Unpowered Gravity-Feed Smart Irrigation Valve

Dr Bernie Omodei
Measured Irrigation
5/50 Harvey Street East, Woodville Park SA 5011
Mobile 0403 935277
Email bomodei@measuredirrigation.com.au
Website www.measuredirrigation.com.au

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2. Introduction

Any swing check valve can be converted into an Unpowered Gravity-Feed Smart Irrigation Valve to control the scheduling of drip integration.

The high flow rate of the valve needs to be seen to be believed. For example, a 50mm Unpowered Gravity-Feed Smart Irrigation Valve with an inlet pressure of 3 metres head (30 kPa) can deliver 3.5 litres per second. The valve can also operate at almost zero pressure.

Two containers are used with the inner container floating on water in the outer container. The swing check valve is mounted inside the inner container. An adjustable control dripper is connected to the outlet from the swing check valve so that, during the irrigation event, it drips water into the outer container via the lid of the inner container. During the irrigation event, the water level in the outer container rises, and when water level reaches the high level the swing check valve closes and the irrigation stops automatically. A polyester cover allows water to wick from inside the outer container to outside the outer container to evaporate. Between irrigation events, the water level falls as water wicks to the outside of the outer container and evaporates. When the water level reaches the low level, the swing check valve opens and the irrigation starts automatically.

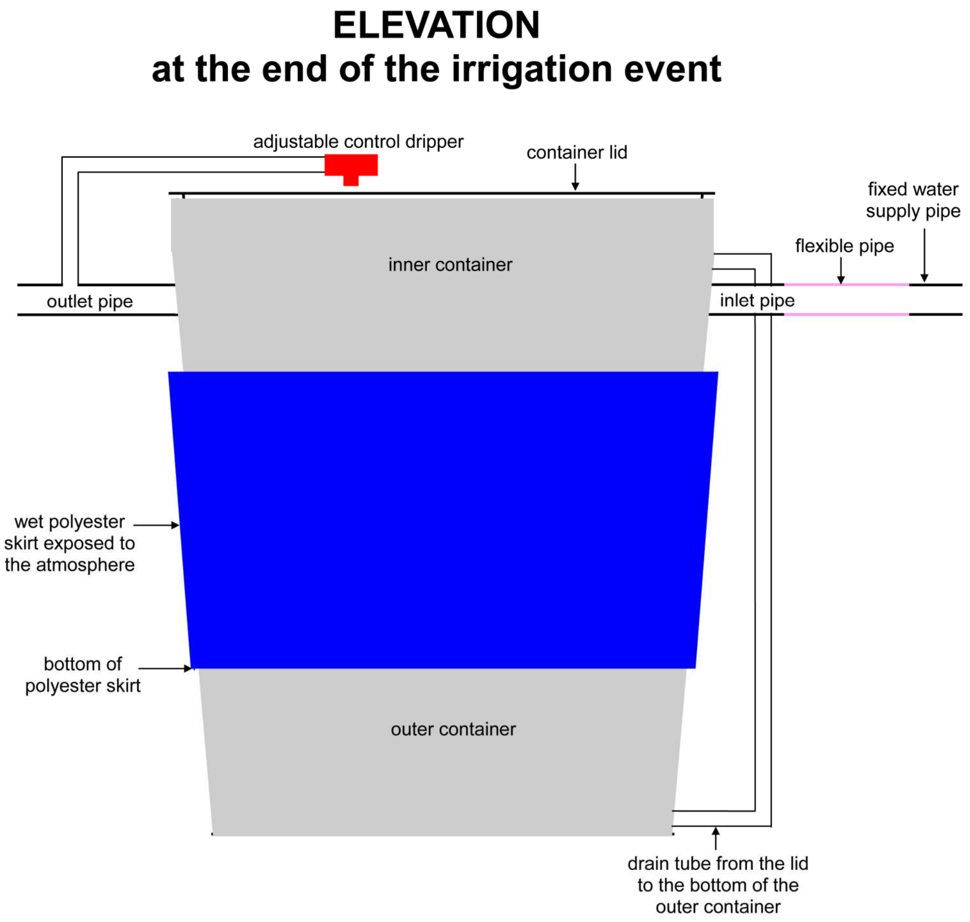
The control volume is the volume of water in the outer container between the high level and the low level. It is the volume of water that evaporates from the outer the container between irrigation events. It is also the volume of water discharged by the adjustable control dripper during the irrigation event.

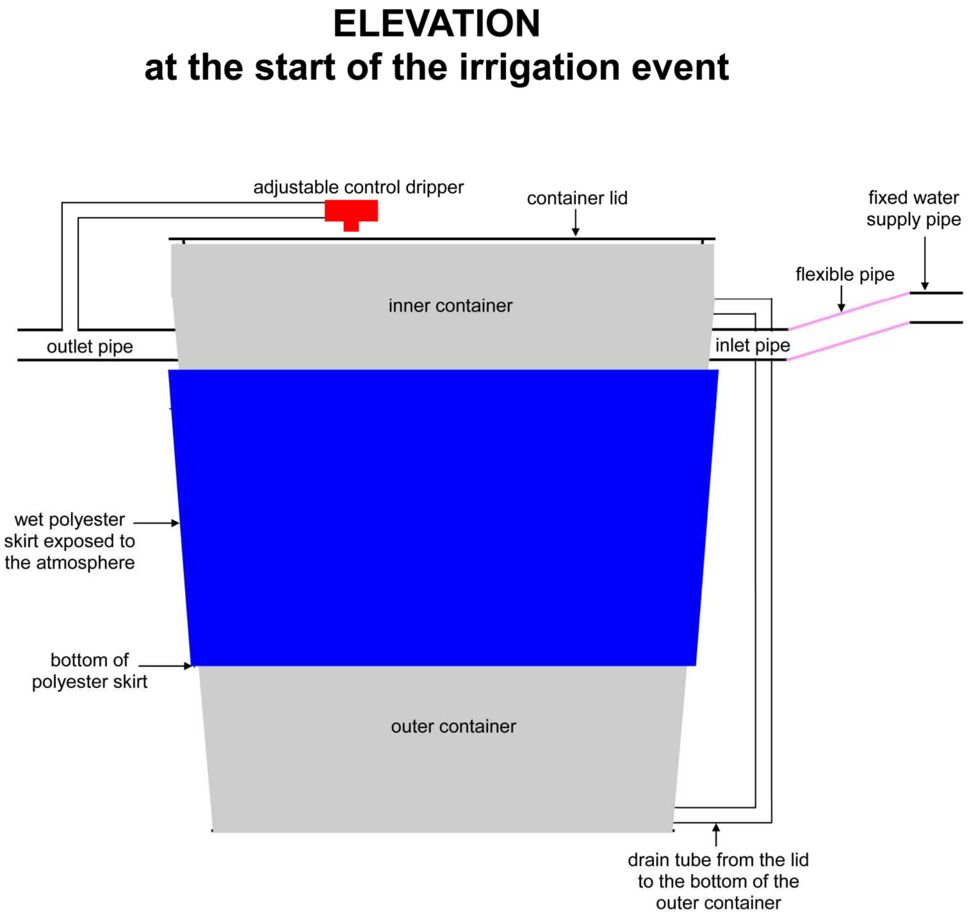
The irrigation scheduling responds automatically to onsite evaporation and rainfall. The rate at which the water level in the outer container falls depends on the onsite evaporation rate. When it rains, water collects on the lid of the inner container and drains via a drain tube to the outer container. The rain that has entered the outer container between irrigation events must also evaporate from the container. Hence, the next irrigation event is delayed.

The maximum flow rate for an Unpowered Gravity-Feed Smart Irrigation Valve is the same as the maximum flow rate for the swing check valve. This allows the Unpowered Gravity-Feed Smart Irrigation Valve to provide very high flow rates.

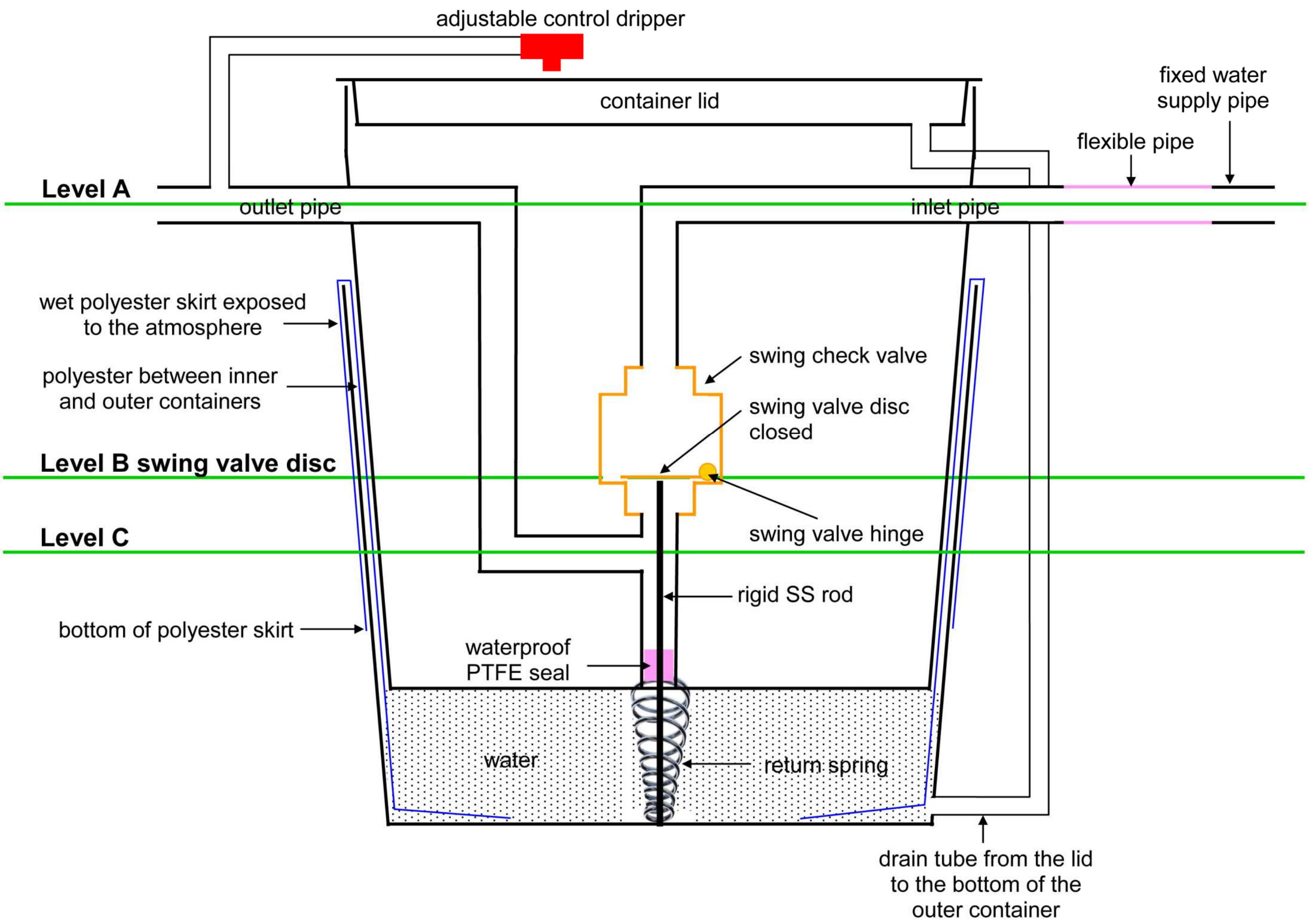
During the irrigation event, a rigid stainless steel rod opens the valve by pushing the hinged disc up. At the end of the irrigation event when the water level has reached the high level, the stainless steel rod is no longer in contact with the disc and the valve closes.

2. Elevation and cross-section diagrams

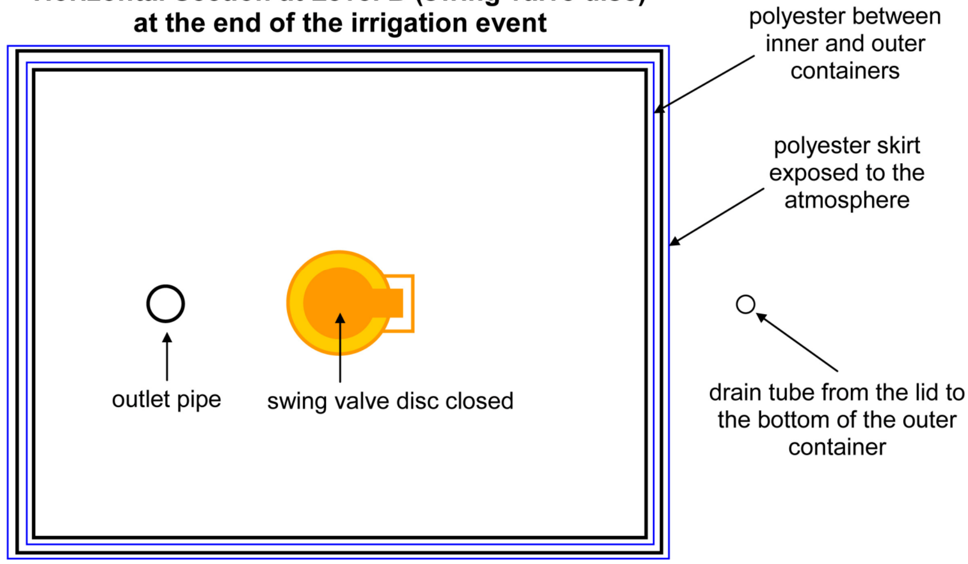




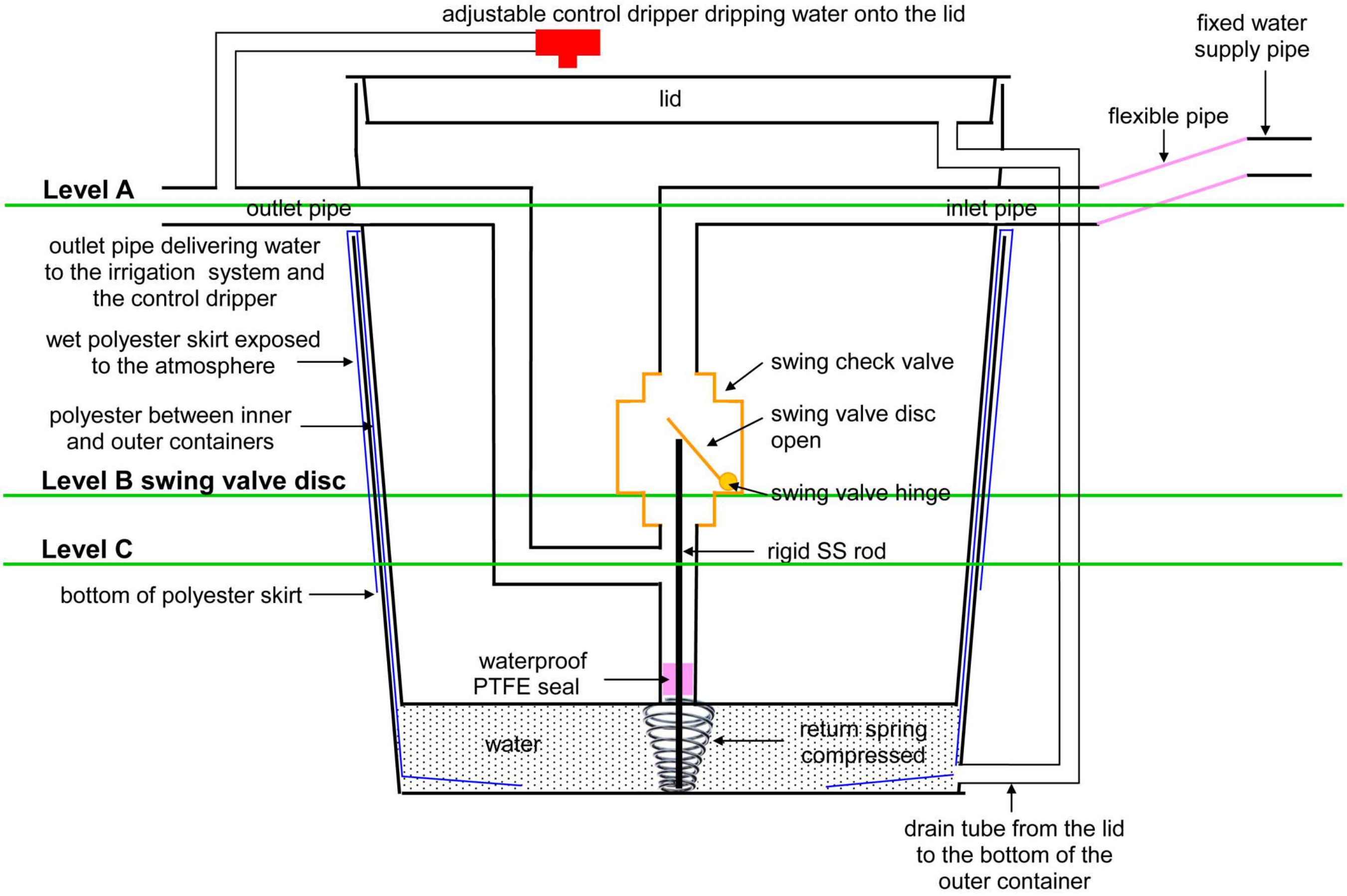
Vertical Section
at the end of the irrigation event



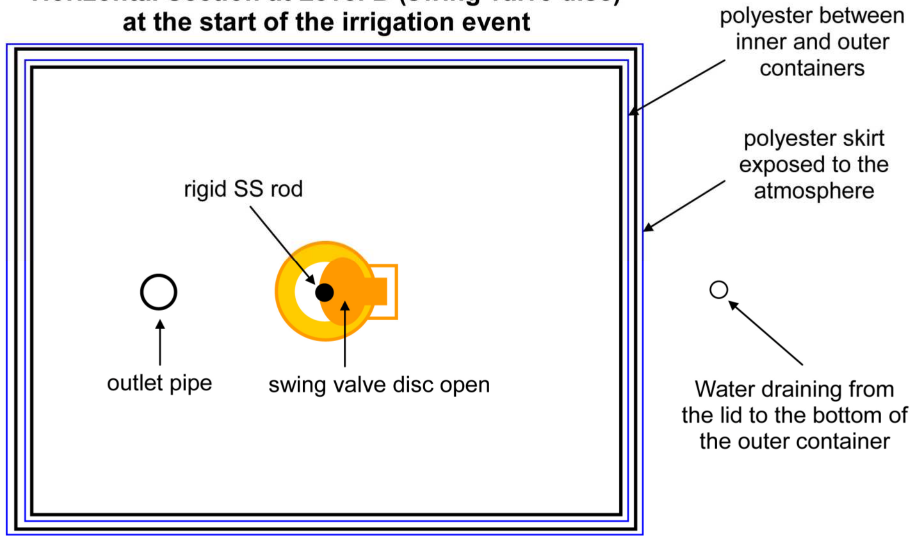
Horizontal Section at Level B (swing valve disc)
at the end of the irrigation event



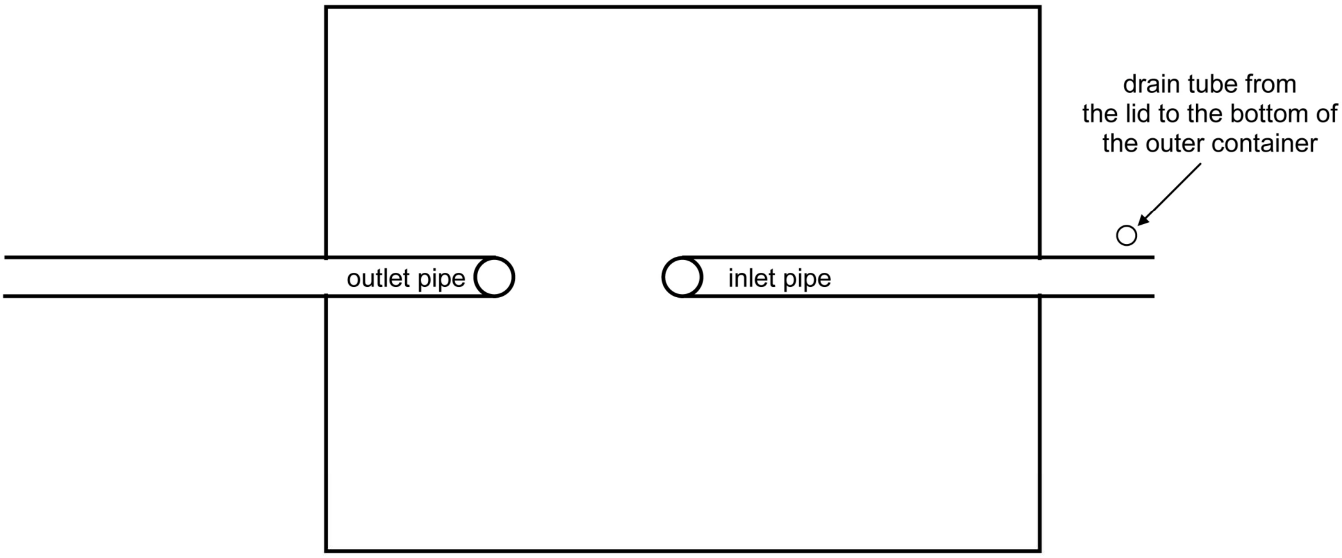
Vertical Section
at the start of the irrigation event



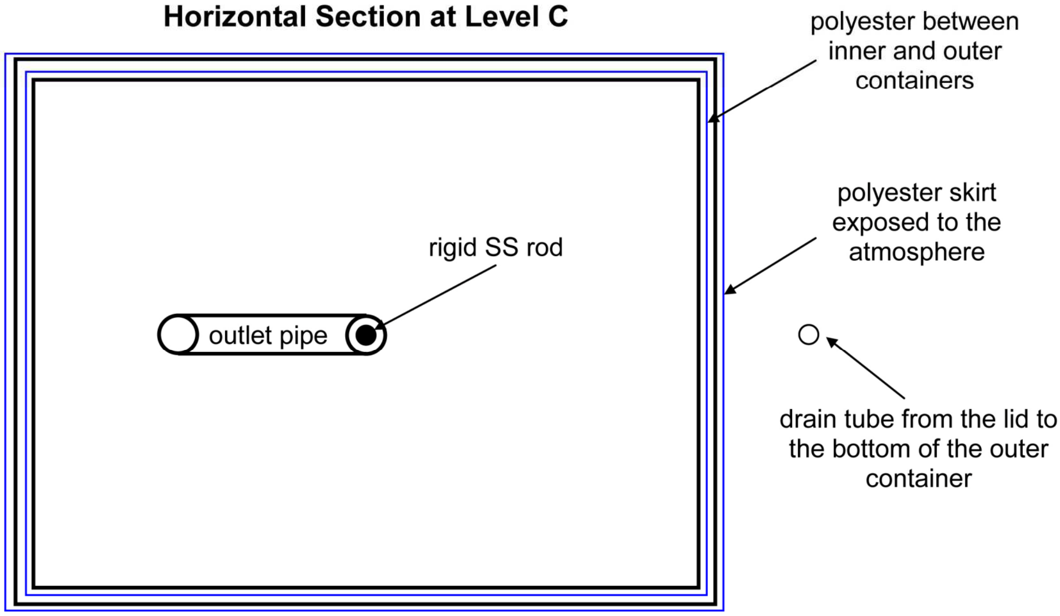
Horizontal Section at Level B (swing valve disc)
at the start of the irrigation event



Horizontal Section at Level A



Horizontal Section at Level C



3. Key features

1. Unpowered (no batteries, no wires, no solar panels, no electronics, no computers, and no WiFi)
2. No irrigation controller required
3. Water supply pressure can be almost zero
4. Very high flow rate
5. Uses NPC (non pressure compensating) drippers.
6. Use the adjustable control dripper to adjust the dripper discharge
7. Adjust the length of the polyester skirt to adjust the interval between irrigation events
8. Responds automatically to onsite evaporation and rainfall
9. The irrigation frequency increases significantly during a heat wave
10. When it rains, water enters the outer container and delays the start of the next irrigation event
11. Can be used for furrow irrigation
12. Simple, unpowered, and low tech, and therefore fewer things can go wrong
13. Leave your irrigation application unattended for weeks on end

	Unpowered Gravity-Feed Smart Irrigation Valve	Solenoid valve with smart Wi-Fi irrigation controller
No solenoid valve required	Yes	No
No wiring required	Yes	No
No power required	Yes	No
Responds to onsite evaporation and rainfall	Yes	No (uses data from the BOM)
Can operate at very low pressure	Yes	No

Table1. Comparison of a Unpowered Gravity-Feed Smart Irrigation Valve versus a solenoid valve with smart Wi-Fi irrigation controller

4. Adjusting the dripper discharge and the irrigation frequency

Adjusting the dripper discharge

If your plants are not getting enough water, reduce the flow rate of the control dripper. Reducing the flow rate of the control dripper increases the duration of the irrigation event and so your plants get more water. If your plants are getting too much water, increase the flow rate of the control dripper.

Adjusting the dripper discharge does not affect the interval between irrigation events.

You may wish to measure the dripper discharge by placing an empty measuring container under one of the irrigation drippers so that water drips into the container during the irrigation event.

Adjusting the irrigation frequency

The irrigation frequency is determined by how quickly water evaporates from the polyester skirt. The irrigation frequency is adjusted by exposing more or less of the polyester skirt. The time interval between irrigation events can be from half a day to a week or more.

Adjusting the irrigation frequency does not affect the dripper discharge.

5. Weather-based irrigation control

The interval between irrigation events depends on the prevailing onsite weather conditions. When it is hot and dry, the water evaporates from the polyester cover more quickly and so the interval between irrigation events is shorter. When it is cool and overcast, the water evaporates more slowly and so the interval between irrigation events is longer.

When it rains, water enters the outer container via the drain tube from the lid, and so the start of the next irrigation event is delayed. Any rainwater that has entered the outer container between irrigation events needs to evaporate before the next irrigation event can start.

To avoid irrigating during the heat of the day, you can turn off the water supply. Alternatively, a tap timer can be used so that water is only available between sunset and sunrise.

Most smart irrigation controllers do not use onsite weather data. Instead they use weather data from the Bureau of Meteorology.

An Unpowered Gravity-Feed Smart Irrigation Valve uses prevailing onsite weather information (namely, evaporation and rainfall) rather than information from the Bureau of Meteorology, and so it is ideal for greenhouse applications. Because an Unpowered Gravity-Feed Smart Irrigation Valve uses onsite weather information, it is more water-efficient than a conventional smart irrigation controller. And nothing is more energy efficient than unpowered.

6. Installing the 50mm Unpowered Gravity-Feed Smart Irrigation Valve

The 50mm Unpowered Gravity-Feed Smart Irrigation Valve has a maximum flow rate of 3.5 litres per second when the inlet pressure is 30 kPa (3 metres head). The valve is designed to operate within the pressure range zero to 30 kPa.

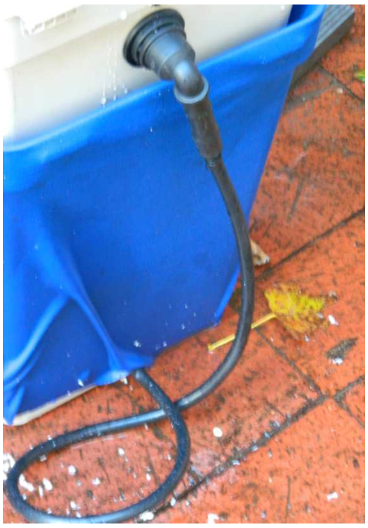
Position the valve in a location where the evaporation and rainfall are the same as the evaporation and rainfall for the plants. Connect the flexible hose to a fixed water supply so that the fixed water supply is 8 cm higher than the inlet to the valve. The vertical pipe is attached to the inlet to suppress water hammer when the valve closes. The vertical pipe must be air tight so that the sealed air inside the pipe can absorb the shock wave generated by water hammer. You may need to adjust the height of the fixed water supply so that the inner container is centred inside the outer container during the irrigation event.

The adjustable control dripper should be higher than the irrigation drippers so that water does not drain through the control dripper at the end of the irrigation event.

Connect the irrigation application to the outlet from the valve.

There is a small hole in the centre of the lid so that water that collects on the lid drains into the outer container via the delivery tube.

Turn on the water supply and the irrigation should start immediately. During the irrigation event the adjustable control dripper delivers water to the outer container via the delivery tube, and so that the inner container rises. When the inner container reaches the high level the irrigation stops automatically. Water evaporates from the outer container via the polyester skirt. When the inner container reaches the low level, the irrigation starts again automatically.

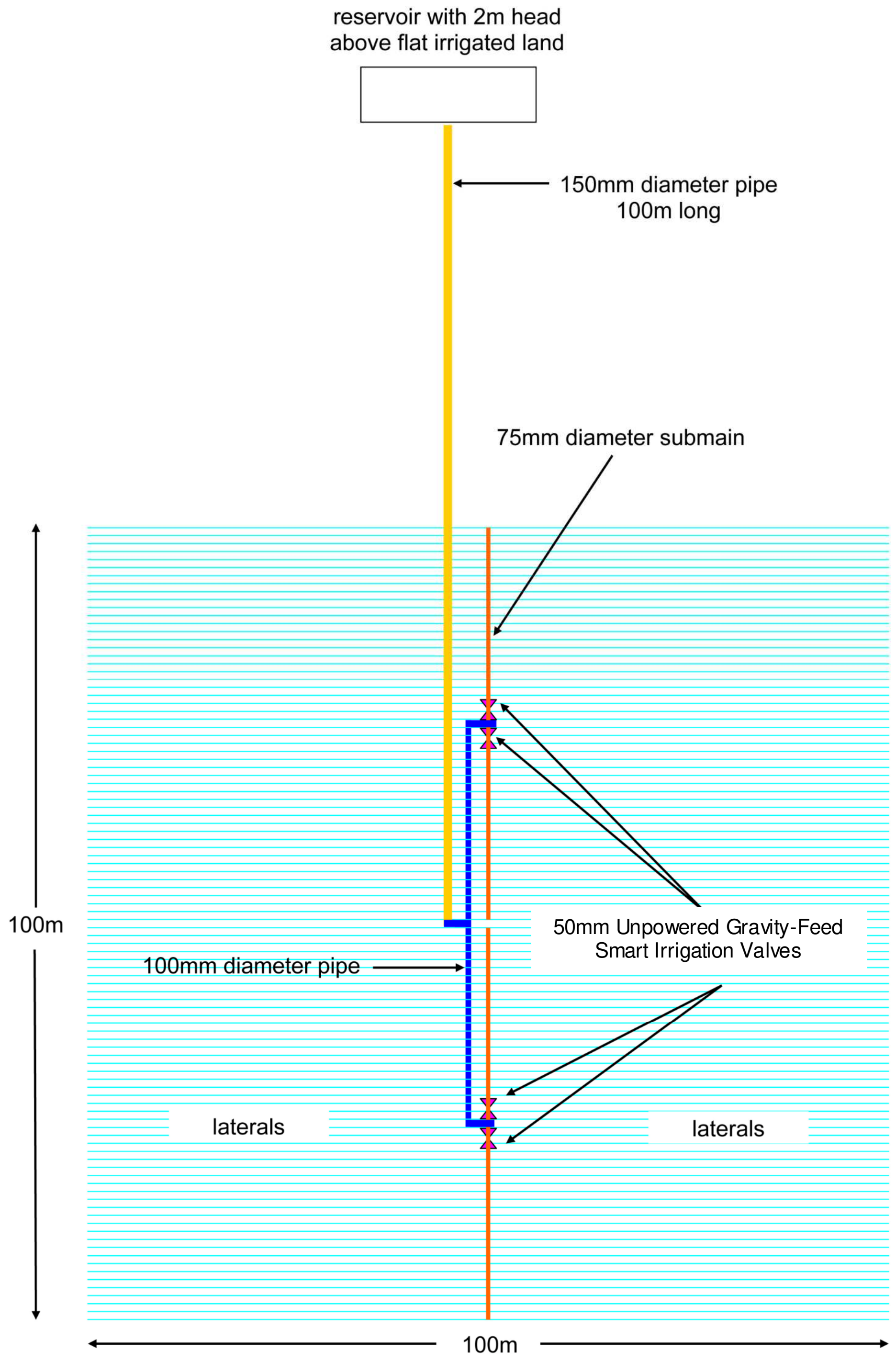


Tube delivering water from the control dripper to the outer container

Lid removed showing the brass swing check valve

7. Gravity feed drip irrigation of one hectare

The diagram below is an example of gravity feed drip irrigation of one hectare using 10000m of Toro Aqua Traxx and four 50mm Unpowered Gravity-Feed Smart Irrigation Valves.



The total irrigated area is 1 ha (100m x 100m) using 10000m of 16mm Toro Aqua Traxx, 1 L/H @ 55 kPa, 0.3m spacing between the drippers, and 1m spacing between the laterals.

The application uses four 50mm Unpowered Gravity-Feed Smart Irrigation Valves, and each valve delivers water to ¼ ha (100m x 25m).

The results of an EPANET simulation are as follows:

- Demand from the reservoir is 540 L/M (32400 L/H)
- The pressure range for the drippers is 0.59m to 0.70m
- The discharge rate range for the drippers is 0.348 L/H to 0.384 L/H

EPANET is a software tool developed by the U.S. Environmental Protection Agency for the simulation of the dynamic hydraulic behaviour of irrigation systems.