Vancouver Landfill: Landfill Gas Collection and Utilization Project

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Abstract

The Vancouver Landfill is owned and operated by the City of Vancouver and is located in the southwest corner of Burns Bog in Delta, B.C. An active landfill gas (LFG) collection and control system has been operated at the Landfill since 1990 to prevent odours and reduce greenhouse gas emissions. In 2003, the City of Vancouver expanded the existing collection system such that the system now collects approximately 2000 standard cubic feet per minute (scfm) of LFG at a methane content of approximately 50%. The gas collection system includes approximately 200 vertical extraction wells, and 10 horizontal extraction laterals. The laterals are bedded in approximately 2 metres of construction and demolition material that acts as a gas collection and drainage layer.

Since September 2003, a beneficial use system owned by Maxim Power Corporation has been operating at the Landfill. Maxim pipes LFG to CanAgro Greenhouses, and at the greenhouse burns the gas generating 5.55 MW of electricity for sale to B.C. Hydro and 100,000 GJ/year of heat for sale to CanAgro.

The project results in the recovery of approximately 500,000 GJ/year of energy, the total energy requirements of 3,000 to 4,000 homes, and results in a reduction of more than 230,000 tonnes per year CO2 equivalents or the emissions of approximately 45,000 automobiles. The City of Vancouver will receive revenues of approximately $400,000 per year for the duration of the 20-year contract period.

Background

The Vancouver Landfill is located in the southwest corner of Burns Bog in the Corporation of Delta, British Columbia, approximately 20 kilometres south of the City of Vancouver. The Vancouver Landfill is a municipal solid waste (MSW) landfill and is owned and operated by the City of Vancouver.

The Landfill has operated since 1966, and in 2003 received 450,000 tonnes of MSW. The Landfill serves over 900,000 residents and associated businesses from a catchment area including Vancouver, Delta, Richmond, White Rock, the University of B.C. Endowment Lands, and a portion of Surrey. The Landfill is part of the Greater Vancouver Regional District's (GVRD) disposal system consisting of two landfills and a waste to energy facility that collectively serve 2,000,000 people.

The Landfill is considered a long-term disposal facility under the 1995 GVRD Solid Waste Management Plan with a remaining capacity of approximately 18,000,000 tonnes (approximately 12 million tonnes currently in place). In September 1999 Vancouver and Delta reached an agreement that, among other things, provides an operating framework for the Landfill until 2037. The conclusion of the Vancouver-Delta Agreement has allowed the City to proceed with long-term planning and capital improvements including expansions to the site's LFG control system.

The Ministry of Water, Land and Air Protection (MOWLAP), formerly Environment, Lands and Parks, under an Operational Certificate (OC) regulate the operation of the Landfill. The OC includes provisions for controlling and recovering LFG at the Vancouver Landfill.

The City of Vancouver has operated an active landfill gas (LFG) collection and flare system at the Vancouver Landfill since 1991. The original system covered approximately 84 hectares of the site and included 190 vertical collection wells, plus a blower/flare system. The system was installed for odour control. Landfill gas is also used to heat and provide hot water for the Landfill's administration building. Most of the 1991 system has now been decommissioned.

In 2000, the system was expanded over an additional 58 hectares that had been filled since 1990. The 2000 system expansion includes:

- 156 vertical high density polyethylene (HDPE) wells (225 mm bore with 100 mm diameter perforated well casings;
- over 10,000 metres of buried HDPE piping in sizes ranging from 150 mm to 450 mm;
- a replacement blower/flare system (skid mounted), consisting of 2 multistage centrifugal blowers (1,500 standard scfm each), 2 refractory-lined steel enclosed-type flares (1,500 scfm each); and
- an automated alarm, shut-off and monitoring system for LFG flow rates, flare operating temperatures and LFG CH4 and O2 content.

The 2000 gas system expansion commenced operating in February 2001, generating approximately 2000 scfm of LFG. By January 2004, the 2000 expansion area was generating approximately 1300 scfm of LFG.

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Site Characteristics

The natural topography of the Landfill site is relatively flat, and the water table is generally within 1 metre of the ground level. The total area of the property is approximately 635 hectares and the footprint of the landfill is

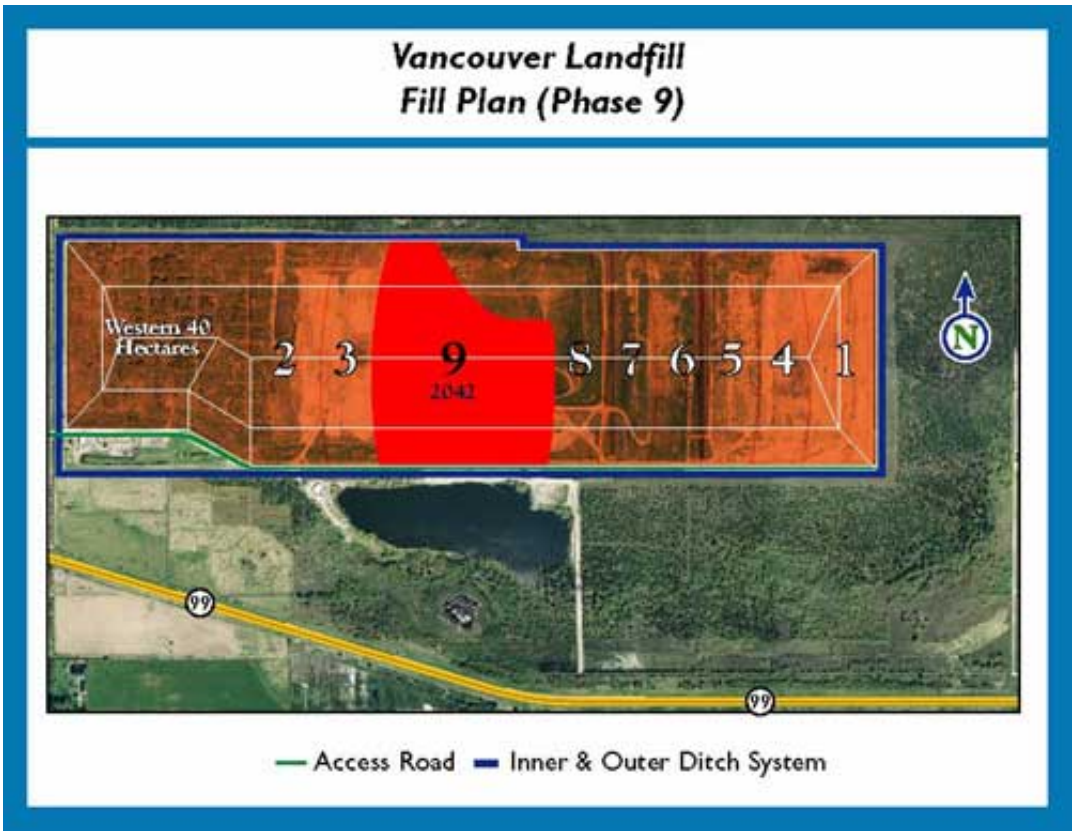
225 hectares. Disposal of MSW at the site has proceeded from west to east. The Landfill's Design and Operations Plan (Sperling Hansen, 2000) includes filling the existing footprint to a total height of 39 metres over the remaining site life of 40 years.

The Landfill is underlain by compressible peat, up to 6 meters thick, which in turn is underlain by flood plain deposits of silty-clay, and sand. The combined thickness of the compressed peat and silty-clay layer is a minimum of 4 metres thick. The peat and silty-clay layers provide a leachate migration barrier that is approximately twice as effective as the minimum requirements of the B.C. Landfill Criteria for Municipal Solid Waste (MOWLAP, 1993) for an engineered landfill liner (one metre thick, $1x10^{-9}$ m/s, minimum 30 cm hydraulic head) (Gartner Lee, 2000).

The Landfill is constructed by installing compacted lifts of MSW over a 3 metre thick mattress of primarily wood construction and demolition (C&D) material. The C&D mattress is installed on top of the peat to provide a working surface for heavy equipment and act as a conduit for leachate to perimeter leachate collection ditches. Leachate is pumped to a local municipal sewage treatment plant.

Refuse is deposited in 5 metre thick lifts. The active landfill area is the most eastern landfill phase, Phase 1 in Figure 1. Phase 1 will be filled to a maximum height of approximately 35 metres by 2005 or 2006. The remaining landfill phases: 3, and then 2 to 9, will be filled over the rest of the Landfill's operating life.

Figure 1: Vancouver Landfill Fill Plan



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2003 Landfill Gas System Expansion

In May 2001, Vancouver City Council approved the next phase of the LFG system expansion at an estimated cost of $1,750,000. This phase involves:

- 10 horizontal gas collection wells, each 200 metres long and 150 mm diameter) within Phase 1
- 50 vertical wells, 75 mm diameter casing, 225 mm borehole, in Phase 1 and in an area of the Landfill filled originally in the 1980's and recently recontoured to promoted drainage

A horizontal gas collection system was installed in Phase 1 to allow the collection of LFG in this area prior to closure of Phase 1. Early gas collection minimizes odours, reduces greenhouse gas emissions and provides more LFG for beneficial use. Golder Associates Ltd. provided professional services for design and installation of the system.

The horizontal gas collection laterals were installed within a 2 metre thick layer of woodwaste C&D material installed on top of the third layer of MSW. Approximately three more lifts of MSW will be installed on top of the C&D material prior to achieving the full landfill height in this phase of approximately 35 metres. The C&D material will act as a gas collection layer improving the flow of gas to the horizontal pipe network, and improving drainage within the landfill. Improving drainage within the landfill will reduce the potential for flooding of the gas collection laterals. Due to the low hydraulic conductivity of compacted MSW, flooding of horizontal gas collection pipes could cause of system failure.

Gas system construction occurred over the summer of 2003, and gas from the horizontal laterals will come on line as additional MSW is filled over top of the C&D material. By the end of January 2004, 3 of the 10 lateral wells were operating. The gas flow from these lines equals approximately 900 scfm, of a total approximately 2300 scfm for the entire system.

Future Gas Collection Potential

Given that the Landfill is expected to operate for up to an additional 40 years, LFG will be generated long into the future. Maximum LFG generation is expected to occur at the time of closure of the Landfill in approximately 2040 and is expected to equal up to 6,000 scfm (Conestoga Rovers and Associates, 1999). Increased gas collection will occur incrementally as each phase of the Landfill is completed and closed.

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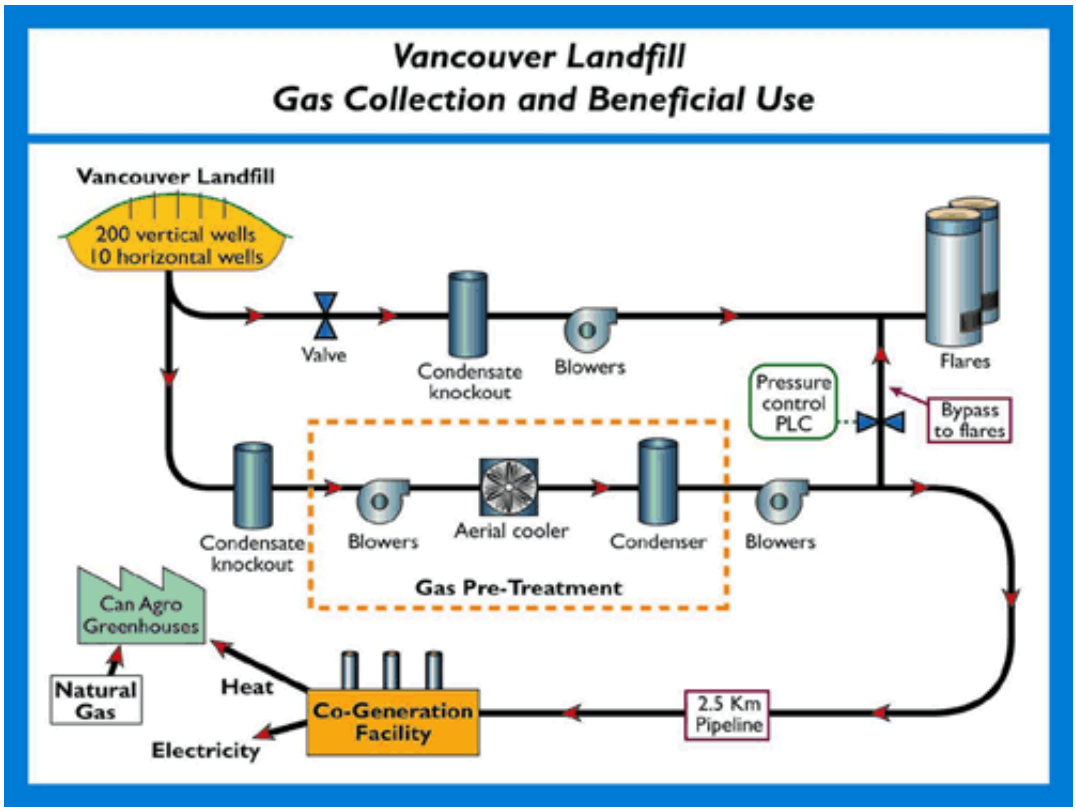
Landfill Gas Beneficial Use

In January 2001, the City issued a request for proposals (RFP) for LFG beneficial use. The RFP outlined the City's desire to find a partner that would finance, design, build and operate a beneficial use facility. The City received a total of 5 proposals for the project with utilization concepts including: drying sea urchin shells for fertilizer, upgrading the gas to pipeline quality for delivery to a local natural gas line, heating greenhouses, direct use in a cement kiln and cogeneration at a neighboring greenhouse. Maxim Power Corporation (Maxim) provided the cogeneration proposal. Maxim's proposal was rated highest, and therefore City staff began negotiations with Maxim.

Maxim's proposal involved:

- an investment of approximately $10,000,000 by Maxim
- construction of compressors and condensate removal systems at the Landfill blower/flare station
- construction of a 2.5 kilometre pipeline from the Landfill to CanAgro's greenhouses south of the Landfill
- construction of a power station including 5.55 MW of generating capacity using three Cat 3532 generators (reciprocating engines)
- use of the hot water from the engines to provide 100,000 GJ per year of heat to CanAgro's greenhouses

A schematic of the system is provided in Figure 2



In January 2003 Maxim and Vancouver signed an agreement regarding the project. The agreement has a 20-year term and Vancouver will receive approximately $400,000 per year in revenues from the project. Vancouver 's revenues will be used to offset the cost of operating the LFG collection system.

Maxim cut the ribbon for the facility on September 10, 2003. By November 2003, the system was operating at full capacity of 2000 scfm at 50% methane. Any LFG that is not utilized by Maxim will continue to be flared until Maxim installs additional electrical generating capacity. CanAgro is also expected to install a new boiler system that will be able to directly combust residual LFG.

Maxim is selling electricity from the project to B.C. Hydro as "green power". B.C. Hydro is paying a premium for the power as part of its initiative to meet 10% of increased demand for electricity through a variety of new green energy sources through 2010 (B.C. Hydro, 2003). Maxim has a contract with B.C. Hydro to install a 4th engine at the facility and will be producing a total of 7.4 MW of electricity by the end of 2004.

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Environmental Benefits

Vancouver 's goals in collecting and combusting landfill gas include odour reduction, landfill gas emission reductions, and energy recovery. Landfills are potentially a significant source of greenhouse gas emissions because methane has a greenhouse gas potential of 21 times carbon dioxide. Collecting and burning LFG significantly reduces greenhouse gas emissions due to the conversion of methane to carbon dioxide. International protocols specify that carbon dioxide generated by landfills or through the combustion of LFG does not need to be counted as a greenhouse gas emission because the carbon dioxide had previously been stored in the plant or animal was from atmospheric sources (EPA, 2002). Therefore, the net increase in carbon dioxide is zero.

Table 1 provides an estimate of the total carbon dioxide emission reductions associated with the Vancouver Landfill gas collection and control system and the Maxim cogeneration facility based on a flow of 2000 scfm of LFG at 50% methane (the current capacity of the beneficial use system). The table uses a baseline condition of venting the LFG.

Table 1: Vancouver Landfill LFG Collection and Beneficial Use Carbon Dioxide Emission Reduction

Activity	**CO2 Equivalent Emission Reduction (tonnes/year)**
LFG Collection and Combustion	200,000
Electrical Generation	27,000
Greenhouse Natural Gas Reduction	5,000
Total	**232,000**

Notes:

- Assume alternative electrical generation method is simple cycle electrical using natural gas (e.g. Burrard Thermal)
- Assume greenhouse alternative fuel is natural gas

As a reference, an automobile produces approximately 5 tonnes/year of CO2 equivalents. Therefore, the net greenhouse gas emission reduction associated with LFG collection and beneficial use at the Vancouver Landfill is equal to the emissions of approximately 45,000 automobiles.

The amount of energy available from the project is equal to approximately 500,000 GJ/year or the energy requirements of 3,000 to 4,000 households.

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[top]

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