Pacific Missile Range Facility Combined Heat and Power Feasibility Study, Kekaha Landfill Gas Study

Kekaha Landfill

Conclusions:

- Methane Percentages in the 50 – 60% range, typical of landfills.
- Landfill Gas is relatively free of any corrosives harmful to boilers or electric generation equipment
  - Low H2S
  - Low Siloxanes
  - Low Halogenated Compounds

TABLE NO. 4-1
LFG RECOVERY PROJECTION -- PHASE I AREA
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	(mmcf/day)	(mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	(mmcf/day)	(mmBtu/yr)
1970	4,300	4,300	0	0.00	0	0%	0	0.00	0
1971	4,800	9,100	2	0.00	463	0%	0	0.00	0
1972	5,300	14,400	4	0.01	963	0%	0	0.00	0
1973	5,900	20,300	6	0.01	1,497	0%	0	0.00	0
1974	6,500	26,800	8	0.01	2,077	0%	0	0.00	0
1975	7,000	33,800	10	0.01	2,699	0%	0	0.00	0
1976	8,000	41,800	13	0.02	3,352	0%	0	0.00	0
1977	9,000	50,800	15	0.02	4,089	0%	0	0.00	0
1978	10,000	60,800	18	0.03	4,905	0%	0	0.00	0
1979	11,000	71,800	22	0.03	5,799	0%	0	0.00	0
1980	12,200	84,000	25	0.04	6,768	0%	0	0.00	0
1981	13,600	97,600	29	0.04	7,829	0%	0	0.00	0
1982	15,100	112,700	34	0.05	9,001	0%	0	0.00	0
1983	16,800	129,500	39	0.06	10,292	0%	0	0.00	0
1984	18,600	148,100	44	0.06	11,717	0%	0	0.00	0
1985	20,700	168,800	50	0.07	13,283	0%	0	0.00	0
1986	23,000	191,800	56	0.08	15,016	0%	0	0.00	0
1987	25,600	217,400	64	0.09	16,933	0%	0	0.00	0
1988	28,400	245,800	72	0.10	19,058	0%	0	0.00	0
1989	32,000	277,800	80	0.12	21,406	0%	0	0.00	0
1990	35,000	312,800	90	0.13	24,053	0%	0	0.00	0
1991	45,000	357,800	101	0.15	26,925	0%	0	0.00	0
1992	50,000	407,800	116	0.17	30,766	0%	0	0.00	0
1993	150,000	557,800	132	0.19	35,003	0%	0	0.00	0
1994	43,200	601,000	187	0.27	49,849	0%	0	0.00	0
1995	0	601,000	198	0.29	52,642	0%	0	0.00	0
1996	0	601,000	191	0.27	50,679	0%	0	0.00	0
1997	0	601,000	183	0.26	48,790	0%	0	0.00	0
1998	0	601,000	177	0.25	46,971	0%	0	0.00	0
1999	0	601,000	170	0.24	45,219	0%	0	0.00	0
2000	0	601,000	164	0.24	43,533	0%	0	0.00	0
2001	0	601,000	158	0.23	41,910	0%	0	0.00	0
2002	0	601,000	152	0.22	40,347	0%	0	0.00	0
2003	0	601,000	146	0.21	38,843	0%	0	0.00	0
2004	0	601,000	141	0.20	37,394	0%	0	0.00	0
2005	0	601,000	135	0.19	36,000	0%	0	0.00	0
2006	0	601,000	130	0.19	34,658	0%	0	0.00	0
2007	0	601,000	125	0.18	33,365	100%	125	0.18	33,365

TABLE NO. 4-1 (continued...)
LFG RECOVERY PROJECTION -- PHASE I AREA
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate	Refuse In-Place	LFG Recovery Potential			LFG System Coverage	LFG Recovery from Planned System		
	(tons/yr)	(tons)	(scfm)	(mmcf/day)	(mmBtu/yr)	(%)	(scfm)	(mmcf/day)	(mmBtu/yr)
2008	0	601,000	121	0.17	32,121	100%	121	0.17	32,121
2009	0	601,000	116	0.17	30,924	100%	116	0.17	30,924
2010	0	601,000	112	0.16	29,771	100%	112	0.16	29,771
2011	0	601,000	108	0.16	28,661	100%	108	0.16	28,661
2012	0	601,000	104	0.15	27,592	100%	104	0.15	27,592
2013	0	601,000	100	0.14	26,563	100%	100	0.14	26,563
2014	0	601,000	96	0.14	25,573	100%	96	0.14	25,573
2015	0	601,000	93	0.13	24,619	100%	93	0.13	24,619
2016	0	601,000	89	0.13	23,701	100%	89	0.13	23,701
2017	0	601,000	86	0.12	22,817	100%	86	0.12	22,817
2018	0	601,000	83	0.12	21,967	100%	83	0.12	21,967
2019	0	601,000	80	0.11	21,147	100%	80	0.11	21,147
2020	0	601,000	77	0.11	20,359	100%	77	0.11	20,359
2021	0	601,000	74	0.11	19,600	100%	74	0.11	19,600
2022	0	601,000	71	0.10	18,869	100%	71	0.10	18,869
2023	0	601,000	68	0.10	18,165	100%	68	0.10	18,165
2024	0	601,000	66	0.09	17,488	100%	66	0.09	17,488
2025	0	601,000	63	0.09	16,836	100%	63	0.09	16,836
2026	0	601,000	61	0.09	16,208	100%	61	0.09	16,208
2027	0	601,000	59	0.08	15,604	100%	59	0.08	15,604
2028	0	601,000	56	0.08	15,022	100%	56	0.08	15,022
2029	0	601,000	54	0.08	14,462	100%	54	0.08	14,462
2030	0	601,000	52	0.08	13,923	100%	52	0.08	13,923

Methane Content of LFG Adjusted to:	50%	
Selected Decay Rate Constant (k):	0.0380	
Selected Ultimate Methane Recovery Rate (Lo):	2,800	cu ft/ton

TABLE NO. 4-4
LFG RECOVERY PROJECTION -- PHASES I AND II COMBINED
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	(mmcf/day)	(mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	(mmcf/day)	(mmBtu/yr)
1970	4,300	4,300	0	0.00	0	0%	0	0.00	0
1971	4,800	9,100	2	0.00	463	0%	0	0.00	0
1972	5,300	14,400	4	0.01	963	0%	0	0.00	0
1973	5,900	20,300	6	0.01	1,497	0%	0	0.00	0
1974	6,500	26,800	8	0.01	2,077	0%	0	0.00	0
1975	7,000	33,800	10	0.01	2,699	0%	0	0.00	0
1976	8,000	41,800	13	0.02	3,352	0%	0	0.00	0
1977	9,000	50,800	15	0.02	4,089	0%	0	0.00	0
1978	10,000	60,800	18	0.03	4,905	0%	0	0.00	0
1979	11,000	71,800	22	0.03	5,799	0%	0	0.00	0
1980	12,200	84,000	25	0.04	6,768	0%	0	0.00	0
1981	13,600	97,600	29	0.04	7,829	0%	0	0.00	0
1982	15,100	112,700	34	0.05	9,001	0%	0	0.00	0
1983	16,800	129,500	39	0.06	10,292	0%	0	0.00	0
1984	18,600	148,100	44	0.06	11,717	0%	0	0.00	0
1985	20,700	168,800	50	0.07	13,283	0%	0	0.00	0
1986	23,000	191,800	56	0.08	15,016	0%	0	0.00	0
1987	25,600	217,400	64	0.09	16,933	0%	0	0.00	0
1988	28,400	245,800	72	0.10	19,058	0%	0	0.00	0
1989	32,000	277,800	80	0.12	21,406	0%	0	0.00	0
1990	35,000	312,800	90	0.13	24,053	0%	0	0.00	0
1991	45,000	357,800	101	0.15	26,925	0%	0	0.00	0
1992	50,000	407,800	116	0.17	30,766	0%	0	0.00	0
1993	150,000	557,800	132	0.19	35,003	0%	0	0.00	0
1994	128,800	686,600	187	0.27	49,849	0%	0	0.00	0
1995	125,700	812,300	233	0.33	61,859	0%	0	0.00	0
1996	216,700	1,029,000	275	0.40	73,088	0%	0	0.00	0
1997	93,300	1,122,300	352	0.51	93,696	0%	0	0.00	0
1998	64,300	1,186,600	377	0.54	100,249	0%	0	0.00	0
1999	67,600	1,254,200	389	0.56	103,434	0%	0	0.00	0
2000	72,800	1,327,000	402	0.58	106,857	0%	0	0.00	0
2001	77,200	1,404,200	416	0.60	110,711	0%	0	0.00	0
2002	74,700	1,478,900	432	0.62	114,896	0%	0	0.00	0
2003	81,100	1,560,000	446	0.64	118,655	0%	0	0.00	0
2004	86,500	1,646,500	462	0.67	122,963	0%	0	0.00	0
2005	89,200	1,735,700	480	0.69	127,692	0%	0	0.00	0
2006	92,320	1,828,020	498	0.72	132,536	0%	0	0.00	0
2007	95,550	1,923,570	517	0.74	137,535	77%	400	0.58	106,284
2008	98,890	2,022,460	537	0.77	142,695	77%	412	0.59	109,523
2009	45,800	2,068,260	557	0.80	148,022	76%	424	0.61	112,893

TABLE NO. 4-4 (continued...)
LFG RECOVERY PROJECTION -- PHASES I AND II COMBINED
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	(mmcf/day)	(mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	(mmcf/day)	(mmBtu/yr)
2010	0	2,068,260	554	0.80	147,435	100%	554	0.80	147,435
2011	0	2,068,260	534	0.77	141,937	100%	534	0.77	141,937
2012	0	2,068,260	514	0.74	136,645	100%	514	0.74	136,645
2013	0	2,068,260	495	0.71	131,550	100%	495	0.71	131,550
2014	0	2,068,260	476	0.69	126,645	100%	476	0.69	126,645
2015	0	2,068,260	458	0.66	121,923	100%	458	0.66	121,923
2016	0	2,068,260	441	0.64	117,376	100%	441	0.64	117,376
2017	0	2,068,260	425	0.61	113,000	100%	425	0.61	113,000
2018	0	2,068,260	409	0.59	108,786	100%	409	0.59	108,786
2019	0	2,068,260	394	0.57	104,730	100%	394	0.57	104,730
2020	0	2,068,260	379	0.55	100,825	100%	379	0.55	100,825
2021	0	2,068,260	365	0.53	97,065	100%	365	0.53	97,065
2022	0	2,068,260	351	0.51	93,446	100%	351	0.51	93,446
2023	0	2,068,260	338	0.49	89,962	100%	338	0.49	89,962
2024	0	2,068,260	326	0.47	86,607	100%	326	0.47	86,607
2025	0	2,068,260	314	0.45	83,378	100%	314	0.45	83,378
2026	0	2,068,260	302	0.43	80,269	100%	302	0.43	80,269
2027	0	2,068,260	291	0.42	77,276	100%	291	0.42	77,276
2028	0	2,068,260	280	0.40	74,395	100%	280	0.40	74,395
2029	0	2,068,260	269	0.39	71,621	100%	269	0.39	71,621
2030	0	2,068,260	259	0.37	68,950	100%	259	0.37	68,950

Methane Content of LFG Adjusted to: 50%
Selected Decay Rate Constant (k): 0.0380
Selected Ultimate Methane Recovery Rate (Lo): 2,800 cu ft/ton

TABLE NO. 4-5
LFG RECOVERY PROJECTION -- PHASES I - III COMBINED
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	(mmcf/day)	(mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	(mmcf/day)	(mmBtu/yr)
1970	4,300	4,300	0	0.00	0	0%	0	0.00	0
1971	4,800	9,100	2	0.00	463	0%	0	0.00	0
1972	5,300	14,400	4	0.01	963	0%	0	0.00	0
1973	5,900	20,300	6	0.01	1,497	0%	0	0.00	0
1974	6,500	26,800	8	0.01	2,077	0%	0	0.00	0
1975	7,000	33,800	10	0.01	2,699	0%	0	0.00	0
1976	8,000	41,800	13	0.02	3,352	0%	0	0.00	0
1977	9,000	50,800	15	0.02	4,089	0%	0	0.00	0
1978	10,000	60,800	18	0.03	4,905	0%	0	0.00	0
1979	11,000	71,800	22	0.03	5,799	0%	0	0.00	0
1980	12,200	84,000	25	0.04	6,768	0%	0	0.00	0
1981	13,600	97,600	29	0.04	7,829	0%	0	0.00	0
1982	15,100	112,700	34	0.05	9,001	0%	0	0.00	0
1983	16,800	129,500	39	0.06	10,292	0%	0	0.00	0
1984	18,600	148,100	44	0.06	11,717	0%	0	0.00	0
1985	20,700	168,800	50	0.07	13,283	0%	0	0.00	0
1986	23,000	191,800	56	0.08	15,016	0%	0	0.00	0
1987	25,600	217,400	64	0.09	16,933	0%	0	0.00	0
1988	28,400	245,800	72	0.10	19,058	0%	0	0.00	0
1989	32,000	277,800	80	0.12	21,406	0%	0	0.00	0
1990	35,000	312,800	90	0.13	24,053	0%	0	0.00	0
1991	45,000	357,800	101	0.15	26,925	0%	0	0.00	0
1992	50,000	407,800	116	0.17	30,766	0%	0	0.00	0
1993	150,000	557,800	132	0.19	35,003	0%	0	0.00	0
1994	128,800	686,600	187	0.27	49,849	0%	0	0.00	0
1995	125,700	812,300	233	0.33	61,859	0%	0	0.00	0
1996	216,700	1,029,000	275	0.40	73,088	0%	0	0.00	0
1997	93,300	1,122,300	352	0.51	93,696	0%	0	0.00	0
1998	64,300	1,186,600	377	0.54	100,249	0%	0	0.00	0
1999	67,600	1,254,200	389	0.56	103,434	0%	0	0.00	0
2000	72,800	1,327,000	402	0.58	106,857	0%	0	0.00	0
2001	77,200	1,404,200	416	0.60	110,711	0%	0	0.00	0
2002	74,700	1,478,900	432	0.62	114,896	0%	0	0.00	0
2003	81,100	1,560,000	446	0.64	118,655	0%	0	0.00	0
2004	86,500	1,646,500	462	0.67	122,963	0%	0	0.00	0
2005	89,200	1,735,700	480	0.69	127,692	0%	0	0.00	0
2006	92,320	1,828,020	498	0.72	132,536	0%	0	0.00	0
2007	95,550	1,923,570	517	0.74	137,535	77%	400	0.58	106,284
2008	98,890	2,022,460	537	0.77	142,695	77%	412	0.59	109,523
2009	102,350	2,124,810	557	0.80	148,022	76%	424	0.61	112,893

TABLE NO. 4-5 (continued...)
LFG RECOVERY PROJECTION -- PHASES I - III COMBINED
KEKAHA LANDFILL, KAUAI, HAWAII

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	(mmcf/day)	(mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Planned System (scfm)	(mmcf/day)	(mmBtu/yr)
2010	105,930	2,230,740	577	0.83	153,524	99%	570	0.82	151,697
2011	109,640	2,340,380	599	0.86	159,206	97%	579	0.83	154,025
2012	113,480	2,453,860	621	0.89	165,075	95%	589	0.85	156,546
2013	117,450	2,571,310	643	0.93	171,139	93%	599	0.86	159,262
2014	121,560	2,692,870	667	0.96	177,404	91%	610	0.88	162,176
2015	125,810	2,818,680	691	1.00	183,879	90%	622	0.89	165,292
2016	130,210	2,948,890	717	1.03	190,569	88%	634	0.91	168,611
2017	0	2,948,890	743	1.07	197,484	100%	743	1.07	197,484
2018	0	2,948,890	715	1.03	190,120	100%	715	1.03	190,120
2019	0	2,948,890	688	0.99	183,031	100%	688	0.99	183,031
2020	0	2,948,890	663	0.95	176,207	100%	663	0.95	176,207
2021	0	2,948,890	638	0.92	169,636	100%	638	0.92	169,636
2022	0	2,948,890	614	0.88	163,311	100%	614	0.88	163,311
2023	0	2,948,890	591	0.85	157,222	100%	591	0.85	157,222
2024	0	2,948,890	569	0.82	151,359	100%	569	0.82	151,359
2025	0	2,948,890	548	0.79	145,716	100%	548	0.79	145,716
2026	0	2,948,890	527	0.76	140,282	100%	527	0.76	140,282
2027	0	2,948,890	508	0.73	135,052	100%	508	0.73	135,052
2028	0	2,948,890	489	0.70	130,016	100%	489	0.70	130,016
2029	0	2,948,890	471	0.68	125,168	100%	471	0.68	125,168
2030	0	2,948,890	453	0.65	120,501	100%	453	0.65	120,501

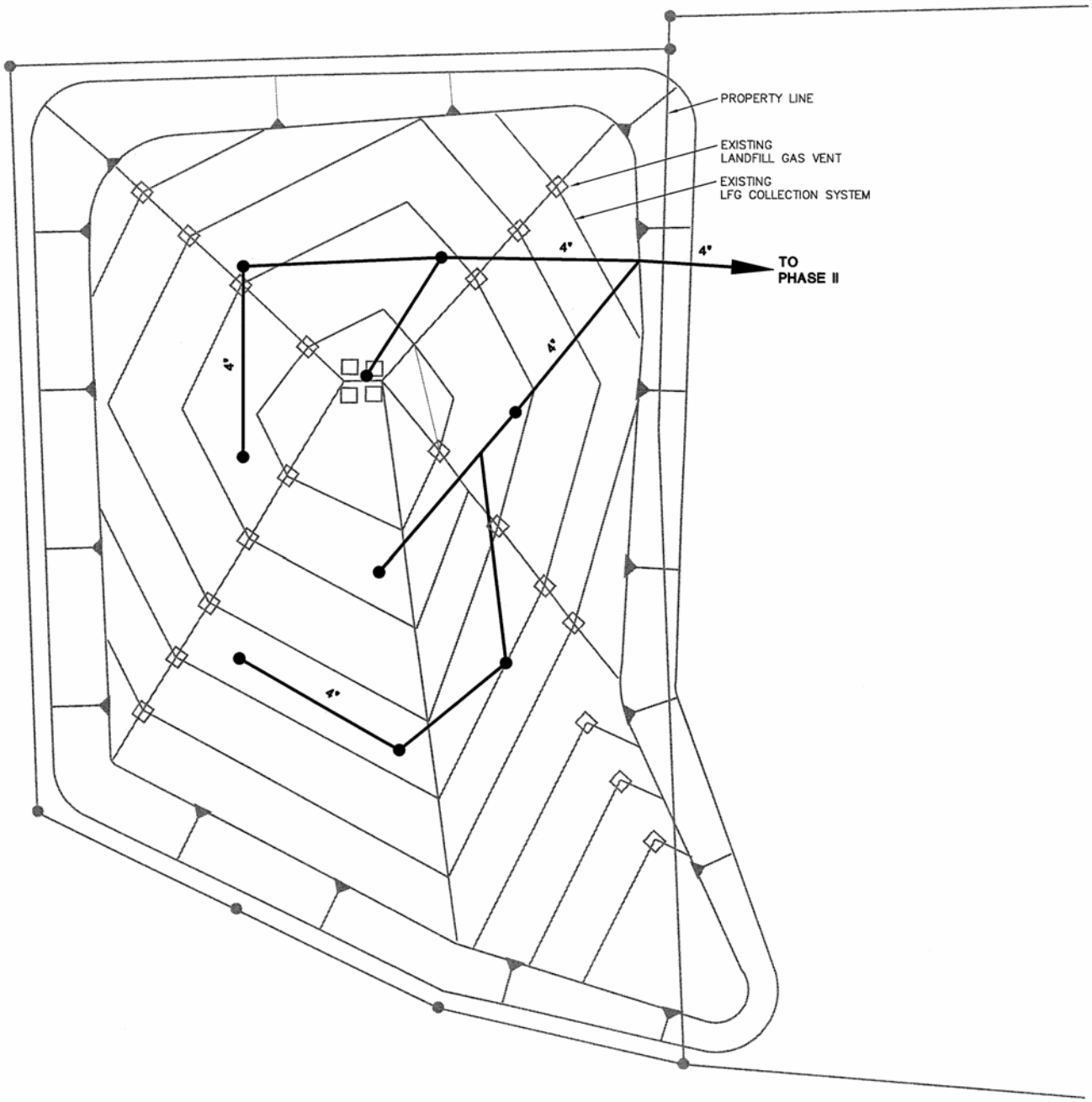
Methane Content of LFG Adjusted to:	50%	
Selected Decay Rate Constant (k):	0.0380	
Selected Ultimate Methane Recovery Rate (Lo):	2,800	cu ft/ton

ENERGY PRODUCTION

- A FLOW OF 400 SCFM AT 50% METHANE COULD SUPPORT ABOUT 1,100 KW OF ELECTRIC POWER PRODUCTION CAPACITY.

TABLE NO. 5-1
BUDGET COST ESTIMATE FOR
PHASE I AND PHASE II
LANDFILL GAS COLLECTION SYSTEM

Component	Quantity	Unit Price	Extended Price
Wellheads	39	$600	$23,400
Well Aprons	9	$400	$3,600
Extraction Wells	2,310 feet	$90	$207,900
4-inch LFG Pipe	5,700 feet	$8	$45,600
6-inch LFG Pipe	1,900 feet	$10	$19,000
8-inch LFG Pipe	1,700 feet	$12	$20,400
Condensate Sumps	3	$12,000	$36,000
2-inch Condensate Pipe	2,800 feet	$3	$8,400
2-inch Air Pipe	2,800 feet	$3	$8,400
6-inch Transmission Line	200 feet	$32	$6,400
		Subtotal	**$379,100**
		Engineering	$30,000
		Contingency	$40,000
		Grand Total	**$449,100**



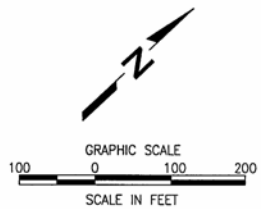


FIGURE 5-1

KEHAHA LANDFILL PHASE I
PROPOSED LANDFILL GAS COLLECTION SYSTEM

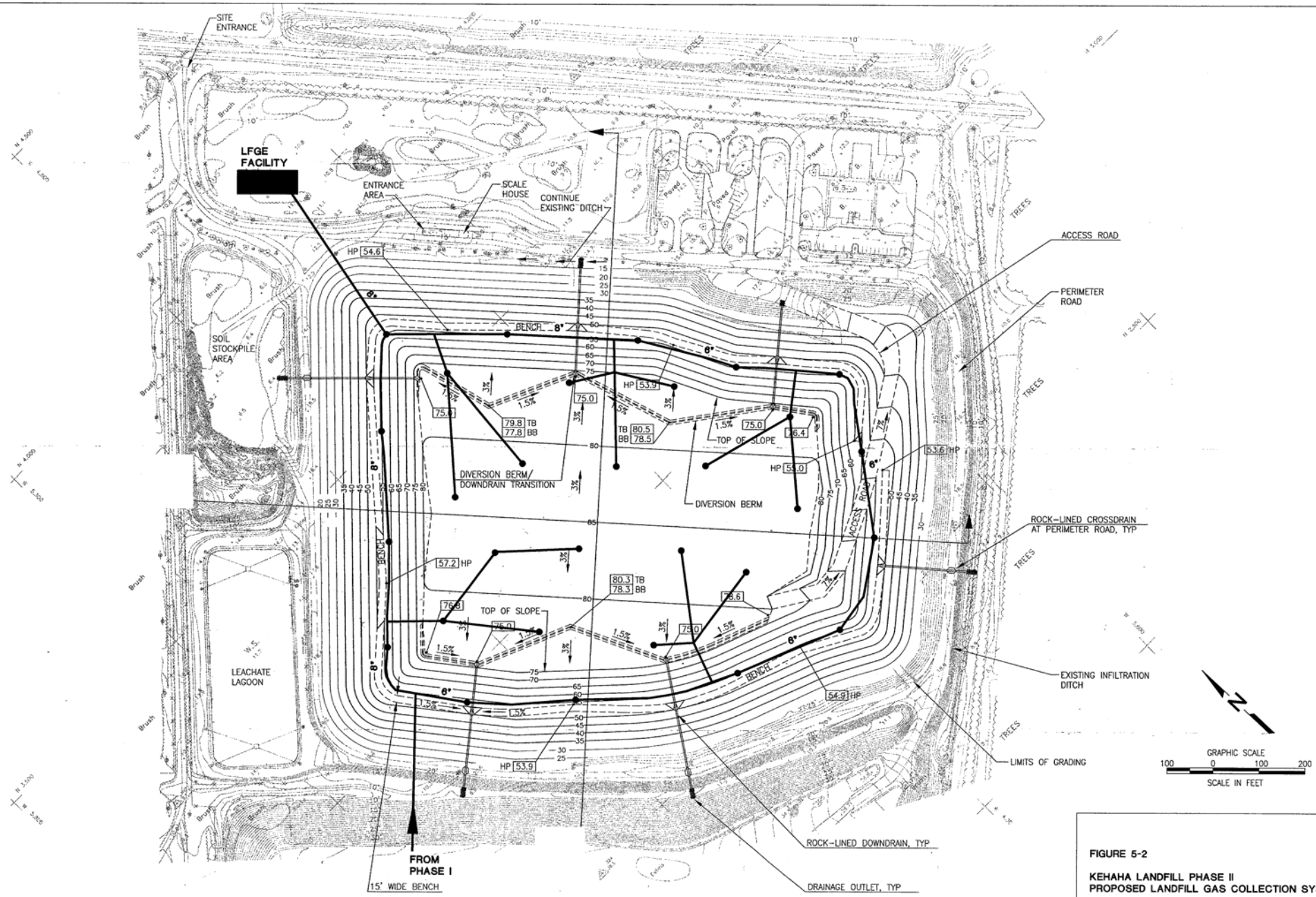


FIGURE 5-2

KEHAHA LANDFILL PHASE II
PROPOSED LANDFILL GAS COLLECTION SYSTEM

TABLE NO. 6-1
BUDGET COST ESTIMATE FOR
LANDFILL GAS PROCESSING SKID

Equipment	
Compressor	$110,000
Reheat Heat Exchanger	$15,000
Chilled Water Heat Exchanger	$15,000
Chiller	$30,000
Methane Analyzer	$20,000
Coalescing Filter	$5,000
Computer and PLC	$30,000
Power Distribution Panel	$15,000
On-Skid Installation	
Piping/Valves	$35,000
Electrical	$30,000
Other Fabrication Work	$35,000
Off-Skid Installation	
Foundation	$15,000
Fence	$10,000
Grading/Crushed Stone	$15,000
Rigging	$5,000
Electric Power Supply	$30,000
Piping Interconnection	$5,000
Engineering	$30,000
Contingency	$45,000
Total	**$495,000**

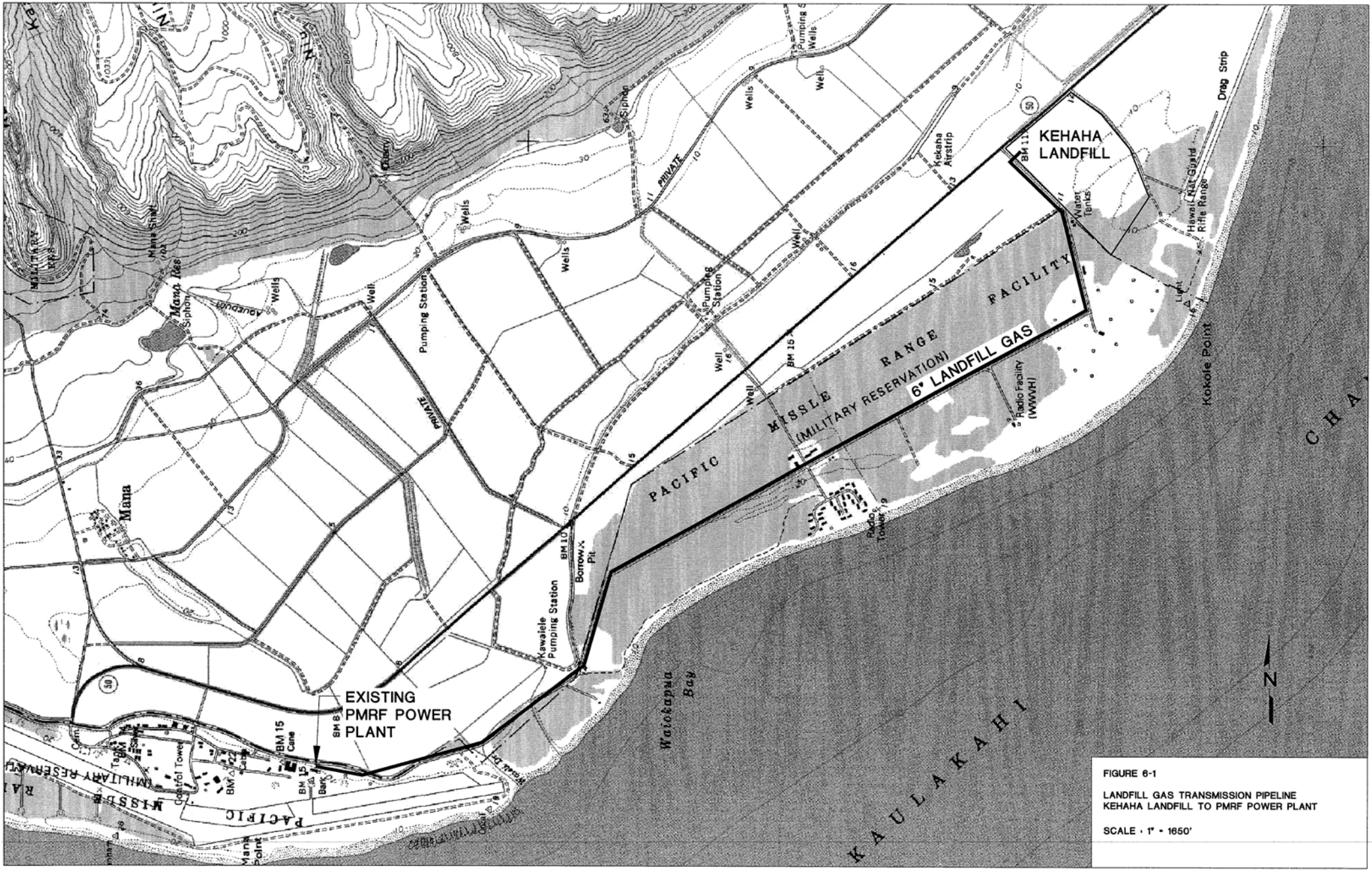


FIGURE 6-1

LANDFILL GAS TRANSMISSION PIPELINE
KEHAHA LANDFILL TO PMRF POWER PLANT

SCALE - 1" = 1650'