1-5-1990

Costs of alternative irrigation systems for vegetable crops

G J. Luke

T C. Calder

ISSN 0729-3135
May 1990

Cost of Alternative Irrigation Systems for Vegetable Crops

G.J. Luke and T.C. Calder

Resource Management Technical Report No. 104

Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

Contents

1. Introduction

Micro-irrigation systems have presented vegetable growers with an increased range of irrigation options. There is now a choice between the traditional fixed sprinklers (butterflies and knockers) and a range of trickle irrigation equipment. A few growers use alternatives such as centre pivots or hard moved lines.

There are many factors to be considered when choosing the most suitable system.

The factors in the choice include:

cost

reliability

effectiveness

durability

interchangeability.

Trial programmes have shown that used correctly, trickle systems are just as effective as more traditional sprinkler systems, and very reliable. The durability of the system is dependent upon the type used, its quality and how it is handled.

A major problem with trickle systems continues to be its interchangeability. While systems can be designed for virtually any crop, the ability to grow alternative crops with the one system, is somewhat limited. Only crops of similar row spacings can be grown with the one trickle system.

Growers have also to be concerned about the apparently high cost of trickle. This has been one factor which has tended to dissuade many from its use. The purpose of this report is to provide accurate costings for a range of irrigation systems so that more informed decisions can be made. These costs include the initial capital expense, and recurring costs such as replacement, maintenance and operating. These costs are also expressed as a net present value.

No attempt has been made to compare the benefits of the alternative systems. Some reduced pumping costs have been assigned to the trickle systems, but there is no account taken of potential fertilizer savings. At the same time a higher level of grower management and time may be needed with the trickle. Finally, while Department of Agriculture trials have shown yield and quality improvements with trickle, changes to the management of the sprinklers may do the same.

2. Methods

In some instances capital items such as pumps, motors, controllers and filters could be used on larger areas. An individual design for any prospective area is therefore recommended.

A one hectare block of different irrigation systems was designed. The systems selected for comparison, and the appendices in which details of the design and costings are given are:

permanent overhead - butterflies (Appendix 1)

permanent overhead - knockers (Appendix 2)

trickle or drip irrigation (Appendix 3)

T-Tape® (Appendix 4)

The trickle and T-Tape® systems are also compared for different spacings suitable for crops such as melons (1 m x 1 m) and for row type vegetable crops (0.4 m x 0.2 m). As the in-field laterals have a limited although unknown durability different life expectancies of these parts are also costed (10 and 20 years for trickle and 3, 4 and 5 years for T-Tape®).

$$NPV = \sum_{n=1}^{20} \frac{C}{(1+i)^n}$$

NPVs were calculated over 20 years, this being the life expectancy of the fixed sprinkler systems.

Details of the costings are provided in the appendices. The basis upon which these were made are:

Capital costs At July 1989 prices. These costs assume that the water is available at the surface, next to the field. No allowance is made for bores or deep well pumps. These costs are incurred in the first year for all the alternatives compared.

Maintenance costs 2 per cent of capital cost per year.

Replacement costs Costs of renewing laterals and emitters at predetermined time intervals. The frequency with which the replacement costs are incurred depends upon the system and the life expectancy scenario. Full details are shown in the respective appendices

Running costs This was calculated on the basis of irrigation applied per season and the energy needed. The irrigation application is for 1340 mm per season, times the crop factor (1.4 for sprinklers and 0.8 for trickle). The pump duty (water volume x head) in kilowatts, is multiplied by hours of operation and price of electricity. In July 1989 power cost 12cents/kw.

Net Present Value for each alternative were calculated where:

3. Results and Discussion

The capital and annual costs (maintenance and operating), and the NPV of different systems are as follows:

	CAPITAL	ANNUAL OPERATING	NPV
Butterflies	17,030	747	23,830
Knockers	9,338	1,041	19,755
Trickle 1m x 1m 10yr life	8,361	246	13,118
Trickle 1m x 1m 20yr life	8,361	246	10,190
Trickle 0.4m x 0.2m 10yr life	53,381	1,143	86,096
Trickle 0.4m x 0.2m 20yr life	53,381	1,143	60,930
T-Tape® 1m x 1m 3yr life	3,722	153	10,277
T-Tape® 1m x 1m 4yr life	3,722	153	8,621
T-Tape® 1m x 1m 5yr life	3,722	153	7,719
T-Tape® 0.4m x 0.2m 3yr life	7,291	222	22,449
T-Tape® 0.4m x 0.2m 4yr life	7,291	222	18,308
T-Tape® 0.4m x 0.2m 5yr life	7,291	222	16,057

Based on 1989 prices, systems such as T-Tape® at any likely spacings, and the traditional type of trickle at wide spacings, are cheaper than sprinklers such as butterflies and premiers. The conventional trickle system at specimens close enough for row vegetable crops is considerably more expensive than sprinklers.

The difference between the two sprinkler systems is of interest. The closer spaced butterflies cost more to install than the knockers, but are about 25% cheaper to run (due to the lower pressure required).

Wide spaced conventional point source trickle systems, suitable for crops such as melons, are definitely competitive with sprinklers. There may, however, be a higher level of management and attention to irrigation scheduling required.

The extremely high capital cost, and relatively high operating cost of close spaced trickle would appear to rule it out as an option.

However, the line source T-Tape® equipment appears to be competitive. Even at the close spacing the NPV's are similar to the sprinkler system. In this case quality considerations (sand in lettuce heads or damage to flowers due to overhead sprinklers) may determine the choice. Finally one consideration which must be made is the ability to grow different crops with one set trickle or T-tape® layout. If a grower specializes in row crops or melons then there would not be a problem. If, however, he varies his crops then the closer spaced systems would be needed. Careful evaluation of that spacing for all the alternatives (e.g. celery vs lettuce vs carrots) will be needed.

These prices should be re-assessed from time to time, and compared with yields when trial results are available.

4. Conclusions

The results reveal a wide range of Net Present Values when the alternative irrigation systems are compared. Clearly the newer types of tapes such as T-tape® can be highly competitive.

Before a grower chooses a system he should have several options designed and costed. Individual site variations, economics of scale, availability of labour for installation and management and many other factors could influence the final decision.

The ongoing Department of Agriculture trial programme is aiming to provide better management options for growers using both sprinklers and trickle. The outcomes of these trials need to be assessed in order to fully evaluate all of the systems described.

Appendix 1: Butterfly Sprinklers

Technical details for 1 ha (100 m x 100 m)

Lateral spacing	= 6 m (17 laterals/ha)
Sprinkler spacing	= 6 m (17 sprinklers/lateral)
Operating pressure	= 140 kPa
Sprinkler output	= 16 L/min
Three laterals operate per station	= 5.6 sections.

(see layout on Page 11)

Components and costings

COMPONENT	UNIT COST ($)	COST ($)
Submain		
96m – 100mm Class 9 PVC	105.52/length	1,688.32
17 - 100mm x 50 mm reducing tees	33.98/ea	577.66
34 – 50mm valve sockets	3.94/ea	133.96
17 - 50mm solenoid valves	136.00/ea	2,312.00
Spraylines		
238 - 50mm x 20mm faucet tees	8.00/ea	1,904.00
17 - 50mm x 40mm reducing bushes	3.12/ea	53.04
17 - 40mm x 32mm reducing bushes	2.34/ea	39.78
51 - 32mm x 20mm faucet tees	3.87/ea	197.37
17 – 32mm caps	l.57/ea	26.69
1377m – 50mm Class 9 PVC	35.54/length	8,156.43
306m - 32mm Class 9 PVC	20.88/length	1,064.88
289 - butterfly sprinkler~	1l.70/ea	3,381.30
289 - 2m black risers	5.52/ea	1,595.28
Total list price		21,130.71
Pump and motor		1,699.00
Controller		1,500.00
Total capital cost		$24,329.71
Less 30%		$17,030.80

Maintenance cost = 2% of capital cost = $340/year.

Operating costs

1340mm evaporation x 1.4 (crop factor) = 1900mm/year.

Application rate = 26.66mm/hr.

Operate for 1900/26.66 = 71.27 hrs/section/year.

5.6 sections = 399 hrs operation/year.

Pump duty

$$\frac{13.6 \text{ L/sec} \times 9.81 \times 32\text{m head}}{0.5 \text{ efficiency}} = 8.8 \text{ kw}$$

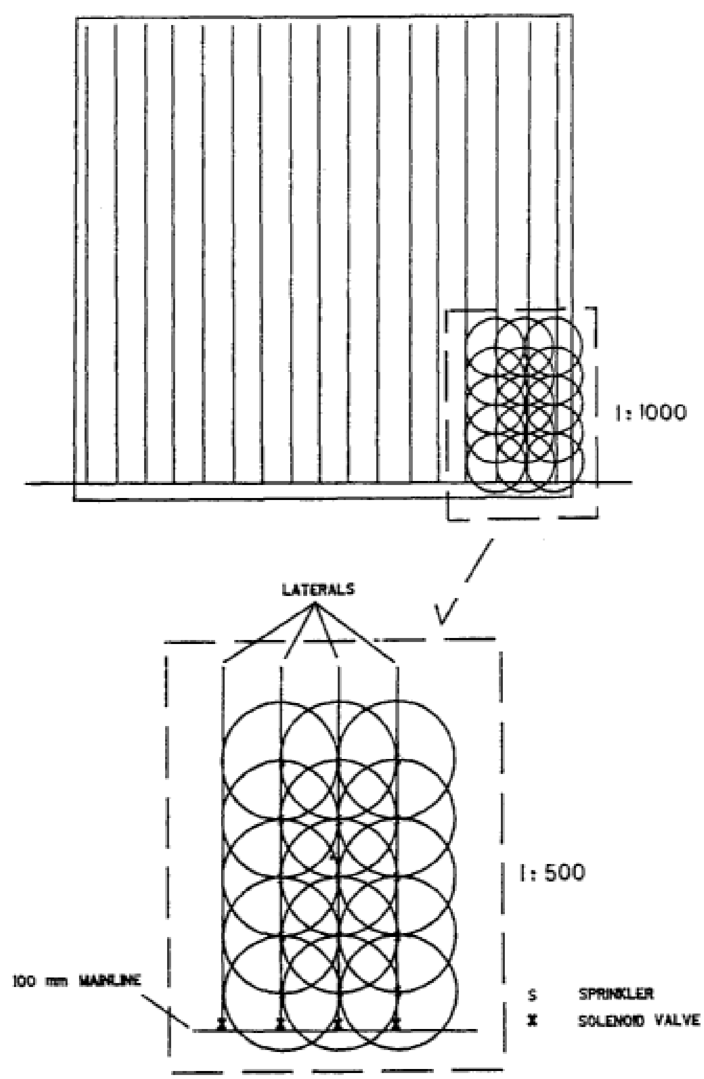
8.5 kw x 399 hrs = 3,392 kw hrs

@ 12cents = $407/yr

Butterflies NPV

$$NPV = \sum_{t=1}^{20} \frac{c_t}{(1+i)^t}$$

YEAR	CAPITAL	MAINTENANCE	OPERATING	TOTAL	PV
1	17,030	340	407	17,777	16,614
2	-	340	407	747	652
3	-	340	407	747	610
4	-	340	407	747	570
5	-	340	407	747	533
6	-	340	407	747	498
7	-	340	407	747	465
8	-	340	407	747	435
9	-	340	407	747	406
10	-	340	407	747	380
11	-	340	407	747	355
12	-	340	407	747	332
13	-	340	407	747	310
14	-	340	407	747	290
15	-	340	407	747	271
16	-	340	407	747	253
17	-	340	407	747	236
18	-	340	407	747	221
19	-	340	407	747	206
20	-	340	407	747	193
				NPV	23,830



LAYOUT FOR BUTTERFLY SPRINKLERS

Appendix 2: Knockers

Technical details for 1 ha (100 m x 100 m)

Lateral spacing	= 12m (9 laterals/ha)
Sprinkler spacing	= 12m (9 sprinklers/lateral)
Operating pressure	= 240 kPa
Sprinkler output	= 20 L/min
Four laterals operate per station	= 3 sections.

(See layout on page 16)

Components and costings

COMPONENT	UNIT COST ($)	COST)$)
Submain		
96m –100mm Class 9 PVC	105.52/length	1,688.32
9 - 100mm x 50mm reducing tees	33.98/ea	305.82
18 - 50mm valve sockets	3.94/ea	70.92
9 – 50mm solenoid valves	136.00/ea	1,224.00
Spraylines		
54 – 50mm x 20mm faucet tees	8.00/ca	432.00
9 - 50mm x 40mm reducing bushes	3.12/ca	28.08
9 – 40mm x 32mm reducing bushes	2.34/ca	21.06
27 - 32mm x 20mm faucet tees	3.87/ca	104.49
9 – 32mm caps	1.57/ca	14.13
459m - 50mm Class 9 PVC	35.54/length	2,718.81
432m – 32mm Class 9 PVC	20.88/length	1,503.36
81 - premier knockers	15.20/ca	1,231.20
81 – 2m x 20mm risers	5.52/ca	447.12
81 - sprinkler couplings	3.00/ca	243.00
Pump and motor		1,808.00
Controller		1,500.00
Total capital cost		$13,340.31
Less 30%		$9,338.22

Maintenance cost = 2% of capital cost = $187/year.

Operating costs

1340 mm evaporation x 1.4 (crop factor) = 1900 mm/year.

Application rate = 8.33 mm/hr.

Operate for 1900/8.33 = 228 hrs/section/yr.

3 sections = 684 hrs operation/year.

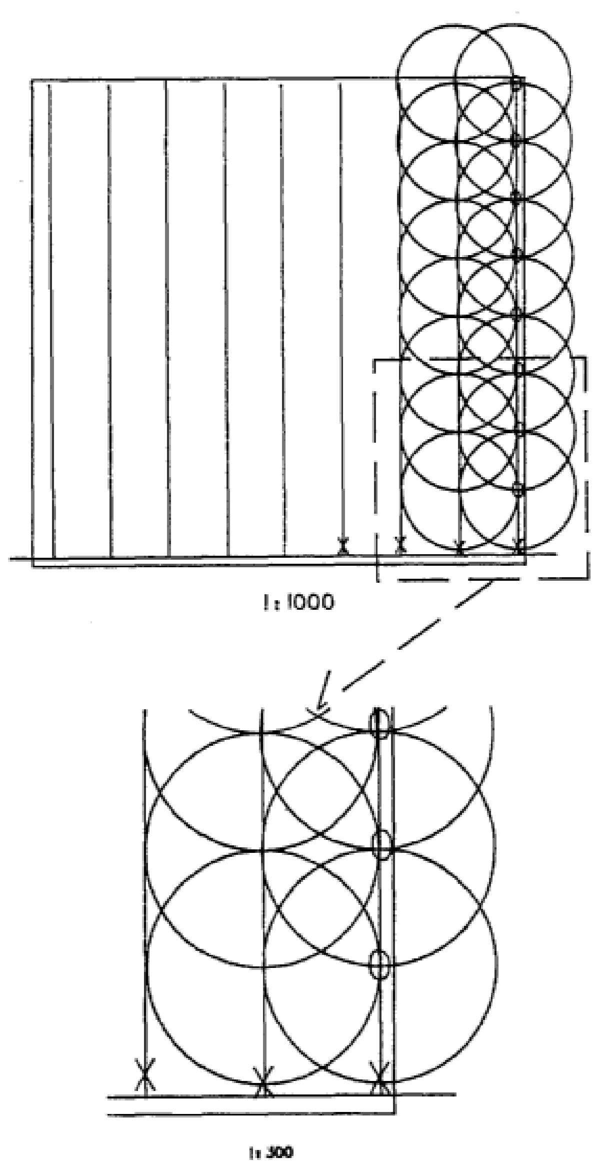
Pump duty

$$\frac{12\text{L/sec} \times 9.81 \times 44\text{m head}}{0.5 \text{ efficiency}} = 10.4 \text{ kw}$$

Knockers NPV

$$NPV = \sum_{t=1}^{20} \frac{ct}{(1+i)^t}$$

YEAR	CAPITAL	MAINTENANCE	OPERATING	TOTAL	PV
1	9,338	187	854	10,379	9,700
2	-	187	854	1,041	909
3	-	187	854	1,041	850
4	-	187	854	1,041	794
5	-	187	854	1,041	742
6	-	187	854	1,041	694
7	-	187	854	1,041	648
8	-	187	854	1,041	606
9	-	187	854	1,041	566
10	-	187	854	1,041	529
11	-	187	854	1,041	494
12	-	187	854	1,041	462
13	-	187	854	1,041	432
14	-	187	854	1,041	404
15	-	187	854	1,041	377
16	-	187	854	1,041	353
17	-	187	854	1,041	330
18	-	187	854	1,041	308
19	-	187	854	1,041	288
20	-	187	854	1,041	269
				NPV	19,755



LAYOUT FOR KNOCKER SPRINKLERS

Appendix 3: Trickle Irrigation

Technical details for 1 ha (100 m x 100 m)

Lateral spacing	= 1m (100 laterals/ha)
Emitter spacing	= 1m (100 emitters/lateral)
Operating pressure	= 120 kPa
Emitter output	= 2 L/hour

Water in one section

(see layout on page 21)

Components and costings

COMPONENT	UNIT COST ($)	COST ($)
Mains and Submains		
200m - 50mm Class 6 PVC	21.33/length	710.93
1 – 50mm solenoid valve	136.00	136.00
2 – 50mm valve sockets	3.94	7.88
2 – 50mm tees	5.20	10.40
4 – 50mm caps	1.90	7.60
Laterals		
10,000m – 13mm trickle line	92.85/300m	3,156.90
10,000 - 2L drippers	0.50/ea	5,000.00
100 - grommets	0.40/ea	40.00
100 - take-offs	0.30/ea	30.00
Filter		1,500.00
Sand		104.00
Screen filter		300.00
Controller		540.00
Pump and motor		400.00
Total Capital Cost		11,943.71
Less 30%		8360.60

Maintenance cost (2% of capital cost) = $167/year.

Operating costs

1340mm evaporation x 0.8 (crop factor) = 1100mm/year

Application rate = 2mm/hr

Operate for 1100/2 = 550 hrs/section/year.

1 section = 550 hrs operation/year.

Pump duty

$$\frac{5.5\text{L/sec} \times 9.81 \times 15\text{m head}}{0.7\text{ efficiency}} = 1.2\text{ kw}$$

1.2 kw x 550hrs = 660 kw hrs

@ $0.12 cents = $79/year

Replacement costs

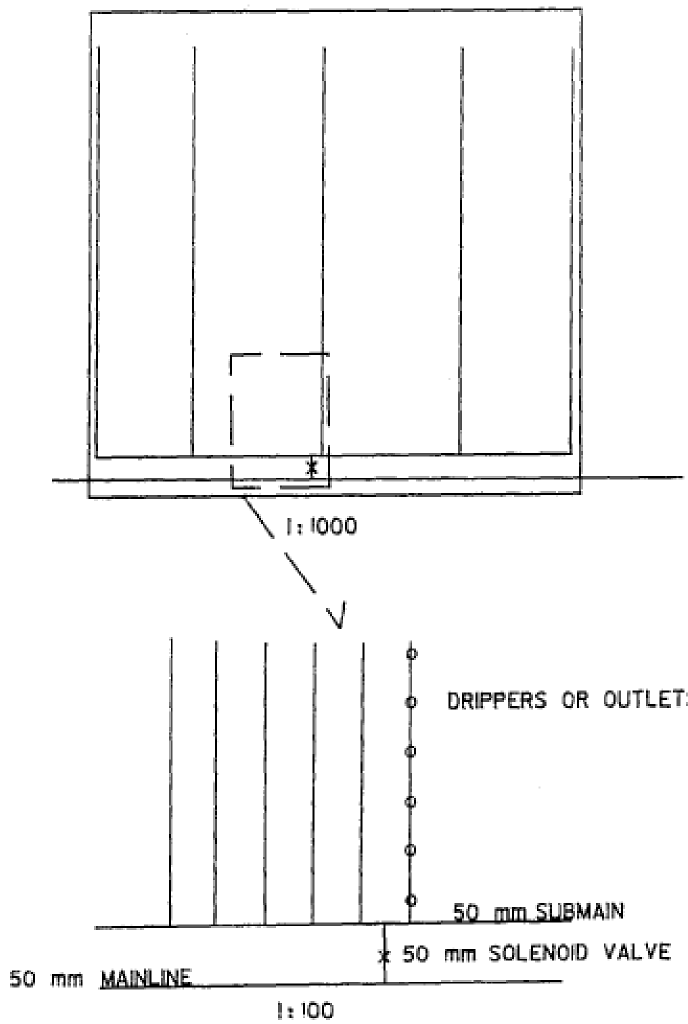
These depend upon the life expectancy of the laterals. Two scenarios are considered. Replacing laterals, drippers, grommets and take-off s every 10 or 20 years.

Trickle 1 m x 1 m NPV

Calculations as follows:

Capital cost	Year 1	$8,361
Maintenance costs	Year 1-20	$167
Operating costs	Year 1-20	$79
Replacement	Year 10	$5,759

YEAR	TOTAL COST REPLACEMENT		PV REPLACEMENT	
	10 YEAR	20 YEAR	10 YEAR	20 YEAR
1	8,361	8,361	7,814	7,814
2	246	246	215	215
3	246	246	201	201
4	246	246	188	188
5	246	246	175	175
6	246	246	164	164
7	246	246	153	153
8	246	246	143	143
9	246	246	134	134
10	6,005	246	3,053	125
11	246	246	117	117
12	246	246	109	109
13	246	246	102	102
14	246	246	95	95
15	246	246	89	89
16	246	246	83	83
17	246	246	78	78
18	246	246	73	73
19	246	246	68	68
20	246	246	64	64
		NPV	13,118	10,190



LAYOUT FOR TRICKLE EMITTERS
OR T.TAPE OUTLETS (1m x 1m)

Technical details (0.4 m x 0.2 m)

Lateral spacing	= 0.4m (250 laterals/ha)
Emitter spacing	= 0.2m (500 emitters/lateral)
Operating pressure	= 100 kPa
Emitter output	= 2 L/hour

Water in 13 sections.

(see layout on page 26)

Components and costings

COMPONENT	UNIT COST ($)	COST ($)
Mains and submains		
200M - 50mm Class 6 PVC	21.33/length	710.93
26 – 50mm tees	5.20/ea	135.20
26 – 50mm valve sockets	3.94/ea	102.44
13 – 50mm solenoid valves	136.00/ea	1,768.00
26 – 50mm caps	1.90/ea	49.40
Laterals		
25,000 m - 13mm trickle line	92.85/300 m	7,799.40
125,000 – 2 L/hr drippers	0.50/ea	62,500.00
500 - grommets	0.40/ea	200.00
500 - take-offs	0.30/ea	150.00
Filter		1,500.00
Sand		104.00
Screen filter		300.00
Controller		540.00
Pump and motor		400.00
		76,259.37
	Less 30%	53,381.56

Maintenance cost (2% of capital cost) = $1067/year

Operating costs

1340 mm evaporation x 0.8 (crop factor) = 1100mm/year

Application rate = 25mm/hr

Operate for 1100 + 25 = 44 hrs/section/year

13 sections = 572 hrs operation/year

Pump duty

$$\frac{5.3\text{L/sec} \times 9.81 \times 15\text{m head}}{0.7\text{ efficiency}} = 1.1\text{ kw}$$

1.1kw x 572 hrs = 629kw hrs

@ $0.12 cents = $76/year

Replacement costs

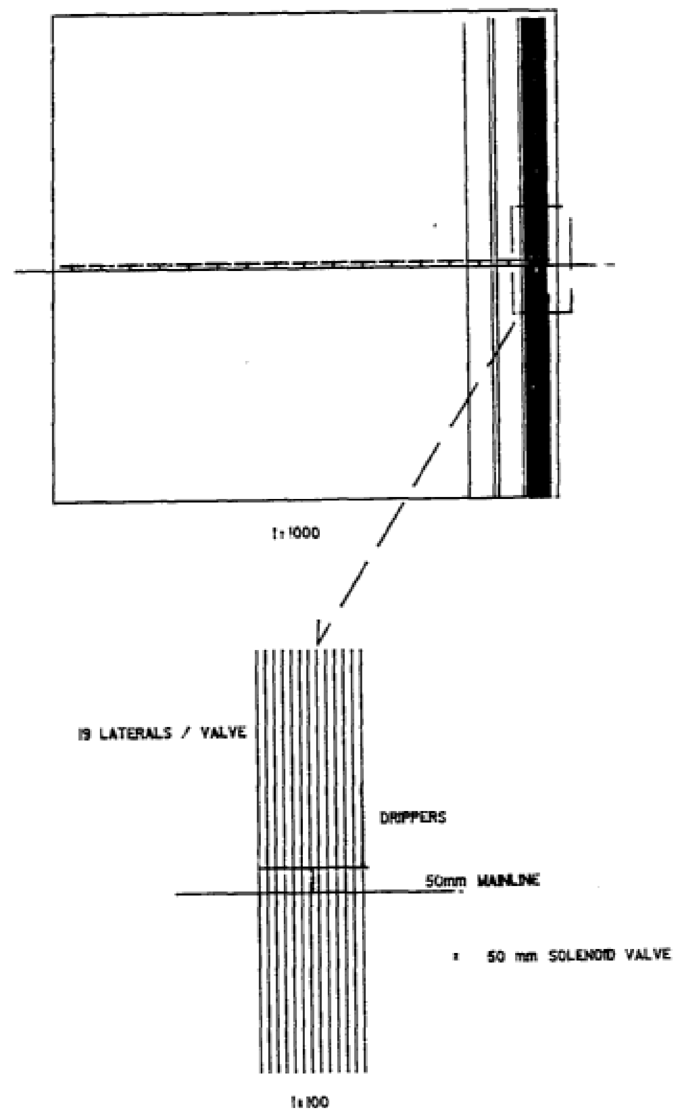
Based on replacing laterals, drippers, grommets and take-offs every 10 or 20 years.

Trickle 0.4 m x 0.2 m NPV

Calculations as follows:

Capital cost	Year 1	$53,381
Maintenance costs	Year 1-20	$1,067
Operating costs	Year 1-20	$ 76
Replacement	Year 10	$49,507

YEAR	TOTAL COST REPLACEMENT		PV REPLACEMENT	
	10 YEAR	20 YEAR	10 YEAR	20 YEAR
1	53,381	53,381	49,889	49,889
2	1,143	1,143	998	998
3	1,143	1,143	933	933
4	1,143	1,143	872	872
5	1,143	1,143	815	815
6	1,143	1,143	762	762
7	1,143	1,143	712	712
8	1,143	1,143	665	665
9	1,143	1,143	623	623
10	50,684	1,143	25,747	581
11	1,143	1,143	543	543
12	1,143	1,143	508	508
13	1,143	1,143	474	474
14	1,143	1,143	443	443
15	1,143	1,143	414	414
16	1,143	1,143	387	387
17	1,143	1,143	362	362
18	1,143	1,143	338	338
19	1,143	1,143	316	316
20	1,143	1,143	295	295
		NPV	86,096	60,930



LAYOUT FOR TRICKLE EMITTERS
(0.4 X 0.2)

Appendix 4: T-Tape®

Technical details for 1 ha (100 m x 100 in) at 1 m x 1 m

Lateral spacing	= 1m (100 laterals/ha)
Outlet spacing	= 1m (100 emitters/lateral)
Operating pressure	= 55 kPa
Tape output	= 1 L/m/hour

Operate in two sections.

(see layout on page 21)

Components and costings

COMPONENT	UNIT COST ($)	COST ($)
Mains and Submains		
200m - 50mm Class 6 PVC	21.33/length	711.00
4 – 50mm tees	5.20/ea	20.80
2 – 50mm solenoid valves	136.00/ea	272.00
2 – 50mm valve sockets	3.94/ea	15.76
4 – 50mm caps	1.90/ea	7.60
Laterals		
10,000m - High flow T-Tape®	0.24/m	2,400.00
100 - adapters	0.93/ea	93.00
100 -grommets	0.36/ea	36.00
Pump and motor		416.00
Controller		345.00
Filter		1,000.00
Total capital cost		5,317.16
Less 30%		3,722.01

Maintenance cost (2% of capital cost) = $74/year

Operating costs

1340 nun evaporation x 0.8 (crop factor) = 1100mm/year

Application rate = 1mm/hr

Operate for 1100/1 = 1100 hours/section/year.

2 sections = 2200 hrs operation/year.

Pump duty

$$\frac{1.4\text{L/sec} \times 9.81 \times 15\text{m head}}{0.7\text{ efficiency}} = 0.3\text{ kw}$$

0.3kw x 2200hrs = 660kw hrs

@ $0.12cents = $79/year

Replacement costs

These depend upon the life expectancy of the tape. Three scenarios are allowed for, namely replacing all the tape, adapters and grommets every 3, 4 or 5 years.

T-Tape® 1 m x 1 m NPV

Calculations as follows:

Capital cost	Year 1	$3,722
Maintenance cost	Year 1-20	$ 74
Operating cost	Year 1-20	$ 79

Replacement scenarios

Years 4, 7, 10, 13, 16, 19	$1,770
Years 5, 9, 13, 17	$1,770
Years 6, 11, 16	$1,770

YEAR	TOTAL REPLACEMENT COST			PV REPLACEMENT		
	3 YRLY	4 YRLY	5 YRLY	3 YRLY	4 YRLY	5 YRLY
1	3,875	3,875	3,875	3,621	3,621	3,621
2	153	153	153	134	134	134
3	153	153	153	125	125	125
4	1,923	153	153	1,467	117	117
5	153	1,923	153	109	1,371	109
6	153	153	1,923	102	102	1,281
7	1,923	153	153	1,198	95	95
8	153	153	153	89	89	89
9	153	1,953	153	83	1,046	3
10	1,923	153	153	978	78	78
11	153	153	1,923	73	73	914
12	153	153	153	70	70	70
13	1,923	1,923	153	798	798	63
14	153	153	153	59	59	59
15	153	153	153	55	55	55
16	1,923	153	1,923	651	52	651
17	153	1,923	153	48	609	48
18	153	153	153	45	45	45
19	1,923	153	153	532	42	42
20	153	153	153	40	40	40
			NPV	10,277	8,621	7,719

Technical details for 1 ha (100 m x 100 m) at 0.4 m x 0.2 m

Lateral spacing	= 0.4 m (250 laterals/ha)
Outlet spacing	= 0.2 m (500 outlets/lateral)
Operating pressure	= 55 kPa
Tape output	= 5 L/m/hour

Operate in 3 sections.

(see layout on page 35)

Components and costings

COMPONENT	UNIT COST ($)	COST ($)
Mains and Submains		
100 m –100mm Class 6 PVC	54.22/length	903.30
100 m – 80mm Class 6 PVC	33.39/length	556.50
3 – 100mm x 80 mm tees	36.68/ea	110.04
3 – 80mm x 80 nun tees	19.56/ea	58.68
3 – 80mm solenoid valves	200.00/ea	600.00
6 – 80mm valve sockets	9.00/ea	54.00
6 – 80mm caps	8.31/ea	49.86
Laterals		
25,000 m - High flow T-Tape®	0.24/rn	6,000.00
250 - grommets	0.36/ea	90.00
250 - adapters	0.93/ea	232.50
Pump and motor		416.00
Controller		345.00
Filter		1,000.00
Total capital cost		10,415.88
Less 30%		7,291.12

Maintenance cost (2% of capital cost) = $146/year

Operating costs

1340 mm evaporation x 0.8 (crop factor)	= 1100 mm/year.
Application rate	= 12.5 mm/hr.
Operate for 1100/12.5	= 88 hours/section/year.
3 sections	= 264 hrs operation/year.

Pump duty

$$\frac{11.6 l/sec \times 9.81 \times 15m\ head}{0.7\ efficiency} = 2.4\ kw$$

2.4 kw x 264hrs = 634 kw hrs

@ $0.12cents = $76/year

Replacement costs

Three scenarios are costed. Replacement of tape, adapters and grommets every 3, 4 or 5 years.

T-Tape (0.4 m x 0.2 m) NPV

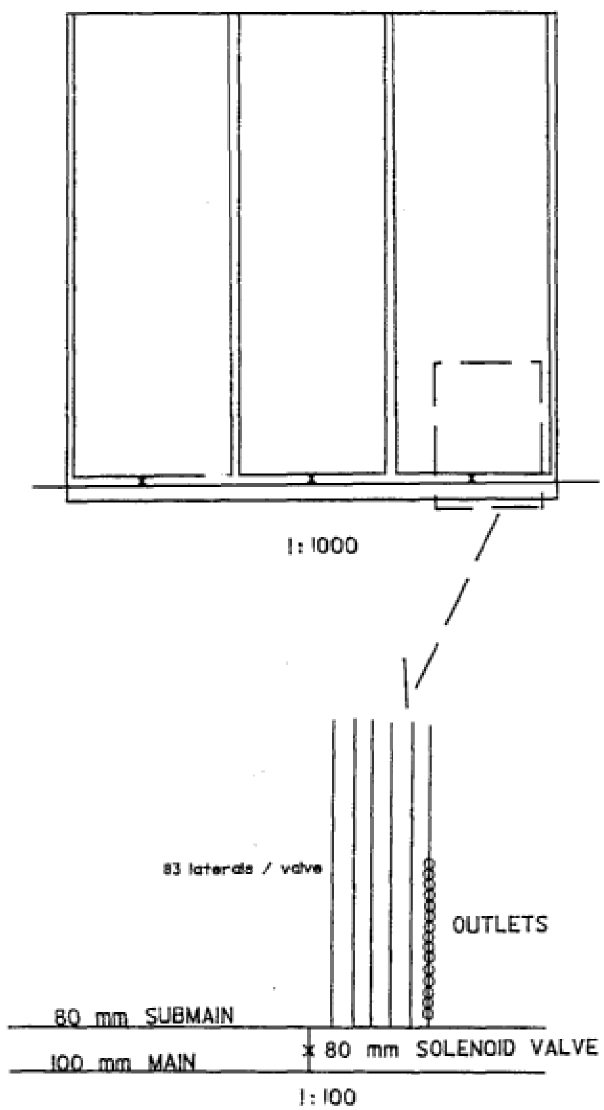
Calculations as follows:

Capital cost	Year 1	$7,291
Maintenance cost	Year 1-20	$ 146
Operating cost	Year1-20	$ 76

Replacement scenarios:

Years 4, 7, 10, 13, 16, 19	$4,425
Years 5, 9, 13, 17	$4,425
Years 6, 11, 16	$4,425

YEAR	TOTAL REPLACEMENT COST			PV REPLACEMENT		
	3 YRLY	4 YRLY	5 YRLY	3 YRLY	4 YRLY	5 YRLY
1	7,513	7,513	7,513	7,366	7,366	7,366
2	222	222	222	194	194	194
3	222	222	222	181	181	181
4	4,647	222	222	3,545	169	169
5	222	4,647	222	158	3,313	158
6	222	222	4,647	150	150	3,096
7	4,647	222	222	2,894	138	138
8	222	222	222	129	129	129
9	222	4,647	222	121	2,528	121
10	4,647	222	222	2,362	113	113
11	222	222	4,647	105	105	2,208
12	222	222	222	98	98	98
13	4,647	4,647	222	1,928	1,928	92
14	222	222	222	86	86	86
15	222	222	222	80	80	80
16	4,647	222	4,647	1,574	75	1,574
17	222	4,647	222	70	1,471	70
18	222	222	222	66	66	66
19	4,647	222	222	1,285	61	61
20	222	222	222	57	57	57
			NPV	22,449	18,308	16,057



LAYOUT FOR T.TAPE (0.4m x 0.2m)