REPORT OF THE PUMP TEST AND PRE-FEASIBILITY STUDY FOR LANDFILL GAS RECOVERY AND UTILIZATION AT THE DEONAR LANDFILL MUMBAI, INDIA

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

EXECUTIVE SUMMARY

This Preliminary-Feasibility Study Report addresses the potential implementation of a landfill gas (LFG) collection, control and utilization project at the Deonar Landfill located in Mumbai, India. The U.S. EPA's Landfill Methane Outreach Program (LMOP) has commissioned this report for the Greater Mumbai Municipal Corporation.

For this evaluation, the project was assumed to consist of the installation of a landfill gas collection system to extract LFG to fuel a power plant using internal combustion engine generators. The project also would involve flaring any unused LFG. An alternative non-utilization project scenario also was evaluated in which all collected LFG would be flared. Revenues for the project would be generated from the sale of credits for the reduction of greenhouse gas emissions and (in the case of the power plant project) from energy sales (exporting power to the grid or selling LFG to end users). The emission reductions are created by the combustion of methane, which makes up approximately 50 percent of LFG. Methane has a global warming potential about 21 times that of carbon dioxide (CO_2).

As part of this investigation, a pump test was conducted at the Deonar Landfill. This test has provided additional information regarding the available LFG volume and quality at the landfill, along with other physical information such as buried waste characteristics and leachate levels within the waste mass. The results of the test indicated that the initial LFG recovery projections prepared via mathematical modeling do not require an adjustment.

The following is a summary of the relevant project information:

- The Deonar Landfill has been used historically as a disposal site for the City of Mumbai, India. The site is owned and operated by the Greater Mumbai Municipal Corporation, began receiving waste in 1927, has about 10 million tonnes of waste in place currently, and is projected to stop receiving organic wastes and partially close in 2010 after receiving approximately 12.7 million tonnes of municipal solid waste (MSW).

- The site currently comprises a total of about 120 hectares area used for waste disposal, with depths ranging from about three to 22 meters. The Greater Mumbai Municipal Corporation reports plans for closing approximately 69 hectares of disposal area in the near future. Waste from these areas will be excavated and transferred to the remaining 51 hectare area to achieve a final (2010) average depth of about 40 to 45 meters.

- The landfill does not have an existing active landfill gas collection and control system or passive gas vents.

- Historical records of waste disposal were not available. Historical waste disposal was estimated based on reported amount waste in place in 2005 and reported disposal rates for recent years. Future waste disposal was estimated based on the projected closure year (2010), estimated current disposal rates, and an assumed schedule for developing organic waste processing (composting) facility capacity between 2008 and 2010.

- Gas recovery projections:

  - Projected gas recovery in 2009 after the completion of the gas collection and control system is estimated to be approximately 3,616 cubic meters per hour (2,128 cubic feet per minute) under a mid-range estimate. The LFG recovery rate is expected to increase to 3,831 cubic meters per hour (2,255 cubic feet per minute) in 2010, and decline rapidly thereafter, reaching 1,200 cubic meters per hour (706 cubic feet per minute) in 2015 and 625 cubic meters per hour (368 cubic feet per minute) in 2020.

- Power plant sizing:

  - Assuming start-up of a power plant in January 2009, sufficient gas is estimated to be available to support a 1.64 MW power plant (consisting of two I.C. engines). Due to declining gas recovery, only one 820 kW engine can be supported after 2016.

- Flaring only project:

  - Assuming start-up of a flaring only project in January 2009, sufficient gas is estimated to be available to combust a maximum of approximately 68.5 mmBtus per hour in 2010.

- Projection of methane emissions reduction:

  - A project to capture and combust LFG generated at the landfill would generate direct CO_2 equivalent (CO_2e) emission reductions totaling approximately 1,352,060 tonnes for the period 2009 through 2022, through reduction of landfill methane emissions.

  - An LFG Energy (LFGE) project at the landfill would result in an estimated additional 93,881 tonnes of indirect CO_2e emission reductions for the period 2009 through 2022 by displacing electricity produced via other sources.

No industrial facilities were identified in the vicinity of the landfill which could serve as potential end-users of collected LFG.

The project economics were analyzed for the 2008 - 2022 period under different scenarios, including 2008 equity investment percentage (25 or 100 percent), project type (power generation with flaring of excess gas or flaring of all collected gas), project duration, and emission reduction pricing ($8 or $10/tonne of CO_2e). A power sales price of $0.058/kWh was assumed for the LFGE project; this price is estimated based on the most recent data on wholesale tariff rates set by the Maharashtra Electricity Regulatory Commission for the Maharashtra State Power Generation Company Limited (MSPGCL).[1] Emission reduction sales prices of $8 and $10 per

[1] Source: Maharashtra Electricity Regulatory Commission, MERC Multiple Year Tariff Order for MSPGCL for Fiscal Year 2007-08 to Fiscal Year 2009-10.

tonne of CO_2-equivalent methane reduced by the project were used in the economic analysis of both the LFGE and the flaring only projects; these emission reduction sales prices are based on recent trends in emission reduction pricing.

The results of the analysis indicate that the economic feasibility of either an LFGE or a flaring project appears favorable enough to likely attract developers/investors under scenarios evaluated for emission reduction price, duration of emission reduction revenues, and project financing.

A summary of economic indicators is presented in Table ES-1 below.

TABLE ES-1: SUMMARY OF ECONOMIC EVALUATION

	Period Emission Reduction Revenues are Received[1]	Emission Reduction Price ($/tonne)	Equity Investments (%)	Net Present Value (x1,000 $)	Internal Rate of Return (%)
Power Plant	2009 - 2012	8	100	$151	15.2%
	2009 - 2012	10	100	$869	21.4%
	2009 - 2012	8	25	$673	57.7%
	2009 - 2012	10	25	$1,390	90.4%
	2009 - 2018	8	100	$1,118	21.3%
	2009 - 2018	10	100	$2,167	28.3%
	2009 - 2018	8	25	$1,639	66.0%
	2009 - 2018	10	25	$2,689	95.4%
Flaring Only	2009 - 2012	8	100	$144	17.1%
	2009 - 2012	10	100	$920	33.0%
	2009 - 2012	8	25	$291	41.4%
	2009 - 2012	10	25	$1,067	100.6%
	2009 - 2018	8	100	$698	25.0%
	2009 - 2018	10	100	$1,703	39.6%
	2009 - 2018	8	25	$973	99.0%
	2009 - 2018	10	25	$1,977	152.0%

- Project duration is 2008 – 2022 under the power plant scenario regardless of duration of receipt of revenues from emission reductions. For the flaring only project, project duration is from 2008 until revenues from emission reductions end.

SECTION 1.0
INTRODUCTION

EPA's Landfill Methane Outreach Program (LMOP) is pleased to present this Preliminary-Feasibility Study Report for the implementation of a LFG collection, control and utilization project at the Deonar Landfill in Mumbai, India. This pre-feasibility study has been prepared by SCS Engineers (SCS) and LMOP (Project Team) as part of the EPA's Methane-to-Markets Program, an international initiative to help partner countries reduce global methane emissions. The Deonar Landfill was identified as a candidate for a LFG capture and utilization project for a number of reasons, including:

- Landfill size (volume), depth of fill, and future capacity.
- The continued filling and remaining capacity of the landfill would be expected to result in an increase in LFG supply until organic waste disposal ceases.
- The use of LFG as a fuel for a project at the landfill would result in a net reduction of carbon emissions directly from the combustion of methane, and perhaps also indirectly from the displacement of other carbon fuels.

1.1 OBJECTIVES AND APPROACH

The objectives of this evaluation are as follows:

- Assess the technical and economic feasibility of the development of an LFG control and utilization project at the landfill.
- To quantify the potential greenhouse gas (GHG) emission reduction from implementing a project.
- To provide the Greater Mumbai Municipal Corporation with a tool to assist potential project developers in making informed decisions regarding additional investigations or moving forward with a project at the landfill.

The approach taken for this study is as follows:

- Reviewing site conditions and available background information, including waste quantities and composition, landfill type and configuration, and meteorological data.
- Installing three test extraction wells and monitoring probes for pump testing; conducting the pump test and evaluating the results. The pump test was conducted from late May through early July 2007.
- Estimating the LFG recovery potential from the landfill using computer modeling based on available information, pump test results, and engineering experience at similar landfills.

- Quantifying the potential for on-site electricity generation using LFG as a fuel, or for selling LFG to off-site industrial facilities.

- Estimating the required elements for the gas collection and utilization system (number and depth of wells, piping sizes and lengths, flare capacities, etc.) for the purpose of evaluating the capital and operational costs required for implementing gas collection and flaring at the landfill.

- Estimating the capital and operational costs of implementing an energy recovery project,.

- Evaluating the project economics by quantifying capital and operational costs and sources of revenues, and calculating the net present value and internal rate of return.

1.2 LANDFILL GAS UTILIZATION BACKGROUND

Landfills produce LFG as organic materials decompose under anaerobic (without oxygen) conditions. LFG is composed of approximately equal parts methane and carbon dioxide, with trace concentrations of volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and other constituents. Both of the two primary constituents of LFG (methane and carbon dioxide) are considered to be greenhouse gases (GHG) which contribute to global warming, although the Intergovernmental Panel on Climate Change (IPCC) does not consider the carbon dioxide specifically present in raw LFG to be a GHG (it is considered to be “biogenic”, and therefore a natural part of the carbon cycle).

Methane present in raw LFG is, however, considered to be a GHG. In fact, methane is a much more potent GHG than carbon dioxide, with a global warming potential of approximately 21 times that of CO_2. Therefore, the capture and combustion of methane (transforming it to carbon dioxide and water) in an LFG flare, an engine generator or other device, results in a substantial net reduction of GHG emissions. Additional benefits beyond GHG emission reductions include the potential for improvement in local air quality through the destruction of HAPs and VOCs through LFG combustion.

LFG can leave a landfill by two natural pathways: by migration into the adjacent subsurface and by venting through the landfill cover system. In both cases, without capture and control the LFG (and methane) will ultimately reach the atmosphere. The volume and rate of methane emission from a landfill is a function of the total quantity of organic material buried in the landfill and its age and moisture content, compaction techniques, temperature, and waste type and particle size. While the methane emission rate will decrease after a landfill is closed (as the organic fraction is depleted), a landfill will typically continue to emit methane for many (20 or more) years after its closure.

A common means for controlling LFG emissions is to install an LFG collection and control system. LFG control systems are typically equipped with a combustion (or other treatment) device designed to destroy methane, VOCs, and HAPs prior to their emission to the atmosphere.

Good quality LFG (high methane content with low oxygen and nitrogen levels) can be utilized as a fuel to offset the use of conventional fossil fuels or other fuel types. The heating value typically ranges from 400 to 600 Btus (British thermal units) per standard cubic foot (scf), which is approximately one half the heating value of natural gas. Existing and potential uses of LFG generally fall into one of the following categories: electrical generation, direct use for heating/boiler fuel (medium-Btu), upgrade to high Btu gas, and other uses such as vehicle fuel. This study focuses on evaluation of a potential electrical generation project and a direct use project.

1.3 PROJECT LIMITATIONS

During this evaluation, the Project Team relied upon information provided and various assumptions in completing the LFG recovery modeling and economic evaluation. Judgments and analysis are based upon this information and the Project Team's experience with LFG collection and utilization systems. Specific limitations include:

- LFG production estimates are based on a desktop analysis and visual observation of the landfill and its operations.

- Because the landfill does not currently have an LFG recovery system, the economic analysis uses typical capital and operating cost data for similar systems rather than project specific information.

- The LFG recovery projections have been prepared in accordance with the care and skill generally exercised by reputable LFG professionals, under similar circumstances, in this or similar localities. No other warranty, express or implied, is made as to the professional opinions presented herein. Changes in the landfill property use and conditions (for example, variations in rainfall, water levels, landfill operations, final cover systems, or other factors) may affect future gas recovery at the landfill. LMOP does not guarantee the quantity or quality of available LFG.

- Assumptions were made in this pre-feasibility study regarding the future availability and accessibility of areas of the landfill for installing a gas collection system, based on information available at the time this study was conducted. These assumptions were made in the absence of specific information regarding the dates that various portions of the landfill will become accessible for wellfield development, and the age of the waste in each area. Because the assumptions were used to estimate a schedule for collection system build-out and coverage of the LFG generating refuse mass, they have significant impacts on projected future LFG recovery and resulting estimates of project feasibility.

- Although a pump test helps reduce the uncertainties of predicting LFG recovery, it also has limitations. First, the pump test is conducted on only a limited area of the landfill and the results are assumed to apply to the entire site. Secondly, pump tests can only indicate the quantity of LFG during the period of the field test and don't provide any indication of future gas resources.

- This modeling work has been conducted exclusively for the use of the Greater Mumbai Municipal Corporation for this Pre-Feasibility Study. No other party, known or unknown to LMOP or SCS Engineers is intended as a beneficiary of this report or the information it contains. Third parties use this report at their own risk. LMOP and SCS Engineers assume no responsibility for the accuracy of information obtained from, or provided by, third-party sources.

- This report was developed using assumptions regarding future plans for excavating portions of the landfill site, disposing of waste on top of remaining portions of the site, and developing organic waste processing and composting capacity, from information provided by the Greater Mumbai Municipal Corporation. This report does not include a detailed evaluation of the impacts of these activities on LFG generation and recovery, the likelihood that the assumed e schedule for site development can be achieved, or the impacts of variations in the project schedule on LFG generation and recovery.

SECTION 2.0

PROJECT BACKGROUND INFORMATION

2.1 LANDFILL BACKGROUND

The Deonar Landfill is located in Mumbai, India, a coastal city in the western region of India with a population of approximately 13 million people. The climate in the region is tropical and wet. The region experiences a humid season from March through October and a dry season from November through February. Annual average temperature is 27 degrees C (81 degrees F), and annual average precipitation is 2,130 millimeters (84 inches).[2]

The landfill is an unlined historical dump site which is owned and operated by the City of Mumbai. The site opened in 1927 and is expected to remain in operation for approximately another 30 years; however, by Indian law the landfill will be required to receive only inert wastes after an organic waste processing and composting facility is built and begins operation. The composting facility will be constructed in modules over the next few years during which disposal in the landfill will decline. Organic waste disposal is expected to end by mid-2010, and the landfill will receive inorganic waste only, including approximately 500 tonnes per day of processing rejects from the composting facility (25 percent of 2,000 tonnes per day delivered to the facility).

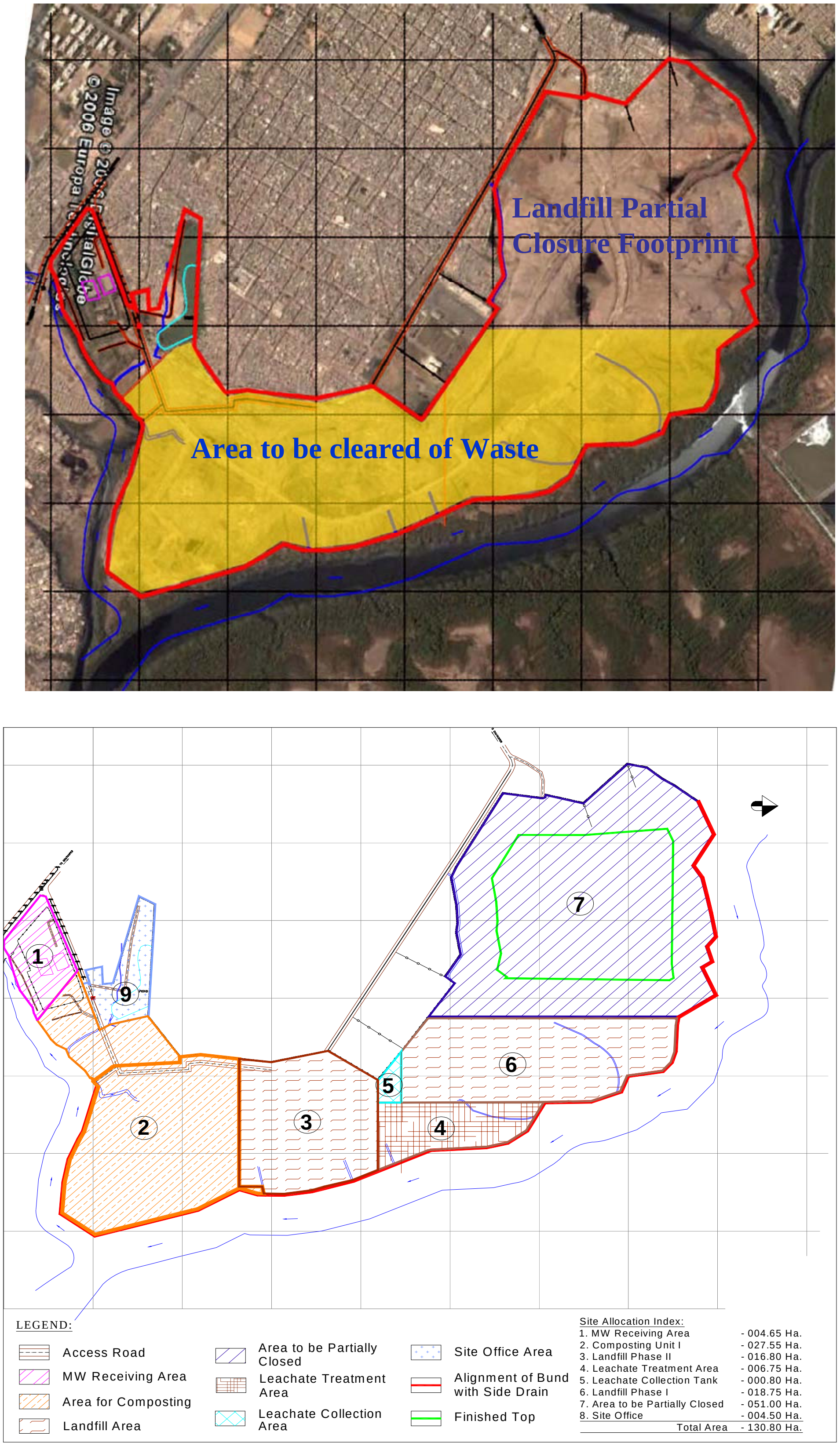
<u>Landfill Physical Characteristics</u>

The existing landfill property covers a total of 131 hectares, of which approximately 120 hectares have been used for waste disposal. The landfill is currently in the process of removing wastes from approximately 69 hectares in the southern and eastern portion of the site and depositing it in a 51 hectare area in the northwest portion of the site. This will create space within the site boundary for developing composting areas, leachate treatment areas, and future waste disposal areas. The 69 hectare area to be excavated contains wastes deposited approximately 20 to 80 years ago. The 51 hectare disposal area, which contains wastes disposed over the past 20 years, will be partially closed by 2010. Figure 2-1 on the following page includes an aerial photograph showing the 69 hectare area to be excavated and the 51 hectare area to receive the excavated waste and the site management plan proposed by the City of Mumbai.

The current waste disposal areas range in depth from a few meters up to approximately 22 m. Currently, the 51 hectare area is approximately 15 to 22 meters deep. When the transfer of wastes from the 69 hectare disposal area is complete, the 51 hectare area is projected to have waste depths of approximately 40 to 45 m. Most of the existing landfill surface is flat or gently sloping, which tends to cause leachate to accumulate during heavy rains. Ponding of surface waters is evident in low lying areas as indicated in the aerial photograph on the following page. Leachate collection does not occur at the site.

[2] Source: www.worldclimate.com

Figure 2-1. Site Management Plan – Deonar Landfill



The site does not apply cover soils except during the months of March through May when large quantities of silt (approximately 4,000 tonnes per day) are deposited in select areas on the landfill surface (see Figure 2-2 below). The source of the silt is the city's drainage ditches and canals, which are cleared in the Spring in anticipation of the summer monsoon rains.

Figure 2-2. Silt Deposits at Deonar Landfill

Waste is compacted using a bulldozers, which reportedly achieve an in-place density of approximately 900 to 1,000 kg per cubic meter.

There is a large group of waste pickers operating in the active disposal area (see Figure 2-3 below). Although the waste pickers are controlled by the landfill operators during the day, security of LFG extraction equipment could be an issue, especially at night, because there is no security fencing around the site.

Figure 2-3. Active Disposal Area Showing Waste Pickers

2.2 WASTE DISPOSAL RATES

Historical records of waste disposal rates are not available for the Deonar Landfill. There is a truck scale at the entrance but it does not appear to be actively used to record incoming truck weights. Historical and future waste disposal estimates were developed using the following information provided by the Greater Mumbai Municipal Corporation and their consultant, Jineshwar-Gravit-JV :

- The site has been operated as a historical dump site since 1927.
- The landfill had 7.88 million tonnes in place as of mid-2005, based on a survey of existing topography.
- The landfill has a reported in-place waste density of 900 – 1,000 kg per cubic meter.
- Average waste disposal increased from approximately 2,000 tonnes per day in 2005 to approximately 3,000 tonnes per day in 2006.

- The site currently is accepting an average of approximately 3,000 to 4,000 tonnes per day of waste. During the months of March, April, and May, approximately 4,000 tonnes per day (360,000 tonnes per year) of silt is disposed.
- In 2008, the transfer of wastes from 69 hectares of the landfill to the remaining 51 hectare area will be completed and a composting facility will be constructed. The composting facility will be constructed in four modules, each with a 500 tonne per day capacity.
- Starting in 2009, the composting facility will go on line and waste disposal in the landfill (excluding seasonal silt and composting facility rejects) will be reduced to an average of 2,000 tonnes per day in 2009.
- During the first half of 2010, the landfill will receive an average of 500 tonnes per day (excluding seasonal silt and composting facility rejects). Starting on July 1, 2010 the landfill will stop receiving organic wastes and only receive silt and inorganic rejects from composting facility.

Disposal estimates for wastes excluding seasonal silt deposits and composting facility rejects were developed for the period of 1970 – 2010. Based on estimated waste composition and decay rates for the region, almost all organic wastes disposed prior to 1970 will have fully decomposed by 2005 when the waste volume estimate was performed (and would no longer be producing LFG). Historical waste disposal rates for 1970 – 2005 were estimated based on the reported 2005 disposal rate and estimated waste in place (7.88 million tonnes as of mid-2005). Annual growth in disposal during this period was estimated to be 10 percent for consistency with the 2005 waste in place and disposal figures. Disposal in 2006 was estimated to be 3,000 tonnes per day (1,095,000 tonnes per year). Disposal in 2007 and 2008 assumes that the 10 percent annual increase in disposal continues (based on the reports of 3,000 – 4,000 tonnes/day current disposal rates). Disposal is estimated to decline to 730,000 tonnes in 2009 and to 91,000 tonnes in 2010. Only inorganic waste disposal is projected to occur after mid-2010, which will not generate LFG.

Based on these assumptions, the landfill will receive a total of approximately 12.7 million tonnes of waste (excluding silt deposits and composting facility rejects) from 1970 through mid-2010. Table 2-1 summarizes the waste disposal estimates for Deonar Landfill.

2.3 WASTE COMPOSITION

Waste composition is an important consideration in evaluating an LFG recovery project, in particular the organic content, moisture content, and “degradability” of the various waste fractions. For example, landfills with a high amount of food wastes, which are highly degradable, will tend to produce LFG sooner but over a shorter length of time. The effect of waste composition on LFG production is discussed further in Section 4.

Data on the composition of wastes disposed at the Deonar Landfill was not available. Waste composition data from the Gorai Landfill in Mumbai reported by TCE Consulting Engineers in a Methane to Markets workshop presentation in Mumbai on March 6, 2007 was used for this study. Waste materials observed during the pump test well drilling operations were recorded but did not provide a representative sampling for estimating the percentages of each waste type.

General observations of waste composition during the pump test appears consistent with the waste composition data provided in Table 2-2, which shows that food waste and construction and demolition waste (including earth fill) make up over 65 percent of wastes disposed.

TABLE 2-1. WASTE DISPOSAL RATES
DEONAR LANDFILL, INDIA

Year	Waste Disposed (Mg/year)	Cumulative Waste Disposed (Mg)	Year	Waste Disposed (Mg/year)	Cumulative Waste Disposed (Mg)
1970	27,700	27,700	1991	204,900	1,977,860
1971	30,470	58,170	1992	225,400	2,203,260
1972	33,520	91,690	1993	247,900	2,451,160
1973	36,870	128,560	1994	272,700	2,723,860
1974	40,560	169,120	1995	300,000	3,023,860
1975	44,620	213,740	1996	330,000	3,353,860
1976	49,080	262,820	1997	363,000	3,716,860
1977	53,990	316,810	1998	399,300	4,116,160
1978	59,390	376,200	1999	439,200	4,555,360
1979	65,330	441,530	2000	483,100	5,038,460
1980	71,860	513,390	2001	531,400	5,569,860
1981	79,050	592,440	2002	584,500	6,154,360
1982	86,960	679,400	2003	643,000	6,797,360
1983	95,660	775,060	2004	707,300	7,504,660
1984	105,200	880,260	2005	765,000	8,269,660
1985	115,700	995,960	2006	1,095,000	9,364,660
1986	127,300	1,123,260	2007	1,205,000	10,569,660
1987	140,000	1,263,260	2008	1,326,000	11,895,660
1988	154,000	1,417,260	2009	730,000	12,625,660
1989	169,400	1,586,660	2010	91,000	12,716,660
1990	186,300	1,772,960	2011	0	12,716,660

TABLE 2-2. WASTE COMPOSITION DATA

Component	Fraction of Waste Stream (%)
Food Waste	35.7
Garden Waste	6.3
Wood Waste	0.0
Paper and Cardboard	11.8
Plastics	5.0
Rubber, Leather	2.5
Textiles	7.5
Other Organics	0.0
Metals	0.8
Glass and ceramics	0.4
Construction and demolition waste (including sand and earth fill)	30.0
TOTAL	**100.0**

2.4 EXISTING GAS COLLECTION SYSTEM

No LFG collection system or venting wells exist at the Deonar Landfill.

SECTION 3.0
LANDFILL GAS PUMP TEST PROGRAM

3.1 PUMP TEST BACKGROUND INFORMATION

A pump test program was conducted at the Deonar Landfill. The objectives of the pump test were:

- To measure vacuum (pressure) and flow relationships while actively extracting LFG from the landfill.
- To measure sustainable methane levels of the extracted LFG during the pump test.
- To measure vacuum (pressure) in probes to estimate the lateral vacuum influence of the active pump test.
- To measure oxygen levels of the extracted biogas during the pump test to check for air infiltration through the landfill surface during the pump test.
- Utilize the results of the pump test to refine the projections of landfill gas recovery.

The pump test generally consisted of the following physical elements and equipment:

- A total of three vertical extraction wells constructed with HDPE piping (referred to as Wells 1, 2, and 3). All three wells were installed on the top deck of the central portion of the landfill. Well depths were as follows: Well 1 was 15 m; Well 2 was 12 m; and Well 3 was 8.5 m. Well construction consisted of a 0.10 meter diameter PVC well casing and the annulus was backfilled with 1 to 3 centimeter diameter stone, bentonite clay, and soil. Figure 3-1 presents a typical detail of construction for the extraction wells. Well construction logs are provided in Appendix A.
- A total of 9 gas and pressure monitoring probes. Three probes were installed for each extraction well. The probes were installed to a depth of approximately 2 meters, and were spaced in line at distances of about 5, 15, and 25 meters from each extraction well. Figure 3-2 presents a typical detail of construction for the monitoring probes.
- An electrically-powered mechanical blower, to exert a vacuum on the extraction wells and withdraw LFG from the wells. The blower was powered on-site by a portable diesel powered electrical generator and was run continuously during the pump test.
- Interconnection of the three extraction wells and the blower with 2-inch and 4-inch diameter flexible piping. Flow control valves were installed at each extraction well and at the blower inlet to allow adjustment of vacuum and flow both system-wide and at individual wells. Figure 3-3 is a drawing showing the layout of the pump test system.

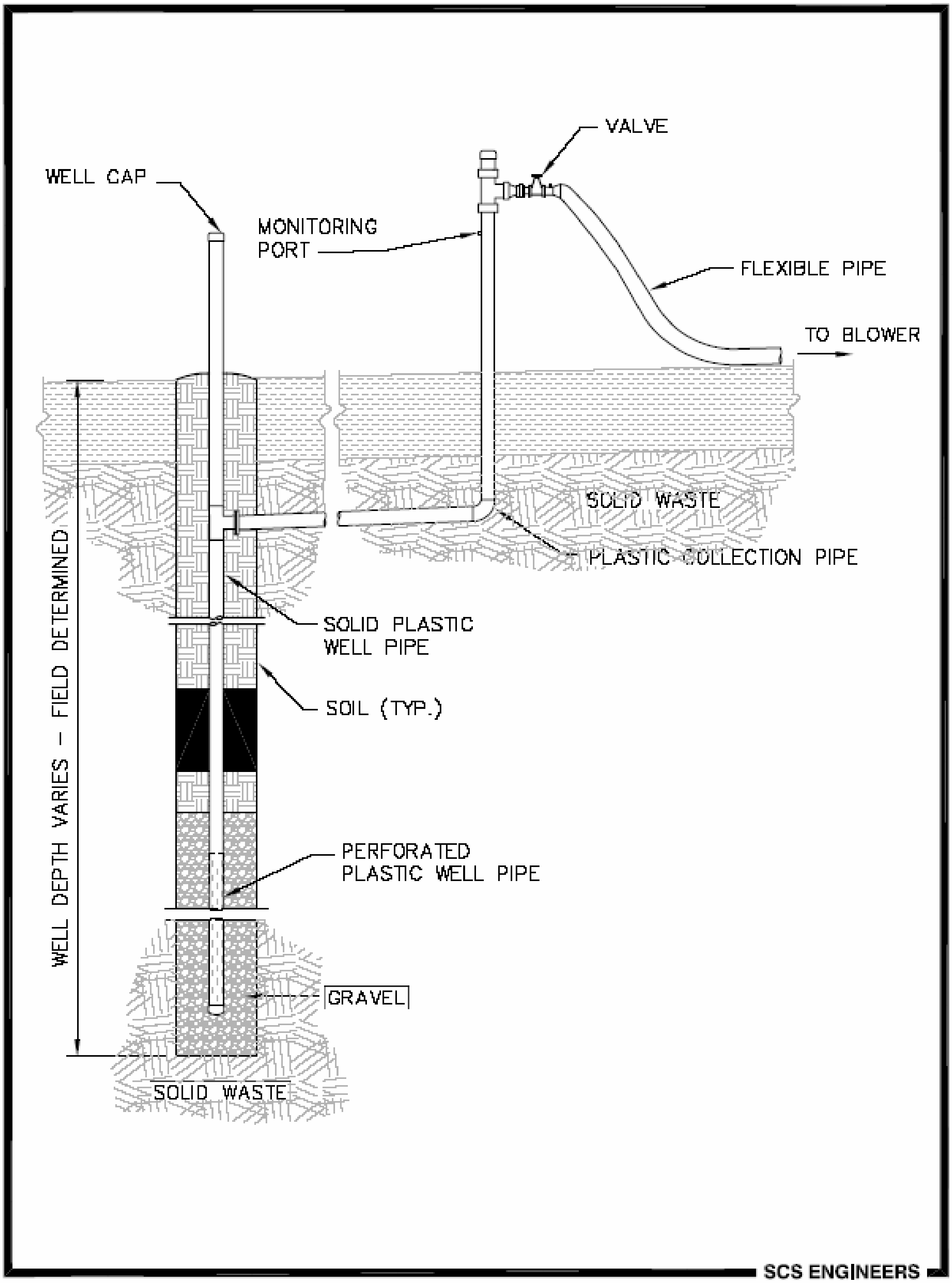


Figure 3-1. Typical LFG Extraction Well and Well-head Diagram

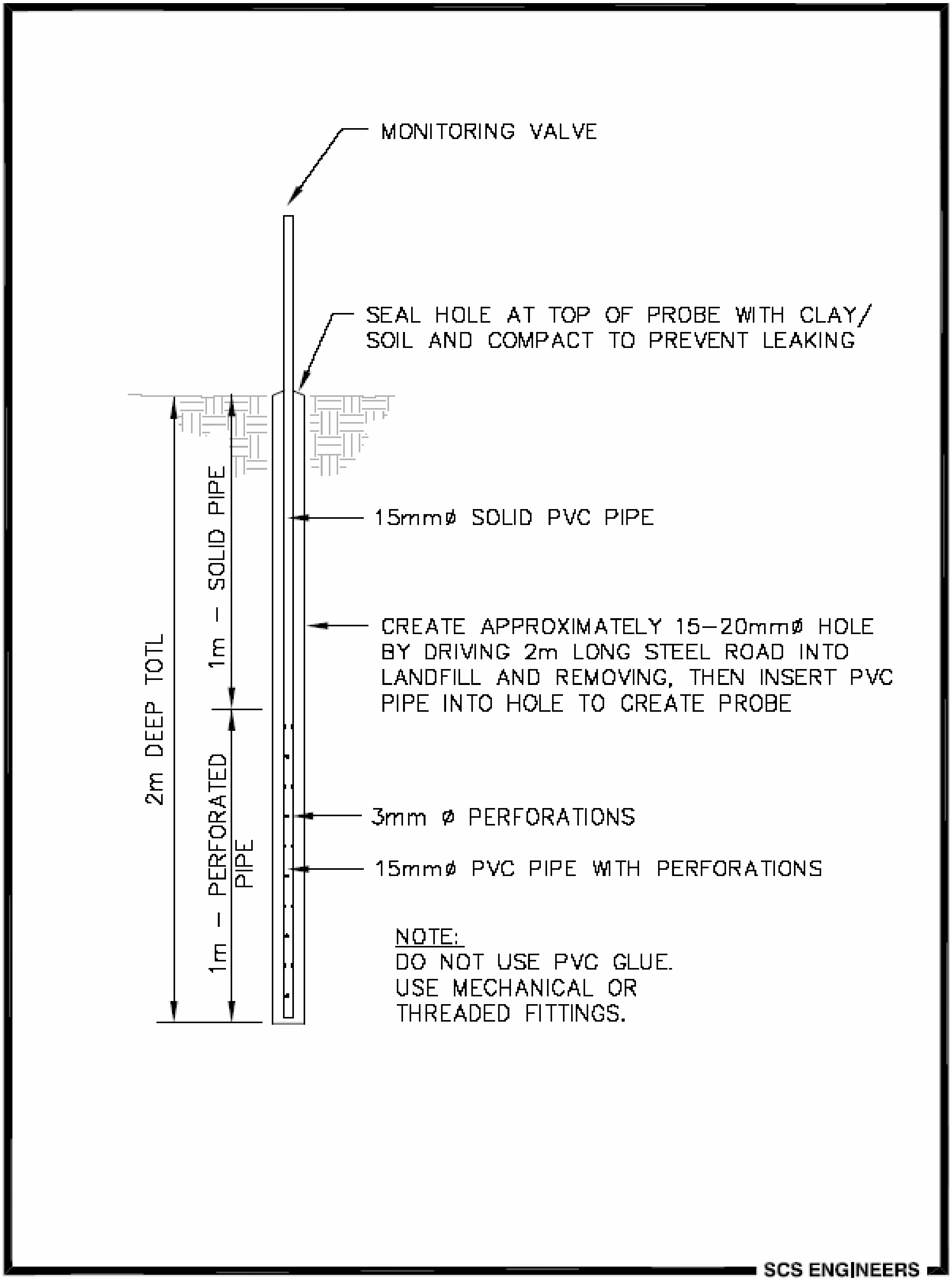


Figure 3-2. Monitoring Probe Diagram

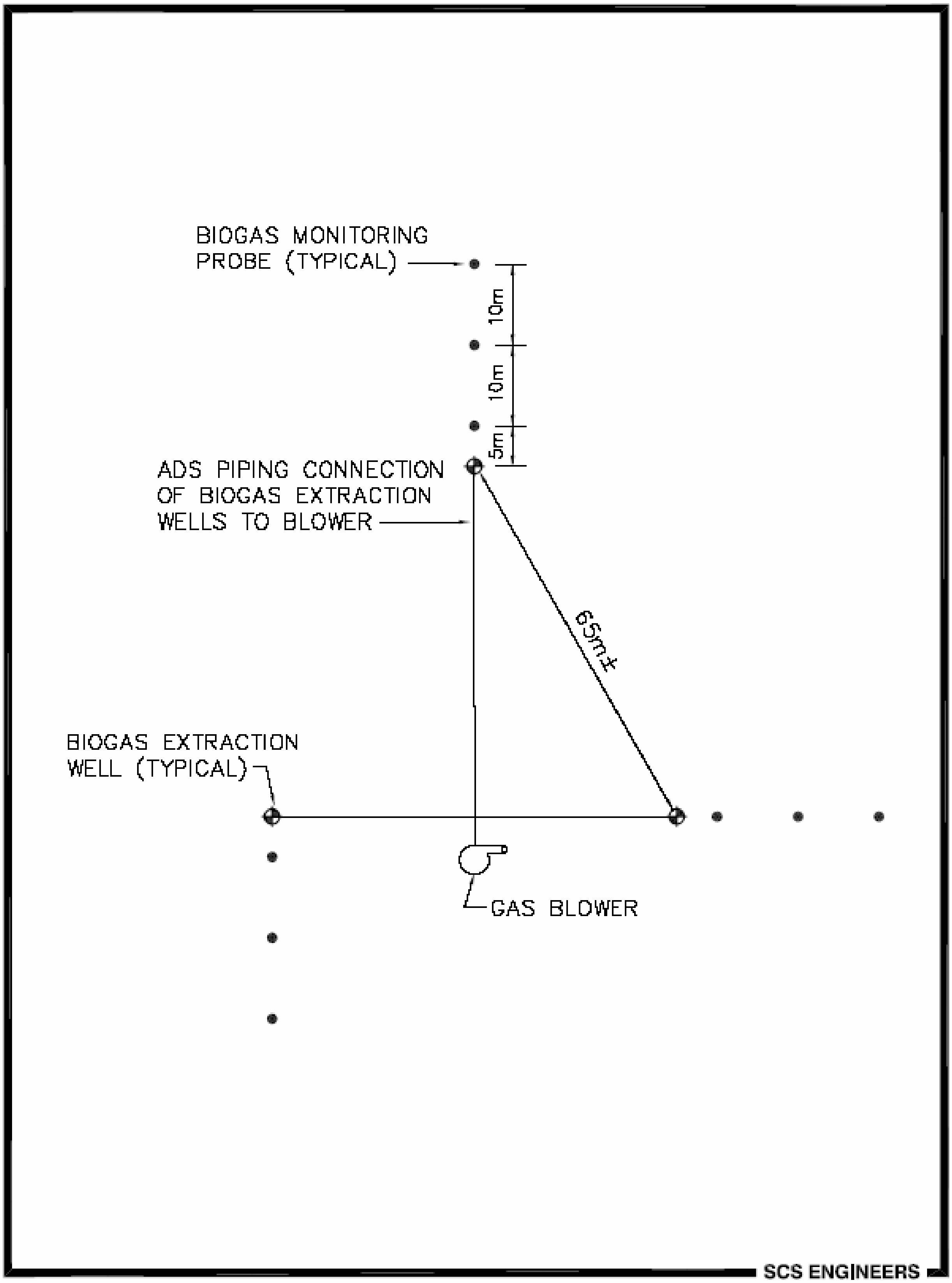


Figure 3-3. Pump Test Layout

- Gas testing, and flow and pressure monitoring equipment. Gas quality (methane, oxygen) and static pressure measurements were taken using a Landtec GEM 500 Infrared Gas Analyzer (GEM 500). Gas velocity measurements were taken using an Accu-Flow meter and the GEM 500.

The Project Team contracted with Jineshwar Gravit JV for the drilling and construction of the three extraction wells and the installation of the nine monitoring probes. SCS Engineers and Gravit Engineering Works (Gravit) performed the installation of the blower, motor, generator, and interconnecting piping, and provided construction oversight.

SCS personnel were on-site during drilling and well installation activities and observed the following:

- The types of municipal solid waste materials encountered during drilling; waste types were recorded and are listed in the well logs provided in Attachment A.
- Waste materials and soil cuttings were observed to be very wet.
- Leachate was not encountered in each of the three boreholes during well drilling and installation.

Gravit performed monitoring of the wells and probes and recorded the data. Figures 3-4 and 3-5 below show photographs of the drill rig during probe installation and an extraction well, blower, and collection piping used during the pump test.

Figure 3-4. Pump Test Drill Rig

Figure 3-5. Pump Test Extraction Well, Blower, and Collection Piping

3.2 PUMP TEST ACTIVITIES AND RESULTS

Test Program: Active Conditions

On the morning of May 28, the blower was turned on and active extraction conditions were established. During active gas pumping, wells, probes, and the blower were monitored several times daily for the following parameters:

- Wells: methane, oxygen, static pressure, temperature, and gas flow velocity;
- Probes: methane, oxygen, and static pressure; and
- Blower: gas flow velocity.

For various reasons, most notably difficulty in communicating especially through remote communications (i.e. via email or phone) between SCS and Gravit, data collected through the end of June was not valid and could not be used for the pump test. The analysis presented in this report includes valid data taken between July 4 and July 7. Appendix B provides a complete data set showing the monitoring data taken during this valid period for the three wells, nine probes, and the blower.

Extraction Well Data

Tables 3-1 through 3-3 summarize the monitoring results for Wells 1 through 3, respectively, and show the average of the measured values and calculated flows for each day.

TABLE 3-1. SUMMARY OF WELL 1 MONITORING RESULTS

Date	Methane (%)	Oxygen (%)	Pressure (in. w.c.)	Temperature (F)	Velocity (fpm)	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	56.3	1.9	-7.5	85.0	535	41.4	21.8
4-Jul-07	58.0	1.4	-8.0	85.0	610	47.2	25.6
4-Jul-07	64.9	2.1	-8.2	84.0	563	43.6	26.5
5-Jul-07	50.8	3.8	-8.1	79.0	632	48.9	23.5
5-Jul-07	60.9	0.8	-8.2	74.0	579	44.8	26.0
5-Jul-07	69.6	1.9	-8.4	81.0	567	43.9	28.7
6-Jul-07	56.3	1.9	-7.5	85.0	563	43.6	23.0
6-Jul-07	59.0	1.1	-8.2	86.0	550	42.6	23.4
6-Jul-07	56.0	0.1	-7.2	84.0	520	40.2	21.2
7-Jul-07	62.0	2.1	-8.1	84.0	370	28.6	16.6
7-Jul-07	60.9	2.0	-7.8	84.0	350	27.1	15.5
7-Jul-07	52.0	4.5	-8.6	83.0	450	34.8	17.0
Averages	**55.2**	**2.0**	**-8.0**	**82.8**	**524**	**40.5**	**22.4**

TABLE 3-2. SUMMARY OF WELL 2 MONITORING RESULTS

Date	Methane (%)	Oxygen (%)	Pressure (in. w.c.)	Temperature (F)	Velocity (fpm)	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	50.2	2.3	-14.3	85	306	23.7	10.9
4-Jul-07	48.6	3.9	-13.8	86	408	31.6	14.1
4-Jul-07	62.9	0.5	-14.7	85	375	29.0	16.8
5-Jul-07	64.8	0.5	-13.6	77	463	35.8	21.7
5-Jul-07	64.4	0.7	-14.0	69	396	30.6	18.7
5-Jul-07	63.6	0.2	-13.2	82	403	31.2	18.4
6-Jul-07	50.2	2.3	-14.3	85	336	26.0	12.0
6-Jul-07	62.0	1.6	-13.6	87	325	25.1	14.3
6-Jul-07	63.0	1.5	-14.5	85	315	24.4	14.1
7-Jul-07	69.5	0.3	-13.2	83	430	33.3	21.4
7-Jul-07	71.3	0.3	-12.9	85	400	30.9	20.4
7-Jul-07	71.1	0.3	-13.0	86	340	26.3	17.2
Averages	**57.5**	**1.2**	**-13.8**	**82.9**	**375**	**29.0**	**16.7**

TABLE 3-3. SUMMARY OF WELL 3 MONITORING RESULTS

Date	Methane (%)	Oxygen (%)	Pressure (in. w.c.)	Temperature (F)	Velocity (fpm)	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	42.0	4.3	-2.6	82.0	510	39.5	15.8
4-Jul-07	39.1	4.3	-2.3	86.0	605	46.8	17.3
4-Jul-07	32.1	6.0	-2.1	85.0	538	41.6	12.7
5-Jul-07	44.1	3.5	-5.8	77.0	596	46.1	19.4
5-Jul-07	40.6	3.8	-5.8	71.0	602	46.6	18.3
5-Jul-07	37.6	4.7	-10.0	80.0	586	45.3	16.0
6-Jul-07	42.0	4.3	-2.6	82.0	310	24.0	9.6
6-Jul-07	30.2	8.0	-5.3	85.0	350	27.1	7.7
6-Jul-07	32.2	6.0	-5.1	84.0	445	34.4	10.5
7-Jul-07	36.6	5.8	-8.6	82.0	425	32.9	11.3
7-Jul-07	33.0	7.5	-8.6	84.0	510	39.5	12.2
7-Jul-07	32.9	8.1	-8.8	85.0	475	36.7	11.3
Averages	**35.2**	**5.5**	**-5.6**	**81.9**	**496**	**38.4**	**13.5**

The results of the extraction well monitoring indicate that Wells 1 and 2 had very high gas quality ranging from 48 to 71 percent methane, while Well 3 had lower gas quality ranging from 30 to 44 percent. Variations in methane percent, LFG flows, and methane flows in each of the wells do not appear correlated in time with applied vacuum, which was fairly consistent in Wells 1 and 2, but fluctuated between 2 and 10 inches of water column in Well 3.

Overall, Well 1 was the most productive well in terms of methane and LFG flows during the pump test. Methane flow reached a maximum in Well 1 late in the day on July 5 when methane quality also reached a maximum, and generally declined thereafter in response to declining LFG flows. In Well 2, LFG and methane flows reached their highest levels early on July 5 and declined thereafter until July 7, when the second highest levels of LFG and methane flows were attained. In Well 3, methane flows reached maximum levels early on July 5 at the same time that LFG flows were slightly below maximum levels. Later on July 5, vacuum applied to Well 3 was increased to maximum levels, and then reduced to lower levels on the morning of July 6. These actions appeared to impact methane percentages, LFG flows, and methane flows, which reached minimum levels on July 6. On July 7, following increases in applied vacuum, Well 3 experienced moderate improvements in methane quality, LFG flows, and methane flows.

Steady state conditions may have been established during the pump test because of the long time period of operations (late May – early July). The monitoring data provide mixed evidence regarding steady state conditions. Fairly consistent methane quality, LFG flow, and methane flow figures suggest that steady state conditions may have been reached during the pump test. On the other hand, observed increases in methane quality and flow in response to increases in applied vacuum suggest that steady-state conditions may not have been reached. The short duration of the period during which valid data were recorded adds uncertainty to any conclusions regarding the achievement of steady-state conditions during the pump test.

Monitoring Probe Data--

As mentioned previously, a total of 9 monitoring probes (three per well) were installed. The objective of these probes is to measure gas quality and static pressures at varying distances from each extraction well in order to estimate the radius or volume of influence of each well.

The most direct indication that a monitoring probe is within the influence of an extraction well is the establishment of a vacuum at the probe. Another indication is a decline in methane content accompanied by an increase in the concentrations of oxygen and balance gases.

Tables 3-4 through 3-12 present the monitoring data for each of the probes. The probe monitoring data for the July 4 – 7 period also is provided in Appendix B.

TABLE 3-4. SUMMARY OF MONITORING RESULTS FOR PROBE 1A (10m from Well 1)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	53.9	0.1	0.0	-7.5
4-Jul-07	64.4	0.2	0.0	-8.0
4-Jul-07	62.5	0.3	0.0	-8.2
5-Jul-07	65.4	0.2	0.0	-8.1
5-Jul-07	65.7	0.0	0.0	-8.2
5-Jul-07	64.5	0.1	0.0	-8.4
6-Jul-07	53.9	0.1	0.0	-7.5
6-Jul-07	68.6	0.2	0.0	-8.2
6-Jul-07	65.6	0.1	0.1	-7.2
7-Jul-07	69.5	0.2	0.0	-8.1
7-Jul-07	70.8	0.2	0.0	-7.8
7-Jul-07	70.9	0.2	0.0	-8.6

TABLE 3-5. SUMMARY OF MONITORING RESULTS FOR PROBE 1B (20m from Well 1)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	59.6	0.0	0.6	-7.5
4-Jul-07	63.8	0.0	0.4	-8.0
4-Jul-07	62.8	0.2	0.4	-8.2
5-Jul-07	65.8	0.1	0.0	-8.1
5-Jul-07	66.2	0.0	-0.3	-8.2
5-Jul-07	65.0	0.0	0.5	-8.4
6-Jul-07	59.6	0.0	0.6	-7.5
6-Jul-07	69.1	0.1	0.3	-8.2
6-Jul-07	69.0	0.1	0.2	-7.2
7-Jul-07	67.7	0.1	0.4	-8.1
7-Jul-07	71.5	0.1	0.4	-7.8
7-Jul-07	72.2	0.2	0.4	-8.6

TABLE 3-6. SUMMARY OF MONITORING RESULTS FOR PROBE 1C (30m from Well 1)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	32.4	7.1	0.1	-7.5
4-Jul-07	47.3	4.8	0.0	-8.0
4-Jul-07	38.4	7.6	0.0	-8.2
5-Jul-07	68.1	2.9	-1.8	-8.1
5-Jul-07	65.8	3.8	-1.2	-8.2
5-Jul-07	54.7	3.6	-0.8	-8.4
6-Jul-07	32.4	7.1	0.1	-7.5
6-Jul-07	67.3	1.7	0.0	-8.2
6-Jul-07	65.3	1.6	0.0	-7.2
7-Jul-07	66.7	1.5	0.0	-8.1
7-Jul-07	65.2	3.3	0.0	-7.8
7-Jul-07	66.9	2.2	0.0	-8.6

TABLE 3-7. SUMMARY OF MONITORING RESULTS FOR PROBE 2A (10m from Well 2)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	73.5	0.2	0.0	-14.3
4-Jul-07	75.3	0.2	0.1	-13.8
4-Jul-07	74.5	0.2	0.2	-14.7
5-Jul-07	78.2	0.1	0.0	-13.6
5-Jul-07	76.9	0.0	0.1	-14.0
5-Jul-07	79.4	0.0	0.2	-13.2
6-Jul-07	73.5	0.2	0.0	-14.3
6-Jul-07	76.6	0.2	0.1	-13.6
6-Jul-07	73.3	0.2	0.1	-14.5
7-Jul-07	76.1	0.1	0.1	-13.2
7-Jul-07	77.4	0.1	0.1	-12.9
7-Jul-07	76.6	0.1	0.1	-13.0

TABLE 3-8. SUMMARY OF MONITORING RESULTS FOR PROBE 2B (20m from Well 2)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	63.3	0.0	0.1	-14.3
4-Jul-07	65.2	0.0	0.2	-13.8
4-Jul-07	65.7	0.0	0.0	-14.7
5-Jul-07	68.8	0.0	0.0	-13.6
5-Jul-07	68.1	0.0	0.1	-14.0
5-Jul-07	67.1	0.0	0.0	-13.2
6-Jul-07	63.3	0.0	0.1	-14.3
6-Jul-07	70.3	0.1	0.0	-13.6
6-Jul-07	70.1	0.1	0.0	-14.5
7-Jul-07	73.5	0.0	0.0	-13.2
7-Jul-07	73.1	0.1	0.0	-12.9
7-Jul-07	71.8	0.1	0.0	-13.0

TABLE 3-9. SUMMARY OF MONITORING RESULTS FOR PROBE 2C (30m from Well 2)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	82.8	0.0	0.1	-14.3
4-Jul-07	83.7	0.0	0.4	-13.8
4-Jul-07	83.7	0.1	0.2	-14.7
5-Jul-07	83.9	0.0	0.2	-13.6
5-Jul-07	83.3	0.0	0.2	-14.0
5-Jul-07	82.2	0.0	0.2	-13.2
6-Jul-07	82.8	0.0	0.1	-14.3
6-Jul-07	76.6	0.1	0.0	-13.6
6-Jul-07	74.6	0.1	0.0	-14.5
7-Jul-07	74.3	0.0	0.0	-13.2
7-Jul-07	73.9	0.0	0.0	-12.9
7-Jul-07	74.0	0.0	0.0	-13.0

TABLE 3-10. SUMMARY OF MONITORING RESULTS FOR PROBE 3A (10m from Well 3)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	0.8	17.4	-0.1	-2.6
4-Jul-07	0.7	17.5	-0.1	-2.3
4-Jul-07	0.8	17.8	-0.2	-2.1
5-Jul-07	1.1	17.7	-0.5	-5.8
5-Jul-07	1.0	17.7	-1.0	-5.8
5-Jul-07	1.1	17.7	-1.0	-10.0
6-Jul-07	0.8	17.4	-0.1	-2.6
6-Jul-07	1.6	17.6	-0.6	-5.3
6-Jul-07	0.5	17.5	-0.5	-5.1
7-Jul-07	2.0	17.7	-0.6	-8.6
7-Jul-07	2.1	17.8	-0.3	-8.6
7-Jul-07	2.0	17.9	-0.4	-8.8

TABLE 3-11. SUMMARY OF MONITORING RESULTS FOR PROBE 3B (20m from Well 3)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	67.4	0.6	0.0	-2.6
4-Jul-07	65.9	0.6	0.0	-2.3
4-Jul-07	66.8	0.7	0.0	-2.1
5-Jul-07	69.9	0.6	0.0	-5.8
5-Jul-07	69.4	0.5	0.0	-5.8
5-Jul-07	69.7	0.5	0.0	-10.0
6-Jul-07	67.4	0.6	0.0	-2.6
6-Jul-07	73.8	0.7	0.0	-5.3
6-Jul-07	72.6	0.6	0.0	-5.1
7-Jul-07	74.8	0.7	0.0	-8.6
7-Jul-07	75.2	0.7	0.0	-8.6
7-Jul-07	75.4	0.7	0.0	-8.8

TABLE 3-12 SUMMARY OF MONITORING RESULTS FOR PROBE 3C (30m from Well 3)

DATE	Methane (%)	Oxygen (%)	Static Pressure (in. w.c.)	Applied Vacuum at Adjacent Well (in. w.c.)
4-Jul-07	0.6	18.1	0.0	-2.6
4-Jul-07	0.6	18.0	0.0	-2.3
4-Jul-07	0.6	18.3	-0.1	-2.1
5-Jul-07	0.9	18.3	0.0	-5.8
5-Jul-07	0.9	18.2	0.0	-5.8
5-Jul-07	0.8	18.1	0.0	-10.0
6-Jul-07	0.6	18.1	0.0	-2.6
6-Jul-07	1.4	18.1	-0.2	-5.3
6-Jul-07	0.7	17.1	-0.1	-5.1
7-Jul-07	2.0	18.2	-0.2	-8.6
7-Jul-07	2.0	18.2	-0.2	-8.6
7-Jul-07	2.1	18.1	-0.3	-8.8

The probe monitoring data indicates that the monitoring probes near Well 1 were within the "radius of influence" (ROI) of the extraction well on July 5, when a vacuum was established for part of the day at Probes 1B, and during all three measurements taken at Probe 1C. A significant methane decline at Probe 1C during the first measurement on the following day (July 6) also is suggestive of extraction well influence at this probe. These data indicate that the probes were within the influence of extraction Well 1, and suggest that the ROI of Well 1 at the applied vacuums during this period extended to and likely beyond the farthest probe (1C), located about 25 meters from Well 1. The probe monitoring data for Wells 2 and 3 provide no evidence of the extent of the ROI.

Blower Data--

Monitoring of the LFG flow velocity was conducted at the inlet to the gas blower to calculate gas flows. Methane measurements were not taken but can be approximated based on average methane percentages measured at the wells. A summary of the monitoring results for the blower is provided below in Table 3-13. The complete set of blower monitoring data for the July 4 – 7 period is provided in Appendix B.

TABLE 3-13. SUMMARY OF BLOWER MONITORING RESULTS

DATE	Methane % (est. based on well data)	Velocity (fpm)	LFG Flow (cfm)	LFG Flow @ 50% Methane (cfm)	Methane Flow (cfm)
4-Jul-07	49.5	745	57.6	57.1	28.5
4-Jul-07	48.6	856	66.2	64.3	32.2
4-Jul-07	53.3	829	64.1	68.4	34.2
5-Jul-07	53.2	998	77.2	82.2	41.1
5-Jul-07	55.3	886	68.5	75.8	37.9
5-Jul-07	56.9	923	71.4	81.3	40.7
6-Jul-07	49.5	787	60.9	60.3	30.1
6-Jul-07	50.4	865	66.9	67.5	33.7
7-Jul-07	56.0	698	54.0	60.5	30.3
7-Jul-07	55.1	769	59.5	65.5	32.8
7-Jul-07	52.0	702	54.3	56.5	28.2
AVERAGES	**52.7**	**823**	**63.7**	**67.2**	**33.6**

The blower data indicates that LFG and methane flows steadily increased during the first day and reached a maximum on July 5, when average methane quality at the wells also was at a maximum. LFG and methane flows declined sharply on July 6 and remained at fairly constant levels for the remainder of the pump test. As shown in Table 3-13, LFG flows adjusted to 50 percent methane averaged 67.2 cfm (114.2 m^3/hour) during the pump test.

3.3 INTERPRETATION OF PUMP TEST RESULTS

The Project Team evaluated the results of the pump test to determine if they can be used for the projection of LFG recovery rates at the landfill (see Section 4.0). The general procedure by which the pump test data are utilized for this purpose is as follows:

- Estimate the maximum steady-state flow rate achievable in the pump test area. Although the monitoring data does not provide strong evidence of the achievement of steady state conditions, the long duration of the pump test suggest that the average recovery rate observed during this period may approximate steady state conditions. As shown in Table 3-13, the average LFG recovery rate (adjusted to 50 percent methane) during this period was 67.2 cfm (114 m^3/hour).

- Estimate the radius of influence (ROI) of the extraction wells. The monitoring data indicates that on July 5 the ROI of Well 1 extended at least to the outermost probes (Probe 1C) located 25 meters from the well, and likely beyond.

  General industry guidelines suggest that the ROI of an extraction well is a function of the well depth, and that extraction wells typically have a ROI between 1.25 and 3 times its depth, depending on well construction, refuse permeability, and other factors. The probe data from Well 1 suggest that the ROI was at least 25 meters, which is 1.67 times the well depth of 15 meters.

  Based on these considerations and the results of the pump test, the Project Team estimates the average ROI of Well 3 under the conditions established during the pump test to be approximately 2 times the well depth of 15 meters, or 30 meters. Although the probe data for Wells 2 and 3 did not provide any clear indication of an ROI, the Project Team assumes that Wells 2 and 3 also have an ROI of approximately 2 times the well depths (12 m and 8.5 m). The estimated ROIs for Wells 2 and 3 are therefore 24 meters and 17 meters, respectively.

- Estimate the volume of refuse within the ROI of the extraction wells. Using the estimated ROI values for each well, the volume of refuse within the influence of the three wells during the pump test was calculated using an estimated average refuse depth of 20 meters; this volume is estimated to be approximately 110,898 cubic meters.

- Estimate the unit recovery rate representing conditions achieved during the pump test (in cubic feet of LFG per year per pound of waste). Based on information provided by the City of Mumbai, the in-place refuse density at the landfill is estimated to be approximately 950 kg per cubic meter (approximately 1,600 lbs/yd^3). This density can be applied to the volume of waste estimated to be within the influence of the pump test (110,898 m^3), which results in 105,353 tonnes. The pump test average flow rate of 114 m^3/hour converts to 1,000,344 cubic meters per year, which results in a unit recovery rate of approximately 9.5 cubic meters per tonne per year.

- Extrapolate the unit recovery rate achieved during the pump test to the estimated total amount of refuse in the region of the landfill where the pump test was performed. Based on information provided by the City of Mumbai, the area of the landfill where the pump test was performed contained wastes disposed in the past 20 years. The estimate for total waste disposed from 1987 – 2006 is 8,843,900 tonnes. Extrapolation of the pump test unit recovery rate (9.5 m^3/Mg-year) by the total estimated amount of waste deposited from 1987 - 2006 from Table 2-3 (8,843,900 tonnes). Based on this, the project team estimates that the average gas capture at the entire landfill in 2007 (if a comprehensive gas collection system were in place) would be approximately 9,586 m^3/hour, or 5,642 cfm. This estimate for the potential recovery rate was used for comparison against the LFG recovery projections developed in Section 4.

SECTION 4.0
LANDFILL GAS RECOVERY PROJECTIONS

4.1 INTRODUCTION

For projecting LFG recovery rates from the Deonar Landfill, the Project Team utilized the results of the pump test (see Section 3) to refine the mathematical modeling parameters. Specifically, the projected rate of 5,348 cfm (9,086 m^3/hour) for the landfill was used to evaluate the model and make adjustments as needed. The specific modeling approach is discussed below.

4.2 LANDFILL GAS MATHEMATICAL MODELING

Landfill gas is generated by the anaerobic decomposition of solid waste within a landfill. It is typically composed of between 40 to 60 percent methane, with the remainder primarily being carbon dioxide. The rate at which LFG is generated is largely a function of the type of waste buried and the moisture content and age of the waste. As is widely accepted throughout the industry, the LFG generation rate generally can be described by a first-order decay equation.

To estimate the potential LFG recovery rate for the landfill, the Project Team utilized the SCS-LMOP International LFG model that employs a first-order decay equation identical to the algorithm in the U.S. EPA's landfill gas emissions model (LandGEM). The international LFG model is described in detail below.

SCS-LMOP International LFG Model

The Project Team has developed a first-order decay model for estimating the LFG recovery potential of landfills. The model, essentially a modified version of the EPA's LandGEM, was developed based on actual LFG collection/recovery data from over 160 landfills across the U.S., and adjusted to account for conditions at disposal sites in India.

When calibrating the model, the Project Team identified trends in the LFG collection data that were used to develop the model. Specifically, it was apparent that different values for the ultimate methane recovery potential [Lo] and the decay rate constant [k] were appropriate depending upon the amount of precipitation a landfill receives.

The SCS-LMOP International LFG Model also uses an alternate approach to conventional LFG modeling, which is to estimate recovery directly. This approach requires an evaluation or estimate of the current and future coverage of the LFG collection system, generally defined as that fraction of the landfill under active collection. Many factors can affect system coverage, including: well spacing and depth, depth of well perforations, presence of a flexible membrane liner (FML) or low-permeability cover system, landfill type and depth, condition of LFG collection system, and other design and operational issues.

The Project Team used the model to estimate the projected LFG recovery rates for the landfill through 2035 using the following criteria and assumptions:

- **Refuse Disposal Rates -** The historical filling rates used in the model are provided in Table 2-1. As described in Section 2-1, the landfill has received waste since 1927, had about 7.88 million tonnes in place in 2005, and is projected to stop receiving MSW in mid-2010 after receiving a total of approximately 12.72 million tonnes.

- **Methane Content of LFG –** Because the methane content of LFG fluctuates over time, it is standard industry practice to normalize the methane content to 50 percent for the purposes of LFG modeling.

- **Methane Rate Constant [k] -** The decay rate constant is a function of refuse moisture content, nutrient availability, pH, and temperature. For the Mumbai evaluation, three different k values were used based on the degradability of the waste components (see discussion of model inputs below).

- **Methane Recovery Potential [Lo] -** The methane recovery potential is the total amount of methane that a unit mass of refuse will produce given enough time. The Lo is a function of the organic content of the waste. For the Deonar Landfill, The Project Team started with a default Lo value of 85 cubic meters per tonne (2,723 ft^3/ton) for recovery from U.S. landfills based on the AP-42 recommended values of 100 cubic meters per tonne (3,204 ft^3/ton) for Lo when modeling LFG generation, and 85 percent for the maximum achievable collection efficiency. This value was then adjusted based on the ratios of the organic content of U.S. waste and waste at the landfill (see discussion of model inputs below).

- **Methane Correction Factor [MCF] –** At unmanaged disposal sites such as Deonar, aerobic conditions will exist in a significant portion of the waste mass. To account for the portion of disposed waste which does not attain anaerobic conditions and produce LFG, the Intergovernmental Panel on Climate Change (IPCC) recommends that unmanaged sites greater than 5 meters in depth apply a methane correction factor (MCF) of 0.8 to account for the estimated amount of aerobic decay.[3] The MCF was applied to the Lo as discussed below.

- **LFG System Coverage.** Varies. The model estimates both the potential “recoverable” LFG from a landfill assuming a 100 percent comprehensive LFG collection system, and the projected rate of LFG recovery using the estimated LFG system coverage. System coverage is a measure of the fraction of the refuse mass which is under active collection.

  The LFG system coverage factor is based on engineering judgment, and considers many factors including: whether the landfill is closed or active, extent and type of soil cover and liners, the type of well construction and gas system construction, the level of operation that is provided, the likelihood that system components such as pipes and wells may be damaged by landfill operations and/or settlement, how quickly damaged pipes and wells (and other equipment, such as blowers, etc.) are likely to be repaired, leachate levels in wells, and other factors. This value falls within the range of 0 percent (for no gas

[3] MCF is 0.4 for unmanaged sites less than 5 meters deep.

collection system) to 100 percent (for a comprehensive collection system over a closed landfill with excellent construction and operation).

Modifications to the LFG system coverage can be made to account for expected collection system expansions or if other changes to the LFG system or landfill are anticipated (e.g., landfill closure or partial capping, increasing flows due to the presence of additional fill material). Active landfills generally tend to have lower system coverage than closed landfills due to the lack of final cover and the interferences caused by active filling operations or by waste pickers. Another potential issue that can limit system coverage is concern over security of equipment (wells, piping, etc.), particularly at landfills that allow public access.

Deonar is an active site with limited soil cover and a significant population of waste pickers. There is no security fencing around the site to prevent unauthorized access. In order to prevent loss or damage to equipment, wells need to be installed only in closed areas with adequate fencing or walls to prevent unauthorized access. Wells are to be installed in the 51 hectare disposal area that will be partially closed by 2010. No wells are planned for disposal areas (covering 69 hectares) where wastes are to be removed.

Given the above considerations, the Project Team has employed three system coverage scenarios in order to develop a range of estimates of predicted recovery with the proposed collection system. All three scenarios assume that adequate security fencing will be installed in inactive portions of the site to allow a comprehensive LFG collection system to be installed in all portions of the 51 hectare area containing substantial waste deposits (i.e., over 15 m) starting in 2008 and completed by the end of 2009 The scenarios also assume that leachate management activities, including pumping out leachate accumulated in extraction wells, will be employed to limit the impact on LFG collection rates if leachate is encountered. Estimates of collection system coverage assume system start-up on January 1, 2009 and vary under each of the three scenarios according to the expected level of skill and effort employed to operate and maintain the system.

The three scenarios result in low, mid-range, and high projections and are as follows:

1. The low recovery scenario assumes that a moderate level of skill and effort is employed in the operation and maintenance of the collection system (e.g., including wellfield monitoring and adjustment about once per month). System coverage is assumed to be 35 percent after system start-up in 2009 and increase to 45 percent in 2010. The Project Team considers the low recovery estimates to be conservative and should be employed only if a large margin of safety is needed.

2. The mid-range recovery scenario assumes that a moderately high level of skill and effort is employed in the operation and maintenance of the collection system (e.g., including wellfield monitoring and adjustment 2 to 3 times per month). System coverage is assumed to be 50 percent after system start-up in 2009 and increase to 60 percent in 2010. The Project Team considers the mid-range recovery scenario to be its best estimates of likely recovery and recommends its use in the economic evaluation.

3. The high recovery scenario assumes that highest possible level of skill and effort is employed in the operation and maintenance of the collection system (e.g., including weekly or more frequent wellfield monitoring and adjustment). System coverage is assumed to be 60 percent after system start-up in 2009 and increase to 70 percent in 2010. The Project Team considers the high recovery estimates to be ambitious and attainable only if the maintenance of an optimal LFG recovery system is considered to be a top priority.

Note that, in addition to the potential variability in system coverage and the level of operation and maintenance, mathematical modeling of LFG is inherently uncertain. The Project Team considered (and tried to account for) this modeling uncertainty in selecting the values for the high and low recovery scenarios when estimating the LFG recovery potential.

Model Inputs--

For estimating the model parameters decay rate (k) and methane recovery capacity (Lo) for the landfill, the Project Team took into consideration the estimated composition of waste buried in the Deonar Landfill. The Project Team compared the estimated composition of waste disposed in the landfill with U.S. EPA's waste characterization data for U.S. landfills. These data are presented in Table 4-1.

TABLE 4-1: COMPARISON OF WASTE COMPOSITION (%)

COMPONENTS	DEONAR LANDFILL[1]	TYPICAL U.S.[2]	DEGRADABILITY CATEGORY	DECAY RATE (k)
Food	35.7	11.5	Fast	0.40
Green Waste[3]	3.15	5.6	Fast	0.40
Other Organic[4]	0.0	1.6	Fast	0.40
Green Waste[3]	3.15	5.6	Medium	0.08
Paper	11.8	26.6	Medium	0.08
Wood	0.0	10.3	Slow	0.02
Rubber, Leather, Textiles	10.0	6.9	Slow	0.02
Plastics, Metals, Glass	6.2	9.7	Inert	0.0
Other Inorganic	30.0	5.4	Inert	0.0

<u>Notes to Table 4-1</u>:

1. No waste site-specific composition data was available for the Deonar Landfill. Deonar waste composition was estimated based on data for the Gorai Landfill in Mumbai.
2. U.S. data reflect 2001 MSW disposal data (source: USEPA, October 2003. Municipal Solid Waste in the United States: 2001 Facts and Figures - Table 3), with construction and demolition waste added (source: California Integrated Waste Management Board. 1999 California Statewide Waste Disposal Characterization Study).
3. Assumes 50 percent of green waste disposed is highly degradable and 50 percent is moderately degradable.

One particularly important difference between the two sets of data is that the waste stream at the Deonar Landfill contains significantly more food wastes (which are highly degradable) than typical U.S. wastes. Because food waste is so readily degraded, it produces LFG sooner, but over a shorter length of time. Therefore, a graph of LFG generation from wastes that are high in food waste, green waste, and other similar readily-degraded wastes will show a steeper slope in the LFG generation rate (reaching peak flows more rapidly), but a lower sustainable long term yield than the generation rate from waste with slower-degrading components. In the model, this effect is reflected in the parameter k.

Furthermore, the waste stream at the Deonar Landfill contains both a higher organic fraction than U.S. wastes and a higher level of moisture, primarily due to the food waste. The higher organic content will tend to increase the potential for methane generation per ton of waste. Conversely, however, the increased moisture content (which is inert) will tend to decrease the potential for methane generation per ton of waste. In the model, these effects are reflected in the parameter Lo.

The specific approach for developing each parameter is discussed below.

Methane Recovery Potential--The Lo value used was derived by modifying an estimated Lo value for U.S. landfills based on the ratios of dry organic waste percentages of average U.S. vs. Deonar Landfill waste, and the estimated MCF. Table 4-2 summarizes the calculation of the Lo value.

The value for the potential methane generation capacity (Lo) for the Deonar Landfill was estimated to be 60 cubic meters per tonne (1,855 ft^3/ton).

TABLE 4-2. CALCULATION OF THE Lo VALUE

	U.S. LANDFILLS	**DEONAR LANDFILL**	**RATIO: DEONAR / U.S.**
Organic %	63.3%	63.8%	1.01
Dry weight %	81.5%	68.8%	0.84
Lo value before MCF adjust	85 m^3/Mg	72.4 m^3/Mg	0.85
MCF	1	0.8	0.8
Lo value	85 m^3/Mg	57.9 m^3/Mg	0.68

Methane Decay Rate Constant--The k value reflects the fraction of refuse which decays in a given year and produces methane. An alternative approach to estimating a single k value for the entire landfill is to assign k values to different portions of the waste stream, based on their relative decay rates. Laboratory studies have suggested that fast-decaying organic refuse such as food waste typically decays at 5 times the rate of medium decay rate materials, such as wet paper, and 20 times the rate of slowly decaying components of the waste stream, such as textiles.[4] Because landfill moisture content significantly affects decay rates, the values of the decay rates for the fast, medium, and slow decaying waste fractions will vary with moisture as well. However, the relative rates of decay are expected to remain constant, despite varying landfill moisture.

The primary benefit of evaluating decay rates for different waste components is that it provides a tool for comparing average U.S. k values to k values at specific landfills which may have significantly differing waste compositions. The procedure assumes that fast, medium, and slow decaying waste components will each have fixed k values for a given moisture regime in a landfill. Using average annual precipitation as a surrogate for landfill moisture conditions, fast, medium, and slow waste component k values can be developed for landfills with a given precipitation value, if a single overall k value is known for the entire landfill and can be used to calibrate the three k values.

The Project Team employs a set of default k values when preparing LFG recovery projections for U.S. landfills for USEPA LMOP. The k values vary with average annual precipitation as follows: 0.02/year for sites experiencing less than 20 inches of precipitation per year; 0.04/year for sites experiencing 20-39 inches of precipitation per year; and 0.065 for sites experiencing 40 or more inches of precipitation per year.

Mumbai receives 2,130 millimeters (84 inches) of rainfall annually. Because few areas in the continental U.S. experience greater than 50 inches per year, there is little data to evaluate the effect of very high precipitation on waste decay rates and k values in the U.S. For this study, it is assumed that the observed increases in k values with precipitation continues at higher precipitation rates, which implies a k value of 0.10 for sites experiencing 84 inches per year precipitation. Given this estimated U.S. value the procedure of developing k values for the Deonar Landfill based on the appropriate k value for an average landfill in the U.S. experiencing 2,130 mm (84 inches) per year of precipitation is as follows:

1. Prepare a single-k LFG model run using the Deonar disposal data and the k value that would be appropriate for an average site in the U.S. experiencing 84 inches per year of precipitation (0.10/year).

2. Using the percentages of fast, medium, and slow-decaying waste components in the average U.S. waste stream and the Deonar disposal data, prepare a multi-phased LFG model (summing the results of the fast, medium, and slow refuse decay calculations). Keeping the fast to medium to slow ratios constant, adjust the fast-decaying waste k value so that the resulting LFG recovery projection matches as closely as possible the results of the single k model run using the U.S. default k value. The resulting k values are to be used in a 3-k model run for Deonar Landfill using the Deonar waste composition percentages.

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[4] Ehrig, Hans-Jürgen, "Prediction of Gas Production from Laboratory-Scale Tests." Landfilling Waste: LFG Edited by T.H. Christenson, R. Cossu and R. Stegmann, E & FN Spon, London: 1996.

The values for the three methane generation rate constants (k) initially used for modeling of LFG recovery at the Deonar Landfill, prior to adjustments for the results of the pump test, are as follows:

- Fast-decaying waste: 0.40 per year;
- Medium-decaying waste: 0.08 per year; and
- Slowly-decaying waste: 0.02 per year.

4.3 LANDFILL GAS MODELING RESULTS

The Project Team estimated both the LFG recovery potential at the landfill (essentially the amount of LFG the Project Team estimates to be available to be collected) and the expected LFG recovery rate (which accounts for the system coverage factor described above). As mentioned previously, the model results were compared with the results of the pump test to evaluate whether modifications to the model assumptions were required. The recovery projections and the comparison to the pump test results are described below.

LFG Recovery Potential

Using the assumptions outlined above, the Project Team estimates that the LFG recovery potential for the entire landfill in 2007 is 5,983 m^3/hour (3,522 cfm). When a model run is performed using waste disposal inputs for 1987 through 2006 only (the portion of the landfill evaluated in the pump test) and the above assumptions, the estimated LFG recovery potential is 5,937 m^3/hour (3,494 cfm). This estimate can be compared with the 9,586 m^3/hour (5,642 cfm) estimate for the total recovery potential for the same mass of waste (8,843,900 tonnes disposed from 1987 – 2006) based on the results of the pump test.

The results of the pump test are 61 percent higher than the model results, indicating that the model may underestimate recovery potential at the site. The Project Team's opinion is that the difference between the gas recovery rates projected via the pump test results and those projected via mathematical modeling is significant but does not warrant adjusting the modeling coefficients due to the following sources of uncertainty regarding the pump test results:

- Various problems with data recording described in Section 3 limited the time period with valid data to only four days (July 4-7).
- Steady state conditions may not have been established during the pump test.
- The volume of waste estimated to be within the influence of the pump test wells was less than one percent of the total waste deposited at the landfill (1.2% of waste deposited in 1970 – 2006). The very small fraction of waste included in the pump test may not be representative of the remainder of the landfill.

Due to these uncertainties, the Project Team chose a conservative approach and did not adjust the gas modeling approach according to the pump test results.

The model projects that the LFG recovery potential will be 6,883 m^3/hour (4,051 cfm) in 2008, and reach a maximum of 7,232 m^3/hour (4,257 cfm) in 2009. Potential recovery is projected to decline thereafter, reaching 6,384 m^3/hour (3,758 cfm) in 2010, 2,000 m^3/hour (1,177 cfm) in 2015, and 1,041 m^3/hour (613 cfm) in 2020.

Expected LFG Recovery (Mid-Range Scenario)

The Project Team assumes that LFG recovery at the landfill will begin in January 2009. Under the mid-range scenario, actual LFG recovery is projected to be 3,616 m^3/hour (2,168 cfm) in 2009 and 3,831 m^3/hour (2,255 cfm) in 2010. LFG recovery is projected to decline thereafter, reaching 2,912 m^3/hour (1,714 cfm) in 2011, 1,200 m^3/hour (706 cfm) in 2015, and 625 m^3/hour (368 cfm) in 2020.

Assuming that 100 percent of the amount of LFG recovered is available for use for electrical generation (i.e., not accounting for available engine capacities or parasitic loads), a 2.0 MW power plant could be supported from 2009 through 2015 and a 1.0 MW power plant could be supported from 2016 through 2020. Table 4-3 presents a summary of the projected potential LFG recovery rates, actual LFG recovery rates under the mid-range scenario, and corresponding maximum power plant sizes that could be supported by the projected amounts of LFG for 2009-2023.

Tables C-1 and C-2 in Appendix C provide detailed results of the LFG modeling, including the following:

- Estimated annual disposal rates and waste in place values.
- The projected LFG recovery potential through 2035 (in m^3/hour, cfm, and mmBtu/hour).
- The k values used for the fast, medium, and slowly decaying waste fractions.
- The Lo value calculated for all wastes and the Lo value used in the model runs for the organic portion of the waste only (equal to the calculated Lo value divided by the fraction of organic waste).
- Annual collection system coverage estimates under the low-range, mid-range, and high-range recovery scenarios.
- Predicted LFG recovery under each of the three scenarios after accounting for system coverage (in m^3/hour, cfm, and mmBtu/hour).
- The maximum electrical power plant size (in kW) that can be supported by the predicted LFG recovery rates under each scenario.
- Estimated emission reductions based on the predicted LFG recovery rates under each scenario (including emissions reduction from LFG combustion only, not including avoided emissions from electricity generation or fuel displacement).

The projected LFG recovery potential and predicted LFG recovery rates under the low-range, mid-range, and high-range scenarios are also shown graphically in Figure C-1 of Appendix C.

TABLE 4-3. SUMMARY OF LFG MODELING RESULTS UNDER THE MID-RANGE RECOVERY SCENARIO - DEONAR LANDFILL

Year	Potential LFG Recovery Rate (m^3/hour)	Estimated Collection System Coverage (%)	Projected Actual LFG Recovery Rate (m^3/hour)	Projected Actual LFG Recovery Rate (cfm)	Projected Maximum Project Capacity (MW)
2009	7,232	50%	3,616	2,128	6.0
2010	6,384	60%	3,831	2,255	6.3
2011	4,854	60%	2,912	1,714	4.8
2012	3,742	60%	2,245	1,322	3.7
2013	2,961	60%	1,777	1,046	2.9
2014	2,404	60%	1,442	849	2.4
2015	2,000	60%	1,200	706	2.0
2016	1,700	60%	1,020	600	1.7
2017	1,473	60%	884	520	1.5
2018	1,297	60%	778	458	1.3
2019	1,156	60%	694	408	1.1
2020	1,041	60%	625	368	1.0
2021	945	60%	567	334	0.9
2022	863	60%	518	305	0.9
2023	791	60%	475	279	0.8

SECTION 5.0
LANDFILL GAS COLLECTION AND UTILIZATION SYSTEM

5.1 INTRODUCTION

This section addresses the expected components of a full-scale LFG collection and utilization system. Based on the evaluation of the potential for LFG recovery at the Deonar Landfill in Section 4, the quantity of recoverable LFG appears to be sufficient for developing a project to utilize LFG as a fuel source for on-site electrical generation or for direct use in an off-site industrial facility. Electricity generated at the on-site LFG Energy (LFGE) facility can provide cost savings from avoided electricity purchases for on-site energy needs and revenues from the sale of unused electricity to the local power grid. The sale of LFG for direct use at a nearby industrial facility can generate significant revenues while requiring less initial facility costs than an LFGE facility.

In order to ensure the combustion of all collected LFG, and to maximize the amount of greenhouse gas (GHG) emission reductions achieved, any LFG not combusted in the LFGE facility will be burned in a flare. Additional GHG emission reductions can be realized from an LFGE project to the extent that fuel sources normally employed for electricity generation are displaced by the use of methane in the LFGE facility.

5.2 COLLECTION AND CONTROL SYSTEM COMPONENTS

The landfill does not currently have a landfill gas collection system. Therefore, the installation of an active LFG collection and control system including new wells and an enclosed flare is assumed for the cost analysis in this report. Also included is an analysis of the costs of an on-site LFGE facility, in the case of electricity generation.

Based observations of the area during the pump test, no industrial facility that could potentially serve as a suitable end user for LFG was observed to exist within several kilometers surrounding the landfill. This absence of any industrial facilities was confirmed by Greater Mumbai Municipal Corporation personnel. As a result, an analysis of the costs for a facility for delivering LFG to a nearby end-user (gas treatment skid and pipeline) was not prepared for this pre-feasibility study.

A disposal sequencing plan for the 51 hectare area was not available. The Project Team used a drawing showing 2005 surface contours, site observations during the pump test, and estimates of waste volumes following the transfer of wastes into the 51 hectare area, to estimate the areas that will contain wastes in 2010. This will include a 20-hectare top deck area and 20 hectares of side slopes (assuming 3 to 1 slopes). Areas outside of this 40 hectare footprint contain little or no wastes currently. Future disposal in these areas is assumed to be limited to non-LFG producing inorganic wastes.

To maximize LFG recovery rates, a comprehensive collection system should be installed in the top deck area of the landfill. Construction of the collection and flaring system and LFGE facility, including about 80 percent of the total number of extraction wells and associated lateral piping, is assumed to occur in 2008 to allow system start-up to occur in January 2009. The remaining wells and laterals are assumed to be installed in 2009 and go on-line in January 2010.

5.3 COLLECTION AND CONTROL SYSTEM CONSTRUCTION

Collection and Control System Components

The Project Team has the following general recommendations for the LFG collection system:

- Installation of 73 vertical extraction wells, or about 3 wells for every 4 acres of waste including side slopes (1.5 wells per acre of top deck area). Once available, operational data can be used to evaluate the well spacing by assessing flow rates from individual wells and the range of vacuum influence exerted by the wells.

  The pump test data indicated that the ROI of the extraction wells is approximately 30 meters. The Project Team used this site-specific ROI for developing the estimated number and depth of wells required. Well depths and estimated ROIs were adjusted to account for estimated future refuse depths (40 – 45 m).

  For budgetary purposes, the Project Team assumes that each extraction well would be fitted with a wellhead with a flow control valve and gas monitoring ports.

- Installation of approximately 7,050 meters of HDPE piping to connect the extraction wells with the flare station and LFG control plant. This piping includes main gas header piping designed to accommodate greater gas flow rates, and smaller lateral gas piping designed to connect the main header piping to the extraction wells.

  For budgetary purposes, the Project Team assumes that the header piping will be 300 to 500 mm in diameter, and the lateral piping will be 150 mm in diameter.

- Installation of a condensate management system. Condensate, which forms in the LFG piping network as the warm gas cools, can cause significant operational problems if not managed properly. The LFG collection system must be designed to accommodate the formation of condensate. The Project Team presumes that this will be accomplished with condensate sumps and drainage piping.

  For budgetary purposes, the Project Team assumes that two condensate sumps with pumps and 1400 m of 100 m HDPE piping for condensate discharge will be required.

- Installation of a blower and flaring station. The Project Team has assumed that the flaring system will be an enclosed-type flare so that exhaust components can be tested and quantified, if applicable, for registration of emission reductions (exhaust testing is not possible on candlestick-type open flares).

  For budgetary purposes, the Project Team has assumed that the system construction would include installing approximately 3,900 cubic meters per hour (2,300 cfm) of gas flaring capacity and blower equipment. This capacity is sufficient to handle the maximum projected LFG recovery rate (which will occur in 2010).

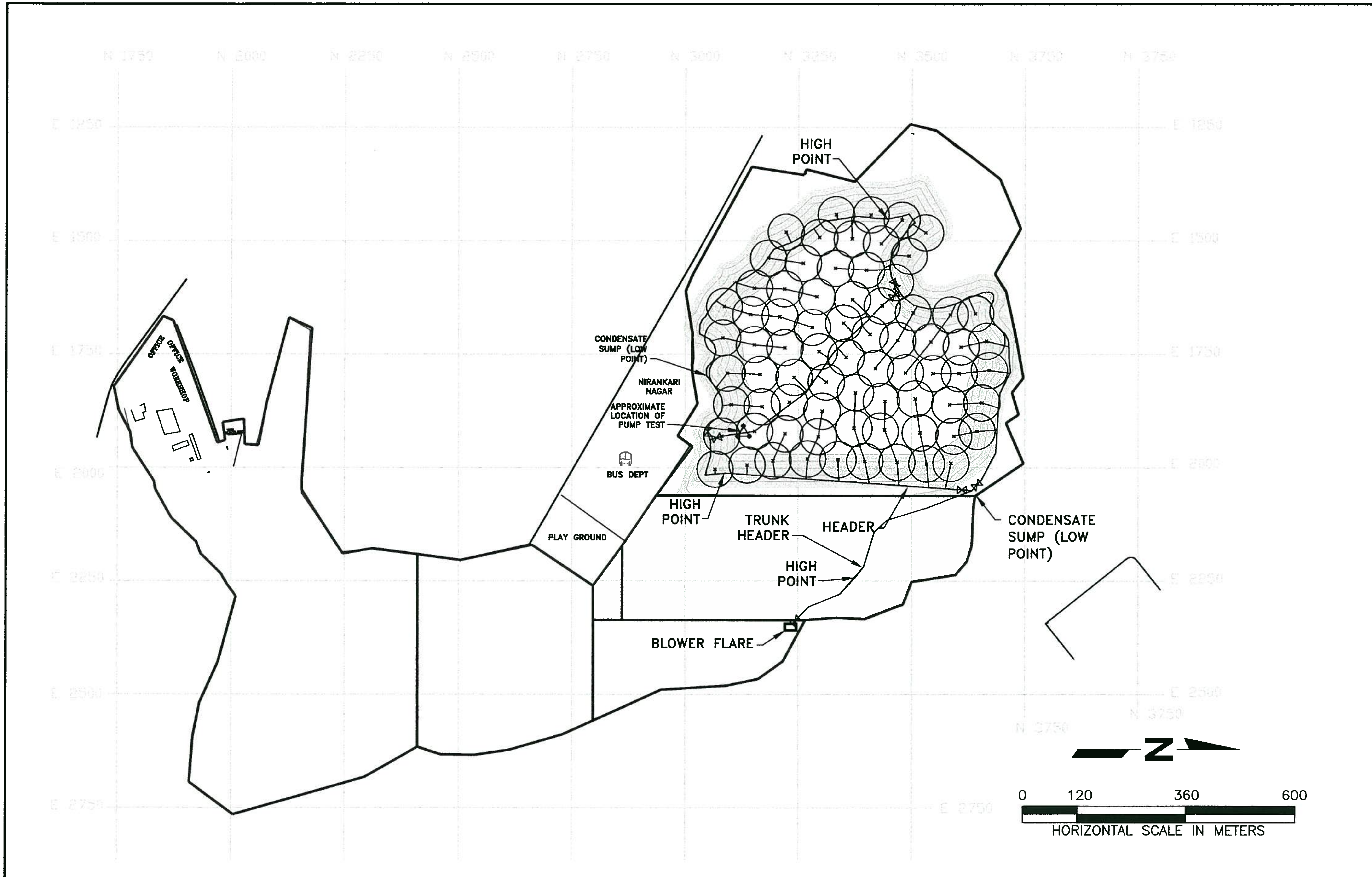
- Installation of an LFG utilization plant under the LFGE project option. For budgetary purposes, the Project Team has assumed that the initial system construction would occur in 2008 and include installing a two reciprocating engine generators each with a gross capacity of 820 kW, for a total capacity of 1.64 MW. The facility would begin operation in January 2009 and require approximately 1,000 m^3/hour (588 cfm) of LFG to operate at full capacity. The Project Team has assumed that some pre-treatment of the LFG will be required to remove moisture.

  Based on the LFG recovery projections provided in Section 4, sufficient LFG may be available in 2009 and 2010 to support a much larger LFGE facility (up to 6 MW). Declining LFG recovery rates after 2010 would support progressively smaller projects. Unless reciprocating engines can be moved to other projects after 2010, a more practical approach is to install only enough capacity that can be supported for an extended period. A 1.64 MW project can be supported for 8 years (through 2016). After 2016, one of the engines will need to be sold or moved to another project. The LFG recovery projections indicate that a 0.82 MW project can be supported through 2022. Starting in 2023, insufficient LFG will be available to support the 0.82 MW engine.

  Combustion gas turbines also have been used successfully for LFG-fired electric power generation. However, combustion turbines require a high-pressure fuel supply and typically two stages of gas compression, which results in a higher net heat rate (turbines do, however, generally have lower emission of combustion products [primarily NOx]). Based on these factors, the Project Team feels that reciprocating engines may be more appropriate for the Deonar LFGE project than turbines.

As noted above, all gas collection and flaring system components except for approximately 20 percent of the wells (14 wells) and associated lateral piping are assumed to be installed in 2008. The remaining wells and laterals are to be constructed in 2009.

Figure 5-1 shows the conceptual layout of the proposed system, including the existing pump test wells.



PROPOSED LFG COLLECTION SYSTEM

DEONAR LANDFILL
MUMBAI, INDIA

CLIENT:
US EPA LANDFILL METHANE OUTREACH PROGRAM
WASHINGTON, D.C.

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS
4222 E THOMAS RD, SUITE 310, PHOENIX, AZ 85018
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DSN. BY: RM
CHK BY: AS
APP. BY: AS

CADD FILE: Deonar LFG Plan
DATE: SEPTEMBER 2007
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FIGURE: 5-A

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CLIENT:
US EPA LANDFILL METHANE OUTREACH PROGRAM
WASHINGTON, D.C.

PROPOSED LFG COLLECTION SYSTEM
DEONAR LANDFILL
MUMBAI, INDIA

PROJ.NO. 02.205509.00 | DWN BY: TOM | Q/A RVW BY: AS
DSN. BY: RM | CHK BY: AS | APP. BY: AS

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CADD FILE: Deonar LFG Plan
DATE: SEPTEMBER 2007
SCALE:
FIGURE: 5-A

Collection System Maintenance

In order to maintain a high level of efficiency for the LFG collection system, and thus maximize LFG recovery rates and emission reductions, implementing a regular program of operation and maintenance of the gas collection system equipment will be necessary.

Following system start-up, operational data should be reviewed with respect to the system design criteria, and adjustments and repairs made as appropriate. Adjustments to the wellfield layout that are indicated by operating data may include the following:

- Wells that are unproductive or are damaged will need to be repaired or replaced.
- Areas of the landfill where monitoring data indicate a surplus of LFG may yield higher recovery rates if additional wells are installed.
- Ongoing monitoring of leachate levels in wells will indicate whether or not additional leachate pumps are required.

SECTION 6.0
EVALUATION OF PROJECT COSTS

For purposes of evaluating the project economics, the Project Team estimated the capital costs for development of an LFG recovery system and utilization project at the landfill. The Project Team also estimated the expected annual costs for collection system expansions and operation and maintenance of the LFG collection system.

6.1 LANDFILL GAS COLLECTION AND FLARING SYSTEM COSTS

Budgetary Construction Cost Estimate

The Project Team estimates the budgetary cost (in 2007 U.S. dollars prior to inflation) for the LFG collection and flaring system construction to be $2,961,000. These are costs associated with the proposed gas collection system described previously, including: gas extraction wells, header and lateral piping, condensate management, and installation of a blower and enclosed flaring station.

Table 6-1 presents a summary of the cost items. A more detailed outline of these costs and their associated quantities is presented in Appendix D.

TABLE 6-1: BUDGETARY COSTS FOR INITIAL LFG COLLECTION AND CONTROL SYSTEM

ITEM	TOTAL ESTIMATED COST (U.S. $)
Mobilization and project management	$160,000
Vertical extraction wells and wellheads (73 wells, 30 m average depth; 73 wellheads)	$601,000
Leachate pumping equipment (assumed required for 50% of the wells)	$185,000
Main gas header collection piping (assume about 3,550 m of HDPE ranging from 300-510 mm diameter and header valves (assume 6)	$748,000
Lateral piping (assume about 3,500 m of 150 mm diameter)	$161,000
Condensate management	$103,000
Blower and flaring equipment (enclosed flare)(1)	$375,000
Security fencing around landfill	$225,000
Engineering/contingency, and up-front (pre-operational) costs(2)	$403,000
TOTAL ESTIMATED COST	**$2,961,000**

Notes to Table 6-1:

1. Blower and flaring equipment includes: blower and flare, construction and site work, LFG measurement and recording equipment, flare start-up costs, and emissions testing.
2. Pre-operational costs cover up-front costs required for obtaining revenues from emission reductions, including: preparation of a Monitoring Plan and PDD, registration, validation, and legal fees.

Budgetary Estimate for Annual System Operation and Maintenance

The Project Team estimates the budgetary cost for annual operation and maintenance of the gas collection system to be approximately 7 percent of the construction costs (excluding security fence construction), or about $107,000 (U.S.) in 2009 and $117,000 in 2010 onward (prior to inflation adjustments). These costs include those associated with operation and maintenance of the existing collection system such as labor, testing equipment and parts, routine maintenance and system repairs, and limited replacement of existing wells and piping.

Other annual costs include those associated with the process of obtaining emission reductions, including registration fees, and monitoring and verification of the emission reductions. These costs are estimated to be $30,000 (U.S.) prior to inflation adjustments.

6.2 ELECTRICAL GENERATION PROJECT COSTS

The Project Team estimated the capital and annualized costs for implementing an LFG-fueled IC engine power plant. These costs are presented below.

Budgetary Estimate of Initial Plant Cost

The Project Team estimates that the capital cost for implementing an LFG-fueled 1.64 MW (gross) IC engine power plant to be approximately $2,486,000 (U.S.). This cost is additional to the LFG collection and flaring system. Table 6-2 presents a summary of the initial cost items. A more detailed outline of the initial costs and their associated quantities is presented in Appendix D.

Budgetary Estimate for Annual Operation and Maintenance

The Project Team estimates the budgetary cost for annual operation and maintenance of the power plant to be approximately 2 cents per kilowatt-hour of electricity output, or about $264,000 per year (based on a 1.64 MW plant capacity and prior to inflation adjustments). These costs include those associated with operation and maintenance of the power plant such as labor, testing equipment and parts, routine maintenance and repairs, and minor equipment replacement. Based on the LFG modeling results, the Project Team estimates that the plant capacity will need to be reduced to a 820 kW facility in 2017. After the end of the 15-year project period in 2022, the plant will need to be closed due to declining gas flows that will likely be insufficient to support the 820 kW engine..

Other annual costs such as wellfield operation and maintenance and project monitoring and emission reduction verification are included in the collection and flaring system annual operation and maintenance costs (see above).

TABLE 6-2: BUDGETARY COSTS FOR IC ENGINE POWER PLANT

ITEM	TOTAL ESTIMATED COST ($)
Mobilization and project management	$130,000
Plant construction/sitework (incl. piping)	$80,000
LFG measuring and recording equipment	$35,000
LFG pre-treatment and engine-generator for 820 kW LFG-fueled power plant *	$1,640,000
Plant substation (switchgear, main breaker, step-up transformer)	$200,000
Electrical Interconnection	$150,000
Source Test	$25,000
Engineering/Contingency (~10% of other costs)	$226,000
TOTAL ESTIMATED COST	**$2,486,000**

*Note to Table 6-2: Plant costs assume containerized engine generators with no other building for this equipment

SECTION 7.0
ECONOMIC EVALUATION

The economics of implementing a gas recovery and utilization project at the landfill were evaluated using the projected capital and annualized costs outlined in Section 6, and anticipated revenues described below.

For purposes of this evaluation, the Project Team assumed that the revenue streams include those associated with the sale and/or offset of electricity as well as revenues associated with GHG emissions reductions (i.e., the purchase of emissions reductions generated by the project).

Although not a utilization option, flaring collected LFG instead of using to generate electricity would produce significant environmental benefits and potential revenues from methane emissions reduction. Because emission reductions are typically the only source of revenues from a flaring only project, prices received for the emission reductions will largely determine economic feasibility. A flaring only project will produce lower revenues than an LFGE project but may be more economically feasible to develop at the landfill due to much lower capital investment costs.

A summary of the economic evaluation and assumptions is presented below. More detailed analysis of the economics is presented in Appendix E.

7.1 SUMMARY OF ASSUMPTIONS

The following general assumptions were used in evaluating the project economics:

- Two financing options were considered, one with no financing of capital expenditures (i.e., 100% initial application of capital expenditures), and one with financing of 75 percent of initial capital expenditures (25% equity investment).[5]

- Two scenarios for the pricing of emission reductions were considered, with sales prices of $8 and $10 per tonne of CO_2-equivalent (CO_2e) emission reductions. Two scenarios for the period over which these prices are received were evaluated – Scenario 1 which assumes revenues from 2009 through 2012, and Scenario 2 which assumes revenues from 2009 through 2018.

- The economic evaluation of the LFGE project covered a 15-year period (2008 – 2022). The economic evaluation of the flaring only project considered shorter time periods based on the reasoning that the project would not be likely to continue when there was no longer any source of revenue from emission reductions. The time periods considered for the flaring only project were therefore 2008 through 2012 (5 years) under Scenario 1 and 2008 through 2018 (11 years) under Scenario 2.

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[5] These percentages were chosen to reflect the typical range in the level of financing. Actual levels of financing will vary, and result in different estimates of financial feasibility, but the percentages chosen for this study should cover the likely range of effects produced by varying levels of project financing.

- An interest rate of 14 percent is used for the NPV analysis.
- An interest rate of 10 percent is used for the loan financing.
- Initial investment for the LFG collection and flaring system and power plant is assumed to occur in 2008. Loan payback period is assumed to be 10 years for the LFGE project, four years for the flaring only project under Scenario 1, and 10 years for the flaring only project under Scenario 2.
- For purposes of this analysis, payment of approximately 20 percent of the emission reduction revenue to the landfill owner for use of LFG was considered (represented by a rate of $0.67/MMBtu under the $8 per tonne emission reduction price scenario and $0.84/MMBtu under the $10 per tonne emission reduction price scenario). This is based on international experience that payment to the landfill owner for LFG typically ranges between 10 and 30 percent of the emission reduction revenue. If the landfill owner were to self develop the project (which is not typical) this value could be assumed to be zero.
- Future operation and maintenance and system expansion expenditures escalate at an annual rate of 3 percent.
- Under the power plant scenario, the following assumptions apply:
  - The power plant will consist of two 820 kW IC engines that will be operational from 2009 through 2016 and one 820 kW IC engines that will be operational from 2017 through 2022.
  - A 7 percent reduction in electricity output by the plant was assumed to account for parasitic load, and a plant capacity factor of 90 percent was assumed to account for routine and non-routine plant downtime. Landfill gas collected during plant downtime will be routed to the flare for combustion.
  - All electricity generated by the project is assumed to be sold off-site at a rate of $0.058 per kWhr.
- The gas collection system and flare will be operational from January 2009 through the end of the project period (2012, 2018, or 2022). The flare will be used to combust excess gas under the power plant scenario. Under the flaring only scenario, no capital or operating costs are incurred for the LFGE facility, and no revenues from electricity sales are received.

7.2 PROJECT EXPENDITURES

The following project expenditures were considered under the power plant scenario:

- Initial capital investment for LFG collection system, flare, and power plant occurs in 2008 (see Section 6).

- Capital investment for the completion of the LFG collection system occurs in 2009.
- Purchase of LFG from landfill owner.
- Annual cost for operation and maintenance of the LFG collection system, flare, and power plant (see Section 6).

The following project expenditures were considered under the flaring only scenario:

- Initial capital investment for LFG collection system and flare occurs in 2008 (see Section 6).
- Capital investment for the completion of the LFG collection system occurs in 2009.
- Purchase of LFG from landfill owner.
- Annual cost for operation and maintenance of the LFG collection system and flare (see Section 6).

7.3 PROJECT REVENUES

For the economic evaluation, the following project revenues were considered under the power plant scenario:

- The power plant produces a total of 12,292 MWh/year from 2009 through 2016 and 6,146 MWh/year from 2017 through 2022, which is sold to the power grid at a rate of U.S. $0.058/kWh. This price is estimated based on the most recent data on wholesale tariff rates set by the Maharashtra Electricity Regulatory Commission for the Maharashtra State Power Generation Company Limited (MSPGCL).[6]
- GHG emission reductions are sold at a rate of U.S. $8 or $10 per tonne CO_2e. The sale of emission reductions is considered for the years 2009 through 2012 under power plant Scenario 1 and 2009 through 2018 under power plant Scenario 2.
- LFG collected in excess of the power plant capacity, along with LFG collected during plant downtime is assumed to be combusted in the flare.

For the economic evaluation, the following project revenues were considered under the flaring only scenario:

- GHG emission reductions are sold at a rate of U.S. $8 or $10 per tonne CO_2e. The sale of emission reductions is considered for the years 2009 through 2012 under Flaring Only Scenario 1 and 2009 through 2018 under Flaring Only Scenario 2.

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[6] Source: Maharashtra Electricity Regulatory Commission, MERC Multiple Year Tariff Order for MSPGCL for Fiscal Year 2007-08 to Fiscal Year 2009-10.

- All collected LFG is assumed to be combusted in the flare.

Appendix E presents a more detailed summary of the anticipated project revenue streams.

7.4 SUMMARY OF ECONOMIC EVALUATIONS

Power Plant Scenario

Tables 7-1 and 7-2 present a summary of the results of the economic evaluation of the power plant project under Scenario 1 (emission reduction revenues through 2012) and Scenario 2 (emission reduction revenues through 2018), and provide a general comparison of the effects of the various financing and emission reductions sales price scenarios using the estimated net present value (NPV) and the internal rate of return (IRR) of the project. These values include revenues from both GHG emissions reductions and from LFG project utilization revenue. The results are presented on a pre-tax basis.

TABLE 7-1: SUMMARY OF ECONOMIC EVALUATION OF PROPOSED POWER PLANT PROJECT – SCENARIO 1: EMISSION REDUCTION REVENUES FROM 2009 THROUGH 2012

Project Period	Emission Reduction Price ($/tonne)	Equity Investments (%)	Net Present Value (x1,000 $)	Internal Rate of Return (%)
2008 - 2022	8	100	$151	15.2%
2008 - 2022	10	100	$869	21.4%
2008 - 2022	8	25	$673	57.7%
2008 – 2022	10	25	$1,390	90.4%

TABLE 7-2: SUMMARY OF ECONOMIC EVALUATION OF PROPOSED POWER PLANT PROJECT – SCENARIO 2: EMISSION REDUCTION REVENUES FROM 2009 THROUGH 2018

Project Period	Emission Reduction Price ($/tonne)	Equity Investments (%)	Net Present Value (x1,000 $)	Internal Rate of Return (%)
2008 - 2022	8	100	$1,118	21.3%
2008 - 2022	10	100	$2,167	28.3%
2008 – 2022	8	25	$1,639	66.0%
2008 – 2022	10	25	$2,689	95.4%

As shown in Tables 7-1 and 7-2, economics for the LFGE project appear attractive under all emission reduction price and financing scenarios evaluated. Increases in emission reduction price, the extension of emission reduction revenues through 2018, and project financing all have a positive impact on NPV and IRR values.

Flaring Only Scenario

Tables 7-3 and 7-4 present a summary of the results of the economic evaluation for the flaring only projects under Scenario 1 (emission reduction revenues through 2012) and Scenario 2 (emission reduction revenues through 2018). The tables present a general comparison of the effects of various financing and emission reduction sales price scenarios, using the estimated NPV and IRR of the project. These values include revenues from GHG emissions reductions. The results are presented on a pre-tax basis.

TABLE 7-3. SUMMARY OF ECONOMIC EVALUATION OF THE PROPOSED FLARING ONLY PROJECT – SCENARIO 1: EMISSION REDUCTION REVENUES FROM 2009 THROUGH 2012

Project Period	Emission Reduction Price ($/tonne)	Equity Investments (%)	Net Present Value (x1,000 $)	Internal Rate of Return (%)
2008 – 2012	8	100	$144	17.1%
2008 – 2012	10	100	$920	33.0%
2008 – 2012	8	25	$291	41.4%
2008 – 2012	10	25	$1,067	100.6%

As shown in Table 7-3, economics for the flaring project appear attractive under all emission reduction price and financing scenarios when revenues from emission reductions are assumed to occur only through 2012 (Scenario 1). Project financing appears to cause moderate increases in NPV and very large increases in IRR.

TABLE 7-4. SUMMARY OF ECONOMIC EVALUATION OF THE PROPOSED FLARING ONLY PROJECT – SCENARIO 2: EMISSION REDUCTION REVENUES FROM 2008 THROUGH 2018

Project Period	Emission Reduction Price ($/tonne)	Equity Investments (%)	Net Present Value (x1,000 $)	Internal Rate of Return (%)
2008 – 2018	8	100	$698	25.0%
2008 – 2018	10	100	$1,703	39.6%
2008 – 2018	8	25	$973	99.0%
2008 – 2018	10	25	$1,977	152.0%

As shown in Table 7-4, economics for the flaring project appear attractive under all emission reduction price and financing scenarios when revenues from emission reductions are assumed to occur through 2018 (Scenario 2). As in Scenario 1, project financing appears to cause moderate increases in NPV and very large increases in IRR.

Summary of Economic Evaluation Results

As shown in Tables 7-1 through 7-4, both an LFGE and a flaring project appear to be economically attractive under all scenarios analyzed for emission reduction prices, time period for receiving emission reductions, and financing. When LFGE and flaring only projects are compared using the same assumptions (i.e. matching scenarios), they yield similar NPV and IRR values. LFGE has moderately higher NPV values under most scenarios, while flaring only has slightly higher IRR values under most scenarios, and significantly higher when revenues from emission reductions continue through 2018.

The Deonar Landfill is projected to have high initial LFG recovery rates until 2010, after which LFG recovery is projected to decline very rapidly due to high waste decay rates. Despite these declines in LFG flows, project economic feasibility is helped by the delivery of significant revenues early in the project period. This observation emphasizes the importance of rapid project development. Any delays in achieving the project development schedule assumed in this study can have serious negative impacts on project economics.

SECTION 8
ENVIRONMENTAL BENEFITS

8.1 GREENHOUSE GAS EMISSIONS REDUCTIONS

Methane from solid waste disposal on land is one of the major sources of greenhouse gas (GHG) emissions. Its capture and oxidation to carbon dioxide results in an environmental benefit. This benefit may be measured and traded under a number of different emission reduction trading schemes world wide.

In order to qualify for trading of emission reductions, normally a project must be able to prove that there is no requirement under law, or mandated by waste disposal licenses or other regulations, to control the emission of the particular greenhouse gas relating to the project. This appears to be the case at Deonar Landfill.

While flaring is the normal method for thermal oxidation of LFG, any process which prevents the emission of methane to the atmosphere would also qualify for tradable emission reductions. The carbon dioxide created by the thermal oxidation of methane is considered to be "short cycle" and the product of the normal carbon cycle; and therefore does not need to be accounted for under the current methodologies.

The Project Team estimated the potential GHG emission reductions associated with an LFGE project or flaring only project at the landfill (in metric tons of methane/year and metric tonnes of CO_2 equivalent/year using a methane/CO_2 equivalency factor of 21) for the evaluation period. Table 8-1 presents a summary of the GHG emission reduction projections for the period 2009 through 2022. A flaring only project would achieve the direct emission reductions shown in the table. A LFGE project would achieve both the direct and indirect emission reductions.

The projections shown in Table 8-1 assume that all of the LFG recovered through the proposed projects is combusted, and includes additional greenhouse gas emission reductions associated with the displacement of other fuels sources through electricity generation.

8.2 ENVIRONMENTAL BENEFITS FROM LANDFILL GAS UTILIZATION

Environmental benefits resulting from LFG utilization include indirect emission reductions from the displacement of conventional fuels as well as direct emission reductions from the combustion of LFG at the power plant. The environmental benefits can be described in a variety of ways which are listed below.

TABLE 8-1: SUMMARY OF PROJECTED GHG EMISSION REDUCTIONS

Year	Direct GHG Emission Reductions (Tonnes Co_2e/Year)	Indirect GHG Emission Reductions (Tonnes Co_2e/Year)	Total GHG Emission Reductions (Tonnes Co_2e/Year)
2009	221,138	13,152	234,290
2010	234,271	13,152	247,423
2011	178,105	13,152	191,257
2012	137,326	13,152	150,478
2013	108,651	13,152	121,803
2014	88,207	13,152	101,359
2015	73,375	13,152	86,527
2016	62,389	13,152	75,541
2017	54,061	6,576	60,637
2018	47,588	6,576	54,164
2019	42,425	6,576	49,001
2020	38,204	6,576	44,780
2021	34,670	6,576	41,246
2022	31,651	6,576	38,227
TOTALS FOR PERIOD	**1,352,061**	**144,672**	**1,496,733**

For a power plant with a capacity of 1.64 MW, annual environmental benefits include a reduction of 3,190 metric tonnes of methane from LFG combustion, which is equivalent to 60,777 tonnes of CO_2 emissions (direct benefit), and the displacement of 9,408 tonnes of CO_2 emissions from conventional energy sources (indirect benefit). These benefits would be reduced by 50 percent after 2016 when the power plant capacity is reduced to 820 kW. Direct benefits would also include flaring of LFG not used at the LFGE facility. Based on the projected LFG recovery rates, an average of 4,599 tonnes of methane per year (96,576 tonnes CO_2e) will be combusted during the 22 year project period. After adding the average indirect benefits during the project period (6,706 tonnes per year of CO_2 reduction) average annual emission reductions are equivalent to 103,282 tonnes of CO_2. The combined total benefits are equivalent to the following:

- Removing emissions equivalent to 19,973 cars.
- Planting 28,462 acres of forest.
- Offsetting the use of 511 railcars of coal.
- Preventing the use of 242,228 barrels of oil.
- Powering 1,050 homes per year.

SECTION 9
CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS AND RECOMMENDATIONS

The Deonar Landfill is a large landfill that has operated as a historic dump site since 1927. It currently has about 10 million tonnes of waste in place and is projected to partially close in 2010 after receiving a total of about 12.7 million tonnes of waste. Potential revenues from electricity sales and emission reductions that would result from an LFGE project would be sufficient to offset the estimated capital, operating, and maintenance costs of a project under all emission reduction and financing scenarios analyzed. Similarly, potential revenues from emission reductions that would result from a flaring project also were found to be sufficient to offset the estimated capital, operating, and maintenance costs under all emission reduction and financing scenarios analyzed.

Both the NPV and the IRR values were positive for all scenarios evaluated under both the LFGE and flaring project options. The highest NPV value was achieved under the LFGE project when an emission reduction price of $10 per tonne is received through 2018 with project financing. The highest IRR value was achieved under the flaring only project when an emission reduction price of $10 per tonned is received through 2018 with project financing. In general, project economics are favored by the high revenues early in the project period. This observation emphasizes the importance of rapid project development. Any delays in achieving the project development schedule assumed in this study can have serious negative impacts on project economics.

The results of this study indicate that further evaluation of either an LFGE project or LFG flaring project beyond the scope of this pre-feasibility study is warranted. Recommended next steps in the process of moving towards project development would include the following:

- Continue looking for interested parties for the development of an LFG project.
- Prepare detailed LFG collection and flaring system design and cost estimates.
- Conduct a detailed evaluation of a LFGE electric generation project including electric sector regulations as they apply to small renewable generators, interconnect requirements, and tax implications.
- Conduct a detailed evaluation of potential revenues from emission reductions and from electricity sales, and the revenue sharing expectations of the City of Mumbai.

Note that the economic analysis essentially indicates the cash flow to the project developer (assumed to be a third party). For this evaluation, the revenue to the Greater Mumbai Municipal Corporation is represented by the sale of LFG at $0.67 or $0.84 per mmBtu (for emission reduction prices of $8 or $10, respectively). Adjustments to this rate have a significant impact on the cash flow to the developer. At this pre-feasibility phase, negotiable parameters such as this cannot be further refined.

The results of this study are based on limited contingency factors included in the cost estimates for capital and O&M. Further refinement of some of the assumptions used in the economic evaluation possibly may change the results of this pre-feasibility analysis.

APPENDIX A

PUMP TEST WELL LOGS

SCS ENGINEERS
Environmental Consultants
11260 Roger Bacon Drive
Reston, Virginia 20190-5282
703 471-6150 FAX 703 471-6676

Deonar Landfill
Mumbai, India
SCS File No. 02205509.00

WELL CONSTRUCTION

Date Completed	: 5/13/2007
Hole Diameter	: 12"
Drilling Method	: Air Rotary
Stone	: Washed 1/2" - 1"

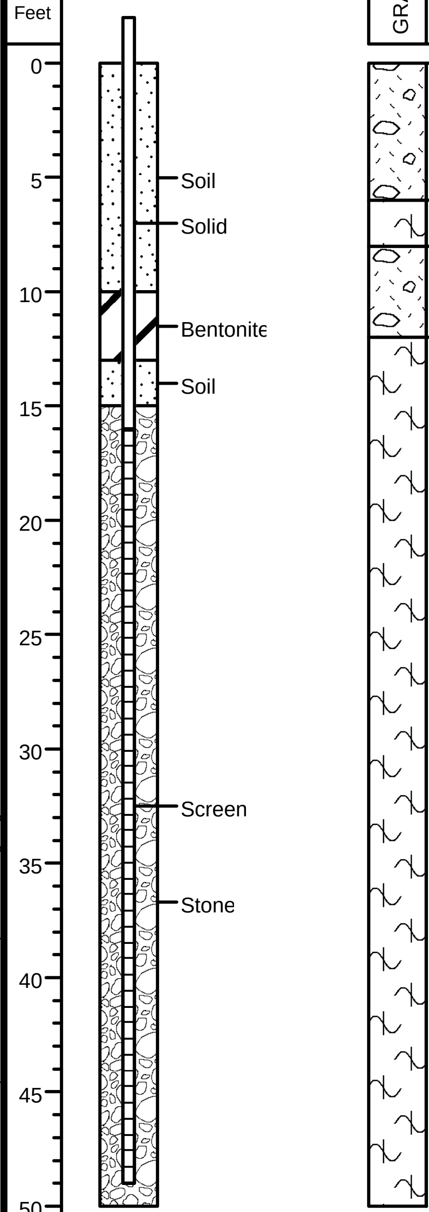
WELL CASING

Material	: Sch. 80 PVC
Diameter	: 4"
Joints	: Glued/ Screwed
	: 4" coupling

LOG OF BORING Well-01

Date Started:	: 5/12/2007
Company	: Jineshwar
Company Rep	: Bhauash Shah
Logged By	: SCS/ R. Moeller

Well: Well-01
Elev.:



DESCRIPTION

SOIL, SILT, ROCK, dry

WASTE, plastic, dry

SOIL, WASTE, dry

FEW CUTTINGS TO SURFACE

Leachate not encountered during drilling or well installatic

End of Boring = 50' below grade.

09-24-2007 q:\lfg\02205509.00\Pump Test\Mumbai Pump Test\Boring Logs\Well-01.bor

SCS ENGINEERS

Environmental Consultants
11260 Roger Bacon Drive
Reston, Virginia 20190-5282
703 471-6150 FAX 703 471-6676

Deonar Landfill
Mumbai, India
SCS File No. 02205509.00

WELL CONSTRUCTION	
Date Completed	: 5/13/2007
Hole Diameter	: 12"
Drilling Method	: Air Rotary
Stone	: Washed 1/2" - 1"
WELL CASING	
Material	: Sch. 80 PVC
Diameter	: 4"
Joints	: Glued/ Screwed
	: 4" coupling

LOG OF BORING Well-02

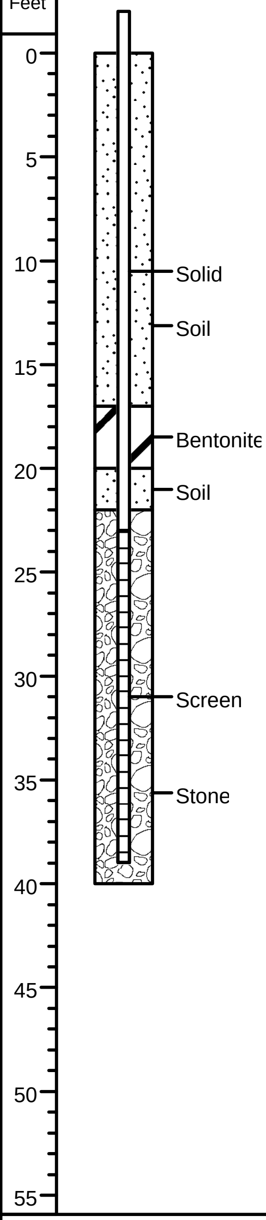
Date Started:	: 5/12/2007
Company	: Jineshwar
Company Rep	: Bhauash Shah
Logged By	: SCS/ R. Moeller

Depth in Feet

Well: Well-02
Elev.:

GRAPHIC

DESCRIPTION



FEW CUTTINGS
SOIL, WASTE, organics, plastics, dry

WASTE, moist from 10' to 20'

Borhole collapsed at 35', rebored twice to full depth
using air to exhaust waste.

Final depth 39'

Borehole drilled to 55'

End of Boring = 40' below grade.

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Reston, Virginia 20190-5282
703 471-6150 FAX 703 471-6676

Deonar Landfill
Mumbai, India
SCS File No. 02205509.00

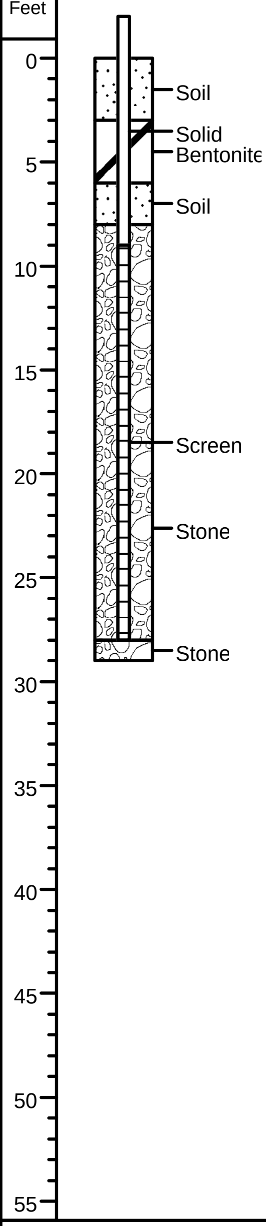
WELL CONSTRUCTION	
Date Completed	: 5/13/2007
Hole Diameter	: 12"
Drilling Method	: Air Rotary
Stone	: Washed 1/2" - 1"
WELL CASING	
Material	: Sch. 80 PVC
Diameter	: 4"
Joints	: Glued/ Screwed
	: 4" coupling

LOG OF BORING Well-03

Date Started:	: 5/12/2007
Company	: Jineshwar
Company Rep	: Bhauash Shah
Logged By	: SCS/ R. Moeller

Depth in Feet

Well: Well-03
Elev.:



GRAPHIC

DESCRIPTION

SOIL, SILT, ROCK

WASTE, plastic

Few cuttings returned to surface due to drilling method,
applied air pressure could not force out heavy decompsed
organic cuttings to surface.

Borehole redrilled three times to between 50' and 55',
each time borehole collapsed to 19' to 28' deep.

Leachate not encountered during drilling
or well installation

End of Boring = 28' below grade.

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APPENDIX B

PUMP TEST MONITORING DATA

WELLS

Well 1

Date	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]	Velocity [fpm]	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	56.3	1.9	-7.5	85.0	535	41.4	21.8
4-Jul-07	58.0	1.4	-8.0	85.0	610	47.2	25.6
4-Jul-07	64.9	2.1	-8.2	84.0	563	43.6	26.5
5-Jul-07	50.8	3.8	-8.1	79.0	632	48.9	23.5
5-Jul-07	60.9	0.8	-8.2	74.0	579	44.8	26.0
5-Jul-07	69.6	1.9	-8.4	81.0	567	43.9	28.7
6-Jul-07	56.3	1.9	-7.5	85.0	563	43.6	23.0
6-Jul-07	59.0	1.1	-8.2	86.0	550	42.6	23.4
6-Jul-07	56.0	0.1	-7.2	84.0	520	40.2	21.2
7-Jul-07	62.0	2.1	-8.1	84.0	370	28.6	16.6
7-Jul-07	60.9	2.0	-7.8	84.0	350	27.1	15.5
7-Jul-07	52.0	4.5	-8.6	83.0	450	34.8	17.0
Averages	55.2	2.0	-8.0	82.8	524	40.5	22.4

Well 2

Date	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]	Velocity [fpm]	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	50.2	2.3	-14.3	85	306	23.7	10.9
4-Jul-07	48.6	3.9	-13.8	86	408	31.6	14.1
4-Jul-07	62.9	0.5	-14.7	85	375	29.0	16.8
5-Jul-07	64.8	0.5	-13.6	77	463	35.8	21.7
5-Jul-07	64.4	0.7	-14.0	69	396	30.6	18.7
5-Jul-07	63.6	0.2	-13.2	82	403	31.2	18.4
6-Jul-07	50.2	2.3	-14.3	85	336	26.0	12.0
6-Jul-07	62.0	1.6	-13.6	87	325	25.1	14.3
6-Jul-07	63.0	1.5	-14.5	85	315	24.4	14.1
7-Jul-07	69.5	0.3	-13.2	83	430	33.3	21.4
7-Jul-07	71.3	0.3	-12.9	85	400	30.9	20.4
7-Jul-07	71.1	0.3	-13.0	86	340	26.3	17.2
Averages	57.5	1.2	-13.8	82.9	375	29.0	16.7

Well 3

Date	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]	Velocity [fpm]	LFG Flow [acfm]	Methane Flow [scfm]
4-Jul-07	42.0	4.3	-2.6	82.0	510	39.5	15.8
4-Jul-07	39.1	4.3	-2.3	86.0	605	46.8	17.3
4-Jul-07	32.1	6.0	-2.1	85.0	538	41.6	12.7
5-Jul-07	44.1	3.5	-5.8	77.0	596	46.1	19.4
5-Jul-07	40.6	3.8	-5.8	71.0	602	46.6	18.3
5-Jul-07	37.6	4.7	-10.0	80.0	586	45.3	16.0
6-Jul-07	42.0	4.3	-2.6	82.0	310	24.0	9.6
6-Jul-07	30.2	8.0	-5.3	85.0	350	27.1	7.7
6-Jul-07	32.2	6.0	-5.1	84.0	445	34.4	10.5
7-Jul-07	36.6	5.8	-8.6	82.0	425	32.9	11.3
7-Jul-07	33.0	7.5	-8.6	84.0	510	39.5	12.2
7-Jul-07	32.9	8.1	-8.8	85.0	475	36.7	11.3
Averages	35.2	5.5	-5.6	81.9	496	38.4	13.5

WELL 1 PROBES

Date	Time	Vacuum at Adjacent EW	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]
Probe 1-1 (5 meters)						
4-Jul-07	12.00		53.9	0.1	0.0	89.0
4-Jul-07	15.00		64.4	0.2	0.0	86.0
4-Jul-07	19.00		62.5	0.3	0.0	87.0
5-Jul-07	12.00		65.4	0.2	0.0	78.0
5-Jul-07	15.00		65.7	0.0	0.0	76.0
5-Jul-07	19.00		64.5	0.1	0.0	82.0
6-Jul-07	12.00		53.9	0.1	0.0	89.0
6-Jul-07	15.00		68.6	0.2	0.0	87.0
6-Jul-07	19.00		65.6	0.1	0.1	85.0
7-Jul-07	12.00		69.5	0.2	0.0	84.0
7-Jul-07	15.00		70.8	0.2	0.0	85.0
7-Jul-07	19.00		70.9	0.2	0.0	86.0
Probe 1-2 (15 meters)						
4-Jul-07	12.00		59.6	0.0	0.6	89.0
4-Jul-07	15.00		63.8	0.0	0.4	87.0
4-Jul-07	19.00		62.8	0.2	0.4	87.0
5-Jul-07	12.00		65.8	0.1	0.0	77.0
5-Jul-07	15.00		66.2	0.0	-0.3	76.0
5-Jul-07	19.00		65.0	0.0	0.5	83.0
6-Jul-07	12.00		59.6	0.0	0.6	89.0
6-Jul-07	15.00		69.1	0.1	0.3	87.0
6-Jul-07	19.00		69.0	0.1	0.2	86.0
7-Jul-07	12.00		67.7	0.1	0.4	84.0
7-Jul-07	15.00		71.5	0.1	0.4	86.0
7-Jul-07	19.00		72.2	0.2	0.4	87.0
Probe 1-3 (25 meters)						
4-Jul-07	12.00		32.4	7.1	0.1	86.0
4-Jul-07	15.00		47.3	4.8	0.0	87.0
4-Jul-07	19.00		38.4	7.6	0.0	85.0
5-Jul-07	12.00		68.1	2.9	-1.8	77.0
5-Jul-07	15.00		65.8	3.8	-1.2	76.0
5-Jul-07	19.00		54.7	3.6	-0.8	82.0
6-Jul-07	12.00		32.4	7.1	0.1	86.0
6-Jul-07	15.00		67.3	1.7	0.0	87.0
6-Jul-07	19.00		65.3	1.6	0.0	85.0
7-Jul-07	12.00		66.7	1.5	0.0	84.0
7-Jul-07	15.00		65.2	3.3	0.0	85.0
7-Jul-07	19.00		66.9	2.2	0.0	88.0

WELL 2 PROBES

Date	Time	Vacuum at Adjacent EW	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]
Probe 2-1 (5 meters)						
4-Jul-07	12.00		73.5	0.2	0.0	85.0
4-Jul-07	15.00		75.3	0.2	0.1	88.0
4-Jul-07	19.00		74.5	0.2	0.2	88.0
5-Jul-07	12.00		78.2	0.1	0.0	76.0
5-Jul-07	15.00		76.9	0.0	0.1	70.0
5-Jul-07	19.00		79.4	0.0	0.2	83.0
6-Jul-07	12.00		73.5	0.2	0.0	85.0
6-Jul-07	15.00		76.6	0.2	0.1	87.0
6-Jul-07	19.00		73.3	0.2	0.1	85.0
7-Jul-07	12.00		76.1	0.1	0.1	84.0
7-Jul-07	15.00		77.4	0.1	0.1	86.0
7-Jul-07	19.00		76.6	0.1	0.1	87.0
Probe 2-2 (15 meters)						
4-Jul-07	12.00		63.3	0.0	0.1	82.0
4-Jul-07	15.00		65.2	0.0	0.2	88.0
4-Jul-07	19.00		65.7	0.0	0.0	88.0
5-Jul-07	12.00		68.8	0.0	0.0	77.0
5-Jul-07	15.00		68.1	0.0	0.1	71.0
5-Jul-07	19.00		67.1	0.0	0.0	83.0
6-Jul-07	12.00		63.3	0.0	0.1	82.0
6-Jul-07	15.00		70.3	0.1	0.0	89.0
6-Jul-07	19.00		70.1	0.1	0.0	87.0
7-Jul-07	12.00		73.5	0.0	0.0	84.0
7-Jul-07	15.00		73.1	0.1	0.0	86.0
7-Jul-07	19.00		71.8	0.1	0.0	86.0
Probe 2-3 (25 meters)						
4-Jul-07	12.00		82.8	0.0	0.1	81.0
4-Jul-07	15.00		83.7	0.0	0.4	89.0
4-Jul-07	19.00		83.7	0.1	0.2	87.0
5-Jul-07	12.00		83.9	0.0	0.2	77.0
5-Jul-07	15.00		83.3	0.0	0.2	72.0
5-Jul-07	19.00		82.2	0.0	0.2	81.0
6-Jul-07	12.00		82.8	0.0	0.1	81.0
6-Jul-07	15.00		76.6	0.1	0.0	88.0
6-Jul-07	19.00		74.6	0.1	0.0	86.0
7-Jul-07	12.00		74.3	0.0	0.0	83.0
7-Jul-07	15.00		73.9	0.0	0.0	86.0
7-Jul-07	19.00		74.0	0.0	0.0	86.0

WELL 3 PROBES

Date	Time	Vacuum at Adjacent EW	Methane [%]	Oxygen [%]	Pressure [in. WC]	Temp [F]
Probe 3-1 (5 meters)						
4-Jul-07	12.00		0.8	17.4	-0.1	84.0
4-Jul-07	15.00		0.7	17.5	-0.1	90.0
4-Jul-07	19.00		0.8	17.8	-0.2	86.0
5-Jul-07	12.00		1.1	17.7	-0.5	78.0
5-Jul-07	15.00		1.0	17.7	-1.0	72.0
5-Jul-07	19.00		1.1	17.7	-1.0	82.0
6-Jul-07	12.00		0.8	17.4	-0.1	84.0
6-Jul-07	15.00		1.6	17.6	-0.6	86.0
6-Jul-07	19.00		0.5	17.5	-0.5	85.0
7-Jul-07	12.00		2.0	17.7	-0.6	83.0
7-Jul-07	15.00		2.1	17.8	-0.3	86.0
7-Jul-07	19.00		2.0	17.9	-0.4	85.0
Probe 3-2 (15 meters)						
4-Jul-07	12.00		67.4	0.6	0.0	85.0
4-Jul-07	15.00		65.9	0.6	0.0	90.0
4-Jul-07	19.00		66.8	0.7	0.0	86.0
5-Jul-07	12.00		69.9	0.6	0.0	78.0
5-Jul-07	15.00		69.4	0.5	0.0	71.0
5-Jul-07	19.00		69.7	0.5	0.0	82.0
6-Jul-07	12.00		67.4	0.6	0.0	85.0
6-Jul-07	15.00		73.8	0.7	0.0	85.0
6-Jul-07	19.00		72.6	0.6	0.0	85.0
7-Jul-07	12.00		74.8	0.7	0.0	83.0
7-Jul-07	15.00		75.2	0.7	0.0	86.0
7-Jul-07	19.00		75.4	0.7	0.0	87.0
Probe 3-3 (25 meters)						
4-Jul-07	12.00		0.6	18.1	0.0	86.0
4-Jul-07	15.00		0.6	18.0	0.0	88.0
4-Jul-07	19.00		0.6	18.3	-0.1	86.0
5-Jul-07	12.00		0.9	18.3	0.0	79.0
5-Jul-07	15.00		0.9	18.2	0.0	71.0
5-Jul-07	19.00		0.8	18.1	0.0	82.0
6-Jul-07	12.00		0.6	18.1	0.0	86.0
6-Jul-07	15.00		1.4	18.1	-0.2	86.0
6-Jul-07	19.00		0.7	17.1	-0.1	86.0
7-Jul-07	12.00		2.0	18.2	-0.2	83.0
7-Jul-07	15.00		2.0	18.2	-0.2	86.0
7-Jul-07	19.00		2.1	18.1	-0.3	86.0

BLOWER

Date	Time	Methane (est. based on well data) [%]	Velocity [fpm]	LFG Flow [acfm]	Est. LFG Flow @ 50% Methane [acfm]	Est. Methane Flow [acfm]
4-Jul-07	12.00	49.5	745	57.6	57.1	28.5
4-Jul-07	15.00	48.6	856	66.2	64.3	32.2
4-Jul-07	19.00	53.3	829	64.1	68.4	34.2
5-Jul-07	12.00	53.2	998	77.2	82.2	41.1
5-Jul-07	15.00	55.3	886	68.5	75.8	37.9
5-Jul-07	19.00	56.9	923	71.4	81.3	40.7
6-Jul-07	12.00	49.5	787	60.9	60.3	30.1
6-Jul-07	15.00	50.4	865	66.9	67.5	33.7
7-Jul-07	12.00	56.0	698	54.0	60.5	30.3
7-Jul-07	15.00	55.1	769	59.5	65.5	32.8
7-Jul-07	19.00	52.0	702	54.3	56.5	28.2
PUMP TEST AVERAGES:		**52.7**	**823**	**63.7**	**67.2**	**33.6**

APPENDIX C

LFG RECOVERY PROJECTIONS

TABLE C-1
PROJECTION OF POTENTIAL LANDFILL GAS RECOVERY AND RECOVERY UNDER MID-RANGE SCENARIO
DEONAR LANDFILL, MUMBAI, INDIA

						MID-RANGE RECOVERY SCENARIO							
Year	Disposal Rate (Mg/yr)	Refuse In-Place (Mg)	LFG Recovery Potential (m^3/hr)	(cfm)	(mmBtu/hr)	Collection System Coverage (%)	Predicted LFG Recovery (m^3/hr)	(cfm)	(mmBtu/hr)	Maximum Power Plant Capacity* (MW)	Baseline LFG Flow (m^3/hr)	Methane Emissions Reduction Estimates** (tonnes CH4/yr)	(tonnes CO_2eq/yr)
1970	27,700	27,700	0	0	0.0	0%	0	0	0.0	0.0	0	0	0
1971	30,470	58,170	71	42	1.3	0%	0	0	0.0	0.0	0	0	0
1972	33,520	91,690	112	66	2.0	0%	0	0	0.0	0.0	0	0	0
1973	36,870	128,560	148	87	2.6	0%	0	0	0.0	0.0	0	0	0
1974	40,560	169,120	181	107	3.2	0%	0	0	0.0	0.0	0	0	0
1975	44,620	213,740	213	125	3.8	0%	0	0	0.0	0.0	0	0	0
1976	49,080	262,820	245	144	4.4	0%	0	0	0.0	0.0	0	0	0
1977	53,990	316,810	278	164	5.0	0%	0	0	0.0	0.0	0	0	0
1978	59,390	376,200	312	184	5.6	0%	0	0	0.0	0.0	0	0	0
1979	65,330	441,530	349	206	6.2	0%	0	0	0.0	0.0	0	0	0
1980	71,860	513,390	389	229	7.0	0%	0	0	0.0	0.0	0	0	0
1981	79,050	592,440	432	255	7.7	0%	0	0	0.0	0.0	0	0	0
1982	86,960	679,400	479	282	8.6	0%	0	0	0.0	0.0	0	0	0
1983	95,660	775,060	531	312	9.5	0%	0	0	0.0	0.0	0	0	0
1984	105,200	880,260	587	345	10.5	0%	0	0	0.0	0.0	0	0	0
1985	115,700	995,960	648	381	11.6	0%	0	0	0.0	0.0	0	0	0
1986	127,300	1,123,260	715	421	12.8	0%	0	0	0.0	0.0	0	0	0
1987	140,000	1,263,260	789	465	14.1	0%	0	0	0.0	0.0	0	0	0
1988	154,000	1,417,260	870	512	15.6	0%	0	0	0.0	0.0	0	0	0
1989	169,400	1,586,660	959	565	17.1	0%	0	0	0.0	0.0	0	0	0
1990	186,300	1,772,960	1,057	622	18.9	0%	0	0	0.0	0.0	0	0	0
1991	204,900	1,977,860	1,164	685	20.8	0%	0	0	0.0	0.0	0	0	0
1992	225,400	2,203,260	1,282	754	22.9	0%	0	0	0.0	0.0	0	0	0
1993	247,900	2,451,160	1,411	831	25.2	0%	0	0	0.0	0.0	0	0	0
1994	272,700	2,723,860	1,554	914	27.8	0%	0	0	0.0	0.0	0	0	0
1995	300,000	3,023,860	1,710	1,007	30.6	0%	0	0	0.0	0.0	0	0	0
1996	330,000	3,353,860	1,882	1,108	33.6	0%	0	0	0.0	0.0	0	0	0
1997	363,000	3,716,860	2,072	1,219	37.0	0%	0	0	0.0	0.0	0	0	0
1998	399,300	4,116,160	2,280	1,342	40.7	0%	0	0	0.0	0.0	0	0	0
1999	439,200	4,555,360	2,509	1,477	44.8	0%	0	0	0.0	0.0	0	0	0
2000	483,100	5,038,460	2,760	1,625	49.3	0%	0	0	0.0	0.0	0	0	0
2001	531,400	5,569,860	3,037	1,788	54.3	0%	0	0	0.0	0.0	0	0	0
2002	584,500	6,154,360	3,341	1,967	59.7	0%	0	0	0.0	0.0	0	0	0
2003	643,000	6,797,360	3,676	2,164	65.7	0%	0	0	0.0	0.0	0	0	0
2004	707,300	7,504,660	4,044	2,380	72.3	0%	0	0	0.0	0.0	0	0	0
2005	765,000	8,269,660	4,439	2,613	79.3	0%	0	0	0.0	0.0	0	0	0
2006	1,095,000	9,364,660	5,056	2,976	90.3	0%	0	0	0.0	0.0	0	0	0
2007	1,205,000	10,569,660	5,983	3,522	106.9	0%	0	0	0.0	0.0	0	0	0
2008	1,326,000	11,895,660	6,883	4,051	123.0	0%	0	0	0.0	0.0	0	0	0
2009	730,000	12,625,660	7,232	4,257	129.2	50%	3,616	2,128	64.6	6.0	0	10,530	221,138
2010	91,000	12,716,660	6,384	3,758	114.1	60%	3,831	2,255	68.5	6.3	0	11,156	234,271
2011	0	12,716,660	4,854	2,857	86.7	60%	2,912	1,714	52.0	4.8	0	8,481	178,105
2012	0	12,716,660	3,742	2,203	66.9	60%	2,245	1,322	40.1	3.7	0	6,539	137,326
2013	0	12,716,660	2,961	1,743	52.9	60%	1,777	1,046	31.7	2.9	0	5,174	108,651
2014	0	12,716,660	2,404	1,415	43.0	60%	1,442	849	25.8	2.4	0	4,200	88,207
2015	0	12,716,660	2,000	1,177	35.7	60%	1,200	706	21.4	2.0	0	3,494	73,375
2016	0	12,716,660	1,700	1,001	30.4	60%	1,020	600	18.2	1.7	0	2,971	62,389
2017	0	12,716,660	1,473	867	26.3	60%	884	520	15.8	1.5	0	2,574	54,061
2018	0	12,716,660	1,297	763	23.2	60%	778	458	13.9	1.3	0	2,266	47,588
2019	0	12,716,660	1,156	681	20.7	60%	694	408	12.4	1.1	0	2,020	42,425
2020	0	12,716,660	1,041	613	18.6	60%	625	368	11.2	1.0	0	1,819	38,204
2021	0	12,716,660	945	556	16.9	60%	567	334	10.1	0.9	0	1,651	34,670
2022	0	12,716,660	863	508	15.4	60%	518	305	9.2	0.9	0	1,507	31,651
2023	0	12,716,660	791	466	14.1	60%	475	279	8.5	0.8	0	1,382	29,027
2024	0	12,716,660	728	428	13.0	60%	437	257	7.8	0.7	0	1,272	26,711
2025	0	12,716,660	672	395	12.0	60%	403	237	7.2	0.7	0	1,174	24,645
2026	0	12,716,660	621	365	11.1	60%	373	219	6.7	0.6	0	1,085	22,785
2027	0	12,716,660	575	338	10.3	60%	345	203	6.2	0.6	0	1,005	21,098
2028	0	12,716,660	533	314	9.5	60%	320	188	5.7	0.5	0	931	19,560
2029	0	12,716,660	495	291	8.8	60%	297	175	5.3	0.5	0	864	18,154
2030	0	12,716,660	460	270	8.2	60%	276	162	4.9	0.5	0	803	16,862
2031	0	12,716,660	427	251	7.6	60%	256	151	4.6	0.4	0	746	15,675
2032	0	12,716,660	397	234	7.1	60%	238	140	4.3	0.4	0	694	14,580
2033	0	12,716,660	370	218	6.6	60%	222	131	4.0	0.4	0	646	13,571
2034	0	12,716,660	344	203	6.2	60%	207	122	3.7	0.3	0	602	12,639
2035	0	12,716,660	321	189	5.7	60%	193	113	3.4	0.3	0	561	11,777

MODEL INPUT PARAMETERS:

	Fast Decay	Med. Decay	Slow Decay	Total Site Lo
Assumed Methane Content of LFG:	50%			
Decay Rate Constant (k):	0.400	0.080	0.020	
CH4 Recovery Pot. (Lo) (ft3/ton):	2,330	2,330	2,330	1,855
Metric Equivalent Lo (m3/Mg):	73	73	73	58

NOTES:

* Maximum power plant capacity assumes a gross heat rate of 10,800 Btus per kW-hr (hhv).

**Emission reductions do not include electricity generation.

Total estimated emission reductions for the 2009-2022 period = **1,352,060 tonnes CO2e**

TABLE C-2
PROJECTION OF LANDFILL GAS RECOVERY UNDER HIGH AND LOW RECOVERY SCENARIOS
DEONAR LANDFILL, MUMBAI, INDIA

	HIGH RECOVERY SCENARIO								LOW RECOVERY SCENARIO							
	Collection System Coverage	Predicted LFG Recovery			Maximum Power Plant Capacity*	Baseline LFG Flow	Methane Emissions Reduction Estimates**		Collection System Coverage	Predicted LFG Recovery			Maximum Power Plant Capacity*	Baseline LFG Flow	Methane Emissions Reduction Estimates**	
Year	(%)	(m^3/hr)	(cfm)	(mmBtu/hr)	(MW)	(m^3/hr)	(tonnes CH4/yr)	(tonnes CO_2eq/yr)	(%)	(m^3/hr)	(cfm)	(mmBtu/hr)	(MW)	(m^3/hr)	(tonnes CH4/yr)	(tonnes CO_2eq/yr)
1970	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1971	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1972	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1973	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1974	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1975	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1976	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1977	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1978	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1979	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1980	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1981	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1982	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1983	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1984	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1985	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1986	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1987	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1988	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1989	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1990	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1991	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1992	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1993	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1994	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1995	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1996	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1997	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1998	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
1999	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2000	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2001	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2002	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2003	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2004	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2005	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2006	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2007	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2008	0%	0	0	0.0	0.0	0	0	0	0%	0	0	0.0	0.0	0	0	0
2009	60%	4,339	2,554	77.5	7.2	0	12,636	265,366	35%	2,531	1,490	45.2	4.2	0	7,371	154,797
2010	70%	4,469	2,630	79.9	7.4	0	13,015	273,316	45%	2,873	1,691	51.3	4.8	0	8,367	175,703
2011	70%	3,398	2,000	60.7	5.6	0	9,895	207,789	45%	2,184	1,286	39.0	3.6	0	6,361	133,579
2012	70%	2,620	1,542	46.8	4.3	0	7,629	160,214	45%	1,684	991	30.1	2.8	0	4,904	102,994
2013	70%	2,073	1,220	37.0	3.4	0	6,036	126,759	45%	1,332	784	23.8	2.2	0	3,880	81,488
2014	70%	1,683	990	30.1	2.8	0	4,900	102,908	45%	1,082	637	19.3	1.8	0	3,150	66,155
2015	70%	1,400	824	25.0	2.3	0	4,076	85,604	45%	900	530	16.1	1.5	0	2,621	55,031
2016	70%	1,190	701	21.3	2.0	0	3,466	72,787	45%	765	450	13.7	1.3	0	2,228	46,792
2017	70%	1,031	607	18.4	1.7	0	3,003	63,071	45%	663	390	11.8	1.1	0	1,931	40,546
2018	70%	908	534	16.2	1.5	0	2,644	55,519	45%	584	343	10.4	1.0	0	1,700	35,691
2019	70%	809	476	14.5	1.3	0	2,357	49,496	45%	520	306	9.3	0.9	0	1,515	31,819

TABLE C-2
PROJECTION OF LANDFILL GAS RECOVERY UNDER HIGH AND LOW RECOVERY SCENARIOS
DEONAR LANDFILL, MUMBAI, INDIA

HIGH RECOVERY SCENARIO

Year	Collection System Coverage (%)	Predicted LFG Recovery (m^3/hr)	Predicted LFG Recovery (cfm)	Predicted LFG Recovery (mmBtu/hr)	Maximum Power Plant Capacity* (MW)	Baseline LFG Flow (m^3/hr)	Methane Emissions Reduction Estimates** (tonnes CH4/yr)	Methane Emissions Reduction Estimates** (tonnes CO_2eq/yr)
2020	70%	729	429	13.0	1.2	0	2,122	44,571
2021	70%	661	389	11.8	1.1	0	1,926	40,449
2022	70%	604	355	10.8	1.0	0	1,758	36,927
2023	70%	554	326	9.9	0.9	0	1,613	33,864
2024	70%	510	300	9.1	0.8	0	1,484	31,163
2025	70%	470	277	8.4	0.8	0	1,369	28,752
2026	70%	435	256	7.8	0.7	0	1,266	26,582
2027	70%	402	237	7.2	0.7	0	1,172	24,614
2028	70%	373	220	6.7	0.6	0	1,087	22,820
2029	70%	346	204	6.2	0.6	0	1,009	21,179
2030	70%	322	189	5.7	0.5	0	937	19,673
2031	70%	299	176	5.3	0.5	0	871	18,287
2032	70%	278	164	5.0	0.5	0	810	17,010
2033	70%	259	152	4.6	0.4	0	754	15,833
2034	70%	241	142	4.3	0.4	0	702	14,745
2035	70%	225	132	4.0	0.4	0	654	13,740

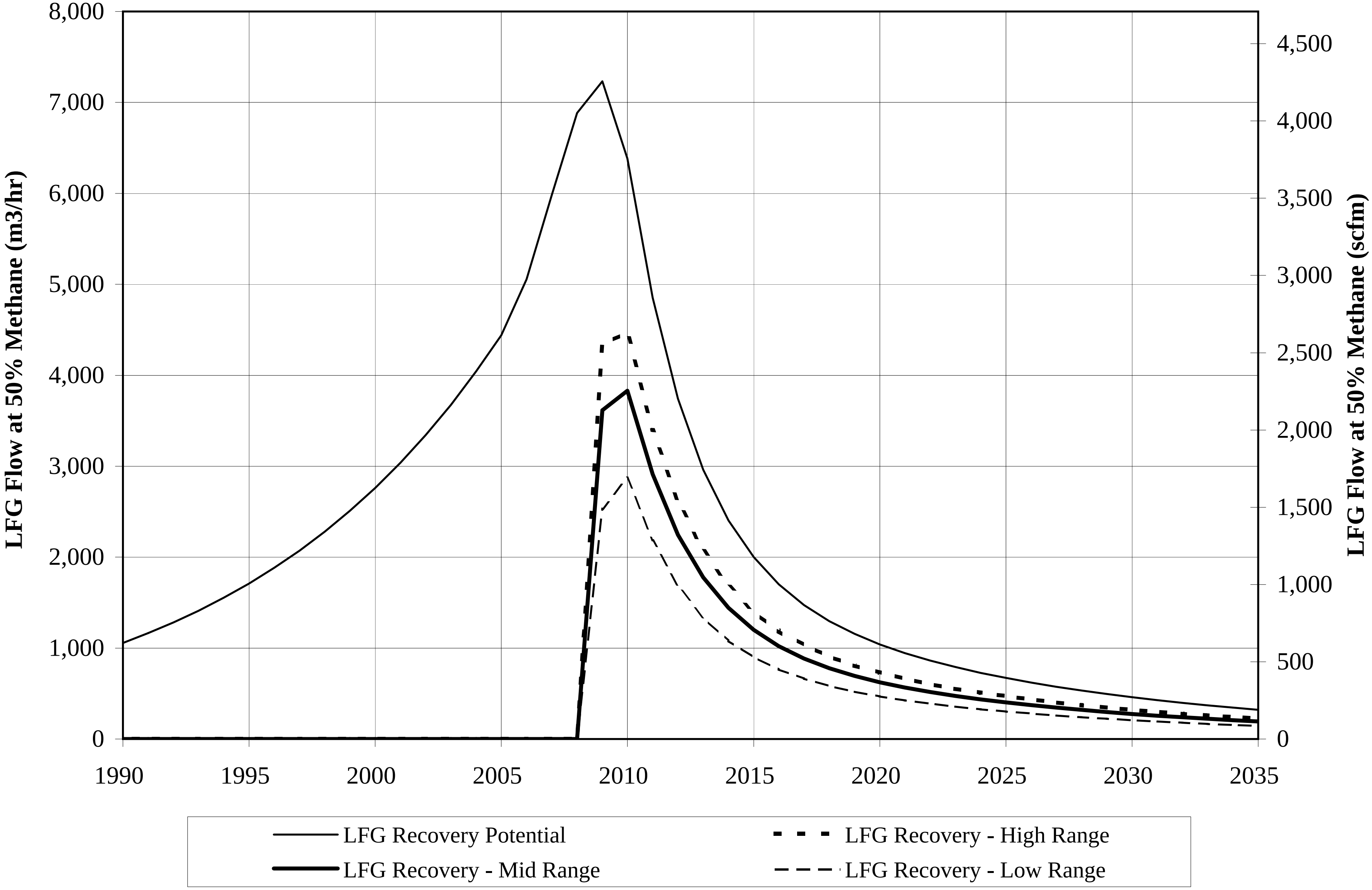
LOW RECOVERY SCENARIO

Year	Collection System Coverage (%)	Predicted LFG Recovery (m^3/hr)	Predicted LFG Recovery (cfm)	Predicted LFG Recovery (mmBtu/hr)	Maximum Power Plant Capacity* (MW)	Baseline LFG Flow (m^3/hr)	Methane Emissions Reduction Estimates** (tonnes CH4/yr)	Methane Emissions Reduction Estimates** (tonnes CO_2eq/yr)
2020	45%	469	276	8.4	0.8	0	1,364	28,653
2021	45%	425	250	7.6	0.7	0	1,238	26,003
2022	45%	388	228	6.9	0.6	0	1,130	23,739
2023	45%	356	210	6.4	0.6	0	1,037	21,770
2024	45%	328	193	5.9	0.5	0	954	20,033
2025	45%	302	178	5.4	0.5	0	880	18,484
2026	45%	279	164	5.0	0.5	0	814	17,088
2027	45%	259	152	4.6	0.4	0	753	15,823
2028	45%	240	141	4.3	0.4	0	699	14,670
2029	45%	223	131	4.0	0.4	0	648	13,615
2030	45%	207	122	3.7	0.3	0	602	12,647
2031	45%	192	113	3.4	0.3	0	560	11,756
2032	45%	179	105	3.2	0.3	0	521	10,935
2033	45%	166	98	3.0	0.3	0	485	10,178
2034	45%	155	91	2.8	0.3	0	451	9,479
2035	45%	144	85	2.6	0.2	0	421	8,833

NOTES:
* Maximum power plant capacity assumes a gross heat rate of 10,800 Btus per kW-hr (hhv).
**Emission reductions do not include electricity generation.
Total estimated emission reductions for the 2009-2022 period = **1,584,775 tonnes CO2e**

NOTES:
* Maximum power plant capacity assumes a gross heat rate of 10,800 Btus per kW-hr (hhv).
**Emission reductions do not include electricity generation.
Total estimated emission reductions for the 2009-2022 period = **1,002,988 tonnes CO2e**

Figure C-1. LFG Recovery Projection
Deonar Landfill, Mumbai, India



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APPENDIX D

CONSTRUCTION COST ESTIMATES

TABLE D-1. ESTIMATE OF PROJECT CAPITAL COSTS (2008)
LANDFILL GAS COLLECTION AND FLARING SYSTEM
DEONAR LANDFILL, MUMBAI, INDIA

Cost Item	Quantity	Unit	Unit Cost (U.S. $)	Total Initial Cost (U.S. $)
Mobilization and Project Management	1	each	$150,000	$150,000
New vertical extraction wells (59 wells x 30m average depth)	1770	m	$255	$451,000
Gas wellheads	59	each	$600	$35,000
Leachate pumping equipment (assumed required in 50% of wells)	30	each	$5,000	$150,000
Gas header piping (assume 510 mm [20 in]) - below ground	550	m	$270	$149,000
Gas header piping (assume 460 mm [18 in]) - below ground	600	m	$230	$138,000
Gas header piping (assume 350 mm [14 in]) - below ground	1,200	m	$165	$198,000
Gas header piping (assume 300 mm [12 in]) - below ground	1,200	m	$175	$210,000
Gas lateral piping (assume 150 mm [6 in]) - above ground	2,800	m	$46	$129,000
Condensate piping (assume 100 mm [4 in]) - above ground	1,400	m	$39	$55,000
Main header valve (assume 460 mm [18 in]) - above ground	2	each	$16,000	$32,000
Main header valve (assume 350 mm [14 in]) - above ground	2	each	$7,000	$14,000
Main header valve (assume 300 mm [12 in]) - above ground	2	each	$3,500	$7,000
Condensate sumps with electric pumps	2	each	$24,000	$48,000
Security fencing around landfill	1	each	$225,000	$225,000
LFG enclosed flaring station (2,300 cfm/3,900 m^3/hr LFG capacity)	1	each	$250,000	$250,000
Flare station construction and sitework	1	each	$50,000	$50,000
Flare start-up	1	each	$15,000	$15,000
Source test	1	each	$25,000	$25,000
LFG measurement and recording equipment	1	each	$35,000	$35,000
Engineering, Contingency, and Up-front CDM Transaction Costs	1	each	$395,000	$395,000
	Total construction cost (2007 U.S. $) =			**$2,761,000**

Notes:
1. Extraction well costs include drilling and well construction. 25% was added to high end U.S. costs due to site conditions.
2. Flare station includes flare, blowers, flame arrester, controls, piping, valves, foundation and fencing.
3. 75 wellheads are required and include permanent wellheads for the 3 pump test wells. 15 of the wells are to be constructed in 2009.

TABLE D-2. ESTIMATE OF PROJECT CAPITAL COSTS FOR 2009 SYSTEM EXPANSION
LANDFILL GAS COLLECTION AND FLARING SYSTEM
DEONAR LANDFILL, MUMBAI, INDIA

Cost Item	Quantity	Unit	Unit Cost (U.S. $)	Total Cost (U.S. $)
Mobilization and Project Management	1	each	$10,000	$10,000
New vertical extraction wells (14 x 30m depth)	420	m	$255	$107,000
Gas wellheads	14	each	$600	$8,000
Leachate pumping equipment (assumed required in 50% of wells)	7	each	$5,000	$35,000
Gas lateral piping (assume 150 mm [6 in]) - above ground	700	m	$46	$32,000
Engineering, Contingency	1	each	$8,000	$8,000
	Total construction cost (2007 U.S. $) =			**$200,000**

TABLE D-3. ESTIMATE OF PROJECT CAPITAL COSTS
1640 KW RECIPROCATING ENGINE LFGE PROJECT
DEONAR LANDFILL, MUMBAI, INDIA

NOTE: Costs are additional to collection system and flare station costs

Cost Item	Quantity	Unit	Unit Cost (U.S. $)	Total Initial Cost (U.S. $)
Mobilization and Project Management	1	each	$130,000	$130,000
Plant construction and sitework	1	each	$80,000	$80,000
LFG blower and treatment (no additional required)	0	each	$200	$0
LFG measurement and recording equipment	1	each	$35,000	$35,000
1640 kW LFG-fueled power plant ($1000/kW installed capacity)	1,640	each	$1,000	$1,640,000
Plant Substation (switchgear, main breaker, step-up transformer)	1	each	$200,000	$200,000
Electric Interconnection	1	each	$150,000	$150,000
Right of Way (assumed right of way purchase not required)	0	each	$0	$0
Source Test	1	each	$25,000	$25,000
Engineering and Contingency	10%	percent	$226,000	$226,000
	Total construction cost (2007 U.S. $) =			**$2,486,000**

APPENDIX E

ECONOMIC EVALUATION

TABLE E-1. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
NO FINANCING, $8/TONNE GHG CREDITS THROUGH 2012

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$0.00	$0.00	$0.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$1,769,107**	**$1,874,168**	**$1,424,840**	**$1,098,607**	**$0**	**$0**	**$0**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808
Equity Contribution to Capital Cost	$2,761,000	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$0	$0	$0
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$2,761,000**	**$736,821**	**$581,247**	**$493,433**	**$429,527**	**$135,635**	**$139,704**	**$143,895**
NET CASH FLOW	**($2,761,000)**	**$1,032,286**	**$1,292,920**	**$931,407**	**$669,081**	**($135,635)**	**($139,704)**	**($143,895)**
NPV		**$144,033**						
INTERNAL RATE OF RETURN		**17.1%**						

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	100%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$2,761,000	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	4.0	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-2. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
WITH 75% DEBT, $8/TONNE GHG CREDITS THROUGH 2012

	0	1	2	3	4	5	6	7
	2008	2009	2010	2011	2012	2013	2014	2015
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	90%	90%	90%	90%	90%	90%	90%	90%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$0.00	$0.00	$0.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0
	------------	------------	------------	------------	------------	------------	------------	------------
GRAND TOTAL REVENUE	**$0**	**$1,769,107**	**$1,874,168**	**$1,424,840**	**$1,098,607**	**$0**	**$0**	**$0**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808
Equity Contribution to Capital Cost	$690,250	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$0	$0	$0
Annual Debt Service	$0	$653,261	$653,261	$653,261	$653,261	$0	$0	$0
	------------	------------	------------	------------	------------	------------	------------	------------
TOTAL ANNUAL COSTS	**$690,250**	**$1,390,082**	**$1,234,509**	**$1,146,695**	**$1,082,788**	**$135,635**	**$139,704**	**$143,895**
NET CASH FLOW	**($690,250)**	**$379,025**	**$639,659**	**$278,146**	**$15,820**	**($135,635)**	**($139,704)**	**($143,895)**
NPV		**$290,818**						
INTERNAL RATE OF RETURN		**41.4%**						

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	90%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	25%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$690,250	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	4.0	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-3. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
NO FINANCING, $8/TONNE OF GHG CREDITS THROUGH 2018

	0 **2008**	**1** **2009**	**2** **2010**	**3** **2011**	**4** **2012**	**5** **2013**	**6** **2014**	**7** **2015**	**8** **2016**	**9** **2017**	**10** **2018**
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$869,204	$705,657	$586,997	$499,111	$432,488	$380,702
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$1,769,107**	**$1,874,168**	**$1,424,840**	**$1,098,607**	**$869,204**	**$705,657**	**$586,997**	**$499,111**	**$432,488**	**$380,702**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804
Equity Contribution to Capital Cost	$2,761,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.78	$0.80	$0.82	$0.85	$0.87	$0.90
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$216,004	$180,622	$154,757	$135,534	$120,966	$109,676
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$2,761,000**	**$736,821**	**$581,247**	**$493,433**	**$429,527**	**$385,404**	**$355,104**	**$334,473**	**$320,642**	**$311,627**	**$306,057**
NET CASH FLOW	**($2,761,000)**	**$1,032,286**	**$1,292,920**	**$931,407**	**$669,081**	**$483,800**	**$350,553**	**$252,523**	**$178,469**	**$120,861**	**$74,645**
NPV		**$698,208**									
INTERNAL RATE OF RETURN		**25.0%**									

	2008		
INITIAL GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$8.00
INITIAL NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	100%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$2,761,000	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-4. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLYPROJECT
DEONAR LANDFILL
WITH 75% DEBT, $8/TONNE GHG CREDIT THROUGH 2018

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$869,204	$705,657	$586,997	$499,111	$432,488	$380,702
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$1,769,107**	**$1,874,168**	**$1,424,840**	**$1,098,607**	**$869,204**	**$705,657**	**$586,997**	**$499,111**	**$432,488**	**$380,702**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804
Equity Contribution to Capital Cost	$690,250	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.78	$0.80	$0.82	$0.85	$0.87	$0.90
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$216,004	$180,622	$154,757	$135,534	$120,966	$109,676
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143
Annual Debt Service	$0	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005
TOTAL ANNUAL COSTS	**$690,250**	**$1,073,826**	**$918,252**	**$830,438**	**$766,532**	**$722,409**	**$692,109**	**$671,479**	**$657,647**	**$648,632**	**$643,062**
NET CASH FLOW	**($690,250)**	**$695,281**	**$955,915**	**$594,402**	**$332,076**	**$146,795**	**$13,548**	**($84,482)**	**($158,536)**	**($216,144)**	**($262,360)**
NPV		**$972,675**									
INTERNAL RATE OF RETURN		**99.0%**									

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	25%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$690,250	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-5. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
NO FINANCING AND $8/TONNE GHG CREDITS THROUGH 2012, 14 YEARS OF GCCS OPERATION

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018	11 2019	12 2020	13 2021	14 2022
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	0	0	0	0	0	0	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$68,276	$68,276	$68,276	$68,276	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,571,701**	**$2,698,791**	**$2,272,154**	**$1,969,293**	**$826,481**	**$851,275**	**$876,814**	**$903,118**	**$465,106**	**$479,059**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$5,247,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.0206	$0.0212	$0.0219	$0.0225	$0.0232	$0.0239	$0.0246	$0.0253	$0.0261	$0.0269	$0.0277	$0.0285	$0.0294	$0.0303
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$5,247,000**	**$1,009,093**	**$861,688**	**$782,287**	**$727,046**	**$442,080**	**$455,342**	**$469,002**	**$483,072**	**$325,111**	**$334,865**	**$344,911**	**$355,258**	**$365,916**	**$376,893**
NET CASH FLOW	**($5,247,000)**	**$1,562,608**	**$1,837,104**	**$1,489,867**	**$1,242,247**	**$384,401**	**$395,933**	**$407,811**	**$420,046**	**$139,994**	**$144,194**	**$148,520**	**$152,976**	**$157,565**	**$162,292**
NPV	**$150,992**														
INTERNAL RATE OF RETURN	**15.2%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	100%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$5,247,000		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-6. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
WITH 75% DEBT FINANCING AND $8/TONNE GHG CREDIT THROUGH 2012, 14 YEARS OF GCCS OPERATION

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	0	0	0	0	0	0	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$68,276	$68,276	$68,276	$68,276	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,571,701**	**$2,698,791**	**$2,272,154**	**$1,969,293**	**$826,481**	**$851,275**	**$876,814**	**$903,118**	**$465,106**	**$479,059**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$1,311,750	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.021	$0.021	$0.022	$0.023	$0.023	$0.024	$0.025	$0.025	$0.026	$0.027	$0.028	$0.029	$0.029	$0.030
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$0	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$1,311,750**	**$1,649,537**	**$1,502,131**	**$1,422,731**	**$1,367,489**	**$1,082,523**	**$1,095,786**	**$1,109,446**	**$1,123,516**	**$965,555**	**$975,309**	**$344,911**	**$355,258**	**$365,916**	**$376,893**
NET CASH FLOW	**($1,311,750)**	**$922,165**	**$1,196,660**	**$849,424**	**$601,803**	**($256,042)**	**($244,510)**	**($232,632)**	**($220,398)**	**($500,450)**	**($496,250)**	**$148,520**	**$152,976**	**$157,565**	**$162,292**
NPV	**$672,589**														
INTERNAL RATE OF RETURN	**57.7%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	25%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$1,311,750		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-7. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
NO FINANCING AND $8/TONNE GHG CREDITS THROUGH 2018, 14 YEARS OF GCCS OPERATION

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018	11 2019	12 2020	13 2021	14 2022
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$869,204	$705,657	$586,997	$499,111	$432,488	$380,702	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	8,535	8,535	8,535	8,535	4,267	4,267	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$34,138	$34,138	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,571,701**	**$2,698,791**	**$2,272,154**	**$1,969,293**	**$1,763,962**	**$1,625,209**	**$1,532,087**	**$1,470,506**	**$931,732**	**$893,899**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$5,247,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.78	$0.80	$0.82	$0.85	$0.87	$0.90	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$216,004	$180,622	$154,757	$135,534	$120,966	$109,676	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.0206	$0.0212	$0.0219	$0.0225	$0.0232	$0.0239	$0.0246	$0.0253	$0.0261	$0.0269	$0.0277	$0.0285	$0.0294	$0.0303
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$0	$0	$0	$0
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$5,247,000**	**$1,009,093**	**$861,688**	**$782,287**	**$727,046**	**$691,849**	**$670,742**	**$659,581**	**$655,503**	**$484,080**	**$483,684**	**$344,911**	**$355,258**	**$365,916**	**$376,893**
NET CASH FLOW	**($5,247,000)**	**$1,562,608**	**$1,837,104**	**$1,489,867**	**$1,242,247**	**$1,072,113**	**$954,467**	**$872,506**	**$815,003**	**$447,652**	**$410,215**	**$148,520**	**$152,976**	**$157,565**	**$162,292**
NPV	**$1,117,804**														
INTERNAL RATE OF RETURN	**21.3%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	100%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$5,247,000		2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-8. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
WITH 75% DEBT FINANCING AND $8/TONNE GHG CREDIT THROUGH 2018, 14 YEARS OF GCCS OPERATION

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00	$8.00
CER Revenue from Methane Reductions ($/yr)	$0	$1,769,107	$1,874,168	$1,424,840	$1,098,607	$869,204	$705,657	$586,997	$499,111	$432,488	$380,702	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	8,535	8,535	8,535	8,535	4,267	4,267	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$68,276	$34,138	$34,138	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,571,701**	**$2,698,791**	**$2,272,154**	**$1,969,293**	**$1,763,962**	**$1,625,209**	**$1,532,087**	**$1,470,506**	**$931,732**	**$893,899**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$1,311,750	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.67	$0.69	$0.71	$0.73	$0.75	$0.78	$0.80	$0.82	$0.85	$0.87	$0.90	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$390,611	$426,222	$333,757	$265,060	$216,004	$180,622	$154,757	$135,534	$120,966	$109,676	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.021	$0.021	$0.022	$0.023	$0.023	$0.024	$0.025	$0.025	$0.026	$0.027	$0.028	$0.029	$0.029	$0.030
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$0	$0	$0	$0
Annual Debt Service	$0	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$1,311,750**	**$1,649,537**	**$1,502,131**	**$1,422,731**	**$1,367,489**	**$1,332,292**	**$1,311,186**	**$1,300,024**	**$1,295,946**	**$1,124,524**	**$1,124,127**	**$344,911**	**$355,258**	**$365,916**	**$376,893**
NET CASH FLOW	**($1,311,750)**	**$922,165**	**$1,196,660**	**$849,424**	**$601,803**	**$431,670**	**$314,023**	**$232,063**	**$174,559**	**($192,792)**	**($230,229)**	**$148,520**	**$152,976**	**$157,565**	**$162,292**
NPV	**$1,639,402**														
INTERNAL RATE OF RETURN	**66.0%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$8.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.67
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	25%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$1,311,750		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-9. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
NO FINANCING, $10/TONNE GHG CREDITS THROUGH 2012

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$0.00	$0.00	$0.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,211,384**	**$2,342,710**	**$1,781,050**	**$1,373,259**	**$0**	**$0**	**$0**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808
Equity Contribution to Capital Cost	$2,761,000	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$2,761,000**	**$835,931**	**$689,393**	**$578,118**	**$496,781**	**$169,400**	**$174,482**	**$179,717**
NET CASH FLOW	**($2,761,000)**	**$1,375,453**	**$1,653,316**	**$1,202,932**	**$876,479**	**($169,400)**	**($174,482)**	**($179,717)**
NPV		**$919,826**						
INTERNAL RATE OF RETURN		**33.0%**						

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	100%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$2,761,000	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	4.0	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-10. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
WITH 75% DEBT, $10/TONNE GHG CREDITS THROUGH 2012

	0	1	2	3	4	5	6	7
	2008	2009	2010	2011	2012	2013	2014	2015
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	90%	90%	90%	90%	90%	90%	90%	90%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$0.00	$0.00	$0.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,211,384**	**$2,342,710**	**$1,781,050**	**$1,373,259**	**$0**	**$0**	**$0**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808
Equity Contribution to Capital Cost	$690,250	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822
Annual Debt Service	$0	$653,261	$653,261	$653,261	$653,261	$0	$0	$0
TOTAL ANNUAL COSTS	**$690,250**	**$1,489,192**	**$1,342,655**	**$1,231,379**	**$1,150,042**	**$169,400**	**$174,482**	**$179,717**
NET CASH FLOW	**($690,250)**	**$722,192**	**$1,000,055**	**$549,671**	**$223,217**	**($169,400)**	**($174,482)**	**($179,717)**
NPV		**$1,066,611**						
INTERNAL RATE OF RETURN		**100.6%**						

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	90%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	25%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$690,250	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	4.0	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-11. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLY PROJECT
DEONAR LANDFILL
NO FINANCING, $10/TONNE OF GHG CREDITS THROUGH 2018

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$1,086,506	$882,071	$733,746	$623,889	$540,610	$475,877
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,211,384**	**$2,342,710**	**$1,781,050**	**$1,373,259**	**$1,086,506**	**$882,071**	**$733,746**	**$623,889**	**$540,610**	**$475,877**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804
Equity Contribution to Capital Cost	$2,761,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.97	$1.00	$1.03	$1.06	$1.10	$1.13
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$270,811	$226,451	$194,023	$169,923	$151,658	$137,504
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$2,761,000**	**$835,931**	**$689,393**	**$578,118**	**$496,781**	**$440,211**	**$400,934**	**$373,740**	**$355,032**	**$342,320**	**$333,885**
NET CASH FLOW	**($2,761,000)**	**$1,375,453**	**$1,653,316**	**$1,202,932**	**$876,479**	**$646,295**	**$481,138**	**$360,006**	**$268,857**	**$198,290**	**$141,992**
NPV		**$1,702,514**									
INTERNAL RATE OF RETURN		**39.6%**									

	2008		
INITIAL GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$10.00
INITIAL NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	100%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$2,761,000	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-12. ECONOMIC ANALYSIS OF PROPOSED FLARING ONLYPROJECT
DEONAR LANDFILL
WITH 75% DEBT, $10/TONNE GHG CREDITTHROUGH 2018

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018
Gross Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Plant Capacity (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plant Capacity Factor	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078
Off Site Power Sales (MWh/yr)	0	0	0	0	0	0	0	0	0	0	0
Off Site Power Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$1,086,506	$882,071	$733,746	$623,889	$540,610	$475,877
CERs from Energy Displacement (tonnes CO2eq/yr)	0	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$2,211,384**	**$2,342,710**	**$1,781,050**	**$1,373,259**	**$1,086,506**	**$882,071**	**$733,746**	**$623,889**	**$540,610**	**$475,877**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804
Equity Contribution to Capital Cost	$690,250	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.97	$1.00	$1.03	$1.06	$1.10	$1.13
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$270,811	$226,451	$194,023	$169,923	$151,658	$137,504
Power Plant O&M Rate ($/kWhr)	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Annual Power Plant O&M Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143
Annual Debt Service	$0	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005	$337,005
TOTAL ANNUAL COSTS	**$690,250**	**$1,172,936**	**$1,026,398**	**$915,123**	**$833,786**	**$777,216**	**$737,939**	**$710,745**	**$692,037**	**$679,325**	**$670,890**
NET CASH FLOW	**($690,250)**	**$1,038,448**	**$1,316,311**	**$865,927**	**$539,474**	**$309,290**	**$144,133**	**$23,001**	**($68,148)**	**($138,715)**	**($195,013)**
NPV		**$1,976,981**									
INTERNAL RATE OF RETURN		**152.0%**									

	2008		
GROSS PLANT CAPACITY (MW)	0.00	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	0.00	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	0%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	0	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	0	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$2,761,000	POWER PLANT O&M COST ($/kW-hr)	$0.000
EQUITY PERCENTAGE	25%	POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$690,250	2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%	2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%	2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10	GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-13. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
NO FINANCING AND $10/TONNE GHG CREDITS THROUGH 2012, 14 YEARS OF GCCS OPERATION

	0 2008	1 2009	2 2010	3 2011	4 2012	5 2013	6 2014	7 2015	8 2016	9 2017	10 2018	11 2019	12 2020	13 2021	14 2022
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	0	0	0	0	0	0	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$85,346	$85,346	$85,346	$85,346	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$3,031,047**	**$3,184,402**	**$2,645,433**	**$2,261,014**	**$826,481**	**$851,275**	**$876,814**	**$903,118**	**$465,106**	**$479,059**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$5,247,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.0206	$0.0212	$0.0219	$0.0225	$0.0232	$0.0239	$0.0246	$0.0253	$0.0261	$0.0269	$0.0277	$0.0285	$0.0294	$0.0303
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$40,317	$41,527	$42,773	$44,056
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$5,247,000**	**$1,108,203**	**$969,834**	**$866,972**	**$794,300**	**$475,845**	**$490,120**	**$504,824**	**$519,969**	**$363,115**	**$374,008**	**$385,228**	**$396,785**	**$408,689**	**$420,949**
NET CASH FLOW	**($5,247,000)**	**$1,922,844**	**$2,214,569**	**$1,778,462**	**$1,466,714**	**$350,636**	**$361,155**	**$371,990**	**$383,149**	**$101,991**	**$105,051**	**$108,202**	**$111,449**	**$114,792**	**$118,236**
NPV	**$868,781**														
INTERNAL RATE OF RETURN	**21.4%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	100%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$5,247,000		2009 REGISTRATION, MONITORING, VERIFICATION C	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-14. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
WITH 75% DEBT FINANCING AND $10/TONNE GHG CREDIT THROUGH 2012, 14 YEARS OF GCCS OPERATION

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	0	0	0	0	0	0	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	0	0	0	0	0	0	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$85,346	$85,346	$85,346	$85,346	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$3,031,047**	**$3,184,402**	**$2,645,433**	**$2,261,014**	**$826,481**	**$851,275**	**$876,814**	**$903,118**	**$465,106**	**$479,059**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$1,311,750	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.97	$1.00	$1.03	$1.06	$1.10	$1.13	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.021	$0.021	$0.022	$0.023	$0.023	$0.024	$0.025	$0.025	$0.026	$0.027	$0.028	$0.029	$0.029	$0.030
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$40,317	$41,527	$42,773	$44,056
Annual Debt Service	$0	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$1,311,750**	**$1,748,647**	**$1,610,277**	**$1,507,415**	**$1,434,743**	**$1,116,289**	**$1,130,564**	**$1,145,268**	**$1,160,412**	**$1,003,558**	**$1,014,452**	**$385,228**	**$396,785**	**$408,689**	**$420,949**
NET CASH FLOW	**($1,311,750)**	**$1,282,400**	**$1,574,125**	**$1,138,018**	**$826,270**	**($289,808)**	**($279,289)**	**($268,454)**	**($257,294)**	**($538,453)**	**($535,393)**	**$108,202**	**$111,449**	**$114,792**	**$118,236**
NPV	**$1,390,378**														
INTERNAL RATE OF RETURN	**90.4%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	25%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$1,311,750		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-15. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
NO FINANCING AND $10/TONNE GHG CREDITS THROUGH 2018, 14 YEARS OF GCCS OPERATION

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
Carbon Dioxide Equivalency (for CH4)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$1,086,506	$882,071	$733,746	$623,889	$540,610	$475,877	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	8,535	8,535	8,535	8,535	4,267	4,267	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$42,673	$42,673	$0	$0	$0	$0
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GRAND TOTAL REVENUE	**$0**	**$3,031,047**	**$3,184,402**	**$2,645,433**	**$2,261,014**	**$1,998,332**	**$1,818,692**	**$1,695,905**	**$1,612,353**	**$1,048,388**	**$997,609**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$5,247,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.97	$1.00	$1.03	$1.06	$1.10	$1.13	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$270,811	$226,451	$194,023	$169,923	$151,658	$137,504	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.0206	$0.0212	$0.0219	$0.0225	$0.0232	$0.0239	$0.0246	$0.0253	$0.0261	$0.0269	$0.0277	$0.0285	$0.0294	$0.0303
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$40,317	$41,527	$42,773	$44,056
Annual Debt Service	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
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TOTAL ANNUAL COSTS	**$5,247,000**	**$1,108,203**	**$969,834**	**$866,972**	**$794,300**	**$746,655**	**$716,571**	**$698,847**	**$689,892**	**$514,773**	**$511,512**	**$385,228**	**$396,785**	**$408,689**	**$420,949**
NET CASH FLOW	**($5,247,000)**	**$1,922,844**	**$2,214,569**	**$1,778,462**	**$1,466,714**	**$1,251,677**	**$1,102,121**	**$997,058**	**$922,461**	**$533,615**	**$486,097**	**$108,202**	**$111,449**	**$114,792**	**$118,236**
NPV	**$2,166,956**														
INTERNAL RATE OF RETURN	**28.3%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.070
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	100%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$5,247,000		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%

TABLE E-16. ECONOMIC ANALYSIS OF PROPOSED LFGTE PROJECT
DEONAR LANDFILL
WITH 75% DEBT FINANCING AND $10/TONNE GHG CREDIT THROUGH 2018, 14 YEARS OF GCCS OPERATION

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Gross Plant Capacity (MW)	0.00	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	0.82	0.82	0.82	0.82	0.82	0.82
Net Plant Capacity (MW)	0.00	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	0.76	0.76	0.76	0.76	0.76	0.76
Plant Capacity Factor	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%	92%
Off Site Power Sales Rate ($/kWh)	$0.058	$0.060	$0.062	$0.063	$0.065	$0.067	$0.069	$0.071	$0.073	$0.076	$0.078	$0.080	$0.083	$0.085	$0.088
Off Site Power Sales (MWh/yr)	0	12,292	12,292	12,292	12,292	12,292	12,292	12,292	12,292	6,146	6,146	6,146	6,146	6,146	6,146
Off Site Power Revenue	$0	$734,318	$756,347	$779,038	$802,409	$826,481	$851,275	$876,814	$903,118	$465,106	$479,059	$493,431	$508,234	$523,481	$539,185
LFG Recovery Rate (m3/hr)	0	3,616	3,831	2,912	2,245	1,777	1,442	1,200	1,020	884	778	694	625	567	518
Baseline Reduction (m3/hr)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methane Emission Reduction (tonnes/yr)	0	10,530	11,156	8,481	6,539	5,174	4,200	3,494	2,971	2,574	2,266	2,020	1,819	1,651	1,507
CERs from Methane Reductions (tonnes CO2eq/yr)	0	221,138	234,271	178,105	137,326	108,651	88,207	73,375	62,389	54,061	47,588	0	0	0	0
CER Sales Rate ($/tonne CO2eq)	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
CER Revenue from Methane Reductions ($/yr)	$0	$2,211,384	$2,342,710	$1,781,050	$1,373,259	$1,086,506	$882,071	$733,746	$623,889	$540,610	$475,877	$0	$0	$0	$0
CERs from Energy Displacement (tonnes CO2eq/yr)	0	8,535	8,535	8,535	8,535	8,535	8,535	8,535	8,535	4,267	4,267	0	0	0	0
CER Revenue from Energy Displacement ($/yr)	$0	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$85,346	$42,673	$42,673	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$0**	**$3,031,047**	**$3,184,402**	**$2,645,433**	**$2,261,014**	**$1,998,332**	**$1,818,692**	**$1,695,905**	**$1,612,353**	**$1,048,388**	**$997,609**	**$493,431**	**$508,234**	**$523,481**	**$539,185**
LFG Recovered (MMBtu/yr)	0	566,021	599,635	455,874	351,496	278,100	225,773	187,808	159,689	138,373	121,804	108,590	97,785	88,741	81,014
Equity Contribution to Capital Cost	$1,311,750	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
LFG Purchase Price ($/MMBtu)	$0.84	$0.87	$0.89	$0.92	$0.95	$0.97	$1.00	$1.03	$1.06	$1.10	$1.13	$0.00	$0.00	$0.00	$0.00
Annual Cost for LFG Purchase ($)	$0	$489,721	$534,368	$418,442	$332,314	$270,811	$226,451	$194,023	$169,923	$151,658	$137,504	$0	$0	$0	$0
Power Plant O&M Rate ($/kWhr)	$0.020	$0.021	$0.021	$0.022	$0.023	$0.023	$0.024	$0.025	$0.025	$0.026	$0.027	$0.028	$0.029	$0.029	$0.030
Annual Power Plant O&M Cost	$0	$272,272	$280,440	$288,853	$297,519	$306,445	$315,638	$325,107	$334,860	$172,453	$177,627	$182,955	$188,444	$194,097	$199,920
Annual GCCS O&M and 2009 Expansion	$0	$316,210	$124,125	$127,849	$131,685	$135,635	$139,704	$143,895	$148,212	$152,658	$157,238	$161,955	$166,814	$171,818	$176,973
Annual Registration, Monitoring&Verification	$0	$30,000	$30,900	$31,827	$32,782	$33,765	$34,778	$35,822	$36,896	$38,003	$39,143	$40,317	$41,527	$42,773	$44,056
Annual Debt Service	$0	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$640,444	$0	$0	$0	$0
TOTAL ANNUAL COSTS	**$1,311,750**	**$1,748,647**	**$1,610,277**	**$1,507,415**	**$1,434,743**	**$1,387,099**	**$1,357,015**	**$1,339,291**	**$1,330,336**	**$1,155,217**	**$1,151,956**	**$385,228**	**$396,785**	**$408,689**	**$420,949**
NET CASH FLOW	**($1,311,750)**	**$1,282,400**	**$1,574,125**	**$1,138,018**	**$826,270**	**$611,233**	**$461,677**	**$356,614**	**$282,017**	**($106,829)**	**($154,347)**	**$108,202**	**$111,449**	**$114,792**	**$118,236**
NPV	**$2,688,554**														
INTERNAL RATE OF RETURN	**95.4%**														

	2008	2017		
GROSS PLANT CAPACITY (MW)	1.64	0.82	CER SALES RATE ($/tonne CO2eq)	$10.00
NET PLANT CAPACITY (MW) (7% parasitic load)	1.53	0.76	2008 OFF SITE POWER SALES RATE ($/kWhr)	$0.058
PLANT CAPACITY FACTOR	92%	92%	POWER PRICE ESCALATION	3.0%
ANNUAL POWER PRODUCTION (MWh/yr)	12,292	6,146	AVOIDED PURCHASE PRICE ($/kWh)	$0.050
ON SITE POWER CONSUMPTION (MWH/yr)*	0	0	LFG PURCHASE RATE ($/MMBtu)	$0.84
OFF SITE POWER SALE (MWH/yr)	12,292	6,146	FUEL ESCALATION RATE	3.0%
TOTAL FACILITY INITIAL CAPITAL COST	$5,247,000		POWER PLANT O&M COST ($/kW-hr)	$0.020
EQUITY PERCENTAGE	25%		POWER PLANT O&M ESCALATION	3.0%
EQUITY CONTRIBUTION	$1,311,750		2009 REGISTRATION, MONITORING, VERIFICATION C(	$30,000
DEBT INTEREST RATE	10.0%		2009 GCCS O&M COST ($2007)	$107,000
NPV RATE	14.0%		2010 GCCS O&M COST ($2007)	$117,000
FINANCING LIFE (years)	10.0		GCCS O&M/UPGRADES ESCALATION	3.0%