Introduction to Irrigation Management

Evaluating your pressurised system

System 7

Non-overlapping under-canopy

Micro-spray system

Version: WA 20 September 2011

These materials are part of the WaterWise on the Farm education program Introduction to Irrigation Management. They were developed by NSW Agriculture staff from the Water Management subprogram with major input from Lindsay Evans.

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AIM

The aim of this workbook is to provide you with skills and Knowledge to assist you with your evaluation of your irrigation system. In order to assess your irrigation system you will need to determine the rate that water is being applied, and how uniformly that water is being distributed over your irrigated field.

To determine this information you will need to calculate the Mean Application Rate (MAR) and Distribution Character percentage (DC%) for your system. These worksheets outline the equipment and procedure needed for you to perform these calculations for a non-overlapping under-canopy spray system.

SYSTEM OVERVIEW

Non-overlapping under-canopy irrigation is a form of micro-irrigation that has been around since the 1950s. It is used mainly for irrigating tree crops, orchards, some vegetables, nurseries and urban parks and gardens.

With this form of irrigation, individual sprinklers are placed adjacent to trees or vines so as to deliver water to the plant rootzone rather than water the entire field.

There are a great number and variety of micro-sprinklers on the market suitable for non-overlapping under-canopy irrigation. These micro-sprinklers come in various sizes, perform various duties, and have different discharges, pressures, diameter of throw and distribution of throw.

The design and selection of the correct micro-sprinkler, filter, mainlines and other components for your requirements is therefore essential for the efficient operation of your irrigation system.

Sprinklers operate within a pressure range between 50 kPa and 300 kPa. The maximum working head of 300 kPa is adopted where low-density polyethylene pipe is used in the laterals.

Discharge rate can vary from 20 litres per hour to over 300 litres per hour. Sprinkler discharges over any operating block are generally designed with a pressure differential tolerance of +/- 10%, so as to maintain a near uniform flow distribution. Pressure compensating sprinklers have aided this over recent years.

Filtration is an integral part of any micro-irrigation system and needs to be able to filter out any particles 1/3 to 1/6 of the smallest nozzle orifice. Filter selection will vary depending upon the quality of the water supply source.

Irrigation systems can be fully automated or manually controlled, thus giving better control over the frequency of application.

EQUIPMENT NEEDED

To measure sprinkler coverage:

- Catch cans
- Weights to prevent catch cans blowing away
- A shovel to smooth catch can area, and where necessary for partially burying the cans
- A measuring cylinder or jug with graduations in millilitres
- A 30-metre measuring tape and possibly a short rule
- A calculator, a pen and evaluation sheets
- Manufacturer's sprinkler performance charts
- For overhead systems you will require a ladder or platform to access the emitters

To measure pressure:

- An accurate pressure gauge with an appropriate scale so it works mid-range at your normal pressures (say 0 to 400 kPa) to 1000 kPa.
- A Pitot tube attachment (pronounced pit-oh) (Figure 1), or a threaded 15 mm PVC tee and fittings such as reducing bushes for small low-level sprinklers, or a Schrader valve (Figure 2), or a needle valve fitting.

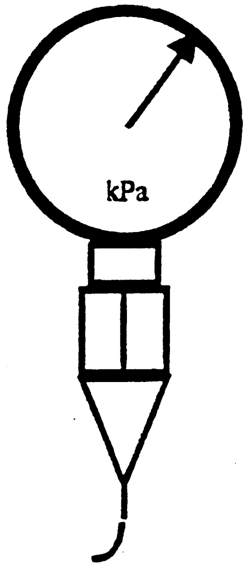


Figure 1: Pitot Tube

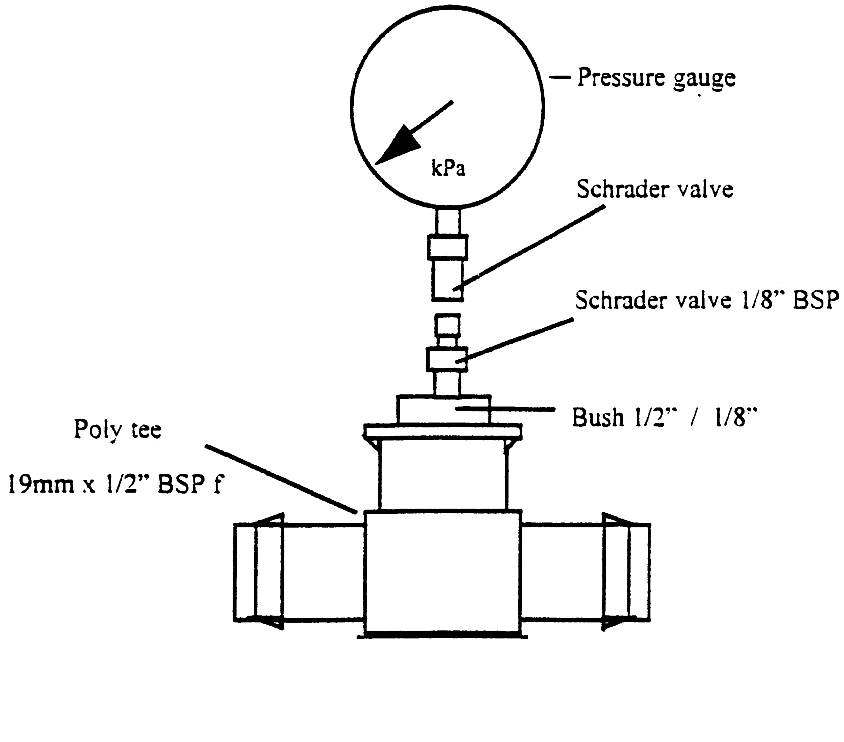


Figure 2: Schrader Valve

To measure flow:

- Plastic tubing that can be placed over the sprinkler nozzles and long enough to go from the sprinkler to a container
- A measuring cylinder, jug or bucket, clearly marked in litres
- A watch capable of measuring seconds

Kits containing some of this equipment are available on loan from your WaterWise on the Farm facilitator.

EVALUATION METHOD

To assess the performance of your system, you need to measure the pressure and flow at a number of different points in the system. To measure evenness of application, (called the Distribution Characteristic) we need to collect the output of the sprinklers where it reaches the ground.

W do this by using a number of catch cans spread out in the wetted area (or throw) of the sprinkler. Working through the following procedure will assist you to determine the MAR and DC% for your irrigation system.

Step 1 Gather the relevant data for your irrigation system. Record this data in the Data Sheet.

Step 2 Choose rows and sprinklers to be used for the catch can test. Make sure water can be caught from only one sprinkler (no overlap). It is suggested that you select sprinklers for which you are checking the pressure and flow (if they are suitable).

Step 3 Give the rows an identification number (Row B, Row C with the can nearest the sprinkler being B1 out to B6). Draw a sketch of the layout so you know which can is where.

Step 4 Decide on the spacing you will use for your catch cans. Place the catch cans in a row across the diameter of the sprinkler's wetted circle as shown in Figure 3.

Note! The can closest to the sprinkler is only **half this spacing**.

For example, if the catch cans are to be 0.5 m apart then the first Catch can should be 0.25 m from the sprinkler. Use enough cans to collect to the edge of the wetted circle of the sprinkler. The more closely spaced your cans are, the more accurate your result will be.

Make sure the catch cans are upright and stable. If necessary, weight them down with stones or gravel. With certain types of sprinkler, it may be necessary to sink the cans into the ground. Make sure that grass and other foliage does not interfere with water entering the catch cans, and make sure the sprinkler is sitting vertically.

Step 5 Turn on the water to fill and pressurise the lines.

Note! Ensure that water does not enter the catch cans until the system is operating at normal pressure.

Step 6 Start the test and leave the sprinklers running for the duration of the test. **Record the test time in minutes on your Catch Can Record Sheet.** (If you run for a different time, you will need to adjust your calculation to simulate an hour-long test).

Step 7 Check your irrigation system for malfunctions, blockages, leaks and damage. Record any faults in your maintenance report and schedule on your data sheet.

Step 8 Measure the Flow Rate and pressure at the extremities of the test block.

Step 9 Check your pump unit and record the pump operation in your pump record sheet.

Step 10 At the end of the test period, accurately measure the volumes of water collected by pouring the contents of each catch can into a graduated jug or measuring cylinder and recording the results on the record sheet.

Step 11 Complete the MAR, DC%, and pressure and flow variation calculations in the evaluation sheets.

Step 12 Repeat Steps 1 to 7 for several sites.

Data sheet - Example

Name:	Tina Scatterayn	Date: July 3 2000

Location:	Bathurst
Crop:	Crab apples
Soil type/texture:	Sandy Loam
Effective root depth:	35 mm (0.35 metres)
RAW for crop:	15 mm
Sprinkler make:	Netafim
Sprinkler model:	vibrospray
Nozzle colour	Sky blue
Nominal Flow	34 at 200 kPa
Tree spacing	4 metres
Row spacing	5 metres
Sprinkler distance to tree	0.5 metres
Sprinkler height:	180 mm
Sprinkler wetted diameter:	3.2 metres
Sprinkler spacing in row:	4 metres
Usual length of irrigation:	6 hours
Usual frequency of irrigation	3 days
Catch Can Diameter	113 mm
Catch Can Spacing	0.5 metres

Maintenance Report	Maintenance Schedule
Two emitters blocked	Unblock emitters 3 July 2003
Leak at junction 5	Replace seals at junction 5 7 July 2003

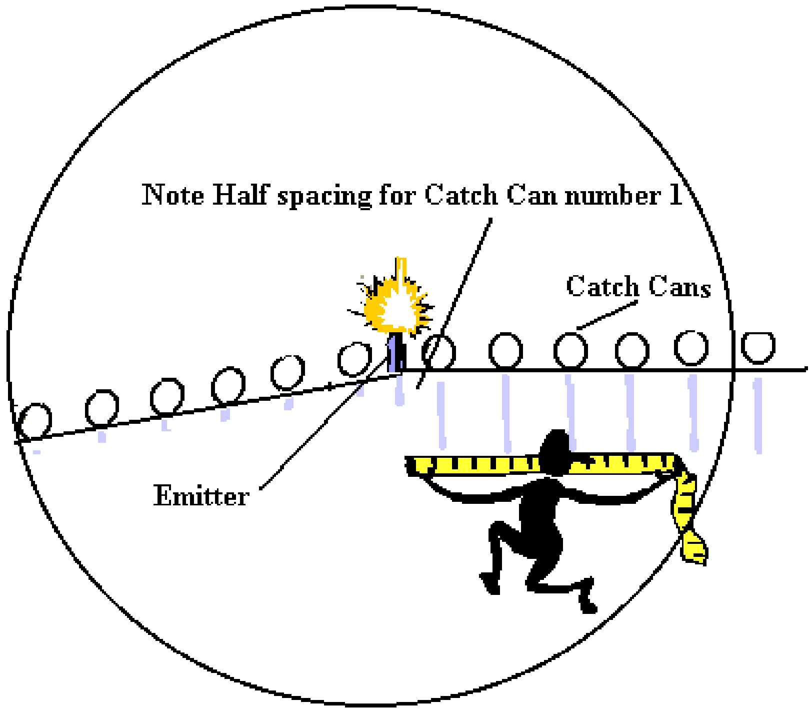


Figure 3: Positioning for two radials of catch cans

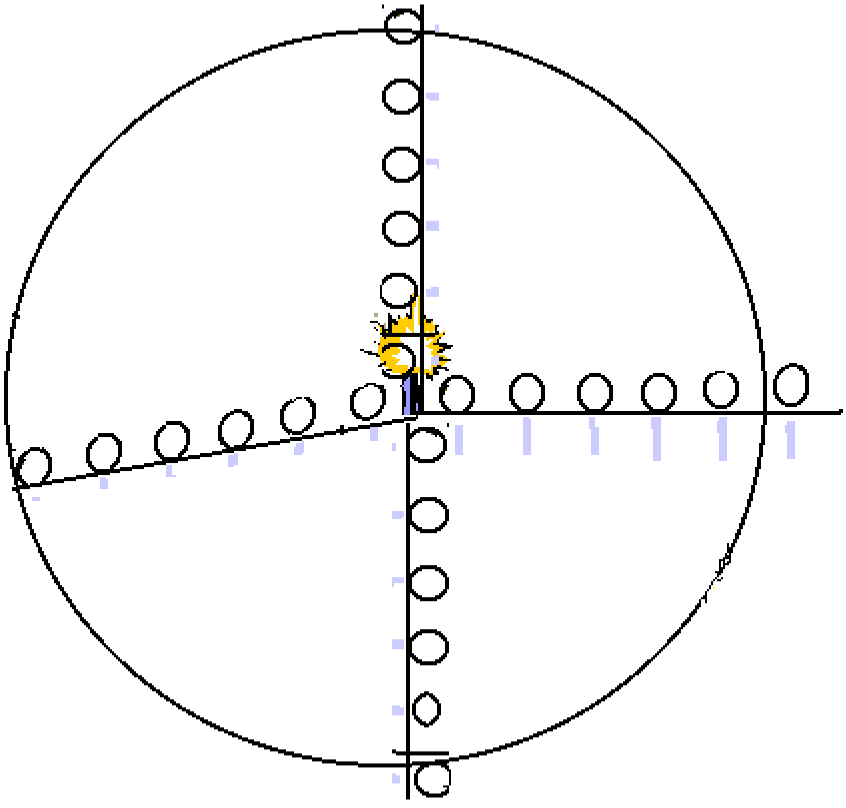


Figure 4: Positioning for four radials of catch cans

Catch can record sheet- (example data)

Catch can record sheet- (example data)

Name: Tina Scatterayn   Date: 3 / 7 / 2000   Crop: Crab Apples

	A	B	C	D	E	F	G	H	K	N
Catch can	Distance from sprinkler (metres)	2 Row Test		4 Row Test		**Totals for each position** (mL) **B + C + D + E**	**Totals converted per hour** (mL/h) **F ÷ Test time (min) x 60**	**Average Volume** (mL/h) **G ÷ number of test rows**	**Depth of application** (mm) **H ÷ Can conversion** (Table 2)	**Area Adjusted Depth** **Distance from Sprinkler** (metres) **x Depth of application** (mm) **A × K**
		Test Radial 1	Test Radial 2	Test Radial 3	Test Radial 4					
1	***0.25***	***78***	***76***	**-**	**-**	***154***	***154***	***77***	***7.7***	***1.9***
2	***0.75***	***66***	***70***	**-**	**-**	***136***	***136***	***68***	***6.8***	***5.1***
3	***1.25***	***25***	***39***	**-**	**-**	***64***	***64***	***32***	***3.2***	***4***
4	***1.75***	***0***	***8***	**-**	**-**	***8***	***8***	***4***	***0.4***	***0.7***
5	***2.25***	***0***	***0***	**-**	**-**	***0***	***0***	***0***	***0***	***0***
6										
7										
8										
9										
10										
11										
									Total	***11.7 [P]***

Start time : 11.25   **Finish time: 12.25**   **Length of test: 60 minutes**

Completing the catch can record sheet

Step 1 Record your Catch Can spacing **[A]**

Step 2 Record the volume caught in each Catch Can

Step 3 Complete the totals column **[F]** of the catch can record sheet by adding the Catch Can volumes at each position from the test rows. Convert the totals to a per-hour rate in column **[G]**

Step 4 Calculate the average volume **[H]** collected at each position by dividing the Converted total volume of the catch cans **[G]** by the number of test rows.

Step 5 Divide the average volume **[H]** by the catch can Conversion figure from Table 2. This will convert your volume into depth (mm) **[K]**

Step 6 You now need to multiply the catch can distance from the sprinkler **[A]** by the depth of application **[K]** to obtain the Area adjusted values for the final column [N]. We need to adjust the depth of application to account for the circular wetting pattern and non-overlap of the emitters.

Step 7 Add up all of the Area adjusted values figures in the final column to obtain **[P].**

With this figure we are able to calculate the MAR and DC for our irrigation system.

Notes on Catch Cans

For catch cans of 110 to 115 mm diameter across the top, we may simply divide the collected amount by 10 to obtain the depth (in millimetres) of irrigation.

For example, if we collected 674 mL, then we divide this figure by 10 to obtain the irrigation depth of 67.4 mm.

Converting Volume into depth using different Catch Cans

In order to convert volume into depth (millimetres) we need to use a conversion factor. The conversion factors are listed in Table 2. You select your conversion factor by measuring the diameter of the mouth of your catch can

For instance, if the diameter of your catch can is 110 mm then our conversion factor from Table 2 will be 9.5 (circled).

If our cans collected 674 mL, then the conversion is our volume divided by the conversion factor;

674 mL ÷ 9.5 = 71 mm

Therefore the depth of water applied during the example test was 71 mm

Table 2: Converting mL to mm of irrigation

Diameter of catch can (mm)	Figure to divide the collected amount by
75	4.4
80	5.0
90	6.4
100	7.9
102	8.2
104	8.5
106	8.8
108	9.2
110	9.5
112	9.9
113	10.0
114	10.2
115	10.4
120	11.3
125	12.25
145	16.5
165	21.3
200	31.4

If you use 4-litre square plastic ice cream containers, 1 litre collected in one of these is equivalent to 25 mm of irrigation.

On a calculator, use

"water collected in mL" ÷ 40 = ………… mm

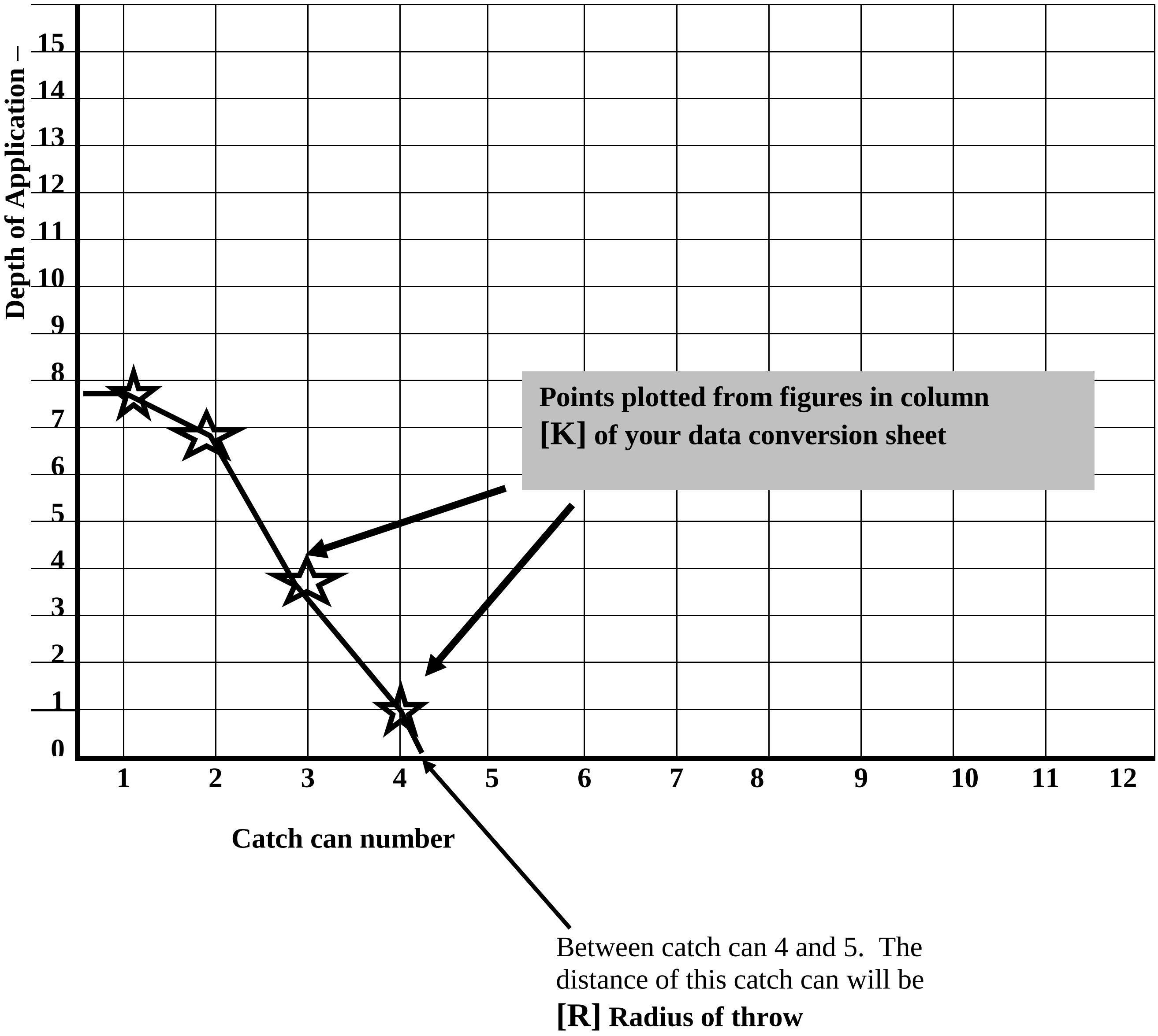
Graphing your data

To calculate distribution of the sprinkler coverage we now need to graph the sprinkler output. Our example irrigation system has been plotted below in Figure 5.

Step 1 Take the readings of application depth **[K]** from your data conversion sheet and on a blank graph; mark the output for each position moving away from the sprinkler.

Step 2 Join the points to form an application curve. **Later**, after you have done the next section, you will add the horizontal MAR line to the chart and mark position [T].

Figure 5: Depth of Irrigation

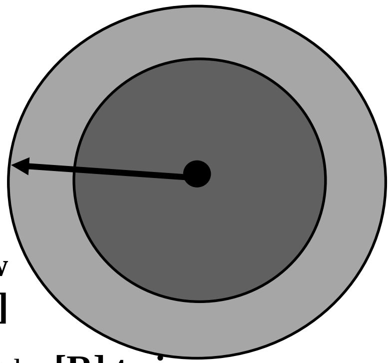


The ideal shape for the graph above would be flat, showing that all areas were getting an equal coverage of water. In reality, most systems will be similar to that shown in the example, with coverage falling further from the sprinkler/emitter.

Calculating MAR

Step 1 Note the radius of throw by looking at the catch can record sheet, and noting where the coverage cuts off. Alternatively, you may note the point **[R]** on the graph you plotted. The catch can identified by [R] will tell you the distance from the emitter.

For our Example the
Effective radius of Sprinkler coverage **[R]** = 1.8 **metres**



Radius of throw of sprinkler [R]

Step 2 Take **[P]** from the data conversion sheet and divide it by **[R] twice.**

Call the result **[S].**

[S] = [P] ÷ [R] ÷ [R]

Step 3 If the catch cans are spaced at 0.5 m intervals, then [S] is the MAR.

If the catch cans are **not** spaced at 0.5 m, then multiply [S] by twice the catch can spacing to obtain the MAR (see the example below).

Table 3: Calculating MAR - Example

If catch cans are spaced at 0.5 metres apart	**S = MAR**
[S] = [P] ÷ [R] ÷ [R]	
[P]	**11.7**
[R]	**1.8 metres**
S = **At 0.5 m spacings MAR**	**11.7 ÷ 1.8 ÷ 1.8** **= 3.6 mm/h**
If catch cans are **not** spaced at 0.5 m apart:	
[S] x 2 x catch can spacing (metres)	

In our example, Tina Scatterayn chose to place his Catch Cans at 0.5 m intervals. Therefore [S] is equal to MAR.

That is the Mean Application Rate for the system that Tina has tested is **3.6 mm per hour**

Calculating the Distribution Characteristic (DC)

Step 1 On your sprinkler graph (figure 5), draw a horizontal line across the graph at the MAR value you calculated in Table 3.

Step 2 Mark the point where this line crosses your application curve.

Step 3 Read down from this intersection point to the catch can position axis. The distance in metres from the sprinkler to this catch can position will give us the **[T]** figure needed for the calculation of the Distribution Characteristic.

Step 4 Using the values of **[R]** and **[T]** you can now determine the DC using Table 4.

The DC is a comparison between the area that has received the **average** depth, with the total wetted area. It is **only** used in non-overlapping irrigation systems.

Because our wetted areas are circles, we need to multiply **[T]** by itself (T x T), and then **[R]** by itself (R x R).

[T] x [T] is then divided by [R] x [R].

The result is multiplied by 100 to convert the figure into a percentage.

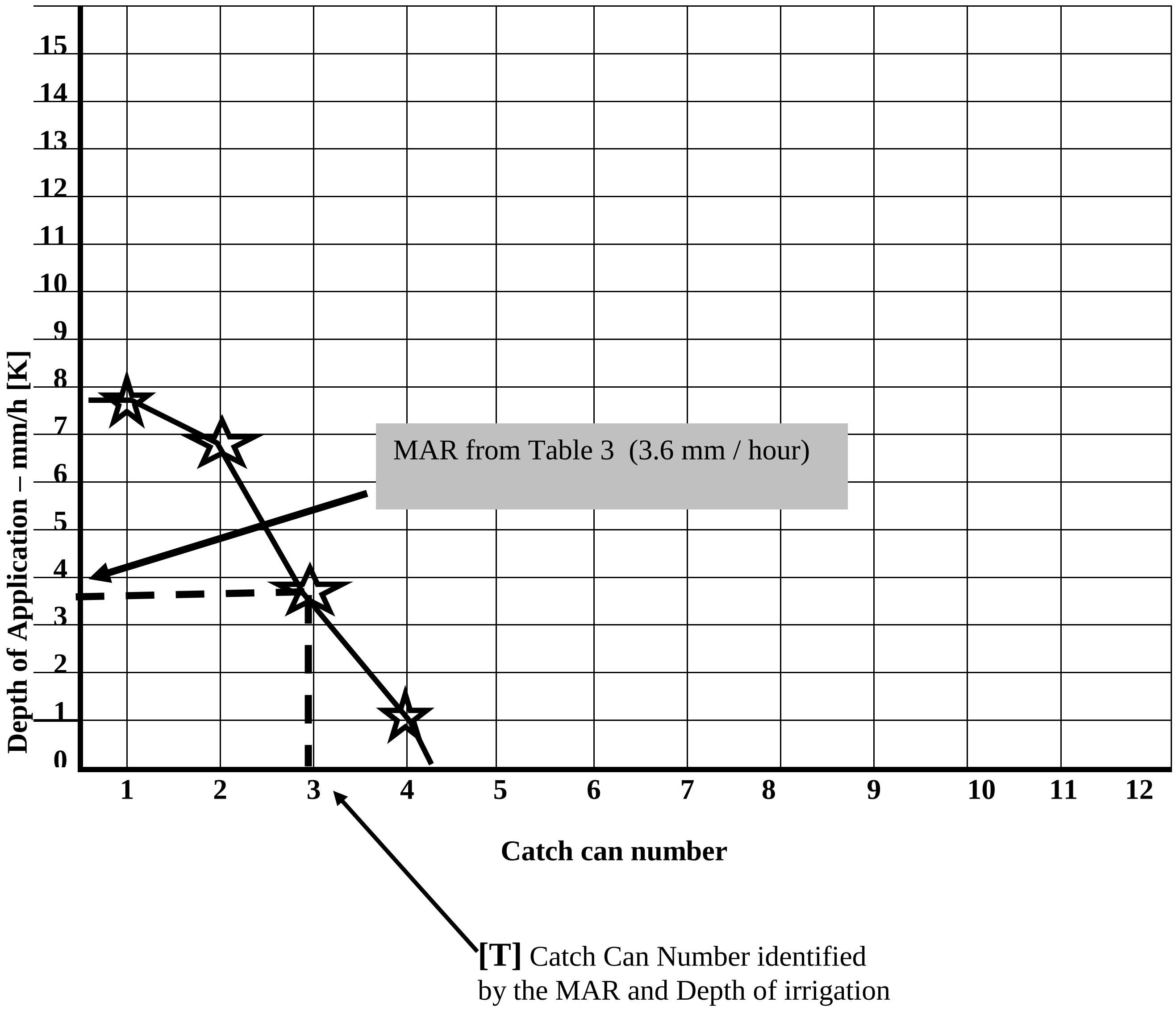
This procedure for calculating the Distribution Characteristic is outlined in the example below.

Calculating DC – Example

Plotting the MAR of 3.6 mm per hour on Figure 6, we can determine that the MAR crosses our depth of irrigation line at **Catch can number 3**. This will be our [T].

Catch Can 3 was placed **1.25** m from the sprinkler. Therefore **[T] is 1.25 m**

Figure 6: Estimating MAR



From the Catch Can Record Sheet, Catch Can number 3 is 1.25 metres from the emitter

NOTE! [T] would be a good location for a tensiometer or other soil moisture monitoring device.

Now that we have our [T] and [R] figures we can use table 4 to calculate our Distribution Characteristic

Table 4: Calculating Distribution Characteristic

DC % = $T^2 \div R^2 \times 100$	
T	**1.25 metres**
R	**1.8 metres**
T^2	**T x T** **1.25 x 1.25** **= 1.56**
R^2	**R x R** **1.8 x 1.8** **= 3.24**
therefore **DC % = $T^2 \div R^2 \times 100$**	
	1.56 ÷ 3.24 x 100 **= 48.1%** **(say 48%)**

Therefore, our Distribution Characteristic for the example system is 48 %

A DC value greater than 50% is acceptable. If the DC value is below 50%, there is room for improvement in the system. Failure to make improvements will mean some areas will not get enough water. If you increase irrigation time to compensate for this, you will over-water some parts, resulting in waterlogging and run-off, and increased pumping costs.

How long to irrigate

Using the MAR value and the RAW value for the crop on this soil, you may estimate how long you need to irrigate to ensure adequate wetting from this sprinkler.

Irrigation Time: Example

Irrigation time = RAW ÷ MAR	
RAW (from Table 1)	**15 mm**
MAR	**3.6 mm/hour**
Irrigation time =	**RAW ÷ MAR** **15 ÷ 3.6** = **4.2 hours**

How much of the crop area is wetted?

It is sometimes useful to know is how much of the total crop area is wetted by your irrigation system. The example below shows how to work this out.

	Example
Wetted area %	= **π x T^2 ÷ crop area × 100**
π (pi)	**3.14**
T^2	**T x T** 1.25 **x** 1.25 **=** 1.56
Crop area	**Tree Spacing x Row Spacing** 4 x 5 (From Table 1) = 20
	π x T^2 ÷ Crop area x 100 **3.14 x 1.56 ÷ 20 x 100** = **24.5 %**

A minimum of 25% wetted area is an acceptable percentage for most tree crops and soil types.

Measuring Flow Rate and Pressure

Measure the Flow Rate and Pressure of the sprinklers at the extremities of the block being irrigated (Figure 7). This will show any variability across the block.

The extremities of your system are usually the highest and lowest sprinklers, and the nearest and furthest sprinklers from the Valve. In other words, select the first and last sprinklers of the first and last laterals in the block. The selected sprinklers (circled) are then checked while the system is operating at its normal operating pressure.

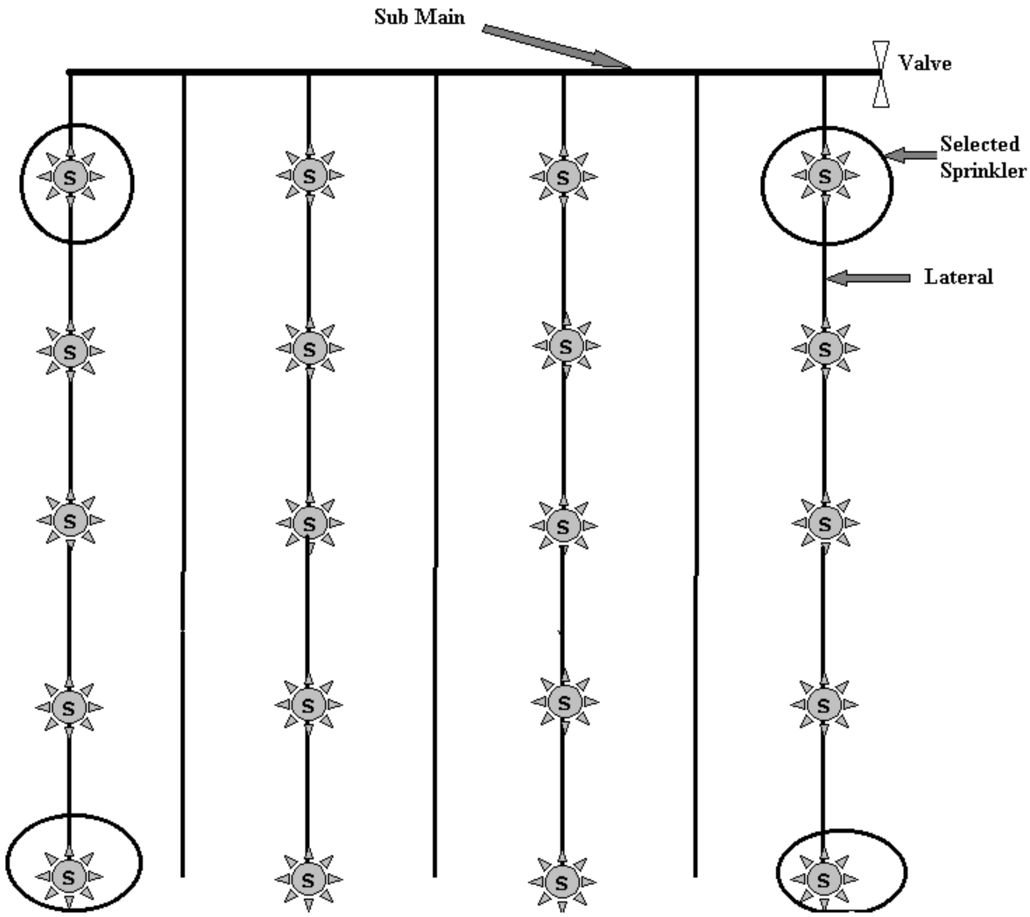


Figure 7: Field layout for measuring the Flow Rate and Pressure

Once the system has reached it's normal operating pressure, measure the Flow Rate. Place a length of flexible plastic tubing over the nozzle and direct the sprinkler discharge into a container for a minimum of 15 seconds. Transfer the water into a measuring cylinder and record the result in Table 5. Use the equations in the table to calculate your Flow Rate.

Measure the pressure by the placing the point of the Pitot tube into the sprinkler stream about 3 mm from the nozzle. Record the pressure in Table 5.

For a Tee piece or Schrader valve, pinch off the lead tubing and unscrew the sprinkler from the stand or stake. Screw in the tee piece or valve and replace the sprinkler on top of the fitting. Release the lead tube and allow the sprinkler to operate normally. Record the pressure in Table 5.

Table 5: Flow Rate and Pressure Field record sheet

Fill in details of lateral and sprinkler/emitter positions below

Flow rate = Output (litres) / Test Time (Minutes) x 60 (litres/hour)					
Sprinkler Position		Near	Far	High	Low
Sprinkler Output	A	182 mL*	190 mL*	159 mL*	195 mL*
* Convert mL into Litres by dividing by 1000	B	A / 1000 182 / 1000 = 0.3 seconds*	A / 1000 190 / 1000 = 0.19 Litre	A / 1000 159 / 1000 = 0.159 Litre	A / 1000 195 / 1000 = 0.195 Litre
Test Time	C	18 seconds*	20 seconds*	17 seconds*	20 seconds*
* Convert second into minute by dividing by 60	D	C / 60 18 / 60 = 0.3 minutes	C / 60 20 / 60 = 0.33 minutes	C / 60 17 / 60 = 0.28 minutes	C / 60 20 / 60 = 0.33 minutes
Flow Rate	E	B / D x 60 0.182 / 0.3 x 60 = 36.4 L/h	B / D x 60 0.19 / 0.33 x 60 = 34.5 L/h	B / D x 60 0.159 / 0.28 x 60 = 34.1 L/h	B / D x 60 0.195 / 0.33 x 60 = 35.4 L/h
Pressure (kPa)	F	250 kPa	260 kPa	240 kPa	270 kPa
Wetted diamter (metres)	G	4.0 metres	4.1 metres	3.9 metres	4.3 metres

For each outlet tested note down the brand/model, nozzle colour (size), nominal flow rate and spacings on your Data sheet (Table 1). If a large variation occurs between readings, you should conduct more checks to ensure your readings are true. If they are, you then need to identify why there is such a large variation in the system.

What do the pressure and flow readings tell us?

You have collected a series of figures on your record sheet. Using these figures, you can calculate the variations for the system. Too great a variation indicates that the system is not operating most effectively. Pressure variation is written as ± % indicating it is 'above' or 'below' the desired figure.

Calculating the pressure variation

Maximum Pressure from Table 5	**A**	270
Minimum Pressure from Table 5	**B**	240
Add the maximum and minimum pressures.	**C**	**maximum + minimum** **A + B** 270 + 240 = 510
Divide the result by two. This gives the midpoint pressure	**D**	**C ÷ 2** 510 ÷ 2 = 255 kPa
To calculate the pressure variation Take the midpoint from the maximum.	**E**	**maximum – midpoint** **A - D** 270 - 255 kPa = 15 kPa
Divide the difference by the midpoint.	**F**	**E ÷ D** 15 ÷ 255 = 0.0588
Multiply by 100 to get a percentage.		**F x 100** 0.0588 **x 100** = 5.88 **% (close enough to 6%)**
Pressure variation is:		= **± 6%**

In the above example the pressure variation is ± 6 %. A variation of more than ± 10% is unacceptable and indicates either a poor system design or that the valve unit has a problem.

(Note that pressure variation comparisons are only valid if all outlets/sprinklers are the same. If pressure compensators are used in your system, you will need to account for these.)

Calculating flow variation

Maximum Flow Rate (From Table 5)	**A**	36.4
Minimum Flow Rate (from Table 5)	**B**	34.1
Add the maximum and minimum flow	**C**	**Maximum + minimum** A + B 36.4 + 34.1 = 70.5
Divide the result by two to give the midpoint. Midpoint flow is	**D**	**C ÷ 2** 70.5 ÷ **2** = 35.25 **L/min**
Take the midpoint from the maximum	**E**	**Maximum – midpoint** **A - D** 36.4 - 35.25 = 1.15
Divide the difference by the midpoint	**F**	**E ÷ D** 1.15 ÷ 35.25 = 0.033
Multiply by 100 to get a percentage. Flow variation is written as a ± %.		**F x 100** 0.033 **x 100** = ± 3.3 %

Check these figures out against the yellow sprinklers in the appendices supplied with the pressure workshop notes.

How close was this set?

In a large block, you may wish to test more sprinklers. Similarly, if you find a large variation you should test some additional ones. You could select sprinklers in (say) laterals 5 and 10, or just at random across the block.

NB Volumes are in Litres and times in minutes. If you use other units, do not forget to convert them!

Note: If there are unusual conditions such as strong wind or a steep slope, use four rows of cans. Call these Row D and Row E.

Pump Unit Record sheet

Name	Date:	Test Block:

Pump	
Make:	
Model:	
Age: years	
Impeller size: mm	
Pump speed (RPM):	
Has the impeller been turned down or replaced?	If Yes, When?
Do you have a performance chart?	If No see your dealer!

Transmission			
Type (Please circle)	**Direct coupled**	**Belts and Pulleys**	**Gear driven**
Pump pulley (PCD):			
Prime mover pulley (PCD)			
Type of belt (circle)	**V Belt**	**Flat Belt**	**Other**
Number of belts			
Distance between pulleys		Metres	

Prime mover
Type:
Model:
Age: Years
Prime mover speed (RPM)

Suction	
Foot valve and strainer size:	mm
Suction Pipe diameter:	mm
Suction pipe Length:	metres
Type of Pipe:	
Static lift (water level to pump):	metres

Pump Unit Operation			
Friction loss for suction pipe:	1	metre (generally)	**A**

Pressure at discharge:	………….	kPa*	* *if not in kPa then convert*	**B**
Water Meter reading (start):	…………..		*Kilolitres or Megalitres?*	**C**
Water Meter reading (end):	…………..		*Kilolitres or Megalitres?*	**D**
Time at water meter reading (start):	……………		*Use 24 hour clock*	**E**
Time at water meter reading (end):	……………		*Use 24 hour clock*	**F**
Duration of pumping:	***Time at end reading - Time at start reading*** ***F - E*** **………. - ……….** **= ………… hours**			***G***

Maintenance
Previous service (Date):
Details of service:
Next service (Date):

Select your Type of meter and record your readings

Power Readings										
	Disc Meter	**1**	**2**	**3**	**Electronic meter**	**1**	**2**	**3**	**Fuel**	
H	r/kWh				Reading at start				Level at start	
J	Multiplier on meter				Reading at end				Level at end	
N	Number of disc revolutions				Multiplier (stated on bill)				Temperature	
T	Time for N (seconds)				Time between reading (seconds)				Oil Level (Dip stick)	
$	Price / kWhr				Price / kWhr				Price /litre of fuel	

Filter Losses		
Filter pressure Losses = Pressure at filter inlet - pressure at filter outlet		
Filter location:		
Pressure at filter inlet:		**PI**
Pressure at filter outlet		**PO**
Pressure Differential	= PI - PO = ………… - ………… = ………… kPa	
Normal allowance is about 70 kPa (7 metres)		

Pump Calculations

Pump Flow Rate		
Water Pumped	D - C ………… - ………… Select unit of Reading = ……………. KL or ……………. ML	**P**
Convert volume pumped into Litres	If your meter reads in Kilolitres P (KL) / 1000 ………… / ………… = ………….. Litres	
Convert volume pumped into Litres	If your meter reads in Megalitres P (ML) / 100000 ………… / ………… = ………….. Litres	**Q**
Flow Rate of pump	Volume pumped (litres Duration of Pumping (hours) / 3600 Q G / 3600 …………… / …………… / …………… = …………… L/s	**R**

Identify the power course and complete the Power used sheet appropriate for your situation.

Power Used - Disc Meter	1	2	3	
	N x 3600 x J ………. x 3600 x ………. = ……………			**a**
	H x T ………. x ………. = ……………			**b**
Power used	a / b ………. / ………. = …………… kW			**c**
Add the power used	Meter 1 c + Meter 2 c + Meter 3 c = ……………			**kW**
Pump Calibration Power per megalitre = Power used (kW) / Flow Rate (L/s) / 0.0036				
	kW / R / 0.0036 ………. x ………. x 0.0036 = …………… kWh/ML			**CAL**
Cost	CAL x $ ………. x ………. = ……………			

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease flow rate or increase the power used to pump each mega litre of water. Clogged filters may be indicated by an increase in the pressure differential.

<table>
<tr><th>Power Used - Electronic</th><th>1</th><th>2</th><th>3</th><th></th></tr>
<tr><td></td><td>N x 3600 x J
………. x 3600 x ……….
= ……………</td><td></td><td></td><td>a</td></tr>
<tr><td colspan="5">Power Used = Difference in meter readings x 3600 x Multiplier / Time</td></tr>
<tr><td>Power used</td><td>a / b
………. / ……….
= …………… kW</td><td></td><td></td><td>c</td></tr>
<tr><td colspan="4">Add all the Power used together =</td><td>kW</td></tr>
<tr><td colspan="4">Calibration = Power used (kW) / Flow Rate (L/s) / 0.0036</td><td></td></tr>
<tr><td></td><td colspan="3">kW / R / 0.0036
………. x ………. x 0.0036
= …………… kWh/ML</td><td>CAL</td></tr>
<tr><td colspan="4">Cost = CAL x $</td><td></td></tr>
<tr><td></td><td colspan="3">………. x ……….
= ……………</td><td></td></tr>
</table>

Note: Another method to estimate costs per ML - Read water meter reading when council reads your electricity meter and then compare the electricity bill to the water used (Most recent water reading minus previous water reading).

Power bill / Water Use

For example Electricity bill = \$5400, water usage = 270 ML

= \$5400 / 270

= \$20 per ML

Power Used - Diesel		
Fuel used	At start - at finish H - J …….. - ………… = ………… Litres	**b**
Pump Duration	………. hours	
Pump fuel use	b ÷ G …….. ÷ ……….. = ………….. Litres of fuel per hour	**c**
Time to pump one megalitre	1000000 ÷ Flow Rate (L/s) ÷ 3600 1000000 ÷ R ÷ 3600 = 1000000 ÷ …….. ÷ 3600 = ………. hours	**d**
Fuel used to pump one ML	c x d …….. x ………..	**e**
Running Cost	e x $ ………. x ………… = …………..	
To estimate the kW of a diesel powered unit we may use the following equation Volume of fuel per hour ÷ 0.34		
	c ÷ 0.34 **= ………….. kW**	

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease Flow rate or increase the power used to pump each megalitre of water. Clogged filters may be indicated by an increase in the pressure differential.

Pumping Unit Efficiency

When you check your pump you should also look at the suction. That is, are there any air pockets or leaks? Recording equipment such as gauges and meters should also be regularly serviced and calibrated. Gauges should be easily removable so that they may be stored away from the vibrations of the pump.

Pump efficiency is difficult to determine and will vary between pumps. Power usage in diesel pumps cannot be easily measured. However using the data you have collected you may be able to estimate the efficiency of electric pumping units. By collecting further data on your pump, a pump expert may be able to determine the efficiency of your pump and whether it is suitable for the duty of your system.

Efficiency of Pumping Unit = Flow rate x head (m) ÷ power

Pumping Unit Efficiency		
Suction Static lift	metres	**S**
Friction Loss	Assume 1 metre	**A**
Pressure at Discharge	kPa	**B**
Convert kPa Pressure into Head (metres)	kPa pressure x 0.102 B x 0.102 = ……… metres	**PM**
Head	PM + S + A ………….. + ………….. + 1 = ………… metres	**Head**
Flow rate	…………. L/s	**R**
Power		**kW**
Efficiency = Flow rate x Head (m) ÷ power = R x Head ÷ kW		
	= ……… x ………… ÷ ……… = ………….. %	

Note: Dirty filter will drastically affect operation pressure of emitter.

Compare your findings on the pump curve for your pump

Irrigation System Evaluation Activity

Complete the exercises outline in the following blank Evaluation Sheets

EVALUATION SHEETS

Data sheet

Name:	Date:
Location:	
Crop:	
Soil type/texture:	
Effective root depth:	metre
RAW for crop:	mm
Sprinkler make:	
Sprinkler model:	
Nozzle size:	mm
Nominal Flow	at kPa
Lateral spacing:	metre
Tree spacing	metre
Row spacing	metre
Sprinkler distance to tree	metre
Sprinkler height:	mm
Sprinkler wetted diameter:	metre
Sprinkler spacing in row:	metre
Usual length of irrigation:	hours
Usual frequency of irrigation	days
Catch Can Diameter	mm
Catch Can Spacing	

Maintenance Record	Maintenance Schedule

Catch can record sheet

Catch can record sheet- (example data)

Name: Date: Crop:

	A	B	C	D	E	F	G	H	K	N
Catch can	Distance from sprinkler (metres)	2 Row Test		4 Row Test		**Totals for each position (**mL**)**	**Totals converted per hour (**mL/h**)**	**Average Volume (**mL/h**)**	**Depth of application (**mm**)**	**Area Adjusted Depth**
		Test Radial 1	Test Radial 2	Test Radial 3	Test Radial 4	**B + C + D + E**	**F ÷ Test time (min) x 60**	**G ÷ number of test rows**	**H ÷ Can conversion** (Table 2)	**Distance from Sprinkler** (metres) **x Depth of application** (mm) **A × K**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
									Total	

Start time : __.__ **Finish time:** __.__ **Length of test:** **60 minutes**

Completing the catch can record sheet

Step 1 Record your Catch Can spacing **[A]**

Step 2 Record the volume caught in each Catch Can

Step 3 Complete the totals column **[F]** of the catch can record sheet by adding the Catch Can volumes at each position from the test rows. Convert the totals to a per-hour rate in column **[G]**

Step 4 Calculate the average volume **[H]** collected at each position by dividing the Converted total volume of the catch cans **[G]** by the number of test rows.

Step 5 Divide the average volume **[H]** by the catch can Conversion figure from Table 2. This will convert your volume into depth (mm) **[K]**

Step 6 You now need to multiply the catch can distance from the sprinkler **[A]** by the depth of application **[K]** to obtain the Area adjusted values for the final column [N]. We need to adjust the depth of application to account for the circular wetting pattern and non-overlap of the emitters.

Step 7 Add up all of the Area adjusted values figures in the final column to obtain **[P].**

With this figure we are able to calculate the MAR and DC for our irrigation system.

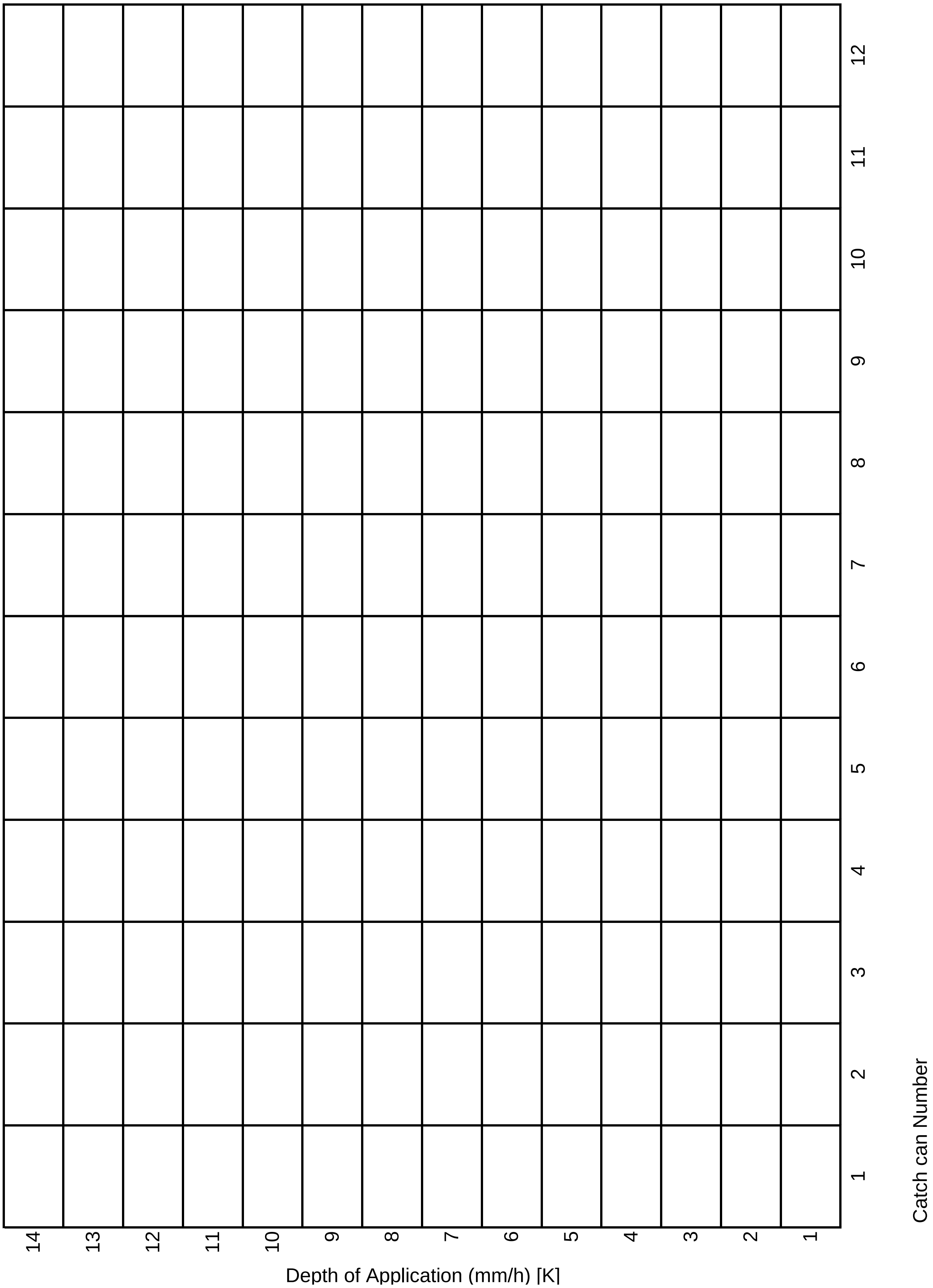
Graphing your data

To calculate distribution of the sprinkler coverage we now need to graph the sprinkler output. Our example irrigation system has been plotted below in Figure 5.

Step 1 Take the readings of application depth **[K]** from your data conversion sheet and on a blank graph; mark the output for each position moving away from the sprinkler.

Step 2 Join the points to form an application curve. **Later**, after you have done the next section, you will add the horizontal MAR line to the chart and mark position [T].

Figure 5: Depth of Irrigation



Calculating MAR

Step 1 Note the radius of throw either by looking at the catch can record sheet, and noting where the coverage cuts off. Alternatively, you may note the point **[R]** on the graph you plotted.

Step 2 Take **[P]** from the data conversion sheet and divide it by **[R] twice.**

Call the result **[S].**

[S] = [P] ÷ [R] ÷ [R]

Step 3 If the catch cans are spaced at 0.5 m intervals, then [S] is the MAR.

If the catch cans are **not** spaced at 0.5 m, then multiply [S] by twice the catch can spacing to obtain the MAR (see the example below).

Table 3: Calculating MAR - Example

[S] = [P] ÷ [R] ÷ [R]	
[P]	…………
[R]	………….. **metres**
[S] * * If catch cans are spaced at 0.5 metres apart **[S] = MAR**	**[P] ÷ [R] ÷ [R]** = ..…….. ÷ ……… ÷ ……… = ………. **mm/h**
If catch cans are **not** spaced at 0.5 m apart:	
MAR =	**S x 2 x catch can spacing (m)** **……. x 2 x …………** **= ………….. mm / h**

Calculating DC (Distribution Characteristic)

Step 1 On your sprinkler graph (figure 5), draw a horizontal line across the graph at the MAR value you calculated in Table 3.

Step 2 Mark the point where this line crosses your application curve.

Step 3 Read down from this intersection point to the catch can position axis. The distance in metres from the sprinkler to this catch can position will give us the **[T]** figure needed for the calculation of the Distribution Characteristic.

Step 4 Using the values of **[R]** and **[T]** you can now determine the DC using Table 4.

Now that we have our [R] and [T] figures we can use Table 4 to calculate our Distribution Characteristic

Table 4: Calculating Distribution Characteristic

DC % = T^2 ÷ R^2 x 100	
T	**…………. metres**
R	**………… metres**
T^2	**T x T** **……….. x ………..** **= …………**
R2	**R X R** **……….. x ……….** **= ……….**
DC % = T^2 ÷ R^2 x 100	
	………. ÷ ……… x 100 **= ………..%**

How long to irrigate?

Irrigation Time:

RAW (from Table 1)	**…………mm**
MAR	**………… mm/hour**
Irrigation time =	**RAW ÷ MAR**
	……… ÷ ……….. **= ………… hours**

How much of the crop area is wetted?

It is sometimes useful to know is how much of the total crop area is wetted by your irrigation system. The example below shows how to work this out.

Wetted area %	= **π x T^2 ÷ Crop Area × 100**
π	**3.14**
T^2 (from Table 4)	T x T ……………… **x** ……………… ………………
Crop Area	**Tree spacing x Row spacing (Table 1)** ……………… **x** ……………… ………………
	π x T^2 ÷ Crop Area x 100 **3.14 x ……... ÷ ……….. x 100** = ……… **%**

A minimum of 25% wetted area is an acceptable percentage for most tree crops and soil types.

Table 5: Flow Rate and Pressure Field record sheet

Fill in details of lateral and sprinkler/emitter positions below

Flow rate = Output (litres) / Test Time (Minutes) x 60 (litres/hour)					
Sprinkler Position		Near	Far	High	Low
Sprinkler Output	**A**	……... mL*	……... mL*	……... mL*	……... mL*
* Convert mL into Litres by dividing by 1000	**B**	**A / 1000** **……... / 1000** **= ………... Litre**	**A / 1000** **……... / 1000** **= ………... Litre**	**A / 1000** **……... / 1000** **= ………... Litre**	**A / 1000** **……... / 1000** **= ………... Litre**
Test Time	**C**	**……... seconds***	**……... seconds***	**……... seconds***	**……... seconds***
* Convert second into minute by dividing by 60	**D**	**C / 60** **……... / 60** **= ………... minutes**	**C / 60** **……... / 60** **= ………... minutes**	**C / 60** **……... / 60** **= ………... minutes**	**C / 60** **……... / 60** **= ………... minutes**
Flow Rate	**E**	**B / D x 60** **……... / ……... x 60** **= ……... L/h**	**B / D x 60** **……... / ……... x 60** **= ……... L/h**	**B / D x 60** **……... / ……... x 60** **= ……... L/h**	**B / D x 60** **……... / ……... x 60** **= ……... L/h**
Pressure (kPa)	**F**	**……... kPa**	**……... kPa**	**……... kPa**	**……... kPa**
Wetted diamter (metres)	**G**	**……... metres**	**……... metres**	**……... metres**	**……... metres**

Calculating the pressure variation

Maximum Pressure from Table 5	**A**	…………
Minimum Pressure from Table 5	**B**	………….
Add the maximum and minimum pressures.	**C**	**maximum + minimum** **A + B** ………. + ………… = **……….**
Divide the result by two. This gives the midpoint pressure	**D**	**C ÷ 2** ………. ÷ **2** ………… **kPa**
To calculate the pressure variation Take the midpoint from the maximum.	**E**	**maximum – midpoint** **A - D** ………. – ………. = **………. kPa**
Divide the difference by the midpoint.	**F**	**E ÷ D** **……….** ÷ **……….** = **……………..**
Multiply by 100 to get a percentage.		**F x 100** ………… **x 100** = **…………%**
Pressure variation is:		= ± **…………%**

Calculating flow variation

Maximum Flow Rate (From Table 5)	**A**	………..
Minimum Flow Rate (from Table 5)	**B**	………….
Add the maximum and minimum flow	**C**	**Maximum + minimum** A + B ……….. + ……….. = …………..
Divide the result by two to give the midpoint. Midpoint flow is	**D**	**C ÷ 2** ………… ÷ **2** = ………… **L/min**
Take the midpoint from the maximum	**E**	**Maximum – midpoint** **A - D** ………. – ……….. = …………
Divide the difference by the midpoint	**F**	**E ÷ D** …………. ÷ ………. = …………..
Multiply by 100 to get a percentage.		**F x 100** …………. **x 100**
Flow variation is written as a ± %.		= ± ………… **%**

Pump Unit Record sheet

Name	Date:	Test Block:

Pump	
Make:	
Model:	
Age: years	
Impeller size: mm	
Pump speed (RPM):	
Has the impeller been turned down or replaced?	If Yes, When?
Do you have a performance chart?	If No see your dealer!

Transmission			
Type (Please circle)	**Direct coupled**	**Belts and Pulleys**	**Gear driven**
Pump pulley (PCD):			
Prime mover pulley (PCD)			
Type of belt (circle)	**V Belt**	**Flat Belt**	**Other**
Number of belts			
Distance between pulleys	Metres		

Prime mover
Type:
Model:
Age: Years
Prime mover speed (RPM)

Suction	
Foot valve and strainer size:	mm
Suction Pipe diameter:	mm
Suction pipe Length:	metres
Type of Pipe:	
Static lift (water level to pump):	metres

Pump Unit Operation			
Friction loss for suction pipe:	1	metre (generally)	**A**

Pressure at discharge: ………… kPa* * *if not in kPa then convert*		**B**
Water Meter reading (start): ………….. *Kilolitres or Megalitres?*		**C**
Water Meter reading (end): ………….. *Kilolitres or Megalitres?*		**D**
Time at water meter reading (start): …………… *Use 24 hour clock*		**E**
Time at water meter reading (end): …………… *Use 24 hour clock*		**F**
Duration of pumping:	***Time at end reading - Time at start reading*** ***F - E*** **………. - ……….** **= ………… hours**	**G**

Maintenance
Previous service (Date):
Details of service:
Next service (Date):

Select your Type of meter and record your readings

Power Readings										
	Disc Meter	**1**	**2**	**3**	**Electronic meter**	**1**	**2**	**3**	**Fuel**	
H	r/kWh				Reading at start				Level at start	
J	Multiplier on meter				Reading at end				Level at end	
N	Number of disc revolutions				Multiplier (stated on bill)				Temperature	
T	Time for N (seconds)				Time between reading (seconds)				Oil Level (Dip stick)	
$	Price / kWhr				Price / kWhr				Price /litre of fuel	

Filter Losses	
Filter pressure Losses = Pressure at filter inlet - pressure at filter outlet	
Filter location:	
Pressure at filter inlet:	**PI**
Pressure at filter outlet	**PO**
Pressure Differential	= PI - PO = ………… - ………… = ………… kPa
Normal allowance is about 70 kPa (7 metres)	

Pump Calculations

Pump Flow Rate		
Water Pumped	D - C Select unit of Reading ………… - …………. = …………… KL or ……………. ML	**P**
Convert volume pumped into Litres	If your meter reads in Kilolitres P (KL) / 1000 ………… / ………… = ………….. Litres	
Convert volume pumped into Litres	If your meter reads in Megalitres P (ML) / 100000 ………… / ………… = ………….. Litres	**Q**
Flow Rate of pump	Volume pumped (litres Duration of Pumping (hours) / 3600 Q G / 3600 …………… / …………… / …………… = …………… L/s	**R**

Identify the power course and complete the Power used sheet appropriate for your situation.

Power Used - Disc Meter	1	2	3	
	N x 3600 x J ………. x 3600 x ………. = ……………			a
	H x T ………. x ………. = ……………			b
Power used	a / b ………. / ………. = …………… kW			c
Add the power used	Meter 1 c + Meter 2 c + Meter 3 c = ……………			kW
Pump Calibration Power per megalitre = Power used (kW) / Flow Rate (L/s) / 0.0036				
	kW / R / 0.0036 ………. x ………. x 0.0036 = …………… kWh/ML			CAL
Cost	CAL x $ ………. x ………. = ……………			

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease flow rate or increase the power used to pump each mega litre of water. Clogged filters may be indicated by an increase in the pressure differential.

Power Used - Electronic	**1**	**2**	**3**	
	N x 3600 x J ……… x 3600 x ……… = ……………			**a**
Power Used = Difference in meter readings x 3600 x Multiplier / Time				
Power used	a / b ……… / ……… = …………… kW			**c**
Add all the Power used together =				**kW**
Calibration = Power used (kW) / Flow Rate (L/s) / 0.0036				
	kW / R / 0.0036 ……… x ……… x 0.0036 = …………… kWh/ML			**CAL**
Cost = CAL x $				
	……… x ……… = ……………			

Note: Another method to estimate costs per ML - Read water meter reading when council reads your electricity meter and then compare the electricity bill to the water used (Most recent water reading minus previous water reading).

Power bill / Water Use

For example Electricity bill = $5400, water usage = 270 ML

= $5400 / 270

= $20 per ML

Power Used - Diesel		
Fuel used	At start - at finish H - J …….. - …………. = ………… Litres	**b**
Pump Duration	………. hours	
Pump fuel use	b ÷ G …….. ÷ ……….. = ………….. Litres of fuel per hour	**c**
Time to pump one megalitre	1000000 ÷ Flow Rate (L/s) ÷ 3600 1000000 ÷ R ÷ 3600 = 1000000 ÷ …….. ÷ 3600 = ………. hours	**d**
Fuel used to pump one ML	c x d …….. x ………..	**e**
Running Cost	e x \$ ………. x ………… = …………..	
To estimate the kW of a diesel powered unit we may use the following equation Volume of fuel per hour ÷ 0.34		
	c ÷ 0.34 **= ………….. kW**	

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease Flow rate or increase the power used to pump each megalitre of water. Clogged filters may be indicated by an increase in the pressure differential.

Pumping Unit Efficiency

When you check your pump you should also look at the suction. That is, are there any air pockets or leaks? Recording equipment such as gauges and meters should also be regularly serviced and calibrated. Gauges should be easily removable so that they may be stored away from the vibrations of the pump.

Pump efficiency is difficult to determine and will vary between pumps. Power usage in diesel pumps cannot be easily measured. However using the data you have collected you may be able to estimate the efficiency of electric pumping units. By collecting further data on your pump, a pump expert may be able to determine the efficiency of your pump and whether it is suitable for the duty of your system.

Efficiency of Pumping Unit =Flow rate x head (m) ÷ power

Pumping Unit Efficiency		
Suction Static lift	metres	**S**
Friction Loss	Assume 1 metre	**A**
Pressure at Discharge	kPa	**B**
Convert kPa Pressure into Head (metres)	kPa pressure x 0.102 B x 0.102 = ………. metres	**PM**
Head	PM + S + A …………… + …………… + 1 = ………… metres	**Head**
Flow rate	…………. L/s	**R**
Power		**kW**
Efficiency = Flow rate x Head (m) ÷ power = R x Head ÷ kW		
	= ……… x ………… ÷ ……… = ………….. %	

Note: Dirty filter will drastically affect operation pressure of emitter.

Compare your findings on the pump curve for your pump

EVALUATION SHEETS

Data sheet

Name:	Date:
Location:	
Crop:	
Soil type/texture:	
Effective root depth:	metre
RAW for crop:	mm
Sprinkler make:	
Sprinkler model:	
Nozzle size:	mm
Nominal Flow	at kPa
Lateral spacing:	metre
Tree spacing	metre
Row spacing	metre
Sprinkler distance to tree	metre
Sprinkler height:	mm
Sprinkler wetted diameter:	metre
Sprinkler spacing in row:	metre
Usual length of irrigation:	hours
Usual frequency of irrigation	days
Catch Can Diameter	mm
Catch Can Spacing	

Maintenance Record	**Maintenance Schedule**

Catch can record sheet

Catch can record sheet- (example data)

Name:						Date:			Crop:	
	A	B	C	D	E	F	G	H	K	N
Catch can	Distance from sprinkler (metres)	2 Row Test		4 Row Test		**Totals for each position (**mL**)** **B + C + D + E**	**Totals converted per hour (**mL/h**)** **F ÷ Test time (min) x 60**	**Average Volume (**mL/h**)** **G ÷ number of test rows**	**Depth of application (**mm**)** **H ÷ Can conversion** (Table 2)	**Area Adjusted Depth** **Distance from Sprinkler** (metres) **x Depth of application** (mm) **A × K**
		Test Radial 1	Test Radial 2	Test Radial 3	Test Radial 4					
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
									Total	

Start time : __:__

Finish time: __:__

Length of test: 60 minutes

Completing the catch can record sheet

Step 8 Record your Catch Can spacing **[A]**

Step 9 Record the volume caught in each Catch Can

Step 10 Complete the totals column **[F]** of the catch can record sheet by adding the Catch Can volumes at each position from the test rows. Convert the totals to a per-hour rate in column **[G]**

Step 11 Calculate the average volume **[H]** collected at each position by dividing the Converted total volume of the catch cans **[G]** by the number of test rows.

Step 12 Divide the average volume **[H]** by the catch can Conversion figure from Table 2. This will convert your volume into depth (mm) **[K]**

Step 13 You now need to multiply the catch can distance from the sprinkler **[A]** by the depth of application **[K]** to obtain the Area adjusted values for the final column [N]. We need to adjust the depth of application to account for the circular wetting pattern and non-overlap of the emitters.

Step 14 Add up all of the Area adjusted values figures in the final column to obtain **[P].**

With this figure we are able to calculate the MAR and DC for our irrigation system.

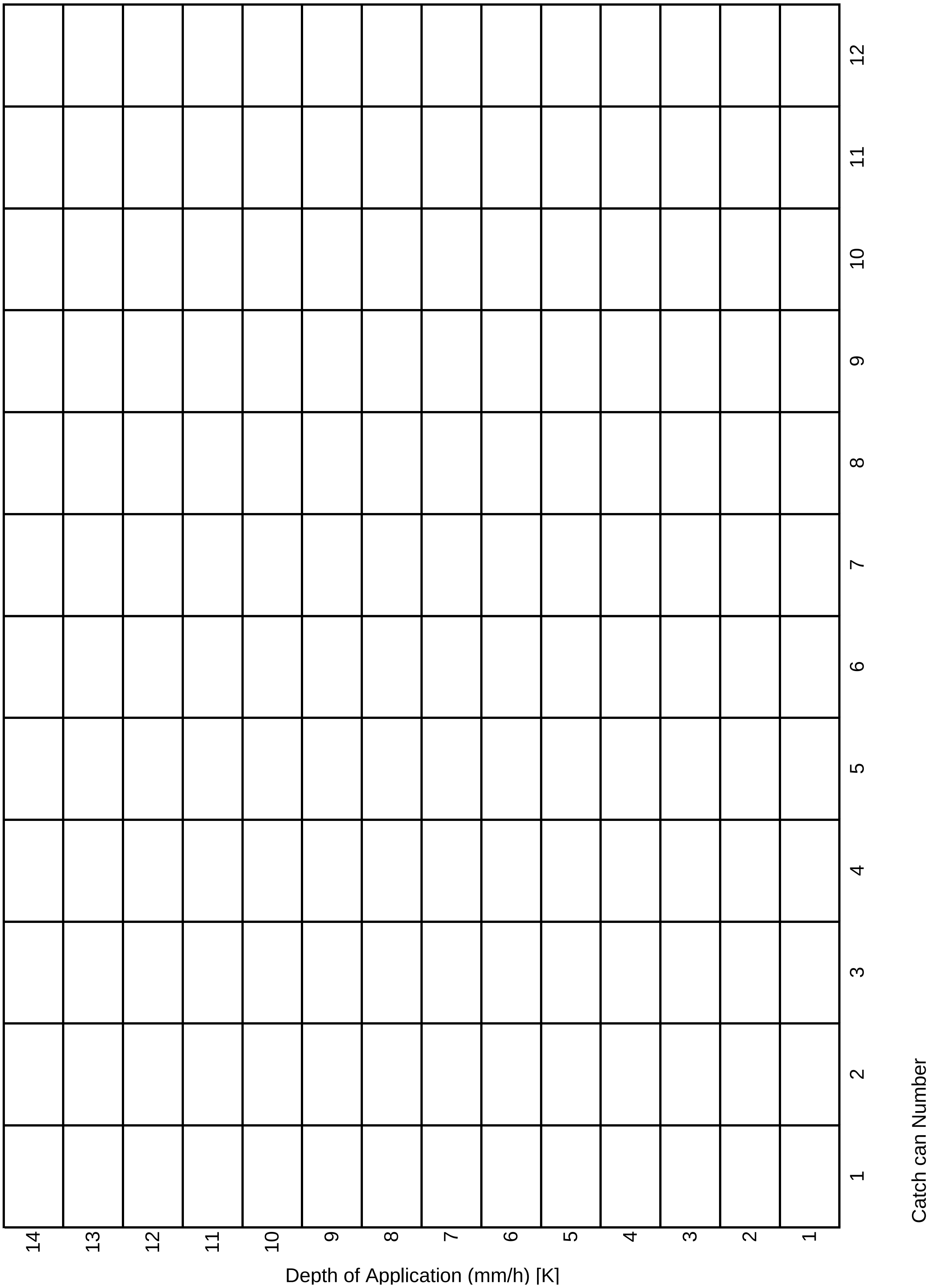
Graphing your data

To calculate distribution of the sprinkler coverage we now need to graph the sprinkler output. Our example irrigation system has been plotted below in Figure 5.

Step 3 Take the readings of application depth **[K]** from your data conversion sheet and on a blank graph, mark the output for each position moving away from the sprinkler.

Step 4 Join the points to form an application curve. **Later**, after you have done the next section, you will add the horizontal MAR line to the chart and mark position [T].

Figure 5: Depth of Irrigation



Calculating MAR

Step 4 Note the radius of throw either by looking at the catch can record sheet, and noting where the coverage cuts off. Alternatively, you may note the point **[R]** on the graph you plotted.

Step 5 Take **[P]** from the data conversion sheet and divide it by **[R] twice.**

Call the result **[S].**

$$[S] = [P] \div [R] \div [R]$$

Step 6 If the catch cans are spaced at 0.5 m intervals, then [S] is the MAR.

If the catch cans are **not** spaced at 0.5 m, then multiply [S] by twice the catch can spacing to obtain the MAR (see the example below).

Table 3: Calculating MAR - Example

[S] = [P] ÷ [R] ÷ [R]	
[P]	…………
[R]	………….. **metres**
[S] * * If catch cans are spaced at 0.5 metres apart **[S] = MAR**	**[P] ÷ [R] ÷ [R]** = **..…….. ÷ ……… ÷ ………** = **………. mm/h**
If catch cans are **not** spaced at 0.5 m apart:	
MAR =	**S x 2 x catch can spacing (m)** **……. x 2 x …………** = **………….. mm / h**

Calculating DC (Distribution Characteristic)

Step 5 On your sprinkler graph (figure 5), draw a horizontal line across the graph at the MAR value you calculated in Table 3.

Step 6 Mark the point where this line crosses your application curve.

Step 7 Read down from this intersection point to the catch can position axis. The distance in metres from the sprinkler to this catch can position will give us the **[T]** figure needed for the calculation of the Distribution Characteristic.

Step 8 Using the values of **[R]** and **[T]** you can now determine the DC using Table 4.

Now that we have our [R] and [T] figures we can use Table 4 to calculate our Distribution Characteristic

Table 4: Calculating Distribution Characteristic

DC % = T^2 ÷ R^2 x 100	
T	**…………. metres**
R	**………… metres**
T^2	**T x T** **……….. x ………..** **= …………**
R2	**R X R** **……….. x ……….** **= ……….**
DC % = T^2 ÷ R^2 x 100	
	………. ÷ ……… x 100 **= ………..%**

How long to irrigate?

Irrigation Time:

RAW (from Table 1)	**…………mm**
MAR	**………… mm/hour**
Irrigation time =	**RAW ÷ MAR**
	……… ÷ ………. **= ………… hours**

How much of the crop area is wetted?

It is sometimes useful to know is how much of the total crop area is wetted by your irrigation system. The example below shows how to work this out.

Wetted area %	= π **x T^2 ÷ Crop Area × 100**
π	**3.14**
T^2 (from Table 4)	T x T **……………… x ………………** **………………**
Crop Area	**Tree spacing x Row spacing (Table 1)** **……………… x ………………** **………………**
	π x T^2 ÷ Crop Area x 100 **3.14 x …….. ÷ ………. x 100** = ……… **%**

A minimum of 25% wetted area is an acceptable percentage for most tree crops and soil types.

Table 5: Flow Rate and Pressure Field record sheet

Fill in details of lateral and sprinkler/emitter positions below

Flow rate = Output (litres) / Test Time (Minutes) x 60 (litres/hour)					
Sprinkler Position		Near	Far	High	Low
Sprinkler Output	**A**	…….. mL*	…….. mL*	…….. mL*	…….. mL*
* Convert mL into Litres by dividing by 1000	**B**	**A / 1000** **…….. / 1000** **= ……….. Litre**	**A / 1000** **…….. / 1000** **= ……….. Litre**	**A / 1000** **…….. / 1000** **= ……….. Litre**	**A / 1000** **…….. / 1000** **= ……….. Litre**
Test Time	**C**	**…….. seconds***	**…….. seconds***	**…….. seconds***	**…….. seconds***
* Convert second into minute by dividing by 60	**D**	**C / 60** **…….. / 60** **= ……….. minutes**	**C / 60** **…….. / 60** **= ……….. minutes**	**C / 60** **…….. / 60** **= ……….. minutes**	**C / 60** **…….. / 60** **= ……….. minutes**
Flow Rate	**E**	**B / D x 60** **…….. / …….. x 60** **= …….. L/h**	**B / D x 60** **…….. / …….. x 60** **= …….. L/h**	**B / D x 60** **…….. / …….. x 60** **= …….. L/h**	**B / D x 60** **…….. / …….. x 60** **= …….. L/h**
Pressure (kPa)	**F**	**…….. kPa**	**…….. kPa**	**…….. kPa**	**…….. kPa**
Wetted diamter (metres)	**G**	**…….. metres**	**…….. metres**	**…….. metres**	**…….. metres**

Calculating the pressure variation

Maximum Pressure from Table 5	**A**	…………
Minimum Pressure from Table 5	**B**	………….
Add the maximum and minimum pressures.	**C**	**maximum + minimum** **A + B** ………. + ………… = ………..
Divide the result by two. This gives the midpoint pressure	**D**	**C ÷ 2** ………. ÷ **2** ………… **kPa**
To calculate the pressure variation Take the midpoint from the maximum.	**E**	**maximum – midpoint** **A - D** ………. – ……….. = ……….. **kPa**
Divide the difference by the midpoint.	**F**	**E ÷ D** ……….. ÷ ……….. = ……………..
Multiply by 100 to get a percentage.		**F x 100** ………… **x 100** = …………%
Pressure variation is:		= ± …………%

Calculating flow variation

Maximum Flow Rate (From Table 5)	**A**	………..
Minimum Flow Rate (from Table 5)	**B**	………….
Add the maximum and minimum flow	**C**	**Maximum + minimum** A + B **……….. + ………..** **= …………..**
Divide the result by two to give the midpoint. Midpoint flow is	**D**	**C ÷ 2** **………… ÷ 2** **= ………… L/min**
Take the midpoint from the maximum	**E**	**Maximum – midpoint** **A - D** **………. – ………..** **= …………**
Divide the difference by the midpoint	**F**	**E ÷ D** **…………. ÷ ……….** **= …………..**
Multiply by 100 to get a percentage.		**F x 100** **…………. x 100**
Flow variation is written as a ± %.		**= ± ………… %**

Pump Unit Record sheet

Name	Date:	Test Block:

Pump	
Make:	
Model:	
Age: years	
Impeller size: mm	
Pump speed (RPM):	
Has the impeller been turned down or replaced?	If Yes, When?
Do you have a performance chart?	If No see your dealer!

Transmission			
Type (Please circle)	**Direct coupled**	**Belts and Pulleys**	**Gear driven**
Pump pulley (PCD):			
Prime mover pulley (PCD)			
Type of belt (circle)	**V Belt**	**Flat Belt**	**Other**
Number of belts			
Distance between pulleys	Metres		

Prime mover	
Type:	
Model:	
Age:	Years
Prime mover speed (RPM)	

Suction	
Foot valve and strainer size:	mm
Suction Pipe diameter:	mm
Suction pipe Length:	metres
Type of Pipe:	
Static lift (water level to pump):	metres

Pump Unit Operation			
Friction loss for suction pipe:	1	metre (generally)	**A**

Pressure at discharge: …………. kPa* ** if not in kPa then convert*		**B**
Water Meter reading (start): ………….. *Kilolitres or Megalitres?*		**C**
Water Meter reading (end): ………….. *Kilolitres or Megalitres?*		**D**
Time at water meter reading (start): …………… *Use 24 hour clock*		**E**
Time at water meter reading (end): …………… *Use 24 hour clock*		**F**
Duration of pumping:	***Time at end reading - Time at start reading*** ***F - E*** **………. - ……….** **= ………… hours**	***G***

Maintenance
Previous service (Date):
Details of service:
Next service (Date):

Select your Type of meter and record your readings

Power Readings										
	Disc Meter	**1**	**2**	**3**	**Electronic meter**	**1**	**2**	**3**	**Fuel**	
H	r/kWh				Reading at start				Level at start	
J	Multiplier on meter				Reading at end				Level at end	
N	Number of disc revolutions				Multiplier (stated on bill)				Temperature	
T	Time for N (seconds)				Time between reading (seconds)				Oil Level (Dip stick)	
$	Price / kWhr				Price / kWhr				Price /litre of fuel	

Filter Losses		
Filter pressure Losses = Pressure at filter inlet - pressure at filter outlet		
Filter location:		
Pressure at filter inlet:		**PI**
Pressure at filter outlet		**PO**
Pressure Differential	= PI - PO = ………… - ………… = ………… kPa	
Normal allowance is about 70 kPa (7 metres)		

Pump Calculations

Pump Flow Rate		
Water Pumped	D - C ………… - …………. = …………… KL or …………… ML Select unit of Reading	**P**
Convert volume pumped into Litres	If your meter reads in Kilolitres P (KL) / 1000 ………… / ………… = ………….. Litres	
Convert volume pumped into Litres	If your meter reads in Megalitres P (ML) / 100000 ………… / ………… = ………….. Litres	**Q**
Flow Rate of pump	Volume pumped (litres Duration of Pumping (hours) / 3600 Q G / 3600 …………… / …………… / …………… = …………… L/s	**R**

Identify the power course and complete the Power used sheet appropriate for your situation.

Power Used - Disc Meter	1	2	3	
	N x 3600 x J ………. x 3600 x ………. = ……………			**a**
	H x T ………. x ………. = ……………			**b**
Power used	a / b ………. / ………. = …………… kW			**c**
Add the power used	Meter 1 c + Meter 2 c + Meter 3 c = ……………			**kW**
Pump Calibration Power per megalitre = Power used (kW) / Flow Rate (L/s) / 0.0036				
	kW / R / 0.0036 ………. x ………. x 0.0036 = …………… kWh/ML			**CAL**
Cost	CAL x $ ………. x ………. = ……………			

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease flow rate or increase the power used to pump each mega litre of water. Clogged filters may be indicated by an increase in the pressure differential.

Power Used - Electronic	**1**	**2**	**3**	
	N x 3600 x J ………. x 3600 x ………. = ……………			**a**
Power Used = Difference in meter readings x 3600 x Multiplier / Time				
Power used	a / b ………. / ………. = …………… kW			**c**
Add all the Power used together =				**kW**
Calibration = Power used (kW) / Flow Rate (L/s) / 0.0036				
	kW / R / 0.0036 ………. x ………. x 0.0036 = …………… kWh/ML			**CAL**
Cost = CAL x $				
	………. x ………. = ……………			

Note: Another method to estimate costs per ML - Read water meter reading when council reads your electricity meter and then compare the electricity bill to the water used (Most recent water reading minus previous water reading).

Power bill / Water Use

For example Electricity bill = $5400, water usage = 270 ML

= $5400 / 270

= $20 per ML

Power Used - Diesel		
Fuel used	At start - at finish H - J …….. - …………. = ………… Litres	**b**
Pump Duration	………. hours	
Pump fuel use	b ÷ G …….. ÷ ……….. = ………….. Litres of fuel per hour	**c**
Time to pump one megalitre	1000000 ÷ Flow Rate (L/s) ÷ 3600 1000000 ÷ R ÷ 3600 = 1000000 ÷ …….. ÷ 3600 = ………. hours	**d**
Fuel used to pump one ML	c x d …….. x ………..	**e**
Running Cost	e x $ ………. x ………… = …………..	
To estimate the kW of a diesel powered unit we may use the following equation Volume of fuel per hour ÷ 0.34		
	c ÷ 0.34 **= ………….. kW**	

Compare your findings to your previous records. Variation in your findings to previous records may indicate changes in your system and its efficiency. Damaged or worn impellers may decrease Flow rate or increase the power used to pump each megalitre of water. Clogged filters may be indicated by an increase in the pressure differential.

Pumping Unit Efficiency

When you check your pump you should also look at the suction. That is, are there any air pockets or leaks? Recording equipment such as gauges and meters should also be regularly serviced and calibrated. Gauges should be easily removable so that they may be stored away from the vibrations of the pump.

Pump efficiency is difficult to determine and will vary between pumps. Power usage in diesel pumps cannot be easily measured. However using the data you have collected you may be able to estimate the efficiency of electric pumping units. By collecting further data on your pump, a pump expert may be able to determine the efficiency of your pump and whether it is suitable for the duty of your system.

Efficiency of Pumping Unit =Flow rate x head (m) ÷ power

Pumping Unit Efficiency		
Suction Static lift	metres	**S**
Friction Loss	Assume 1 metre	**A**
Pressure at Discharge	kPa	**B**
Convert kPa Pressure into Head (metres)	kPa pressure x 0.102 B x 0.102 = ……… metres	**PM**
Head	PM + S + A …………… + …………… + 1 = ………… metres	**Head**
Flow rate	…………. L/s	**R**
Power		**kW**
Efficiency = Flow rate x Head (m) ÷ power = R x Head ÷ kW		
	= ……… x ………… ÷ ……… = ………….. %	

Note: Dirty filter will drastically affect operation pressure of emitter.

Compare your findings on the pump curve for your pump.