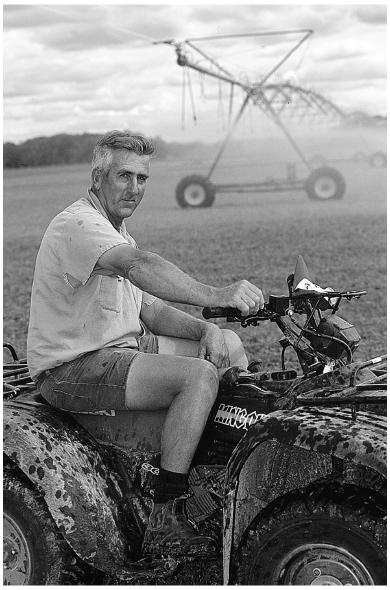
WaterWise on the Farm



# Introduction to
# Irrigation Management

## Evaluating your pressurised system

*System 3*

**Centre pivots**

**150501**

This evaluation method has been developed by members of the Water Management Program team including Rob Hoogers and Peter Smith.



This version May 15 2001

CONTENTS

# Aims

The aim of this workshop is to evaluate your centre pivot irrigation system. To do this you need to determine the rate that water is being applied, and how uniformly that water is being distributed over your irrigation area. To check these you need to know the mean application (MA) and distribution uniformity (DU) for your system. These worksheets outline the equipment and procedure needed for you to complete these tasks.

# Overview of centre pivot irrigators

A centre pivot is a travelling irrigation line that pivots at one end and rotates in a circle. It is made up of towers (commonly 4 to 12) that support the irrigation pipe and spray outlets. They have a pair of wheels at the junction of each tower that is driven by electric motors or hydraulic motors (oil or water). The speed of the pivot system is usually set on the outside wheels with the other drive points engaging when they get behind or a valve is adjusted with the angle of that joint.

The size of the sprinkler outlets increases because the outer sections of the pivot are covering a larger area than the centre sections. This means that the longer a pivot is, the greater the application rate needed at the end.

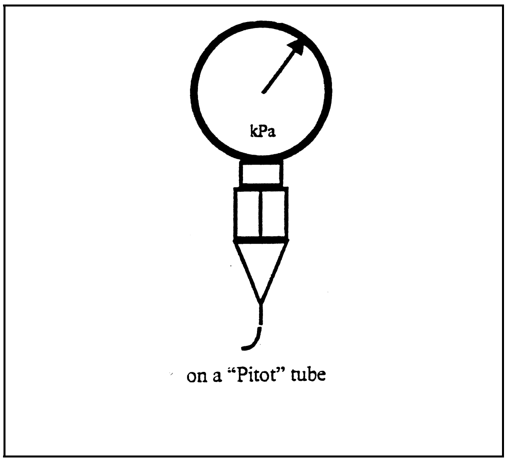
A major advantage of centre pivots is that they can operate at quite low pressures, thus reducing pumping cost. If the site is undulating, pressure regulators are fitted to each sprinkler outlet to equalise the output at varying heights. Most modern centre pivots operate at only 100 kPa. With pipes from the centre to the pump site, the total pressure required can be as low as 300 kPa.

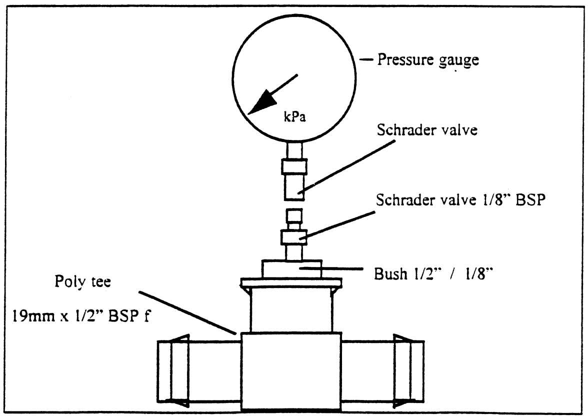
# Equipment needed

***To measure pressure:***

- an accurate pressure gauge with an appropriate scale so it works mid-range at your normal pressures (say 0 to 600 kPa)
- a pitot tube attachment (pronounced pit-oh), or a threaded 15 mm PVC tee and fittings such as reducing bushes for small low-level sprinklers, or a Schrader valve.

**Figure 1 (a and b)**




**Schrader valve**

***To measure sprinkler coverage:***

- catch cans
- gravel pieces to place in cans to stop them blowing away
- 30 metre tape for measuring distances in laying out the container row and estimating the machine’s speed
- stop watch
- manufacturer’s nozzle specifications giving pressure and flow, and instructions for setting machine speed
- a measuring cylinder or jug with graduations in millilitres
- a calculator, a pen and record sheets

# Evaluation method

To assess the performance of your centre pivot system, you need to measure the pressure and flow at various points in the system, the operating speed at the far end, and the output of the sprinklers using catch cans. From these you will be able to calculate the application and uniformity. To do this, work through the following procedure.

> **Occupational Health and Safety**
>
> Whilst working with your centre pivot irrigator you, and anyone assisting you, should at all times be aware of the inherent dangers associated with working near moving machinery. Safety should be the primary concern at all times.

1. Fill out the first sections of the centre pivot data sheet with details about the crop, soils and the centre pivot. You will need to measure the length of each span and the distance to the last wheel track (where the travel speed will be measured).

*Speed measurement*

Note that the pivot must be moving (at its normal speed) throughout the test, otherwise the difference in flow rates between the inboard and outboard sprinklers will give you incorrect results. If all is correct, the depths in all of the catch cans will be similar.

2. Measure the pivot's speed by staking out a measured distance (10 m) around the outer wheel track and recording the time required for the end drive unit to travel between the stakes. Record the time and distance on the data sheet.

*Water output measurement*

3. Place the catch cans at equal spacings (5 m to 10 m) to cover the whole wetted length of the pivot. (The number used doesn't matter, but they must be evenly spaced.)
4. Measure the width of the wetting pattern near the end drive unit and record this.
5. After the system has passed all catch cans, and no more water is landing in them, measure the volumes in the catch cans and record these on the catch can sheet.

*Measuring pressure and flow*

6. Measure and record the pressure and flow at outlets near the start and end of the pivot and also at other positions on towers along the pivot.

*Calculating the results*

7. After taking all measurements, you can move inside to complete the calculations. Because the calculations for a centre pivot are quite complex, it is best to put the figures into a computer spreadsheet and let it work out the results. Your trainer should have the appropriate program. If you are doing the evaluation at home, ask for a copy of the program or get your local irrigation adviser to assist you. The program may be available to download from the WaterWise web pages on NSW Agriculture's web site.
8. Record the results in the application results table. If you are happy to use a calculator, the procedure is fully detailed at the end of these notes.

# Centre pivot data sheet (sample data)

| | | | |
|---|---|---|---|
| Name: | John & Jean Smith | Crop: | Lucerne |
| Location: | Wagga | Soil texture: | Sandy loam over sand |

Date of test: July 7 2002

| | |
|---|---|
| Effective root depth: | 1.0 m |
| RAW for crop: | 48 mm |
| Normal frequency of irrigation: | 1 to 2 days |

## Irrigator details

| | | | |
|---|---|---|---|
| Number of spans: | 4 | Length of spans: | 55 m<br>55 m<br>55 m<br>81 m |
| Sprinkler spacing along spans: | m | | |
| Number of sprinklers along span: | | | |
| | | Total length: | 246 m |
| Sprinkler make/model: | Lindsay Zimmatic | | |
| Sprinkler model: | XYZ | Pressure compensated | Yes y/n |

| **Speed measurement** | | **Calculated data** | |
|---|---|---|---|
| Pivot (length) radius to outside wheel track | 220 m | Circumference of outside wheel track (6.28 x Pivot radius) **[A]** | 1382 m |
| Pegged distance **[X]** (at end drive unit) | 10 m | | |
| Time to move pegged distance **[Y]** | 7 m 15 s (435 s) | Travel speed **[B]** **[X] ÷ [Y in seconds] x 3600** | 10 ÷435 x 3600<br>82.8 m/hr |
| Width of wetted pattern on end span test site. **[C]** | 10 m | Time for one revolution of the pivot [A] ÷ [B] =**[D]** | 16.7 hours |

# Application results table

| | Example | Your data |
|---|---|---|
| **Mean application per pass:** From computer program OR your own calculations using procedure at end of these notes. | **9.8 mm** | |
| The application per pass should be compared to the rootzone RAW on the data sheet. For the example, the application depth is one quarter of the RAW. | | |
| **Lower quarter output per pass** From computer program OR your own calculations using procedure at end of these notes. | **8.0 mm** | |
| **Distribution uniformity** From computer program OR your own calculations using procedure at end of these notes. | **81 %** | |

A distribution uniformity above 75% is quite acceptable for field crops. If the DU is too low, this means that at least 25% of the area being irrigated is receiving less water than the rest.

# Pressure and flow record sheet (example)

| | Nozzle type | Time for 10L | Flow: measured | Flow as per system design (if known) | Pressure: measured | Pressure as per system design |
|---|---|---|---|---|---|---|
| At Pivot centre | | | | | 158 kPa | 172 kPa |
| Span 1, last sprinkler | no.14 | 106 s | 0.09 L/s | 0.12 L/s | 130 kPa | 171 kPa |
| Span 2, last sprinkler | no.23 | 40 s | 0.25 L/s | 0.27 L/s | 121 kPa | 152 kPa |
| Span 3, last sprinkler | no.28 | 28 s | 0.36 L/s | 0.27 L/s | 112 kPa | 137 kPa |
| Span 4, last sprinkler | no.33 | 20.5 s | 0.49 L/s | 0.39 L/s | 112 kPa | 125 kPa |
| Span 5, last sprinkler | | | | | | |
| Span 6, last sprinkler | | | | | | |

# Catch can sheet (example)

If you have access to the computer program you only need to fill in columns 2 and 3 of this table. The computer will do the rest.

Property location: **Singleton,** Centre pivot - no end gun, 16th Aug 2000

| Span # | Catch can position number | Volume collected in can mL | Weighted catch Column 2 x Column 3 |
|---|---|---|---|
| 1 | 1 | ignore | 0 |
| 1 | 2 | 65 | 130 |
| 1 | 3 | 80 | 240 |
| 1 | 4 | 52 | 208 |
| 1 | 5 | 81 | 405 |
| 2 | 6 | 80 | 480 |
| 2 | 7 | 78 | 546 |
| 2 | 8 | 91 | 728 |
| 2 | 9 | 83 | 747 |
| 2 | 10 | 88 | 880 |
| 3 | 11 | 126 | 1386 |
| 3 | 12 | 80 | 960 |
| 3 | 13 | 140 | 1820 |
| 3 | 14 | 105 | 1470 |
| 3 | 15 | 95 | 1425 |
| 4 | 16 | 88 | 1408 |
| 4 | 17 | 96 | 1632 |
| 4 | 18 | 108 | 1944 |
| 4 | 19 | 128 | 2432 |
| 4 | 20 | 93 | 1860 |
| 4 | 21 | 85 | 1785 |
| 5 | 22 | 96 | 2112 |
| | 23 | dry | 0 |
| | 24 | dry | 0 |
| | 25 | dry | 0 |
| | 26 | dry | 0 |
| | 27 | dry | 0 |
| | 28 | dry | 0 |
| | 29 | dry | 0 |
| | 30 | dry | 0 |
| | 31 | dry | 0 |
| | 32 | dry | 0 |
| | 33 | dry | 0 |
| | 34 | dry | 0 |
| | 35 | dry | 0 |
| | 36 | dry | 0 |

# Calculating the mean application (MA) per pass

Fill in column 4 of the table by multiplying column 2 by column 3 for each can position.

| | | |
|---|---|---|
| **Total of all the used position numbers**<br>Add up the numbers in Column 2 where water was collected in the can Ignore empty can numbers. | **252 [TN]** | |
| **Total of all weighted catches**<br>Add up the numbers in column 4. | **24598**<br>**[TC]** | |
| Weighted average = **TC ÷ TN** | **= 24598 ÷ 252mL**<br>**= 97.6 mL** | |
| Use the catch can conversion table to convert mL to mm<br>(113mm can used for example) | **=9.76 mm**<br>**Say 9.8 mm [MA]** | |

Transfer the MA figure to the application results table (earlier).

# Calculating distribution uniformity

| | | |
|---|---|---|
| Calculate ¼ of the weighted catches | **= TC ÷ 4**<br><br>**= 24598 ÷ 4**<br><br>**= 6149 [LQ]** | |

- Look through column 3 (the volumes) and **rank the lowest** amounts, 1st, 2nd 3rd etc. Do this for about one third of the cans..
- Add up the figures in column 4 starting at the lowest rank (1st) and as you add each figure note the total.
- As soon as the total exceeds the figure for LQ above stop and remove the last figure - so the total is less than LQ.
- The figures you have added are your LQ catches- shade or highlight them on your table.

| | | |
|---|---|---|
| Total the position numbers (column 2) for the shaded cans. **[TNLQ]** | **= 69** | |
| Add up the weighted catches for the shaded cans **[TCLQ]** | **= 5501** | |
| Weighted LQ average =<br>**TCLQ ÷ TNLQ** | **= 5501 ÷ 69 mL**<br>**= 80.0 mL** | |
| Use the catch can conversion table to convert mL to mm **[LQDepth]**<br>(113mm can used for example) | **= 8.0 mm** | |
| Distribution Uniformity **[DU]** | **= LQDepth ÷ MA**<br><br>**= 8 ÷ 9.8**<br><br>**= 0.81**<br><br>**= 81 %** | |

Transfer the DU figure to the Application Results Table (earlier)

## Table 1 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.

If the size of the catch cans is different, or you wish to be more accurate, use the table alongside.

Divide the amount caught by the figure in the right hand column. For instance, if the diameter is 110 mm and you catch 674 mL this is 674 ÷ 9.5 = 71 mm

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**

**Converting mL to mm**

| 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 |

# Blank evaluation sheets

## Centre pivot data sheet (sample data)

| | |
|---|---|
| Name: | Crop: |
| Location: | Soil texture: |

| | | |
|---|---|---|
| Date of test: | Effective root depth: | m |
| | RAW for crop: | mm |
| | Normal frequency of irrigation: | days |

### Irrigator details

| | | |
|---|---|---|
| Number of spans: | Length of spans: | .. m<br>.. m<br>.. m<br>.. m<br>.. m<br>.. m |
| Sprinkler spacing along spans: m | | |
| Number of sprinklers along span: | | |
| | Total length: | …. m |
| Sprinkler make/model: | | |
| Sprinkler model: | Pressure compensated | …. y/n |

| Speed measurement | | Calculated data | |
|---|---|---|---|
| Pivot (length) radius to outside wheel track | ….. m | Circumference of outside wheel track<br>(6.28 x Pivot radius) **[A]** | ……m |
| Pegged distance **[X]**<br>(at end drive unit) | … m | | |
| Time to move pegged distance **[Y]** | .. m … s<br>….. s | Travel speed **[B]**<br>**[X] ÷ [Y in seconds] x 3600** | ……m/hr |
| Width of wetted pattern on end span test site.<br>**[C]** | ….. m | Time for one revolution of the pivot<br>[A] ÷ [B] =**[D]** | …..<br>hours |

# Application results table

| | Example | Your data |
|---|---|---|
| **Mean Application per pass:** From computer program OR your own calculations using procedure at end of these notes | **9.8 mm** | |
| The application per pass should be compared to the Rootzone RAW on the data sheet. For the example the application depth is one quarter of the RAW. | | |
| **Lower quarter output per pass** From computer program OR your own calculations using procedure at end of these notes | **8.0 mm** | |
| **Distribution Uniformity** From computer program OR your own calculations using procedure at end of these notes | **81 %** | |
| A Distribution Uniformity above 75% is quite acceptable for field crops If the DU is too low, this means that at least 25% of the area being irrigated is receiving less water than the rest. | | |

# Pressure and flow record sheet (example)

| | Nozzle type | Time for 10L | Flow - measure d | Flow as per system design (if known) | Pressure – measure d | Pressure as per system design |
|---|---|---|---|---|---|---|
| At Pivot centre | | | | | … kPa | …. kPa |
| Span 1, last sprinkler | no… | …. s | …. L/s | …..L/s | … kPa | …. kPa |
| Span 2, last sprinkler | no…. | … s | ….. L/s | …. L/s | …. kPa | … kPa |
| Span 3, last sprinkler | no…. | …s | …..L/s | ….. L/s | …. kPa | … kPa |
| Span 4, last sprinkler | no…. | .. s | ….. L/s | ….. L/s | …. kPa | …. kPa |
| Span 5, last sprinkler | | | | | | |
| Span 6, last sprinkler | | | | | | |

# Catch can sheet

If you have access to the computer program you only need to fill in columns 2 and 3 of this table. The computer will do the rest.

| Property location: | | | |
|---|---|---|---|
| | | Date: | |
| **Span #** | **Catch can position number** | **Volume collected in can mL** | **Weighted Catch**<br>**Column 2 x Column 3** |
| | 1 | | |
| | 2 | | |
| | 3 | | |
| | 4 | | |
| | 5 | | |
| | 6 | | |
| | 7 | | |
| | 8 | | |
| | 9 | | |
| | 10 | | |
| | 11 | | |
| | 12 | | |
| | 13 | | |
| | 14 | | |
| | 15 | | |
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| | 29 | | |
| | 30 | | |
| | 31 | | |
| | 32 | | |
| | 33 | | |
| | 34 | | |
| | 35 | | |
| | 36 | | |

| Calculating the Mean Application per pass | | |
|---|---|---|
| **Fill in column 4 of the table by multiplying column 2 by column 3 for each can position.** | | |
| **Total of all the used position numbers**<br>Add up the numbers in Column 2 where water was collected in the can  Ignore empty can numbers. | **252 [TN]** | |
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| Use the catch can conversion table to convert mL to mm (113mm can used for example) | **=9.76 mm**<br>**Say 9.8 mm [MA]** | |
| Transfer the MA figure to the Application Results table (earlier) | | |

| **Calculating Distribution Uniformity** | | |
|---|---|---|
| Calculate ¼ of the weighted catches | **= TC ÷ 4**<br>**= 24598 ÷ 4**<br>**= 6149 [LQ]** | |

- Look through column 3 (the volumes) and **rank the lowest** amounts, 1st, 2nd 3rd etc. Do this for about one third of the cans..
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| Distribution Uniformity **[DU]** | **= LQDepth ÷ MA**<br>**= 8 ÷ 9.8**<br>**= 0.81**<br>**= 81 %** | |

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## Table 1 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.

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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**

**Converting mL to mm**

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| 114 | 10.2 |
| 115 | 10.4 |
| 120 | 11.3 |
| 125 | 12.25 |
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