STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA

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EXECUTIVE SUMMARY

Greenhouse gas (GHG) emissions from landfills represent a significant source of potential emission reductions for Canada. Conestoga Rovers & Associates (CRA) has been retained to undertake a strategic assessment of the additional potential to reduce greenhouse gas emissions from landfill sites over and above those identified in previous studies for Environment Canada. This project covers the identification and preliminary assessment of the potential to recover landfill gas from landfill sites not included in the original work undertaken in 1999.

The earlier study conducted for Environment Canada as part of the work of the Landfill Gas Sub-Group of the Municipalities Table utilized screening criteria to focus on the larger sites in Canada. Sites with the largest potential for installation of LFG capture and flaring systems were identified in the 1999 study and prioritized with respect to GHG reduction potential. The quantity of emission reductions identified in the 1999 study accounted for approximately 50 percent of the total of all GHG emissions from landfills for Canada estimated by Environment Canada. Environment Canada's estimate was based on a macro review of the total emissions from Canada based on population and numerous other related assumptions. The present study established revised screening criteria that would include smaller sites to identify additional sources of potential emission reductions that were not quantified in the previous studies. The overall objective of this exercise was to understand and rationalize the outstanding balance of the emission reductions that have not yet been accounted for and to assess them as potential sources of future emission reductions.

Since 1999, there have been a few changes in the economic and regulatory framework that may eventually have some bearing on the viability of LFG capture and utilization projects. As of 2002, three of the landfill sites detailed in the 1999 report have been allocated funds though the Green Municipal Enabling Fund (GMEF) but very few tangible gains have been made to emission reductions from landfills in Canada.

Environment Canada undertakes a Greenhouse Gas Inventory on a regular basis. The latest report was published in 2000 for the 1999 inventory. The total potential eCO_2 emissions from landfills across Canada were estimated at 27.74 Mtonnes, including the captured and emitted eCO_2. The present study was reviewed the basis and rationale for Environment Canada's baseline and current estimates of national GHG emissions to assess their validity and inherent variability. The review indicated that there were inconsistencies in the Environment Canada model that should be modified and corrected. The equations used and modeling approach are similar. The differences in output are attributed primarily to selection of the input parameters and discounting for inorganic waste quantities. It is believed that the GHG emissions estimates prepared by Environment Canada for the early 1990s are somewhat higher than reported and that the overall trend is slightly declining rather than increasing.

The updated inventory identified and included 27 additional municipal solid waste landfill sites that meet the modified screening criteria to include smaller sites. According to the most recent available data from Statistics Canada, approximately 21 million tonnes of waste were disposed of across Canada based on population and annual per capita waste generation rates. Of this total quantity, approximately 71 percent has been accounted for by the updated inventory.

Based on the findings of the report the following conclusions are made:

1. GHG emissions from landfills in Canada are close to being stable and are likely declining slowly from a peak emissions rate that likely took place in the late 1980s. Environment Canada's inventory reports for GHG emissions from landfills between 1990 and 1999 increases by more than 20 percent from less than 23 Mtonnes/year to almost 28 Mtonnes/year. This trend is not consistent with the assumptions used and the available data base that presently exists. Based on the data presented in Table 3.1, the quantity of contributing organic waste peaked in 1985. The LFG emissions should have peaked prior to 1990.
2. The Environment Canada emission estimates under predict the 1990 baseline GHG emissions from landfills. The future projections of total potential GHG emissions from waste should be very consistent and level over the next 20 years. Since the emissions profile in any given year is a function of the historical waste filling, the future trends will react slowly regardless of any measures taken to reduce organics disposal in landfills. Essentially, successful and rapid movement towards waste diversion and other 3Rs targets will have only minimal impact over the 2008-2012 period. Any real benefits are well into the future and primarily beyond 2020. This study has made a simplifying assumption that the population increases match any offsetting declines in organics disposal to landfills as a result of proactive diversion and reduction policies. The results of this study are relatively insensitive to this factor over the target period.
3. In the modeling assessment and sensitivity review, it was found that the generation rate constant (k) has a very limited impact on the national emissions estimate but it can have a very significant impact on the emission estimate for a specific site. The k values assigned in the original Environment Canada emission estimates were assigned incorrectly. The parameter assignment that ranged from

a low of 0.003 to 0.028 should be revised to the range from 0.02 to 0.05. The two primary factors considered were rainfall and temperature. Moisture is a critical factor but temperature, in this specific application, is not. The landfills are generally quite deep and the decomposition processes are exothermic in nature. Temperature should not have a major influence on the k factor except for some very northerly sites, which have no influence on the findings of this study.

4. In looking at the overall emissions estimate for Canada, the total emissions constant (Lo) is the dominant factor in the modeling since it establishes the total quantity of emissions that can be released by the decomposition of the organic matter in the waste. In theory, a tonne of decomposable organic matter will generate approximately 600 cubic meters of landfill gas or 300 cubic metres of methane. One of the largest areas of both variability and uncertainty in the modeling assessment is the factor being used for the organic/inorganic fraction in the total quantity of wastes. The Environment Canada value assigned to Lo was declining over the period from 1988 to 1999. A modest decline in this parameter would be acceptable but care must be taken not to reduce this parameter and also deduct allowances for inorganic waste disposal from the total waste stream quantities used. At an assigned Lo value of 170 cubic metres, there is an inherent assumption that almost 50 percent of the mass is not decomposable organic material.

5. The 1999 inventory study accounted for 66 percent of Canada's waste stream landfilled at the 86 largest landfill sites across the nation. This report accounted for an additional 5 percent of Canada's waste stream in an additional 28 mid-size landfill sites across Canada. This leaves an estimated 29 percent of Canada's waste stream. This waste is accounted for as follows:
   - waste landfilled in small rural landfills below the revised screening criteria;
   - waste that is exported for disposal in other jurisdictions (e.g., United States);
   - waste that is incinerated;
   - waste that is treated by other systems (e.g., anaerobic digestion or composting); and
   - variance in the input parameters and assumptions that have necessarily been used in the estimations of waste quantity generation and GHG generation/emission.

6. Approximately 42 percent of the GHG emissions estimate by Environment Canada was accounted for in the 1999 inventory and an additional 5 percent has been identified in this study. These quantities are within the expected assumption base used for the analyses. For example, if it is assumed that two thirds of the total quantity of waste is accounted for and the collection efficiency

is 75 percent, then approximately 50 percent of the total emissions are accounted for. When we review the variance in the organic fraction of the waste mass, this is considered a reasonable level of correlation, within the sensitivity band for assessing the total emission reductions from landfills.

7. Implementing LFG capture and flaring systems at the 75 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 7,400,000 tonnes of GHG emission reduction in 1999. Over the next 20 years the rate of recovery from these sites would average approximately 7,000,000 tonnes/year at an average cost of approximately $1.45/tonne. Approximately 1,000,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $2.34/tonne.

8. Implementing LFG capture and flaring systems at the 85 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 8,340,000 tonnes of GHG emission reduction in 1999 at a slightly increased average cost of $1.51/tonne. Approximately 1,200,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $2.43/tonne. The analyses indicated that the unit cost to reduce emission by increasing the gas collection system efficiency to 85 percent may be viable but it would entail changes and consideration in the development sequence and operations planning for the landfills.

9. Implementing LFG capture and flaring systems at the 95 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 9,850,000 tonnes of GHG emission reduction in 1999 at a substantively increased average cost of $4.26/tonne. Approximately 1,340,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $4.98/tonne. The analyses indicated that the unit cost to reduce emission by increasing the gas collection system efficiency to 95 percent may be technically viable but it would be expensive and would entail major changes in the design, development sequence and operations planning for the landfills.

10. The costs identified in conclusions 7, 8, and 9 do not include allowance for private sector involvement, financing and a return on investment. It is expected that GHG emission reduction values would have to increase by at least 30 percent above the price points noted above with some associated long term confidence in sustainable revenue to initiate private sector interest in the emission reduction projects.

been developed by private sector developers if there is economic merit to construct and operate the facilities. Generally secure revenue streams in the range of $0.06/kWhr, or the equivalent over at least a 10-year term are required to support the economics for a LFG utilization project. This total revenue could be supplemented by revenue from GHG emission reductions but this aspect of the revenue stream would be secondary unless the value of the emission reductions started to exceed $5/tonne. Real revenue for emission reductions would reduce the minimum electrical power purchase price required to support the economics. However, the values would need to be relatively secure for a minimum 10-year term before this revenue stream would become significant enough to encourage very many projects.

12. The total emissions estimates for Canada fall within an envelope between approximately 35 and 45 Mtonnes/year based on the model being used and reasonable selection of input parameters. This is significantly higher than the current reported numbers of approximately 28 Mtonnes/year for 1999 by Environment Canada. There is no attenuation or reduction factor for the effects of soil covers on this estimate that may reduce the total emissions significantly, particularly from the smaller and mid sized landfills.

13. The current GMEF and GMIF funding programs administered by the FCM have, to date, had limited success in encouraging development of LFG projects.

14. As the size of the landfill site decreases, the greater will be the technical difficulty in achieving high collection system efficiencies and the higher will be the cost to achieve emission reductions.

Based on the results of this assessment, the following recommendations are made:

1. The basis and rationale for Environment Canada's emission estimates should be reviewed in detail and revised to reflect current understanding of the various input parameters and pertinent assumptions. The Lo value assigned to the wastes prior to 1988 is too high and should be revised. The k values are too low and should also be revised. The assumptions made regarding waste quantities and per capita contributions have a significant bearing on the projections made. These assumptions should also be reviewed in detail to ensure that the baseline and future projections are both realistic and supportable.

2. Given the increasing costs and the declining benefits, it is unlikely that further survey of smaller sites would yield any viable options for further GHG emission reductions from landfills and is not considered warranted

GHG emission reductions from landfills and is not considered warranted unless GHG emission reduction costs and benefits are valued at well above $5/tonne.

3. The basis for funding support for GHG emission reduction projects from landfills should be reviewed and revised if there is an expectation to show real and significant gains in emission reductions over the next 10 years and beyond.

4. There should be an attenuation or reduction factor included in the modeling analyses that accounts for the effects of soil cover systems. This item should be reviewed and addressed for future emissions modeling estimates from landfills. This factor would tend to lower the overall emissions estimate.

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1.0 INTRODUCTION

Environment Canada has recognized that greenhouse gas (GHG) emissions from landfills represent a significant source of potential emission reductions for Canada. Over the past few years, various studies by Environment Canada, and others, have developed estimates of the potential emission reductions that may be achieved from landfills. Further studies have documented emission reductions that have already been achieved through effective management of the landfill gas resource in Canada. Conestoga Rovers & Associates (CRA) has been retained to undertake a strategic assessment of the additional potential to reduce greenhouse gas emissions from landfill sites over and above those identified in previous studies for Environment Canada.

Expanding or implementing landfill gas recovery systems can play an important role in Canada's commitment to reduce greenhouse gas emissions. It has been estimated that approximately 28,000,000 tonnes of carbon dioxide equivalents are presently emitted from landfills annually. At present, approximately 6,000,000 tonnes are being collected and flared/utilized [1] leaving a residual balance of approximately 22,000,000 tonnes of carbon dioxide equivalents being emitted. The earlier studies conducted for Environment Canada as part of the work of the Landfill Gas Sub-Group of the Municipalities Table utilized a screening criteria to focus on the larger sites in Canada. The 1999 study identified a further 6,000,000 tonnes of potential emission reductions that could be developed, along with an estimate of the costs to achieve the additional emission reductions at the identified sites.

The estimates noted above still leave an outstanding undeveloped potential for further emission reductions of more than 50 percent of the total national estimate of greenhouse gas emissions from landfills. Some of these potential additional emission reductions may still be achievable at costs that may be competitive with other opportunities for achieving emission reductions. This project expands upon the identification and preliminary assessment of the potential to recover landfill gas from landfill sites in Canada not included in the original 1999 study. The scope of the supplementary assessment is summarized in the following:

- Review the methodology for and estimates provided in Canada's latest inventory of greenhouse gas emissions (1999), and provide an initial assessment of the quality of this inventory relative to known landfill sites, landfill gas recovery projects and current waste management practices. The review will assess past estimates as well

[1] Inventory of Landfill Gas Recovery and Utilization in Canada, Environment Canada, December 1999.

as both current and future projections to understand the overall potential for emission reductions from landfills in Canada. The variance in the national emission estimates will be provided along with discussion of critical assumptions and parameters that impact the total emission estimates;

- Review the listing of landfill sites in Canada and to expand the information base both regionally and nationally to account for some of the remaining quantities of greenhouse gas emissions from landfills. The review will use population and the existing 1999 site listing to identify missing sources of significance;
- Provide a preliminary assessment of the potential to recover further quantities of landfill gas, and the likely range of costs for capturing, flaring and/or additional utilization of landfill gas from these sites. Sites examined in recent feasibility studies under the FCM Green Fund will be briefly reviewed in this assessment; and
- Present the above in a report. The report will provide recommendations for any next steps and will identify areas for further work to improve the quality of information on opportunities to reduce greenhouse gas emissions from landfill sites in Canada.

2.0 BACKGROUND

This project is one of Environment Canada's initiatives in the federal climate change strategy to develop action plans to further reduce GHG emissions as a part of Canada's commitment made in Kyoto in 1997 to reduce GHG emissions to 6 percent below 1990 levels during the period 2008 to 2012. The municipal solid waste sector has been identified as having potential to achieve significant, early reductions in GHG emissions.

2.1 LANDFILL GAS SUB-COMMITTEE WORK

The Landfill Gas (LFG) Sub-Committee was formed in July 1998 with the mandate to develop options for reducing GHG emissions from landfill sites including the capture, flaring, and utilization of landfill gas.

To fulfill its mandate, the Landfill Gas Sub-Committee, with the support of Environment Canada, carried out the following three steps in assembling the information necessary to develop the options paper:

- a Foundation Paper to provide the background and rationale;
- a detailed inventory to identify and assess landfill sites in Canada with the most potential for additional GHG emission reductions; and
- a national consultation process culminating in a workshop with stakeholders from governments, municipalities, and the private sector.

The landfill gas sector has repeatedly been identified as having the potential to demonstrate real and significant reductions to Canada's GHG emissions. Specifically, landfill gas generated through the anaerobic decomposition of organic wastes in landfills is reported by Environment Canada in 1999 to be one of Canada's most significant sources of anthropogenic (man-made) methane (26 percent).

2.2 IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS RECOVERY AND UTILIZATION (JULY 1999)

In support of the LFG Sub-Committee work program noted above, Environment Canada initiated a study to identify, assess and rank landfill sites across Canada that present the best opportunities to control and utilize LFG to reduce GHG emissions (least cost for most GHG reduction). Sites with existing LFG capture/flaring and utilization were further evaluated to estimate the percentage of gas collected and whether there was potential for additional improvements. The sites were identified and prioritized with respect to GHG reduction potential.

A secondary objective of the 1999 study was to identify possible obstacles that may hinder or prevent use of the captured methane. To date, there are only a relatively modest percentage of landfill sites that have controls in place to destroy the methane by flaring or to use it as an energy source.

The site screening criteria for this 1999 assessment was based on the following key factors:

- waste tonnage in place (small, medium and large landfills);
- age of waste; and
- service life of the landfill.

The following screening criteria matrix was developed to identify candidate sites with LFG generation and GHG emission reduction potential:

Site Closure	*Minimum Capacity at Site Closure (tonnes)*
Prior to 1980	Not considered further
1980 – 1985	>2.5 million
1985 – 1990	>2.0 million
1990 – 1999	>1.5 million
Active Landfills	>1.0 million

Sites that met the above criteria were entered onto the master site list and were cross-referenced against Canada's population density to ensure that all large population centres were represented. One other important consideration was that only sites and fill capacities that were currently approved in their respective jurisdictions were considered in the analyses. At the time, waste export was not considered to be a major issue or consideration in the evaluation.

Flaring Action

The 1999 assessment projected that there was potential for additional capture and flaring of LFG from 73 landfill sites to reduce GHG emissions by more than 6,000,000 tonnes of eCO_2 each year for the time frame identified in the Kyoto protocol and beyond.

Flaring also yields a number of secondary benefits such as: reducing the emissions of other trace gases found in the landfill, some of which are toxic and/or GHGs; reducing the potential for odour emissions; and, reducing the potential for any subsurface landfill gas migration.

In the 1999 study, the average costs of the greenhouse gas reductions from capture and flaring at the 73 identified sites over the 2008-2012 period were estimated as follows:

Cost(1999$) (per tonne eCO_2)	*Total GHG Emission Reduction (eCO_2 tonnes/year)*
< $1.00	~ 800,000
$1.00 - $2.00	~ 4,000,000
$2.00 - $3.00	~1,500,000

It should be noted that the above values represent a best estimate of the required capital to construct and operate facilities to obtain the emission reductions. However, there is no consideration for a return on investment that would be required if the private sector were to become involved to develop the resource.

Utilization Action

The 1999 assessment determined that there was potential to further increase GHG emission reductions through developing landfill gas utilization projects thereby bringing in revenues, displacing the use of another fuel source, and obtaining what were hoped to eventually become valuable eCO_2 emission reductions. There was a potential for incremental GHG emission reduction due to displacement of other fuel use on the same grouping of sites of almost 700,000 tonnes per year, assuming natural gas as the marginal displacement fuel. The above noted estimates were incremental to the GHG emission reductions established for capture and flaring.

A combined approach with both flaring and utilization appeared to offer the lowest cost for the greatest overall GHG emission reduction, but this was very sensitive to the assumptions related to the revenue that could be achieved for the energy products. The issue of the private sector need for a return on investment to encourage it to participate in projects was, and remains, a significant factor. It was estimated that in 2010, more than 6,000,000 tonnes of eCO_2 reduction could be realized by developing the 40 largest sites (>5,000,000 tonnes of total waste capacity at closure).

The market conditions for the primary energy products were the governing factors pertinent to the economic feasibility of a LFG utilization project, unless the value of emission reductions increases substantively beyond the $2.00 per tonne level. The primary motivation for private sector involvement is a return on investment for a particular project or possibly protecting returns in some other market sector that could be affected by an enforceable federal of provincial policy related to energy products or GHG emissions. Variations in the energy product values and revenues that change significantly both geographically and over time are beyond the scope of this report. However, under present market conditions, the energy product valuations remain the primary motivator for the economics of a landfill gas utilization project.

2.3 CURRENT MARKET CONDITIONS FOR ENERGY PRODUCTS FROM LFG UTILIZATION

Since the 1999 study was completed, there have been a few changes in the economic and regulatory framework that may eventually have some bearing on the viability of LFG capture and utilization projects.

The deregulation of the electrical power market has been proceeding slowly. In Ontario, the electrical power market deregulation took effect on May 1, 2002. The average wholesale-power sales rate in Ontario is now expected to be in the range between $0.042 and $0.050/kWhr (2002 Dollars). This is somewhat improved from the 1999 projections but still remains highly speculative and beyond the scope of this report. There is a general expectation that electrical power pricing may oscillate somewhat for the first few years following the start of the deregulation until the demand/supply aspects of the market eventually stabilize.

The conditions in the deregulated market in Alberta have been somewhat variable and unstable over the term since the deregulation of power came into effect. Prices have increased from those prior to deregulation but not to a level that would encourage landfill projects to be developed unless they can support themselves on their basic economics without consideration being given for any value of the emission reductions.

Most of the other provinces are watching the process in Alberta and Ontario but there have been no major changes to the current market access as yet. In British Columbia, BC Hydro is offering a modified and enhanced power pricing structure for some qualifying renewable energy projects but not in the form of any standardized offering and not at levels that are adequate to generate much private sector interest. A prospective project at the Vancouver Landfill has been undergoing discussions regarding a LFG utilization project based on a front end loaded power sales agreement. However, the City has taken responsibility for the LFG collection system costs to improve the economic viability of the project. Additionally, the Vancouver landfill represents the largest and most reliable fuel resource of all of the landfill sites in British Columbia from the perspective of yielding a stable long-term energy resource for the development.

There have been some developments in the area of recognizing renewable energy and granting enhanced revenue streams for qualifying projects. The Eco Logo certification of "green power " qualifying projects now in its final review stages. The current version of ECP-79 does allow LFG utilization projects to qualify. However, the rules and guidelines remain quite restrictive and it remains to be demonstrated whether or not it will encourage the development of any LFG to energy projects. To date, the net positive overall environmental benefits of LFG emissions controls have not been recognized in the development of the policy.

Natural gas prices have been highly variable over the past few years. This should offer a significant advantage to potential LFG projects where access to markets for direct use of the fuel exist. As discussed in the 1999 study, direct uses of the fuel is a highly attractive approach where a viable end user presently exists in relatively close proximity to a site. There have been two new direct fuel use projects initiated in Ontario since the 1999 study was published. Unfortunately, there are few, if any, additional candidate projects for this type of LFG utilization development in Canada over the next 10 years.

The generally accepted average power sales rate (net of charges) that would encourage LFG use for electrical power generation is in the range of \$0.06/kWhr. This represents a premium of \$0.015 to \$0.030/kWhr over the current market pricing depending upon the province. Converting this revenue into equivalent value for GHG emission reductions, the value is approximately \$3.00 to \$6.00/tonne eCO_2. This revenue stream would need to be perceived as stable as that from the sale of an energy product (e.g., electricity or fuel etc.) for at least a 10-year term to effectively encourage and support LFG utilization project development. To date, long-term contracts for sale of emission reductions at confirmed price structures have not been generally available.

2.4 GREEN MUNICIPAL ENABLING FUNDS

The Federation of Canadian Municipalities (FCM) has been given mandate to administer two funds to encourage GHG emission reduction initiatives of its members. The Green Municipal Enabling Fund (GMEF) exists to provide federal assistance to municipalities in search of potential new technologies or best practices. The fund, with \$25 million allocated to it, will be in operation from 2000 to 2005 and available to those municipalities and their private or public sector partners that meets GMEF goals and requirements. GMEF hopes to contribute to 150 municipal projects yearly through grants covering up to 50 percent of relevant costs with a maximum contribution of $100,000. The projects must be innovative in nature and assess the economic, environmental and/or technical aspects involved. These feasibility studies should strive to improve air, water or soil quality, protect the climate or promote use of renewable resources. Further, each study should demonstrate the potential for their project to produce measurable and verifiable results by improving environmental performance or energy efficiency.

As of May 2002, three landfill sites have been allocated funds though the GMEF:

Location/Proponent	*Funds Allocated*	*Landfill Name*	*Project Overview*
London, ON The City of London	$42,500	W12A	Feasibility study for collecting and flaring landfill gas and, where it is impractical, to extract gas using a biofilter
District of Fraser, BC District of Fraser, Fort George	$42,000	Foothills Boulevard	Study will assess the options of utilization of landfill gas from this landfill including financing options, potential partners, approvals, permits, and greenhouse gas credits.
Nanaimo, BC The City of Nanaimo	$29,500	Cedar Road	Expected to close in 2005, the study will assess the possibility of expanding the current landfill gas collection system in the short term to increase collection rates.

The number of applications and approved feasibility studies will have to increase substantively over the next 3 years if the FCM and Environment Canada are to approach their stated goal of 150 municipal projects.

There is also a Green Municipal Investment Fund (GMIF) that has been established to encourage projects identified through the GMEF process, or any other mechanism that identifies a qualifying project. The GMIF is intended to be used to develop and implement full-scale projects that produce measurable and verifiable results related to GHG emission reductions. Unfortunately, to date no projects have received any funding pursuant to this process. One project at the Vancouver Landfill had been negotiating an application for loan funding support under this program but it has not yet been finalized and executed. There is also some recent consideration being given to the application of the funding criteria that may allow some grant/loan arrangements to encourage the development of a few innovative projects, although no successful applications have been made to date.

3.0 NATIONAL GHG EMISSIONS INVENTORY - REVIEW AND VALIDATION

Environment Canada undertakes a Greenhouse Gas Inventory on a periodic basis. The latest report, published in 2000 for the 1999 inventory, indicates a total methane (CH_4) emission of 1,040.72 kilotonnes or approximately 21.86 mega tonnes (Mtonnes) of eCO_2 emissions from solid waste disposal on land. This inventory presents the net emissions, which has deductions for the LFG that is captured, flared and/or used. The total potential eCO_2 emissions from landfills across Canada for 1999 were estimated at 27.74 Mtonnes, including the captured and emitted eCO_2.

In 1999, 42 active LFG capture and utilization systems were combusting an estimated 280 kilotonnes of methane or 5.9 Mtonnes of eCO_2. Of these active systems, 26 landfills flared the captured gas, while the remaining 16 facilities utilized the gas to generate electricity or heat. At these 16 facilities, the majority (68 percent or 192 kt/year of CH_4) of the captured LFG was utilized and the remaining 32 percent (89 kt/year or CH_4) was flared[1].

The balance of Section 3 provides background information to these estimates as well as an explanation of how the LFG estimate was developed by Environment Canada, followed by a review and critique of the estimate.

3.1 LANDFILL GAS GENERATION MODELING- ENVIRONMENT CANADA

A number of models are available for estimating LFG production. Accepted industry standard models are generally first order kinetic models that rely on a number of basic assumptions regarding site specific conditions. These models are used to predict the LFG generation rate over time for a typical unit mass of solid waste. This LFG generation rate curve is then applied to projections of solid waste filling at each site to produce an estimate of the LFG production for the entire site. LFG is produced by the anaerobic decomposition of organic wastes. The first phase of decomposition generally takes place during the first year after the waste has been placed in the site and the majority of the LFG is generated within the first 20 years of landfilling, although emissions may continue for over 100 years.

The volume of GHGs released from a landfill is a function of the LFG generating potential and the nature of any capture and/or utilization systems that may be in place.

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1 Inventory of Landfill Gas Recovery and Utilization in Canada, Environment Canada, December 1999.

LFG consists of approximately 50 percent methane and 50 percent carbon dioxide and other trace gas constituents. The methane component of LFG is a potential energy resource, and a powerful GHG that contributes to global climate change. Methane is a GHG that has 21 times the global warming potential of carbon dioxide based on a 100-year time horizon [2].

The rate of increase of atmospheric methane is among the highest of all GHGs. Increases in methane emissions are reported to represent more than 20 percent of the overall increase in GHGs in Canada during the period 1990 to 1995 [3]. Because of methane's global warming potential, reductions in methane emissions can have a much more immediate and significant impact on the atmosphere than is calculated strictly by considering carbon dioxide emissions.

The Scholl Canyon model is the most widely used first order kinetic model, which uses site specific landfilling history/projections together with some predefined input parameters to estimate LFG production. The Scholl Canyon model is used to estimate LFG production over time as a function of the LFG generation constant (k), the methane generation potential (L_0), historic filling records, and projections of waste filling.

Methane Generation Rate (k)

The methane generation rate constant (k) represents the first order rate at which methane is generated following landfilling. The constant is influenced by:

- moisture content;
- availability of nutrients;
- pH; and
- temperature.

The moisture within a landfill is considered to be one of the most important parameters controlling gas generation rates. Moisture provides the aqueous environment necessary for gas production and also serves as a medium for transporting nutrients and bacteria. The moisture content in the landfill is strongly influenced by climatic conditions (rainfall, etc.), initial moisture content of the landfilled waste and specific landfill design features such as type of base liner, type of leachate collection, type of cover and programs such as rapid stabilization. Since the generation rate is largely a function of

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[2] Climate Change 1995, Intergovernmental Panel on Climate Change.
[3] Canada's Second National Report on Climate Change, 1997.

rainfall, the default value for k varies from region to region. Typically, k values range from 0.02/year for dry sites to 0.07/year for wet sites.

The k values are largely based on tests conducted at various US landfills and are related to precipitation assuming that moisture content of a landfill is a direct function of precipitation. Environment Canada selected and utilized the following k values, calculated by B.H. Levelton (1991) based on the mean daily temperature and average annual precipitation for each province.

Values of k

Province	k
British Columbia	0.028
Alberta	0.006
Saskatchewan	0.006
Manitoba	0.006
Ontario	0.024
Quebec	0.024
New Brunswick	0.011
Prince Edward Island	0.011
Nova Scotia	0.011
Newfoundland	0.011
North West Territories	0.003
Yukon	0.003

In reviewing the assignments of the rate constant (k) to the individual provinces, it appears some inappropriate assumptions were used that induces error into the national estimate of GHG emissions from landfills. The k value should be varied regionally based on moisture content but should not be adjusted based on temperature and overall meteorological conditions. Anaerobic decomposition of organic materials within landfills is an exothermic reaction, and heat is generated. Temperature effects are therefore dampened and not typically observed to be a significant factor except in very shallow landfills or in the extreme north. Therefore, the above noted parameter assignments to the various provinces and territories should be revised in developing both the baseline and projected estimates of GHG emissions in Canada.

<u>Methane Generation Potential (Lo)</u>

The generation potential is the total yield of methane produced by a unit mass of waste. The generation potential is largely dependent on the waste composition, specifically the percentage of organic matter in the landfilled waste. Production of LFG can result in total yields of LFG in the range of 125 m^3 of CH_4 per/tonne of waste up to 310 m^3 of CH_4 per/tonne of waste (45 to 111 kg CH_4/tonne of waste at 50 percent CH_4), (2 to 5 cubic feet/lb)).

The Lo is based on the carbon content of the waste, the biodegradable carbon fraction, and a stoichiometric conversion factor. As indicated in the table below, the assumption made by Environment Canada implied that the organic content of the waste landfilled was very high prior to 1988 and has declined in recent years.

Values of Lo

Year	*Lo (m³ of CH₄/tonne of refuse)*
Prior to 1988	230
1988 – 1990	195
1991	194
1992	190
1993	186
1994	183
1995	178
1996	175
1997	170
1998	167
1999	163
2000	160

The historical values assigned to Lo induce a significant error factor into the analyses and estimates of GHG emissions. Lo is empirically assigned to reflect the heterogeneous nature of the wastes and that not all of the waste that is included for a specific site is decomposable organic materials. In sites where there is limited knowledge of the waste mix and types, there is tendency to use a lower value of Lo. The current efforts towards waste diversion have had some influence on the characteristics of the waste that is disposed in the landfills. There have been some reductions in the organic wastes disposed in some landfills but there have also been similar, and likely more successful, efforts at diverting inorganic materials from the waste stream.

Recycling and diversion efforts to date would tend to have kept the organic decomposable fraction of the total waste mass relatively constant and not declining dramatically as shown above. Unless there is site specific information that would justify an unusual parameter assignment, the Lo factor should not be revised dramatically. The historical value of 230 used by Environment Canada has significant implications for the baseline estimate that may not be supportable. Additionally, the trend in the parameter assignment noted above would yield a declining total emissions estimate that is in conflict with the increasing emissions trend reported by Environment Canada.

Waste Generation

The amount of waste landfilled annually is the dominant factor in estimating LFG generation. Generally at older landfills where the data is not available, annual waste tonnages are estimated based on per capita population contributions combined with the year that the landfill opened.

Only a portion of the waste stream disposed of in the landfills contributes to the generation of landfill gas. This factor is critical to the understanding of both the national and site specific estimates of landfill gas generation. The confusion in the contributing organic fraction of the waste generation and the assignment of the Lo parameter noted above are occasionally in conflict and can represent the equivalent of double counting depending upon how these parameters are considered in the analyses.

The quantity of solid waste disposed in landfills between 1941 to 1989 was estimated by Levelton (1991). For years 1990 to 1996, the amount of waste landfilled has been estimated based on a 1996 Environment Canada study containing solid waste data for 1992. Using this data, a per capita landfilling rate for each province was calculated. These rates are adjusted for the other years based on data from the National Solid Waste Inventory (CCME, 1998). The total waste disposed each year has been determined by multiplying the per capita landfilling rate by the provincial population as recorded by Statistics Canada(#91-213-XPB). Waste disposal estimates that have been used are provided in Table 3.1.

Summary of Environment Canada Emission Estimates

Using the above input parameters Environment Canada estimated the total GHG emissions from solid waste disposal on land, including managed and unmanaged waste disposal. The total CH_4 produced (emitted and recovered) was used to estimate the total eCO_2 production that is 21 times the total CH_4 produced.

The following table presents the results of the Environment Canada estimates between 1990 and 1999:

TABLE 3.1

POPULATION AND WASTE GENERATION ESTIMATES STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LFG RECOVERY AND UTITLIZATION IN CANADA

Environment Canada

			Waste Generation Rates			Assumed
Year	Population (1000's) (1)	Assumed Population (1000s) (2)	EC (3)	Ontario (4)	Assumed (2)	Tonnage (2)
				(tonnes/pers/year)		(million tonnes/year)
1940	11,907.06	11,907.06		1.000	1.000	11.91
1941	12,145.21	12,145.21		1.000	1.000	12.15
1942	12,388.11	12,388.11		1.000	1.000	12.39
1943	12,635.87	12,635.87		1.000	1.000	12.64
1944	12,888.59	12,888.59		1.000	1.000	12.89
1945	13,146.36	13,146.36		1.000	1.000	13.15
1946	13,409.29	13,409.29		1.000	1.000	13.41
1947	13,677.47	13,677.47		1.000	1.000	13.68
1948	13,951.02	13,951.02		1.000	1.000	13.95
1949	14,230.04	14,230.04		1.000	1.000	14.23
1950	14,514.65	14,514.65		1.000	1.000	14.51
1951	14,804.94	14,804.94		1.000	1.000	14.80
1952	15,101.04	15,101.04		1.000	1.000	15.10
1953	15,403.06	15,403.06		1.000	1.000	15.40
1954	15,711.12	15,711.12		1.000	1.000	15.71
1955	16,025.34	16,025.34		1.000	1.000	16.03
1956	16,345.85	16,345.85		1.000	1.000	16.35
1957	16,672.77	16,672.77		1.000	1.000	16.67
1958	17,006.22	17,006.22		1.000	1.000	17.01
1959	17,346.35	17,346.35		1.000	1.000	17.35
1960	17,693.27	17,693.27		1.000	1.000	17.69
1961	18,047.14	18,047.14		1.000	1.000	18.05
1962	18,408.08	18,408.08		1.000	1.000	18.41
1963	18,776.24	18,776.24		1.000	1.000	18.78
1964	19,151.77	19,151.77		1.000	1.000	19.15
1965	19,534.80	19,534.80		1.000	1.000	19.53
1966	19,925.50	19,925.50		1.000	1.000	19.93
1967	20,324.01	20,324.01		1.000	1.000	20.32
1968	20,730.49	20,730.49		1.000	1.000	20.73
1969	21,145.10	21,145.10		1.000	1.000	21.15
1970	21,568.00	21,568.00	-	1.000	1.000	21.57
1971	22,039.59	22,039.59	-	1.000	1.000	22.04
1972	22,289.90	22,289.90	-	1.000	1.000	22.29
1973	22,572.71	22,572.71	-	1.000	1.000	22.57
1974	22,906.84	22,906.84	-	1.000	1.000	22.91
1975	23,239.88	23,239.88	-	0.996	0.996	23.15
1976	23,533.62	23,533.62	-	0.996	0.996	23.44
1977	23,802.21	23,802.21	-	0.996	0.996	23.71
1978	24,026.16	24,026.16	-	0.996	0.996	23.93
1979	24,279.77	24,279.77	-	0.996	0.996	24.18

TABLE 3.1

POPULATION AND WASTE GENERATION ESTIMATES
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LFG RECOVERY AND UTITLIZATION IN CANADA
Environment Canada

Year	*Population (1000's)* (1)	*Assumed Population (1000s)* (2)	*Waste Generation Rates* EC (3)	Ontario (4)	Assumed (2)	*Assumed Tonnage* (2)
			(tonnes/pers/year)			*(million tonnes/year)*
1980	24,604.11	24,604.11	-	0.996	0.996	24.51
1981	24,920.64	24,920.64	-	0.996	0.996	24.82
1982	25,194.07	25,194.07	-	0.996	0.996	25.09
1983	25,434.68	25,434.68	-	0.996	0.996	25.33
1984	25,678.16	25,678.16	-	0.996	0.996	25.58
1985	25,915.35	25,915.35	-	0.996	0.996	25.81
1986	26,190.42	26,190.42	-	0.946	0.946	24.77
1987	26,548.67	26,548.67	-	0.895	0.895	23.77
1988	26,941.26	26,941.26	-	0.845	0.845	22.76
1989	27,413.73	27,413.73	-	0.794	0.794	21.78
1990	27,817.25	27,817.25	-	0.744	0.744	20.70
1991	28,126.90	28,126.90	-	0.726	0.730	20.53
1992	28,485.51	28,485.51	-	0.708	0.730	20.79
1993	28,811.72	28,811.72	-	0.689	0.730	21.03
1994	29,140.56	29,140.56	0.73	0.671	0.730	21.27
1995	29,454.99	29,454.99	-	0.653	0.710	20.91
1996	29,771.69	29,771.69	0.69	0.642	0.690	20.54
1997	30,376.46	30,376.46	-	0.632	0.690	20.96
1998	30,613.33	30,613.33	0.69	0.621	0.690	21.12
1999	30,324.91	30,324.91	-	0.610	0.690	20.92
2000	30,585.34	30,585.34	-	0.588	0.690	21.10
2001	30,859.48	30,859.48	-	0.583	0.690	21.29
2002	31,156.39	31,156.39	-	0.577	0.690	21.50
2003	31,506.70	31,156.39	-	0.572	0.690	21.50
2004	31,751.50	31,156.39	-	0.566	0.690	21.50
2005	31,992.10	31,156.39	-	0.561	0.690	21.50
2006	32,228.60	31,156.39	-	0.545	0.690	21.50
2007	32,461.60	31,156.39	-	0.529	0.690	21.50
2008	32,691.30	31,156.39	-	0.514	0.690	21.50
2009	32,917.70	31,156.39	-	0.498	0.690	21.50
2010	33,141.20	31,156.39	-	0.482	0.690	21.50
2011	33,361.70	31,156.39	-	0.482	0.690	21.50
2012	33,579.40	31,156.39	-	0.482	0.690	21.50
2013	33,794.20	31,156.39	-	0.482	0.690	21.50
2014	34,006.00	31,156.39	-	0.482	0.690	21.50
2015	34,214.60	31,156.39	-	0.482	0.690	21.50
2016	34,419.80	31,156.39	-	0.482	0.690	21.50
2017	34,621.30	31,156.39	-	0.482	0.690	21.50
2018	34,818.70	31,156.39	-	0.482	0.690	21.50
2019	35,011.60	31,156.39	-	0.482	0.690	21.50

TABLE 3.1

POPULATION AND WASTE GENERATION ESTIMATES
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LFG RECOVERY AND UTITLIZATION IN CANADA
Environment Canada

Year	Population (1000's) [1]	Assumed Population (1000s) [2]	Waste Generation Rates EC [3] (tonnes/pers/year)	Ontario [4]	Assumed [2]	Assumed Tonnage [2] (million tonnes/year)
2020	35,199.50	31,156.39	-	0.482	0.690	21.50
2021	35,381.70	31,156.39	-	0.482	0.690	21.50
2022	35,557.80	31,156.39	-	0.482	0.690	21.50
2023	35,727.20	31,156.39	-	0.482	0.690	21.50
2024	35,889.50	31,156.39	-	0.482	0.690	21.50
2025	36,044.10	31,156.39	-	0.482	0.690	21.50
2026	36,190.60	31,156.39	-	0.482	0.690	21.50
2027		31,156.39			0.690	21.50
2028		31,156.39			0.690	21.50
2029		31,156.39			0.690	21.50
2030		31,156.39			0.690	21.50

Notes:

(1) Source: Statistics Canada, projected population by age group, and sex, July 1 2000 - 2026, Table 052-0001

(2) Population and waste genration rate was assumed to stabilize for the projected years due to diversion of organic materials as well as the 3R program

(3) Table 2.1, Waste Management Industry Survey, Business and Government Sectors, Statistics Canada, 1998

(4) Draft - Reducing Greenhouse Gas Emissions from Landfills: Review and Quantification, Ontario Ministry of the Environment, July 2000

Year	*CH_4 emissions[4] (ktonnes)*		*CH_4 recovery[2] (ktonnes)*	*Total CH_4 produced (ktonnes)*	*eCO_2 (Mtonnes)*	*Net Emissions eCO_2 (Mtonnes)*
	Waste disposal on Land	*Waste Incineration*				
1990	882.39	0.44	210.60	1093.43	22.96	18.54
1991	912.14	0.45	213.93	1126.52	23.66	19.16
1992	932.39	0.49	223.93	1156.81	24.29	19.59
1993	955.09	0.31	228.97	1184.37	24.87	20.06
1994	965.71	0.31	244.24	1210.26	25.42	20.93
1995	969.68	0.34	266.20	1236.22	25.96	20.37
1996	972.57	0.33	289.28	1262.18	26.51	20.43
1997	995.95	0.33	292.41	1288.69	27.06	21.61
1998	1018.13	0.33	280.00	1298.46	27.27	21.39
1999	1040.72	0.33	280.00	1321.05	27.74	21.86

3.2 SENSITIVITY MODELING

The GHG emissions estimate was reviewed using the same Scholl Canyon model adopted by Environment Canada, but using somewhat different input parameters.

The LFG production calculations are estimates and, as such, actual values measured may differ somewhat from those calculated. For this reason several sets of parameters were selected to provide a lower and upper boundary for the estimated LFG production. The following input values and approach were used:

- US EPA model input data, where k = 0.05; Lo = 170 m^3 of CH_4/tonne of waste;
- MOE model input data, where k = 0.04; Lo = 125 m^3 of CH_4/tonne of waste; and
- a customized model run, where k is modified by province based on rainfall; Lo = 125 & 170 m^3 of CH_4/tonne of waste.

The customized model runs assumed the following parameters:

[4] Canada's Greenhouse Gas Inventory 1990 – 1999, Sectoral Report for Waste, 2000.

Province/Territory	*Assumed Generation Rates (k)*	*Assumed CH_4 Generation Potential (Lo m^3/tonne)*
Newfoundland	0.04	125&170
PEI	0.04	125&170
Nova Scotia	0.04	125&170
New Brunswick	0.04	125&170
Quebec	0.04	125&170
Ontario	0.04	125&170
Manitoba	0.02	125&170
Saskatchewan	0.02	125&170
Alberta	0.02	125&170
British Columbia	0.04	125&170
Yukon and NW T	N/A	N/A

As previously noted in Table 3.1, the annual waste generation was derived from the combination of annual population trend and per capita waste generation rates. Statistic Canada's population inventory and projected population from 2001 to 2026 were used as input data for the annual population. The per capita waste generation rates were developed from a combination of waste generation rates reported by the Ontario Ministry of the Environment and Environment Canada.

The tonnage of municipal solid waste landfilled annually was assumed to stabilize in 2000 due to the continued diversion of organic materials as well as existing 3R programs. Essentially, in the base case it is being assumed that increasing waste generation from the increasing population base is offset by the numerous waste diversion initiatives leaving a constant organic mass for the modeling of future emissions. A rapid increase in organics diversion from landfills, beyond that inherent in this assumption, would eventually decrease future GHG emissions from landfills but any significant changes to the emissions estimates would not be seen until 2020 and beyond.

Generally it was determined that, the waste stream contains 34 percent residential waste, 53 percent industrial/commercial/institutional (ICI), and 13 percent inorganics (construction, demolition and other)[5].

Figure 3.1 presents the assumed waste generation rates used as input parameters for the Scholl Canyon model. This figure and Table 3.1 illustrate that the organic waste disposal peaked in 1985. Given the simple nature of the model being used, the peak in the emissions should have been governed by this factor.

[5] Waste Management Industry Survey, Business and Government Sectors, Statistics Canada, 1998.

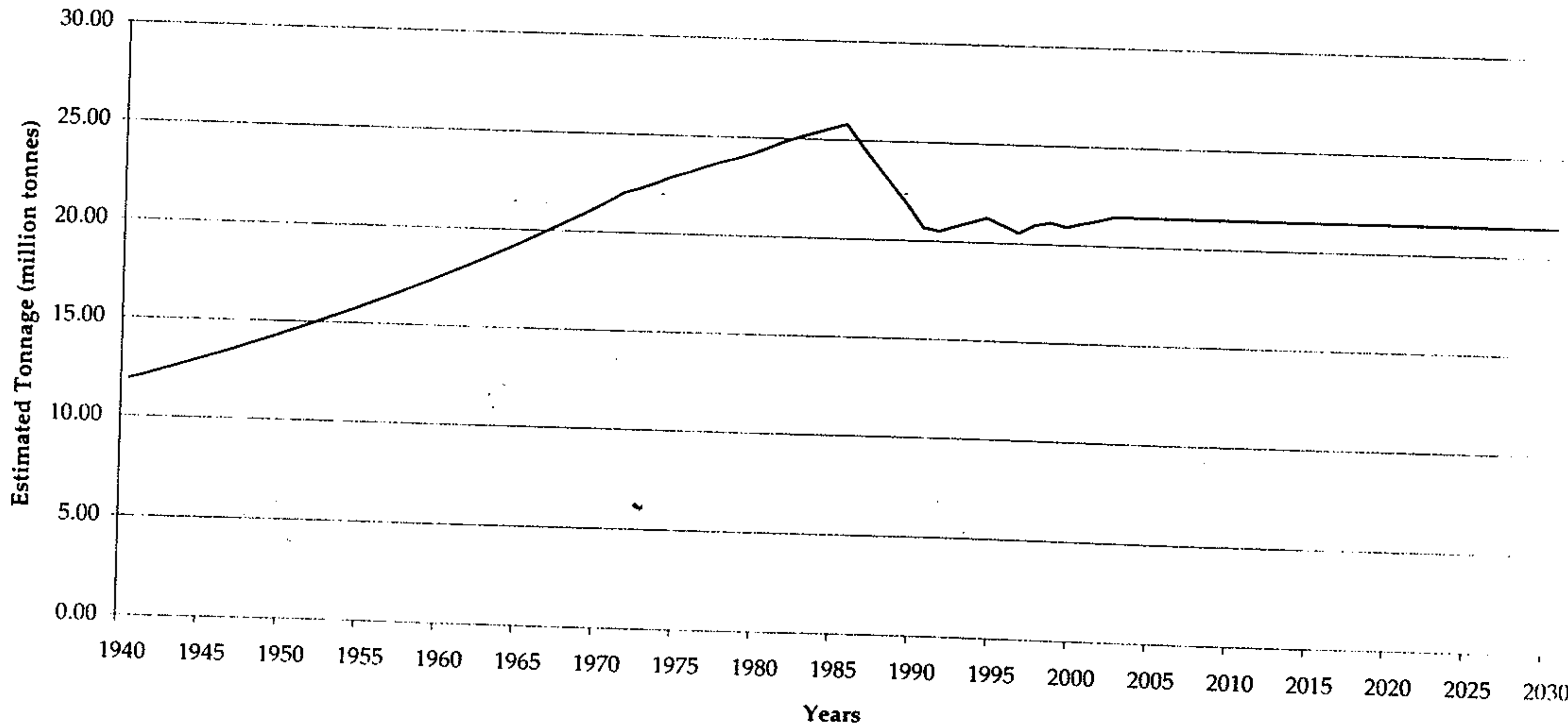


figure 3.1
ESTIMATED ORGANIC WASTE CONTRIBUTING QUANTITIES
STRATEGIC ASSESSMENT OF THE ADDITIONAL
POTENTIAL FOR LFG RECOVERY AND UTILIZATION IN CANADA
Environment Canada

Figure 3.2 presents the GHG emission estimates based on the above sets of input parameters. The emission estimates do not assume any LFG recovery from the municipal solid waste landfilled. The output for the US EPA model using an Lo of 170 yields the highest estimate of total emissions during the time frame presented. There is an inflection point in all of the curves that follow the peak in organic waste disposal in 1985. The rate constant k will eventually become almost irrelevant to the magnitude of the overall total emissions curves if the data set is over a long enough time period and the contributing waste mass is relatively constant. The overall curve should rise or fall consistent with the quantity of contributing waste. The curves in Figure 3.2 appear to have a slight incline or increasing trend but this is simply a function of the limited data set that starts in 1940. Waste disposed prior to that date is still contributing to the overall emissions but is not reflected in the curves presented. The customized curves are sloped and appear to be increasing more rapidly than the US EPA and MOE curves. This is because the lower k factors being used tend to extend the LFG production curves over a longer time period. Therefore, using a limited data set starting from 1940 has more of an apparent effect on these curves, particularly in the earlier years.

The US EPA model allows a reduction for inorganics in the waste stream and the assumed waste generation rate across Canada was reduced by 15 percent in developing and presenting the applicable curve in Figure 3.2. Eventually the customized curve using an Lo of 170 will intersect and exceed the US EPA curve since over a longer period of record, the total contributing quantity of organic materials is the governing factor for the National estimate of GHG emissions from landfills.

The customized provincial model provides the lower boundary of the envelope due to the lower assumed organic content of the waste and assumptions made for drier climatic conditions in the Prairie Provinces. This curve will eventually converge with the MOE curve over a long enough period of record that removes the influence of the k factor in the total emissions estimate.

3.3 DISCUSSION OF GHG EMISSIONS ESTIMATES

Field conditions vary from site to site, and the records of the real organic decomposable fraction of the wastes disposed has a great deal of inherent uncertainty and variability. Therefore it is best if the LFG production and GHG emissions estimate are represented as an envelope or range in predicted generation/emissions.

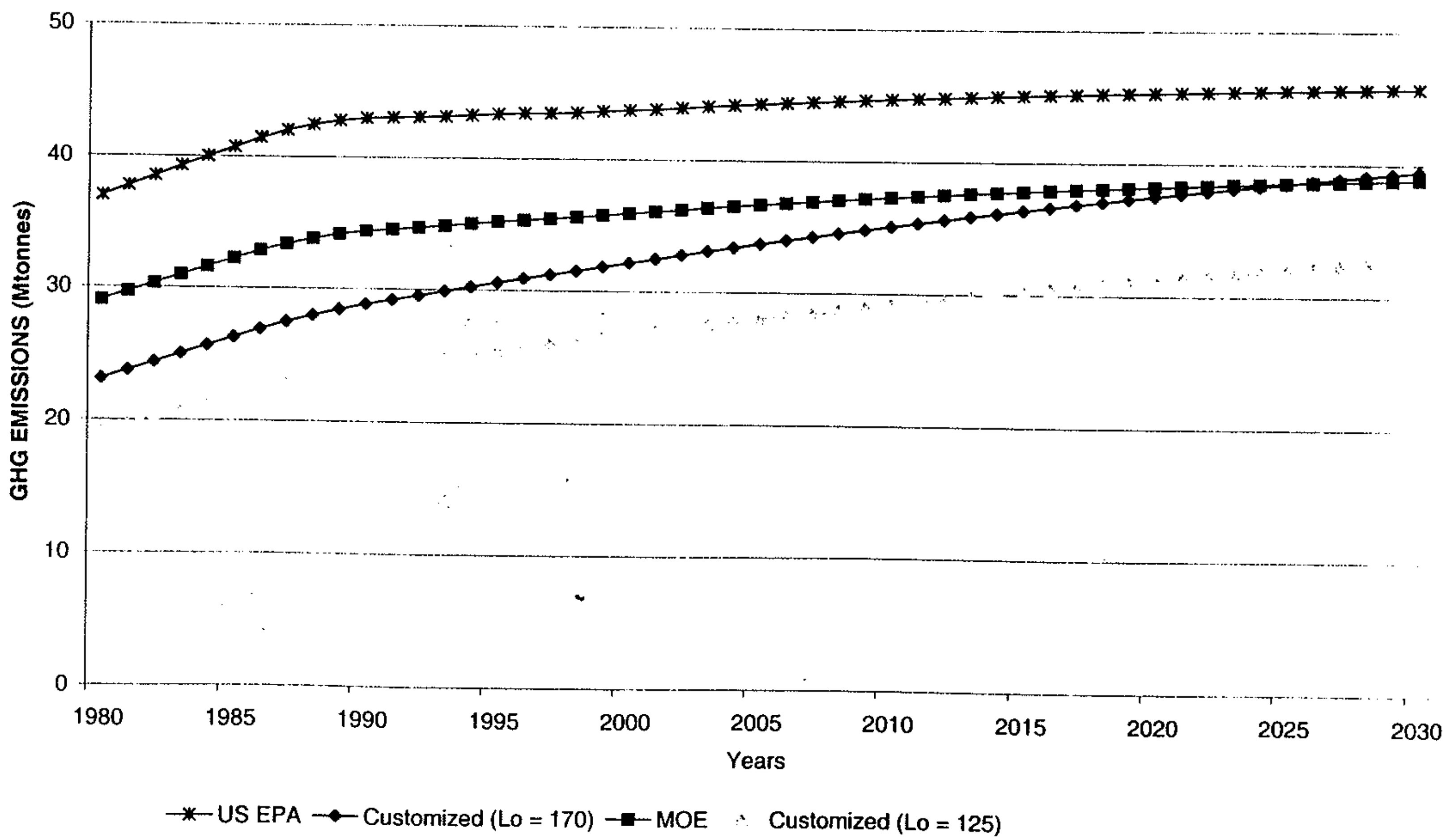


figure 3.2
GHG EMISSIONS MODELING ESTIMATES
STRATEGIC ASSESSMENT OF THE ADDITIONAL
POTENTIAL FOR LFG RECOVERY AND UTILIZATION IN CANADA
Environment Canada

Figure 3.3 compares the model output presented in Figure 3.2 with the reported EC GHG inventory estimates from 1990 to 1999. The EC estimates show an increasing trend through the 1990s that does not appear consistent with the input data and assumptions being used. Over the same period, the assumed Lo has been reduced and the contributing mass of waste has decreased (refer to Table 3.1) from its assumed peak of 25,810,000 tonnes in 1985. Based on the assumptions that appear to have been used by EC, the GHG emissions should have been decreasing over this period.

The emissions from landfills are likely at or above the presently reported estimates being provided by EC and the baseline estimates in the early 1990s appear to be under-estimates. The most representative scenario is likely using a provincially adjusted k value and an Lo value of 170 m^3 of CH_4/tonne. This would yield a total emissions of more than 40,000,000 tonnes/year in the baseline year of 1990 and relatively flat thereafter.

It is important that there be discussion and understanding of the practical differences between an overall emissions estimate for Canada and specific emission estimates for individual landfill sites. Although it was previously indicated that the emissions estimate for the country would be quite flat and that the rate constant would not be a key factor for the overall estimate, this is not true for each individual landfill site. For individual site assessments the rate constant k becomes much more critical to the emissions characteristics of the individual site. Since emissions reductions must be achieved on a site specific basis, this becomes a critical consideration. A higher rate constant (k) produces a higher peak in the LFG production for a site. The rate constants used by EC are too low to be used for typical individual site analyses and emission estimates.

One other factor that is not considered to date is the attenuation or reduction factor associated with emissions through cover systems on landfills. Discussion of this factor is beyond the scope of this report but it should be identified as a consideration in developing baseline estimates and future targets. In basic principle, there will be some reduction of emissions associated with cover systems. The performance is a function of: the rate of emissions on a compound specific basis; the soil characteristics of the cover; the thickness and construction of the cover; and the meteorology.

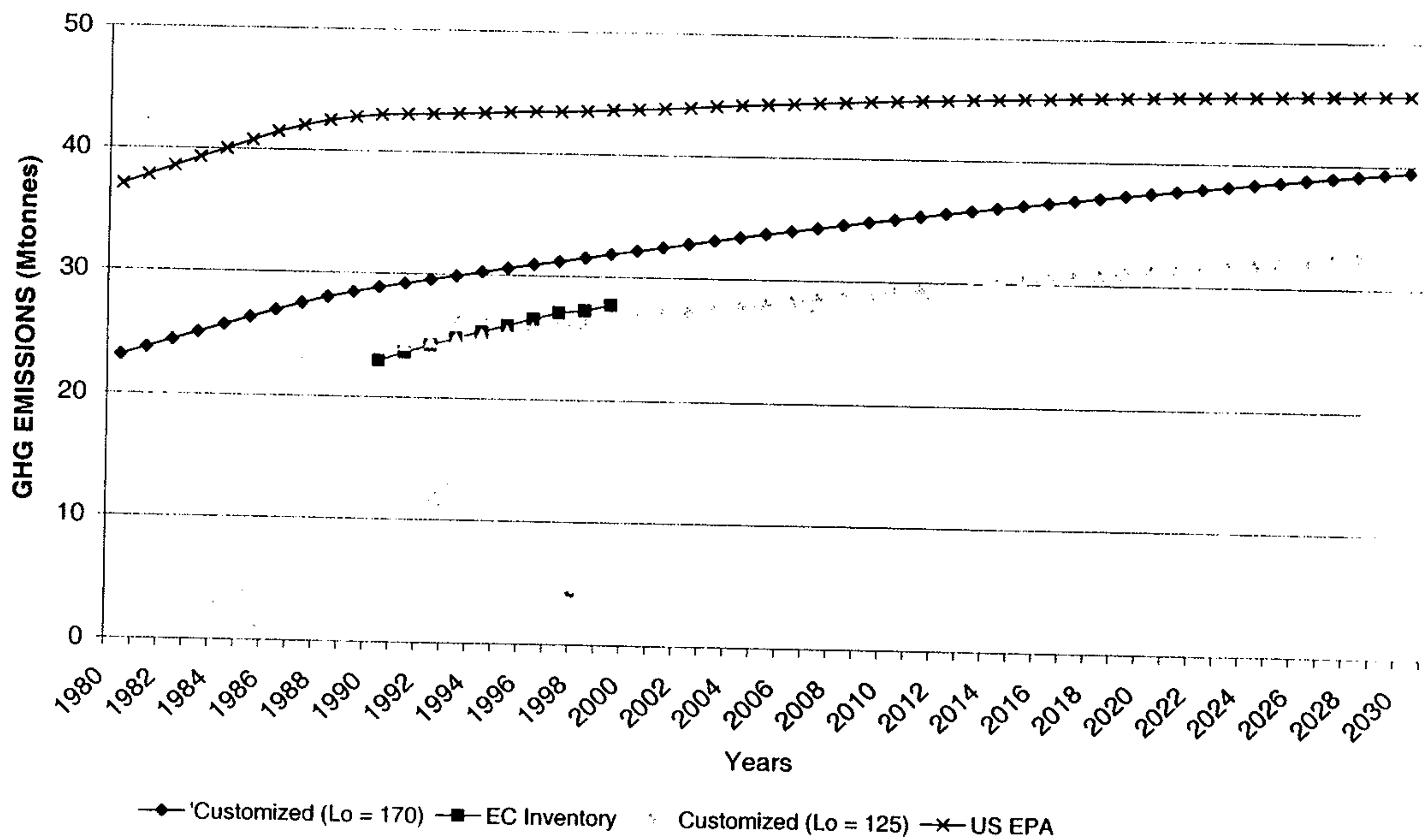


figure 3.3
SENSITIVITY REVIEW - GHG EMISSION ESTIMATES
STRATEGIC ASSESSMENT OF THE ADDITIONAL
POTENTIAL FOR LFG RECOVERY AND UTILIZATION IN CANADA
Environment Canada

4.0 NATIONAL WASTE STREAM IDENTIFICATION

Well over 10,000 landfill sites have been identified across Canada, varying from very small private sites to large municipal landfills. LFG capture generally takes place at some of the large sites where LFG collection systems are installed to mitigate LFG migration or odour issues. A significant portion of the uncontrolled GHG emissions originate from small to medium sized sites, where the owner/operators have no incentive or requirement to capture the LFG that is generated. It was recognized that landfilling practices vary significantly from province to province based on socioeconomic factors as well as distribution of population. Since the emissions are a function of population, it was determined to use population distribution as a tool to assist in identifying any waste disposal sites or waste disposal quantity discrepancies from the 1999 study to improve the overall estimate of emissions across Canada.

Table 4.1 indicates the waste disposal rates and quantities for each province in Canada. A total of approximately 21 million tonnes of solid waste was disposed in 1998. Approximately 87 percent of this waste was classed as residential and industrial commercial waste, and 13 percent of the waste stream was reported as inorganic materials with minimal methane generation potential, such as contaminated fill and construction and demolition debris. Some of the 13 percent inorganic waste stream was, and still is, found within the municipal waste stream accepted at landfills that are the focus of this study and some goes directly to large inorganic landfill sites.

The 1999 inventory study identified the 86 largest operating or recently closed landfills in the country. The focus of the current study is to identify potential emissions reductions for medium to small size landfills that were not considered in the earlier assessment. A secondary objective of the current report is to rationalize the apparent difference between the estimates of total GHG emissions based on the entire Canadian population base and the quantity of potential emission reductions identified in the 1999 study, which appeared to leave more than 50 percent of the overall emissions not accounted for. The data assembled in Table 4.1 will be used as the baseline for comparison to see what fraction of Canada's GHG emissions can be accounted for in the surveys of the landfills in both the 1999 inventory and in this supplementary assessment.

TABLE 4.1
PROVINCIAL SUMMARY

Province/Territory	*Waste Disposed in 1998*	*Waste Disposed per Capita*	*Residential*	*ICI*	*Construction and Demolition*	*Other*	*Percentage Res. & ICI*	*Population*	*Percentage of Canadian Population*
	(1)	*(1)*	*(1)*	*(1)*	*(1)*	*(1)*		*(2)*	
Newfoundland	366,280	0.67	x	210,313	x	-	57.42%	533,761	1.75%
PEI	x	x	39,225	x	x	-	x	139,000	0.46%
Nova Scotia	502,577	0.54	183,231	271,249	x	x	90.43%	942,691	3.10%
New Brunswick	468,571	0.62	182,970	242,656	x	x	90.83%	757,077	2.49%
Quebec	5,537,465	0.75	2,076,654	2,881,038	566,194	13480	89.53%	7,410,504	24.33%
Ontario	6,988,157	0.61	2,526,581	3,692,281	733,507	35788	88.99%	11,874,436	38.99%
Manitoba	964,726	0.85	277,686	577,980	x	x	88.70%	1,150,034	3.78%
Saskatchewan	848,408	0.83	286,716	493,984	x	x	92.02%	1,015,783	3.34%
Alberta	2,527,817	0.87	616,270	1,258,006	611,493	42048	74.15%	2,907,822	9.55%
British Columbia	2,458,484	0.61	707,729	1,341,228	408,211	1316	83.34%	3,724,500	12.23%
Yukon and NW T	x	x	x	x	x	x	x	x	x
Canada	**20,840,883**	**0.69**	**7,057,117**	**11,040,800**	**2,626,383**	**116583**	86.84%	**30,455,608**	100.00%

Notes:
(1) Source: Waste Management Industry Survey, Business and Government Sectors, Statistics Canada, 1998
(2) Source: Statistics Canada, projected population by age group, and sex, July 1 2000 - 2026, Table 052-0001

5.0 IDENTIFICATION OF GHG EMISSION SOURCES

The national GHG estimate and survey of existing sites was revisited to ensure that all geographic and other factors are considered. Much of the unidentified emission reduction potential from landfills resides in the already identified sites as well as the smaller sites that did not meet the original screening criteria for the 1999 inventory.

In order to identify additional GHG emissions from municipal solid waste landfills, broader screening criteria were developed:

- population of 50,000;
- active sites with an approved design capacity of at least 500,000 tonnes;
- tonnage in place greater than 250,000 tonnes;
- annual filling rate of 30,000 tonnes/year; and
- any other receivers of significant quantity of waste from various population centres (eg. waste export).

A search was undertaken to identify population centres with over 50,000 residents. These population centres were compared to the original landfill site inventory conducted in 1999 to identify potential additional landfill sites. The population centres not accounted for in the inventory were identified and researched to investigate local landfilling practices and identify any missing sites of significance.

5.1 NATIONAL WASTE INVENTORY

Table 5.1 summarizes the updated inventory of 113 landfill sites across Canada. *(Note that the Sudbury Landfill is a dual entry because of its recent approval status making the total listing count on the table of 114 sites.)* This table includes the additional sites identified as well as the sites included in the 1999 survey. The individual Site Fact Sheets for the additional sites are included in Appendix A.

Table 5.2 includes a summary of the total tonnage of waste accounted for in the 1999 inventory as well as in the most recent inventory. The waste accounted for in the inventories was compared to the waste disposal reported for 1998 in the Waste Management Survey, Business and Government Sectors, Statistics Canada. This waste deposition is directly related to the GHG emission, therefore it is the primary tool to identify where unidentified emissions may be found.

TABLE 5.1

INVENTORY OF CANADIAN LANDFILL SITES
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

	Site Name	Location	Open	Close	Landfill Area (ha)	Estimated Landfill Area (ha)	Average Depth (m)	Annual Filling Rate (tonnes)	Waste in Place (tonnes)	Site Capacity at Closure (tonnes)	Waste Composition	LFG Production Estimate (cfm) 2000	2010	2020
Alberta														
Sites Listed in 1999 Inventory Report														
1	CLOVER BAR	EDMONTON, ALBERTA	1975	2009	80	68.8	30	70,000	12,400,000	13,200,000	80% MSW, 10% ICI, 10% CD	4,640	3,400	2,150
2	EAST CALGARY	CALGARY, ALBERTA	1968	2050	360	197.9	15	400,000	6,500,000	19,000,000	18% MSW, 26% ICI & 56% CD	1,210	1,620	1,740
3	LETHBRIDGE REGIONAL	LETHBRIDGE, ALBERTA	1983	2050	20	13.0	60	60,000	900,000	5,000,000	MSW	600	840	1,050
4	MEDICINE HAT	MEDICINE HAT, ALBERTA	1969	2030	16	16.0	50	55,000	1,200,000	7,000,000	90% MSW, 10% ICI	570	1,130	1,910
5	RED DEER	RED DEER, ALBERTA	1972	2003	36.5	20.3	10	63,000	1,000,000	1,300,000	MSW	570	490	310
6	RYLEY	BEAVER COUNTY, ALBERTA	1985	N/A	12.5	12.5	0	222,000	830,000	44,000,000	80% MSW, 20% CD	680	1,780	2,630
7	SHEPARD	CALGARY, ALBERTA	1968	2050	360	177.1	15	250,000	3,800,000	17,000,000	24% MSW, 18% ICI, 58% fill	780	1,200	1,480
8	SPY HILL	CALGARY, ALBERTA	1968	2050	325	177.1	15	141,000	3,600,000	17,000,000	58% MSW, 34% ICI & 8% CD	1,370	1,640	1,900
9	WEST EDMONTON	EDMONTON, ALBERTA	1974	2009	50	50.0	12	550,000	5,000,000	17,000,000	50% MSW & 50% contaminated soils	1,730	2,670	1,660
10	WOOD BUFFALO	FORT MCMURRAY, ALBERTA	1984	2005	32	32.0	10	60,000	1,000,000	17,000,000	MSW	610	490	320
Additional Sites for Consideration														
11	LEDUC	LEDUC, ALBERTA	1978	2025	30	23.4	11	40,000	720,000	1,650,000	MSW, CD, ICI	380	530	630
12	FOOTHILLS	DISTRICT OF FOOTHILLS, ALBERTA	1980	2060	63	20.0	6	22,000	N/A	N/A	MSW, CD	200	300	430
13	CAMROSE	CAMROSE, ALBERTA	1983	2037	N/A	19.5	10	25,000	360,000	1,250,000	MSW, CD, ICI	210	320	430
14	DRAYTON VALLEY	DRAYTON VALLEY, ALBERTA	1987	2018	N/A	7.5	15	14,850	400,000	716,000	MSW, ICI, CD.	240	270	310
15	ROSERIDGE	MORINVILLE, ALBERTA	1980	2050	N/A	39.1	10	30,000	827,000	2,500,000	MSW, CD	340	490	810
British Columbia														
Sites Listed in 1999 Inventory Report														
16	CACHE CREEK	CACHE CREEK, BRITISH COLUMBIA	1989	2010	0	40.0	0	236,000	2,660,000	6,900,000	MSW	2,150	3,890	2,640
17	CAMPBELL MOUNTAIN	PENTICTON, BRITISH COLUMBIA	1972	2016	9.5	9.5	0	50,000	1,000,000	1,560,000	MSW	520	550	500
18	CEDAR ROAD	NANAIMO, BRITISH COLUMBIA ,	1955	2002	40	40.0	20 - 25 m	90,000	1,100,000	1,500,000	MSW	560	520	330
19	BAILEY	CHILLIWACK, BRITISH COLUMBIA	1974	2007	0	10.0	0	73,000	900,000	1,100,000	MSW	430	490	310
20	COQUITLAM	COQUITLAM, BRITISH COLUMBIA	1975	1983	26	26.0	10	0	2,500,000	2,500,000	MSW	890	560	360
21	FOOTHILLS BOULEVARD	(1) PRINCE GEORGE, BRITISH COLUMBIA	1974	2021	44.6	44.6	6	66,200	1,260,000	3,000,000	MSW, ICI, CD	680	950	1,250
22	HARTLAND	VICTORIA, BRITISH COLUMBIA	1954	2050	50	33.7	65	213,525	4,500,000	14,000,000	MSW	1,790	2,470	2,880
23	JACKMAN	LANGLEY, BRITISH COLUMBIA	1968	1990	14	14.0	12	0	2,000,000	2,000,000	MSW	740	480	300
24	KELOWNA	KELOWNA, BRITISH COLUMBIA	1966	2018	0	0.0	0	50,000	1,000,000	2,000,000	MSW	570	720	770
25	PIGEON LAKE	CUMBERLAND, BRITISH COLUMBIA	1960	2021	32	11.0	15	31,000	776,000	1,060,000	MSW	370	360	280
26	PORT MANN	SURREY, BRITISH COLUMBIA	1969	1997	16	16.0	0	0	4,000,000	4,000,000	MSW	1,800	1,130	730
27	PREMIER STREET	NORTH VANCOUVER, BRITISH COLUMBIA	1956	1988	20	20.0	0	0	4,500,000	4,500,000	MSW	1,430	930	590
28	VANCOUVER	DELTA, BRITISH COLUMBIA	1966	2037	225	225.0	10-12	400,000	13,000,000	30,000,000	80% MSW, 20% CD	5,180	5,640	6,080
Additional Sites for Consideration														
29	GREATER VERNON	VERNON, BRITISH COLUMBIA	1980	2017	13.9	13.2	10	30,000	330,000	845,915	MSW, ICI, CD	200	350	400
30	MISSION FLATS	KAMLOOPS, BRITISH COLUMBIA	1975	2050	N/A	14.1	50	45,000	750,000	4,500,000	MSW	540	700	890
31	CAMPBELL RIVER	COURTNEY, BRITISH COLUMBIA	1964	2014	10.7	10.7	5 to 25	21,350	157,504	533,000	MSW, ICI, CD	140	250	250
32	MINNIE'S PIT	MISSION, BRITISH COLUMBIA	1973	2027	5.4	5.4	unknown	14,300	240,000	900,000	MSW, ICI, CD	130	200	300
Manitoba														
Sites Listed in 1999 Inventory Report														
33	BRADY ROAD	WINNIPEG, MANITOBA	1973	2150	800	250.0	6	500,000	4,000,000	50,000,000	MSW	2,640	3,790	4,190
34	KILCONA	WINNIPEG, MANITOBA	1978	1987	34	34.0	6	0	3,200,000	3,200,000	MSW	1,330	900	570
35	SUMMIT ROAD	WINNIPEG, MANITOBA	1964	1998	130	130.0	3	0	3,500,000	3,500,000	MSW	1,570	980	640
Additional Sites for Consideration														
36	EASTVIEW	BRANDON, MANITOBA	1979	2050	57	40.0	24	55,471	unknown	unknown	MSW, ICI, CD	580	780	930
New Brunswick														
Sites Listed in 1999 Inventory Report														
37	SAINT JOHN	SAINT JOHN, NEW BRUNSWICK	1997	2022	N/A	10.0	N/A	85,000	90,000	2,100,000	MSW	210	700	1,030
Newfoundland														
Sites Listed in 1999 Inventory Report														
38	ROBIN HOOD BAY REGIONAL	SAINT JOHN'S, NEWFOUNDLAND	1960	2025	40	40.0	variable	130,000	1,750,000	5,000,000	MSW	1,200	1,690	2,000
Nova Scotia														
Sites Listed in 1999 Inventory Report														
39	BEECH HILL	ANTIGONISH, NOVA SCOTIA	1991	2011	24	24.0	0	50,000	1,000,000	3,000,000	MSW	860	1,640	1,200
40	HIGHWAY 101	UPPER SACKVILLE, NOVA SCOTIA	1977	1997	32	32.0	12	0	4,000,000	4,000,000	MSW	2,120	1,120	860

TABLE 5.1

INVENTORY OF CANADIAN LANDFILL SITES
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

	Site Name	Location	Open	Close	Landfill Area (ha)	Estimated Landfill Area (ha)	Average Depth (m)	Annual Filling Rate (tonnes)	Waste in Place (tonnes)	Site Capacity at Closure (tonnes)	Waste Composition	LFG Production Estimate (cfm) 2000	2010	2020
Ontario														
Sites Listed in 1999 Inventory Report														
41	AURORA	AURORA, ONTARIO	1938	1984	26	23.4	20	0	3,000,000	3,000,000	MSW	660	420	260
42	BEARE ROAD	SCARBOROUGH, ONTARIO	1967	1983	65	65.0	0	0	9,600,000	9,600,000	MSW	3,010	1,910	1,210
43	BENSFORT ROAD	PETERBOROUGH, ONTARIO	1981	1999	8.6	8.6	15	44,000	1,000,000	1,000,000	MSW	610	380	250
44	BRITANNIA	MISSISSAUGA, ONTARIO	1980	2003	60	60.0	20	450,000	10,000,000	11,000,000	MSW	5,780	4,640	3,000
45	BROCK WEST	PICKERING, ONTARIO	1975	1996	64.4	64.4	0	0	18,200,000	18,200,000	MSW	9,210	5,920	3,750
46	CAMBRIDGE	CAMBRIDGE, ONTARIO	1973	2006	38	33.3	15	70,000	2,500,000	3,200,000	MSW	1,330	1,300	840
47	CARP	OTTAWA, ONTARIO	1972	2012	34	24.6	40	260,000	3,500,000	6,300,000	MSW	1,390	1,820	1,380
48	CORNWALL	CORNWALL, ONTARIO	1985	2027	29	29.0	0	60,000	730,000	2,600,000	MSW	510	770	950
49	EASTVIEW	GUELPH, ONTARIO	1962	2004	80	35.2	20	90,000	4,000,000	4,500,000	MSW	1,730	1,360	870
50	ESSEX COUNTY #3	ESSEX, ONTARIO	1971	1997	85	64.7	14	0	5,800,000	5,800,000	MSW	2,700	1,720	1,100
51	ESSEX-WINDSOR REGIONAL	ESSEX, ONTARIO	1997	2022	56	50.0	25	180,000	260,000	8,000,000	80% MSW, 14% ICI, 6% CD	390	2,040	3,460
52	GLANBROOK	HAMILTON, ONTARIO	1981	2020	100	31.3	30	100,000	3,000,000	6,000,000	MSW & Commercial	1,810	1,990	2,280
53	GLENRIDGE	ST CATHARINES, ONTARIO	1976	2001	17.4	12.7	19	50,000	1,330,000	1,544,600	MSW	690	510	330
54	GREEN LANE	SOUTHWOLD TWP., ONTARIO	1978	2020	44	43.8	15	60,000	980,000	4,200,000	MSW	640	1,480	2,010
55	HIGHWAY 48	STOUFFVILLE, ONTARIO	1962	1985	36	21.9	15	0	2,100,000	2,100,000	MSW	810	510	320
56	JOHN STREET	THUNDER BAY, ONTARIO	1972	2011	76.8	54.7	10	100,000	1,500,000	3,500,000	MSW	910	1,710	1,250
57	KEELE VALLEY	VAUGHAN, ONTARIO	1983	2002	99.2	99.2	45	1,600,000	22,000,000	28,000,000	MSW	18,313	14,008	8,730
58	MARSH DRIVE	NORTH BAY, ONTARIO	1962	1994	18	9.5	33	0	2,000,000	2,000,000	MSW	790	510	320
59	MOHAWK	BRANTFORD, ONTARIO	1960	2065	73	44.6	35	67,000	4,000,000	10,000,000	MSW	1,740	1,740	1,740
60	MOUNTAIN ROAD	NIAGARA FALLS, ONTARIO	1968	2000	24	24.0	0	75,000	1,900,000	2,000,000	MSW	880	590	380
61	NIAGARA WASTE SYSTEMS	THOROLD, ONTARIO	1982	2009	65	65.0	0	600,000	5,500,000	12,000,000	5% MSW, 80% ICI & 15% CD	1,750	3,050	1,900
62	NORTH SHERIDAN	MISSISSAUGA, ONTARIO	1966	1980	0	0.0	18	0	2,500,000	2,500,000	MSW	790	480	290
63	PETROLIA	PETROLIA, ONTARIO	1948	2057	26	23.4	20	20,000	680,000	3,000,000	MSW	290	350	420
64	REGION OF HALTON	MILTON, ONTARIO	1992	2040	49.5	49.5	10	90,000	500,000	6,400,000	MSW	580	1,130	1,650
65	RICHMOND	NAPANEE, ONTARIO	1954	2004	N/A	9.9	33	125,000	1,500,000	2,100,000	MSW	710	800	510
66	RIDGE	BLENHEIM, ONTARIO	1966	2019	0	0.0	33	125,000	3,600,000	17,400,000	assumed 50% MSW, 50% CD	1,090	3,080	4,290
67	SARNIA	SARNIA, ONTARIO	1970	1999	24	21.3	11	0	1,300,000	1,500,000	MSW	770	480	310
68	SAULT STE. MARIE	SAULT STE. MARIE, ONTARIO	1960	2017	24	24.0	0	84,000	2,500,000	3,300,000	MSW	1,140	1,030	900
69	SUDBURY	(2) SUDBURY, ONTARIO	1955	2001	22.7	22.7	10	54,000	1,500,000	1,800,000	MSW	710	540	350
70	TARO (EAST QUARRY)	HAMILTON, ONTARIO	1996	2016	59	59.0	0	450,000	1,000,000	10,000,000	ICI - contaminated soils	1,260	4,370	5,060
71	TOM HOWE	NANTICOKE, ONTARIO	1974	2022	26.8	26.8	15	52,000	1,040,000	2,600,000	MSW	590	860	1,030
72	TRAIL ROAD/NEPEAN	OTTAWA, ONTARIO	1959	2009	74	74.0	varies	155,000	8,200,000	10,200,000	MSW	3,600	4,700	2,940
73	UPPER OTTAWA STREET	HAMILTON, ONTARIO	1952	1980	50	31.3	25	0	5,000,000	5,000,000	50% MSW, 50% CD	520	330	210
74	W12A	LONDON, ONTARIO	1977	2007	107	107.0	0	200,000	5,000,000	6,600,000	assumed MSW	2,910	2,760	1,750
75	WARWICK	WARWICK, ONTARIO	1972	2025	89	89.0	25	56,000	1,602,000	20,470,000	20% MSW, 40% ICI	500	3,340	5,300
76	WATERLOO	WATERLOO, ONTARIO	1972	2026	71	71.0	25	255,000	5,000,000	12,000,000	MSW	2,810	3,600	4,100
Additional Sites for Consideration														
77	OXFORD	SALFORD, ONTARIO	1986	2020	43.7	27.2	15	89,000	unknown	2,612,000	MSW, ICI, CD	470	960	1,300
78	OWEN SOUND	OWEN SOUND, ONTARIO	1983	2004	10	4.2	19	25,400	434,200	510,000	MSW, ICI, CD	240	240	150
79	MERRICK	NORTH BAY, ONTARIO	1994	2014 +	16.4	5.4	26	44,000	330,066	900,000	MSW, ICI, CD	190	440	420
80	ALICE - FRASER	RENFREW COUNTY, ONTARIO	1977	2005	12.06	8.8	20	70,900	728,000	1,128,000	MSW, ICI	430	560	350
81	SANDY HALLOW	BARRIE, ONTARIO	1964	2034	16.6	16.6	25	64,000	1,760,000	3,136,000	MSW	800	880	870
82	NOTTAWASAGA	CLEARVIEW TOWNSHIP	1970	2014	40.5	12.9	11	15,400	680,000	910,000	MSW	350	370	310
83	LINDSAY/OPS	KAWARTHA LAKES, ONTARIO	1980	2026	10.7	10.7	15	25,000	500,000	1,520,000	MSW, ICI, CD	200	370	510
84	SUDBURY (EXPANSION)	(2) SUDBURY, ONTARIO	1955	2020	22.7	22.7	10	100,000	1,800,000	3,800,000	MSW	860	1,420	1,810
PEI														
Sites Listed in 1999 Inventory Report														
85	PRINCE COUNTY	SUMMERSIDE, P E I	1977	1994	24	5.0	N/A	0	400,000	400,000	MSW	190	120	0

TABLE 5.1

INVENTORY OF CANADIAN LANDFILL SITES
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

	Site Name	Location	Open	Close	Landfill Area (ha)	Estimated Landfill Area (ha)	Average Depth (m)	Annual Filling Rate (tonnes)	Waste in Place (tonnes)	Site Capacity at Closure (tonnes)	Waste Composition	LFG Production Estimate (cfm) 2000	2010	2020
Quebec														
Sites Listed in 1999 Inventory Report														
86	COOK	AYLMER, QUEBEC	1975	1991	41	20.8	12	0	1,600,000	1,600,000	MSW	680	440	280
87	VILLE DE SHERBROOKE	SHERBROOKE, QUEBEC	1954	2025	26	26.0	0	80,000	2,160,000	4,600,000	40% MSW, 60% ICI	630	830	1,000
88	L'ACADIE	ST-JEAN-SUR-RICHELIEU, QUEBEC	1976	1991	12	12.0	8	0	1,500,000	1,500,000	MSW	650	430	270
89	LACHENAIE	LACHENAIE, QUEBEC	1968	2004	62	62.0	17	738,500	7,000,000	10,800,000	MSW	3,770	4,460	2,850
90	L'ASCENSION	L'ASCENSION, QUEBEC	1982	2045	24	24.0	13	36,400	800,000	2,800,000	MSW	490	580	650
91	LATERRIERE	LATERRIERE, QUEBEC	1971	1995	45 (site total)	19.5	12	0	1,500,000	1,500,000	MSW	710	460	290
92	MAGOG	MAGOG, QUEBEC	1975	2001	24	24.0	10	150,000	1,900,000	2,300,000	MSW	1,120	860	550
93	MELOCHE	KIRKLAND, QUEBEC	1980	1990	9	9.0	61	0	3,500,000	3,500,000	MSW	1,590	1,050	660
94	MIRABEL	MIRABEL, QUEBEC	1976	2004	0	0.0	31	200,000	1,500,000	2,200,000	MSW	960	950	610
95	RIVIERE-DES-PRARIES	RIVIERE-DES-PRARIES, QUEBEC	1982	1995	800 (site total)	31.3	7	0	1,400,000	1,400,000	MSW	70	50	30
96	RIVIERE-DES-VASES	RIVIERE-DU-LOUP, QUEBEC	1979	2015	3	3.0	7	35,000	600,000	1,000,000	25% MSW, 50% ICI, 25% Rubble	160	210	190
97	STE-CECILE-DE-MILTON	STE-CECILE-DE-MILTON, QUEBEC	1973	2005	40	16.7	15	40,000	1,300,000	1,600,000	30% MSW, 70% ICI	410	430	280
98	STE-GENEVIEVE-DE-BERTHIER	STE-GENEVIEVE-DE-BERTHIER, QUEBEC	1978	2011	67	64.5	10	300,000	1,540,000	4,130,000	60% MSW & 40% ICI	830	1,660	1,230
99	STE-SOPHIE	STE-SOPHIE, QUEBEC	1964	2010	80	80.0	12	788,000	3,500,000	8,000,000	60% MSW, 40% CD	1,630	2,560	1,720
100	ST-ETIENNE-DES-CRES	ST-ETIENNE-DES-CRES, QUEBEC	1977	2030	10	10.0	9	106,360	1,400,000	6,500,000	56% MSW, 44% ICI	590	1,070	1,370
101	CENTRE ENVIRONNEMENTAL DE ST. MICHEL	MONTREAL, QUEBEC	1968	2008	175	93.8	65	550,000	34,200,000	39,000,000	MSW	14,740	12,890	8,120
102	ST-NICEPHORE	ST-NICEPHORE, QUEBEC	1984	2008	70	70.0	24	680,000	5,000,000	13,500,000	40% MSW, 50% ICI, 10% CD	3,040	4,880	3,050
103	ST-TITE-DES-CAPS	ST-TITE-DES-CAPS, QUEBEC	1979	2025	N/A	123.4	10	88,000	800,000	7,900,000	15% MSW, 10% ICI, 75% cinders	260	490	660
Additional Sites for Consideration														
104	ST-GEORGE-DE-CACOUNA	CACOUNA, QUEBEC	1979	2020	15.6	15.6	8	28,000	880,000	1,760,000	MSW	470	550	750
105	RIMOUSKI	VILLE DE RIMOUSKI, QUEBEC	1981	2003	25	13.2	7	35,000	478,400	589,280	MSW, ICI, CD	260	280	180
106	ST COME-LINIERE	VILLE DE GEORGES, QUEBEC	1974	2002	N/A		2	28,768	752,000	756,000	MSW, ICI	360	280	180
107	ST LAMBERT-DE-LAUZON	ST LAMBERT-DE-LAUZON, QUEBEC	1998	2026	40	40.0	1.5	40,000	180,000	2,300,000	MSW, CD	100	440	880
108	L'ANSE-A-GILLES	L'ISLET-SUR-MER, QUEBEC	1983	2003	20	20.0	2	27,000	432,000	480,000	MSW, ICI, CD	240	220	140
109	COWANSVILLE	COWANSVILLE, QUEBEC	1977	2045	29	26.3	18	57,500	1,440,000	3,024,000	MSW, ICI, CD	450	580	690
110	THETFORD MINES	THETFORD MINES, QUEBEC	1981	2005-2006	18.75	14.5	7	24,500	431,000	650,000	MSW, ICI, CD	250	330	210
Saskatchewan														
Sites Listed in 1999 Inventory Report														
111	FLEET STREET	REGINA, SASKATCHEWAN	1960	2010	80	50.5	30	350,000	7,100,000	9,700,000	65% MSW, 35% CD	2,250	2,300	1,460
112	SPADINA	SASKATOON, SASKATCHEWAN	1955	2015	37.4	18.5	35	114,000	2,750,000	4,150,000	MSW	1,130	1,270	1,100
Additional Sites for Consideration														
113	PRINCE ALBERT	PRINCE ALBERT, SASKATCHEWAN	1972	2050	4.4	4.4	24	36,000	834,330	N/A	MSW, ICI	400	520	610
114	MOOSE JAW	MOOSE JAW, SASKATCHEWAN	1922	2030 - 2050	60	60	10	40,000	unknown	unknown	MSW, ICI, CD	530	630	710

Notes:

N/A Not Available

(1) Hart Landfill was changed to Foothills Boulevard, the data obtained in the 1999 report was erroneous, the Foothills Boulevard Fact Sheet contains the updated data

(2) Expansion approved in 1999, projections for the entire site are presented under the expanded site and include filling period since 1955.

TABLE 5.2

WASTE STREAM SUMMARY
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

Province	*Annual Filling Rate (tonnes)*				*Waste Disposed in 1998 (tonnes)* [3]	*Percentatge Accounted for*	
	1999 Inventory	*Additional Sites*	*Other*	*Total*		*1999 Inventory*	*Total*
Alberta	1,871,000	131,850		2,002,850	2,527,817	74%	79%
British Columbia	1,209,725	110,650	240,000 [1]	1,560,375	2,458,484	49%	63%
Manitoba	500,000	55,471		555,471	964,726	52%	58%
New Brunswick	85,000	--		85,000	468,571	18%	18%
Newfoundland	130,000	--		130,000	366,280	35%	35%
Nova Scotia	50,000	--		50,000	502,577	10%	10%
Ontario	5,472,000	433,700	735,000 [2]	6,640,700	6,988,157	78%	95%
PEI	0	--		0	x	x	x
Quebec	3,792,260	216,268		4,008,528	5,537,465	68%	72%
Saskatchewan	464,000	76,000		540,000	848,408	55%	64%
Total	**13,573,985**	**1,023,939**		**14,597,924**	**20,662,485**	**66%**	**71%**

Notes:

(1) Waste is incinerated.

(2) Waste is exported to the United States.

(3) Source: Waste Management Industry Survey, Business and Government Sectors, Statistics Canada, 1998

Approximately 21 million tonnes of waste was disposed of in 1998 across Canada, based on population and annual per capita waste generation rates. The 1999 inventory of the larger municipal solid waste landfills accounted for approximately 13.6 million tonnes of annual waste disposal, which is approximately 66 percent of the national annual total for 1998. The current study identified an additional 1.1 million tonnes of annual waste disposal, which increases the waste accounted for to 71 percent of the national total.

This leaves an estimated 29 percent of Canada's waste stream. This waste is accounted for as follows:

- waste landfilled in small rural landfills below the revised screening criteria;
- waste that is exported for disposal in other jurisdictions (e.g. United States);
- waste that is incinerated;
- waste that is treated by other systems (e.g. anaerobic digestion or composting); and
- variance in the input parameters and assumptions that have necessarily been used in the estimations of waste quantity generation and GHG generation/emission.

Based on Canada's geographic layout, large consolidated municipal solid waste sites are not the most practical or accessible for landfilling in the more remote areas of the country. Many small rural communities still have landfill sites that are very small in size with limited or no engineered controls in place. Waste export to the United States is practiced along border cities, the largest exporter being the Greater Toronto Area in Ontario, exporting in excess of 735,000 tonnes of waste to Michigan annually and expected to increase dramatically to in the range of 2,000,000 tonnes/year by the end of 2003. Waste export may also account for some of the waste disposal for Manitoba and New Brunswick. Nova Scotia has a large composting facility that handles most of the waste from the largest municipality in the province.

The following summarizes the waste stream distribution across Canada:

Description	*Estimated Percent of Waste*
Large sites (1999 Inventory)	66 percent
Medium sites (2002 Inventory)	5 percent
Waste export	approximately 5-10 percent
Waste incineration or other waste treatment	Up to 5 percent
Disposal in other unidentified small and mid sized sites	approximately 15-20 percent

The above estimates should be recognized as having a confidence band when being used for developing the associated GHG emissions estimates. A confidence band of at least plus or minus 15 percent should be considered. It will be important to review the assumptions used in detail for determining any baseline emission reduction targets.

Atlantic Provinces - Newfoundland, PEI, Nova Scotia and New Brunswick
Less than 8 percent of Canada's population resides in the Atlantic Provinces, with the population spread in smaller rural centres. This is reflected in the provinces' landfilling practices with relatively few landfills that meet the criteria of either inventory. No additional sites were identified to have met the criteria of the latest inventory.

Quebec
Approximately 25 percent of Canada's population resides in Quebec, with some larger population centres. Approximately 68 percent of the total waste stream was accounted for during the 1999 inventory and an additional 4 percent was identified during the most recent inventory.

Ontario
Approximately 40 percent of Canada's population resides in Ontario, within Canada's largest population centres. Approximately 79 percent of the waste stream was accounted for during the 1999 inventory and an additional 7 percent was identified during the most recent inventory.

Prairie Provinces - Manitoba, Saskatchewan and Alberta
Approximately 17 percent of Canada's population reside in the Prairies, largely in a rural setting. Approximately 67 percent of the waste stream was accounted for during the 1999 inventory and an additional 6 percent was identified during the most recent inventory.

British Columbia
Over 12 percent of Canada's population resides in British Columbia. Approximately 49 percent of the waste stream was accounted for during the 1999 inventory and additional 17 percent was identified during the most recent inventory.

5.2 GHG EMISSIONS FROM LANDFILL SITES

Canada's Greenhouse Gas Inventory for 1999 presents an estimate that accounts for approximately 50 percent of the modeled quantity of total emissions. The estimate appears to be reasonable given that the 1999 study identified approximately 66 percent of the estimated annual waste quantity for Canada and also assumed that approximately 75 percent of the total quantity of gas being generated at the listed sites could be collected. This yields an overall emissions reduction potential of approximately 50 percent of the total estimated emissions (0.66*0.75=0.495). If we consider a recommended plus/minus variance of 15 percent, the estimate is well within the expected envelope.

Table 5.3 summarizes the emissions reduction potential from the identified sites in both the 1999 and current studies based on the 75 percent, 85 percent and 95 percent collection efficiencies. The collection efficiencies are based on a relatively high performance standard for LFG recovery rate of 75 percent of the total produced in a typical landfill. The assumed recovery rate could be achieved by utilizing common collection methods in a good overall design. Increasing the collection system performance to an 85 percent recovery rate may be realized by increasing the density of the LFG collection field at most landfills, such as installing additional wells/trenches. The 85 percent target is considered achievable at an additional cost but there would need to be very close cooperation with overall landfill operations and maintenance plans. Further, it would require the LFG controls to become a key element of landfill management planning and the sequence of development for each candidate landfill. The larger that the landfill site is, the more achievable would be the higher efficiency targets. In CRA's opinion, higher collection system performance demands would only be practical on the larger sites that were the focus of the 1999 study unless there was a large valuation placed on the emission reductions.

A 95 percent recovery rate could be realized at some landfills by the installation of a low permeability cover to minimize LFG emissions to the atmosphere. This approach, although technically viable, would constitute a major change in landfill development and closure plans and would require substantive changes to landfill management practices in all jurisdictions in Canada. There would also be certain changes to the gas generation characteristics of the landfills associated with their moisture content that would have to be reviewed and addressed.

TABLE 5.3

GHG EMISSIONS ESTIMATE (2000)
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

Province	*LFG Collection Efficiency* (2)(3)(4)		*Equivalent Annual* eCO_2 *(tonnes/year)* *1999 Inventory*	*Additional Sites*	*Total*
Alberta	*Base*		862,779	115,131	977,909
	10%		1,005,753	130,481	1,136,235
	20%		1,148,728	145,832	1,294,560
British Columbia	*Base*		913,770	84,877	998,647
	10%		1,105,486	96,194	1,201,680
	20%		1,297,202	107,511	1,404,714
Manitoba	*Base*		465,564	48,741	514,306
	10%		527,640	55,240	582,880
	20%		589,715	61,739	651,454
New Brunswick	*Base*		17,648	-	17,648
	10%		20,001	-	20,001
	20%		22,354	-	22,354
Newfoundland	*Base*		100,844	-	100,844
	10%		114,290	-	114,290
	20%		127,736	-	127,736
Nova Scotia	*Base*		163,592	-	163,592
	10%		196,982	-	196,982
	20%		230,373	-	230,373
Ontario	*Base*		3,257,662	297,491	3,555,153
	10%		3,994,103	337,156	4,331,259
	20%		4,807,053	376,821	5,183,874
PEI	*Base*		15,967	-	15,967
	10%		18,096	-	18,096
	20%		20,225	-	20,225
Quebec	*Base*		762,481	165,777	928,258
	10%		927,082	189,643	1,116,725
	20%		1,241,043	213,510	1,454,553
Saskatchewan	*Base*		284,045	78,154	362,199
	10%		321,917	88,575	410,492
	20%		359,790	98,995	458,785
Total	*Base*		6,844,352	790,171	7,634,523
	10%		8,231,350	897,290	9,128,640
	20%		9,844,219	1,004,409	10,848,628
Estimated GHG quantities accounted for: (1)					
	Base (75%)	16,391,340	41.8%	4.8%	46.6%
	10% (85%)	18,576,852	44.3%	4.8%	49.1%
	20% (95%)	20,762,364	47.4%	4.8%	52.3%

Notes:

(1) The percentage of eCO2 accounted for is compared against data for 1999 presented in Canada's Greenhouse Gas Inventory 1990 - 1999.

(2) Base case scenario assumes a general LFG collection efficiency of 75%, unless site specific data available.

(3) +10% - an additional 10% increase in the base case LFG collection efficiency, includes the expansion of the collecti field and utilization facility

(4) +20% - an additional 20% increase in the base case LFG collection efficiency, includes the expansion of the collecti field, installation of a cover system and expansion of the utilization facility

6.0 FEASIBILITY AND COST OF ADDITIONAL EMISSION REDUCTIONS FROM LANDFILLS

Currently, the primary barrier to LFG capture and flaring is cost. Utilization of the captured LFG could potentially provide a revenue stream that can offset some or all of the costs of LFG collection. Production of electrical power or use of LFG as a heating fuel (natural gas replacement or supplement) are two LFG utilization approaches that have been widely applied and proven to be technically sound.

Table 6.1 indicates the eCO_2 emission reduction for three scenarios for each of the individual provinces across Canada. The base case scenario considers traditional LFG recovery practices with a general LFG collection efficiency of 75 percent, unless known site specific data indicates otherwise. The additional 10 percent scenario assumes the upgrading of the LFG recovery system to increase the general LFG collection efficiency to 85 percent of the estimated LFG production rate. The additional 20 percent scenario represents a more aggressive scenario, where 95 percent of the estimated LFG production is recovered. This case assumes the installation of a synthetic cap system and the increased cost of well installations to achieve this increased collection efficiency.

The costs provided do not include any provision for loan or borrowing costs and they do not include any recognition of the concept of a return on investment since there is no assumed revenue stream for capture and flaring. It is expected that the unit costs for emission reductions from capture and flaring would have to increase by at least 30 percent with secure long term contracts for sale of the GHG emission reductions before private developers would become interested based on a profit incentive.

Table 6.1 indicates that under the base case for the larger landfill sites identified in the 1999 EC study, the actual cost to obtain the emission reductions would be in the range generally up to somewhat above $2.00/tonne. To undertake this initiative on a revenue based approach, it is estimated that a secure long term revenue stream of $2.50 to $4.00/tonne eCO_2 would be required. For the smaller sites identified in this study, the actual cost to achieve the emission reductions typically increases by more than 50 percent and a secure long term revenue stream approaching $5.00/tonne eCO_2 would likely be required to encourage private sector investment. The smaller sites would be perceived as higher risk and not worth the effort unless a much higher return on investment were considered achievable.

The costs for the 85 percent recovery scenario are slightly above those for the base case scenario but there would be a much higher perceived risk of recovery that may further

TABLE 6.1

PROVINICAL COST COMPARISON
STRATEGIC ASSESSMENT OF THE ADDITIONAL POTENTIAL FOR LANDFILL GAS RECOVERY AND UTILIZATION IN CANADA
ENVIRONMENT CANADA

Province	LFG Collection Efficiency (1)(2)(3)	Present Value Cost of LFG Capture and Flaring (Million Dollars)		Present Value Cost of Utilization (Million Dollars)		Annual eCO2 (tonnes/year)		Emission Reductions Cost/tonne for Capture and Flaring	
		1999 Inventory	Additional Sites	1999 Inventory	Additional Sites	1999 Inventory	Additional Sites	1999 Inventory	Additional Sites
Alberta	Base	$35.1	$8.5	$61.4	$10.9	999,759	164,992	$1.76	$2.59
	10%	$41.6	$10.1	$67.6	$12.0	1,160,998	186,991	$1.79	$2.69
	20%	$156.9	$26.7	$73.7	$13.1	1,322,236	208,990	$5.93	$6.38
British Columbia	Base	$21.7	$4.6	$67.7	$8.0	942,809	121,853	$1.15	$1.87
	10%	$25.7	$5.4	$74.5	$8.9	1,140,091	138,101	$1.13	$1.95
	20%	$99.6	$12.0	$81.3	$9.7	1,337,372	154,348	$3.72	$3.88
Manitoba	Base	$12.7	$3.0	$24.7	$4.2	465,284	64,148	$1.36	$2.34
	10%	$15.0	$3.5	$27.1	$4.7	527,322	72,701	$1.42	$2.43
	20%	$77.3	$9.6	$29.6	$5.1	589,360	81,254	$6.56	$5.91
New Brunswick	Base	$1.9	-	$3.5	-	54,344	-	$1.70	-
	10%	$2.2	-	$3.9	-	61,590	-	$1.77	-
	20%	$3.7	-	$4.3	-	68,836	-	$2.70	-
Newfoundland	Base	$3.8	-	$7.9	-	136,980	-	$1.38	-
	10%	$4.5	-	$8.6	-	155,244	-	$1.44	-
	20%	$10.5	-	$9.4	-	173,508	-	$3.04	-
Nova Scotia	Base	$6.5	-	$11.0	-	156,495	-	$2.08	-
	10%	$7.7	-	$12.1	-	186,375	-	$2.06	-
	20%	$16.2	-	$13.2	-	216,255	-	$3.75	-
Ontario	Base	$86.0	$15.2	$206.4	$26.8	3,513,414	406,178	$1.22	$1.88
	10%	$101.7	$18.0	$227.0	$29.5	3,803,727	460,335	$1.34	$1.96
	20%	$320.9	$34.6	$247.6	$32.2	4,602,980	514,493	$3.49	$3.36
PEI	Base	$0.9	-	$0.9	-	8,684	-	$5.33	-
	10%	$1.1	-	$1.0	-	9,842	-	$5.54	-
	20%	$1.9	-	$1.1	-	10,999	-	$8.46	-
Quebec	Base	$35.5	$13.2	$67.9	$14.5	818,506	206,395	$2.17	$3.19
	10%	$42.0	$15.5	$74.7	$16.0	988,036	235,677	$2.13	$3.29
	20%	$132.0	$35.2	$81.5	$17.4	1,192,302	264,959	$5.54	$6.65
Saskatchewan	Base	$8.8	$5.1	$14.9	$6.3	266,397	95,242	$1.65	$2.67
	10%	$10.4	$6.0	$16.4	$6.9	301,917	107,941	$1.72	$2.78
	20%	$20.9	$15.8	$17.9	$7.5	337,436	120,640	$3.09	$6.54
Total	Base (75%)	$212.9	$49.6	$466.3	$70.8	7,362,673	1,058,809	$1.45	$2.34
	+10% (85%)	$251.8	$58.5	$513.0	$77.9	8,335,141	1,201,746	$1.51	$2.43
	+20% (95%)	$839.8	$133.8	$559.6	$85.0	9,851,284	1,344,684	$4.26	$4.98

Notes:

(1) Base case scenario assumes a general LFG collection efficiency of 75%, unless site specific data available.

(2) +10% - an additional 10% increase in the base case LFG collection efficiency, includes the expansion of the collection field and utilization facility

(3) +20% - an additional 20% increase in the base case LFG collection efficiency, includes the expansion of the collection field, installation of a cover system and expansion of the utilization facility

increase the margins expected if the private sector were to become involved on the basis of revenue for GHG credits.

In the optimized case (95 percent) recovery of modeled emissions from specific landfills, the costs would increase dramatically because it would entail major changes to the landfill design and operations with items such as synthetic cover systems. To encourage private sector interest in a project like this would require a market valuation for GHG emission reductions could exceed \$10/ tonne eCO_2 for most of the sites included in this survey. It would actually be less costly to initiate LFG utilization with no expectation of revenue from the facility than to consider expensive capping systems for the respective landfills.

Assigning a value to GHG emission reductions that would encourage LFG utilization is difficult given the variable nature of energy prices that would apply in each of the provincial markets. It is likely that any site that has an efficient collection and control system in place could attract LFG utilization development if the power sales revenue or equivalent energy price was at or above \$0.06/kWh. The best price that is currently available in any of the current markets is about \$0.05/kWh. Therefore, a long term guaranteed price for GHG emission reductions would need to be from a minimum of \$2.50/tonne eCO^2 to have any positive influence on the development of LFG utilization projects.

Table 6.1 illustrates that the cost of collection and flaring to achieve emission reductions is more expensive for the small and mid size sites. It also indicates that the cost of capture and flaring is proportionately much larger when compared to the utilization costs for the small and mid size sites. Approximately 1,000,000 tonnes of eCO^2 emissions per year from capture and flaring could be achieved from the additional sites identified in this report for a total present value cost of approximately \$50,000,000.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the above report the following conclusions are made:

1. GHG emissions from landfills in Canada are close to being stable and are likely declining slowly from a peak emissions rate that likely took place in the late 1980s. Environment Canada's inventory reports for GHG emissions from landfills between 1990 and 1999 increases by more than 20 percent from less than 23 Mtonnes/year to almost 28 Mtonnes/year. This trend is not consistent with the assumptions used and the available data base that presently exists. Based on the data presented in Table 3.1, the quantity of contributing organic waste peaked in 1985. The LFG emissions should have peaked prior to 1990.

2. The Environment Canada emission estimates under predict the 1990 baseline GHG emissions from landfills. The future projections of total potential GHG emissions from waste should be very consistent and level over the next 20 years. Since the emissions profile in any given year is a function of the historical waste filling, the future trends will react slowly regardless of any measures taken to reduce organics disposal in landfills. Essentially, successful and rapid movement towards waste diversion and other 3R's targets will have only minimal impact over the 2008-2012 period. Any real benefits are well into the future and primarily beyond 2020. This study has made a simplifying assumption that the population increases match any offsetting declines in organics disposal to landfills as a result of proactive diversion and reduction policies. The results of this study are relatively insensitive to this factor over the target period.

3. In the modeling assessment and sensitivity review, it was found that the generation rate constant (k) has a very limited impact on the national emissions estimate but it can have a very significant impact on the emission estimate for a specific site. The k values assigned in the original Environment Canada emission estimates were assigned incorrectly. The parameter assignment that ranged from a low of 0.003 to 0.028 should be revised to the range from 0.02 to 0.05. The two primary factors considered were rainfall and temperature. Moisture is a critical factor but temperature, in this specific application, is not. The landfills are generally quite deep and the decomposition processes are exothermic in nature. Temperature should not have a major influence on the k factor except for some very northerly sites, which have no influence on the findings of this study.

4. In looking at the overall emissions estimate for Canada, the total emissions constant (Lo) is the dominant factor in the modeling since it establishes the total quantity of emissions that can be released by the decomposition of the organic

matter in the waste. In theory, a tonne of decomposable organic matter will generate approximately 600 cubic meters of landfill gas or 300 cubic metres of methane. One of the largest areas of both variability and uncertainty in the modeling assessment is the factor being used for the organic/inorganic fraction in the total quantity of wastes. The Environment Canada emissions estimate of Lo was declining over the period from 1988 to 1999. A modest decline in this parameter would be acceptable but care must be taken not to reduce this parameter and also deduct allowances for inorganic waste disposal from the total waste stream quantities used. At an assigned Lo value of 170 cubic metres, there is an inherent assumption that almost 50 percent of the mass is not decomposable organic material.

5. The 1999 inventory study accounted for 66 percent of Canada's waste stream landfilled at the 86 largest landfill sites across the nation. This report accounted for an additional 5 percent of Canada's waste stream in an additional 28 mid-size landfill sites across Canada. This leaves an estimated 29 percent of Canada's waste stream. This waste is accounted for as follows:
   - waste landfilled in small rural landfills below the revised screening criteria;
   - waste that is exported for disposal in other jurisdictions (e.g. United States);
   - waste that is incinerated;
   - waste that is treated by other systems (e.g. anaerobic digestion or composting); and
   - variance in the input parameters and assumptions that have necessarily been used in the estimations of waste quantity generation and GHG generation/emission.

6. Approximately 42 percent of the GHG emissions estimate by Environment Canada was accounted for in the 1999 inventory and an additional 5 percent has been identified in this study. These quantities are within the expected assumption base used for the analyses. For example, if it is assumed that two thirds of the total quantity of waste is accounted for and the collection efficiency is 75 percent, then approximately 50 percent of the total emissions are accounted for. When we review the variance in the organic fraction of the waste mass, this is considered a reasonable level of correlation, within the sensitivity band for assessing the total emission reductions from landfills.

7. Implementing LFG capture and flaring systems at the 75 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 7,400,000 tonnes of GHG emission reduction in 1999. Over the next 20 years the rate of recovery from these sites would average approximately 7,000,000 tonnes/year at an average cost of approximately $1.45/tonne. Approximately

1,000,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $2.34/tonne.

8. Implementing LFG capture and flaring systems at the 85 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 8,340,000 tonnes of GHG emission reduction in 1999 at a slightly increased average cost of $1.51/tonne. Approximately 1,200,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $2.43/tonne. The analyses indicated that the unit cost to reduce emission by increasing the gas collection system efficiency to 85 percent may be viable but it would entail changes and consideration in the development sequence and operations planning for the landfills.

9. Implementing LFG capture and flaring systems at the 95 percent recovery rate at the landfills identified in the 1999 inventory would have yielded approximately 9,850,000 tonnes of GHG emission reduction in 1999 at a substantively increased average cost of $4.26/tonne. Approximately 1,340,000 tonnes/year of additional emission reductions have been estimated at the sites identified in this study at an average cost of approximately $4.98/tonne. The analyses indicated that the unit cost to reduce emission by increasing the gas collection system efficiency to 95 percent may be technically viable but it would be expensive and would entail major changes in the design, development sequence and operations planning for the landfills.

10. The costs identified in conclusions 7,8 and 9 do not include allowance for private sector involvement, financing and a return on investment. It is expected that GHG emission reduction values would have to increase by at least 30 percent above the price points noted above with some associated long term confidence in sustainable revenue to initiate private sector interest in the emission reduction projects.

11. There is a substantive increase in total capital required for LFG utilization projects at any of the identified sites. To date, LFG utilization projects have only been developed by private sector developers if there is economic merit to construct and operate the facilities. Generally secure revenue streams in the range of $0.06/kWhr, or the equivalent, over at least a 10 year term are required to support the economics for a LFG utilization project. This total revenue could be supplemented by revenue from GHG emission reductions but this aspect of the revenue stream would be secondary unless the value of the emission reductions started to exceed $5/tonne. Real revenue for emission reductions would reduce the minimum electrical power purchase price required to support the economics. However, the values would need to be relatively secure for a

minimum 10 year term before this revenue stream would become significant enough to encourage very many projects.

12. The total emissions estimates for Canada fall within an envelope between approximately 35 and 45 Mtonnes/year based on the model being used and reasonable selection of input parameters. This is significantly higher than the current reported numbers of approximately 28 Mtonnes/year for 1999 by Environment Canada. There is no attenuation or reduction factor for the effects of soil covers on this estimate that may reduce the total emissions significantly, particularly from the smaller and mid sized landfills.

13. The current GMEF and GMIF funding programs administered by the FCM have, to date, had limited success in encouraging development of LFG projects.

14. As the size of the landfill site decreases, the greater will be the technical difficulty in achieving high collection system efficiencies and the higher will be the cost to achieve emission reductions.

Based on the results of this assessment, the following recommendations are made:

1. The basis and rationale for Environment Canada's emission estimates should be reviewed in detail and revised to reflect current understanding of the various input parameters and pertinent assumptions. The Lo value assigned to the wastes prior to 1988 is too high and should be revised. The k values are too low and should also be revised. The assumptions made regarding waste quantities and per capita contributions have a significant bearing on the projections made. These assumptions should also be reviewed in detail to ensure that the baseline and future projections are both realistic and supportable.

2. Given the increasing costs and the declining benefits, it is unlikely that further survey of smaller sites would yield any viable options for further GHG emission reductions from landfills and is not considered warranted unless GHG emission reduction costs and benefits are valued at well above $5/tonne.

3. The basis for funding support for GHG emission reduction projects from landfills should be reviewed and revised if there is an expectation to show real and significant gains in emission reductions over the next 10 years and beyond.

4. There should be an attenuation or reduction factor included in the modeling analyses that accounts for the effects of soil cover systems. This item should be reviewed and addressed for future emissions modeling

estimates from landfills. This factor would tend to lower the overall emissions estimate.

APPENDIX A

ADDITIONAL SITE FACT SHEETS

ALBERTA

SITE FACT SHEET

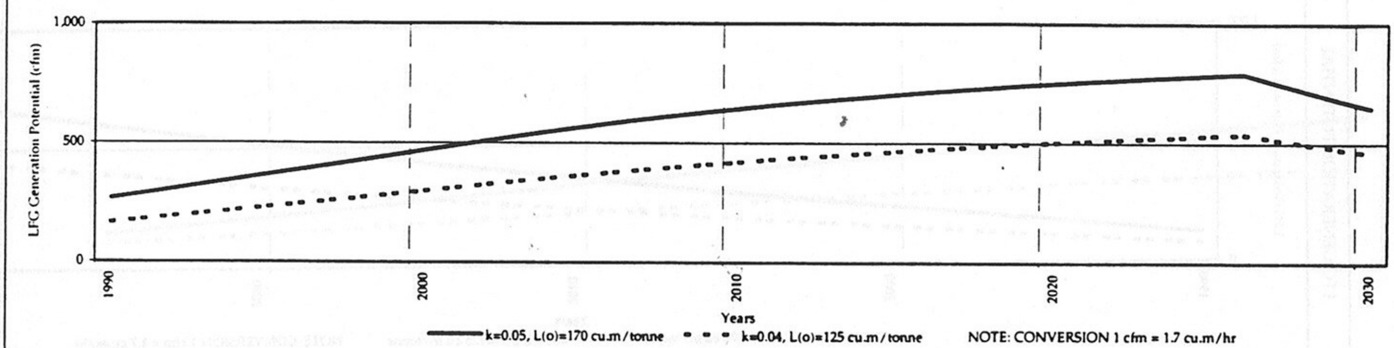
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	LEDUC	Site Location:	LEDUC, ALBERTA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Province of Alberta	**Utilization System Owner:**	n/a
Contact Name:	Allan Yamashita	Contact Name:	
Address:	#1 Alexandra Park Leduc, AB, T9E 4C4	Address:	
Tel.No.:	780-980-7151	Tel.No.:	
Fax No.:	780-980-7127	Fax No.:	
Email:	ayamishita@leduc.ab.ca	Email:	
Background:			
Year Open:	1978	Landfill Area (ha):	30
Year Close:	2025	Liner:	in new cell
Filling Rate (tonnes/year):	40,000	Capping:	clay
Waste in Place (tonnes):	720,000	Leachate Collection:	full drainage system
Site Capacity (tonnes):	1,650,000	Local Fuel Demand :	none
Average Depth of Waste (m):	11	Site Setting:	Agricultural
Type of Waste:	MSW, CD, ICI		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	380
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	530
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	630
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,080,000
		Annual O&M Cost of Additional Capture and Flaring:	$108,000
Average CO_2 Equivalent (tonnes/year):	43,139	Value of Additional GHG Credits:	$617,007
Total CO_2 Equivalent (tonnes):	862,779	Cost/tonne of CO_2:	$2.319

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	78,059	Capital Cost of Additional LFG Utilization:	$1,827,425
Additional Electrical Generation Potential (MW):	0.9	Annual O&M Cost of Additional Utilization:	$120,062
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,447)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,064)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	FOOTHILLS	Site Location:	DISTRICT OF FOOTHILLS, ALBER

SITE DESCRIPTION SUMMARY

Landfill Owner:	Municipal District of Foothills	Utilization System Owner:	
Contact Name:		Contact Name:	
Address:	309 MacLeod Trail, Box 5605 High River, AB	Address:	
Tel.No.:		Tel.No.:	
Fax No.:		Fax No.:	
Email:		Email:	

Background:

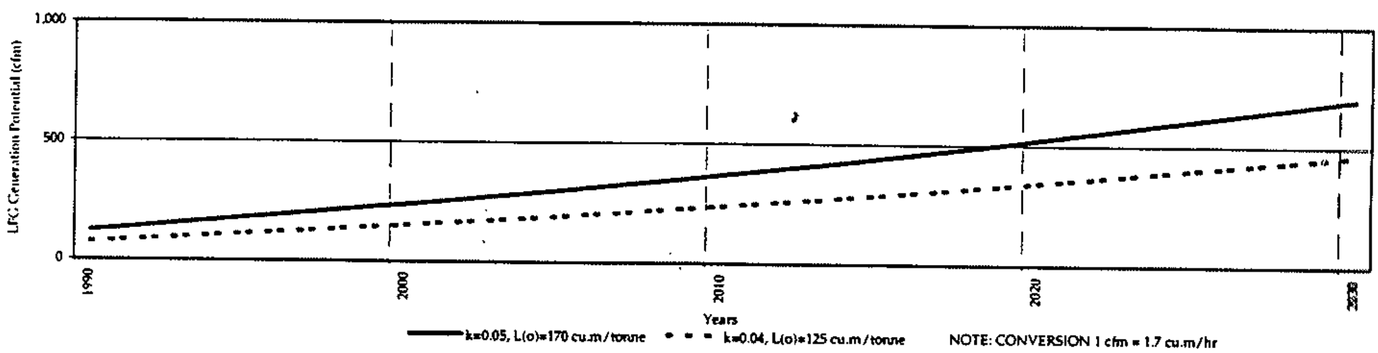
Year Open:	1980	Landfill Area (ha):	63
Year Close:	2060	Liner:	HDPE
Filling Rate (tonnes/year):	22,000	Capping:	clay @closure (start 2002)
Waste in Place (tonnes):	N/A	Leachate Collection:	full
Site Capacity (tonnes):	N/A	Local Fuel Demand :	none
Average Depth of Waste (m):	6	Site Setting:	Rural / Residential
Type of Waste:	MSW, CD		

Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	LFG Generation Potential (@ 50% CH_4 Content):	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	200
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	300
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	430
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$900,000
		Annual O&M Cost of Additional Capture and Flaring:	$90,000
Average CO_2 Equivalent (tonnes/year):	26,051	Value of Additional GHG Credits:	$372,608
Total CO_2 Equivalent (tonnes):	521,029	Cost/tonne of CO_2:	$3.201

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	47,140	Capital Cost of Additional LFG Utilization:	$1,103,575
Additional Electrical Generation Potential (MW):	0.6	Annual O&M Cost of Additional Utilization:	$72,505
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,316)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,688)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	CAMROSE	Site Location:	CAMROSE, ALBERTA

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Camrose	**Utilization System Owner:**	
Contact Name:	Mark Barret	Contact Name:	
Address:	Camrose, AB T4V 0S8	Address:	
Tel.No.:	780-672-4428	Tel.No.:	
Fax No.:	780-672-6316	Fax No.:	
Email:	mbarrett@camrose.com	Email:	

Background:

Year Open:	1983	Landfill Area (ha):	N/A
Year Close:	2037	Liner:	none
Filling Rate (tonnes/year):	25,000	Capping:	clay
Waste in Place (tonnes):	360,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	1,250,000	Local Fuel Demand :	none
Average Depth of Waste (m):	10	Site Setting:	Rural / Agricultural
Type of Waste:	MSW, CD, ICI		

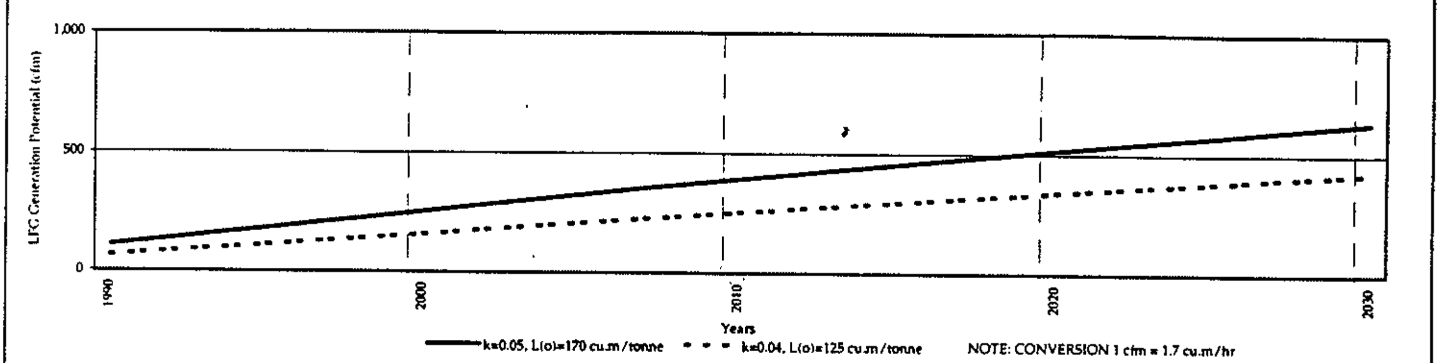
Migration Monitoring: none

Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	210
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	320
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	430
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$720,000
		Annual O&M Cost of Additional Capture and Flaring:	$72,000
Average CO_2 Equivalent (tonnes/year):	26,892	Value of Additional GHG Credits:	$384,628
Total CO_2 Equivalent (tonnes):	537,836	Cost/tonne of CO_2:	$2.480

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	48,660	Capital Cost of Additional LFG Utilization:	$1,139,174
Additional Electrical Generation Potential (MW):	0.6	Annual O&M Cost of Additional Utilization:	$74,844
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($985)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,370)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

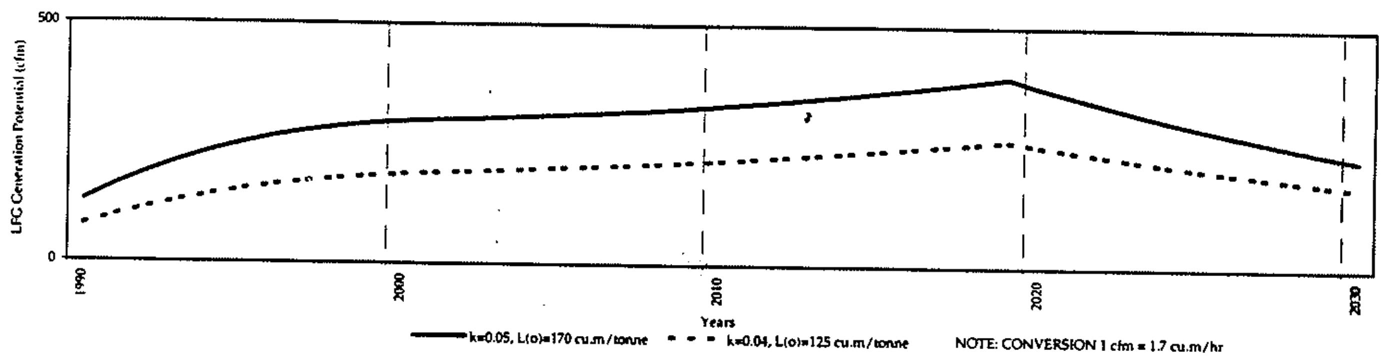
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	DRAYTON VALLEY	Site Location:	DRAYTON VALLEY, ALBERTA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Town of Drayton Valley	**Utilization System Owner:**	
Contact Name:	Randy Clark	Contact Name:	
Address:	5120 - 152ns Street, Box 6837 Drayton Valley, AB	Address:	
Tel.No.:	780-514-2200	Tel.No.:	
Fax No.:	780-542-5753	Fax No.:	
Email:	rclark@town.draytonvalley.ab.ca	Email:	
Background:			
Year Open:	1987	Landfill Area (ha):	N/A
Year Close:	2018	Liner:	clay in new cell
Filling Rate (tonnes/year):	14,850	Capping:	clay
Waste in Place (tonnes):	400,000	Leachate Collection:	full drainage system in new cell
Site Capacity (tonnes):	716,000	Local Fuel Demand :	none
Average Depth of Waste (m):	15	Site Setting:	Agricultural
Type of Waste:	MSW, ICI, CD.		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	240
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	270
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	310
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$800,000
		Annual O&M Cost of Additional Capture and Flaring:	$80,000
Average CO_2 Equivalent (tonnes/year):	22,970	Value of Additional GHG Credits:	$328,536
Total CO_2 Equivalent (tonnes):	459,402	Cost/tonne of CO_2:	$3.227

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	41,564	Capital Cost of Additional LFG Utilization:	$973,044
Additional Electrical Generation Potential (MW):	0.5	Annual O&M Cost of Additional Utilization:	$63,929
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,172)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,500)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

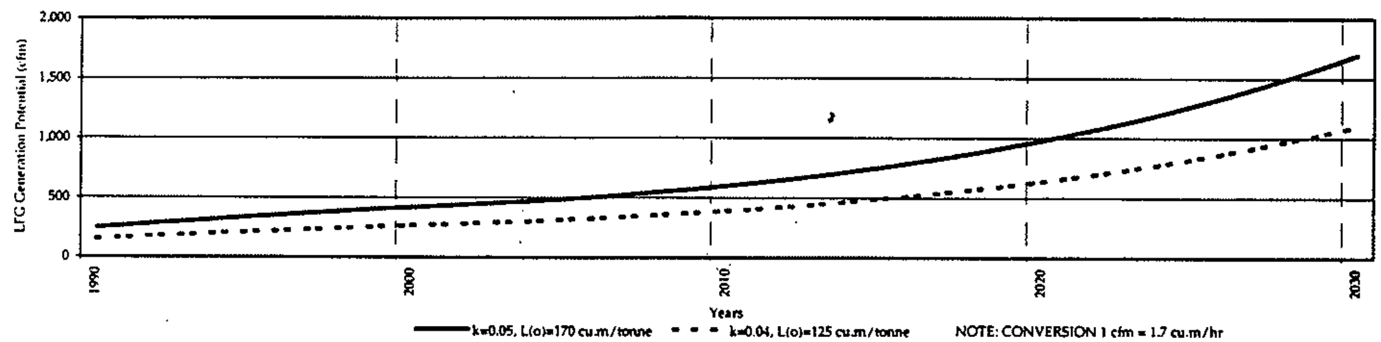
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	ROSERIDGE	Site Location:	MORINVILLE, ALBERTA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Province of Alberta	**Utilization System Owner:**	
Contact Name:	Cathy Armour	Contact Name:	
Address:	Box 19, Site 1, RR 1 Morinville AB	Address:	
Tel.No.:	780-939-5678	Tel.No.:	
Fax No.:	780-939-4788	Fax No.:	
Email:	manager@roseridge.ab.ca	Email:	
Background:			
Year Open:	1980	Landfill Area (ha):	N/A
Year Close:	2050	Liner:	clay
Filling Rate (tonnes/year):	30,000	Capping:	clay
Waste in Place (tonnes):	827,000	Leachate Collection:	full drainage system
Site Capacity (tonnes):	2,500,000	Local Fuel Demand :	none
Average Depth of Waste (m):	10	Site Setting:	Rural / Agricultural
Type of Waste:	MSW, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	340
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	490
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	810
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,116,450
		Annual O&M Cost of Additional Capture and Flaring:	$111,645
Average CO_2 Equivalent (tonnes/year):	45,940	Value of Additional GHG Credits:	$657,072
Total CO_2 Equivalent (tonnes):	918,803	Cost/tonne of CO_2:	$2.251
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	83,128	Capital Cost of Additional LFG Utilization:	$1,946,088
Additional Electrical Generation Potential (MW):	1.0	Annual O&M Cost of Additional Utilization:	$127,858
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,481)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,138)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

BRITISH COLUMBIA

SITE FACT SHEET

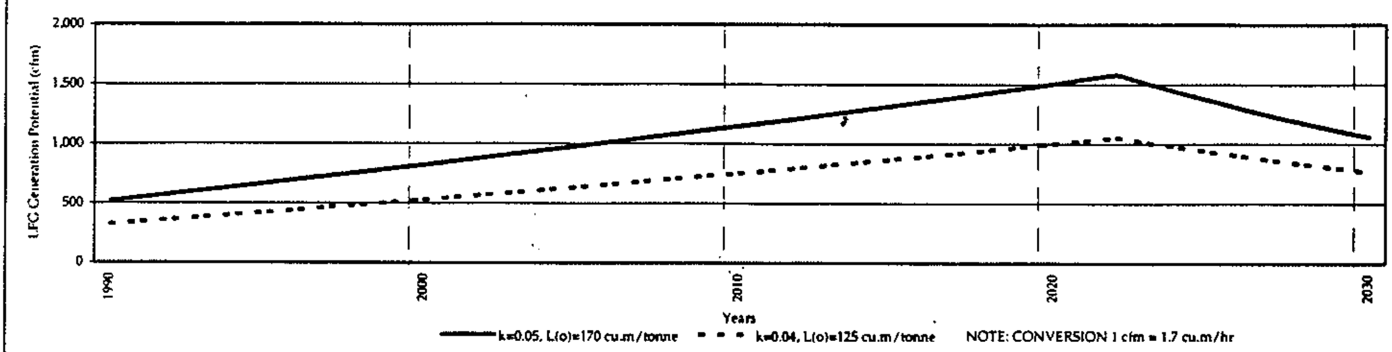
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	FOOTHILLS BOULEVARD (previously erroneously referred to as Hart)	Site Location:	PRINCE GEORGE, BRITISH COLUMBIA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Regional District of Fraser-Fort George	**Utilization System Owner:**	n/a
Contact Name:	Jim Martin	Contact Name:	
Address:	155 George St. Prince George, BC, V2l 1P8	Address:	
Tel.No.:	(250) 960-4486	Tel.No.:	
Fax No.:	(250-563-7848	Fax No.:	
Email:	jmartin@rdffg.bc.ca	Email:	
Background:			
Year Open:	1974	Landfill Area (ha):	44.6
Year Close:	2021	Liner:	none
Filling Rate (tonnes/year):	66,200	Capping:	progressive placement of clay
Waste in Place (tonnes):	1,260,000	Leachate Collection:	none
Site Capacity (tonnes):	3,000,000	Local Fuel Demand :	none
Average Depth of Waste (m):	6	Site Setting:	Rural / Industrial
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:			
Number of Monitoring Locations:	none	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	680
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	950
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	1250
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☐ No ☑	Capital Cost of Additional LFG Capture and Flaring:	$1,701,000
		Annual O&M Cost of Additional Capture and Flaring:	$170,100
Average CO_2 Equivalent (tonnes/year):	80,675	Value of Additional GHG Credits:	$1,153,883
Total CO_2 Equivalent (tonnes):	1,613,508	Cost/tonne of CO_2:	$1.953
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	145,981	Capital Cost of Additional LFG Utilization:	$3,417,521
Additional Electrical Generation Potential (MW):	1.7	Annual O&M Cost of Additional Utilization:	$224,531
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,137)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($3,291)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

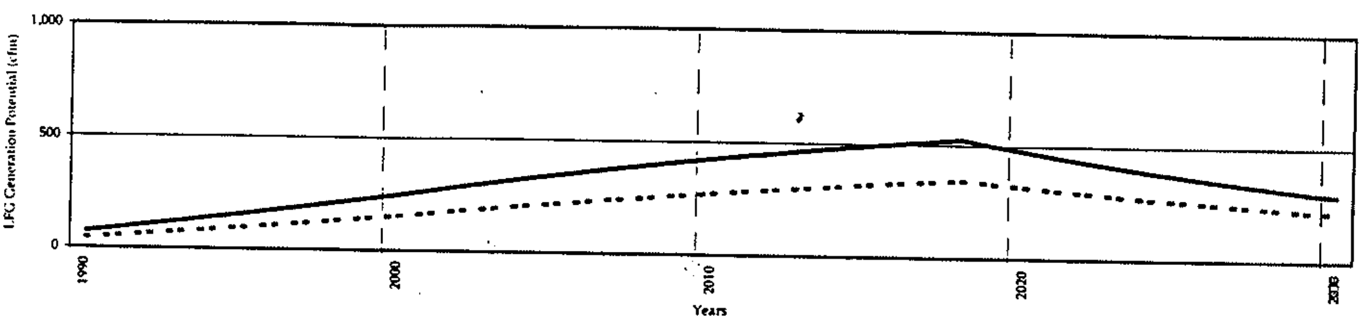
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	GREATER VERNON	Site Location:	VERNON, BRITISH COLUMBIA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Giant Industries	**Utilization System Owner:**	
Contact Name:	Robert James	Contact Name:	
Address:		Address:	
Tel.No.:	(250) 542 - 4949	Tel.No.:	
Fax No.:	(250) 452 - 7223	Fax No.:	
Email:		Email:	
Background:			
Year Open:	1980	Landfill Area (ha):	13.9
Year Close:	2017	Liner:	none
Filling Rate (tonnes/year):	30,000	Capping:	none planned
Waste in Place (tonnes):	330,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	845,915	Local Fuel Demand :	Industrial subdivision planned
Average Depth of Waste (m):	10	Site Setting:	Industrial / Rural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	200
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	350
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	400
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$660,000
		Annual O&M Cost of Additional Capture and Flaring:	$66,000
Average CO_2 Equivalent (tonnes/year):	26,612	Value of Additional GHG Credits:	$380,621
Total CO_2 Equivalent (tonnes):	532,234	Cost/tonne of CO_2:	$2.298
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	48,154	Capital Cost of Additional LFG Utilization:	$1,127,307
Additional Electrical Generation Potential (MW):	0.6	Annual O&M Cost of Additional Utilization:	$74,064
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($881)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,262)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	MISSION FLATS	Site Location:	KAMLOOPS, BRITISH COLUMBIA

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Kamloops	**Utilization System Owner:**	
Contact Name:	Jim McNeely	Contact Name:	
Address:	7 Victoria St. W Kamloops, BC	Address:	
Tel.No.:	(250) 828-3535	Tel.No.:	
Fax No.:	(250) 828-1766	Fax No.:	
Email:	jmcneely@city.kamloops.bc.cs	Email:	

Background:

Year Open:	1975	Landfill Area (ha):	N/A
Year Close:	2050	Liner:	none
Filling Rate (tonnes/year):	45,000	Capping:	clay
Waste in Place (tonnes):	750,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	4,500,000	Local Fuel Demand :	unknown
Average Depth of Waste (m):	50	Site Setting:	Rural
Type of Waste:	MSW		

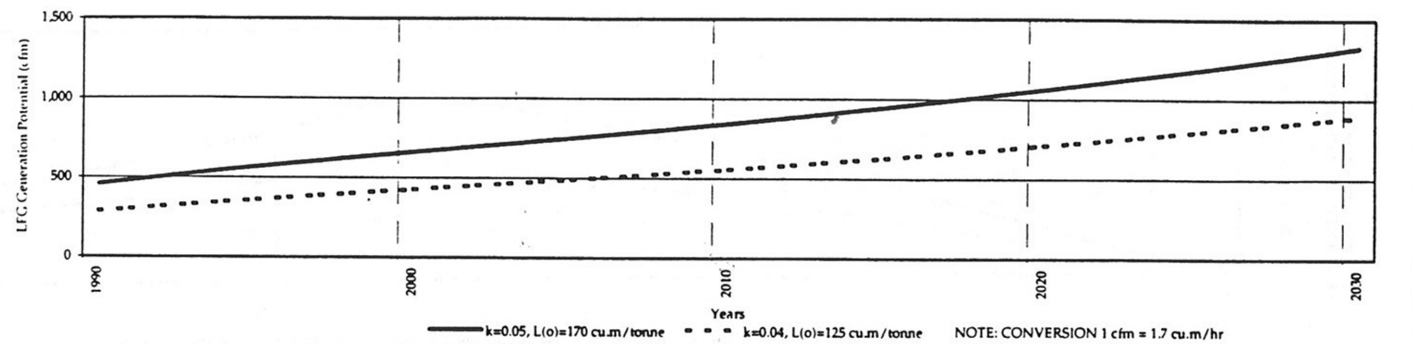
Migration Monitoring: none

Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	540
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	700
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	890
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,012,500
		Annual O&M Cost of Additional Capture and Flaring:	$101,250
Average CO_2 Equivalent (tonnes/year):	59,666	Value of Additional GHG Credits:	$853,393
Total CO_2 Equivalent (tonnes):	1,193,324	Cost/tonne of CO_2:	$1.572

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	107,965	Capital Cost of Additional LFG Utilization:	$2,527,542
Additional Electrical Generation Potential (MW):	1.3	Annual O&M Cost of Additional Utilization:	$166,059
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,142)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,996)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

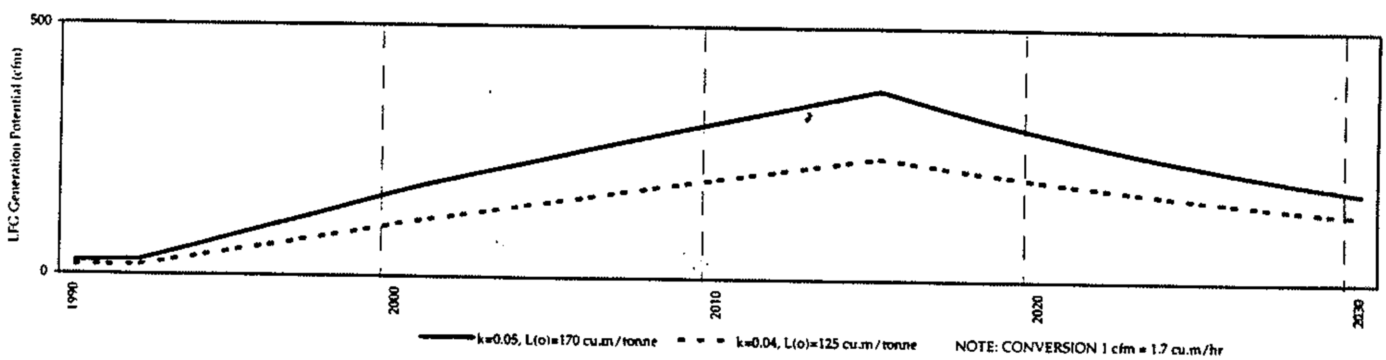
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR
ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	CAMPBELL RIVER	Site Location:	COURTNEY, BRITISH COLUMBIA

SITE DESCRIPTION SUMMARY

Landfill Owner:	Regional District of Comox-Strathcona	**Utilization System Owner:**	
Contact Name:	John Cooper	Contact Name:	
Address:	350n 17 Street Courtnay, BC, V9N 1Y4	Address:	
Tel.No.:	(250) 334-6000	Tel.No.:	
Fax No.:	(250) 334-4358	Fax No.:	
Email:	jcooper@rdcs.bc.ca	Email:	
Background:			
Year Open:	1964	Landfill Area (ha):	10.7
Year Close:	2014	Liner:	none
Filling Rate (tonnes/year):	21,350	Capping:	clay and geosynthetic
Waste in Place (tonnes):	157,504	Leachate Collection:	none
Site Capacity (tonnes):	533,000	Local Fuel Demand :	Ready mix plant
Average Depth of Waste (m):	5 to 25	Site Setting:	Rural & Industrial
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	140
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	250
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	250
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$500,000
		Annual O&M Cost of Additional Capture and Flaring:	$50,000
Average CO_2 Equivalent (tonnes/year):	17,928	Value of Additional GHG Credits:	$256,418
Total CO_2 Equivalent (tonnes):	358,557	Cost/tonne of CO_2:	$2.584
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	32,440	Capital Cost of Additional LFG Utilization:	$759,449
Additional Electrical Generation Potential (MW):	0.4	Annual O&M Cost of Additional Utilization:	$49,896
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($693)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($949)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

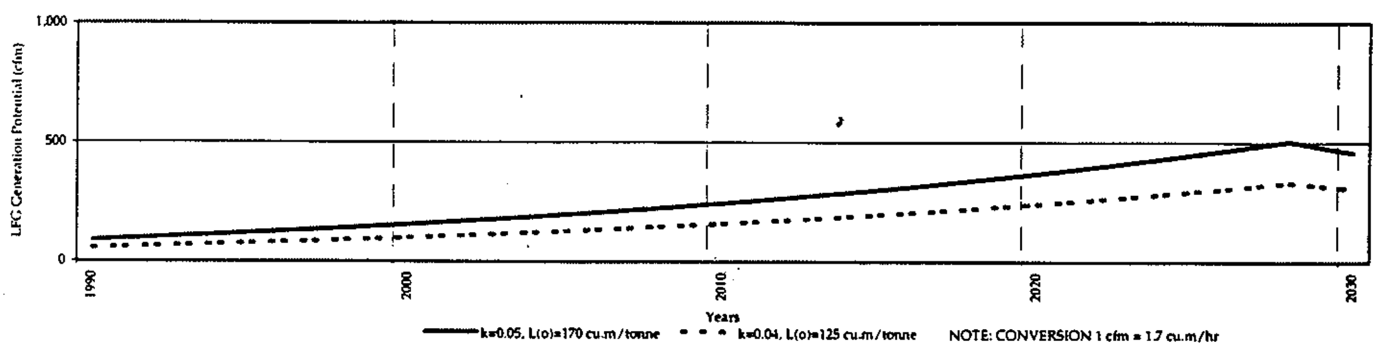
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	MINNIE'S PIT	Site Location:	MISSION, BRITISH COLUMBIA

SITE DESCRIPTION SUMMARY

Landfill Owner:	District of Mission	**Utilization System Owner:**	
Contact Name:	Mike Hofer	Contact Name:	
Address:	8645 Stave Lake St. Mission, BC	Address:	
Tel.No.:	(604) 820-3736	Tel.No.:	
Fax No.:	(604) 826-7951	Fax No.:	
Email:	mhofer@city.mission.bc.ca	Email:	
Background:			
Year Open:	1973	Landfill Area (ha):	5.4
Year Close:	2027	Liner:	none
Filling Rate (tonnes/year):	14,300	Capping:	progressive placement of geosynthetic
Waste in Place (tonnes):	240,000	Leachate Collection:	
Site Capacity (tonnes):	900,000	Local Fuel Demand :	none
Average Depth of Waste (m):	unknown	Site Setting:	Rural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	130
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	200
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	300
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$500,000
		Annual O&M Cost of Additional Capture and Flaring:	$5,000
Average CO_2 Equivalent (tonnes/year):	17,648	Value of Additional GHG Credits:	$252,412
Total CO_2 Equivalent (tonnes):	352,955	Cost/tonne of CO_2:	$1.537
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	31,933	Capital Cost of Additional LFG Utilization:	$747,583
Additional Electrical Generation Potential (MW):	0.4	Annual O&M Cost of Additional Utilization:	$49,116
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($313)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($565)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

MANITOBA

SITE FACT SHEET

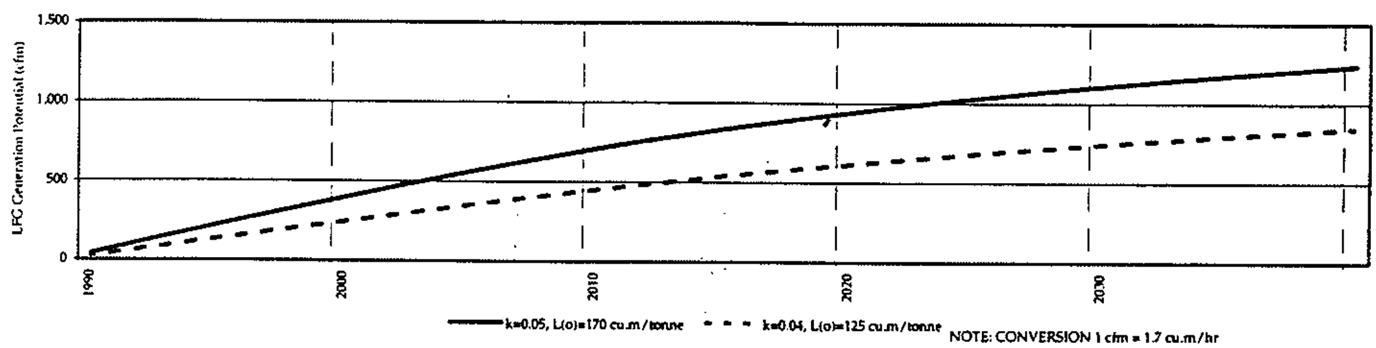
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	EASTVIEW	Site Location:	BRANDON, MANITOBA

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Brandon	**Utilization System Owner:**	
Contact Name:	Wayne Kingdon	Contact Name:	
Address:	410 - 9th Street Brandon, Manitoba	Address:	
Tel.No.:	(204) 729 - 2285	Tel.No.:	
Fax No.:	(204) 729 - 2191	Fax No.:	
Email:		Email:	
Background:			
Year Open:	1979	Landfill Area (ha):	57
Year Close:	2050	Liner:	HDPE
Filling Rate (tonnes/year):	55,471	Capping:	clay
Waste in Place (tonnes):	unknown	Leachate Collection:	partial drainage tile
Site Capacity (tonnes):	unknown	Local Fuel Demand :	none
Average Depth of Waste (m):	24	Site Setting:	Industrial
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:			
Number of Monitoring Locations:	none	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	580
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	780
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	930
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,620,000
		Annual O&M Cost of Additional Capture and Flaring:	$162,000
Average CO_2 Equivalent (tonnes/year):	64,148	Value of Additional GHG Credits:	$917,497
Total CO_2 Equivalent (tonnes):	1,282,963	Cost/tonne of CO_2:	$2.340
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	116,075	Capital Cost of Additional LFG Utilization:	$2,717,404
Additional Electrical Generation Potential (MW):	1.4	Annual O&M Cost of Additional Utilization:	$178,533
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,176)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($3,094)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

ONTARIO

SITE FACT SHEET

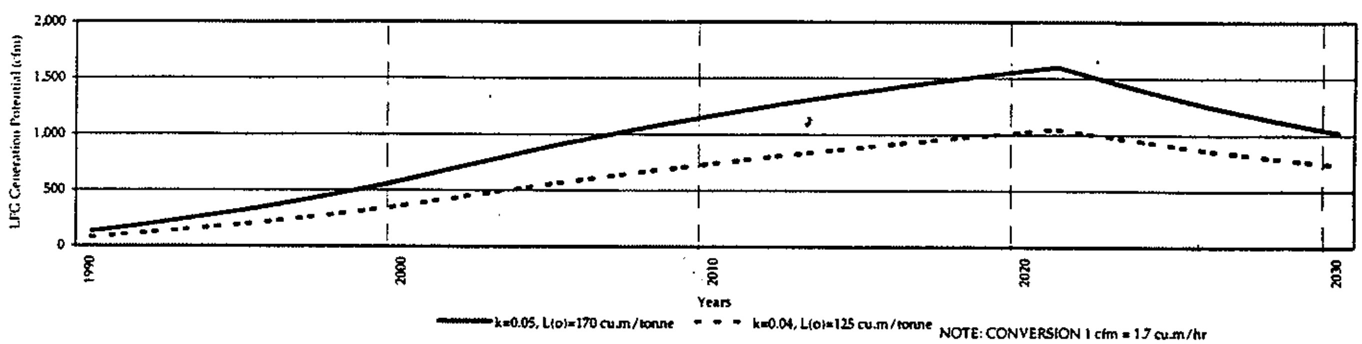
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR
ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	OXFORD	Site Location:	SALFORD, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	Corporation of the County of Oxford	**Utilization System Owner:**	
Contact Name:		Contact Name:	
Address:	P.O. Box 397, 415 Hunter St. Woodstock, ON., N4S 7Y3	Address:	
Tel.No.:	(519) 539-9800	Tel.No.:	
Fax No.:	(519) 537-3024	Fax No.:	
Email:	www.county.oxford.on.ca	Email:	
Background:			
Year Open:	1986	Landfill Area (ha):	43.7
Year Close:	2020	Liner:	none
Filling Rate (tonnes/year):	89,000	Capping:	clay
Waste in Place (tonnes):	unknown	Leachate Collection:	toe drain
Site Capacity (tonnes):	2,612,000	Local Fuel Demand :	Town of Ingersoll
Average Depth of Waste (m):	15	Site Setting:	Rural / Agricultural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	470
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	960
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	1300
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,800,000
		Annual O&M Cost of Additional Capture and Flaring:	$180,000
Average CO_2 Equivalent (tonnes/year):	76,474	Value of Additional GHG Credits:	$1,093,785
Total CO_2 Equivalent (tonnes):	1,529,471	Cost/tonne of CO_2:	$2.181
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	138,378	Capital Cost of Additional LFG Utilization:	$3,239,525
Additional Electrical Generation Potential (MW):	1.6	Annual O&M Cost of Additional Utilization:	$212,837
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,360)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($3,454)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR
ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	OWEN SOUND	Site Location:	OWEN SOUND, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Owen Sound	Utilization System Owner:	
Contact Name:	Chris Hughes	Contact Name:	
Address:	808 2nd Ave. E.	Address:	
Tel.No.:	519-376-4274	Tel.No.:	
Fax No.:	519-372-1209	Fax No.:	
Email:	chughes@c.owensound.com	Email:	

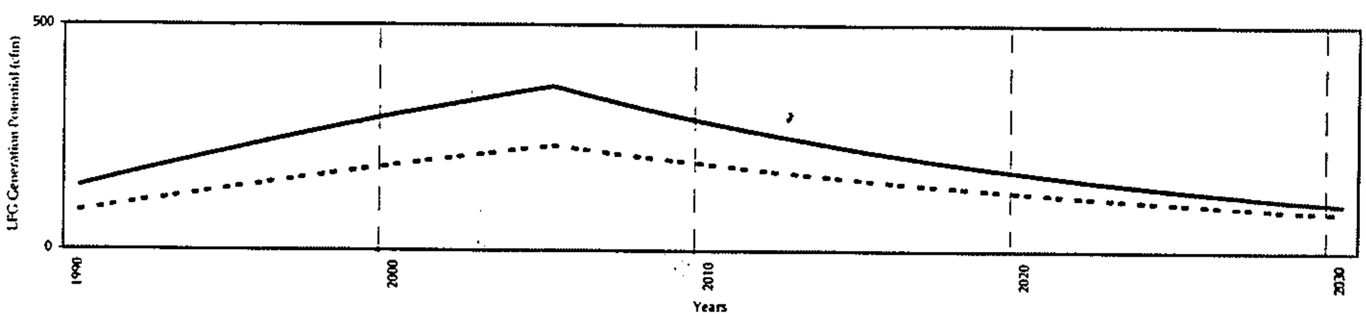
Background:			
Year Open:	1983	Landfill Area (ha):	10
Year Close:	2004	Liner:	natiave clay
Filling Rate (tonnes/year):	25,400	Capping:	clay
Waste in Place (tonnes):	434,200	Leachate Collection:	toe drain
Site Capacity (tonnes):	510,000	Local Fuel Demand :	none
Average Depth of Waste (m):	19	Site Setting:	Agricultural / Rural
Type of Waste:	MSW, ICI, CD		

Migration Monitoring:			
Number of Monitoring Locations:	4	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	0	System Description:	

Existing LFG Capture and Flaring: Yes ☐ No ☑		LFG Generation Potential (@ 50% CH_4 Content):	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	240
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	240
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	150
LFG Collection System:			

Existing LFG Utilization: Yes ☐ No ☑			
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$868,400
		Annual O&M Cost of Additional Capture and Flaring:	$86,840
Average CO_2 Equivalent (tonnes/year):	17,648	Value of Additional GHG Credits:	$252,412
Total CO_2 Equivalent (tonnes):	352,955	Cost/tonne of CO_2:	$4.559

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	31,933	Capital Cost of Additional LFG Utilization:	$747,583
Additional Electrical Generation Potential (MW):	0.4	Annual O&M Cost of Additional Utilization:	$49,116
Potential Unit Revenue:		Cost Benefit (NPV) (1000s):	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,353)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,605)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

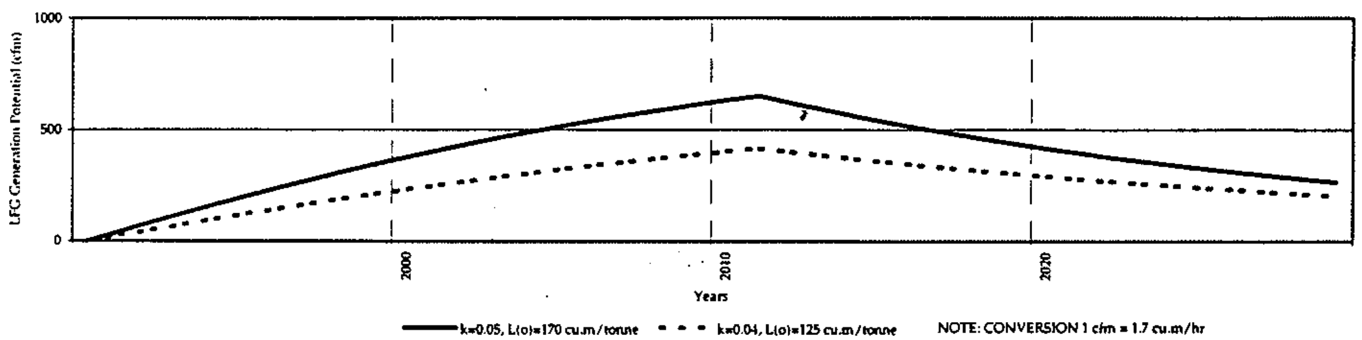
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	MERRICK	Site Location:	NORTH BAY, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of North Bay	**Utilization System Owner:**	n/a
Contact Name:	John Miller	Contact Name:	
Address:	P.O. Box 360, North Bay	Address:	
Tel.No.:	(705) 474-0626 ext. 306	Tel.No.:	
Fax No.:	(705) 495-0936	Fax No.:	
Email:	john.miller@citynorthbay.ca	Email:	
Background:			
Year Open:	1994	Landfill Area (ha):	16.4
Year Close:	2014 +	Liner:	none
Filling Rate (tonnes/year):	44,000	Capping:	proposed clay
Waste in Place (tonnes):	330,066	Leachate Collection:	toe drain
Site Capacity (tonnes):	900,000	Local Fuel Demand :	none
Average Depth of Waste (m):	26	Site Setting:	Rural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	190
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	440
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	420
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$660,132
		Annual O&M Cost of Additional Capture and Flaring:	$66,013
Average CO_2 Equivalent (tonnes/year):	29,413	Value of Additional GHG Credits:	$420,687
Total CO_2 Equivalent (tonnes):	588,258	Cost/tonne of CO_2:	$2.079
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	53,222	Capital Cost of Additional LFG Utilization:	$1,245,971
Additional Electrical Generation Potential (MW):	0.6	Annual O&M Cost of Additional Utilization:	$81,860
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($850)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,271)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	ALICE - FRASER	Site Location:	RENFREW COUNTY, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	Ottawa Valley Waste Management Board	Utilization System Owner:	
Contact Name:		Contact Name:	
Address:		Address:	
Tel.No.:	(613) 735-7537	Tel.No.:	
Fax No.:	(613) 735-1837	Fax No.:	
Email:		Email:	

Background:

Year Open:	1977	Landfill Area (ha):	12.06
Year Close:	2005	Liner:	none
Filling Rate (tonnes/year):	70,900	Capping:	clay
Waste in Place (tonnes):	728,000	Leachate Collection:	none
Site Capacity (tonnes):	1,128,000	Local Fuel Demand :	none
Average Depth of Waste (m):	20	Site Setting:	rural
Type of Waste:	MSW, ICI		

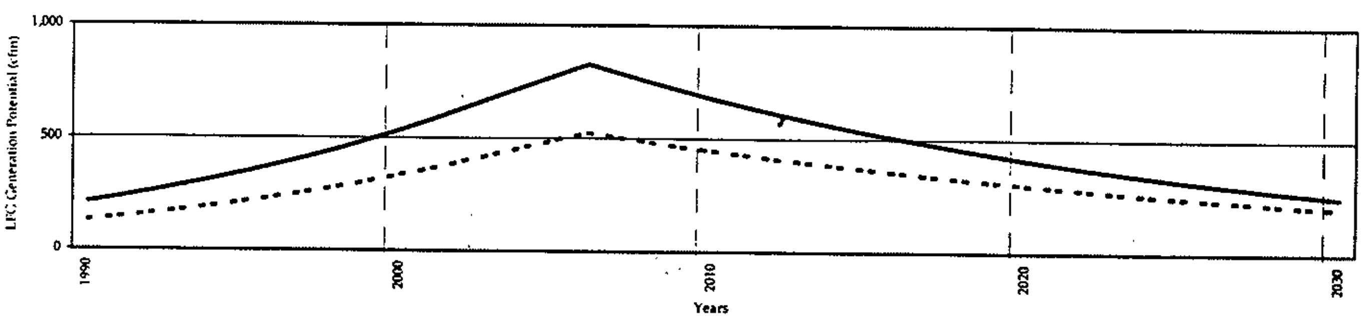
Migration Monitoring:

Number of Monitoring Locations:	29	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	Data not available	System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	430
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	560
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	350
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☑	Capital Cost of Additional LFG Capture and Flaring:	$1,092,000
		Annual O&M Cost of Additional Capture and Flaring:	$109,200
Average CO_2 Equivalent (tonnes/year):	37,536	Value of Additional GHG Credits:	$536,876
Total CO_2 Equivalent (tonnes):	750,730	Cost/tonne of CO_2:	$2.695

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	67,922	Capital Cost of Additional LFG Utilization:	$1,590,097
Additional Electrical Generation Potential (MW):	0.8	Annual O&M Cost of Additional Utilization:	$104,469
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,530)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,067)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

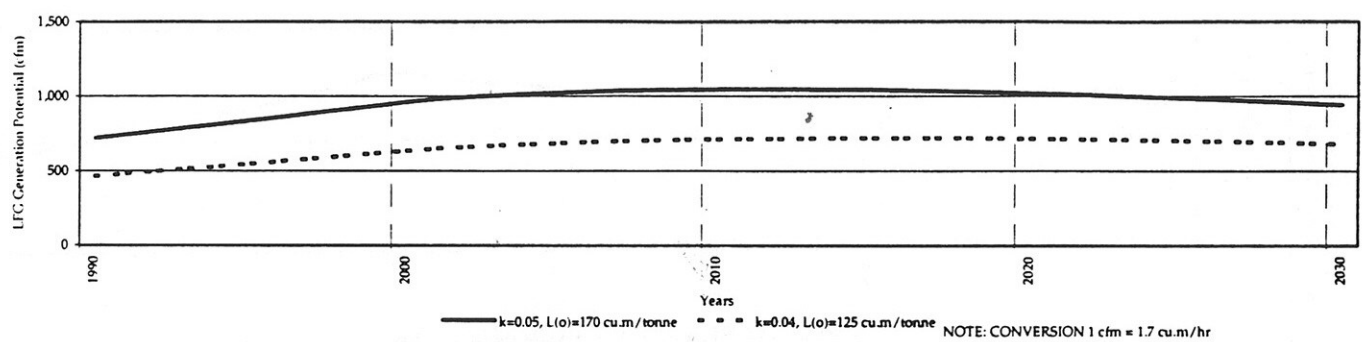
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	SANDY HALLOW	Site Location:	BARRIE, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Barrie	**Utilization System Owner:**	
Contact Name:	Alex Scott	Contact Name:	
Address:		Address:	
Tel.No.:	(705) 739 4220	Tel.No.:	
Fax No.:		Fax No.:	
Email:	ascott@city.barrie.on.ca	Email:	
Background:			
Year Open:	1964	Landfill Area (ha):	16.6
Year Close:	2034	Liner:	none
Filling Rate (tonnes/year):	64,000	Capping:	on 50% of site
Waste in Place (tonnes):	1,760,000	Leachate Collection:	partial perimeter collector
Site Capacity (tonnes):	3,136,000	Local Fuel Demand :	
Average Depth of Waste (m):	25	Site Setting:	rural with some residential
Type of Waste:	MSW		
Migration Monitoring:			
Number of Monitoring Locations:	10	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	0	System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	800
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	880
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	870
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☑	Capital Cost of Additional LFG Capture and Flaring:	$1,760,000
		Annual O&M Cost of Additional Capture and Flaring:	$176,000
Average CO_2 Equivalent (tonnes/year):	71,431	Value of Additional GHG Credits:	$1,021,667
Total CO_2 Equivalent (tonnes):	1,428,627	Cost/tonne of CO_2:	$2.283
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	129,254	Capital Cost of Additional LFG Utilization:	$3,025,930
Additional Electrical Generation Potential (MW):	1.5	Annual O&M Cost of Additional Utilization:	$198,804
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,345)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($3,367)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	NOTTAWASAGA	Site Location:	CLEARVIEW TOWNSHIP

SITE DESCRIPTION SUMMARY

Landfill Owner:	County of Simcoe	**Utilization System Owner:**	n/a
Contact Name:	Mark Aitken	Contact Name:	
Address:	County of Simcoe-Administration Centre 1110 Highway 26 Midhurst, Ontario, L0L 1X0	Address:	
Tel.No.:	(705) 726-9300 ext. 289	Tel.No.:	
Fax No.:	(705) 726-9832	Fax No.:	
Email:	maitken@county.simcoe.on.ca	Email:	

Background:

Year Open:	1970	Landfill Area (ha):	40.5
Year Close:	2014	Liner:	partial (clay/composite)
Filling Rate (tonnes/year):	15,400	Capping:	50% of site
Waste in Place (tonnes):	680,000	Leachate Collection:	perimeter collector
Site Capacity (tonnes):	910,000	Local Fuel Demand :	none
Average Depth of Waste (m):	11	Site Setting:	rural
Type of Waste:	MSW		

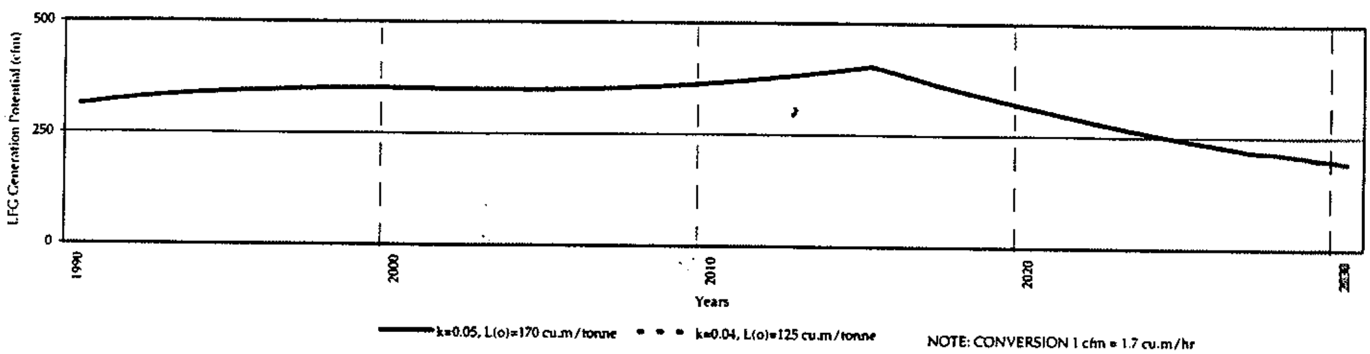
Migration Monitoring:

Number of Monitoring Locations:	26	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	0	System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	350
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	370
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	310
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,360,000
		Annual O&M Cost of Additional Capture and Flaring:	$136,000
Average CO_2 Equivalent (tonnes/year):	28,853	Value of Additional GHG Credits:	$412,674
Total CO_2 Equivalent (tonnes):	577,053	Cost/tonne of CO_2:	$4.367

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	52,209	Capital Cost of Additional LFG Utilization:	$1,222,238
Additional Electrical Generation Potential (MW)	0.6	Annual O&M Cost of Additional Utilization:	$80,301
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,105)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,518)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	LINDSAY/OPS	Site Location:	KAWARTHA LAKES, ONTARIO

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Kawartha Lakes	**Utilization System Owner:**	
Contact Name:	Julie Preslie	Contact Name:	
Address:	50 Wolfe St. Lindsay, K9V 2J2	Address:	
Tel.No.:	(705) 878-1282	Tel.No.:	
Fax No.:	(705) 328-3122	Fax No.:	
Email:	jpreslie@city.kawarthalakes.on.ca	Email:	

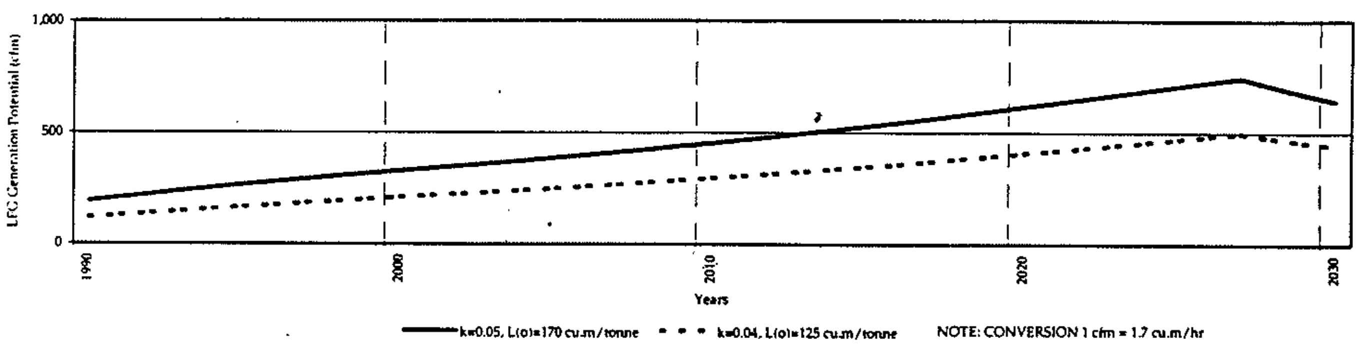
Background:			
Year Open:	1980	Landfill Area (ha):	10.7
Year Close:	2026	Liner:	partial clay and geosynthetic
Filling Rate (tonnes/year):	25,000	Capping:	partial clay and geosynthetic
Waste in Place (tonnes):	500,000	Leachate Collection:	partial toe drain/full drainage
Site Capacity (tonnes):	1,520,000	Local Fuel Demand :	correctional facility
Average Depth of Waste (m):	15	Site Setting:	agricultural / industrial
Type of Waste:	MSW, ICI, CD		

Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	200
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	370
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	510
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$750,000
		Annual O&M Cost of Additional Capture and Flaring:	$75,000
Average CO_2 Equivalent (tonnes/year):	30,253	Value of Additional GHG Credits:	$432,706
Total CO_2 Equivalent (tonnes):	605,066	Cost/tonne of CO_2:	$2.297

Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	54,743	Capital Cost of Additional LFG Utilization:	$1,281,570
Additional Electrical Generation Potential (MW):	0.6	Annual O&M Cost of Additional Utilization:	$84,199
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,001)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,434)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	SUDBURY (EXPANSION)	Site Location:	SUDBURY, ONTARIO
Expansion approved since 1999, projections for the entire site are presented.			

SITE DESCRIPTION SUMMARY

Landfill Owner:	Regional Municipality of Sudbury	**Utilization System Owner:**	
Contact Name:	Dave Caverson	Contact Name:	
Address:	P.O. Box 3700 Stn A 200 Brady Street Sudbury ON, P3A 5W5	Address:	
Tel.No.:	(705) 673-2171	Tel.No.:	
Fax No.:	(705) 673-5171	Fax No.:	
Email:		Email:	

Background:

Year Open:	1955	Landfill Area (ha):	22.7
Year Close:	2020	Liner:	none
Filling Rate (tonnes/year):	100,000	Capping:	
Waste in Place (tonnes):	1,800,000	Leachate Collection:	none
Site Capacity (tonnes):	3,800,000	Local Fuel Demand :	none
Average Depth of Waste (m):	10	Site Setting:	rural
Type of Waste:	MSW		

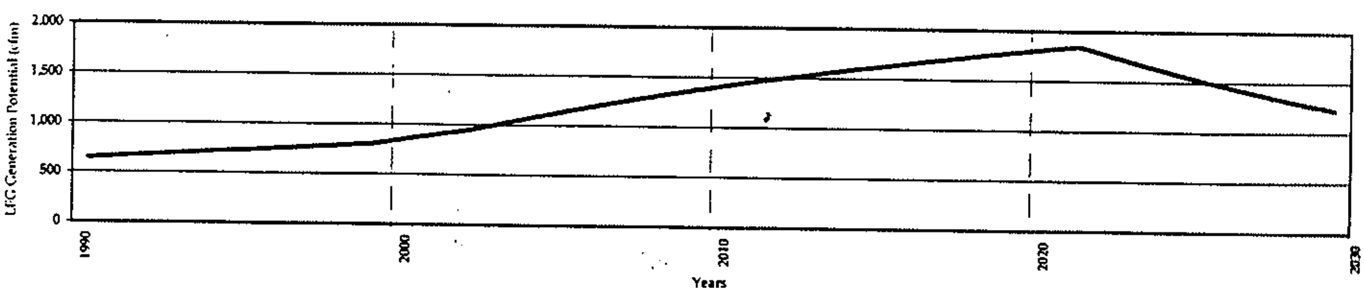
Migration Monitoring:

Number of Monitoring Locations:	0	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	860
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	1420
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	1810
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☐ No ☑	Capital Cost of Additional LFG Capture and Flaring:	$1,800,000
		Annual O&M Cost of Additional Capture and Flaring:	$180,000
Average CO_2 Equivalent (tonnes/year):	114,570	Value of Additional GHG Credits:	$1,638,674
Total CO_2 Equivalent (tonnes):	2,291,406	Cost/tonne of CO_2:	$1.455

Additional LFG Utilization Potential (2000-2020):

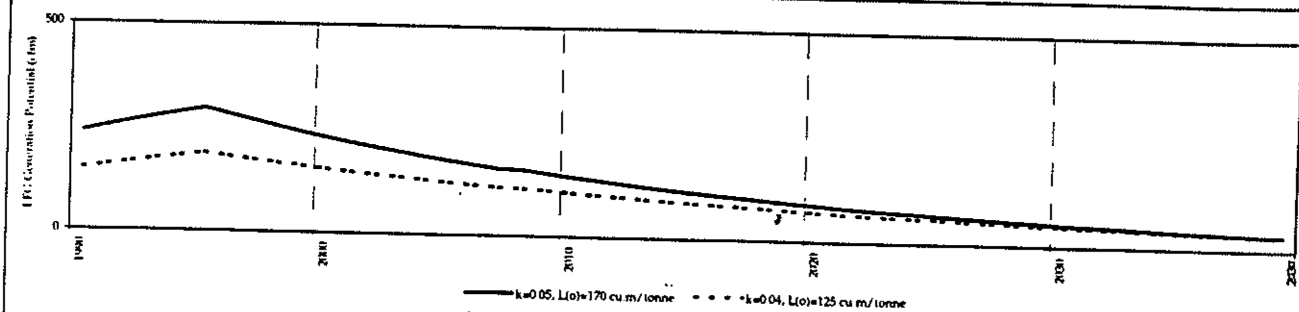
Total CO_2 Displaced (tonnes):	207,314	Capital Cost of Additional LFG Utilization:	$4,853,355
Additional Electrical Generation Potential (MW):	2.4	Annual O&M Cost of Additional Utilization:	$318,865
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,936)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	not applicable
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($3,575)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	not applicable

PRINCE EDWARD ISLAND

Site Name:	PRINCE COUNTY	Site Location:	SUMMERSIDE, P.E.I

Landfill Owner:	Province of PEI	**Utilization System Owner:**	
Contact Name:	Kevin Curley	Contact Name:	
Address:		Address:	
Tel.No.	(902) 368-5038	Tel.No.	
Fax No.		Fax No.	
Email		Email	
Background:			
Year Open:	1977	Landfill Area (ha):	24
Year Close:	1994	Liner:	0.6 m clay
Filling Rate (tonnes/year)	0	Capping:	1 m clay
Waste in Place (tonnes):	400,000	Leachate Collection:	partial
Site Capacity (tonnes):	400,000	Local Fuel Demand :	none
Average Depth of Waste (m):	N/A	Site Setting:	rural
Type of Waste:	MSW		
Migration Monitoring:			
Number of Monitoring Locations:	0	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**Potential LFG Production (@ 50% CH_4 Content)**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm)	190
Methane Concentration (%v/v):		Average Production in 2010 (cfm)	120
Average Annual CO_2 Equivalent (tonnes):			
LFG Collection System:		Average Production in 2020 (cfm)	80
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.699 cu.m/hr

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☐ No ☑	Capital Cost of Additional LFG Capture and Flaring:	$500,000
		Annual O&M Cost of Additional Capture and Flaring:	$50,000
Average Annual CO_2 Equivalent (tonnes):	10,084	Total Greenhouse Gas Credits:	$144,235
Total CO_2 Equivalent (tonnes):	201,689	Cost/tonne of CO_2:	$4.593
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	18,248	Capital Cost of Additional LFG Utilization:	$500,000
Additional Electrical Generation Potential (MW):	0.2	Annual O&M Cost of Additional Utilization:	$50,000
Potential Unit Revenue		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.028	a) Electrical Power (with GHG credits):	($1,588)
b) Electrical Power Wheeling ($/kW):	($0.008)	b) Direct Use of LFG (with GHG credits):	($8,029)
c) Green Power ($/kW):	$0.004	c) Electrical Power (without GHG credits):	($2,130)
d) Direct Use of LFG ($/cu.m):	$0.025	d) Direct Use of LFG (without GHG credits):	($8,174)

QUEBEC

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	ST-GEORGE-DE-CACOUNA	Site Location:	CACOUNA, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	Ville de Riviere-Du-Loup	**Utilization System Owner:**	
Contact Name:	Michaud Alain	Contact Name:	
Address:	200 DeLage, C.P.37 Riviere-Du-Loup, G5R 3Y7	Address:	
Tel.No.:	(418) 867-6664	Tel.No.:	
Fax No.:	(418) 862-1082	Fax No.:	
Email:	amicvrdl@icrdl.net	Email:	

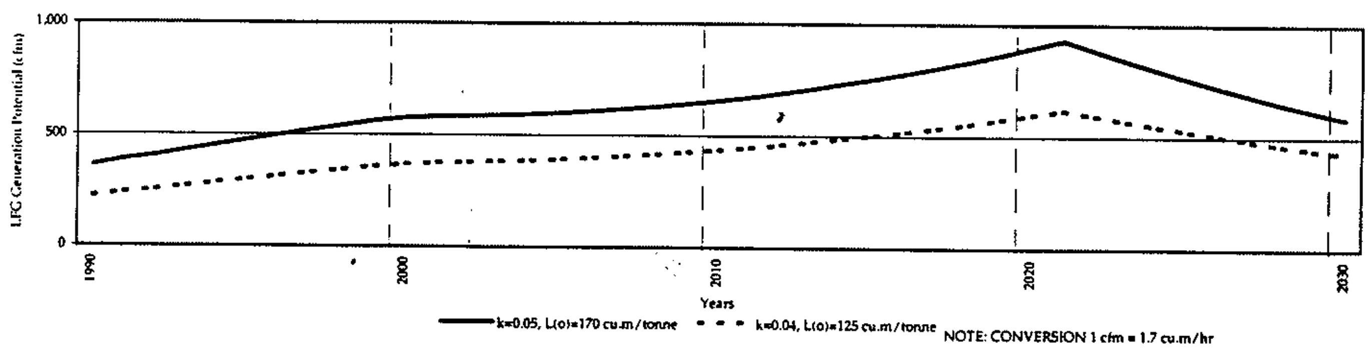
Background:			
Year Open:	1979	Landfill Area (ha):	15.6
Year Close:	2020	Liner:	clay
Filling Rate (tonnes/year):	28,000	Capping:	clay
Waste in Place (tonnes):	880,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	1,760,000	Local Fuel Demand :	some
Average Depth of Waste (m):	8	Site Setting:	Argricultural
Type of Waste:	MSW		

Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	470
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	550
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	750
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,320,000
		Annual O&M Cost of Additional Capture and Flaring:	$132,000
Average CO_2 Equivalent (tonnes/year):	49,582	Value of Additional GHG Credits:	$709,157
Total CO_2 Equivalent (tonnes):	991,635	Cost/tonne of CO_2:	$2.466

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	89,718	Capital Cost of Additional LFG Utilization:	$2,100,352
Additional Electrical Generation Potential (MW):	1.1	Annual O&M Cost of Additional Utilization:	$137,993
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,803)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,512)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

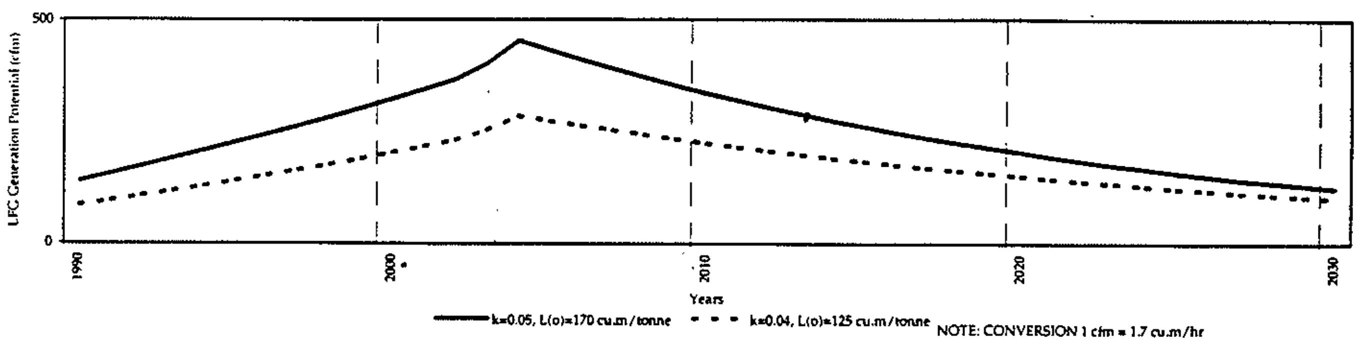
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	RIMOUSKI	Site Location:	VILLE DE RIMOUSKI, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	Ville De Rimouski	**Utilization System Owner:**	
Contact Name:	Rene Belanger	Contact Name:	
Address:	205, Ave Cathedrale, Ville De Rimouski	Address:	
Tel.No.:	(418) 724-3114	Tel.No.:	
Fax No.:	(418) 724-2852	Fax No.:	
Email:		Email:	
Background:			
Year Open:	1981	Landfill Area (ha):	25
Year Close:	2003	Liner:	none
Filling Rate (tonnes/year):	35,000	Capping:	clay
Waste in Place (tonnes):	478,400	Leachate Collection:	toe drain
Site Capacity (tonnes):	589,280	Local Fuel Demand :	none
Average Depth of Waste (m):	7	Site Setting:	Rural / Agricultural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:			
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	260
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	280
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	180
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$861,120
		Annual O&M Cost of Additional Capture and Flaring:	$86,112
Average CO_2 Equivalent (tonnes/year):	20,169	Value of Additional GHG Credits:	$288,471
Total CO_2 Equivalent (tonnes):	403,377	Cost/tonne of CO_2:	$3.955

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	36,495	Capital Cost of Additional LFG Utilization:	$854,380
Additional Electrical Generation Potential (MW):	0.4	Annual O&M Cost of Additional Utilization:	$56,133
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,312)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,600)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	ST COME-LINIERE	Site Location:	VILLE DE GEORGES, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:

Landfill Owner:	R.I. Comte Beauce Sud
Contact Name:	Roger Turcotte
Address:	3500-6th Ave Ville St. George, G5Y 3Y9
Tel.No.:	(418) 226-2226
Fax No.:	(428) 226-0464
Email:	ricbs@globetrotter.net

Utilization System Owner:

Contact Name:	
Address:	
Tel.No.:	
Fax No.:	
Email:	

Background:

Year Open:	1974	Landfill Area (ha):	N/A
Year Close:	2002	Liner:	HDPE
Filling Rate (tonnes/year):	28,768	Capping:	clay
Waste in Place (tonnes):	752,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	756,000	Local Fuel Demand :	none
Average Depth of Waste (m):	2	Site Setting:	Rural
Type of Waste:	MSW, ICI		

Migration Monitoring:

Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

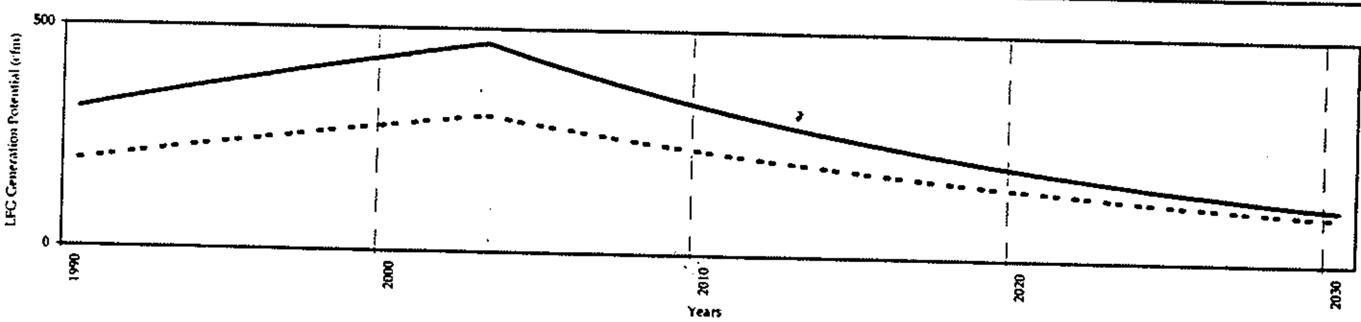
Existing LFG Capture and Flaring: Yes ☐ No ☑

LFG Flow Rate (cfm):		**LFG Generation Potential (@ 50% CH_4 Content):**	
Methane Concentration (%v/v):		Average Production in 2000 (cfm):	360
Average CO_2 Equivalent (tonnes/year):		Average Production in 2010 (cfm):	280
LFG Collection System:		Average Production in 2020 (cfm):	180

Existing LFG Utilization: Yes ☐ No ☑

LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,353,600
		Annual O&M Cost of Additional Capture and Flaring:	$135,360
Average CO_2 Equivalent (tonnes/year):	22,970	Value of Additional GHG Credits:	$328,536
Total CO_2 Equivalent (tonnes):	459,402	Cost/tonne of CO_2:	$5.459

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	41,564	Capital Cost of Additional LFG Utilization:	$973,044
Additional Electrical Generation Potential (MW):	0.5	Annual O&M Cost of Additional Utilization:	$63,929
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,159)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,488)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

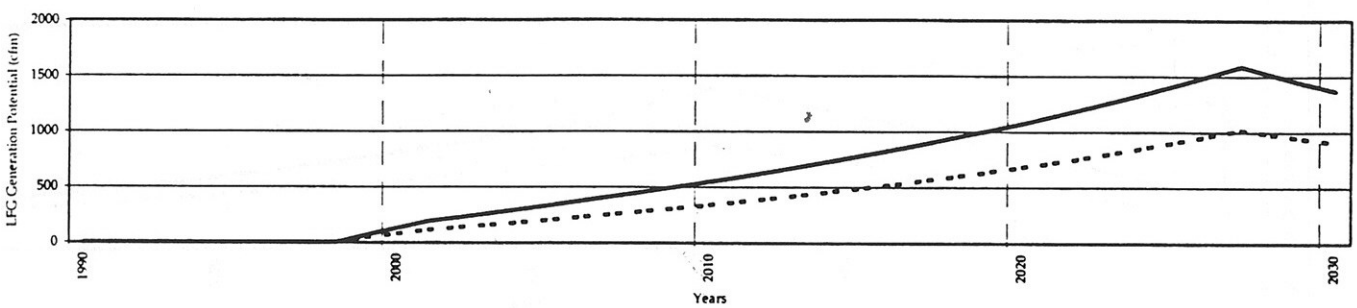
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	ST LAMBERT-DE-LAUZON	Site Location:	ST LAMBERT-DE-LAUZON, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	ntermunicipal des Chutes-de-la-Chaudier	**Utilization System Owner:**	
Contact Name:	Louis Fleury	Contact Name:	
Address:	1114, Reu de Pont St Lambert-de-Lauzon, G0S 2W0	Address:	
Tel.No.:	(418) 889-8662	Tel.No.:	
Fax No.:	(418) 889-5157	Fax No.:	
Email:	lfleury@chutes-chaudiere.com	Email:	
Background:			
Year Open:	1998	Landfill Area (ha):	40
Year Close:	2026	Liner:	geosynthetic
Filling Rate (tonnes/year):	40,000	Capping:	gesosynthetic
Waste in Place (tonnes):	180,000	Leachate Collection:	toe drain
Site Capacity (tonnes):	2,300,000	Local Fuel Demand :	none
Average Depth of Waste (m):	1.5	Site Setting:	Rural / Agricultural
Type of Waste:	MSW, CD		
Migration Monitoring:			
Number of Monitoring Locations:	6	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	<1.25	System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	100
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	440
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	880
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$500,000
		Annual O&M Cost of Additional Capture and Flaring:	$50,000
Average CO_2 Equivalent (tonnes/year):	39,777	Value of Additional GHG Credits:	$568,929
Total CO_2 Equivalent (tonnes):	795,549	Cost/tonne of CO_2:	$1.165
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	71,977	Capital Cost of Additional LFG Utilization:	$1,685,028
Additional Electrical Generation Potential (MW):	0.8	Annual O&M Cost of Additional Utilization:	$110,706
Potential Unit Revenue:		Cost Benefit (NPV) (1000s):	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($449)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,018)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR
ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	L'ANSE-A-GILLES	Site Location:	L'ISLET-SUR-MER, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	R.I.G.D.S. de L'anse-A-Gilles	**Utilization System Owner:**	
Contact Name:	Martine Fortin	Contact Name:	
Address:	156, 5th Ave L'Islet-Sur-Mer, G0R 2C0	Address:	
Tel.No.:	(418) 247-3884	Tel.No.:	
Fax No.:	(418) 247-3885	Fax No.:	
Email:	ridgsag@globetrotter.net	Email:	

Background:

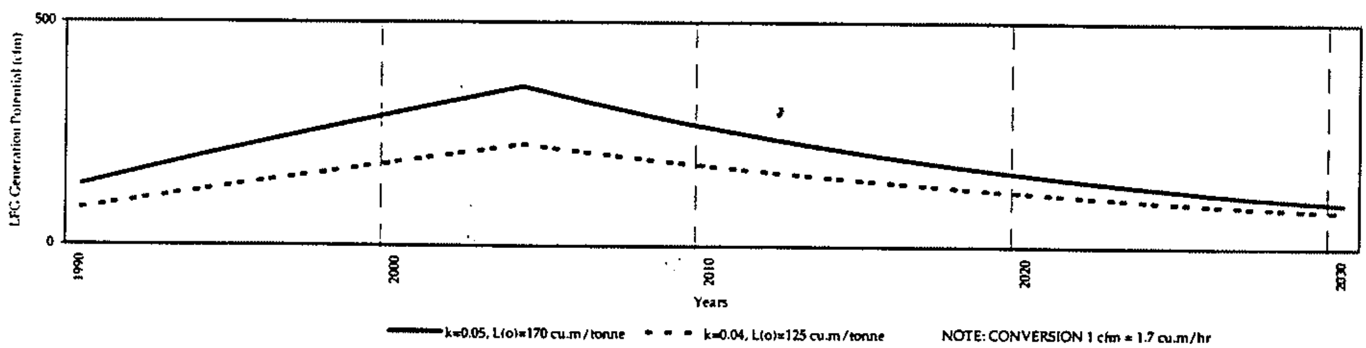
Year Open:	1983	Landfill Area (ha):	20
Year Close:	2003	Liner:	none
Filling Rate (tonnes/year):	27,000	Capping:	clay
Waste in Place (tonnes):	432,000	Leachate Collection:	yes
Site Capacity (tonnes):	480,000	Local Fuel Demand :	none
Average Depth of Waste (m):	2	Site Setting:	Agricultural
Type of Waste:	MSW, ICI, CD		

Migration Monitoring:	none		
Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	240
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	220
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	140
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$777,600
		Annual O&M Cost of Additional Capture and Flaring:	$77,760
Average CO_2 Equivalent (tonnes/year):	16,807	Value of Additional GHG Credits:	$240,392
Total CO_2 Equivalent (tonnes):	336,148	Cost/tonne of CO_2:	$4.286

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	30,413	Capital Cost of Additional LFG Utilization:	$711,984
Additional Electrical Generation Potential (MW):	0.4	Annual O&M Cost of Additional Utilization:	$46,777
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,200)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,441)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

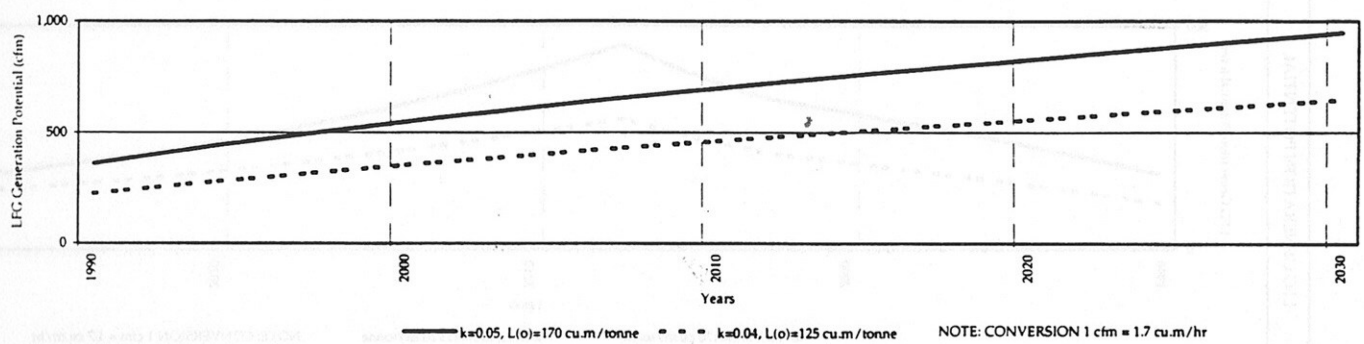
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	COWANSVILLE	Site Location:	COWANSVILLE, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	R.I.G.D.S. de Cowansville	**Utilization System Owner:**	
Contact Name:	Caroline Losnier	Contact Name:	
Address:	2500 Rang St joseph Cowansville	Address:	
Tel.No.:	(450) 263-2351	Tel.No.:	
Fax No.:	(450) 263-4977	Fax No.:	
Email:	riedsbm@qc.aira.com	Email:	
Background:			
Year Open:	1977	Landfill Area (ha):	29
Year Close:	2045	Liner:	2 HDPE liners
Filling Rate (tonnes/year):	57,500	Capping:	none
Waste in Place (tonnes):	1,440,000	Leachate Collection:	toe drain, with treatment
Site Capacity (tonnes):	3,024,000	Local Fuel Demand :	Cowansville
Average Depth of Waste (m):	18	Site Setting:	Rural
Type of Waste:	MSW, ICI, CD		
Migration Monitoring:			
Number of Monitoring Locations:	16	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	50	System Description:	
Existing LFG Capture and Flaring:	Yes ☑ No ☐	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):	118	Average Production in 2000 (cfm):	450
Methane Concentration (%v/v):	50	Average Production in 2010 (cfm):	580
Average CO_2 Equivalent (tonnes/year):	13,222	Average Production in 2020 (cfm):	690
LFG Collection System:	17 active wells with flare		
Existing LFG Utilization:	Yes ☑ No ☐		
LFG End Use:	flaring	Btu of LFG (Btu/cf):	500
LFG Utilized (cfm):	118	Financial Arrangement:	none

LFG GENERATION POTENTIAL



COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,440,000
		Annual O&M Cost of Additional Capture and Flaring:	$144,000
Average CO_2 Equivalent (tonnes/year):	34,959	Value of Additional GHG Credits:	$500,016
Total CO_2 Equivalent (tonnes):	699,187	Cost/tonne of CO_2:	$3.816
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	87,183	Capital Cost of Additional LFG Utilization:	$2,041,020
Additional Electrical Generation Potential (MW):	1.0	Annual O&M Cost of Additional Utilization:	$134,095
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,222)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,722)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	THETFORD MINES	Site Location:	THETFORD MINES, QUEBEC

SITE DESCRIPTION SUMMARY

Landfill Owner:	Ville de Thetford Mines	**Utilization System Owner:**	Les Constructions de L'Amiante Inc.
Contact Name:	Richard LaFlamme	Contact Name:	
Address:	C.P. 489 Thetford Mines, G6G 5T3	Address:	1209, S. Smith Blvd. Thetford Mines
Tel.No.:	(418) 335-2981, ext.280	Tel.No.:	(418) 338-8552
Fax No.:	(418) 335-6698	Fax No.:	(418) 338-8450
Email:	servtech@ville.thetfordmines.qc.ca	Email:	constamiante@minfo.net

Background:

Year Open:	1981	Landfill Area (ha):	18.75
Year Close:	2005-2006	Liner:	none
Filling Rate (tonnes/year):	24,500	Capping:	clay
Waste in Place (tonnes):	431,000	Leachate Collection:	toe drains
Site Capacity (tonnes):	650,000	Local Fuel Demand :	unknown
Average Depth of Waste (m):	7	Site Setting:	Rural / Residential/Commercial
Type of Waste:	MSW, ICI, CD		

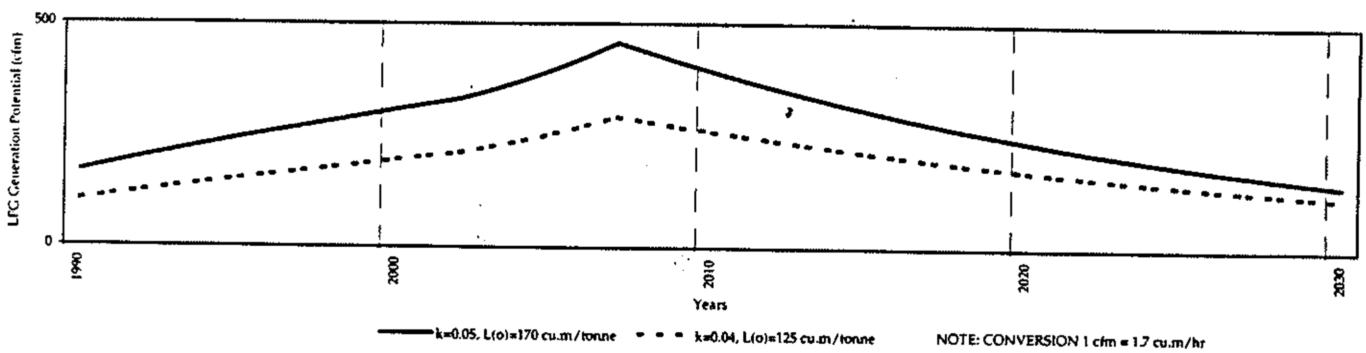
Migration Monitoring:

Number of Monitoring Locations:	8	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):	6	System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	250
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	330
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	210
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$862,000
		Annual O&M Cost of Additional Capture and Flaring:	$86,200
Average CO_2 Equivalent (tonnes/year):	22,130	Value of Additional GHG Credits:	$316,517
Total CO_2 Equivalent (tonnes):	442,594	Cost/tonne of CO_2:	$3.609

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	40,043	Capital Cost of Additional LFG Utilization:	$937,445
Additional Electrical Generation Potential (MW):	0.5	Annual O&M Cost of Additional Utilization:	$61,590
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,292)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($1,608)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SASKATCHEWAN

SITE FACT SHEET

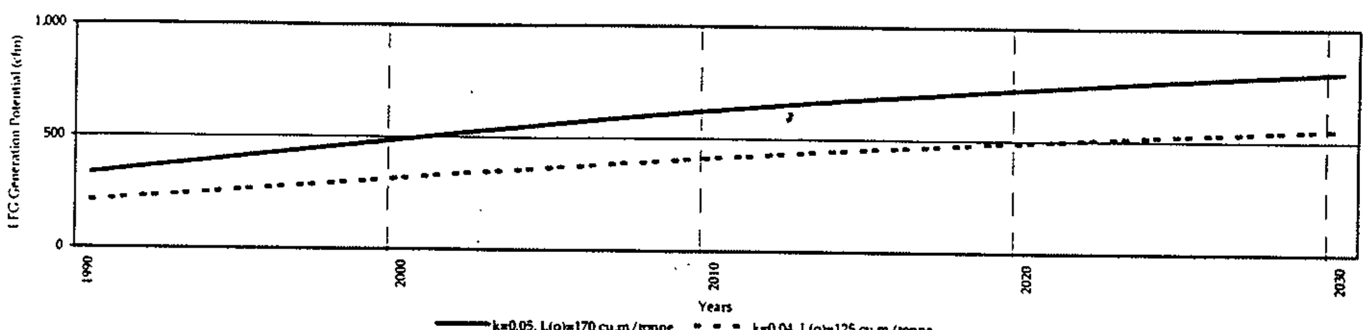
IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	PRINCE ALBERT	Site Location:	PRINCE ALBERT, SASKATCHEWAN

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Prince Albert	**Utilization System Owner:**	
Contact Name:	Verden Jeancart	Contact Name:	
Address:	1084 Central Avenue Prince Albert, Sask.	Address:	
Tel.No.:	(306) 953-4900	Tel.No.:	
Fax No.:	(306) 953-4915	Fax No.:	
Email:	vjeancart.citypa@cksympatico.ca	Email:	
Background:			
Year Open:	1972	Landfill Area (ha):	4.4
Year Close:	2050	Liner:	none
Filling Rate (tonnes/year):	36,000	Capping:	clay
Waste in Place (tonnes):	834,330	Leachate Collection:	none
Site Capacity (tonnes):	N/A	Local Fuel Demand :	none
Average Depth of Waste (m):	24	Site Setting:	Rural
Type of Waste:	MSW, ICI		
Migration Monitoring:			
Number of Monitoring Locations:	none	Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	
Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	400
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	520
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	610
LFG Collection System:			
Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):			
Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,251,496
		Annual O&M Cost of Additional Capture and Flaring:	$125,150
Average CO_2 Equivalent (tonnes/year):	42,859	Value of Additional GHG Credits:	$613,000
Total CO_2 Equivalent (tonnes):	857,176	Cost/tonne of CO_2:	$2.705
Additional LFG Utilization Potential (2000-2020):			
Total CO_2 Displaced (tonnes):	77,552	Capital Cost of Additional LFG Utilization:	$1,815,558
Additional Electrical Generation Potential (MW):	0.9	Annual O&M Cost of Additional Utilization:	$119,282
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($1,756)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,369)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na

SITE FACT SHEET

IDENTIFICATION OF POTENTIAL LANDFILL SITES FOR ADDITIONAL GAS FLARING AND UTILIZATION IN CANADA
Environment Canada

Site Name:	MOOSE JAW	Site Location:	MOOSE JAW, SASKATCHEWAN

SITE DESCRIPTION SUMMARY

Landfill Owner:	City of Moose Jaw	**Utilization System Owner:**	
Contact Name:	Ryan Johnson	Contact Name:	
Address:	228 Main Street N. Moose Jaw, Sask., S6H 3J8	Address:	
Tel.No.:	(306) 694 - 4491	Tel.No.:	
Fax No.:	(306) 691 - 0292	Fax No.:	
Email:		Email:	

Background:

Year Open:	1922	Landfill Area (ha):	60
Year Close:	2030 - 2050	Liner:	none
Filling Rate (tonnes/year):	40,000	Capping:	partial clay till
Waste in Place (tonnes):	unknown	Leachate Collection:	none
Site Capacity (tonnes):	unknown	Local Fuel Demand :	none
Average Depth of Waste (m):	10	Site Setting:	Rural
Type of Waste:	MSW, ICI, CD		

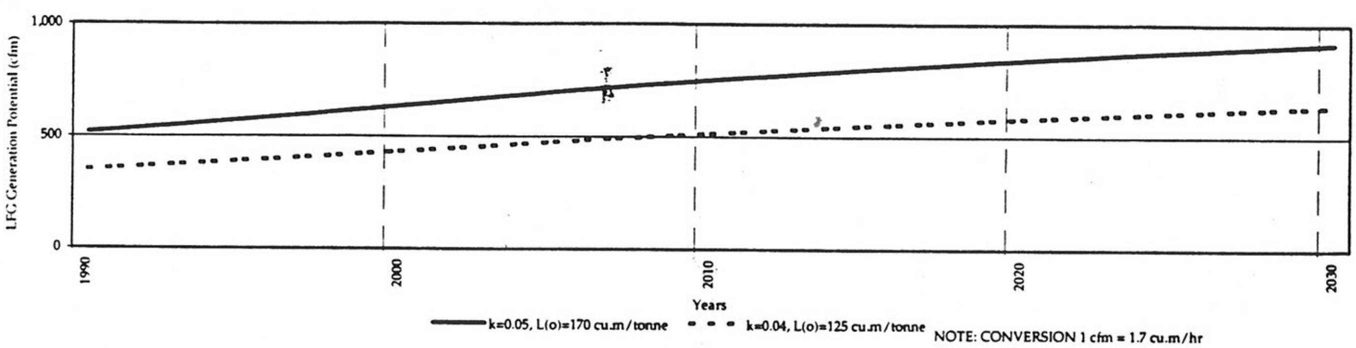
Migration Monitoring: none

Number of Monitoring Locations:		Migration Control System:	Yes ☐ No ☑
Methane Concentration (%v/v):		System Description:	

Existing LFG Capture and Flaring:	Yes ☐ No ☑	**LFG Generation Potential (@ 50% CH_4 Content):**	
LFG Flow Rate (cfm):		Average Production in 2000 (cfm):	530
Methane Concentration (%v/v):		Average Production in 2010 (cfm):	630
Average CO_2 Equivalent (tonnes/year):		Average Production in 2020 (cfm):	710
LFG Collection System:			

Existing LFG Utilization:	Yes ☐ No ☑		
LFG End Use:		Btu of LFG (Btu/cf):	
LFG Utilized (cfm):		Financial Arrangement:	

LFG GENERATION POTENTIAL



NOTE: CONVERSION 1 cfm = 1.7 cu.m/hr

COST-BENEFIT ANALYSIS

Additional LFG Capture and Flaring Potential (2000-2020) (75% of Average LFG Generation Potential):

Install/Upgrade Existing System:	Yes ☑ No ☐	Capital Cost of Additional LFG Capture and Flaring:	$1,500,000
		Annual O&M Cost of Additional Capture and Flaring:	$150,000
Average CO_2 Equivalent (tonnes/year):	52,383	Value of Additional GHG Credits:	$749,223
Total CO_2 Equivalent (tonnes):	1,047,660	Cost/tonne of CO_2:	$2.653

Additional LFG Utilization Potential (2000-2020):

Total CO_2 Displaced (tonnes):	94,786	Capital Cost of Additional LFG Utilization:	$2,219,016
Additional Electrical Generation Potential (MW):	1.1	Annual O&M Cost of Additional Utilization:	$145,789
Potential Unit Revenue:		**Cost Benefit (NPV) (1000s):**	
a) Electrical Power ($/kW):	$0.038	a) Electrical Power (with GHG credits):	($2,093)
b) Electrical Power Wheeling ($/kW):	($0.006)	b) Direct Use of LFG (with GHG credits):	na
c) Green Power ($/kW):	$0.006	c) Electrical Power (without GHG credits):	($2,842)
d) Direct Use of LFG ($/cu.m):	$0.030	d) Direct Use of LFG (without GHG credits):	na