Large Terracotta Irrigation Controller for Latching Solenoids User Manual

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In ground installation of the Large Terracotta Irrigation Controller for Latching Solenoids

Above ground installation of the Large Terracotta Irrigation Controller for Latching Solenoids

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1. Introduction

The Large Terracotta Irrigation Controller for Latching Solenoids is suitable for automatic sprinkler irrigation or drip irrigation, and can be installed either above ground or in ground. The Terracotta Irrigation Controller includes a valve that operates with water supply pressure in the range 10 kPa to 800 kPa. The interval between irrigation events responds automatically to the on-site prevailing weather conditions (namely, evaporation and rainfall). For in ground installation, the interval between irrigation events also responds automatically to the transpiration requirements of your plant at their current stage of growth.

All the power required is provided by a small 9 volt battery inside the control box.

Terracotta is porous and so the water level in the pot falls as water seeps through the pot. A float inside the pot floats on the water. When the water level reaches the low level, a magnet inside the float activates the valve so that the valve opens and the irrigation starts. During the irrigation event a control dripper drips water into the pot and the water level rises. When the water level reaches the high level, the magnet inside the float disengages from the valve so that the valve closes and the irrigation stops.

Float and the water level

Float showing the ring magnet at the bottom of the float

This remarkable low-cost invention may enable poor smallholders in remote locations to grow higher-valued crops cost-effectively.

The valve has a 15mm inlet and outlet, and so it is not suitable for large irrigation applications that require a bigger valve.

Valve and the 15mm inlet and outlet

2. Key features of the Large Terracotta Irrigation Controller for Latching Solenoids

1. Use for any size irrigation application with any size latching solenoid valve
2. The power supply is a small 9 volt battery inside the control box
3. Water supply pressure 10 kPa to 800 kPa
4. Use for sprinkler irrigation or drip irrigation
5. Use for gravity feed or pressurised irrigation
6. Use with PC (pressure compensating) drippers or NPC (non pressure compensating) drippers
7. Adjust the water usage rate by adjusting the control dripper
8. Adjust the interval between irrigation events by adjusting the float
9. Adjusting the water usage rate does not affect the interval between irrigation events, and adjusting the interval between irrigation events does not affect the water usage rate
10. Responds automatically to on-site evaporation and rainfall
11. The irrigation frequency increases significantly during a heat wave
12. Install above ground or in ground
13. For in ground installation the controller responds automatically to plant transpiration
14. Provided the same drippers are used throughout the irrigation application (including the control dripper), the water usage rate is independent of the water supply pressure
15. Irrigate directly from a rainwater tank without using a pump
16. Water in the terracotta pot is protected from algae, mosquitoes and thirsty animals
17. Simple and low tech, and therefore fewer things can go wrong
18. Leave your irrigation application unattended for months on end

3. Installing the Large Terracotta Irrigation Controller for Latching Solenoids

Step 1 (for above ground installation). Position the Large Terracotta Irrigation Controller in a suitable location in your garden so that the evaporation at the controller matches the evaporation at your plants. You may wish to use 2 bricks to support the Large Terracotta Irrigation Controller.

Step 1 (for in ground installation). Dig a hole midway between two adjacent plants and position the Large Terracotta Irrigation Controller in the hole so that rim of the pot is above ground level. Back fill soil around the pot. There should be no irrigation drippers near the two plants.

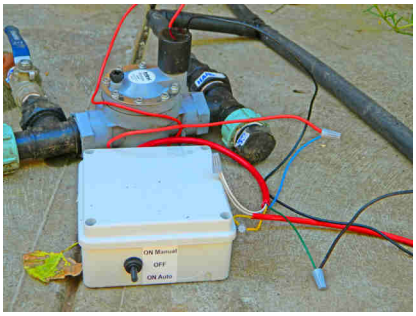
For plants with a deep root zone you may wish to install the Large Terracotta Irrigation Controller below the surface. Appendix 2 provides instructions for installing the Large Terracotta Irrigation Controller so that the rim of the terracotta pot is up to 250 mm below the surface.

Step 2. Connect a water supply to the irrigation controller. The water pressure should be at least 10 kPa during the irrigation event.

Step 3. Connect the adjustable control dripper to the irrigation zone so that it drips water into the terracotta saucer during the irrigation event.

Step 4. The control box has 4 colour-coded wires that need to be connected to the latching solenoid and the float switch.

Control box


Four colour-coded wires connected to the latching solenoid and the float switch

Connect the **yellow** wire to one of the wires from the float switch.
Connect the **white** wire to the other wire from the float switch.
Connect the **blue** wire to one of the red wire from the latching solenoid.
Connect the **green** wire to the black wire from the latching solenoid.

If there are 2 latching solenoid valves, connect the second latching solenoid in parallel with the first latching solenoid.

4. How to use the Large Terracotta Irrigation Controller for Latching Solenoids

Turn on the water supply and the irrigation starts immediately. The control dripper drips water into the terracotta pot during the irrigation. The irrigation stops automatically after the control volume of water has dripped into the pot. The **control volume** is defined as the volume of water that seeps through the terracotta pot between irrigation events.

The irrigation starts again automatically after the control volume of water has seeped through the pot. The cycle continues indefinitely and so you can leave your garden unattended for months on end. A saucer sits on top of the pot so that the water in the pot is protected from algae, mosquitoes and thirsty animals. There are 6 small drain holes in the saucer.

When using a conventional irrigation controller, you need to set the start time and the end time for each irrigation event. However, with the Terracotta Irrigation Controller you don't need a timer. The duration of the irrigation event is simply the time it takes for the control volume of water to drip into the pot.

It is important to note here that the control dripper is adjustable. If you reduce the flow rate of the control dripper, it takes a lot longer for the control volume of water to drip into the pot and so the duration of the irrigation event increases and your plants get more water. On the other hand, if you increase the flow rate of the control dripper, the control volume of water drips into the pot more quickly and so the duration of the irrigation event decreases and your plants get less water. Adjust the control dripper so that the irrigation delivers the appropriate amount of water to your plants at their current stage of growth.

The control dripper is adjustable.

The time it takes for the control volume of water to seep through the pot depends on the prevailing on-site weather conditions. When it is hot and dry, the water seeps more quickly and so the interval between irrigation events is shorter. When it is cool and overcast, the water seeps more slowly and so the interval between irrigation events is longer.

If it rains, rainwater collects in the saucer and drains into the pot. This means that the start of the next irrigation event is delayed. In addition to the control volume of water that needs to seep through the pot between irrigation events, any rainwater that has entered the pot between irrigation events also needs to seep through the pot.

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

The Terracotta Irrigation Controller uses on-site weather data (namely, evaporation and rainfall). Most smart irrigation controllers do not use on-site weather data. Instead they use weather data from the Bureau of Meteorology.

The Terracotta Irrigation Controller can be used for both gravity feed and pressurised irrigation. It can be used with pressure compensating drippers and non pressure compensating drippers. It can also be used with weeper hose or soaker hose.

You can irrigate directly from a rainwater tank by gravity feed without using a pump provided that the water level in the tank is at least 1 metre higher than the valve at the bottom of the Terracotta Irrigation Controller.

It is recommended that you adjust the interval between irrigation events before adjusting the water usage rate. You may need to adjust the interval between irrigation events and the water usage rate as the plants grow and their water requirements change.

Note that the term **water usage rate** refers to the number of litres per week used by the irrigation system.

How to adjust the interval between irrigation events

You can adjust the interval between irrigation events by adjusting the gap between the upper and lower floats. The interval between irrigation events if the time it takes for the control volume of water to seep through the porous terracotta pot. To adjust the gap by 4 mm, rotate the upper float by two and a quarter turns.

Adjusting the interval between irrigation events does not change the water usage rate. For example, if you decrease the interval between irrigation events by increasing the gap between the upper and lower floats, the amount of water used during the irrigation event increases automatically to ensure that the water usage rate (litres per week for example) remains the same.

To adjust the interval between irrigation events, adjust the gap between the upper and lower floats

The following table shows the control volume for various values of the gap between the upper and lower floats.

gap between the upper and lower floats	control volume
zero gap	400 ml
4 mm	620 ml
8 mm	845 ml
12 mm	1075 ml
16 mm	1310 ml
20 mm	1550 ml
24 mm	1800 ml
28 mm	2050 ml
32 mm	2300 ml

Table 1. Control volume for various gaps between the upper and lower floats

How to adjust the water usage rate

Position an empty measuring container under one of the drippers so that water drips into the container during the irrigation event. At the end of the irrigation event check the amount of water in the measuring container. You should also check the moisture in the soil.

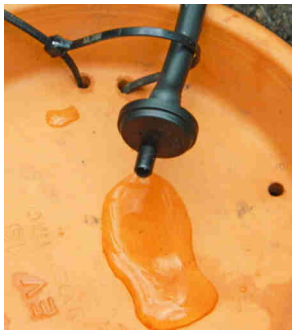
If your plants are not getting enough water, reduce the flow rate of the control dripper. Reducing the flow rate of the control dripper increases the duration of the irrigation event and so your plants get more water. If your plants are getting too much water, increase the flow rate of the control dripper.

Adjusting the water usage rate does not affect the interval between irrigation events.

5.1 When is dripper discharge independent of pressure?

Conventional drip irrigation systems control the volume of water discharged by a dripper by using PC (pressure compensating) drippers to control the flow rate and an irrigation controller to control the time. In a domestic garden with mains water supply, many zones are usually required to ensure that the pressure in each zone does not fall below the lower limit for pressure compensation. The irrigation controller is programmed so that each zone is irrigated at a different time.

With identical NPC drippers (including the control dripper) at approximately the same level and negligible variations in the pressure within the zone due to frictional head loss, the Terracotta Irrigation Controller ensures that the volume of water discharged by each dripper during the irrigation event is approximately the same regardless of the pressure. If the water supply pressure decreases, the flow rate of the NPC drippers also decreases. However, the duration of the irrigation event increases automatically to ensure that the control volume of water is discharged by each dripper. For domestic gardens on level ground, the irrigation system can usually be designed so that variations in pressure within the zone due to frictional head loss are negligible.



The adjustable control dripper has been replaced by an on-line irrigation dripper.

By using the Terracotta Irrigation Controller in this way, many zones with PC drippers can be combined into a single zone with NPC drippers and a single Terracotta Irrigation Controller, and so the cost of the irrigation system can be reduced dramatically.

Because each irrigation dripper discharges the control volume of water during the irrigation event, the water usage rate is often too much or too little for your plants at their current stage of growth. There is an ingenious solution to this problem whereby identical NPC irrigation drippers are used to assemble a special control dripper called a **fractional dripper**. The flow rate of a fractional dripper is a fixed fraction of the flow rate of the irrigation drippers used to assemble the fractional dripper, **regardless of the pressure**. For example, if the control dripper is a fractional dipper with one quarter of the flow rate of an irrigation dripper, then the volume of water discharged by each of the irrigation drippers is 4 times the control volume regardless of the pressure.

If the water usage rate is more than your plants require at their current stage of growth, the water usage rate can be decreased by using more than one irrigation dripper for the control dripper.

If the water usage rate is more than your plants require at their current stage of growth, the water usage rate can be decreased by using more than one irrigation dripper for the control dripper.

See the Appendix 1 for more information about fractional drippers.

Using different on-line NPC drippers

We now consider a method of using different on-line NPC (non pressure compensating) drippers for the irrigation application so that dripper discharge remains largely unaffected by changes in pressure. On-line NPC drippers are usually available with flow rates of 2 L/H, 4 L/H and 8 L/H (at a pressure of 100 kPa). Suppose that a combination of these drippers is used for the irrigation application (including the control dripper). Provided that all drippers have the same emitter discharge exponent (see the manufacturer's specifications), that all drippers are at approximately the same level, and that variations in pressure within the zone due to frictional head loss are negligible, then the Terracotta Irrigation Controller ensures that the volume of water discharged by an irrigation dripper during the irrigation event remains approximately constant within the manufacturer's recommended pressure range. For example, a dripper discharge of 1076 ml occurs when the gap between the upper and lower discs is 24 mm, the control dripper is 2 L/H (at 100 kPa) and the irrigation drippers are 8 L/H (at 100 kPa).

The control volume for the Large Terracotta Irrigation Controller for Latching Solenoids is in the range 400 ml to 2300 ml. This means that you may be able to avoid using a fractional dripper and still obtain a satisfactory discharge from each dripper during the irrigation event.

In practice the emitter discharge exponent for drippers with a different flow rate is unlikely to be exactly the same. It is therefore preferable to use identical drippers throughout the irrigation zone.

For some applications it may be difficult to source suitable drippers that have exactly the same emitter discharge exponent. In general, the ratio of the flow rate of two emitters with different emitter discharge exponents can be calculated by the following formula.

$$\frac{q_2}{q_1} = r\left(\frac{100}{p}\right)^{x_2 - x_1}$$

where q_2 is the flow rate of the high flow emitter at 100 kPa

q_1 is the flow rate of the low flow emitters at 100 kPa

r is the ratio of the high flow rate to the low flow rate at 100 kPa

p is the pressure in kPa

x_2 is the emitter discharge exponent of the high flow emitter

x_1 is the emitter discharge exponent of the low flow emitter

This formula can be used to determine whether the variations in the ratio of the flow rates for different pressures are acceptable.

Gravity feed irrigation from a rainwater tank

Suppose you are using gravity feed drip irrigation on level ground from a rainwater tank without using a pump. If you are using a conventional irrigation controller, you are faced with the problem that the dripper discharge decreases as the water level in the tank falls. This problem is solved by using the Terracotta Irrigation Controller with the appropriate control dripper. The volume of water discharged by each dripper during an irrigation event is independent of the water level in the tank. The water level in the tank should be at least one metre higher than the valve at the bottom of the Terracotta Irrigation Controller. A header tank on a stand at least 1 metre is ideal. A low cost transfer pump can be used to fill the header tank between irrigation events.

The Large Terracotta Irrigation Controller for Latching Solenoids is a **game-changer** for automated gravity feed irrigation on level ground from a rainwater tank.

5.2 When is sprinkler discharge independent of pressure?

Within their operational pressure range, sprinklers have an emitter discharge exponent of 0.5.

Therefore the sprinkler discharge during the irrigation event is independent of pressure provided that the emitter discharge exponent of the control dripper is also 0.5.

6. Conclusion

The Terracotta Irrigation Controller uses a radically different approach to irrigation scheduling called Measured Irrigation. See the Measured Irrigation website for more information: www.measuredirrigation.com.au

Conventional irrigation systems **indirectly** control the volume of water discharged by a dripper by using PC drippers to control the flow rate and an irrigation controller to control the time. However, Measured Irrigation **directly** controls the volume of water discharged by a dripper, rather than controlling the flow rate and the time. Because it is no longer necessary to control the flow rate, one can use NPC drippers as well as PC drippers.

PC drippers stop working altogether at low pressure. Provided that the PC drippers continue to discharge water, they can be used outside the pressure range recommended by the manufacturer. NPC drippers can be used with any water supply pressure in the range 10 kPa to 800 kPa.

The Terracotta Irrigation Controller uses on-site weather information rather than information from the Bureau of Meteorology, and so it is ideal for greenhouse applications.

The Large Terracotta Irrigation Controller for Latching Solenoids is a game-changer for automated irrigation on level ground from a rainwater tank. If you are using pressurised irrigation with pressure compensating drippers, the following items are required.

- Pump for the rainwater tank
- Additional solenoid valves (one needed for each additional zone)
- Conventional irrigation controller
- Hose clamps

None of these items are required when you use the Large Terracotta Irrigation Controller for Latching Solenoids, and so the cost of installing and running the irrigation systems can be reduced dramatically.

Weather-based smart irrigation controllers

According to the Irrigation Association (USA), weather-based controllers use weather data to calculate evapotranspiration, the amount of water that evaporates from the soil surface or is used by the plant. Based on local weather conditions, smart controllers automatically adjust the irrigation schedule to deliver only enough water to meet the plant needs. Different controllers use different sources of weather data. These include on-site weather sensors, data from a local weather station or data from the internet.

The cost of the on-site weather sensors required to calculate evapotranspiration is prohibitively expensive. Hence almost all weather-based irrigation controllers use data from the nearest weather station to approximate the on-site evapotranspiration. Weather-based irrigation controllers calculate evapotranspiration by multiplying the crop coefficient by the reference evapotranspiration. Reference evapotranspiration uses a formula based only on weather data. Furthermore, the crop coefficient is a theoretical value that depends upon the stage of growth of the crop.

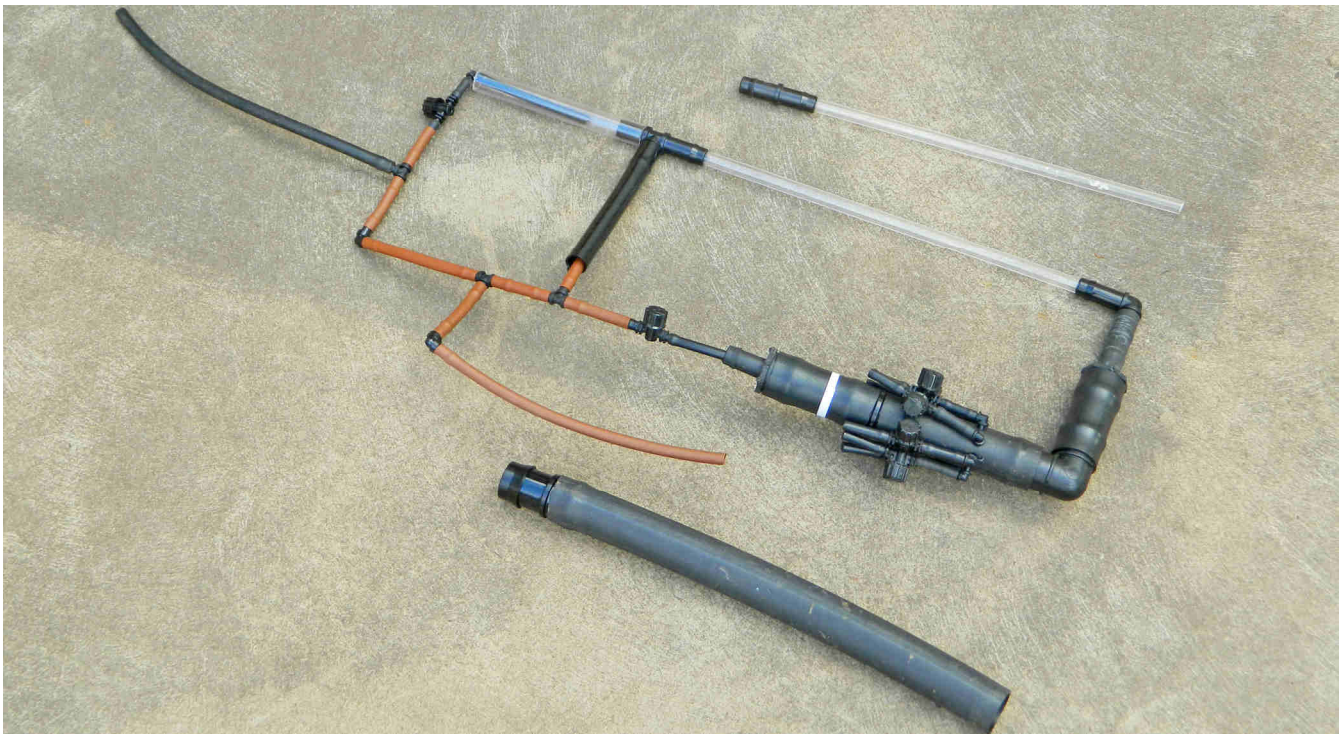
The Large Terracotta Irrigation Controller for Latching Solenoids can be used for any size solenoid valve, and so the irrigation zone can very large provided that the plants in the zone have similar water requirements. The Terracotta Irrigation Controller responds to changes in the actual on-site evaporation from the soil surface and the on-site water usage by the plants for transpiration. This approach to irrigation control is more appropriate than using a theoretical formula based on off-site weather data.

A thorough evaluation is required of the Large Terracotta Irrigation Controller for Latching Solenoids compared with smart irrigation controllers currently being used. Such an evaluation would require extensive field trials.

Appendix 1. Fractional drippers

To ensure that each irrigation dripper discharges the appropriate volume of water during the irrigation event regardless of the pressure, you can use a control dripper that delivers a fixed fraction of the volume of water discharged by an irrigation dripper. This can be done for either PC (pressure compensating) drippers or NPC (non pressure compensating) drippers.

If you are using PC drippers, then the pressure at the drippers does not need to be within the pressure range specified by the manufacturer for pressure compensation. However PC drippers stop working altogether at low pressure so when using a fractional dripper always check that the drippers are working.



Fractional dripper tool

Fractional dripper tool

The fractional dripper tool may be purchased from the Measured Irrigation website. The construction of the fractional dripper tool is an excellent DIY project.

Fitting drippers to the fractional dripper tool

To use the tool you require 10 identical irrigation drippers. If you are using dripline, you can prepare 10 identical irrigation drippers by cutting the dripline into short lengths with one dripper per length and sealing one end.

Two of the drippers are used as **upper drippers** and the remaining 8 drippers are used as **lower drippers.** One of the upper drippers is connected inside the 25mm polypipe so that the outlet of the dripper is at the level of the white line. To access this dripper you need to disconnect the 25mm polypipe at the joiner just below the white line. You also need to disconnect the 4mm micro valve from the dripper. The other upper dripper is outside the 25mm polypipe and the outlet of the dripper is also at the level of the white line.

To access the first upper dripper, disconnect the 25mm polypipe at the joiner just below the white line and disconnect the 4mm micro valve from the dripper.

The other upper dripper is outside the 25mm polypipe and the outlet of the dripper at the same level as the outlet of the first dripper.

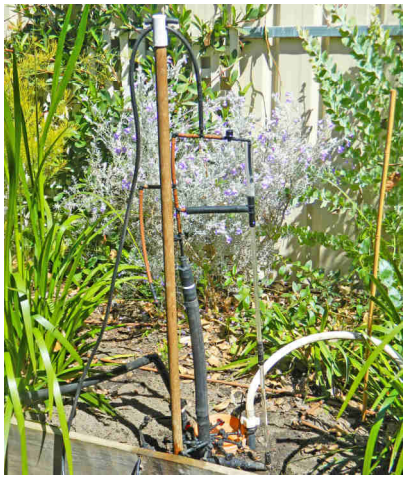
Each of the lower drippers is connected to 4mm polypipe connected to a 4mm micro valve so that the outlet of the dripper is at the same level as the 4mm elbows inserted in the 25mm polypipe.

Each of the lower drippers is connected to a 4mm micro valve

The fractional dripper needs to be suspended above the terracotta pot. The irrigation system provides the water supply for the fractional dripper.

A clear tube allows the user to view the water level in the 25mm polypipe. The water level should always be below the white line. An extra length of 25mm polypipe and an extra length of clear tube are provided so that the 25mm polypipe can be extended to ensure that the water level is below the white line. Provided that the water level is low enough, it is preferable not to use the extension.

When using the fractional dripper, it is preferable that the upper drippers are at the same level as the irrigation drippers. For this to be the case, you may need to relocate the Terracotta Irrigation Controller to a location in your garden where the pot is low enough.



The fractional dripper is suspended above the terracotta pot

You can use the fractional dripper tool to make a fractional dripper with any of the following fractions of the flow rate of the identical irrigation drippers:
1/8, 1/7, 1/6, 1/5, 1/4, 2/7, 1/3, 2/5, 3/8, 3/7, 1/2, 4/7, 5/8, 5/7, 3/4, 4/5, 5/6, 6/7, 7/8

The fractional dripper has almost the same emitter discharge exponent as the identical irrigation drippers. Therefore the flow rate of a fractional dripper is a fixed fraction of the flow rate of the irrigation drippers used to assemble the fractional dripper, regardless of the pressure.

To make a fractional dripper for dripline you need to cut the dripline into short lengths with one dripper per length and one end blocked.

The following table provides the setup details for the available fractions for the fractional dripper.

Fractional dripper fraction	Number of closed lower drippers	Number of open lower drippers	Number of open lower drippers supplying the output of the fractional dripper
1/8 (0.125)	0	8	1
1/7 (0.143)	1	7	1
1/6 (0.167)	2	6	1
1/5 (0.200)	3	5	1
1/4 (0.250)	4	4	1
2/7 (0.286)	1	7	2
1/3 (0.333)	5	3	1
2/5 (0.400)	3	5	2
3/8 (0.375)	0	8	3
3/7 (0.429)	1	7	3
1/2 (0.500)	6	2	1
1/2 (0.500)	4	4	2
4/7 (0.571)	1	7	4
5/8 (0.625)	0	8	5
5/7 (0.714)	1	7	5
3/4 (0.750)	4	4	3
4/5 (0.800)	3	5	4
5/6 (0.833)	2	6	5
6/7 (0.857)	1	7	6
7/8 (0.875)	0	8	7

Table 2. Fractional dripper setup details

Flow rate of the upper drippers

The flow rate of the irrigation drippers and the upper drippers should all be approximately the same. You may wish to use the following procedure to increase the flow rate of the upper dripper inside the 25mm polypipe to match the flow rate of one of the irrigation drippers more precisely.

Measure the flow rates of the irrigation dripper and the upper dripper outside the 25mm polypipe. If the flow rate of the irrigation dripper is greater than the flow rate of the upper dripper, calculate the difference in flow rates. The 4mm micro valve above the clear tube can then be used to provide the extra flow rate to the upper dripper inside the 25mm polypipe so that it exactly matches the flow rate of the irrigation dripper.

The following pictures provide examples of fully assembled fractional dripper being used as the control dripper for the Terracotta Irrigation Controller.

Fraction 1/8 for online drippers (8 open lower drippers, one lower dripper as control dripper) water supply pressure 40 kPa

Fraction 1/8 for online dripper, water supply pressure 100 kPa. The extension tube is used so that the water level showing in the clear tube is below the white line.

Fraction 2/7 for 8mm Netafim dripline (1 closed lower dripper, 7 open lower drippers and 2 open lower drippers as control dripper) water supply pressure 100 kPa. This setup is used for a garden in Adelaide with more than 400 drippers.

Fraction 1/4 for online dripper (4 closed lower drippers, 4 open lower drippers and

Fraction 1/2 for13mm dripline (4 closed lower drippers , 4 open lower drippers and 2 open lower drippers as control dripper) water supply pressure 100 kPa

Appendix 2. Subsurface installation

Follow the instructions below to install the Large Terracotta Irrigation Controller for Latching Solenoids so that the rim of the terracotta pot is up to 250 mm below the surface.

Step1. Connect a commercial large round valve box to the terracotta pot. One way of doing this is to drill small holes in the terracotta pot and the valve box and to securely connect the valve box to the terracotta pot with cable ties.

Step 2. Use a 15 mm socket and a 15x300 mm threaded riser to extend the input and output pipes.

Step 3. Insert a length of 8 mm flexible tube into the 8 mm hole in the lid of the valve box. Connect the adjustable control dripper to the tube under the lid. Connect the other end of the tube above the lid to the irrigation system.

Step 4. Dig a hole midway between two adjacent plants and place the terracotta pot and valve box in the hole. Back fill soil around the valve box. There should be no irrigation drippers near these two plants. The lid of the valve box should be above the surface.