Appendix 1

BACKGROUND INFORMATION USED IN DESIGN CALCULATIONS

Sluice gate design

This design is based on a fully-flowing pipe formula, suitable for concrete or other pipe-type sluices

Basic Data

Area of system to be served, ha	10.000	Pipe internal dia. metres :	0.750
Minimum acceptable exchange rate/per day	0.200	Number of pipes	1.000
Average depth of pond system, metres	1.000	Pipe length metres	12.000
Pond base datum point (PB), metres	2.300	Friction factor	**0.030**
Tide curve datum point (TC), metres	0.000	**Entrance coefficient**	0.500
Starting inner level, metres (PB)	0.600	Discharge coefficient	0.7 Il
Critical tide, lower level (TC)	1.500	Scouring velocity rn/sec	0.500
Critical tide, upper level (TC)	3.750		

Tidal Curve Data

Time (Hrs.)	Degrees	TC (rn)	PB (m)	Mean lvi PB (m)	Sluice position	Flow rate m3/sec	tnti lvi (m)	Flow status	Velocity rn/sec	Protec-tion length
.000	.000	1.500	- _.800			.000	.600		.000	.000
.500	7.200	1.782	—.516	—.659	shut	.000	.600	stopped	.000	.000
1.000	14.400	2.060	_.240	– .379	shut	.000	.600	stopped	.000	.000
1.500	21.600	2.328	.028	– .106	shut	.000	.600	stopped	.000	.000
2.000	28.800	2.584	.284	***.156***	shut	.000	.600	stopped	.000	.000
2.500	36.000	2.823	.523	.403	shut	.000	.600	stopped	.000	.000
3.000	43.200	3.040	.740	.631	open	.246	.604	flowing	.557	2.452
3.500	50.000	3.234	.934	.837	open	.670	**.616**	flowing	1.517.	6.675
4.000	57.600	3.400	1.100	1.017	open	.879	.632	flowing	1.990	8.758
4.500	64.800	3.536	1.236	1.168	open	1.017	***.651***	flowing	2.302	10.130
5.000	72.000	3.640	1.340	**1.288**	open	**1.110**	**.651**	flowing	2.512	11.051
5.500	79.200	**3.710**	**1.410**	**1.375**	open	**1.167**	**.692**	flowing	2.641	**11.619**
6.000	86.400	3.746	1.446	**1.428**	open	**1.193**	**.713**	flowing	2.700	**11.878**
6.500	93.600	3.746	1.446	1.446	open	1.190	**.734**	flowing	**2.693**	**11.848**
7.000	100.800	**3.710**	**1.410**	**1.428**	open	**1.157**	**.755**	flowing	**2.620**	**11.527**
7.500	108.000	3.640	1.340	**1.375**	open	1.094	.775	flowing	2.477	10.898
8.000	115.200	3.536	1.236	**1.288**	open	.995	**.793**	flowing	**2.253**	**9.914**

Note:

TC (column 3) **stands for tidal level on local hydrographic datum.**

PB (column 4) Equivalent tidal level, at the outside of the sluice gate, on land survey **datum.**

Intl. level (column 8) **Internal pond/supply** channel level on **land survey datum.**

PB (column 4) **TC** - 2.3m, the difference between the two datum standards. This is then **related to the internal level to determine whether the gate should be shut (if outside level lower than inside) or open (the converse),** and if open, **what water velocity would** result from the difference in levels from the **outside to the** inside **of the** sluice. **The water velocity over the time period, multiplied by** the effective sluice cross sectional area, gives the incremental **volume delivered to the pond system over the period.**

Time (Hrs.)	Degrees	TC (m)	PB (rn)	Mean lvi **PB** (rn)	Sluice position	Flow rate (m3/sec)	Intl lvl (m)	Flow status	Velocity (m/sec)	Protection length
1.000	14.400	2.060	.240	.379	shut	.000	.980	stopped	.000	.000
1.500	21.600	2.328	.028	.106	shut	.000	.980	stopped	.000	.000
2.000	28.800	2.584	.284	.156	shut	.000	.980	stopped	.000	.000
2.500	36.000	2.823	.523	.403	shut	.000	.980	stopped	.000	.000
3.000	43.200	3.040	.740	.631	shut	.000	.980	stopped	.000	.000
3.500	50.400	3.234	.934	.837	shut	.000	.980	stopped	.000	.000
4.000	57.600	3.400	1.100	1.017	open	.266	.985	flowing	.603	2.652
4.500	64.800	3.536	1.236	1.168	open	.595	.995	flowing	1.346	***5.922***
5.000	72.000	3.640	1.340	1.288	open	.752	1.009	overflow	1.701	7.485
5.500	79.200	3.710	1.410	1.375	open	.841	1.024	overflow	1.903	8.375
6.000	86.400	3.746	1.446	1.428	open	.883	1.040	overflow	1.999	8.796
6.500	93.600	3.746	1.446	1.446	open	.885	1.056	overflow	2.004	8.815
7.000	100.800	3.710	1.410	1.428	open	.848	1.071	overflow	1.919	8.442
7.500	108.000	3.640	1.340	1.375	open	.766	1.085	overflow	1.734	7.630
8.000	115.200	3.356	1.236	1.288	open	.626	1.096	overflow	1.417	6.235
8.500	122.400	3.400	1.100	1.168	open	.372	1.103	overflow	.841	3.702
9.000	129.600	3.234	.934	1.017	shut	.000	1.103	stopped	.000	.000
9.500	136.800	3.040	.740	.837	shut	.000	1.103	stopped	.000	.000
10.000	144.000	2.823	.523	.631	shut	.000	1.103	stopped	.000	.000
5.000	72.000	3.640	1.340	1.288	open	.921	.865	flowing	2.085	9.174
5.500	79.200	3.710	1.410	1.375	open'	.992	.883	flowing	2.246	9.884
6.000	86.400	3.746	1.446	1.428	open	1.026	.902	flowing	2.322	10.217
6.500	93.600	3.746	1.446	1.446	open	1.025	.920	flowing	2.320	10.210
7.000	100.800	3.710	1.410	1.428	open	.990	.938	flowing	2.242	9.865
7.500	108.000	3.640	1.340	1.375	open	.919	.954	flowing	2.080	9.153
8.000	115.200	3.536	1.236	1.288	open	.803	.969	flowing	1.817	7.994
8.500	122.400	3.4(X)	1.100	1.168	open	.620	.980	flowing	1.403	6.174
9.000	129.600	3.324	.934	1.017	open	.266	.985	flowing	.602	2.650
9.500	136.800	3.040	.740	.837	shut	.000	.985	stopped	.000	.000
10.000	144.000	2.823	.523	.631	shut	.000	.985	stopped	.000	.000
10.500	151.200	2.584	.284	.403	shut	.000	.985	stopped	.000	.000
11.000	158.400	2.328	.028	.156	shut	.000	.985	stopped	.000	.000
11.500	165.600	2.060	.240	.106	shut	.000	.985	stopped	.000	.000
12.000	172.800	1.782	.518	.379	shut	.000	.985	stopped	.000	.000
12.500	180.000	1.500	.800	.659	shut	.000	.985	stopped	.000	.000
.000	.000	1.500	.800			.000	.980		.000	.000
.500	7.200	1.782	.518	.659	shut	.000	980	stopped	.000	.000
8.500	122.400	3.400	1.100	1.168	open	.851	.808	flowing	1.926	8.476
9.000	129.600	3.234	.934	1.017	open	.635	.820	flowing	1.436	6.320
9.500	136.800	3.040	.740	.837	open	.183	.823	flowing	.413	1.819
10.000	144.000	2.823	.523	.631	shut	.000	.823	stopped	.000	.000
10.500	151 .200	2.584	.284	.403	shut	.000	.823	stopped	.000	.000
11.000	158.400	2.238	.028	.156	shut	.000	.823	stopped	.000	.000
11.500	165.600	2.060	.240	.106	shut	.000	.823	stopped	.000	.000
12.000	172,800	1.782	.518	.379	shut	.000	.823	stopped	.000	.000
12.500	180.000	1.500	.800	.659	shut	.000	.823	stopped	.000	.000

Time (Hrs.)	Degrees	TC (m)	PB (m)	Mean lvl PB (m)	Sluice position	Flow rate (m^3/sec)	Intl lvi (m)	Flow status	Velocity (m/sec)	Protection length
.000	.000	1.500	.800			.000	.820		.000	.000
.500	7.200	1.782	.518	.659	shut	.000	.820	stopped	.000	.000
1.000	14.400	2.060	.240	.379	shut	.000	.820	stopped	.000	.000
1.500	21.600	2.328	.028	.106	shut	.000	.820	stopped	.000	.000
2.000	28.800	2.584	.284	.156	shut	.000	.820	stopped	.000	.000
2.500	36.000	2.823	.523	.403	shut	.000	.820	stopped	.000	.000
3.000	43.200	3.040	.740	.631	shut	.000	.820	stopped	.000	.000
3.500	50.400	3.234	.934	.837	open	.181	.823	flowing	.410	1.802
4.000	57.600	3.400	1.100	1.017	open	.611	.834	flowing	1.384	6.089
4.500	64.80	3.536	1.236	1.168	open	.803	.849	flowing	1.817	7.995
10.500	151.200	2.584	.284	.403	shut	.000	1.103	stopped	.000	.000
11.000	158.400	2.328	.028	.156	shut	.000	1.103	stopped	.000	.000
11.500	165.600	2.060	.240	.106	shut	000	1.103	stopped	.000	.000
12.000	172.800	1.782	.518	.379	shut	.000	1.103	stopped	.000	.000
12.500	180.00	1.500	.800	.659	shut	000	1.103	stopped	.000	.000

Appendix 2

COST OUTLINE: SLUICES

Option A *Seasonal cutting/refilling*

Note This provides for the use of a very simple low-cost structure during the dry season. The bund can be filled partially during the wet season, or completely filled during peak flooding time. The main disadvantages of this system are the lack of effective means of flow and level control, the difficulty of providing water exchange during periods when the wall is rebuilt to protect against flood waters.

Costs : Where width = 1.5m, CSA = 16 m^2, allowing 6 Rs/m^3 to include additional costs of loosening and reconsolidating soil, cost for 2 cycles of cutting/refilling per year is

2x2x1.5x16 = 576Rs/yr

Option B *Simple tar or oil barrel sluice*

Note This is a semi-permanent sluice, with an estimated lifespan of 5 years, if adequately protected. The system is costed with two alternative level control devices, both set internally. A sluice length of 7 metres is assumed.

Costs : *Main Sluice:* Earthworks, allow 250 Rs. 7 barrels @ 100 Rs, welding, allow 150 Rs. tar coating, allow 200 Rs, bamboo piling/fixing (allow 5 lengths) 150 Rs.

Total = 1450 Rs.

Sluice **(a) Wooden Box, 6 m x** I m x 1 m, 20 mm thick, @ 4000

Control Rs/m^3 = 1120 Rs, plus labour, 2 man-days @ 20 Rs = 40 Rs, nails, etc. 10 Rs, tar 50 Rs, broken brick/bamboo foundation, allow 100 Rs.

Total = 1320 Rs.

(b) Brick, approx 18 m^2 of single course construction, allow 50 bricks/m^2 900 bricks @ 1200 Rs. 1000 = 1080 Rs, mortar, allow 200 Rs, broken brick concrete/bamboo pile foundation, allow 300 Rs, labour 4 man-days @ 20 Rs = 80 Rs.

Total = 1660 **Rs.**

Thus annualised costs, assuming a 5-year life, net of financing charges, etc., is

Sluice with wooden control structure : **554** Rs/yr
Sluice with brick control structure : 622 **Rs/yr**

Option C *Simple 'bamboo cement' sluice*

Note : This is more experimental in concept than other designs using bamboo matting and woven strips as the tensile components in the structure, with mortar/concrete as the compressive element. As the bamboo is not very strong, and as it may deteriorate relatively quickly in these conditions, a life span of 3 years is assumed. As the control structure may last longer than this, it may be feasible either to repair the pipe section or to construct a lower-specification control section.

Costs : Bamboo mesh area, 7 m x 0.75 m dia x 2 layers = 32 m^2 @ 4 Rs/m^2 is 128 Rs. Allow 12 poles for bracing and piling @ 30 Rs = 360 Rs. Mortar at 3 mm

thicknessxl6 m^2 xI.5t/ m^3 = 720kg; 120 kgcement, 215 Rs, 600 kgsand, 80 Rs, total mortar *295* Rs. Earthworks, **allow** *250* Rs, labour allow 3 days @ 20 Rs, 60 Rs.

Total = 1093 Rs.

Thus annualised costs, including water control structure with 3- year life, would be

Sluice with **wooden control structure** : 840 Rs/yr
Sluice with brick control structure : **918 Rs/yr**

Option D *Concrete 'hume' pipe*

Note This would be the conventional form of construction. It is assumed that a **properly constructed pipe would have a life of 10 years.**

Costs **Materials** : 3 **pipes** 1000 Rs **and 2 collars @ 150 Rs,** 2.5 ft **size, total** 3300 **Rs. Piling and fixing, including concrete support for collars; allow** 1000 **Rs. Earthworks, 250 Rs, labour, allow 6 man-days @ 20 Rs = 120 Rs.**

Total = 4670 Rs.

Annualised costs, allowing 1320 Rs to replace wooden control box, and 1000 **Rs to repair brick box**

Sluice with wooden control structure : 731 Rs/yr
Sluice with brick control structure : 733 Rs/yr

Option E *Wooden sluice box*

Note **This would** use **a tarred wood box structure, similar to that of the proposed water control structure, with slightly heavier timbers. Assumed lifespan is 5 years.**

Costs **Dimensions 7 m x 0.8 m x 0.8 m by 25 cm thick = 0.56 m^3 allow 0.7 m^3 to include bracing timber, @** *4500/* m^3 **3150 Rs, plus labour, 4 man-days, 80 Rs, earthworks 250 Rs, piling/fixing, 150 Rs, tar** 200 **Rs.**

Total = 3830 Rs.

Annualised costs

Sluice with wooden control structure 1030 Rs/yr
Sluice with brick control structure : 1098 Rs/yr

Appendix 3

COST OUTLINE: PROTECTIVE WORKS

On a typical exterior sluice, a floor area of approximately 15 m^2 on each side, plus (minimum) **10 m^2 each side of external wing area and** 5 m^2 **internal wing area would be required to protect the sluice and its works from scouring. The options would be as follows**

Option A : *Single-skin brick*

Note : **A layer of brick** edge on is used, with mortar jointing, laid over a shallow broken-brick base for **the apron areas. For wall protection, reinforcing** buttresses are provided.

Costs : **Allow 60 m^2 @ 50 bricks/m^2**, plus **30% to provide foundations, abutments, etc., @** 1200 **Rs/1000, 4680 Rs. Allow 600 Rs for mortar, 16 man-days labour, 320 Rs, allow** 400 **Rs for foundations.**

Total = **6000 Rs.**

Option B : *Bamboo facing, brick apron*

Note **The apron area is constructed as option A, the walls and facing being made from woven split bamboo poles, with matting reinforcement, tied and pinned** back **into the dike.**

Costs : **Allow** 3000 **Rs. (pro-rata for area covered) fof apron, allow** 1 pole/m^2 **x 30 m^2** = 900 **Rs, plus 6 man-days for fixing,** tying, **120 Rs, plus** 100 **Rs for miscellaneous** materials.

Total = 4120 **Rs.**

Option C *Bamboo facing and apron*

Note : **Facing section as option B, apron made for a higher** density **split bamboo, over brick rubble foundation.**

Costs **Allow 1120 Rc for facings (as option B). Bamboo, fixing, etc. for apron, allow double : 2240 Rs, plus brick rubble, 30 m^2 x 0.2 m = 6 m^3; 360 Rs.**

Total = 3720 **Rs.**

Option D *Light bamboo/matting*

Note : **A lighter-grade construction could be made for limited lifespan use, by fixing single or double layers of bamboo mat on the more exposed surfaces. A lifespan of perhaps** 1 **to 2 years might be feasible.**

Costs : **At 4 Rs/m^2, with double-layer matting, 480 Rs, plus materials - bamboo for pinning in matting, allow** 100 **Rs, plus labour, 6 man-days, 120 Rs.**

Total = 700 **Rs.**

Appendix 4

COST OUTLINE: SILVIPISCICULTURE PROJECT

Note — Based on 40 ha unit, with 10 ha water area.

Construction cost:

Wall volumes — Main dike, say 500 x 800 m, 2.5 m high, *1.5* m crown, allow 12 m^3/metre length, @ average 31,200 m^3 at 5 Rs/m^3 = 156,000 Rs, plus ground clearance, topsoil, etc., 31,200 m^2 @ 1.8 Rs/:m^2 = 56,160 Rs.

Total = 212,160 **Rs.**

Sluice — Allow the amortised cost of cut and fill as base cost, with two sluices, 1 metre width, at 6 Rs/m^3 cut and fill, two cycles per year, 10% r, cost is = **5,760 Rs.**

Earthworks — 30,000 m^3 of the dike volume is taken from the inside of the site, and the pond area is excavated to an average 0.7 m, 70,000 m^3 of earth is produced, with net surplus of 40,000 m^3. If this is used for ridges, etc., at 5 Rs/m^3 cut and place, cost = 200,000 Rs.

With a typical ridge cross-section of 2.5 m^2. this provides 16,000 m of ridging. Allowing 4,000 m^3 for internal dividing walls, this provides 60 x 240 m ridges, or 30 x 480 m ridges.

If the system were designed for the minimal amount of earth movement, with the most efficient excavation and construction, with, say a main pond area which could be filled to a greater depth and shallow side channels, a total volume of say 40,000 m^3 could be used, leaving 10,000 m^3 for internal ridges, dividing walls, etc. At a reduced cost of 4 Rs/m^3. minimum cost of internal earthworks = 40,000 **Rs.**

Miscellaneous — Allowance for survey, materials, huts, etc. = 25,000 **Rs.**

Returns — Fish/shellfish production, based on recorded yields, with surplus 20% for actual market prices as prices recorded are 'ex-farm gate' = **45,600 Rs.**

Incidental returns, wood, grazing, etc. allow 400 Rs/ha, on 30 ha of land area = 12,000 **Rs.**

Total Returns = **57,600 Rs.**

Summary of costs and returns:

Overall capital costs, assuming average 0.7 m excavation in pond areas = **442,920 Rs.**
(approx. 11,100 **Rs/ha)**

In optimal conditions, with restricted excavation volumes, etc. cost could be reduced to = **282,920 Rs.**
(approx. 7,100 Rs/ha)

With only three wall sides (eg. if there were common walls with other plots), cost could be further reduced, perhaps to 200,000 Rs. or 5,000 **Rs/ha**

On a simply amortised basis, the annualised cost of the system would be about 28,300 - 44,300 Rs/yr

Costs of casual labour, maintenance, etc., at 1,000 man-days work/yr = **20,000 Rs/yr**

Revenue from products, etc. = 57,600 **Rs/yr**

Gross returns = **(6,700)** - 9,300 **Rs/yr**