Table 1. Average Wetland Influent Hydraulic and BOD_5 Loading Rate Parameters

Influent Loading Rate	Hydraulic Loading Rate	Hydraulic[a] Retention Time	BOD[b] Loading Rate		TKN[d] Loading Rate	
	L/day	days	mg/L	kg/ha/day[c]	mg/L	kg/ha/day[c]
High	13,234	5.7	80.6	13.18	89.3	14.60
Medium	8,043	8.7	80.6	8.01	89.3	8.87
Low	5,821	11.4	80.6	5.80	89.3	6.42

[a]Hydraulic Retention Time (HRT) $= \frac{(L)(W)(y)(n)}{Q}$

Where: L=Length of wetland (m)
W=Width of wetland (m)
y=operating water depth, 0.1524 m
n=porosity of litter/stalks, 0.65 for mature wetland
$Q = \frac{\text{Flow in } (m^3/d) + \text{Flow out } (m^3/d)}{2}$

HRT over both tiers, $Q = \frac{\text{Flow into upper tier } (m^3/day) + \text{Flow out of lower tier } (m^3/day)}{2}$

[b]Biological/biochemical oxygen demand.
[c]BOD loading rate based on two-tiered system.
[d]Total kjeldahl nitrogen.
[e]TKN loading rate based on two-tiered system.

Table 2. Wastewater Treatment Efficiencies for Constructed Wetland Cells Loaded at Three BOD Loading Rates[a] Over 23 Months

Wetland	Upper Tier			Lower Tier		Total
	Inflow	Outflow	Reduction	Outflow	Reduction	Reduction
Loading	mg/L	mg/L	%	mg/L	%	%
High						
TKN	89.3	56.2	37.1	36.0	35.9	59.7
NH_3-N	63.6	44.3	30.3	28.7	35.2	54.9
BOD_5	80.6	37.8	53.1	24.3	35.7	69.9
TP	31.6	26.9	13.2	18.0	33.1	41.9
TSS	161.6	39.6	75.5	33.6	15.2	79.2
Medium						
TKN	89.3	45.3	49.6	27.1	40.2	69.7
NH_3-N	63.6	36.2	43.1	21.0	42.0	67.0
BOD_5	80.6	28.6	64.5	15.0	47.6	81.4
TP	31.0	22.4	27.7	15.5	30.8	50.0
TSS	161.6	34.6	78.6	25.5	26.3	84.2
Low						
TKN	89.3	33.8	62.2	20.2	40.2	77.4
NH_3-N	63.6	27.2	57.2	14.7	46.0	76.9
BOD_5	80.6	20.5	74.6	9.5	53.7	88.2
TP	31.0	16.1	48.1	10.8	32.9	65.2
TSS	161.6	28.2	82.6	25.1	11.0	84.5

[a]Loading rates (kg BOD/ha/d): high=13.18; medium=8.01; and low=5.80.
TKN Loading Rates (kg TKN/ha/d): high=14.60; medium=8.87; and low=6.42.

Table 3. Wastewater Treatment Based on Three Loading Rates of TKN[a] and BOD_5 Entering and Exiting a Two-Tiered Wetland System Over 23 Months

	Upper Tier			Lower Tier		Total
Wetland	Inflow	Outflow	Reduction	Outflow	Reduction	Reduction
Loading	kg/ha/day	kg/ha/day	%	kg/ha/day	%	%
High						
TKN	14.60	9.44	35.3	6.74	28.6	53.8
BOD_5	13.18	6.35	51.8	4.55	28.3	65.5
Medium						
TKN	8.87	4.99	43.7	3.48	30.3	60.8
BOD_5	8.01	3.15	60.7	1.92	39.0	76.0
Low						
TKN	6.42	3.05	52.5	2.07	32.1	67.8
BOD_5	5.80	1.85	68.1	0.97	47.6	83.3

[a] BOD_5 Loading Rates (kg/ha/day): high=13.18; medium=8.01; and low=5.80.
[b] TKN Loading Rates (kg/ha/day): high=14.60; medium=8.87, and low=6.42.
Note: See Table 1 for loading rate calculations.

Table 4. Overall Treatment Efficiency of Constructed Wetlands Treating Swine Lagoon Effluent

Analytes	Lagoon Effluent[a] mg/L	Recycle Water[b] after Wetland Treatment mg/L	Reduction %	Farm Pond[c] mg/L
TKN	148.5	7.7	94.8	2.1
NH_3-N	117.2	2.2	98.1	0.5
NO_3-N	1.1	3.7	+236.4	1.2
COD	492.9	103.2	79.1	40.0
BOD	125.6	13.8	89.0	3.4
TP	56.0	6.8	87.9	1.4
TSS	210.4	34.7	83.5	20.2
FCG[d]	590000	374	99.9	62

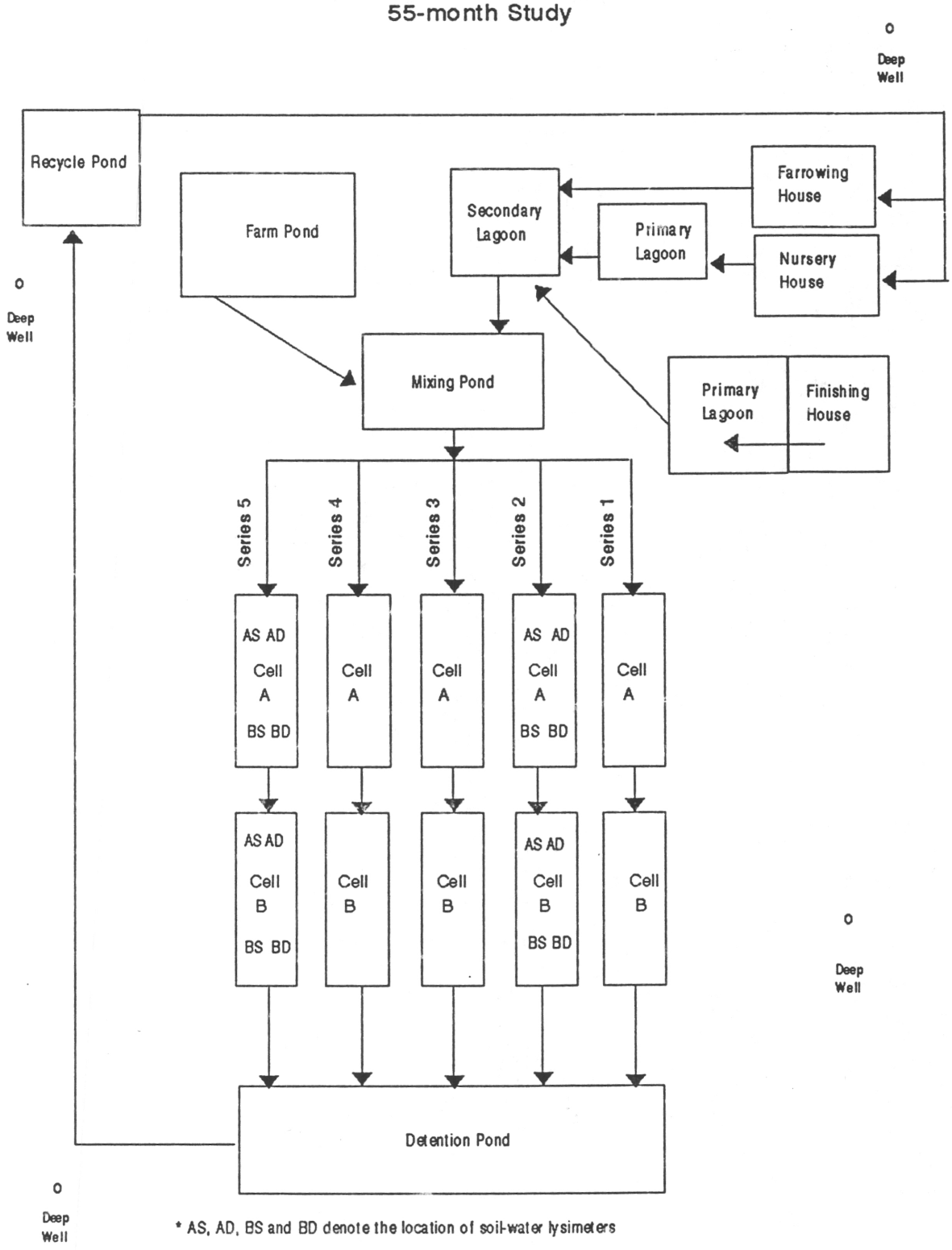
[a]Raw wastewater prior to treatment
[b]Final treated wastewater recycled for cleaning swine facilities
[c]Natural overland flow from grasslands due to rainfall events
[d]Fecal coliform bacteria, #/100 mL

Table 5. Decline of *E. coli* O157:H7 and *S. typhimurium* in wastewater

	Time to achieve 1 and 8 log reductions of bacterial counts			
	E. coli 0157:H7		*S. typhimurium*	
	1 log[a]	8 log[b]	1 log	8 log
	Days		Days	
Primary Lagoon	2.45	19.6	1.85	14.8
Secondary Lagoon	1.94	15.5	1.81	14.5
Detention Pond	2.28	18.2	1.94	15.5
Recycle Pond	2.44	19.5	2.25	18.0

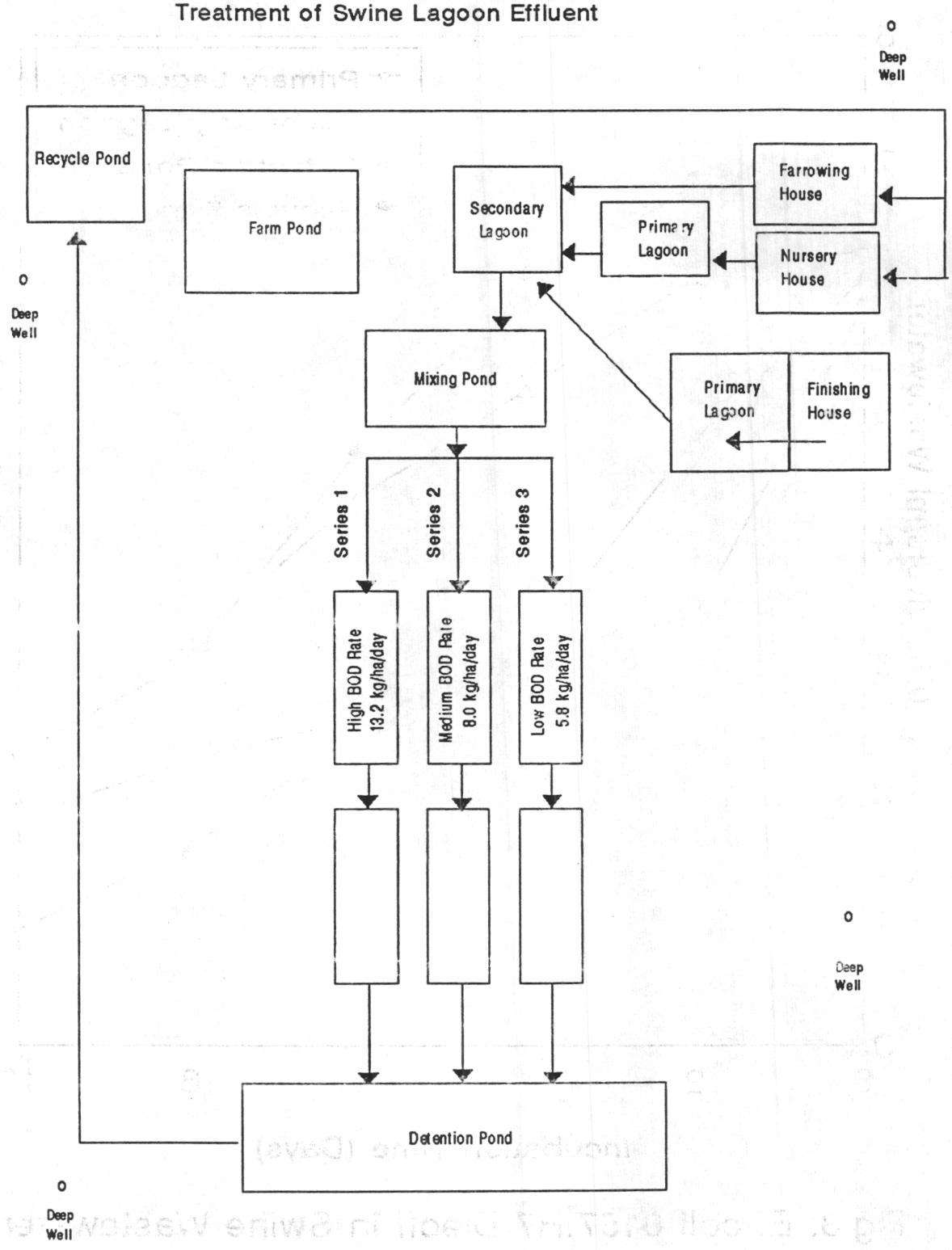
a) Days required for bacterial count to decline 1 log or 90%.
b) Days for count to decline from 1 million bacteria/ml to 1/100 ml.

Figure 1. Flow Path of Swine Lagoon Effluent Through the Constructed Wetland System at SMSS 55-month Study



* AS, AD, BS and BD denote the location of soil-water lysimeters

Figure 2. Plan View for Evaluating BOD_5 Loading on Wetland Treatment of Swine Lagoon Effluent



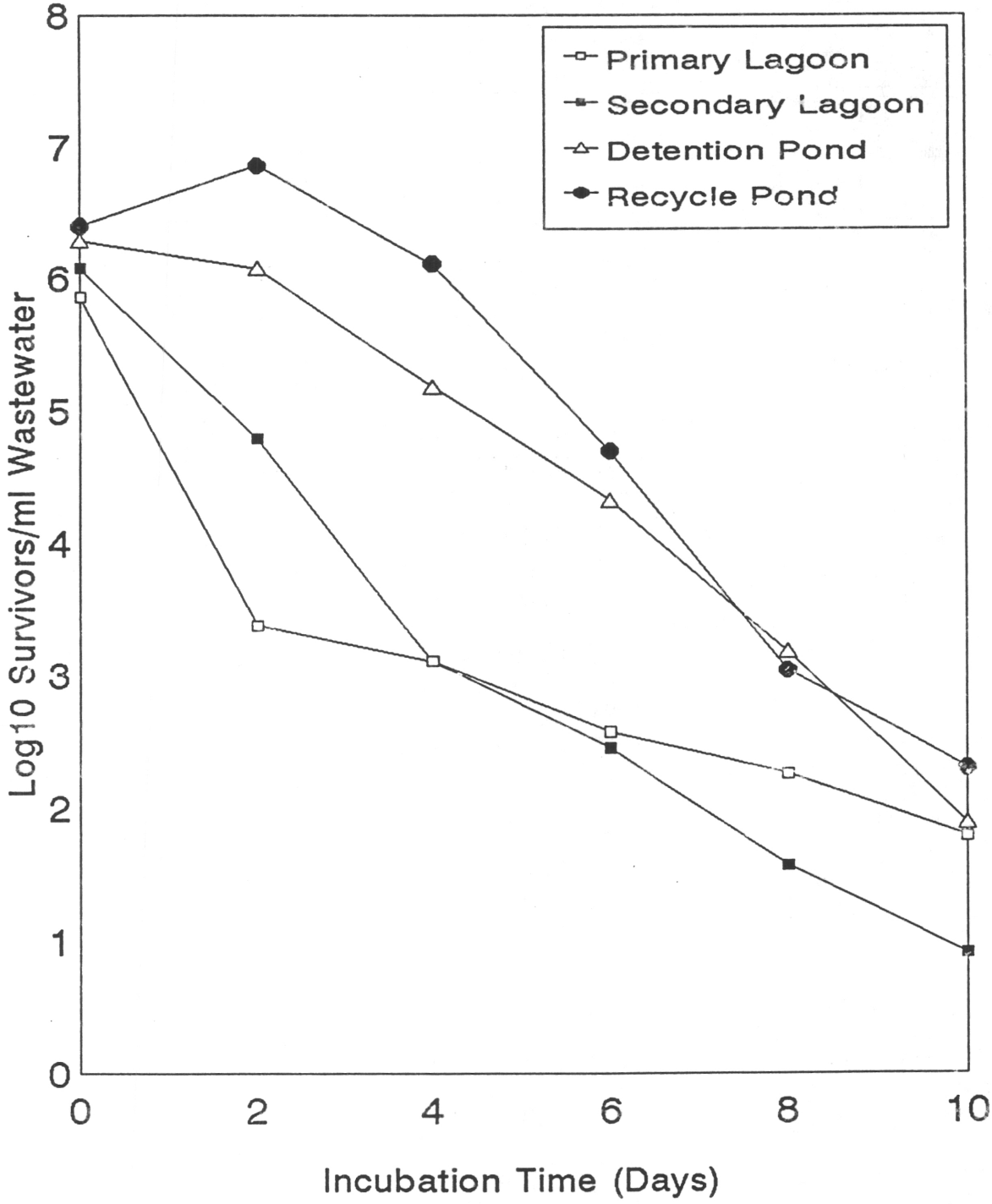


Fig.3. E. coli 0157:H7 Dieoff in Swine Wastewater

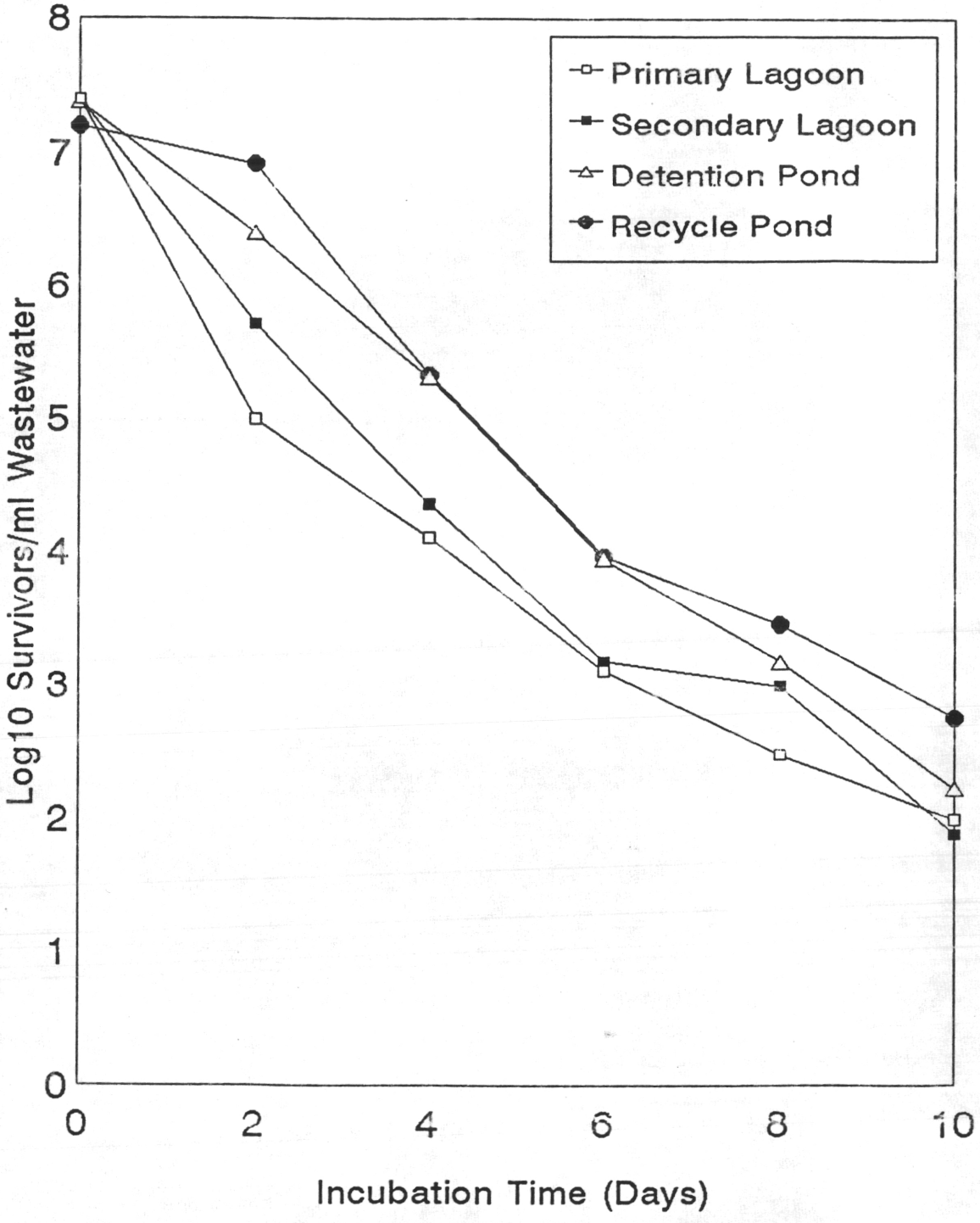


Fig.4. Salmonella Dieoff in Swine Wastewater