EVALUATING A LATERAL MOVE IRRIGATION SYSTEM

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Contents

Equipment needed

To measure sprinkler coverage:

- Catchcans
- Weights to prevent catchcans blowing away
- A shovel to smooth catchcan 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
- Pegs or markers
- A calculator, a pen and evaluation sheets (you may need extra copies of the data sheets)
- Manufacturer's sprinkler performance charts

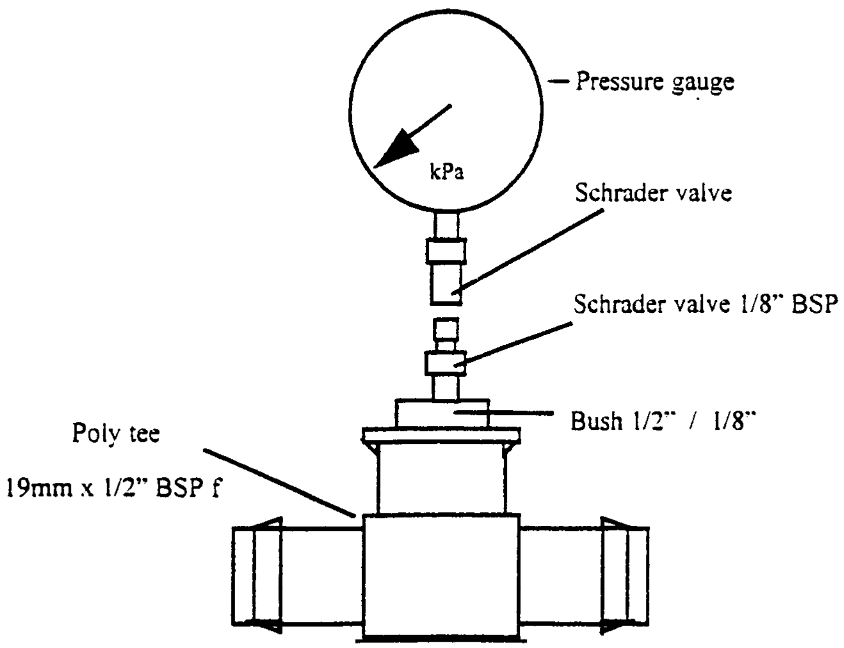
To measure flow:

- A container of known volume eg. 10 L bucket
- Stop watch

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
- Tees and fittings to install above pressure regulators (eg. Figure 1), sufficient for several emitters

Figure 1: Fittings and Schrader Valve



Evaluation method

To assess the performance of lateral or linear move irrigation system, it is necessary to measure the pressure at various points in the system, its operating speed and the output of the emitters using catchcans. To do this, work though the following procedure.

1. Record wind speed and direction (see Table 1). Field tests are ideally done in zero wind conditions and should not be done if the wind is stronger than a light breeze.
2. Fill out the first sections of the centre pivot data sheet with details about the crop, soils and the centre pivot. Measure the length of each span.

Water output measurement

3. Choose a suitable location for the test so that catchcans may be placed across the pathway of the boom or linear move. If possible, the location should be flat and level, and far enough ahead of the boom so that no water enters the catchcans before they are all set up.
4. Ideally, two rows of catch cans, with rows no more than 50m apart, should be used to check variation along the direction of travel.
   - Set out the catchcans no more than 5 metres apart. (For greater accuracy, use International Standard ISO 11545 maximum of 3m apart.)
5. Ensure that the cans are in a straight line parallel to the boom and that none will be displaced as the irrigator moves past.
   - Add at least two extra containers on each side to allow for changes in wind speed or direction.
   - If rain is likely, place another can away from the boom to record rain during the test. Any rain must be deducted from the amount caught in **each** catchcan.
6. When the system is operating, measure the length of the wetted width from the front to the rear of the boom. Placing a peg (or marker) at the limits of throw, then measuring the distance between the pegs after the machine has passed is the simplest way.
7. When the irrigator has completely passed over all of the catchcans, measure and record the volumes in **each** container. Each volume MUST be written in the correct space on the field record sheet. If there is no catch can or no reading at a position, leave it blank.
8. Spreadsheet calculators for converting catch can volume to depth, calculating average application, uniformity, etc. may be available from your irrigation advisor or agency.

Measuring pressure and flow

9. Record the make, model and nozzle size or colour of the emitters.
10. Attach tees and fittings (Figure 1) above the pressure regulator and emitter at selected emitters for measuring the pressure. Ideally you would select a known emitter from each span, for example the 3rd last emitter of each span. As a minimum you could select, at least one on the first span, one on the last span and one in between.
11. When the system is operating, record the pressure of the selected emitters using the pressure gauge. If a gauge is fitted, take a reading at the cart too.
12. When the system is operating, measure the flow rate by holding the large container of known volume under one emitter and timing how long it takes to fill. Record measurements from at least one emitter per span and note the span and emitter position numbers. If a flow meter is fitted, take a reading at the cart too.

Speed measurement

13. Measure the speed:
    - Place a marker or peg next to one wheel and then, say, 20 minutes later, place another next to the same wheel. (A longer time will give a more accurate result.)
14. Record the distance covered and time.
15. Record the control panel settings/readings.
16. Measure and record the tyre sizes and pressures.

Example data is provided to show methods of calculations. A blank data sheet is also provided.

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

Lateral Move Data Sheet – Example

Property name: *Flatland* **Date of field test:** *3rd March 2008*

Location/block	*Paddock 5 blocks 4,5,6*
Crop	*Lucerne*
Soil texture of Block	*Self-mulching clay*
Effective root depth	*1,000* mm
Rootzone RAW	*83* mm
Max. infiltration rate	*50* mm/h
Designed Flow Rate	*4500* USGPM *284* L/s
Designed pressure	*30* psi *206* kPa
Emitter make	*Nelson*
Emitter model	*D3000B*
Nozzle type/size	*#31* *6.15* mm
Pressure regulated?	*Yes – 10 psi*
Emitter spacing	*3.3* ft *1.0* metres
Length of spans	*161* ft *49.1* metres
No. of spans	*18*
Number of emitters per span	*48*
Length of overhang	cart side: *16.7 m* other side: *8.4 m*
No. emitters on overhang	*11*
Total length	*2910* ft *887* metres
End gun(s) present?	YES *NO*
End gun radius	*n/a*
Emitter wetted width	*11.4* metres
Irrigation run length	*2,900* metres
Irrigable area	*887m x 2900m = 2,572,300 m^2 = 257 ha*
Speed setting and depth applied – taken from control panel	*25% (15.2mm application)*
Time to travel test distance	*9* minutes *10* seconds
Distance travelled	*10* metres
Catchcan diameter	*113* mm
Catchcan spacing	*3.0* Metres
Wind speed and direction	*Light Breeze from North west*

Lateral Move Data Sheet

Property name: **Date of field test:**

Location/block	
Crop	
Soil texture of Block	
Effective root depth	mm
Rootzone RAW	mm
Max. infiltration rate	mm/h
Designed Flow Rate	USGPM L/s
Designed pressure	psi kPa
Emitter make	
Emitter model	
Nozzle type/size	mm
Pressure regulated?	
Emitter spacing	Ft metres
Length of spans	ft metres
No. of spans	
Number of emitters per span	
Length of overhang	cart side: other side:
No. emitters on overhang	
Total length	ft metres
End gun(s) present?	YES NO
End gun radius	
Emitter wetted width	metres
Irrigation run length	metres
Irrigable area	
Speed setting and depth applied – taken from control panel	
Time to travel test distance	minutes seconds
Distance travelled	metres
Catchcan diameter	mm
Catchcan spacing	metres
Wind speed and direction	

Checking System Capacity – example

System Capacity or	= Daily pump flow rate (L/day) ÷ Field irrigated area (m^2) = Pump flow rate (ML/day) x 100 ÷ Field irrigated area (ha)	
Daily pump flow rate	= *284* L/s = *284* x 3600 secs x 24 hrs L/day = *24,537,600* L/day = *24.54* ML/day	
System Capacity	= *24,537,600* ÷ *2,572,300* m^2 = *9.5* mm/day	

Max daily crop water use = Max daily Point Potential ET x Crop Coefficient (Kc)		
Max daily PPET	8.0 mm/day	PPET
Peak Kc (lucerne)	1.15	Kc
Max daily crop water use (CWU)	= PPET x Kc = 8.0 x 1.15 = 9.2 mm/day	CWU

Allowance must be made for:

- Pump Utilisation Ratio (P.U.R) – the proportion of the total possible time that pumping is actually occurring. This may be reduced for spraying, cultivating, machine and pump maintenance, dry movement of lateral move, refuelling, etc.

- Application Efficiency (Ea) – loss of water between the nozzle and root zone

This is the ***Managed*** System Capacity, and it should be at least equal to Max. daily CWU.

Pump Utilisation ratio:	0.80 (80%)	PUR
Application Efficiency:	0.90 (90%)	Ea
Managed System Capacity	= System Capacity x P.U.R x Ea = 9.5 x 0.80 x 0.90 = 6.8 mm/day	
Is Managed System Capacity adequate?	*No*	

Check tyre pressures – example

Tyre size:	16.9 x 24	
Tyre pressures – recommended	100 kPa (15 psi)	
Tyre pressures – measured	205 kPa (30 psi)	

Checking System Capacity

System Capacity **or**	**= Daily pump flow rate (L/day) ÷ Field irrigated area (m^2)** **= Pump flow rate (ML/day) x 100 ÷ Field irrigated area (ha)**	
Daily pump flow rate	**= L/s** **= x 3600 secs x 24 hrs L/day** **= L/day** **= ML/day**	
System Capacity	**= ÷ m^2** **= mm/day**	
Max daily crop water use = Max daily Point Potential ET x Crop Coefficient (Kc)		
Max daily PPET	**mm/day**	**PPET**
Peak Kc		**Kc**
Max daily crop water use (CWU)	**= PPET x Kc** **= x** **= mm/day**	**CWU**

Allowance must be made for:

- Pump Utilisation Ratio (P.U.R) – the proportion of the total possible time that pumping is actually occurring. This may be reduced for spraying, cultivating, machine and pump maintenance, dry movement of lateral move, refuelling, etc.

- Application Efficiency (Ea) – loss of water between the nozzle and root zone

This is the ***Managed*** System Capacity, and it should be at least equal to max. daily CWU.

Pump Utilisation ratio:		**PUR**
Application Efficiency:		**Ea**
Managed System Capacity	**= System Capacity x P.U.R x Ea** **= x x** **=**	
Is Managed System Capacity adequate?		

Check tyre pressures

Tyre size:		
Tyre pressures – recommended	**kPa psi**	
Tyre pressures – measured	**kPa psi**	

Catchcan record sheet – example

Span no. – east side	Catchcan position	Volume collected (mL)	Divide volume by conversion factor (Table 2)	Depth (mm)
1	1	0	÷ 10	0
1	2	190	÷ 10	19
1	3	250	÷ 10	25
1	4	210	÷ 10	21
1	5	230	÷ 10	23
1	6	250	÷ 10	25
1	7	300	÷ 10	30
1	8	300	÷ 10	30
1	9	310	÷ 10	31
1	10	380	÷ 10	38
1	11	400	÷ 10	40
1	12	380	÷ 10	38
1	13	200	÷ 10	20
1	14	250	÷ 10	25
1	15	300	÷ 10	30
1	16	380	÷ 10	38
1	17	280	÷ 10	28
1	18	190	÷ 10	19
1	19	170	÷ 10	17
1	20	200	÷ 10	20
1	21	250	÷ 10	25
1	22	280	÷ 10	28
1	23	250	÷ 10	25
1	24	250	÷ 10	25
1	25	180	÷ 10	18
1	26	220	÷ 10	22
1	27	200	÷ 10	20
1	28	0	÷ 10	0
1	29	-	÷ 10	-
1	30	-	÷ 10	-
	TOTAL	**6800**	÷ 10	680 **A**
Number of cans with water				26 **C**

Converting mL to mm of irrigation

To convert volume into depth (millimetres) a conversion factor is needed – listed in Table 2. Select a conversion factor by measuring the diameter of the mouth of the catchcan

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

If the cans collected 674 mL, then the conversion is the 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.

For catch-cans of 110 to 115 mm diameter across the top, dividing the collected amount by 10 to get mm of irrigation is likely to be accurate enough. For instance if you collected 674 mL, this approximates closely to a depth of 67.4 mm.

Table 2

Diameter of catchcan (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

If using 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

“volume collected mL” ÷ 40 = ………. mm

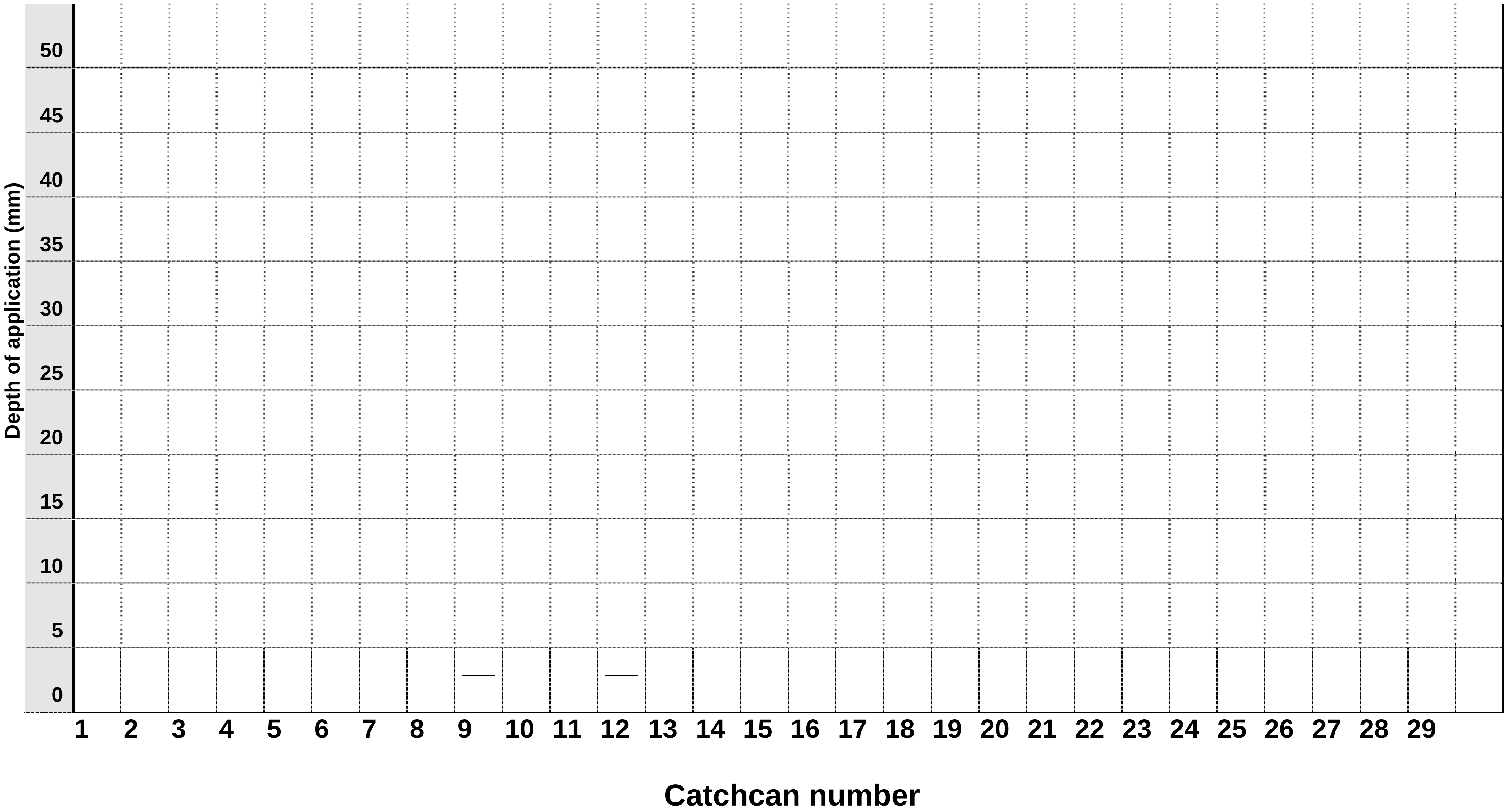
Catchcan record sheet

Span no.	Catchcan position	Volume collected (mL)	Divide volume by conversion factor (Table 2)	Depth (mm)
	TOTAL		÷	**A**
Number of cans with water				**CC**

Example of a spreadsheet calculator for converting catch can volume to depth

	Catch Can	Row 1 Volume (mL)	Row 1 Depth (mm)	Row 2 Volume (mL)	Row 2 Depth (mm)
Span 1	1	125	13.15	155	16.31
	2	170	17.89	250	26.31
	3	170	17.89	210	22.10
	4	175	18.41	245	25.78
	5	225	23.68	150	15.78
	6	205	21.57	170	17.89
	7	235	24.73	160	16.84
	8	200	21.05	250	26.31
	9	210	22.10	190	19.99
	10	210	22.10	x	x
	11	X	X	230	24.20
	12	X	X	290	30.52
	13	165	17.36	200	21.05
	14	X	X	230	24.20
	15	X	X	160	16.84
	16	X	X	X	X
Span 2	17	X	X	X	X
	18	X	X	240	25.25
	19	X	X	X	X
	20	X	X	X	X
	21	132	13.89	X	X
	22	X	X	X	X
	23	X	X	192	20.20
	24	X	X	180	18.94
	25	X	X	200	21.05
	26	110	11.57	X	X
	27	X	X	170	17.89
	28	183	19.26	207	21.78
	29	200	21.05	156	16.42
	30	160	16.84	156	16.42
	31	195	20.52	126	13.26
	32	137	14.42	192	20.20
Span 3	33	91	9.58	84	8.84
	34	197	20.73	190	19.99
	35	202	21.26	167	17.57
	36	166	17.47	200	21.05
	37	147	15.47	144	15.15
	38	197	20.73	220	23.15
	39	112	11.79	168	17.68
	40	150	15.78	200	21.05
	41	131	13.78	180	18.94
	42	185	19.47	208	21.89
	43	140	14.73	X	X
	44	178	18.73	256	26.94
	45	156	16.42	232	24.41
	46	172	18.10	234	24.62
	47	190	19.99	268	28.20
	48	87	9.15	218	22.94

Graph of depths



Calculating the average application depth and rate

Average Application Depth = Total application depth collected ÷ Number of catchcans with water		
Average Application Depth (AAD) – example	**= A ÷ CC** **=** *680* **÷** *26* **=** *26.2* **mm**	
Average Application Depth (AAD)	**= A ÷ CC** **= ÷** **= mm**	**AAD**
AAD – specified	**At _______ % speed (control panel) setting:** ***mm inches***	
Difference between measured and specified AAD:		
Travel speed = distance travelled during test ÷ time taken during test		
Distance travelled during test	**………………. metres**	**E**
Irrigator test time	**…….. minutes …….. seconds**	**F**
Travel speed	**= E ÷ F** **= ………. ÷ ……………….** **= ……………… m/sec** **= ……………… m/min** **= …………….. m/hour**	**S**
Difference between measured and specified speed:		
Average Application Rate (AAR) = emitter flow (L/h) ÷ (wetted width x emitter spacing)		
Sprinkler wetted width	**…………………. metres**	**G**
Emitter spacing	**………………… metres**	**ES**
AAR	**= (EF x 3600) ÷ (ES x G)** **= (x 3600) ÷ (x)** **= ( ) ÷ ( )** **= mm/h**	**AAR**

Calculating Distribution Uniformity (DU)

Spreadsheet calculators for DU may be available from agencies, consultants, etc.

Distribution Uniformity compares the average of the lowest quarter of the catch can depths to the average of all the catch can depths.

Determining Lowest Quarter catch cans – example:

Number of Catchcans *with water*	26 **cans**	CC
One quarter of catchcans [LQ cans] Divide number of catchcans by 4	**= CC ÷ 4** **=** 26 **÷ 4** **=** 6.5 **=** 7	**LQ cans**
On your Catchcan record sheet highlight the lowest amounts for the number of LQ cans. *These are you Lowest Quarter Catchcans (LQ Cans)*		
Total depth of the selected LQ cans	**=** 19 + 20 + 19 + 17 + 20 + 18 + 20 **=** 133 **mm**	B

Number of Catchcans *with water*	**cans**	**CC**
One quarter of catchcans [LQ cans] Divide number of catchcans by 4	**= CC ÷ 4** **= ………. ÷ 4** **=**	**LQ cans**
Total depth of the selected LQ cans	**=** **= mm**	**B**
Average depth Lowest Quarter (LQ) cans = Total depths LQ cans ÷ no. LQ cans		
Average depth of LQ	**= B ÷ LQ cans** **= ÷** **= mm**	C
Distribution Uniformity = Average depth of LQ cans ÷ AAD		
DU	**= C ÷ AAD x 100** **= ÷ x 100** **= %**	DU

Calculating Coefficient of Uniformity (CU)

Spreadsheet calculators for CU may be available from agencies, consultants, etc.

Coefficient of Uniformity is a measure of the deviation of each catch can depth from the average catch can depth.

Calculation of Absolute Deviation – example:

Span no. – east side	Catchcan position	Catchcan depth (mm)	Average Application Depth (AAD)	Absolute deviation (mm-AAD) (without + or -)
1	1	0	26.2	-
1	2	19	26.2	7.2
1	3	25	26.2	1.2
1	4	21	26.2	5.2
1	5	23	26.2	3.2
1	6	25	26.2	1.2
1	7	30	26.2	3.8
1	8	30	26.2	3.8
1	9	31	26.2	4.8
1	10	38	26.2	11.8
1	11	40	26.2	13.8
1	12	38	26.2	11.8
1	13	20	26.2	6.2
1	14	25	26.2	1.2
1	15	30	26.2	3.8
2	16	38	26.2	11.8
2	17	28	26.2	1.8
2	18	19	26.2	7.2
2	19	17	26.2	9.2
2	20	20	26.2	6.2
2	21	25	26.2	1.2
2	22	28	26.2	1.8
2	23	25	26.2	1.2
2	24	25	26.2	1.2
2	25	18	26.2	8.2
2	26	22	26.2	4.2
2	27	20	26.2	6.2
2	28	0	26.2	-
2	29	-	26.2	-
2	30	-	26.2	-
Total Absolute Deviation				139.2 **V**

Calculation sheet for Absolute Deviation:

Span no. – east side	Catchcan position	Catchcan depth (mm)	Average Application Depth (AAD)	Absolute deviation (mm-AAD) (without + or -)
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
	13			
	14			
	15			
	16			
	17			
	18			
	19			
	20			
	21			
	22			
	23			
	24			
	25			
	26			
	27			
	28			
	29			
	30			
Total Absolute Deviation				**V**

Calculating Mean Absolute Deviation and CU – example:

Mean absolute deviation	**= Total Absolute Variation ÷ CC** **= V ÷ CC** **=** 139.2 ÷ 26 **=** 5.35	MV
Coefficient of Uniformity ~ Mean Absolute Variation ÷ AAD		
CU	**= 1 – (MV ÷ AAD) x 100** **= 1 –** (5.35 ÷ 26.2**) x 100** **= 1 –** (0.20**) x 100** **=** 0.80 **x 100** **=** 80%	**CU**

Calculating Mean Absolute Deviation and CU:

Mean absolute deviation	**= Total Absolute Variation ÷ CC** **= V ÷ CC** **= ÷** **=**	MV
Coefficient of Uniformity ~ Mean Absolute Variation ÷ AAD		
CU	**= 1 – (MV ÷ AAD) x 100** **= 1 – (÷) x 100** **= 1 – ( ) x 100** **= x 100** **= %**	**CU**

DU and CU conventional benchmark, no-wind: 90%

If the DU or CU is ***below*** an acceptable benchmark, then changes to the irrigation system may be required in order to improve it.

Relationship between DU and water depth variation: ('Chemigation and Fertigation Basics for California' 2003, CalPoly)

DU	Ratio of max depth to min depth
70%	2.2
75%	1.9
80%	1.7
85%	1.5
90%	1.3
95%	1.1

2.2 means the highest watered area receives 2.2 times or 120% more than the lowest

1.1 means the highest watered area receives 1.1 times or 10% more than the lowest

Flow measurements

Volume of large container: _______________ Lc

	Nozzle type	Time for …….. Lc (Seconds)	Flow – measured Lc ÷ B (L/s)	Flow – as per system design (L/s)	Flow difference C – D	Flow variation E ÷ D x 100 (± %)
	A	B	C	D	E	F
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Span: sprinkler:						
Average flow:			EF			

Calculating flow variation

Maximum Flow Rate	**…………… L/s**	**H**
Minimum Flow Rate	**…………… L/s**	**I**
Add the maximum and minimum flow	**= MAXIMUM + MINIMUM** **= H + I** **= ……... + ………** **= ………………..**	**J**
Divide the result by two to give the midpoint. Midpoint flow is	**= J ÷ 2** **= ….……. ÷ 2** **= ….….…. L/sec**	**K**
Take the midpoint from the maximum	**= Maximum – midpoint** **= H – K** **= ……… – ……..** **= …………**	**L**
Divide the difference by the midpoint	**= L ÷ K** **= ….. ÷ ……..** **= …………**	**M**
Multiply by 100 to get a percentage	**= M x 100** **= ….. x 100**	
Flow variation is written as a ± %	 **= ± ………. %**	

A variation of more than ± 5% may be unacceptable.

Pressure measurements

	Pressure measured above regulator kPa (psi)	Pressure specified above regulator kPa (psi)	Pressure difference A – B	Pressure Variation C ÷ B x 100 (%)
	A	B	C	D
Specified regulator pressure:				
Cart:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Span: sprinkler:				
Average of sprinklers:				

Note that for pressure regulators to work properly, the pressure above a regulator should be at least 35 kPa (5 psi) higher than the specified regulator pressure.

Calculating sprinkler pressure variation

Maximum Pressure	**……………. kPa**	**N**
Minimum Pressure	**…………… kPa**	**O**
Add the maximum and minimum pressures.	**= maximum + minimum** **= N + O** **= ……. + ……….** **= ………… kPa**	**P**
Divide the result by two. This gives the midpoint pressure	**= P ÷ 2** **= ……… ÷ 2** **= ………. kPa**	**Q**
Take the midpoint from the maximum.	**= maximum – midpoint** **= N – Q** **= ………… – ………….** **= ……… kPa**	**R**
Divide the difference by the midpoint.	**= R ÷ Q** **= ………. ÷ ………….** **= …………….**	**U**
Multiply by 100 to get a percentage.	**= U x 100** **= …….. x 100** **= ………. %**	
Pressure variation is:	**= ± ……… %**	

A variation of more than ± 10% is probably unacceptable and suggests poor system design.

Rough cross check – pump flow rate from catch can test

No. emitters x average emitter flow rate **Overall flow rate**	**= *………..* sprinklers x …….. L/s** **= …………. L/s**
Pump flow rate – specified	**= *…………..* L/s**
How does the specified compare to the overall?	