SUMMARY REPORT TO MANAGER
For City Council Meeting of June 12, 2006

SUBJECT: LANDFILL - GAS TO ENERGY FEASIBILITY

INITIATED BY: Noel D. Bush, Utilities Director

RESOLUTION SUMMARY: The attached resolution receives and files the report prepared by CTI & Associates on the Gas to Energy Feasibility Study for the City of Midland Landfill.

ITEMS ATTACHED:

1. Letter of transmittal
2. Resolution
3. CTI Report "Gas to Energy Feasibility Study"

CITY COUNCIL ACTION:

1. 3/5 vote required to approve resolution

NDB:jjs

City of Midland

City Hall • 333 West Ellsworth Street • Midland, Michigan 48640-5132 • 989.837.3300 • 989.835.2717 Fax • www.midland-mi.org

June 8, 2006

Honorable Mayor and City Council
City of Midland
Midland, Michigan 48640

LANDFILL GAS TO ENERGY FEASIBILITY STUDY

Dear Councilmen:

The City of Midland owns and operates a municipal sanitary landfill located at 4311 East Ashman Street. The construction and operation of the landfill is regulated by the Michigan Department of Environmental Quality-Waste Management Division. The Landfill site, which accepts waste generated in Midland County, has 72 acres of closed waste cells, and is licensed to operate 78 acres of new fill area. The landfill is currently in compliance with all current state and federal regulations.

For the past 12 months City staff and CTI & Associates of Brighton, Michigan have been investigating the production of methane at the landfill to determine if the landfill will remain compliant with air emission regulations. As the volume of refuse increases at the landfill the methane gas production rate increases as well. The investigation concludes that a sufficient volume of waste will be in place in cells 14 and 15 by early 2008. At that time the landfill will begin to exceed the regulatory emissions limits set by the State and will mandate an upgrade from passive gas collection (a series of wells with flares to destroy the gas) to active collection (a light vacuum to extract the gas to be destroyed).

Faced with the certainty of investing in an active collection system in the future, with an estimated cost of $1,000,000, staff also began to evaluate the feasibility of marketing the methane gas through generating electricity or collecting and selling the gas to the pipeline.

The results of the study found that with increasing costs in both natural gas and electricity, production and marketing of landfill methane gas is now economically feasible.

Attached is a report prepared by CTI on the feasibility of gas to energy at the City of Midland Landfill. Representatives from CTI will be present at this evening's meeting to discuss the findings of the study to Council.

Respectfully submitted,

Noel D. Bush, Utilities Director

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CITY OF
Midland
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BY COUNCILMAN

RESOLVED, that the report prepared by CTI & Associates on the Gas to Energy Feasibility Study for the City of Midland Landfill be received and filed in the office of the City Clerk.

YEAS:

NAYS:

ABSENT:

I, Selina Tisdale, City Clerk, City of Midland, Counties of Bay and Midland, State of Michigan, do hereby certify that the foregoing is a true and correct copy of a resolution adopted by a   yea vote of all the Councilmen present at a regular meeting of the City Council held Monday, June 12, 2006.

Selina Tisdale, City Clerk

File: Water - 060612 Gas to Energy Report.doc

Gas to Energy Feasibility Study

City of Midland Landfill
Midland, Michigan

Prepared for

City of Midland Landfill
4311 East Ashman Road
Midland, Michigan 48642

May 2006

Prepared by

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Project No. 68042026

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1.0 INTRODUCTION

The City of Midland Landfill (CML, Site) has been in operation for more than thirty years. With a current capacity of approximately 10 million Mg, and a total waste placement of 2.5 million Mg, the City would like to explore the feasibility of installation of a gas-to-energy facility. The purpose of this feasibility study is to determine whether installation of an active gas collection and control system and gas-to-energy facility at the City of Midland Landfill would be beneficial for the City. This feasibility study includes background testing information including Tier II testing completed at the facility in 2003, an estimate of current and future NMOC emissions, gas extraction uncertainties due to the Site's past waste placement, gas generation estimates, gas-to-energy options, and recommendations.

Gas extraction estimates are made over a time period beginning in 2008. This timeframe was chosen for two reasons: first, Tier II testing in 2008 may show that the landfill has a regulatory requirement to install an active gas collection and control system, secondly, if the city chooses to install a collection and control system and gas-to-energy facility even though there is no regulatory requirement, 2008 is the earliest that this system could feasibly be operational given time constraints associated with the bidding process and construction.

2.0 BACKGROUND

CML is currently constructed in three separate waste placement areas (refer to figure 2-1). "Area A" located directly west of the main access road contains approximately 1 million cubic yards of waste in place. This area is currently closed and is composed of approximately 90% construction debris and 10% residential waste. Since the amount of residential material is minimal, this area is not considered viable for landfill gas recovery and has not been included in this feasibility study.

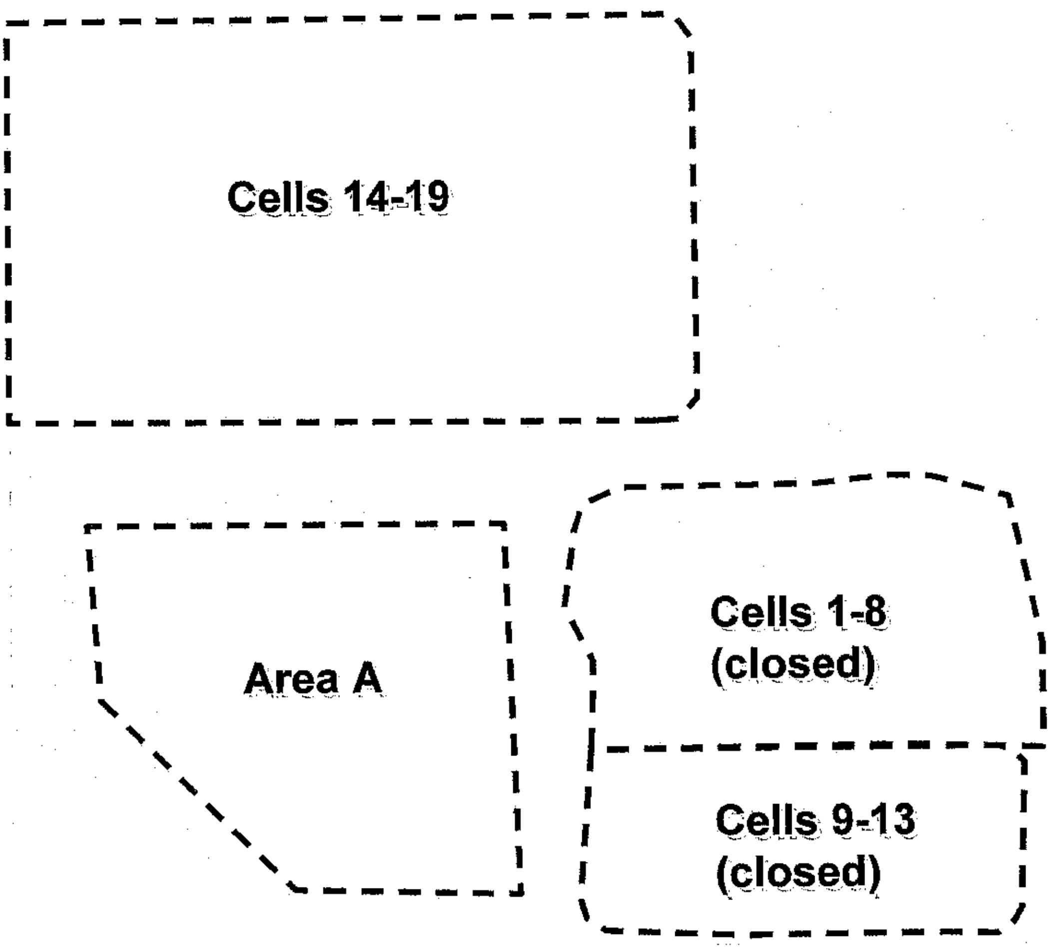

Figure 2-1. Schematic Plan of City of Midland Landfill Showing Waste Placement Areas.

The closed area across from "Area A" on the east side of the main access road is composed of Cells 1-13. Waste was placed in this area from 1975 until 1998 and there is approximately 1.5 million Mg waste in place in this area. This waste is believed to be primarily residential with some construction material. It is believed that gas extraction may be more difficult than in the active cells in this area due to the use of clay daily cover when the cells were open. However, several passive gas vents in this area show high methane quality and solar flares retrofitted on passive gas vents in cells 9-13 burn continuously. This area is considered viable for gas recovery. However, extraction rates will likely be diminished due to past waste placement practices.

Cells 14 and 15 are currently active and accepting waste. Waste was initially placed in Cell 14 starting in 1998 and both cells are composed primarily of residential waste. Cell 14 will be ready for gas well installation starting in 2008 and finishing in 2009. Cell 15 will be ready for gas well installation when in closes in 2010. Future Cells 16-19 are to be located just west of Cells 14 and 15 and also will accept primarily residential waste. A preliminary examination of waste acceptance estimates and cell capacities suggests that Cell 16 will be ready for gas extraction in 2018 and Cell 17 will be ready for gas extraction in 2026.

3.0 WASTE ACCEPTANCE ESTIMATES

For the purposes of modeling landfill gas production rates, waste acceptance on a yearly basis was estimated using historic records, compaction estimates, as well as general knowledge of site conditions. Future acceptance rate were estimated to be approximately 150,000 Mg per year based on past acceptance rates. Table 3-1 summarizes the historical waste acceptance rates used in gas production modeling.

Table 3-1. City of Midland Landfill Waste Acceptance Rates.

Year	Waste Acceptance (Mg)
1975	33,280
1976	66,560
1977	66,560
1978	66,600
1979	66,500
1980	66,600
1981	66,500
1982	66,600
1983	66,600
1984	66,500
1985	66,600
1986	66,650
1987	66,450
1988	66,600
1989	62,910
1990	70,490
1991	66,000
1992	67,000
1993	66,000
1994	67,000
1995	67,000
1996	66,000
1997	67,000
1998	65,380
1999	216,700
2000	188,500
2001	200,500
2002	174,300
2003	203,300

4.0 CURRENT INFRASTRUCTURE

At present, Cells 1-13 at CML have passive gas vents installed and in Cells 9-13 these gas vents are connected to solar flares. Passive gas vents are constructed of 6" diameter PVC pipe and are of varying depths, but include at least 10 feet on solid piping and 10 feet of perforated piping. Twelve passive vents in Cells 1-8 also serve as leachate extraction wells and include leachate pumps. For purposes of this feasibility stidy, all passive gas vents including leachate collection-passive gas vent combination wells that showed adequate gas quality in the 2003 Tier II testing are considered viable for the future gas extraction system.

A "sand blanket" (sand trenches) connects the passive gas vents in Cells 1-8, while perforated piping is used to connect vents in Cells 9-13. It is not likely that the sand trenches or perforated piping would be used in the active gas extraction system.

5.0 TIER II TESTING AND NMOC EMISSIONS ESTIMATES

5.1 Tier II Testing Results

In March of 2003, CML underwent Tier II testing to prove that the annual Non-Methane Organic Compound (NMOC) emissions for the Site were below the 50 Mg/year threshold which would require the landfill to install an active gas collection system pursuant to 40 CFR 60.752. The results of this testing showed that the concentration of NMOC for CML was 179.38 parts per million by volume (ppmv). Since the concentration of NMOC is very low (compared with the generic constant otherwise used in modeling of 4,000 ppmv), the Site has not yet reached 50 Mg/year NMOC emissions rate. Additionally, with such a low NMOC concentration, it is unlikely that this threshold will be reached in the near future, provided that the NMOC concentration does not increase significantly.

In 2008, CML will be required to undergo Tier II testing again. Cells 14 and 15, which were not included in the last test, will be included in the new testing. It is anticipated that the concentration of NMOC will be higher in 2008 with the new test results. The 2003 Tier II testing results appear in Figure 5-1.

Midland Tier II - Field Sampling Data

Sample Name	Liquid Level (bgl)	CH4	CO2	O2	BAL	Well Pressure	Sample Canister#	Pre-Test Tank Pressure	Post-Test Tank Pressure	Sample Time 03/04/03
Center Flare	NA	56.9	39	0	4.2	1.4	N116	-18	-3	14:27
East Flare	NA	56.1	39.2	0	4.2	1.9	N65	-18	-3	14:17
East Flare (Duplicate)	NA	56.1	39.2	0	4.2	1.9	N42	-18	-3	14:05
VDW1	9.95	61.2	35.8	0	0	1.9	N213	-19	-3	12:30
VDW11	20.7	58.3	40.3	0	0.6	6.6	N413	-18	-3	13:03
VDW12	11.85	1.7	2.5	18.4	77.4	0	*NS	*NS	*NS	*NS
VDW2	6.2	56.2	27.7	2.4	14.1	0.2	N86	-18	-3	12:33
VDW3	4.3	61.4	34.5	0	3.1	0	N85	-17.5	-3	12:42
VDW4	5.1	7.1	8.2	16.1	68.5	0	*NS	*NS	*NS	*NS
VDW5	8.4	7.9	15.1	14.7	62.3	0	*NS	*NS	*NS	*NS
VDW6	12.4	63.8	33.8	0	0	1	N337	-19	-4	12:58
VDW7	7	0.2	1	19.2	79.2	0.1	*NS	*NS	*NS	*NS
VDW8	7.2	67.2	35.2	0	0	15.8	N447	-19	-3	2:16
VDW9	5.8	33.8	14	9.9	42.3	0	*NS	*NS	*NS	*NS
VW1	5	3	1.3	19.6	76.1	0	*NS	*NS	*NS	*NS
VW10	16.5	59.3	41.2	0	0	2.4	N317	-20	-4	1:50
VW14	11.3	60	40	0	0	2.6	N401	-17.5	-3	13:44
VW11	5.1	34.1	24	8.3	33.4	0	*NS	*NS	*NS	*NS
VW12	10.17	57.2	38.8	0.3	3.5	2.8	N134	-18	-4	8:45
VW13	17.8	56.3	38.3	0.3	4.9	1.4	N312	-17.5	-3	13:21
VW15	6.8	49.7	32.9	1.9	15.6	0.2	N425	-18	-3	15:20
VW2	7.6	0.1	1.8	20.7	77.3	0.1	*NS	*NS	*NS	*NS
VW3	6.1	0.1	0.1	21	78.7	0	*NS	*NS	*NS	*NS
VW4	3.1	1.6	1.9	20.3	76.2	0	*NS	*NS	*NS	*NS
VW5	3	0.1	0.2	21	78.7	0	*NS	*NS	*NS	*NS
VW6	3.9	0.7	0.6	20.8	77.9	0	*NS	*NS	*NS	*NS
VW7	3.8	0	0.1	20.8	78.9	0	*NS	*NS	*NS	*NS
VW8	2.3	0.1	0.1	20.9	78.9	0	*NS	*NS	*NS	*NS
VW9	4.9	60	40	0	0	1.2	N10	-19	-4	2:48
West Flare	NA	56	39.7	0	4.2	1.4	N339	-18	-3	14:45

NA =Not Applicable
NS = No Sample / Poor Gas quality

Figure 5-1. Midland Tier II Field Sampling Data.

5.2 Future NMOC Emissions Estimates

In order to prepare for future requirements to install an active gas collection and control system, CTI simulated yearly NMOC emissions at different concentrations of NMOC, ranging from 200 ppmv to 600 ppmv. This simulation was completed to determine during what year the 50 Mg of NMOC threshold would be reached and an active gas collection system would become mandatory. Figures 5-2 and 5-3 present the results of this simulation.

	NMOC Emissions (Mg)					
Year	C_{NMOC} = 179 ppmv	C_{NMOC} = 300 ppmv	C_{NMOC} = 400 ppmv	C_{NMOC} = 500 ppmv	C_{NMOC} = 600 ppmv	Limit
2005	15.8	26.6	35.4	44.3	53.1	50.0
2006	16.9	28.4	37.9	47.3	56.8	50.0
2007	18.0	30.1	40.2	50.2	60.3	50.0
2008	19.0	31.8	42.4	53.0	63.6	50.0
2009	19.9	33.4	44.5	55.6	66.8	50.0
2010	20.8	34.9	46.5	58.1	69.8	50.0
2011	21.7	36.3	48.4	60.5	72.6	50.0
2012	22.5	37.7	50.2	62.8	75.4	50.0
2013	23.3	39.0	52.0	65.0	78.0	50.0
2014	24.0	40.2	53.6	67.0	80.4	50.0
2015	24.7	41.4	55.2	69.0	82.8	50.0
2016	25.4	42.5	56.7	70.8	85.0	50.0
2017	26.0	43.6	58.1	72.6	87.1	50.0
2018	26.6	44.6	59.4	74.3	89.1	50.0
2019	27.2	45.5	60.7	75.9	91.0	50.0
2020	27.7	46.4	61.9	77.4	92.9	50.0
2021	28.2	47.3	63.1	78.8	94.6	50.0
2022	28.7	48.1	64.2	80.2	96.3	50.0
2023	29.2	48.9	65.2	81.5	97.8	50.0
2024	29.6	49.7	66.2	82.8	99.3	50.0
2025	30.1	50.4	67.2	84.0	100.7	50.0
2026	30.5	51.1	68.1	85.1	102.1	50.0
2027	30.8	51.7	68.9	86.2	103.4	50.0
2028	31.2	52.3	69.7	87.2	104.6	50.0
2029	31.6	52.9	70.5	88.1	105.8	50.0
2030	31.9	53.4	71.3	89.1	106.9	50.0
2031	32.2	54.0	72.0	89.9	107.9	50.0
2032	32.5	54.5	72.6	90.8	108.9	50.0
2033	32.8	54.9	73.3	91.6	109.9	50.0

Figure 5-2. City of Midland Landfill NMOC Emissions Estimates. Shaded cells indicate time when 50 Mg NMOC threshold will be reached.

The results of this simulation show that at current concentrations, the 50 Mg NMOC limit will not be reached. However, at 300 ppmv, the threshold will be reached in 2025 and at 400 ppmv, the limit will be reached as early as 2012. For any concentrations at or above 500 ppmv, the 50 Mg limit would be exceeded in 2008 when the next Tier II testing is to be performed.

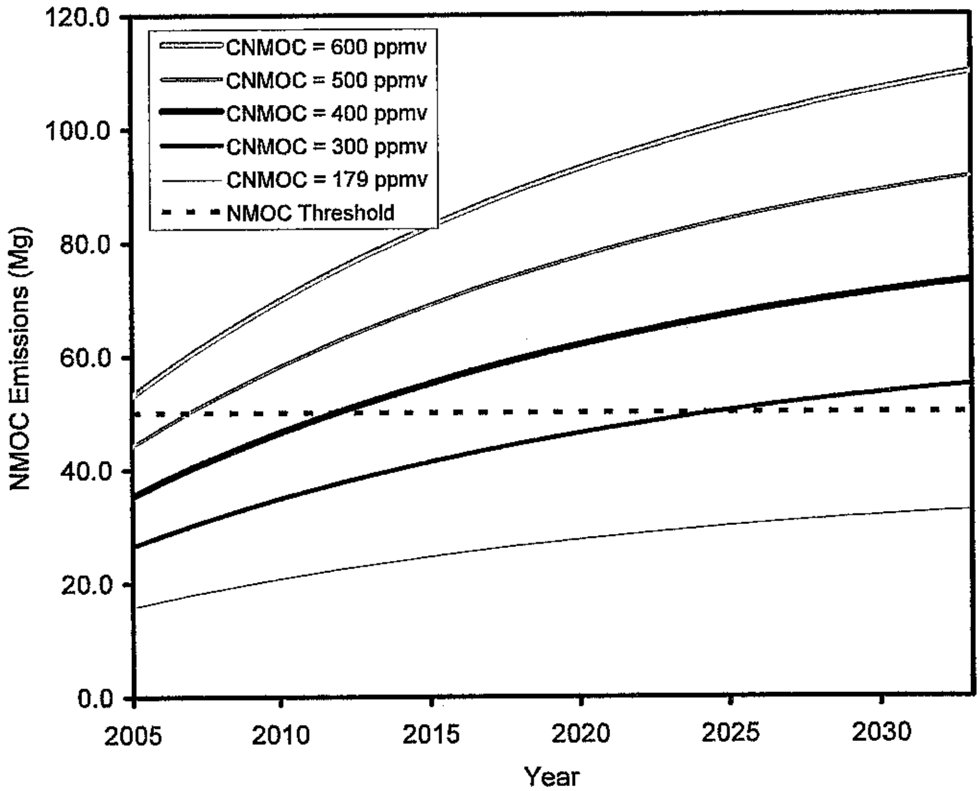

Figure 5-3. City of Midland Landfill NMOC Emissions Estimates.

6.0 GAS EXTRACTION UNCERTAINTIES

Due to waste placement practices, daily cover methods, and dated waste materials, assumptions were made regarding the extraction potential of landfill gas in different areas of the landfill. Typically, the Environmental Protection Agency (EPA) estimates that an efficient gas collection and control system should extract approximately 75% of the gas generated. However, a more conservative approach was taken in this feasibility study and site-specific generation potentials were developed through use of historic information and future estimates.

Tier II testing in Cells 1-13 found poor gas quality or no gas present at some of the passive gas vents along the northern edge of the Cells, primarily in Cells 1 through 6. Additionally, as is discussed in Section 1, clay was typically used as daily cover and "clay lenses" may be present in the waste which may prohibit the collection of gas and contribute to the poor condition of has vents that have watered in. Since information about this area indicates a lower gas collection potential, an extraction rate of 60% is used for all estimates in this area.

Active Cells 14 and 15 as well as future Cells 16 and 17 were assumed to have a collection efficiency of 70%, a number that is more commonly seen in gas extraction systems and was chosen as to not overestimate the extraction potential of CML.

7.0 CONVENTIONAL GAS EXTRACTION ESTIMATES

7.1 Assumptions

For the purposes of modeling gas production at CML, the EPA's LandGEM Version 3.02 was used.

Using the EPA regular assumptions, all conventional landfill cells are assumed to have a potential methane generation capacity (L_0) of 100 m^3/Mg, a methane generation rate (k) of 0.04 $year^{-1}$, a methane content of 50% (EPA assumption), and a NMOC concentration of 179.38 ppmv. However, due to the significant proportion of the waste stream at CML from construction and demolition debris (CDD), the value of L_0 used in the analysis of each cell was reduced to account for the proportion of CDD waste estimated in each cell. Cells 1 through 19 were modeled as conventional cells according to these parameters.

7.2 Gas Generation and Extraction Potential

The LanGEM model estimates gas generation potential as the amount of gas generated on a continual basis. For example, the 2006 gas generation estimate shows the amount of gas that could be collected if there were gas wells located in every area that produced gas. In practice, this is not the case. It is likely that the maximum amount of gas that could be collected would be roughly 75% of the generated gas for an efficient gas collection system. Additionally, the collection of that gas would depend on the gas collection and control system design. The LandGEM model is based on waste acceptance and it assumes that waste is placed and begins generating gas immediately and that gas is available for extraction. While this is the case the infrastructure for gas collection is not always available as soon as the waste is placed. The 2006 waste generation potential assumes that waste in Cell 15 produces gas that can be extracted in 2006. However, given the fact that horizontal collectors are not in place in that cell, the earliest that landfill gas could be collected would be when the cell was close to final grade and vertical wells could be installed. This would not likely be until 2010.

Estimating gas generation and extraction potential on a continual basis is not considered to be truly representative of what CML can expect to extract and use in a gas-to-energy operation. A realistic approach that considers when infrastructure will be placed is a more accurate way of predicting extraction rates.

7.3 Realistic Extraction Schedule

In order to characterize extraction rates that are more realistic, a schedule was created to outline when different sections of the gas control and collection system will be online. This schedule assumes that construction of a collection system in Cells 1 through 13 will begin in 2007 and be online by 2008. Cell 14's extraction system will be placed over the course of two years, 2008 and 2009. Cell 15 will close in 2010 and the entire collection system will be placed in Cell 16 in 2018 and in Cell 17 in 2026. The addition of the remaining cells to the gas extraction network are similarly modeled.

Given this schedule, the availability of gas from each area was determined. Gas from Cells 1 through 13 will be available in 2008. Half of the gas available in Cell 14 can be utilized in 2008 and all gas from this cell will be available in 2009. In 2010 gas from Cell 15 can be assumed to be available. Gas from Cell 16 will be available in 2018 and from Cell 17 in 2026.

At this time, given CML's low NMOC emissions, there is no regulatory requirement to install a gas collection and control system. If a voluntary system is placed, there is no requirement to expand the system at a set time interval. However, should Tier II testing in 2008 demonstrate that CML's emissions have exceeded 50 Mg, a gas collection and control system will be required and the system will have to be expanded to any cells that are closed with waste in place for at least 2 years or active cells with waste in place for 5 years. Given this regulatory constraint, the schedule for future cells may have to be changed so that gas wells are incorporated after five years instead of the seven or eight years proposed above.

7.4 Gas Production Results

With the schedule for well installation described in above, gas production rates were estimated using LandGEM 3.02. Gas production potential was evaluated from 2008 (when the collection system is first brought online). The results of the gas production estimation appear in Figure 7-1. Gas production estimates trend upward through the completion of Cell 19, after which time the gas production rate begins to decay. Thus, the maximum estimated production rate for conventional landfill operations is approximately 1,200 standard cubic feet per minute (scfm), realized in 2045.

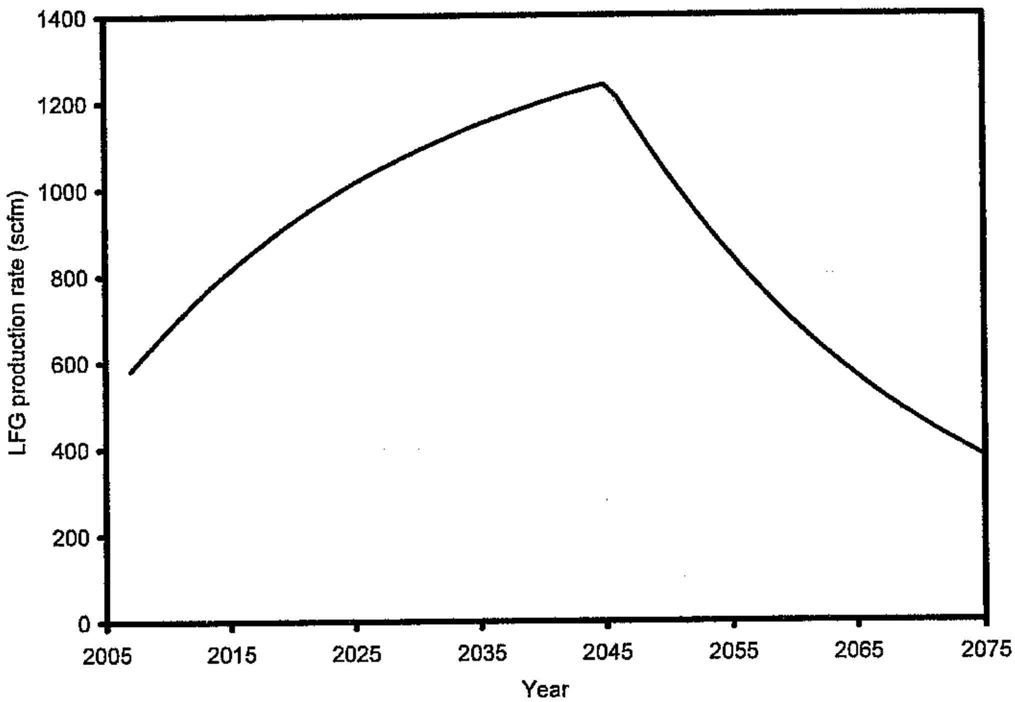

Figure 7-1. Gas Production Results for Conventional Landfill Operation.

8.0 ENHANCED LEACHATE RECIRCULATION CELLS

While Cells 1 through 15 must be operated as conventional cells, CML may wish to consider operation of Cells 16 through 19 in the future as enhanced leachate recirculation cells or, preferably, bioreactor cells. Gas production in enhanced cells is vastly increased and occurs over a shorter time period than in conventional cells. Modeling was done to show the difference in gas production rates between operation of these cells as conventional cells versus enhanced cells. Results of this modeling appears in Figure 8-1.

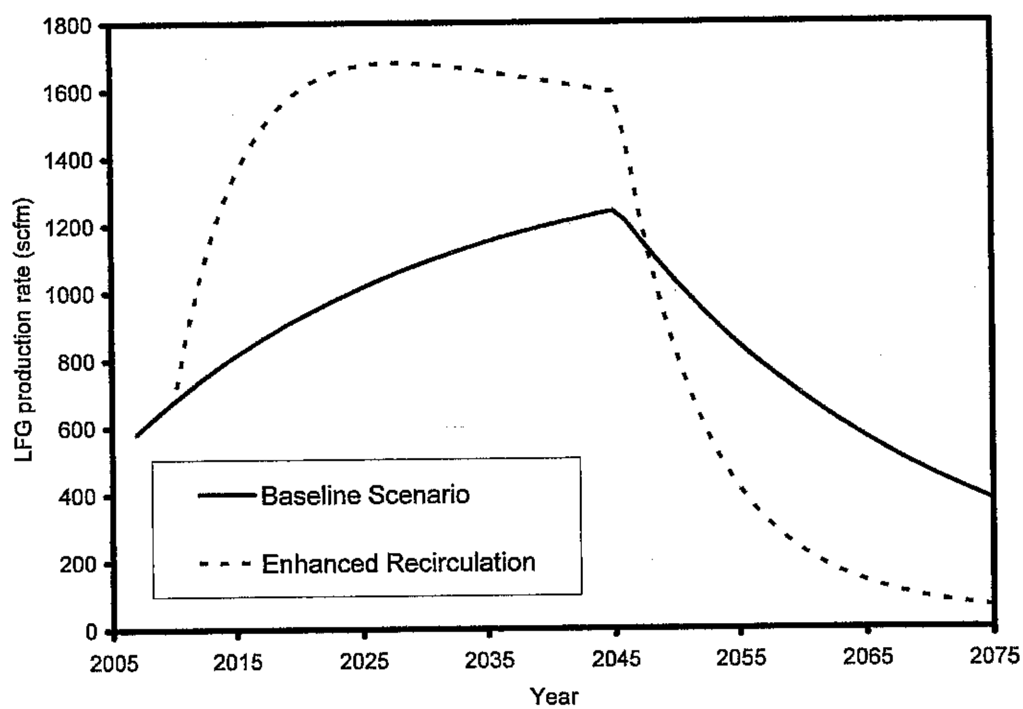

Figure 8-1. Gas Production Results for Enhanced Leachate Recirculation Operation Versus Conventional Landfill Operation (Baseline Scenario).

8.1 Assumptions

For the purposes of modeling gas production from CML, the EPA's LandGEM Version 3.02 was used.

All conventional landfill cells (Cells 1 through 15) were assumed to have a methane potential generation capacity (L_0), a methane generation rate (k) and a NMOC concentration according to the discussion in the previous section. Cells 16 through 19 were modeled as enhanced recirculation cells with a L_0 = 100 m^3/Mg for the municipal solid waste (MSW) portion of the waste, as done previously. In contrast to the conventional cell models, the enhanced recirculation cells are modeled with a k = 0.24 $year^{-1}$ to account for the faster gas generation rate anticipated for these cells. This rate was chosen based on research on bioreactor cells in Michigan that indicated a methane generation rate six times greater than conventional cells.

The same schedule for bringing wells online was used for Cells 1 through 15 as in the conventional gas production estimate. However, for Cells 16 through 19, the wells are assumed to be online when the cell begins receiving waste. This assumption is made since the recommended practice for enhanced leachate recirculation cells is to install a gas collection system prior to enhanced operation. Furthermore, prior installation of a gas collection and control system is required for bioreactor operation. This requirement is typically achieved using horizontal gas collection wells that can be updated as more waste is filled.

8.2 Gas Production Estimate

As evidenced by the two different curves in Figure 8-1, there is a significant difference in gas production rates between the conventional and bioreactor models. A peak gas production rate of 1,700 scfm is estimated for the enhanced condition. Accordingly, the gas production potential of the waste is realized much sooner and a corresponding sharp decrease in production rate is estimated following the completion of Cell 19 waste filling.

The practical implication of these estimates is that gas can be more efficiently recovered under the enhanced recirculation scenario since the year-to-year production rate is much greater during the timeframe when gas can be economically recovered. Therefore, the revenue potential of the gas produced by the waste can be more fully realized under this scenario.

To fully explore the efficacy of improved landfill operations on gas recovery, a third scenario was also generated. Under this scenario, the construction and demolition debris (CDD) waste is segregated from the incoming waste stream and diverted to a dedicated Type-III cell. Therefore, the MSW content and correspondingly, the methane generation potential, of the waste in Cells 16 through 19 is increased. Furthermore, since the overall waste volume entering Cells 16 through 19 is reduced by removing the CDD, the length of time required to fill these Cells (the "Site life") is increased. Figure 8-2 shows the results of the gas production modeling under these conditions. Under this scenario, the same increased rate of gas production realized under the enhanced operation is seen as well as an increase in the useful duration of gas production. This scenario represents a significant improvement in the gas extraction potential over the conventional scenario.

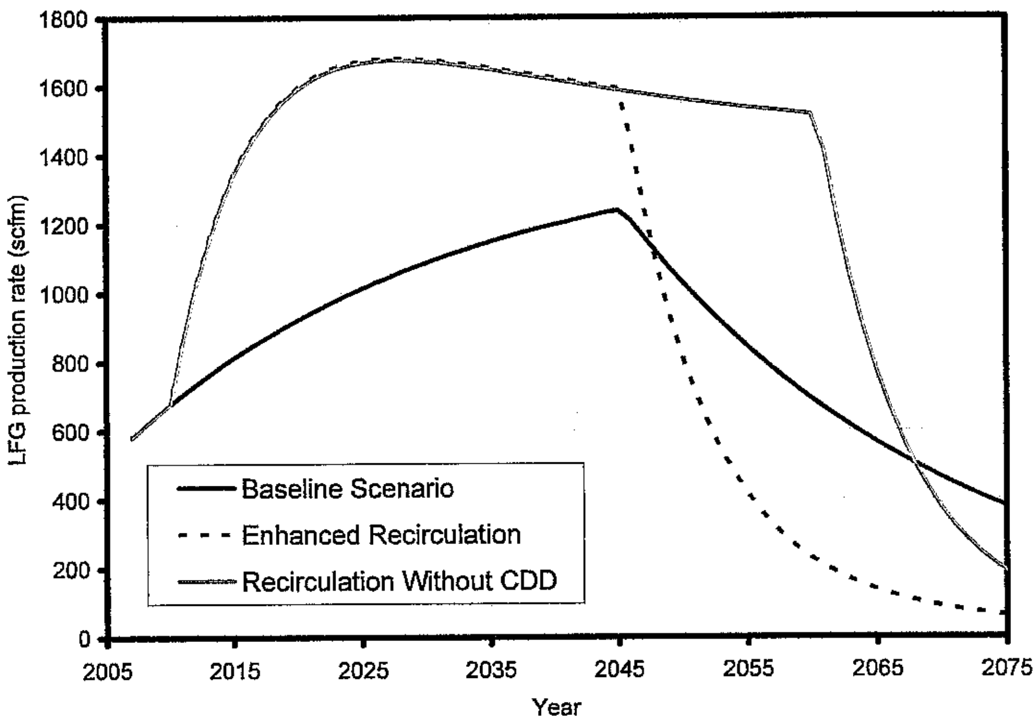

Figure 8-2. Gas Production Results for Enhanced Leachate Recirculation Operation, Enhanced Leachate Recirculation Without Commingled CDD Waste, and Conventional Landfill Operation (Baseline Scenario).

9.0 GAS-TO-ENERGY OPTIONS

The primary gas-to-energy options considered for this feasibility study include purifying landfill gas to compressed natural gas and electricity production using internal combustion engines. These options have been chosen as they are the most widely practiced in the industry.

9.1 Compressed Natural Gas

Landfill gas is composed of approximately 50% methane by volume. Approximately 70% of this methane can be converted to compressed natural gas. Upgrade of landfill gas to high BTU gas requires treatment to remove the carbon dioxide and other impurities.

If a pipeline carrying medium to high BTU natural gas travels near the landfill, pipeline injection may be an attractive option. However, conversion of landfill gas to natural gas can be an inefficient process and gas quality is a major concern because the gas must meet certain specifications before it can be introduced to the pipeline.

The City of Midland Landfill also has the option to send the natural gas to other City structures or sell the gas to other end users.

9.2 Electricity Production Using Internal Combustion Engines

One option for gas-to-energy production is using landfill gas to generate electricity for on-site use or for distribution to the local electric power grid.

Two types of engines are used in the generation of electricity from landfill gas. These include gas turbines and internal combustion engines. Since there is a large volume of gas required for gas turbines and they run on a continual basis, these engines are typically used only at larger landfills with maximum gas production potential. Internal combustion engines, however, are suitable for smaller landfills such as CML.

Internal combustion engines are stationary engines that can use medium-BTU landfill gas to generate electricity. These units are commonly used at landfills because of their ability to be turned on and off depending on the electricity need, and their ability to operate under poor BTU gas conditions. Electricity generated by this method could be sold to the City's grid system, used by the City in its structures, or sold to other end users.

9.3 Other Gas-to-Energy Options

Alternate options can be considered for the use of landfill gas from CML. One of the most promising options for the landfill may be landfill gas direct use for industrial boilers. Other options that can be considered include heating a greenhouse or generating electricity using fuel cells.

10.0 ECONOMIC AND OTHER CONSIDERATIONS

10.1 Existing Infrastructure and Capital Investment Needs

At the current time, CML has no regulatory requirement to install an active gas collection system. While CML has some existing infrastructure for gas collection, considerable capital investment would be required in order to install and operate an efficient gas collection and control system.

As discussed in previous sections, CML currently has passive gas vents installed in Cells 1 through 13. These vents are designed in such a manner as to be used as active collection wells in the future and fit the specifications required under federal law as far as materials and design are concerned. However, Tier II testing in March of 2003 revealed that 14 of the 30 sampling wells had poor gas quality and could not be adequately sampled. These findings suggest that these wells may have to be replaced if they are found to not be functional.

Additionally, sand trenches and/or perforated piping used to connect gas vents may have to be removed to ensure that the system functions as designed. While sand trenching provides a medium for gas flow between the gas collection wells, the addition of vacuum to the system may allow oxygen to infiltrate into the trenches and enter the collection system. If this condition proves to be a problem, the trenches may have to either be filled or the cap reinforced to eliminate air infiltration.

In addition to upgrades to existing infrastructure, new gas extraction wells will be required for Cells 14 through 19. A complete active gas collection and control system also includes and flare and blower, headers and associated piping to each well, and other appurtenances to the gas system.

Costs for the gas-to-energy component of the active gas system will depend on the gas-to-energy project developed. For the high BTU option, this equipment includes compressors, purification equipment, and a pipeline connection for injection. For the electricity generation option, equipment includes limited purification equipment, generators, and electrical equipment. Fully developed estimates of the capital costs associated with the gas-to-energy project are to be developed in the follow up economic analysis to this feasibility study.

10.2 Cash Flow

The capital cost to the City will vary significantly depending on whether the City chooses to finance the project alone, hire a third party developer to finance the project, or share the investment. In many cases, third party developers will design and construct the project and then pay the City a royalty based on the sale of the gas by the third party developer.

Some considerations that should be made regarding the estimate of possible revenue to the City include fluctuations in market electricity and natural gas prices; uncertainty in attainable prices from potential buyers; and operating and maintenance costs. Fully developed estimates of the cash flows associated with potential gas-to-energy projects are to be developed in the follow up economic analysis to this feasibility study.

10.3 Other Considerations

Considerations other than revenue should be made when assessing which gas-to-energy option may be more beneficial to the City. One thing that should be considered is if there is a need for additional power at the Site or in the surrounding City. If the need for additional power exists, considerations of localized demand and power company cooperation must also be considered prior to negotiations for sale. If the need for additional power to the electric grid or additional gas to the natural gas pipeline does not exist, then direct use of landfill gas to supplement boiler fuel may be more beneficial to the City.

Another consideration may be which gas-to-energy option is the most environmentally conscious. For example, some internal combustion engines produce large amounts of secondary pollutants. While the control of landfill gas is typically environmentally beneficial, some technologies may reduce the amount of benefit that is gained due to secondary pollution concerns.

Regulatory concerns should always be considered as well. A question that should be asked is how will the operation of a gas-to-energy system affect the permits and regulatory requirements of the existing landfill. For example, if a gas-to-energy facility is built at the Site, the existing renewable operating permit will have to be modified to incorporate a new emissions unit for a gas-to-energy facility.

11.0 CONCLUSIONS AND RECOMMENDATIONS

11.1 Conclusions

At the current time there is no regulatory obligation for CML to install an active gas collection and control system. CML can voluntarily install a gas collection and control system for the purposes of controlling landfill gas or for use in a gas-to-energy facility. As is outlined in this report, gas extraction will likely be more difficult in some areas due to the type of waste, the age of waste, and the placement practices at the time of waste burial. The results of the last Tier II test showed that test area where gas was present has good gas quality, and the continuous burning of non-assisted solar flares in Cells 9 through 13 indicates the presences of combustible gas.

Gas extraction rates will vary considerably depending on whether the City chooses to operate the future landfill cells in a conventional manner or under an enhanced leachate recirculation plan. The amount of gas that is extracted is directly proportional to the amount of gas that can sold for revenue. Determining future operation of these cells should be done so that the true potential for gas extraction can be realized before a gas-to-energy option is chosen.

11.2 Recommendations

The price for which either natural gas or electricity can be sold will vary greatly depending on the local need for each resource. Contacting local natural gas and electricity suppliers to discuss demand and facilitate pre-negotiations for gas or electricity sales will be beneficial to the City and may be an important step to determine whether a gas-to-energy project will be viable. If the demand for these energy resources does not exist in the City, the need at the Site should be assessed. CML could use the landfill gas to produce electricity and use the electricity to power the Site itself. This option will benefit the City by reducing electricity costs. Fully developed estimates of the cash flows associated with potential gas-to-energy projects are to be developed in the follow up economic analysis to this feasibility study. The results of this analysis will serve to guide the ultimate decision on the type of energy project to pursue.

This study has shown the beneficial effect of enhanced leachate recirculation on gas generation rates. The resulting increase in gas generation rate allows for more of the waste gas generation potential to be realized as economically viable gas. Therefore, the City should consider developing an enhanced leachate recirculation plan, or, preferably, a bioreactor, which offers superior performance over conventional landfill operations.

Finally, this study has shown the beneficial effect of separating CDD waste from the waste stream entering Cells 14 through 19 in terms of economically viable gas production. Furthermore, a dedicated CDD cell would less expensive to construct and operate, conserving space in the relatively expensive Cells 14 through 19 for more effective disposal of MSW. Therefore, the City should consider developing a CDD landfill cell at CML.