RMCG

# Comparison of irrigation system costs – update 2018.

Farm Water Program

7th June 2018

| |
|---|
| *It should be noted that the information provided in this report is general in nature and any recommendations contained in this publication do not constitute advice by RMCG or the Goulburn Broken CMA and Farm Water consortium partners. No person should act on the basis of the contents of this publication, whether as to matters of fact or opinion or other content, without first obtaining specific, independent professional advice which confirms the information contained in this publication.* |

# 1 Executive Summary

The purpose of this report is to provide a simple financial comparison of the total costs of ownership of different irrigation systems that are installed at current recommended practice in northern Victoria. These were estimated for efficient systems and inefficient pumped systems. This was done in 2014 using 2014 cost assumptions and then updated in 2018 with new power, water and labour cost assumptions, especially after water prices had risen. The 2014 results are shown alongside the 2018 results.

The overall conclusion for the 2018 costs is that drip and centre pivot irrigation had lower total costs than other forms of irrigation. Using the 2014 assumptions, which included lower water costs, then there was little difference between systems.

However, in both 2014 and 2018 there is a large difference in the total costs for inefficient versus efficient systems, which suggests the design, maintenance and management of a system are important drivers of total costs.

Annual ownership costs comprise interest and depreciation on the value of a system. With existing systems these costs are sunk costs and can be the difference between staying with old system with no extra ownership costs and investing a new system, which entails additional ownership costs. For a farm with existing systems the additional ownership costs of a new system has to be less than the benefit of saved operating cost and potential productivity increase of a new system.

Systems with lower ownership costs tend to be better suited to farm enterprises that irrigate opportunistically, as fixed costs are lower when enterprises are dried off and water prices tend to be lower in years when they are used.

# 2 Purpose

The purpose of this report is to provide a simple financial comparison of the total costs of ownership of different irrigation systems that are installed at current recommended practice.

There is concern that systems are being adopted or encouraged on the basis of low capital costs, without consideration of the total costs of ownership of the different systems.

This paper compares systems for their ownership and annual cost components. It takes the view from a farm financial perspective.

This paper considers costs only, and so any crop productivity differences between the systems are ignored. It also ignores other important drivers such as affordability, business scale, labour utilisation or risk.

This paper considers the following irrigation systems:

- Gravity surface irrigation (channel) – border check
- Pipe and riser (pumped system) – border check
- Centre pivot sprinklers
- Subsurface drip.

All systems were assumed to be well designed and operated and were compared in two ways:

- As all pumped systems being efficient;
- using low efficiency in pumped systems that are below industry standards, but often typical of what is found in the field.

# 3 Analysis for efficient systems

## 3.1 INTRODUCTION

The financial costs of setting up and running an irrigation system includes capital costs – including interest and depreciation on the capital cost; or ownership costs. And annual costs due to operation and maintenance including power, repairs, motorbike, labour, and water costs. Each of these are calculated for a hypothetical 40 ha development.

## 3.2 CAPITAL COSTS

Data from Farm Water completed projects was compiled to assess farm capital costs per ha. These are shown in the Table 3-1 and Table 3-2 below. The costs adopted for this analysis is shown in Table 3-3.

**Table 3-1: Results of cost analysis[1] per combined ha different systems – completed projects from rounds 1 and 2** (As Round One NVIRP did not include all costs these have been excluded below.)

| SYSTEM | COST PER HA COMBINED | | |
|---|---|---|---|
| (Count of projects) | 10th percentile | Median | 90th percentile |
| Pipe and Riser (105) - mostly pumped systems for border check | $2,932 | $5,241 | $8,453 |
| Non pipe and Riser (154) - mostly gravity channel systems for border check | $2,250 | $5,002 | $7,467 |
| Sprinkler (7) – mostly centre pivot | $3,740 | $4,569 | $6,557 |

**Table 3-2: Results of cost analysis per combined ha different systems – quoted costs from round 3 VFMP tranche 1**

| SYSTEM | AVERAGE COST PER HA |
|---|---|
| Pipe and Riser (sum of pipe and riser + reuse + lasering) - mostly pumped systems for border check | $6,899 = $2,016 + $972 + $3,911 |
| Non pipe and Riser (sum of laser grade cost + reuse + channel upgrade) - mostly gravity channel systems for border check | $3,767 = $2,016 + $972 + $779 |
| Sprinkler (22) - mostly centre pivot | $5,498 |

An additional $1,000/ha has been added to typical costs to allow for unreported capital costs to match the experience from interviewed case studies. As below.

**Table 3-3: Adopted capital cost of different systems for this analysis**

| SYSTEM | TYPICAL $/HA SYSTEM COST BEFORE ADDITIONAL UNREPORTED COSTS | ADOPTED COST PER HA INCLUDING ADDITIONAL UNREPORTED COSTS OF $1,000/HA |
|---|---|---|
| Pipe and Riser | $6,500 | $7,500 |
| Non pipe and Riser | $5,000 | $6,000 |
| Sprinkler | $5,500 | $6,500 |

There were no drip irrigation projects in the sample analysed, so it has been assumed that the upfront capital costs for drip are $10,000/ha. This is in line with industry estimates.

[1] See Separate RMCG 2014 IAL Paper for details on methodology to calculate costs per ha

Annual ownership costs comprise interest and depreciation on the value of a system. With existing systems these costs are sunk costs and can be the difference between staying with old system with no extra ownership costs and investing a new system, which entails additional ownership costs. For a farm with existing systems the additional ownership costs of a new system has to be less than the benefit of saved operating cost and potential productivity increase of a new system.

Systems with lower ownership costs tend to be better suited to farm enterprises that irrigate opportunistically, as fixed costs are lower when enterprises are dried off and water prices tend to be lower in years when they are used.

The table below illustrates the ownership costs[2] of the different systems assuming a 40 ha project, 6% cost of capital, straight line depreciation and the life of components as listed, with nil salvage / residual value. Note in reality, individual projects will vary enormously depending upon the site, type of system etc.

**Table 3-4: Capital costs of different systems**

**Capital Costs for gravity channel surface irrigation (not pumped)**

| Item | New Value (2014 $) | Productive life (years) | Value at end of period ($) | Annual Depreciation ($/yr) | Annual Interest Cost of capital ($/year) | Total ownership costs ($/year) |
|---|---|---|---|---|---|---|
| Improved gravity surface irrigation | $ 240,000 | 25 | $ - | $ 9,600 | $ 14,400 | $ 24,000 |
| **TOTAL** | **$ 240,000** | | **$ -** | **$ 9,600** | **$ 14,400** | **$ 24,000** |
| per hectare | **$ 6,000** | | **$ -** | **$ 240** | **$ 360** | **$ 600** |

Note: This analysis assumes no pumping is required. The cost of installing a flood irrigation system can vary enormously, and these figures are presented as a guide only.

**Capital Costs for pumped PIPE AND RISER surface Irrigation**

| Item | New Value (2014 $) | Productive life (years) | Value at end of period ($) | Annual Depreciation ($/yr) | Annual Interest Cost of capital ($/year) | Total ownership costs ($/year) |
|---|---|---|---|---|---|---|
| pipe and riser pumped surface irrigation | $ 280,000 | 25 | $ - | $ 11,200 | $ 16,800 | $ 28,000 |
| Pump, motor | $ 20,000 | 15 | $ - | $ 1,333 | $ 1,200 | $ 2,533 |
| **TOTAL** | **$ 300,000** | | **$ -** | **$ 12,533** | **$ 18,000** | **$ 30,533** |
| per hectare | **$ 7,500** | | **$ -** | **$ 313** | **$ 450** | **$ 763** |

**Capital Costs for Centre Pivot Irrigation**

| Item | New Value (2014 $) | Productive Life (years) | Value at end of period ($) | Annual Depreciation ($/yr) | Annual Interest Cost of capital ($/year) | Total ownership costs ($/year) |
|---|---|---|---|---|---|---|
| **TOTAL** | **$ 260,000** | **15** | **$ -** | **$ 17,333** | **$ 15,600** | **$ 32,933** |
| per hectare | **$ 6,500** | | **$ -** | **$ 433** | **$ 390** | **$ 823** |
| | | | | -$ 0 | | |

**Capital Costs for Drip Irrigation**

| Item | New Value (2014 $) | Productive Life (years) | Value at end of period ($) | Annual Depreciation ($/yr) | Annual Interest Cost of capital ($/year) | Total ownership costs ($/year) |
|---|---|---|---|---|---|---|
| **TOTAL** | **$ 400,000** | **$ 15** | **$ -** | **$ 26,667** | **$ 24,000** | **$ 50,667** |
| per hectare | $ 10,000 | | **$ -** | **$ 667** | **$ 600** | **$ 1,267** |

It should be noted that systems with lower annual ownership costs, such as gravity surface irrigation in the above example, tend to be better suited to farm enterprises that irrigate opportunistically, as fixed costs will be lower when enterprises are dried off.

[2] Note 1 - This method of comparing costs is simpler than conducting a discounted cash flow. Note 2 –Using the adopted method above when charging interest costs a common convention (Barnard & Nix, Farm Planning & Control, 1982) is to charge the interest cost on half the initial capital cost on the grounds that the irrigation system is being written off and the depreciation charges could be reinvested until the system needs to be replaced. Alternatively a lower interest rate is sometimes used to account for this. In this case, in order to simplify, we have applied 6% across the entire initial capital cost. It could be argued that this may overestimate capital costs. Modifying these assumptions makes a small difference to the overall results. For example, it reduces the interest charges by $180/ha for gravity channel, $225/ha for pipe and riser, $195/ha for centre pivot and $300/ha for drip. This changes the annual ownership costs to be $420/ha gravity channel, $538/ha pipe and riser, $628/ha centre pivot and $967/ha for drip. i.e. the order of cheapest to most expensive is the same.

## 3.3 UNIT ASSUMPTIONS

The table below lists key assumptions.

**Table 3-5: Assumptions for different systems, 2018 figures in red, 2014 figures shown in blue**

**Assumptions used in the analysis**

| | | | | |
|---|---|---|---|---|
| ***Area irrigated:*** | 40.0 | hectares | | |
| | | | 2014 assumptions | |
| ***Water cost:*** | $275.00 | /ML, includes delivery charge | 125 | |
| | | plus temporary water price (equal to the annualised capital value) | | |
| ***Water use:*** | | | Range | |
| Gravity channel surface irrigation | 9.0 | ML/ha | 8.0 - 12.0 | ML/ha |
| Pipe and riser | 8.5 | ML/ha | 7.5 - 11.5 | ML/ha |
| Centre Pivot | 7.0 | ML/ha | 3.0 - 11.0 | ML/ha |
| Drip | 6.0 | ML/ha | 5.0 - 7.0 | ML/ha |
| ***Lateral Spacing:*** | | | | |
| Permanent/Temporary SDI | 1.0 | metres | | |
| ***Productive Life:*** | | | | |
| Improved Flood/Surface | 25 | years | | |
| Centre Pivot | 15 | years | | |
| Drip | 15 | years | | |

***Pumping:***

| | centre pivot | drip | pipe & riser |
|---|---|---|---|
| Pump size (kW) | 30 | 16 | 17 |
| Number of shifts | 1 | 6 | 20 |
| Application rate (mm/hr) | 0.55 | 3.20 | 25 |
| Pumping hours per season | 1,273 | 1,125 | 680 |
| Total kWh per season | 38,182 | 18,000 | 11,560 |
| Kwh/ha | 955 | 450 | 289 |

| | | | 2014 assumptions |
|---|---|---|---|
| ***Power charges:*** | 28 | c/kWh, standard rate | 25 |
| | $35.00 | /month service charge | 30 |
| ***Interest rate on borrowings/ opportunity cost:*** | 6.0% | | |
| ***Labour costs:*** | $35.00 | /hour | 25 |
| ***4 wheel motorbike running costs:*** | $12.00 | /hour including fuel | 10 |

Notes:

- Water cost include temporary water price plus the GMW delivery charge.
- Pumping costs are based on pumping from a GMID channel supply to commanded land. Private diversion or ground water supplied systems where pumping lift and distances to paddocks are higher can have substantially higher costs.
- Crop type - a cut and carry lucerne crop (or similar) with above water use.
- Spraying and other agronomic practices are assumed to be the same for each system. In reality there may be differences; e.g. drip includes fertigation.

**2014 versus 2018 Cost assumptions**

The change in assumptions were:

- Water costs were increased from the $125/ML used in 2014 to $275/ML[3]. This included water charges as well as the annual cost of owning or leasing water.
- Power costs were increased from an average of 25c/kWh to 28c/kWh with service charges increased from $30 to $35/month.
- Labour costs were increased from an average of $25/hr to $35/hr, but were reduced by 0.5 hours/ha/y for drip, centre pivot and pipe and riser to allow for increasing functionality of automation.
- 4 wheel/motor bike costs were increased from $10/hr to $12/hr including fuel.

[3] The price of water allocation in 2018 exceeded $400/ML, but this is considered above the average long term price.

## 3.4 OPERATION AND MAINTENANCE COSTS

The table below illustrates the annual operation and maintenance costs assumed for the different systems. All systems are assumed to be used every year, meet modern design and are efficient.

**Table 3-6: Operation and maintenance 2018 costs (2014 cost assumptions shown in blue)**

Operating Costs for **gravity channel surface irrigation (not pumped)**

| Operation | Labour | | | Other | | Total | |
|---|---|---|---|---|---|---|---|
| | Unit hrs/ha | Total hours | Cost $ | Unit $/ha | Total $ | $ | $/ha |
| Irrigation | 8 | 320 | 11,200 | 0 | 0 | 11,200 | 280 |
| R&M irrigation system | | | | 20 | 800 | 800 | 20 |
| Motorbike | | | | 96 | 3,840 | 3,840 | 96 |
| Power (incl. Service charge) | | | | 0 | 0 | 0 | 0 |
| Water | | | | 2,475 | 99,000 | 99,000 | 2,475 |
| **TOTAL** | **8** | **320** | **11,200** | **2,591** | **103,640** | **114,840** | **2,871** |

Operating Costs for **Pipe and Riser**

| Operation | Labour | | | Other | | Total | |
|---|---|---|---|---|---|---|---|
| | Unit hrs/ha | Total hours | Cost $ | Unit $/ha | Total $ | $ | $/ha |
| Irrigation | 5.5 | 220 | 7,700 | 0 | 0 | 7,700 | 193 |
| R&M irrigation system | | | | 20 | 800 | 800 | 20 |
| Motorbike | | | | 66 | 2,640 | 2,640 | 66 |
| Power (incl. Service charge) | | | | 91 | 3,657 | 3,657 | 91 |
| Water | | | | 2,338 | 93,500 | 93,500 | 2,338 |
| **TOTAL** | **5.5** | **220** | **7,700** | **2,515** | **100,597** | **108,297** | **2,707** |

Irrigation was 6 hours irrigation hrs for centre pivot

Operating Costs for **Centre Pivot** Irrigation

| Operation | Labour | | | Other | | Total | |
|---|---|---|---|---|---|---|---|
| | Unit hrs/ha | Total hours | Cost $ | Unit $/ha | Total $ | $ | $/ha |
| Irrigation | 2 | 80 | 2,800 | 0 | 0 | 2,800 | 70 |
| R&M irrigation system | | | | 70 | 2,800 | 2,800 | 70 |
| Motorbike | | | | 24 | 960 | 960 | 24 |
| Power (incl. Service charge) | | | | 278 | 11,111 | 11,111 | 278 |
| Water | | | | 1,925 | 77,000 | 77,000 | 1,925 |
| **TOTAL** | **2** | **80** | **2,800** | **2,297** | **91,871** | **94,671** | **2,367** |

Irrigation was 2.5 hours irrigation hrs for centre pivot

Operating Costs for **Drip** Irrigation

| Operation | Labour | | | Other | | Total | |
|---|---|---|---|---|---|---|---|
| | Unit hrs/ha | Total hours | Cost $ | Unit $/ha | Total $ | $ | $/ha |
| Irrigation | 1.00 | 40 | 1,400 | 0 | 0 | 1,400 | 35 |
| R&M irrigation system | 1.0 | 40 | 1,400 | 60 | 2,400 | 3,800 | 95 |
| Motorbike | | | | 12 | 480 | 480 | 12 |
| Power (incl. Service charge) | | | | 137 | 5,460 | 5,460 | 137 |
| Water | | | | 1,650 | 66,000 | 66,000 | 1,650 |
| **TOTAL** | **2** | **80** | **2,800** | **1,859** | **74,340** | **77,140** | **1,929** |

Irrigation was 1.5 irrigation hrs for drip
reduced due to automation

Note: R&M refers to repairs and maintenance. R&M labour is included in irrigation labour for all systems except for drip, where it is shown separately.

## 3.5 ENERGY ASSUMPTIONS

Using the assumptions above, for efficient systems the operational energy requirements are:

- Nil for improved surface (gravity) irrigation
- 289 kWh/ha for pumped pipe and riser
- 450 kWh/ha for drip
- 955 kWh/ha for centre pivot.

This compares with ranges previously estimated for energy costs[4] as:

- 200–400 kWh a pumped pipe and riser system
- 400–800 kWh for a drip system
- 700–1,400 kWh for a centre pivot sprinkler system

Therefore, the adopted values are within the expected ranges.

The green house gas emissions and energy requirements **from pumping** are likely to increase on conversion from an old style gravity system on perennial pasture by approximately:

- 200–400 kWh and 300–600 kg Co2-e per ha for a pumped pipe and riser system
- 400–800 kWh and 500–1,000 kg Co2-e per ha for a drip system
- 700–1,400 kWh and 1,000–2,000 kg Co2-e per ha for a centre pivot sprinkler system.

The low values reflect systems operating at design specifications, with the high numbers being close to less efficient systems.

However, it should be noted this marginal change in emissions does not consider other possibly more important green house gas impacts associated with the system change (e.g. labour, productivity etc.); change in pasture digestibility through better irrigation management; or broader greenhouse gas impacts associated with embedded energy and earthmoving.

[4] See Draft Paper RMCG 2014 A Comparison Of The Energy Requirements And Greenhouse Gas Emissions Of Different Irrigation Systems.

## 3.6 TOTAL COSTS FOR A 40 HA DEVELOPMENT

The tables below summarise the costs.

**Table 3-7: A summary of capital and annual costs for improved surface, pipe and riser, centre pivot and drip irrigation systems**

**2014 costs**

| Costs for 40 hectares | Gravity channel surface irrigation | Pipe & riser | Centre Pivot | Drip |
|---|---|---|---|---|
| Total system costs (capital) | 240,000 | 300,000 | 260,000 | 400,000 |
| Annual ownership costs (depreciation & interest) | 24,000 | 30,533 | 32,933 | 50,667 |
| Annual operating costs (tractor, labour, water, power) | 57,000 | 54,950 | 51,205 | 40,360 |
| **Total annualised costs** | **81,000** | **85,483** | **84,139** | **91,027** |

**2018 costs**

| Costs for 40 hectares | Gravity channel surface irrigation | Pipe & riser | Centre Pivot | Drip |
|---|---|---|---|---|
| Total system costs (capital) | 240,000 | 300,000 | 260,000 | 400,000 |
| Annual ownership costs (depreciation & interest) | 24,000 | 30,533 | 32,933 | 50,667 |
| Annual operating costs (tractor, labour, water, power) | 114,840 | 108,297 | 94,671 | 77,140 |
| **Total annualised costs** | **138,840** | **138,830** | **127,604** | **127,807** |

As shown in Table 3-6 the main reasons why annual operating costs are higher with gravity channel surface irrigation are due to higher labour and higher water use.

## 3.7 TOTAL COSTS PER HA

The tables below summarise the costs and their sensitivity to key variables.

**Table 3-8: A summary of capital and annual operating costs for improved surface, pipe and riser, centre pivot and drip irrigation systems**

**2014 Costs**

| Costs per hectare | Gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| Total system costs (capital) | 6,000 | 7,500 | 6,500 | 10,000 |
| Annual ownership costs (depreciation & interest) | 600 | 763 | 823 | 1,267 |
| Annual operating costs (labour, water, power) | 1,425 | 1,374 | 1,280 | 1,009 |
| **Total annualised costs** | **2,025** | **2,137** | **2,103** | **2,276** |

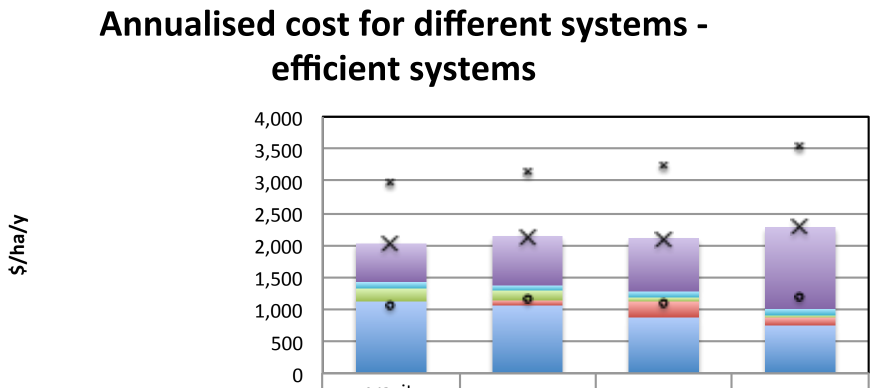
**2018 Costs**

| Costs per hectare | Gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| Total system costs (capital) | 6,000 | 7,500 | 6,500 | 10,000 |
| Annual ownership costs (depreciation & interest) | 600 | 763 | 823 | 1,267 |
| Annual operating costs (labour, water, power) | 2,871 | 2,707 | 2,367 | 1,929 |
| **Total annualised costs** | **3,471** | **3,471** | **3,190** | **3,195** |

Using 2014 cost assumptions the largest difference in total annualised costs was between gravity channel (lowest cost) and drip systems at $251/ha/y (highest cost). But a relatively minor difference relative to total costs.

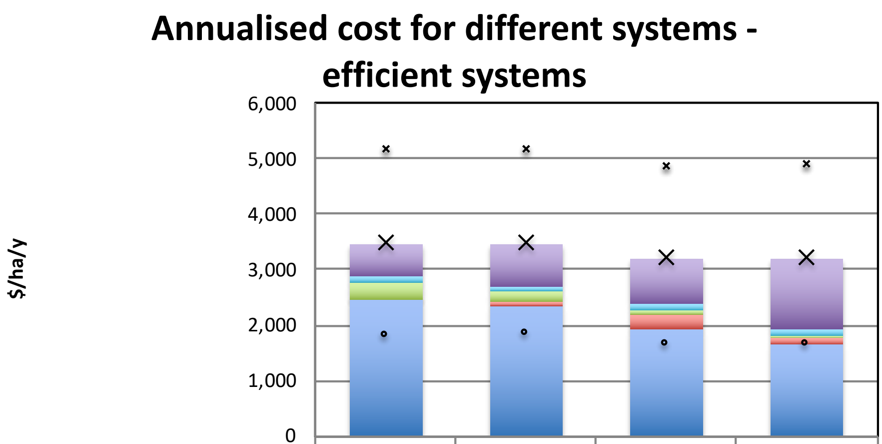
Using the 2018 cost assumptions the largest difference in total annualised costs was between gravity channel (highest cost) and centre pivot systems at $281/ha/y (lowest cost). But still a relatively minor difference. The change in assumptions, particularly increase in water costs changed the relative differences between systems, provided they are all irrigated every year.

**2014 Cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 823 | 1,267 |
| repairs, maintenance & motorbike | 100 | 80 | 95 | 100 |
| labour | 200 | 150 | 62.5 | 37.5 |
| power | 0 | 81 | 248 | 122 |
| water | 1,125 | 1,063 | 875 | 750 |
| total | 2,025 | 2,137 | 2,103 | 2,276 |
| total optimistic (low estimate) | 1,075 | 1,168 | 1,083 | 1,186 |
| total pessimistic (high estimate) | 2,996 | 3,163 | 3,232 | 3,531 |

**2018 Cost Assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 823 | 1,267 |
| repairs, maintenance & motorbike | 116 | 86 | 94 | 107 |
| labour | 280 | 192.5 | 70 | 35 |
| power | 0 | 91 | 278 | 137 |
| water | 2,475 | 2,338 | 1,925 | 1,650 |
| total | 3,471 | 3,471 | 3,190 | 3,195 |
| total optimistic (low estimate) | 1,798 | 1,835 | 1,627 | 1,646 |
| total pessimistic (high estimate) | 5,165 | 5,163 | 4,862 | 4,911 |

**Figure 3-1: Annual costs $ per ha for efficient systems.**

## 3.8 SENSITIVITY TESTING

The sensitivity around individual costs were tested in Table 3-9. Discussions with farmers and an examination of the data from various case studies confirm enormous ranges. For example**:**

- High costs associated with centre pivots that get bogged and the need to replace after ten years;
- major overhauls to replace sprinklers, tyres and track maintenance
- wide ranges in power costs, some being very low due to the use of off peak tariffs.

The main factors that influence operating costs, capital costs, and system life are design, maintenance and management. Therefore, optimistic and pessimistic scenarios have been developed to explore cost ranges in costs:

- The optimistic scenario is based on operating costs being 50% of assumed base case, capital costs being 33% lower and an additional five years life is gained from the system.
- The pessimistic scenario is that the base case operating costs are increased to 150% of assumed base case, capital costs are 33% higher and five years reduced life occurs.

**Table 3-9: Sensitivity of annual costs $/ha to changes in key variables per hectare**

**2014 Cost assumptions**

| Key variable | Base Case | Gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|---|
| Labour charged @ $50.00 | Labour charged @ $25.00 | +200 | +150 | +63 | +63 |
| Power rate @ 10.00c/kWh | Power rate @ 25.00c/kWh | n/a | -43 | -143 | -68 |
| Power rate @ 20.00c/kWh | | n/a | -14 | +48 | +23 |
| Power rate @ 30.00c/kWh | | n/a | +14 | +48 | +23 |
| Water cost @ $75.00 | | -450 | -425 | -350 | -300 |
| Water cost @ $100.00 | Water cost @ $125.00 | -225 | -213 | -175 | -150 |
| Water cost @ $150.00 | per ML includes delivery charges | +225 | +213 | +175 | +150 |
| Interest charged @ 4.0% | 6.0% | -120 | -150 | -130 | -200 |
| Interest charged @ 8.0% | | +120 | +150 | +130 | +200 |
| all annual operating costs -50% | | -713 | -687 | -640 | -505 |
| all annual operating costs +50% | | +713 | +687 | +640 | +505 |
| Total system capital cost -33% | | -198 | -252 | -272 | -418 |
| Total system capital cost +33% | | +198 | +252 | +272 | +418 |
| Interest charged @ 500.0% | | -40 | -30 | -108 | -167 |
| -Interest charged @ 500.0% | | +60 | +87 | +217 | +333 |
| ***Optimistic case (50% operating cost, -33% capital cost, +5 years life)*** | | **-951** | **-969** | **-1,020** | **-1,089** |
| ***Pessimistic case (150% operating cost, +33% capital, -5 years)*** | | ***+971*** | ***+1,025*** | ***+1,128*** | ***+1,256*** |

**2018 Cost assumptions**

| Key variable | Base Case | Gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|---|
| Labour charged @ $50.00 | Labour charged @ $35.00 | +120 | +83 | +30 | +30 |
| Power rate @ 15.00c/kWh | Power rate @ 28.00c/kWh | n/a | -38 | -124 | -59 |
| Power rate @ 25.00c/kWh | | n/a | -9 | +67 | +32 |
| Power rate @ 35.00c/kWh | | n/a | +20 | +67 | +32 |
| Water cost @ $200.00 | | -675 | -638 | -525 | -450 |
| Water cost @ $250.00 | Water cost @ $275.00 | -225 | -213 | -175 | -150 |
| Water cost @ $300.00 | per ML includes delivery charges | +225 | +213 | +175 | +150 |
| Interest charged @ 4.0% | 6.0% | -120 | -150 | -130 | -200 |
| Interest charged @ 8.0% | | +120 | +150 | +130 | +200 |
| all annual operating costs -50% | | -1,436 | -1,354 | -1,183 | -964 |
| all annual operating costs +50% | | +1,436 | +1,354 | +1,183 | +964 |
| Total system capital cost -33% | | -198 | -252 | -272 | -418 |
| Total system capital cost +33% | | +198 | +252 | +272 | +418 |
| Increased life of infrastructure by 5 years | | -40 | -30 | -108 | -167 |
| -Decreased life of infrastructure by 5 years | | +60 | +87 | +217 | +333 |
| ***Optimistic case (50% operating cost, -33% capital cost, +5 years life)*** | | **-1,674** | **-1,636** | **-1,563** | **-1,549** |
| ***Pessimistic case (150% operating cost, +33% capital, -5 years)*** | | ***+1,694*** | ***+1,692*** | ***+1,672*** | ***+1,716*** |

The sensitivity analysis shows that all systems examined had large ranges between optimistic and pessimistic scenarios, these ranges are wider ($+/- 1,000/ha/y in 2014 and $+/- $1,600/ ha in 2018) that the differences in costs between efficient systems ($251/ha/y in 2014 and $281/ha/y in 2018 from Table 3-8).

This indicates that design, maintenance and management are more important drivers of total costs than the differences between the types of efficient systems.

## 3.9 CONCLUSIONS

Based on the assumptions adopted, despite differences in capital upfront costs, there is little difference in total costs between the systems, when they are all efficient (Figure 3-1).

Key sensitivities that drive annualised costs are:

- Capital cost, interest rate and life
- Water cost and water use
- Power cost for centre pivot systems
- Labour cost for surface (gravity) and pipe and riser

Capital costs and energy costs are higher for pressurised systems, but this is offset by reduced labour and reduced water costs.

Sensitivity testing has highlighted wide ranges and this is illustrated in the optimistic and pessimistic scenarios each system.

Compared to the 2014 assumptions costs have risen by $1,446/ha for gravity channel, $1,334/ha for pipe and riser, $1,087/ha for centre pivot and $919/ha for drip. Most of this increase is associated with higher water costs.

For efficient systems the 2018 results indicate:

- Centre pivot and subsurface drip have lower costs relative to other systems. Their high fixed costs are offset by low variable costs if used annually. But if systems are not used annually then it can make sense to continue to use surface irrigation systems as their fixed costs are lower.
- Sensitivity analysis showed that all systems examined had large ranges between optimistic and pessimistic scenarios, these ranges are wider ($+/- 1,600/ha/y) than the differences in costs between systems.
- Annual ownership costs comprise interest and depreciation on the value of a system. With existing systems these costs are sunk costs and can be the difference between staying with old system with no extra ownership costs and investing a new system, which entails additional ownership costs.

# 4 Analysis for inefficient systems

## 4.1 RATIONALE

There are a number of papers suggests that in practice, and over time the efficiency of pumped systems can decline. For example:

***Water and Energy Efficiency of Centre Pivots on Dairies.*** *Peter Smith, Scott Richards, David Deane , NSW DPI IAL Conference 2013, Griffith.*

*"Field tests were conducted on 17 centre pivot systems and one lateral move system on 11 properties. Most systems were in the order of 10 years old. The distribution uniformity ranged from 40% to 79% with an average of 56%, which is low relative to a benchmark of 90% for an excellent system. The average coefficient of uniformity (at 75%), pumping efficiency (at 52%) and pressure uniformity were also well below industry specifications.*

*The paper concluded that there is large scope for improvement in efficiencies. If performance was restored to specification, then an average reduction in energy consumption of 37% was possible.*

*This suggests that the practical energy requirements of centre pivots after ten years of practice can often be much higher than the theoretical design specifications."*

Gavan Lamb, DEPI, Gippsland reports similar findings[5] of poor performance of pumped irrigation systems in the field.

Maxine Schache, DEPI, Mildura[6] in an analysis of system checks, 2012 also reports below specification performance of both drip and sprinkler systems.

*"Very few of the irrigation systems tested using the system check process met the industry performance standards for pressure variation, discharge variation and discharge uniformity. The lack of irrigation system performance in these areas can have both negative productivity and environmental impacts. An unevenness in water applied across a patch or property be it through sprinklers or drippers can lead to uneven crop growth."*

These results suggest that both power and water use in the field can have poor efficiency.

In this analysis it is assumed that inefficient system are represented by:

**Scenario 1)** has a low distribution uniformity that results in 30% higher power use and higher water use than the base case. To test for high water use the assumed ML/ha was increased by +0.5 ML/ha for pipe and riser so that it is 9 ML/ha, +2 ML/ha for centre pivot so it is also 9 ML/ha and +1.5 ML/ha for drip so it is 7.5 ML/ha. But this increase cannot always be expected, as some irrigators may not increase water use if the power cost was high. Therefore, scenario 2 was also tested.

**Scenario 2)** has same water use as the base case i.e. 9 ML/ha for gravity surface, 8.5 ML/ha for pipe and riser, 7 ML/ha for centre pivot and 6 ML/ha for drip. But with a 30% higher power cost.

Capital costs were assumed to be the same as efficient systems.

[5] http://www.talle.biz/depi.pdf accessed 27/8/14
[6] http://www.hin.com.au/__data/assets/pdf_file/0010/7201/Analysis-of-the-results-of-the-2009-2011-systems-checks.pdf accessed 27/8/14

## 4.2 CHANGE IN OPERATION AND MAINTENANCE COSTS DUE TO SYSTEM INEFFICIENCIES

### 2014 ASSUMPTIONS

**Scenario 1** for 2014 assumptions inefficiency increased the cost of:

- Gravity channel by nil – as no power cost or change in water use
- Pipe and riser by $90/ha/y ($27 due to power and $63 due to increased water)
- Centre pivot by $410/ha/y ($160 due to power and $250 due to increased water)
- Drip by $258/ha/y ($70 due to power and $188 due to increased water)

**Scenario 2** increased the cost of power only, with no change in water use; the results were:

- Gravity channel by nil – as no power cost or change in water use
- Pipe and riser by $22/ha/y
- Centre pivot by $71/ha/y
- Drip by $34/ha/y

### 2018 ASSUMPTIONS

**Scenario 1** for 2018 assumptions increased the cost of:

- Gravity channel by nil – as no power cost or change in water use
- Pipe and riser by $168/ha/y ($30 due to power and $138 due to increased water)
- Centre pivot by $729/ha/y ($179 due to power and $550 due to increased water)
- Drip by $491/ha/y ($79 due to power and $413 due to increased water)

**Scenario 2** increased the cost of power only, with no change in water use; the results were:

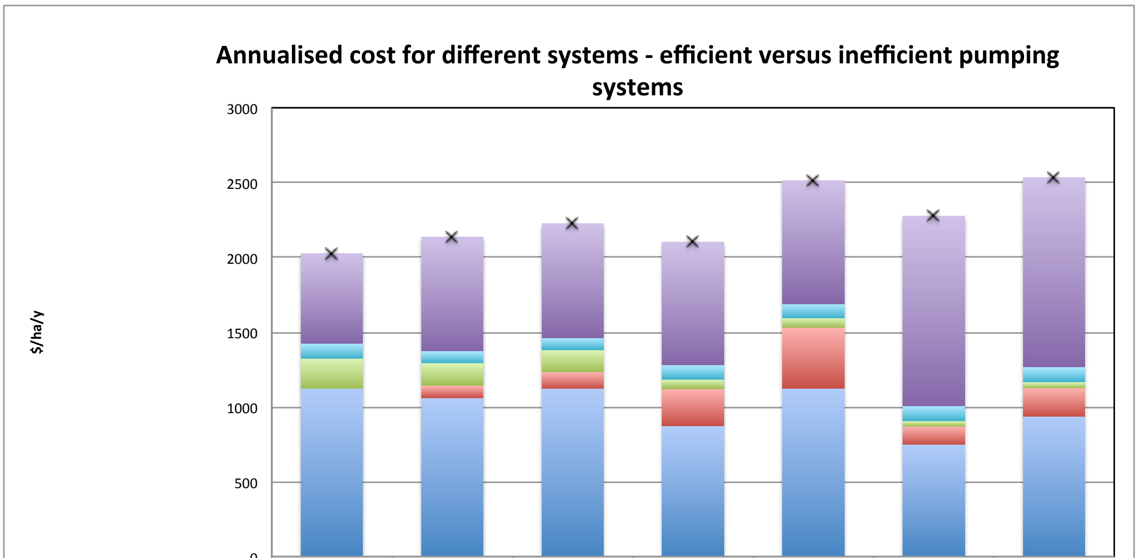
- Gravity channel by nil – as no power cost or change in water use
- Pipe and riser by $24/ha/y
- Centre pivot by $80/ha/y
- Drip by $38/ha/y

## 4.3 CHANGE IN OVERALL RESULTS – DUE TO INCREASED POWER USE AND INCREASED WATER USE

### 4.3.1 SCENARIO 1 - INCREASED POWER & INCREASED WATER USE

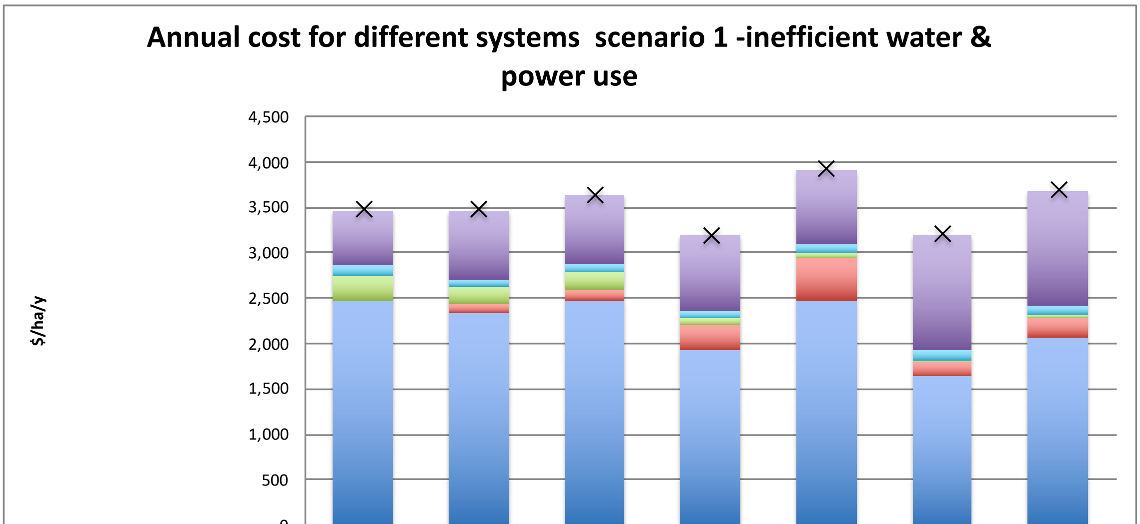
Inefficient water and power use can be caused by inadequate design and/or poor maintenance and management. This results in higher cost with the additional water use being the main reason for this cost increase, as it increases both water and power costs. Figure 4-1 shows the results for each system.

**2014 cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | inefficient pipe and riser | Centre Pivot | inefficient centre pivot | Drip | inefficient drip |
|---|---|---|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 763 | 823 | 823 | 1267 | 1267 |
| repairs, maintenance & motorbike | 100 | 80 | 80 | 95 | 95 | 100 | 100 |
| labour | 200 | 150 | 150 | 63 | 63 | 38 | 38 |
| power | 0 | 81 | 108 | 248 | 408 | 122 | 192 |
| water | 1125 | 1063 | 1125 | 875 | 1125 | 750 | 938 |
| total | 2025 | 2137 | 2227 | 2103 | 2514 | 2276 | 2533 |

**2018 cost assumptions**



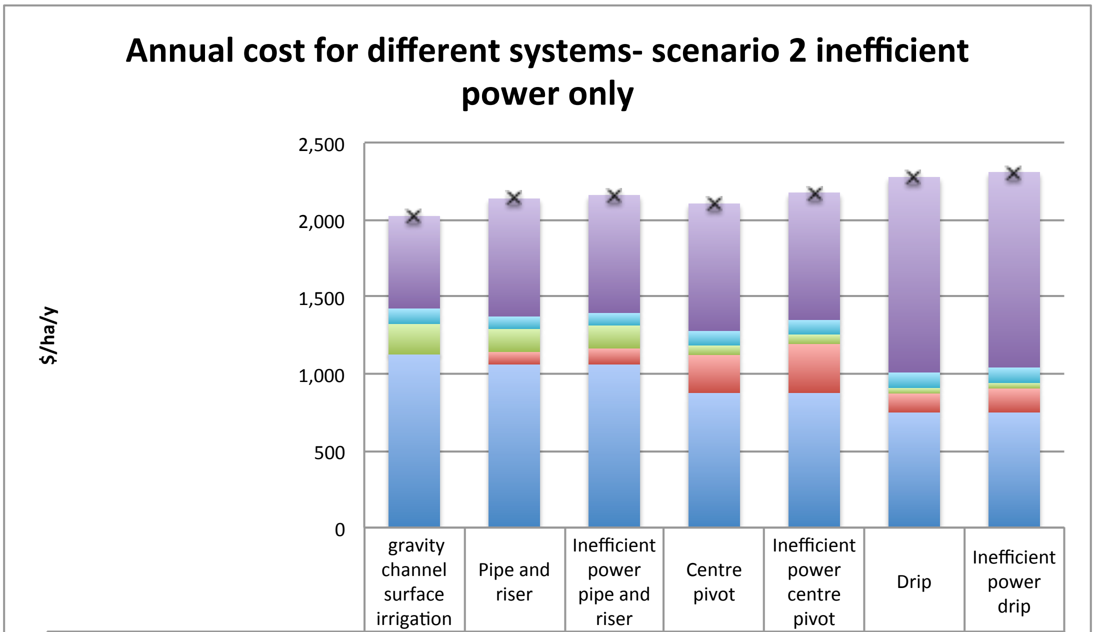

| | gravity channel surface irrigation | Pipe and riser | Inefficient Pipe and Riser | Centre pivot | Inefficient Centre Pivot | Drip | Inefficient Drip |
|---|---|---|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 763 | 823 | 823 | 1,267 | 1,267 |
| repairs, maintenance & motorbike | 116 | 86 | 86 | 94 | 94 | 107 | 107 |
| labour | 280 | 193 | 192.5 | 70 | 70 | 35 | 35 |
| power | 0 | 91 | 122 | 278 | 457 | 137 | 215 |
| water | 2,475 | 2,338 | 2,475 | 1,925 | 2,475 | 1,650 | 2,063 |
| total | 3,471 | 3,471 | 3,639 | 3,190 | 3,920 | 3,195 | 3,686 |

**Figure 4-1: Annual costs per ha – low efficiency of water & power- scenario 1**

### 4.3.2 SCENARIO 2 – INCREASED POWER USE ONLY

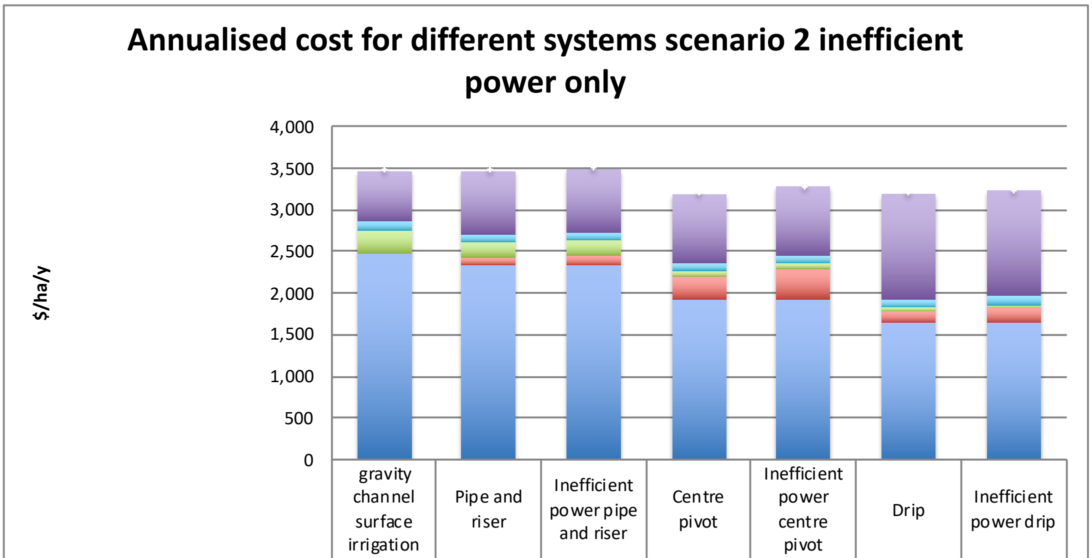
Increasing the power cost by 30%, with no change in water use had a much smaller impact on the total cost (e.g. for 2018 a rise of $80/ha for centre pivot is 2.5% of the total annualised cost). See Figure 4-2.

**2014 Cost assumptions**




| | gravity channel surface irrigation | Pipe and riser | Inefficient power pipe and riser | Centre pivot | Inefficient power centre pivot | Drip | Inefficient power drip |
|---|---|---|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 763 | 823 | 823 | 1,267 | 1,267 |
| repairs, maintenance & motorbike | 100 | 80 | 80 | 95 | 95 | 100 | 100 |
| labour | 200 | 150 | 150 | 63 | 63 | 38 | 38 |
| power | 0 | 81 | 103 | 248 | 319 | 122 | 155 |
| water | 1,125 | 1,063 | 1,063 | 875 | 875 | 750 | 750 |
| total | 2,025 | 2,137 | 2,159 | 2,103 | 2,175 | 2,276 | 2,309 |

**2018 Cost assumptions**




| | gravity channel surface irrigation | Pipe and riser | Inefficient power pipe and riser | Centre pivot | Inefficient power centre pivot | Drip | Inefficient power drip |
|---|---|---|---|---|---|---|---|
| annual ownership costs | 600 | 763 | 763 | 823 | 823 | 1,267 | 1,267 |
| repairs, maintenance & motorbike | 116 | 86 | 86 | 94 | 94 | 107 | 107 |
| labour | 280 | 193 | 192.5 | 70 | 70 | 35 | 35 |
| power | 0 | 91 | 116 | 278 | 358 | 137 | 174 |
| water | 2,475 | 2,338 | 2,338 | 1,925 | 1,925 | 1,650 | 1,650 |
| total | 3,471 | 3,471 | 3,495 | 3,190 | 3,270 | 3,195 | 3,233 |

**Figure 4-2: Annual costs per ha – low efficiency of power only- scenario 2**

## 4.4 CONCLUSIONS

As would be expected, if the systems have as per scenario 1:

- Inefficient power (+30% more) and
- Inefficient water use (+0.5 ML/ha pipe & riser, +2 ML/ha centre pivot, +1.5 ML/ha drip)

above the base case[7] then inefficient pumped systems have higher costs than gravity channel irrigation.

This is largely due to increased water use, rather than the power cost increase.

Increasing power costs by 30% without an increase in water use, as per scenario 2, has a much smaller impact on total costs.

This illustrates that with pumping technology, it is very important to have high efficiency. i.e. optimum design, maintenance and management in order to achieve the cost efficiency that is possible.

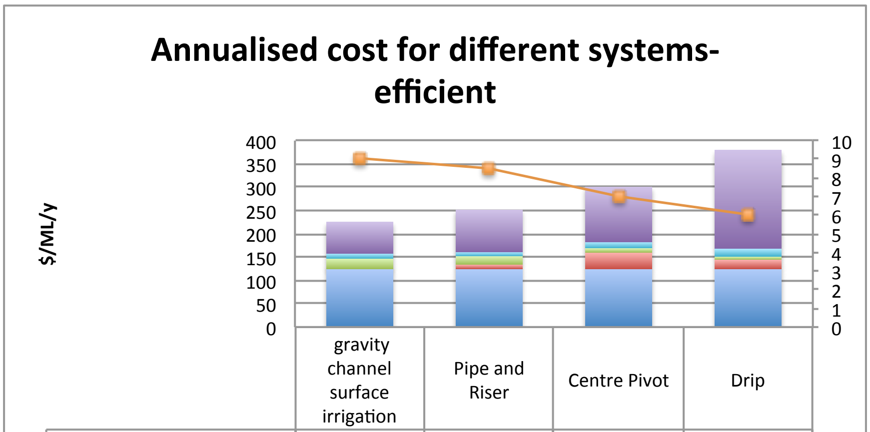
The overall conclusion is that design, maintenance and management of a system are more important drivers of total costs than considering the type of system on its own.

[7] Under base case assumptions gravity channel = 9 ML/ha, pipe and riser = 8.5 ML/ha, centre pivot = 7 ML/ha and drip = 6 ML/ha. Under inefficient case all use 9 ML/ha except for drip that uses 7.5 ML/ha.

# 5 Costs per ML

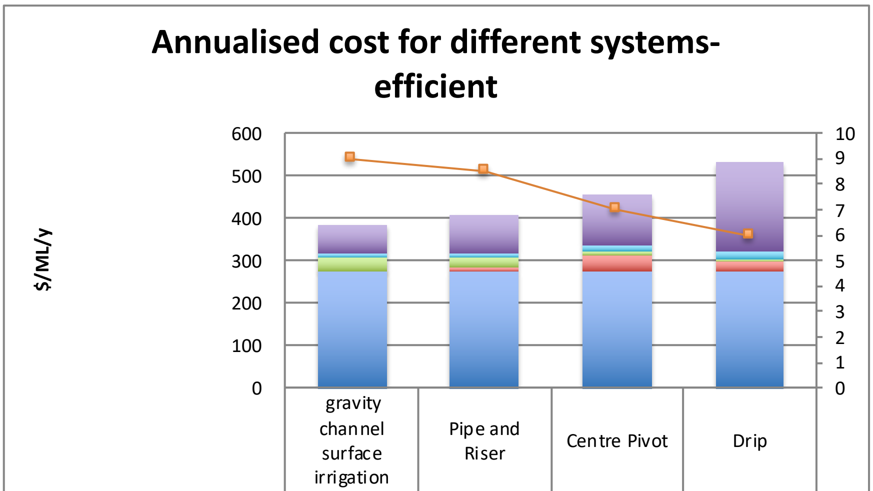
Costs are often calculated per ML of use. This section provides costs on this basis for each of the three scenarios investigated.

**2014 Cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 90 | 118 | 211 |
| repairs, maintenance & motorbike | 11 | 9 | 14 | 17 |
| labour | 22 | 18 | 9 | 6 |
| power | 0 | 10 | 35 | 20 |
| water | 125 | 125 | 125 | 125 |
| total | 225 | 251 | 300 | 379 |
| ML/ha | 9 | 8.5 | 7 | 6 |

**2018 Cost assumptions**

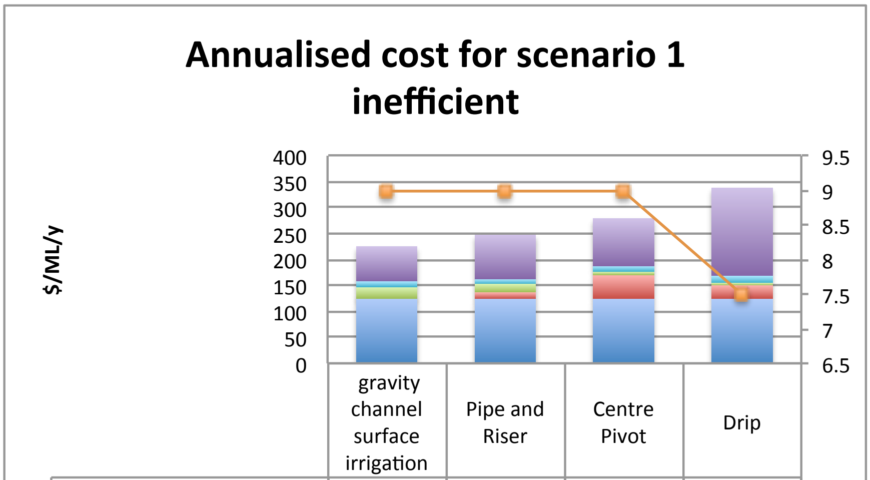



| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 90 | 118 | 211 |
| repairs, maintenance & motorbike | 13 | 10 | 13 | 18 |
| labour | 31 | 23 | 10 | 6 |
| power | 0 | 11 | 40 | 23 |
| water | 275 | 275 | 275 | 275 |
| total | 386 | 408 | 456 | 533 |
| ML/ha | 9 | 8.5 | 7 | 6 |

**Figure 5-1: Efficient systems- base case $/ML/y**

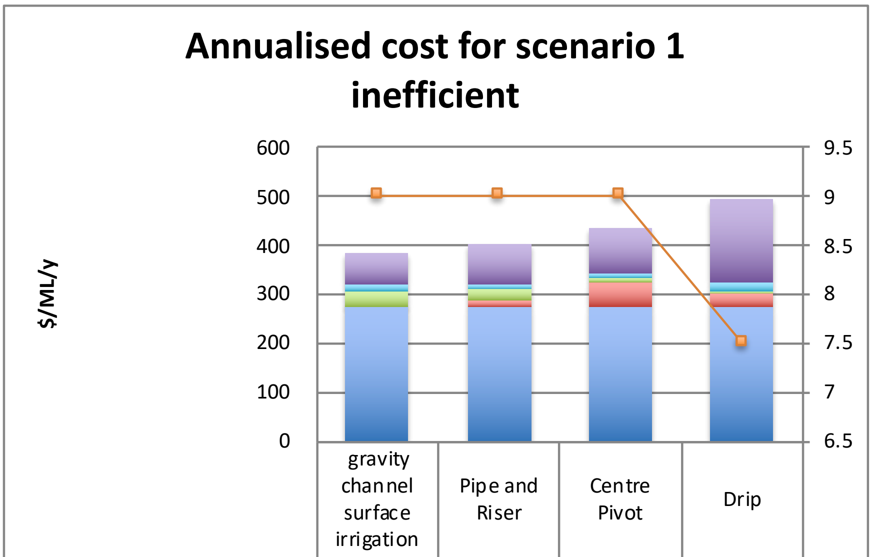
Figure 5-1 illustrates that pumped systems have a higher cost per ML used. This is partly because they use less ML/ha. Having a high cost per ML is acceptable if the ML/ha is low and production per ha is high.

**2014 Cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 85 | 91 | 169 |
| repairs, maintenance & motorbike | 11 | 9 | 11 | 13 |
| labour | 22 | 17 | 7 | 5 |
| power | 0 | 12 | 45 | 26 |
| water | 125 | 125 | 125 | 125 |
| total | 225 | 247 | 279 | 338 |
| ML/ha | 9 | 9 | 9 | 7.5 |

**2018 Cost assumptions**

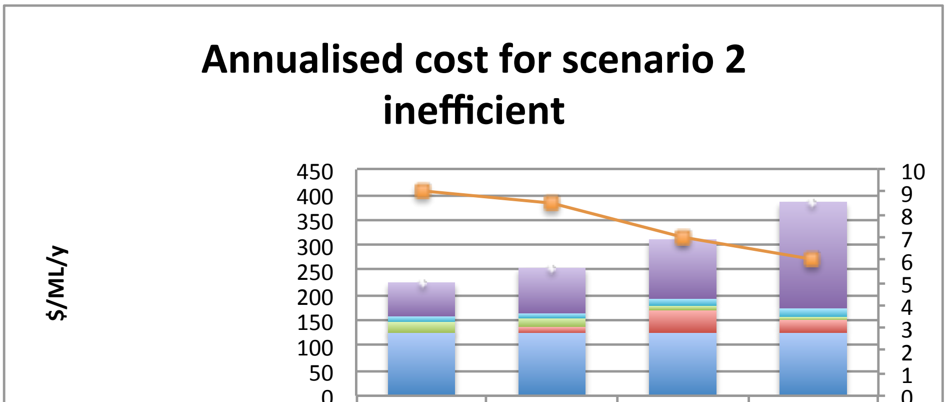



| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 85 | 91 | 169 |
| repairs, maintenance & motorbike | 13 | 10 | 10 | 14 |
| labour | 31 | 21 | 8 | 5 |
| power | 0 | 14 | 51 | 29 |
| water | 275 | 275 | 275 | 275 |
| total | 386 | 404 | 436 | 492 |
| ML/ha | 9 | 9 | 9 | 7.5 |

**Figure 5-2: Inefficient systems – scenario 1- 30% higher power cost per kWh and more ML/ha for pumped systems in $/ML/y**

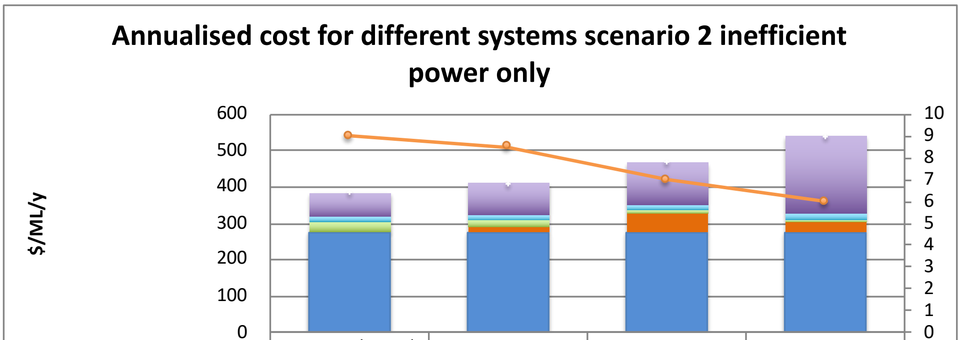
Figure 5-2 illustrates that costs per ML for pumped systems are lower than the base case with scenario 1 inefficient systems, but only because the system is applying excess ML/ha.

**2014 Cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 90 | 118 | 211 |
| repairs, maintenance & motorbike | 11 | 9 | 14 | 17 |
| labour | 22 | 18 | 9 | 6 |
| power | 0 | 12 | 46 | 26 |
| water | 125 | 125 | 125 | 125 |
| total | 225 | 254 | 311 | 385 |
| ML/ha | 9 | 8.5 | 7 | 6 |

**2018 Cost assumptions**




| | gravity channel surface irrigation | Pipe and Riser | Centre Pivot | Drip |
|---|---|---|---|---|
| annual ownership costs | 67 | 90 | 118 | 211 |
| repairs, maintenance & motorbike | 13 | 10 | 13 | 18 |
| labour | 31 | 23 | 10 | 6 |
| power | 0 | 14 | 51 | 29 |
| water | 275 | 275 | 275 | 275 |
| total | 386 | 411 | 467 | 539 |
| ML/ha | 9 | 8.5 | 7 | 6 |

**Figure 5-3: Inefficient systems – scenario 2- 30% higher power and same ML/ha as base case in $/ML/y**

Figure 5-3 illustrates that costs per ML are higher than the base case due to additional power cost for the same water use.

This report has been prepared by:


**RM Consulting Group Pty Ltd trading as RMCG**

135 Mollison Street, Bendigo, Victoria 3550

(03) 5441 4821 — rmcg.com.au — ABN 73 613 135 247

Offices in in Bendigo, Melbourne, Torquay and Warragul (Victoria) and Penguin and Hobart (Tasmania)


**Key Project Contact**


Charles Thompson

0428 179 701 — charlest@rmcg.com.au


**Document review and authorisation**

**Job Number: 6-G-17**

| Doc Version | Final/Draft | Date | Author | Reviewed by | Quality checked | Release approved by | Issued to |
|---|---|---|---|---|---|---|---|
| 1.0 | Draft | 12/12/2018 | C. Thompson | | | CT | Megan McFarlane |
| 2.0 | Draft | 20/5/2019 | C. Thompson | | | CT | Megan McFarlane |
| 3.0 | Final | 7/6/19 | C. Thompson | CT | J. Belz | CT | Megan McFarlane |