Appendix P. Cap Infiltration Evaluation and Landfill Gas Generation Modeling

Appendix P1. Cap Infiltration Evaluation

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Acronyms and Abbreviations

22 CCR	Title 22 California Code of Regulations
27 CCR	Title 27 California Code of Regulations
CCR	California Code of Regulations
cm/sec	centimeter per second
GCL	geosynthetic clay liner
HDPE	high-density polyethylene
HELP-3	Hydrologic Evaluation of Landfill Performance, Version 3

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Section 1. Introduction

The Hydrologic Evaluation of Landfill Performance, Version 3 (HELP-3), computer simulation model developed by the U.S. Environmental Protection Agency was used to estimate the infiltration potential through the landfill final cap. The results of the infiltration analysis will be used for evaluating the final cap alternatives proposed for the Hunters Point Shipyard Parcel E-2 Landfill.

The HELP-3 computer simulation model performs a daily accounting of precipitation, runoff, evapotranspiration, lateral drainage, and percolation (infiltration) based on climatologic data and material properties of the final cap. The following sections describe the HELP-3 model default parameters, the types of caps assessed, layer characteristics, the HELP-3 infiltration analysis, and infiltration analysis results.

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Section 2. Default Parameters

The HELP-3 model requires climatologic data, material layer, soil type, geosynthetic properties, and installation quality information. Maintained in the model's database are default climatologic data for different cities throughout the United States and default properties for a variety of soils and geosynthetic materials when site and material-specific data are unavailable. The HELP-3 model used data from the San Francisco default station, the closest climatological station to Parcel E-2, for this analysis. The climatological data for the San Francisco default station consist of precipitation, evapotranspiration, and solar radiation data. Table 1 summarizes the average monthly precipitation and temperature data from the San Francisco default station.

Table 1. Monthly Precipitation and Temperature Data from HELP-3 San Francisco Default Station

Month	Precipitation (inches)	Temperature (°F)
January	4.65	48.50
February	3.23	51.60
March	2.64	52.80
April	1.53	54.80
May	0.32	57.80
June	0.11	60.80
July	0.03	62.20
August	0.05	63.00
September	0.19	63.90
October	1.06	60.60
November	2.35	54.50
December	3.55	49.20
Mean Annual	19.71	56.64

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Section 3. Types of Caps Assessed

Three different caps were assessed using the HELP-3 model: the *Title 27 California Code of Regulations* [CCR] (27 CCR)-compliant prescriptive standard cap, 27 CCR-compliant engineered alternative cap, and *Title 22 CCR* (22 CCR)-compliant equivalent multilayer cap. Fundamental design criteria as used in the HELP-3 model are provided below.

27 CCR-Compliant Prescriptive Standard Cap

- 1.0-foot-thick vegetative soil layer
- 1.0-foot-thick low-permeability soil layer (permeability less than or equal to 1×10^{-6}centimeter per second [cm/sec])
- 2.0-foot-thick foundation layer

27 CCR-Compliant Engineered Alternative Cap

- 1.5-foot-thick vegetative soil layer
- Drainage geocomposite
- 60-mil high-density polyethylene (HDPE) geomembrane
- 2.0-foot-thick foundation layer

22 CCR-Compliant Equivalent Multilayer Cap

- 1.5-foot-thick vegetative soil layer
- Drainage geocomposite
- 60-mil HDPE geomembrane
- Geosynthetic clay liner (GCL)
- 2.0-foot-thick foundation layer

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Section 4. Layer Characteristics

The HELP-3 model is capable of using four different layer types: a vertical percolation layer, a lateral drainage layer, a soil barrier layer, and a geomembrane barrier layer. The HELP-3 model recognizes the vegetative soil and foundation layer as vertical percolation layers. The geocomposite drainage layer is considered a lateral drainage layer. The low-permeability soil layer, GCL, and geomembrane liner are considered barrier layers. The following sections discuss each type of layer. In addition to layer types, the HELP-3 model contains default properties for a wide range of soils and geosynthetic products. Porosity, field capacity, wilting point, initial water content, and saturated hydraulic conductivity are included in the database. Table 2 summarizes the values used in this analysis.

Table 2. Default HELP-3 Material Properties

Classification			Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)
No.	USDA	USCS				
0	Barrier Soil[a]		0.453	0.372	0.273	1.0×10^{-6}
7	FSL	SM	0.473	0.222	0.104	5.2×10^{-2}
10	SCL	SC	0.398	0.244	0.136	1.2×10^{-4}
17	GCL		0.750	0.747	0.400	3.0×10^{-9}
34	Drainage Geocomposite		0.850	0.010	0.005	$3.3 \times 10^{+1}$
35	HDPE					2.0×10^{-13}

Notes:

a User-defined soil type
GCL Geosynthetic clay liner
HDPE High-density polyethylene
SC Sand with clayey fines
SM Sand with silty fines
USCS Unified Soil Classification System
USDA U.S. Department of Agriculture
vol/vol Volume by volume

4.1. VERTICAL PERCOLATION LAYERS

The HELP-3 default No.7, a silty sand having a saturated hydraulic conductivity ($k = 5.2 \times 10^{-4}$ cm/sec), was assumed to represent the vegetative soil material that will be imported to the site. Default No. 10, a clayey sand, ($k = 1.2 \times 10^{-4}$ cm/sec) was assumed for the foundation layer and was assumed to be the predominant existing soil cover at the site. These soil types were used in the analysis for all final cap alternatives.

4.2. LATERAL DRAINAGE LAYERS

The drainage geocomposite, default No. 34, was chosen for the subdrain layer placed below the vegetative soil cover and immediately above the flexible membrane layer. This material would be installed on the top deck and side slope areas of the Landfill. This material was used in the analysis for the 27 CCR-compliant engineered alternative cap and 22 CCR-compliant equivalent multilayer cap alternatives.

4.3. BARRIER SOIL AND GEOMEMBRANE LAYERS

The proposed flexible membrane layer for the 27 CCR-compliant engineered alternative cap is a 60-mil HDPE geomembrane, and the equivalent barrier soil layer for the 22 CCR-compliant equivalent multilayer cap is a GCL. Default No. 35 and No. 17 were assigned to the HDPE geomembrane and GCL, respectively. The low-permeability soil layer ($k \leq 1 \times 10^{-6}$ cm/sec), the barrier soil layer for the 27 CCR-compliant prescriptive standard cap, was assigned soil type No. 0, which is a user-defined soil type.

The HELP-3 model is also capable of modeling defects in the geomembrane resulting from its manufacture (for example, pinholes), installation, and overall placement quality (subgrade conditions, degree of geomembrane contact, etc.). For this analysis, two pinholes per acre, two installation defects, and “good” placement quality were assumed for each simulation. These parameters represent good engineering practice.

Section 5. HELP-3 Infiltration Analysis

The HELP-3 computer simulations were run for 30 years (post-closure period) for several final cap alternatives proposed for the Landfill. The modeled area was a typical 1-acre area of the top deck (2 to 10 percent slope) of the Landfill. The analysis was not performed on the 3:1 (horizontal:vertical) or steeper side slope areas because it was assumed that these areas would perform similarly or better than the top deck area. The Landfill area was modeled with 100 percent runoff potential. It was further assumed that native grasses adaptive to open space environment would be used for vegetative cover; therefore, additional irrigation water (other than that required for establishing initial vegetative growth) was not included in the analysis.

Final closure conditions were modeled based on the final cap alternatives proposed for the Landfill. For each modeled final cap sections, the initial water content of the soil layers was assumed to be at or near the field capacity. This assumption results in conservative, steady-state flow conditions. Average annual and peak daily infiltration through the final cap and peak daily head on the geomembrane were examined for each simulation. Additional information for precipitation and runoff on the final cap was also noted.

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Section 6. Infiltration Analysis Results

HELP-3 model results for the 27 CCR-compliant engineered alternative cap and 22 CCR-compliant equivalent multilayer cap alternatives are similar. For both types of cap, the peak daily and annual average infiltration are 0.00087 and 0.03347 inch per acre, respectively. Similarly, the estimated peak daily and annual average head on the geomembrane layer for both alternatives are 0.077 and 0.001 inch, respectively.

For the 27 CCR-compliant prescriptive standard cap, the peak daily and annual average infiltration through the final cap are 0.068 and 5.7 inches per acre, respectively. These values are much greater than the 27 CCR-compliant engineered alternative and 22 CCR-compliant multilayer cap alternatives. The estimated peak daily head over the low-permeability soil layer is 12 inches, equal to the vegetative layer thickness. This condition could also cause instability on the 3:1 side slope areas of the Landfill.

Table 3 summarizes the peak daily and average annual values.

Table 3. HELP-3 Model Results For Final Cap Alternatives

Cap Type	Peak Daily			Annual Average[a]		
	Runoff (inches)	Infiltration (inches)	Head[b] (inches)	Runoff (inches)	Infiltration (inches)	Head[b] (inches)
27 CCR-Compliant Prescriptive Standard Cap	3.764	0.06818	12.0	1.663	5.70418	1.667
27 CCR-Complaint Engineered Alternative Cap	1.343	0.00087	0.077	0.094	0.03347	0.001
22 CCR-Complaint Equivalent Multilayer Cap	1.343	0.00092	0.077	0.094	0.03333	0.001

Notes:

[a] Based on 30-year simulation period

[b] Depth of water-saturated soil above the flexible membrane or barrier soil layer

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Appendix P2 Landfill Gas Generation Modeling

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Acronyms and Abbreviations

EPA	U.S. Environmental Protection Agency
lbs/cy	pounds per cubic yard
LFG	landfill gas
LFGM	Landfill Gas Generation Model
m^3/yr	cubic meters per year
scfm	standard cubic feet per minute

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Section 1. Introduction

The U.S. Environmental Protection Agency's (EPA) Clean Air Act model (40 Code of Federal Regulations Part 60) and Shaw's proprietary Landfill Gas Generation Model (LFGM) were used to estimate the rate of landfill gas (LFG) generation expected for the next 30 years at the Parcel E-2 landfill. The results of the modeling will be used to support the evaluation of the final LFG containment and treatment alternatives proposed in the Parcel E-2 Feasibility Study.

To achieve the objective of this site-specific LFG generation assessment, the following tasks were completed:

- Reviewed site background information.
- Reviewed documents describing historical landfilling operations and practices at the site that may impact LFG generation or collection.
- Reviewed recent data related to the Landfill's current LFG generation characteristics evidenced by LFG migration and monitoring data from points penetrating the landfill.
- Developed input values to the LFGM for waste composition, tonnage, and other site-specific factors based on the information gathered from review of the available site documents and data.
- Modeled two separate scenarios for assumed waste composition, a low organics case and a high organics case, due to limited knowledge of the actual Landfill waste stream composition.
- Compared the output of the LFGM to the recent LFG monitoring data.
- Finalized the LFGM by fine tuning some of the input parameters based on a comparison of the initial model output and the recent LFG site data.

The following sections describe the EPA model, the LFGM model, site-specific input assumptions, and the modeling results.

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Section 2. EPA Clean Air Act Model Description

The EPA Clean Air Act model is a variation of the Scholl Canyon model and defines the generation of LFG as occurring in an exponential decay fashion. The input parameters to the EPA model include the annual refuse acceptance rate and default values for the methane generation potential, and methane generation constant, which were determined from the EPA's nationwide database of landfills. The following is the governing equation for the EPA model, input parameter definitions, and the default input values to the model:

$$Q_{CH_4} = \sum 2k \, L_0 \, M_i \, e^{-kt_i}$$, where;

Q_{CH4} = The methane gas generation rate (cubic meters per year [m3/yr])

k = Methane gas generation constant (per year [yr-1])

L_0 = Methane generation potential (cubic meters per Megagram)

M_i = Mass of refuse in the ith section (Megagrams)

t_i = Age of the ith section (years)

The results are then converted to cubic feet per minute of LFG.

Default values for the methane generation constant and the methane generation potential, are those developed by the EPA for the New Source Performance Standards for Municipal Solid Waste Landfills adopted in March 1996. The default values used in the Parcel E-2 modeling were those for a semi-arid climate and are listed in Table 1, “Summary of Model Set-Up Assumptions.” Results of the EPA model are discussed in Section 4.0.

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Section 3. LFGM Description

The LFGM was used in this assessment to more accurately estimate future LFG generation for the Parcel E-2 landfill than projected by the EPA model. The LFGM was initially developed over 20 years ago, built upon the EPA's Clean Air Act model as its foundation. It has since been revised based on Shaw/EMCON's extensive experience at over 350 landfills across the USA, Europe, Canada, and Mexico and now includes additional site-specific variables that are believed to influence LFG generation rates. Today, the LFGM allows detailed input of waste composition, LFG generation lag and conversion times, varying LFG yield for each type of waste, and other factors not considered in the EPA's highly conservative model. The results of the LFGM have proven to be more accurate in projecting actual site-specific LFG generation rates as opposed to the conservative EPA model, which typically predicts much higher rates. The more detailed LFGM was developed to reduce the high bias generated by the EPA model so that treatment systems could be properly sized rather than oversized due to a maximum predicted rate that is usually never reached. The following subsections summarize the underlying assumptions of the LFGM and the key variable input parameters to the LFGM.

3.1. UNDERLYING ASSUMPTIONS

The primary underlying assumptions of the LFGM and related definitions are as follows:

- Refuse decomposition and LFG generation occur in five sequential phases.
- A batch unit of refuse consists of municipal and industrial non-hazardous solid waste placed over 1 year. A batch unit of refuse experiences each of the five phases of decomposition as a single unit (Augenstein and Pacey, 1991).
- Homogeneous decomposition conditions exist with respect to both time and space (e.g., moisture conditions do not change with location within the landfill or over the lifetime of the landfill).
- LFG, as generated, consists entirely of methane and carbon dioxide.
- After refuse decomposition reaches anaerobic methanogenic conditions, LFG generation from a unit of decomposable waste is modeled as a linear increase. Once the required nutrients for LFG generation become limited, LFG generation is assumed to decline exponentially (Augenstein and Pacey, 1991).
- The volume of LFG generated during anaerobic methanogenesis (Phase 4) is set equal to a fraction of the total volume of LFG generated (based on site climatic conditions and operational procedures). This value varies between 85 and 97.5 percent of the total LFG generation.
- The total LFG yield is a sum of the series of yearly LFG yields generated by the decomposition of each batch unit of refuse.

- The constituents of a unit batch of refuse are divided into subgroups of rapidly, moderately, and slowly decomposing items, and non-decomposable items.
- Decomposable materials include:
  - Food wastes
  - Paper wastes
  - Garden wastes
  - Wood wastes
  - Textile and leather wastes
- Non-decomposable items include:
  - Plastics
  - Metals
  - Glass and ceramics
  - Rocks, dirt, and ash

In addition to these baseline assumptions, site-specific input parameters (variables) are developed based on reported observations and professional assumptions. The key input variables unique to the LFGM are described in the following subsection.

3.2. KEY VARIABLE INPUT PARAMETERS

Key variable input parameters to the LFGM include the yearly refuse acceptance rate, the waste stream composition, and unit methane yields. These variables are described in the following subsections. The site specific values for these variables used in the Parcel E-2 modeling effort are summarized in Section 4.0.

3.2.1. Yearly Refuse Acceptance Rate

The rate at which the landfill accepts and places refuse is defined as the yearly refuse acceptance rate and is directly proportional to the estimated LFG generation. In all cases, the refuse acceptance rate is calculated based on information regarding the opening and closing years of the landfill, the amount of fill currently in place at the landfill, the ratio of refuse to daily and intermediate cover soils, historical and future refuse growth rates, and any material diversions due to recycling or composting. It should be noted that the refuse acceptance rate used for the LFG modeling analysis may not necessarily be the recorded refuse acceptance rate of the landfill. This discrepancy occurs for two reasons. First, the acceptance profiles used for modeling are calculated based on the value of in-place fill and not from actual gate refuse acceptance values. Second, only organic municipal and industrial non-hazardous solid wastes are considered to yield LFG in significant quantities. This results in a refuse acceptance profile less than the landfill's actual acceptance rate at the landfill gate. The actual refuse acceptance profile could also include construction and demolition debris; however, this component is not considered to yield significant quantities of LFG, so it is typically not included in the refuse acceptance rate used in the LFGM.

3.2.2. Waste Stream Composition

The relative composition of the waste stream is used to estimate the LFG that may be generated from a unit of refuse. The waste stream is divided into rapidly, moderately, and slowly decomposing items, and non-decomposable items. The LFGM uses a stoichiometric analysis to estimate the amount of LFG that may be generated from each of these groups. The LFG generation results for each group are then combined to estimate the total LFG generated based on the waste stream composition. The relative waste stream composition is obtained directly from the information provided within historical documents. In the event that site-specific waste stream composition data are not available, a default waste stream composition is used by the LFGM that is based on the 1992 EPA National Average values (Characterization of Municipal Solid Waste in the United States 1992 Update, Franklin Associates, July 1992).

3.2.3. Unit Methane Yields

From research into extensive studies and in-situ field studies conducted by Shaw at the Mountain View Landfill in California, upper and lower limits of unit methane yields were estimated. Results of the studies indicated that the upper limit of methane yield is typically 1.8 cubic feet of methane per pound of dry refuse (ft^3 CH_4/lb dry), while the lower limit of methane generation is 1.0 ft^3 CH_4/lb dry.

Section 4. LFGM Input Assumptions

This section summarizes the site-specific assumptions governing the input values used in the LFGM.

4.1. SITE SPECIFIC MODEL INPUTS

The site specific variables input into the LFGM include the yearly refuse acceptance rate, the waste stream composition, and unit methane yields, as described in Section 3.2. The site specific values for these variables used in the modeling effort were developed through a review of available site background information. Table 1 summarizes the model set-up assumptions and input values for both the low and high organics scenarios.

4.1.1. Yearly Refuse Acceptance Rate

The yearly refuse acceptance rate for the Landfill is summarized in the first two columns of Table 2, “Summary of LFG Generation Modeling Output.” The Landfill reportedly began accepting refuse in 1958. For the period of 1958 to 1974 it was assumed refuse placement increased by 1 percent per year for the low organics scenario and 2 percent per year for the high organics scenario. Total refuse placement was set equal to a volume 25 percent greater than the current estimated volume of the landfill (based on the assumption that settlement and degradation has occurred) and assuming a refuse placement density of 1,000 pounds per cubic yard (lbs/cy) for the low organics scenario and 1,200 lbs/cy for the high organics scenario.

It was reported that the site accepted a wide variety of wastes. This information was used to revise the waste profile to favor industrial and other type waste reported to have been accepted at the site. Therefore, the annual refuse tonnages used as input into the LFGM were modified to reflect these conditions.

4.1.2. Waste Stream Composition

Other than a higher fraction of industrial wastes, no other site specific data was provided for the relative composition of the Landfill waste stream. Therefore, the LFGM’s default composition values for MSW (typically based on the 1992 EPA National Average) were revised to account for this information and used for estimating the LFG generation rates for the Parcel E-2 Landfill. A ratio of 5:1 residential waste to construction/industrial waste was used in the high organics scenario, while a ratio of 1:2 residential waste to construction/industrial waste was used in the low organics scenario.

4.1.3. Unit Methane Yields

None of the information provided suggests that the methane yields for the site would differ from the LFGM default values. Therefore, the upper limit methane yield of 1.8 ft^3 CH_4/lb dry, and the lower limit of 1.0 ft^3 CH_4/lb dry, were used for methane generation.

Section 5. Summary of Results

A summary of the output generated by both the EPA model and the LFGM is provided in Table 2. Results of the conservative EPA model predicted LFG generation rates over the next thirty years (2007-2036) to range from 13 to 40 standard cubic feet per minute (scfm) (Table 2). Whereas, the more accurate site specific LFGM projected LFG generation rates ranging from 4 to 24 scfm, roughly 40 to 70% less than the EPA model estimate. The daily volumes of LFG generation, based on the LFGM model results, equals roughly 6,000 to 35,000 standard cubic feet per day; which quickly accumulates and exceeds the gas pore space available in the landfill.

The LFGM provides a relatively broad estimate of the rate of LFG generation and the EPA model typically provides an overly conservative estimate of LFG generation. For the purposes of this assessment, however, the LFG generation estimates only represent conceptual projections, derived using generally accepted computer modeling techniques. They are not based on any long-term field data or studies and should not be construed to represent actual future LFG quantities without taking appropriate steps to verify the current LFG generation values. The projected LFG generation rates should be only used for conceptual estimates and decisions.

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Tables

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Table 1
Summary of Model Set-Up Assumptions, Parcel E-2 Landfill, Hunters Point Shipyard, San Francisco, CA

Model Parameters	High Organics Scenario	Low Organics Scenario	Information Source
Waste Quantity			
Total Waste-in-Place	591,000 cy	591,000 cy	Assumes landfill volume at closure was 25% more than the estimated current volume of 473,000 CY (Sec. 12.2.3 of the RI/FS), due to settlement and degradation.
Waste-to-Soil ratio	5:1	2.5:1	Typical soil cover quantities.
Waste density	1,200 lbs/cy	1,000 lbs/cy	Assumed typical of older landfills.
Total Waste-in-Place	295,501 tons	211,076 tons	Calculated.
Annual growth rate	2%	1%	Assumed typical of older Bay Area landfills.
Waste Composition			
MSW Composition	EMCON Default	EMCON Default	
C&D Composition (organics)	5% paper, 25% wood	5% paper, 25% wood	Based on boring logs from site characterization efforts between 1988 and 1992.
MSW-to-CD ratio	5:1	1:2	Based on boring logs from site characterization efforts between 1988 and 1992 and limited written historical information.
Kinetic Parameters			
EMCON Decay Times	Moderately dry	Moderately dry	Based on semi-arid region.
EPA Model k	0.02	0.02	Semi-arid AP-42: Compilation of Air Pollutant Factors
EPA Model L_o	4411 ft^3/Mg (124 m^3/Mg)	3531 ft^3/Mg (100 m^3/Mg)	Former and Current AP-42:Compilation of Air Pollutant Factors

Notes:
EPA denotes U.S. Environmental Protection Agency.
ft^3/Mg denotes cubic feet per megagram.
k denotes methane gas generation constant.
L_o denotes methane generation potential.
lbs/cy denotes pounds per cubic yard.
m^3/Mg denotes cubic meter per megagram.
MSW denotes municipal solid waste.

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Table 2
Summary of LFG Generation Modeling Output, Parcel E-2 Landfill Feasibility Study
Hunters Point Shipyard, San Francisco, CA

Year	Annual Refuse Acceptance Rate		EPA's Clean Air Act Model LFG Generation Rate		Shaw's Landfill Gas Generation Model Upper Limit of LFG Generation Rate	
	High Organics Scenario (tons)	Low Organics Scenario (tons)	High Organics Scenario (scfm)	Low Organics Scenario (scfm)	High Organics Scenario (scfm)	Low Organics Scenario (scfm)
1958	14,766	11,453	0	0	0	0
1959	15,061	11,567	4	3	1	0
1960	15,363	11,683	9	5	4	1
1961	15,670	11,800	13	8	6	2
1962	15,983	11,918	17	11	9	3
1963	16,303	12,037	22	13	12	4
1964	16,629	12,157	26	16	15	5
1965	16,962	12,279	31	18	19	6
1966	17,301	12,402	35	21	24	8
1967	17,647	12,526	39	23	29	10
1968	18,000	12,651	44	26	34	11
1969	18,360	12,777	48	28	39	13
1970	18,727	12,905	53	31	44	15
1971	19,102	13,034	57	33	49	16
1972	19,484	13,164	62	36	53	18
1973	19,873	13,296	66	38	58	20
1974	20,271	13,429	71	41	62	21
1975	0	0	75	43	67	23
1976	0	0	74	42	70	23
1977	0	0	73	41	71	24
1978	0	0	71	40	71	24
1979	0	0	70	40	72	25
1980	0	0	68	39	72	25
1981	0	0	67	38	71	25
1982	0	0	66	37	70	24
1983	0	0	64	37	68	24
1984	0	0	63	36	65	23
1985	0	0	62	35	62	22
1986	0	0	61	34	59	21
1987	0	0	59	34	56	20
1988	0	0	58	33	53	19
1989	0	0	57	32	51	18
1990	0	0	56	32	49	18
1991	0	0	55	31	47	17
1992	0	0	54	31	45	16
1993	0	0	53	30	43	16
1994	0	0	52	29	41	15
1995	0	0	51	29	39	15
1996	0	0	50	28	38	14
1997	0	0	49	28	36	14
1998	0	0	48	27	34	13
1999	0	0	47	27	33	13
2000	0	0	46	26	32	12
2001	0	0	45	26	30	12
2002	0	0	44	25	29	12
2003	0	0	43	25	28	11
2004	0	0	42	24	27	11
2005	0	0	41	24	26	10
2006	0	0	41	23	25	10
2007	0	0	40	23	24	10
2008	0	0	39	22	23	9
2009	0	0	38	22	22	9
2010	0	0	37	21	21	9
2011	0	0	37	21	20	8
2012	0	0	36	20	19	8
2013	0	0	35	20	19	8
2014	0	0	35	20	18	8

Table 2
Summary of LFG Generation Modeling Output, Parcel E-2 Landfill Feasibility Study
Hunters Point Shipyard, San Francisco, CA

Year	Annual Refuse Acceptance Rate		EPA's Clean Air Act Model LFG Generation Rate		Shaw's Landfill Gas Generation Model Upper Limit of LFG Generation Rate	
	High Organics Scenario (tons)	Low Organics Scenario (tons)	High Organics Scenario (scfm)	Low Organics Scenario (scfm)	High Organics Scenario (scfm)	Low Organics Scenario (scfm)
2015	0	0	34	19	17	7
2016	0	0	33	19	17	7
2017	0	0	33	19	16	7
2018	0	0	32	18	15	7
2019	0	0	31	18	15	6
2020	0	0	31	17	14	6
2021	0	0	30	17	14	6
2022	0	0	29	17	13	6
2023	0	0	29	16	13	6
2024	0	0	28	16	12	5
2025	0	0	28	16	12	5
2026	0	0	27	15	11	5
2027	0	0	27	15	11	5
2028	0	0	26	15	10	5
2029	0	0	26	15	10	5
2030	0	0	25	14	10	4
2031	0	0	25	14	9	4
2032	0	0	24	14	9	4
2033	0	0	24	13	9	4
2034	0	0	23	13	8	4
2035	0	0	23	13	8	4
2036	0	0	22	13	8	4
2037	0	0	22	12	8	4
2038	0	0	21	12	7	3
2039	0	0	21	12	7	3
2040	0	0	21	12	7	3

Notes:
EPA denotes U.S. Environmental Protection Agency
LFG denotes landfill gas
scfm denotes standard cubic feet per minute