

MEMORANDUM

Lamb Island Dairy Remediation Project – Performance Estimates for Overland Flow Terraces and HIA-EcoReactor- Swale System

TO: Terry Horan/HSA
COPIES: Bob Knight/WSI
FROM: Chris Keller/WSI
DATE: February 12, 2004

The attached performance estimates were prepared at the request of HSA Engineers and Scientists (HSA) based upon direction provided by the South Florida Water Management District (District). These estimates provide a variation on previous phosphorus (P) removal modeling work completed by WSI (WSI, 2003a; WSI, 2003b) for the Lamb Island Dairy Remediation Project. These results represent expected P removal for individual 24-hour rainfall events (1-year, 5-year, and 10-year return periods). Exhibit 1 presents the estimated edge of field concentrations for each of the storm events identified above for varying runoff P concentrations (3.5 milligrams per liter [mg/L] and 7.9 mg/L).

EXHIBIT 1

Estimated Edge of Field Phosphorus Concentrations

Case	1-yr	5-yr	10-yr
Overland Flow Terraces			
P _{runoff} = 3.5 mg/L	3.0	3.1	3.2
P _{runoff} = 7.9 mg/L	6.7	7.0	7.2
HIA-Ecoreactor-Swale			
P _{runoff} = 7.9 mg/L	4.2	4.4	4.6

It should be noted that the k-C* model (Kadlec and Knight, 1996) used for this and previous project memoranda was not developed for single rainfall event modeling. Accordingly, the model output is representative of expected system performance if the hydraulic and P loading rates shown in the following output sheets were sustained over a long period of time. Actual performance may vary from the estimates summarized above.

References

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. CRC/Lewis Publishers, Boca Raton, FL. 893 pp.

Wetland Solutions, Inc. 2003a. Draft Memorandum –Lamb Island Dairy Remediation Project – Estimated Performance of Overland Flow Terraces. Prepared for HSA Engineers and Scientists. December 3, 2003.

Wetland Solutions, Inc. 2003b. Draft Memorandum – Estimated Performance of the Proposed Lamb Island Dairy Remediation Project. Prepared for HSA Engineers and Scientists. November 10, 2003.

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 1-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	1.9	1.9	1.9	2.8	6.3	11.2	16.2	23.4

Annual Average Runoff Rate (gpm) 1433 2544 3654 5291

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	2.064	1433	8.0	2,920	7,812	20.3	74.2
Q _{out} =	2.064	1,433	8.0	2,920	7,812	20.3	74.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀ 10.2
TP _{runoff} =	3.50	60.24	6.34	27.32	7.11	C* 0.05
TP _{FWM} =	3.50	60.24	6.34	27.32	7.11	θ 1.00
TP _{out} =	3.06	52.61	5.54	23.86	6.21	
TP _{rem} =	0.44	7.63	0.80	3.46	0.90	
TP _{rem} (%) =	13	13	13	13	13	

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	2.064	1,433	7.1	2,593	7,812	18.0	65.9
Q _{runoff} =	1.599	1111	5.5	2,009	6,054	14.0	51.0
Q _{out} =	3.663	2,544	12.6	4,602	13,865	32.0	116.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	3.06	52.61	4.92	23.86	5.51	k ₂₀ 10.2
TP _{runoff} =	3.50	46.68	4.36	21.17	4.89	C* 0.05
TP _{FWM} =	3.25	99.29	9.28	45.03	10.40	θ 1.00
TP _{out} =	2.98	91.12	8.52	41.32	9.54	
TP _{rem} =	0.27	8.17	0.76	3.71	0.86	
TP _{rem} (%) =	8	8	8	8	8	

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.663	2,544	61.3	22,381	13,865	155.7	568.5
Q _{runoff} =	1.599	1111	26.8	9,772	6,054	68.0	248.2
Q _{out} =	5.262	3,654	88.1	32,153	19,919	223.8	816.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	2.98	91.12	41.42	41.32	46.41	k ₂₀ 10.2
TP _{runoff} =	3.50	46.68	21.22	21.17	23.78	C* 0.05
TP _{FWM} =	3.14	137.80	62.64	62.50	70.19	θ 1.00
TP _{out} =	3.10	136.12	61.87	61.73	69.34	
TP _{rem} =	0.04	1.68	0.77	0.76	0.86	
TP _{rem} (%) =	1	1	1	1	1	

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	5.262	3,654	12.1	4,421	19,919	30.8	112.3
Q _{runoff} =	2.357	1637	5.4	1,980	8,922	13.8	50.3
Q _{out} =	7.619	5,291	17.5	6,401	28,841	44.5	162.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	3.10	136.12	8.51	61.73	9.53	k ₂₀ 14
TP _{runoff} =	3.50	68.80	4.30	31.20	4.82	C* 0.05
TP _{FWM} =	3.22	204.91	12.81	92.93	14.35	θ 1.00
TP _{out} =	2.963	188.27	11.77	85.38	13.19	
TP _{rem} =	0.26	16.64	1.04	7.55	1.17	
TP _{rem} (%) =	8	8	8	8	8	

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 5-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	2.8	2.8	2.8	3.8	9.3	16.6	23.8	33.6

Annual Average Runoff Rate (gpm) 2112 3749 5385 7606

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	3.041	2112	11.8	4,303	11,512	29.9	109.3
Q _{out} =	3.041	2,112	11.8	4,303	11,512	29.9	109.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	10.2
TP _{runoff} =	3.50	88.77	9.34	40.26	10.47	C*	0.05
TP _{FWM} =	3.50	88.77	9.34	40.26	10.47	θ	1.00
TP _{out} =	3.19	80.97	8.52	36.72	9.55		
TP _{rem} =	0.31	7.80	0.82	3.54	0.92		
TP _{rem} (%) =	9	9	9	9	9		

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.041	2,112	10.5	3,821	11,512	26.6	97.0
Q _{runoff} =	2.357	1637	8.1	2,961	8,922	20.6	75.2
Q _{out} =	5.398	3,749	18.6	6,781	20,433	47.2	172.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.19	80.97	7.57	36.72	8.48	k ₂₀	10.2
TP _{runoff} =	3.50	68.80	6.43	31.20	7.21	C*	0.05
TP _{FWM} =	3.33	149.77	14.00	67.92	15.69	θ	1.00
TP _{out} =	3.14	141.29	13.20	64.08	14.80		
TP _{rem} =	0.19	8.48	0.79	3.85	0.89		
TP _{rem} (%) =	6	6	6	6	6		

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	5.398	3,749	90.4	32,983	20,433	229.5	837.8
Q _{runoff} =	2.357	1637	39.5	14,401	8,922	100.2	365.8
Q _{out} =	7.755	5,385	129.8	47,384	29,355	329.7	1203.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.14	141.29	64.22	64.08	71.97	k ₂₀	10.2
TP _{runoff} =	3.50	68.80	31.27	31.20	35.04	C*	0.05
TP _{FWM} =	3.25	210.08	95.49	95.28	107.01	θ	1.00
TP _{out} =	3.22	208.34	94.70	94.48	106.12		
TP _{rem} =	0.03	1.75	0.79	0.79	0.89		
TP _{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	7.755	5,385	17.9	6,515	29,355	45.3	165.5
Q _{runoff} =	3.199	2221	7.4	2,687	12,108	18.7	68.3
Q _{out} =	10.953	7,606	25.2	9,203	41,463	64.0	233.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.22	208.34	13.02	94.48	14.59	k ₂₀	14
TP _{runoff} =	3.50	93.37	5.84	42.34	6.54	C*	0.05
TP _{FWM} =	3.30	301.70	18.86	136.83	21.13	θ	1.00
TP _{out} =	3.114	284.43	17.78	128.99	19.92		
TP _{rem} =	0.19	17.28	1.08	7.83	1.21		
TP _{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 10-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	3.8	3.8	3.8	4.8	12.7	22.5	32.3	44.7
Annual Average Runoff Rate (gpm)					2866	5087	7309	10114

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	4.127	2866	16.0	5,840	15,623	40.6	148.3
Q _{out} =	4.127	2,866	16.0	5,840	15,623	40.6	148.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	10.2
TP _{runoff} =	3.50	120.47	12.68	54.64	14.21	C*	0.05
TP _{FWM} =	3.50	120.47	12.68	54.64	14.21	θ	1.00
TP _{out} =	3.27	112.58	11.85	51.06	13.28		
TP _{rem} =	0.23	7.89	0.83	3.58	0.93		
TP _{rem} (%) =	7	7	7	7	7		

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	4.127	2,866	14.2	5,185	15,623	36.1	131.7
Q _{runoff} =	3.199	2,221	11.0	4,018	12,108	28.0	102.1
Q _{out} =	7.326	5,087	25.2	9,203	27,731	64.0	233.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.27	112.58	10.52	51.06	11.79	k ₂₀	10.2
TP _{runoff} =	3.50	93.37	8.73	42.34	9.78	C*	0.05
TP _{FWM} =	3.37	205.95	19.25	93.40	21.57	θ	1.00
TP _{out} =	3.23	197.28	18.44	89.47	20.66		
TP _{rem} =	0.14	8.66	0.81	3.93	0.91		
TP _{rem} (%) =	4	4	4	4	4		

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	7.326	5,087	122.6	44,762	27,731	311.5	1137.0
Q _{runoff} =	3.199	2,221	53.5	19,544	12,108	136.0	496.4
Q _{out} =	10.524	7,309	176.2	64,306	39,839	447.5	1633.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.23	197.28	89.67	89.47	100.49	k ₂₀	10.2
TP _{runoff} =	3.50	93.37	42.44	42.34	47.56	C*	0.05
TP _{FWM} =	3.31	290.65	132.11	131.81	148.05	θ	1.00
TP _{out} =	3.29	288.87	131.30	131.01	147.14		
TP _{rem} =	0.02	1.78	0.81	0.81	0.91		
TP _{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	10.524	7,309	24.2	8,842	39,839	61.5	224.6
Q _{runoff} =	4.040	2,806	9.3	3,395	15,294	23.6	86.2
Q _{out} =	14.565	10,114	33.5	12,237	55,133	85.2	310.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	3.29	288.87	18.05	131.01	20.23	k ₂₀	14
TP _{runoff} =	3.50	117.94	7.37	53.49	8.26	C*	0.05
TP _{FWM} =	3.35	406.80	25.43	184.49	28.49	θ	1.00
TP _{out} =	3.204	389.15	24.32	176.49	27.26		
TP _{rem} =	0.15	17.65	1.10	8.00	1.24		
TP _{rem} (%) =	4	4	4	4	4		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 1-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	1.9	1.9	1.9	2.8	6.3	11.2	16.2	23.4

Annual Average Runoff Rate (gpm) 1433 2544 3654 5291

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	2.064	1433	8.0	2,920	7,812	20.3	74.2
Q _{out} =	2.064	1,433	8.0	2,920	7,812	20.3	74.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	10.2
TP _{runoff} =	7.90	135.96	14.31	61.66	16.04	C*	0.05
TP _{FWM} =	7.90	135.96	14.31	61.66	16.04	θ	1.00
TP _{out} =	6.89	118.60	12.48	53.79	13.99		
TP _{rem} =	1.01	17.36	1.83	7.87	2.05		
TP _{rem} (%) =	13	13	13	13	13		

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	2.064	1,433	7.1	2,593	7,812	18.0	65.9
Q _{runoff} =	1.599	1111	5.5	2,009	6,054	14.0	51.0
Q _{out} =	3.663	2,544	12.6	4,602	13,865	32.0	116.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	6.89	118.60	11.08	53.79	12.42	k ₂₀	10.2
TP _{runoff} =	7.90	105.37	9.85	47.79	11.04	C*	0.05
TP _{FWM} =	7.33	223.97	20.93	101.57	23.46	θ	1.00
TP _{out} =	6.72	205.38	19.19	93.14	21.51		
TP _{rem} =	0.61	18.59	1.74	8.43	1.95		
TP _{rem} (%) =	8	8	8	8	8		

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2.2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.663	2,544	61.3	22,381	13,865	155.7	568.5
Q _{runoff} =	1.599	1111	26.8	9,772	6,054	68.0	248.2
Q _{out} =	5.262	3,654	88.1	32,153	19,919	223.8	816.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	6.72	205.38	93.36	93.14	104.62	k ₂₀	10.2
TP _{runoff} =	7.90	105.37	47.90	47.79	53.67	C*	0.05
TP _{FWM} =	7.08	310.75	141.25	140.93	158.29	θ	1.00
TP _{out} =	6.99	306.92	139.51	139.19	156.34		
TP _{rem} =	0.09	3.83	1.74	1.74	1.95		
TP _{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	5.262	3,654	12.1	4,421	19,919	30.8	112.3
Q _{runoff} =	2.357	1637	5.4	1,980	8,922	13.8	50.3
Q _{out} =	7.619	5,291	17.5	6,401	28,841	44.5	162.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	6.99	306.92	19.18	139.19	21.50	k ₂₀	14
TP _{runoff} =	7.90	155.28	9.71	70.42	10.88	C*	0.05
TP _{FWM} =	7.27	462.20	28.89	209.62	32.37	θ	1.00
TP _{out} =	6.678	424.33	26.52	192.44	29.72		
TP _{rem} =	0.60	37.87	2.37	17.18	2.65		
TP _{rem} (%) =	8	8	8	8	8		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 5-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	2.8	2.8	2.8	3.8	9.3	16.6	23.8	33.6

Annual Average Runoff Rate (gpm) 2112 3749 5385 7606

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	3.041	2112	11.8	4,303	11,512	29.9	109.3
Q _{out} =	3.041	2,112	11.8	4,303	11,512	29.9	109.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	10.2
TP _{runoff} =	7.90	200.36	21.09	90.87	23.63	C*	0.05
TP _{FWM} =	7.90	200.36	21.09	90.87	23.63	θ	1.00
TP _{out} =	7.20	182.62	19.22	82.82	21.54		
TP _{rem} =	0.70	17.74	1.87	8.05	2.09		
TP _{rem} (%) =	9	9	9	9	9		

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.041	2,112	10.5	3,821	11,512	26.6	97.0
Q _{runoff} =	2.357	1637	8.1	2,961	8,922	20.6	75.2
Q _{out} =	5.398	3,749	18.6	6,781	20,433	47.2	172.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.20	182.62	17.07	82.82	19.13	k ₂₀	10.2
TP _{runoff} =	7.90	155.28	14.51	70.42	16.26	C*	0.05
TP _{FWM} =	7.51	337.91	31.58	153.25	35.39	θ	1.00
TP _{out} =	7.08	318.61	29.78	144.49	33.37		
TP _{rem} =	0.43	19.30	1.80	8.75	2.02		
TP _{rem} (%) =	6	6	6	6	6		

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	5.398	3,749	90.4	32,983	20,433	229.5	837.8
Q _{runoff} =	2.357	1637	39.5	14,401	8,922	100.2	365.8
Q _{out} =	7.755	5,385	129.8	47,384	29,355	329.7	1203.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.08	318.61	144.82	144.49	162.29	k ₂₀	10.2
TP _{runoff} =	7.90	155.28	70.58	70.42	79.10	C*	0.05
TP _{FWM} =	7.33	473.89	215.40	214.91	241.39	θ	1.00
TP _{out} =	7.27	469.92	213.60	213.11	239.36		
TP _{rem} =	0.06	3.97	1.81	1.80	2.02		
TP _{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	7.755	5,385	17.9	6,515	29,355	45.3	165.5
Q _{runoff} =	3.199	2221	7.4	2,687	12,108	18.7	68.3
Q _{out} =	10.953	7,606	25.2	9,203	41,463	64.0	233.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.27	469.92	29.37	213.11	32.91	k ₂₀	14
TP _{runoff} =	7.90	210.74	13.17	95.57	14.76	C*	0.05
TP _{FWM} =	7.45	680.65	42.54	308.69	47.67	θ	1.00
TP _{out} =	7.021	641.35	40.08	290.86	44.92		
TP _{rem} =	0.43	39.31	2.46	17.83	2.75		
TP _{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 10-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

Total	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
	3.8	3.8	3.8	4.8	12.7	22.5	32.3	44.7

Annual Average Runoff Rate (gpm) 2866 5087 7309 10114

Terrace Compartment 1

Parameter	acres	ft ²	hectares	m ²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	4.127	2866	16.0	5,840	15,623	40.6	148.3
Q _{out} =	4.127	2,866	16.0	5,840	15,623	40.6	148.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀ 10.2
TP _{runoff} =	7.90	271.92	28.62	123.32	32.08	C* 0.05
TP _{FWM} =	7.90	271.92	28.62	123.32	32.08	θ 1.00
TP _{out} =	7.38	253.97	26.73	115.18	29.96	
TP _{rem} =	0.52	17.96	1.89	8.14	2.12	
TP _{rem} (%) =	7	7	7	7	7	

Terrace Compartment 2

Parameter	acres	ft ²	hectares	m ²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	4.127	2,866	14.2	5,185	15,623	36.1	131.7
Q _{runoff} =	3.199	2221	11.0	4,018	12,108	28.0	102.1
Q _{out} =	7.326	5,087	25.2	9,203	27,731	64.0	233.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	7.38	253.97	23.74	115.18	26.60	k ₂₀ 10.2
TP _{runoff} =	7.90	210.74	19.70	95.57	22.07	C* 0.05
TP _{FWM} =	7.61	464.71	43.43	210.75	48.67	θ 1.00
TP _{out} =	7.28	444.99	41.59	201.81	46.60	
TP _{rem} =	0.32	19.71	1.84	8.94	2.06	
TP _{rem} (%) =	4	4	4	4	4	

Terrace Compartment 3

Parameter	acres	ft ²	hectares	m ²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	7.326	5,087	122.6	44,762	27,731	311.5	1137.0
Q _{runoff} =	3.199	2221	53.5	19,544	12,108	136.0	496.4
Q _{out} =	10.524	7,309	176.2	64,306	39,839	447.5	1633.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	7.28	444.99	202.27	201.81	226.67	k ₂₀ 10.2
TP _{runoff} =	7.90	210.74	95.79	95.57	107.35	C* 0.05
TP _{FWM} =	7.47	655.73	298.06	297.39	334.01	θ 1.00
TP _{out} =	7.42	651.68	296.22	295.55	331.95	
TP _{rem} =	0.05	4.06	1.84	1.84	2.07	
TP _{rem} (%) =	1	1	1	1	1	

Wetland Compartment

Parameter	acres	ft ²	hectares	m ²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	10.524	7,309	24.2	8,842	39,839	61.5	224.6
Q _{runoff} =	4.040	2806	9.3	3,395	15,294	23.6	86.2
Q _{out} =	14.565	10,114	33.5	12,237	55,133	85.2	310.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters
TP _{in} =	7.42	651.68	40.73	295.55	45.64	k ₂₀ 14
TP _{runoff} =	7.90	266.20	16.64	120.72	18.64	C* 0.05
TP _{FWM} =	7.56	917.88	57.37	416.27	64.29	θ 1.00
TP _{out} =	7.226	877.71	54.86	398.06	61.47	
TP _{rem} =	0.33	40.16	2.51	18.21	2.81	
TP _{rem} (%) =	4	4	4	4	4	

Lamb Island Dairy
Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 1-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	1.9	2.8	1.9	6.3	7.9	10.2
Annual Average Runoff Rate (gpm)				1433	1776	2314

HIA

Parameter	acres	ft ²	hectares	m ²
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	2.064	1433	1.9	694	7,812	4.8	17.6
Q _{out} =	2.064	1,433	1.9	694	7,812	4.8	17.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	0
TP _{runoff} =	7.90	135.96	3.40	61.66	3.81	C*	0.05
TP _{FWM} =	7.90	135.96	3.40	61.66	3.81	θ	1.00
TP _{out} =	7.90	135.96	3.40	61.66	3.81		
TP _{rem} =	0.00	0.00	0.00	0.00	0.00		
TP _{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft ²	hectares	m ²
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	2.064	1,433	11.7	4,268	7,812	29.7	108.4
Q _{runoff} =	0.494	343	2.8	1,022	1,871	7.1	26.0
Q _{out} =	2.558	1,776	14.5	5,290	9,682	36.8	134.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.90	135.96	20.92	61.66	23.44	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	6.37	135.96	20.92	61.66	23.44	θ	1.00
TP _{out} =	5.75	122.61	18.86	55.61	21.14		
TP _{rem} =	0.63	13.35	2.05	6.05	2.30		
TP _{rem} (%) =	10	10	10	10	10		

Swale

Parameter	acres	ft ²	hectares	m ²
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	2.558	1,776	18.8	6,877	9,682	47.9	174.7
Q _{runoff} =	0.774	537	5.7	2,081	2,929	14.5	52.8
Q _{out} =	3.332	2,314	24.5	8,957	12,611	62.3	227.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	5.75	122.61	24.52	55.61	27.48	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	4.41	122.61	24.52	55.61	27.48	θ	1.00
TP _{out} =	4.15	115.38	23.08	52.33	25.86		
TP _{rem} =	0.26	7.24	1.45	3.28	1.62		
TP _{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy

Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 5-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	2.8	3.8	2.8	9.3	11.4	14.9
Annual Average Runoff Rate (gpm)				2112	2578	3370

HIA

Parameter	acres	ft ²	hectares	m ²
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	3.041	2112	2.8	1,022	11,512	7.1	26.0
Q _{out} =	3.041	2,112	2.8	1,022	11,512	7.1	26.0

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	0
TP _{runoff} =	7.90	200.36	5.01	90.87	5.61	C*	0.05
TP _{FWM} =	7.90	200.36	5.01	90.87	5.61	θ	1.00
TP _{out} =	7.90	200.36	5.01	90.87	5.61		
TP _{rem} =	0.00	0.00	0.00	0.00	0.00		
TP _{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft ²	hectares	m ²
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.041	2,112	17.2	6,289	11,512	43.8	159.7
Q _{runoff} =	0.671	466	3.8	1,387	2,539	9.7	35.2
Q _{out} =	3.712	2,578	21.0	7,676	14,050	53.4	195.0

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.90	200.36	30.83	90.87	34.54	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	6.47	200.36	30.83	90.87	34.54	θ	1.00
TP _{out} =	6.03	186.59	28.71	84.62	32.17		
TP _{rem} =	0.45	13.78	2.12	6.25	2.38		
TP _{rem} (%) =	7	7	7	7	7		

Swale

Parameter	acres	ft ²	hectares	m ²
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	3.712	2,578	27.3	9,979	14,050	69.4	253.5
Q _{runoff} =	1.140	792	8.4	3,066	4,317	21.3	77.9
Q _{out} =	4.852	3,370	35.7	13,045	18,367	90.8	331.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	6.03	186.59	37.32	84.62	41.82	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	4.61	186.59	37.32	84.62	41.82	θ	1.00
TP _{out} =	4.42	178.95	35.79	81.16	40.11		
TP _{rem} =	0.19	7.64	1.53	3.46	1.71		
TP _{rem} (%) =	4	4	4	4	4		

Lamb Island Dairy
 Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 10-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	3.8	4.8	3.8	12.7	15.3	20.0
Annual Average Runoff Rate (gpm)				2866	3454	4529

HIA

Parameter	acres	ft ²	hectares	m ²
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	0.000	0	0.0	0	0	0.0	0.0
Q _{runoff} =	4.127	2866	3.8	1,387	15,623	9.7	35.2
Q _{out} =	4.127	2,866	3.8	1,387	15,623	9.7	35.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	0.00	0.00	0.00	0.00	0.00	k ₂₀	0
TP _{runoff} =	7.90	271.92	6.80	123.32	7.62	C*	0.05
TP _{FWM} =	7.90	271.92	6.80	123.32	7.62	θ	1.00
TP _{out} =	7.90	271.92	6.80	123.32	7.62		
TP _{rem} =	0.00	0.00	0.00	0.00	0.00		
TP _{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft ²	hectares	m ²
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	4.127	2,866	23.4	8,535	15,623	59.4	216.8
Q _{runoff} =	0.847	588	4.8	1,752	3,207	12.2	44.5
Q _{out} =	4.974	3,454	28.2	10,287	18,830	71.6	261.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	7.90	271.92	41.83	123.32	46.88	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	6.55	271.92	41.83	123.32	46.88	θ	1.00
TP _{out} =	6.22	257.84	39.67	116.94	44.45		
TP _{rem} =	0.34	14.08	2.17	6.38	2.43		
TP _{rem} (%) =	5	5	5	5	5		

Swale

Parameter	acres	ft ²	hectares	m ²
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m ³ /d	cm/d	m/yr
Q _{in} =	4.974	3,454	36.6	13,374	18,830	93.1	339.7
Q _{runoff} =	1.548	1075	11.4	4,161	5,859	29.0	105.7
Q _{out} =	6.522	4,529	48.0	17,535	24,688	122.0	445.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP _{in} =	6.22	257.84	51.57	116.94	57.79	k ₂₀	14
TP _{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP _{FWM} =	4.74	257.84	51.57	116.94	57.79	θ	1.00
TP _{out} =	4.60	249.95	49.99	113.36	56.02		
TP _{rem} =	0.15	7.90	1.58	3.58	1.77		
TP _{rem} (%) =	3	3	3	3	3		