Technical Data Supporting Experimental Objectives for Biosolids Injection Demonstration Project

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Executive Summary

The City of Los Angeles and Terralog Technologies have proposed an innovative technology to thermally treat and convert biosolids into clean energy by deep well injection. A permit application for an experimental demonstration project titled "Converting Biosolids to Methane through Deep Injection and Biodegradation" was submitted to the US EPA in June 2001. The proposed experimental program will include both field measurements (monitoring and fluid and gas sampling) and supporting laboratory experiments to better interpret and optimize the field observations.

The experimental objectives are to demonstrate and measure to what extent:

1) The high temperature in the deep subsurface (about 55°C or 131°F) will thermally treat (sterilize) the biosolids;
2) Biodegredation in the subsurface will convert the biomass to methane and carbon dioxide;
3) The carbon dioxide will be permanently sequestered through solubility trapping in the formation brine; and
4) Methane will be generated that may eventually be recovered for beneficial use (thereby providing a relatively clean renewable energy source).

Although definitive technical validation can only come from field demonstration and measurements, there are some background data already available suggesting the field experiment has good chances for success. The purpose of this document is to provide the EPA with technical data supporting the experimental objectives for the biosolids injection demonstration project. This data comes from two sources: first, a new report on the results of high temperature digestion pilot tests at the Hyperion Treatment Plant (Appendices A and B); and second, preliminary laboratory experiments on high-temperature biodegradation completed at the University of California, Los Angeles (UCLA, 2001).

Data from the high temperature tests at Hyperion and at UCLA support the following conclusions:

- Treatment and sterilization of biosolids is temperature related. Under thermophilic conditions in digester D1 (about 130°F) fecal coliform counts were reduced well below the 1000 MPN/G Class A limit. In comparison, under mesophilic conditions in digester D2 (about 96°F) fecal coliform counts remained well above the Class A limit (about 10 to 100 times higher). Therefore in the target injection interval at Terminal Island, where the temperature is between 123 to 144°F, biosolids should be thermally treated and sterilized within a few days.
- Under anaerobic thermophilic conditions expected in the subsurface, biosolids will biodegrade into methane and carbon dioxide within a couple months. The methane to

carbon dioxide gas production ratio should be on the order of 2:1, as observed at the Hyperion Treatment Plant. This ratio is similar with the findings at Terminal Island Treatment Plant.

- The biosolids will be converted to carbon dioxide at a rate of up to 2120 scf per ton of biosolids injected and should be dissolved and permanently sequestered in formation brine.
- The biosolids will be converted to methane at a rate of up to 3930 scf per ton of biosolids injected.

Introduction

The City of Los Angeles and Terrralog submitted a proposal to the EPA "Converting Biosolids to Methane through Deep Injection and Biodegradation" in June 2001. The experimental objectives are to demonstrate and measure to what extent:

1. The high temperature in the deep subsurface (about 55°C or 131°F) will thermally treat (sterilize) the biosolids;
2. Biodegredation in the subsurface will convert the biomass to methane and carbon dioxide;
3. The carbon dioxide will be permanently sequestered through solubility trapping in the formation brine; and
4. Methane will be generated that may eventually be recovered for beneficial use (thereby providing a relatively clean renewable energy source).

New data from thermophilic (high temperature) and mesophilic (low temperature) digestion tests at the Hyperion Treatment Plant, combined with laboratory tests conducted at UCLA, support the hypotheses presented above.

Summary of Hyperion Anaerobic Mesophilic and Thermophilic Digestion Test

A pilot test to evaluate treatment levels and gas generation under mesophilic and thermophilic conditions was performed at the Hyperion Treatment Plant during 2001. Detailed data for October, 2001, is presented in Appendix A and described in this report. This is a period during which one digester was clearly under thermophilic conditions (about 130 ^{o}F) and one digester was clearly under sustained mesophilic conditions (about 96 ^{o}F) at similar feed rates, thereby allowing direct comparison. We also present in Appendix B a two-year summary of data for all digesters at Hyperion.

Hyperion currently employs twenty new egg-shaped digesters and six conventional low digesters to stabilize primary and waste activated sludge. About 2 million gallons per day (MG/D) of Primary Sludge (PS) settling from advance primary treatment process is pumped and distributed equally into the 26 digesters through primary sludge lines. Another 0.8 MGD Thickened Waste Activated Sludge (TWAS) discharges from the Waste Activate Sludge Thickening Facility is also pumped and distributed into all the digesters.

The twenty egg-shaped digesters are grouped into three operational batteries called D1, D2, and E. Digester D1 was set at thermophilic conditions (about 130°F or 55°C), and digester D2 was set at the mesophilic condition (about 96°F or 35°C). A summary of their operational conditions and resulting process parameters is presented in Table 1.

Table 1. Hyperion Plant Mesophilic and Thermophilic Test Summary

	Mesophilic Digester– D2	Thermophilic Digester – D1
Average Temperature	96 ^oF	130 ^oF
Retention Time	18 days	19 days
Average steam consumption	80 k lbs/day	269 k lbs/day
Average sludge feed rate	1.03 MG/D	0.85 MG/D
Average digested gas production	2.37 MSCF/day	2.02 MSCF/day
Average CH4 produced	1.54 MSCF/day	1.31 MSCF/day
Average CO2 produced	0.83 MSCF/day	0.71 MSCF/day
Average fecal coliform count	290,000 MPN/G	88 MPN/G
EPA Pathogen Requirement Met	Class B	Class A

Steam is used to maintain optimal process temperature. The mesophilic digester required about 80,000 lbs/day of steam to maintain an average temperature of about 96 ^oF for an average retention time of about 18 days. The thermophilic digester required more than three times as much steam (about 269,000 lbs/day) to maintain an average temperature of about 130^oF for an average retention time of about 19 days.

Both digesters produced a substantial amount of biogas, containing methane and carbon dioxide. The biogas produced through the digestion process is collected and conveyed to on-site gas storage and compressor facilities, where it is piped to the Scattergood Power Generating Station, and/or to the on-site boilers. The gas storage and compressor facility also has the capability of routing excess digester gas through the gas flare facility.

Evidence for Enhanced Treatment at High Temperature

Figure 1 presents a summary of fecal coliform counts measured in digesters D1 and D2 during October, 2001. Under thermophilic conditions, the fecal coliform count after discharge averages about 88 MPN/G, thus meeting Class A pathogen requirements set by the EPA (less than 1000 MPN/G). Under mesophilic conditions the fecal coliform count averages about 290,000 MPN/G. Therefore, the higher temperature conditions provide enhanced biosolids treatment.

The same treatment process should occur when we inject biosolids into the deep subsurface reservoir. The in-situ temperature underground will cook and digest the biosolids continually to treat and sterilize the sludge into benign materials. The injection reservoir targets will be the Ranger and the Upper Terminal zones, where the reservoir temperatures are on the order of 125 to 145°F. Through deep well injection, we will subject the biosolids to thermophilic conditions naturally for eternity.

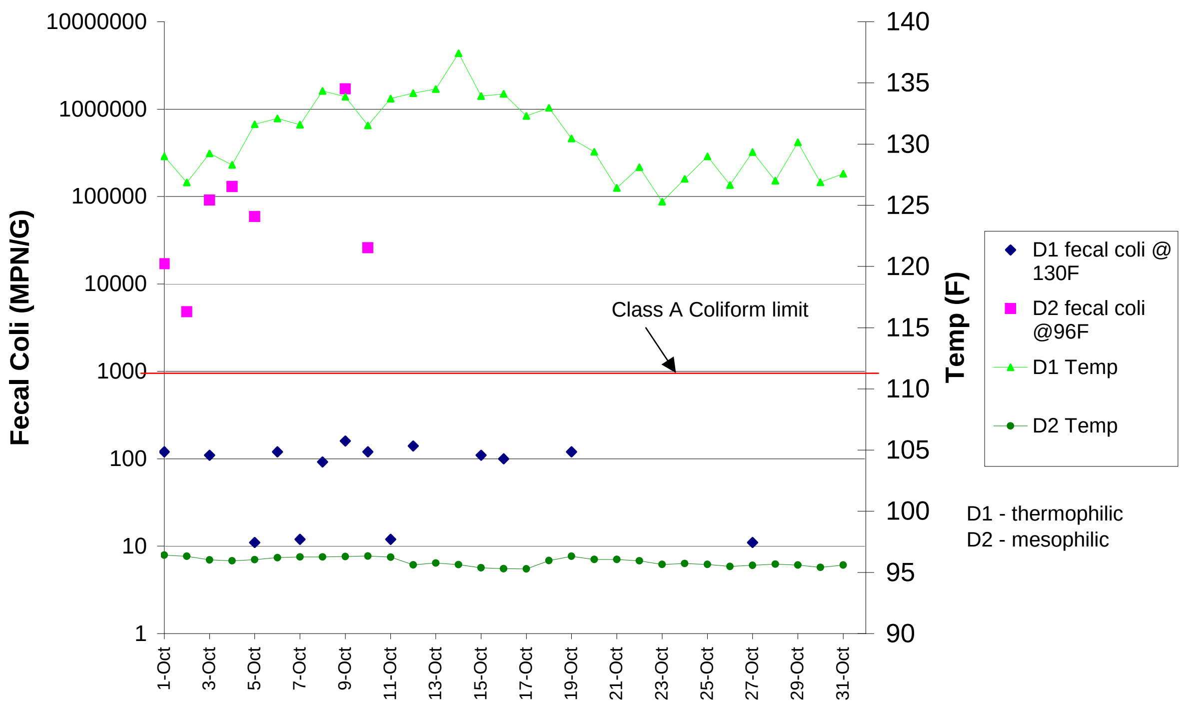

Figure 1. Comparison of fecal coliform count under thermophilic and mesophilic conditions

Evidence for Methane and Carbon Dioxide Generation at High Temperature

Figure 2 presents a summary of methane and carbon dioxide generated in digesters D1 and D2 during October 2001. Average biogas production rates are also summarized in Table 1. Under thermophilic conditions, approximately 1.31 MSCF/day of methane and 0.71 MSCF/day of carbon dioxide were generated from an average feed rate of about 0.85 MGD. Under mesophilic conditions, approximately 1.54 MSCF/day of methane and 0.83 MSCF/day of carbon dioxide were generated from an average federate of about 1.03 MGD. As illustrated in Figure 2, the pilot tests therefore indicate that both thermophilic and mesophilic digestion will create biogas at roughly equal rates. In terms of volatile solids loading, about 6 to 8 scf of methane were produced and about 3 to 4 scf of carbon dioxide were produced per lb of volatile solids. As summarized in Appendix A, the average percentage of volatile solids destroyed in about 58%.

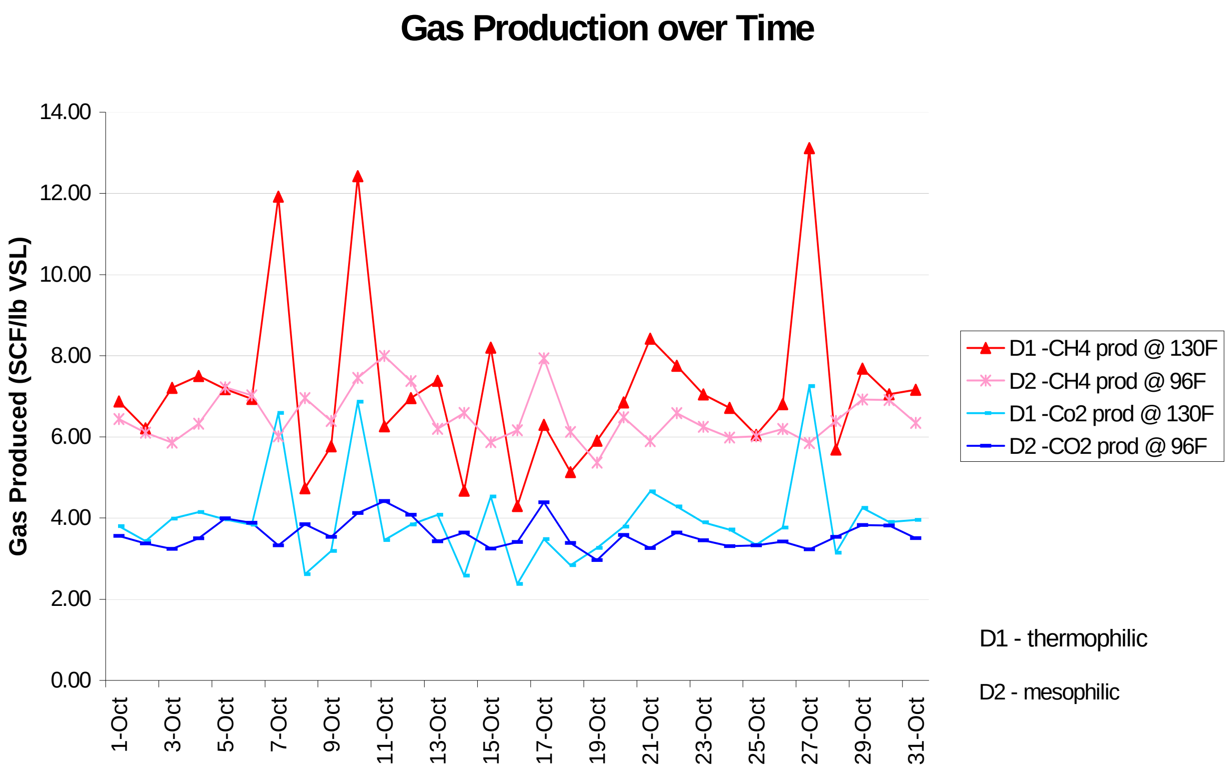

Figure 2. CH4 and CO2 Gas Production from D1 and D2 digesters

The temperature in the deep subsurface will be between 125 and 140F and the conditions will be anaerobic (lacking oxygen), similar to the conditions in the thermophilic digestion tests at Hyperion. Therefore, it is reasonable to assume that the biosolids will biodegrade into methane and carbon dioxide in a similar manner.

The primary difference, however, is that in the subsurface the biosolids will also be exposed to higher salinity fluids, to formation minerals, and to pressure. Still, we expect biodegradation to occur, although perhaps at slower rates as the bacteria adapt. To support this conclusion, we note that laboratory experiments conducted at UCLA demonstrated methane and carbon dioxide production from digested biosolids, even in the presence of high salinity and core materials. Figure 3 presents a summary of methane and carbon dioxide generated from digested sludge (biosolids) in the laboratory at varying temperature.   Hence we conclude that digested gas (methane and carbon dioxide) will be produced when biosolids are injected into the deep subsurface at Terminal Island.   Two objectives of the field experiment are to evaluate how much gas is produced and how quickly.

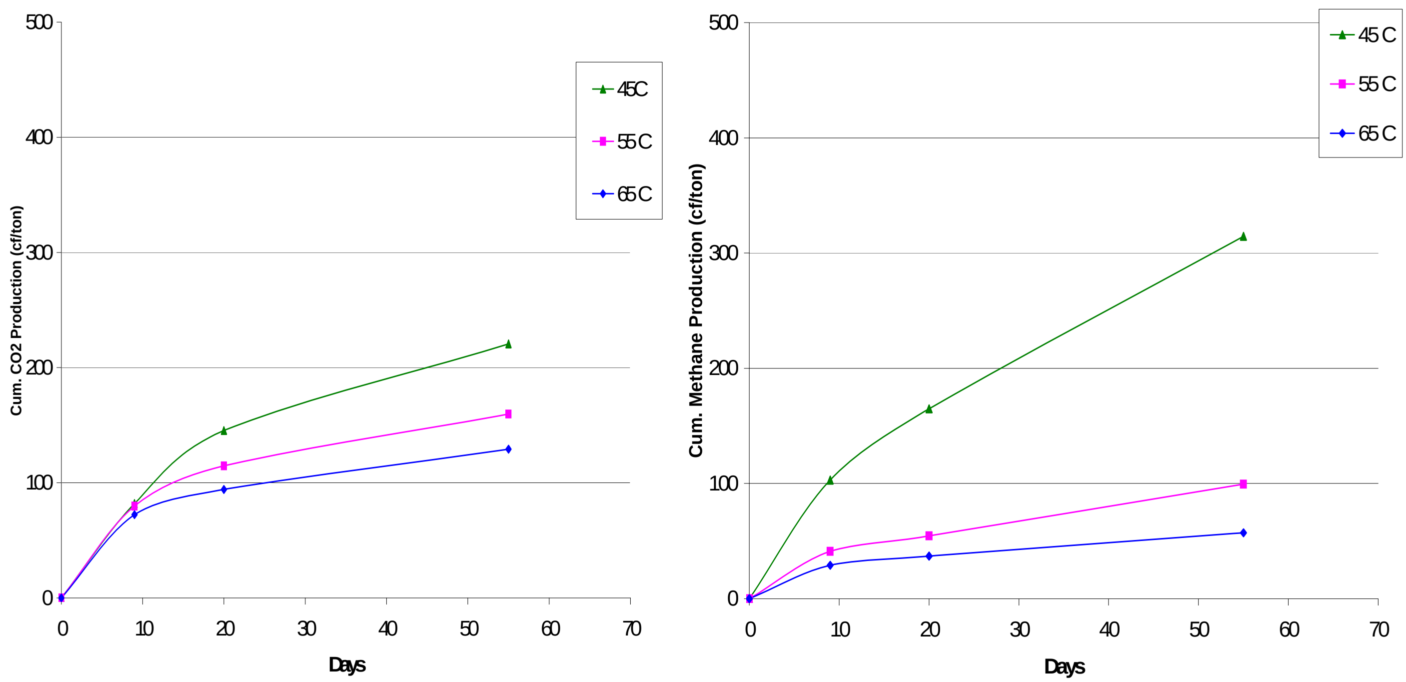

Figure 3 Carbon Dioxide and Methane Production in UCLA Tests
(treated biosolids in brine and mixed with core material)

Potential CH_4 and CO_2 generation from biosolids through Deep Well Injection

Next we estimate the potential CH4 and CO2 that might be generated in the subsurface through deep well injection of biosolids material that have already undergone surface digestion. We can consider several possible scenarios:

1) Assuming 100% of the remaining volatile solids (after surface digestion) will be eventually converted to biogas, at a ratio of 65% methane to 35% CO2;
2) Assuming the remaining volatile solids (after surface digestion) are destroyed by an additional 58%, at a ratio of 65% methane to 35% CO2; and
3) Assuming biosolids are converted to CH4 and CO2 consistent with UCLA laboratory experiments at 45 C.

Biosolids "wet cake" is about 28% solids and 72% liquid. As summarized in the Hyperion Digestion Tests in Appendix A, the ratio of volatile solids to total solids after digestion is about 62%. Therefore, each ton of Biosolids will contain about 0.174 tons of remaining volatile solids (0.28 X 0.62).

The Hyperion Tests indicate that about 34800 scf of biogas is generated from each ton of volatile solids destroyed, of which 65% is CH4 and 35% is CO2. Therefore, the amount of CH4 produced is about 22620 scf/ton volatile solids destroyed and the amount of CO2 produced is about 12180 scf/ton volatile solids destroyed. We can estimate the amount of gas that might be produced under varying biodegradation assumptions with the following equation:

CH4 produced = (22620 scf/ton VSD) X (0.174 ton VS/ton-biosolids); and
CO2 produced = (12180 scf/tonVSD) X (0.174 ton VS/ton-biosolids)

Where VS represents the amount of volatile solids and VSD represents the amount of volatile solids destroyed. Applying the equation above, Table 2 summarizes the gas production for an assumed destruction ratio (VSD/VS) in the subsurface of 100% and 58%. We further compare these estimates to the amount of as produced in the UCLA lab experiments.

Table 2. Methane and Carbon Dioxide Production Rate Estimates

Digested Gas	100% of remaining VS destroyed	58% of remaining VS destroyed	UCLA Lab Experiment @45°C
CH_4 /ton-biosolids	3936 scf/ton	2282 scf/ton	344 CF/ton
CO_2 /ton-biosolids	2119 scf/ton	1229 scf/ton	241 CF/ton

For full scale injection of about 400 tons/day x 250 days/year (about 100,000 tons/yr), the total amount of CH_4 produced might therefore range from about 34 million to 390 million cubic feet per year and the total amount of CO_2 sequestered might range from about 24 million to 212 million cubic feet per year.

Summary of Economic Benefits

There are additional tangible cost savings and other intangible benefits that will be created from deep well injection of biosolids. They can be summarized as follow:

- The cost of 269,000 lb per day of steam that is needed to heat the digester to thermophilic condition,
- The cost of dewatering sludge into biosolids,
- Transportation cost for trucking biosolids to landfills,
- Landfill cost,
- Reduced pollution and congestion related to trucking of biosolids,
- Protection of groundwater and surface water
- Reduced surface land use impairment,
- Reduced greenhouse gas release to the atmosphere, and
- Potential recovery and reuse of generated methane as a clean fuel.

Conclusions

A detailed program of monitoring, field measurements, and sampling has been proposed to accomplish the experimental objectives for the proposed biosolids injection demonstration project. The field measurements will be supported by additional laboratory experiments at high temperature and high pressure. The objectives of such measurements are to confirm that biosolids injected into the deep subsurface will be treated to high standards and eventually biodegraded into methane and carbon dioxide. We have presented in this and previous reports results from recent pilot plant tests and past laboratory tests data to support our contention that this will in fact occur. The true validation, however, will come from actual field demonstration.

Appendix A
Summary of Oct. 2001 Thermophilic/Mesophilic Digestion Data

HYPERION TREATMENT PLANT

SUMMARY OF OCT. 2001 THERMOPHILIC TESTING/MESOPHILIC DIGESTION DATA FOR BATTERY D1, D2, & E

October 2001	FEED SLUDGE		FLOW TO EACH BATTERY													DIGESTED SLUDGE								
	PS+TWAS		D1		D2		TEMPERATURE			STEAM CONSUM.			GAS PROD			TOTAL SOLIDS			VOL SOLIDS		FECAL COLI D1	FECAL COLI	LOAD	Gas Prod
	TS	TVS	PS	TWAS	PS	TWAS	D1	D2	E	D1	D2	E	D1	D2	E	DS	OUT	DESTR	TVS	VSD		D2	RATE	Rate
DATE DAY	klbs - in		MGD		MGD		F			KLBS			MSCF			%	klbs	%	klbs	%	MPN/G	MPN/G	#VS/cf/D	cf/#VSD
1 MON	841	614	0.75	0.19	0.72	0.34	129.0	96.4	96.9	237	65	39	1.99	2.28	2.02	1.7	420	50.1	272	55.6	120	17000	0.104	18.3
2 TUE	935	692	0.78	0.20	0.72	0.27	126.9	96.3	96.7	281	65	29	2.20	2.27	2.04	1.7	413	55.9	251	63.7		4800	0.117	14.7
3 WED	872	659	0.78	0.17	0.71	0.42	129.2	96.0	96.2	281	67	47	2.15	2.21	1.95	1.8	472	45.9	297	54.9	110	91000	0.111	17.4
4 THU	842	615	0.76	0.17	0.72	0.29	128.3	96.0	96.2	370	79	80	2.27	2.21	1.90	1.7	405	51.8	251	59.3		130000	0.104	17.5
5 FRI	816	597	0.73	0.14	0.72	0.20	131.6	96.1	96.3	335	85	86	2.04	2.27	2.00	1.8	410	49.8	242	59.4	11	59000	0.101	17.8
6 SAT	808	601	0.68	0.13	0.69	0.16	132.1	96.2	96.5	318	80	85	2.01	2.18	1.99	1.9	405	49.8	254	57.7	120		0.101	17.7
7 SUN	873	621	0.18	0.06	0.85	0.29	131.6	96.3	96.5	244	79	80	1.11	2.62	2.33	1.9	401	54.1	247	60.1	12		0.105	16.2
8 MON	875	630	0.58	0.19	0.72	0.24	134.3	96.3	96.4	259	78	77	1.30	2.36	2.18	1.8	412	52.9	252	60.0	92		0.106	15.3
9 TUE	934	688	0.74	0.18	0.72	0.28	133.9	96.3	96.4	233	78	72	1.86	2.38	2.17	1.9	465	50.2	285	58.5	1	1700000	0.116	15.8
10 WED	763	545	0.35	0.07	0.81	0.31	131.5	96.3	96.3	121	71	68	1.49	2.68	2.40	1.9	425	44.2	276	49.4	160	26000	0.092	24.1
11 THU	847	597	0.73	0.14	0.72	0.32	133.7	96.2	96.2	308	69	67	1.76	2.58	2.34	1.8	444	47.6	272	54.4	12		0.101	20.2
12 FRI	835	629	0.73	0.14	0.72	0.24	134.2	95.6	96.2	358	68	66	1.94	2.41	2.26	1.9	452	45.8	287	54.4	140		0.106	19.1
13 SAT	940	697	0.36	0.07	0.75	0.27	134.5	95.8	96.1	369	67	66	1.19	2.59	2.51	2.0	434	53.8	276	60.5			0.118	14.5
14 SUN	959	712	0.73	0.14	0.72	0.29	137.4	95.6	96.0	327	68	69	1.44	2.52	2.40	1.9	465	51.5	297	58.3			0.120	15.1
15 MON	850	619	0.48	0.09	0.75	0.38	133.9	95.4	96.0	317	76	82	1.57	2.42	2.11	1.8	401	52.8	251	59.4	110		0.105	16.4
16 TUE	939	673	0.58	0.14	0.78	0.30	134.1	95.3	96.0	71	79	89	1.12	2.55	2.26	1.8	415	55.8	255	62.0	100		0.114	14.0
17 WED	640	457	0.43	0.19	0.46	0.27	132.3	95.3	96.2	48	81	80	1.46	2.25	1.74	2.1	325	49.3	198	56.7			0.077	20.6
18 THU	818	603	0.77	0.28	0.76	0.31	133.0	96.0	96.5	45	78	76	1.91	2.36	1.54	1.8	395	51.7	247	59.0			0.102	16.4
19 FRI	891	635	0.87	0.31	0.86	0.28	130.5	96.3	96.8	202	76	66	2.61	2.27	0.95	1.7	376	57.8	233	63.4	120		0.107	15.2
20 SAT	854	622	0.77	0.27	0.76	0.25	129.4	96.1	95.9	244	76	53	2.47	2.27	1.42	1.9	444	48.0	274	55.9			0.105	17.9
21 SUN	856	619	0.64	0.20	0.82	0.28	126.4	96.1	94.0	302	77	41	2.50	2.30	1.59	2.5	570	33.5	338	45.4			0.105	22.7
22 MON	NC	NC	0.70	0.24	0.80	0.25	128.1	96.0	93.2	316	79	33	2.29	2.45	1.96	1.6	375	NC	223	NC			NC	NC
23 TUE	896	661	0.77	0.27	0.76	0.23	125.3	95.7	93.5	310	83	29	2.74	2.29	1.75	1.9	439	51.0	272	58.9			0.112	17.4
24 WED	885	656	0.77	0.26	0.76	0.19	127.2	95.7	92.8	317	80	29	2.65	2.12	1.58	1.8	407	54.0	251	61.7			0.111	15.8
25 THU	913	671	0.77	0.26	0.76	0.21	129.0	95.6	91.0	326	93	31	2.42	2.22	1.70	1.8	411	55.0	260	61.3			0.113	15.5
26 FRI	862	630	0.77	0.25	0.76	0.24	126.7	95.5	90.5	349	95	36	2.49	2.22	1.56	1.8	412	52.2	251	60.2			0.106	16.6
27 SAT	847	611	0.24	0.08	0.87	0.32	129.4	95.6	89.7	337	97	43	1.56	2.64	1.73	1.9	400	52.8	240	60.7	11		0.103	16.0
28 SUN	1035	772	0.77	0.24	0.76	0.30	127.0	95.7	88.9	337	97	43	2.20	2.64	1.85	2.0	519	49.9	319	58.6			0.130	14.6
29 MON	833	589	0.74	0.26	0.73	0.27	130.1	95.6	88.9	245	100	103	2.62	2.41	1.68	1.9	425	48.9	267	54.7			0.100	20.8
30 TUE	873	636	0.77	0.39	0.76	0.31	126.9	95.4	89.1	230	102	121	2.65	2.33	1.70	1.8	462	47.1	282	55.6			0.108	19.0
31 WED	831	607	0.77	0.28	0.76	0.30	127.6	95.6	89.5	286	104	122	2.53	2.27	1.64	1.8	423	49.1	262	56.8			0.103	18.7
TOTAL	25962	18960	20.50	6.01	23.20	8.60				8324	2491	2003					13221		8186					
MAXIMU	1035	772	0.87	0.39	0.87	0.42	137.4	96.4	97.6	370	104	122	2.74	2.68	2.51	2.5	570	57.8	338	63.7	160	1700000	0.130	24.1
MINIMU	640	457	0.18	0.06	0.46	0.16	120.7	64.0	88.5	45	65	29	1.11	2.12	0.95	1.6	325	33.5	198	45.4			0.077	14.0
AVERAG	865	632	0.66	0.19	0.75	0.28	130.5	115	94.4	269	80	65	2.02	2.37	1.91	1.9	426	50.4	264	57.9	88	290000	0.107	17.4

D1&D2: data for PS in VSL, total VSL and Gas/VSL for Oct. 22 = average data point

PS Primary Sludge

TWAS Thickened Waste Activated Sludge

TVS Total Volatile Solids

Destroyed Solid

Volatile Solids Loaded

Total Solids

Appendix B
Summary of Anaerobic Digestion Process Data

HYPERION TREATMENT PLANT
SUMMARY OF ANAEROBIC DIGESTION PROCESS DATA

Mon Yr	FEED SLUDGE						LOW DIGESTERS (CONVENTIONAL)									HIGH DIGESTERS (EGG-SHAPED) W/ SOME OF TANKS IN THEMOPHILIC TESTING										DIGESTER GAS		
	PS		TWAS		TVS		FLOW		DT	LOADING	T	TVS	TVS		GAS	FLOW		DT	LOADING	T	# TANK	TVS	TVS		GAS	GAS	CH4	CO2
	TS	TVS	TS	TVS	PS	TWAS	PS	TWAS		RATE	AVG	OUT	DESTR		PROD	PS	TWAS		RATE	AVG	THERM	OUT	DESTR		PROD	PROD		
	(%)		(%)		KLBS/D		MGD		DAY	#VS/CF/D	F	KLB/D	KLB/D	%	MSCF	MGD		DAY	#VS/CF/D	F	TEMP	KLB/D	KLB/D	%	MSCF/D	MSCF/D	%	%
Mar 2000	3.2	78.0	6.1	86.3	595	179	0.84	0.00	18.5	0.086	95.8	66	106	61	1.232	2.02	0.41	18.2	0.102	94.8	0	224	379	62.5	6.021	7.253	63.9	36.1
Apr	3.2	79.2	6.0	86.4	575	170	0.68	0.00	23.5	0.070	96.5	54	87	61.1	1.179	2.08	0.40	17.8	0.102	96.2	0	224	376	62.7	6.439	7.618	65	35.2
May	3.1	78.3	6.2	84.8	546	161	0.51	0.00	32.7	0.053	96.5	39	65	62.3	1.030	2.16	0.37	17.4	0.102	96.2	0	229	373	61.6	6.864	7.894	64	35.6
Jun	3.1	76.7	5.8	83.7	546	153	0.59	0.00	26.5	0.059	96.5	45	68	56.8	1.119	2.26	0.38	16.8	0.091	97.1	1	230	339	57.9	6.598	7.717	65	35.5
Jul	2.9	78.3	5.6	82.3	572	153	0.56	0.00	29.1	0.053	96.5	48	58	55.2	0.990	2.45	0.40	17.4	0.102	98.4	2	266	353	56.9	6.470	7.460	65	35.0
Aug	2.7	77.9	5.0	81.7	578	164	1.00	0.00	17.1	0.053	96.5	87	85	50.2	1.949	2.33	0.49	17.4	0.102	98.5	3	247	323	56.5	5.974	7.922	65	34.9
Sep	2.9	78.4	5.3	84.8	593	165	0.88	0.00	18.4	0.053	96.5	68	95	57.3	1.086	2.32	0.44	17.4	0.102	99.1	4	244	357	59.3	6.385	7.471	65	35.3
Oct	3.0	77.8	5.3	84.2	601	136	0.82	0.00	20.6	0.052	96.4	71	88	55.3	1.032	2.33	0.37	16.3	0.129	100.4	4	241	345	58.3	6.526	7.558	65	35.1
Nov	3.1	79.0	4.7	84.5	640	161	0.86	0.00	19.6	0.052	96.4	71	99	58.1	1.028	2.35	0.49	16.3	0.102	103.2	5	240	387	60.9	6.810	7.838	64	35.7
Dec	2.9	78.3	4.9	84.6	590	178	0.83	0.00	20.5	0.053	96.5	74	80	53.9	1.006	2.36	0.52	16.3	0.102	106.5	6	247	371	59.5	6.720	7.726	64	36.2
Jan 2001	2.8	78.4	4.7	83.9	605	173	0.94	0.00	16.9	0.054	95.9	76	97	55.3	1.727	2.35	0.53	15.0	0.102	106.0	6	229	375	60.9	6.418	8.145	64	35.7
Feb	2.9	78.4	5.8	83.7	637	151	1.05	0.10	14.5	0.055	96.2	110	97	47.7	1.912	2.37	0.27	16.4	0.101	107.4	6	219	330	59.6	6.627	8.539	64	36.0
Mar	2.9	78.3	6.4	83.7	674	191	1.23	0.02	12.3	0.054	96.2	120	109	48.3	2.062	2.39	0.41	15.4	0.102	107.2	6	241	388	61.6	6.705	8.767	64	36.2
Apr	3.0	79.2	6.4	83.7	580	178	0.62	0.00	25.9	0.054	96.3	60	61	49.1	1.697	2.37	0.40	15.7	0.102	107.7	6	237	400	61.2	6.513	8.210	64	36.0
May	3.1	78.7	5.6	83.4	631	221	0.50	0.00	32.9	0.054	96.9	47	51	53.1	1.426	2.61	0.57	13.6	0.102	107.4	6	296	455	60.4	7.080	8.506	64	35.7
Jun	3.0	78.6	5.6	82.9	520	233	0.43	0.00	38.8	0.054	96.5	40	46	53.1	1.227	2.17	0.60	15.6	0.101	107.3	6	263	400	60.1	7.501	8.728	65	35.3
Jul	2.9	77.9	5.7	81.1	527	239	0.59	0.00	26.8	0.054	96.8	53	60	52.5	1.490	2.16	0.62	15.6	0.101	106.9	6	263	388	59.5	6.690	8.180	65	35.2
Aug	2.8	78.6	5.5	82.1	519	198	0.71	0.00	22.9	0.054	96.8	66	63	49.9	1.942	2.12	0.53	16.5	0.101	107.0	6	253	332	56.4	6.077	8.019	65	34.8
Sep	2.9	78.0	5.5	81.3	516	232	0.62	0.00	25.8	0.053	96.5	57	58	50.8	1.745	2.13	0.61	15.8	0.102	107.4	6	257	375	59.3	6.522	8.267	65	35.1
Oct	3.0	77.8	5.1	81.2	509	273	0.56	0.00	28.9	0.054	96.5	53	53	50.0	1.665	2.05	0.80	15.4	0.114	107.0	6	272	400	58.9	6.278	7.944	65	35.3
Nov	2.9	78.8	5.3	82.1	511	198	0.56	0.00	28.3	0.055	96.3	51	57	52.8	1.639	2.06	0.55	16.6	0.101	104.0	6	250	349	57.6	6.359	7.998	64	35.7
Dec	2.9	79.4	5.7	82.7	525	213	0.60	0.00	26.3	0.059	95.4	61	56	49.7	1.738	2.07	0.54	16.6	0.105	103.7	6	246	372	59.9	6.719	8.457	64	35.7
Jan 2002	3.0	79.0	5.6	82.5	535	249	0.65	0.00	24.2	0.064	95.9	56	71	57.1	1.952	2.06	0.65	16.0	0.111	102.2	6	247	408	61.5	6.181	8.133	64	36.1
Feb	2.9	78.9	5.5	82.8	558	265	0.83	0.00	18.6	0.080	95.2	72	86	55.6	2.228	2.04	0.70	15.8	0.111	103.3	6	245	414	62.6	5.938	8.166	64	36.1
AVE																											64.4	35.6