Disposal Capacity Requirements	▪ 1,000,000 m^3 of capacity (equivalent tonnage). Enough to secure disposal capacity for entire Study Period.

Consideration of Preferred Options	
General Implementation Requirements	▪ Confirm if expansion or developing new landfill adjacent to existing site and finalize site boundaries. ▪ Acquire applicable approvals to develop facility.
General Implementation Timeframe	▪ Seven (7) to ten (10) years. See Section 6.4 for more information.

Below is a summary of advantages and disadvantages of the preferred option.

6.3.1 Summary of Recommended Preferred Option Advantages

The following provides a list of advantages related to the preferred option:

- Option provides opportunity to collect landfill gas.
- No threatened species known within 500 m of the site.
- No ANSIs identified within 500 m of the landfill footprint.
- Possible to develop landfill footprint without removing any hedgerows or woodlands.
- Lands within 500 m of the site are currently used for agricultural operations, but most of the land is leased to the farmers.
- Option is most compatible with existing and surrounding land uses when compared to all other options.
- Existing County owned property provides buffer zone greater than minimum required. Option provides the largest buffer zone of all the in-County disposal options presented.
- No residential, institutional land use designations within 1km of the site.
- Low density of residences on the road network within 1 km of the site.
- No known institutional receptors on the road network within 1 km of the site.
- Area where development could take place has not been identified as having potential archaeological resources.
- Based on capital cost, higher amount of direct and indirect employment related to construction than most other options.
- Lowest estimated net operating and total capital costs over planning period when compared to all other options. Lowest net present value (NPV) of all the options.
- Biggars Lane Landfill site currently serviced by hydro and has an existing stormwater management facility for collection of stormwater. Current upgrades being implemented at the site include a second stormwater management facility.
- Option has the most surplus lands available when compared to all other options.
- No property acquisition is required.

6.3.2 Summary of Recommended Preferred Option Disadvantages

The following provides a list of disadvantages related to the preferred option:

- Potential does exist, as with the other options, for impact to surface water and groundwater resources.
- Potential does exist, as with most other options, for the presence of endangered species within 500 m of the site.
- Potential does exist, as with the other options, for the presence of species of concern within 500 m of the site.
- Potential does exist, as with the other options, for the presence of rare species within 500 m of the site.
- Natural hazards identified, as with the other options, within 500 m of the landfill footprint.
- Provincially or other significant wetlands identified, as with some other options, within 500 m of the landfill footprint.
- Individual Environmental Assessment, EPA approvals and zoning by-law amendment required.
- Residences within, as with the other options, 500 m of the site.
- One area designated and used as a parks and recreation area (i.e. golf course) is noted within 500 m of the site. It's also located on the road network within 1 km of the site.
- Prime agricultural lands located throughout and within 500 m of the site.

6.4 APPROVALS PROCESS FOR PREFERRED OPTIONS

There are three 'phases' of approvals required to develop new landfill disposal capacity in Ontario and therefore proceed with the preferred option:

Phase 1 – Preparation and submission of an Environmental Assessment Terms of Reference (EA ToR) to the Ministry of the Environment for approval. The EA ToR identifies the process the County would follow to undertake an Environmental Assessment under the Environmental Assessment Act. Consultation with a broad cross-section of interested stakeholders is required during the development of the EA ToR. Generally, the process to develop, consult on and obtain approval of an EA ToR can take up to two (2) years.

Phase 2 – Preparation and submission of an Environmental Assessment Study to the Ministry of the Environment for approval. Following the approved EA ToR, the County would conduct a detailed EA Study, examining alternatives for waste disposal and identifying the net effects of the preferred alternative. Extensive consultation with interested stakeholders is required during this process. Generally, an EA Study requires in the order of two (2) to three (3) years to complete and another one (1) to two (2) years to obtain approval.

Phase 3 – Preparation and submission of an Environmental Protection Act (EPA) application(s) in order to obtain a Certificate of Approval to build and operate the facility. Some of this process can be coincident with the EA process, but generally it requires an additional year or two (2) following EA approval for the EPA permits to be issued.

Depending on the nature of the facility, it can take in the order of a year or more for the facility to be developed and commissioned.

In summary, it can take in the order of seven (7) to ten (10) years for new landfill disposal capacity to be approved and developed in Ontario. This is the expected timeline for the approvals process to develop new landfill capacity at Biggars Lane.

7.0 CONCLUSION

This report has been prepared by Stantec for the sole benefit of the County of Brant. The report may not be used by any other person or entity without the express written consent of the County of Brant. Any use of this report by a third party, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The information and conclusions contained in this report are based on work undertaken by trained professional and technical staff in accordance with generally accepted practices at the time the work was performed.

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