Irrigation Efficiency

Principles to Practice

Evaluating your pressurised system

System 5

Fixed under-canopy micro

System 6

Fixed overhead, solid set

Bike shift

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.

CONTENTS

AIM

To assess your irrigation system you need to determine the rate that water is being applied, and how uniformly that water is being distributed. To check these you need to know the MAR, the DU, and the pressures and flows within your system.

These worksheets outline the equipment and procedures needed for you to evaluate fixed overhead, solid set and bike shift and fixed under-canopy micro irrigation systems.

SYSTEM OVERVIEW

Fixed overhead

Fixed overhead systems are used for permanent horticultural plantings, like orchards, and in certain circumstances, effluent irrigation of pastures.

Fixed overhead systems are 'permanent' irrigation systems. Like most pressure irrigation systems, they rely on a pump to deliver water to the irrigation area via a permanent, buried mainline. The mainline is usually a plastic material like PVC.

The irrigation area is divided into a number of blocks. A sub main (one for each block) runs off the mainline and serves that block. Sub mains are permanent (buried) and are usually a plastic material like PVC or polythene. From the sub main, water reaches the crop though a permanent (generally buried) grid of laterals fitted with sprinklers on riser pipes. Laterals are usually a plastic material like PVC or polythene.

In orchards, the sprinklers are on riser pipes that extend above the tree canopy. Riser pipes are usually of small diameter (15 – 25 mm) PVC, polythene or galvanised wrought iron pipes. In effluent systems the 1–1.5 m high risers are normally galvanised wrought iron pipe braced to prevent damage from grazing stock.

Fixed overhead sprinklers are generally 'knocker' type and provide from 5 to 20 mm/h and operate between 200 and 350 kPa. They are normally spaced on a rectangular or square grid up to about 20 x 20 metres, though triangular spacings are sometimes used.

Pros of fixed overhead

- Low (or no) labour requirement.
- Suited to automation.
- Frost control possible.
- Low maintenance.

Cons of fixed overhead

- High capital cost per hectare.
- Wetting patterns liable to distortion in windy conditions.
- Difficult to maintain sprinklers on tall risers.
- Bracing required for tall risers and effluent areas.

Solid set

This irrigation system is suited to seedlings and vegetable crops or crops that need to be rotated from field to field each year. The system can remain in place for the life of the crop and be removed prior to harvest or it can be used in the seedling stage, prior to transplant, and then moved to the next irrigation block.

Like most pressure irrigation systems, the solid set system relies on a pump to deliver water to the irrigation areas via a permanent, buried mainline. The mainline is usually a plastic material like PVC.

The irrigation area is divided into a number of blocks. A sub main (one for each block) runs off the mainline and serves that block. Sub mains are either permanent (buried) or portable (surface laid). Buried sub mains are usually a plastic material like PVC or polythene and surface sub mains are either a metal material like aluminium or a plastic material like polythene. From the sub main, water reaches the crop though a surface grid of laterals fitted with sprinklers. Laterals are usually aluminium but polythene laterals are sometimes used.

Solid set sprinklers are generally of the 'knocker' type and provide from 5 to 20 mm/h and operate between 200 and 450 kPa.

Pros of solid set

- Low labour requirement.
- Low (or no) crop damage due to pipe movement.
- No laneways required.

Cons of solid set

- High capital cost per hectare.
- Wetting patterns liable to distortion in windy conditions.

Bike shift

As the name implies, bike shift irrigation is the shifting of irrigation positions with the aid of a bike.

It is mainly used to irrigate pastures and is most commonly found on dairy enterprises. It can be adapted to irrigate some horticultural crops like vegetables, orchards and ornamental plants, but this is only possible where laneways are provided to allow bike movement of irrigation positions.

Like most pressure irrigation systems, bike shift relies on a pump to deliver water to the irrigation areas via a permanent, buried mainline. The mainline is usually a plastic material like PVC. The bike shift irrigation area is divided into a number of blocks. A turf valve connected to the mainline by a buried polythene lateral serves each block.

Flexible, low-density polythene piping runs from each turf valve to a sprinkler mounted on a skid frame. The frame design allows it to be easily picked up and towed with a bike and is stable enough not to be overturned by stock. Generally, the number of irrigation positions per turf valve is either 12 or 9. Each of these positions is served in turn by the same sprinkler.

Bike shift sprinklers generally provide from 3 to 6 mm/hour and operate between 250 and 300 kPa.

Pros of bike shift

- Medium pressure sprinklers means lower pumping cost and lower class mainlines.
- All paddocks are watered simultaneously.
- Suited to odd shaped paddocks.
- Can be used in hilly areas provided sprinklers are fitted with pressure regulators.

Cons of bike shift

- It is only suited to pasture irrigation unless provision is made for laneways in horticultural crops.
- A 4 wheeled bike is generally required, particularly for areas greater than 10 ha.
- Labour and time required to shift hoses is high.
- Need for good surface to move the skid frame.
- Slower watering time.

Fixed under-canopy micro-irrigation systems

These systems are suited to under-tree irrigation and also have specific application in some intensive horticulture enterprises like ornamental and vegetable growing.

Like most pressure irrigation systems, micro-irrigation systems rely on a pump to deliver water to the irrigation areas via a permanent, buried mainline. The mainline is usually a plastic material like PVC.

The irrigation area is divided into a number of blocks. A sub main (one for each block) runs off the mainline and serves that block. Sub mains are usually permanent (buried) and are typically of a plastic material like PVC or polythene. From the sub main, water reaches the crop though a surface (not often buried) grid of laterals fitted with micro emitters. Laterals are normally of polythene pipe.

Fixed under-canopy micro systems have two types of emitters. One is a fixed spray head (known as a micro jet but sometimes called a micro spray) and the other is a small rotating sprinkler (usually called a mini sprinkler). Both types require water filtration to avoid emitter blockages due to their small discharge openings.

Microjets can provide between 20 and 200 litres per hour at operating pressures between 100 and 250 kPa. Their diameter of coverage ranges from about 1 to 7 metres.

Mini sprinklers can provide up to 600 litres per hour at operating pressures between 150 and 350 kPa. Their diameter of coverage ranges from about 2 to 12 metres.

Pros of micro

- Good control of rootzone moisture.
- Suited to automation.
- Low labour costs.
- Low pumping costs.
- Fertigation (and chlorination) possible though the system.
- Crop access possible during (or shortly after) irrigation cycles.

Cons of micro

- High capital cost.
- Frequent watering may be required (not always a con).
- Blockages of emitters.
- Defined maintenance regime (with visual assessment of operating system) required.
- Emitters easily damaged in farming operations like fruit picking.

EQUIPMENT NEEDED FOR SYSTEM EVALUATION

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.

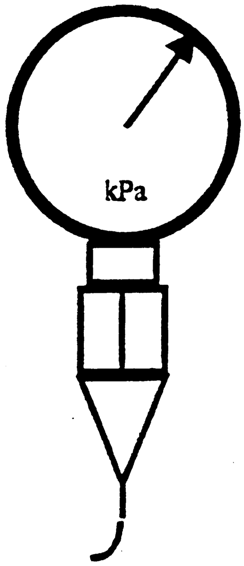


Figure 1: Pitot Tube

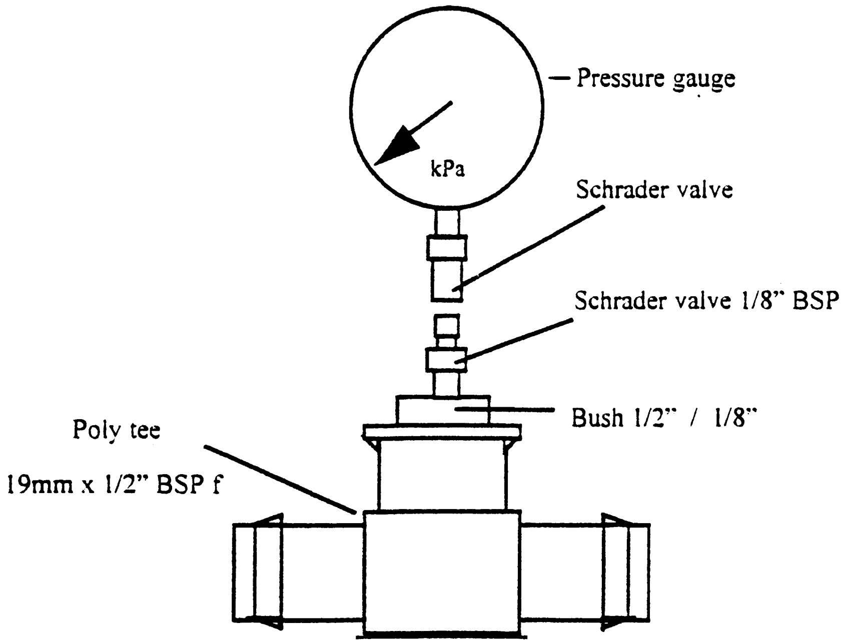


Figure 2: Schrader Valve

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 various points in the system, and to measure evenness of application you need to collect the output of the sprinklers using catch cans. Work though the following procedure.

Step 1 Fill out a Data Sheet for the system you are evaluating. On your Data Sheet, note the brand, type, model, colour nozzle sizes and normal operating pressures of the sprinklers to be used as well as the spacings of the sprinklers and catch cans.

Step 2 Place the catch cans in a grid pattern (Figure 3). Use a tape measure to make sure they are the correct distance apart. Typical spacings are 3 metres however your catch can spacing will depend upon your system.

Catch cans nearest to the emitters are positioned at half the spacings of the other catch cans. Make sure that the catch cans are upright and stable, and if necessary weight them down with stones or gravel. You should also make sure that grass and other foliage does not interfere with water entering the catch cans.

Step 3 Turn on the water to fill and pressurise the lines. **Make sure you stop the emitters rotating and direct water away from the catch cans.** When the system has been fully pressurised, measure and record the pressure and flow of the emitters to be tested. (If any emitters have double jets, take a measurement at each jet and add the results together).

Step 4 **Start the test.** Release the emitter arms and run the test, recording the start time. Ideally, the test time should be for one hour.

Step 5 Check the system for malfunctions, leaks, blockages, and damage. Record any faults in your maintenance report and schedule on your field record sheet.

Step 6 While the test is in progress, check the pressures and flows at a number of other positions on other laterals and record these on the **pressure and flow evaluation sheets.**

Step 7 Whilst the test is in progress record the wind direction and strength (see Table 1).

Step 8 Check the pump unit and record the pump operation in your **pump record sheet**.

Step 9 At the end of the test period, stop the emitters. Accurately measure the volume of water collected in each can. Use a graduated jug or measuring cylinder. Record the volumes on your **catch can record sheet.**

Step 10 Transfer the catch can data to the **overlap addition sheet**. Convert the volumes collected (mL) to irrigation depth (mm) using Table 2.

Step 11 Calculate the MAR and DU for your system using the **Evaluation sheets**.

Step 12 Calculate the average pressure, and average flow for the sprinklers tested.

If/when time permits:

Step 13 Repeat the test for several sites and under different conditions (for example, windy or calm).

Catch can layout

Choose four sprinklers along two laterals for the test (Figure 3), or four adjoining sprinklers (Figure 4) to create a grid for catch can layout.

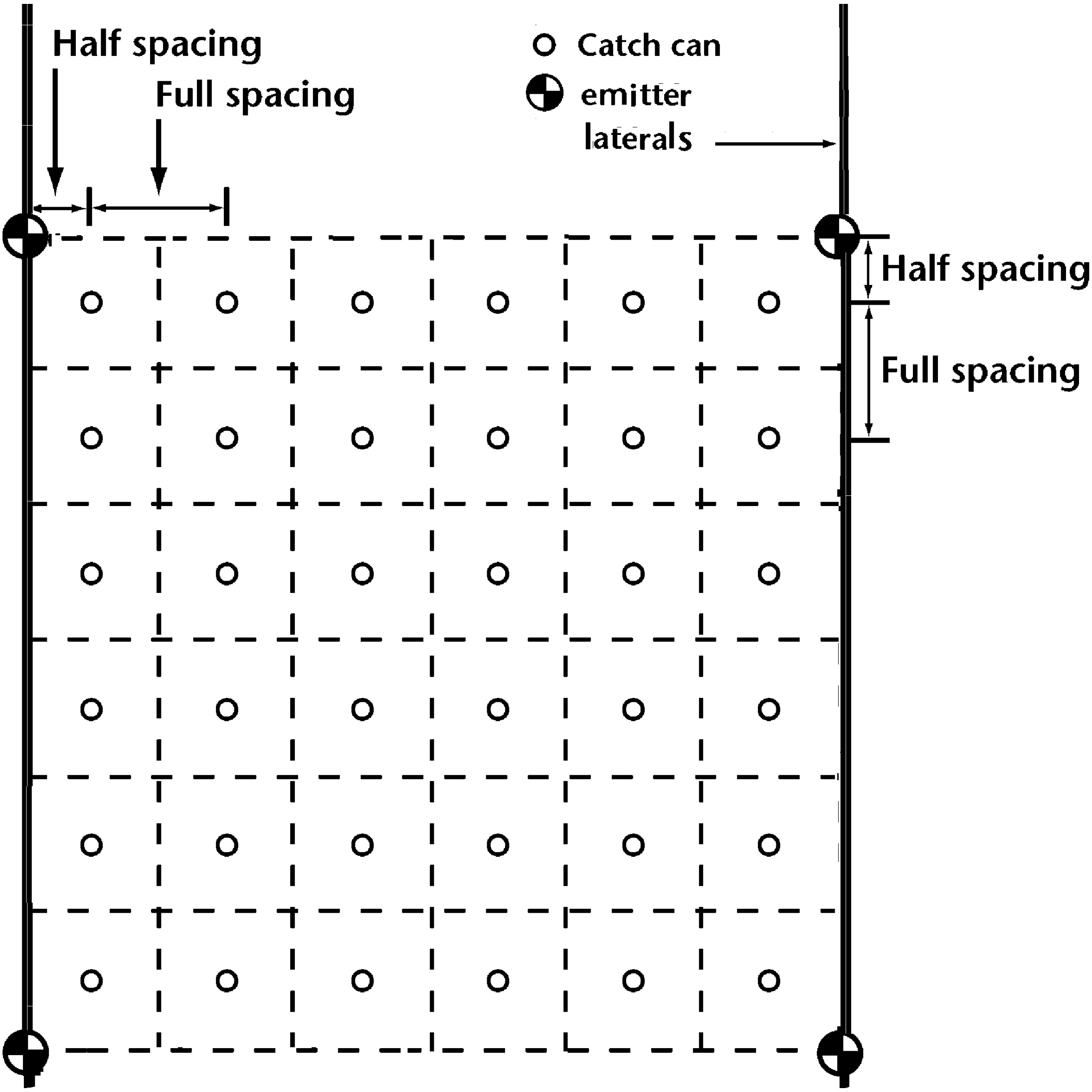


Figure 3: Typical catch can layout

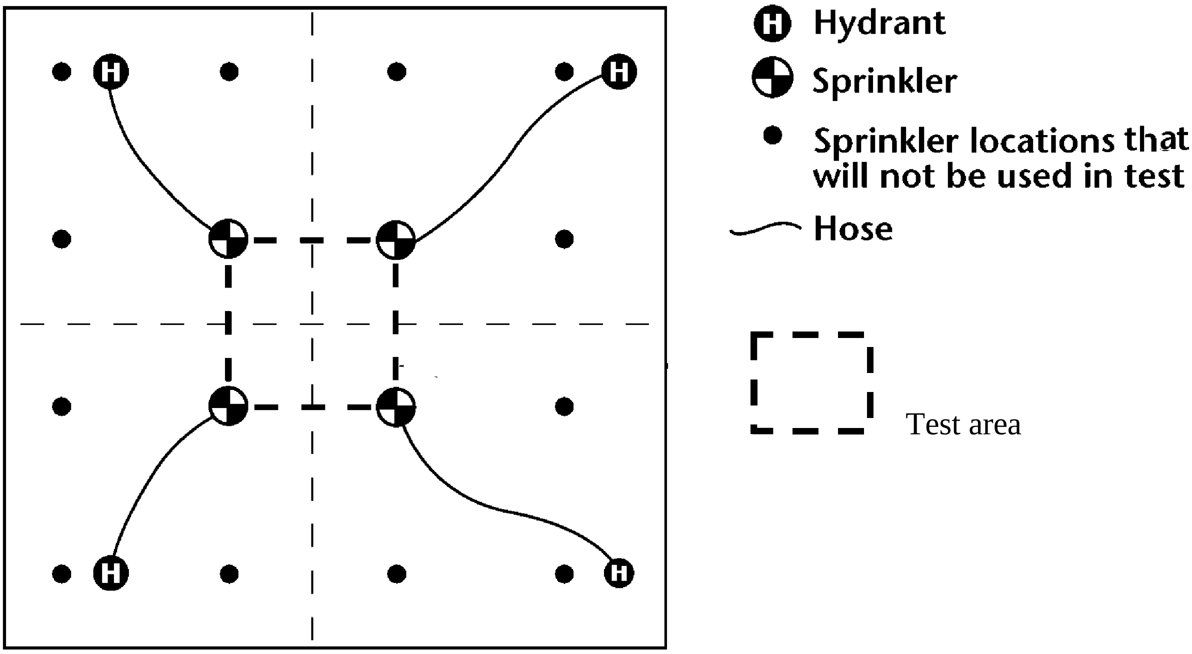


Figure 4: Layout for a bike shift system

Set out the catch cans as shown. The cans nearest the emitters are positioned at half the normal can spacing.

Position the cans 4 metres apart for 20-metre emitter spacing (36 containers, 5 spaces of 4 metres). For under canopy micro systems the cans will be positioned much closer at 1 metre apart. This will give you a test grid of 6 m x 6 m.

For an 18-metre emitter spacing, position the cans at 3 metres apart. This will give you a test grid of 7 x 7 (a total of 49 cans). Other spacings and more or less cans can be used for different arrangements. There is nothing ‘magic’ about the number of cans!

Table 1: Wind Speed

Wind speed guide		
Visible effect	**Wind description**	**Speed (knots)**
Calm. Smoke rises vertically.	Calm.	00
Direction of wind shown by smoke drift but not wind vane.	Light air.	02
Wind felt on face. Leaves rustle. Vane moved by wind.	Light breeze.	05
Leaves and small twigs in constant motion. Wind extends light flag.	Gentle breeze.	09
Raises dust and loose paper. Small branches are moved.	Moderate breeze.	13
Small trees in leaf begin to sway. Crested wavelets on inland waters.	Fresh breeze.	18
Large branches in motion. Whistling heard in telegraph wires.	Strong breeze.	24
Whole trees in motion. Inconvenience felt when walking against wind.	Moderate gale.	30
Breaks twigs off trees. Generally impedes progress.	Fresh gale.	37
Slight structural damage occurs.	Strong gale.	44
Trees uprooted. Considerable structural damage. Seldom experienced inland.	Whole gale.	52
Very rarely experienced. Accompanied by widespread damage.	Storm. Hurricane.	60 68

Source: Bureau of Meteorology

Data Sheet (example)

Date: July 3 2000

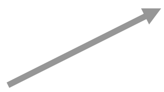
Name:	Harley Mobilus
Crop	Pasture
Location/block	Phillip Creek
Irrigation system	Bike Shift
Soil texture of Block	Sandy loam
Effective root depth	150 **mm** (0.15 metres)
Rootzone RAW	10 **mm**
Maximum infiltration rate	30 **mm/h**
Designed Flow Rate	300 **Litres per second at** 350 **kPa**
Emitter make	BSA
Emitter model	2000/1
Nozzle type/size	5 **mm**
Emitter spacing	3 **metres**
Operating pressure	440 **kPa**
Irrigation frequency	6 **days**
Emitter wetted diameter	6 **metres**
Test start time	11.40 am
Test end time	12.40 am
Test duration	60 **minutes**
Wind direction & speed during test	Light breeze
Catch Can Diameter	113 **mm**
Catch Can spacing	4 **metres**

Catch can record sheet

						TOTAL of row
54	39	24	26	35	51	229
36	29	21	18	27	34	165
22	21	16	21	19	24	123
28	24	19	16	23	27	137
36	23	18	18	26	35	156
51	34	25	23	37	49	219
			Total of all container depths:			1029 ml

Start time 11.40 **Finish Time** 12.40 **Test duration** 1 hour

Wind direction (draw an arrow relative to the catch can layout)



Maintenance Record	Maintenance Schedule
Two blocked emitters	*Unblock emitters 3 July 2003*
Small leak at junction 5 South end	*Replace seals at junction 5*
	7 July 2003

Table 2: Converting mL to mm of irrigation

For catch-cans of 110 to 115 mm diameter across the top, just divide the collected amount by 10 to get mm of irrigation. For instance if you collected 674 mL, this is equivalent to a depth of 67.4 mm

Calculating MAR

Step 1 Add up all the volumes of irrigation in millilitres.

Step 2 Convert the total volume of the catch cans to depth of irrigation using the data in Table 2.

Step 3 Divide this total by the number of catch cans.

Step 4 If the test duration was NOT exactly one hour you now need to convert the average obtained to a per hour equivalent. (Do this by dividing the average by the test duration (minutes) and then multiplying by 60 (see the example) to obtain **MAR** per hour.)

The mean application rate (MAR) is the average rate (in mm/h) that water is applied to the wetted area of the soil.

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
220	38.0

Average Application = Total application ÷ Number of catch cans Depth Depth collected		
Add up volumes in all catch cans	1029 ml	**A**
Convert into depth (mm) Use Table 2	Total volume ÷ Catch can conversion factor 1029 ÷ 10 = 102.9 mm	**B**
Number of catch cans used	36	**CC**
Average Application Depth =	**B ÷ CC** = 102.9 ÷ 36 = 2.86 mm	**D**
MAR = Average application ÷ Test Time (minutes) x 60		
Irrigation test time	60 **minutes**	**E**
	D ÷ E x 60	
	2.86 ÷ 60 x 60 **= 2.86 mm per hour**	**MAR**

Calculating DU

Step 1 Find the 25% (¼) of catch cans with the lowest amounts in them. Circle these on your record sheet. These are your LQ cans.

Step 2 Add up the volumes in the LQ cans.

Step 3 Convert the volume to depth (using Table 2). This is your LQ depth.

Step 4 Divide the LQ depth by the number of LQ cans. This gives you the LQ average.

Step 5 If the test duration was NOT exactly one hour you now need to convert the average obtained in 'Step 4' to a per hour equivalent**.** (Do this by dividing the average by the test duration (minutes) and then multiplying by 60 (see the example)).

Step 6 Divide the **LQ** average (per hour rate) by the **MAR** to obtain the **DU**.

Step 7 Multiply the result by 100 to make it into a percentage.

A DU of 85 % is acceptable. If the DU is ***below*** this, then changes to your irrigation system may be required in order to improve the DU%. It is a good idea to check the original specifications supplied with the irrigator to make sure the system is operating correctly.

Example data with full calculations

Number of Catch cans	**36 cans**	**A**
One quarter of catch cans Divide number of catch cans by 4 (If not a whole number round down)	**A ÷ 4** **36 ÷ 4** **= 9**	**LQ cans**
On your Catch Can record sheet highlight the lowest amounts (mm) for the appropriate number of LQ cans. *These are you Lowest Quarter Catch Cans (LQ Cans)*		
Volume of the selected LQ cans	**16+16+18+18+18+19+19+21+21** **= 166 ml**	**B**
Convert volume into depth	**LQ Volume ÷ conversion factor (Table 2)** **B ÷ Conversion factor** **166 ÷ 10** **= 16.6 mm**	**C**
Average depth of LQ cans = Total depth of LQ cans ÷ number of LQ cans		
Average depth of LQ cans	= **C ÷ LQ cans** = **16.6 mm ÷ 9 cans** **= 1.84 mm**	**D**
Test time	60 minutes	**E**
Convert into mm/hour	D ÷ E x 60 1.84 ÷ 60 x 60 = 1.84 mm/hour	**F**
DU = Average depth of LQ cans ÷ MAR		
MAR	**2.86**	**G**
DU =	**F ÷ G** **= 1.84 ÷ 2.86** **= 0.64**	**DU**
Convert DU into a percentage = **DU x 100**		
As a percentage the DU is	**0.64 x 100** **= 64 %**	

How long to irrigate

Now that we know the MAR and DU for our system we can calculate the time it will take our system to fill our soil's RAW.

To do this we simply take the RAW for the soil and divide this by the MAR of our system. The result indicates how long it will take to apply the RAW amount. The effectiveness of this application is however, affected by the system DU%.

Example: How long to irrigate to replenish RAW

	Example	
RAW for this crop	**10 mm**	**RAW**
MAR (calculated earlier)	**2.86 mm/h**	**MAR**
Irrigation Time =	**RAW ÷ MAR** **10 ÷ 2.86** **= 3.5 hours**	**Time**
Because the system is a bike shift, the time calculated for irrigation represent a single shift		

The irrigation time is sometimes increased to compensate for uneven application. **This is a management decision** and you must carefully consider the points below. The consequences of increasing the irrigation time are:

- Increased water use
- Increased pumping costs
- Excessive run-off and losses to deep drainage
- Allocation/supply may mean smaller areas can be irrigated
- Yield may decrease due to waterlogged roots
- Yield may increase as all areas get sufficient water

To estimate the extra time you would need to allow for less than 100% distribution uniformity we simply divide our Irrigation time by our distribution uniformity (DU%).

The example below demonstrates the additional time needed to compensate for an inefficient system.

Extra irrigation Time Required due to system DU%

Irrigation Time	**3.5 hours**
DU%	**63 % (0.684)**
DU % adjusted time for EACH shift	**Irrigation Time ÷ DU** **3.5 ÷ 0.63** **= 5.5 hours**

Thus, an extra four and a half hours are required due to the system distribution uniformity of 63%

Maintain your irrigation system and MAXIMISE distribution uniformity (DU).

Measuring pressure and flow

Step 1 Select which sprinklers are to be checked. Check the near, far, high and low positions as a minimum.

Step 2 Measuring the pressure and flow at each position. Make sure the system is operating at the normal pressure in the normal shift arrangement!

Large under-tree sprinklers or overhead sprinklers

- Pressure: Position the Pitot tube and gauge with the point of the tube about 3 mm (1/8') from the nozzle in the stream of the water.

- Flow: Place a length of flexible plastic tubing over the nozzle and direct the discharge into a container for a minimum of 15 seconds. If two nozzles are fitted, they need to be tested separately and their flows (L/min) need to be added together to give the total flow rate of the sprinkler.

For under canopy systems, hold the impact arm back and direct the stream into the container. Avoid losses from splashing! Use a measuring cylinder to record the volume (mL).

For each sprinkler tested note down the brand/model, nozzle size, colour, nominal flow rate, and spacings on your evaluation sheet.

Hint: straight-drilled nozzle sizes can be checked using the shank end of unworn drill bits. The one with the snuggest fit is the current size of the nozzle. Check against the manufacturer's charts for the correct size.

Low-level sprinklers

- Pressure: Pinch off the lead tubing and unscrew the sprinkler from the stand or stake. Screw the T-piece holding the pressure gauge onto the stand or stake and replace the sprinkler on top of the fitting. Release the lead tube and allow the sprinkler to operate normally. Record the sprinkler pressure reading on your evaluation sheet.

- Flow: Direct the stream into a bucket for one minute. Avoid losses from splashing. Use a graduated measuring cylinder to record the volume in (mL). Record the volume on your evaluation sheet.

For each outlet tested note down the brand/model, nozzle size, colour, nominal flow rate, and spacings on your evaluation sheet.

Hint: straight-drilled nozzle sizes can be checked using the shank end of unworn drill bits. The one with the snuggest fit is the current size of the nozzle. Check against the manufacturer's charts for the correct size.

Step 3 Make sure all results are recorded.

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.

Pressure and flow record sheet

	Example data				
Emitter position	**1st Emitter**	**1st Mid-position**	**2nd Mid-position**	**Last Emitter**	
Pressure (kPa)	***300***	***275***	***285***	***270***	**A**
Container volume (litres)	***38***	***37.5***	***25***	***38***	**B**
Catch time (seconds)	***62.5***	***66***	***42***	***67***	**C**
Calculated flow rate	**B ÷ C x 60**	**B ÷ C x 60**	**B ÷ C x 60**	**B ÷ C x 60**	
Flow Rate (L/s)	***36.5***	***34.1***	***35.7***	***34***	

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

What do the pressure and flow readings tell us?

Calculating average pressure

Average pressure provides an indication of whether the valve unit is operating as it was designed to do. It can also be used in conjunction with manufacturer's information to calculate flow rate. The table below gives an indication of the typical operating pressures of various irrigation systems.

Add all pressure readings together.	***300 + 275 + 285 + 270 = 1130***
Divide the total by the number of the number of measurement sites. This gives the average pressure.	***1130 ÷ 4*** ***= 282.5 kPa***

The average pressure calculated should be compared against the correct pressure rates for the sprinklers being used. This can also enable the correct flow rate for that pressure to be determined.

You have collected a series of figures on your record sheet. Using these figures, you may 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	**A**	***300 kPa***
Minimum Pressure	**B**	***270 kPa***
Add the maximum and minimum pressures.	**C**	**maximum + minimum** **A + B** ***300 + 270*** ***= 570***
Divide the result by two. This gives the midpoint pressure	**D**	**C ÷ 2** ***570 ÷ 2*** = ***285*** **kPa**
To calculate the pressure variation Take the midpoint from the maximum.	**E**	**maximum – midpoint** **A - D** ***300 – 285*** **kPa** = ***15*** **kPa**
Divide the difference by the midpoint.	**F**	**E ÷ D** ***15 ÷ 285*** = ***0.0526***
Multiply by 100 to get a percentage.		**F x 100** ***0.0526*** **x 100** ***= 5.26 %***
Pressure variation is:		***= ± 5%***

In the above example the pressure variation is ± 5 %. 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***	***36.5***
Minimum Flow Rate (from Table 5)	**B**	***34***
Add the maximum and minimum flow	**C**	**Maximum + minimum** A + B ***36.5 + 34*** **=** ***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** ***36.5 – 35.25*** **=** ***1.25***
Divide the difference by the midpoint	**F**	**E ÷ D** ***1.25 ÷ 35.25*** **=** ***0.035***
Multiply by 100 to get a percentage. Flow variation is written as a ± %.		**F x 100** ***0.035*** **x 100** = ***3.5 %*** = **±** ***3.5 %***

If the variation is more than ± 5%, it is unacceptable.

Check these figures out against the yellow sprinklers in the appendices supplied with the pressure workshop notes. How close was this set?

EVALUATION METHOD

To assess the performance of your system, you need to measure the pressure and flow at various points in the system, and to measure evenness of application you need to collect the output of the sprinklers using catch cans. Work though the following procedure.

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Step 3 Turn on the water to fill and pressurise the lines. **Make sure you stop the emitters rotating and direct water away from the catch cans.** When the system has been fully pressurised, measure and record the pressure and flow of the emitters to be tested. (If any emitters have double jets, take a measurement at each jet and add the results together).

Step 4 **Start the test.** Release the emitter arms and run the test, recording the start time. Ideally, the test time should be for one hour.

Step 5 Check the system for malfunctions, leaks, blockages, and damage. Record any faults in your maintenance report and schedule on your field record sheet.

Step 6 While the test is in progress, check the pressures and flows at a number of other positions on other laterals and record these on the **pressure and flow evaluation sheets.**

Step 7 Whilst the test is in progress record the wind direction and strength (see Table 1).

Step 8 Check the pump unit and record the pump operation in your **pump record sheet**.

Step 9 At the end of the test period, stop the emitters. Accurately measure the volume of water collected in each can. Use a graduated jug or measuring cylinder. Record the volumes on your **catch can record sheet.**

Step 10 Transfer the catch can data to the **overlap addition sheet**. Convert the volumes collected (mL) to irrigation depth (mm) using Table 2.

Step 11 Calculate the MAR and DU for your system using the **Evaluation sheets**.

Step 12 Calculate the average pressure, and average flow for the sprinklers tested.

If/when time permits:

Step 13 Repeat the test for several sites and under different conditions (for example, windy or calm).

Catch can layout

Choose four sprinklers along two laterals for the test (Figure 3), or four adjoining sprinklers (Figure 4) to create a grid for catch can layout.

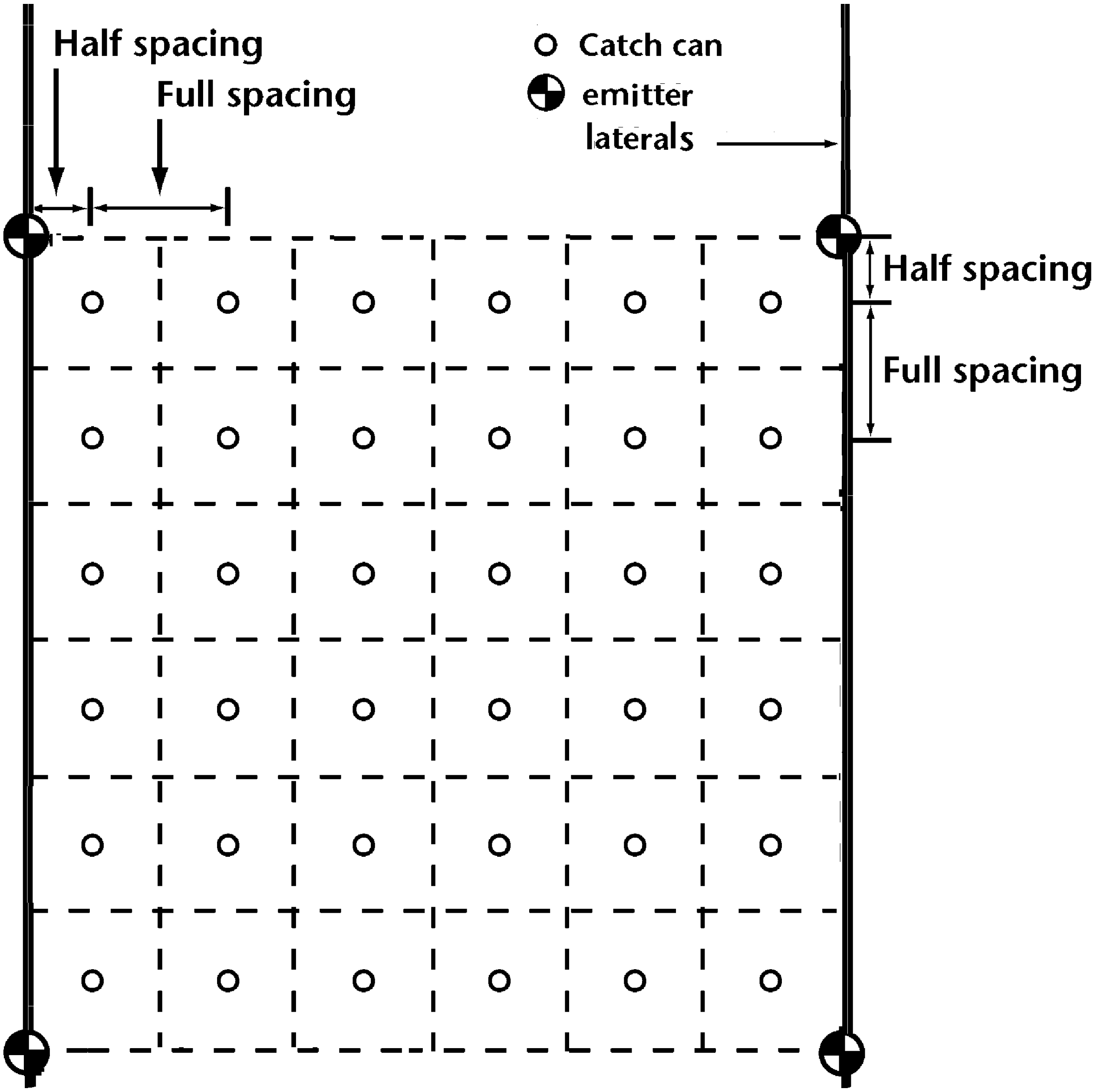

Figure 3: Typical catch can layout

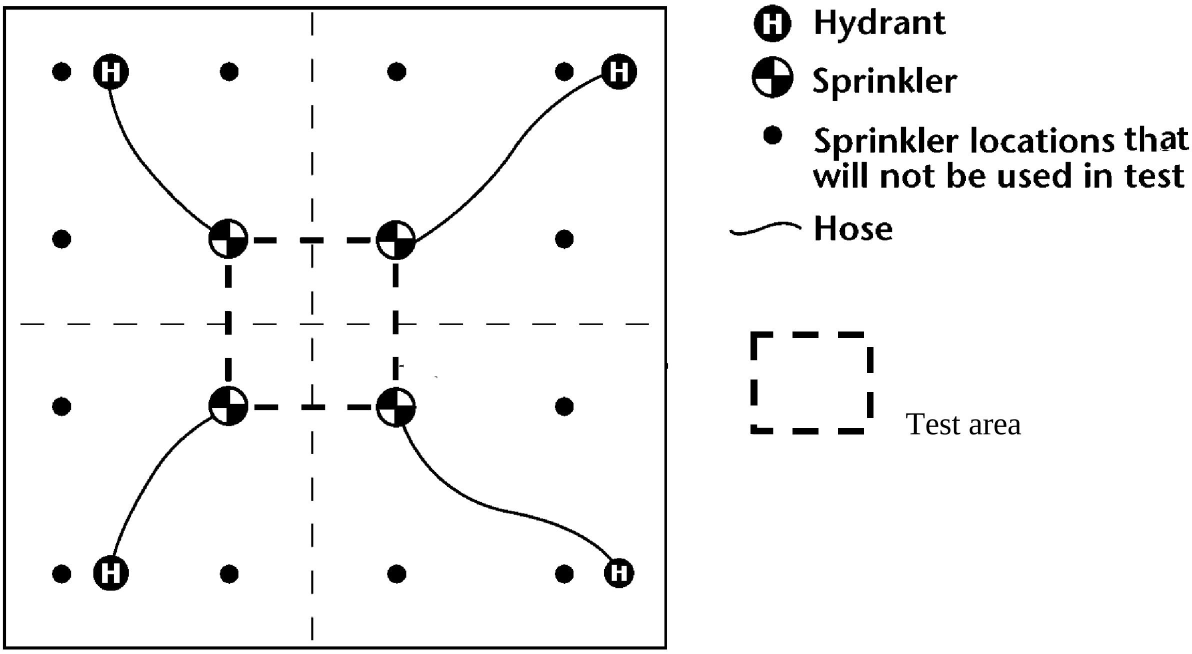

Figure 4: Layout for a bike shift system

Set out the catch cans as shown. The cans nearest the emitters are positioned at half the normal can spacing.

Position the cans 4 metres apart for 20-metre emitter spacing (36 containers, 5 spaces of 4 metres). For under canopy micro systems the cans will be positioned much closer at 1 metre apart. This will give you a test grid of 6 m x 6 m.

For an 18-metre emitter spacing, position the cans at 3 metres apart. This will give you a test grid of 7 x 7 (a total of 49 cans). Other spacings and more or less cans can be used for different arrangements. There is nothing 'magic' about the number of cans!

Table 1: Wind Speed

Wind speed guide		
Visible effect	**Wind description**	**Speed (knots)**
Calm. Smoke rises vertically.	Calm.	00
Direction of wind shown by smoke drift but not wind vane.	Light air.	02
Wind felt on face. Leaves rustle. Vane moved by wind.	Light breeze.	05
Leaves and small twigs in constant motion. Wind extends light flag.	Gentle breeze.	09
Raises dust and loose paper. Small branches are moved.	Moderate breeze.	13
Small trees in leaf begin to sway. Crested wavelets on inland waters.	Fresh breeze.	18
Large branches in motion. Whistling heard in telegraph wires.	Strong breeze.	24
Whole trees in motion. Inconvenience felt when walking against wind.	Moderate gale.	30
Breaks twigs off trees. Generally impedes progress.	Fresh gale.	37
Slight structural damage occurs.	Strong gale.	44
Trees uprooted. Considerable structural damage. Seldom experienced inland.	Whole gale.	52
Very rarely experienced. Accompanied by widespread damage.	Storm. Hurricane.	60 68

Source: Bureau of Meteorology

Data Sheet (example)

Date:

Name:	
Crop	
Location/block	
Irrigation system	
Soil texture of Block	
Effective root depth	**mm** *(metres)*
Rootzone RAW	**mm**
Maximum infiltration rate	**mm/h**
Designed Flow Rate	**Litres per second at kPa**
Emitter make	
Emitter model	
Nozzle type/size	**mm**
Emitter spacing	**metres**
Operating pressure	**kPa**
Irrigation frequency	**days**
Emitter wetted diameter	**metres**
Test start time	
Test end time	
Test duration	**minutes**
Wind direction & speed during test	
Catch Can Diameter	**mm**
Catch Can spacing	**metres**

Catch can record sheet

						TOTAL of row
			Total of all container depths:			ml

Start time **Finish Time** **Test duration**

Wind direction (draw an arrow relative to the catch can layout)

Maintenance Record	Maintenance Schedule

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

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 108 mm then our conversion factor from Table 2 will be 9.2 (circled).

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

674 mL ÷ 9.2 = 73 mm

Therefore the depth of water applied during the example test was 73 mm

If you use 4 litres 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

For catch-cans of 110 to 115 mm diameter across the top, just divide the collected amount by 10 to get mm of irrigation. For instance if you collected 674 mL, this is equivalent to a depth of 67.4 mm

Calculating MAR

Step 1 Add up all the volumes of irrigation in millilitres.

Step 2 Convert the total volume of the catch cans to depth of irrigation using the data in Table 2.

Step 3 Divide this total by the number of catch cans.

Step 4 If the test duration was NOT exactly one hour you now need to convert the average obtained to a per hour equivalent. (Do this by dividing the average by the test duration (minutes) and then multiplying by 60 (see the example) to obtain **MAR** per hour.)

The mean application rate (MAR) is the average rate (in mm/h) that water is applied to the wetted area of the soil.

Average Application = Total application ÷ Number of catch cans Depth Depth collected		
Add up volumes in all catch cans	………… ml	**A**
Convert into depth (mm) Use Table 2	Total volume ÷ Catch can conversion factor ………… ÷ ………… = ………… mm	**B**
Number of catch cans used	…………	**CC**
Average Application Depth =	**B ÷ CC** = ………… ÷ ………… = ………… mm	**D**
MAR = Average application ÷ Test Time (minutes) x 60		
Irrigation test time	**minutes**	**E**
	D ÷ E x 60	
	………… ÷ ………… **x 60** **=** ………… **mm per hour**	**MAR**

Calculating DU

Step 1 Find the 25% (¼) of catch cans with the lowest amounts in them. Circle these on your record sheet. These are your LQ cans.

Step 2 Add up the volumes in the LQ cans.

Step 3 Convert the volume to depth (using Table 2). This is your LQ depth.

Step 4 Divide the LQ depth by the number of LQ cans. This gives you the LQ average.

Step 5 If the test duration was NOT exactly one hour you now need to convert the average obtained in 'Step 4' to a per hour equivalent. (Do this by dividing the average by the test duration (minutes) and then multiplying by 60 (see the example).

Step 6 Divide the LQ average (per hour rate) by the MAR to obtain the DU.

Step 7 Multiply the result by 100 to make it into a percentage.

A DU of 85 % is acceptable. If the DU is ***below*** this, then changes to your irrigation system may be required in order to improve the DU%. It is a good idea to check the original specifications supplied with the irrigator to make sure the system is operating correctly.

Example data with full calculations

Number of Catch cans	………… **cans**	**A**
One quarter of catch cans Divide number of catch cans by 4 (If not a whole number round down)	**A ÷ 4** ………… ÷ **4** = …………	**LQ cans**
On your Catch Can record sheet highlight the lowest amounts (mm) for the appropriate number of LQ cans. *These are you Lowest Quarter Catch Cans (LQ Cans)*		
Volume of the selected LQ cans	……+……+……+……+……+……+……+……+……+……+… = ………… **ml**	**B**
Convert volume into depth	**LQ Volume ÷ conversion factor (Table 2)** **B ÷ Conversion factor** ………… ÷ ………… = ………… **mm**	**C**
Average depth of LQ cans = Total depth of LQ cans ÷ number of LQ cans		
Average depth of LQ cans	= **C ÷ LQ cans** = ………… **mm** ÷ ………… **cans** = ………… **mm**	**D**
Test time	………… minutes	**E**
Convert into mm/hour	D ÷ E x 60 ………… ÷ ………… x 60 = ………… mm/hour	**F**
DU = Average depth of LQ cans ÷ MAR		
MAR	…………	**G**
DU =	**F ÷ G** = ………… ÷ ………… = …………	**DU**
Convert DU into a percentage = **DU x 100**		
As a percentage the DU is	………… **x 100** = ………… %	

How long to irrigate

Now that we know the MAR and DU for our system we can calculate the time it will take our system to fill our soil's RAW.

	Example	
RAW for this crop	………… **mm**	**RAW**
MAR (calculated earlier)	………… **mm/h**	**MAR**
Irrigation Time =	**RAW ÷ MAR** ………… ÷ ………… = ………… **hours**	**Time**

To estimate the extra time you would need to allow for less than 100% distribution uniformity we simply divide our Irrigation time by our distribution uniformity (DU%).

Extra irrigation Time Required due to system DU%

Irrigation Time	………… **hours**
DU%	………… %
DU % adjusted time for EACH shift	**Irrigation Time ÷ DU** ………… ÷ ………… = ………… **hours**

Maintain your irrigation system and MAXIMISE distribution uniformity (DU).

Measuring pressure and flow

Step 1 Select which sprinklers are to be checked. Check the near, far, high and low positions as a minimum.

Step 2 Measuring the pressure and flow at each position. Make sure the system is operating at the normal pressure in the normal shift arrangement!

Step 3 Make sure all results are recorded.

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.

Pressure and flow record sheet

	Your data				
Emitter position	**1st Emitter**	**1st Mid-position**	**2nd Mid-position**	**Last Emitter**	
Pressure (kPa)					**A**
Container volume (litres)					**B**
Catch time (seconds)					**C**
Calculated flow rate	**B ÷ C x 60**	**B ÷ C x 60**	**B ÷ C x 60**	**B ÷ C x 60**	
Flow Rate (L/s)					

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

What do the pressure and flow readings tell us?

Calculating average pressure

Average pressure provides an indication of whether the valve unit is operating as it was designed to do. It can also be used in conjunction with manufacturer's information to calculate flow rate.

Add all pressure readings together.	……… + ……… + ……… + ……… = …………
Divide the total by the number of the number of measurement sites. This gives the average pressure.	……… ÷ ……… = ………… ***kPa***

The average pressure calculated should be compared against the correct pressure rates for the sprinklers being used. This can also enable the correct flow rate for that pressure to be determined.

You have collected a series of figures on your record sheet. Using these figures, you may 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	**A**	**…………** ***kPa***
Minimum Pressure	**B**	**…………** ***kPa***
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** = **………… 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:		**=** ***± 5%***

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***	. . . .
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. Flow variation is written as a ± %.		**F x 100** **. . . . . x 100** = **. . . . .%** = ± **. . . . .%**

If the variation is more than ± 5%, it is unacceptable.

Check these figures out against the sprinklers in the appendices supplied with the pressure workshop notes. How close was this set?

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			
Number of belts			
Pulley distance Metres			

Prime mover
Type:
Model:
Age: Years
Operating 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

<table>
<tr><th colspan="3">Pump Unit Operation</th></tr>
<tr><td colspan="2">Friction loss for suction pipe: 1 metre (generally)</td><td>A</td></tr>
<tr><td colspan="2">Pressure at discharge: …………. kPa* * if not in kPa then convert</td><td>B</td></tr>
<tr><td colspan="2">Water Meter reading (start): ………….. Kilolitres or Megalitres?</td><td>C</td></tr>
<tr><td colspan="2">Water Meter reading (end): ………….. Kilolitres or Megalitres?</td><td>D</td></tr>
<tr><td colspan="2">Time at water meter reading (start): …………… Use 24 hour clock</td><td>E</td></tr>
<tr><td colspan="2">Time at water meter reading (end): …………… Use 24 hour clock</td><td>F</td></tr>
<tr><td>Duration of pumping:</td><td>Time at end reading - Time at start reading
F - E
………. - ……….
= ………… hours</td><td>G</td></tr>
</table>

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 Convert volume pumped into Litres	If your meter reads in Kilolitres P (KL) / 1000 ………… / ………… = ………….. 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	**G**
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 mega litre 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 they can 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 filters will drastically affect operation pressure of emitter.

Compare your findings on the pump curve for your pump