LANDFILL GAS GENERATION ASSESSMENT PROCEDURE GUIDELINES

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BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

Landfill Gas Generation Assessment

Procedure Guidelines

Prepared pursuant to Section 4 of the
Landfill Gas Management Regulation

Approved: David Ranson — August, 2009

Director of Environmental Quality Branch — Date

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ACKNOWLEDGEMENTS

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ACRONYMS AND ABBREVIATIONS

CH_4	methane
CO_2	carbon dioxide
Guideline	Landfill Gas Generation Assessment Procedure Guidance
IC&I	industrial, commercial, and institutional (category of waste type)
IPCC	International Panel on Climate Change
k	rate constant used in landfill gas modeling (1/year)
L_o	methane generation potential used in landfill gas modeling (m^3 methane/tonne of waste)
LBT	landfill bioreactor technology
LFG	landfill gas
MOE	British Columbia Ministry of Environment
MSW	municipal solid waste (category of waste type)
O_2	oxygen
O&M	operations and maintenance
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency

DEFINITIONS

director	A person employed by the government and designated in writing by the minister as a director of waste management or as an acting, deputy, or assistant director of waste management.
environmental management act	The British Columbia Environmental Management Act, SBC 2003, Chapter 23, Assented to October 23, 2003.
guidelines	The most recent edition of landfill gas management guidelines approved by the director and published on a publicly accessible website maintained by or on behalf of the MOE.
landfill gas	A mixture of gases generated by the decomposition of municipal solid waste.
municipal solid waste	As defined by the Environmental Management Act, refuse that originates from residential, commercial, institutional, demolition, land clearing or construction sources, or refuse specified by a Director to be included in a waste management plan.
qualified professional	In relation to a duty or function under the Landfill Gas Management Regulation, a professional who: • is an applied scientist or technologist specializing in a particular applied science or technology • is registered in British Columbia with a professional organization's code of ethics and is subject to disciplinary action by that organization • through suitable education, experience, accreditation, and knowledge respecting solid waste and landfill gas management, may reasonably be relied on to provide advice within their area of expertise, which area of expertise is applicable to the duty or function
regulated landfill site	A landfill site that: • has 100,000 tonnes or more of municipal solid waste in place • receives 10,000 or more tonnes of municipal solid waste for disposal into landfill site in any calendar year after 2008
regulation	British Columbia Landfill Gas Management Regulation, Order in Council No. 903, Ordered and Approved December 8, 2008.

UNITS OF MEASURE AND CONVERSION FACTORS

Unit of Measurement	Conversion to Equivalent Unit of Measurement
1 millimetre (mm)	0.039 inch (in)
1 metre (m)	3.281 feet (ft)
1 m^3/hour (m^3/hr)	0.589 ft^3/minute (cfm)
1 hectare (ha)	2.471 acres
1 tonne	1.102 short ton
0 degrees Celsius (°C)	32 degrees Fahrenheit (°F)
1 megawatt (MW)	3,412,141.635 British Thermal Units (Btu)/hr
1 m^3/hr CH_4	5.74 tonnes CH_4/year[1]
1 cfm CH_4	9.75 tonnes CH_4/year[1]
1 year	8760 hours
1 m^3 CH_4	0.6557 kilogram (kg) CH4[1]

Note:

(1) - Methane gas density: 0.6557 kg/m^3 (25°C and 1 atm) (CRA, 1996)

PREFACE

This Guideline has been developed for the British Columbia Ministry of Environment (MOE) to provide a procedure for the assessment of landfill gas (LFG) generation at municipal solid waste (MSW) landfills in British Columbia (BC) and to provide guidelines for landfill owners and operators to comply with the British Columbia Landfill Gas Management Regulation (Regulation), approved and ordered on December 8, 2008.

This Guideline and the procedure herein are based on a review of proven LFG generation models, selection of a modeling methodology suitable for the assessment of LFG generation for BC landfills, and comparison of modeled generation with LFG collection data from six BC landfills with LFG collection systems.

The Scholl Canyon first order decay model was selected as the most suitable model for the assessment of LFG generation for BC landfills. The selection of site-specific input parameters (hereafter called the selection of modeling methodology) integrates elements of the Handbook for the Preparation of Landfill Gas to Energy Projects in Latin America and the Caribbean (CRA, 2004), GasSIM (Golder, 2002), and IPCCC (UNFCCC, 2008) methodologies. The model accounts for the main factors responsible for LFG generation while providing a matrix approach that allows users to input site-specific information regarding climatic conditions, specifically precipitation. While a number of inputs have been described, these are all generally obtainable by landfill owners and operators. Additionally, the model allows the user to characterize their waste into a number of fractions and to account for landfill management practices as they relate to water infiltration. These items are important for a geographical area as diverse as BC, which sees large ranges in precipitation levels.

In preparing the Guideline, Conestoga-Rovers & Associates (CRA) has sought to balance accounting for site-specific conditions that affect LFG generation with developing a consistent and user-friendly calculation procedure. It is acknowledged that the procedure in this Guideline does not account for all possible factors affecting LFG generation, and that the general state of the LFG modeling field still relies on highly empirical modeling formulations and techniques. There are no comprehensive science-based models available that fully account for the range of factors that affect the process. However, CRA has utilized an empirical model basis in conjunction with actual site data to determine reasonable parameters. As this is a regulatory-based model, it is important to note that the objectives of the model are exclusively to determine the status of BC landfills as they pertain to the Landfill Gas Management Regulation. Where the objective of an LFG generation assessment is beyond that of ascertaining this status

(i.e., to develop a utilization assessment), a detailed site-specific assessment should be carried out.

Quantitative factors such as waste tonnage, waste characteristics, and precipitation have been included in the selection of site-specific model parameters. As precipitation does not necessarily result in infiltration into the waste in place, a qualitative factor to account for differences in landfill design and operation has been included. As with all model formulations, the output from the model is highly dependent on the completeness and quality of the input information utilized.

CRA compared LFG collection data provided by landfill owners and operators to LFG generation estimates using the methodology in this Guideline. Where possible, LFG collection data was paired with site development information to estimate the characteristics of the waste from which LFG was collected, such as age of waste and leachate elevations, and with LFG collection system development information to estimate the portion of waste subject to LFG collection. This information was used to validate calculated collection efficiencies by taking into account site-specific factors, such as the installation of an LFG collection system in only a portion of the landfilled waste. If collection efficiencies were not consistent with site-specific information, then the model input parameters were revisited. Using this iterative approach, representative model parameters were developed with the information available. The accuracy of this approach is limited by the number of landfills in BC with LFG collection systems and by the variability in the LFG collection system collection data for BC landfills. To expand the data available, LFG collection data and operational information from other landfills in North America were used in the iterative approach to developing model parameters. The model parameters provided in this Guideline are supported by historical LFG collection data.

It is expected that this Guideline will be used by landfill owners and operators and qualified professionals in the preparation of LFG generation assessments in accordance with the Landfill Gas Management Regulation. The Guideline is intended as a user-friendly step-by-step procedure to estimate annual methane generation from MSW landfills in BC.

SECTION 1 - INTRODUCTION

This Guideline is intended to be used by landfill owners, operators, and qualified professionals. It provides the user with a guide to conducting landfill gas (LFG) generation assessments as required by the British Columbia Landfill Gas Management Regulation (Regulation), approved and ordered on December 8, 2008 (Regulation). This Guideline has been organized into the following Sections:

Section 2 describes the waste tonnage thresholds in the LFG Management Regulation that trigger the requirement to complete an LFG generation assessment.

Section 3 discusses previous LFG generation assessments and how these reports can be used to complete an LFG Generation Assessment for the LFG Management Regulation.

Section 4 describes the information required to complete an LFG Generation Assessment as well as the preferred sources of the required information.

Section 5 describes how the methane generation rate (k), methane generation potential (L_o), and water addition factor are selected and how waste is categorized.

Section 6 describes how to use the spreadsheet developed to estimate LFG production based on the information identified in Section 4 and the constants (k, L_o, and water addition factor) selected in Section 5.

Section 7 identifies the content and format of the LFG Generation Assessment Report to be submitted to the MOE. This section also includes a checklist identifying all information required in the Regulation.

Section 8 describes the next steps for a landfill owner based on the modelled annual methane generation rate.

The flowchart presented on Figure 1.1 provides an overview of the LFG generation assessment procedure.

Landfill Gas Background

LFG is generated as a result of physical, chemical, and microbial processes occurring within the waste. Due to the organic nature of most waste, it is the microbial processes that govern the gas generation process (Christensen, 1989). These processes are sensitive to their environment; therefore, a number of natural and man-made conditions will affect the microbial population and thus the LFG production rate. Short-term studies

carried out on full-size landfills, using data from LFG extraction tests, indicate a range of LFG production between 0.05 and 0.40 m^3 of LFG per kilogram of waste placed into a landfill (Ham, 1989). The mass of waste accounts for both solid materials (75 to 80 percent by mass) and moisture (20 to 25 percent by mass). This range is a function of the organic content of the waste that is placed into the landfill.

Waste composition is the most important factor in assessing the LFG generation potential of a site. The maximum potential volume of LFG is dependent on the quantity and type of organic content within the waste mass (Environment Canada, 1996), since the decomposing organic wastes are the source for all LFG produced. Other factors that influence the rate of LFG production include moisture content, nutrient content, bacterial content, pH level, temperature, and the site-specific design and operations plan.

Moisture is the primary limiting factor in the rate of waste decomposition (McBean et al., 1995; Reinhart, 1996). The moisture conditions within the landfill are a function of many factors. Municipal solid waste (MSW) is generally stored in water shedding structures such as lidded bins and plastic bags and does not retain significant moisture from precipitation. MSW in wet climates will have a slightly higher moisture content than waste collected in dry climates, but the overall difference is relatively small and difficult to capture in modeling. A typical average moisture content of waste is 25 percent (McBean et al., 1995). The moisture content of the receiving landfill is generally much more important a factor than are the precipitation levels of the waste-generating area, given that the waste is exposed to the landfill climate for a much longer period of time. Essentially, this means that the overall moisture content of the waste is much more strongly influenced by precipitation levels in that area than they are by the moisture content of the waste as it first arrives. Other landfilling factors also affect results. MSW landfilled in thin lifts with a large proportion of cover soil in dry climates may lose moisture due to evaporation. The evaporation of moisture in dry climates is related to the surface area of waste in contact with the atmosphere and therefore is limited in medium and large landfills, where waste is landfilled quickly and exposure to dry air is limited.

Landfills are typically constructed and filled in a sequential layered pattern. This factor is important in understanding how moisture moves into and through the waste. The layering effect tends to result in substantially different flow characteristics for the movement of leachate and infiltration of water into the landfill. Controlling the moisture content and other factors that influence the microbial population that produces LFG can have a great impact on the percentage of potential total LFG that is produced and the rate at which it is produced. It is possible to somewhat control the rate of LFG

production through engineered waste management systems. Conventional sanitary landfills as practiced in North America in the 1970s and 80s are generally referred to as "dry tombs" because the approach taken in designing them was to minimize water contacting the waste with a view toward minimizing excursions of the resulting leachate into the groundwater. However, this practice also limits the rate of anaerobic activity within the waste. The current trend is towards landfill bioreactor technology (LBT) systems, which augment the amount of water contacting the waste, to rapidly stabilize the wastes. This technique can produce large initial LFG generation rates while decreasing their rate of generation sharply after a few years.

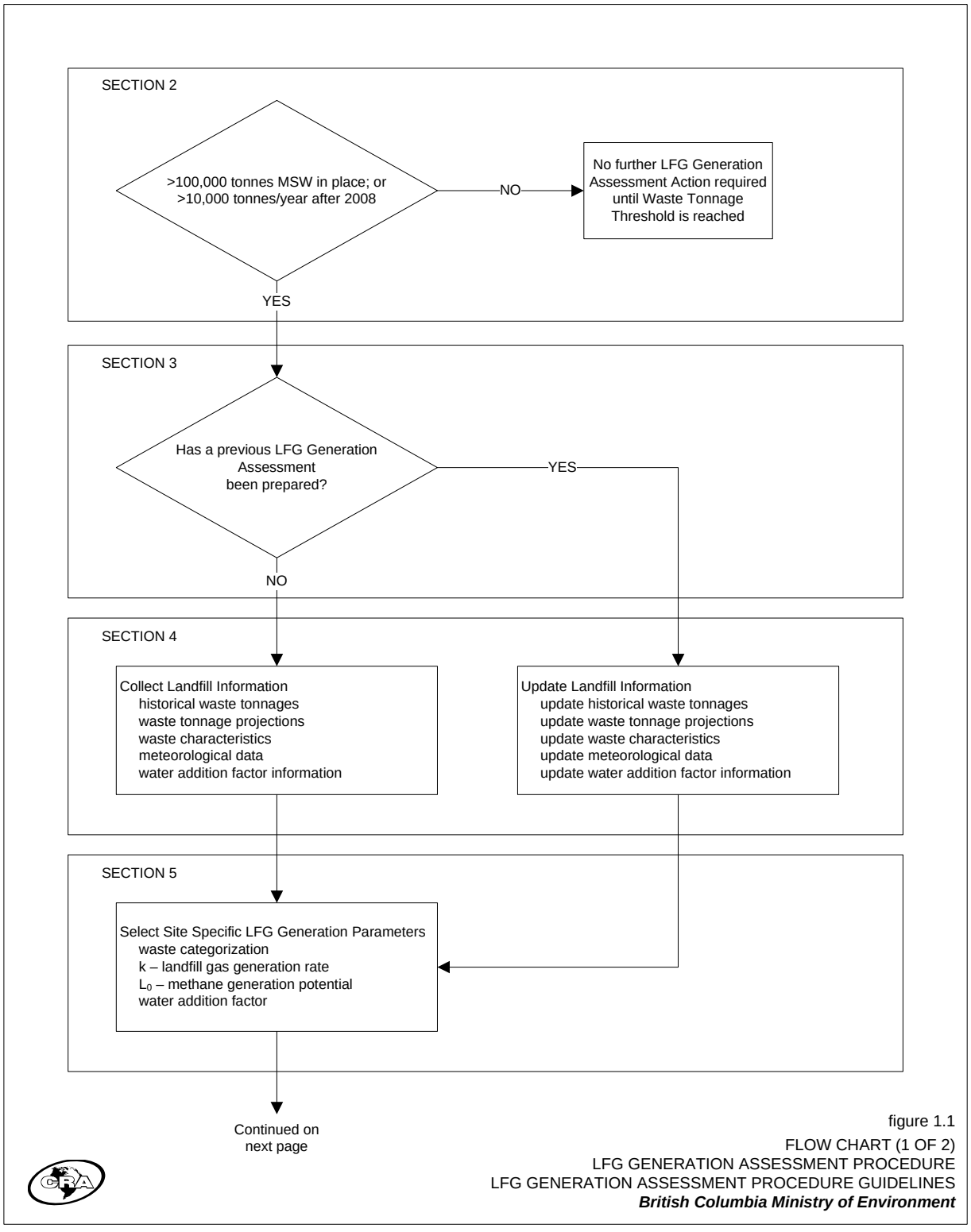

figure 1.1
FLOW CHART (1 OF 2)
LFG GENERATION ASSESSMENT PROCEDURE
LFG GENERATION ASSESSMENT PROCEDURE GUIDELINES
British Columbia Ministry of Environment

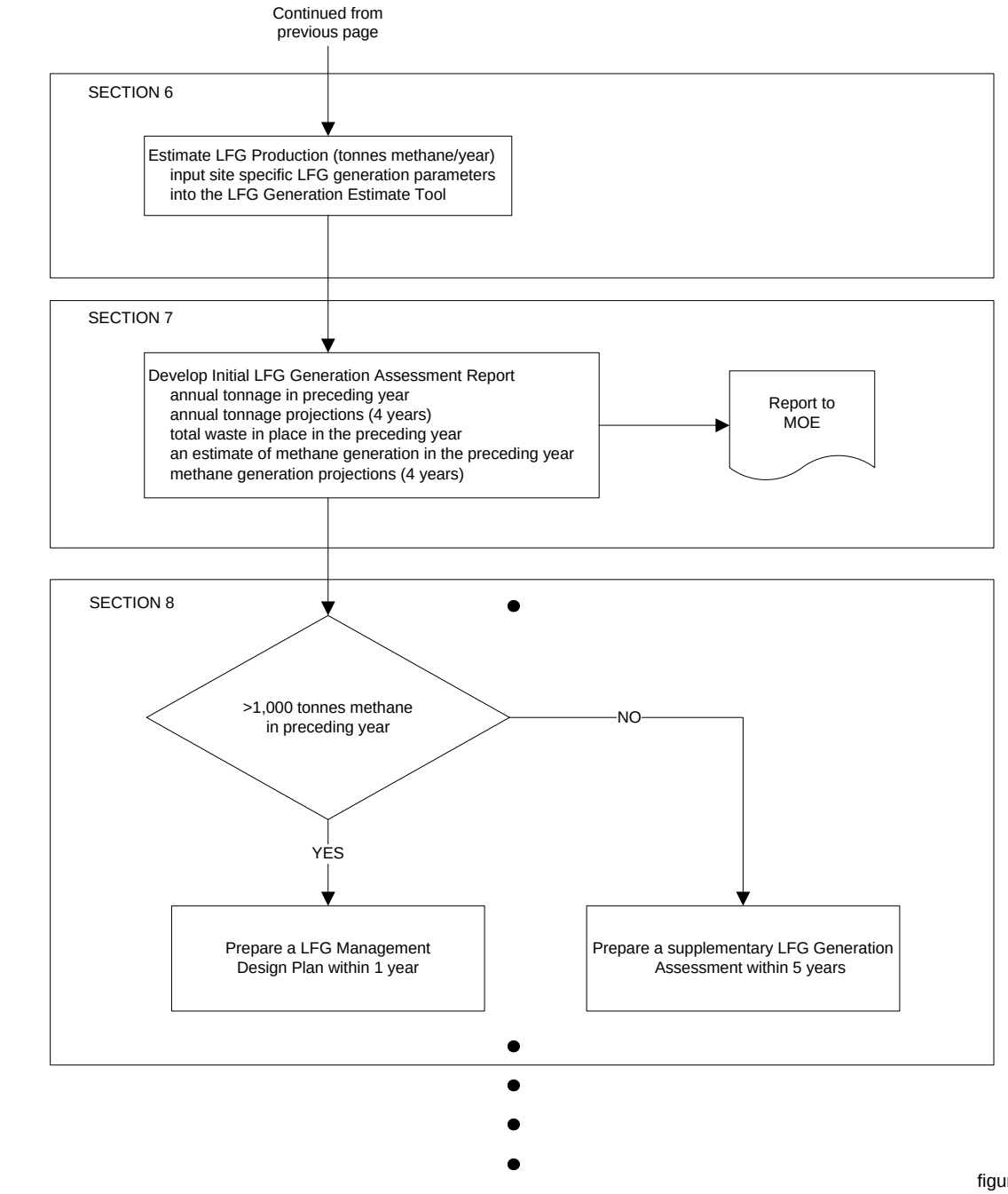

figure 1.1
FLOW CHART (2 OF 2)
LFG GENERATION ASSESSMENT PROCEDURE
LFG GENERATION ASSESSMENT PROCEDURE GUIDELINES
British Columbia Ministry of Environment

SECTION 2 - REQUIREMENT TO COMPLETE A LANDFILL GAS GENERATION ASSESSMENT

This section describes the waste tonnage thresholds that determine the regulatory requirement to prepare an LFG Generation Assessment.

The Regulation applies to landfills that accept MSW on or after January 1st, 2009. A landfill is termed a *regulated landfill site* under the Regulation if it has 100,000 tonnes or more of MSW in place or receives 10,000 or more tonnes of MSW in any calendar year after 2008.

MSW is defined in the Environmental Management Act as follows:

- refuse that originates from residential, commercial, institutional, demolition, land clearing, or construction sources; or
- refuse specified by a director to be included in a waste management plan.

The landfill permit or operational certificate issued by the MOE identifies whether a landfill is permitted/authorized to accept MSW.

In years for which weigh scale records are not available, the annual waste tonnage received should be estimated by a qualified professional. The estimation of historical waste tonnage based on landfill volume/airspace consumed and the application of an apparent waste density (tonnes MSW per cubic meter of air space) that does not understate tonnes of waste in place is acceptable. Landfill volume/airspace should be estimated based on topographic or aerial surveys. The qualified professional should take into account operating procedures employed at the landfill (i.e., compaction, cover material, cover frequency, etc.) while selecting an appropriate apparent waste density that does not underestimate the tonnes of waste in place. Apparent waste density in a landfill site can range from less than 500 kg/m^3 to more than 1,000 kg/m^3 and should be assigned based on knowledge of the site-specific conditions including the geometry of the disposal site.

If landfill volume/airspace information is not available a population based waste disposal estimate is acceptable.

In all cases where weigh scale records are available, weigh scale records must be used.

SECTION 3 - PREVIOUS LANDFILL GAS GENERATION ASSESSMENTS

Previous LFG generation assessments can act as a useful record of historical site-specific information and should be reviewed as a starting point to completing the LFG generation assessment described in this Guideline.

Previous LFG generation assessments have been prepared for the majority of landfills in BC in varying degrees of detail to estimate the annual emission of non-methanogenic organic compounds (NMOCs), as per the landfill criteria for municipal solid waste or as specified in landfill permits or operational certificates. In addition, many landfills in BC have voluntarily investigated and assessed the feasibility of LFG utilization and have prepared LFG generation assessments for this purpose. Previous LFG generation assessments can be found as stand-alone documents or as part of integrated landfill documents such as design and operation plans.

LFG generation assessments generally include the following information:

- historical waste tonnage estimates;
- projected waste tonnages;
- average annual precipitation;
- discussion of waste characteristics;
- LFG generation rate, k, estimate;
- LFG generation potential, L_o, estimate; and
- estimate of LFG generation rates over the life of the landfill.

Previous LFG generation assessments should be gathered, reviewed, and potentially synthesized to minimize information collection and synthesis described in Section 4.

SECTION 4 - INFORMATION COLLECTION AND SYNTHESIS

The following sections describe the information required to complete the LFG generation assessment calculations. Historical and projected waste quantities, waste characteristics, and meteorological data, as well as the preferred methods for gathering this information, will be explained and discussed.

Information collection and synthesis should begin with the review of previous LFG generation assessments as described in Section 3.

4.1 HISTORICAL WASTE TONNAGE

Direct measurement (landfill entrance weigh scale data) is the preferred source of annual historical waste tonnage information. This is also a reliable source for estimating the mass of each waste type received. If such information is available, it must be used for this LFG generation assessment.

For the purpose of these Guidelines, the historical data on annual waste tonnage should cover the period from the first year of the landfill operations or thirty years before the year in which the assessment is taking place, whichever is more recent, to the year immediately preceding the year in which the assessment is conducted.

In years for which weigh scale records are not available, the annual waste tonnage received should be estimated by a qualified professional. The estimation of historical waste tonnage based on landfill volume/airspace consumed and the application of an apparent waste density (tonnes MSW per cubic meter of air space) that does not understate tonnes of waste in place is acceptable. Landfill volume/airspace should be estimated based on topographic or aerial surveys. The qualified professional should take into account operating procedures employed at the landfill (i.e., compaction, cover material, cover frequency, etc.) while selecting an appropriate apparent waste density that does not underestimate the tonnes of waste in place. Apparent waste density in a landfill site can range from less than 500 kg/m^3 to more than 1,000 kg/m^3 and should be assigned based on knowledge of the site-specific conditions including the geometry of the disposal site.

If landfill volume/airspace information is not available a population based waste disposal estimate is acceptable.

In all cases where weigh scale records are available, weigh scale records must be used.

4.2 PROJECTED WASTE TONNAGE

Projected annual waste tonnages for four consecutive years following the year of the LFG generation assessment should be estimated by a qualified professional using the best information available.

Information available to estimate projected annual waste tonnages may include:

- landfill annual tonnage limits specified in a landfill permit or operational certificate;
- historical annual tonnages per capita;
- maximum annual approved filling rate;
- typical (conservative) per capita waste generation rates for BC;
- projected population growth estimated from historical growth rates in the landfill service area; and
- anticipated results of diversion programs (recycling and reuse) planned for implementation in the period of the projected waste tonnages.

4.3 WASTE CHARACTERISTICS

An accurate estimate of waste composition is required to accurately predict the LFG generation potential of a site. The total amount of LFG that can be generated from a unit mass of waste is dependent on the fraction and type of organic content of the waste, because the decomposing organic wastes are the source for all LFG produced. For the purposes of this guideline, waste is characterized into three categories: relatively inert, moderately decomposable, and decomposable.

Information describing the characteristics of waste landfilled can be gathered from historical weigh scale records and waste characterization studies. Typical waste types are presented in Appendix A. Information regarding the type and mass of waste received will be used in selecting methane generation potential, L_o, described in Section 5.

4.4 METEOROLOGICAL DATA

The moisture content within a landfill is one of the most important parameters affecting the gas generation rate. Moisture provides an aqueous environment necessary for

anaerobic processes responsible for LFG production, and serves as a medium for transporting nutrients and bacteria that play a major role in the decomposition process.

The moisture content within a landfill is influenced primarily by the infiltration of precipitation through the landfill cover and active area. Other factors that affect the moisture content in the waste and the rate of LFG generation include the initial moisture content of the waste, the amount and type of daily cover used at the site, the permeability and time of placement of final cover, the type of base liner, the leachate collection system, and the depth of waste in the site.

For the purpose of this Guideline, average annual precipitation data from a meteorological station located closest to the landfill site should be used as the average annual precipitate at the landfill. Precipitation data will be used in selecting the LFG generation rate, k, in Section 5. BC climatic station locations and meteorological data can be obtained from Environment Canada (http://climate.weatheroffice.ec.gc.ca/). Appendix B presents annual precipitation data from active climate stations in close proximity to a selection of landfills in BC. The annual average precipitation in Appendix B is based on Environment Canada Climate Normals and Averages 1971 to 2000. If the Climate Normals and Averages does not include an active weather station in close proximity to a landfill location, the average annual precipitation can be estimated from the more detailed information in the Environment Canada Canadian Daily Climate Data database (ftp://arcdm20.tor.ec.gc.ca/pub/dist/CDCD/).

4.5 WATER ADDITION INFORMATION

As described in Section 4.4, the moisture content within a landfill is one of the most important parameters affecting the LFG generation rate and is influenced primarily by the infiltration of precipitation through the landfill cover and the nature and composition of the waste.

Precipitation will run off or enter the waste mass based on the cover material, cover slopes, and storm water management works. Facilitating runoff of storm water from the landfill cover will decrease water infiltration into the landfill. A lack of water or moisture in the waste mass may inhibit the production of LFG. Facilitating infiltration of storm water into the waste mass through the use of permeable cover soils, flat slopes, or leachate injection systems will increase the moisture content of the waste in place and may increase LFG generation if lack of moisture was previously limiting LFG generation.

Information should be collected on the following:

- nature, depth and permeability of cover material;
- slope of landfill surfaces;
- characteristics of drainage ditches;
- handling of storm water at the active face;
- extent of any leachate recirculation or storm water injection; and
- other information affecting the infiltration of precipitation into the waste mass.

The information above will be used in Section 5 to aid in assessing the addition of water into the waste mass.

SECTION 5 - LANDFILL GAS GENERATION PARAMETER SELECTION

The following section describes the procedure for selecting site-specific LFG generation model input parameters and tonnage. Appendix C presents an example of the LFG generation parameter selection procedure.

5.1 WASTE CATEGORIZATION

Waste landfilled should be segregated into the following three categories by mass:

- relatively inert;
- moderately decomposable; and
- decomposable.

Relatively inert waste includes waste materials with low or no degradable organic carbon, such as metal, glass, plastic, soil, contaminated soils, and water treatment plant screened fines.

Moderately decomposable waste includes materials with a degradable organic carbon fraction that will decompose at a moderate or slower rate such as paper, wood, wooden furniture, rubber, textiles, and construction and demolition material.

Decomposable waste includes materials with a high degradable organic carbon fraction that will decompose relatively quickly such as food waste, yard waste, and slaughterhouse waste.

Appendix A presents a comprehensive list of waste types and appropriate categories. If a waste type is not included in Appendix A, a qualified professional may categorize the waste based on professional judgment.

Direct weigh scale measurements should be used to quantify the annual mass for each category. Alternatively, the total annual mass from the weigh scale can be used together with waste characterization studies to develop an estimate of the annual mass for each category.

If waste characterization information (weigh scale data by waste type or waste characterization study) is not available, the total mass of waste disposed may be included in the decomposable category as the most conservative scenario. This includes

any category that is labeled as "mixed solid waste" or the equivalent. Characterization and categorization of disposed waste and subsequent use of those categories for the LFG generation assessment is strongly encouraged. Waste characterization may be carried out by a qualified professional based either on direct site-specific data or representative waste characterization studies relevant to the waste disposed of at the site.

A summary of available waste categorization data must be included in the LFG Generation Assessment Report to be submitted to the MOE as outlined in Appendix E.

In addition, a table summarizing historical and projected waste mass (for a period of 30 years prior to year of assessment or from the beginning of filling operations) must be included in the LFG Generation Assessment Report to be submitted to the MOE as outlined in Appendix E. The historical and projected annual waste quantities must be categorized by mass into relatively inert, moderately decomposable, and decomposable wastes.

5.2 METHANE GENERATION POTENTIAL, L_O

The methane generation potential, L_o, represents the total potential yield of methane from a mass of waste (m^3 of methane per tonne of waste). The L_o value is dependent on the composition of waste, and in particular the fraction of organic matter present. The fraction of organic matter present in waste dictates the L_o and potential for methane generation. This Guideline characterizes waste into relatively inert, moderately decomposable, and decomposable as described in the previous section.

Each category of waste has a different potential for methane generation. Table 5.1 below presents values for L_o assigned to each category of waste as defined in this Guideline. Note that the parameters assigned are based on the waste categorization described in Section 5.1 and it is important as a result to properly categorize the waste. The table presented in Appendix A identifies which waste types should be allocated to the relatively inert, moderately decomposable, and decomposable categories.

Table 5.1 – Waste Characterization and Methane Potential

Waste Characterization	*Methane Generation Potential L_o (m^3 methane/tonne)*
Relatively Inert	20
Moderately Decomposable	120
Decomposable	160

5.3 LANDFILL GAS GENERATION RATE, K

The methane generation rate, k, represents the first-order biodegradation rate at which methane is generated following waste placement. This constant is influenced by moisture content, the availability of nutrients, pH, and temperature.

For determining the value of k, average annual precipitation data from the meteorological station located closest to the landfill site should be used. For each category/type of waste, the k value should be selected based on annual average precipitation.

Table 5.2 below presents values for k assigned to each category of waste.

Table 5.2 – Methane Generation Rate Selection Matrix

	Methane Generation Rate (k) Values		
Annual Precipitation	*Relatively Inert*	*Moderately Decomposable*	*Decomposable*
<250 mm	0.01	0.01	0.03
>250 to <500 mm	0.01	0.02	0.05
>500 to <1,000 mm	0.02	0.04	0.09
>1,000 to <2,000 mm	0.02	0.06	0.11
>2,000 to <3,000 mm	0.03	0.07	0.12
>3,000 mm	0.03	0.08	0.13

5.4 WATER ADDITION FACTOR

The value of k chosen from the table above should be corrected based on storm water management, the extent of leachate recirculation and/or storm water injection, cover

properties, and landfill operational practices. Table 5.3 below presents the three water addition factors.

Table 5.3 – Water Addition Factor

Landfill Conditions	*Water Addition Factor*
Low to negligible water addition to the waste mass "dry tomb type landfill"	0.9
Partial infiltration or water addition to the waste mass	1.0
Addition of water into the waste mass "bioreactor type landfill"	1.1

After selecting the three k values in Table 5.2, based on the precipitation at the site, multiply each k value by the appropriate water addition factor in Table 5.3. The selection of the water addition factor should be completed by a qualified professional based on site-specific conditions. If little to no storm water is infiltrating into the waste or is added to the waste mass, then a downwards correction factor should be applied (i.e., 0.9). If a portion of storm water infiltrates and/or there is partial recirculation of leachate into the waste mass, then a factor of unity will be applied (i.e., 1.0). If storm water infiltrates and leachate is recirculated into the waste mass, then the upwards correction factor (i.e., 1.1) should be used.

Table 5.4 below presents potential landfill scenarios and the appropriate water addition factor to be applied.

Table 5.4 – Water Addition Factor Selection Examples

Implementation of Landfill Storm Water Management Best Practices	*Cover Properties*	*Leachate recirculation and/or storm water injection*	*Methane Generation Rate (k) Correction Factor*
Fully implemented across the site	Sloped low permeability cover	None	0.9
Fully implemented across the site	Sloped low permeability cover	Leachate recirculation	1.0
Partially implemented across the site	Sloped low permeability cover on a portion of the site	None	1.0
Majority of storm water infiltrates into the waste mass	Not a low permeability cover	Leachate recirculation	1.1
Fully implemented across the site	Sloped low permeability cover	Leachate recirculation and storm water injection	1.1

SECTION 6 - LANDFILL GAS AND METHANE GENERATION ESTIMATE

The quantity of methane generated each year is calculated using the Scholl Canyon model. The modeling methodology has been standardized by recommending data collection methods, using a standard base model for all landfills in BC, and selecting model parameters appropriate for site-specific conditions typically encountered in BC. The modeling methodology also includes interpretation of site-specific waste characteristics and landfill storm water management practices.

A Landfill Gas Generation Estimate Tool (LFG Tool) has been developed in Microsoft Excel® to facilitate the modeling of methane emissions. The LFG Tool provides a template for data output, automatically performs required calculations, and provides a concise data output summary. The LFG Tool is presented in Appendix D.

Macro Security

The worksheet contains a custom program called a macro to estimate the LFG generation. In order to run the Model, the macro security must be set to "Medium" ("Low" is not recommended due to security concerns). To ensure that macro security is set to Medium, open Excel and select "Tools → Macro → Security…" which will display the pop-up menu. In the pop-up window select "Medium" and then "OK." Once the macro security has been changed to Medium, the LFG Tool can be opened.

Opening the Model

Open the model file "Guidance Document-App-D-T-1.xls." The user will be prompted with the macro security pop-up window. The user must select "Enable Macro Security."

Using the LFG Tool

The LFG Tool spreadsheet comprises three worksheets that can be selected by clicking on the tabs at the bottom of the Microsoft Excel window. The titles of the worksheets are displayed on the corresponding tabs. The worksheets contained in the Microsoft Excel file are as follows:

- Instructions;
- T1-Report Information (Sheet T1); and
- T2-LFG Generation (Sheet T2).

A summary of the instructions for operating the spreadsheet are displayed on the Instructions worksheet, the output from the model is displayed on Sheet T1, and the data input locations are on Sheet T2.

The following text provides step-by-step instructions on how to use the spreadsheet.

Detailed Instructions

Step 1 Enter the calendar year of the LFG Generation Assessment in Sheet T1 cell B1.

Step 2 Enter k value (after Water Addition Factor Correction) for Relatively Inert waste in Sheet T2 cells H16 to H50. Refer to Section 5 for determination of k values.

Step 3 Enter k value (after Water Addition Factor Correction) for Moderately Decomposable waste in Sheet T2 cells I16 to I50.

Step 4 Enter k value (after Water Addition Factor Correction) for Decomposable waste in Sheet T2 cells J16 and J50.

Step 5 Enter historical annual mass of Relatively Inert waste received, in tonnes, for the 30 years preceding the LFG Generation Assessment into Sheet T2 cells E16 to E45 (highlighted green). For years prior to landfill opening, leave cells blank. Repeat this procedure for Moderately Decomposable and Decomposable wastes in Sheet T2 cells F16 to F45 and G16 to G45 (highlighted green), respectively. Refer to Sections 4.1 and 5.1 for determination of historical annual mass of waste received.

Step 6 Enter predicted annual mass of Relatively Inert waste received, in tonnes, for the year of the LFG Generation Assessment and for the four consecutive years immediately after the year of LFG Generation Assessment in Sheet T2 cells E46 to E50 (highlighted orange). Repeat this procedure for Moderately Decomposable and Decomposable wastes in Sheet T2 cells F46 to F50 and G46 to G50 (highlighted orange), respectively. Refer to Sections 4.2 and 5.1 for determination of projected annual mass of waste received.

Step 7 Use the data from Sheet T1 to complete the LFG Generation Assessment Report. Refer to Appendix D for the LFG Generation Assessment Report template.

The amount of historical data considered can be changed by entering the desired amount of data (in years of data before the assessment) into Sheet T2 cell D5. The default is 30 years of historical data prior to the year of assessment.

SECTION 7 - LANDFILL GAS GENERATION ASSESSMENT REPORTING

This section presents the format and content of an LFG Generation Assessment Report to be submitted in compliance with the Regulation. The requirements in this section are based on the Regulation. An LFG Generation Assessment Report must be completed by the landfill owner or operator to communicate the results of the LFG generation assessment to the MOE. A report template that prescribes the format, organization, and content of the LFG Generation Assessment Report is presented in Appendix E.

The LFG Generation Assessment Report Template includes all information required by the initial Landfill Gas Generation Assessment and Report section (Section 4) of the Landfill Gas Management Regulation. The location of each regulatory requirement in the Landfill Gas Assessment Report Template is presented in Table 7.1.

Table 7.1 – Landfill Gas Generation Assessment Reporting Checklist

Landfill Gas Management Regulation - Initial Landfill Gas Generation Assessment and Report (Section 4) Requirements	*Relevant Landfill Gas Generation Assessment Report Sections*	*Item Completed*
4 (1)	Signature Page	
4 (2) (a)	Section 2.1 – Landfill Information	
4 (2) (b)	Section 2.1 – Landfill Information	
4 (2) (c)	Section 2.1 – Landfill Information	
4 (2) (d)	Table 3.1 - LFG Generation Model Results	
4 (2) (e)	Table 3.1 - LFG Generation Model Results	
4 (3) (a)	Section 2.1 – Landfill Information Table 3.1 - LFG Generation Model Results	
4 (3) (b) (i)	Appendix A – Annual Waste Tonnage Records	
4 (3) (b) (ii)	Appendix A – Annual Waste Tonnage Records	
4 (3) (c)	Section 2.5 – Additional Information	

Landfill Gas Management Regulation - Initial Landfill Gas Generation Assessment and Report (Section 4) Requirements	*Relevant Landfill Gas Generation Assessment Report Sections*	*Item Completed*
4 (3) (d)	Section 1.1 – Site Background Section 1.2 – Previous LFG Generation Assessments Section 2.2 – Climate Section 2.3 – Model Parameters Used and Justification Section 4.0 – Discussion of LFG Generation Model Results Section 5.0 – Discussion of Next Steps	
4 (3) (e)	Section 1.0 – Introduction Signature Page	
4 (4)	Section 1.3 – Previous LFG Generation Assessments	
4 (5)	Section 1.2 – Introduction	

The Landfill Gas Assessment Report submission date to the director is dependent on the quantity of waste in place and annual quantity of waste received. The schedule for submittal of the Landfill Gas Assessment Report is as follows:

- If the quantity of waste in place is equal to or greater than 100,000 tonnes or if the annual quantity of waste received exceeds 10,000 tonnes before January 1, 2009, the report must be submitted no later than January 1, 2011.
- If the quantity of waste in place reaches or exceeds 100,000 tonnes after January 1, 2009, the report must be submitted on or before the later of the following dates:
  - March 31 of the year immediately following the year in which 100,000 tonnes of waste was exceeded; or
  - January 1, 2011.
- If the annual quantity of waste received for disposal into the landfill site reaches or exceeds 10,000 tonnes on or after January 1, 2009, the report must be submitted on or before the later of the following dates:
  - March 31 of the year immediately following the year in which more than 10,000 tonnes of waste was received; or
  - January 1, 2011.

The following three examples are presented to clarify the Landfill Gas Assessment Report submittal requirements.

Scenario 1 - Landfill Gas Assessment Report Submittal Requirements

The quantity of waste in place reaches 100,000 tonnes in September 2012. The Landfill Gas Assessment Report must be submitted to the director on or before March 31, 2013.

Scenario 2 - Landfill Gas Assessment Report Submittal Requirements

The annual mass of waste disposed of in the landfill exceeded 10,000 tonnes in 2009. The Landfill Gas Assessment Report must be submitted to the director on or before January 1, 2011.

Scenario 3 - Landfill Gas Assessment Report Submittal Requirements

The quantity of waste in place reached 100,000 tonnes in September 1998. The Landfill Gas Assessment Report must be submitted to the director on or before January 1, 2011.

SECTION 8 - NEXT STEPS

The required actions for landfill owners and operators after completion of the LFG Assessment Report are dependent on the results of the LFG generation assessment. This section describes the next steps after completing and submitting an LFG Generation Assessment as per the Regulation. The required actions are summarized in Table 8.1 below.

Table 8.1 – Actions Required after Initial LFG Generation Assessment Report

Regulated Landfills (>100,000 tonnes in place or >10,000 tonnes/yr after January 1, 2009)		
Estimated LFG Production	***Greater than 1,000 tonnes CH_4 in calendar year preceding assessment***	***Less than 1,000 tonnes CH4 in calendar year preceding assessment***
Initial LFG Generation Assessment Report	Required (see Section 7 for requirements)	Required (see Section 7 for requirements)
LFG Management Design Plan	Submit to MOE in the calendar year immediately after the calendar year of the assessment	Submit to MOE anytime
Annual Report	Submit to MOE annually	Submit to MOE annually
Supplementary LFG Generation Assessment and Reports	Not applicable because LFG collection system will be in place and reporting occurs as annual reports	Conduct assessment/review in fifth calendar year following the calendar year of the previous assessment or review

A summary of the actions required after completion of the LFG Generation Assessment Report must be included in the LFG Generation Assessment Report to be submitted to the MOE as outlined in Appendix E.

The following sections describe the actions required if the estimated LFG production in the calendar year preceding the assessment is greater than 1,000 tonnes and the actions required if the estimated LFG production in the calendar year preceding the assessment is less than 1,000 tonnes.

Greater than 1,000 tonnes

In accordance with the Regulation, the LFG Management Design Plan must be prepared for a regulated landfill site if, as a result of the LFG assessment, the landfill was estimated to generate 1,000 tonnes or more of methane in the calendar year preceding the calendar year in which the LFG assessment was conducted. The An LFG

Management Design Plan must be submitted to the director no later than one year after the LFG Generation Assessment Report was required to be submitted to the director.

The LFG Management Design Plan must be prepared by a qualified professional in accordance with the Landfill Gas Management Regulation and include the following information:

- a description of existing or planned methods, management practices, and processes for LFG management at the landfill site
- a plan for the installation, operation, and maintenance of LFG management facilities at the landfill site, including a contingency plan for disruption in LFG management for scheduled or emergency maintenance or replacement of LFG management facilities
- recommendations for optimizing LFG management at the landfill site
- any other information required under the regulations
- any other information requested in writing by the director
- certification by a qualified professional that the plan was prepared in accordance with the guidelines

Once the LFG Management Design Plan has been accepted by the director, the owner or operator of the landfill site must install the LFG management facility described in the LFG Management Design Plan. The owner or operator must also implement LFG management practices, processes, and methods for LFG management in accordance with any guidelines respecting:

- migration of LFG;
- use of landfill covers;
- operation of LFG management facilities;
- LFG collection equipment;
- LFG flaring equipment; and
- LFG management facilities maintenance, including the number of days annually that LFG management facilities may be shutdown.

The LFG facility described in the accepted design plan and the LFG management practices must be installed and implemented no later than four years after the date the Design Plan is submitted to the director.

The owner or operator of a regulated landfill is also required to file an annual report with the director. The template presented in Appendix F should be used to develop the Annual Report.

If an LFG management facility is not installed at the landfill site, Section 4 of the annual report template is not applicable and should be removed from the template prior to submission of the report. The report template presented in Appendix F includes the following information relevant to a regulated landfill without an LFG management facility:

- quantity of municipal solid waste received for disposal into the landfill site;
- composition of municipal solid waste received for disposal into the landfill site, if the owner or operator has monitored or analyzed the composition of the municipal solid waste;
- a description of any organics diversion program used at the landfill site; and
- any additional information requested in writing by the director.

If an LFG management facility is installed at the landfill site, all sections of annual report template presented in Appendix F should be included in the Annual Report. The annual report template includes the following information relevant for landfill sites with LFG management facilities:

- quantity of municipal solid waste received for disposal into the landfill site;
- composition of municipal solid waste received for disposal into the landfill site, if the owner or operator has monitored or analyzed the composition of the municipal solid waste;
- a description of any organics diversion program used at the landfill site;
- daily volume (ft^3, m^3) of landfill gas collected at the site calculated by a qualified professional using best available data;
- daily operational hours of the gas collection system;
- daily composition of landfill gas collected at the site, including percent methane, carbon dioxide, and oxygen;
- daily volume (ft^3, m^3) of landfill gas that is flared or used as an alternative to flaring at the site calculated by a qualified professional using best available data;
- daily composition of landfill gas that is flared or used as an alternative to flaring the site, including percent methane, carbon dioxide, and oxygen, as determined by a qualified professional using best available data;
- daily operational hours of the gas flaring system;

- if landfill gas is used as an alternative to flaring, a description of the alternative use;
- a description of any periods when the landfill gas management facilities at the landfill site were shutdown, and the reasons for the shutdown;
- a description of any significant maintenance or operation problems encountered;
- the efficiency of any landfill gas management facilities used at the landfill site, including:
  - an evaluation of the existing efficiency of the facilities,
  - the method and supporting data used to calculate the efficiency of the facilities, and
  - the owner's or operator's plan for increasing the efficiency of the facilities;
- municipal solid waste composition studies if available;
- plans to be implemented at the landfill site in the next reporting year for:
  - modifications or other changes to the landfill gas management facilities, and
  - periods when the landfill gas management facilities will be out of operation; and
- any additional information requested in writing by the director.

Less than 1,000 tonnes

If the LFG assessment conducted in accordance with the regulation was estimated to be less than 1,000 tonnes of methane in the calendar year preceding the calendar year in which the LFG assessment was conducted, the owner or operator of the regulated site may submit an LFG facilities design plan to the director at any time.

The owner or operator of a regulated landfill producing less than 1,000 tonnes of methane in the calendar year preceding the calendar year in which the LFG assessment was conducted is required to file an annual report with the director. The template presented in Appendix F should be used to develop the annual report.

Section 4 of the annual report template is not applicable to regulated landfills producing less than 1,000 tonnes of methane per year and should be removed from the template prior to submission of the report. The annual report template includes the following information relevant to a regulated landfill producing less than 1,000 tonnes of methane per year:

- quantity of municipal solid waste received for disposal into the landfill site;
- composition of municipal solid waste received for disposal into the landfill site, if the owner or operator has monitored or analyzed the composition of the municipal solid waste;

- a description of any organics diversion program used at the landfill site; and
- any additional information requested in writing by the director.

In addition to the annual report, the owner or operator of a regulated landfill with methane production of less than 1,000 tonnes in the year preceding the calendar year in which the LFG assessment was conducted must, between January 1 and March 31 of the fifth calendar year following the calendar year of the previous assessment or review, ensure that a qualified professional conducts a supplementary assessment or reviews the previous assessment to determine if there have been any material changes in the information in the report since the previous report. After the qualified professional conducts a supplementary assessment or review, the qualified professional must complete and submit a supplementary report to the director no later than March 31 of the calendar year of the supplementary assessment or review.

SECTION 9 – REFERENCES

British Columbia Ministry of Environment (MOE), Landfill Criteria for Municipal Solid Waste, June 1993, Source: http://www.env.gov.bc.ca/epd/epdpa/mpp/lcmsw.html, last accessed March 25, 2009.

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APPENDICES

APPENDIX A

CATEGORIZED WASTE TYPES

APPENDIX A

CATEGORIZED WASTE TYPES
LANDFILL GAS GENERATION ASSESSMENT PROCEDURE GUIDANCE REPORT
BRITISH COLUMBIA MINISTRY OF ENVIRONMENT

	Relatively Inert	*Moderately Decomposable*	*Decomposable*
Paper			
Office Paper		x	
Newsprint		x	
OCC		x	
Boxboard		x	
Tissue Paper/towelling		x	
Beverage Containers - Drink Box / Aseptic Containers		x	
Single Serving Drink Cups (coffee, tea, fountain, etc.)		x	
Organics			
Food Waste			x
Natural Textiles		x	
Leather		x	
Wood - Unpainted		x	
Wood - Painted		x	
Leaves			x
Plant Clippings			x
Grass			x
X-mas Trees			x
Slaughterhouse Waste			x
Plastics			
Rigid Plastics	x		
Films (plastic bags)	x		
Synthetic Textiles (i.e.. nylon, polyester, etc.)	x		
Carpet	x		
Rubber	x		
Tires	x		
Metals	x		
Electronics	x		
Glass	x		
Building Material			
Gypsum/drywall/plaster	x		
Masonry (bricks, blocks, concrete, etc.)	x		
Rock/sand/dirt/ceramic	x		
Rigid Asphalt Products	x		
Carpet Waste (and underlay)	x		
Other Inorganics (linoleum, etc.)	x		
Asbestos Waste	x		
Bulky Objects			
Appliances	x		
Wooden Furniture (including upholstered)		x	
Non-Wooden Furniture	x		
Mattresses	x		
Soils and Sludges			
Contaminated Soil	x		
WWTP Grit and Screenings	x		
Soil	x		
Asphalt	x		
Unsorted Wastes			
Mixed MSW			x
Construction and Demolition Waste		x	
Yard Waste			x
Medical Facility Wastes		x	
Miscellaneous			
Diapers		x	
Animal Bedding		x	

APPENDIX B

PRECIPITATION DATA

APPENDIX B

ANNUAL AVERAGE PRECIPITATION
LANDFILL GAS GENERATION ASSESSMENT PROCEDURE GUIDANCE REPORT
BRITISH COLUMBIA MINISTRY OF ENVIRONMENT

Landfill Name	*Climate Station*	*Annual Precipitation (mm)*
Alberni Valley	Port Alberni (AUT) (#1036B06)	1,910.7
Armstrong	Vernon (#1128551)	410.0
Bailey	Sardis (#1107080)	1,515.8
Bessborough	Dawson Creek A (#1182285)	482.1
Cache Creek	Spences Bridge Nicola (#1167637)	269.0
Campbell Mtn	Naramata (#1125381)	330.0
Campbell River	Quinsam River Hatchery (#1026639)	1,605.6
Central	Castlegar A (#1141455)	755.2
Central Subregion	Cranbrook City (#1152J02)	401.1
Columbia Regional	Kootenay NP West Gate (#1154410)	424.2
Comox Valley	Comox A (#1021830)	1,179.0
Ecowaste	Richmond Nature Park (#1106PF7)	1,277.4
Foothills	Prince George 15NW (#1096458)	643.9
Ft. Nelson	Fort Nelson A 1192940	451.8
Ft. St. John	Fort St.John A (#1183000)	465.8
Gibraltar	McLeese Lake Granite Mt (#1095018)	509.8
Glenmore	Kelowna A (#1123970)	380.5
Hartland	Saanichton CDA (#1016940)	906.2
Heffley Creek	Heffley Creek (#1163400)	409.0
Knockholt	Burns Lake Campbell Scientific (#1091174)	460.8
Lower Nicola	Merritt STP (#1125079)	322.1
McKelvey Creek3	Warfield(#1148700)	774.9
Mini's Pit	Mission West Abbey (#1105192)	1,875.6
Mission Flats	Kamloops A (#1163780)	279.0
Nanaimo	Nanaimo A (#1025370)	1,162.8
Ootischenia	Castlegar A (#1141455)	755.2
Prince Rupert	Prince Rupert A (#1066481)	2,593.6
Salmon Arm	Salmon Arm A (#1166R45)	669.3
Sechelt	Gibsons Gower Point (#1043152)	1,369.2
Squamish	Squamish Upper (#1047672)	2,366.8
Terrace	Terrace PCC (#1068131)	1,160.7
Thornhill	Terrace PCC (#1068131)	1,160.7
Vancouver	Richmond Nature Park (#1106PF7)	1,277.4
Vernon	Vernon Bella Vista (#1128553)	445.1
Westside	Peachland (#1126070)	401.3

Source:

Environment Canada, National Climate Data and Information Archive, www.climate.weatheroffice.ec.gc.ca (Canadian Climate Normals or Averages 1971-2000)
Environment Canada, Station Information Map Viewer, http://scitech.pyr.ec.gc.ca/climhydro/welcome_e.asp

APPENDIX C

PARAMETER SELECTION EXAMPLES

APPENDIX C - LANDFILL GAS ASSESSMENT PARAMETER SELECTION EXAMPLE

LIST OF ATTACHMENTS

LANDFILL GAS ASSESSMENT PARAMETER SELECTION EXAMPLE

Appendix C presents an example of the process required to compile the data for the Landfill Gas Generation Estimate Tool provided in Appendix D.

The Beach Side Landfill, located in the City of Vancouver, has hired Alright Engineering (who employs a Qualified Professional) to conduct a landfill gas assessment. The operator of the Beach Side Landfill has sent a letter containing the information required to conduct an LFG assessment to Alright Engineering. The letter is presented as Attachment 1 – Example Waste Quantities and Information Letter.

GATHER INFORMATION

STEP 1 – DETERMINE HISTORICAL ANNUAL WASTE TONNAGES

The Beach Side Landfill was able to provide 30 years of scale house data. The information provided by the Beach Side Landfill is attached. Additional information regarding determination of historical annual waste tonnages is provided in Section 4.1 of the Guideline.

STEP 2 – WASTE CHARACTERIZATION INFORMATION

The Beach Side Landfill has both scale and waste composition data available. The waste composition study data will be used to determine the "relatively inert," "moderately decomposable," and "decomposable" fractions of the mixed solid waste collected at the landfill. Had waste composition study data not been available, the entire mass of mixed solid waste would be classified as "decomposable."

STEP 3 – SELECT APPROPRIATE METEOROLOGICAL DATA

The Beach Side Landfill is located at 1133 Beach Ave, Vancouver, BC, V6E 1V1. The average annual precipitation recorded at the closest active Environment Canada climatic station is 1,588.6 mm (1970-2000).

To determine average annual precipitation, the closest Environment Canada Climatic Station was located using the following web site:
http://scitech.pyr.ec.gc.ca/climhydro/mainContent/main_e.asp?province=bc.

Once the name of the closest station was determined, the station name was employed to access the relevant climate data from the National Climate Data and Information Archive. The National Climate Data and Information Archive can be accessed at the following web address:
http://climate.weatheroffice.ec.gc.ca/. Additional information regarding selection of appropriate meteorological data is provided in Section 4.4 of the Guideline.

STEP 4 – ASSESS WATER ADDITION FACTOR INFORMATION

The Beach Side Landfill comprises two separate phases, each covering half of the landfill area. The final cover installed on Phase 1 of the landfill has been designed to minimize the infiltration of precipitation and maximize storm water diversion away from the waste mass. The interim cover on Phase 2 of the landfill is relatively flat and has not been designed to minimize precipitation infiltration; therefore, the majority of storm water in the Phase 2 area infiltrates into the waste. The Beach Side Landfill does not employ leachate recirculation.

Additional information regarding landfill cover and storm water management practices is provided in Section 4.5 of the Guideline.

SELECT LFG GENERATION PARAMETERS

STEP 5 – WASTE CATEGORIZATION

The categorization of the mixed solid waste composition study is presented as Attachment 2 - Example Waste Composition Study and Waste Categorization. The results of the mixed solid waste categorization indicate that 28 percent of Metro Vancouver's mixed solid waste is relatively inert, 52 percent is moderately decomposable, and 21 percent is decomposable. These results were incorporated into the scale house data waste categorization presented in Table 1.

The Beach Side Landfill scale house waste types (mixed solid waste, construction/demolition waste, etc.) were categorized into fractions of relatively inert, moderately decomposable, and decomposable waste. The categorization of the scale house waste types is presented in Table 1 below.

Table 1 – 2008 Scale Data Waste Categorization

Waste Type	*Mass (tonnes)*	*Mass (%)*	*Waste Category*		
			Relatively Inert	*Moderately Decomposable*	*Decomposable*
Mixed Solid Waste	12755.6	82.63%	3613.7	6669.9	2718.2
Mixed Solid Waste w/ Offence	6.2	0.04%	1.7	1.5	2.8
Mixed Solid Waste/Compacted	103.4	0.67%	29.3	25.2	46.9
Construction/Demolition Waste	1335.3	8.65%		1335.3	
Roofing (asphalt/tar/gravel) Waste	876.8	5.68%	876.8		
Roofing (wood) Waste	26.2	0.17%		26.2	
Construction/Demolition w/ Offence	10.8	0.07%		10.8	

Waste Type	*Mass (tonnes)*	*Mass (%)*	*Waste Category*		
			Relatively Inert	*Moderately Decomposable*	*Decomposable*
Sewer Flush Residue	1.5	0.01%	1.5		
Medical Facility Waste	98.8	0.64%		98.8	
Contaminated Soil	52.5	0.34%	52.5		
Dead Animal Waste	7.7	0.05%			7.7
Asbestos Waste (dry or slurry)	29.3	0.19%	29.3		
Food Processing Waste	6.2	0.04%			6.2
Controlled Waste - Misc	21.6	0.14%		21.6	
Grit and Screenings	100.3	0.65%	100.3		
Bio-Solids	1.5	0.01%			1.5
Treatment Works and Pumpings	1.5	0.01%			1.5
Tires (up to 25") over 4 quantity	1.5	0.01%	1.5		
Power Sweep Sites	0.0	0.00%	0.0		
Garbage Tags	0.0	0.00%	0.0		
Blue Box	0.0	0.00%	0.0		
Totals	**15,437**	**100.00%**	**4,707**	**8,189**	**2,785**

The methane generation potential (L_o) and landfill gas generation rate constant (k) will be selected for each waste category (relatively inert, moderately decomposable, and decomposable) in Steps 6, 7, and 8. Additional information regarding waste characterization is provided in Section 4.3 and Appendix A of the Guideline.

STEP 6 – DETERMINE METHANE GENERATION POTENTIAL (L_O)

Each category of waste has a different potential for methane generation. Values of the methane generation potential (L_o) have been prescribed in Section 5.2 of the Guidelines for relatively inert, moderately decomposable, and decomposable waste categories. The L_o values for each waste category at the Beach Side Landfill are presented below in Table 2.

Table 2. Methane Generation Potential (L_o) Values

Waste Category	*Methane Generation Potential (Lo)*
Relatively inert	20 m^3 methane/tonne
Moderately Decomposable	120 m^3 methane/tonne
Decomposable	160 m^3 methane/tonne

The L_o values presented in Table 2 will be input directly into the landfill gas generation model.

STEP 7 – DETERMINE PRESCRIBED LANDFILL GAS GENERATION RATE (k)

Each category of waste has a different landfill gas generation rate constant (k) that is dependent on average annual precipitation data and storm water management, the extent of leachate recirculation and/or storm water injection, cover properties, and landfill operational practices.

Prescribed landfill gas generation rate constants (k) are provided in the Section 5.3 of the Guidelines for each waste category based on annual precipitation. The annual average precipitation at the Beach Side Landfill, as determined in Step 3, is 1,588.6 mm, which falls into the ">1,000 to <2,000 mm" precipitation range in Table 5.2 of the Guideline. The prescribed k values for each waste category at the Beach Side Landfill are presented in Table 3.

Table 3. Selected Landfill Gas Generation Rate Constant (k)

	Landfill Gas Generation Rate Constant (k)		
	Relatively Inert	***Moderately Decomposable***	***Decomposable***
Landfill Gas Generation Rate Constant ($year^{-1}$)	0.02	0.06	0.11

The selected k values for the Beach Side Landfill will be adjusted (Step 8) prior to input into the landfill gas generation model.

STEP 8 – ADJUST k FOR WATER ADDITION FACTOR.

The prescribed k values presented in Table 3 are based solely on waste category and annual average precipitation. The values need to be corrected for storm water management practices, the extent of leachate recirculation and/or storm water injection, cover properties, and landfill operational practices. The water addition information assessment completed in Step 4 concluded that landfill storm water best management practices and low permeability sloped cover have been partially implemented across the site and that leachate recirculation is not taking place. Therefore a water addition factor of 1.0 was assigned to the landfill gas generation rate constant (k) as described in Section 5.4.

Table 4. Final Landfill Gas Generation Rate Constant (k)

	Landfill Gas Generation Rate Constant (k)		
	Relatively Inert	***Moderately Decomposable***	***Decomposable***
Landfill Gas Generation Rate Constant ($year^{-1}$)	0.02	0.06	0.11
Water Addition Factor	1.0	1.0	1.0
Final Landfill Gas Generation Rate Constant ($year^{-1}$)	0.02	0.06	0.11

Beach Side Landfill
1133 Beach Ave
Vancouver, BC V6E 1V1
Phone 123.456.7890
Fax 123.456.7890

March 31, 2009

Alright Engineering
4444 Landfill Design Blvd
Anytown, BC V6X 2V2

Dear Qualified Professional:

RE: Beach Side Landfill 2008 Waste Quantities

I am please to present the 2008 inbound waste quantities as determined from our scale house data. The mass and composition of the waste received in 2008 is presented in Table 1.

Table 1 – 2008 Scale House Data

Waste Type	Weight (tonne)	Weight (%)
Mixed Solid Waste	12,755.6	82.63%
Mixed Solid Waste w/ Offence	6.2	0.04%
Mixed Solid Waste/Compacted	103.4	0.67%
Construction/Demolition Waste	1335.3	8.65%
Roofing (asphalt/tar/gravel) Waste	876.8	5.68%
Roofing (wood) Waste	26.2	0.17%
Construction/Demolition w/ Offence	10.8	0.07%
Sewer Flush Residue	1.5	0.01%
Medical Facility Waste	98.8	0.64%
Contaminated Soil	52.5	0.34%
Dead Animal Waste	7.7	0.05%
Asbestos Waste (dry or slurry)	29.3	0.19%
Food Processing Waste	6.2	0.04%
Controlled Waste - Misc	21.6	0.14%
Grit and Screenings	100.3	0.65%
Bio-Solids	1.5	0.01%
Treatment Works and Pumpings	1.5	0.01%
Tires (up to 25") over 4 quantity	1.5	0.01%
Power Sweep Sites	0.0	0.00%
Garbage Tags	0.0	0.00%
Blue Box	0.0	0.00%
Total	**15,437**	**100.00%**

The waste quantity and composition of waste received at the downtown landfill is consistent from year to year. The annual waste quantities and composition have been identical to the information presented in Table 1 for the last 30 years.

The Beach Side Landfill receives waste from Metro Vancouver. The most recent waste composition study in the collection area analyzed mixed municipal solid waste and was completed in 2005. The results from the waste composition study have been attached to this letter.

There are two equally sized operational phases at the Beach Side Landfill, Phase 1 and 2. Phase 1 has reached final contours and has final cover in place. The Phase 1 final cover was constructed of approximately 1 metre of low permeability clay with a 3:1 side slope and swales every 30 metres. The Phase 1 storm water management system conveys all storm water off-site.

Phase 2 is currently being filled with waste and is covered with interim cover. The interim cover is composed of sand and is relatively flat. The landfill operators have noticed that most of the precipitation infiltrates directly into the waste. Please note that leachate recirculation is not employed at the Beach Side Landfill.

I trust that the information provided in this letter will be adequate for the required landfill gas generation assessment.

Sincerely,

Jan Sherlock
Director of Operations
Beach Side Landfill

SOLID WASTE
COMPOSITION STUDY

for

Greater Vancouver Regional District
5th Floor, 4330 Kingsway
Burnaby, BC
V5H 4G8

Technology Resource Inc.
102 – 980 West First Street
North Vancouver, B.C.
V7P 3N4

January 14, 2005

EXECUTIVE SUMMARY

Direct analysis of solid waste provides important information about the composition of waste produced by various sources. The information is a useful tool for authorities in charge of the reduction and management of the solid waste stream. The Greater Vancouver Regional District (GVRD) is required to update its solid waste compositional data on a regular basis. Technology Resource Inc. (TRI) was engaged to undertake a solid waste composition study on behalf of the Regional District for this purpose. The objectives of the study were to:

- Carefully sort and document the composition of a representative number of waste samples;
- Analyze the waste composition data and classify it according to the waste source, and
- Generate an extrapolation of the waste composition data for the entire GVRD, with consideration of statistical limitations.

This study involved the analysis of a total of 139 samples of solid waste received at three facilities: the Waste to Energy Facility (WTE, Burnaby Incinerator), the Vancouver South Transfer Station (VTS) and the Surrey Transfer Station (STS). The study was conducted from September 8 to November 9, 2004.

The waste samples were classified as originating from either residential curbside pick-up (Residential), residential drop-off (RDO) or industrial/commercial/institutional (ICI) sources, and sorted into 11 primary categories and 107 secondary categories. The composition of each sample was then calculated. The composition data was extrapolated to the entire GVRD waste stream, weighted according to the source distribution of waste generated in the Region. The table below provides a summary of the projection of the study composition data to waste generated in the GVRD by all sources.

Statistical analysis was performed on the primary category data sets, for Residential, RDO and ICI waste, from each of the three facilities. The results of the analysis indicate that the primary category compositions of Paper and Paperboard, Plastics, Organic Waste, Metals, and Glass have a high occurrence of normal distribution. For waste from Residential sources, the results for all of the primary categories apart from Bulky Objects also exhibit a high occurrence of normal distribution. Results from the Bulky Objects category, as well as the Fines category, are generally not normally distributed. Data that follows a normal distribution is more likely to be accurate than data that does not.

Projection of study data to the entire GVRD waste stream

Primary Category / Secondary Category			Total Residential, RDO and ICI		
			Composition	(kg/pers/yr)	(tonnes/yr)
1	**Paper and Paperboard**				
1	Fine paper, incl. computer paper		2.08%	10.39	22,101.77
2	Newsprint		2.29%	11.41	24,272.51
3	Recyclable corrugated cardboard		1.52%	7.60	16,173.43
4	Non-recyclable waxed corrugated cardboard		0.30%	1.50	3,180.89
5	Other non-recyclable corrugated cardboard (contaminated)		1.51%	7.55	16,060.19
6	Boxboard		2.09%	10.42	22,167.67
7	Telus telephone directories		0.25%	1.24	2,645.30
8	Non-Telus telephone directories		0.04%	0.22	475.00
9	Magazines		1.25%	6.26	13,305.66
10	Books		0.64%	3.21	6,836.11
11	Tissue paper / towelling		2.73%	13.60	28,931.16
12	Gable-top beverage containers		0.20%	1.01	2,140.47
13	Aseptic (tetrapack) box beverage containers		0.09%	0.46	968.93
14	Other paper (wrappers, paper plates, cups etc.)		3.63%	18.12	38,525.61
		Total Category	**18.65%**	**93.00**	**197,784.71**
2	**Plastics**				
1	Film - garbage bags		1.21%	6.03	12,814.16
2	Film - other bags		1.08%	5.40	11,485.91
3	Film -sheet		2.49%	12.42	26,423.84
4	Rigid	PETE #1	0.26%	1.30	2,767.02
5	Rigid	HDPE #2 - milk jugs	0.09%	0.44	935.78
6	Rigid	HDPE #2 - other	0.44%	2.21	4,701.19
7	Rigid	PVC #3	0.04%	0.20	432.75
8	Rigid	LDPE #4	0.03%	0.13	277.98
9	Rigid	PP #5	0.12%	0.61	1,295.96
10	Rigid	PS #6	0.90%	4.49	9,559.06
11	Rigid	PS #7	0.01%	0.07	154.63
12	Rigid	unidentified	1.85%	9.25	19,670.54
13	Other plastic items	toys, lawn furniture, etc.	0.48%	2.39	5,083.73
14	Other/mixed plastics		0.26%	1.32	2,797.37
		Total Category	**9.28%**	**46.27**	**98,399.93**

Projection of study data to the entire GVRD waste stream

Primary Category / Secondary Category			Total Residential, RDO and ICI		
			Composition	(kg/pers/yr)	(tonnes/yr)
3	**Organic Waste**				
1	Yard and garden (grass)		1.28%	6.36	13,533.44
2	Yard and garden (small yard waste - leaves, branches)		2.99%	14.92	31,729.17
3	Yard and garden (large yard waste -		0.57%	2.85	6,066.42
		branches >15 cm dia. or >1 m long)			
4	Food Waste (backyard compostable (fruits and veg.)		7.88%	39.32	83,622.23
5	Food waste (other - meats, breads, dairy, fats)		8.59%	42.84	91,101.90
6	Wood pallets		1.69%	8.42	17,911.35
7	Wood furniture		3.26%	16.27	34,605.37
8	Other painted/finished wood - lumber, panelling, siding, shingles		2.12%	10.56	22,467.57
9	Other unpainted wood - lumber, panelling, siding, shingles		7.52%	37.49	79,724.25
10	Textiles - clothing		1.29%	6.43	13,675.28
11	Textiles - other		2.63%	13.14	27,936.42
12	Leather		0.01%	0.06	137.05
13	Rubber (tires)		0.22%	1.09	2,324.67
14	Rubber (other rubber)		0.58%	2.88	6,126.30
15	Multiple materials (footwear, etc.)		4.75%	23.67	50,349.96
		Total Category	**45.37%**	**226.32**	**481,311.38**
4	**Metals**				
1	Ferrous - beer		0.01%	0.03	74.32
2	Ferrous - soft drink		0.02%	0.11	228.62
3	Ferrous - food		0.47%	2.36	5,024.72
4	Ferrous - Kitchen & bathroom faucets		0.30%	1.50	3,179.53
		(sinks, tubs, faucets, etc.)			
5	Ferrous - other		2.10%	10.48	22,281.36
6	Bimetallic - food		0.04%	0.20	428.39
7	Bimetallic - electric motors		0.04%	0.20	417.45
8	Bimetallic - other		0.23%	1.17	2,484.85
9	Non-ferrous - beer		0.03%	0.13	274.18
10	Non-ferrous - soft drink		0.06%	0.30	642.08
11	Non-ferrous - food containers		0.15%	0.73	1,553.91
12	Non-ferrous - foil trays, wrap		0.30%	1.51	3,204.10
13	Non-ferrous - other		0.44%	2.19	4,665.88
		Total Category	**4.19%**	**20.91**	**44,459.39**
5	**Glass**				
1	Glass	Beverage containers	0.44%	2.22	4,710.81
2	Glass	Food containers	0.48%	2.42	5,141.10
3	Glass containers - other		0.17%	0.83	1,758.87
4	Glass - other - plate, mirrors, lightbulbs		0.25%	1.24	2,635.79
		Total Category	**1.34%**	**6.70**	**14,246.58**

Projection of study data to the entire GVRD waste stream

Primary Category / Secondary Category			Total Residential, RDO and ICI		
			Composition	(kg/pers/yr)	(tonnes/yr)
6	**Inorganic**				
1	Gypsum/drywall/plaster		0.93%	4.66	9,910.46
2	Masonry (bricks, blocks, concrete, etc.)		0.11%	0.57	1,209.26
3	Rock/sand/dirt/ceramic		1.41%	7.02	14,926.64
4	Other		0.09%	0.47	991.82
	Total Category		**2.55%**	**12.71**	**27,038.17**
7	**Small Appliances**				
1	Computers		0.74%	3.69	7,845.16
2	Computer monitors		0.32%	1.57	3,346.41
3	Computer printers		0.18%	0.89	1,895.25
4	Televisions		0.69%	3.45	7,345.49
5	Stereo/video equipment		0.62%	3.10	6,586.56
6	Telephones		0.06%	0.32	675.82
7	Other		2.18%	10.86	23,102.73
	Total Category		**4.79%**	**23.89**	**50,797.42**
8	**Hazardous Wastes**				
1	Batteries	Lead acid	0.09%	0.43	913.91
2		Dry cell, alkaline, other	0.09%	0.47	1,002.06
3		Button cell	0.00%	0.00	0.63
4	Medical / biological	Needles and sharps	0.00%	0.01	16.40
5		Animal Cacass	0.00%	0.01	15.62
6		Materials & Equipment	0.12%	0.61	1,307.78
7	HHW in containers	Stains/preservatives	0.00%	0.00	0.00
8		Latex paint	0.06%	0.32	682.40
9		Oil-based paint	0.00%	0.00	1.50
10		Solvents	0.07%	0.36	761.89
11		Cleaners, soaps, etc.	0.02%	0.10	202.92
12		Pesticides, herbicides	0.00%	0.00	0.00
13		Used motor oil bottles	0.01%	0.04	87.99
14		Pharmaceuticals	0.05%	0.24	503.79
15		Other	0.13%	0.62	1,326.15
16	Empty HHW containers	Stains/preservatives	0.01%	0.03	70.02
17		Latex paint	0.21%	1.07	2,265.96
18		Oil-based paint	0.02%	0.12	252.18
19		Solvents	0.03%	0.14	293.26
20		Cleaners, soaps, etc.	0.01%	0.05	102.94
21		Pesticides, herbicides	0.00%	0.00	0.00
22		Used motor oil bottles	0.01%	0.04	77.56
23		Pharmaceuticals	0.03%	0.14	298.64
24		Other	0.11%	0.54	1,148.73
25	Fluorescent light bulbs		0.04%	0.18	382.21
26	Other HHW		0.69%	3.44	7,311.51
	Total Category		**1.79%**	**8.95**	**19,026.06**

Projection of study data to the entire GVRD waste stream

Primary Category / Secondary Category				Total Residential, RDO and ICI		
				Composition	(kg/pers/yr)	(tonnes/yr)
9	**Household Hygiene**					
	1	Biological	Diapers	1.61%	8.04	17,099.03
	2		Animal litter	0.66%	3.30	7,007.58
	3		Other (sanitary napkins, tampons)	0.43%	2.14	4,543.84
			Total Category	**2.70%**	**13.47**	**28,650.44**
10	**Bulky Objects**					
	1	White goods		0.00%	0.00	0.00
	2	Upholstered furniture		0.61%	3.05	6,487.79
	3	Other furniture		2.45%	12.22	25,990.23
	4	Carpet waste		2.86%	14.28	30,370.18
			Total Category	**5.92%**	**29.55**	**62,848.20**
11	**Fines**					
	1	Fines		0.57%	2.86	6,083.61
	2	Combustion residue		0.39%	1.92	4,087.78
	3	Fiberglass fines		0.59%	2.92	6,213.45
			Total Category	**1.54%**	**7.70**	**16,384.84**
			Column Totals	**98.13%**	**489.46**	**1,040,947.12**
			Total received by the GVRD* (tonnes)			**1,060,748.29**
			Total GVRD population	***2,126,719***		

*Data for 2003, provided by the GVRD

The column total of the projected tonnes per year does not equal the total mass of waste received by the GVRD because, due to minor amounts of sample loss and other sources of error, sorted sample masses were not identical to incoming net sample masses. Note that 1,040,947.12 is 98.13% of 1,060,748.29, which is the column total of the projected composition.

WASTE CATEGORIZATION
LANDFILL GAS GENERATION ASSESSMENT
BEACH SIDE LANDFILL
VANCOUVER, BC

	Paper and Paperboard	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Fine paper, incl. computer paper	2.08%		2.08%	
2	Newsprint	2.29%		2.29%	
3	Recyclable corrugated cardboard	1.52%		1.52%	
4	Non-recyclable waxed corrugated cardboard	0.30%		0.30%	
5	(contaminated)	1.51%		1.51%	
6	Boxboard	2.09%		2.09%	
7	Telus telephone directories	0.25%		0.25%	
8	Non-Telus telephone directories	0.04%		0.04%	
9	Magazines	1.25%		1.25%	
10	Books	0.64%		0.64%	
11	Tissue paper / towelling	2.73%		2.73%	
12	Gable-top beverage containers	0.20%		0.20%	
13	Aseptic (tetrapack) box beverage containers	0.09%		0.09%	
14	Other paper (wrappers, paper plates, cups etc.)	3.63%		3.63%	
	Sub Total	**18.62%**	**0.00%**	**18.62%**	**0.00%**

	Plastics	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Film - garbage bags	1.21%	1.21%		
2	Film - other bags	1.08%	1.08%		
3	Film -sheet	2.49%	2.49%		
4	Rigid - PETE #1	0.26%	0.26%		
5	Rigid - HDPE #2 - milk jugs	0.09%	0.09%		
6	Rigid - HDPE #2 - other	0.44%	0.44%		
7	Rigid - PVC #3	0.04%	0.04%		
8	Rigid - LDPE #4	0.03%	0.03%		
9	Rigid - PP #5	0.12%	0.12%		
10	Rigid - PS #6	0.90%	0.90%		
11	Rigid - PS #7	0.01%	0.01%		
12	Rigid - unidentified	1.85%	1.85%		
13	Other plastic items - toys, lawn furniture, etc.	0.48%	0.48%		
14	Other/mixed plastics	0.26%	0.26%		
	Sub Total	**9.26%**	**9.26%**	**0.00%**	**0.00%**

	Organic Wastes	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Yard and garden (grass)	1.28%			1.28%
2	Small yard waste - leaves, branches	2.99%			2.99%
3	Large yard waste - branches >15 cm dia. or >1 m long	0.57%			0.57%
4	Food Waste - backyard compostable (fruits and veg.)	7.88%			7.88%
5	Food waste - other (meats, breads, dairy, fats)	8.59%			8.59%
6	Wood pallets	1.69%		1.69%	
7	Wood furniture	3.26%		3.26%	
8	Other painted/finished wood - lumber, panelling, siding, shingles	2.12%		2.12%	
9	Other unpainted wood - lumber, panelling, siding, shingles	7.52%		7.52%	
10	Textiles - clothing	1.29%		1.29%	
11	Textiles - other	2.63%		2.63%	
12	Leather	0.01%		0.01%	
13	Rubber (tires)	0.22%		0.22%	
14	Rubber (other rubber)	0.58%		0.58%	
15	Multiple materials (footwear, etc.)	4.75%		4.75%	
	Sub Total	**45.38%**	**0.00%**	**24.07%**	**21.31%**

WASTE CATEGORIZATION
LANDFILL GAS GENERATION ASSESSMENT
BEACH SIDE LANDFILL
VANCOUVER, BC

	Metals	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Ferrous - beer	0.01%	0.01%		
2	Ferrous - soft drink	0.02%	0.02%		
3	Ferrous - food	0.47%	0.47%		
4	Ferrous - kitchen & bathroom faucets (sinks, tubs, faucets, etc.)	0.30%	0.30%		
5	Ferrous - other	2.10%	2.10%		
6	Bimetallic - food	0.04%	0.04%		
7	Bimetallic - electric motors	0.04%	0.04%		
8	Bimetallic - other	0.23%	0.23%		
9	Non-ferrous - beer	0.03%	0.03%		
10	Non-ferrous - soft drink	0.06%	0.06%		
11	Non-ferrous - food containers	0.15%	0.15%		
12	Non-ferrous - foil trays, wrap	0.30%	0.30%		
13	Non-ferrous - other	0.44%	0.44%		
	Sub Total	**4.19%**	**4.19%**	**0.00%**	**0.00%**

	Glass	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Glass - Beverage containers	0.44%	0.44%		
2	Glass - Food containers	0.48%	0.48%		
3	Glass containers - other	0.17%	0.17%		
4	Glass - other - plate, mirrors, light bulbs	0.25%	0.25%		
	Sub Total	**1.34%**	**1.34%**	**0.00%**	**0.00%**

	Inorganic	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Gypsum/drywall/plaster	0.93%	0.93%		
2	Masonry (bricks, blocks, concrete, etc.)	0.11%	0.11%		
3	Rock/sand/dirt/ceramic	1.41%	1.41%		
4	Other	0.09%	0.09%		
	Sub Total	**2.54%**	**2.54%**	**0.00%**	**0.00%**

	Small Appliances	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Computers	0.74%	0.74%		
2	Computer monitors	0.32%	0.32%		
3	Computer printers	0.18%	0.18%		
4	Televisions	0.69%	0.69%		
5	Stereo/video equipment	0.62%	0.62%		
6	Telephones	0.06%	0.06%		
7	Other	2.18%	2.18%		
	Sub Total	**4.79%**	**4.79%**	**0.00%**	**0.00%**

WASTE CATEGORIZATION
LANDFILL GAS GENERATION ASSESSMENT
BEACH SIDE LANDFILL
VANCOUVER, BC

	Hazardous Wastes	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Batteries - Lead acid	0.09%	0.09%		
2	Batteries - Dry cell, alkaline, other	0.09%	0.09%		
3	Batteries - Button cell	0.00%	0.00%		
4	Medical / biological - Needles and sharps	0.00%	0.00%		
5	Medical / biological - Animal Carcass	0.00%			0.00%
6	Medical / biological - Materials & Equipment	0.12%	0.12%		
7	HHW in containers - Stains/preservatives	0.00%	0.00%		
8	HHW in containers - Latex paint	0.06%	0.06%		
9	HHW in containers - Oil-based paint	0.00%	0.00%		
10	HHW in containers - Solvents	0.07%	0.07%		
11	HHW in containers - Cleaners, soaps, etc.	0.02%	0.02%		
12	HHW in containers - Pesticides, herbicides	0.00%	0.00%		
13	HHW in containers - Used motor oil bottles	0.01%	0.01%		
14	HHW in containers - Pharmaceuticals	0.05%	0.05%		
15	HHW in containers - Other	0.13%	0.13%		
16	Empty HHW containers - Stains/preservatives	0.01%	0.01%		
17	Empty HHW containers - Latex paint	0.21%	0.21%		
18	Empty HHW containers - Oil-based paint	0.02%	0.02%		
19	Empty HHW containers - Solvents	0.03%	0.03%		
20	Empty HHW containers - Cleaners, soaps, etc.	0.01%	0.01%		
21	Empty HHW containers - Pesticides, herbicides	0.00%	0.00%		
22	Empty HHW containers - Used motor oil bottles	0.01%	0.01%		
23	Empty HHW containers - Pharmaceuticals	0.03%	0.03%		
24	Empty HHW containers - Other	0.11%	0.11%		
25	Fluorescent light bulbs	0.04%	0.04%		
26	Other HHW	0.69%	0.69%		
	Sub Total	**1.80%**	**1.80%**	**0.00%**	**0.00%**

	Household Hygiene	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Biological Diapers	1.61%		1.61%	
2	Animal litter	0.66%		0.66%	
3	Other (sanitary napkins, tampons)	0.43%		0.43%	
	Sub Total	**2.70%**	**0.00%**	**2.70%**	**0.00%**

	Bulky Objects	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	White goods	0.00%	0.00%		
2	Upholstered furniture	0.61%		0.61%	
3	Other furniture	2.45%		2.45%	
4	Carpet waste	2.86%	2.86%		
	Sub Total	**5.92%**	**2.86%**	**3.06%**	**0.00%**

	Fines	Composition of Total Waste	Relatively Inert	Moderately Decomposable	Decomposable
1	Fines	0.57%	0.57%		
2	Combustion residue	0.39%	0.39%		
3	Fiberglass fines	0.59%	0.59%		
	Sub Total	**1.55%**	**1.55%**	**0.00%**	**0.00%**
	Total	**98.09%**	**28.33%**	**48.45%**	**21.31%**

APPENDIX D

LANDFILL GAS GENERATION ESTIMATE TOOL

NOT INCLUDED IN THIS FILE,
REFERENCE THE MS EXCEL FILE POSTED WITH THIS DOCUMENT

APPENDIX E

LANDFILL GAS GENERATION ASSESSMENT REPORT TEMPLATE

LANDFILL GAS GENERATION ASSESSMENT REPORT FOR THE [NAME] LANDFILL

Prepared For:

British Columbia Ministry of Environment

Prepared By:

[Municipality/Corporation]

MARCH 2009

INSTRUCTIONS FOR USE

The following template has been developed to outline the format and content required for landfill gas generation assessment reporting required under British Columbia Landfill Gas Management Regulation (Regulation), approved and ordered on December 8, 2008 (the Regulation).

If all information outlined in the following template is provided completely and accurately all content requirements of Section 4 "Initial Landfill Gas Generation and Assessment Report" of the Regulation will be satisfied. However, the user must consult the requirements described in Section 4(5) of the Regulation to ensure the report is submitted on the schedule required by the director.

The report template has been colour coded to simplify the use of the template. The colours differentiate text that is part of the template (to be included in the report), requirements of the Regulation, and as described in the Guidelines.

The colour coding system is as follows:

Text Colour	Description
Black Text	Black text should be included in the final report.
Blue Text	Blue text is used to describe requirements presented in the Regulation. Blue text should be replaced with the required information and should not be included in the final report.
Brown Text	Brown text is used to describe information in the Guidelines. Brown text should be replaced with site-specific information and should not be included in the final report.

Blue and brown text should not be included in the final version of an LFG assessment report produced using this template. The coloured text is provided to describe the required information and should be replaced by the user to complete the required LFG Generation Assessment Report. The user of this template should convert all text in the final report to black prior to submission of the report to the director.

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LIST OF APPENDICES

1.0 INTRODUCTION

This report has been prepared in accordance with the Landfill Gas Generation Assessment Procedure Guidance Report, prepared for the British Columbia Ministry of Environment by Conestoga-Rovers & Associates (CRA), dated March 2009, and in accordance with the requirements of the British Columbia Ministry of Environment's Landfill Gas Management Regulation (the Regulation), approved and ordered on December 8, 2008. This report has been prepared by a qualified professional and meets the requirements of Section 4(3)(e) of the Regulation.

1.1 LFG ASSESSMENT REQUIREMENTS

The following section presents the information required by Section 4(5) of the Regulation.

This section should include:

- a description of the waste in place and waste received annually in comparison to the threshold levels specified in Section 4(5) of the Regulation;
- the date that LFG report is due to the director as required in Section 4(5) of the Regulation; and
- the first year the landfill received waste as described in Section 4.1 of the Guidelines.

1.2 PREVIOUS LFG GENERATION ASSESSMENTS

The following section presents the information described in Section 3.0 of the Guidelines.

This section should include a summary of all information available from previous landfill gas assessments as described in Section 3.0 of the Guidelines.

2.0 LFG GENERATION ASSESSMENT

2.1 LANDFILL INFORMATION

The following section presents the information required by Sections 4(2)(a), 4(2)(b), 4(2)(c), 4(3)(a), and 4(3)(d) of the Regulation and described in Section 5.1 of the Guidelines.

This section should include:

- annual historical waste tonnages from all years of landfill operation (maximum of 30 years) as required by Sections 4 (2) (a) and 4(3)(a) of the regulation;
- projected mass of waste received for 4 years after the assessment as required by Section 4(2)(b) of the Regulation;
- estimated total waste tonnage of waste in place (sum of annual historical waste tonnages - maximum 30 years) as required by Section 4(2)(c) of the Regulation; and
- waste characteristics, if available, as described in Sections 5.1 of the Guidelines.

2.2 CLIMATE

The following section presents the information required by Section 4(3)(d) of the Regulation and described in Section 5.1 of the Guidelines.

The section should include the average annual precipitation (mm/year) from meteorological station located closest to the landfill site as described in Section 4.4 of the Guidelines.

2.3 MODEL INPUT PARAMETERS USED AND JUSTIFICATION

The following section presents the information required by Section 4(3)(d) of the Regulation and described in Sections 5.2 and 5.3 of the Guidelines.

This section should describe the model parameters used (k and L_o) and the method employed to select the most appropriate values.

2.4 WASTE CATEGORIZATION SUMMARY TABLE

Table 2.1 presents the information required by Section 4(3)(d) of the Regulation and described in Section 5.1 of the Guidelines.

This section should include a table summarizing historical and projected waste mass (for a period 30 years prior to year of assessment). The historical and projected annual waste mass must be categorized into mass of relatively inert, moderately decomposable, and decomposable wastes.

2.5 ADDITIONAL INFORMATION

The following section presents the information required by Section 4(3)(c) of the Regulation.

This section should include any additional information requested in writing by the director as required by Section 4(3)(c) of the Regulation.

3.0 LANDFILL GAS GENERATION MODEL RESULTS

Table 3.1 presents the information required in Sections 4(2)(d), 4(2)(e), and 4(3)(a) of the Regulation.

Table 3.1 Landfill Gas Generation Model Results

	Year of Estimate	*Mass of Methane Produced (tonnes)*
Estimated Quantity of Methane Produced in Year Preceding the Assessment	Year Prior to the Assessment	Mass of Methane Produced in Year Prior to the Assessment (Available in Appendix D of the Guidelines)
Estimated Quantity of Methane Produced in Year of the Assessment	Year of the Assessment	Mass of Methane Produced in the Year of the Assessment (Available in Appendix D of the Guidelines)
Estimated Quantity of Methane Produced One Year after the Assessment	One Year after the Assessment	Mass of Methane Produced One Year after the Assessment (Available in Appendix D of the Guidelines)
Estimated Quantity of Methane Produced Two Years after the Assessment	Two Years after the Assessment	Mass of Methane Produced Two Years after the Assessment (Available in Appendix D of the Guidelines)
Estimated Quantity of Methane Produced Three Years after the Assessment	Three Years after the Assessment	Mass of Methane Produced Three Years after the Assessment (Available in Appendix D of the Guidelines)
Estimated Quantity of Methane Produced Four Years after the Assessment	Four Years after the Assessment	Mass of Methane Produced Four Years after the Assessment (Available in Appendix D of the Guidelines)

4.0 DISCUSSION OF NEXT STEPS

The following section presents the information required by Section 4(3)(c) of the Regulation.

This section should summarize required actions for landfill owners and operators after completion of the LFG Assessment Report as required by the Regulation and described by Section 8.0 of the Guidelines.

Prepared by: Name and Signature

Certified/Approved by: Name; Signature or Stamp

(Report must be certified and approved by a qualified professional)

This signature page fulfills the requirements of Sections 4(1) and 4(3)(e) of the Regulation.

APPENDIX A – ANNUAL WASTE TONNAGE RECORDS

Appendix A presents the information required by Sections 4(3)(b)(i) and 4(3)(b)(ii) of the Regulation.

Appendix A should include waste tonnage and characterization records for the calendar year preceding the assessment year, and all years prior for which records have been maintained (maximum 30 years) as required by Sections 4(3)(b)(i) and 4(3)(b)(ii) of the Regulation.

APPENDIX F

ANNUAL REPORT TEMPLATE

ANNUAL REPORT FOR THE [NAME] LANDFILL

Prepared For:
British Columbia Ministry of Environment

Prepared By:
[Municipality/Corporation]

MARCH 2009

INSTRUCTIONS FOR USE

The following template has been developed to outline the format and content required for annual reporting of landfill operations required under the British Columbia Landfill Gas Management Regulation (the Regulation), approved and ordered on December 8, 2008.

If all information outlined in the following template is provided completely and accurately, all content requirements of Section 12 - Monitoring and Maintaining Records, Section 13 – Production of Records, and Section 14 - Annual Reports of the Regulation will be satisfied. However, the user must consult the requirements described in Section 14(3) of the Regulation to ensure the report is submitted on the schedule required by the director of the British Columbia Ministry of the Environment (MOE).

The report template has been colour coded to simplify the use of the template. The colours differentiate text that is part of the template (to be included in the report), requirements of the Regulation, and as described in the Guidelines.

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1.0 INTRODUCTION

This report has been prepared in accordance with the requirements of the British Columbia Ministry of Environment's Landfill Gas Management Regulation (Regulation), approved and ordered on December 8, 2008, and in accordance with the Landfill Gas Generation Assessment Procedure Guidance Report, as prepared for the British Columbia Ministry of Environment (MOE) by Conestoga-Rovers & Associates (CRA), dated March 2009. This report has been prepared by a qualified professional and meets the requirements of Section 4(3)(e) of the Regulation.

1.1 RECORDS

The following section presents the information required under Section 12(3), 13, and 14(1)(a) of the Regulation.

(Landfill owner or operator) certifies that all records required under Section 12(3) of the British Columbia Ministry of Environment Landfill Gas Management Regulation are retained for a period of at least 10 years after they are made. Furthermore, the records will be produced for inspection or copying, upon written request from the director, in the time period specified by the director as required in Section 13 of the Regulation.

2.0 QUANTITY AND SOURCES OF MUNICIPAL WASTE RECEIVED

The following section presents the information required under Sections 12(1)(a) and 14(1)(a) of the Regulation.

This section should include:

- quantity and sources of MSW received
- quantity of MSW received categorized by mass of relatively inert, moderately decomposable, and decomposable wastes

2.1 WASTE COMPOSITION

The following section presents the information required under Sections 12(1)(b), 12(1)(c), 14(1)(a), and 14(2)(g) of the Regulation and described in Section 5.1 of the Guidelines.

This section should include the composition of MSW received, if monitored and analyzed (i.e., a waste study was conducted).

2.2 WASTE DIVERSION

The following section presents the information required under Section 14(1)(b) of the Regulation.

This section should include a description of any organics diversion program used at the landfill site.

3.0 ADDITIONAL INFORMATION

The following section presents the information required under Sections 14(1)(c) and 14(2)(i) of the Regulation.

This section should include any additional information requested in writing by the director.

4.0 LANDFILL GAS MANAGEMENT FACILITIES

This section is only applicable if installation of landfill gas management facilities is required at the landfill site under Section 8 of the Regulation.

4.1 GAS COMPOSITION QUANTITYAND QUALITY

The following section presents the information required under Sections 12(2)(b) and 14(2)(a) of the Regulation.

This section should include:

- daily volume (ft^3 or m^3) of landfill gas collected at the site;
- daily composition of landfill gas collected at the site, including percent methane, carbon dioxide, and oxygen, as determined by a qualified professional using best available data; and

- daily operational hours of the gas collection system.

4.1 GAS FLARING AND UTILIZATION

The following section presents the information required under Sections 12(2)(c), 14(2)(b), and 14(2)(c) of the Regulation.

This section should include:

- daily volume (ft^3 or m^3) of landfill gas that is flared or used as an alternative to flaring at the site calculated by a qualified professional using best available data;
- daily composition of landfill gas that is flared or used as an alternative to flaring the site, including percent methane, carbon dioxide, and oxygen, as determined by a qualified professional using best available data;
- daily operational hours of the gas flaring system; and
- if landfill gas is used as an alternative to flaring, a description of the alternative use.

4.2 SYSTEM EFFICIENCY

The following section presents the information required under Section 14(2)(f) of the Regulation. The landfill gas management system efficiency is defined as the system output divided by modeled production times 100%.

This section should describe the efficiency of any landfill gas management facilities used at the landfill site, including:

- an evaluation of the existing efficiency of the facilities;
- the method and supporting data used to calculate the facilities' efficiency; and
- the owner's or operator's plan for increasing the facilities' efficiency.

4.3 SYSTEM MAINTENANCE

The following section presents the information required under Sections 12(2)(a), 14(2)(d), and 14(2)(e) of the Regulation.

This section should include:

- a description of any periods when the landfill gas management facilities at the landfill site were shutdown, and the reasons for the shutdown; and
- a description of any significant maintenance or operational problems encountered.

4.4 SYSTEM MODIFICATIONS AND UPGRADES

The following section presents the information required under Sections 12(1)(c), 14(1)(a), 14(2)(h)(i), and 14(2)(h)(ii) of the Regulation.

Implemented Modifications and Upgrades

This section should include:

- system modifications and upgrades implemented in the reporting period for which this report is being produced; and
- impacts of system modifications and upgrades implemented in reporting period for which this report is being produced.

Planned Modifications and Upgrades

This section should describe:

- modifications or other changes to the landfill gas management facilities planned for the next reporting year; and
- periods when the landfill gas management facilities will be out of operation during the next reporting year.

Prepared by: Name and Signature

Certified/Approved by: Name; Signature or Stamp

(Report must be certified and approved by a qualified professional)

This signature page fulfills the requirements of Sections 4(1) and 4(3)(e) of the Regulation.