Nutrient Transport in a Restored Riparian Wetland

G. Vellidis, R. Lowrance, P. Gay, and R. K. Hubbard (2003).

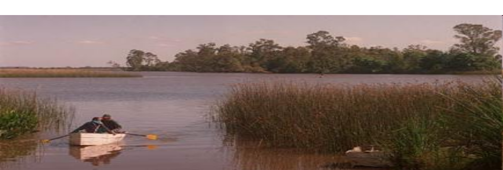
J. Environ. Qual. Vol 32

Presented by Bruno Bazzoni, Natalie Corrales & Adriana Rodríguez

Introduction

Although a number of studies of riparian forest buffer restoration were begun in the 1990s, and some components of these studies have been reported, the authors exposed that there are still very few estimates of the ability of restored riparian forest buffers to remove nutrients from agricultural runoff and shallow ground water.

- **The <u>objective</u> of this study was to determine the effects of a restored forested riparian wetland system on surface transport of N and P entering the buffer from adjacent upland agricultural production sites, including a liquid manure application area and a pasture.**





Materials & Methods

Study Site

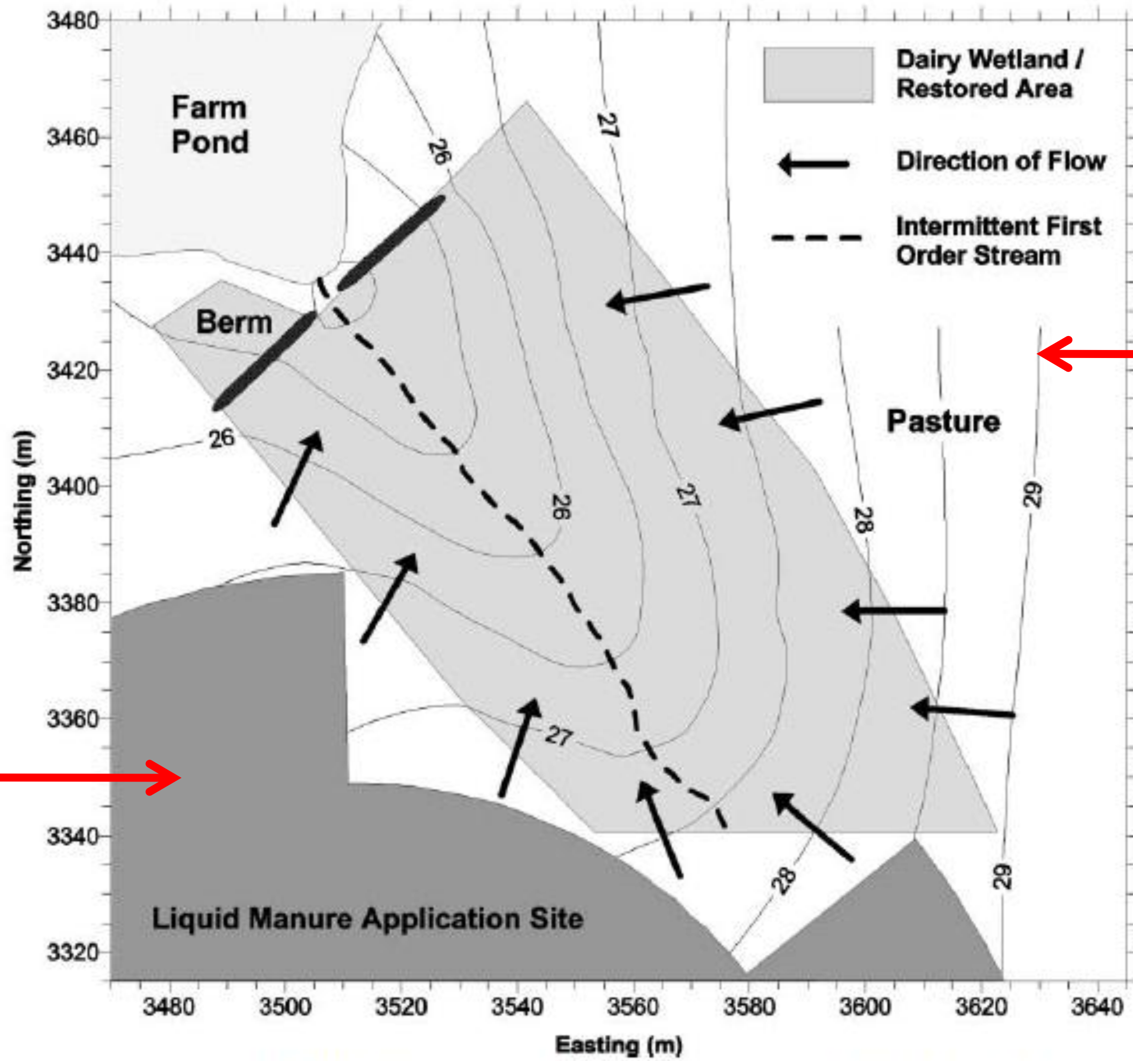
Animal & Dairy Science Research Farm :
Dairy Wetland

The **climate** is humid subtropical (mean temp. 19ºC) with abundant rainfall (av. 1210 mm/year during study, 1991-1999)

Fig. 1. The Dairy Wetland research site is located near Tifton, Georgia, within the Suwannee River basin of the U.S. Coastal Plain.

Materials & Methods

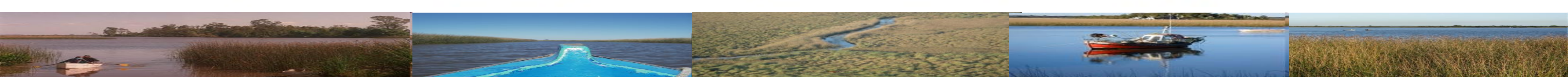
Study Site



300 kg N/ha yr + 150 kg P/ ha yr

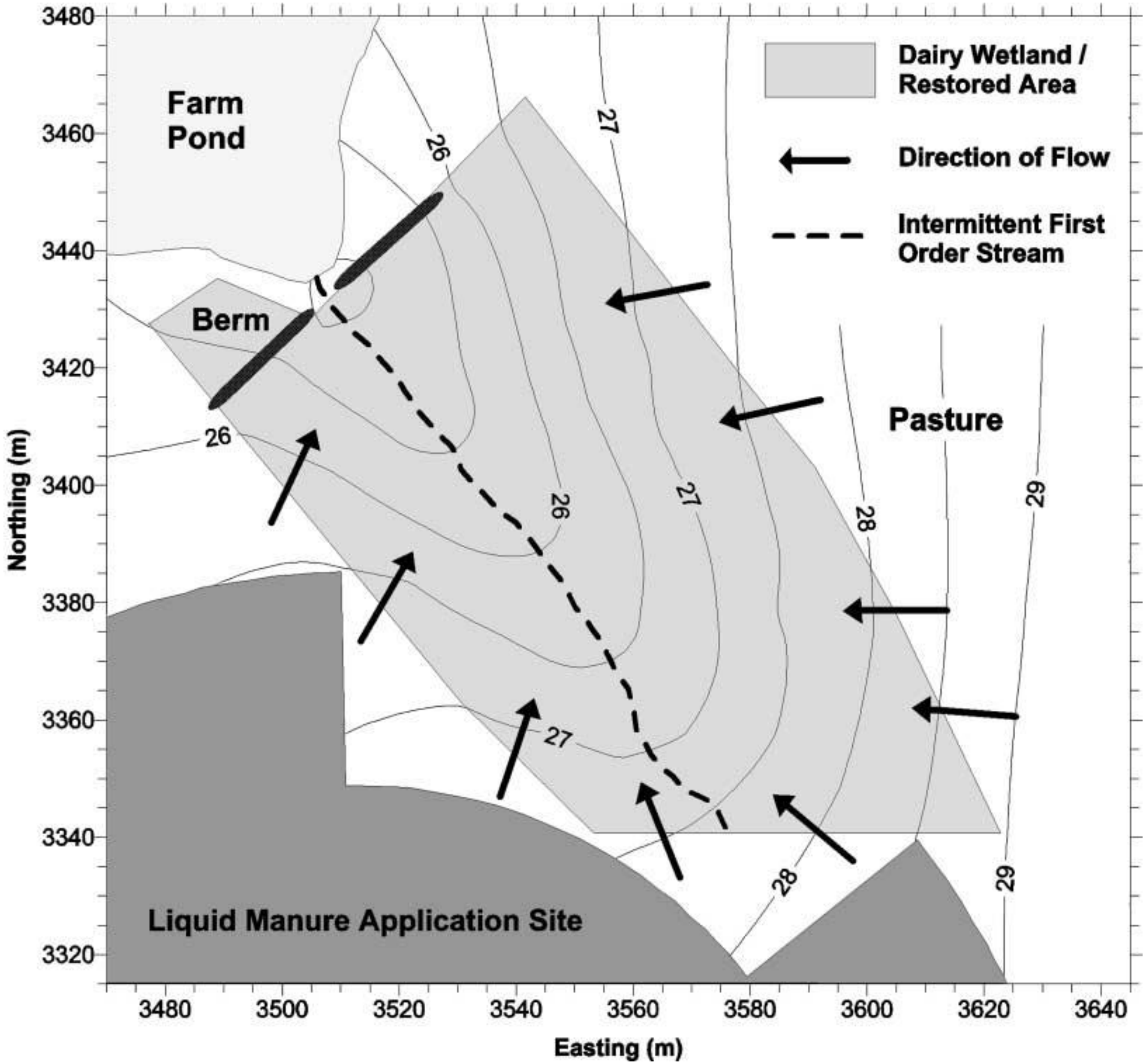
600 kgN/ha yr

Fig. 2. Topography and hydrography of the Dairy Wetland (shaded light gray) and the surrounding uplands. Elevations are given in meters above an arbitrary reference point. Berms along the northern edge of the Dairy Wetland route surface flow to a flume at the outlet.



Materials & Methods

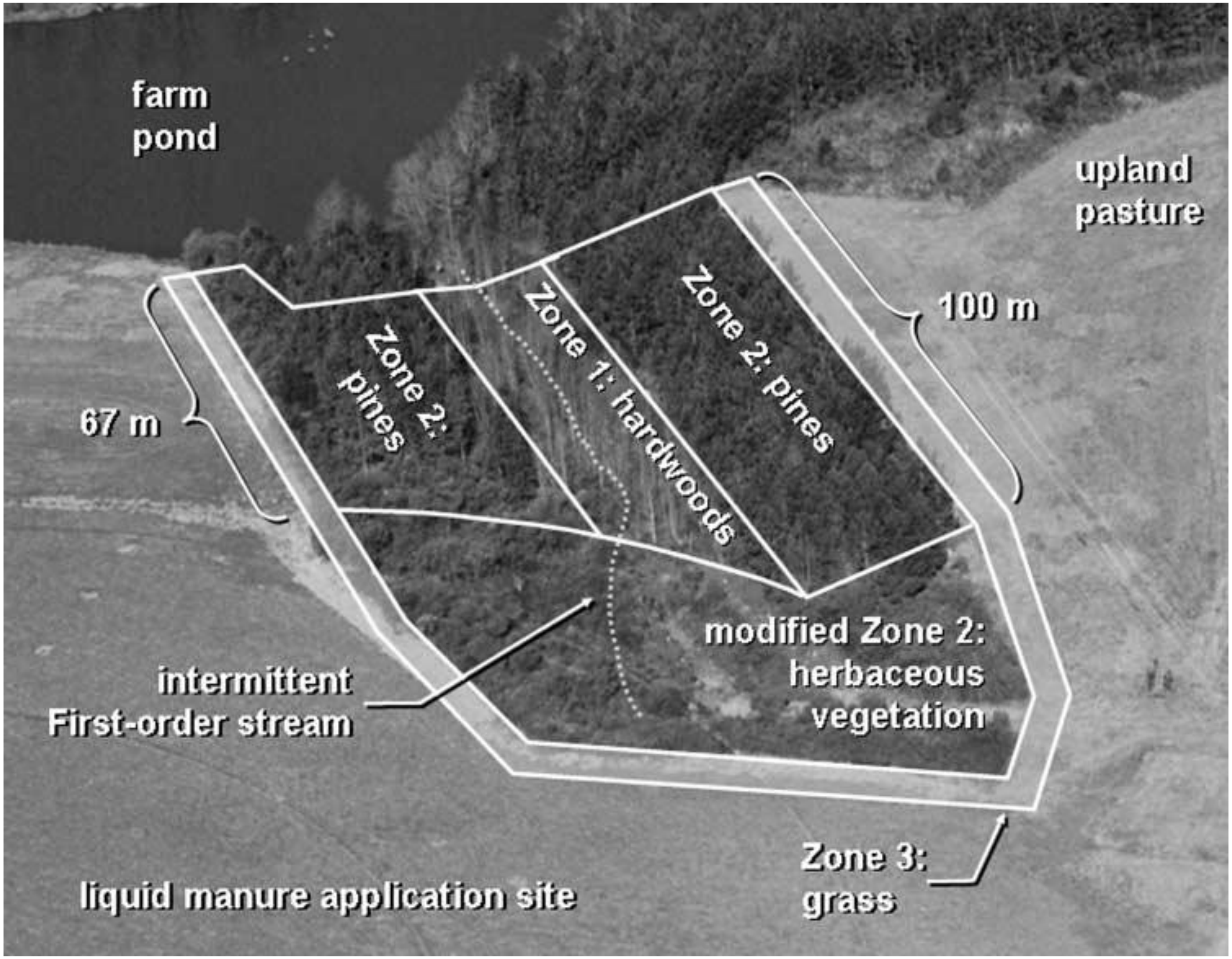
Size : 1 ha
First order stream (intermittent)
Depth: 1.5m



Topography and hydrography of the Dairy Wetland (shaded light gray) and the surrounding uplands.

Materials & Methods

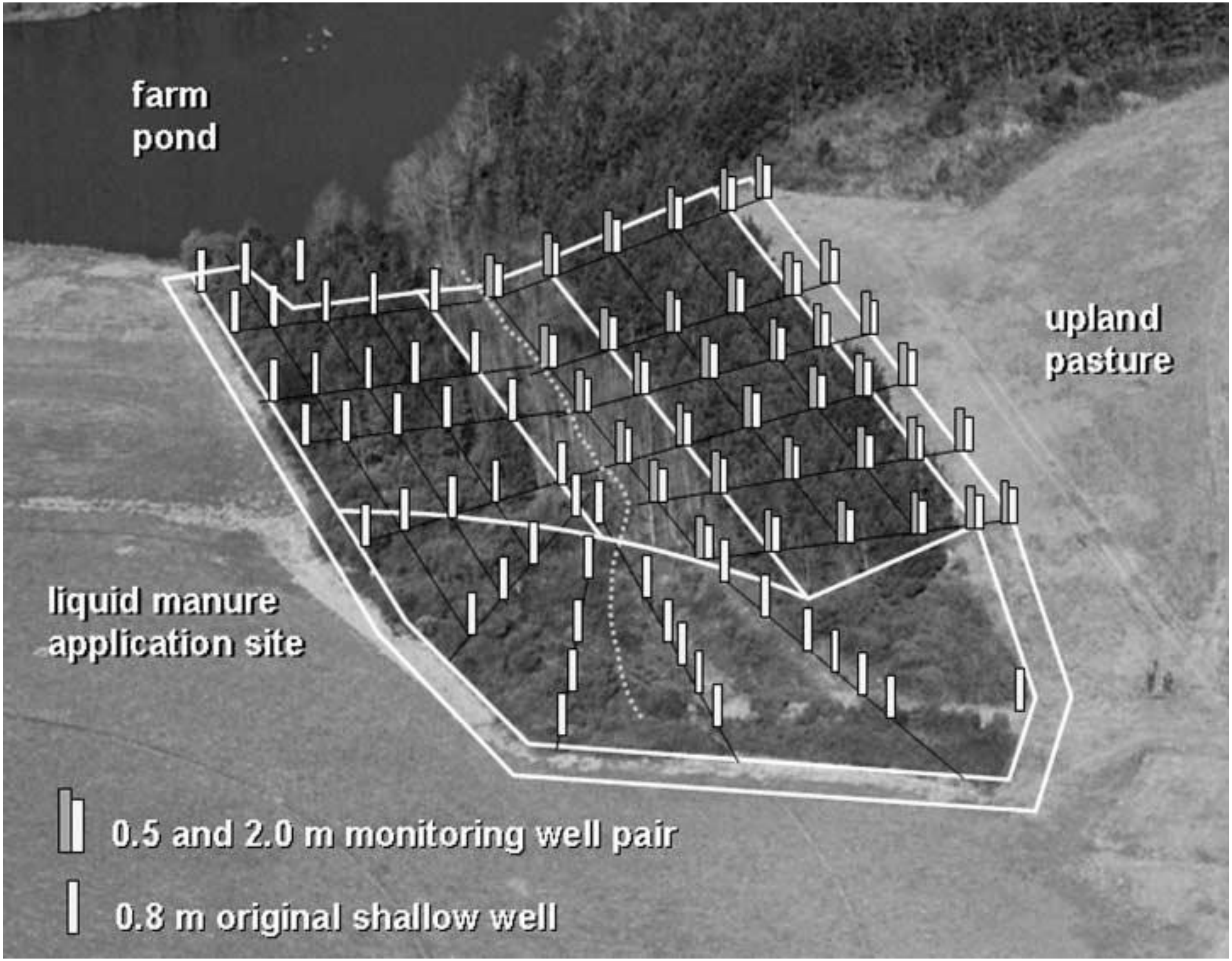
Restoration Design



Perspective view of the Dairy Wetland and the surrounding uplands showing how the three-zone riparian buffer system was implemented during restoration of the site.

Materials & Methods

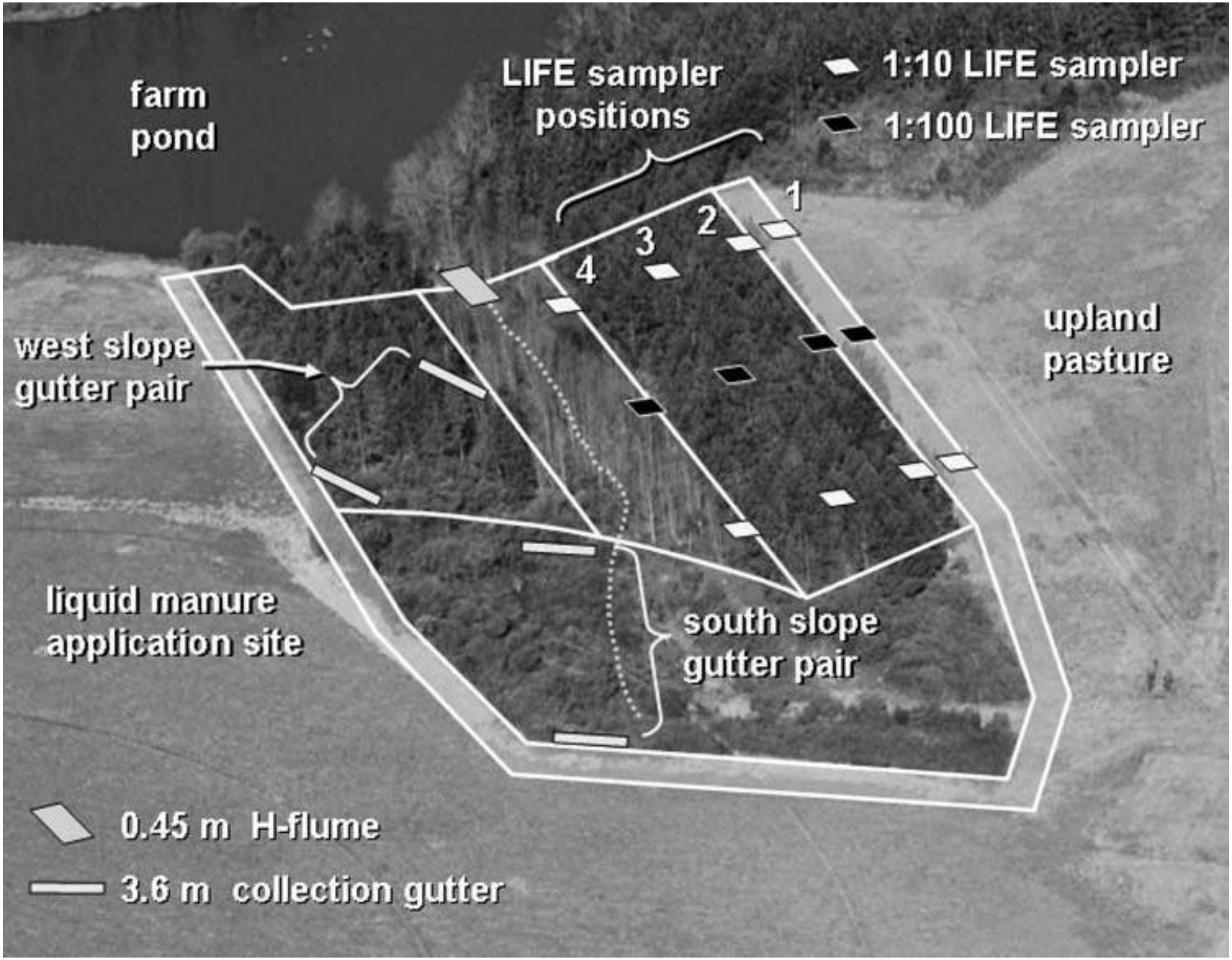
Ground water Monitoring



Perspective view of the Dairy Wetland and the surrounding uplands showing the ground water monitoring well network consisting of 42 original shallow wells and 72 new wells.

Run off Monitoring

Materials & Methods



Perspective view of the Dairy Wetland and the surrounding uplands showing the location of the paired 3.6-m collection gutters, the 12 low-impact flow event surface runoff collectors, the H-flume, and the boundaries of the three zones.

Materials & Methods

Analysis in samples (surface run off & ground water):

NO_3^- –N

NH_4^+-N

DRP

Cl^-

PT

TKN

Water & Nutrient Mass Balances:

entering run off

entering subsurface flow

precipitation

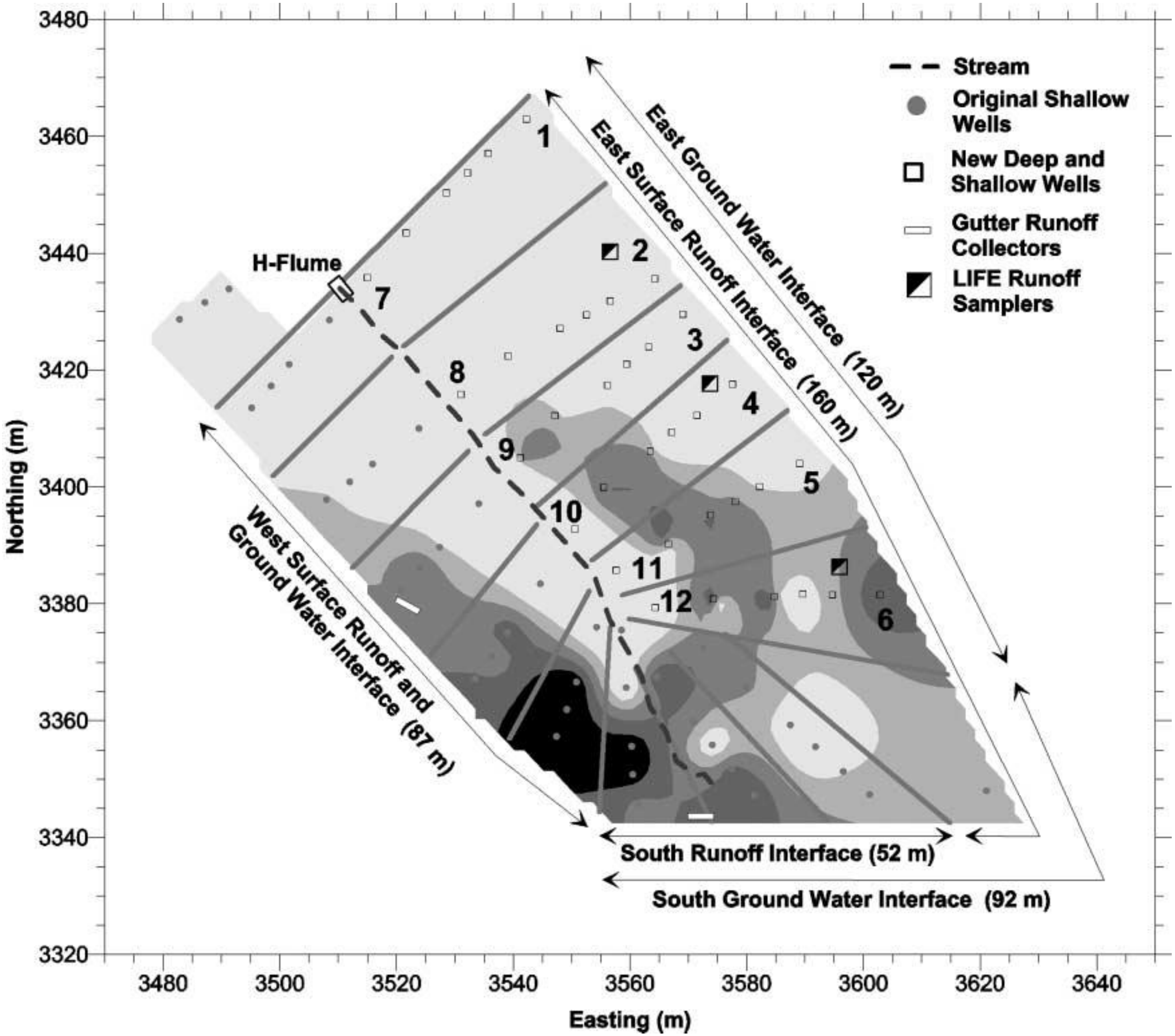
existing streamflow

existing subsurface flow

evapotranspiration

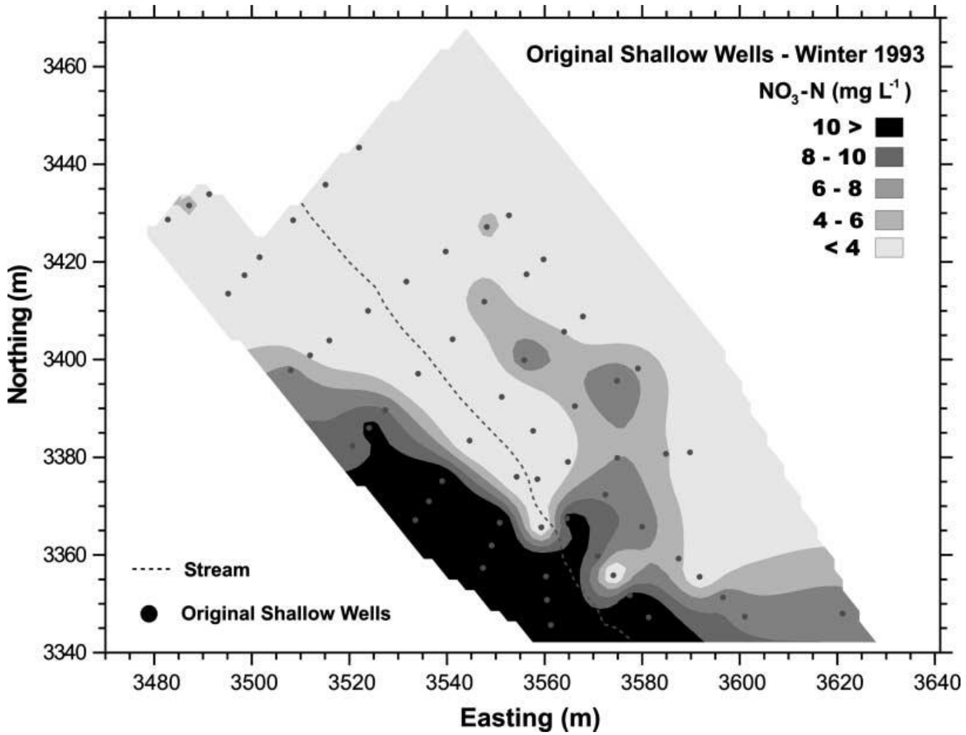
Materials & Methods

Data Analysis



Map of the Dairy Wetland showing the contributing areas assigned to each well to calculate ground water loads and the surface runoff and ground water perimeter interface lengths. The map is superimposed on a shallow ground water nitrate contour map.

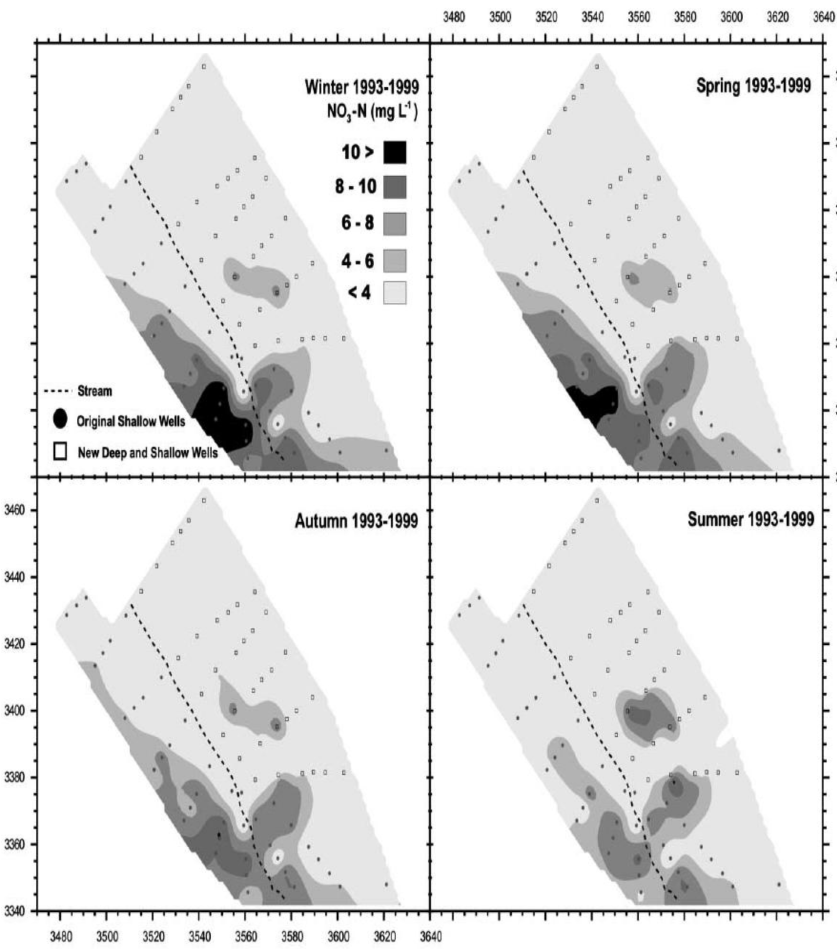
Results & Discusion



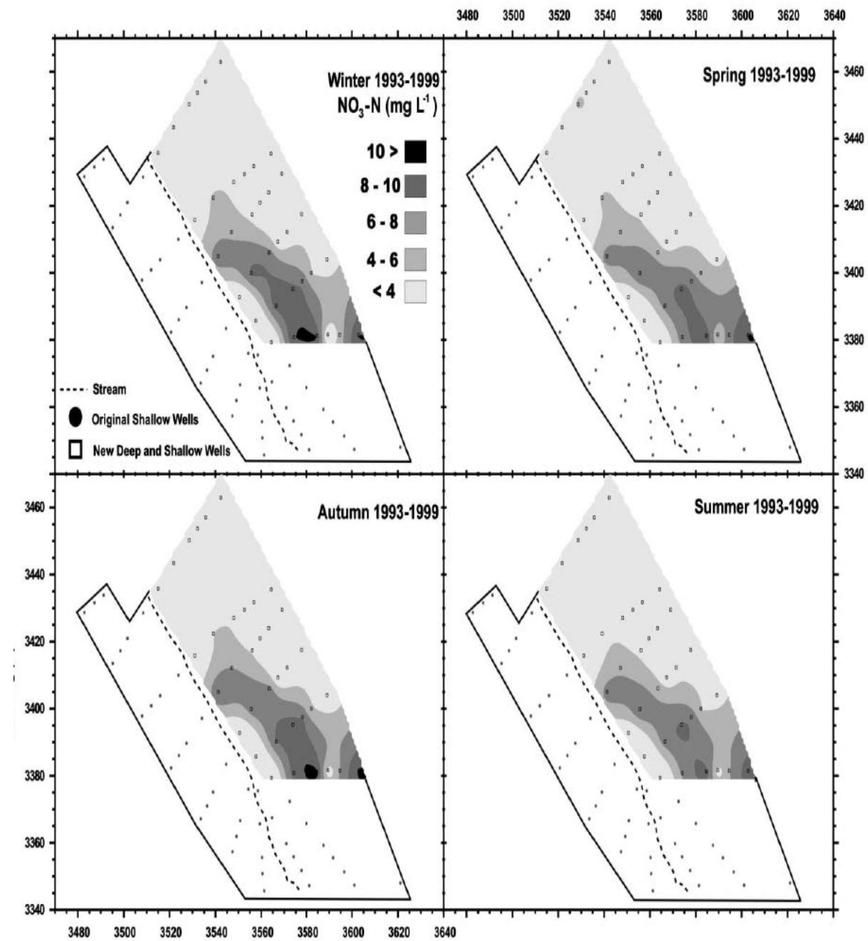
63 shallow wells (0.1–0.8 m)

- Distinct preferential flow paths through the wetland, and partial bypass
- The front plume is attenuated
- The location of the plume coincides with the location of the old drainage ditches

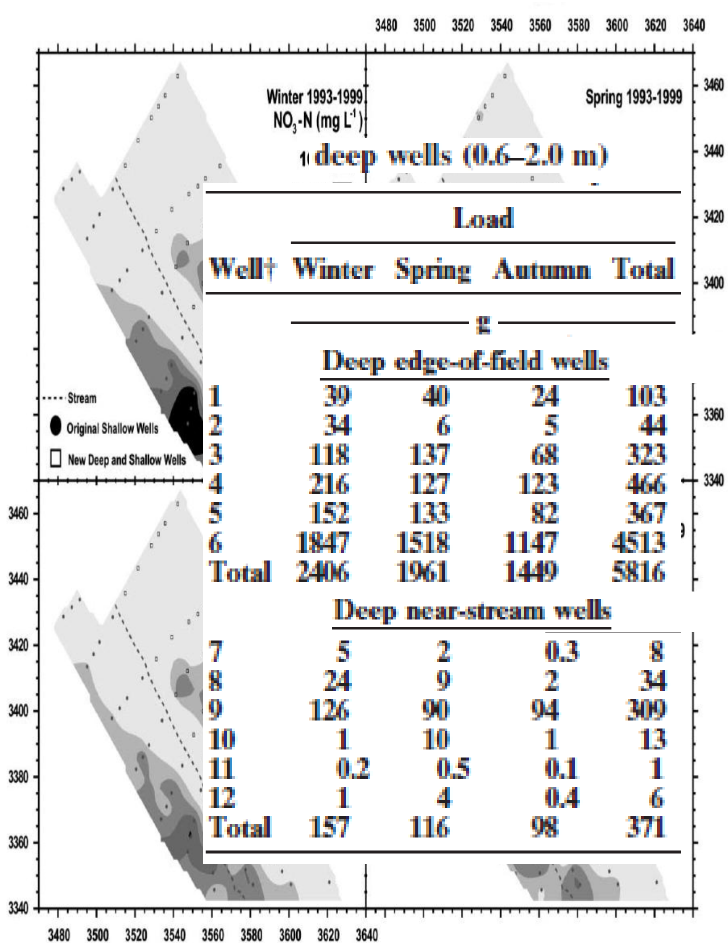
- Incoming concentrations higher in winter and spring



42 shallow wells (0.1–0.8 m) and
36 new shallow (0.1–0.6 m) wells.



36 deep wells (0.6–2.0 m)



deep wells (0.6–2.0 m)

Well†	Load: Winter	Spring	Autumn	Total
	g			
	Deep edge-of-field wells			
1	39	40	24	103
2	34	6	5	44
3	118	137	68	323
4	216	127	123	466
5	152	133	82	367
6	1847	1518	1147	4513
Total	2406	1961	1449	5816
	Deep near-stream wells			
7	5	2	0.3	8
8	24	9	2	34
9	126	90	94	309
10	1	10	1	13
11	0.2	0.5	0.1	1
12	1	4	0.4	6
Total	157	116	98	371

Deep and Shallow wells

Deep wells

42 shallow wells (0.1–0.8 m) and
36 deep wells (0.6–2.0 m) wells.

Mean nutrient concentrations in surface runoff

Position	Mean nutrient concentration						
	NO_3–N	NH_4–N	TKN†	Total N	Cl	DRP‡	Total P
	mg L^{-1}						
	Trough collectors						
F4, south upslope	1.18 (0.16, 226)	0.96 (0.27, 223)	7.51 (0.69, 109)	8.48 (0.71, 109)	23.0 (0.90, 225)	2.00 (0.11, 225)	2.01 (0.18, 85)
F1, south downslope	0.58 (0.15, 398)	1.03 (0.26, 398)	4.94 (0.46, 202)	5.25 (0.46, 202)	23.7 (0.56, 399)	0.70 (0.08, 399)	0.94 (0.13, 140)
Significance level	<0.0001	0.0001	<0.0001	<0.0001	0.18 (NS§)	<0.0001	<0.0001
F3, west upslope	0.86 (0.18, 73)	1.19 (0.43, 72)	12.99 (2.88, 41)	13.6 (1.89, 41)	19.1 (1.71, 72)	2.14 (0.51, 73)	2.30 (0.47, 34)
F2, west downslope	0.31 (0.06, 181)	0.35 (0.09, 180)	5.95 (0.58, 113)	6.19 (0.59, 113)	27.2 (1.1, 180)	0.53 (0.13, 181)	0.33 (0.05, 88)
Significance level	<0.0001	<0.0001	0.07 (NS)	0.008	<0.0001	<0.0001	<0.0001

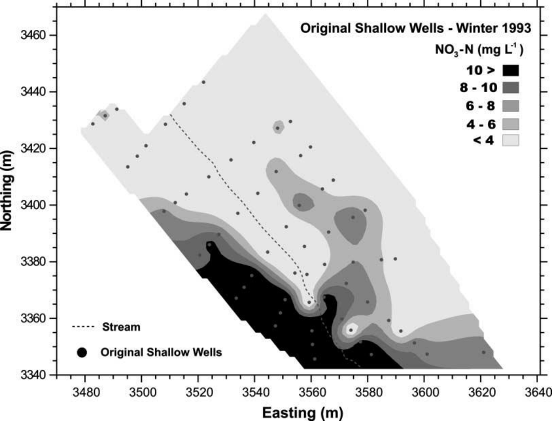
• Most results were as expected with edge of field concentrations significantly higher than the stream flow outputs. **The exception was ammonium**.





Table 3. Measured annual water balance and nutrient mass balance in the Dairy Wetland.

Budget item and interface length	Water	Nutrients						
		NO_3–N	NH_4–N	TKN†	Total N	Cl	DRP‡	Total P
	$m^3\ yr^{-1}$	$kg\ yr^{-1}$						
Entering Dairy Wetland								
Entering with runoff								
West edge, 87 m	1 963	1.1	0.5	14.6	15.7	32.9	2.1	3.3
South Edge, 52 m	5 690	11.4	3.3	43.7	55.2	118.7	7.7	12.1
East Edge, 160 m	6 595	2.4	3.8	31.8	34.2	102.1	2.1	2.5
Total, 299 m	14 248	14.9	7.6	90.1	105.1	253.7	11.9	17.9
Entering with ground water								
West edge, 87 m	643	3.9	0.3	3.2	7.1	20.9	0.1	0.9
South edge, 92 m	766	4.1	0.1	2.3	6.4	14.4	0.1	1.6
East edge deep, 120 m	671	5.8	0.1	0.6	6.4	13.7	0.0	0.0
East edge shallow, 120 m	446	0.2	0.1	1.0	1.2	9.2	0.0	0.0
Total, 299 m	2 527	14.0	0.6	7.1	21.1	58.2	0.2	2.5
Precipitation	12 100	1.7	8.1	11.2	12.9	3.6	0.4	0.4
Total entering	28 900	30.6	16.3	108.4	139.1	315.5	12.5	20.8
Leaving Dairy Wetland								
Leaving with runoff								
H-flume, peaks	5 914	1.3	2.4	20.7	22.0	97.9	1.8	2.3
H-flume, base flow	5 201	2.2	3.0	12.8	14.9	101.2	1.3	1.6
Total	11 115	3.5	5.4	33.5	36.9	199.1	3.1	3.9
Leaving with ground water								
West stream, 73 m	633	0.2	0.4	4.0	4.2	29.6	0.1	1.3
South stream, 21 m	159	0.9	0.0	0.5	1.4	3.5	0.0	0.2
East stream deep, 78 m	124	0.4	0.1	0.1	0.5	2.7	0.0	0.0
East stream shallow, 78 m	314	0.1	0.1	0.6	0.8	5.3	0.0	
Total, 172 m	1 230	1.6	0.6	5.2	6.9	41.1	0.1	1.5
Evapotranspiration	9 780							
Total leaving	22 130	5.1	6.0	38.7	43.8	240.2	3.2	5.4
Differences								
Difference§	6 800	25.5	10.3	69.7	95.3	75.3	9.3	15.4
Retention and removal, %¶	23	83	63	64	69	24	74	74
Balanced total leaving#	29 060	6.7	7.9	50.8	57.5	315.5	4.2	7.1
Balanced difference	−160	23.9	8.4	57.6	81.6	0.0	8.3	13.7
Balanced retention and removal, %	−1	78	52	53	59	0	66	66



Water and Nutrient Mass Balance

- Loads to the west and south edges can be attributed to the liquid manure land application
- Loads to the east edge can be attributed to the pasture

- Entering water volumes are dominated by runoff and precipitation
- The south edge received the highest influx of water in surface runoff; given by increased seepage and runoff from liquid dairy manure put onto the upland.
- Incoming ground water volumes are similar from the three sides
- Retention and removal rates for nitrogen species ranged from aprox. 78% for nitrate to 52% for ammonium, and final retention rates for both DRP and total P were 66%.
- Denitrification was 83% of the balanced N retention and removal. The reminder of the N and the P retention would be accounted for by vegetation uptake and soil storage.
- Flow- weighted concentrations for this watershed were 1.01 (for N) and 0,27 (for P) mg/L. This is twice the Nitrogen and the same Phophorus concentration than the larger watershed that contains it.

1) What are the main findings of WET functioning in your paper?

Reduce the load of N and P

2) Is there any doubt about the functioning of WET as an ecosystem services given in your paper?

No

3) Can WET reduce the load of N and P, and how efficient is it?

It can reduce NT 59%, NO_3 78%, NH_4 52% & PT 66%

4) How to install and manage this system?

Hidrology, headwater of the watershed, first order stream. Hardwoods and pinus, herbaceus and grasses. Restored one, original vegetation.

Monitoring input and output of runoff, ground water. Harvesting

5)Other ecosystem services given by this system?

Erosion, Carbon Sink, Aesthetic value, Habitat diversity, N_2 producer