Environmental Consultants

SCS ENGINEERS

DESIGN REPORT

for

RESH ROAD SANITARY LANDFILL
LANDFILL GAS MANAGEMENT SYSTEM

Presented to:

WASHINGTON COUNTY
ENGINEERING DEPARTMENT
DIVISION OF PUBLIC WORKS
80 W. Baltimore Street
Hagerstown, Maryland 21740

Presented by:

SCS ENGINEERS
11260 Roger Bacon Drive
Reston, Virginia 20190
(703) 471-6150

July 10, 2002
File No. 02201085.00

TABLE OF CONTENTS

EXHIBITS

APPENDICES

SECTION 1.0

INTRODUCTION

This report presents the design rationale and criteria for the proposed landfill gas (LFG) collection system for the Resh Road Sanitary Landfill.

1.1 LANDFILL BACKGROUND

The Resh Road Landfill (RRLF) is located approximately three miles west of Hagerstown, Maryland, on a 140-acre parcel of land. The waste footprint is about 75 acres, consisting of eight cells. Operations began in the early 1980s and ceased on January 18, 2001. The landfill is owned and operated by Washington County. Presently, no LFG is collected at the site. The quantity of in-place waste is approximately 2.2 million tons.

1.2 SYSTEM OBJECTIVES

Consistent with SCS' scope of services, the LFG collection system components will be sized to control LFG generated in the landfill. The objectives of the proposed LFG management system are as follows:

- Collecting and destructing LFG to reduce methane emissions to the atmosphere.
- Maintaining the integrity of the cap.
- Complying with applicable State and Federal regulations.
- Controlling potential odors.
- Controlling potential LFG migration.

All of the above objectives rely on efficient LFG collection and appropriate combustion equipment such as a candlestick flare. Uncollected LFG emitted to the atmosphere can cause odors, and methane in LFG is a greenhouse gas. The presence of a geomembrane cap reduces the potential for such emissions, but does not reduce the need for LFG collection to control potentially damaging pressure buildup beneath the cap. The presence of a cap also increases the potential of subsurface LFG migration, thus increasing the need for proper LFG collection and control.

1.3 AIR EMISSIONS

The Resh Road Sanitary Landfill is not required to comply with the Clean Air Act New Source Performance Standards (NSPS) and Emission Guidelines (EG) for sanitary landfills, nor with Title V and the corresponding MDE emission rules (COMAR

26.11.19). It is exempt from NSPS because of its size (i.e., it has less than 2.5 million metric tons of waste in place).

1.4 MARYLAND SOLID WASTE MANAGEMENT REGULATIONS

The present Maryland Solid Waste Management Regulations state that the concentration of methane in on-site structures must not exceed 25 percent of the lower explosive limit (LEL) or 100 percent of the LEL at the landfill property boundary. The RRLF is subject to these regulations, and the objective of the LFG system design is to meet these requirements. Reportedly, an old burn dump exists to the east of Cell 1. This LFG system is not designed to extract gas from this area.

1.5 FINAL COVER SYSTEM

The permeability of the cover system on a landfill affects the LFG collection efficiency. The RRLF is scheduled to upgrade its existing cap. The minimum 2-foot thick intermediate soil layer over refuse will be maintained. A new cap will be installed over this intermediate soil layer. The cap will consist of a woven geotextile being placed on the existing cover followed by a 40 mil textured HDPE synthetic liner. On top of this will be a geocomposite consisting of a geonet sandwiched between two layers of geotextile. Finally a 1'-8" compacted soil layer and 4-inches of topsoil will be placed to finish the construction of the cap. Geomembrane caps typically enhance LFG collection efficiency by reducing the amount of air infiltration caused by wells under vacuum.

1.6 LANDFILL GAS CHARACTERISTICS

SCS installed six gas wells in an effort to characterize the LFG at the RRLF. These wells were installed in Cells 1, 2, 4, 5, N-1, and N-3. Drilling logs for these wells are included in Appendix A. Testing of these wells has shown good quality gas, with pressure in most of them. The results of this testing are shown below.

Well in Cell	Pressure (in.- w.c.)	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Balance (%)	Water Level (from bottom)
1	+0.5	60.1	38.9	0.4	0.6	7 ft.
2,3	+0.6	57.0	43.0	0	0	0
4	0	59.7	39.3	0	1.0	0
5	+0.1	56.8	43.2	0	0	3 ft.
N1	0	56.8	43.2	0	0	0
N3	0	44.0	27.7	0	28.3	0

SECTION 2.0

LFG RECOVERY ESTIMATES

The landfill gas model used by SCS Engineers is a first-order model, similar to the U.S. Environmental Protection Agency (EPA) Landfill Gas Emissions Model (LandGEM). The model developed by SCS Engineers calculates gas recovery, not gas generation. The model uses input variables for methane recovery potential (Lo) and annual gas recovery rate (k) that have been developed specifically by SCS based on a database of approximately 100 operational landfill gas collection systems. The estimated landfill gas recovery projections are based on our engineering judgment as of the date of this report.

The LFG recovery projection for the RRLF is shown in Exhibits 1 and 2. SCS prepared the model using the following input parameters:

1. **Refuse Filling History and Projections:** The in-place waste volume, as provided by the Washington County Solid Waste Department from 1989 until closure.

2. **LFG Decay Rate Constant (k):** A k value of 0.067/year was used based on the SCS database.

3. **Ultimate Methane Recovery Rate (L_o):** A L_o value of 3,070 cubic feet (ft^3)/ton was used based on the SCS database.

4. **System Coverage:** For this exercise, SCS considered the wellfield layout, the landfill design (e.g., waste depths, liner and cap construction, and sideslopes), and the wellfield operating data.

2.1 SCS MODEL RESULTS

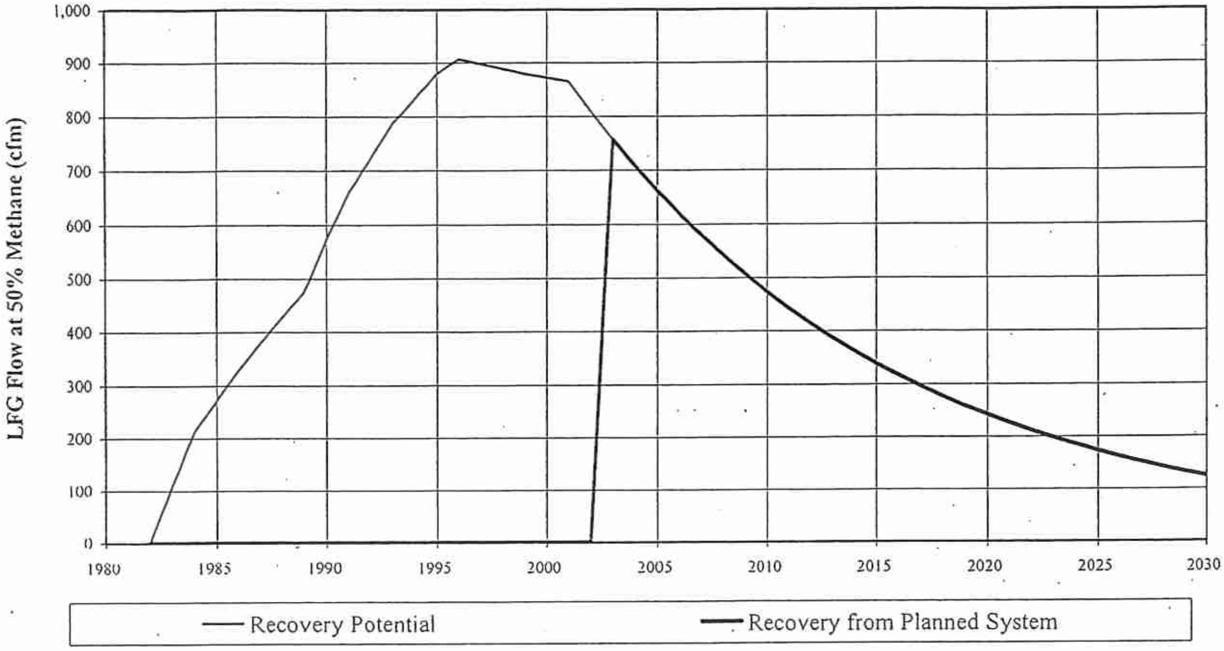
The LFG recovery rate should equal the LFG recovery potential with closure and capping of the landfill. The collection system is designed to provide 100 percent coverage of the waste disposal footprint. Site LFG recovery was expected to peak in 1996, at about 907 scfm. The model estimates that LFG recovery will be approximately 800 scfm at system startup.

EXHIBIT 1. LFG RECOVERY PROJECTION
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MARYLAND

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1982	150,000	150,000	0	0.00	0	0%	0	0.00	0
1983	150,000	300,000	110	0.16	29,200	0%	0	0.00	0
1984	100,000	400,000	212	0.31	56,508	0%	0	0.00	0
1985	100,000	500,000	272	0.39	72,313	0%	0	0.00	0
1986	100,000	600,000	327	0.47	87,094	0%	0	0.00	0
1987	100,000	700,000	379	0.55	100,917	0%	0	0.00	0
1988	100,000	800,000	428	0.62	113,844	0%	0	0.00	0
1989	177,927	977,927	474	0.68	125,933	0%	0	0.00	0
1990	169,043	1,146,970	573	0.83	152,409	0%	0	0.00	0
1991	147,852	1,294,822	660	0.95	175,439	0%	0	0.00	0
1992	150,750	1,445,572	725	1.04	192,852	0%	0	0.00	0
1993	130,605	1,576,177	788	1.14	209,701	0%	0	0.00	0
1994	136,826	1,713,003	833	1.20	221,536	0%	0	0.00	0
1995	115,525	1,828,528	879	1.27	233,815	0%	0	0.00	0
1996	67,718	1,896,246	907	1.31	241,152	0%	0	0.00	0
1997	67,310	1,963,556	898	1.29	238,706	0%	0	0.00	0
1998	65,928	2,029,484	889	1.28	236,340	0%	0	0.00	0
1999	67,978	2,097,462	879	1.27	233,858	0%	0	0.00	0
2000	68,046	2,165,508	872	1.26	231,936	0%	0	0.00	0
2001	0	2,165,508	865	1.25	230,152	0%	0	0.00	0
2002	0	2,165,508	809	1.17	215,237	0%	0	0.00	0
2003	0	2,165,508	757	1.09	201,289	100%	757	1.09	201,289
2004	0	2,165,508	708	1.02	188,244	100%	708	1.02	188,244
2005	0	2,165,508	662	0.95	176,045	100%	662	0.95	176,045
2006	0	2,165,508	619	0.89	164,637	100%	619	0.89	164,637
2007	0	2,165,508	579	0.83	153,967	100%	579	0.83	153,967
2008	0	2,165,508	541	0.78	143,990	100%	541	0.78	143,990
2009	0	2,165,508	506	0.73	134,658	100%	506	0.73	134,658
2010	0	2,165,508	474	0.68	125,932	100%	474	0.68	125,932
2011	0	2,165,508	443	0.64	117,771	100%	443	0.64	117,771
2012	0	2,165,508	414	0.60	110,139	100%	414	0.60	110,139
2013	0	2,165,508	387	0.56	103,001	100%	387	0.56	103,001
2014	0	2,165,508	362	0.52	96,326	100%	362	0.52	96,326
2015	0	2,165,508	339	0.49	90,084	100%	339	0.49	90,084
2016	0	2,165,508	317	0.46	84,246	100%	317	0.46	84,246
2017	0	2,165,508	296	0.43	78,786	100%	296	0.43	78,786
2018	0	2,165,508	277	0.40	73,681	100%	277	0.40	73,681
2019	0	2,165,508	259	0.37	68,906	100%	259	0.37	68,906
2020	0	2,165,508	242	0.35	64,440	100%	242	0.35	64,440
2021	0	2,165,508	227	0.33	60,264	100%	227	0.33	60,264
2022	0	2,165,508	212	0.31	56,359	100%	212	0.31	56,359
2023	0	2,165,508	198	0.29	52,707	100%	198	0.29	52,707
2024	0	2,165,508	185	0.27	49,291	100%	185	0.27	49,291
2025	0	2,165,508	173	0.25	46,097	100%	173	0.25	46,097
2026	0	2,165,508	162	0.23	43,109	100%	162	0.23	43,109
2027	0	2,165,508	152	0.22	40,316	100%	152	0.22	40,316
2028	0	2,165,508	142	0.20	37,703	100%	142	0.20	37,703
2029	0	2,165,508	133	0.19	35,260	100%	133	0.19	35,260
2030	0	2,165,508	124	0.18	32,975	100%	124	0.18	32,975
2031	0	2,165,508	116	0.17	30,838	100%	116	0.17	30,838
2032	0	2,165,508	108	0.16	28,839	100%	108	0.16	28,839
2033	0	2,165,508	101	0.15	26,970	100%	101	0.15	26,970
2034	0	2,165,508	95	0.14	25,223	100%	95	0.14	25,223
2035	0	2,165,508	89	0.13	23,588	100%	89	0.13	23,588

ASSUMED METHANE CONTENT OF LFG: 50%
SELECTED DECAY RATE CONSTANT: 0.067
SELECTED ULTIMATE METHANE RECOVERY RATE: 3,070 cu ft/ton

EXHIBIT 2. LFG RECOVERY PROJECTION GRAPH
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MD



SECTION 3.0

LANDFILL GAS COLLECTION SYSTEM

3.1 VERTICAL EXTRACTION WELL DEPTH AND SPACING

A total of 97 vertical wells are proposed for the landfill as shown on the drawings. Vertical extraction wells will be installed at depths approximating 75% of the depth of refuse in all Cells 2, 3, 4, 5, N1, and N3. Vertical extraction wells will be installed to approximately 5-feet from the bottom of the landfill in Cell 1. SCS assumes that the effective radius of influence of each extraction well would be approximately 5 times the length of solid pipe in the well (i.e., a solid pipe length of 20 feet would correspond to a radius of influence of 100 feet). This assumption is based on SCS pump tests and full-scale system operations experience at other landfills. Extraction wells will be spaced on the vertices of an equilateral triangle (to optimize the zone of influence overlap). Vertical wells are proposed to be located centrally within the Landfill to extract methane-rich gas to reduce the potential for off-site LFG migration and LFG emissions through the landfill surface. Monitoring and flow control for the wells will be provided by an aboveground wellhead. A summary of the proposed wellfield is as follows:

- 94 new extraction wells in top areas of the landfill currently uncovered by wells.
- 11 wells connected to existing leachate risers in Cells N1, N2 and N3.

No vertical extraction wells are proposed for Cell N2 since the depth of waste is very shallow. Gas collection from this area will be accomplished through the use of connections to the leachate collection system risers.

3.2 WELLFIELD PIPE SIZING

The LFG collection piping which delivers the LFG to the blower/flare station will be sized to consider the head losses throughout the piping network to minimize the vacuum requirements of the system. The extraction blower and header piping will be designed to deliver a minimum of 15 inches of water column (in.-w.c.) of vacuum to each extraction wellhead in the LFG collection system. The collection system components will be conservatively sized based on the LFG collection rate. Header size calculations are included in Appendix B.

3.3 VANDAL RESISTANT LFG COLLECTION SYSTEM FEATURES

SCS has attempted to reduce the visibility and accessibility of appurtenances on the LFG collection system that may otherwise prove tempting to vandals. Measures taken include:

- LFG header pipe will be buried.

- Blower/flare station will have a barbed wire fence.
- Below-grade handholes, valve vaults, etc., will have locks and/or bolts requiring special tools for access.
- Wellheads will be enclosed.

SECTION 4.0

BLOWER/FLARE STATION

4.1 BLOWER SELECTION

Blower selection for the RRLF is based on the landfill gas collection model results presented earlier in this report. According to the SCS model, the maximum LFG collection rate for the future of the landfill is about 800 cfm.

To handle this flowrate, two 500 scfm blowers will be installed in parallel. The use of two blowers offers increased flexibility in LFG control. For the first few years both blowers will be running at less than full capacity until the flow rate drops to a point where only one blower needs to operate. Based on our modeling estimates, this should be in approximately 2010, at which point the second blower will be used for full capacity backup in the event of a failure.

SCS anticipates the following specifications for the blower:

- Two blowers, both active for a few years and then one to be standby to provide 100 percent redundancy.
- Blowers are industrial grade, centrifugal type to provide a wide range of flows and long-term service. The blowers shall have non-sparking totally enclosed fan cooled (TEFC) motors appropriate for National Electric Code (NEC) Class 1 Division 2 environments equipped with variable frequency drives. The blowers will not be in an enclosed structure; therefore, the motors are not required to be explosion proof.
- Total blower capacity of 1000 cfm at approximately 35 inches of water column inlet vacuum and 15 inches outlet pressure (vacuum ratings based on similarly sized extraction systems at other landfills).
- Minimum 15 HP TEFC motors wired for 480V, 3-phase service.

A programmable logic controller (PLC) will be specified to receive signals from the devices listed above and communicate with the appropriate equipment (flare, blower, valves, etc.) to perform the necessary function.

4.2 BLOWER/ FLARE STATION CONSIDERATION

The blower/flare station is sited in the central portion of the site adjacent to Cells 2 and 3. This location offers several advantages:

- Conveniently located for Allegheny Power to bring three-phase power. SCS anticipates that electrical power will be brought in at the eastern end of the site, from the existing maintenance building.

- A cleared area surrounded by native trees to help to screen the facility from local residences.

- Close to an existing access road.

The blower/flare station location will be surrounded by an 8-foot-high chain link and barbed wire fence provided with a swing gate for access. The proposed blower/flare station location is intended to keep it out of view. In addition, the gate may be locked to deter trespassers or vandals.

The flare will be an open or utility-type with a stack sized to handle 1,000 scfm at 500 Btu/cf. The flare shall have a turndown ratio of at least 10-to-1. In addition, a flame monitoring system will be necessary to automatically shut off the flow of LFG (via blower shutdown and valve closure) in the even of a flame outage. The flare controls shall signal a shutdown and activate an auto dialer in case of flame outage. The flare shall have automatic re-light capability. The blower/flare station piping layout will include a tee and blind flange at the blower outlet to allow for LFG transport to a possible LFG utilization project.

The flare foundation is the primary structural element at the blower/flare station. To accommodate the flare, the foundation should be approximately 7 feet square to adequately withstand 100 miles per hour (MPH) wind loading. The foundation will consist of concrete about 1-½ feet thick, reinforced with deformed steel bars. The final flare foundation design will depend on soil conditions at the site and the final flare design.

Hydrogen sulfide is a corrosive gas often found at trace levels in LFG, which along with VOC's, sulfur oxides, and organic halides, can affect certain components of the system. In the blower/flare station, measures will be taken to protect the equipment that will come into contact with the LFG. The blowers will be specified to have coatings on the internal parts to protect the impellers and blower casings. The connection piping, valves, and fittings will have plastic, stainless steel, or other non-corrosive components. In addition, the flame arrester, flare tip, stack, and pilot/ignition assemblies will be specified as stainless steel or other corrosion-resistant material.

SECTION 5.0

CONDENSATE PRODUCTION AND CONTROL

Condensate is formed as the temperature and pressure of LFG extracted from the landfill changes in the collection system piping. Four condensate traps are planned for the landfill. Management of LFG condensate at the Resh Road Sanitary Landfill will be handled as follows:

- Condensate formed in the lateral piping from the wellhead to the header will drain into the header pipes.
- Condensate formed in laterals connected to remote wellheads will be drained back into the leachate collection system.
- Condensate formed in the header piping on the landfill will drain into the condensate traps (designated CT-1, -2, -3 and -4 on the design drawings). The traps will drain by gravity to the existing leachate collection system.
- An in-line condensate knock-out pot, serving as a moisture separator will be capable of handling 150 gpd and equipped with a filter or demister pad to maximize condensate removal upstream of blowers to minimize corrosion.

Condensate in header piping can form a blockage in the gas system if it collects in a low point and is not removed from the header system. To maintain positive drainage, a minimum 3 percent slope is specified for collection piping on the landfill surface. Differential settlement under the piping is less of a concern in areas off the refuse mounds, so a minimum slope of 1 percent is anticipated for piping located on natural soil.

The total quantity of condensate collected by the LFG system is expected to be highest during the winter months when the temperature differential of LFG from the wellhead to the flare station is greatest. Condensate generation is estimated to be approximately 250 gallons per day. This value represents the anticipated maximum daily amount from 800 cfm of LFG, which is the anticipated collection rate, if an LFG temperature of 120 degrees F at the wellhead and 40 degrees F at the blower is assumed.

SECTION 6.0

CONSTRUCTION COST ESTIMATE

Presented on the following page is the construction cost estimate for the LFG collection system. The unit prices are based on actual unit price bids for similar projects in Maryland and Virginia over the past several years.

CONSTRUCTION COST ESTIMATE
LANDFILL GAS COLLECTION AND CONTROL SYSTEM
RESH ROAD SANITARY LANDFILL, HAGERSTOWN, MARYLAND

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
1	Mobilization / Demobilization	1	LS	$20,000	$20,000
2	LFG Blower/Flare Station	1	LS	$175,000	$175,000
3	12" Dia. HDPE Piping and Fittings	70	LF	$31	$2,170
4	10" Dia. HDPE Piping and Fittings	135	LF	$27	$3,645
5	8" Dia. HDPE Piping and Fittings	2,050	LF	$23	$47,150
6	6" Dia. HDPE Piping and Fittings	14,500	LF	$16	$232,000
7	4" Dia. HDPE Piping and Fittings	9,550	LF	$15	$143,250
8	10" Dia. LFG Header Isolation Valve	1	EA	$1,800	$1,800
9	8" Dia. LFG Header Isolation Valve	4	EA	$1,100	$4,400
10	6" Dia. LFG Header Isolation Valve	14	EA	$700	$9,800
11	Condensate Trap	4	EA	$6,500	$26,000
12	LFG Wellheads	105	EA	$450	$47,250
13	LFG Wells	3,930	LF	$65	$255,450
14	Road Crossing	415	LF	$25	$10,375
15	Directional Bore Road Crossing	150	LF	$40	$6,000
16	Wellhead and Valve Vaults	124	EA	$300	$37,200
		TOTAL CONSTRUCTION COST			$984,000

APPENDIX A

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-1
DEPTH 36'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-8	Topcover	Dry	80
8-25	household	Dry	80
25-28	household, tires	Dry	80
28-36	household, C&D	Saturated	80

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-2
DEPTH 37'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-4	Topcover	Dry	
4-17	wood, dirt	Dry	70 @ 10'
17-37	wood, slight traces household,	Wet @ 25'	70@ 20'
	dirt		75 @ 30'

COMMENTS : 75% dirt

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH **978-355-5100**
FAX **978-355-0111**

Client: SCS
Location: Hagerstown, MD

Hole size: 30"
Driller: S. Garrison
Helper: J. Goosman

WELL NO. C-4
DEPTH 49'
Start date: 4-4-02
Finish date: 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-4	Topcover	Dry	
4-25	household,wood	Dry	80 @ 10'
25-40	household,plastic	Dry	90 @ 20'
40-49	household,wood	wet	110 @ 30'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-5
DEPTH 36'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-2	Topcover	Dry	
2-17	household	Dry	70 @ 10'
17-30	household,metal	Dry	90 @ 20'
30-36	household,wood	wet	97 @ 30'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client: SCS
Location: Hagerstown, MD

Hole size: 30"
Driller: S. Garrison
Helper: J. Goosman

WELL NO. N-1
DEPTH 50'
Start date 4-4-02
Finish date 4-5-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-2	dirt		75 @ 10'
2-36	household	dry	85 @ 20'
36-41	metal, wood, plastic	moderate	92 @ 30'
41-50	dirt, household	dry	97 @ 40'
			110 @ 50'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client	SCS
Location	Hagerstown, MD
Hole size	30"
Driller	S. Garrison
Helper	J. Goosman

WELL NO.	N-3
DEPTH	30'
Start date	4-5-02
Finish date	4-5-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-1	top cover		
1-30	household, plastic, carpet	dry	60 @ 10'
			100 @ 30'

COMMENTS

APPENDIX B

PIPE SIZE / HEADLOSS CALCULATIONS
FOR RESH ROAD SANITARY LANDFILL

Calculated by: Michael Kalish
Date: 10-Jul-02

The Spitzglass formula was used for headloss calculations :

P = ((Q^2)*L)/((C^2)*(D^5))

where:
P = pressure loss (in.-wc)
Q = flow rate (cf/hr)
L = equivalent length of pipe (ft.)
C = 3550/(1+(3.6/D)+(0.03*D))^0.5
D = pipe diameter (in.)

Velocity (V) criteria:
D >= 12 in., V <= 2000 fpm
D <= 12 in., V <= 1200 fpm

LFG FLOW (cfm) = 2/3*(pi)*(ROI)^2*H*r/27/525600
ROI = Radius of influence (ft)
H = Refuse depth (ft)
r = LFG generation rate (cf/cy/yr)

WELL DEPTH criteria:
1. Wells to 5' from approximate bottom in Cell 1
2. Wells to 75% refuse depth in Cells 2, 3, 4, 5, N1, a
3. Wells 21, 39, 46, 59, 81, and 93 are existing
4. Cell N2 has gas collection through leachate risers

LFG FLOW ESTIMATE

INPUT — CALCULATION

LFG GEN. RATE 130 cf/cy/yr
ROI FACTOR 5 times solid pipe length

WELL #	BASE ELEVATION (ft)	FINAL ELEVATION (ft)	REFUSE DEPTH (ft)	WELL DEPTH (ft)	SOLID PIPE LENGTH (ft)	ROI (ft)	LFG FLOW (cfm)
1	505	566	61	46	20	100	9
2	515	566	51	38	20	100	7
3	510	577	67	50	20	100	10
4	515	570	55	41	20	100	8
5	515	570	55	41	20	100	8
6	505	577	72	54	20	100	10
7	510	558	48	36	20	100	7
8	500	556	56	42	20	100	8
9	498	578	80	60	20	100	12
10	500	556	56	42	20	100	8
11	495	550	55	41	20	100	8
12	495	542	47	35	20	100	7
13	490	545	55	41	20	100	8
14	485	540	55	41	20	100	8
15	480	536	56	42	20	100	8
16	485	564	79	59	20	100	11
17	480	538	58	44	20	100	8
18	490	555	65	49	20	100	9
19	490	571	81	61	20	100	12
20	490	576	86	65	20	100	12
21	505	576	71	36	15	75	4
22	498	574	76	57	20	100	11
23	495	556	61	46	20	100	9
24	500	564	64	48	20	100	9
25	525	562	37	32	20	100	6
26	520	570	50	45	20	100	9
27	538	574	36	31	20	100	6
28	525	570	45	40	20	100	8
29	538	570	32	27	15	75	3
30	532	566	34	29	20	100	6
31	520	575	55	50	20	100	10
32	538	566	28	23	15	75	2
33	525	560	35	30	20	100	6
34	520	566	46	41	20	100	8
35	521	552	31	26	15	75	3
36	520	552	32	27	15	75	3
37	520	554	34	29	20	100	6
38	520	554	34	29	20	100	6
39	520	571	51	36	15	75	4
40	520	562	42	37	20	100	7
41	520	576	56	51	20	100	10
42	490	572	82	62	20	100	12
43	484	568	84	63	20	100	12
44	481	538	57	43	20	100	8
45	483	546	63	47	20	100	9
46	485	563	78	48	15	75	5
47	485	562	77	58	20	100	11
48	485	540	55	41	20	100	8

49	477	536	59	44	20	100	8
50	480	555	75	56	20	100	11
51	478	539	61	46	20	100	9
52	470	526	56	42	20	100	8
53	470	534	64	48	20	100	9
54	486	556	70	53	20	100	10
55	470	508	38	29	20	100	5
56	470	544	74	56	20	100	11
57	470	542	72	54	20	100	10
58	470	506	36	27	15	75	3
59	470	539	69	36	15	75	4
60	470	524	54	41	20	100	8
61	470	518	48	36	20	100	7
62	470	520	50	38	20	100	7
63	470	528	58	44	20	100	8
64	470	522	52	39	20	100	7
65	470	531	61	46	20	100	9
66	470	531	61	46	20	100	9
67	470	544	74	56	20	100	11
68	470	554	84	63	20	100	12
69	490	558	68	51	20	100	10
70	487	538	51	38	20	100	7
71	488	530	42	32	20	100	6
72	486	554	68	51	20	100	10
73	484	562	78	59	20	100	11
74	488	539	51	38	20	100	7
75	485	562	77	58	20	100	11
76	487	541	54	41	20	100	8
77	487	550	63	47	20	100	9
78	480	533	53	40	20	100	8
79	480	514	34	26	20	100	5
80	478	549	71	53	20	100	10
81	476	552	76	50	15	75	5
82	487	527	40	30	20	100	6
83	477	535	58	44	20	100	8
84	477	536	59	44	20	100	8
85	478	520	42	32	20	100	6
86	475	513	38	29	20	100	5
87	474	534	60	45	20	100	9
88	474	508	34	26	15	75	3
89	476	536	60	45	20	100	9
90	474	506	32	24	15	75	3
91	476	516	40	30	20	100	6
92	478	523	45	34	20	100	6
93	504	562	58	30	15	75	3
94	508	561	53	40	20	100	8
95	506	561	55	41	20	100	8
96	504	544	40	30	20	100	6
LC-1							5
LC-2							5
LC-3							5
LC-4							5
LC-5							5
LC-6							5
LC-7							5
LC-8							5
LC-9							5
LC-10							5
LC-11							5
TOTAL							800

Header Section	Length (ft)	Diameter (in)		3	4	6	8	10	12	14	16	18	20	22
		Nominal	Actual											
NONE	0	NA	NA											
1	127	4	3.97	0	127	0	0	0	0	0	0	0	0	0
2	200	4	3.97	0	200	0	0	0	0	0	0	0	0	0
3	185	4	3.97	0	185	0	0	0	0	0	0	0	0	0
4	110	4	3.97	0	110	0	0	0	0	0	0	0	0	0
5	220	6	5.85	0	0	220	0	0	0	0	0	0	0	0
6	45	6	5.85	0	0	45	0	0	0	0	0	0	0	0
7	95	6	5.85	0	0	95	0	0	0	0	0	0	0	0
8	535	6	5.85	0	0	535	0	0	0	0	0	0	0	0
9	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
10	285	6	5.85	0	0	285	0	0	0	0	0	0	0	0
11	100	6	5.85	0	0	100	0	0	0	0	0	0	0	0
12	50	6	5.85	0	0	50	0	0	0	0	0	0	0	0
13	335	6	5.85	0	0	335	0	0	0	0	0	0	0	0
14	170	6	5.85	0	0	170	0	0	0	0	0	0	0	0
15	125	6	5.85	0	0	125	0	0	0	0	0	0	0	0
16	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
17	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
18	80	6	5.85	0	0	80	0	0	0	0	0	0	0	0
19	70	6	5.85	0	0	70	0	0	0	0	0	0	0	0
20	45	6	5.85	0	0	45	0	0	0	0	0	0	0	0
21	55	6	5.85	0	0	55	0	0	0	0	0	0	0	0
22	90	6	5.85	0	0	90	0	0	0	0	0	0	0	0
23	255	6	5.85	0	0	255	0	0	0	0	0	0	0	0
24	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
25	370	6	5.85	0	0	370	0	0	0	0	0	0	0	0
26	120	6	5.85	0	0	120	0	0	0	0	0	0	0	0
27	35	6	5.85	0	0	35	0	0	0	0	0	0	0	0
28	145	6	5.85	0	0	145	0	0	0	0	0	0	0	0
29	155	6	5.85	0	0	155	0	0	0	0	0	0	0	0
30	35	6	5.85	0	0	35	0	0	0	0	0	0	0	0
31	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
32	180	6	5.85	0	0	180	0	0	0	0	0	0	0	0
33	90	6	5.85	0	0	90	0	0	0	0	0	0	0	0
34	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
35	195	6	5.85	0	0	195	0	0	0	0	0	0	0	0
36	145	6	5.85	0	0	145	0	0	0	0	0	0	0	0
37	180	6	5.85	0	0	180	0	0	0	0	0	0	0	0
38	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
39	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
40	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
41	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
42	400	6	5.85	0	0	400	0	0	0	0	0	0	0	0
43	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
44	240	6	5.85	0	0	240	0	0	0	0	0	0	0	0
45	335	6	5.85	0	0	335	0	0	0	0	0	0	0	0
46	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
47	140	6	5.85	0	0	140	0	0	0	0	0	0	0	0
48	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
49	105	6	5.85	0	0	105	0	0	0	0	0	0	0	0
50	95	6	5.85	0	0	95	0	0	0	0	0	0	0	0
51	135	6	5.85	0	0	135	0	0	0	0	0	0	0	0
52	110	8	7.61	0	0	0	110	0	0	0	0	0	0	0
53	120	8	7.61	0	0	0	120	0	0	0	0	0	0	0
54	70	12	11.25	0	0	0	0	0	70	0	0	0	0	0
55	135	10	9.49	0	0	0	0	135	0	0	0	0	0	0
56	110	8	7.61	0	0	0	110	0	0	0	0	0	0	0
57	195	8	7.61	0	0	0	195	0	0	0	0	0	0	0
58	155	8	7.61	0	0	0	155	0	0	0	0	0	0	0
59	145	8	7.61	0	0	0	145	0	0	0	0	0	0	0

60	160	8	7.61		0	0	0	160	0	0	0	0	0	0	0	
61	110	8	7.61		0	0	0	110	0	0	0	0	0	0	0	
62	170	8	7.61		0	0	0	170	0	0	0	0	0	0	0	
63	150	6	5.85		0	0	150	0	0	0	0	0	0	0	0	
64	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
65	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
66	65	6	5.85		0	0	65	0	0	0	0	0	0	0	0	
67	170	6	5.85		0	0	170	0	0	0	0	0	0	0	0	
68	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
69	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
70	155	6	5.85		0	0	155	0	0	0	0	0	0	0	0	
71	490	6	5.85		0	0	490	0	0	0	0	0	0	0	0	
72	260	6	5.85		0	0	260	0	0	0	0	0	0	0	0	
73	105	6	5.85		0	0	105	0	0	0	0	0	0	0	0	
74	35	6	5.85		0	0	35	0	0	0	0	0	0	0	0	
75	80	6	5.85		0	0	80	0	0	0	0	0	0	0	0	
76	50	6	5.85		0	0	50	0	0	0	0	0	0	0	0	
77	65	6	5.85		0	0	65	0	0	0	0	0	0	0	0	
78	230	6	5.85		0	0	230	0	0	0	0	0	0	0	0	
79	195	6	5.85		0	0	195	0	0	0	0	0	0	0	0	
80	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
81	160	6	5.85		0	0	160	0	0	0	0	0	0	0	0	
82	160	6	5.85		0	0	160	0	0	0	0	0	0	0	0	
83	290	6	5.85		0	0	290	0	0	0	0	0	0	0	0	
84	70	6	5.85		0	0	70	0	0	0	0	0	0	0	0	
85	225	6	5.85		0	0	225	0	0	0	0	0	0	0	0	
86	295	6	5.85		0	0	295	0	0	0	0	0	0	0	0	
87	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
88	160	8	7.61		0	0	0	160	0	0	0	0	0	0	0	
89	180	8	7.61		0	0	0	180	0	0	0	0	0	0	0	
90	125	8	7.61		0	0	0	125	0	0	0	0	0	0	0	
91	290	8	7.61		0	0	0	290	0	0	0	0	0	0	0	
92	110	4	3.97		0	110	0	0	0	0	0	0	0	0	0	
	15152			TOTAL	0	732	12185	2030	135	70	0	0	0	0	0	15152
				DIAMETER	3	4	6	8	10	12	14	16	18	20	22	

HDPE SDR 17	
Nominal	Actual
3	3.00
4	3.97
6	5.85
8	7.61
10	9.49
12	11.25
13	11.81
14	12.35
16	14.12
18	15.88
20	17.65
22	19.41

CASE #1
SDR 17 PIPE

02-Jul-02

From	Through	Length (ft.)	Branch Flow (cfm)	Header Flow (cfm)	Diameter (in.)	Velocity (fpm)	Pressure Loss (in.-w.c.)	Loss per 100 ft. (in.-w.c.)	Notes
CELL N2, N3									
95	1	127	8	8	3.97	93	0.00	0.00	
94	2	200	8	16	3.97	186	0.03	0.02	
						SUBTOTAL	0.03		
96	3	185	6	6	3.97	70	0.00	0.00	
97	4	110	5	5	3.97	58	0.00	0.00	
LC-10	5	220	5	10	5.85	54	0.00	0.00	
LC-9	6	45	5	15	5.85	80	0.00	0.00	
						SUBTOTAL	0.01		MAX = 0.03
2,5	7	95	16	31	5.85	166	0.01	0.01	
LC-8	8	535	5	36	5.85	193	0.05	0.01	
LC-6,LC-7	9	175	10	46	5.85	246	0.03	0.02	
LC-5	10	285	5	51	5.85	273	0.06	0.02	
						SUBTOTAL	0.14		
LC-2,3,4	11	100	15	15	5.85	80	0.00	0.00	
LC-1	12	50	5	20	5.85	107	0.00	0.00	
						SUBTOTAL	0.00		
10,12	13	335	51	71	5.85	380	0.13	0.04	
						SUBTOTAL	0.30		MAX CELLS N2,N3
CELL N1 SOUTHERN LOOP									
88	22	90	3	3	5.85	16	0.00	0.00	
87	23	255	9	12	5.85	64	0.00	0.00	
86	24	150	5	17	5.85	91	0.00	0.00	
85	25	370	6	23	5.85	123	0.01	0.00	
84	26	120	8	31	5.85	166	0.01	0.01	
82	27	35	6	37	5.85	198	0.00	0.01	
83	28	145	8	45	5.85	241	0.02	0.02	
80,81	29	155	15	60	5.85	321	0.04	0.03	
79	30	35	5	65	5.85	348	0.01	0.03	
						SUBTOTAL	0.11		
CELL N1 NORTHERN LOOP									
85	24	150	6	6	5.85	32	0.00	0.00	
86	23	255	5	11	5.85	59	0.00	0.00	
87	22	90	9	20	5.85	107	0.00	0.00	
88	21	55	3	23	5.85	123	0.00	0.00	
LC-11	20	45	5	28	5.85	150	0.00	0.01	
89	19	70	9	37	5.85	198	0.01	0.01	
90	18	80	3	40	5.85	214	0.01	0.01	
91	17	200	6	46	5.85	246	0.03	0.02	
92	16	190	6	52	5.85	279	0.04	0.02	
93	15	125	3	55	5.85	295	0.03	0.02	
15,30	14	170	65	117	5.85	627	0.17	0.10	
						SUBTOTAL	0.30		MAX CELL N1
N CELLS									
13,14	31	175	71	188	5.85	1007	0.46	0.26	
HALF N	32	180	94	94	5.85	504	0.12	0.07	CELLS 2,3
HALF N	33	90	94	94	5.85	504	0.06	0.07	CELLS 1,4,5

CASE #1
SDR 17 PIPE

02-Jul-02

From	Through	Length (ft.)	Branch Flow (cfm)	Header Flow (cfm)	Diameter (in.)	Velocity (fpm)	Pressure Loss (in.-w.c.)	Loss per 100 ft. (in.-w.c.)	Notes
CELLS 2,3 NORTHERN LOOP									
14	35	195	8	8	5.85	43	0.00	0.00	
13	36	145	8	16	5.85	86	0.00	0.00	
12	37	180	7	23	5.85	123	0.01	0.00	
11	38	175	8	31	5.85	166	0.01	0.01	
10	39	175	8	39	5.85	209	0.02	0.01	
8,9	40	190	20	59	5.85	316	0.05	0.03	
7	41	190	7	66	5.85	354	0.06	0.03	
8	42	400	8	74	5.85	396	0.16	0.04	
4	43	200	8	82	5.85	439	0.10	0.05	
3,2	44	240	17	99	5.85	530	0.18	0.07	
						SUBTOTAL	0.59		
CELLS 2,3 SOUTHERN LOOP									
32	45	335	94	94	5.85	504	0.22	0.07	
15	46	200	8	102	5.85	546	0.16	0.08	
16,17	47	140	19	121	5.85	648	0.15	0.11	
18,19,20	48	150	33	154	5.85	825	0.27	0.18	
23	49	105	9	163	5.85	873	0.21	0.20	
22	50	95	11	174	5.85	932	0.21	0.23	
6,21,24	51	135	23	197	5.85	1055	0.39	0.29	
1	52	110	9	206	7.61	652	0.09	0.08	
44,52	53	120	99	305	7.61	966	0.21	0.18	
						SUBTOTAL	1.91		MAX CELLS 2,3
CELLS 1,4,5 NORTHERN LOOP									
33	84	70	94	94	5.85	504	0.05	0.07	
66	85	225	9	103	5.85	552	0.18	0.08	
67,68	86	295	23	126	5.85	675	0.35	0.12	
69,70	87	140	17	143	5.85	766	0.21	0.15	
53,54,73,72,71	88	160	46	189	7.61	598	0.11	0.07	
74,75	89	180	18	207	7.61	655	0.15	0.08	
76	90	125	8	215	7.61	681	0.11	0.09	
42,77	91	290	21	236	7.61	747	0.31	0.11	
						SUBTOTAL	1.46		
CELLS 1,4,5 SOUTHERN LOOP									
65	82	160	9	9	5.85	48	0.00	0.00	
64	81	160	7	16	5.85	86	0.00	0.00	
63	80	180	8	24	5.85	129	0.01	0.00	
62	79	195	7	31	5.85	166	0.01	0.01	
61	78	230	7	38	5.85	204	0.02	0.01	
60	77	65	8	46	5.85	246	0.01	0.02	
59	76	50	4	50	5.85	268	0.01	0.02	
58	75	80	3	53	5.85	284	0.02	0.02	
56,57	74	35	21	74	5.85	396	0.01	0.04	
55	72,73	365	5	79	5.85	423	0.17	0.05	
51,52	71	490	17	96	5.85	514	0.34	0.07	
49,50	70	155	19	115	5.85	616	0.15	0.10	
47,48	69	140	19	134	5.85	718	0.19	0.13	
45,46	68	180	14	148	5.85	793	0.29	0.16	
43,44	67	170	20	168	5.85	900	0.36	0.21	
40,41	66	65	17	185	5.85	991	0.17	0.26	
38,39	65	140	10	195	5.85	1045	0.40	0.28	
37	64	180	6	201	5.85	1077	0.54	0.30	
36	63	150	3	204	5.85	1093	0.47	0.31	
34,35	62	170	11	215	7.61	681	0.15	0.09	
33	61	110	6	221	7.61	700	0.10	0.09	
32	60	160	2	223	7.61	706	0.15	0.09	
30,31	59	145	16	239	7.61	757	0.16	0.11	
28,29	58	155	11	250	7.61	791	0.18	0.12	
27	57	195	6	256	7.61	810	0.24	0.12	
25,26	56	110	15	271	7.61	858	0.15	0.14	
						SUBTOTAL	4.32		MAX CELLS 1,4,5
56,91	55	135	236	507	9.49	1032	0.21	0.16	
53,55	54	70	305	812	11.25	1176	0.12	0.17	
						OVERALL=	4.65		

Project No.: 2201085
Project Name: Resh Road Sanitary Landfill
File Name: R:\lfg\02201085\tech\condensate.xls
Calculated by: Michael Kalish
Date: 7/10/02

QUANTITY OF CONDENSATE AT THE RESH ROAD SANITARY LANDFILL

Data and Assumptions:

LFG Flow		800	scfm
Standard Temp.		60	F
Standard Pressure		14.7	psia
Temp. of LFG at Wellhead		100	F
Temp. of LFG at Blower		40	F
Vacuum at Wellhead		10	in-W.C.
Vacuum at Blower		40	in-W.C.
Water Vapor Pressure	@ 100 F (37.8 C) =	49.1	mm Hg
	@ 60F (15.5C) =	13.21	mm Hg
	@ 40 F (4.4 C) =	6.27	mm Hg
Amount of Condensate Removed from Landfill Prior to Blower=		50%	
LFG is Saturated with Water at Wellhead			

QUANTITY OF CONDENSATE AT THE RESH ROAD SANITARY LANDFILL

Calculations

Volume of LFG at Wellhead Conditions:	
(PV/T)1 = (PV/T)2	
Volume at Wellhead Conditions	883 cfm
Pounds of Water Vapor in LFG at Wellhead	
PV = nRT	
Moles of Water=	0.1 moles/min
Pounds of Water=	2.5 Lbs/min
Volume of LFG at Blower Conditions:	
(PV/T)1 = (PV/T)2	
Volume at Blower Conditions=	853 cfm
Pounds of Water Vapor in LFG at Blower:	
PV = nRT	
Moles of Water=	0.0405829 moles/min
Pounds of Water=	0.7304928 Lbs/min
Amount of Condensate Prior to Blower	
Lbs. at Wellhead - Lbs. at Blower=	1.8 Lbs/min
Convert to Gallons per Day=	307 Gal/day
TOTAL CONDENSATE PER DAY AT THE KO POT:	
50% of the vapor condensed before the blower	
= 154 Gal/day	
TOTAL CONDENSATE PER DAY AT THE KO POT:	154 Gal/day

Resh Road Sanitary Landfill - Hagerstown, MD
LFG System Sizing

Blower/Flare Capacity

Total Flow = 1,000 cfm

System Head Losses (Estimated):

Pressure Required at Flare Inlet =	10 in-wc
Headloss Through Knockout =	5 in-wc
Minor Losses (Valves, Fittings) =	10 in-wc
Headloss through Flame Arrestor =	5 in-wc
Headloss in Piping =	5 in-wc
Available Vacuum at Wellhead =	15 in-wc
Total Headloss	50 in-wc

Specify 2 Blowers Capable of Providing 500 cfm at 50 in-wc, Max. Surge Point = 200 cfm

Specify 1 Candle Flare Capable of Handling 1,000 cfm of LFG with 50% Methane
Min. Turndown Ratio = 10:1

Max. Heat Rate = (1000cf/min.)(500Btu/cf) = 30 MM Btu/Hr
Min. Heat Rate = (200cf/min.)(300Btu/cf) = 3.6 MM Btu/Hr

Environmental Consultants

SCS ENGINEERS

DESIGN REPORT

for

RESH ROAD SANITARY LANDFILL
LANDFILL GAS MANAGEMENT SYSTEM

Presented to:

WASHINGTON COUNTY
ENGINEERING DEPARTMENT
DIVISION OF PUBLIC WORKS
80 W. Baltimore Street
Hagerstown, Maryland 21740

Presented by:

SCS ENGINEERS
11260 Roger Bacon Drive
Reston, Virginia 20190
(703) 471-6150

July 10, 2002
File No. 02201085.00

TABLE OF CONTENTS

EXHIBITS

APPENDICES

SECTION 1.0

INTRODUCTION

This report presents the design rationale and criteria for the proposed landfill gas (LFG) collection system for the Resh Road Sanitary Landfill.

1.1 LANDFILL BACKGROUND

The Resh Road Landfill (RRLF) is located approximately three miles west of Hagerstown, Maryland, on a 140-acre parcel of land. The waste footprint is about 75 acres, consisting of eight cells. Operations began in the early 1980s and ceased on January 18, 2001. The landfill is owned and operated by Washington County. Presently, no LFG is collected at the site. The quantity of in-place waste is approximately 2.2 million tons.

1.2 SYSTEM OBJECTIVES

Consistent with SCS' scope of services, the LFG collection system components will be sized to control LFG generated in the landfill. The objectives of the proposed LFG management system are as follows:

- Collecting and destructing LFG to reduce methane emissions to the atmosphere.
- Maintaining the integrity of the cap.
- Complying with applicable State and Federal regulations.
- Controlling potential odors.
- Controlling potential LFG migration.

All of the above objectives rely on efficient LFG collection and appropriate combustion equipment such as a candlestick flare. Uncollected LFG emitted to the atmosphere can cause odors, and methane in LFG is a greenhouse gas. The presence of a geomembrane cap reduces the potential for such emissions, but does not reduce the need for LFG collection to control potentially damaging pressure buildup beneath the cap. The presence of a cap also increases the potential of subsurface LFG migration, thus increasing the need for proper LFG collection and control.

1.3 AIR EMISSIONS

The Resh Road Sanitary Landfill is not required to comply with the Clean Air Act New Source Performance Standards (NSPS) and Emission Guidelines (EG) for sanitary landfills, nor with Title V and the corresponding MDE emission rules (COMAR

26.11.19). It is exempt from NSPS because of its size (i.e., it has less than 2.5 million metric tons of waste in place).

1.4 MARYLAND SOLID WASTE MANAGEMENT REGULATIONS

The present Maryland Solid Waste Management Regulations state that the concentration of methane in on-site structures must not exceed 25 percent of the lower explosive limit (LEL) or 100 percent of the LEL at the landfill property boundary. The RRLF is subject to these regulations, and the objective of the LFG system design is to meet these requirements. Reportedly, an old burn dump exists to the east of Cell 1. This LFG system is not designed to extract gas from this area.

1.5 FINAL COVER SYSTEM

The permeability of the cover system on a landfill affects the LFG collection efficiency. The RRLF is scheduled to upgrade its existing cap. The minimum 2-foot thick intermediate soil layer over refuse will be maintained. A new cap will be installed over this intermediate soil layer. The cap will consist of a woven geotextile being placed on the existing cover followed by a 40 mil textured HDPE synthetic liner. On top of this will be a geocomposite consisting of a geonet sandwiched between two layers of geotextile. Finally a 1'-8" compacted soil layer and 4-inches of topsoil will be placed to finish the construction of the cap. Geomembrane caps typically enhance LFG collection efficiency by reducing the amount of air infiltration caused by wells under vacuum.

1.6 LANDFILL GAS CHARACTERISTICS

SCS installed six gas wells in an effort to characterize the LFG at the RRLF. These wells were installed in Cells 1, 2, 4, 5, N-1, and N-3. Drilling logs for these wells are included in Appendix A. Testing of these wells has shown good quality gas, with pressure in most of them. The results of this testing are shown below.

Well in Cell	Pressure (in.- w.c.)	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	Balance (%)	Water Level (from bottom)
1	+0.5	60.1	38.9	0.4	0.6	7 ft.
2,3	+0.6	57.0	43.0	0	0	0
4	0	59.7	39.3	0	1.0	0
5	+0.1	56.8	43.2	0	0	3 ft.
N1	0	56.8	43.2	0	0	0
N3	0	44.0	27.7	0	28.3	0

SECTION 2.0

LFG RECOVERY ESTIMATES

The landfill gas model used by SCS Engineers is a first-order model, similar to the U.S. Environmental Protection Agency (EPA) Landfill Gas Emissions Model (LandGEM). The model developed by SCS Engineers calculates gas recovery, not gas generation. The model uses input variables for methane recovery potential (Lo) and annual gas recovery rate (k) that have been developed specifically by SCS based on a database of approximately 100 operational landfill gas collection systems. The estimated landfill gas recovery projections are based on our engineering judgment as of the date of this report.

The LFG recovery projection for the RRLF is shown in Exhibits 1 and 2. SCS prepared the model using the following input parameters:

1. **Refuse Filling History and Projections:** The in-place waste volume, as provided by the Washington County Solid Waste Department from 1989 until closure.
2. **LFG Decay Rate Constant (k):** A k value of 0.067/year was used based on the SCS database.
3. **Ultimate Methane Recovery Rate (L_o):** A L_o value of 3,070 cubic feet (ft^3)/ton was used based on the SCS database.
4. **System Coverage:** For this exercise, SCS considered the wellfield layout, the landfill design (e.g., waste depths, liner and cap construction, and sideslopes), and the wellfield operating data.

2.1 SCS MODEL RESULTS

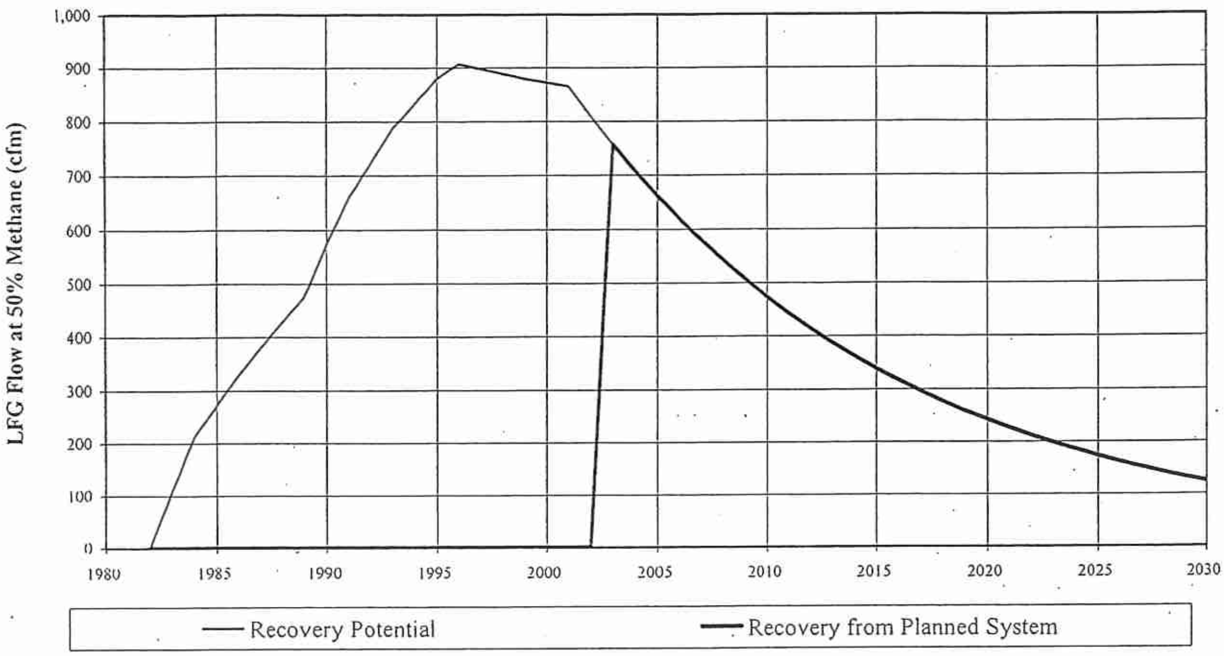
The LFG recovery rate should equal the LFG recovery potential with closure and capping of the landfill. The collection system is designed to provide 100 percent coverage of the waste disposal footprint. Site LFG recovery was expected to peak in 1996, at about 907 scfm. The model estimates that LFG recovery will be approximately 800 scfm at system startup.

EXHIBIT 1. LFG RECOVERY PROJECTION
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MARYLAND

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1982	150,000	150,000	0	0.00	0	0%	0	0.00	0
1983	150,000	300,000	110	0.16	29,200	0%	0	0.00	0
1984	100,000	400,000	212	0.31	56,508	0%	0	0.00	0
1985	100,000	500,000	272	0.39	72,313	0%	0	0.00	0
1986	100,000	600,000	327	0.47	87,094	0%	0	0.00	0
1987	100,000	700,000	379	0.55	100,917	0%	0	0.00	0
1988	100,000	800,000	428	0.62	113,844	0%	0	0.00	0
1989	177,927	977,927	474	0.68	125,933	0%	0	0.00	0
1990	169,043	1,146,970	573	0.83	152,409	0%	0	0.00	0
1991	147,852	1,294,822	660	0.95	175,439	0%	0	0.00	0
1992	150,750	1,445,572	725	1.04	192,852	0%	0	0.00	0
1993	130,605	1,576,177	788	1.14	209,701	0%	0	0.00	0
1994	136,826	1,713,003	833	1.20	221,536	0%	0	0.00	0
1995	115,525	1,828,528	879	1.27	233,815	0%	0	0.00	0
1996	67,718	1,896,246	907	1.31	241,152	0%	0	0.00	0
1997	67,310	1,963,556	898	1.29	238,706	0%	0	0.00	0
1998	65,928	2,029,484	889	1.28	236,340	0%	0	0.00	0
1999	67,978	2,097,462	879	1.27	233,858	0%	0	0.00	0
2000	68,046	2,165,508	872	1.26	231,936	0%	0	0.00	0
2001	0	2,165,508	865	1.25	230,152	0%	0	0.00	0
2002	0	2,165,508	809	1.17	215,237	0%	0	0.00	0
2003	0	2,165,508	757	1.09	201,289	100%	757	1.09	201,289
2004	0	2,165,508	708	1.02	188,244	100%	708	1.02	188,244
2005	0	2,165,508	662	0.95	176,045	100%	662	0.95	176,045
2006	0	2,165,508	619	0.89	164,637	100%	619	0.89	164,637
2007	0	2,165,508	579	0.83	153,967	100%	579	0.83	153,967
2008	0	2,165,508	541	0.78	143,990	100%	541	0.78	143,990
2009	0	2,165,508	506	0.73	134,658	100%	506	0.73	134,658
2010	0	2,165,508	474	0.68	125,932	100%	474	0.68	125,932
2011	0	2,165,508	443	0.64	117,771	100%	443	0.64	117,771
2012	0	2,165,508	414	0.60	110,139	100%	414	0.60	110,139
2013	0	2,165,508	387	0.56	103,001	100%	387	0.56	103,001
2014	0	2,165,508	362	0.52	96,326	100%	362	0.52	96,326
2015	0	2,165,508	339	0.49	90,084	100%	339	0.49	90,084
2016	0	2,165,508	317	0.46	84,246	100%	317	0.46	84,246
2017	0	2,165,508	296	0.43	78,786	100%	296	0.43	78,786
2018	0	2,165,508	277	0.40	73,681	100%	277	0.40	73,681
2019	0	2,165,508	259	0.37	68,906	100%	259	0.37	68,906
2020	0	2,165,508	242	0.35	64,440	100%	242	0.35	64,440
2021	0	2,165,508	227	0.33	60,264	100%	227	0.33	60,264
2022	0	2,165,508	212	0.31	56,359	100%	212	0.31	56,359
2023	0	2,165,508	198	0.29	52,707	100%	198	0.29	52,707
2024	0	2,165,508	185	0.27	49,291	100%	185	0.27	49,291
2025	0	2,165,508	173	0.25	46,097	100%	173	0.25	46,097
2026	0	2,165,508	162	0.23	43,109	100%	162	0.23	43,109
2027	0	2,165,508	152	0.22	40,316	100%	152	0.22	40,316
2028	0	2,165,508	142	0.20	37,703	100%	142	0.20	37,703
2029	0	2,165,508	133	0.19	35,260	100%	133	0.19	35,260
2030	0	2,165,508	124	0.18	32,975	100%	124	0.18	32,975
2031	0	2,165,508	116	0.17	30,838	100%	116	0.17	30,838
2032	0	2,165,508	108	0.16	28,839	100%	108	0.16	28,839
2033	0	2,165,508	101	0.15	26,970	100%	101	0.15	26,970
2034	0	2,165,508	95	0.14	25,223	100%	95	0.14	25,223
2035	0	2,165,508	89	0.13	23,588	100%	89	0.13	23,588

ASSUMED METHANE CONTENT OF LFG: 50%
SELECTED DECAY RATE CONSTANT: 0.067
SELECTED ULTIMATE METHANE RECOVERY RATE: 3,070 cu ft/ton

EXHIBIT 2. LFG RECOVERY PROJECTION GRAPH
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MD



SECTION 3.0

LANDFILL GAS COLLECTION SYSTEM

3.1 VERTICAL EXTRACTION WELL DEPTH AND SPACING

A total of 97 vertical wells are proposed for the landfill as shown on the drawings. Vertical extraction wells will be installed at depths approximating 75% of the depth of refuse in all Cells 2, 3, 4, 5, N1, and N3. Vertical extraction wells will be installed to approximately 5-feet from the bottom of the landfill in Cell 1. SCS assumes that the effective radius of influence of each extraction well would be approximately 5 times the length of solid pipe in the well (i.e., a solid pipe length of 20 feet would correspond to a radius of influence of 100 feet). This assumption is based on SCS pump tests and full-scale system operations experience at other landfills. Extraction wells will be spaced on the vertices of an equilateral triangle (to optimize the zone of influence overlap). Vertical wells are proposed to be located centrally within the Landfill to extract methane-rich gas to reduce the potential for off-site LFG migration and LFG emissions through the landfill surface. Monitoring and flow control for the wells will be provided by an aboveground wellhead. A summary of the proposed wellfield is as follows:

- 94 new extraction wells in top areas of the landfill currently uncovered by wells.
- 11 wells connected to existing leachate risers in Cells N1, N2 and N3.

No vertical extraction wells are proposed for Cell N2 since the depth of waste is very shallow. Gas collection from this area will be accomplished through the use of connections to the leachate collection system risers.

3.2 WELLFIELD PIPE SIZING

The LFG collection piping which delivers the LFG to the blower/flare station will be sized to consider the head losses throughout the piping network to minimize the vacuum requirements of the system. The extraction blower and header piping will be designed to deliver a minimum of 15 inches of water column (in.-w.c.) of vacuum to each extraction wellhead in the LFG collection system. The collection system components will be conservatively sized based on the LFG collection rate. Header size calculations are included in Appendix B.

3.3 VANDAL RESISTANT LFG COLLECTION SYSTEM FEATURES

SCS has attempted to reduce the visibility and accessibility of appurtenances on the LFG collection system that may otherwise prove tempting to vandals. Measures taken include:

- LFG header pipe will be buried.

- Blower/flare station will have a barbed wire fence.
- Below-grade handholes, valve vaults, etc., will have locks and/or bolts requiring special tools for access.
- Wellheads will be enclosed.

SECTION 4.0

BLOWER/FLARE STATION

4.1 BLOWER SELECTION

Blower selection for the RRLF is based on the landfill gas collection model results presented earlier in this report. According to the SCS model, the maximum LFG collection rate for the future of the landfill is about 800 cfm.

To handle this flowrate, two 500 scfm blowers will be installed in parallel. The use of two blowers offers increased flexibility in LFG control. For the first few years both blowers will be running at less than full capacity until the flow rate drops to a point where only one blower needs to operate. Based on our modeling estimates, this should be in approximately 2010, at which point the second blower will be used for full capacity backup in the event of a failure.

SCS anticipates the following specifications for the blower:

- Two blowers, both active for a few years and then one to be standby to provide 100 percent redundancy.
- Blowers are industrial grade, centrifugal type to provide a wide range of flows and long-term service. The blowers shall have non-sparking totally enclosed fan cooled (TEFC) motors appropriate for National Electric Code (NEC) Class 1 Division 2 environments equipped with variable frequency drives. The blowers will not be in an enclosed structure; therefore, the motors are not required to be explosion proof.
- Total blower capacity of 1000 cfm at approximately 35 inches of water column inlet vacuum and 15 inches outlet pressure (vacuum ratings based on similarly sized extraction systems at other landfills).
- Minimum 15 HP TEFC motors wired for 480V, 3-phase service.

A programmable logic controller (PLC) will be specified to receive signals from the devices listed above and communicate with the appropriate equipment (flare, blower, valves, etc.) to perform the necessary function.

4.2 BLOWER/ FLARE STATION CONSIDERATION

The blower/flare station is sited in the central portion of the site adjacent to Cells 2 and 3. This location offers several advantages:

- Conveniently located for Allegheny Power to bring three-phase power. SCS anticipates that electrical power will be brought in at the eastern end of the site, from the existing maintenance building.

- A cleared area surrounded by native trees to help to screen the facility from local residences.

- Close to an existing access road.

The blower/flare station location will be surrounded by an 8-foot-high chain link and barbed wire fence provided with a swing gate for access. The proposed blower/flare station location is intended to keep it out of view. In addition, the gate may be locked to deter trespassers or vandals.

The flare will be an open or utility-type with a stack sized to handle 1,000 scfm at 500 Btu/cf. The flare shall have a turndown ratio of at least 10-to-1. In addition, a flame monitoring system will be necessary to automatically shut off the flow of LFG (via blower shutdown and valve closure) in the even of a flame outage. The flare controls shall signal a shutdown and activate an auto dialer in case of flame outage. The flare shall have automatic re-light capability. The blower/flare station piping layout will include a tee and blind flange at the blower outlet to allow for LFG transport to a possible LFG utilization project.

The flare foundation is the primary structural element at the blower/flare station. To accommodate the flare, the foundation should be approximately 7 feet square to adequately withstand 100 miles per hour (MPH) wind loading. The foundation will consist of concrete about 1-½ feet thick, reinforced with deformed steel bars. The final flare foundation design will depend on soil conditions at the site and the final flare design.

Hydrogen sulfide is a corrosive gas often found at trace levels in LFG, which along with VOC's, sulfur oxides, and organic halides, can affect certain components of the system. In the blower/flare station, measures will be taken to protect the equipment that will come into contact with the LFG. The blowers will be specified to have coatings on the internal parts to protect the impellers and blower casings. The connection piping, valves, and fittings will have plastic, stainless steel, or other non-corrosive components. In addition, the flame arrester, flare tip, stack, and pilot/ignition assemblies will be specified as stainless steel or other corrosion-resistant material.

SECTION 5.0

CONDENSATE PRODUCTION AND CONTROL

Condensate is formed as the temperature and pressure of LFG extracted from the landfill changes in the collection system piping. Four condensate traps are planned for the landfill. Management of LFG condensate at the Resh Road Sanitary Landfill will be handled as follows:

- Condensate formed in the lateral piping from the wellhead to the header will drain into the header pipes.
- Condensate formed in laterals connected to remote wellheads will be drained back into the leachate collection system.
- Condensate formed in the header piping on the landfill will drain into the condensate traps (designated CT-1, -2, -3 and -4 on the design drawings). The traps will drain by gravity to the existing leachate collection system.
- An in-line condensate knock-out pot, serving as a moisture separator will be capable of handling 150 gpd and equipped with a filter or demister pad to maximize condensate removal upstream of blowers to minimize corrosion.

Condensate in header piping can form a blockage in the gas system if it collects in a low point and is not removed from the header system. To maintain positive drainage, a minimum 3 percent slope is specified for collection piping on the landfill surface. Differential settlement under the piping is less of a concern in areas off the refuse mounds, so a minimum slope of 1 percent is anticipated for piping located on natural soil.

The total quantity of condensate collected by the LFG system is expected to be highest during the winter months when the temperature differential of LFG from the wellhead to the flare station is greatest. Condensate generation is estimated to be approximately 250 gallons per day. This value represents the anticipated maximum daily amount from 800 cfm of LFG, which is the anticipated collection rate, if an LFG temperature of 120 degrees F at the wellhead and 40 degrees F at the blower is assumed.

SECTION 6.0

CONSTRUCTION COST ESTIMATE

Presented on the following page is the construction cost estimate for the LFG collection system. The unit prices are based on actual unit price bids for similar projects in Maryland and Virginia over the past several years.

CONSTRUCTION COST ESTIMATE
LANDFILL GAS COLLECTION AND CONTROL SYSTEM
RESH ROAD SANITARY LANDFILL, HAGERSTOWN, MARYLAND

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	TOTAL
1	Mobilization / Demobilization	1	LS	$20,000	$20,000
2	LFG Blower/Flare Station	1	LS	$175,000	$175,000
3	12" Dia. HDPE Piping and Fittings	70	LF	$31	$2,170
4	10" Dia. HDPE Piping and Fittings	135	LF	$27	$3,645
5	8" Dia. HDPE Piping and Fittings	2,050	LF	$23	$47,150
6	6" Dia. HDPE Piping and Fittings	14,500	LF	$16	$232,000
7	4" Dia. HDPE Piping and Fittings	9,550	LF	$15	$143,250
8	10" Dia. LFG Header Isolation Valve	1	EA	$1,800	$1,800
9	8" Dia. LFG Header Isolation Valve	4	EA	$1,100	$4,400
10	6" Dia. LFG Header Isolation Valve	14	EA	$700	$9,800
11	Condensate Trap	4	EA	$6,500	$26,000
12	LFG Wellheads	105	EA	$450	$47,250
13	LFG Wells	3,930	LF	$65	$255,450
14	Road Crossing	415	LF	$25	$10,375
15	Directional Bore Road Crossing	150	LF	$40	$6,000
16	Wellhead and Valve Vaults	124	EA	$300	$37,200
		TOTAL CONSTRUCTION COST			$984,000

APPENDIX A

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-1
DEPTH 36'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-8	Topcover	Dry	80
8-25	household	Dry	80
25-28	household, tires	Dry	80
28-36	household, C&D	Saturated	80

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-2
DEPTH 37'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-4	Topcover	Dry	
4-17	wood, dirt	Dry	70 @ 10'
17-37	wood, slight traces household,	Wet @ 25'	70@ 20'
	dirt		75 @ 30'

COMMENTS : 75% dirt

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. C-4
DEPTH 49'
Start date 4-4-02
Finish date 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-4	Topcover	Dry	
4-25	household, wood	Dry	80 @ 10'
25-40	household, plastic	Dry	90 @ 20'
40-49	household, wood	wet	110 @ 30'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client: SCS
Location: Hagerstown, MD

Hole size: 30"
Driller: S. Garrison
Helper: J. Goosman

WELL NO.: C-5
DEPTH: 36'
Start date: 4-4-02
Finish date: 4-4-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-2	Topcover	Dry	
2-17	household	Dry	70 @ 10'
17-30	household,metal	Dry	90 @ 20'
30-36	household,wood	wet	97 @ 30'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client SCS
Location Hagerstown, MD

Hole size 30"
Driller S. Garrison
Helper J. Goosman

WELL NO. N-1
DEPTH 50'
Start date 4-4-02
Finish date 4-5-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-2	dirt		75 @ 10'
2-36	household	dry	85 @ 20'
36-41	metal,wood,plastic	moderate	92 @ 30'
41-50	dirt,household	dry	97 @ 40'
			110 @ 50'

COMMENTS

DRILLING LOG

RECOVERY DRILLING SERVICES
PO BOX 505
SOUTH BARRE, MA 01074

PH 978-355-5100
FAX 978-355-0111

Client	SCS
Location	Hagerstown, MD
Hole size	30"
Driller	S. Garrison
Helper	J. Goosman

WELL NO.	N-3
DEPTH	30'
Start date	4-5-02
Finish date	4-5-02

DEPTH	COMPOSITION	MOISTURE	TEMP
0-1	top cover		
1-30	household,plastic,carpet	dry	60 @ 10'
			100 @ 30'

COMMENTS

APPENDIX B

PIPE SIZE / HEADLOSS CALCULATIONS
FOR RESH ROAD SANITARY LANDFILL

Calculated by: Michael Kalish
Date: 10-Jul-02

The Spitzglass formula was used for headloss calculations :

P = ((Q^2)*L)/((C^2)*(D^5))

where:
P = pressure loss (in.-wc)
Q = flow rate (cf/hr)
L = equivalent length of pipe (ft.)
C = 3550/(1+(3.6/D)+(0.03*D))^0.5
D = pipe diameter (in.)

Velocity (V) criteria:
D >= 12 in., V <= 2000 fpm
D <= 12 in., V <= 1200 fpm

LFG FLOW (cfm) = 2/3*(pi)*(ROI)^2*H*r/27/525600
ROI = Radius of influence (ft)
H = Refuse depth (ft)
r = LFG generation rate (cf/cy/yr)

WELL DEPTH criteria:
1. Wells to 5' from approximate bottom in Cell 1
2. Wells to 75% refuse depth in Cells 2, 3, 4, 5, N1, a
3. Wells 21, 39, 46, 59, 81, and 93 are existing
4. Cell N2 has gas collection through leachate risers

LFG FLOW ESTIMATE

INPUT | CALCULATION

LFG GEN. RATE 130 cf/cy/yr
ROI FACTOR 5 times solid pipe length

WELL #	BASE ELEVATION (ft)	FINAL ELEVATION (ft)	REFUSE DEPTH (ft)	WELL DEPTH (ft)	SOLID PIPE LENGTH (ft)	ROI (ft)	LFG FLOW (cfm)
1	505	566	61	46	20	100	9
2	515	566	51	38	20	100	7
3	510	577	67	50	20	100	10
4	515	570	55	41	20	100	8
5	515	570	55	41	20	100	8
6	505	577	72	54	20	100	10
7	510	558	48	36	20	100	7
8	500	556	56	42	20	100	8
9	498	578	80	60	20	100	12
10	500	556	56	42	20	100	8
11	495	550	55	41	20	100	8
12	495	542	47	35	20	100	7
13	490	545	55	41	20	100	8
14	485	540	55	41	20	100	8
15	480	536	56	42	20	100	8
16	485	564	79	59	20	100	11
17	480	538	58	44	20	100	8
18	490	555	65	49	20	100	9
19	490	571	81	61	20	100	12
20	490	576	86	65	20	100	12
21	505	576	71	36	15	75	4
22	498	574	76	57	20	100	11
23	495	556	61	46	20	100	9
24	500	564	64	48	20	100	9
25	525	562	37	32	20	100	6
26	520	570	50	45	20	100	9
27	538	574	36	31	20	100	6
28	525	570	45	40	20	100	8
29	538	570	32	27	15	75	3
30	532	566	34	29	20	100	6
31	520	575	55	50	20	100	10
32	538	566	28	23	15	75	2
33	525	560	35	30	20	100	6
34	520	566	46	41	20	100	8
35	521	552	31	26	15	75	3
36	520	552	32	27	15	75	3
37	520	554	34	29	20	100	6
38	520	554	34	29	20	100	6
39	520	571	51	36	15	75	4
40	520	562	42	37	20	100	7
41	520	576	56	51	20	100	10
42	490	572	82	62	20	100	12
43	484	568	84	63	20	100	12
44	481	538	57	43	20	100	8
45	483	546	63	47	20	100	9
46	485	563	78	48	15	75	5
47	485	562	77	58	20	100	11
48	485	540	55	41	20	100	8

49	477	536	59	44	20	100	8
50	480	555	75	56	20	100	11
51	478	539	61	46	20	100	9
52	470	526	56	42	20	100	8
53	470	534	64	48	20	100	9
54	486	556	70	53	20	100	10
55	470	508	38	29	20	100	5
56	470	544	74	56	20	100	11
57	470	542	72	54	20	100	10
58	470	506	36	27	15	75	3
59	470	539	69	36	15	75	4
60	470	524	54	41	20	100	8
61	470	518	48	36	20	100	7
62	470	520	50	38	20	100	7
63	470	528	58	44	20	100	8
64	470	522	52	39	20	100	7
65	470	531	61	46	20	100	9
66	470	531	61	46	20	100	9
67	470	544	74	56	20	100	11
68	470	554	84	63	20	100	12
69	490	558	68	51	20	100	10
70	487	538	51	38	20	100	7
71	488	530	42	32	20	100	6
72	486	554	68	51	20	100	10
73	484	562	78	59	20	100	11
74	488	539	51	38	20	100	7
75	485	562	77	58	20	100	11
76	487	541	54	41	20	100	8
77	487	550	63	47	20	100	9
78	480	533	53	40	20	100	8
79	480	514	34	26	20	100	5
80	478	549	71	53	20	100	10
81	476	552	76	50	15	75	5
82	487	527	40	30	20	100	6
83	477	535	58	44	20	100	8
84	477	536	59	44	20	100	8
85	478	520	42	32	20	100	6
86	475	513	38	29	20	100	5
87	474	534	60	45	20	100	9
88	474	508	34	26	15	75	3
89	476	536	60	45	20	100	9
90	474	506	32	24	15	75	3
91	476	516	40	30	20	100	6
92	478	523	45	34	20	100	6
93	504	562	58	30	15	75	3
94	508	561	53	40	20	100	8
95	506	561	55	41	20	100	8
96	504	544	40	30	20	100	6
LC-1							5
LC-2							5
LC-3							5
LC-4							5
LC-5							5
LC-6							5
LC-7							5
LC-8							5
LC-9							5
LC-10							5
LC-11							5
TOTAL							800

Header Section	Length (ft)	Diameter (in)		3	4	6	8	10	12	14	16	18	20	22
		Nominal	Actual											
NONE	0	NA	NA											
1	127	4	3.97	0	127	0	0	0	0	0	0	0	0	0
2	200	4	3.97	0	200	0	0	0	0	0	0	0	0	0
3	185	4	3.97	0	185	0	0	0	0	0	0	0	0	0
4	110	4	3.97	0	110	0	0	0	0	0	0	0	0	0
5	220	6	5.85	0	0	220	0	0	0	0	0	0	0	0
6	45	6	5.85	0	0	45	0	0	0	0	0	0	0	0
7	95	6	5.85	0	0	95	0	0	0	0	0	0	0	0
8	535	6	5.85	0	0	535	0	0	0	0	0	0	0	0
9	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
10	285	6	5.85	0	0	285	0	0	0	0	0	0	0	0
11	100	6	5.85	0	0	100	0	0	0	0	0	0	0	0
12	50	6	5.85	0	0	50	0	0	0	0	0	0	0	0
13	335	6	5.85	0	0	335	0	0	0	0	0	0	0	0
14	170	6	5.85	0	0	170	0	0	0	0	0	0	0	0
15	125	6	5.85	0	0	125	0	0	0	0	0	0	0	0
16	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
17	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
18	80	6	5.85	0	0	80	0	0	0	0	0	0	0	0
19	70	6	5.85	0	0	70	0	0	0	0	0	0	0	0
20	45	6	5.85	0	0	45	0	0	0	0	0	0	0	0
21	55	6	5.85	0	0	55	0	0	0	0	0	0	0	0
22	90	6	5.85	0	0	90	0	0	0	0	0	0	0	0
23	255	6	5.85	0	0	255	0	0	0	0	0	0	0	0
24	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
25	370	6	5.85	0	0	370	0	0	0	0	0	0	0	0
26	120	6	5.85	0	0	120	0	0	0	0	0	0	0	0
27	35	6	5.85	0	0	35	0	0	0	0	0	0	0	0
28	145	6	5.85	0	0	145	0	0	0	0	0	0	0	0
29	155	6	5.85	0	0	155	0	0	0	0	0	0	0	0
30	35	6	5.85	0	0	35	0	0	0	0	0	0	0	0
31	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
32	180	6	5.85	0	0	180	0	0	0	0	0	0	0	0
33	90	6	5.85	0	0	90	0	0	0	0	0	0	0	0
34	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
35	195	6	5.85	0	0	195	0	0	0	0	0	0	0	0
36	145	6	5.85	0	0	145	0	0	0	0	0	0	0	0
37	180	6	5.85	0	0	180	0	0	0	0	0	0	0	0
38	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
39	175	6	5.85	0	0	175	0	0	0	0	0	0	0	0
40	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
41	190	6	5.85	0	0	190	0	0	0	0	0	0	0	0
42	400	6	5.85	0	0	400	0	0	0	0	0	0	0	0
43	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
44	240	6	5.85	0	0	240	0	0	0	0	0	0	0	0
45	335	6	5.85	0	0	335	0	0	0	0	0	0	0	0
46	200	6	5.85	0	0	200	0	0	0	0	0	0	0	0
47	140	6	5.85	0	0	140	0	0	0	0	0	0	0	0
48	150	6	5.85	0	0	150	0	0	0	0	0	0	0	0
49	105	6	5.85	0	0	105	0	0	0	0	0	0	0	0
50	95	6	5.85	0	0	95	0	0	0	0	0	0	0	0
51	135	6	5.85	0	0	135	0	0	0	0	0	0	0	0
52	110	8	7.61	0	0	0	110	0	0	0	0	0	0	0
53	120	8	7.61	0	0	0	120	0	0	0	0	0	0	0
54	70	12	11.25	0	0	0	0	0	70	0	0	0	0	0
55	135	10	9.49	0	0	0	0	135	0	0	0	0	0	0
56	110	8	7.61	0	0	0	110	0	0	0	0	0	0	0
57	195	8	7.61	0	0	0	195	0	0	0	0	0	0	0
58	155	8	7.61	0	0	0	155	0	0	0	0	0	0	0
59	145	8	7.61	0	0	0	145	0	0	0	0	0	0	0

60	160	8	7.61		0	0	0	160	0	0	0	0	0	0	0	
61	110	8	7.61		0	0	0	110	0	0	0	0	0	0	0	
62	170	8	7.61		0	0	0	170	0	0	0	0	0	0	0	
63	150	6	5.85		0	0	150	0	0	0	0	0	0	0	0	
64	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
65	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
66	65	6	5.85		0	0	65	0	0	0	0	0	0	0	0	
67	170	6	5.85		0	0	170	0	0	0	0	0	0	0	0	
68	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
69	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
70	155	6	5.85		0	0	155	0	0	0	0	0	0	0	0	
71	490	6	5.85		0	0	490	0	0	0	0	0	0	0	0	
72	260	6	5.85		0	0	260	0	0	0	0	0	0	0	0	
73	105	6	5.85		0	0	105	0	0	0	0	0	0	0	0	
74	35	6	5.85		0	0	35	0	0	0	0	0	0	0	0	
75	80	6	5.85		0	0	80	0	0	0	0	0	0	0	0	
76	50	6	5.85		0	0	50	0	0	0	0	0	0	0	0	
77	65	6	5.85		0	0	65	0	0	0	0	0	0	0	0	
78	230	6	5.85		0	0	230	0	0	0	0	0	0	0	0	
79	195	6	5.85		0	0	195	0	0	0	0	0	0	0	0	
80	180	6	5.85		0	0	180	0	0	0	0	0	0	0	0	
81	160	6	5.85		0	0	160	0	0	0	0	0	0	0	0	
82	160	6	5.85		0	0	160	0	0	0	0	0	0	0	0	
83	290	6	5.85		0	0	290	0	0	0	0	0	0	0	0	
84	70	6	5.85		0	0	70	0	0	0	0	0	0	0	0	
85	225	6	5.85		0	0	225	0	0	0	0	0	0	0	0	
86	295	6	5.85		0	0	295	0	0	0	0	0	0	0	0	
87	140	6	5.85		0	0	140	0	0	0	0	0	0	0	0	
88	160	8	7.61		0	0	0	160	0	0	0	0	0	0	0	
89	180	8	7.61		0	0	0	180	0	0	0	0	0	0	0	
90	125	8	7.61		0	0	0	125	0	0	0	0	0	0	0	
91	290	8	7.61		0	0	0	290	0	0	0	0	0	0	0	
92	110	4	3.97		0	110	0	0	0	0	0	0	0	0	0	
	15152			TOTAL	0	732	12185	2030	135	70	0	0	0	0	0	15152
				DIAMETER	3	4	6	8	10	12	14	16	18	20	22	

HDPE SDR 17 Nominal	Actual
3	3.00
4	3.97
6	5.85
8	7.61
10	9.49
12	11.25
13	11.81
14	12.35
16	14.12
18	15.88
20	17.65
22	19.41

CASE #1
SDR 17 PIPE

02-Jul-02

From	Through	Length (ft.)	Branch Flow (cfm)	Header Flow (cfm)	Diameter (in.)	Velocity (fpm)	Pressure Loss (in.-w.c.)	Loss per 100 ft. (in.-w.c.)	Notes
CELL N2, N3									
95	1	127	8	8	3.97	93	0.00	0.00	
94	2	200	8	16	3.97	186	0.03	0.02	
						SUBTOTAL	0.03		
96	3	185	6	6	3.97	70	0.00	0.00	
97	4	110	5	5	3.97	58	0.00	0.00	
LC-10	5	220	5	10	5.85	54	0.00	0.00	
LC-9	6	45	5	15	5.85	80	0.00	0.00	
						SUBTOTAL	0.01		MAX = 0.03
2,5	7	95	16	31	5.85	166	0.01	0.01	
LC-8	8	535	5	36	5.85	193	0.05	0.01	
LC-6,LC-7	9	175	10	46	5.85	246	0.03	0.02	
LC-5	10	285	5	51	5.85	273	0.06	0.02	
						SUBTOTAL	0.14		
LC-2,3,4	11	100	15	15	5.85	80	0.00	0.00	
LC-1	12	50	5	20	5.85	107	0.00	0.00	
						SUBTOTAL	0.00		
10,12	13	335	51	71	5.85	380	0.13	0.04	
						SUBTOTAL	0.30		MAX CELLS N2,N3
CELL N1 SOUTHERN LOOP									
88	22	90	3	3	5.85	16	0.00	0.00	
87	23	255	9	12	5.85	64	0.00	0.00	
86	24	150	5	17	5.85	91	0.00	0.00	
85	25	370	6	23	5.85	123	0.01	0.00	
84	26	120	8	31	5.85	166	0.01	0.01	
82	27	35	6	37	5.85	198	0.00	0.01	
83	28	145	8	45	5.85	241	0.02	0.02	
80,81	29	155	15	60	5.85	321	0.04	0.03	
79	30	35	5	65	5.85	348	0.01	0.03	
						SUBTOTAL	0.11		
CELL N1 NORTHERN LOOP									
85	24	150	6	6	5.85	32	0.00	0.00	
86	23	255	5	11	5.85	59	0.00	0.00	
87	22	90	9	20	5.85	107	0.00	0.00	
88	21	55	3	23	5.85	123	0.00	0.00	
LC-11	20	45	5	28	5.85	150	0.00	0.01	
89	19	70	9	37	5.85	198	0.01	0.01	
90	18	80	3	40	5.85	214	0.01	0.01	
91	17	200	6	46	5.85	246	0.03	0.02	
92	16	190	6	52	5.85	279	0.04	0.02	
93	15	125	3	55	5.85	295	0.03	0.02	
15,30	14	170	65	117	5.85	627	0.17	0.10	
						SUBTOTAL	0.30		MAX CELL N1
N CELLS									
13,14	31	175	71	188	5.85	1007	0.46	0.26	
HALF N	32	180	94	94	5.85	504	0.12	0.07	CELLS 2,3
HALF N	33	90	94	94	5.85	504	0.06	0.07	CELLS 1,4,5

CASE #1
SDR 17 PIPE

02-Jul-02

From	Through	Length (ft.)	Branch Flow (cfm)	Header Flow (cfm)	Diameter (in.)	Velocity (fpm)	Pressure Loss (in.-w.c.)	Loss per 100 ft. (in.-w.c.)	Notes
CELLS 2,3 NORTHERN LOOP									
14	35	195	8	8	5.85	43	0.00	0.00	
13	36	145	8	16	5.85	86	0.00	0.00	
12	37	180	7	23	5.85	123	0.01	0.00	
11	38	175	8	31	5.85	166	0.01	0.01	
10	39	175	8	39	5.85	209	0.02	0.01	
8,9	40	190	20	59	5.85	316	0.05	0.03	
7	41	190	7	66	5.85	354	0.06	0.03	
8	42	400	8	74	5.85	396	0.16	0.04	
4	43	200	8	82	5.85	439	0.10	0.05	
3,2	44	240	17	99	5.85	530	0.18	0.07	
						SUBTOTAL	0.59		
CELLS 2,3 SOUTHERN LOOP									
32	45	335	94	94	5.85	504	0.22	0.07	
15	46	200	8	102	5.85	546	0.16	0.08	
16,17	47	140	19	121	5.85	648	0.15	0.11	
18,19,20	48	150	33	154	5.85	825	0.27	0.18	
23	49	105	9	163	5.85	873	0.21	0.20	
22	50	95	11	174	5.85	932	0.21	0.23	
6,21,24	51	135	23	197	5.85	1055	0.39	0.29	
1	52	110	9	206	7.61	652	0.09	0.08	
44,52	53	120	99	305	7.61	966	0.21	0.18	
						SUBTOTAL	1.91		MAX CELLS 2,3
CELLS 1,4,5 NORTHERN LOOP									
33	84	70	94	94	5.85	504	0.05	0.07	
66	85	225	9	103	5.85	552	0.18	0.08	
67,68	86	295	23	126	5.85	675	0.35	0.12	
69,70	87	140	17	143	5.85	766	0.21	0.15	
53,54,73,72,71	88	160	46	189	7.61	598	0.11	0.07	
74,75	89	180	18	207	7.61	655	0.15	0.08	
76	90	125	8	215	7.61	681	0.11	0.09	
42,77	91	290	21	236	7.61	747	0.31	0.11	
						SUBTOTAL	1.46		
CELLS 1,4,5 SOUTHERN LOOP									
65	82	160	9	9	5.85	48	0.00	0.00	
64	81	160	7	16	5.85	86	0.00	0.00	
63	80	180	8	24	5.85	129	0.01	0.00	
62	79	195	7	31	5.85	166	0.01	0.01	
61	78	230	7	38	5.85	204	0.02	0.01	
60	77	65	8	46	5.85	246	0.01	0.02	
59	76	50	4	50	5.85	268	0.01	0.02	
58	75	80	3	53	5.85	284	0.02	0.02	
56,57	74	35	21	74	5.85	396	0.01	0.04	
55	72,73	365	5	79	5.85	423	0.17	0.05	
51,52	71	490	17	96	5.85	514	0.34	0.07	
49,50	70	155	19	115	5.85	616	0.15	0.10	
47,48	69	140	19	134	5.85	718	0.19	0.13	
45,46	68	180	14	148	5.85	793	0.29	0.16	
43,44	67	170	20	168	5.85	900	0.36	0.21	
40,41	66	65	17	185	5.85	991	0.17	0.26	
38,39	65	140	10	195	5.85	1045	0.40	0.28	
37	64	180	6	201	5.85	1077	0.54	0.30	
36	63	150	3	204	5.85	1093	0.47	0.31	
34,35	62	170	11	215	7.61	681	0.15	0.09	
33	61	110	6	221	7.61	700	0.10	0.09	
32	60	160	2	223	7.61	706	0.15	0.09	
30,31	59	145	16	239	7.61	757	0.16	0.11	
28,29	58	155	11	250	7.61	791	0.18	0.12	
27	57	195	6	256	7.61	810	0.24	0.12	
25,26	56	110	15	271	7.61	858	0.15	0.14	
						SUBTOTAL	4.32		MAX CELLS 1,4,5
56,91	55	135	236	507	9.49	1032	0.21	0.16	
53,55	54	70	305	812	11.25	1176	0.12	0.17	
						OVERALL=	4.65		

Project No.: 2201085
Project Name: Resh Road Sanitary Landfill
File Name: R:\lfg\02201085\tech\condensate.xls
Calculated by: Michael Kalish
Date: 7/10/02

QUANTITY OF CONDENSATE AT THE RESH ROAD SANITARY LANDFILL

Data and Assumptions:

LFG Flow		800 scfm
Standard Temp.		60 F
Standard Pressure		14.7 psia
Temp. of LFG at Wellhead		100 F
Temp. of LFG at Blower		40 F
Vacuum at Wellhead		10 in-W.C.
Vacuum at Blower		40 in-W.C.
Water Vapor Pressure	@ 100 F (37.8 C) =	49.1 mm Hg
	@ 60F (15.5C) =	13.21 mm Hg
	@ 40 F (4.4 C) =	6.27 mm Hg
Amount of Condensate Removed from Landfill Prior to Blower=		50%
LFG is Saturated with Water at Wellhead		

QUANTITY OF CONDENSATE AT THE RESH ROAD SANITARY LANDFILL

Calculations

Volume of LFG at Wellhead Conditions:		
(PV/T)1 = (PV/T)2		
Volume at Wellhead Conditions	883	cfm
Pounds of Water Vapor in LFG at Wellhead		
PV = nRT		
Moles of Water=	0.1	moles/min
Pounds of Water=	2.5	Lbs/min
Volume of LFG at Blower Conditions:		
(PV/T)1 = (PV/T)2		
Volume at Blower Conditions=	853	cfm
Pounds of Water Vapor in LFG at Blower:		
PV = nRT		
Moles of Water=	0.0405829	moles/min
Pounds of Water=	0.7304928	Lbs/min
Amount of Condensate Prior to Blower		
Lbs. at Wellhead - Lbs. at Blower=	1.8	Lbs/min
Convert to Gallons per Day=	307	Gal/day
TOTAL CONDENSATE PER DAY AT THE KO POT:		
50% of the vapor condensed before the blower		
= 154 Gal/day		
TOTAL CONDENSATE PER DAY AT THE KO POT:	154	Gal/day

Resh Road Sanitary Landfill - Hagerstown, MD
LFG System Sizing

Blower/Flare Capacity

Total Flow = 1,000 cfm

System Head Losses (Estimated):

Pressure Required at Flare Inlet =	10 in-wc
Headloss Through Knockout =	5 in-wc
Minor Losses (Valves, Fittings) =	10 in-wc
Headloss through Flame Arrestor =	5 in-wc
Headloss in Piping =	5 in-wc
Available Vacuum at Wellhead =	15 in-wc
Total Headloss	50 in-wc

Specify 2 Blowers Capable of Providing 500 cfm at 50 in-wc, Max. Surge Point = 200 cfm

Specify 1 Candle Flare Capable of Handling 1,000 cfm of LFG with 50% Methane
Min. Turndown Ratio = 10:1

Max. Heat Rate = (1000cf/min.)(500Btu/cf) = 30 MM Btu/Hr
Min. Heat Rate = (200cf/min.)(300Btu/cf) = 3.6 MM Btu/Hr

Environmental Consultants

11260 Roger Bacon Drive
Reston, VA 20190-5282

703 471-6150
FAX 703 471-6676
www.scsengineers.com

SCS ENGINEERS

February 13, 2003
File No.: 02201085.00

Mr. Randy Edwards, PE
Washington County
Engineering Department
Department of Public Works
80 W. Baltimore Street
Hagerstown, MD 21740-6003

Subject: Resh Road Landfill LFG Utilization Report

Dear Mr. Edwards:

SCS is pleased to submit our report assessing the feasibility of landfill gas (LFG) utilization at the Resh Road Landfill. This work was performed in accordance with our scope of services under the landfill capping contract between the County and the Maryland Environmental Service (MES).

After your review of the document, we suggest a meeting to discuss the results of the evaluation. If you have any questions in the meantime, please telephone either of us.

Very truly yours,

Darrin D. Dillah, Ph.D., PE
Project Advisor
SCS ENGINEERS

Eric R. Peterson, PE
Vice President
SCS ENGINEERS

cc: Les Shaw, MES

Environmental Consultants

SCS ENGINEERS

FEASIBILITY ASSESSMENT FOR LANDFILL GAS TO ENERGY AT RESH ROAD SANITARY LANDFILL

TASK 5 LFG UTILIZATION STUDY

Prepared for:

Washington County
Engineering Department
Division of Public Works
80 W. Baltimore Street
Hagerstown, Maryland 21740

SCS Engineers
11260 Roger Bacon Drive
Reston, Virginia 20190
(703) 471-6150

February 2003
File No. 02201085.00

TABLE OF CONTENTS

Section **Page**

EXHIBITS

SECTION 1.0

INTRODUCTION

SCS Engineers (SCS) was retained by Washington County to perform a landfill gas (LFG) utilization feasibility assessment for the Resh Road Landfill (RRLF). In accordance with Task 5 of the contracted scope of work, SCS is submitting this options analysis report for recovering and utilizing LFG from the Landfill.

The physical characteristics of the RRLF are compatible with LFG utilization. The landfill is one of the candidate sites in Maryland identified as part of SCS' study for the Northeast Regional Biomass Program (a DOE program), which is administered by the Coalition of Northeastern Governors. These characteristics include:

- Landfill size (volume), depth of fill, and age.
- The landfill will be capped with a geomembrane, which provides an increased LFG collection efficiency for a LFG collection system.
- A LFG collection system will be installed for emission controls.

Exhibit 1-1 presents the layout for the proposed LFG collection system on RRLF. An assessment of LFG utilization at RRLF is being performed since RRLF will generate LFG for approximately the next 30 years and potential industrial end users that could utilize LFG are near the landfill.

1.1 OBJECTIVES AND APPROACH

The objectives of this study are to assess the feasibility of economic recovery and utilization of LFG.

The approach taken for this study focuses on economics and energy markets, and includes:

- An estimate of the LFG generation and recovery potential from the landfill using computer modeling based on available information, field test data, and engineering experience at similar landfills.
- Energy market options for LFG utilization.
- A cost analysis for the most promising potential use of LFG.
- Alternate approaches for development of a LFG recovery/utilization project.

1.2 LFG UTILIZATION BACKGROUND

Landfills produce LFG as organic materials decompose under anaerobic (without oxygen) conditions. LFG as generated is composed of approximately equal parts of methane and carbon dioxide with trace concentrations of non-methane organic compounds (NMOC). Collected LFG also typically includes some amount of air, which is drawn into the system by the vacuum exerted on the landfill. Methane is a combustible gas that forms an explosive mixture with air when present in concentrations between 5 and 15 percent by volume in air. The combustibility of methane can be both an asset and a liability to a landfill owner - an asset when the gas becomes a source of energy recovered from the landfill, and a liability in terms of potentially hazardous conditions caused by subsurface migration of LFG.

Good quality LFG (high methane and low oxygen and nitrogen) can be utilized as a fuel to offset the use of conventional fossil fuels. 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. Oxygen and nitrogen levels are indicators of air intrusion through the landfill surface or leaks in the LFG collection system; such intrusions must be minimized for economic recovery of the LFG.

Over 300 LFG energy recovery facilities are operating in the U.S. Existing and potential uses of LFG generally fall into one of the following categories: direct use for heating/boiler fuel, electrical generation, upgrade to high Btu gas, and other uses such as vehicle fuel. Approximately two-thirds of the LFG utilization facilities in the U.S. generate electricity.

1.3 PROJECT LIMITATIONS

SCS relied upon existing information provided and various assumptions in modeling the landfill. Judgments and analysis are based upon this information and SCS' experience with LFG collection and utilization systems. Limitations include:

- LFG production estimates are based on a desktop analysis. Existing LFG collection wells (installed by SCS during the collection system design investigation phase) were monitored under passive conditions for one round providing useful but limited data.

- The cost analysis uses published purchase price data and typical capital and operating cost data for similar systems rather than project specific information.

SECTION 2.0

LFG FUEL RESERVES

2.1 LANDFILL BACKGROUND

The RRLF is located approximately three miles west of Hagerstown, Maryland, on a 140-acre parcel of land. The waste footprint is about 75 acres, consisting of eight cells. Operations began in the early 1980s and ceased on January 18, 2001. The landfill is owned and operated by Washington County. Presently, no LFG is collected at the site. The quantity of in-place waste is approximately 2.2 million tons.

The permeability of the cover system on a landfill affects the LFG collection efficiency. The RRLF is scheduled to upgrade its existing cap. The minimum 2-foot thick intermediate soil layer over refuse will be maintained. A new cap will be installed over this intermediate soil layer. The cap will consist of a woven geotextile being placed on the existing cover followed by a 40 mil textured HDPE synthetic liner. On top of this will be a geocomposite consisting of a geonet sandwiched between two layers of geotextile. Finally a 1'-8" compacted soil layer and 4-inches of topsoil will be placed to finish the construction of the cap. Geomembrane caps typically enhance LFG collection efficiency by reducing the amount of air infiltration caused by wells under vacuum.

Cells N-1, N-2, N-3 and Cell 4 have synthetic bottom liner systems. Cells 1, 2, 3 and 5 have a clay bottom liner.

2.2 LFG RECOVERY MODEL

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

SCS developed a modified version of the U.S. EPA landfill gas generation model that is more useful for accurately estimating the LFG recovery potential of landfills. SCS' model was developed based on actual LFG collection/recovery data for over 100 sites across the U.S. It is this modified version of the EPA model that is used in this report and is referred to when discussing the "SCS model."

The parameters input to the model include the historical and expected future annual waste receipts in tons; the expected collection system coverage percentage; and precipitation-based values of the "apparent" ultimate methane recovery potential (L_o) and decay rate constant (k). Based on these variables, the model calculates an annual LFG recovery rate estimate.

When calibrating this model, SCS identified trends in the LFG collection data that were used to develop the model. Specifically, it was apparent that different k and L_o values were appropriate for landfills that receive different amounts of annual rainfall. Hence, the development of the precipitation-based k and L_o, which, depending on the annual rainfall at the site, may vary from the typical default values published by the U.S. EPA.

The two main areas where the modified SCS model differs from the EPA model are as follows:

- The SCS model provides default precipitation-based input variables to reflect site-specific conditions.
- The SCS model estimates LFG recovery directly (rather than applying a "recovery efficiency" to a generation estimate), whereas the EPA model estimates generation.

Each of these modifications is discussed below.

Most LFG models, including the EPA model, estimate LFG generation. To estimate the amount of LFG which can be recovered at a site, engineers typically model LFG generation and apply a recovery "efficiency" rate, which is the estimated fraction of generated LFG which can be recovered, given the LFG collection system currently in place or anticipated. An engineer can estimate whether a site has a relatively high or low recovery efficiency, but has no solid basis to assign a value to it since total generation is unknown. For this reason modelers often rely on the U.S. EPA's *Compilation of Air Pollutant Emission Factors* (which is commonly known as the AP-42 document), which lists emission factors, and states that recovery efficiencies typically range from 60 to 85 percent, with an average of 75 percent.

SCS uses an alternative approach to LFG modeling which is to estimate recovery directly. In most cases, this approach requires an evaluation of the degree of current or proposed collection system coverage. System coverage is defined as the fraction of the total LFG-generating refuse mass under active collection. Many factors can affect system coverage, including well spacing and depth, depth of well perforations, landfill type (mound versus canyon), landfill depth, landfill permeability, as well as other design and operational issues.

2.2.1 Assumptions

SCS' computer model was used to calculate LFG recovery rates for the landfill. The assumptions and criteria used for these computations were:

- **Refuse Filling History -** From July 1989 until closure, the filling history is based on scaled waste receipts provided by the County. The filling history for prior years is based on tonnage estimates by cell location and filling dates also provided by the County.

  The moisture content and organic content of incoming refuse was assumed to be within the range typically seen by SCS for residential and commercial refuse disposed in MSW landfills. No adjustments to the model have been made based on these parameters.

- **Methane Content - 50 percent.** This is the default value assumed by the model.

- **Methane Generation Rate Constant (k)** - 0.067/yr. This is the constant that determines the rate of LFG generation. The SCS model selects a value specifically for this landfill based on the annual precipitation in the vicinity. The rate of 0.067/yr is toward the high end for "k" values and was selected by the model based on the average annual precipitation of approximately 39 inches per year.

- **Potential Methane Generation Capacity (L_o)** - 3,070 ft^3/ton. This value is a constant that represents the potential capacity of MSW to generate methane (a primary constituent of LFG) and depends on the organic and moisture content in the refuse. This value is based on the SCS model default value derived from a precipitation-based database.

- **LFG System Coverage** - 100 percent. The SCS model predicts the potential recoverable LFG (not generation) from a landfill assuming a 100 percent comprehensive LFG collection system. The proposed system to be installed with the landfill cap is considered to be 100 percent comprehensive.

- **System Coverage** - For this exercise, SCS considered the wellfield layout, the landfill design (e.g., waste depths, liner and cap construction, and sideslopes), and the wellfield operating data.

2.2.2 Model Results

The results of the model are presented in tabular form on Exhibit 2-1 and graphically in Exhibit 2-2.

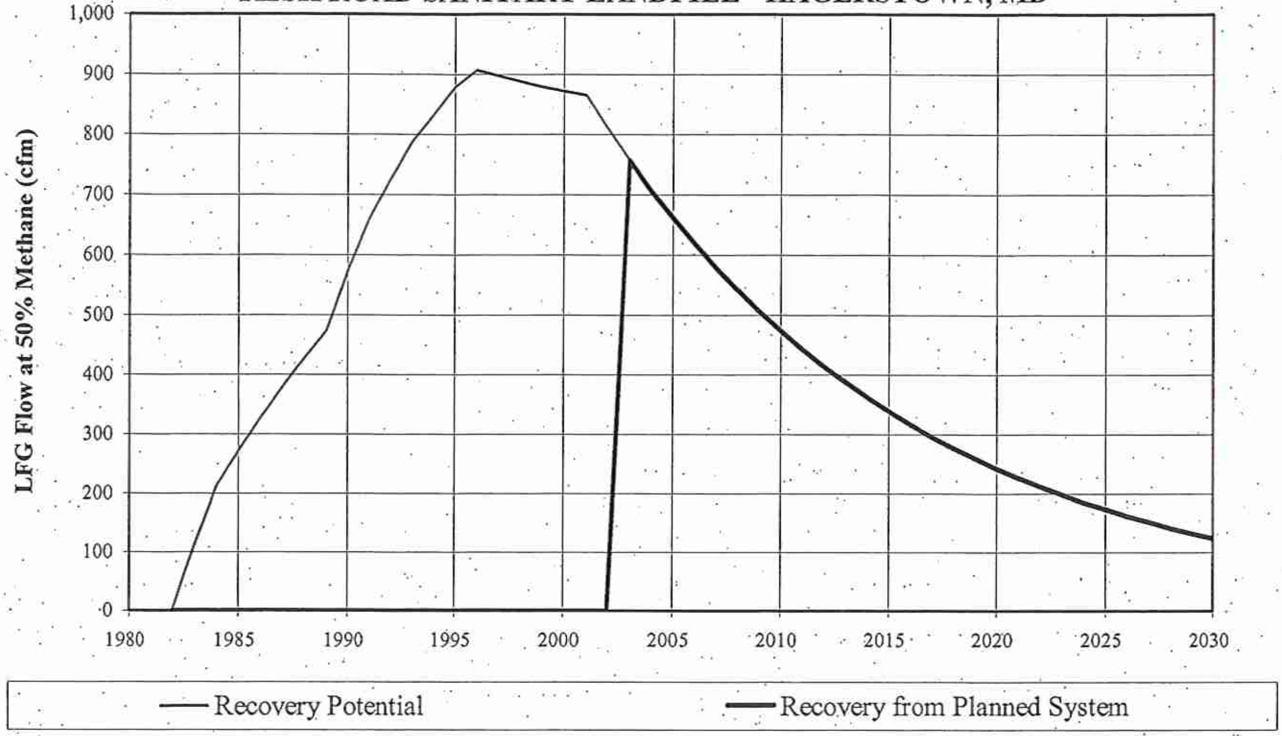
The LFG recovery rate should equal the LFG recovery potential with closure and capping of the landfill. The collection system is designed to provide 100 percent coverage of the waste disposal footprint. Site LFG recovery was expected to peak in 1996, at about 907 scfm. The model estimates that LFG recovery will be approximately 800 scfm at system startup. The model estimates the year 2003 potential LFG recovery as 757 cfm and decreasing yearly thereafter. Over the life of a 10-year LFGTE project, the sustainable LFG flow rate is approximately 387 cfm (year 2013 recovery rate).

Note that these projections have been prepared specifically for the Reichs Ford Landfill and are based on engineering judgment and represent the standard of care that would be exercised by a reasonable professional experienced in the field of landfill gas projections. SCS does not guarantee the quantity of available landfill gas, and no other warranty is expressed or implied. No other party is intended as a beneficiary of this work product, its content, or information embedded therein. Third parties use this report at their own risk. SCS assumes no responsibility for the accuracy of information obtained from, compiled, or provided by other parties.

EXHIBIT 2-1
LFG RECOVERY PROJECTION
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MARYLAND

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1982	150,000	150,000	0	0.00	0	0%	0	0.00	0
1983	150,000	300,000	110	0.16	29,200	0%	0	0.00	0
1984	100,000	400,000	212	0.31	56,508	0%	0	0.00	0
1985	100,000	500,000	272	0.39	72,313	0%	0	0.00	0
1986	100,000	600,000	327	0.47	87,094	0%	0	0.00	0
1987	100,000	700,000	379	0.55	100,917	0%	0	0.00	0
1988	100,000	800,000	428	0.62	113,844	0%	0	0.00	0
1989	177,927	977,927	474	0.68	125,933	0%	0	0.00	0
1990	169,043	1,146,970	573	0.83	152,409	0%	0	0.00	0
1991	147,852	1,294,822	660	0.95	175,439	0%	0	0.00	0
1992	150,750	1,445,572	725	1.04	192,852	0%	0	0.00	0
1993	130,605	1,576,177	788	1.14	209,701	0%	0	0.00	0
1994	136,826	1,713,003	833	1.20	221,536	0%	0	0.00	0
1995	115,525	1,828,528	879	1.27	233,815	0%	0	0.00	0
1996	67,718	1,896,246	907	1.31	241,152	0%	0	0.00	0
1997	67,310	1,963,556	898	1.29	238,706	0%	0	0.00	0
1998	65,928	2,029,484	889	1.28	236,340	0%	0	0.00	0
1999	67,978	2,097,462	879	1.27	233,858	0%	0	0.00	0
2000	68,046	2,165,508	872	1.26	231,936	0%	0	0.00	0
2001	0	2,165,508	865	1.25	230,152	0%	0	0.00	0
2002	0	2,165,508	809	1.17	215,237	0%	0	0.00	0
2003	0	2,165,508	757	1.09	201,289	100%	757	1.09	201,289
2004	0	2,165,508	708	1.02	188,244	100%	708	1.02	188,244
2005	0	2,165,508	662	0.95	176,045	100%	662	0.95	176,045
2006	0	2,165,508	619	0.89	164,637	100%	619	0.89	164,637
2007	0	2,165,508	579	0.83	153,967	100%	579	0.83	153,967
2008	0	2,165,508	541	0.78	143,990	100%	541	0.78	143,990
2009	0	2,165,508	506	0.73	134,658	100%	506	0.73	134,658
2010	0	2,165,508	474	0.68	125,932	100%	474	0.68	125,932
2011	0	2,165,508	443	0.64	117,771	100%	443	0.64	117,771
2012	0	2,165,508	414	0.60	110,139	100%	414	0.60	110,139
2013	0	2,165,508	387	0.56	103,001	100%	387	0.56	103,001
2014	0	2,165,508	362	0.52	96,326	100%	362	0.52	96,326
2015	0	2,165,508	339	0.49	90,084	100%	339	0.49	90,084
2016	0	2,165,508	317	0.46	84,246	100%	317	0.46	84,246
2017	0	2,165,508	296	0.43	78,786	100%	296	0.43	78,786
2018	0	2,165,508	277	0.40	73,681	100%	277	0.40	73,681
2019	0	2,165,508	259	0.37	68,906	100%	259	0.37	68,906
2020	0	2,165,508	242	0.35	64,440	100%	242	0.35	64,440
2021	0	2,165,508	227	0.33	60,264	100%	227	0.33	60,264
2022	0	2,165,508	212	0.31	56,359	100%	212	0.31	56,359
2023	0	2,165,508	198	0.29	52,707	100%	198	0.29	52,707
2024	0	2,165,508	185	0.27	49,291	100%	185	0.27	49,291
2025	0	2,165,508	173	0.25	46,097	100%	173	0.25	46,097
2026	0	2,165,508	162	0.23	43,109	100%	162	0.23	43,109
2027	0	2,165,508	152	0.22	40,316	100%	152	0.22	40,316
2028	0	2,165,508	142	0.20	37,703	100%	142	0.20	37,703
2029	0	2,165,508	133	0.19	35,260	100%	133	0.19	35,260
2030	0	2,165,508	124	0.18	32,975	100%	124	0.18	32,975
2031	0	2,165,508	116	0.17	30,838	100%	116	0.17	30,838
2032	0	2,165,508	108	0.16	28,839	100%	108	0.16	28,839
2033	0	2,165,508	101	0.15	26,970	100%	101	0.15	26,970

EXHIBIT 2-2
LFG RECOVERY PROJECTION GRAPH
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MD



SECTION 3.0

LFG ENERGY MARKETS AND INCENTIVE PROGRAMS

Existing and potential uses of LFG generally fall into one of the following:

- On-Site Uses (direct use and electricity generation);
- Medium Btu use (heating and boiler fuel);
- Electricity sales to utility (using internal combustion engines or gas turbines); and
- Leachate evaporation in specialized units.

SCS investigated the direct use, greenhouse operations, electrical generation, and leachate evaporation options for the utilization of the LFG. Upgrading to pipeline quality natural gas for sale to a utility was not considered because of the high capital costs (for processing LFG to remove carbon dioxide) and for the size of the landfill, which is substantially smaller than is typically required for this utilization technology.

3.1 ON-SITE USE OF LFG

3.1.1 <u>On-Site Direct Use</u>

Direct use of LFG locally is often the simplest and most cost-effective approach. LFG can be used in a variety of ways, but the most common applications include:

- Heating for facilities;
- Various industrial uses requiring process heat or steam (such as in cement manufacturing, glass manufacturing, and stone drying). This option requires an industrial application to be located on site.

RRLF ceased operation on January 18, 2001. The County does not use natural gas or expect to use fuel oil on-site during the post-closure period. Given the County's lack of on-site fuel demand, on-site direct use of the LFG was not evaluated.

3.1.2 <u>On-Site Electricity</u>

As mentioned above, the RRLF is a closed landfill with low electricity demand. The buildings and workshops on-site will not be in use during the post-closure period. Currently, the County spends approximately $2,000 per year for electricity, the majority of which is used to operate the leachate pumps.

Therefore, it is not feasible at this time for the County to use the LFG to generate electricity on-site. Even if the County's electric bill increases tenfold, the capital and operating costs associated with the on-site generation are not warranted.

3.2 MEDIUM BTU USE OF LFG

LFG can be used to replace natural gas or fuel oil as a boiler fuel for space heating and for industrial heating/co-firing applications. Landfill organics decompose and generate LFG continuously and LFG storage is not economically practical; therefore, a continuous use of LFG normally is required. Ideally, the user should be a single customer with a large demand, preferably 24 hours/day, 7 days/week, year-round. Additionally, the user should be relatively nearby: within 2 miles is desirable, although in some cases LFG is transported further (exceeding 8 miles for large projects). The most common use is as a boiler fuel to produce steam or hot water.

Use of LFG as a boiler fuel usually requires limited modifications to conventional equipment. LFG pretreatment, however, is not necessary for boilers, although it can be cost effective to dehydrate LFG prior to piping it off the landfill. Should the County sell LFG to a user, the type of equipment may include:

- Compressors.
- Dehydration system (chillers and/or dryers and filtration).
- Controls and instrumentation.
- Gas transmission pipeline.
- Modifications to existing boilers.

LFG is produced in the landfill continuously; however, the gas processing facility on the landfill may be shut down at times due to maintenance or equipment failure. To ensure a constant supply of gas to a user, an arrangement in which the fuel supply would automatically switch back to utility supplied natural gas (or other fuel) in case of a problem is recommended.

An important consideration in retrofitting boilers is that they may be required to comply with newer more stringent air emissions standards. An advantage of LFG fired boilers is that they typically have lower NO_x emissions than natural gas boilers due to the carbon dioxide in LFG. Permit compliance may require the use of low NO_x burners and a flue gas recirculation system. LFG should be sampled for impurities to determine the need for pre-processing prior to use in the boilers or ovens.

The Los Angeles County Sanitation Districts (LACSD) has four projects using LFG as a boiler fuel and report that it has been a reliable fuel source. Over a 10-year period, LACSD has found LFG from a given landfill to be available over 99.5 percent of the time with an average of five flow interruptions annually. Two local examples are: Sandy Hill Landfill in Prince George County, MD (a new project delivering 2.6 MMcfd of LFG to fuel boilers at the NASA Goddard Space Flight Center), and Pennington Avenue Landfill in Baltimore (a project that for many years supplied LFG to a boiler at a rendering plant before being turned off when LFG supplies diminished).

3.2.1 Potential LFG End Users

SCS contacted Performance Pipe (formerly Phillips Driscopipe) because they potentially have a large demand for fuel since heat is required to produce high density polyethylene (HDPE) pipe from resin. Performance Pipe is located on Hopewell Road, approximately 5 miles southeast of the landfill, and manufactures pipe that is used in this type of application. Unfortunately Phillips only uses natural gas to heat their production area and there are no boilers on site at this location. Process heat energy is provided by electricity. Therefore, LFG usage would be minimal and does not warrant further investigation. Actual energy usage amounts were not available from the company.

In a previous study headed by the Environmental Protection Agency's Landfill Methane Outreach Program (EPA LMOP), Redland Brick and Maryland Paper were identified as potential end-users. Each of these industrial end-users is located approximately 5 miles from RRLF. The study, which combined the LFG production of RRLF with the new adjacent landfill, was based on a gas production rate of 185,400 MM Btu/year over a 15-year period.

The EPA LMOP study found that Redland Brick operated 24 hours per day, 365 days a year and used natural gas fired brick kilns. At the time, it was determined that LFG could supply 85% of Redland Brick's fuel needs and provide the company with energy cost savings of approximately 30-35%. The study also found that Maryland Paper used natural gas fired boilers and operated 350 days per year. At the time of the study, LFG could supply 15% of fuel needs at an estimated energy cost savings of 5-10% for Maryland Paper. These results were presented to the end-users and the County in October of 2000; however, no further action has been taken.

Since that time, natural gas prices have been volatile, hitting a record high of approximately $10/MM Btu in January 2001. Natural gas prices in the US are typically quoted relative to the current market price at the Henry Hub, a well-known trading point for gas located at the convergence of several major pipelines in Henry, Louisiana. Index gas prices are quoted as so many percentage points above or below the Henry Hub. The Henry Hub index price for December 2002 and January 2003 has been over $5/MM Btu. The cost to the end user is more than this amount due to the costs of transmission, distribution, and marketing. Thus, there may be some greater interest now than when the LMOP study was conducted.

3.2.2 Greenhouse Project

SCS investigated the potential use of LFG to heat a greenhouse that could be constructed on the landfill facility property. This section of the report discusses the considerations made in order to estimate the greenhouse energy needs, and to compare those needs with the available LFG estimated previously.

3.2.2.1 Greenhouse Energy Requirements

Greenhouse energy needs can depend on a number of factors as follows:

- **Crop type** dictates the temperature that must be maintained for optimum growth conditions. For example, carnations can tolerate temperatures in the low 50s, while roses require warmer temperatures.

- **Geographic location** can greatly influence the amount of heat required to maintain an acceptable temperature in the greenhouse. It has been reported that at colder, northern latitudes, it takes from 100,000 to 200,000 Btu per square foot (ft^2) of floor area per year to heat a greenhouse during the growing season. A University of California report (*Reducing Energy Costs in California Greenhouses*, Leaflet 21411) states that greenhouses use an average of 115,000 Btu/ft^2 of floor area per year.

- **Building materials** used to construct the greenhouse, from glazing materials to ventilation systems, impact energy demand. Glass, rigid plastic, or plastic film used for walls and ceilings each has different thermal efficiencies which result in different amounts of heat loss.

Electricity is commonly used to power fans, lighting systems and other equipment, while fuels such as oil, natural gas and propane are typically burned to heat the facility. According to the Yahoo Weather website (http://weather.yahoo.com/), the average low temperature in January (the coldest month of the year) is 20 deg. F in Hagerstown, MD. Because these winter temperatures are moderate compared to other regions of the U.S., a greenhouse in the west central portion of Maryland can be expected to have heating needs that fall in the middle to upper end of the previously stated range of 100,000 to 200,000 Btu/ft^2 per year. For the purposes of this feasibility assessment, SCS estimated that the proposed greenhouse would require 175,000 Btu/ft^2 per year to operate through the winter.

3.2.2.2 Preliminary Greenhouse Sizing

The LFG generation and collection quantities predicted by the modeling show that the expected sustained LFG collection rate for the 15-year life of a project is approximately 300 cfm. Based on a heating value of 500 Btu/ft^3 for LFG, the maximum greenhouse area the landfill can support is calculated as follows:

$$(300\ ft^3)(500\ Btu/ft^3)(ft^2\text{-}yr/100{,}000\ Btu)(60\ min/hr)(8{,}760\ hr/yr)$$

$$= 788{,}400\ ft^2 \text{ of floor area} = 18 \text{ acres}$$

Although the calculation shows that the maximum sustainable size of a greenhouse could be 18 acres, a 10-acre greenhouse would utilize approximately 167 cfm of LFG (approximately 56 percent of the collectible LFG). This analysis is presented in Section 4. Further detailed investigation of this option is beyond the scope of work

3.3 ELECTRICITY SALES

Currently, the most prevalent use of LFG is for electricity generation using an internal combustion (IC) engine or gas turbine. Electricity can be used at the landfill or sold to the local electric utility. If electricity is not required at the landfill, it can be distributed through the local power grid. This approach requires close cooperation with the electric power utility. While there are several available technologies for generating electricity, IC engines and gas turbines are the most commonly used energy conversion devices for LFG-to-energy projects. For smaller projects (landfills with less than 1 millions tons of waste and/or gas flow rates lower than 300 cfm), the best electricity generation option might be provided by a microturbines, an emerging technology that caters to electricity capacities between 30 to 200 kW.

The anticipated landfill gas flow rate influences the selection of an appropriate device to generate electricity. Gas turbines typically require higher gas flows than IC engines to make them economically attractive. Therefore, gas turbines are better suited for large landfills. Additionally, gas turbine performance characteristics favor constant full-load operation; as a consequence, turbines are not effective for supplying power for variable electricity loads. Turbines are commonly used to generate electricity that will be distributed through the electric power grid on a continuous basis. IC engines can more easily be turned on and off, and are therefore suitable for supplying intermittent on-site power needs as well as distribution through the grid.

Based on the estimated size of this project, electricity generation may be a suitable energy recovery option at the RRLF. Microturbine technology and IC engines are the two options considered in more detail for electricity generation and sale to the local electric utility.

3.3.1 Microturbines

Microturbines are a recent emerging technology to use LFG to generate electricity. The microturbine is a high-speed turbo-charged generator that produces stationary power. It has been used in aviation for some time but is now being demonstrated on several landfill sites. These units are compact power sources, no larger than industrial air conditioners. They are typically available in sizes ranging between 25 kW to 75 kW and can be chained together to produce up to 1 MW. NOx emissions have been demonstrated to be as low as 1.4 ppm.

Microturbines are more suited to smaller landfills; they are not the most economical technology for large landfills. Since 300 cfm of LFG could be generated from the RRLF for the next 15 years, sufficient LFG could be collected and utilized to generate 667 kW, based on a conversion factor of 450 cfm of LFG (at 50 percent methane) per 1,000 kW gross output. It was assumed that 9-75 kW microturbines would be needed for this application.

3.3.2 Internal Combustion Engines

Internal combustion engines are the most commonly used conversion technology in LFG applications. They are stationary engines, similar to conventional automobile engines that can use medium-Btu gas to generate electricity. One advantage of utilizing IC engines to generate electricity is that they can be purchased in varying capacities ranging from 30 to 2,000 kW. IC engines associated with landfills typically have capacities of 400 to 1,000 kW. Typically an IC engine that produces 1 MW of power will require from 300 to 400 cubic feet per minute of LFG.

The potential LFG generation for the next 15 years is approximately 300 cfm, as previously discussed. Sufficient LFG could be collected and utilized to generate 750 kW, based on a conversion factor of 400 cfm of LFG (at 50 percent methane) per 1,000 kW gross output. For the purpose of this preliminary study, it was assumed that a single engine would be installed. Based on the LFG model, it is unlikely that additional engines would need to be installed.

It is advisable to consider the option of generating electricity using the LFG, even though the capacity of this project is at the lower end of kW generation. The ultimate feasibility of this LFG utilization option depends on the electricity purchase rate paid by the local electric utility.

3.3.3 Allegheny Power

Allegheny Energy, Inc. is the electric utility company serving the landfill. It is composed of three electric utility subsidiaries that provide electric service to more than 1.4 million people in a 31,000 square mile area within Maryland, Ohio, Pennsylvania, Virginia, and West Virginia. Allegheny Power participates in the PJM (Pennsylvania, New Jersey, Maryland) power supply system. The sale of electricity could be based on a percentage of the hourly LMP (locational market price), an index that reflects the value of energy at a specific location and time. This index presently is about $28-$29/MWh ($0.028-$0.029/kWh), as an annualized value. The generation and sale of electricity would be feasible for the County at the minimum rate of $0.03 per kW.

3.4 LEACHATE EVAPORATION

Leachate management can be a troublesome and costly factor in landfill operations. While most landfills utilize off-site leachate treatment and disposal options, some have opted for on-site treatment. Landfill gas fueled leachate evaporation can integrate the utilization of landfill gas with leachate treatment. Leachate evaporation offers the potential of zero discharge if the conditions allow leachate evaporation effluent to be returned to the landfill.

The leachate evaporation process utilizes energy released from LFG combustion to heat and vaporize leachate in specialized evaporation units. One such method involves landfill gas being drawn from a collection system. Leachate is drawn from a storage tank or pond into an evaporator. Landfill gas, introduced together with air, is combusted in the leachate evaporation vessel, evaporating excess moisture and reducing the original volume of the leachate by as much as 97 percent. Vapor from the evaporator can be thermally treated in an enclosed gas flare, while the remaining leachate concentrate (effluent) is treated by conventional treatment methods, either on or off site. Typical costs for leachate evaporation range between $0.05 and $0.10 per gallon (development, capital, and O&M).

Leachate evaporation projects using LFG are generally practical when leachate treatment costs are high enough to mitigate the cost of project development. At RRLF, an average of 3,600,000 gallons per year of leachate are collected and treated at the County's wastewater treatment plant at a cost of approximately $0.055 per gallon ($198,000 annually). Leachate evaporation projects are generally feasible when the average leachate treatment cost for the landfill is above $0.05 per gallon. Since the County's cost is about the same, this option was not studied further. However, should the cost for treating the leachate increase, this option should be reevaluated.

3.5 VEHICLE FUEL

Vehicle fueling with compressed methane extracted from LFG is of interest for both environmental (low emissions) and economic reasons. Driven by the high air pollution levels in Southern California, production of vehicle fuel has been demonstrated at the Puente Hills Landfill near Los Angeles, where several landfill vehicles are fueled with processed LFG.

Processing LFG for vehicle use involves several purification and compression processes. At Puente Hills, dedicated wells of high methane quality and low oxygen (less than 1 percent) were connected to a separate collection system. The Puente Hills Landfill facility uses a process with the following elements:

- Three stages of gas compression to 525 psi.
- Removal of trace organics using carbon guard beds.
- Heating the gas to prevent condensation.
- Running the gas through cellulose acetate membranes to remove CO_2.
- Two additional stages of compression to 3,600 psi.
- Storage tanks and dispenser for vehicles.

The Puente Hills Landfill fueling facility processes 250 cfm of LFG at an estimated capital cost of $900,000. Roughly 1,500-gallon equivalents of gasoline can be produced from 250 cfm of LFG at 50 percent methane in a 24-hour day, which would supply 75 vehicles with 20 gallons a day. At maximum usage (75 trucks per day), the Puente Hills facility could recover its capital investment in 15 years by selling fuel for roughly 40-percent of the equivalent gasoline price. Some refuse collectors in Southern California are now operating Compressed Natural Gas (CNG) vehicles and are thus able to purchase fuel from the landfill. SCS is not aware of any such refuse vehicles in Washington County, therefore vehicle usage may be limited to the County fleet.

The fuel from Puente Hills has been used in cars (1988 Ford Taurus V-6) and heavy-duty vehicles (landfill water truck). Converting a car to CNG operation is a relatively simple process since no internal modifications are necessary to the engine. Conversion of a gasoline vehicle to a bi-fuel vehicle (i.e. runs on either gasoline or LFG vehicle fuel, but not simultaneously) can cost roughly $2,600 for a pick-up truck. Conversion of a Class 8 garbage truck to dual fuel capability (i.e. runs on a mixture of diesel and LFG vehicle fuel) costs an estimated $15,000-$18,000.

Since the County presently does not have a dedicated natural gas fleet or one planned, this option was not further considered.

3.6 INCENTIVE PROGRAMS

LFG utilization carries with it some important benefits to the environment. It is a renewable energy source (thereby conserving fossil fuel) and reduces landfill emissions. In light of these benefits, various government agencies have established incentive programs to encourage the use of LFG as an alternative. Several incentive programs relevant to the Washington County project are summarized below.

3.6.1 Federal Tax Credits

The Section 29 tax credits were included in the Energy Policy Act of 1992 and have been available to qualifying LFG recovery projects. They frequently are necessary to make LFG recovery economically feasible. The current tax credit value is roughly $1 per million Btus (MM Btu). To qualify for the Section 29 tax credits, the project must:

- Produce the gas from biomass, or liquid, gaseous or solid synthetic fuels produced from coal (or lignite).
- Sell the gas to an unrelated party.
- Have the LFG collection system placed in service by June 30, 1998.

Tax credits can be applied through the year 2007 for facilities placed in service after 1992. Unfortunately, Section 29 credits in their current form are not available for the County's project because the system will not satisfy the in-service date.

In 2002, the LFG industry tried to extend Section 29 tax credits and expand Section 45 tax credits via the Energy Bill. No energy bill was passed during the last Congress, so efforts are being renewed this year. As of January 2003, a bill is being crafted to amend the Internal Revenue Code of 1986 to benefit LFG projects. Given the current fiscal climate, however, the impact of the newly proposed tax credit provisions will be relatively modest. A summary of the proposed tax credit provisions is presented below based on the current Senate bill sponsored by Senator Lincoln:

Section 45 Provision –

The existing Section 45 tax credit provides a tax credit of $0.015/kWh for energy generated and sold from a qualifying facility. Eligible fuels currently are wind energy, closed loop biomass, and poultry waste. This bill would add LFG as a qualifying fuel. A full credit value would be provided for projects placed in service before January 2008 with a 5-year pay out period.

For existing operational electricity projects eligible for this credit prior to enactment of the bill, the credit is reduced by 1/3. Anti-double dip language states that if your "facility" has ever received a Section 29 tax credit, it is not eligible for the Section 45 credit.

Section 29 Provision --

The bill proposes a 5-year pay out period for projects placed in service after June '98 and before January '08. A 200,000 cubic feet per day (cfd) volume cap (as natural gas) is placed on gas actually eligible for the credit. This cap translates to 400,000 cfd or 278 cfm for LFG. The value of the credit is $3 per barrel of oil equivalent (i.e., 5.8 MM Btu), which is approximately $0.52/MM Btu – significantly less than the current credit enjoyed by eligible projects. A 1/3 reduction of the proposed credit will be applied to NSPS sites ($2 instead of $3).

For purposes of this evaluation of the economics of LFG utilization, no tax credits are assumed. However, if either of the tax credit provisions passes in this Congress, it may stimulate more developer interest in a project at Resh Road.

3.6.2 <u>Renewable Energy Production Incentive (REPI)</u>

Renewable Energy Production Incentive (REPI) is a program offering a $0.015/kWh payment to owners/operators who produce electricity from solar, wind, biomass, or geothermal sources at qualifying projects. The power plant must be owned and operated by a municipal or non-profit organization to be eligible for payments. The program will be in effect over a 10-year period and is subject to appropriations by Congress and Department of Energy (DOE). To qualify, a project must:

- Generate electricity from solar, wind, biomass, or geothermal sources (burning municipal solid waste for energy is not included).
- Be a public entity or non-profit electric cooperative.
- Use the facility for the first time in 1993 or later (excludes existing facilities).
- Petition DOE for payments.

According to rules published in 1994, DOE should pay the cash subsidies on an annual basis. At the end of each year, the federal government will publish a notice in the <u>Federal Register</u> requesting petitions for payment from eligible entities. Payments would be made in the spring of the following year. If the available funding for a particular year is not enough to cover all eligible projects, then LFG power plants would be a lower priority than power plants using sunlight, geothermal energy, wind, and various other forms of biomass. In this case, the LFG power plant may not receive payments since the funding would be shared among the higher priority energy producers. Therefore, annual payments are not guaranteed.

The program has been oversubscribed for the past two years. Funding has been prorated to LFG projects again this year. If an electrical generation project is pursued, it may be prudent to structure the project to potentially take advantage of this program. Any payments under this program should be treated as an unexpected windfall and not be relied on in the project economics.

3.6.3 Maryland Clean Energy Incentive Act – Senate Bill 670

On May 11, 2000, Governor Glendenning signed the Maryland Clean Energy Incentive Act. This Act, effective July 1, 2000, provides State income tax credits for electricity produced from qualifying energy resources. The tax credit value is $0.0085/kWh for all electricity sold to an unrelated party. The project must be located in Maryland and have originally been placed in service on or after January 1, 2001 but before January 1, 2005. An eligible project can receive the tax credits for a 10-year period. The credit is not indexed for inflation.

Qualified energy resources include:

- Wind energy and closed loop biomass as defined in Section 45 of the IRS code.
- Solid, nonhazardous, cellulosic waste material that is segregated from other waste material and is derived from
  - Any of the following forest-related resources, not including old-growth timber: mill residues, pre-commercial thinnings, slash, or brush.
  - Waste pallets, crates, and dunnage and landscaping or right-of-way trimmings, not including unsegregated MSW and post-consumer waste paper, or
  - Agricultural sources, including orchard tree crops, vineyard, grain, legumes, sugar, and other crop by-products or residues.
- Includes methane gas resulting from the anaerobic decomposition of organic materials in a landfill or wastewater treatment plant.

This credit would help LFG electrical generation projects. For the Washington County project, a project developer likely would need a partner with a large enough Maryland tax burden to take advantage of this credit.

3.6.4 GHG Credits

The Kyoto Protocol of 1997 encourages greenhouse gas (GHG) emissions trading as one of the main avenues to control the global climate change problem. Current efforts are underway to establish the guidelines for such an emissions trading program, though several trades have already taken place in the global marketplace in the absence of such guidelines.

The market for emission reduction credits or verifiable emission reductions (VER) is beginning to take shape and continues to evolve. In January 2003, the formation of the Chicago Climate Change was announced. This exchange will serve as a mechanism for US companies to engage in a voluntary but legally binding GHG trading program. New LFG projects are a good source of GHG VERs as long as the facility is not subject to NSPS (which Resh Road is not).

At this point, SCS is optimistic that sites like Resh Road could realize some monetary benefit to selling VERs from a LFG collection and flaring project. However, because of the uncertainty in marketing GHG credits, we have not included such revenues in this evaluation. The County may want to assign the rights to these credits as part of the LFG utilization project or keep them and market them separately if a project is not developed.

SECTION 4.0

OPTIONS ANALYSIS

Based on our review of the identified options presented in Section 3, SCS has prepared a cost analysis for the energy utilization options with the greatest potential for success.

4.1 DIRECT USE

SCS performed a preliminary cost analysis of direct use to determine the radius in which to search for potential end users. After several trials, it was determined that even at a zero mile radius the sale of LFG to an end user was not feasible.

The following assumptions have been used in the cost analysis:

- Energy sales to User 1 ranging from 161,000 to 63,000 MMBtu/year based on 80% usage rate of the available LFG supply from the landfill.

- Capital costs as presented on Exhibit 4-1 A and B. The capital costs used in the analysis could be considered modest. SCS is familiar with projects that have experienced unit costs both higher and lower than those used in this analysis. For example, pipeline construction costs are based on $200,000 per mile; various factors such as right-of-way requirements and trenching in rock could increase the actual costs. The capital cost estimate allocates $75,000 for modifications at User 1's facility. User 1 could be made financially responsible for improvements made within their facilities to justify the discounted energy costs.

- Operation and maintenance costs of $139,000/year. These costs have also been kept minimal.

- Energy sales price of $3.50/ MMBtu. Recent natural gas energy prices have been in the $5/MMBtu range. We have more conservatively based our analysis on historical prices. The project would likely need to offer significant energy savings (up to 25 percent) to User 1 to secure a long-term fuel supply contract. Total annual savings of $50,000 - $100,000 are usually sufficient to interest an end user to switch fuels and provide a short payback (less than two years) on capital improvements. Pricing could be tied to a natural gas index or could be based on fixed rates indexed to inflation.

- Both public and private financing options are shown. For privately developed project, a $10,000 annual payment to the County was assumed. This is a nominal amount, but probably realistic given the marginal return available from a project at Resh Road.

Model results are presented in Exhibit 4-2A through D for both County and LFG developer ownership assuming pipeline distances of 1 and 5 miles. On paper, it appears that a direct use project to a customer within 1 mile would have a positive cash flow throughout the life of the project and a net present value of approximately 1.2 million dollars.

4.2 ELECTRICAL GENERATION

The major cost elements of a LFG electrical generation facility typically include:

- Blower/compressor and moisture removal equipment.
- Engines, generators, and radiators.
- Electrical (switchgear, motor control centers, transformers, etc.).
- Building and site improvements.
- Utility interconnect.
- Engineering, permitting, legal, etc.

4.2.1 IC Engine Electrical Power Generation Facility

A 750 kW electrical power generation facility typically includes the following elements:

- Installation of one engine generator, rated at 800 - 1,000 kW net output. The skid-mounted package consists of the engine, generator, and support systems.

- Engine control room which would house the engine generator control panels, switchgear, breakers, motor control center, controls, and monitoring systems.

- Total site area required - less than 1/2 acre

The capital cost of a 750 kW facility is typically estimated at $1,000/kW or $750,000 for an economical facility. Power plant operations and maintenance (O&M) costs range from $0.012 to $0.015/kWh.

For the economic analysis, SCS has assumed the following:

- 750 kW electrical generation facility.
- Facility would be on-line in 2004.
- All power would be sold to Allegheny Power. Initial rate of $0.03/kWh was assumed with a 2% annual escalation.
- Plant capital cost of $900,000.
- Power plant operations and maintenance (O&M) costs at $0.014/kWh.
- Two ownership options are presented:

  - Exhibit 4-3A - County Ownership - the project is financed using municipal bonds at 6 percent for 15 years.

- Exhibit 4-3B - Private Section Ownership - the project is financed at 10 percent for 15 years. The County would receive annual payments estimated at $10,000/year. The developer would be eligible for the Maryland Energy Tax Credit of $0.085/kWh.

4.2.2 Microturbine Electrical Power Generation Facility

A 667 kW electrical power generation facility typically includes the following elements:

- A compressor/refrigeration skid to deliver up to 300 scfm of landfill gas to the microturbines;
- Nine 75 kW microturbines;
- Switchgear and electric interconnections to support parallel operation;
- Foundations, piping and wiring to provide a complete outdoor installation;
- A PLC-based control system which will support remote monitoring and control of the power plant.

The capital cost of a 667 kW facility is typically estimated at $2,000/kW or $1,334,000 for an economical facility. Power plant operations and maintenance (O&M) costs are approximately $0.02/kWh.

For the economic analysis, SCS has assumed the following:

- 667 kW electrical generation facility.
- Facility would be on-line in 2003.
- All power would be sold to Allegheny Power. Initial rate of $0.03/kWh was assumed with a 2% annual escalation.
- Plant capital cost of $1,334,000.
- Plant O&M costs at $0.02/kWh.
- Two ownership options are presented:
  - Exhibit 4-2A - County Ownership - the project is financed using municipal bonds at 6 percent for 15 years.
  - Exhibit 4-2B - Private Section Ownership - the project is financed at 10 percent for 15 years. The County would receive annual payments estimated at $10,000/year. The developer would be eligible for the Maryland Energy Tax Credit of $0.085/kWh.

4.2.3 Electrical Generation Comparison

As shown below, the economic benefits of the two best options are as follows:

	Option 1 Electrical Generation using IC Engine Allegheny Power	**Option 2 Electrical Generation using Microturbine Allegheny Power**
LFG Utilization Rate		
2004	35%	40%
2012	60%	68%
Capital Cost	$900,000	$1,334,000
County Owned		
Annual Revenues	$169,000	$138,000
Operating Cost	$153,000	$ 174,000
Net Cash Flow - 2004	$ 16,000	($ 36,000)
Net Cash Flow - 2012	$ 24,000	($ 30,000)
Net Present Value - NPV	$ 28,000	($539,000)
Privately Owned		
Annual Revenues	$216,000	$177,000
Operating Cost	$183,000	$215,000
Net Cash Flow - 2004	$ 34,000	($ 37,000)
Net Cash Flow - 2012	$ 41,000	($ 31,000)
Net Present Value - NPV	$ 37,000	($523,000)

As shown above, the electrical generation and sale to Allegheny Power using an IC Engine is a better option than microturbines when developed either by the County or a private developer. These results are based upon the assumptions stated above including the sale price of the electricity. As indicated by the results, the County or private developer would need to receive a better purchase rate than a $0.03/kWh to make a power generation project attractive.

4.3 GREENHOUSE ECONOMIC ANALYSIS

As discussed in Section 3, an economic analysis of greenhouse usage is presented below. The following analysis is based on a 10-acre greenhouse and assumes that the least expensive construction approaches are utilized. Unit costs for construction are shown below:

Item	**Cost ($/ft^2)**
Rigid Frame Wood Greenhouse	2.00
Site Prep/Driveway/Concrete Floor	3.60
Environmental Control (HVAC)	5.45
TOTAL (rounded)	11.05

The costs shown above were taken from Greenhouse Engineering, Aldrich, R.A. and Bartok, J.W., Northeast Regional Agricultural Service; Cornell University, Ithaca, NY, published in August 1996.

The approximate total cost of greenhouse construction is calculated by multiplying the total square footage of floor area by the cost per square foot as shown below.

(10 acre)(43,560 ft^2/acre)($11.05/ft^2) = $4,813,380

4.3.1 Heating System Cost Comparison

Typically, the economics of an LFG utilization project are compared with the scenario of operating the same project, powered with a readily available fuel such as natural gas. Therefore, the following discussion compares the economics of burning LFG versus natural gas and propane to heat the greenhouse.

It is estimated that propane can be delivered to the site for approximately $1.00 per gallon, which corresponds to approximately $11.00 per million Btu (MMBtu). The price of $1.00 per gallon is an average price for commercial/industrial users in the Maryland area over the last winter season. This information was provided by the U.S. Dept. of Energy, Energy Information Administration. Natural gas can be delivered to the site for approximately $6.00 per 1,000 cubic feet (or /MMBtu) which is slightly less than the average price for commercial consumers in 1998 in Maryland. This information was also provided by the Energy Information Administration. In order for the project to be feasible from an energy purchasing standpoint, the cost to supply the greenhouse with LFG must be less than $5.40/MMBtu (a 10 percent savings compared to natural gas).

The cost per year to recover the LFG is typically equal to the amortized annual capital cost of the LFG collection system plus the annual operating costs. The fact that the Resh Road Landfill will have an operating, comprehensive LFG collection system in place results in significantly reduced capital costs for a direct use project such as a greenhouse. The annual costs for a greenhouse project basically are reduced to the O&M costs for the Resh Road LFG collection system and the amortized annual capital cost of the system modifications to convey LFG to the greenhouse.

The annual O&M costs for the Reichs Ford LFG collection system are estimated to be approximately $90,000 per year. This is based on SCS experience and the EPA LMOP E-Plus model.

The cost per million Btu to supply LFG to the greenhouse can be calculated as follows:

[LFG Flow Rate (cfm)][Heating Value of LFG (Btu/ft^3)][minutes/year][MMBtu/10^6 Btu]

(167 cfm of LFG)(500 Btu/ft^3)(525,600 min/yr)(MMBtu/10^6 Btu) = 43,888 MMBtu/year

$90,000/year ÷ 43,888 MMBtu/year = $2.05 / MMBtu

4.3.2 Greenhouse Summary

This preliminary analysis suggests that the cost to supply the greenhouse with LFG ($2.05/MMBtu) is significantly less than the cost of natural gas ($6.00/MMBtu) or propane ($11.00/MMBtu). Utilization of LFG for a greenhouse at the site results in annual fuel savings of 66 percent ($173,328) compared to natural gas and 81 percent ($392,798) compared to propane. Note that the above comparison did not consider the costs to purchase and install propane storage tanks. Also, the O&M costs assumed the entire LFG collection system would operate and the excess LFG (LFG not utilized by the greenhouse) would be flared.

The economic feasibility of greenhouse operations at the site, however, depends more on product markets and demand than fuel costs. Thus, if greenhouse operations are being considered by the County or private business, the landfill would be a good location for the same. This information would be appropriated to share with potentially interested parties.

EXHIBIT 4-1A. DIRECT GAS SALES VIA 1-MILE PIPELINE

CAPITAL COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
LFG PROCESSING EQUIPMENT				
Precooler	LS	$30,000	1	$30,000
Compressor package	LS	$125,000	1	$125,000
Chilled Glycol Package	LS	$21,000	1	$21,000
Exchanger/Desiccant Skid	LS	$45,000	1	$45,000
Air Compressor/Dryer	LS	$16,000	1	$16,000
Electric Motor Control Center	LS	$25,000	1	$25,000
Instrumentation	LS	$50,000	1	$50,000
Installation/etc.	LS	$75,000	1	$75,000
			Subtotal	$387,000
PIPELINES				
Pipeline to 1st User	MILE	$200,000	1.00	$200,000
Pipeline to 2nd User (additional distance)	MILE	$200,000	0.00	$0
ROW Easements - not included				$0
			Subtotal	$200,000
END USER FACILITY				
End User 1	LS	$75,000	1	$75,000
End User 2	LS	$75,000	0	$0
			Subtotal	$75,000
Subtotal				$662,000
ENGINEERING				
Engineering, Surveying, Legal, Permitting		10%		$66,200
Subtotal				$728,200
Contingency		15%		$109,230
TOTAL ESTIMATE				$837,430
End User 1 Cost	100%			$837,430
End User 2 Cost	0%			$0
ANNUAL O&M COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
Operator/Maintenance Man	Year	$40,000	1	$40,000
Supervisor	Day	$400	12	$4,800
Contract Electrician Crew	Day	$700	12	$8,400
Contract Maintenance Crew	Day	$700	12	$8,400
Lubricants/Process Fluids	LS			$5,000
Machinery Parts & Tools/Safety	LS			$15,000
Office Support/Office Supplies	LS			$10,000
Subtotal				$91,600
Insurance/Bonding/etc.	LS	10%		$9,160
Subtotal				$100,760
Contingency		10%		$10,076
Total Labor and Supplies				$110,836
Electrical Consumption	kWh	$0.06	50	$26,280
based on $0.06/kWh*50kW demand*8760 hours/yr				
Total Annual O&M Costs				$137,116

EXHIBIT 4-1B. DIRECT GAS SALES VIA 5-MILE PIPELINE

CAPITAL COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
LFG PROCESSING EQUIPMENT				
Precooler	LS	$30,000	1	$30,000
Compressor package	LS	$125,000	1	$125,000
Chilled Glycol Package	LS	$21,000	1	$21,000
Exchanger/Desiccant Skid	LS	$45,000	1	$45,000
Air Compressor/Dryer	LS	$16,000	1	$16,000
Electric Motor Control Center	LS	$25,000	1	$25,000
Instrumentation	LS	$50,000	1	$50,000
Installation/etc.	LS	$75,000	1	$75,000
			Subtotal	$387,000
PIPELINES				
Pipeline to 1st User	MILE	$200,000	5.00	$1,000,000
Pipeline to 2nd User (additional distance)	MILE	$200,000	0.00	$0
ROW Easements - not included				$0
			Subtotal	$1,000,000
END USER FACILITY				
End User 1	LS	$75,000	1	$75,000
End User 2	LS	$75,000	0	$0
			Subtotal	$75,000
Subtotal				$1,462,000
ENGINEERING				
Engineering, Surveying, Legal, Permitting		10%		$146,200
Subtotal				$1,608,200
Contingency		15%		$241,230
TOTAL ESTIMATE				$1,849,430
End User 1 Cost	100%			$1,849,430
End User 2 Cost	0%			$0

ANNUAL O&M COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
Operator/Maintenance Man	Year	$40,000	1	$40,000
Supervisor	Day	$400	12	$4,800
Contract Electrician Crew	Day	$700	12	$8,400
Contract Maintenance Crew	Day	$700	12	$8,400
Lubricants/Process Fluids	LS			$5,000
Machinery Parts & Tools/Safety	LS			$15,000
Office Support/Office Supplies	LS			$10,000
Subtotal				$91,600
Insurance/Bonding/etc.	LS	10%		$9,160
Subtotal				$100,760
Contingency		10%		$10,076
Total Labor and Supplies				$110,836
Electrical Consumption	kWh	$0.06	50	$26,280
based on $0.06/kWh*50kW demand*8760 hours/yr				
Total Annual O&M Costs				$137,116

EXHIBIT 4-2A. DIRECT GAS SALES VIA 1-MILE PIPELINE - COUNTY DEVELPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224
TOTAL ANNUAL OPERATING COST	$225,224	$229,394	$233,689	$238,113	$242,670	$247,363	$252,197	$257,177	$262,305	$267,588	$273,028	$278,633	$284,405	$290,350	$296,474
NET CASH FLOW	$338,385	$308,231	$279,151	$251,086	$223,975	$197,771	$172,414	$147,861	$124,060	$100,966	$78,533	$56,721	$35,490	$14,797	($5,396)
NPV - Net Present Value	$1,761,344														
Debt Coverage	4.92	4.57	4.24	3.91	3.60	3.29	3.00	2.71	2.44	2.17	1.91	1.66	1.41	1.17	0.94

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$837,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Capital Cost	$0
Total Capital Cost (User 1 and 2)	$837,430		
Equity Percentage	0%	O&M LFG Collection System	$0
Equity Contribution	$0	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	6.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1030	Landfill Owner Payment	$0
		Payment Escalation (%)	0%

EXHIBIT 4-2B. DIRECT GAS SALES VIA 1-MILE PIPELINE - PRIVATE SECTOR DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	**$563,609**	**$537,625**	**$512,840**	**$489,199**	**$466,645**	**$445,134**	**$424,611**	**$405,038**	**$386,365**	**$368,554**	**$351,561**	**$335,354**	**$319,895**	**$305,147**	**$291,078**
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner/1st Yr Equity	$177,486	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Annual Debt Service	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080
TOTAL ANNUAL OPERATING COST	**$404,566**	**$241,550**	**$246,154**	**$250,896**	**$255,781**	**$260,812**	**$265,994**	**$271,331**	**$276,829**	**$282,491**	**$288,324**	**$294,331**	**$300,518**	**$306,892**	**$313,456**
NET CASH FLOW	**$159,043**	**$296,075**	**$266,686**	**$238,303**	**$210,864**	**$184,323**	**$158,617**	**$133,706**	**$109,536**	**$86,062**	**$63,238**	**$41,023**	**$19,377**	**($1,744)**	**($22,378)**
NPV - Net Present Value	**$1,245,817**														
Debt Coverage	**2.81**	**4.36**	**4.03**	**3.71**	**3.39**	**3.09**	**2.80**	**2.52**	**2.24**	**1.98**	**1.72**	**1.47**	**1.22**	**0.98**	**0.75**

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of Supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$837,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Additional Capital Cost	$0
Total Capital Cost (User 1 and 2)	$837,430		
Equity Percentage	20%	O&M LFG Collection System	$0
Equity Contribution	$167,486	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	10.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1315	Landfill Owner Payment	$100,000
		Payment Escalation (%)	3%

EXHIBIT 4-2C. DIRECT GAS SALES VIA 5-MILE PIPELINE - COUNTY DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422
TOTAL ANNUAL OPERATING COST	$329,422	$333,592	$337,888	$342,311	$346,868	$351,562	$356,396	$361,375	$366,503	$371,786	$377,227	$382,831	$388,603	$394,549	$400,672
NET CASH FLOW	$234,187	$204,032	$174,953	$146,888	$119,777	$93,573	$68,215	$43,663	$19,862	($3,232)	($25,665)	($47,477)	($68,708)	($89,401)	($109,594)
NPV - Net Present Value	$749,344														
Debt Coverage	2.23	2.07	1.92	1.77	1.63	1.49	1.36	1.23	1.10	0.98	0.87	0.75	0.64	0.53	0.42

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$1,849,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Capital Cost	$0
Total Capital Cost (User 1 and 2)	$1,849,430		
Equity Percentage	0%	O&M LFG Collection System	$0
Equity Contribution	$0	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	6.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1030	Landfill Owner Payment	$0
		Payment Escalation (%)	0%

EXHIBIT 4-2D. DIRECT GAS SALES VIA 5-MILE PIPELINE - PRIVATE SECTOR DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner/1st Yr Equity	$379,886	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Annual Debt Service	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521
TOTAL ANNUAL OPERATING COST	$713,407	$347,991	$352,595	$357,338	$362,222	$367,253	$372,435	$377,772	$383,270	$388,932	$394,765	$400,772	$406,960	$413,333	$419,897
NET CASH FLOW	($149,798)	$189,634	$160,245	$131,862	$104,423	$77,881	$52,176	$27,265	$3,095	($20,379)	($43,203)	($65,418)	($87,064)	($108,185)	($128,819)
NPV - Net Present Value	$252,217														
Debt Coverage	0.23	1.97	1.82	1.68	1.54	1.40	1.27	1.14	1.02	0.90	0.78	0.66	0.55	0.44	0.34

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of Supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$1,849,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Additional Capital Cost	$0
Total Capital Cost (User 1 and 2)	$1,849,430		
Equity Percentage	20%	O&M LFG Collection System	$0
Equity Contribution	$369,886	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	10.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1315	Landfill Owner Payment	$100,000
		Payment Escalation (%)	3%

Environmental Consultants

11260 Roger Bacon Drive
Reston, VA 20190-5282

703 471-6150
FAX 703 471-6676
www.scsengineers.com

SCS ENGINEERS

February 13, 2003
File No.: 02201085.00

Mr. Randy Edwards, PE
Washington County
Engineering Department
Department of Public Works
80 W. Baltimore Street
Hagerstown, MD 21740-6003

Subject: Resh Road Landfill LFG Utilization Report

Dear Mr. Edwards:

SCS is pleased to submit our report assessing the feasibility of landfill gas (LFG) utilization at the Resh Road Landfill. This work was performed in accordance with our scope of services under the landfill capping contract between the County and the Maryland Environmental Service (MES).

After your review of the document, we suggest a meeting to discuss the results of the evaluation. If you have any questions in the meantime, please telephone either of us.

Very truly yours,

Darrin D. Dillah, Ph.D., PE
Project Advisor
SCS ENGINEERS

Eric R. Peterson, PE
Vice President
SCS ENGINEERS

cc: Les Shaw, MES

Environmental Consultants

SCS ENGINEERS

FEASIBILITY ASSESSMENT FOR LANDFILL GAS TO ENERGY AT RESH ROAD SANITARY LANDFILL

TASK 5 LFG UTILIZATION STUDY

Prepared for:

Washington County
Engineering Department
Division of Public Works
80 W. Baltimore Street
Hagerstown, Maryland 21740

SCS Engineers
11260 Roger Bacon Drive
Reston, Virginia 20190
(703) 471-6150

February 2003
File No. 02201085.00

TABLE OF CONTENTS

EXHIBITS

SECTION 1.0

INTRODUCTION

SCS Engineers (SCS) was retained by Washington County to perform a landfill gas (LFG) utilization feasibility assessment for the Resh Road Landfill (RRLF). In accordance with Task 5 of the contracted scope of work, SCS is submitting this options analysis report for recovering and utilizing LFG from the Landfill.

The physical characteristics of the RRLF are compatible with LFG utilization. The landfill is one of the candidate sites in Maryland identified as part of SCS' study for the Northeast Regional Biomass Program (a DOE program), which is administered by the Coalition of Northeastern Governors. These characteristics include:

- Landfill size (volume), depth of fill, and age.
- The landfill will be capped with a geomembrane, which provides an increased LFG collection efficiency for a LFG collection system.
- A LFG collection system will be installed for emission controls.

Exhibit 1-1 presents the layout for the proposed LFG collection system on RRLF. An assessment of LFG utilization at RRLF is being performed since RRLF will generate LFG for approximately the next 30 years and potential industrial end users that could utilize LFG are near the landfill.

1.1 OBJECTIVES AND APPROACH

The objectives of this study are to assess the feasibility of economic recovery and utilization of LFG.

The approach taken for this study focuses on economics and energy markets, and includes:

- An estimate of the LFG generation and recovery potential from the landfill using computer modeling based on available information, field test data, and engineering experience at similar landfills.
- Energy market options for LFG utilization.
- A cost analysis for the most promising potential use of LFG.
- Alternate approaches for development of a LFG recovery/utilization project.

1.2 LFG UTILIZATION BACKGROUND

Landfills produce LFG as organic materials decompose under anaerobic (without oxygen) conditions. LFG as generated is composed of approximately equal parts of methane and carbon dioxide with trace concentrations of non-methane organic compounds (NMOC). Collected LFG also typically includes some amount of air, which is drawn into the system by the vacuum exerted on the landfill. Methane is a combustible gas that forms an explosive mixture with air when present in concentrations between 5 and 15 percent by volume in air. The combustibility of methane can be both an asset and a liability to a landfill owner - an asset when the gas becomes a source of energy recovered from the landfill, and a liability in terms of potentially hazardous conditions caused by subsurface migration of LFG.

Good quality LFG (high methane and low oxygen and nitrogen) can be utilized as a fuel to offset the use of conventional fossil fuels. 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. Oxygen and nitrogen levels are indicators of air intrusion through the landfill surface or leaks in the LFG collection system; such intrusions must be minimized for economic recovery of the LFG.

Over 300 LFG energy recovery facilities are operating in the U.S. Existing and potential uses of LFG generally fall into one of the following categories: direct use for heating/boiler fuel, electrical generation, upgrade to high Btu gas, and other uses such as vehicle fuel. Approximately two-thirds of the LFG utilization facilities in the U.S. generate electricity.

1.3 PROJECT LIMITATIONS

SCS relied upon existing information provided and various assumptions in modeling the landfill. Judgments and analysis are based upon this information and SCS' experience with LFG collection and utilization systems. Limitations include:

- LFG production estimates are based on a desktop analysis. Existing LFG collection wells (installed by SCS during the collection system design investigation phase) were monitored under passive conditions for one round providing useful but limited data.

- The cost analysis uses published purchase price data and typical capital and operating cost data for similar systems rather than project specific information.

SECTION 2.0

LFG FUEL RESERVES

2.1 LANDFILL BACKGROUND

The RRLF is located approximately three miles west of Hagerstown, Maryland, on a 140-acre parcel of land. The waste footprint is about 75 acres, consisting of eight cells. Operations began in the early 1980s and ceased on January 18, 2001. The landfill is owned and operated by Washington County. Presently, no LFG is collected at the site. The quantity of in-place waste is approximately 2.2 million tons.

The permeability of the cover system on a landfill affects the LFG collection efficiency. The RRLF is scheduled to upgrade its existing cap. The minimum 2-foot thick intermediate soil layer over refuse will be maintained. A new cap will be installed over this intermediate soil layer. The cap will consist of a woven geotextile being placed on the existing cover followed by a 40 mil textured HDPE synthetic liner. On top of this will be a geocomposite consisting of a geonet sandwiched between two layers of geotextile. Finally a 1'-8" compacted soil layer and 4-inches of topsoil will be placed to finish the construction of the cap. Geomembrane caps typically enhance LFG collection efficiency by reducing the amount of air infiltration caused by wells under vacuum.

Cells N-1, N-2, N-3 and Cell 4 have synthetic bottom liner systems. Cells 1, 2, 3 and 5 have a clay bottom liner.

2.2 LFG RECOVERY MODEL

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

SCS developed a modified version of the U.S. EPA landfill gas generation model that is more useful for accurately estimating the LFG recovery potential of landfills. SCS' model was developed based on actual LFG collection/recovery data for over 100 sites across the U.S. It is this modified version of the EPA model that is used in this report and is referred to when discussing the "SCS model."

The parameters input to the model include the historical and expected future annual waste receipts in tons; the expected collection system coverage percentage; and precipitation-based values of the "apparent" ultimate methane recovery potential (L_o) and decay rate constant (k). Based on these variables, the model calculates an annual LFG recovery rate estimate.

When calibrating this model, SCS identified trends in the LFG collection data that were used to develop the model. Specifically, it was apparent that different k and L_o values were appropriate for landfills that receive different amounts of annual rainfall. Hence, the development of the precipitation-based k and L_o, which, depending on the annual rainfall at the site, may vary from the typical default values published by the U.S. EPA.

The two main areas where the modified SCS model differs from the EPA model are as follows:

- The SCS model provides default precipitation-based input variables to reflect site-specific conditions.
- The SCS model estimates LFG recovery directly (rather than applying a "recovery efficiency" to a generation estimate), whereas the EPA model estimates generation.

Each of these modifications is discussed below.

Most LFG models, including the EPA model, estimate LFG generation. To estimate the amount of LFG which can be recovered at a site, engineers typically model LFG generation and apply a recovery "efficiency" rate, which is the estimated fraction of generated LFG which can be recovered, given the LFG collection system currently in place or anticipated. An engineer can estimate whether a site has a relatively high or low recovery efficiency, but has no solid basis to assign a value to it since total generation is unknown. For this reason modelers often rely on the U.S. EPA's *Compilation of Air Pollutant Emission Factors* (which is commonly known as the AP-42 document), which lists emission factors, and states that recovery efficiencies typically range from 60 to 85 percent, with an average of 75 percent.

SCS uses an alternative approach to LFG modeling which is to estimate recovery directly. In most cases, this approach requires an evaluation of the degree of current or proposed collection system coverage. System coverage is defined as the fraction of the total LFG-generating refuse mass under active collection. Many factors can affect system coverage, including well spacing and depth, depth of well perforations, landfill type (mound versus canyon), landfill depth, landfill permeability, as well as other design and operational issues.

2.2.1 Assumptions

SCS' computer model was used to calculate LFG recovery rates for the landfill. The assumptions and criteria used for these computations were:

- **Refuse Filling History -** From July 1989 until closure, the filling history is based on scaled waste receipts provided by the County. The filling history for prior years is based on tonnage estimates by cell location and filling dates also provided by the County.

  The moisture content and organic content of incoming refuse was assumed to be within the range typically seen by SCS for residential and commercial refuse disposed in MSW landfills. No adjustments to the model have been made based on these parameters.

- **Methane Content - 50 percent.** This is the default value assumed by the model.

- **Methane Generation Rate Constant (k)** - 0.067/yr. This is the constant that determines the rate of LFG generation. The SCS model selects a value specifically for this landfill based on the annual precipitation in the vicinity. The rate of 0.067/yr is toward the high end for "k" values and was selected by the model based on the average annual precipitation of approximately 39 inches per year.

- **Potential Methane Generation Capacity (L_0)** - 3,070 ft^3/ton. This value is a constant that represents the potential capacity of MSW to generate methane (a primary constituent of LFG) and depends on the organic and moisture content in the refuse. This value is based on the SCS model default value derived from a precipitation-based database.

- **LFG System Coverage** - 100 percent. The SCS model predicts the potential recoverable LFG (not generation) from a landfill assuming a 100 percent comprehensive LFG collection system. The proposed system to be installed with the landfill cap is considered to be 100 percent comprehensive.

- **System Coverage** - For this exercise, SCS considered the wellfield layout, the landfill design (e.g., waste depths, liner and cap construction, and sideslopes), and the wellfield operating data.

2.2.2 <u>Model Results</u>

The results of the model are presented in tabular form on Exhibit 2-1 and graphically in Exhibit 2-2.

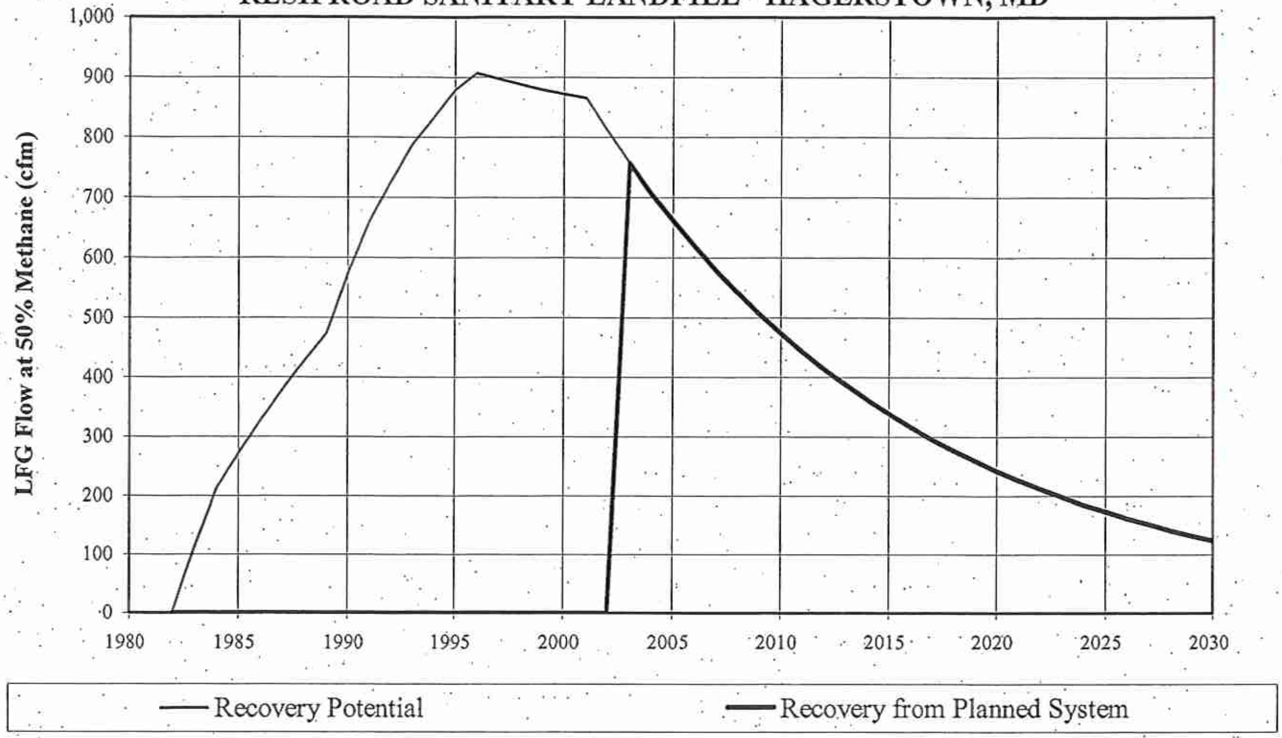
The LFG recovery rate should equal the LFG recovery potential with closure and capping of the landfill. The collection system is designed to provide 100 percent coverage of the waste disposal footprint. Site LFG recovery was expected to peak in 1996, at about 907 scfm. The model estimates that LFG recovery will be approximately 800 scfm at system startup. The model estimates the year 2003 potential LFG recovery as 757 cfm and decreasing yearly thereafter. Over the life of a 10-year LFGTE project, the sustainable LFG flow rate is approximately 387 cfm (year 2013 recovery rate).

Note that these projections have been prepared specifically for the Reichs Ford Landfill and are based on engineering judgment and represent the standard of care that would be exercised by a reasonable professional experienced in the field of landfill gas projections. SCS does not guarantee the quantity of available landfill gas, and no other warranty is expressed or implied. No other party is intended as a beneficiary of this work product, its content, or information embedded therein. Third parties use this report at their own risk. SCS assumes no responsibility for the accuracy of information obtained from, compiled, or provided by other parties.

EXHIBIT 2-1
LFG RECOVERY PROJECTION
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MARYLAND

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	LFG Recovery from Planned System (mmcf/day)	LFG Recovery from Planned System (mmBtu/yr)
1982	150,000	150,000	0	0.00	0	0%	0	0.00	0
1983	150,000	300,000	110	0.16	29,200	0%	0	0.00	0
1984	100,000	400,000	212	0.31	56,508	0%	0	0.00	0
1985	100,000	500,000	272	0.39	72,313	0%	0	0.00	0
1986	100,000	600,000	327	0.47	87,094	0%	0	0.00	0
1987	100,000	700,000	379	0.55	100,917	0%	0	0.00	0
1988	100,000	800,000	428	0.62	113,844	0%	0	0.00	0
1989	177,927	977,927	474	0.68	125,933	0%	0	0.00	0
1990	169,043	1,146,970	573	0.83	152,409	0%	0	0.00	0
1991	147,852	1,294,822	660	0.95	175,439	0%	0	0.00	0
1992	150,750	1,445,572	725	1.04	192,852	0%	0	0.00	0
1993	130,605	1,576,177	788	1.14	209,701	0%	0	0.00	0
1994	136,826	1,713,003	833	1.20	221,536	0%	0	0.00	0
1995	115,525	1,828,528	879	1.27	233,815	0%	0	0.00	0
1996	67,718	1,896,246	907	1.31	241,152	0%	0	0.00	0
1997	67,310	1,963,556	898	1.29	238,706	0%	0	0.00	0
1998	65,928	2,029,484	889	1.28	236,340	0%	0	0.00	0
1999	67,978	2,097,462	879	1.27	233,858	0%	0	0.00	0
2000	68,046	2,165,508	872	1.26	231,936	0%	0	0.00	0
2001	0	2,165,508	865	1.25	230,152	0%	0	0.00	0
2002	0	2,165,508	809	1.17	215,237	0%	0	0.00	0
2003	0	2,165,508	757	1.09	201,289	100%	757	1.09	201,289
2004	0	2,165,508	708	1.02	188,244	100%	708	1.02	188,244
2005	0	2,165,508	662	0.95	176,045	100%	662	0.95	176,045
2006	0	2,165,508	619	0.89	164,637	100%	619	0.89	164,637
2007	0	2,165,508	579	0.83	153,967	100%	579	0.83	153,967
2008	0	2,165,508	541	0.78	143,990	100%	541	0.78	143,990
2009	0	2,165,508	506	0.73	134,658	100%	506	0.73	134,658
2010	0	2,165,508	474	0.68	125,932	100%	474	0.68	125,932
2011	0	2,165,508	443	0.64	117,771	100%	443	0.64	117,771
2012	0	2,165,508	414	0.60	110,139	100%	414	0.60	110,139
2013	0	2,165,508	387	0.56	103,001	100%	387	0.56	103,001
2014	0	2,165,508	362	0.52	96,326	100%	362	0.52	96,326
2015	0	2,165,508	339	0.49	90,084	100%	339	0.49	90,084
2016	0	2,165,508	317	0.46	84,246	100%	317	0.46	84,246
2017	0	2,165,508	296	0.43	78,786	100%	296	0.43	78,786
2018	0	2,165,508	277	0.40	73,681	100%	277	0.40	73,681
2019	0	2,165,508	259	0.37	68,906	100%	259	0.37	68,906
2020	0	2,165,508	242	0.35	64,440	100%	242	0.35	64,440
2021	0	2,165,508	227	0.33	60,264	100%	227	0.33	60,264
2022	0	2,165,508	212	0.31	56,359	100%	212	0.31	56,359
2023	0	2,165,508	198	0.29	52,707	100%	198	0.29	52,707
2024	0	2,165,508	185	0.27	49,291	100%	185	0.27	49,291
2025	0	2,165,508	173	0.25	46,097	100%	173	0.25	46,097
2026	0	2,165,508	162	0.23	43,109	100%	162	0.23	43,109
2027	0	2,165,508	152	0.22	40,316	100%	152	0.22	40,316
2028	0	2,165,508	142	0.20	37,703	100%	142	0.20	37,703
2029	0	2,165,508	133	0.19	35,260	100%	133	0.19	35,260
2030	0	2,165,508	124	0.18	32,975	100%	124	0.18	32,975
2031	0	2,165,508	116	0.17	30,838	100%	116	0.17	30,838
2032	0	2,165,508	108	0.16	28,839	100%	108	0.16	28,839
2033	0	2,165,508	101	0.15	26,970	100%	101	0.15	26,970

EXHIBIT 2-2
LFG RECOVERY PROJECTION GRAPH
RESH ROAD SANITARY LANDFILL - HAGERSTOWN, MD



SECTION 3.0

LFG ENERGY MARKETS AND INCENTIVE PROGRAMS

Existing and potential uses of LFG generally fall into one of the following:

- On-Site Uses (direct use and electricity generation);
- Medium Btu use (heating and boiler fuel);
- Electricity sales to utility (using internal combustion engines or gas turbines); and
- Leachate evaporation in specialized units.

SCS investigated the direct use, greenhouse operations, electrical generation, and leachate evaporation options for the utilization of the LFG. Upgrading to pipeline quality natural gas for sale to a utility was not considered because of the high capital costs (for processing LFG to remove carbon dioxide) and for the size of the landfill, which is substantially smaller than is typically required for this utilization technology.

3.1 ON-SITE USE OF LFG

3.1.1 On-Site Direct Use

Direct use of LFG locally is often the simplest and most cost-effective approach. LFG can be used in a variety of ways, but the most common applications include:

- Heating for facilities;
- Various industrial uses requiring process heat or steam (such as in cement manufacturing, glass manufacturing, and stone drying). This option requires an industrial application to be located on site.

RRLF ceased operation on January 18, 2001. The County does not use natural gas or expect to use fuel oil on-site during the post-closure period. Given the County's lack of on-site fuel demand, on-site direct use of the LFG was not evaluated.

3.1.2 On-Site Electricity

As mentioned above, the RRLF is a closed landfill with low electricity demand. The buildings and workshops on-site will not be in use during the post-closure period. Currently, the County spends approximately $2,000 per year for electricity, the majority of which is used to operate the leachate pumps.

Therefore, it is not feasible at this time for the County to use the LFG to generate electricity on-site. Even if the County's electric bill increases tenfold, the capital and operating costs associated with the on-site generation are not warranted.

3.2 MEDIUM BTU USE OF LFG

LFG can be used to replace natural gas or fuel oil as a boiler fuel for space heating and for industrial heating/co-firing applications. Landfill organics decompose and generate LFG continuously and LFG storage is not economically practical; therefore, a continuous use of LFG normally is required. Ideally, the user should be a single customer with a large demand, preferably 24 hours/day, 7 days/week, year-round. Additionally, the user should be relatively nearby: within 2 miles is desirable, although in some cases LFG is transported further (exceeding 8 miles for large projects). The most common use is as a boiler fuel to produce steam or hot water.

Use of LFG as a boiler fuel usually requires limited modifications to conventional equipment. LFG pretreatment, however, is not necessary for boilers, although it can be cost effective to dehydrate LFG prior to piping it off the landfill. Should the County sell LFG to a user, the type of equipment may include:

- Compressors.
- Dehydration system (chillers and/or dryers and filtration).
- Controls and instrumentation.
- Gas transmission pipeline.
- Modifications to existing boilers.

LFG is produced in the landfill continuously; however, the gas processing facility on the landfill may be shut down at times due to maintenance or equipment failure. To ensure a constant supply of gas to a user, an arrangement in which the fuel supply would automatically switch back to utility supplied natural gas (or other fuel) in case of a problem is recommended.

An important consideration in retrofitting boilers is that they may be required to comply with newer more stringent air emissions standards. An advantage of LFG fired boilers is that they typically have lower NO_x emissions than natural gas boilers due to the carbon dioxide in LFG. Permit compliance may require the use of low NO_x burners and a flue gas recirculation system. LFG should be sampled for impurities to determine the need for pre-processing prior to use in the boilers or ovens.

The Los Angeles County Sanitation Districts (LACSD) has four projects using LFG as a boiler fuel and report that it has been a reliable fuel source. Over a 10-year period, LACSD has found LFG from a given landfill to be available over 99.5 percent of the time with an average of five flow interruptions annually. Two local examples are: Sandy Hill Landfill in Prince George County, MD (a new project delivering 2.6 MMcfd of LFG to fuel boilers at the NASA Goddard Space Flight Center), and Pennington Avenue Landfill in Baltimore (a project that for many years supplied LFG to a boiler at a rendering plant before being turned off when LFG supplies diminished).

3.2.1 Potential LFG End Users

SCS contacted Performance Pipe (formerly Phillips Driscopipe) because they potentially have a large demand for fuel since heat is required to produce high density polyethylene (HDPE) pipe from resin. Performance Pipe is located on Hopewell Road, approximately 5 miles southeast of the landfill, and manufactures pipe that is used in this type of application. Unfortunately Phillips only uses natural gas to heat their production area and there are no boilers on site at this location. Process heat energy is provided by electricity. Therefore, LFG usage would be minimal and does not warrant further investigation. Actual energy usage amounts were not available from the company.

In a previous study headed by the Environmental Protection Agency's Landfill Methane Outreach Program (EPA LMOP), Redland Brick and Maryland Paper were identified as potential end-users. Each of these industrial end-users is located approximately 5 miles from RRLF. The study, which combined the LFG production of RRLF with the new adjacent landfill, was based on a gas production rate of 185,400 MM Btu/year over a 15-year period.

The EPA LMOP study found that Redland Brick operated 24 hours per day, 365 days a year and used natural gas fired brick kilns. At the time, it was determined that LFG could supply 85% of Redland Brick's fuel needs and provide the company with energy cost savings of approximately 30-35%. The study also found that Maryland Paper used natural gas fired boilers and operated 350 days per year. At the time of the study, LFG could supply 15% of fuel needs at an estimated energy cost savings of 5-10% for Maryland Paper. These results were presented to the end-users and the County in October of 2000; however, no further action has been taken.

Since that time, natural gas prices have been volatile, hitting a record high of approximately $10/MM Btu in January 2001. Natural gas prices in the US are typically quoted relative to the current market price at the Henry Hub, a well-known trading point for gas located at the convergence of several major pipelines in Henry, Louisiana. Index gas prices are quoted as so many percentage points above or below the Henry Hub. The Henry Hub index price for December 2002 and January 2003 has been over $5/MM Btu. The cost to the end user is more than this amount due to the costs of transmission, distribution, and marketing. Thus, there may be some greater interest now than when the LMOP study was conducted.

3.2.2 Greenhouse Project

SCS investigated the potential use of LFG to heat a greenhouse that could be constructed on the landfill facility property. This section of the report discusses the considerations made in order to estimate the greenhouse energy needs, and to compare those needs with the available LFG estimated previously.

3.2.2.1 Greenhouse Energy Requirements

Greenhouse energy needs can depend on a number of factors as follows:

- **Crop type** dictates the temperature that must be maintained for optimum growth conditions. For example, carnations can tolerate temperatures in the low 50s, while roses require warmer temperatures.

- **Geographic location** can greatly influence the amount of heat required to maintain an acceptable temperature in the greenhouse. It has been reported that at colder, northern latitudes, it takes from 100,000 to 200,000 Btu per square foot (ft^2) of floor area per year to heat a greenhouse during the growing season. A University of California report (*Reducing Energy Costs in California Greenhouses*, Leaflet 21411) states that greenhouses use an average of 115,000 Btu/ft^2 of floor area per year.

- **Building materials** used to construct the greenhouse, from glazing materials to ventilation systems, impact energy demand. Glass, rigid plastic, or plastic film used for walls and ceilings each has different thermal efficiencies which result in different amounts of heat loss.

Electricity is commonly used to power fans, lighting systems and other equipment, while fuels such as oil, natural gas and propane are typically burned to heat the facility. According to the Yahoo Weather website (http://weather.yahoo.com/), the average low temperature in January (the coldest month of the year) is 20 deg. F in Hagerstown, MD. Because these winter temperatures are moderate compared to other regions of the U.S., a greenhouse in the west central portion of Maryland can be expected to have heating needs that fall in the middle to upper end of the previously stated range of 100,000 to 200,000 Btu/ft^2 per year. For the purposes of this feasibility assessment, SCS estimated that the proposed greenhouse would require 175,000 Btu/ft^2 per year to operate through the winter.

3.2.2.2 Preliminary Greenhouse Sizing

The LFG generation and collection quantities predicted by the modeling show that the expected sustained LFG collection rate for the 15-year life of a project is approximately 300 cfm. Based on a heating value of 500 Btu/ft^3 for LFG, the maximum greenhouse area the landfill can support is calculated as follows:

$$(300\ ft^3)(500\ Btu/ft^3)(ft^2\text{-}yr/100{,}000\ Btu)(60\ min/hr)(8{,}760\ hr/yr)$$

$$= 788{,}400\ ft^2 \text{ of floor area} = 18 \text{ acres}$$

Although the calculation shows that the maximum sustainable size of a greenhouse could be 18 acres, a 10-acre greenhouse would utilize approximately 167 cfm of LFG (approximately 56 percent of the collectible LFG). This analysis is presented in Section 4. Further detailed investigation of this option is beyond the scope of work

3.3 ELECTRICITY SALES

Currently, the most prevalent use of LFG is for electricity generation using an internal combustion (IC) engine or gas turbine. Electricity can be used at the landfill or sold to the local electric utility. If electricity is not required at the landfill, it can be distributed through the local power grid. This approach requires close cooperation with the electric power utility. While there are several available technologies for generating electricity, IC engines and gas turbines are the most commonly used energy conversion devices for LFG-to-energy projects. For smaller projects (landfills with less than 1 millions tons of waste and/or gas flow rates lower than 300 cfm), the best electricity generation option might be provided by a microturbines, an emerging technology that caters to electricity capacities between 30 to 200 kW.

The anticipated landfill gas flow rate influences the selection of an appropriate device to generate electricity. Gas turbines typically require higher gas flows than IC engines to make them economically attractive. Therefore, gas turbines are better suited for large landfills. Additionally, gas turbine performance characteristics favor constant full-load operation; as a consequence, turbines are not effective for supplying power for variable electricity loads. Turbines are commonly used to generate electricity that will be distributed through the electric power grid on a continuous basis. IC engines can more easily be turned on and off, and are therefore suitable for supplying intermittent on-site power needs as well as distribution through the grid.

Based on the estimated size of this project, electricity generation may be a suitable energy recovery option at the RRLF. Microturbine technology and IC engines are the two options considered in more detail for electricity generation and sale to the local electric utility.

3.3.1 Microturbines

Microturbines are a recent emerging technology to use LFG to generate electricity. The microturbine is a high-speed turbo-charged generator that produces stationary power. It has been used in aviation for some time but is now being demonstrated on several landfill sites. These units are compact power sources, no larger than industrial air conditioners. They are typically available in sizes ranging between 25 kW to 75 kW and can be chained together to produce up to 1 MW. NOx emissions have been demonstrated to be as low as 1.4 ppm.

Microturbines are more suited to smaller landfills; they are not the most economical technology for large landfills. Since 300 cfm of LFG could be generated from the RRLF for the next 15 years, sufficient LFG could be collected and utilized to generate 667 kW, based on a conversion factor of 450 cfm of LFG (at 50 percent methane) per 1,000 kW gross output. It was assumed that 9-75 kW microturbines would be needed for this application.

3.3.2 Internal Combustion Engines

Internal combustion engines are the most commonly used conversion technology in LFG applications. They are stationary engines, similar to conventional automobile engines that can use medium-Btu gas to generate electricity. One advantage of utilizing IC engines to generate electricity is that they can be purchased in varying capacities ranging from 30 to 2,000 kW. IC engines associated with landfills typically have capacities of 400 to 1,000 kW. Typically an IC engine that produces 1 MW of power will require from 300 to 400 cubic feet per minute of LFG.

The potential LFG generation for the next 15 years is approximately 300 cfm, as previously discussed. Sufficient LFG could be collected and utilized to generate 750 kW, based on a conversion factor of 400 cfm of LFG (at 50 percent methane) per 1,000 kW gross output. For the purpose of this preliminary study, it was assumed that a single engine would be installed. Based on the LFG model, it is unlikely that additional engines would need to be installed.

It is advisable to consider the option of generating electricity using the LFG, even though the capacity of this project is at the lower end of kW generation. The ultimate feasibility of this LFG utilization option depends on the electricity purchase rate paid by the local electric utility.

3.3.3 Allegheny Power

Allegheny Energy, Inc. is the electric utility company serving the landfill. It is composed of three electric utility subsidiaries that provide electric service to more than 1.4 million people in a 31,000 square mile area within Maryland, Ohio, Pennsylvania, Virginia, and West Virginia. Allegheny Power participates in the PJM (Pennsylvania, New Jersey, Maryland) power supply system. The sale of electricity could be based on a percentage of the hourly LMP (locational market price), an index that reflects the value of energy at a specific location and time. This index presently is about $28-$29/MWh ($0.028-$0.029/kWh), as an annualized value. The generation and sale of electricity would be feasible for the County at the minimum rate of $0.03 per kW.

3.4 LEACHATE EVAPORATION

Leachate management can be a troublesome and costly factor in landfill operations. While most landfills utilize off-site leachate treatment and disposal options, some have opted for on-site treatment. Landfill gas fueled leachate evaporation can integrate the utilization of landfill gas with leachate treatment. Leachate evaporation offers the potential of zero discharge if the conditions allow leachate evaporation effluent to be returned to the landfill.

The leachate evaporation process utilizes energy released from LFG combustion to heat and vaporize leachate in specialized evaporation units. One such method involves landfill gas being drawn from a collection system. Leachate is drawn from a storage tank or pond into an evaporator. Landfill gas, introduced together with air, is combusted in the leachate evaporation vessel, evaporating excess moisture and reducing the original volume of the leachate by as much as 97 percent. Vapor from the evaporator can be thermally treated in an enclosed gas flare, while the remaining leachate concentrate (effluent) is treated by conventional treatment methods, either on or off site. Typical costs for leachate evaporation range between $0.05 and $0.10 per gallon (development, capital, and O&M).

Leachate evaporation projects using LFG are generally practical when leachate treatment costs are high enough to mitigate the cost of project development. At RRLF, an average of 3,600,000 gallons per year of leachate are collected and treated at the County's wastewater treatment plant at a cost of approximately $0.055 per gallon ($198,000 annually). Leachate evaporation projects are generally feasible when the average leachate treatment cost for the landfill is above $0.05 per gallon. Since the County's cost is about the same, this option was not studied further. However, should the cost for treating the leachate increase, this option should be reevaluated.

3.5 VEHICLE FUEL

Vehicle fueling with compressed methane extracted from LFG is of interest for both environmental (low emissions) and economic reasons. Driven by the high air pollution levels in Southern California, production of vehicle fuel has been demonstrated at the Puente Hills Landfill near Los Angeles, where several landfill vehicles are fueled with processed LFG.

Processing LFG for vehicle use involves several purification and compression processes. At Puente Hills, dedicated wells of high methane quality and low oxygen (less than 1 percent) were connected to a separate collection system. The Puente Hills Landfill facility uses a process with the following elements:

- Three stages of gas compression to 525 psi.
- Removal of trace organics using carbon guard beds.
- Heating the gas to prevent condensation.
- Running the gas through cellulose acetate membranes to remove CO_2.
- Two additional stages of compression to 3,600 psi.
- Storage tanks and dispenser for vehicles.

The Puente Hills Landfill fueling facility processes 250 cfm of LFG at an estimated capital cost of $900,000. Roughly 1,500-gallon equivalents of gasoline can be produced from 250 cfm of LFG at 50 percent methane in a 24-hour day, which would supply 75 vehicles with 20 gallons a day. At maximum usage (75 trucks per day), the Puente Hills facility could recover its capital investment in 15 years by selling fuel for roughly 40-percent of the equivalent gasoline price. Some refuse collectors in Southern California are now operating Compressed Natural Gas (CNG) vehicles and are thus able to purchase fuel from the landfill. SCS is not aware of any such refuse vehicles in Washington County, therefore vehicle usage may be limited to the County fleet.

The fuel from Puente Hills has been used in cars (1988 Ford Taurus V-6) and heavy-duty vehicles (landfill water truck). Converting a car to CNG operation is a relatively simple process since no internal modifications are necessary to the engine. Conversion of a gasoline vehicle to a bi-fuel vehicle (i.e. runs on either gasoline or LFG vehicle fuel, but not simultaneously) can cost roughly $2,600 for a pick-up truck. Conversion of a Class 8 garbage truck to dual fuel capability (i.e. runs on a mixture of diesel and LFG vehicle fuel) costs an estimated $15,000-$18,000.

Since the County presently does not have a dedicated natural gas fleet or one planned, this option was not further considered.

3.6 INCENTIVE PROGRAMS

LFG utilization carries with it some important benefits to the environment. It is a renewable energy source (thereby conserving fossil fuel) and reduces landfill emissions. In light of these benefits, various government agencies have established incentive programs to encourage the use of LFG as an alternative. Several incentive programs relevant to the Washington County project are summarized below.

3.6.1 Federal Tax Credits

The Section 29 tax credits were included in the Energy Policy Act of 1992 and have been available to qualifying LFG recovery projects. They frequently are necessary to make LFG recovery economically feasible. The current tax credit value is roughly $1 per million Btus (MM Btu). To qualify for the Section 29 tax credits, the project must:

- Produce the gas from biomass, or liquid, gaseous or solid synthetic fuels produced from coal (or lignite).
- Sell the gas to an unrelated party.
- Have the LFG collection system placed in service by June 30, 1998.

Tax credits can be applied through the year 2007 for facilities placed in service after 1992. Unfortunately, Section 29 credits in their current form are not available for the County's project because the system will not satisfy the in-service date.

In 2002, the LFG industry tried to extend Section 29 tax credits and expand Section 45 tax credits via the Energy Bill. No energy bill was passed during the last Congress, so efforts are being renewed this year. As of January 2003, a bill is being crafted to amend the Internal Revenue Code of 1986 to benefit LFG projects. Given the current fiscal climate, however, the impact of the newly proposed tax credit provisions will be relatively modest. A summary of the proposed tax credit provisions is presented below based on the current Senate bill sponsored by Senator Lincoln:

Section 45 Provision –

The existing Section 45 tax credit provides a tax credit of $0.015/kWh for energy generated and sold from a qualifying facility. Eligible fuels currently are wind energy, closed loop biomass, and poultry waste. This bill would add LFG as a qualifying fuel. A full credit value would be provided for projects placed in service before January 2008 with a 5-year pay out period.

For existing operational electricity projects eligible for this credit prior to enactment of the bill, the credit is reduced by 1/3. Anti-double dip language states that if your "facility" has ever received a Section 29 tax credit, it is not eligible for the Section 45 credit.

Section 29 Provision --

The bill proposes a 5-year pay out period for projects placed in service after June '98 and before January '08. A 200,000 cubic feet per day (cfd) volume cap (as natural gas) is placed on gas actually eligible for the credit. This cap translates to 400,000 cfd or 278 cfm for LFG. The value of the credit is $3 per barrel of oil equivalent (i.e., 5.8 MM Btu), which is approximately $0.52/MM Btu – significantly less than the current credit enjoyed by eligible projects. A 1/3 reduction of the proposed credit will be applied to NSPS sites ($2 instead of $3).

For purposes of this evaluation of the economics of LFG utilization, no tax credits are assumed. However, if either of the tax credit provisions passes in this Congress, it may stimulate more developer interest in a project at Resh Road.

3.6.2 Renewable Energy Production Incentive (REPI)

Renewable Energy Production Incentive (REPI) is a program offering a $0.015/kWh payment to owners/operators who produce electricity from solar, wind, biomass, or geothermal sources at qualifying projects. The power plant must be owned and operated by a municipal or non-profit organization to be eligible for payments. The program will be in effect over a 10-year period and is subject to appropriations by Congress and Department of Energy (DOE). To qualify, a project must:

- Generate electricity from solar, wind, biomass, or geothermal sources (burning municipal solid waste for energy is not included).
- Be a public entity or non-profit electric cooperative.
- Use the facility for the first time in 1993 or later (excludes existing facilities).
- Petition DOE for payments.

According to rules published in 1994, DOE should pay the cash subsidies on an annual basis. At the end of each year, the federal government will publish a notice in the Federal Register requesting petitions for payment from eligible entities. Payments would be made in the spring of the following year. If the available funding for a particular year is not enough to cover all eligible projects, then LFG power plants would be a lower priority than power plants using sunlight, geothermal energy, wind, and various other forms of biomass. In this case, the LFG power plant may not receive payments since the funding would be shared among the higher priority energy producers. Therefore, annual payments are not guaranteed.

The program has been oversubscribed for the past two years. Funding has been prorated to LFG projects again this year. If an electrical generation project is pursued, it may be prudent to structure the project to potentially take advantage of this program. Any payments under this program should be treated as an unexpected windfall and not be relied on in the project economics.

3.6.3 Maryland Clean Energy Incentive Act – Senate Bill 670

On May 11, 2000, Governor Glendenning signed the Maryland Clean Energy Incentive Act. This Act, effective July 1, 2000, provides State income tax credits for electricity produced from qualifying energy resources. The tax credit value is $0.0085/kWh for all electricity sold to an unrelated party. The project must be located in Maryland and have originally been placed in service on or after January 1, 2001 but before January 1, 2005. An eligible project can receive the tax credits for a 10-year period. The credit is not indexed for inflation.

Qualified energy resources include:

- Wind energy and closed loop biomass as defined in Section 45 of the IRS code.
- Solid, nonhazardous, cellulosic waste material that is segregated from other waste material and is derived from
  - Any of the following forest-related resources, not including old-growth timber: mill residues, pre-commercial thinnings, slash, or brush.
  - Waste pallets, crates, and dunnage and landscaping or right-of-way trimmings, not including unsegregated MSW and post-consumer waste paper, or
  - Agricultural sources, including orchard tree crops, vineyard, grain, legumes, sugar, and other crop by-products or residues.
- Includes methane gas resulting from the anaerobic decomposition of organic materials in a landfill or wastewater treatment plant.

This credit would help LFG electrical generation projects. For the Washington County project, a project developer likely would need a partner with a large enough Maryland tax burden to take advantage of this credit.

3.6.4 GHG Credits

The Kyoto Protocol of 1997 encourages greenhouse gas (GHG) emissions trading as one of the main avenues to control the global climate change problem. Current efforts are underway to establish the guidelines for such an emissions trading program, though several trades have already taken place in the global marketplace in the absence of such guidelines.

The market for emission reduction credits or verifiable emission reductions (VER) is beginning to take shape and continues to evolve. In January 2003, the formation of the Chicago Climate Change was announced. This exchange will serve as a mechanism for US companies to engage in a voluntary but legally binding GHG trading program. New LFG projects are a good source of GHG VERs as long as the facility is not subject to NSPS (which Resh Road is not).

At this point, SCS is optimistic that sites like Resh Road could realize some monetary benefit to selling VERs from a LFG collection and flaring project. However, because of the uncertainty in marketing GHG credits, we have not included such revenues in this evaluation. The County may want to assign the rights to these credits as part of the LFG utilization project or keep them and market them separately if a project is not developed.

SECTION 4.0

OPTIONS ANALYSIS

Based on our review of the identified options presented in Section 3, SCS has prepared a cost analysis for the energy utilization options with the greatest potential for success.

4.1 DIRECT USE

SCS performed a preliminary cost analysis of direct use to determine the radius in which to search for potential end users. After several trials, it was determined that even at a zero mile radius the sale of LFG to an end user was not feasible.

The following assumptions have been used in the cost analysis:

- Energy sales to User 1 ranging from 161,000 to 63,000 MMBtu/year based on 80% usage rate of the available LFG supply from the landfill.
- Capital costs as presented on Exhibit 4-1 A and B. The capital costs used in the analysis could be considered modest. SCS is familiar with projects that have experienced unit costs both higher and lower than those used in this analysis. For example, pipeline construction costs are based on $200,000 per mile; various factors such as right-of-way requirements and trenching in rock could increase the actual costs. The capital cost estimate allocates $75,000 for modifications at User 1's facility. User 1 could be made financially responsible for improvements made within their facilities to justify the discounted energy costs.
- Operation and maintenance costs of $139,000/year. These costs have also been kept minimal.
- Energy sales price of $3.50/ MMBtu. Recent natural gas energy prices have been in the $5/MMBtu range. We have more conservatively based our analysis on historical prices. The project would likely need to offer significant energy savings (up to 25 percent) to User 1 to secure a long-term fuel supply contract. Total annual savings of $50,000 - $100,000 are usually sufficient to interest an end user to switch fuels and provide a short payback (less than two years) on capital improvements. Pricing could be tied to a natural gas index or could be based on fixed rates indexed to inflation.
- Both public and private financing options are shown. For privately developed project, a $10,000 annual payment to the County was assumed. This is a nominal amount, but probably realistic given the marginal return available from a project at Resh Road.

Model results are presented in Exhibit 4-2A through D for both County and LFG developer ownership assuming pipeline distances of 1 and 5 miles. On paper, it appears that a direct use project to a customer within 1 mile would have a positive cash flow throughout the life of the project and a net present value of approximately 1.2 million dollars.

4.2 ELECTRICAL GENERATION

The major cost elements of a LFG electrical generation facility typically include:

- Blower/compressor and moisture removal equipment.
- Engines, generators, and radiators.
- Electrical (switchgear, motor control centers, transformers, etc.).
- Building and site improvements.
- Utility interconnect.
- Engineering, permitting, legal, etc.

4.2.1 IC Engine Electrical Power Generation Facility

A 750 kW electrical power generation facility typically includes the following elements:

- Installation of one engine generator, rated at 800 - 1,000 kW net output. The skid-mounted package consists of the engine, generator, and support systems.

- Engine control room which would house the engine generator control panels, switchgear, breakers, motor control center, controls, and monitoring systems.

- Total site area required - less than 1/2 acre

The capital cost of a 750 kW facility is typically estimated at $1,000/kW or $750,000 for an economical facility. Power plant operations and maintenance (O&M) costs range from $0.012 to $0.015/kWh.

For the economic analysis, SCS has assumed the following:

- 750 kW electrical generation facility.
- Facility would be on-line in 2004.
- All power would be sold to Allegheny Power. Initial rate of $0.03/kWh was assumed with a 2% annual escalation.
- Plant capital cost of $900,000.
- Power plant operations and maintenance (O&M) costs at $0.014/kWh.
- Two ownership options are presented:
  - Exhibit 4-3A - County Ownership - the project is financed using municipal bonds at 6 percent for 15 years.

- Exhibit 4-3B - Private Section Ownership - the project is financed at 10 percent for 15 years. The County would receive annual payments estimated at $10,000/year. The developer would be eligible for the Maryland Energy Tax Credit of $0.085/kWh.

4.2.2 Microturbine Electrical Power Generation Facility

A 667 kW electrical power generation facility typically includes the following elements:

- A compressor/refrigeration skid to deliver up to 300 scfm of landfill gas to the microturbines;
- Nine 75 kW microturbines;
- Switchgear and electric interconnections to support parallel operation;
- Foundations, piping and wiring to provide a complete outdoor installation;
- A PLC-based control system which will support remote monitoring and control of the power plant.

The capital cost of a 667 kW facility is typically estimated at $2,000/kW or $1,334,000 for an economical facility. Power plant operations and maintenance (O&M) costs are approximately $0.02/kWh.

For the economic analysis, SCS has assumed the following:

- 667 kW electrical generation facility.
- Facility would be on-line in 2003.
- All power would be sold to Allegheny Power. Initial rate of $0.03/kWh was assumed with a 2% annual escalation.
- Plant capital cost of $1,334,000.
- Plant O&M costs at $0.02/kWh.
- Two ownership options are presented:
  - Exhibit 4-2A - County Ownership - the project is financed using municipal bonds at 6 percent for 15 years.
  - Exhibit 4-2B - Private Section Ownership - the project is financed at 10 percent for 15 years. The County would receive annual payments estimated at $10,000/year. The developer would be eligible for the Maryland Energy Tax Credit of $0.085/kWh.

4.2.3 Electrical Generation Comparison

As shown below, the economic benefits of the two best options are as follows:

	Option 1 Electrical Generation using IC Engine Allegheny Power	**Option 2 Electrical Generation using Microturbine Allegheny Power**
LFG Utilization Rate		
2004	35%	40%
2012	60%	68%
Capital Cost	$900,000	$1,334,000
County Owned		
Annual Revenues	$169,000	$138,000
Operating Cost	$153,000	$ 174,000
Net Cash Flow - 2004	$ 16,000	($ 36,000)
Net Cash Flow - 2012	$ 24,000	($ 30,000)
Net Present Value - NPV	$ 28,000	($539,000)
Privately Owned		
Annual Revenues	$216,000	$177,000
Operating Cost	$183,000	$215,000
Net Cash Flow - 2004	$ 34,000	($ 37,000)
Net Cash Flow - 2012	$ 41,000	($ 31,000)
Net Present Value - NPV	$ 37,000	($523,000)

As shown above, the electrical generation and sale to Allegheny Power using an IC Engine is a better option than microturbines when developed either by the County or a private developer. These results are based upon the assumptions stated above including the sale price of the electricity. As indicated by the results, the County or private developer would need to receive a better purchase rate than a $0.03/kWh to make a power generation project attractive.

4.3 GREENHOUSE ECONOMIC ANALYSIS

As discussed in Section 3, an economic analysis of greenhouse usage is presented below. The following analysis is based on a 10-acre greenhouse and assumes that the least expensive construction approaches are utilized. Unit costs for construction are shown below:

Item	**Cost ($/ft^2)**
Rigid Frame Wood Greenhouse	2.00
Site Prep/Driveway/Concrete Floor	3.60
Environmental Control (HVAC)	5.45
TOTAL (rounded)	11.05

The costs shown above were taken from Greenhouse Engineering, Aldrich, R.A. and Bartok, J.W., Northeast Regional Agricultural Service; Cornell University, Ithaca, NY, published in August 1996.

The approximate total cost of greenhouse construction is calculated by multiplying the total square footage of floor area by the cost per square foot as shown below.

(10 acre)(43,560 ft^2/acre)($11.05/ft^2) = $4,813,380

4.3.1 Heating System Cost Comparison

Typically, the economics of an LFG utilization project are compared with the scenario of operating the same project, powered with a readily available fuel such as natural gas. Therefore, the following discussion compares the economics of burning LFG versus natural gas and propane to heat the greenhouse.

It is estimated that propane can be delivered to the site for approximately $1.00 per gallon, which corresponds to approximately $11.00 per million Btu (MMBtu). The price of $1.00 per gallon is an average price for commercial/industrial users in the Maryland area over the last winter season. This information was provided by the U.S. Dept. of Energy, Energy Information Administration. Natural gas can be delivered to the site for approximately $6.00 per 1,000 cubic feet (or /MMBtu) which is slightly less than the average price for commercial consumers in 1998 in Maryland. This information was also provided by the Energy Information Administration. In order for the project to be feasible from an energy purchasing standpoint, the cost to supply the greenhouse with LFG must be less than $5.40/MMBtu (a 10 percent savings compared to natural gas).

The cost per year to recover the LFG is typically equal to the amortized annual capital cost of the LFG collection system plus the annual operating costs. The fact that the Resh Road Landfill will have an operating, comprehensive LFG collection system in place results in significantly reduced capital costs for a direct use project such as a greenhouse. The annual costs for a greenhouse project basically are reduced to the O&M costs for the Resh Road LFG collection system and the amortized annual capital cost of the system modifications to convey LFG to the greenhouse.

The annual O&M costs for the Reichs Ford LFG collection system are estimated to be approximately $90,000 per year. This is based on SCS experience and the EPA LMOP E-Plus model.

The cost per million Btu to supply LFG to the greenhouse can be calculated as follows:

[LFG Flow Rate (cfm)][Heating Value of LFG (Btu/ft^3)][minutes/year][MMBtu/10^6 Btu]

(167 cfm of LFG)(500 Btu/ft^3)(525,600 min/yr)(MMBtu/10^6 Btu) = 43,888 MMBtu/year

$90,000/year ÷ 43,888 MMBtu/year = $2.05 / MMBtu

4.3.2 Greenhouse Summary

This preliminary analysis suggests that the cost to supply the greenhouse with LFG ($2.05/MMBtu) is significantly less than the cost of natural gas ($6.00/MMBtu) or propane ($11.00/MMBtu). Utilization of LFG for a greenhouse at the site results in annual fuel savings of 66 percent ($173,328) compared to natural gas and 81 percent ($392,798) compared to propane. Note that the above comparison did not consider the costs to purchase and install propane storage tanks. Also, the O&M costs assumed the entire LFG collection system would operate and the excess LFG (LFG not utilized by the greenhouse) would be flared.

The economic feasibility of greenhouse operations at the site, however, depends more on product markets and demand than fuel costs. Thus, if greenhouse operations are being considered by the County or private business, the landfill would be a good location for the same. This information would be appropriated to share with potentially interested parties.

EXHIBIT 4-1A. DIRECT GAS SALES VIA 1-MILE PIPELINE

CAPITAL COST ESTIMATE				
DESCRIPTION	**UNITS**	**UNIT COST**	**QUANTITY**	**COST**
LFG PROCESSING EQUIPMENT				
Precooler	LS	$30,000	1	$30,000
Compressor package	LS	$125,000	1	$125,000
Chilled Glycol Package	LS	$21,000	1	$21,000
Exchanger/Desiccant Skid	LS	$45,000	1	$45,000
Air Compressor/Dryer	LS	$16,000	1	$16,000
Electric Motor Control Center	LS	$25,000	1	$25,000
Instrumentation	LS	$50,000	1	$50,000
Installation/etc.	LS	$75,000	1	$75,000
			Subtotal	$387,000
PIPELINES				
Pipeline to 1st User	MILE	$200,000	1.00	$200,000
Pipeline to 2nd User (additional distance)	MILE	$200,000	0.00	$0
ROW Easements - not included				$0
			Subtotal	$200,000
END USER FACILITY				
End User 1	LS	$75,000	1	$75,000
End User 2	LS	$75,000	0	$0
			Subtotal	$75,000
Subtotal				$662,000
ENGINEERING				
Engineering, Surveying, Legal, Permitting		10%		$66,200
Subtotal				$728,200
Contingency		15%		$109,230
TOTAL ESTIMATE				$837,430
End User 1 Cost	100%			$837,430
End User 2 Cost	0%			$0
ANNUAL O&M COST ESTIMATE				
DESCRIPTION	**UNITS**	**UNIT COST**	**QUANTITY**	**COST**
Operator/Maintenance Man	Year	$40,000	1	$40,000
Supervisor	Day	$400	12	$4,800
Contract Electrician Crew	Day	$700	12	$8,400
Contract Maintenance Crew	Day	$700	12	$8,400
Lubricants/Process Fluids	LS			$5,000
Machinery Parts & Tools/Safety	LS			$15,000
Office Support/Office Supplies	LS			$10,000
Subtotal				$91,600
Insurance/Bonding/etc.	LS	10%		$9,160
Subtotal				$100,760
Contingency		10%		$10,076
Total Labor and Supplies				$110,836
Electrical Consumption	kWh	$0.06	50	$26,280
based on $0.06/kWh*50kW demand*8760 hours/yr				
Total Annual O&M Costs				$137,116

EXHIBIT 4-1B. DIRECT GAS SALES VIA 5-MILE PIPELINE

CAPITAL COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
LFG PROCESSING EQUIPMENT				
Precooler	LS	$30,000	1	$30,000
Compressor package	LS	$125,000	1	$125,000
Chilled Glycol Package	LS	$21,000	1	$21,000
Exchanger/Desiccant Skid	LS	$45,000	1	$45,000
Air Compressor/Dryer	LS	$16,000	1	$16,000
Electric Motor Control Center	LS	$25,000	1	$25,000
Instrumentation	LS	$50,000	1	$50,000
Installation/etc.	LS	$75,000	1	$75,000
			Subtotal	$387,000
PIPELINES				
Pipeline to 1st User	MILE	$200,000	5.00	$1,000,000
Pipeline to 2nd User (additional distance)	MILE	$200,000	0.00	$0
ROW Easements - not included				$0
			Subtotal	$1,000,000
END USER FACILITY				
End User 1	LS	$75,000	1	$75,000
End User 2	LS	$75,000	0	$0
			Subtotal	$75,000
Subtotal				$1,462,000
ENGINEERING				
Engineering, Surveying, Legal, Permitting		10%		$146,200
Subtotal				$1,608,200
Contingency		15%		$241,230
TOTAL ESTIMATE				$1,849,430
End User 1 Cost	100%			$1,849,430
End User 2 Cost	0%			$0

ANNUAL O&M COST ESTIMATE				
DESCRIPTION	UNITS	UNIT COST	QUANTITY	COST
Operator/Maintenance Man	Year	$40,000	1	$40,000
Supervisor	Day	$400	12	$4,800
Contract Electrician Crew	Day	$700	12	$8,400
Contract Maintenance Crew	Day	$700	12	$8,400
Lubricants/Process Fluids	LS			$5,000
Machinery Parts & Tools/Safety	LS			$15,000
Office Support/Office Supplies	LS			$10,000
Subtotal				$91,600
Insurance/Bonding/etc.	LS	10%		$9,160
Subtotal				$100,760
Contingency		10%		$10,076
Total Labor and Supplies				$110,836
Electrical Consumption	kWh	$0.06	50	$26,280
based on $0.06/kWh*50kW demand*8760 hours/yr				
Total Annual O&M Costs				$137,116

EXHIBIT 4-2A. DIRECT GAS SALES VIA 1-MILE PIPELINE - COUNTY DEVELPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224	$86,224
TOTAL ANNUAL OPERATING COST	$225,224	$229,394	$233,689	$238,113	$242,670	$247,363	$252,197	$257,177	$262,305	$267,588	$273,028	$278,633	$284,405	$290,350	$296,474
NET CASH FLOW	$338,385	$308,231	$279,151	$251,086	$223,975	$197,771	$172,414	$147,861	$124,060	$100,966	$78,533	$56,721	$35,490	$14,797	($5,396)
NPV - Net Present Value	$1,761,344														
Debt Coverage	4.92	4.57	4.24	3.91	3.60	3.29	3.00	2.71	2.44	2.17	1.91	1.66	1.41	1.17	0.94

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$837,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Capital Cost	$0
Total Capital Cost (User 1 and 2)	$837,430		
Equity Percentage	0%	O&M LFG Collection System	$0
Equity Contribution	$0	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	6.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1030	Landfill Owner Payment	$0
		Payment Escalation (%)	0%

EXHIBIT 4-2B. DIRECT GAS SALES VIA 1-MILE PIPELINE - PRIVATE SECTOR DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner/1st Yr Equity	$177,486	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Annual Debt Service	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080	$88,080
TOTAL ANNUAL OPERATING COST	$404,566	$241,550	$246,154	$250,896	$255,781	$260,812	$265,994	$271,331	$276,829	$282,491	$288,324	$294,331	$300,518	$306,892	$313,456
NET CASH FLOW	$159,043	$296,075	$266,686	$238,303	$210,864	$184,323	$158,617	$133,706	$109,536	$86,062	$63,238	$41,023	$19,377	($1,744)	($22,378)
NPV - Net Present Value	$1,245,817														
Debt Coverage	2.81	4.36	4.03	3.71	3.39	3.09	2.80	2.52	2.24	1.98	1.72	1.47	1.22	0.98	0.75

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of Supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$837,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Additional Capital Cost	$0
Total Capital Cost (User 1 and 2)	$837,430		
Equity Percentage	20%	O&M LFG Collection System	$0
Equity Contribution	$167,486	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	10.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1315	Landfill Owner Payment	$100,000
		Payment Escalation (%)	3%

EXHIBIT 4-2C. DIRECT GAS SALES VIA 5-MILE PIPELINE - COUNTY DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Debt Service	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422	$190,422
TOTAL ANNUAL OPERATING COST	$329,422	$333,592	$337,888	$342,311	$346,868	$351,562	$356,396	$361,375	$366,503	$371,786	$377,227	$382,831	$388,603	$394,549	$400,672
NET CASH FLOW	$234,187	$204,032	$174,953	$146,888	$119,777	$93,573	$68,215	$43,663	$19,862	($3,232)	($25,665)	($47,477)	($68,708)	($89,401)	($109,594)
NPV - Net Present Value	$749,344														
Debt Coverage	2.23	2.07	1.92	1.77	1.63	1.49	1.36	1.23	1.10	0.98	0.87	0.75	0.64	0.53	0.42

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$1,849,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Capital Cost	$0
Total Capital Cost (User 1 and 2)	$1,849,430		
Equity Percentage	0%	O&M LFG Collection System	$0
Equity Contribution	$0	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	6.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1030	Landfill Owner Payment	$0
		Payment Escalation (%)	0%

EXHIBIT 4-2D. DIRECT GAS SALES VIA 5-MILE PIPELINE - PRIVATE SECTOR DEVELOPMENT

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
QUANTITIES															
Annual LFG Production (MMBtus)	201,289	188,244	176,045	164,637	153,967	143,990	134,658	125,932	117,771	110,139	103,001	96,326	90,084	84,246	78,786
Annual Energy Demand User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Energy Delivered to User 1	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Annual Energy Demand User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Delivered to User 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Energy Delivered (MMBtus)	161,031	150,595	140,836	131,710	123,174	115,192	107,726	100,746	94,217	88,111	82,401	77,061	72,067	67,397	63,029
Excess LFG to Flare (MMBtus)	40,258	37,649	35,209	32,927	30,793	28,798	26,932	25,186	23,554	22,028	20,600	19,265	18,017	16,849	15,757
Pecent of LFG Production Utilized	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
REVENUES															
User 1 Gas Sales Rate ($/MMBtu)	$3.50	$3.57	$3.64	$3.71	$3.79	$3.86	$3.94	$4.02	$4.10	$4.18	$4.27	$4.35	$4.44	$4.53	$4.62
User 1 Energy Payment	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
User 2 Gas Sales Rate ($/MMBtu)	$3.00	$3.06	$3.12	$3.18	$3.25	$3.31	$3.38	$3.45	$3.51	$3.59	$3.66	$3.73	$3.80	$3.88	$3.96
User 2 Energy Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$563,609	$537,625	$512,840	$489,199	$466,645	$445,134	$424,611	$405,038	$386,365	$368,554	$351,561	$335,354	$319,895	$305,147	$291,078
OPERATING EXPENSES															
O&M Cost - LFG Collection System	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
O&M Cost - Utilization System	$139,000	$143,170	$147,465	$151,889	$156,446	$161,139	$165,973	$170,952	$176,081	$181,363	$186,804	$192,409	$198,181	$204,126	$210,250
Payment to Landfill Owner/1st Yr Equity	$379,886	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Annual Debt Service	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521	$194,521
TOTAL ANNUAL OPERATING COST	$713,407	$347,991	$352,595	$357,338	$362,222	$367,253	$372,435	$377,772	$383,270	$388,932	$394,765	$400,772	$406,960	$413,333	$419,897
NET CASH FLOW	($149,798)	$189,634	$160,245	$131,862	$104,423	$77,881	$52,176	$27,265	$3,095	($20,379)	($43,203)	($65,418)	($87,064)	($108,185)	($128,819)
NPV - Net Present Value	$252,217														
Debt Coverage	0.23	1.97	1.82	1.68	1.54	1.40	1.27	1.14	1.02	0.90	0.78	0.66	0.55	0.44	0.34

ASSUMPTIONS

Average Energy Demand User 1 (MMBtu/yr	80% of Supply	User 1 Gas Sales Rate ($/MMBtu)	$3.50
Usage Factor User 1	100%	User 1 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	0%	User 1 Capital Cost	$1,849,430
Average Energy Demand User 2 (MMBtu/yr	0	User 2 Gas Sales Rate ($/MMBtu)	$3.00
Usage Factor User 2	75%	User 2 Gas Sales Rate Escalation (%)	2%
Energy Demand Escalation Rate	2%	User 2 Additional Capital Cost	$0
Total Capital Cost (User 1 and 2)	$1,849,430		
Equity Percentage	20%	O&M LFG Collection System	$0
Equity Contribution	$369,886	O&M Utilization System	$139,000
Interest Rate on Debt & NPV Discount Rate	10.0%	O&M Escalation Rate (%)	3%
Financing Term (years)	15		
Capital Recovery Factor	0.1315	Landfill Owner Payment	$100,000
		Payment Escalation (%)	3%