Irrigation Scheduling with Capacitance Probes

WISE **WATERING**
Irrigation Management Course

These materials are part of the Wise Watering Irrigation Management Program, developed in part from the NSW Agriculture WaterWise on the farm education program and The Mallee Wells Irrigators manual.

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Introduction

There are many methods of irrigation scheduling, using either direct measurements of water use or soil moisture, or indirect measures of water use mainly based on meteorological data.

This course will concentrate on the direct measurement of soil moisture levels.

In this course, we will be measuring soil moisture with a soil capacitance probe, and using this information to determine when to irrigate, and how much water to apply.

Learning outcomes

This *training course* will take you step by step through the development of an irrigation schedule using the soil moisture measurements produced by the probe.

You will learn:

- how to install access tubes for use with the Gopher;
- where to position the tubes;
- how to take readings with the Gopher and manipulate the data; and
- how to use the data to work out when to irrigate and how much to apply

Additional reading

P.Charlesworth, CSIRO Land and Water. "Soil Water Monitoring". Irrigation Insights Number One, 2000.

Measuring soil moisture

If we could readily measure the moisture content of the soil, and we knew the levels of dryness at which yields were depressed, then we could determine when irrigation is needed and how much water to apply; ie., we could schedule the irrigation.

Capacitance probes provide a convenient and relatively low cost instrument for measuring soil moisture level. It is based on “capacitance sensing”; ie., measuring the capacitance of a volume of soil around an access tube. More detailed recording systems are available (AdCon ™ and EnviroSCAN®) that record the soil moisture content specified intervals (eg., each 15 minutes), and relay the results by telemetry to a recording system (service offered by Serve-Ag).

The less sophisticated units are the Gopher® and Diviner 2000® instruments.

These instruments require calibration that relates the reading on the instrument to the actual soil moisture content. Calibration factors vary depending on the soil type, and have been developed by the DPIWE and others.

Use of a Capacitance Probe

The probes require the installation of tubes through the soil profile to well below the bottom of the root zone. For most of our crops this is about 60 cm; so the installation tubes need to be installed to approximately 65 cm.

Capacitance probes use the dielectric constant of the soil, water and air mixture to measure the soil water content; the dielectric constant is proportional to the soil moisture content. Capacitance probes have the ability to measure soil water levels at different depths down the soil profile and record information on a datalogger which can then be transferred to a computer.

The sensor is placed in a tube in the ground and records are made at 100 mm increments down the profile. The information collected can be displayed as chart giving a graphic display of the soil moisture content at different depths down the profile.

Selecting sites for access tubes

In any soil-based monitoring it is important to remember the measurements are taken from a small part of the rootzone, using these measurements we make decisions for the whole of the paddock. To ensure maximum benefit it is important to select monitoring sites which are representative of the irrigation shift.

In Centre Pivot circles, the key points to remember when selecting sites for access tubes are:

- Make sure the site is representative of the main part of the crop, particularly the main soil type. Avoid wheel tracks, wet areas, stunted or sick plants, or areas with disturbed soil.

- Avoid abnormal areas like old fence lines, headlands, farm tracks etc.

- Be at least 5 metres from the wheel line of a tower, and at least one full span from the pivot point.

- Make sure the site is readily accessible for routine readings; but at least 10 metres into the crop. Avoid outside rows exposed to the wind.

- In potatoes, the access tube should be in the middle of the potato mound.

- In raised beds, install the tube at least 0.5 metres from the edge of the bed.

- Avoid placing the tubes under areas watered with end guns; experience shows the water application in this zone to be much less uniform

In paddocks irrigated with a travelling irrigator, monitoring sites should be away from the start and end of runs (say at least 75 metres from the end of the run) and about a quarter of the distance between traveller runs (say 15 metres from the laneway).

Remember to mark the location of each tube with a plastic post (eg., fibre glass stake) as they are easy to loose and very hard to find when crops reach full leaf cover. Also identify each tube with a number for future recording.

Installing the tubes

Depending on the model, tubes are either 50mmm Class 6, or 15 mm Class 6 PVC.

Experience has shown the use of the “under-size hole” method for tube installation gives the best results.

The general procedure is to auger a slightly undersize hole to the required depth, plus 20% to allow for surplus soil to be pushed to the bottom of the hole as the PVC tube is installed. A 19mm wood auger welded to a steel extension bar and T handle has been found to be adequate for the Mini-Gopher.

The tubes MUST have good contact with the surrounding soil; any air gaps or voids will lead to incorrect readings. The correct procedures and installation tools must be used.

It is a wise precaution to install at least 2, and preferably 3 tubes in each crop sowing (eg., each paddock), in case tubes show strange readings caused by air gaps.

The depth of measurement in the soil profile should be the expected rootzone depth plus at least 200 mm, so you have capacity to measure a little beyond the rootzone. For Gopher instruments, remember to allow 40mm below the measuring depth of the sensor head of the probe, plus 70 mm for the tube to protrude above the soil surface.

Soil moistures are normally measured to 600 mm. This requires the tube to be 710 mm long, and the hole to be at least 640 mm deep (plus 20% for the under-size hole technique). It does not matter if there is an air gap below the base of the access tube.

Note that access tubes must be sealed at the bottom, using a cap that is glued into the inside of the access tube. Place a cap over the tube to keep out rain and irrigation.

The top of each access tube must be 70 mm above the surface of the soil (Gopher); this is important as all depth of readings through the soil profile are related to the top of tube.

This is not easy to ensure, particularly in potatoes where soil erodes from around the tube, or the soil level is raised by re-moulding. It is best to flatten the mould

by 30-50 mm to allow for natural settling or erosion; then replace soil if necessary to maintain the height of 70 mm above the soil surface.

It is important not to damage the crop around the access tube; water use around the tube needs to represent what is happening to the crops as a whole so we need to be careful.

It is sometimes difficult to obtain reliable readings in potato moulds, and a tensiometer placed in the middle of the mould provides a reliable check on the readings.

Testing the access tube

Immediately after installation take a set of readings. Look for unexpected variation in the readings as the probe is lowered gently down the tube. Large variations will indicate the presence of air gaps; if these occur abandon the hole.

Calibration

Sensor output is affected by soil type and texture. It is only practical to use 1 calibration for the entire profile. While it is recognised that this will not be correct for Duplex soils, it satisfactory for most scheduling requirements.

You will be provided with an initial calibration to be entered into the Gopher.

Assume the measuring zone is 600 mm unless otherwise instructed. This sets the number of depths that readings will be taken at to 6 (each 100 mm down the profile).

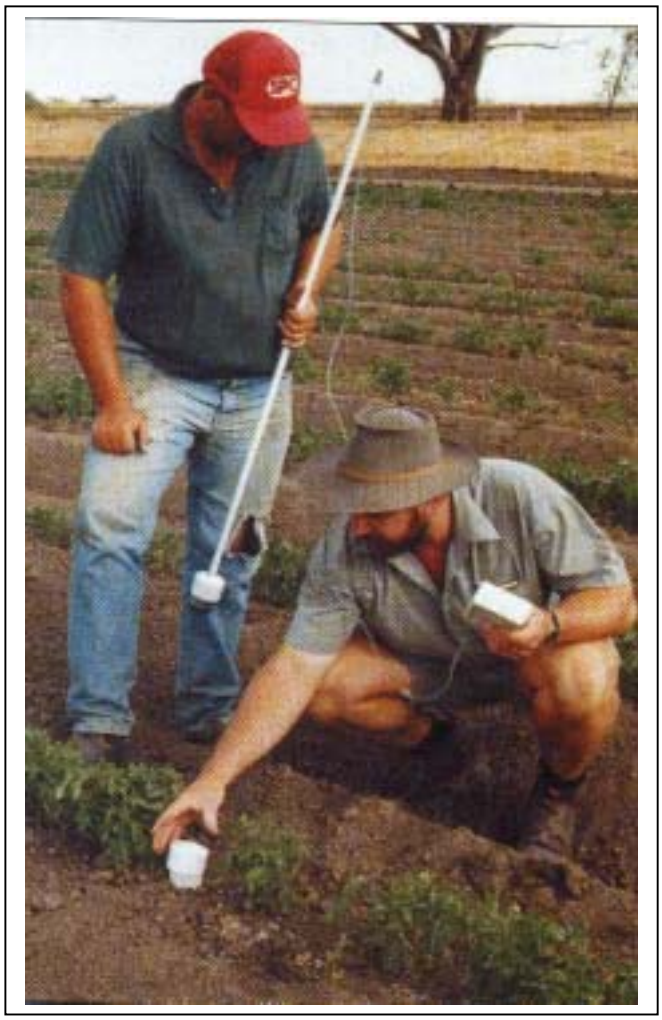
Entering the calibration setting fixes Field Capacity and Refill Point for the profile.

Install a rain gauge

Install a rain gauge to record rainfall or irrigation near at least 1 access tube in a paddock. This allows any changes in profile moisture content to be checked against easily and accurately measured water additions.

For example, reading the probe immediately before and after an irrigation or rainfall event allows convenient checking of the accuracy of the instrument.

Figure 1. Using a Gopher Capacitance Probe



Taking readings

Readings need to be taken at the set range of depths at least twice weekly. Preferably take the readings at about the same time each day; early afternoon is a good time.

After removing the cap, wipe the inside of the tube to remove any condensation.; use paper towel or a rag on a length of dowel if there is condensation deeper in the tube. It is a good idea to wipe the inside of the tube before each reading.

The following instructions are for the Gopher probe.

Follow the menu on the recording box.

- Check the clock; this is important for graphing results.

- Go to “Record Profile”. Select the site number. Make sure the sensor head is at the correct height with the bar under the number one (1) on the measuring rod. Depress the LOG key and wait for the beep.

- Then lower to position 2 and depress the LOG key. Repeat for all profile points.

- Then look at the data. If appears sensible, Store the Data.

The display will show the soil moisture content of each 100 mm layer of soil as a graph, with the moisture content on the vertical axis, and the various soil depths on the horizontal axis (similar to the graph shown as Figure 2).

Recordings over time can be displayed as a Histograph, with an example shown as Figure 3. This shows the change in soil water content of the rootzone over time.

More detailed analysis is available by computer analysis after downloading the results from the field recording instrument to a computer.

The readings

The readings from the Gopher indicate the amount of water, in millimeters, in each 100 mm layer of soil. The also adds each layer to allow us to read out the total amount of water in the soil profile (to the depth of the lowest reading).

What do the readings mean?

The direct readings from the Gopher instrument indicate the Volumetric Moisture Content (VMC, mm of water in the profile). If this is close to the Refill Point then we know that irrigation is needed. The difference between Field capacity and the Volumetric Moisture Content is the amount of water that should be applied.

By reading the soil moisture content immediately before and after a rainfall or irrigation event (when you will know how much water has been added to the soil) you can check whether the instrument indicates the correct change in VWC. If the difference is significant, say by at least 10%, then changing the calibration is required. Seek the advice of an experienced operator to do this.

Figure 2. Graph of soil moisture content against depth at a particular date.

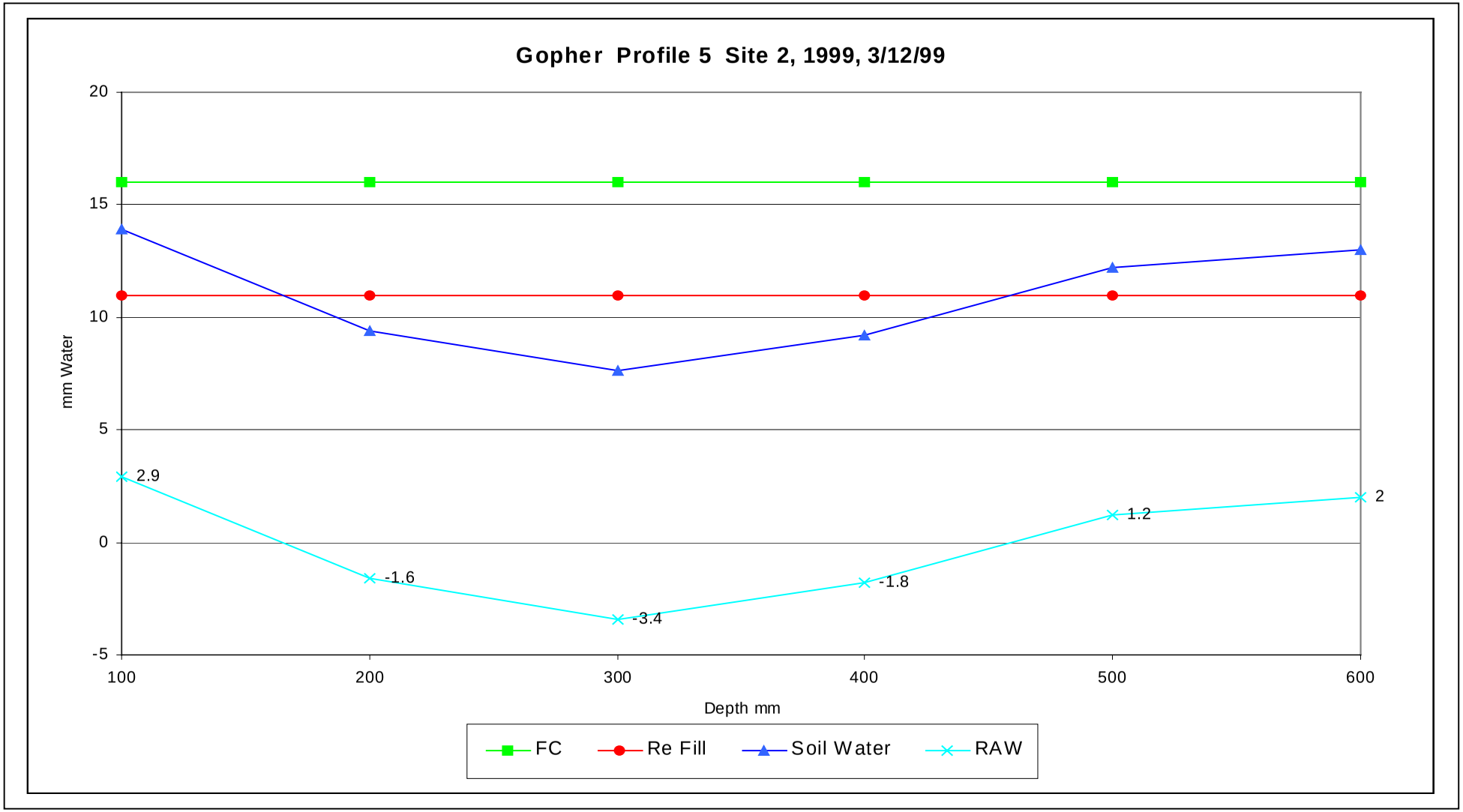
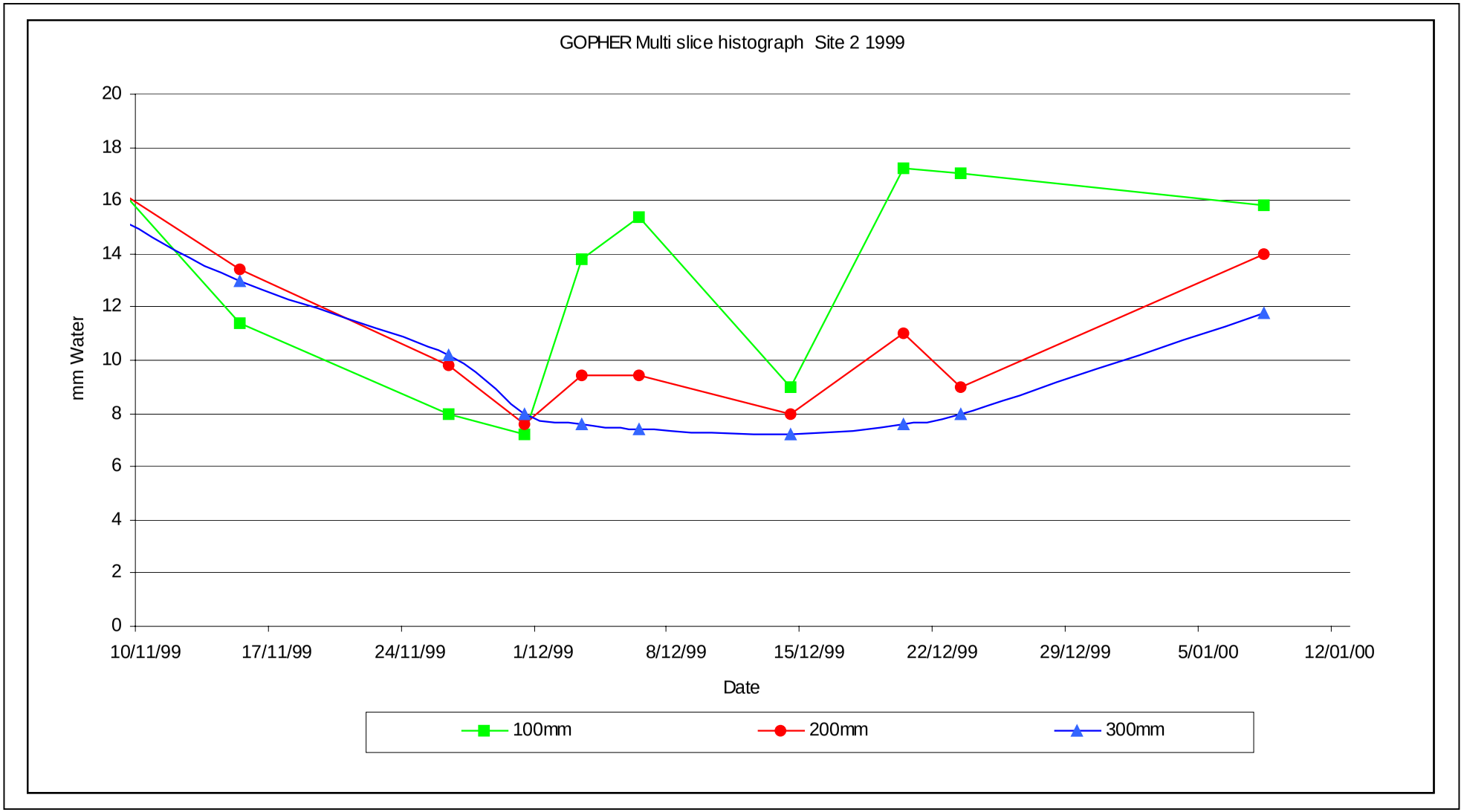


Figure 3. Graph of the moisture content of the root zone over time.



Summary of Gopher instructions

Steps to calibrate the Gopher

1. Turn on the Gopher. Follow prompts.
2. In the Main Menu Select Calibration Entry. Press Enter.
3. Select Site number to be calibrated. Press Enter.
4. Put in the root zone depth. Press Enter.
5. Put in the number of profile points. Press Enter.
6. Put in the Offset (specific number provide with each Gopher). Press Enter.
7. Select the type of instrument (Original, Micro or Ferret). Press Enter
8. Select 1 for auto calibration. Press Enter.
9. Select 1 for single point calibration. Press Enter.
10. Key in number for soil type. Press Enter.
11. Edit FC and Refill. Press enter if okay.
12. Slope : Change or enter (suggest don't change unless provided with an alternative)
13. Store calibration

Recording the profile

1. Turn on the Gopher. Follow prompts.
2. In the Main menu select record profile. Press Enter.
3. Select site number. Press Enter.
4. Make sure the Probe is at the 10 cm mark. Press Log and wait for beep.
5. Move the Probe to the 20cm mark. Press Log and wait for beep.
6. Repeat this process for the number of profile points.
7. Save the data when asked.

How much water is required?

The amount of water to apply irrigation is the same as the RAW figure, assuming the soil has been fully depleted to the Refill Point.

The volume of irrigation water to apply can be calculated as follows:

Example

If a 20 hectare circle requires a 30 mm irrigation then the volume of water required will be:

Volume in megalitres (ML) = Depth (mm) * Area (ha) / 100
= 30(mm) * 20 (ha) / 100
= 6 ML