Draft Research Proposal

Low pressure drip irrigation for agriculture

Revision 4

August 2019

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Title Low pressure drip irrigation for agriculture

Rationale/background/justification

The cost of drip irrigation in agriculture using electric pumps is increasing as the cost of electricity is increasing.

Low pressure or gravity feed drip irrigation would reduce the cost of electricity dramatically.

Research question

The research proposal is to establish field trials to compare the cost effectiveness of low pressure drip irrigation with conventional pressurised drip irrigation. The plot size should be at least one acre.

I propose that the low pressure system be setup so that the irrigation scheduling and dripper volumes are the same as those for a conventional high pressure system. This will hopefully avoid any discussion about the comparative effectiveness of the low pressure irrigation versus the high pressure irrigation.

Activities/methodology

I have used EPANET to simulate a number of low pressure systems for plots of 1 acre, 2 acres, 4 acres and 8 acres. I have assumed that the plots are 100m from a water source at the same level. The results of these simulations need to be tested with field trials.

Below is an example a drip irrigation system for 1 acre using Toro Aquatraxx with 0.3m dripper spacing between the drippers and 1 metre dripper spacing between the laterals.

I suggest the 10 catch cans be used (see diagram below) to measure the volume of water discharged by various drippers during the irrigation event. Catch cans should also be used for the high pressure system. This arrangement will make the data collection very straightforward.

I propose that the initial trials be setup on level land with a plot size of 1 acre.

Assuming that the trials on level land are successful, I propose that further trials be conducted on sloping land using pressure balance valves.

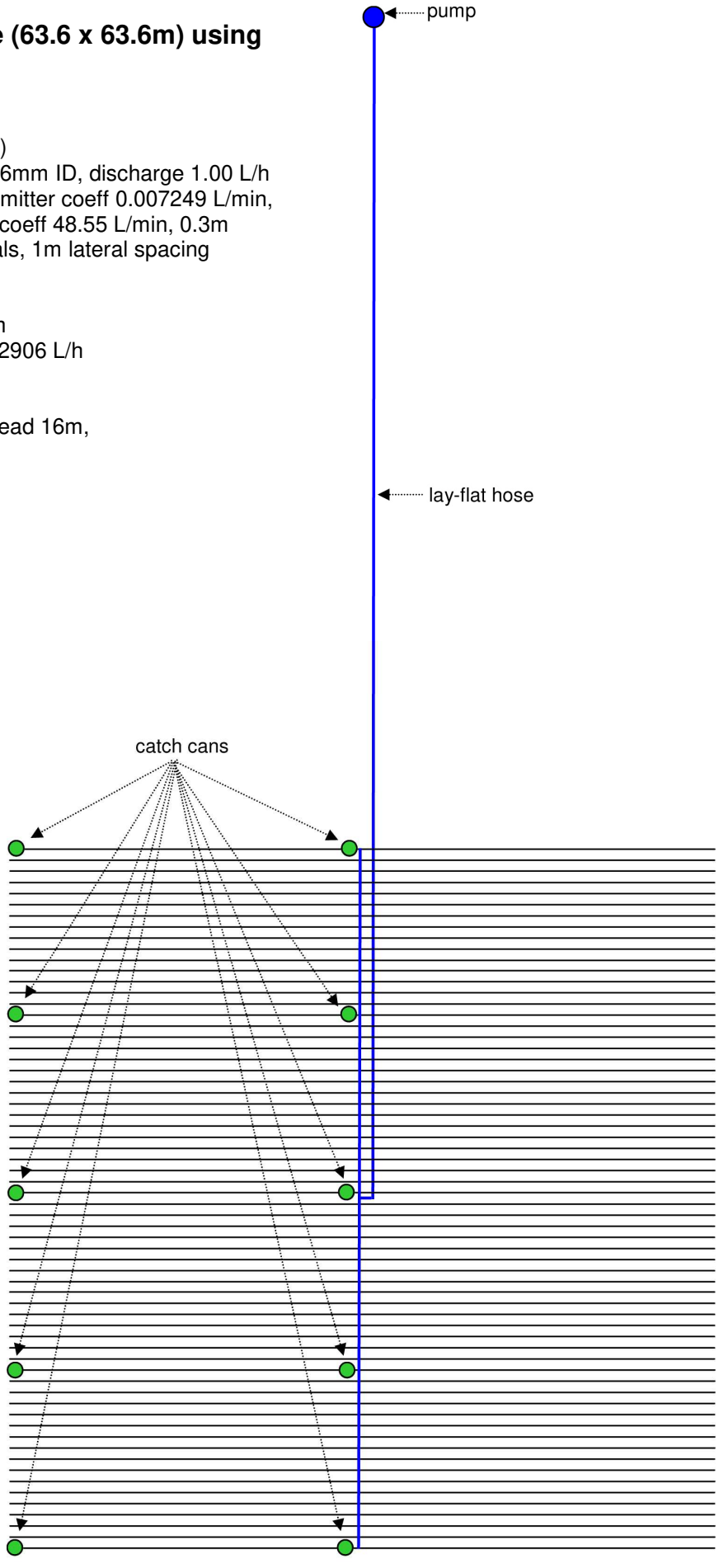
EPANET simulations on level ground

Low pressure irrigation of 1 acre (63.6 x 63.6m) using 2000w swimming pool pump

- pump is 100m from the plot
- 196m of 76mm lay-flat hose (blue)
- 4070m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.76 L/min, half acre coeff 48.55 L/min, 0.3m dripper spacing, 128 X 32m laterals, 1m lateral spacing

demand = 288 L/min
pressure range for drippers: 8.72 to 8.81m
discharge range for drippers: 1.2846 to 1.2906 L/h
max discharge variation = 0.46%

2000w swimming pool pump, maximum head 16m,
maximum flow 500 L/min

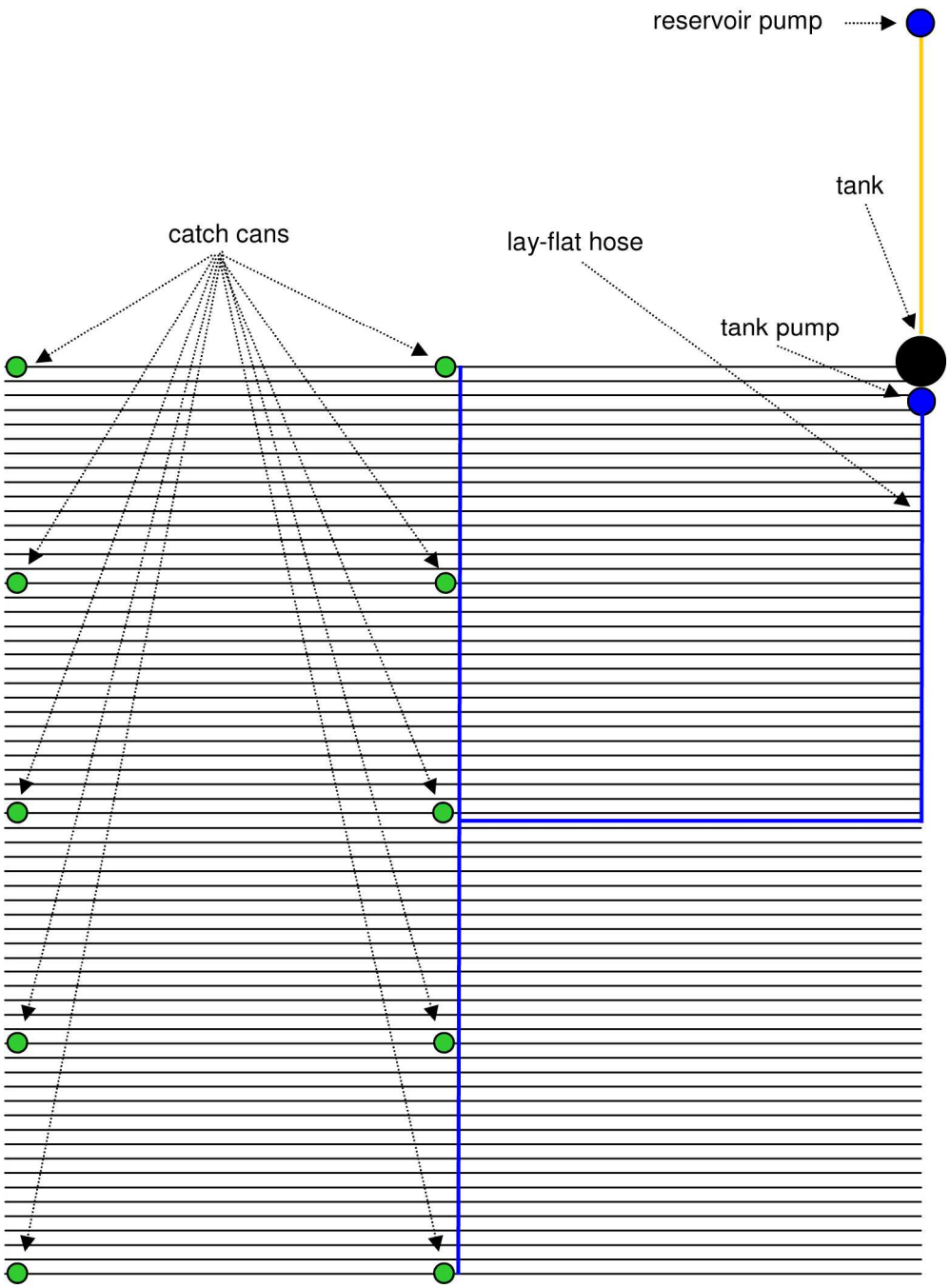


Low pressure irrigation of 1 acre using two 2000w swimming pool pumps and tank

- 2100L tank at a corner of the plot and 100m from a reservoir
- 100m of 50mm poly pipe (yellow)
- 128m of 76mm lay-flat hose (blue)1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.76 L/min, half acre coeff 48.55 L/min, 0.3m dripper spacing, 128 X 32m laterals, 1m lateral spacing

demand range: 297 L/min (tank near empty) to 315 L/min (tank full)
pressure range for drippers with tank near empty: 9.29 to 9.38m
discharge range for drippers with tank near empty: 1.3254 to 1.3320 L/h
max discharge variation with tank near empty = 0.50%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

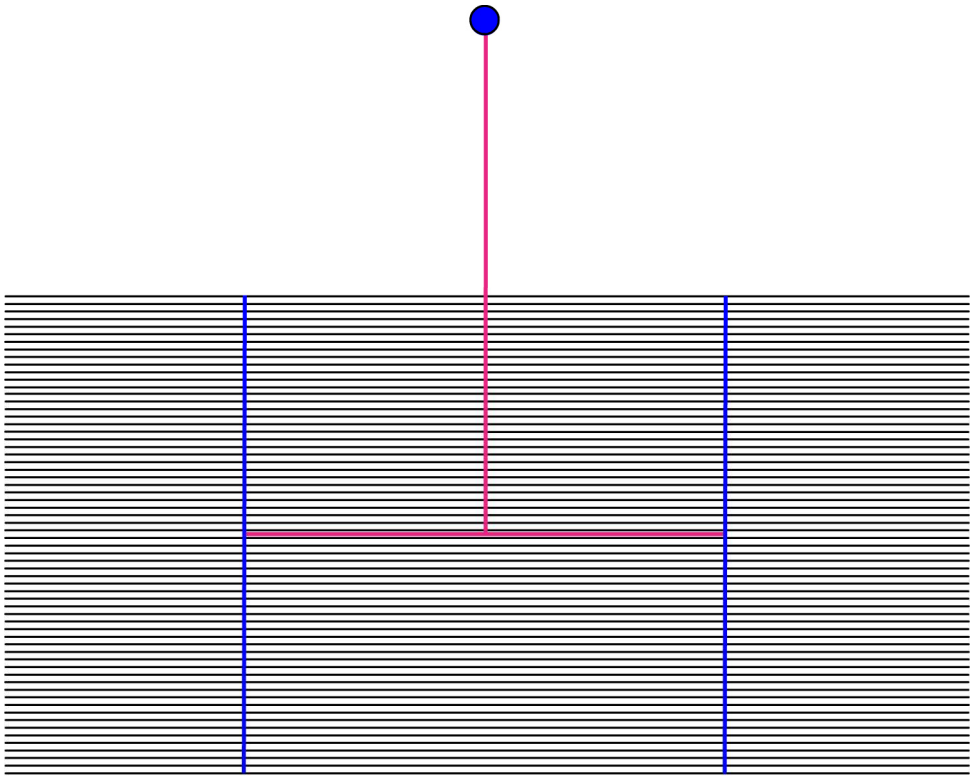


Low pressure irrigation of 2 acres (63.6 x 127.2m) using 2000w swimming pool pump

- pump is 100m from the plot
- 196m of 102mm lay-flat hose (magenta)
- 128m of 76mm lay-flat hose (blue)
- 8140m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.76 L/min, half acre coeff 48.55 L/min, 0.3m dripper spacing, 256 x 32m laterals, 1m lateral spacing

demand = 408 L/min
pressure range for drippers: 4.37 to 4.42m
discharge range for drippers: 0.9090 to 0.9144 L/h
max discharge variation = 0.59%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

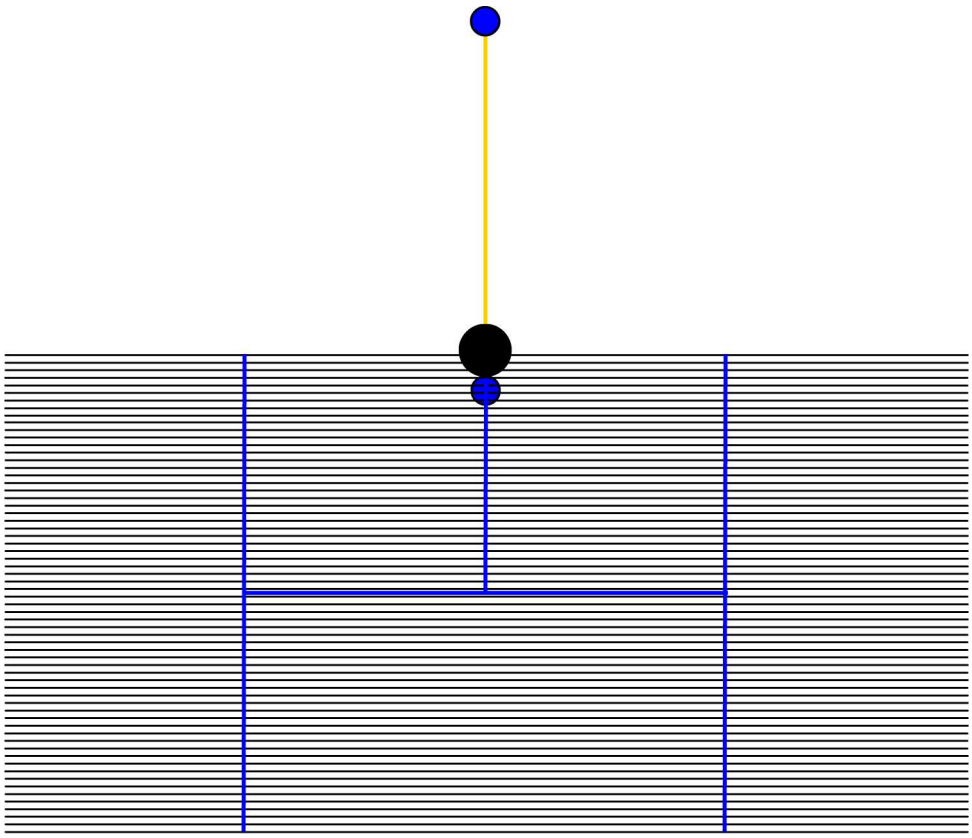


Low pressure irrigation of 2 acres using two 2000w swimming pool pumps and tank

- 3300L tank at the edge of the plot and 100m from a reservoir
- 100m of 50mm poly lay-flay hose (yellow)
- 224m of 76mm lay-flat hose (blue)
- 8140m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.76 L/min, half acre coeff 48.55 L/min, 0.3m dripper spacing, 256 x 32m laterals, 1m lateral spacing

demand range: 413 L/min (tank almost empty) to 438 L/min (tank full)
pressure range for drippers with tank almost empty: 4.47 to 4.52m
discharge range for drippers with tank almost empty: 0.9198 to 0.9252 L/h
max discharge variation with tank almost empty = 0.58%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min



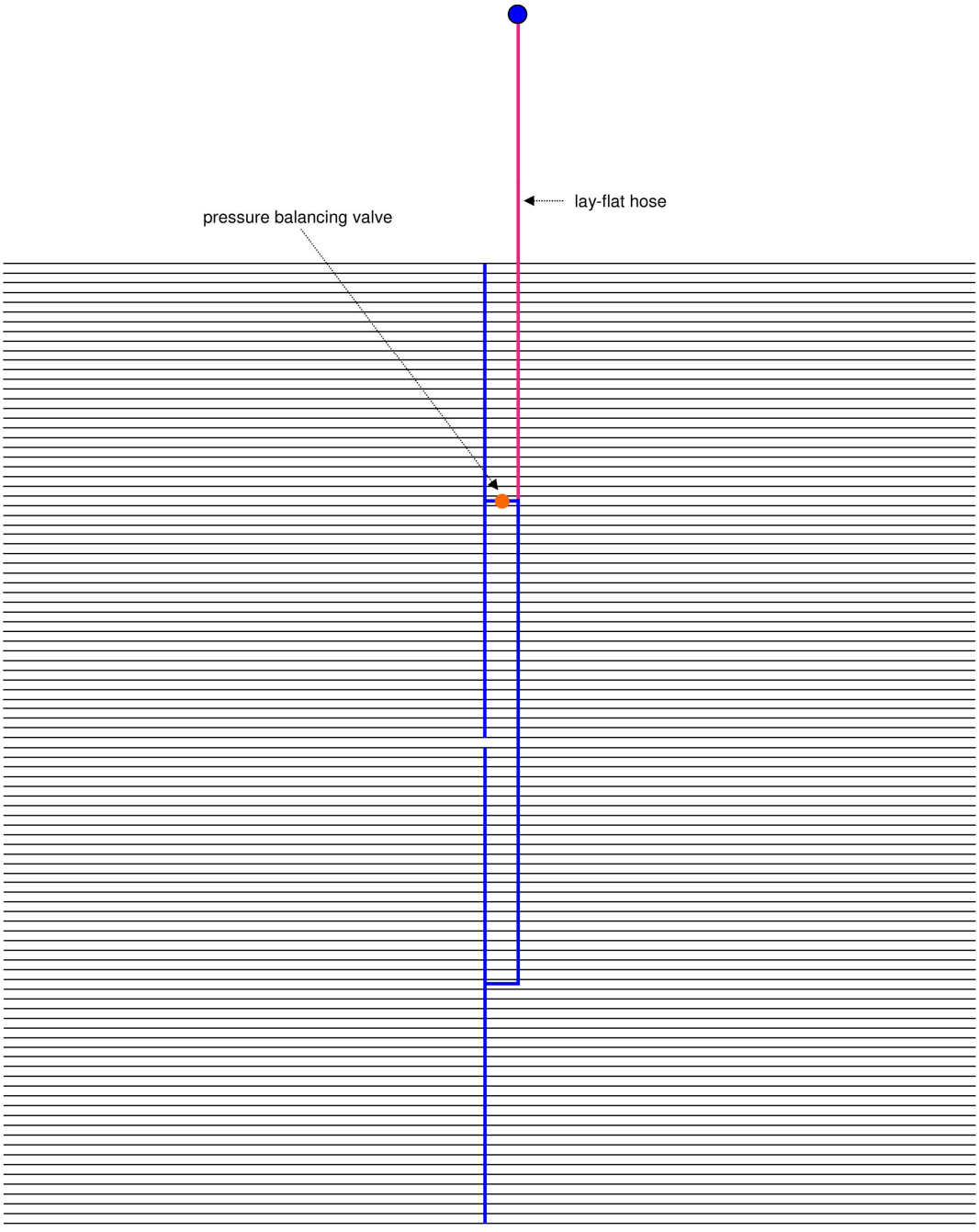
Low pressure irrigation of 1 hectare (100 x 100m) using 2000w swimming pool pump

- pump is 100m from the plot
- 125m of 102mm lay-flat hose (magenta)
- 275m of 76mm lay-flat hose (blue)
- 10000m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 1.202 L/min, 0.25 ha coeff 59.94 L/min, 0.3m dripper spacing, 200 x 50m laterals, 1m lateral spacing

demand = 392 L/min
pressure range for drippers: 2.60 to 2.68m
discharge range for drippers: 0.7044 to 0.7116 L/h
max discharge variation = 1.57%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

An adjustable pressure balancing valve is installed and is shown as an orange dot in the diagram below. The valve is adjusted so that the pressure is balanced between the two halves of the plot. If you don't use a pressure balancing valve, an additional 25m of lay-flat hose is needed to balance the pressures.

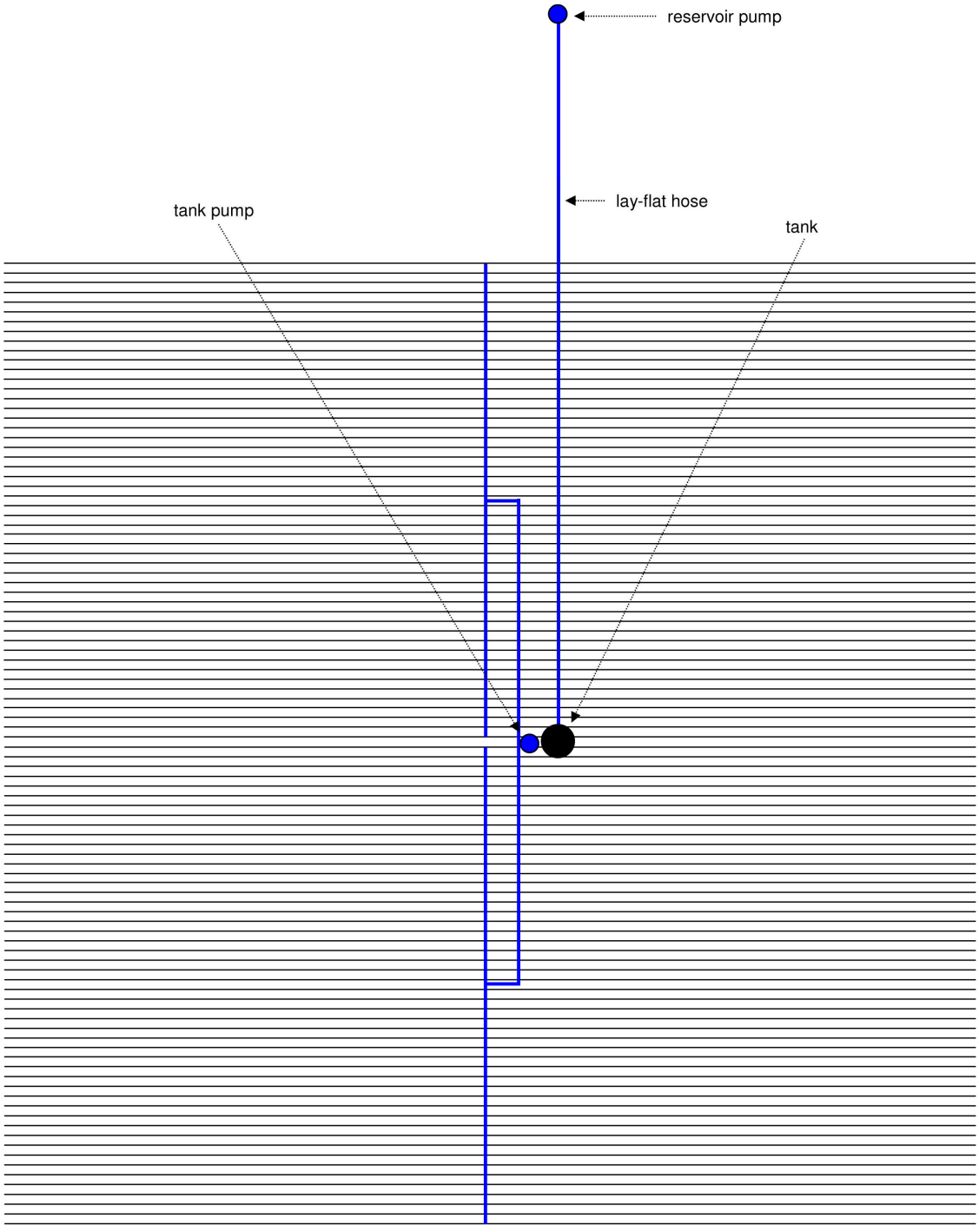


Low pressure irrigation of 1 hectare (100 x 100m) using two 2000w swimming pool pumps and tank

- 5000L tank at the centre of the plot and the plot is100m from a reservoir
- 300m of 76mm lay-flat hose (blue)
- 10000m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 1.2025 L/min, 0.25 ha coeff 60 L/min, 0.3m dripper spacing, 200 x 50m laterals, 1m lateral spacing

demand range: 467 L/min (tank almost empty) to 492 L/min (tank full)
pressure range for drippers with tank almost empty: 3.70 to 3.79m
discharge range for drippers with tank almost empty: 0.8365 to 0.8466 L/h
max discharge variation with tank almost empty = 1.19%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

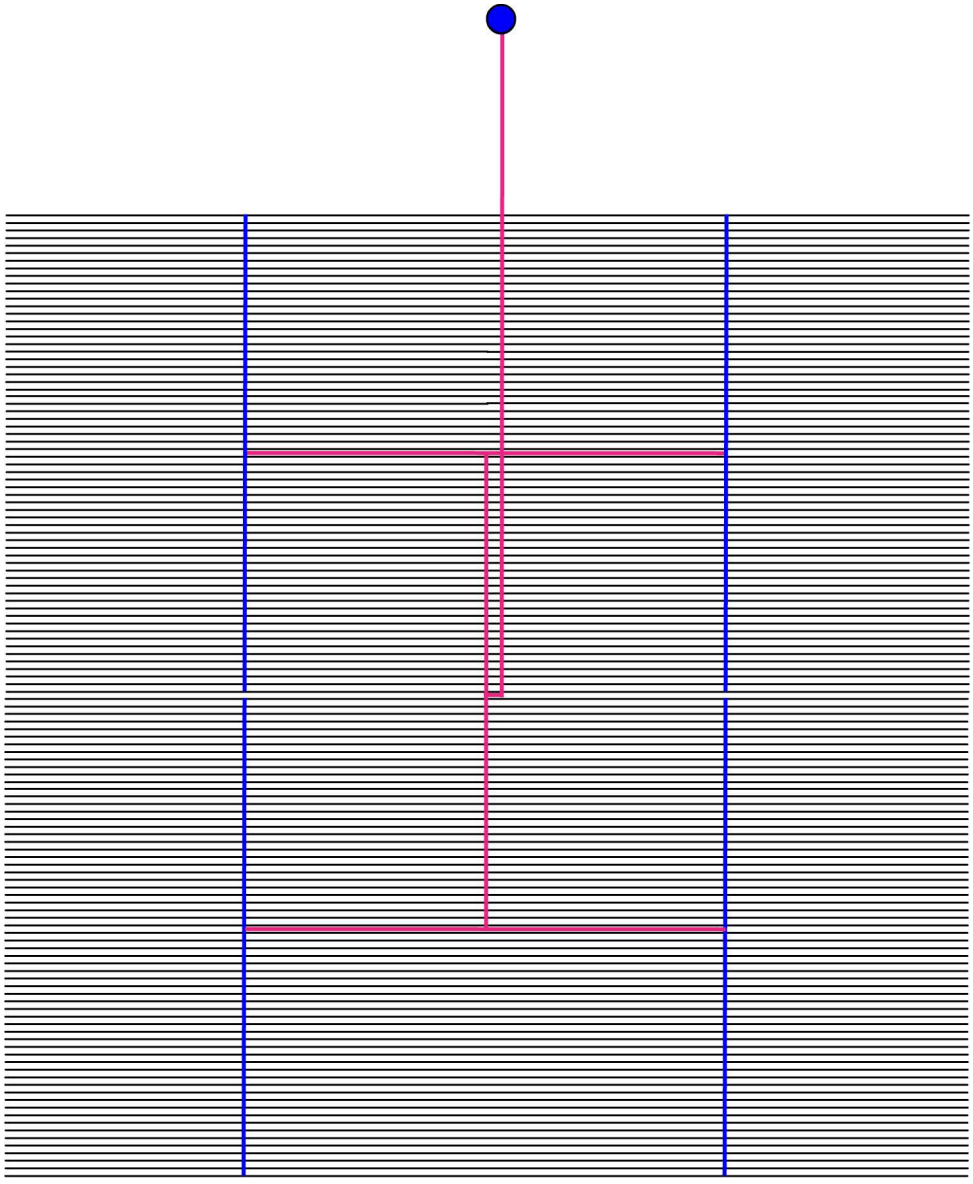


Low pressure irrigation of 4 acres (127.2 x 127.2m) using 2000w swimming pool pump

- pump is 100m from the plot
- 356m of 102mm lay-flat hose (magenta)
- 256m of 76mm lay-flat hose (blue)
- 16280m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.758 L/min, 0.5 acre coeff 48.4 L/min, 0.3m dripper spacing, 512 x 32m laterals, 1m lateral spacing

demand = 455 L/min
pressure range for drippers: 1.36 to 1.38m
discharge range for drippers: 0.5064 to 0.5106 L/h
max discharge variation = 0.82%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

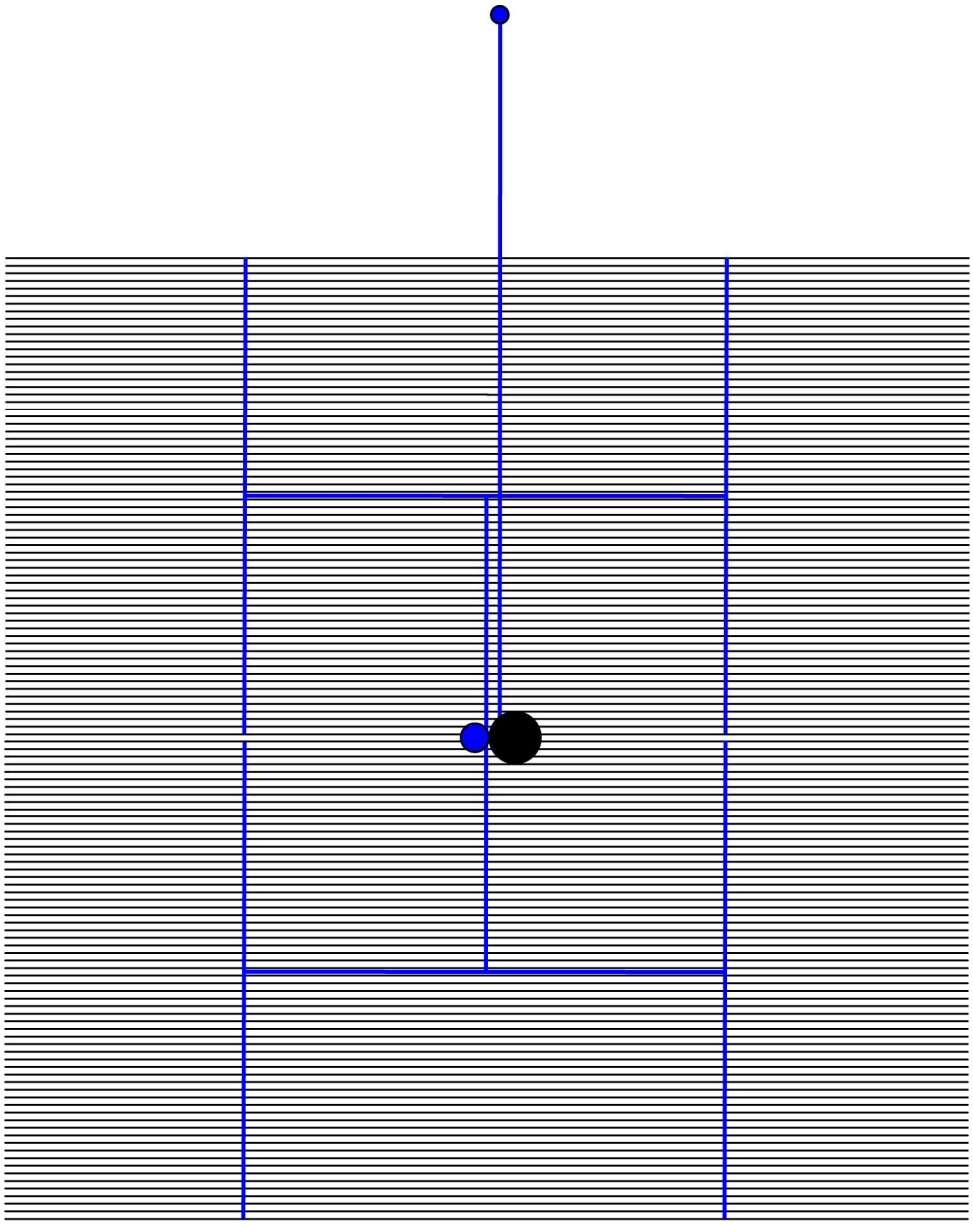


Low pressure irrigation of 4 acres using two 2000w swimming pool pumps and tank

- 5000L tank at the centre of the plot and the plot is 100m from a reservoir
- 568m of 76mm lay-flat hose (blue)
- 16280m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.7585 L/min, 0.5 acre coeff 48.43 L/min, 0.3m dripper spacing, 256 x 32m laterals

demand range: 470 L/min (tank almost empty) to 498 L/min (tank full)
pressure range for drippers with tank almost empty: 1.44 to 1.47m
discharge range for drippers with tank almost empty: 0.5226 to 0.5274 L/h
max discharge variation with tank almost empty = 0.91%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

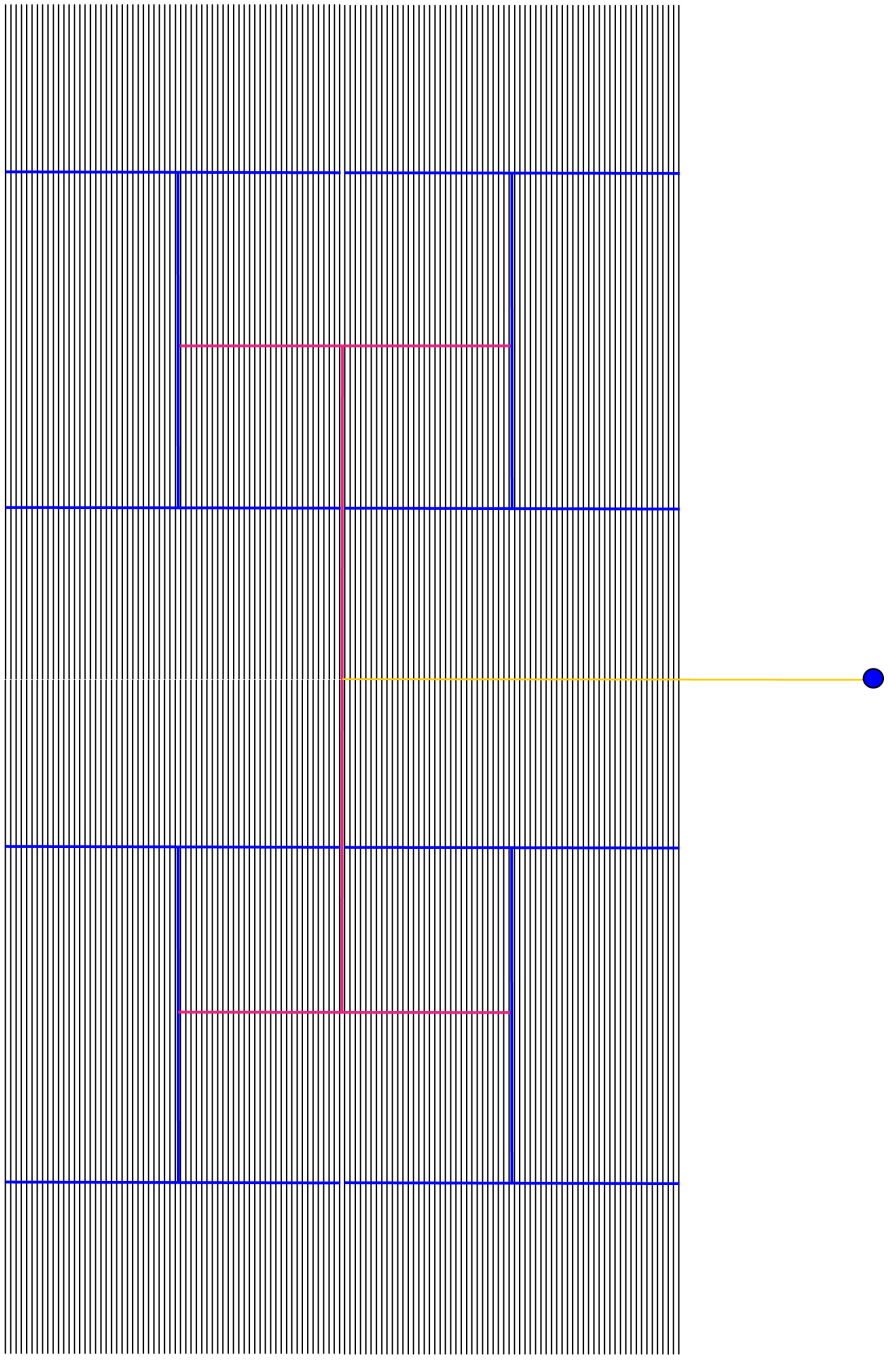


Low pressure irrigation of 8 acres (127.2 x 254.4m) using two 2000w swimming pool pumps

- pumps are 100m from the plot
- 164m of 152mm lay-flat hose (yellow)
- 256m of 102mm lay-flat hose (magenta)
- 768m of 76mm lay-flat hose (blue)
- 32560m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.7585 L/min, 0.5 acre coeff 48.43 L/min, 0.3m dripper spacing, 512 x 32m laterals, 1m lateral spacing

demand = 905 L/min
pressure range for drippers: 1.36 to 1.38m
discharge range for drippers: 0.5070 to 0.5118 L/h
max discharge variation = 0.94%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

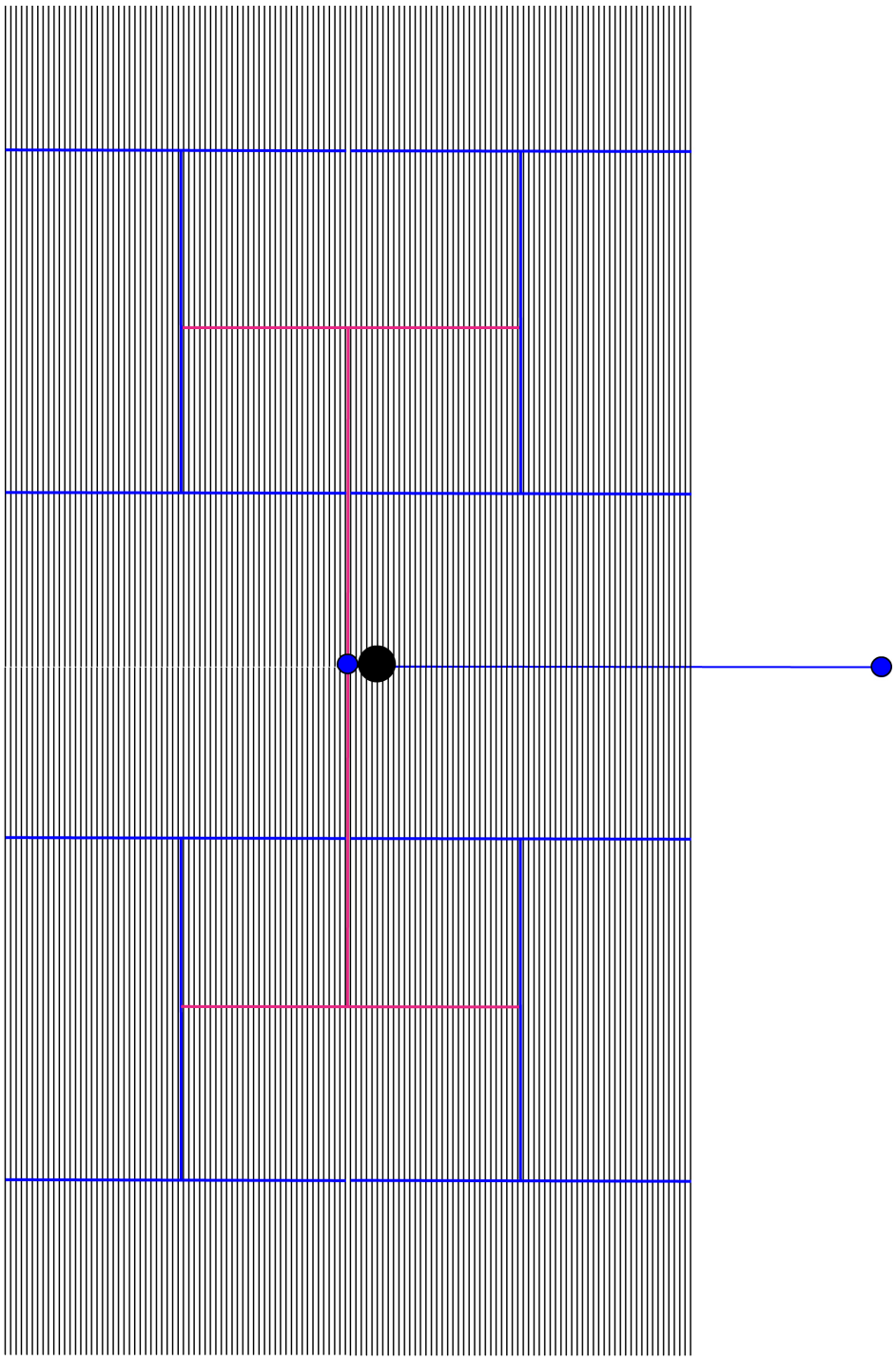


Low pressure irrigation of 8 acres using three 2000w swimming pool pumps and tank

- 10000L tank at the centre of the plot and the plot is 100m from a reservoir
- 952m of 76mm lay-flat hose (blue)
- 256m of 102mm lay-flat hose (magenta)
- 32560m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coeff 0.007249 L/min, lateral coeff 0.7585 L/min, 0.5 acre coeff 48.43 L/min, 0.3m dripper spacing, 512 x 32m laterals, 1m lateral spacing

demand range: 931 L/min (tank almost empty) to 999 L/min (tank full)
pressure range for drippers with tank almost empty: 1.42 to 1.44m
discharge range for drippers with tank almost empty: 0.5178 to 0.5226 L/h
max discharge variation with tank almost empty = 0.92%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min



EPANET simulations on sloping ground

Low pressure irrigation of 1 acre (63.6 x 63.6m) with 5% slope using 2000w swimming pool pump and header tank

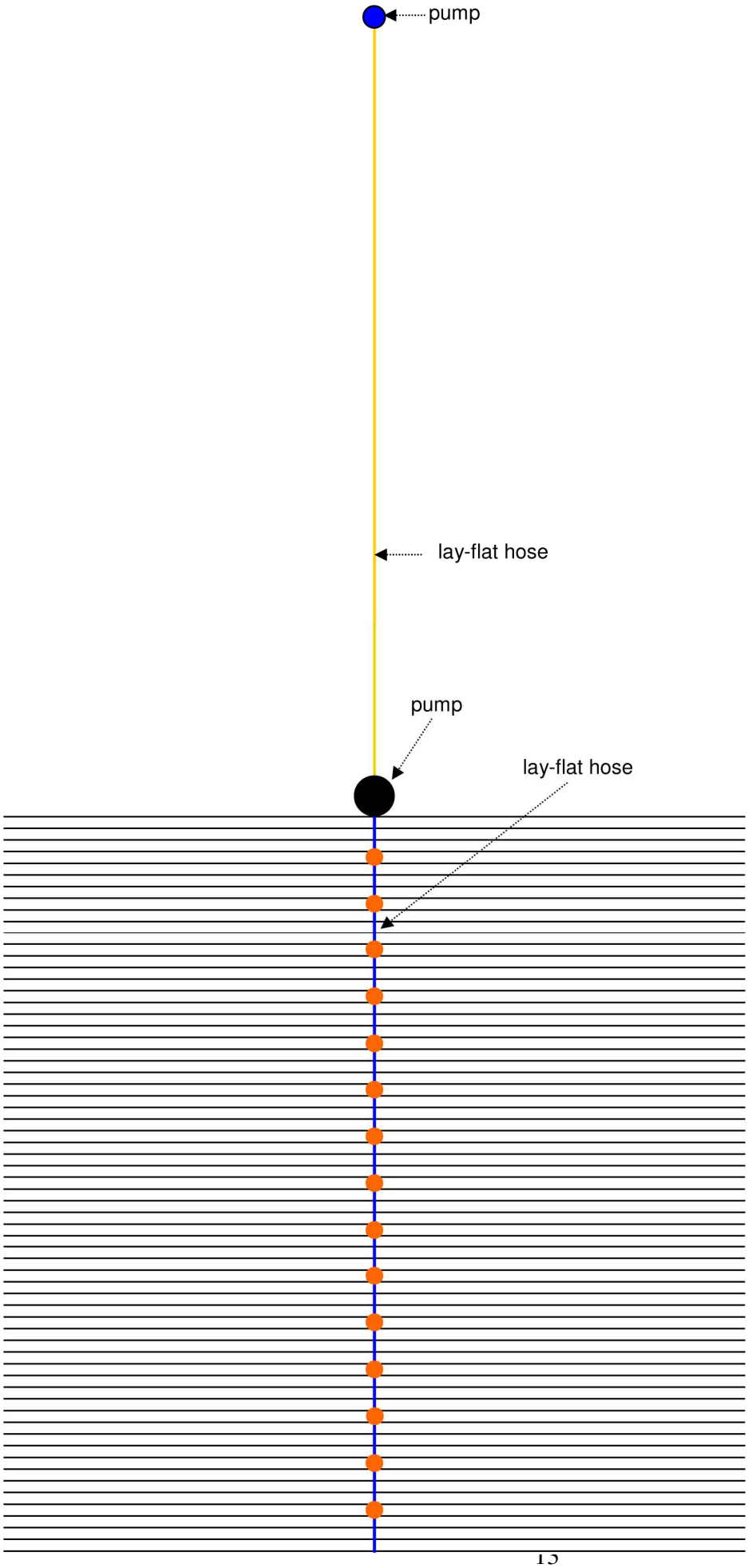
- pump is 100m from the plot and at the same level as the highest point of the plot
- header tank provides 3m head and is next to the highest lateral
- there is a uniform 5% downhill slope in the direction of the flow
- 64m of 76mm lay-flat hose (blue in the diagram below)
- 100m of 50mm lay-flat hose (yellow in the diagram below)
- 4070m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coefficient 0.007249, 32m lateral coefficient 0.7593, 0.3m dripper spacing, 128 X 32m laterals, 1m lateral spacing

demand = 166 L/min
pressure range for drippers: 3.03 to 3.20m
discharge range for drippers: 0.7566 to 0.7776 L/h
max discharge variation = 2.70%

2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

To allow for the 5% downhill slope, an adjustable pressure balancing valve is installed on the submain after each fourth lateral. There are a total of 15 valve and the drop in elevation for consecutive valves is 0.2m. Each of the valves is adjusted in order starting from the highest so that the pressure at the next lateral is the same as the pressure at the first lateral. The valves are shown as orange dots in the diagram below. For ground with a variable downhill slope, it is recommended that the drop in elevation for consecutive pressure balancing valves be 0.2m.

Instead of using a header tank, you may wish to use an adjustable pressure regulator valve.


pump
lay-flat hose
pump
lay-flat hose

Low pressure irrigation of 2 acres (63.6 x 127.2m) with 10% slope using 2000w swimming pool pump and header tank

- pump is 100m from the plot and at the same level as the highest point of the plot
- header tank provides 3m head and is next to the highest lateral
- there is a uniform 10% downhill slope in the direction of the flow
- 100m of 76mm lay-flat hose (blue in the diagram below)
- 96m of 50mm lay-flat hose (yellow in the diagram below)
- 8140m of Toro AquaTraxx NPC 16mm ID, discharge 1.00 L/h @ 5.39m, emitter exponent 0.5, emitter coefficient 0.007249, 64m lateral coefficient 1.514, acre coeff 100.1, 0.3m dripper spacing, 128 X 64m laterals, 1m lateral spacing

demand = 347 L/min
pressure range for drippers: 2.89 to 3.10m
discharge range for drippers: 0.7386 to 0.7654 L/h
max discharge variation = 3.50%

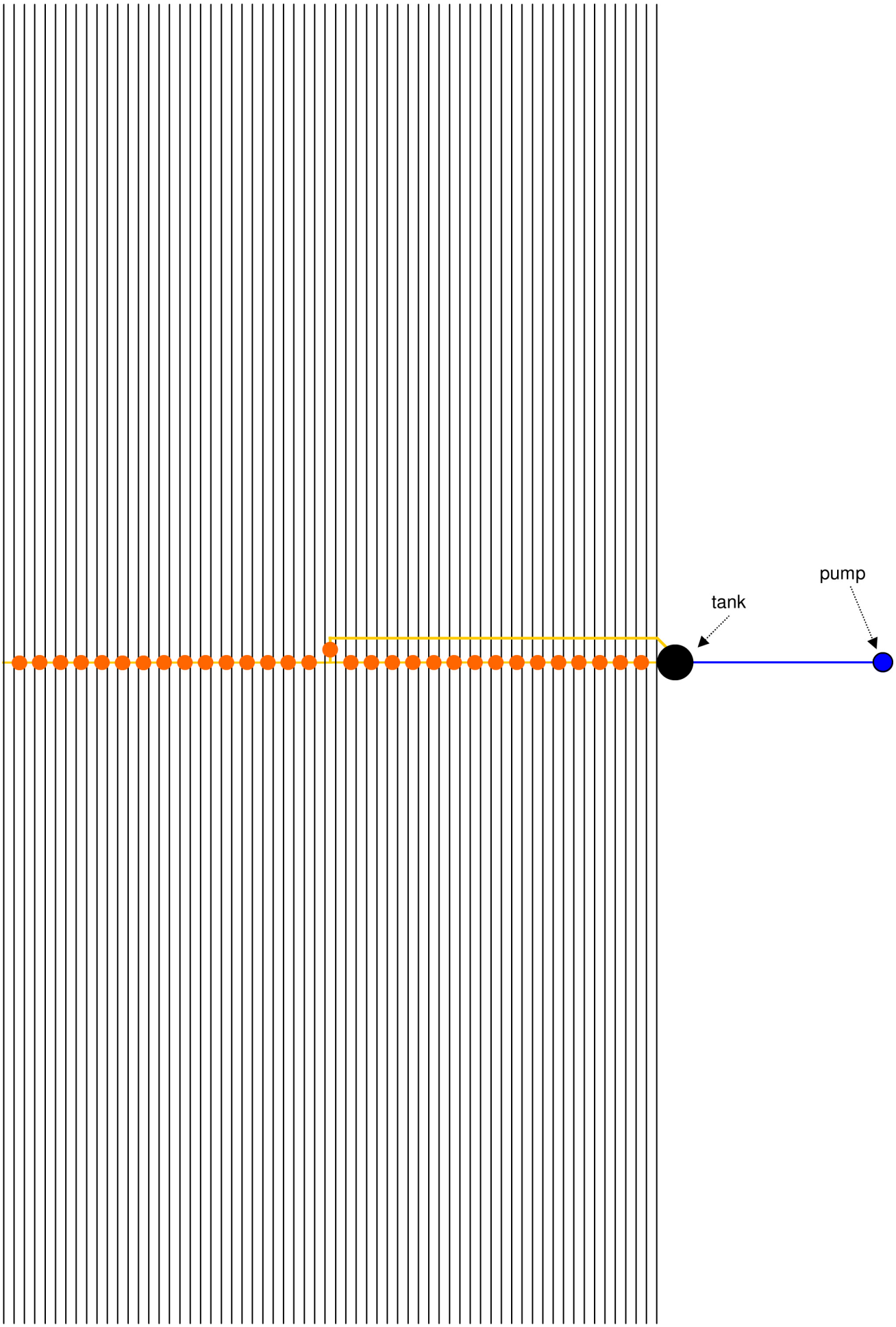
2000w swimming pool pump, maximum head 16m, maximum flow 500 L/min

The plot is divided into two halves. The upper half is connected directly to the header tank and the bottom half is connected to the header tank via 32m of 50mm lay-flat hose (yellow). To allow for the 10% downhill slope, an adjustable pressure balancing valve is installed on the submain after each second lateral. There are 15 valves in the upper half and 15 valves in the lower half. The drop in elevation for consecutive valves is 0.2m. There is also a valve between the header tank and the lower half. The valves are shown as orange dots in the diagram below.

Each of the valves in the upper half is adjusted in order starting from the highest so that the pressure at the next lateral is the same as the pressure at the first lateral. The adjustment process is repeated until all of the laterals in the upper half are at the same pressure.

The valve between the header tank and the lower half is then adjusted so that the pressure at the first lateral in the lower half is the same as the pressure at the first lateral in the upper half. Each of the valves in the lower half is adjusted in order starting from the highest so that the pressure at the next lateral is the same as the pressure at the first lateral in the lower half. The adjustment process is repeated until all of the laterals in the lower half are at the same pressure.

Instead of using a header tank, you may wish to use an adjustable pressure regulator valve.


pump
tank

Budget

The tables below shows an estimate of the cost of materials (incl 10% GST) for drip irrigation using Toro Aquatraxx with 30cm spacing between the drippers and I metre spacing between the laterals.

Low pressure irrigation of 1 acre with 2000w swimming pool pump

Description	Product	Supplier	unit size	quantity	cost per unit	cost
76mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	2	$515.00	$1,030.00
driptape NPC	Toro Aquatraxx EA5081245750	The Irrigation Shop	2285m roll	2	$275.00	$550.00
Lay-flat takeoff fittings single grip	Toro FTAS-LF		1	128	$1.00	$128.00
pump	2000w swimming pool pump	Crazy Sales	1	1	$220.00	$220.00
Total						**$1,928.00**

Low pressure irrigation of 2 acres with 2000w swimming pool pump

Description	Product	Supplier	unit size	quantity	cost per unit	cost
76mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	2	$515.00	$1,030.00
102mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	2	$675.00	$1,350.00
driptape NPC	Toro Aquatraxx EA5081245750	The Irrigation Shop	2285m roll	4	$275.00	$1,100.00
Lay-flat takeoff fittings single grip	Toro FTAS-LF		1	256	$1.00	$256.00
pump	2000w swimming pool pump	Crazy Sales	1	1	$220.00	$220.00
Total						**$3,956.00**

Low pressure irrigation of 4 acres with 2000w swimming pool pump

Description	Product	Supplier	unit size	quantity	cost per unit	cost
76mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	3	$515.00	$1,545.00
102mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	4	$675.00	$2,700.00
driptape NPC	Toro Aquatraxx EA5081245750	The Irrigation Shop	2285m roll	8	$275.00	$2,200.00
Lay-flat takeoff fittings single grip	Toro FTAS-LF		1	512	$1.00	$512.00
pump	2000w swimming pool pump	Crazy Sales	1	1	$220.00	$220.00
Total						**$7,177.00**

Low pressure irrigation of 8 acres with two 2000W swimming pool pumps

Description	Product	Supplier	unit size	quantity	cost per unit	cost
76mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	8	$515.00	$4,120.00
102mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	3	$675.00	$2,025.00
152mm diameter lay-flat hose	Sunnyflo Blue PVC low pressure lay-flat hose	Irrigation Box	100m roll	2	$1,075.00	
driptape NPC	Toro Aquatraxx EA5081245750	The Irrigation Shop	2285m roll	17	$275.00	$4,675.00
Lay-flat takeoff fittings single grip	Toro FTAS-LF		1	1028	$1.00	$1,028.00
pump	2000w swimming pool pump	Crazy Sales	1	2	$220.00	$440.00
Total						**$12,288.00**