

2009 Congress

A TOOL FOR THE ANALYSIS OF IRRIGATION DESIGN ALTERNATIVES

By Ashiel Jumman & Neil Lecler

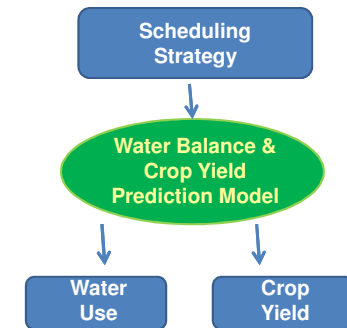


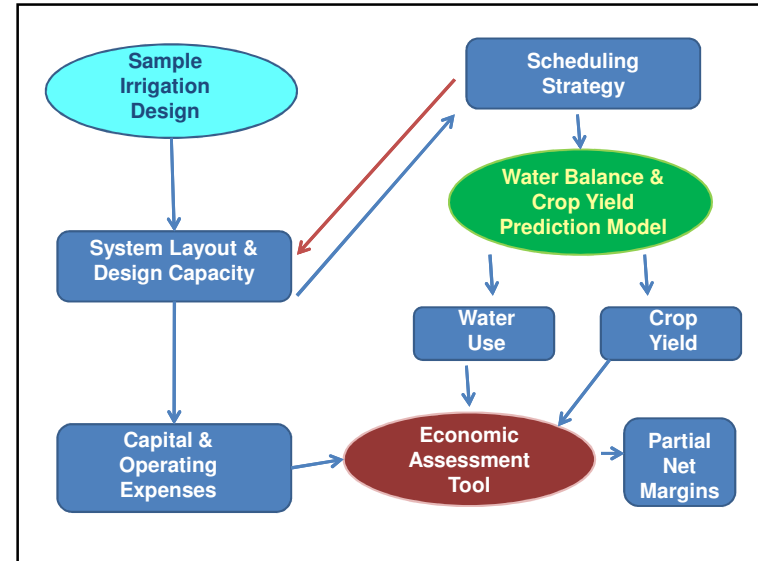
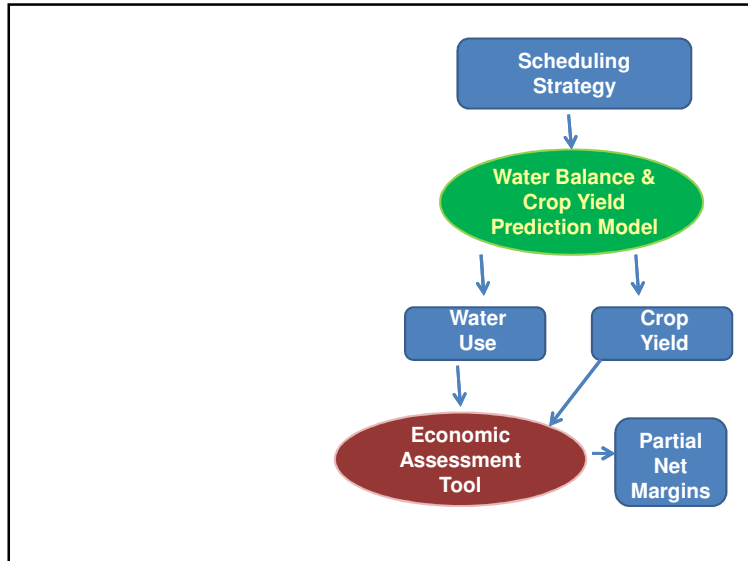
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- Background
- Design Tool
- Application of the spreadsheet based tool
- Acknowledgements

Background: How do designers decide?

- Nozzle diameter and sprinkler spacing?
 - Operating pressures?
 - Distribution Uniformities?
- Peak design **capacities** relating:
 - to stand times and labour issues?
 - Capital expenses relating to hardware?
 - Shallow and deep soils?

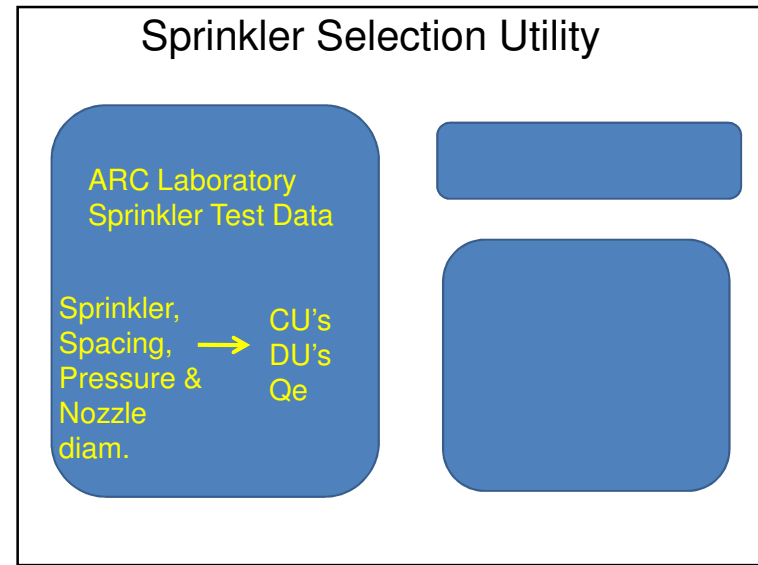
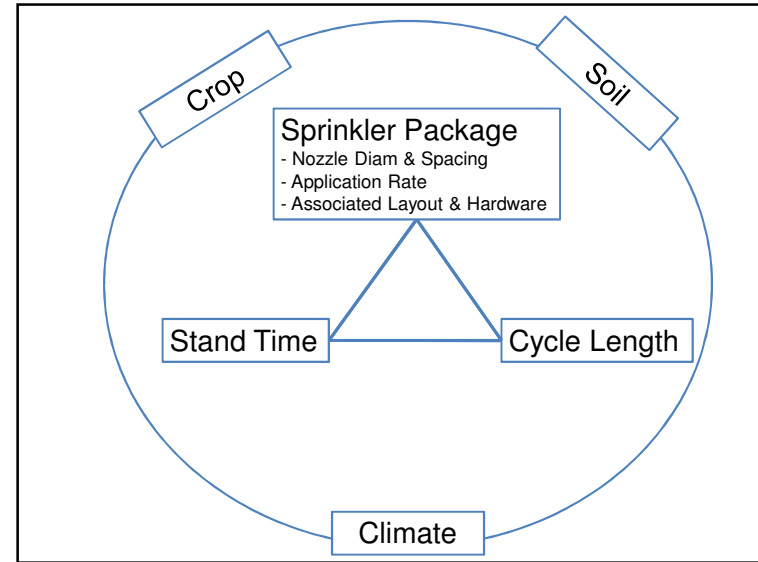
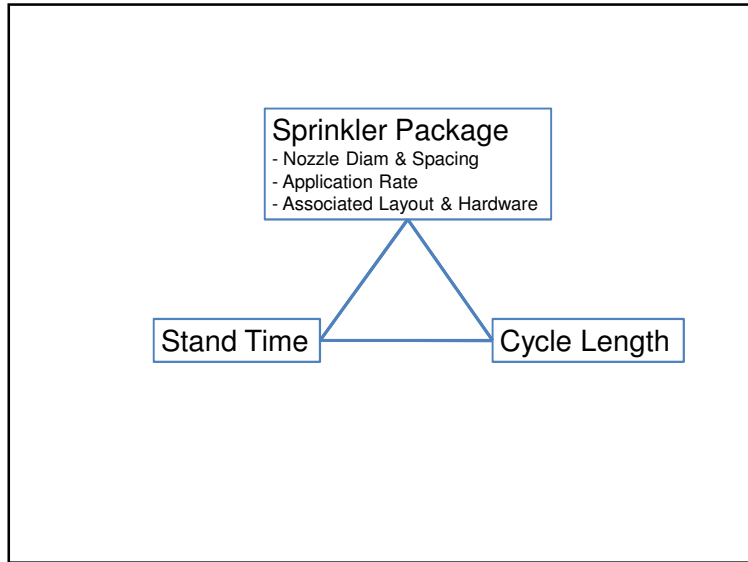


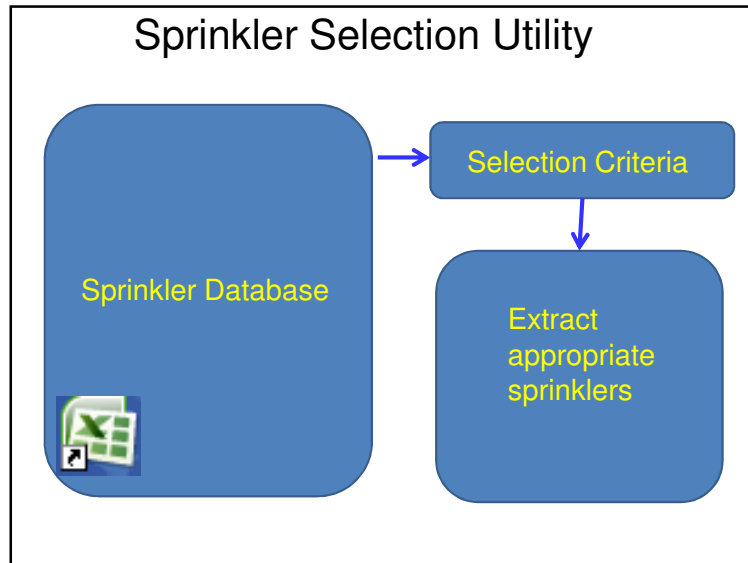


DESIGNING THE SPREADSHEET

Objective of the spreadsheet

- To quickly generate costs for different semi permanent irrigation systems





Sprinkler Type	Nozzle Diam	Nozzel Material	Spreader	Spr Spacing	Lat. Spacing	Appl. Rate (mm/h)	Tri CU%	Tri DU%	Rect CU %	Rect DU%	Test pressure (kPa)
Rainbird 34	4.4		2.3	21	21	4.2	88	82	81	65	349.8
VYRSA 35	4.4	Brass	0	21	21	4.0	86	80	88	81	352.1
Irriline-IR30	4.4	Brass	3.2	21	21	4.0	86	79	87	81	352.1
Irriline-IR30	4.4	Brass	3.2	21	21	4.0	85	78	87	79	352.1
Perrot ZB2	4.2	Plastic	2.4	21	21	4.0	85	78	87	80	352.1
VYRSA 35	4.4	Brass	2.4	21	21	4.0	85	78	87	79	352.1
VYR 56	6	plastic	2.5	21	24	4.1	82	71	85	77	203
VYR 56	6	plastic	2.5	24	21	4.1	80	74	85	77	203
VYR 56	6	plastic	2.5	24	27	4.1	85	79	83	70	302
VYR 56	6	plastic	2.5	27	24	4.1	91	85	83	70	302
VYR 56	5.2	plastic	0	18	24	4.1	75	57	81	65	300
VYR 70	4.8	brass	2.5	18	27	4.0	79	64	82	69	302

Proposed Design Procedure - 3

Stand Time

- Practical application
- Options limited to:
 - 12hrs – Shallow Soils?
 - 6 or 8 hrs – automated?

Cycle Time

- Too Frequent
 - evaporation from the soil surface?
 - full soil profile = potential for water loss if rain occurs after irrigation event

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    graph TD
      A[Sprinkler Package] --- B[Stand Time]
      A --- C[Cycle Length]
  
```

Sprinkler spacing		18			
lateral spacing		21			
Area per sprinkler	m ²	378	Target Application	5.00 mm/day	
Emmitter Flow	m ³ /h	1.6254			
GAR	mm/h	4.30	Gross		
Cycle length	days	10.00	application per cycle	51.6 mm/cycle	
Stand Time	h	12		5.16 mm/day	
sets per day	no	2			
No of sets		20			

			Sprinkler Package	
			Stand Time	Cycle Length
Sprinkler spacing		18		
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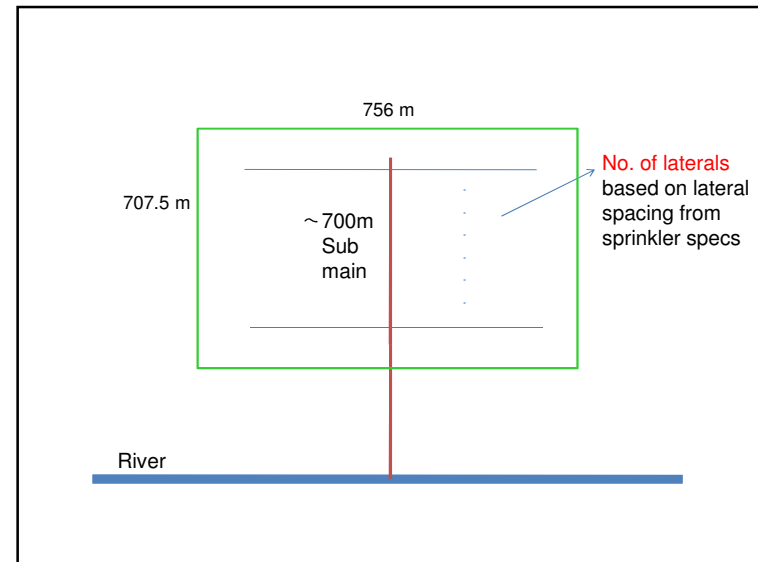
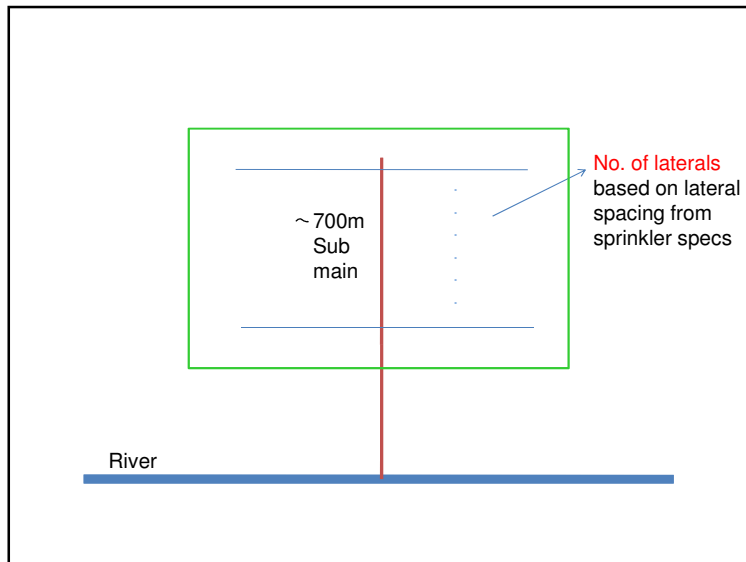
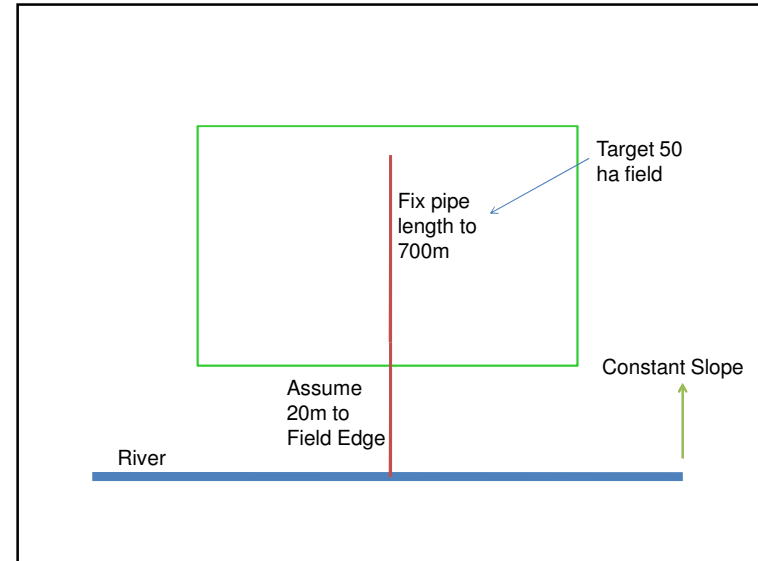
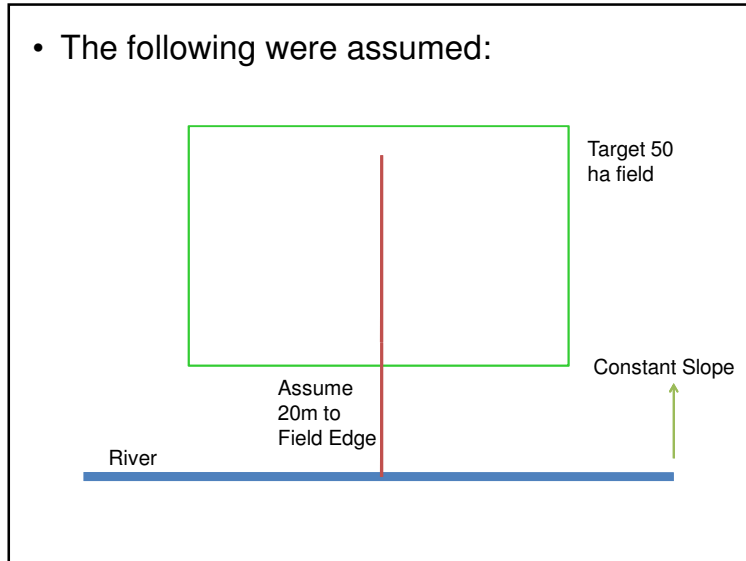
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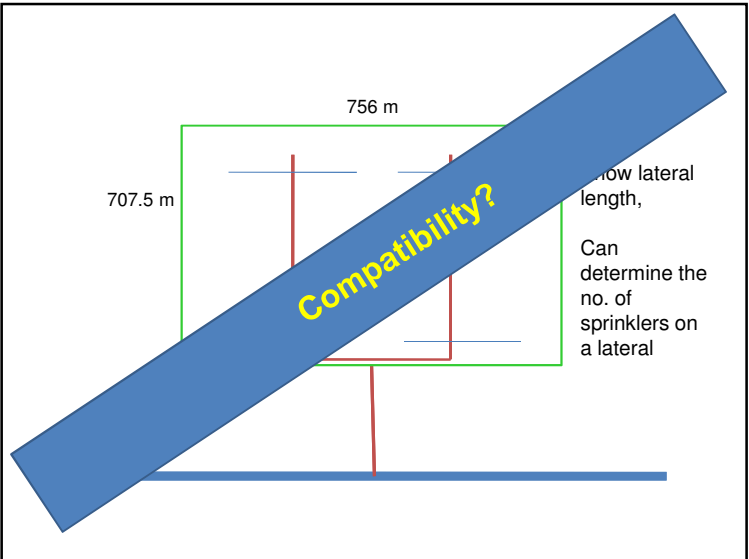
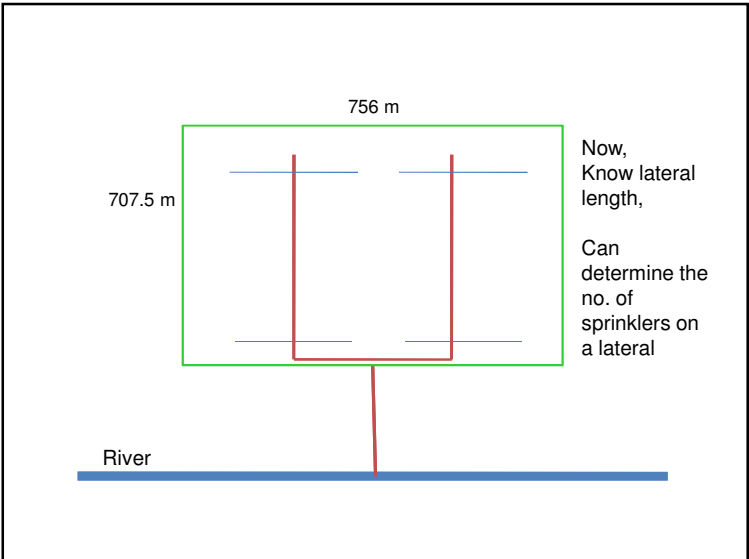
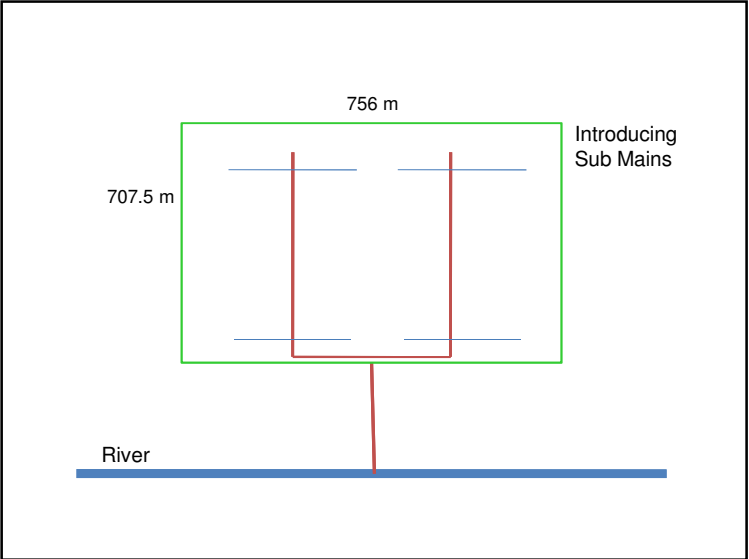
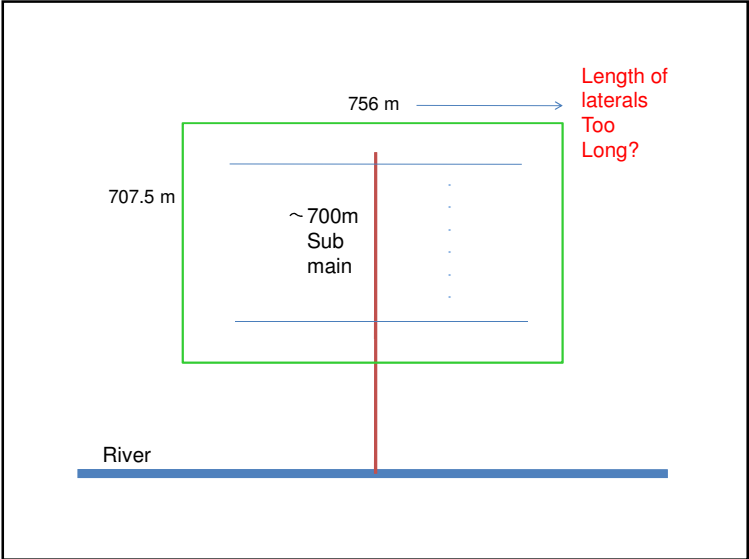
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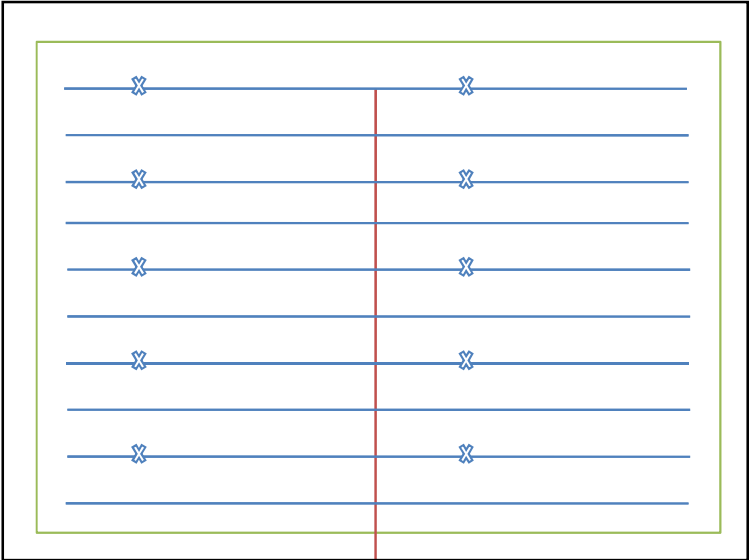
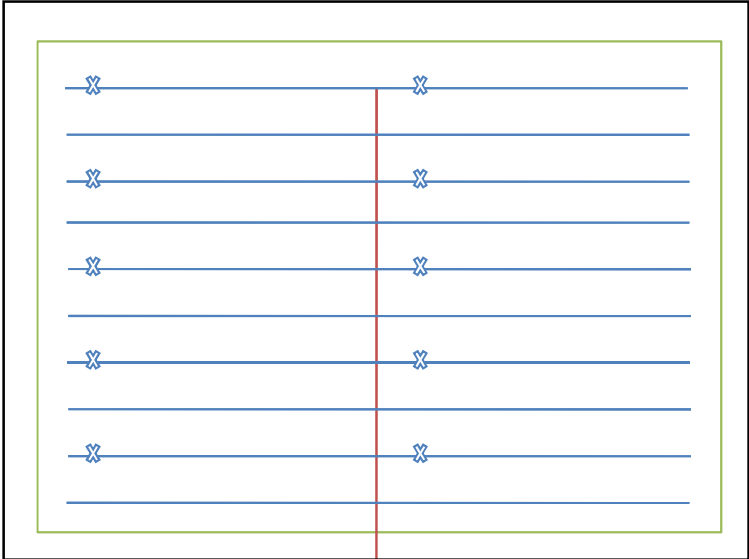
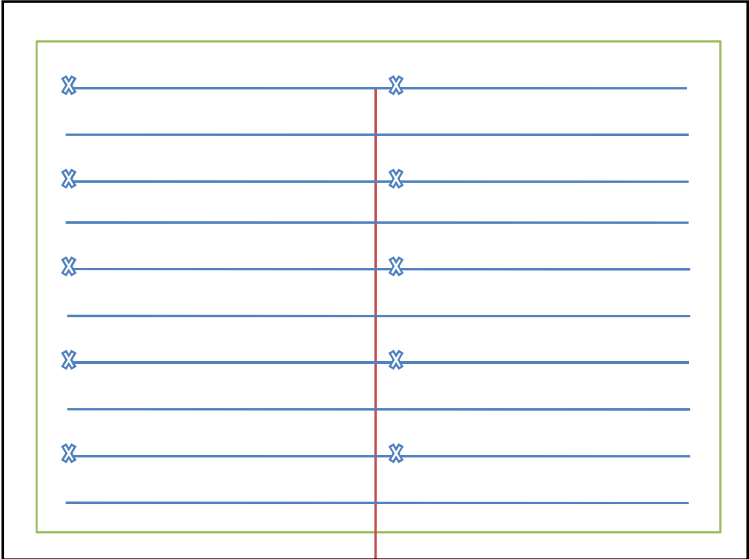
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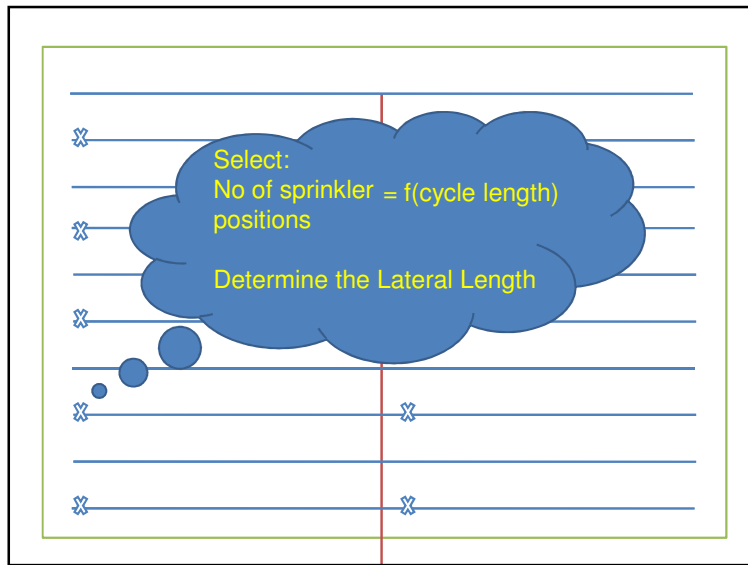
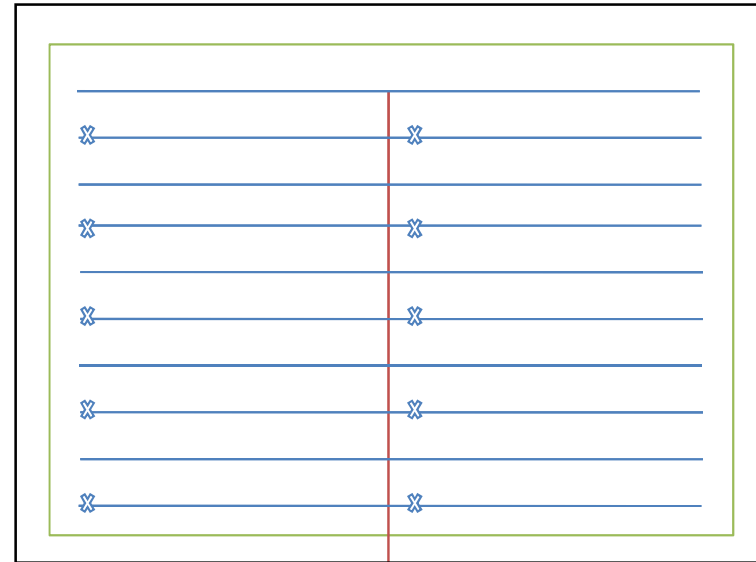
Field Layout?

- The following were assumed:









Fixed Length of Submain	m	700			
No. of laterals/ submain		33			
No of Sub mains	no	2			
No. of sprinklers positions/lat		20			
Lateral Length	m	342.00			
Field Width	m	720.00			
Field Length	m	710.50			
Area	ha	51.16			
No of sprinklers		66.00			
Q	m ³ /h	107.3			
No of operating sprinklers/lat		1.0	or	2 sprinklers per 2 laterals	
No of moves		20			

Cycle Length = 10 days

Hydraulic Calculations?

Lateral Design: AB

	Q	L	Hf	D	Class	Int	V	Hf (HW)	Hf (Gen)	Pressure	Height	Head
	(m ³ /s)	(m)	max	(m)		Diam	(m/s)	(m)	(m)	(kPa)	(m)	(kPa)
			0							300	0	0 (HW)
AB1	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	304		304
AB2	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	308.01		308.01
AB3	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	312.01		312.01
AB4	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	316.01		316.01
AB5	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	320.02		320.02
AB6	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	324.02		324.02
AB7	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	328.02		328.02
AB8	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	332.02		332.02
AB9	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	336.03		336.03
AB10	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	340.03		340.03
AB11	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	344.03		344.03
AB12	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	348.04		348.04
		216	3.24	12				4.80	4.15	60.00		

Hydraulic Calculations?

Lateral Design: AB

	Q	L	Hf	D	Class	Int	V	Hf (HW)	Hf (Gen)	Pressure	Height	Head
	(m ³ /s)	(m)	max	(m)		Diam	(m/s)	(m)	(m)	(kPa)	(m)	(kPa)
			0							300	0	0 (HW)
AB1	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	304		304
AB2	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	308.01		308.01
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AB4	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	316.01		316.01
AB5	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	320.02		320.02
AB6	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	324.02		324.02
AB7	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	328.02		328.02
AB8	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	332.02		332.02
AB9	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	336.03		336.03
AB10	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	340.03		340.03
AB11	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	344.03		344.03
AB12	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	348.04		348.04
		216	3.24	12				4.80	4.15	60.00		

Hydraulic Calculations?

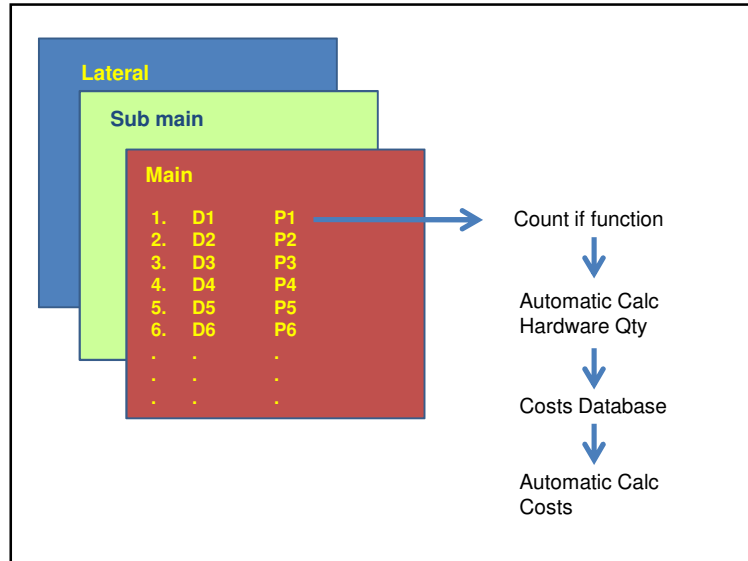
Lateral Design: AB

	Q	L	Hf	D	Class	Int	V	Hf (HW)	Hf (Gen)	Pressure	Height	Head
	(m ³ /s)	(m)	max	(m)		Diam	(m/s)	(m)	(m)	(kPa)	(m)	(kPa)
			0							300	0	0 (HW)
AB1	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	304		304
AB2	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	308.01		308.01
AB3	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	312.01		312.01
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AB8	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	332.02		332.02
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AB12	0.0005	18	0.27	0.032	32&9	0.029	0.684	0.40031	0.415	348.04		348.04
		216	3.24	12				4.80	4.15	60.00		

Hydraulic Calculations?

Sub Main Design CD

	Q	L	Hf	D	Class	Int	V	Hf (HW)	Hf (Gen)	Pressure	Height	Head
	(m ³ /s)	(m)	Max	(m)		Diam	(m/s)	(m)	(m)	(kPa)	(m)	(kPa)
										348.04	14.40	0 (HW)
1	0.0009	21	0.315	0.05	50&4	0.047	0.52	0.1605	0.1649	349.64	14.40	349.64
2	0.0009	21	0.315	0.05	50&4	0.047	0.52	0.1605	0.1649	351.25	14	355.45
3	0.0018	21	0.315	0.063	63&4	0.06	0.64	0.1764	0.1755	353.01	13.6	357.21
4	0.0018	21	0.315	0.063	63&4	0.06	0.64	0.1764	0.1755	354.77	13.1	358.97
5	0.0027	21	0.315	0.075	75&4	0.072	0.67	0.1538	0.1507	356.31	12.7	360.51
6	0.0027	21	0.315	0.075	75&4	0.072	0.67	0.1538	0.1507	357.85	12.3	362.05
7	0.0036	21	0.315	0.075	75&4	0.072	0.89	0.262	0.2508	360.47	11.9	364.67
8	0.0036	21	0.315	0.075	75&4	0.072	0.89	0.262	0.2508	363.09	11.5	367.29
9	0.0045	21	0.315	0.09	90&4	0.086	0.77	0.1629	0.156	364.72	11	368.92
10	0.0045	21	0.315	0.09	90&4	0.086	0.77	0.1629	0.156	366.35	10.6	370.55
11	0.0054	21	0.315	0.09	90&4	0.086	0.92	0.2284	0.2155	368.63	10.2	372.83
12	0.0054	21	0.315	0.09	90&4	0.086	0.92	0.2284	0.2155	370.92	9.78	375.12
13	0.0063	21	0.315	0.09	90&4	0.086	1.08	0.3039	0.283	373.95	9.36	378.15
14	0.0063	21	0.315	0.09	90&4	0.086	1.08	0.3039	0.283	376.99	8.94	381.19

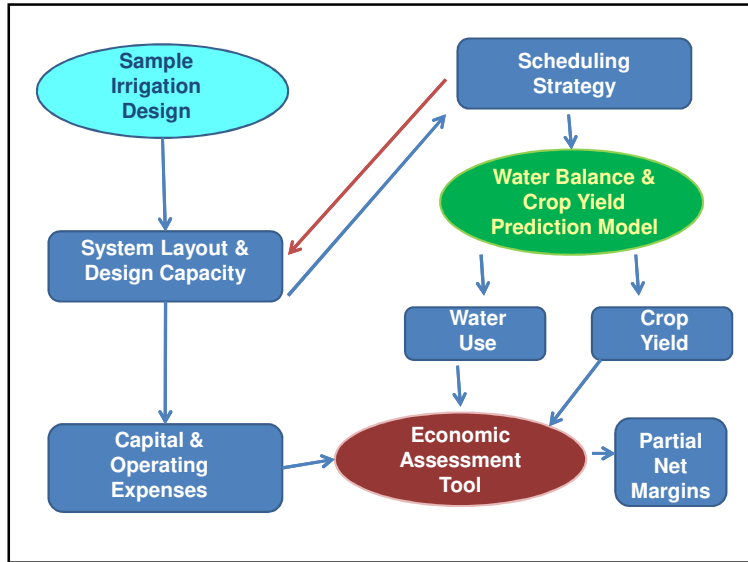


Laterals	Qty	Item Cos	Total Cost	Submains	Qty	Item Cost	Total Cost
125mm Diam.				125mm Diam.			
Class 4 m	0	R.58.49	R.0.00	Class 4 m	84	R.58.49	R.4,912.88
Class 6 m	0	R.68.23	R.0.00	Class 6 m	756	R.68.23	R.51,581.88
Class 9 m	0	R.97.17	R.0.00	Class 9 m	0	R.97.17	R.0.00
Class 12 m	0	R.125.87	R.0.00	Class 12 m	0	R.125.87	R.0.00
Class 16 m	0	R.161.91	R.0.00	Class 16 m	0	R.161.91	R.0.00
Class 20 m	0	R.200.94	R.0.00	Class 20 m	0	R.200.94	R.0.00
		R.0.00				R.0.00	
140mm Diam.				140mm Diam.			
Class 4 m	0	R.72.30	R.0.00	Class 4 m	0	R.72.30	R.0.00
Class 6 m	0	R.85.13	R.0.00	Class 6 m	0	R.85.13	R.0.00
Class 9 m	0	R.123.20	R.0.00	Class 9 m	0	R.123.20	R.0.00
Class 12 m	0	R.160.86	R.0.00	Class 12 m	0	R.160.86	R.0.00
Class 16 m	0	R.204.27	R.0.00	Class 16 m	0	R.204.27	R.0.00
Class 20 m	0	R.256.79	R.0.00	Class 20 m	0	R.256.79	R.0.00

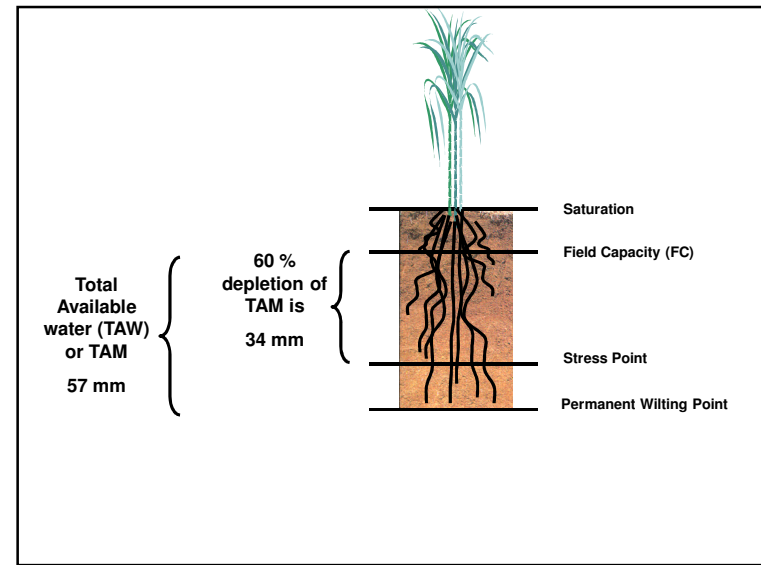
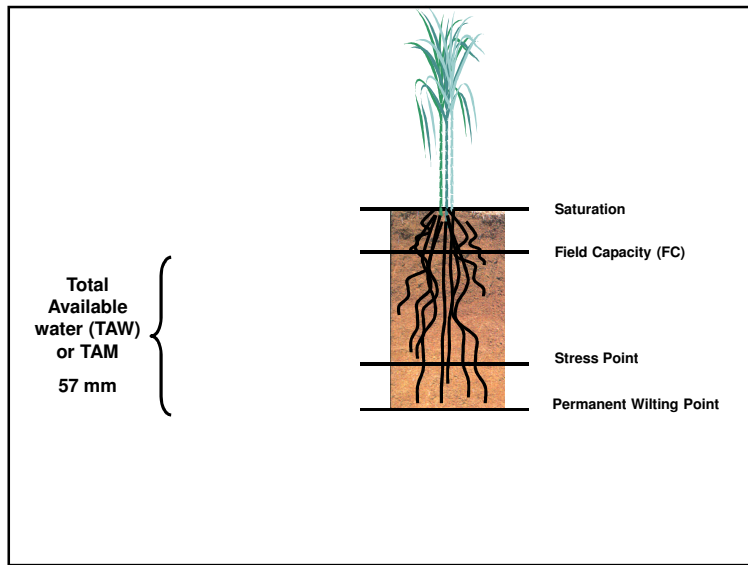
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Class 9 m	0	R.97.17	R.0.00	Class 9 m	0	R.97.17	R.0.00
Class 12 m	0	R.125.87	R.0.00	Class 12 m	0	R.125.87	R.0.00
		R.0.00				R.0.00	
140mm Diam.				140mm Diam.			
Class 4 m	0	R.72.30	R.0.00	Class 4 m	0	R.72.30	R.0.00
Class 6 m	0	R.85.13	R.0.00	Class 6 m	0	R.85.13	R.0.00
Class 9 m	0	R.123.20	R.0.00	Class 9 m	0	R.123.20	R.0.00
Class 12 m	0	R.160.86	R.0.00	Class 12 m	0	R.160.86	R.0.00
Class 16 m	0	R.204.27	R.0.00	Class 16 m	0	R.204.27	R.0.00
Class 20 m	0	R.256.79	R.0.00	Class 20 m	0	R.256.79	R.0.00

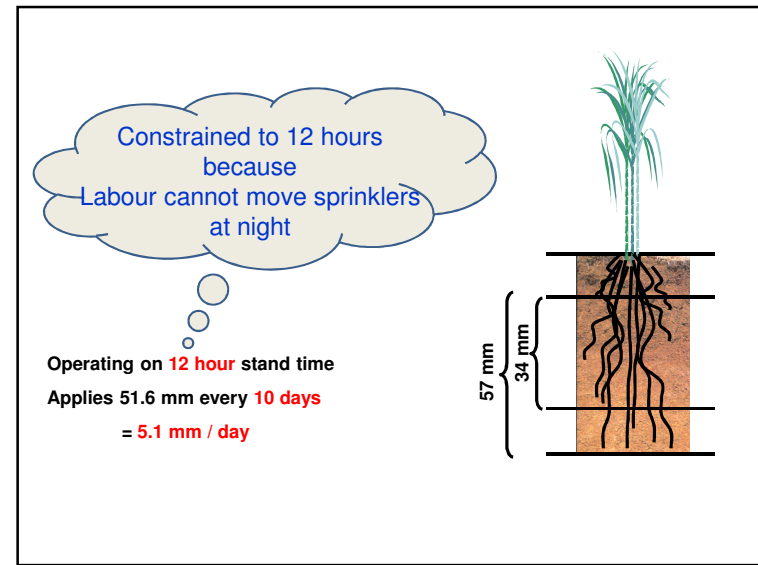
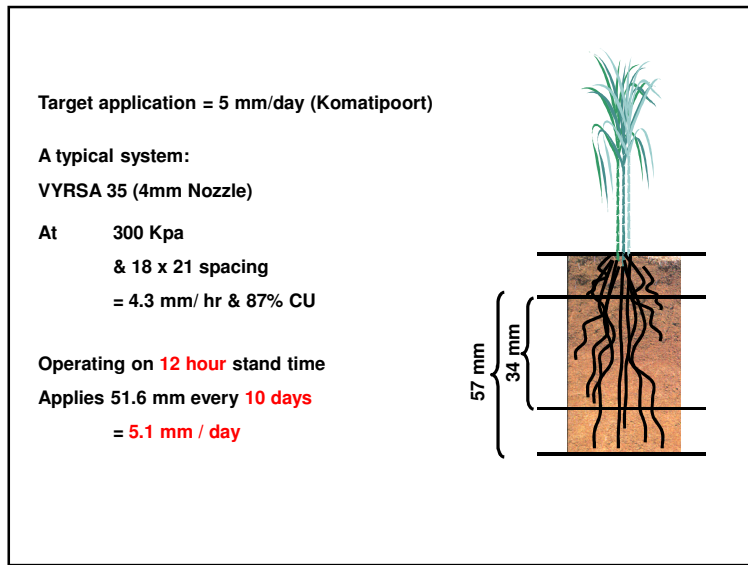
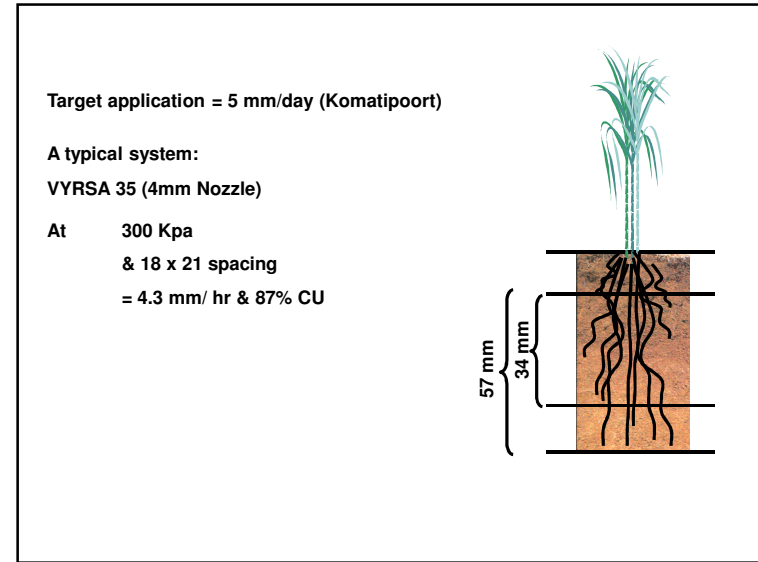
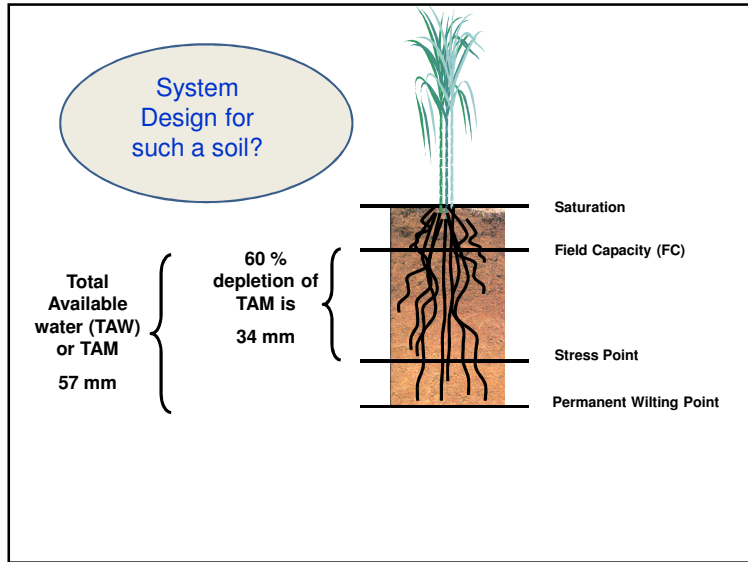
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No	Description	Costs
1	Sprinkler Package	R 52,645.56
2	Underground pipes	R 356,786.54
2.1	Laterals	R 217,879.20
2.2	Sub Mains	R 90,110.02
2.3	Mainline	R 4,082.08
2.4	Pressure regulating valves	R 6,345.24
2.5	Cross pieces at lateral junct	R 38,370.00
4	Trenching costs	
	Laterals @ R6 per meter	R 142,560.00
	Mains and Submains @ R8 per meter	R 14,976.00
	Total	R 566,968.10



Application of Framework to assess strategies on shallow soils





Constrained to 12 hours because Labour cannot move sprinklers at night

Operating on 12 hour stand time
Applies 51.6 mm every 10 days
= 5.1 mm / day

Same system:

VYRSA 35 (4mm Nozzle)
At 300 Kpa & 18 x 21 spacing
= 4.3 mm/ hr & 87% CU

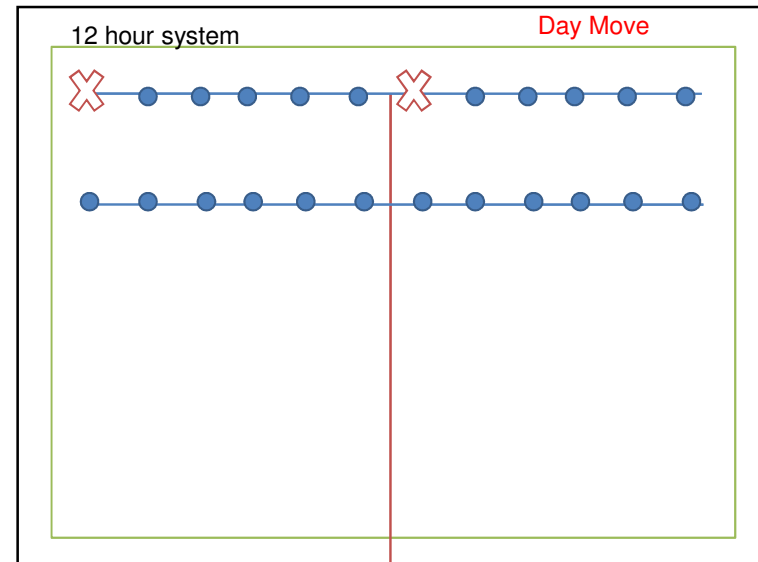
Operating on 8 hour stand time
Applies 34.4 mm every 6 days
= 5.7 mm / day

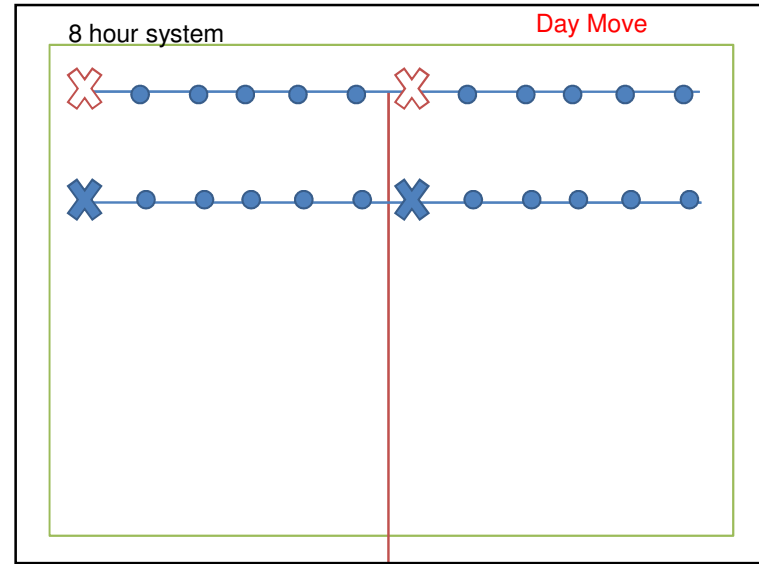
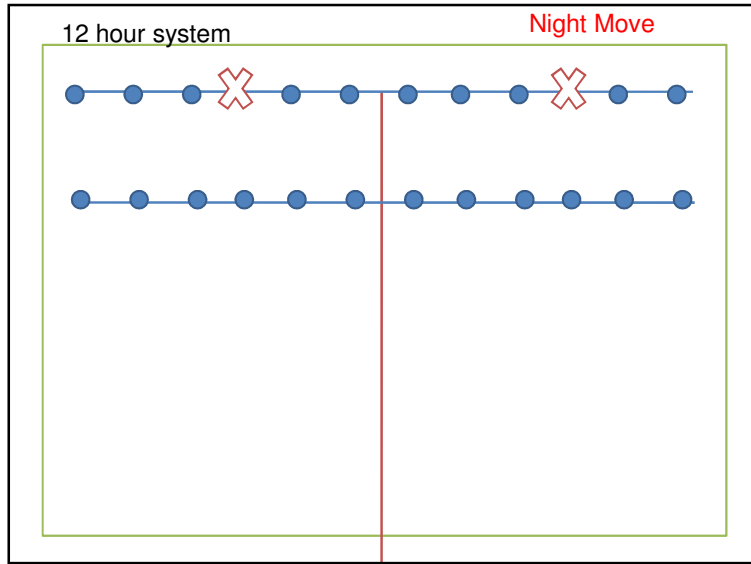
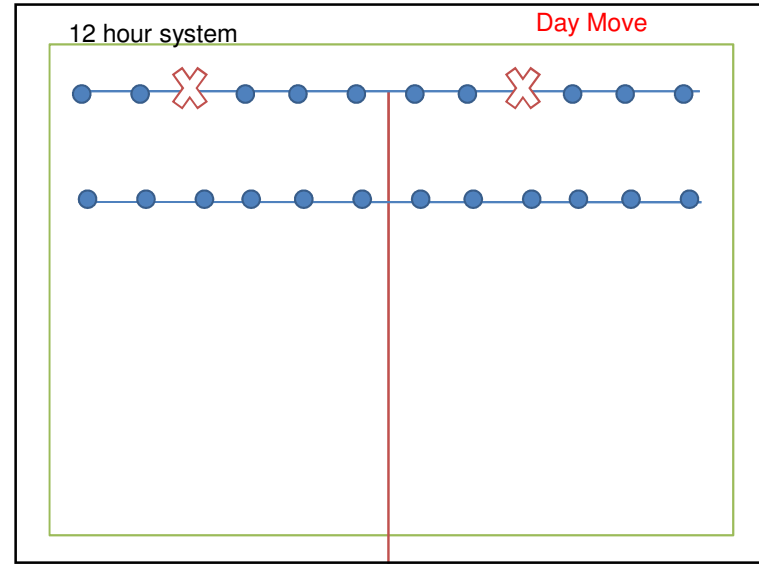
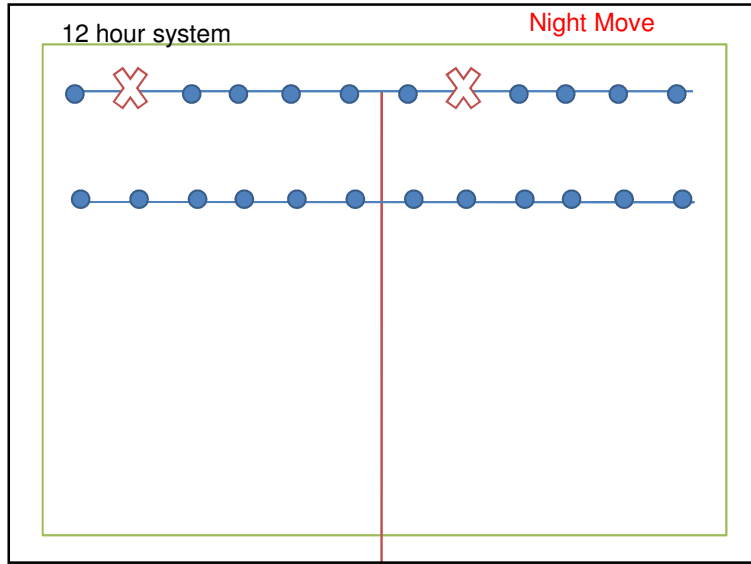
Hypothesis – Yield Improvements will offset Higher costs of 8 hr system

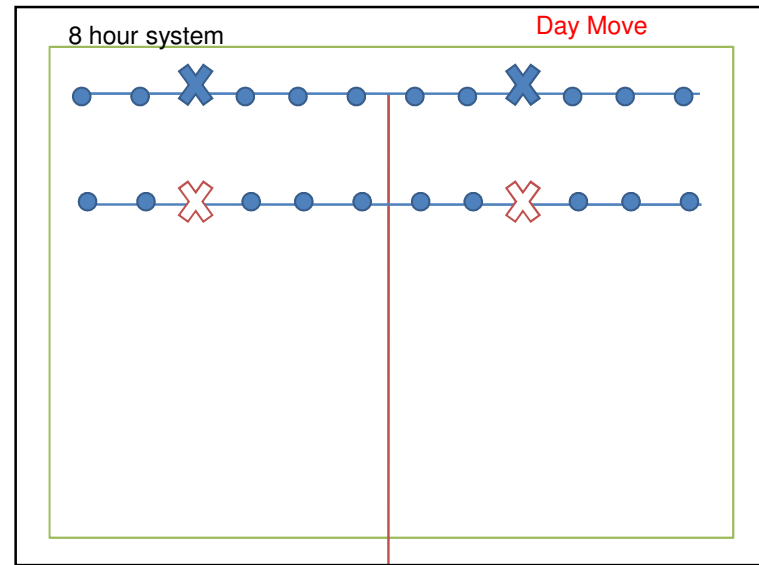
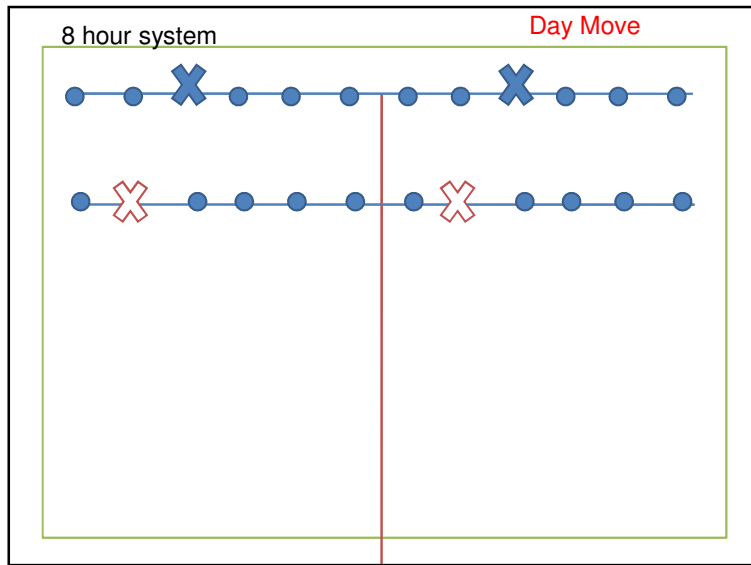
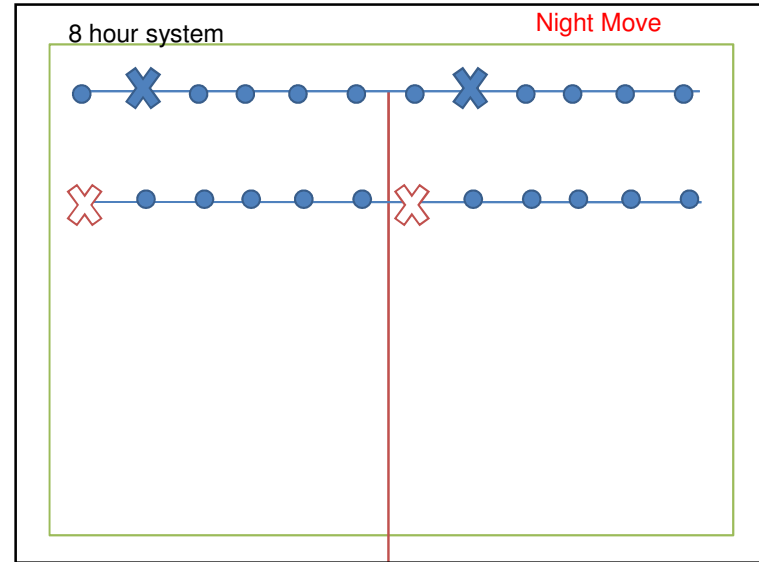
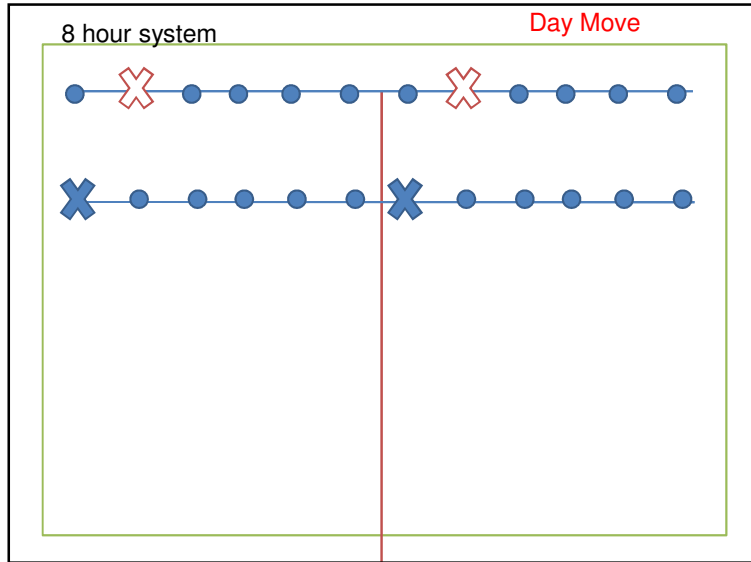
Same system:

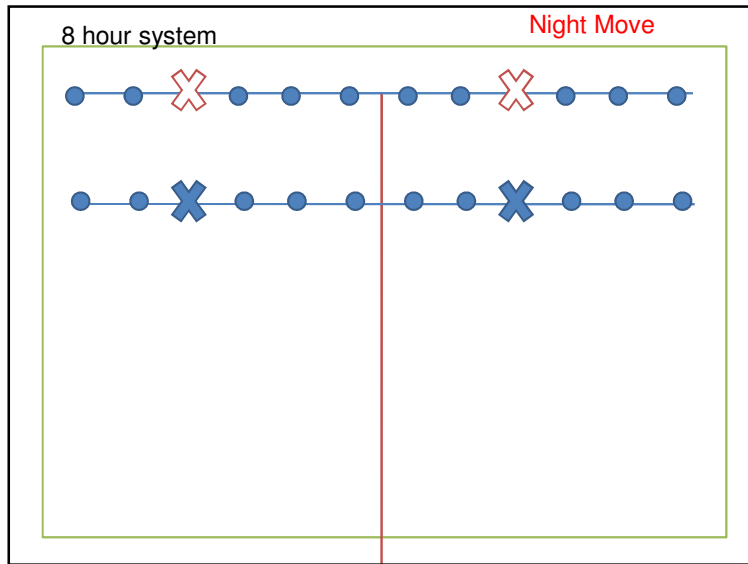
VYRSA 35 (4mm Nozzle)
At 300 Kpa & 18 x 21 spacing
= 4.3 mm/ hr & 87% CU

Operating on 8 hour stand time
Applies 34.4 mm every 6 days
= 5.7 mm / day



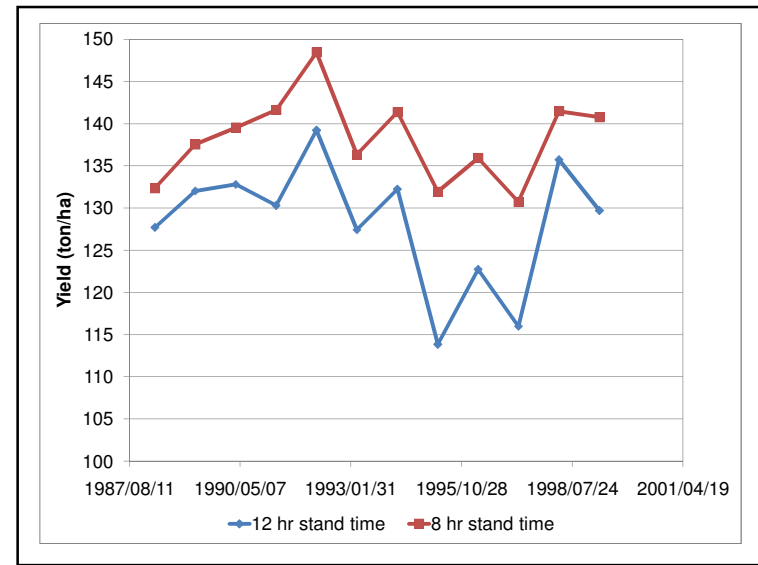
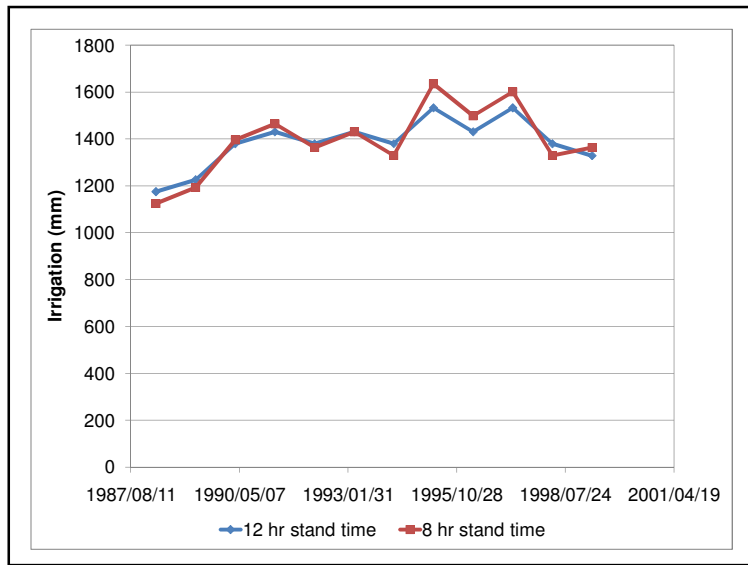


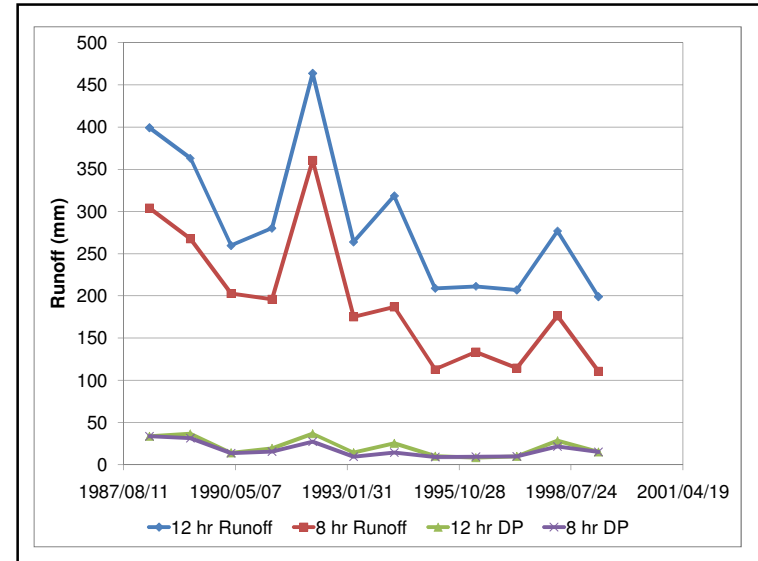
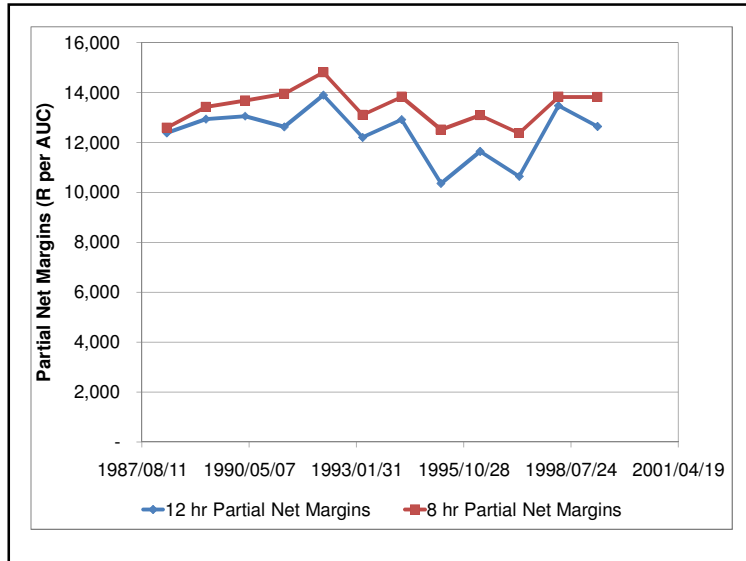




SYSTEM COSTS PER HA

	12 Hr	8 Hr
Sprinkler package	R 1, 039	R 2, 309
Laterals	R 4, 301	R 4, 301
Sub Mains	R 1, 779	R 1, 967
Main Line	R 81	R 90
Senniger Valves	R 125	R 139
Crosses/ Tees / Hydrants	R 758	R 2, 407
Trenching	R 3, 110	R 3, 143
Total	R 11, 193	R 14, 356
%	100%	128%





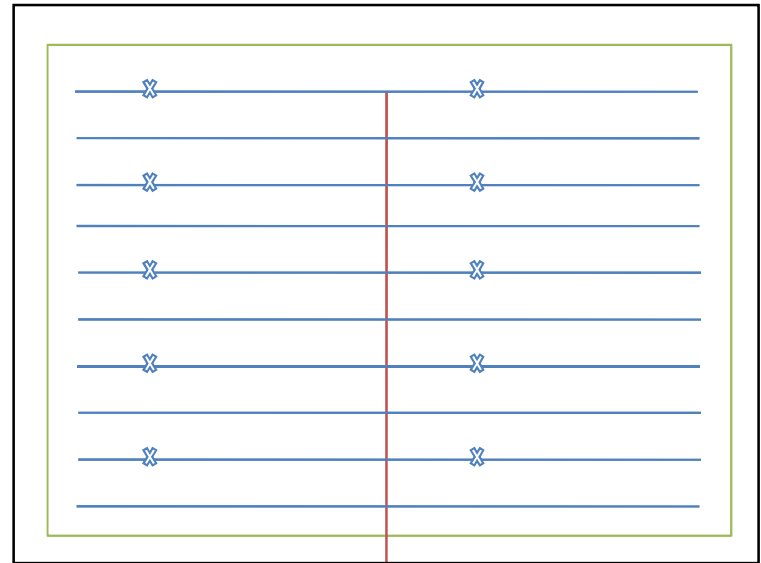
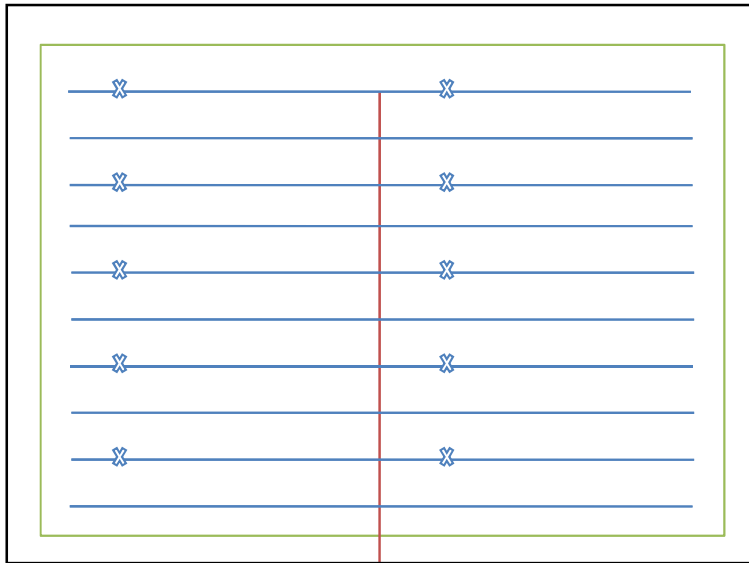
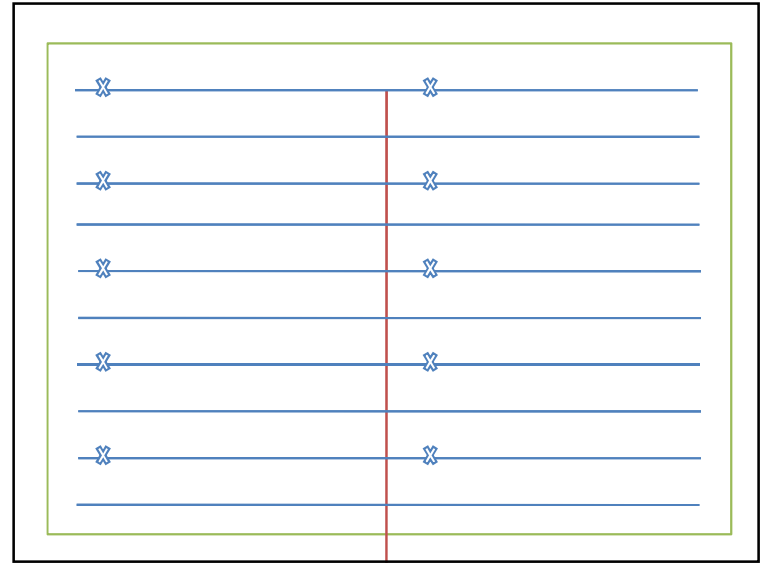
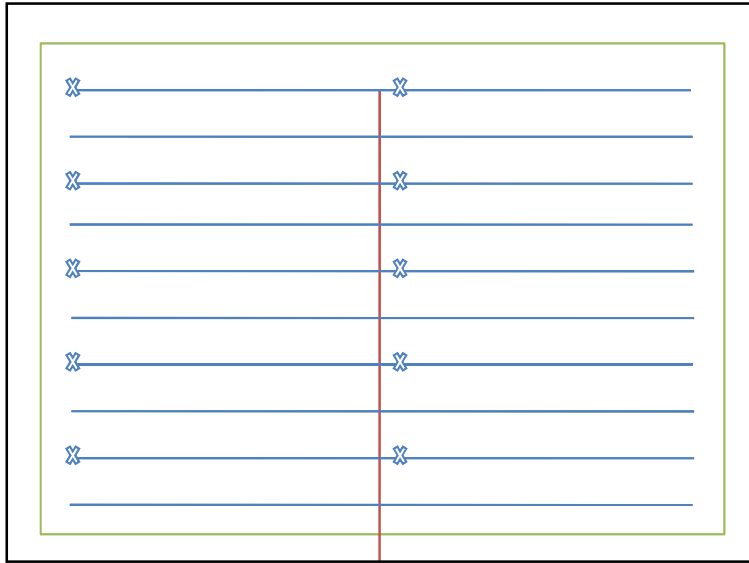
ACKNOWLEDGEMENTS

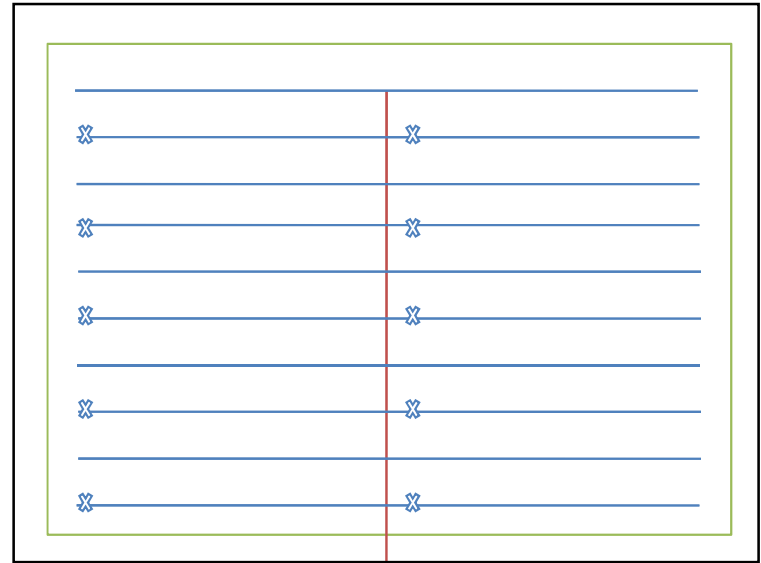
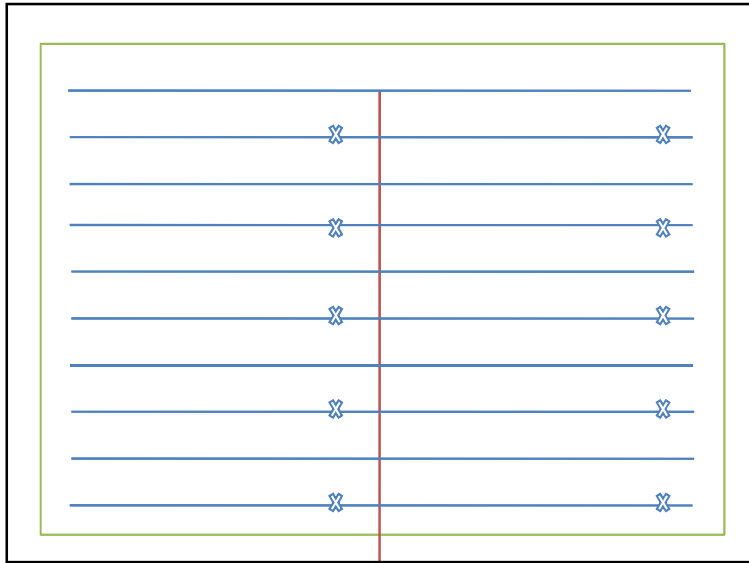
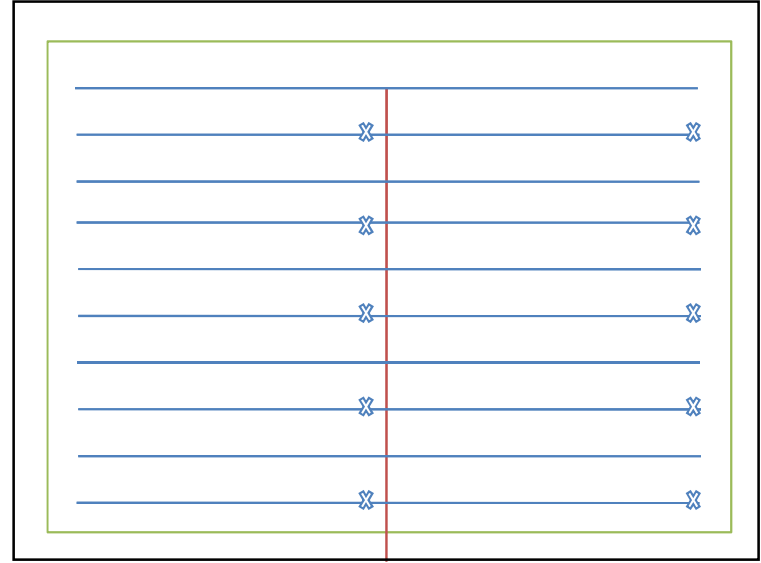
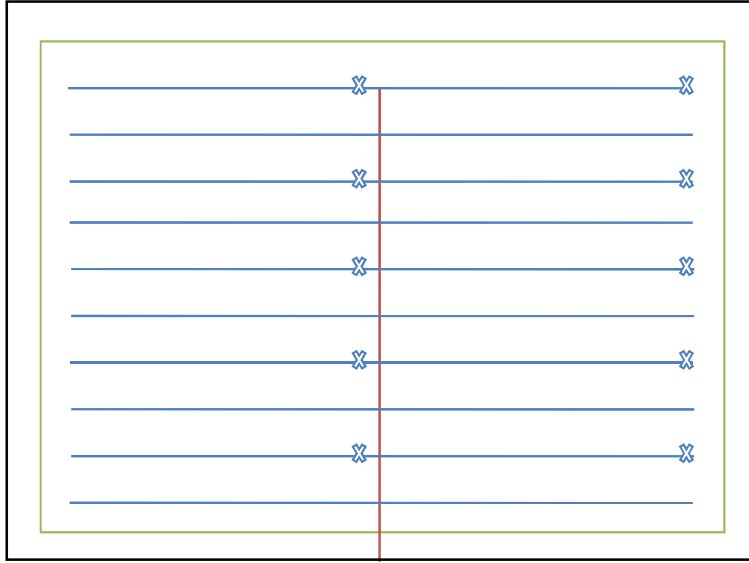
- Dr. Neil Lecler (Co-Author) 
- Mark Zartman, Dr. Senzanje, Peter Tweddle & Rod Harding 
- Felix Reinders & Adriaan van Niekerk 
- Water Research Commission 

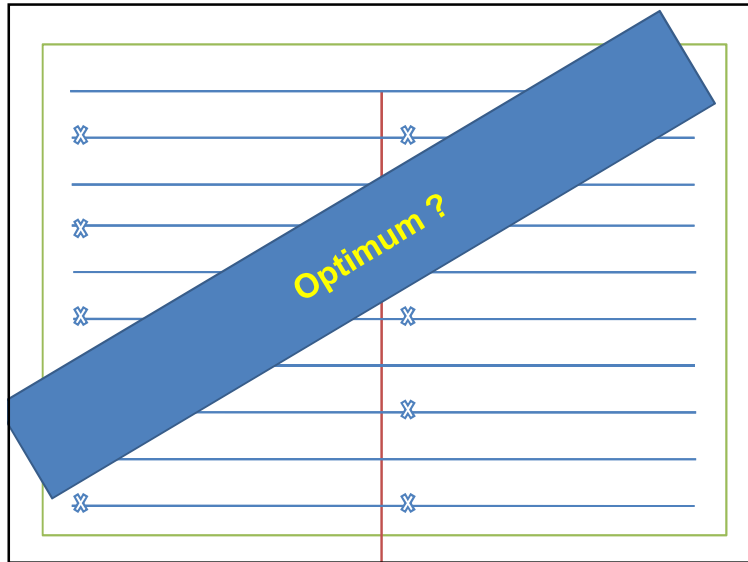





Field Layout and sprinkler operation?

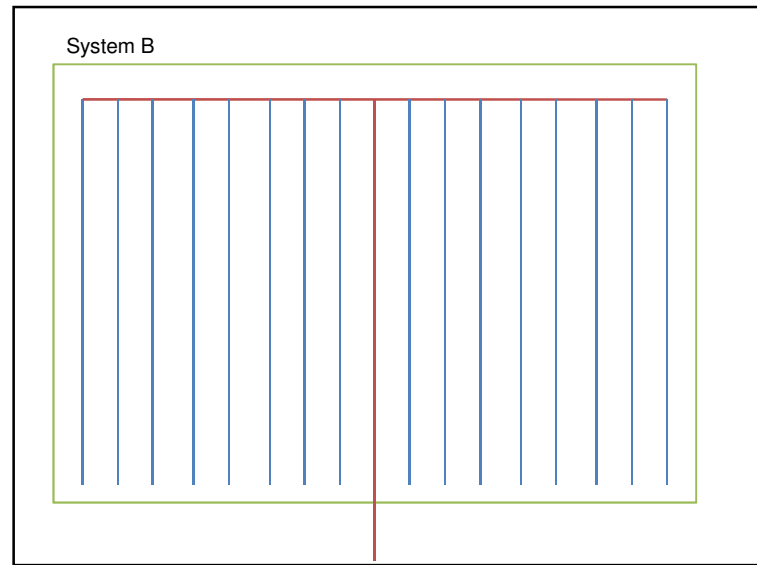
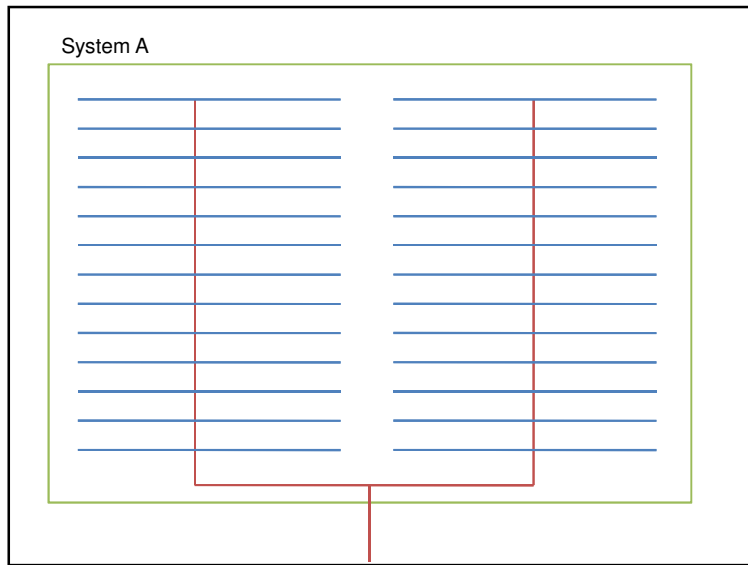


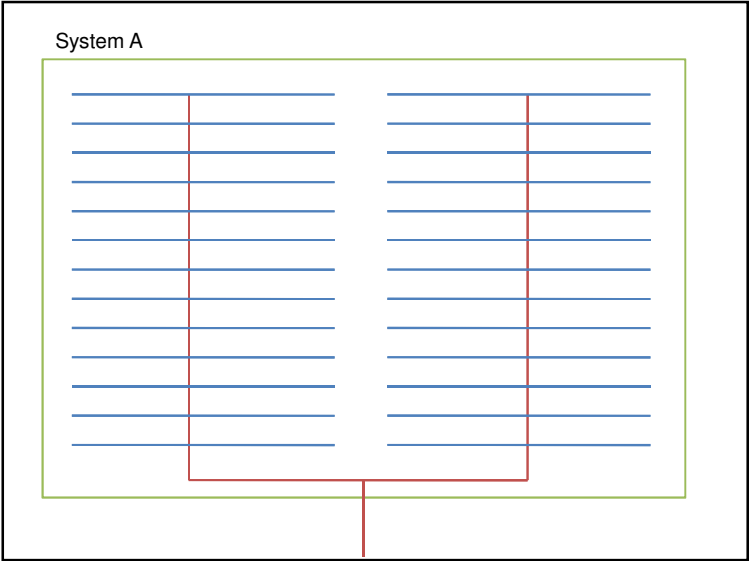
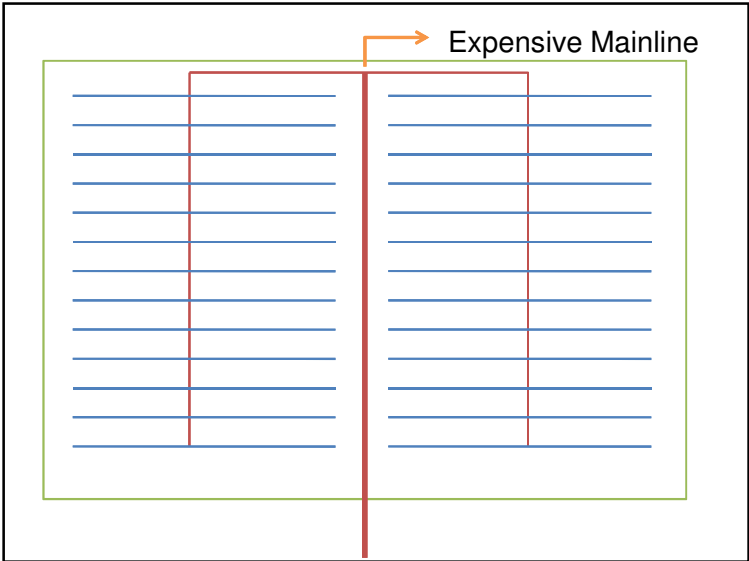
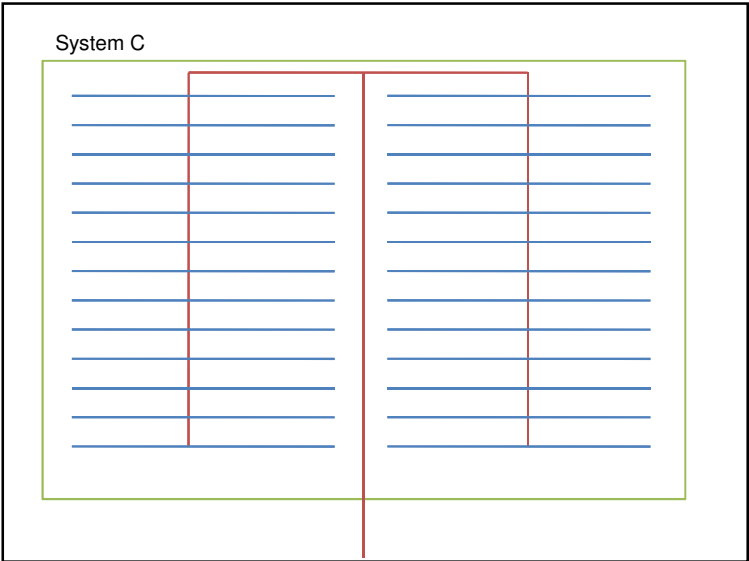


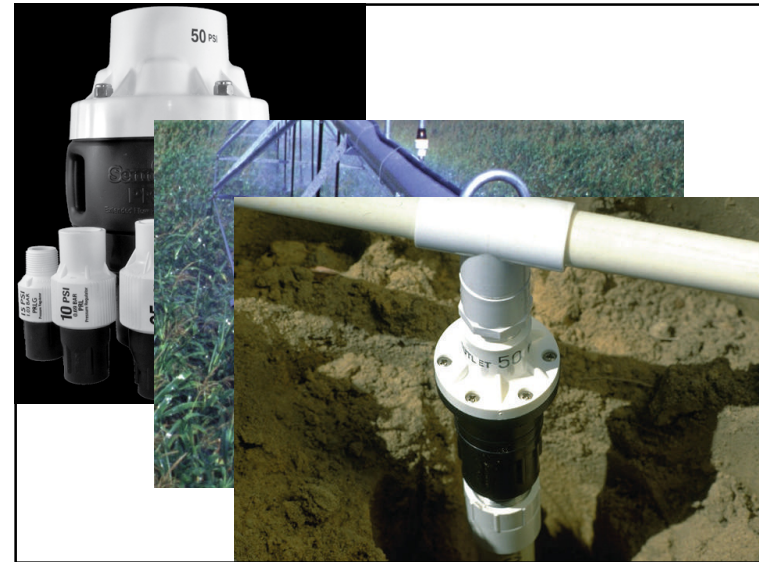
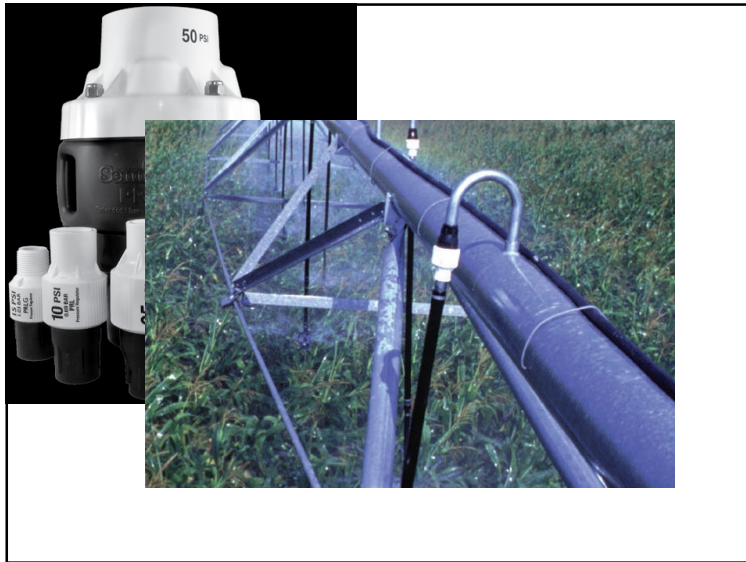





Alternative Pipe Layouts

Challenge of determining the optimum layout







Area = 53.49 ha	System A 	System B 	System C 
Sprinkler package	R 73, 385	R 73, 385	R 73, 385
Laterals	R 303, 710	R 680, 126	R 303, 710
Sub Mains	R 84, 867	R 33, 783	R 109, 177
Main Line	R 4, 082	R 111, 914	R 108, 107
Valves	R 8, 845	--	R 800
Crosses / Tees / Hydrants	R 66, 310	R 31, 974	R 63, 848
Trenching	R 212, 592	R 228, 048	R 218, 016
Total	R 753, 792	R 1, 159, 230	R 877, 043
%	100%	154%	116%