Water Strategies
Irrigation
WOF

Irrigation WOF

Irrigation Performance Test

Farm X

X 2020

Report Number:	WSXXX
Report Prepared By:	X
Date	X/X/2020
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Assessment Summary

An assessment of X Farm irrigation system was undertaken by X of Water Strategies during X 2020.

The scope of the assessment was an ***Irrigation Performance Test***:

- A performance test of the irrigator pressures, flows, actual irrigation depth and the uniformity of application.

The testing methodologies used comply with ISO 11545, ANSI/ASAE S346.1 and the New Zealand Performance Assessment code of practice 2014.

The wind speed during the performance tests was between 0 m/s and 1.2 m/s. This is within permissible testing limits.

Findings:

Specific results can be found in the test results table on page 7

- The pressure to pivots 1, 2, 3 and 4 was adequate for them to operate.
- For pivot 5 the centre pressure at the time of the test was 170 kPa. It should be noted pivot 5 was tested in the downhill position (approximately 2m elevation to the center point) so there was adequate pressure for it to operate at the time of testing. However, if the pivot had been in the uphill position (approximately 4m elevation from the centre point) there would not have been enough pressure. Each meter of head (elevation) requires 9.8 kPa of pressure and for a 103 kPa (15psi) regulator to operate correctly it requires > 138 kPa (20psi) of pressure above it.
- The flow rates to the pivots were adequate for them to operate.
- The application depths of the pivots differed from the control panel application by between 10 and 18%.
- None of the pivots met the minimum lower quartile distribution uniformity (DU_{lq}) standard of >0.80.
- Only pivot 2 met the recommended upper quartile distribution uniformity (DU_{uq}) standard of < 1.25
- Only pivot 2 met the international coefficient of uniformity (CU) standard of > 85%.
- The instantaneous application rates (IAR) of each pivot are within the maximum infiltration rate of the soils found on the property (between 25 and 30 mm/hr).

- For pivots 1, 2, 3 and 4 field observations and the uniformity graphs show the poor to fair uniformity issues are related to the boom back sprinklers around each tower.
- For pivot 5 field observations and the uniformity graph show the poor uniformity issue is related to the entire sprinkler package. The endgun was also applying water over a stream during the test.

Recommendations:

- The sprinkler package for all pivots need to be redesigned so each pivot meets the minimum DU_{lq} standard of >0.80. This must include assessing the current boom back sprinkler design.
- When redesigning the sprinkler package close attention must be paid to the IAR. For the silt loam soil types found on the property the maximum instantaneous application rate of the pivot at the end of the overhang (after the last tower) should not exceed 30 mm/hr.
- The control panel application depth setting inputs should be checked for all pivots.
- The endgun arc settings for pivot 5 should be checked.
- Fluctuations in pressure from the CPW water supply need to be closely monitored. Ideally a minimum operating pressure (particularly for pivot 5) should be established and an alarm or cut-off set accordingly.

Good Farming Practice Assessment

Expectation	Comment
New and upgraded irrigation systems	None of the pivots meet the new irrigation system Good Farming Practice expectation because the distribution uniformity standard of 0.8 is not being met.
Annual assessment & maintenance	N/A
Timing & depth of irrigation meet plant demand	N/A
Management systems	N/A

Irrigation Assessment Results

Full Irrigation Assessment (Performance Test & Scheduling Assessment)			☐
Irrigator Performance Test	☒	Irrigation Scheduling Assessment	☐

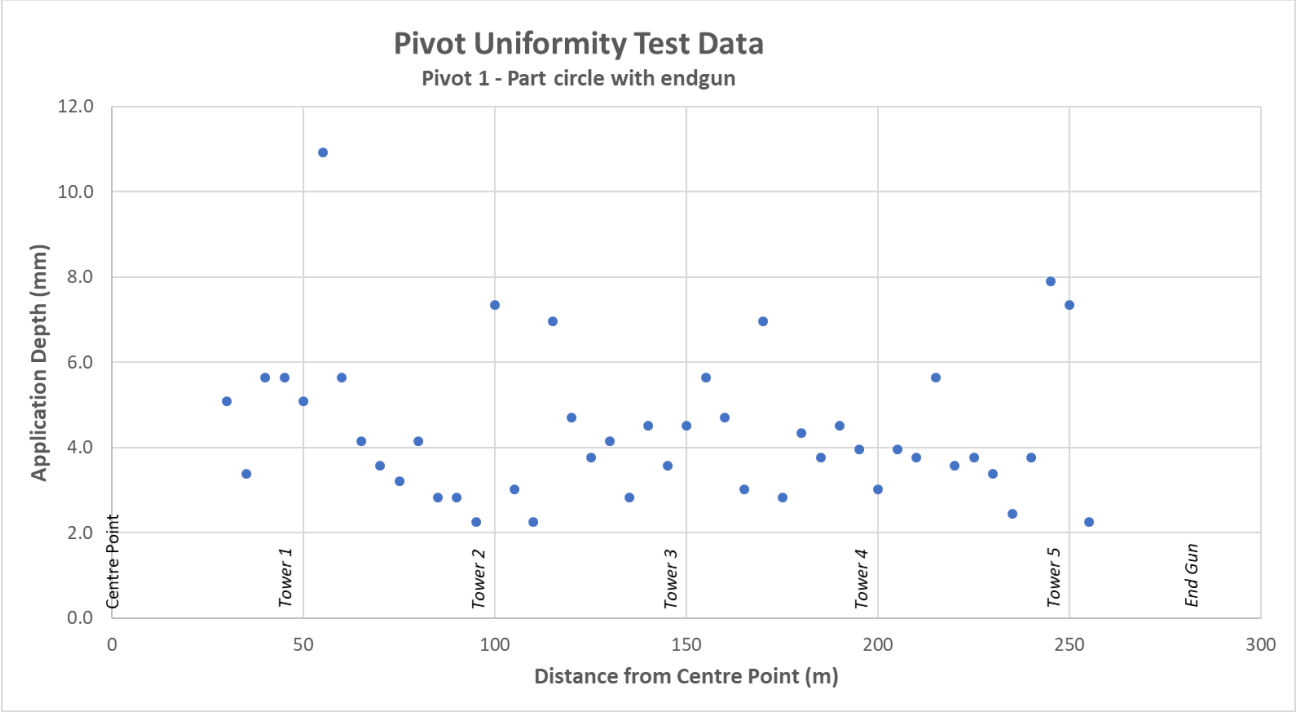
Performance Test:

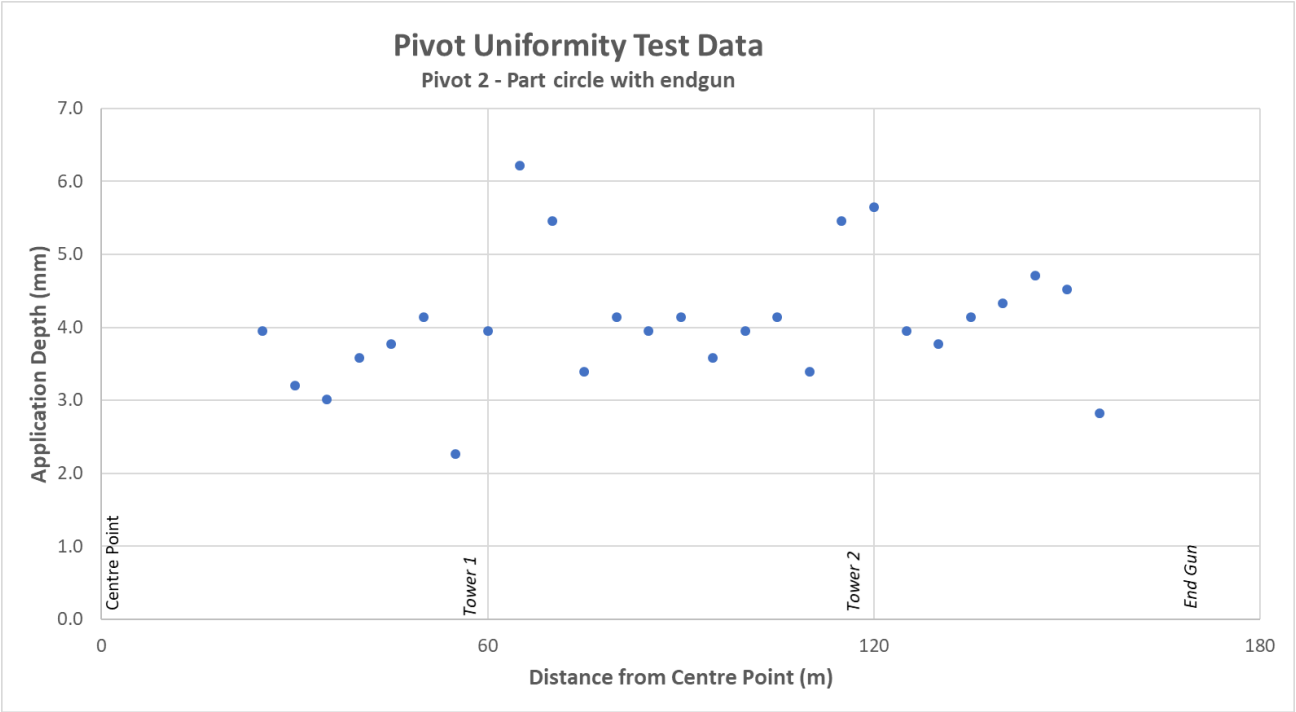
Irrigator Performance	Pivot 1	Pivot 2	Pivot 3	Pivot 4	Pivot 5
Application depth (mm) (control panel)	5	5	5	5	5.1
Application depth (mm) (measured)	4.3	4.1	4.3	4.5	4.5
Flow Rate (l/s) (design)	6.3	6	5.7	10.2	15.7
Flow Rate (l/s) (check flow meter)	6.3	6.1	5.7	10.8	13.5
Centre Pressure (kPa) (centre point)	360	360	390	420	170
End Pressure (kPa) (above end regulator)	260	320	350	320	190
End Pressure (kPa) (below end regulator)	100	100	100	100	100
Pivot Speed (m/min) (at test depth)	0.51	1.03	1.14	0.64	0.75
Rotation time (hours) (at test depth)	21.98	5.36	7.42	24.04	26.19
System capacity (mm/day) (design)	5.0	5.0	9.5	5.0	5.0
System capacity (mm/day) (calculated)	5.6	17.0	10.2	5.0	4.5
*Weighted Distribution Uniformity (DU_{lq})[1]	0.63	0.75	0.73	0.67	0.64
*Weighted Distribution Uniformity (DU_{uq})[2]	1.59	1.23	1.38	1.48	1.33
*Weighted Co-efficient of Uniformity (CU)[3]	70.6	85.4	78.5	74.5	77.1
Instantaneous Application Rate (IAR) (mm/hour)	15.8	26.5	25.0	16.3	19.9

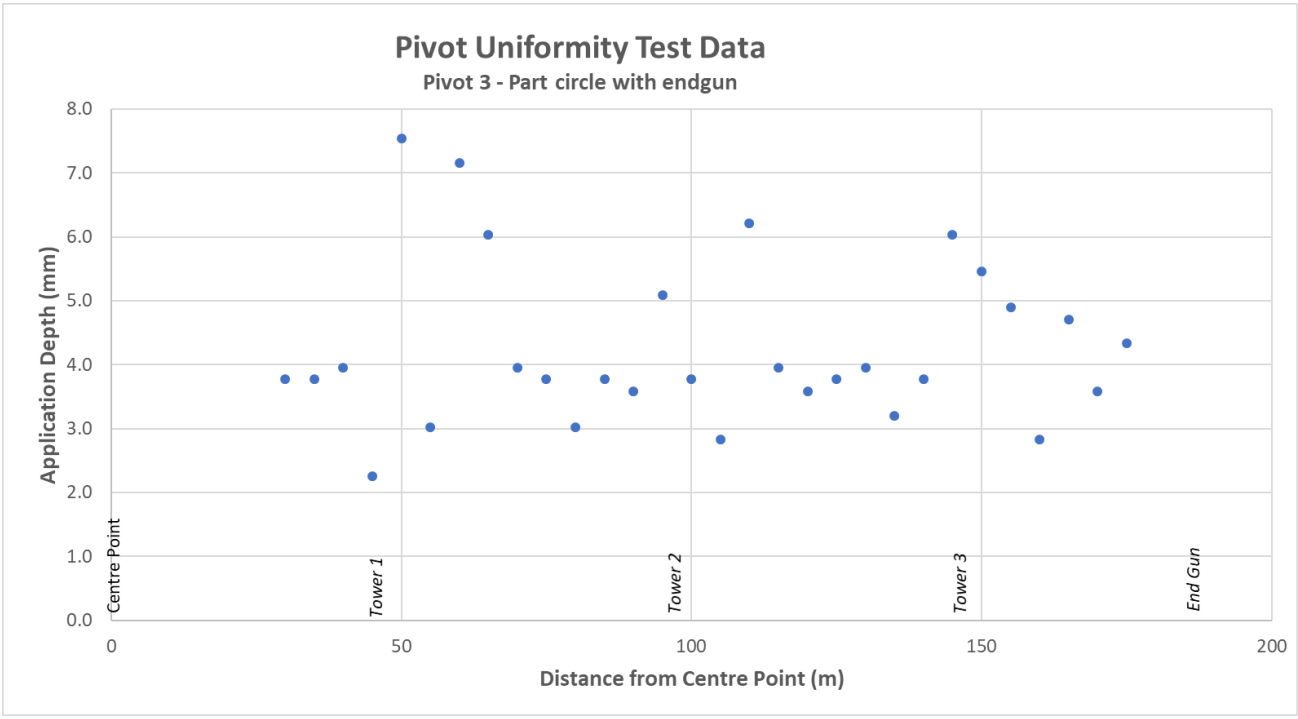
*Calculations exclude the endgun test data

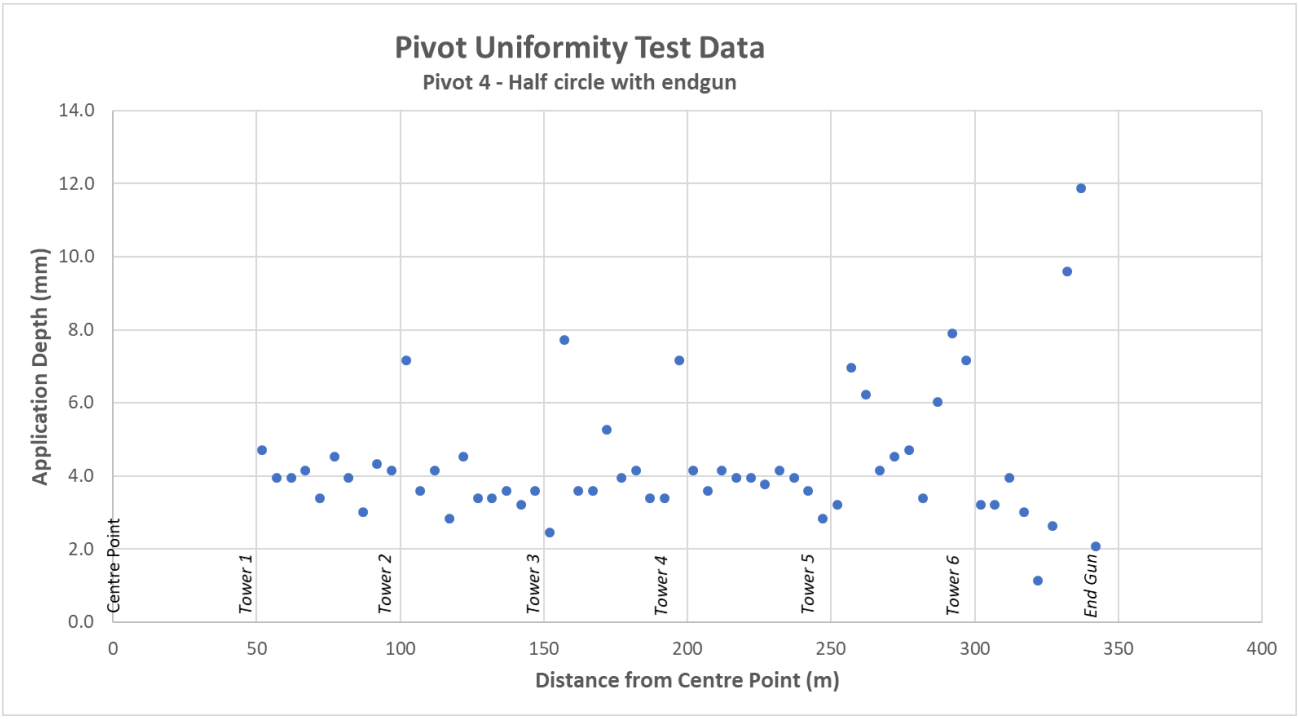
[1] See Appendix A for an explanation of lower quartile distribution uniformity
[2] See Appendix A for an explanation of upper quartile distribution uniformity
[3] See Appendix A for an explanation of coefficient of uniformity

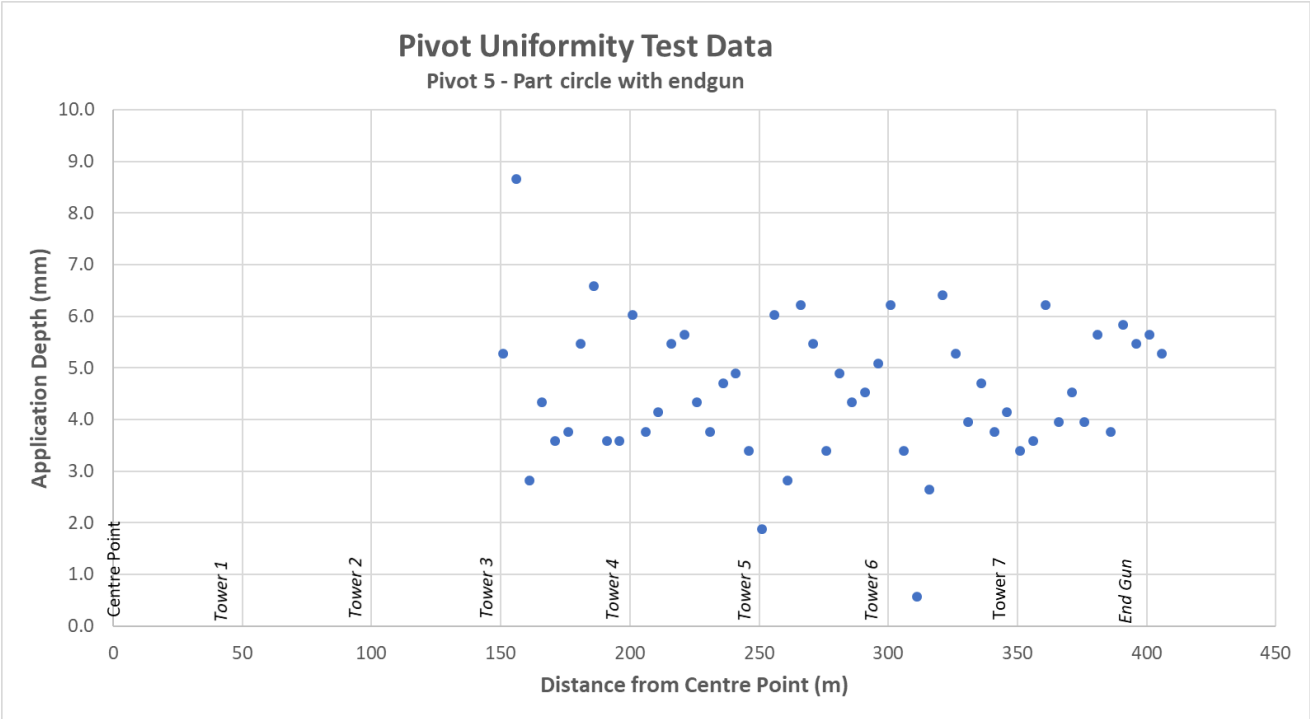
Uniformity and Depth Graphs






Pivot Uniformity Test Data
Pivot 3 - Part circle with endgun
Application Depth (mm)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Centre Point
Tower 1
Tower 2
Tower 3
End Gun
0
50
100
150
200
Distance from Centre Point (m)


Pivot Uniformity Test Data
Pivot 4 - Half circle with endgun
Application Depth (mm)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Centre Point
Tower 1
Tower 2
Tower 3
Tower 4
Tower 5
Tower 6
End Gun
0
50
100
150
200
250
300
350
400
Distance from Centre Point (m)


Pivot Uniformity Test Data
Pivot 5 - Part circle with endgun
Application Depth (mm)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Centre Point
Tower 1
Tower 2
Tower 3
Tower 4
Tower 5
Tower 6
Tower 7
End Gun
0
50
100
150
200
250
300
350
400
450
Distance from Centre Point (m)

Irrigation Assessment Methodology

An assessment of X Farm irrigation was undertaken by X on X 2020.

The wind speed during the performance tests was between 0 m/s and 1.2 m/s. This is within permissible testing limits.

The scope of the assessment was an ***Irrigation Performance Test***.

- A performance test of the irrigator pressures, flows, actual irrigation depth, the uniformity of application and topography in relation to individual tower location.

The irrigation system assessment methodology used complies with:

- ISO 11545;
- ANSI/ASAE S346.1; and
- IrrigationNZ Code of Practice for Performance Assessment (2014).

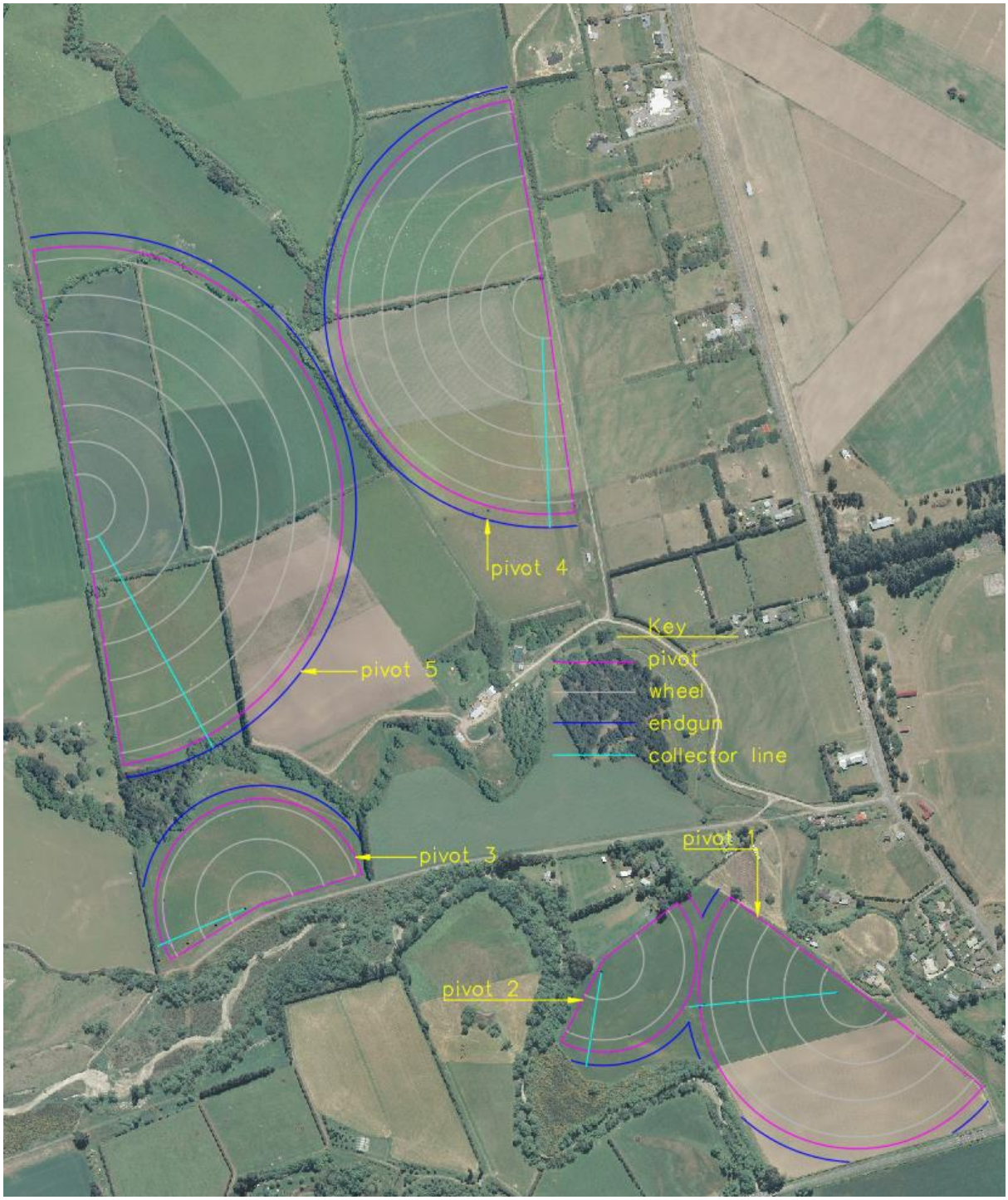
Appendix B contains a detailed description of the irrigation system performance testing procedures.

Background Information

Irrigators

System	Description	Design Specifications (where available)
Pivot 1	• Part-circle 176º • 237 m length • 9.46 ha • 1 year	• Flow Rate – 6.3 l/s • Centre Pressure – 180 kPa • System Capacity – 5 mm/day
Pivot 2	• Part circle – 186º • 138 m length • 3.1 ha • 1 year	• Flow Rate – 1.3 l/s • Centre Pressure – 200 kPa • System Capacity – 5 mm/day
Pivot 3	• Part circle – 198º • 159 m length • 4.6 ha • 1 year	• Flow Rate – 5.7 l/s • Centre Pressure – 350 kPa • System Capacity – 4.85 mm/day
Pivot 4	• Part circle – 180º • 312 m length • 13.8 ha • 1 year	• Flow Rate – 10.2 l/s • Centre Pressure – 430 kPa • System Capacity – 5 mm/day
Pivot 5	• Part circle – 180º • 390 m length • 26.2 ha • 1 year	• Flow Rate – 15.7 l/s • Centre Pressure – 370 kPa • System Capacity – 5 mm/day

Farm Irrigation Layout



Appendix A: Uniformity Explanation

Distribution Uniformity

Distribution uniformity (DU) is a measure of how evenly water is applied to the area being watered. It is expressed as a ratio. The DU should not be confused with the coefficient of uniformity (CU) which is explained below.

The most common measure of DU for is the low quarter DU expressed as DU_{lq}. This is a measure of the average of the lowest quarter of samples, divided by the average of all samples. The higher the DU_{lq}, the better the uniformity of application, i.e. if all samples are equal, the DU_{lq} is 1.0.

For pivots Water Strategies uses the weighted version of the above formula. This recognises that a greater area is irrigated as you move from the centre outwards.

The table below provides a performance rating in relation to the DU_{lq} value. A value of >0.80 is regarded as the minimum standard in NZ.

> 0.90	Excellent
0.80 – 0.89	Good
0.70 – 0.79	Fair
0.60 – 0.69	Poor
> 0.59	Extremely Poor

Source: NZ Performance Assessment Code of Practice 2014

The other DU measure, which can be used for irrigation but is more commonly used for land based effluent applications, is the upper quartile DU expressed as DU_{uq}. It provides a measure of the overwatering risk. Its calculation differs from the lower quartile as the upper quartile of samples is instead divided by the average of all samples. The DU_{uq} standard for land based effluent application is <1.25 (Farm Dairy Effluent Code of practice 2013).

Christiansen's uniformity coefficient

Christiansen's uniformity coefficient (CU) is widely used overseas as a method of calculating the uniformity of irrigation applications. It is calculated by the average depth of irrigation water applied minus the average absolute deviation from this depth then being divided by the average depth applied. A low coefficient of uniformity indicates that water is distributed unevenly over the irrigated area. Well-designed systems should operate at a CU of > 85%.

For pivots the weighted version (Heermann-Hein) of the above formula is used. This recognises that a greater area is irrigated as you move from the centre outwards.

Appendix B: Methodology Detail

Testing Methodology – Center Pivot

The following methodology was used in addition to the methodology set out in the New Zealand Performance Assessment Code of Practice (2014):

1) Pressure test points were installed at the start and end, and for each test point pressures were taken above and below the regulator.
2) For standard pivot systems one line of collectors was used and the collectors placed 5 metres apart.
3) For variable rate pivot systems two lines of collectors were used with the lines starting 3 meters apart. The collectors were placed at 10 metre spacings in each line and offset by 5 metres between each line.
4) Each collectors position was measured to provides an accurate reading of distance from the centre point. This ensures the weighting of the volumes collected is accurate and any issues arising from the test results can be related to a specific location on the machine.
5) A Siemens FUP1010 flow meter was installed at the centre point to provide flow measurement readings during the test.
6) The pivot was run at a 5 mm application rate.
7) The following data was recorded:
    - Centre pressure
    - Pressure readings above and below the end regulator
    - Flow rate
    - Machine speed at the last span tower
    - Span lengths, end overhang length and where applicable endgun radius and corner arm length
    - Wetted width at the end and at two thirds distance along the machine
    - Wind speed and temperature
    - Any general comments