

APPENDIX B
ENGINEERING DOCUMENTATION

CALCULATION SHEET

PAGE 1 OF 2
 PROJECT NO. 63063

CLIENT Sioux Falls, South Dakota
 PROJECT Master Plan

SUBJECT Capacity of Existing
City Sewers to Accept Landfill
Leachate Flow

Prepared By TRW Date 08/14/2003
 Reviewed By DFP Date 8/20/03
 Approved By JES Date 8/27/03

OBJECTIVE

Determine whether existing sewers downstream of the forcemain discharge point have sufficient capacity to accept leachate flow.

ASSUMPTIONS

1. We expect to pump 80 to 100 gpm.
2. Pipe capacities and reserve capacities downstream of the landfill leachate discharge point are shown on the attached table provided by the City of Sioux Falls Engineering Department.

CALCULATIONS

If 100 gpm, then:

$$\frac{100 \text{ gallons}}{\text{minute}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} \times \frac{1 \text{ cf}}{7.48 \text{ gallons}} = 0.223 \text{ cfs}$$

Reserve capacity in all pipes in the sanitary sewer basin (except for the 10-inch pipe at Rolling Hills, which is scheduled to be replaced) is more than .223 cfs.

CONCLUSIONS

∴ A 100 gpm pump (or less) would not overload the existing sewer system.

**SUMMARY OF FLOWS
BASIN 7R
CITY OF SIOUX FALLS**

LAND AREA	Peak Flow cfs	Pipe Size inches	Pipe Capacity cfs	Reserve Capacity cfs	Factor of Safety %
1. Area	4.87	21	7.99	3.12	164%
2. Area (RH & Cry Sprgs)	4.59	18	8.22	3.63	179%
3. Area (Rolling Hills)	4.56	10	1.67	-2.89	37%
4. Pana Tracts	4.29	18	7.15	2.86	167%
5. Sunset Ridge*	4.02	16	8.42	4.40	210%
6. S. of Sunset Ridge	3.61	16	8.42	4.81	233%
7. Sertoma Hills*	3.19	16	8.42	5.23	264%
8. Misty Glen*	2.74	15	3.61	0.87	132%
9. Sundown Estates*	2.40	15	3.61	1.21	150%
10. Candlelight Acres*	2.27	15	3.61	1.34	159%
11. Undeveloped	1.96	12	2.42	0.46	124%
13. Galway Park*	1.29	12	1.80	0.51	139%
14. Jim Jackson	0.77	10	1.25	0.48	163%
15. SW1/4 Sec 34	0.74	10	1.25	0.51	168%

Reserve Capacity = Pipe Capacity - Peak Flow

Factor of Safety = Pipe Capacity/Peak Flow

CLIENT City of Sioux Falls SUBJECT Gas Generation Rate Prepared By DB Date 8/04/03
PROJECT Sioux Falls Landfill Calculation Reviewed By AKW Date 8/14/03
Approved By DFP Date 8/20/03

MSW ACTIVE AREA AND EXPANSION AREA

PURPOSE: To estimate the maximum recoverable volume of landfill gas generated by the Active Landfill in the year after closure 2037 and current year 2003. The areas include the MSW Active Area and 160 Ac. Expansion Area.

METHODS AND ASSUMPTIONS:

- A landfill gas production model developed by Earth Tech, was used to determine the maximum gas generation rate. The model utilizes waste intake rates in tons per year.
- The site started receiving waste in 1979 and will close in 2036.
- The waste intake rates are based on scale data from historical data for years through 1999 and projected waste intake rates through year 2036.
- The gas generation rate of the waste = 0.100 cf / lb waste - year. This measurement is based on an average of gas generation rates for several western landfills with similar climate factors.

CALCULATION:

The parameters described under methods and assumptions will be used to calculate gas generation of the landfill.

The Landfill Gas Production Data Sheet (Attachment 1) requires as input the annual refuse intake rate (ton/year), gas generation rate, LFG theoretical production, recoverable gas percentage and methane concentration. Given these inputs the spreadsheet calculates the gas production rate on an annual basis.

When analyzing the landfill, we will consider the gas generation rate in the current year of 2037, since this is the year after the landfill has closed and will yield the maximum gas generation rate for the facility. Furthermore to be conservative, the recoverable gas produced will be used to size any future landfill equipment.

CONCLUSION:

An estimated maximum recoverable volume of **2,850 cfm** of landfill gas will be produced in 2037, based on the Landfill Gas Production Data sheet (See Attachment 1). While current landfill gas recoverable volume for year 2003 is **831 cfm**. This gas flow estimate pertains to the MSW Active Area plus the 160 Ac. Expansion Area.

Developed by:



Version: 1.01

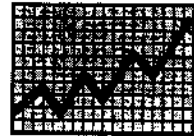
LANDFILL GAS GENERATION MODEL

SITE: Sioux Falls Landfill

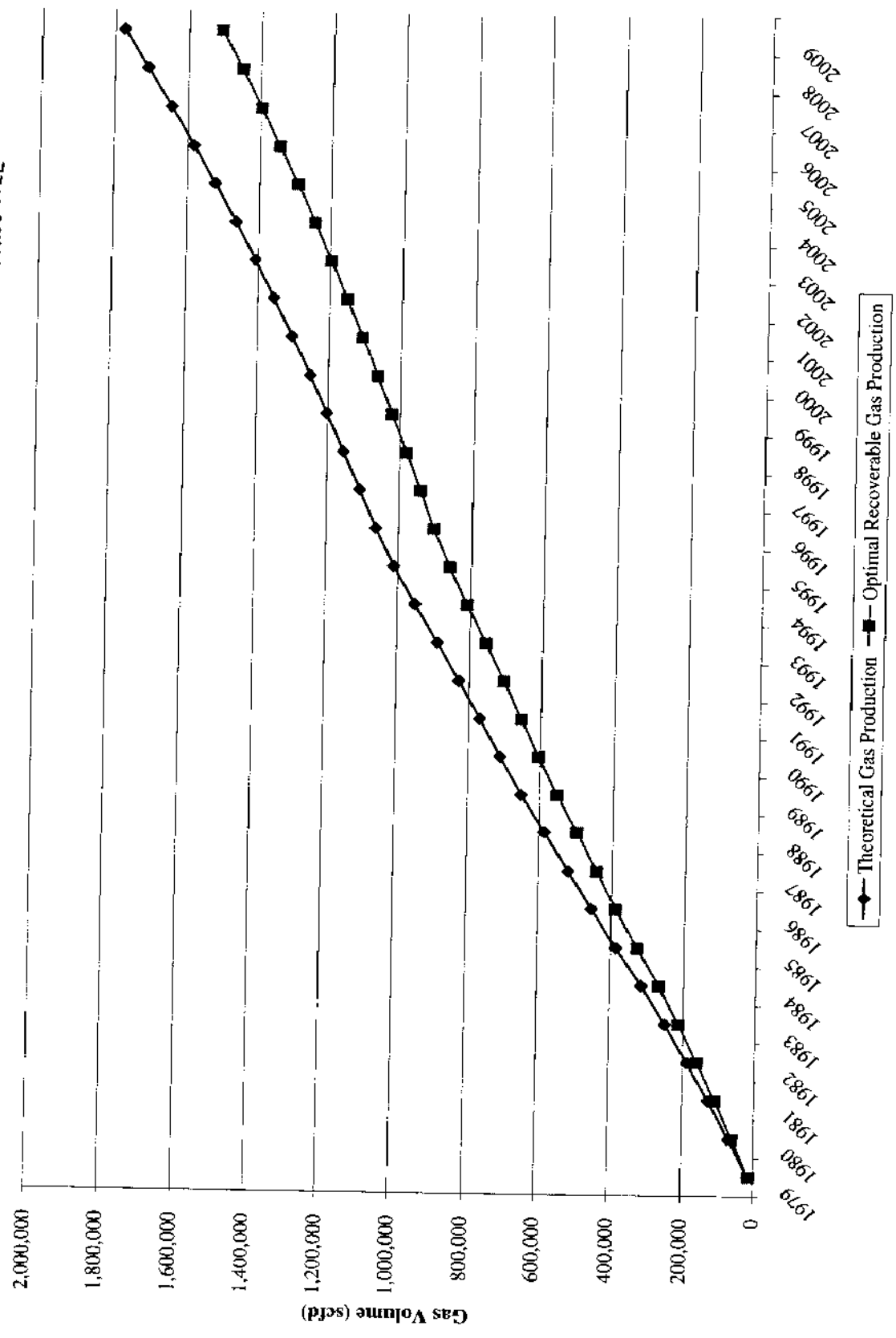
Options

- Standard Gas Volume Curve
- NMOC Emissions Curve
- NMOC/VOCEmissions Curve

- Engine Usage Curve
- Turbine Usage Curve
- MSDS Inventory Curve



**Landfill Gas Production Estimate - SIOUX FALLS REGIONAL
SANITARY LANDFILL**



LANDFILL GAS PRODUCTION DATASHEET

SITE: Sioux Falls Landfill

LFG Generation Rate: 0.1 CU FT/LB-YR @68°F and 14.7 psia
 LFG Theoretical Production: 4.5 CU FT/LB
 Optimal Recoverable LFG: 85 %
 Methane Concentration: 54 %
 Total Disposal Tonnage: 13,300,001 Tons of refuse

YEAR	ANNUAL REFUSE (tons)	LFG PRODUCED (THEORETICAL) (scfd)	LFG RECOVERABLE (OPTIMAL) (scfd)	LFG PRODUCED (THEORETICAL) Excluding Delay Factor) (scfy)	Available Decomposable Waste (lbs)
1979	101,027	13,839	11,763	2.02E+07	1.98E+08
1980	106,671	69,662	59,213	4.11E+07	4.02E+08
1981	113,774	127,537	108,406	6.29E+07	6.15E+08
1982	120,194	187,924	159,736	8.56E+07	8.37E+08
1983	126,778	250,510	212,933	1.09E+08	1.07E+09
1984	136,889	315,795	268,426	1.34E+08	1.31E+09
1985	148,390	385,361	327,557	1.61E+08	1.57E+09
1986	131,850	455,841	387,465	1.83E+08	1.79E+09
1987	141,940	519,340	441,439	2.08E+08	2.03E+09
1988	142,390	585,636	497,791	2.32E+08	2.27E+09
1989	141,180	650,478	552,906	2.55E+08	2.49E+09
1990	132,019	712,127	605,308	2.75E+08	2.69E+09
1991	140,000	769,735	654,274	2.97E+08	2.91E+09
1992	140,000	829,342	704,940	3.19E+08	3.12E+09
1993	154,470	889,606	756,165	3.43E+08	3.35E+09
1994	146,259	953,354	810,351	3.64E+08	3.56E+09
1995	139,297	1,011,356	859,653	3.84E+08	3.75E+09
1996	125,504	1,063,319	903,821	4.01E+08	3.92E+09
1997	128,266	1,108,838	942,512	4.17E+08	4.08E+09
1998	132,686	1,155,085	981,822	4.35E+08	4.25E+09
1999	137,717	1,202,810	1,022,389	4.52E+08	4.42E+09
2000	142,100	1,252,143	1,064,322	4.71E+08	4.60E+09
2001	146,500	1,302,783	1,107,366	4.90E+08	4.79E+09
2002	151,100	1,354,737	1,151,526	5.09E+08	4.98E+09
2003	158,000	1,408,371	1,197,115	5.29E+08	5.18E+09
2004	164,000	1,464,471	1,244,801	5.50E+08	5.38E+09
2005	170,000	1,522,612	1,294,221	5.72E+08	5.59E+09
2006	176,000	1,582,749	1,346,337	5.95E+08	5.81E+09
2007	182,000	1,644,837	1,398,112	6.18E+08	6.04E+09
2008	188,000	1,708,833	1,452,508	6.42E+08	6.27E+09
2009	195,000	1,774,832	1,508,607	6.66E+08	6.52E+09
2010	202,000	1,843,199	1,566,719	6.92E+08	6.77E+09
2011	209,000	1,913,883	1,626,801	7.18E+08	7.02E+09
2012	216,000	1,986,832	1,688,807	7.46E+08	7.29E+09
2013	224,000	2,062,132	1,752,812	7.74E+08	7.57E+09
2014	232,000	2,140,143	1,819,121	8.03E+08	7.85E+09
2015	240,000	2,220,803	1,887,683	8.33E+08	8.15E+09
2016	248,000	2,304,055	1,958,446	8.64E+08	8.45E+09
2017	257,000	2,389,977	2,031,480	8.96E+08	8.77E+09
2018	266,000	2,478,921	2,107,083	9.30E+08	9.09E+09
2019	275,000	2,570,820	2,185,197	9.64E+08	9.43E+09
2020	285,000	2,665,745	2,265,884	1.00E+09	9.77E+09
2021	295,000	2,764,041	2,349,435	1.04E+09	1.01E+10
2022	305,000	2,865,632	2,435,787	1.07E+09	1.05E+10
2023	316,000	2,970,581	2,524,894	1.11E+09	1.09E+10
2024	327,000	3,079,226	2,617,342	1.15E+09	1.13E+10
2025	338,000	3,191,483	2,712,761	1.20E+09	1.17E+10
2026	350,000	3,307,411	2,811,299	1.24E+09	1.21E+10
2027	362,000	3,427,337	2,913,237	1.28E+09	1.26E+10
2028	375,000	3,551,311	3,018,615	1.33E+09	1.30E+10
2029	388,000	3,679,654	3,127,706	1.38E+09	1.35E+10
2030	402,000	3,812,404	3,240,543	1.43E+09	1.40E+10
2031	416,000	3,949,876	3,357,394	1.48E+09	1.45E+10
2032	431,000	4,092,101	3,478,286	1.53E+09	1.50E+10
2033	446,000	4,239,384	3,603,477	1.59E+09	1.55E+10
2034	462,000	4,391,751	3,732,988	1.65E+09	1.61E+10
2035	478,000	4,549,499	3,867,074	1.70E+09	1.67E+10
2036	495,000	4,712,646	4,005,749	1.77E+09	1.73E+10

LANDFILL GAS PRODUCTION DATASHEET

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2037	0	4,811,345	4,089,643	1.73E+09	1.69E+10
2038	0	4,704,426	3,998,762	1.69E+09	1.65E+10
2039	0	4,599,883	3,909,901	1.65E+09	1.61E+10
2040	0	4,497,664	3,823,014	1.61E+09	1.58E+10
2041	0	4,397,716	3,738,058	1.58E+09	1.54E+10
2042	0	4,299,989	3,654,990	1.54E+09	1.51E+10
2043	0	4,204,433	3,573,768	1.51E+09	1.48E+10
2044	0	4,111,001	3,494,351	1.48E+09	1.44E+10
2045	0	4,019,646	3,416,699	1.44E+09	1.41E+10
2046	0	3,930,320	3,340,772	1.41E+09	1.38E+10
2047	0	3,842,980	3,266,533	1.38E+09	1.35E+10
2048	0	3,757,680	3,193,943	1.35E+09	1.32E+10
2049	0	3,674,079	3,122,967	1.32E+09	1.29E+10
2050	0	3,592,432	3,053,568	1.29E+09	1.26E+10
2051	0	3,512,601	2,985,710	1.26E+09	1.23E+10
2052	0	3,434,643	2,919,361	1.23E+09	1.21E+10
2053	0	3,358,220	2,854,487	1.21E+09	1.18E+10
2054	0	3,283,593	2,791,054	1.18E+09	1.15E+10
2055	0	3,210,624	2,729,030	1.15E+09	1.13E+10
2056	0	3,139,277	2,668,385	1.13E+09	1.10E+10
2057	0	3,069,515	2,609,088	1.10E+09	1.08E+10
2058	0	3,001,303	2,551,108	1.08E+09	1.05E+10
2059	0	2,934,608	2,494,417	1.05E+09	1.03E+10
2060	0	2,869,394	2,438,985	1.03E+09	1.01E+10
2061	0	2,805,630	2,384,785	1.01E+09	9.85E+09
2062	0	2,743,283	2,331,790	9.85E+08	9.63E+09
2063	0	2,682,321	2,279,973	9.63E+08	9.41E+09
2064	0	2,622,714	2,229,307	9.41E+08	9.20E+09
2065	0	2,564,431	2,179,766	9.20E+08	9.00E+09
2066	0	2,507,444	2,131,327	9.00E+08	8.80E+09

Year	Tonnage
1979	101,027
1980	106,671
1981	113,774
1982	120,194
1983	126,778
1984	136,889
1985	148,390
1986	131,850
1987	141,940
1988	142,390
1989	141,180
1990	132,019
1991	140,000
1992	140,000
1993	154,470
1994	146,259
1995	139,297
1996	125,504
1997	128,266
1998	132,686
1999	137,717
2000	142,100
2001	146,500
2002	151,100
2003	158,000
2004	164,000
2005	170,000
2006	176,000
2007	182,000
2008	188,000
2009	195,000
2010	202,000
2011	209,000
2012	216,000
2013	224,000
2014	232,000
2015	240,000
2016	248,000
2017	257,000
2018	266,000
2019	275,000
2020	285,000
2021	295,000
2022	305,000
2023	316,000
2024	327,000
2025	338,000
2026	350,000
2027	362,000
2028	375,000
2029	388,000

2030	402,000
2031	416,000
2032	431,000
2033	446,000
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CALCULATION SHEET

Page 1 of 6
Job ID 63063
Cost Code .03

CLIENT City of Sioux Falls SUBJECT Gas Generation Rate Prepared By DB Date 8/10/07
PROJECT Sioux Falls Landfill Calculation for C&D Areas Reviewed By AKW Date 8/14/07
Approved By DFP Date 8/20/07

PURPOSE: To estimate the maximum recoverable volume of landfill gas generated by the C&D Areas of the landfill in the year after closure 2049.

METHODS AND ASSUMPTIONS:

- A landfill gas production model developed by Earth Tech, was used to determine the maximum gas generation rate. The model utilizes waste intake rates in tons per year.
- The site started receiving C&D waste in 2001 and will close in 2048.
- The waste intake rates are based on projected Construction/Demolition and Rubble Fill Areas waste intake rates from year 2001 through year 2048.
- A gas generation rate of the waste = 0.075 cf / lb waste – year is assumed. This measurement is based on an average of gas generation rates for C&D landfills with similar climate factors.
- A LFG Theoretical Yield of 1.0 cf/lb waste is assumed.

CALCULATION:

The parameters described under methods and assumptions will be used to calculate gas generation of the C&D landfill Areas.

The Landfill Gas Production Data Sheet (Attachment 1) requires as input the annual refuse intake rate (ton/year), gas generation rate, LFG theoretical production, recoverable gas percentage and methane concentration. Given these inputs the spreadsheet calculates the gas production rate on an annual basis.

When analyzing the landfill, we will consider the gas generation rate in the year of 2049, since this is the year after the landfill has closed and will yield the maximum gas generation rate for the facility. Furthermore to be conservative, the recoverable gas produced will be used to size any future landfill equipment.

CONCLUSION:

An estimated maximum recoverable volume of **705 cfm** of landfill gas will be produced in 2049, based on the Landfill Gas Production Data sheet (See Attachment 1).

Developed by:



Version: 1.01

LANDFILL GAS GENERATION MODEL

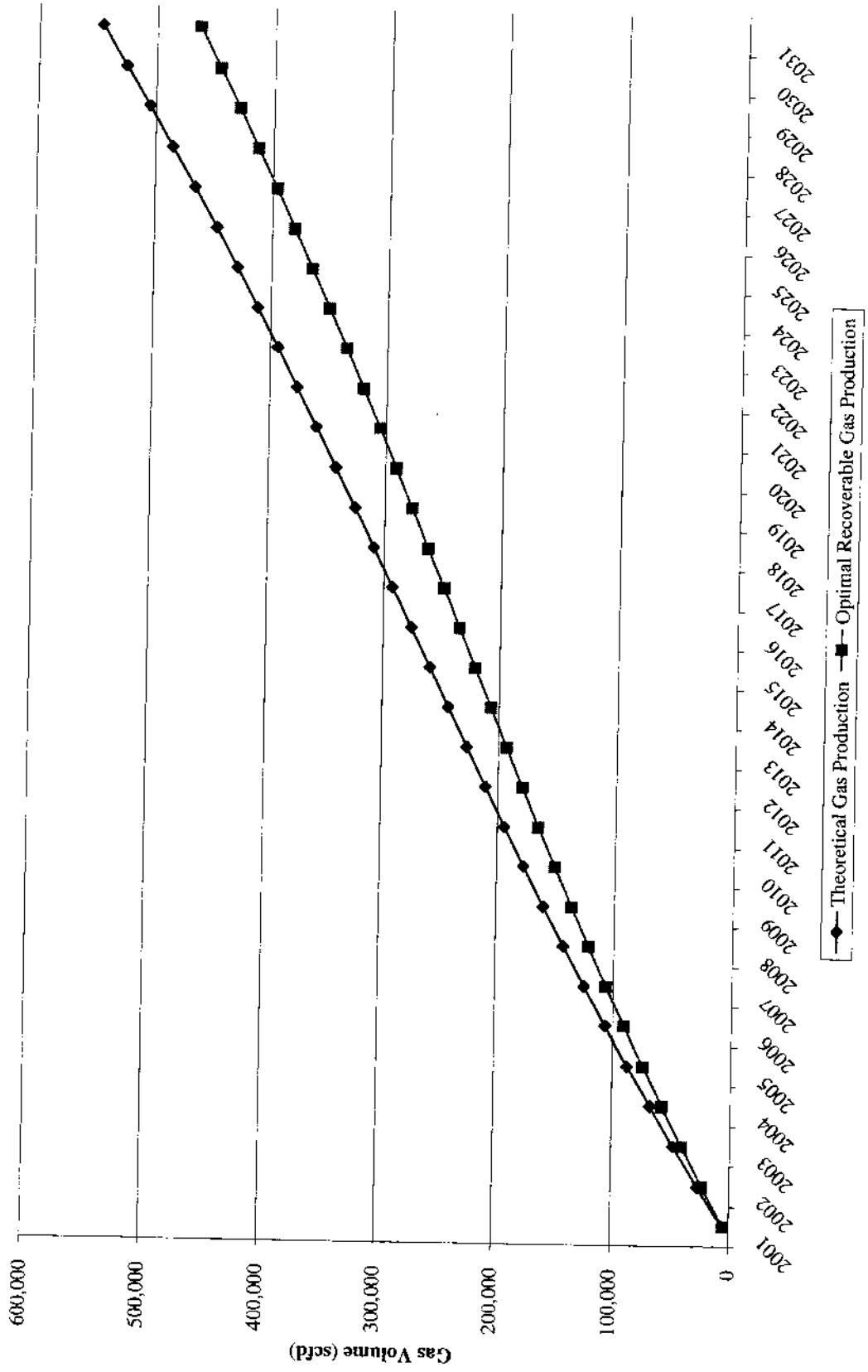
SITE: Sioux Falls Landfill (C&D Areas)

Options

<input checked="" type="checkbox"/> Standard Gas Volume Curve	<input type="checkbox"/> Engine Usage Curve
<input type="checkbox"/> NMOC Emissions Curve	<input type="checkbox"/> Turbine Usage Curve
<input type="checkbox"/> NMOC/VOCEmissions Curve	<input type="checkbox"/> MSDS Inventory Curve



Landfill Gas Production Estimate -



LANDFILL GAS PRODUCTION DATASHEET

SITE: Sioux Falls Landfill (C&D Areas)

LFG Generation Rate: 0.075 CU FT/LB-YR
 LFG Theoretical Production: 1 CU FT/LB @68°F and 14.7 psia
 Optimal Recoverable LFG: 85 %
 Methane Concentration: 54 %
 Total Disposal Tonnage: 6,428,148 Tons of refuse

YEAR	ANNUAL REFUSE (tons)	LFG PRODUCED (THEORETICAL) (scfd)	LFG RECOVERABLE (OPTIMAL) (scfd)	LFG PRODUCED (THEORETICAL) Excluding Delay Factor (scfy)	Available Decomposable Waste (tbs)
2001	53,266	5,473	4,652	7.99E+06	9.85E+07
2002	55,198	27,151	23,078	1.57E+07	1.93E+08
2003	57,200	48,004	40,804	2.31E+07	2.85E+08
2004	59,202	68,116	57,899	3.02E+07	3.73E+08
2005	61,274	87,550	74,418	3.71E+07	4.58E+08
2006	63,419	106,385	90,428	4.39E+07	5.41E+08
2007	65,638	124,697	105,992	5.04E+07	6.22E+08
2008	67,936	142,555	121,172	5.68E+07	7.01E+08
2009	70,313	160,027	136,023	6.31E+07	7.79E+08
2010	72,774	177,173	150,597	6.93E+07	8.55E+08
2011	75,321	194,054	164,946	7.54E+07	9.30E+08
2012	77,958	210,725	179,116	8.14E+07	1.00E+09
2013	80,686	227,238	193,153	8.74E+07	1.08E+09
2014	83,510	243,644	207,098	9.34E+07	1.15E+09
2015	86,433	259,990	220,992	9.94E+07	1.23E+09
2016	89,458	276,322	234,874	1.05E+08	1.30E+09
2017	92,589	292,683	248,781	1.11E+08	1.37E+09
2018	95,830	309,115	262,748	1.17E+08	1.45E+09
2019	99,184	325,659	276,810	1.23E+08	1.52E+09
2020	102,655	342,351	290,989	1.30E+08	1.60E+09
2021	106,248	359,231	305,346	1.36E+08	1.67E+09
2022	109,967	376,334	319,884	1.42E+08	1.75E+09
2023	113,816	393,697	334,642	1.49E+08	1.83E+09
2024	117,799	411,352	349,649	1.55E+08	1.91E+09
2025	121,922	429,335	364,935	1.62E+08	1.99E+09
2026	126,190	447,678	380,527	1.69E+08	2.08E+09
2027	130,606	466,415	396,453	1.75E+08	2.16E+09
2028	135,178	485,577	412,741	1.83E+08	2.25E+09
2029	139,909	505,198	429,418	1.90E+08	2.34E+09
2030	144,806	525,308	446,512	1.97E+08	2.43E+09
2031	149,874	545,940	464,049	2.05E+08	2.53E+09
2032	155,119	567,125	482,056	2.13E+08	2.63E+09
2033	160,549	588,896	500,562	2.21E+08	2.73E+09
2034	166,168	611,285	519,593	2.29E+08	2.83E+09
2035	171,984	634,325	539,176	2.38E+08	2.94E+09
2036	178,003	658,047	559,340	2.47E+08	3.04E+09
2037	184,233	682,486	580,113	2.56E+08	3.16E+09
2038	190,681	707,674	601,523	2.65E+08	3.27E+09
2039	197,355	733,646	623,599	2.75E+08	3.39E+09
2040	204,263	760,437	646,372	2.85E+08	3.52E+09
2041	211,412	788,082	669,870	2.95E+08	3.64E+09
2042	218,811	816,618	694,125	3.06E+08	3.77E+09
2043	226,470	846,081	719,169	3.17E+08	3.91E+09
2044	234,396	876,509	745,033	3.28E+08	4.05E+09
2045	242,600	907,941	771,750	3.40E+08	4.20E+09
2046	251,091	940,416	799,354	3.52E+08	4.35E+09
2047	259,879	973,976	827,880	3.65E+08	4.50E+09
2048	268,975	1,008,662	857,363	3.78E+08	4.66E+09
2049	0	1,015,916	863,528	3.50E+08	4.31E+09
2050	0	939,722	798,764	3.23E+08	3.99E+09
2051	0	869,243	738,856	2.99E+08	3.69E+09
2052	0	804,050	683,442	2.77E+08	3.41E+09
2053	0	743,746	632,184	2.56E+08	3.16E+09
2054	0	687,965	584,770	2.37E+08	2.92E+09
2055	0	636,368	540,912	2.19E+08	2.70E+09
2056	0	588,640	500,344	2.03E+08	2.50E+09
2057	0	544,492	462,818	1.87E+08	2.31E+09
2058	0	503,655	428,107	1.73E+08	2.14E+09

LANDFILL GAS PRODUCTION DATASHEET

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 Methane Concentration: 54 %
 Total Disposal Tonnage: 6,428,148 Tons of refuse

@68°F and 14.7 psia

YEAR	ANNUAL REFUSE (tons)	LFG PRODUCED (THEORETICAL) (scfd)	LFG RECOVERABLE (OPTIMAL) (scfd)	LFG PRODUCED (THEORETICAL) Excluding Delay Factor) (scfy)	Available Decomposable Waste (lbs)
2059	0	465,881	395,999	1.60E+08	1.98E+09
2060	0	430,940	368,299	1.48E+08	1.83E+09
2061	0	398,619	338,826	1.37E+08	1.69E+09
2062	0	368,723	313,414	1.27E+08	1.56E+09
2063	0	341,069	289,908	1.17E+08	1.45E+09
2064	0	315,489	268,165	1.09E+08	1.34E+09
2065	0	291,827	248,053	1.00E+08	1.24E+09
2066	0	269,940	229,449	9.29E+07	1.15E+09
2067	0	249,694	212,240	8.59E+07	1.06E+09
2068	0	230,967	196,322	7.95E+07	9.80E+08
2069	0	213,645	181,598	7.35E+07	9.07E+08
2070	0	197,621	167,978	6.80E+07	8.39E+08
2071	0	182,800	155,380	6.29E+07	7.76E+08
2072	0	169,090	143,726	5.82E+07	7.18E+08
2073	0	156,408	132,947	5.38E+07	6.64E+08
2074	0	144,677	122,976	4.98E+07	6.14E+08
2075	0	133,827	113,753	4.60E+07	5.68E+08
2076	0	123,790	105,221	4.26E+07	5.25E+08
2077	0	114,505	97,330	3.94E+07	4.86E+08
2078	0	105,918	90,030	3.64E+07	4.49E+08
2079	0	97,974	83,278	3.37E+07	4.16E+08
2080	0	90,626	77,032	3.12E+07	3.85E+08
2081	0	83,829	71,254	2.88E+07	3.56E+08
2082	0	77,542	65,910	2.67E+07	3.29E+08
2083	0	71,726	60,967	2.47E+07	3.04E+08
2084	0	66,347	56,395	2.28E+07	2.82E+08
2085	0	61,371	52,165	2.11E+07	2.60E+08
2086	0	56,768	48,253	1.95E+07	2.41E+08
2087	0	52,510	44,634	1.81E+07	2.23E+08
2088	0	48,572	41,286	1.67E+07	2.06E+08

Year	Tonnage
2001	53,266
2002	55,198
2003	57,200
2004	59,202
2005	61,274
2006	63,419
2007	65,638
2008	67,936
2009	70,313
2010	72,774
2011	75,321
2012	77,958
2013	80,686
2014	83,510
2015	86,433
2016	89,458
2017	92,589
2018	95,830
2019	99,184
2020	102,655
2021	106,248
2022	109,967
2023	113,816
2024	117,799
2025	121,922
2026	126,190
2027	130,606
2028	135,178
2029	139,909
2030	144,806
2031	149,874
2032	155,119
2033	160,549
2034	166,168
2035	171,984
2036	178,003
2037	184,233
2038	190,681
2039	197,355
2040	204,263
2041	211,412
2042	218,811
2043	226,470
2044	234,396
2045	242,600
2046	251,091
2047	259,879
2048	268,975
2049	-
2050	-
2051	-