# Options for minimising the impact of drought on turf farm production

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AgEnviro Solutions

AQUEDUCT CONSULTANCY
Irrigation Design and Water Harvesting

# Options for minimising the impact of drought on turf farm production

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# Executive summary

University of NSW received funding from the NSW Government Sector Recovery and Resilience Grant to investigate options for reducing the impact of drought on turf farms. This project assessed 24 turf farm businesses, with more detailed analysis on farms in areas hardest hit by the 2019 drought. AgEnviro was engaged to perform this work, with a summary of the findings provided in this report which was written by Dr Mick Battam (Certified Professional Soil Scientist).

## Turf farm mapping

Turf farm assessments results from this project were combined with those from previous studies. Based on the assessment of 1053 hectares of turf farms across NSW:

- **Grass type:** buffalo was grown on 55% of turf farm areas in the Sydney Basin, with other parts of NSW having an even spread of grasses (33% buffalo, 31% kikuyu, 23% couch)
- **Soil type:** medium & heavy clays were observed on 50% of the turf farm areas, with buffalo more often grown on these soils. Sandy loams, loamy sands & sands were on about 25% of turf farming areas in the Sydney Basin and 35% in other parts of the state
- **Soil nutrient status:** soils were often low in potassium (73% of farms), calcium (48% of farms), phosphorus (41%) and sulphur (70%), with most farms low in micronutrients, especially zinc and boron in areas west of the Great Dividing Range
- **Irrigation system:** big gun travellers were used to irrigate 54% of the turf farming area in areas east of the Great Dividing Range, but only on 4% of area in central NSW which relied more heavily on centre pivots and lateral move systems

Soil compaction was a major issue on most turf farms. Water repellency (hydrophobic soils) was often observed on turf farms west of the Great Dividing Range, especially those with sandy soils.

## Irrigation assessments

Testing of irrigation systems on turf farms found all big gun travellers assessed were applying water unevenly. In contrast, all other systems were found to be capable of applying water evenly, but examples for poorly performing solid set irrigation systems were found (Figure E.1).

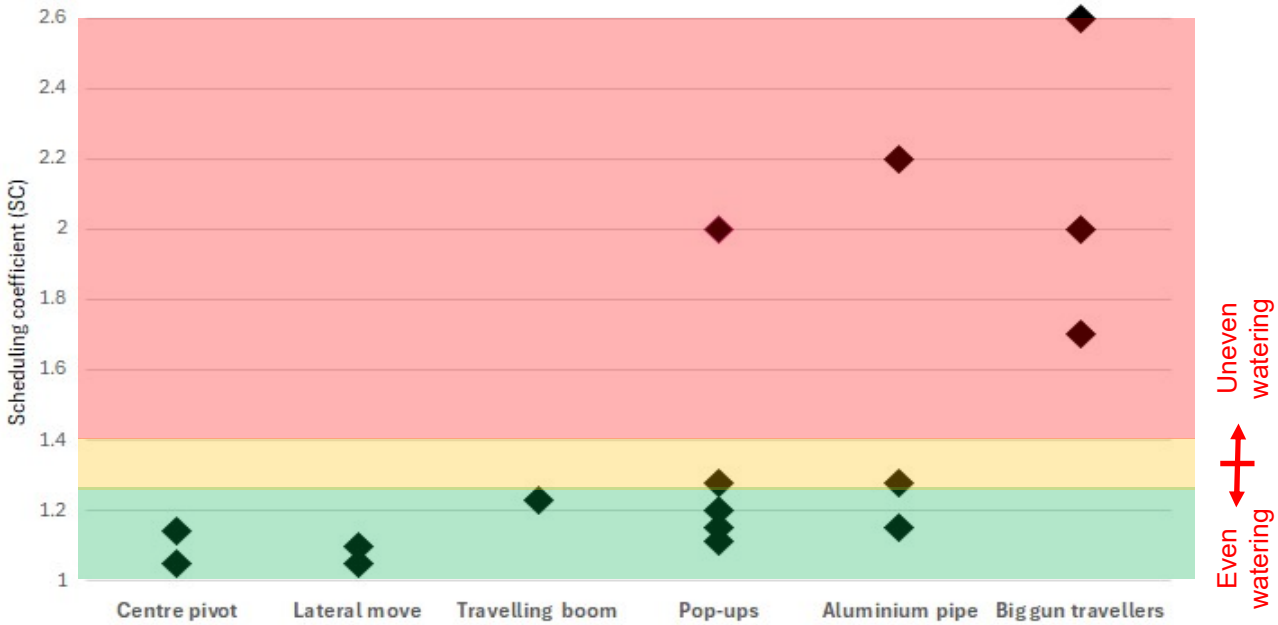



**Figure E.1:** The above chart shows results of turf farm irrigation system tesing (results for 2 centre pivots, 2 lateral moves, 1 travelling boom, etc). Water was applied evenly by centre pivots, lateral moves, travelling booms and well laid out pop up & solid set sprinklers. In contrast, big gun travellers and poorly laid out solid set systems applied water unevenly.

## Turf farm drought mitigation measures

Modelling using 20 years of daily weather data was used to identify the most cost-effective measure for mitigating drought for 6 turf farmers that had inadequate water supply in 2019. In order from most to least cost effective these measures were found to be (Table 9.2):

- Reducing the turf farm watering regime to 25% of $ET_o$ (Farmer A)
- Purchasing additional bore water via temporary transfer (Farmers C & D)
- Installing a dam to mitigate shortfalls in water supply (Farmer F)
- Purchasing a bore licence and installing a bore (Farmer B)
- Installing a more efficient irrigation system (Farmers A & E)
- Amending the soil prior to planting (all farmers)

The cost effectiveness of these measures declined if the drought coincided with a period of water restrictions that reduced home lawn sales. However, even when a 75% decline in the home lawn market was assumed in drought, 12 out of 13 works still had a net monetary benefit.

## Irrigation system life cycle costs

Lifecycle costs over a 25-year period were calculated for various irrigation system types based on system set-up costs assembled by Neale Tweedie, with labour and maintenance costs estimated from discussions with six turf farmers. The analysis found (Figure E.2):

- Lifecycle costs were lowest for centre pivots and well-designed pop-up sprinkler systems (~16 m radius), with the third lowest being the Turbine drive T300 soft hose traveller
- Pumping represents a significant proportion of the costs for operating big gun travellers and poorly designed pop-up sprinkler systems.

These finding suggest pumping costs could be a catalyst for adopting more efficient irrigation systems, even in areas where water is not limiting.

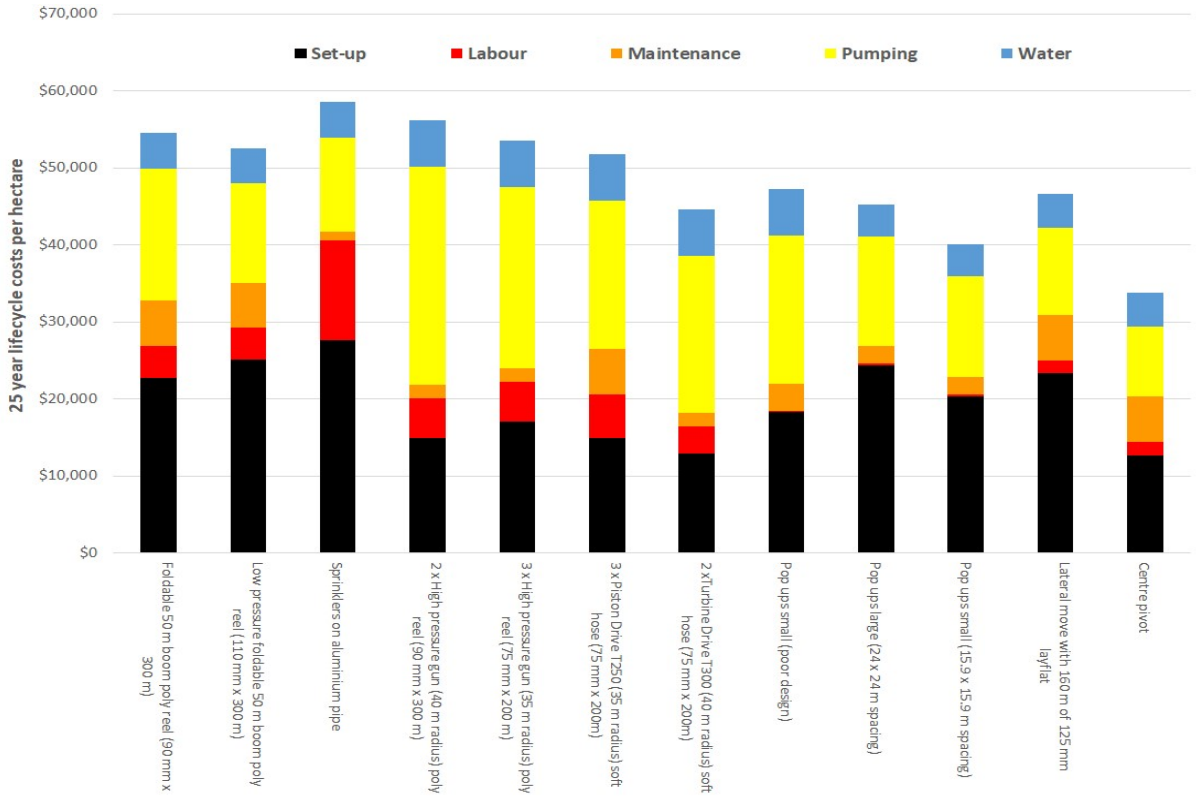



**Figure E.2:** Lifecycle costs for irrigation systems used on turf farms. Assumes water costs of $50 per ML, power costs of $0.41 per KWh, with a base average annual irrigation demand increased by the unevenness of the irrigation system.

# Table of Contents

**Executive summary** ..... **3**

**1 Background** ..... **6**

**2 Farm assessments** ..... **7**

**3 Grass type** ..... **8**

3.1 Sydney Basin ..... 8
3.2 Other parts of NSW ..... 8

**4 Soil type** ..... **9**

**5 Soil chemistry** ..... **10**

**6 Irrigation method** ..... **11**

**7 Irrigation system performance** ..... **12**

7.1 Aluminium solid set sprinkler lines ..... 12
7.2 Pop-ups and fixed big guns ..... 13
7.3 Centre Pivot and lateral move ..... 13
7.4 Travelling booms (cart booms) ..... 14
7.5 Big gun travellers ..... 14
7.6 Boom made from a big gun traveller ..... 15
7.7 Summary of findings ..... 15

**8 Irrigation system costs** ..... **16**

8.1 System set up costs ..... 16
8.2 System lifecycle costs ..... 17
8.3 Other factors influencing choice of irrigation system ..... 18

**9 Drought mitigation measures** ..... **19**

9.1 Sourcing additional water ..... 19
9.2 Installing a more efficient irrigation system ..... 20
9.3 Amending the soil ..... 20
9.4 Scheduling irrigation more accurately ..... 21
9.5 Cost effectiveness of drought mitigation measures ..... 23

**10 Conclusions** ..... **24**

**Appendix A: Irrigation system set up costs** ..... **25**

**Appendix B: Cost benefit analysis outputs** ..... **32**

Farmer A ..... 32
Farmer B ..... 33
Farmer C ..... 34
Farmer D ..... 35
Farmer E ..... 36
Farmer F ..... 37

**Appendix C: Irrigation system application** ..... **38**

# 1 Background

In the 2019 drought at least 6 turf farmers (~17 farms) were struggling to maintain normal turf production rates due to a lack of water. Several other farmers also experienced a decline in water quality during this period. These problems were confounded in some areas by the decline in sales to the home lawn market due to the introduction of residential water restrictions.

The University of NSW received funding from the NSW Government Sector Recovery and Resilience Grant to investigate options for reducing the impact of drought on turf farm production. The project involved assessing 24 turf farm businesses across NSW (Figure 1.1), with more detailed analysis performed on farms located in areas hardest hit by the 2019 drought such as:

- Bathurst
- Dubbo and
- Taree.

AgEnviro Solutions as engaged to perform this work, with a summary of the project findings provided in this report which was written by Dr Mick Battam (Certified Professional Soil Scientist). Major contributions were also made by Rex Sullings (Certified Irrigation Designer) and Neale Tweedie (Hawkesbury Valley Irrigation and Grech's Turf), with assistance from Steve Garland (horticulturalist), Dr Paul Lamble (Certified Irrigation Designer) and Dave McKechnie (Certified Irrigation Agronomist).

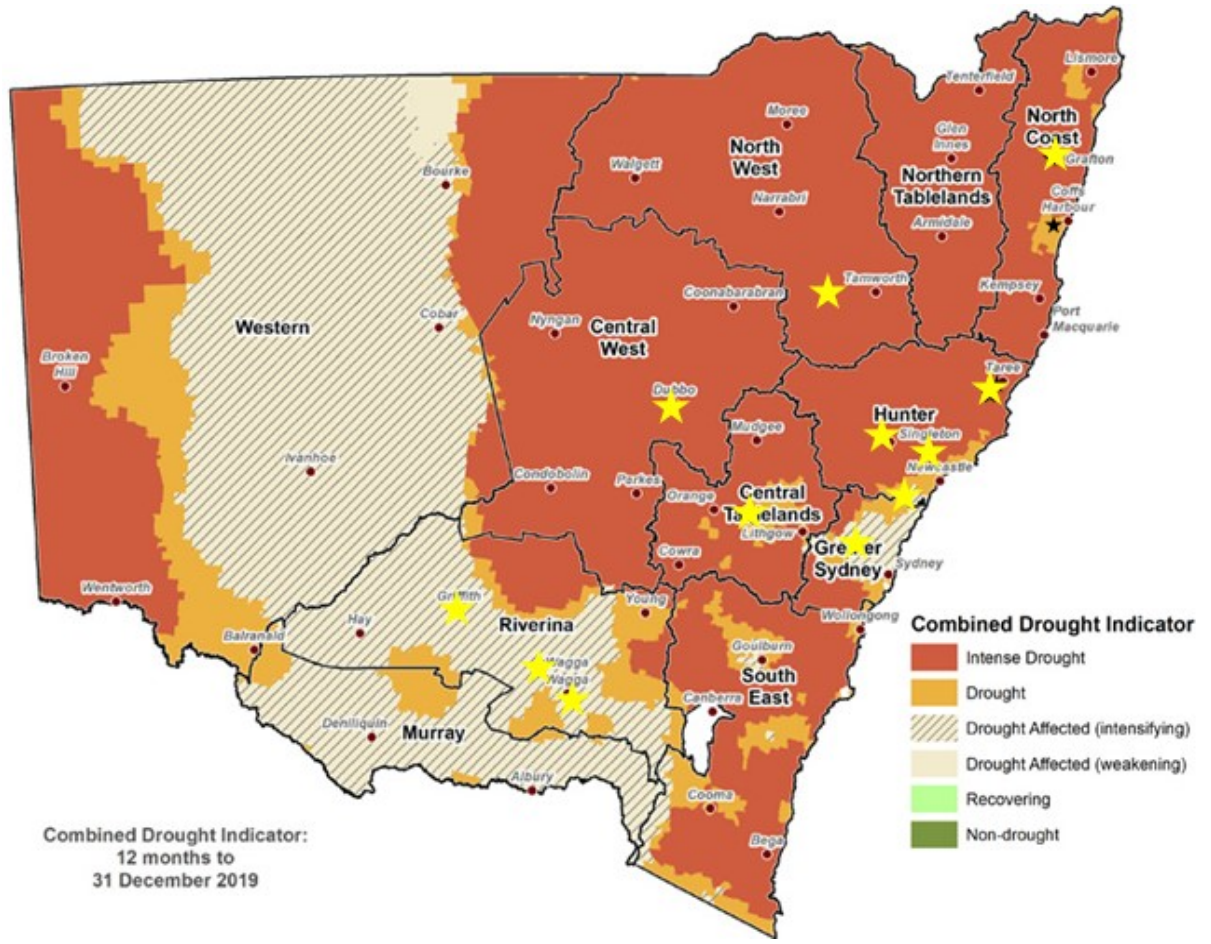



**Figure 1.1:** Verified NSW Combined Drought Indicator to 31/12/2019, with the areas where turf farms were assessed indicated by stars (https://www.dpi.nsw.gov.au/climate-landing/ssu/december-2019).

# 2 Farm assessments

Soil mapping and agronomic chemical analysis was performed on farms located in the:

- Sydney Basin
    - Greener Lawns (Freemans Reach)
    - Lawn Industries (Freemans Reach)
    - All Seasons Turf (Freemans Reach)
    - Advanced Turf (Freemans Reach)
    - ABC Turf (Freemans Reach)
    - Millers Turf (Freemans Reach)
    - Highland Turf (Agnes Banks)
    - Windsor Turf (Cornwallis)
    - AView Turf (Ebenezer)
- Other parts of NSW
    - Lake Wyangan Turf (Griffith)
    - Tarcoola Turf (Narrandera)
    - RivTurf (Wagga)
    - Dubbo Turf Supplies (Dubbo)
    - Turf the Lot (Dubbo)
    - Western Plains Turf (Dubbo)
    - Green Acres Turf (Bathurst)
    - Mardi Park Turf (Yarramalong)
    - Yarramalong Turf (Yarramalong)
    - Highland Turf (long point)
    - Buchanan's Turf (Bolwara)
    - Agland Turf (Nabiac)
    - Earls Turf (Taree)
    - Clarence Valley Turf (Seelands)
    - New Lawn Turf (Manilla)

These findings were also combined with soil mapping previously performed on:

- J & B Buffalo (Agnes Banks)
- D & V Turf (Agnes Banks)
- Billabong Turf (Cornwallis)
- Grech's Turf (Cornwallis)
- S & N Turf (Cornwallis)
- Dad n Daves Turf (Pitt Town Bottoms)
- Hi-Quality Turf (Pitt Town Bottoms)
- Active Turf (Kurmond)
- Glossodia Turf (Glossodia)
- Cobbitty Turf (Theresa Park)

In addition to soil information, the area of turf cultivars and area of different irrigation system types were also mapped on these farms.

# 3 Grass type

Grass type was mapped on 1053 hectares of turf farms across NSW. Buffalo was the dominant grass grown in the Sydney Basin, with other parts of NSW have a more even distribution of buffalo, kikuyu and couch (Figure 3.1). This mapping was performed as part of the flood project.

## 3.1 Sydney Basin

Of the 572 hectares assessed in the Sydney Basin:

- **55% was buffalo:** the most common cultivars were Sir Walter (72% of the buffalo grown), Sapphire (12%), Matilda (5%) and Kings Pride (5%)
- **25% was kikuyu**
- **15% was couch:** the most common cultivars were Santa Ana (24% of the couch grown), Tif Turf (21%), Wintergreen (19%) and Windsor Green (9%)
- **3% was zoysia**

The remaining areas were either fallow or had a cover crop such as oats or mustard.

## 3.2 Other parts of NSW

Of the 481 hectares assessed outside the Sydney basin:

- **33% was buffalo:** the most common cultivar was Sir Walter (92% of the buffalo grown)
- **31% was kikuyu:** apart from the generic form, the most common cultivar was Kenda (15% of the kikuyu grown)
- **23% was couch:** the most common cultivars were Tif Tuf (41% of the couch grown), Santa Ana (40%), Iron Cutter (7%) and Agridark (6%)
- **5% was tall fescue**
- **2% was zoysia**

The remaining areas were either fallow or had a cover crop such as oats.

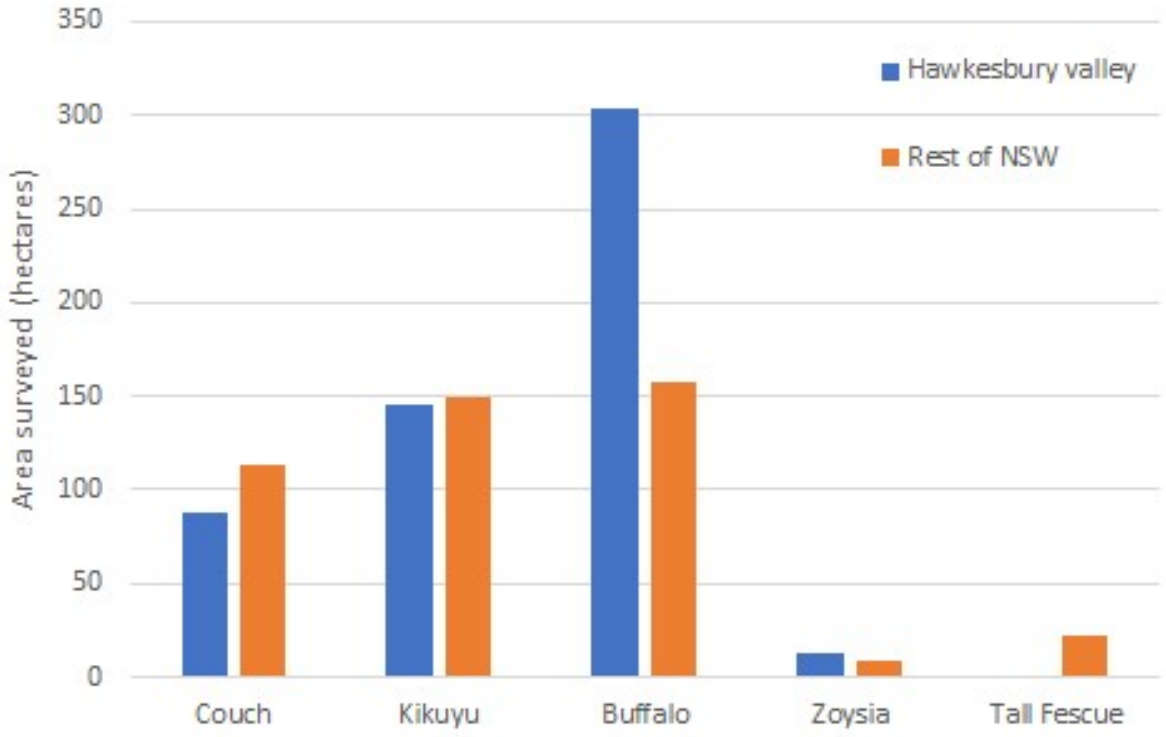



**Figure 3.1:** Turf grasses species grown by 34 NSW turf farmers.

# 4 Soil type

Soil texture was mapped on 1053 hectares of turf farms across NSW which found (Figure 4.1):

- **medium & heavy clay:** observed on 50% of the turf farming area assessed, with buffalo more commonly grown on these soils in areas outside of the Sydney basin
- **light clay & clay loam:** observed on 38% of turf farming areas in the Sydney Basin, but only 14% of turf farming areas in other parts of NSW
- **sandy loams, loamy sands & sands:** observed on 25% of turf farming areas in the Sydney Basin and 35% of the area in other parts of the state. Couch was more commonly grown on these soils (Figure 4.1).

Many of the heavier textured soils were prone to setting hard. As such, it is not surprising to find compaction was one of the most common soil issues observed on turf farms. Whilst most farmers aerate their soils when there is minimal turf cover (not long after harvest), farmers in drier parts of the state often aerate after the turf has achieved more than 80% ground cover to avoid issues with the soil drying out.

Water repellency was a more significant issue on turf farms west of the Great Dividing Range, especially those with sandy soils. Some turf farmers routinely inject low rates of wetting agents into their irrigation system to prevent their soils from becoming hydrophobic.

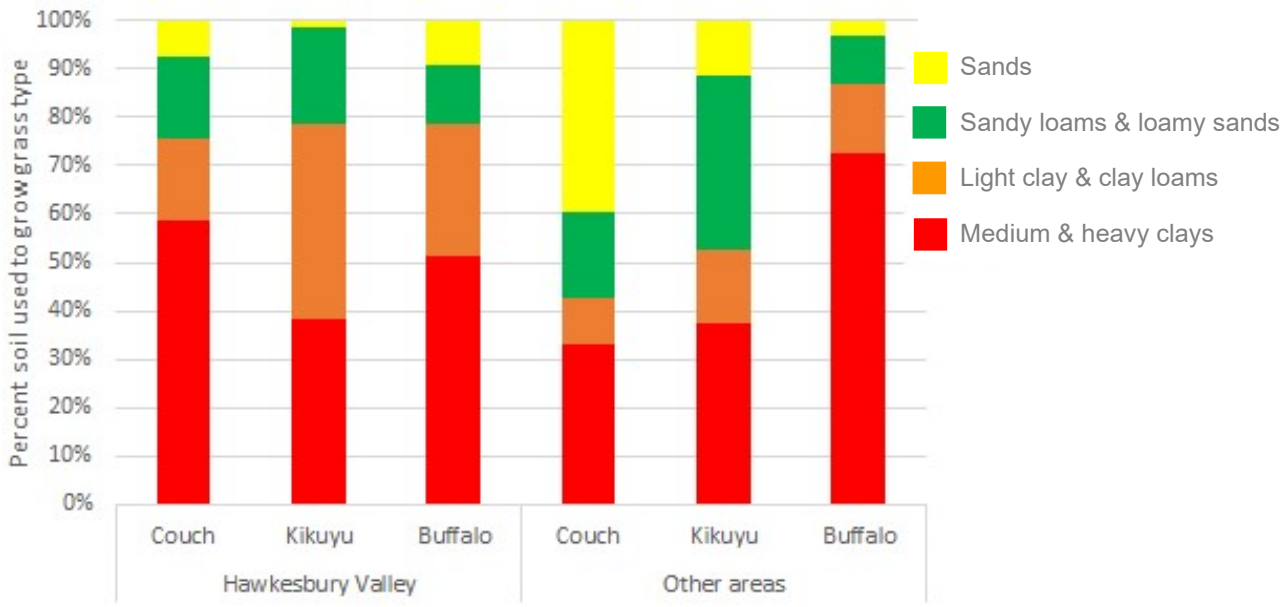



**Figure 4.1:** Soil texture observed on turf farms across NSW

# 5 Soil chemistry

Soil samples were collected on each of the turf farms involved in this study and submitted to the laboratory for agronomic chemical analysis. The results were combined with those from previous turf farm nutrient test results. It was found that farms located in (Figure 5.1):

- **Coastal areas:** soils often low in potassium (56% of farms) and calcium (53% of farms), with some farms also low in phosphorus (28% of farms) and sulphur (20% of farms)
- **West of the Great Dividing Range:** soils were often low in potassium (73% of farms), calcium (48% of farms), phosphorus (41% of farms) and sulphur (70% of farms).

Most farms displayed low levels of micronutrients, especially zinc and boron in areas west of the Great Dividing Range (Figure 5.1).

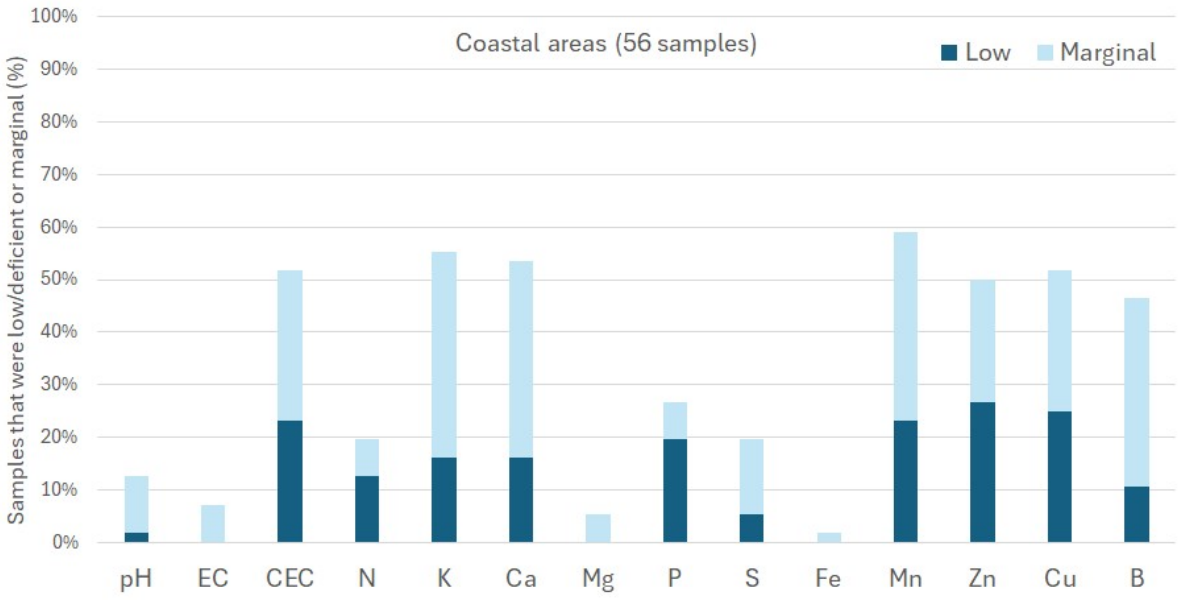
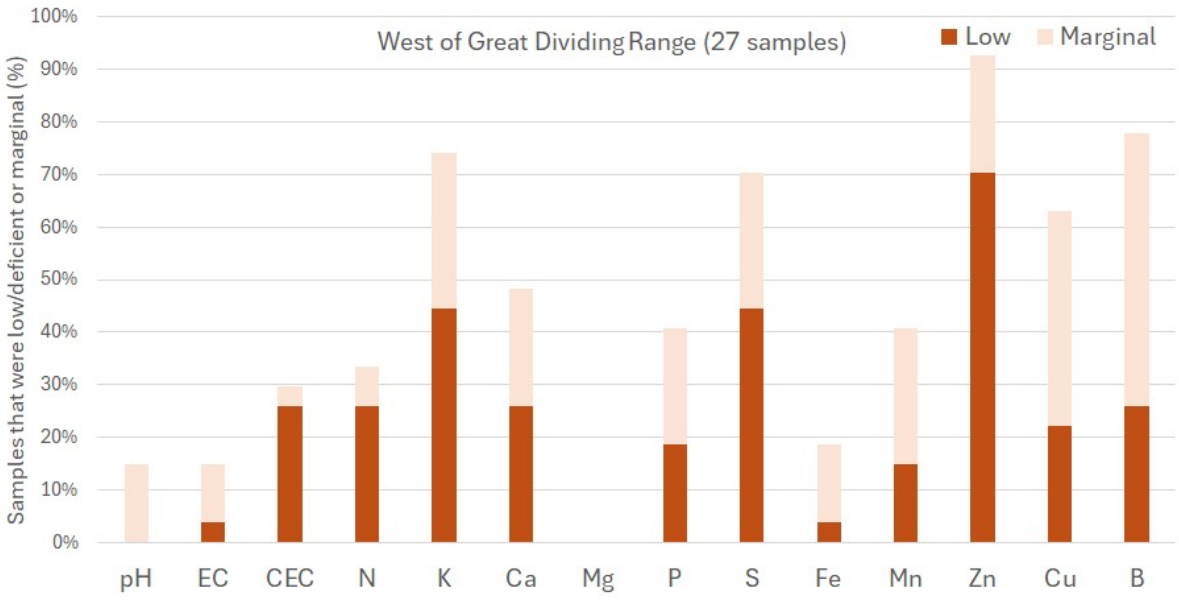



**Figure 5.1:** Occurrence of nutritional issues observed on NSW turf farms in coastal areas (upper) and those located west of the Great Dividing Range (lower).



# 6 Irrigation method

Irrigation system type was mapped on 956 hectares of NSW turf farms which found (Figure 6):

- **Big gun travellers:** used to irrigate 54% of the turf farming areas in the coastal areas, but only 4% of turf farming areas west of the Great Dividing Range
- **Centre pivots and lateral moves:** used on 25% of turf farming areas in the coastal areas and 77% of turf farming areas west of the Great Dividing Range
- **Fixed head sprinklers:** used on about 18% of NSW turf farming areas, with pop-ups used more frequently by turf farmers in coastal areas and permanent set aluminium systems used more often by farmers west of the Great Dividing Range.

Many farms in rural parts of NSW were using hand shift aluminium pipe mounted sprinklers to provide additional water during sprigging and/or leading up to harvest in dry periods.

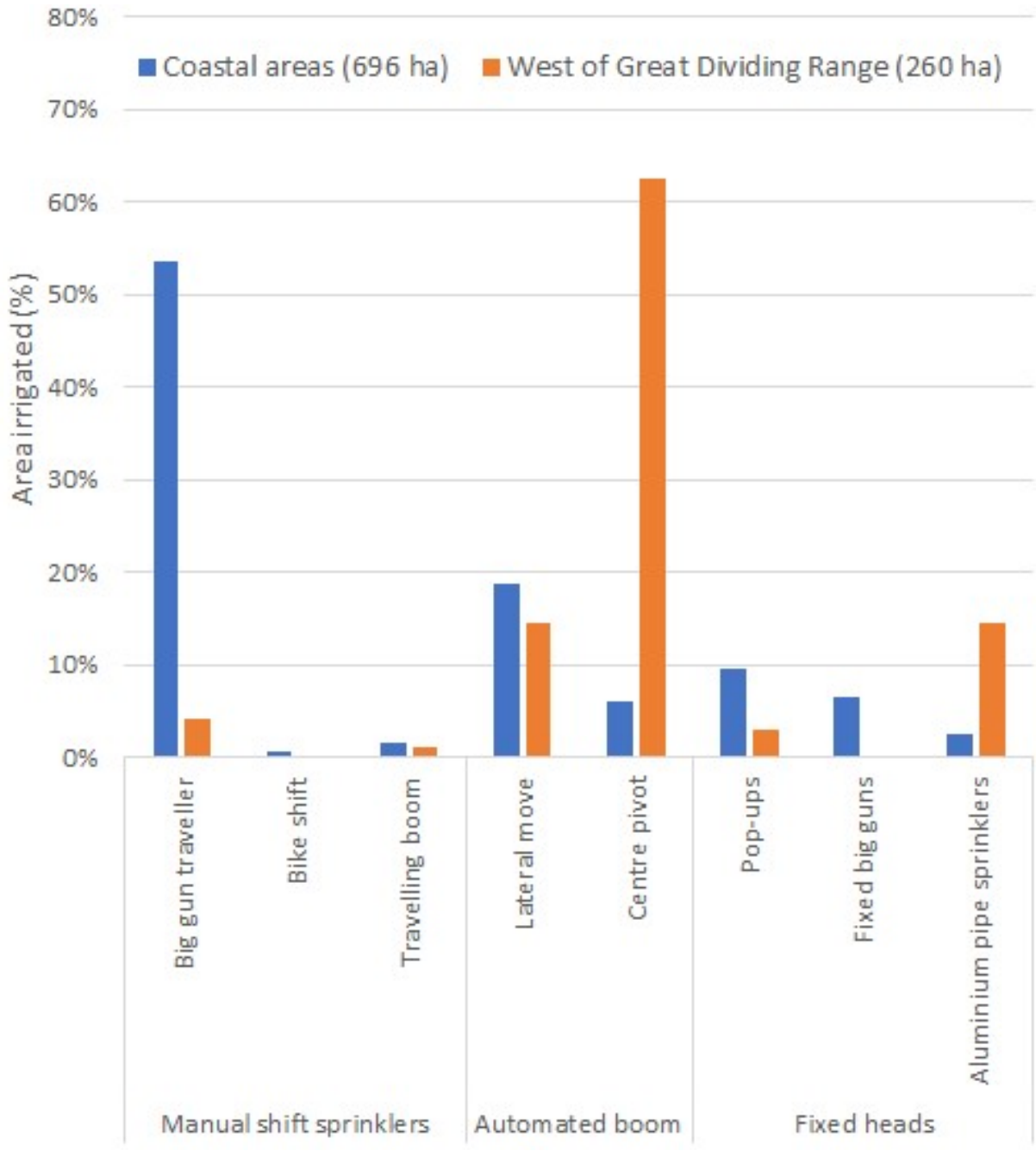



**Figure 6.1:** Irrigation system used to water turf farms across NSW.

# 7 Irrigation system performance

Irrigation system performance was measured on the following farms (some farms have more than one irrigation system), with some of these assessments performed as part of a previous study:

- Earls turf
- Dubbo Turf
- Western Plains Turf
- Green Acres Turf
- Windsor Turf
- Grech's Turf
- Greener Lawns
- ABC Turf
- Active Turf
- Cobbitty Turf
- D & V Turf
- Glossodia Turf.

Irrigation audits were performed by Rex Sullings (certified irrigation designer) and Dave McKechnie (certified irrigation agronomist), with data also provided by Neale Tweedie.

## 7.1 Aluminium solid set sprinkler lines

Catch can test results found these systems can apply water evenly, with an SC (Scheduling Coefficient) of 1.15 to 1.28 observed on two systems. However, on some farms these systems were applying water very unevenly (SC>1.8) due to major issues such as:

- low operating pressures
- some sprinklers being mounted on risers whilst others are not (Figure 7.1)
- different types of sprinkler heads used on the same pipe (Figure 7.1)
- inappropriate spacing between sprinklers (one system used sprinklers spaced 6 m apart on pipes that spaced 17.5 m apart)
- nozzle wear, with some nozzles likely not having been replaced in more than 10 years
- low point drainage: following irrigation events some laterals drained through low lying sprinklers. It then took 9 minutes for all sprinklers to reach full operating pressure during the next watering event. Installation of check valves can address this problem.

The assessments show that by selecting an appropriate sprinkler, nozzle, spacing and operating pressure combination it is possible to apply water evenly using aluminium fixed hand shift lines. However, if the system is not designed and maintained correctly then it will apply water unevenly.

**Figure 7.1:** These sprinklers are mounted on the same lateral despite having different nozzles, with one mounted on a riser whilst the other is not. As such, uneven watering occurs.

## 7.2 Pop-ups and fixed big guns

The evaluation of pop-up irrigation systems found SC values varied from 1.15 to 1.28. These systems have similar sprinklers to those used on sporting fields where SC values of 1.1 to 1.25 can often be achieved. However, an SC of 2.0 was observed on one turf farm, with uneven watering on this site due to a combination of factors including:

- an inappropriate combination of spacing, sprinkler, nozzle and pressure had been used
- different types of sprinklers had been installed
- some of the heads were damaged and/or leaking
- significant amounts of nozzle wear were observed

The results show that it is possible to select a combination of sprinkler, nozzle, operating pressure and spacing that applies water evenly (SC less than 1.2). This is achievable with smaller sprinklers (e.g. Hunter I20s) and larger radius sprinklers (e.g. Hunter I90s and some of the fixed big guns). However, wind is more likely to adversely affect larger radius sprinklers that throw higher into the air.

| Leaking heads during operation | Variable patterns (uneven) |
|---|---|

**Figure 7.2** Various problems were observed with the sprinkler irrigation system

## 7.3 Centre Pivot and lateral move

Catch can test results from two centre pivot systems found these were applying water evenly, with SC of 1.05 to 1.14 respectively. Similar results were observed on two lateral boom systems (SC of 1.1 to 1.23). As such, these systems can apply water evenly if designed, operated and maintained correctly. These systems are also less adversely affected by wind (Figure 8.3).

**Figure 7.3:** Water being applied relatively evenly by a lateral move that is also used as a centre pivot on this farm.

## 7.4 Travelling booms (cart booms)

Travelling booms were only on observed irrigating about 2% of the turf farming areas involved in this study (Figure 6.1). One system was assessed and found to be applying water evenly, with an SC of 1.15 (Figure 7.4).

**Figure 7.4:** Water being applied relatively evenly by a travelling boom (cart boom).

## 7.5 Big gun travellers

Catch can measurements on big gun travellers found these systems apply water unevenly, with SC values varying from 1.6 to almost 3.0. Whilst some travellers displayed high levels of nozzle wear, even some of the well-maintained travellers were found to be applying water unevenly. As such, it is not surprising to find few of these systems in areas west of the Great Dividing Range where water is more likely to be limited (Figure 6.1).

Less even watering is likely to occur in windy conditions, with wind having a major impact on big gun travellers (Figure 7.5).

**Figure 7.5:** In calm conditions big gun travellers apply water unevenly, with this made significantly worse during windy conditions.

## 7.6 Boom made from a big gun traveller

One farmer converted a big gun traveller to a travelling boom. This system had some sprinklers:

- not sitting parallel with the ground
- changing angles relative to the ground as the device travelled on uneven terrain.

Despite these issues the system applied water relatively evenly (SC 1.31).

**Figure 7.6:** Relatively even watering using a travelling big gun converted into a lateral boom.

## 7.7 Summary of findings

The assessment of turf farm irrigation systems found all big gun traveller assessed were applying water unevenly. In contrast, other systems were found to be capable of applying water evenly (Figure 6.6), but examples for poorly performing solid set irrigation systems were found.

The irrigation assessments were generally performed when windspeeds were low. As such, the results would be worse, especially for the big gun travellers that throw water higher in the air.

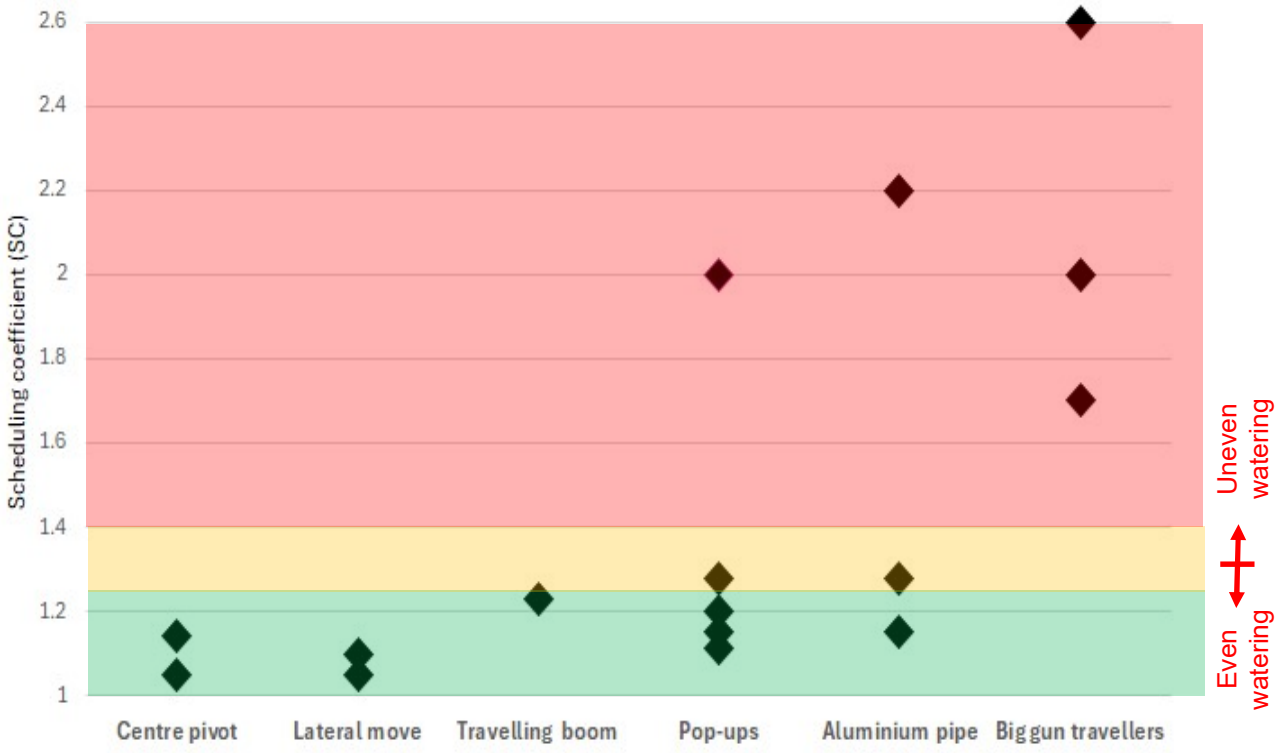



**Figure 7.7:** The above chart shows results of turf farm irrigation system tesing (results for 2 centre pivots, 2 lateral moves, 1 travelling boom, etc). Water was applied evenly by centre pivots, lateral moves, travelling booms and well laid solid set sprinklers. In contrast, big gun travellers and poorly laid out solid set systems applied water unevenly.

# 8 Irrigation system costs

## 8.1 System set up costs

The cost to purchase and install various types of turf farm irrigation systems were estimated by Neale Tweedie (Hawkesbury Valley Irrigation & Grech's Turf). These costs:

- have been calculated using an area to be irrigated of 9 Hectares (22.2 acres), with centre Pivot system calculated over 12.5 hectares to make the system cost viable
- assume a paddock for the design purpose is 150m wide and 600m in length.
- assume an additional 100m of pipe mainline is required to reach the pump station
- exclude pump station purchase and installation costs

Apart from sprinklers on aluminium pipe, the most expensive system to set-up were travelling booms, larger radius pop-up sprinklers and lateral moves. Centre pivots are the cheapest per hectare followed by the Turbine drive T300 (40 m radius) soft hose irrigators (Figure 8.1). A breakdown of the system set-up components and costs are presented in Appendix A.

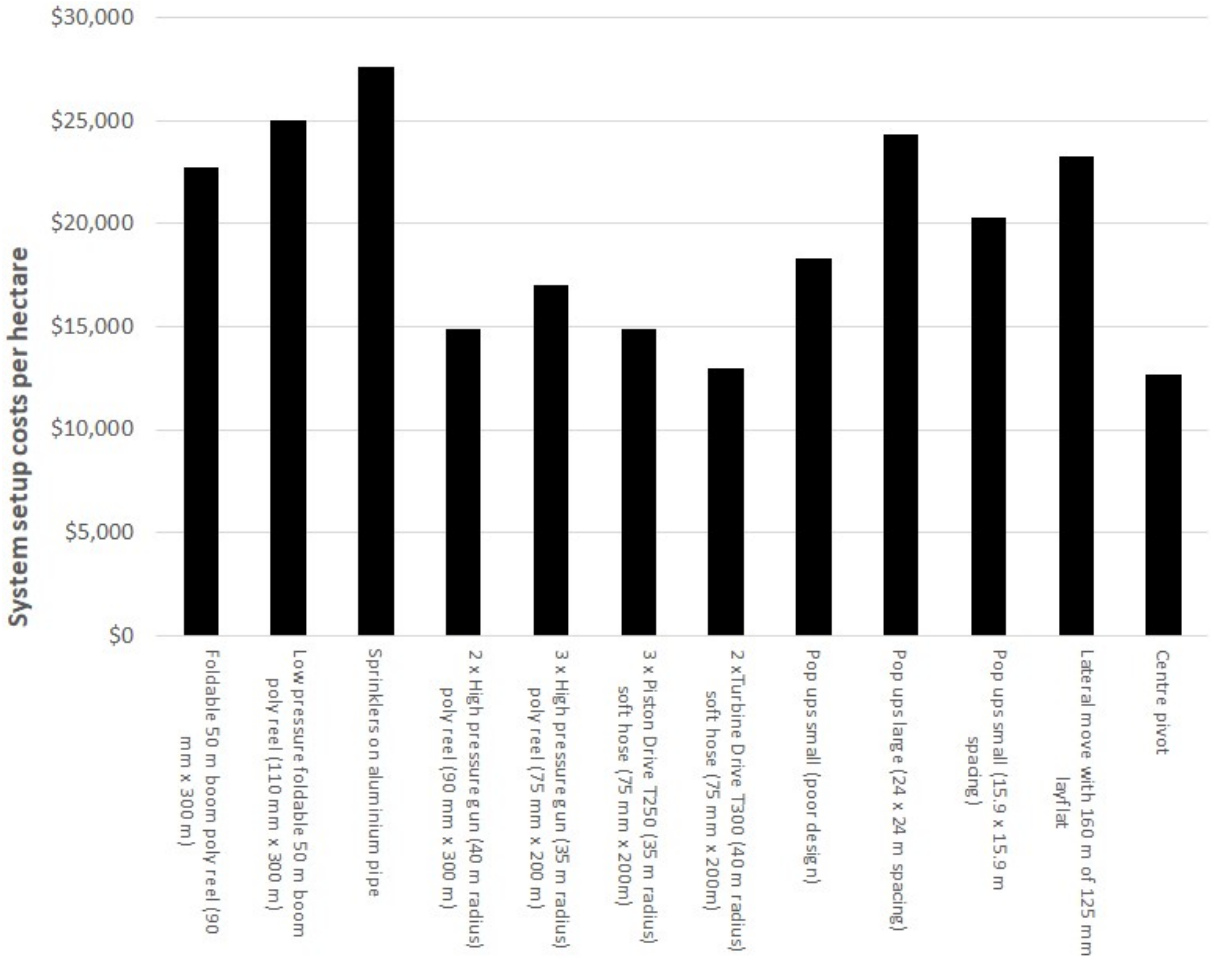



**Figure 8.1:** Set up costs for different irrigation systems used to irrigate turf farms.

## 8.2 System lifecycle costs

Lifecycle costs over a 25-year period were calculated by combining:

- **system set-up costs:** presented in Appendix A and summarised in Figure 8.1
- **Labour and maintenance costs:** based on information provided by Neale Tweedie (Grech's Turf), Matt (New Lawn Turf), Ken (Tarcoola Turf), Alex White (Dubbo Turf Supplies), Joe Muscat (Greener Lawns) and Frank Muscat (J&B Buffalo)
- **Water costs:** assume $50 per ML to purchase water (can increase to more than $400 per ML during drought in some areas), with annual watering requirements based on current practices and irrigation system performance data (Section 7)
- **Pumping costs:** assume $0.41 per kWh, with the pumping power costs based on system operating pressure information provided by Neale Tweedie and a publication written by former DPI officer Peter Smith (Prime Fact 1410, 2015)

Lifecycle costs were lowest for centre pivots and well-designed pop-up sprinkler systems (~16 m radius), with the third lowest being the Turbine drive T300 soft hose traveller. The highest lifecycle costs were aluminium pipes sprinklers (aluminium is expensive), high pressure hose reel big guns, piston drive big guns and travelling booms (Figure 8.2).

Pumping costs are significantly higher for big gun travellers due to a combination of uneven watering and higher operating pressures. However, pumping costs can also be high for poorly designed pop-up irrigation systems, especially those with larger radius sprinklers that have higher operating pressures. These findings suggest that pumping costs to a point could be a catalyst for adopting more efficient irrigation systems, even in areas where water is not limiting (Figure 8.2) and especially if electricity costs continue to rise.

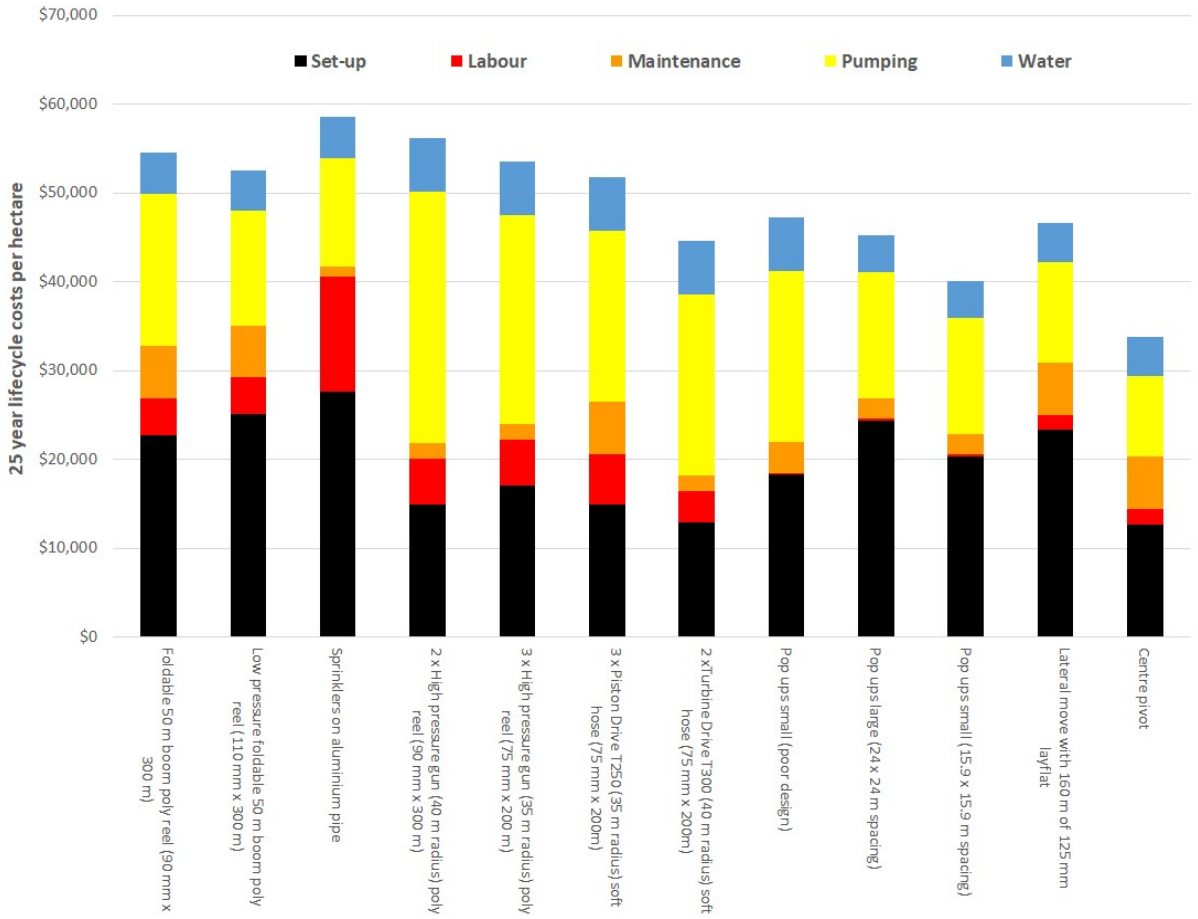



**Figure 8.2:** Lifecycle costs for irrigation systems used on turf farms. Assumes water costs of $50 per ML, power costs of $0.41 per KWh, with a base average annual irrigation demand increased by the unevenness of the irrigation system.

## 8.3 Other factors influencing choice of irrigation system

In addition to lifecycle costs, other factors influence the type of irrigation system used on turf farms. Generally speaking:

- **Big gun travellers:** can handle poor quality water and are relatively easy to transport to higher ground prior to floods. However, these systems are poorly suited to:
    - windy sites (Figure 8.3)
    - sites where water can become limiting (big guns water unevenly and cannot apply less than 10.8 mm (turbine drives) to 14.4 mm (piston drive) per watering event
    - sites where labour is limiting
- **Aluminium solid set sprinklers:** can apply water evenly if well designed and maintained, but are poorly suited to sites:
    - subject to frequent flooding (labour intensive to move lines)
    - where labour is limiting (some farmers spray around pipes and do not move them)
- **Pop-up sprinklers:** poorly suited to sites with low water quality (blockages or corrosion). Are suitable for flood prone sites. They can apply short watering events that enables:
    - accurate watering in of herbicides/fungicides so they are targeted to the root zone and less chemical is absorbed by the plant (less chemical damage to the crop).
    - easy watering of cutting faces for harvesting.
    - quick syringe watering cycles which can cool the turf on a hot day or save water by delaying irrigation prior to an anticipated storm event.
- **Travelling booms:** poorly suited to sites with a low infiltration rate or uneven terrain
- **Lateral move and pivots:** have lower labour costs and can apply water evenly, but are poorly suited to:
    - small/odd-shaped paddocks: several farmers have pivots in rectangular paddocks with pop-ups, fixed big guns or solid set aluminium pipes in the corners
    - Sites subject to flooding that have no higher ground where the irrigator can be stowed prior to flood events.

Whilst it may be cheaper in the long term to upgrade to a more efficient irrigation system, cashflow may prevent or delay the timing of irrigation upgrades.

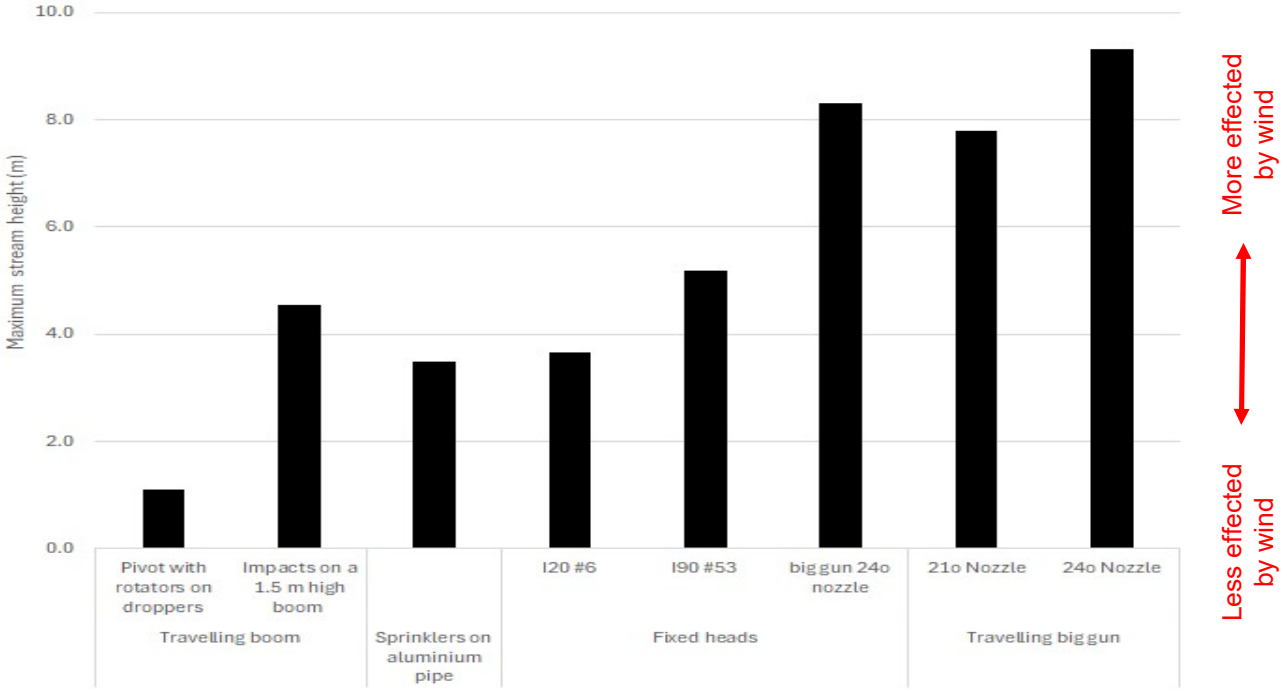



**Figure 8.3:** Maximum height of throw by various turf farm irrigation systems. Systems that throw higher typically have a higher operating pressures (higher pumping costs) and are more effected by wind, but other factors such as droplet size will also have an impact.

# 9 Drought mitigation measures

Six turf farmers (17 farms) had inadequate water supply to maintain normal turf production in the 2019 drought (Table 9.1), with two other farmers observing a decline in water quality. Techniques that could reduce the impact of drought on turf farms are described below which also presents the findings of cost benefit analysis (Appendix B & Table 9.2) for implementing these measures on the six turf farmers listed in Table 9.1. The impact of the measures on turf production for these farms were estimated using water balance modelling based on 20 years of daily weather data.

**Table 9.1:** Impact of the drought on turf farm production for six farmers (17 farms) that had inadequate water supply during drought periods.

| Farmer | No. of farms | Turf production impact | Drought impact on water supply | | Irrigation evenness (SC) |
|---|---|---|---|---|---|
| | | | Inadequate water supply? | Decline in water quality | |
| A | 3 | Intermediate | Inadequate supply | No | >1.6 |
| B | 2 | Major | Inadequate allocation | No | 1.15 |
| C | 1 | Minimal | Inadequate allocation/licence | No | 1.15 |
| D | 5 | Major | Inadequate allocation/licence | No | 1.2 |
| E | 3 | Intermediate | Inadequate bore flow rates | Yes | 1.4 |
| F | 1 | Major | Inadequate bore flow rates | Minor | 1.15 |

## 9.1 Sourcing additional water

Based on discussions with 30 farmers, the water used for irrigating turf farms included river water (21 sites), bore water (5 sites), dam water (2 sites), recycled effluent (1 site) and a combination of river and bore water (2 sites). Of the six farmers that had inadequate water supply during the 2019 drought, additional water could have been sourced by:

- **Purchasing a bore licence and install a bore:** this was the most cost-effective option for mitigating the drought for Farmer B, with a net benefit of $6.48 for every dollar spent;
- **Purchasing additional bore water via temporary transfer:** this was the most cost-effective means for mitigating the drought for:
    - Farmer C: with a net benefit of $23.81 for every dollar spent
    - Farmer D: with a net benefit of $25.62 for every dollar spent
- **Installing a dam to mitigate shortfalls in bore water flow rates:** this was the most cost-effective option for Farmer F, with a net benefit of $11.64 for every dollar spent.

The cost effectiveness of these measures declined if the drought coincided with a period of water restrictions that reduced home lawn sales. However, even when a 75% decline in the home lawn market was assumed during drought, these measures had a net monetary benefit for every dollar spent of $2.46 (Farmer B), $23.81 (Farmer C), $12.81 (Farmer D) and $3.27 (Farmer F).

The payback period for implementing these measures ranged from 3 to 10 years (Appendix B, see page 32).

## 9.2 Installing a more efficient irrigation system

Of the six farmers that had inadequate water supply during the 2019 drought, four had irrigation systems that applied water evenly (Table 9.1). For the remaining two farmers, the impact of the drought could be reduced by installing an irrigation system that applies water evenly. For:

- Famer A: this would result in a net benefit of $2.27 for every dollar spent
- Farmer E: this would result in a net benefit of $3.29 for every dollar spent

If a 75% decline in the home lawn market was assumed during drought, these measures still had a net monetary benefit for every dollar spent of $1.01 (Farmer A), $1.80 (Farmer E).

The payback period for these measures was about 7 years, but this extended to 10 years (Farm E) and 24 years (Farm A) if there is a 75% decline in the home lawn market each drought.

## 9.3 Amending the soil

Of the 1053 hectares assessed, 70% of turf was grown on soil with a clay loam or heavier texture (Section 4), with compaction is a major issue on most farms. Amendment of the soil can be achieved by incorporating suitable forms of fibrous organic matter (e.g. 150 $m^3$ per hectare of AS 4454 compost) prior to planting which typically occurs every 5 to 7 years. Modelling found:

- Farmer A: a net benefit of $1.49 for every dollar spent
- Farmer B: a net benefit of $1.35 for every dollar spent
- Farmer C: a net benefit of $1.83 for every dollar spent
- Farmer D: a net benefit of $3.30 for every dollar spent
- Farmer E: a net benefit of $1.50 for every dollar spent
- Famer F: a net benefit of $1.61 for every dollar spent

However, when a 75% decline in the home lawn market was assumed during drought, these measures had a net monetary benefit for every dollar spent of $1.35 (Farmer B), $1.83 (Farmer C), $2.08 (Farmer D), $1.27 (Farmer E), and $1.44 (Farmer F). However, this would have resulted in a net loss for Farmer A, with every dollar spent only returning $0.74. However, soil amendment will enable turf to grow more rapidly during years when water is not limiting, but this will only result in a further monetary benefit if it coincides an increase in turf sales.

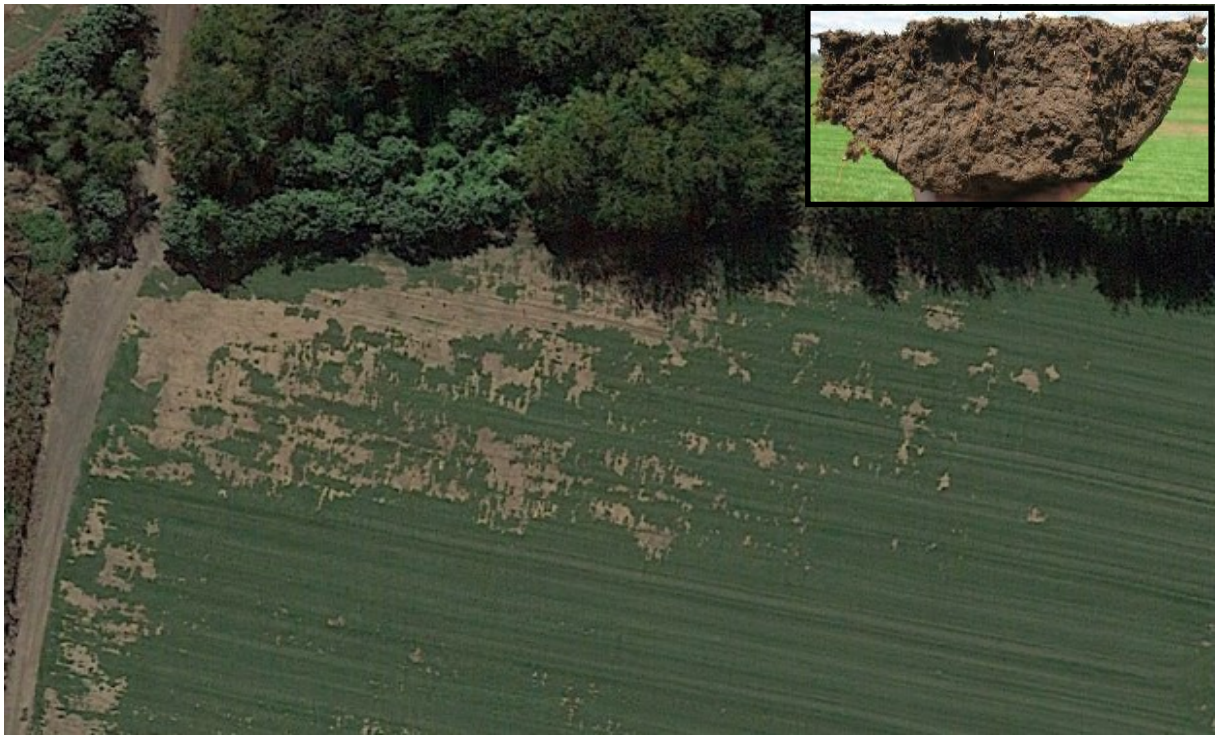


**Figure 9.1:** Turf struggling on the edges and corner of the paddock due to compaction.

## 9.4 Scheduling irrigation more accurately

Sixteen turf farmers provided information on the millimetres of irrigation applied in a typical summer week when no rainfall occurs, with this generally ranging from 16 to 25 mm per week (Figure 9.2). However, after accounting for climate differences, farms located:

- **West of the Great Dividing Range (6 farmers):** the irrigation applied by all 6 farmers was less than 50% of reference crop evapotranspiration rates i.e. 50% of $ET_o$.
- **Hawkesbury, Hunter, central and mid coast (10 farmers):** the irrigation applied ranged from 32 to 82% of $ET_o$.

After accounting for irrigation system unevenness (SC), 4 of the turf farmers were typically applying less than 25% of $ET_o$ to the driest quarter of their paddocks. Despite this, these farms had a similar timeframe between turf harvesting events to those on the other 12 farms, with this being 1100 to 1300 growing degree days (GDD) for kikuyu and most couch cultivars, and 1900 to 2100 GDD for buffalo.

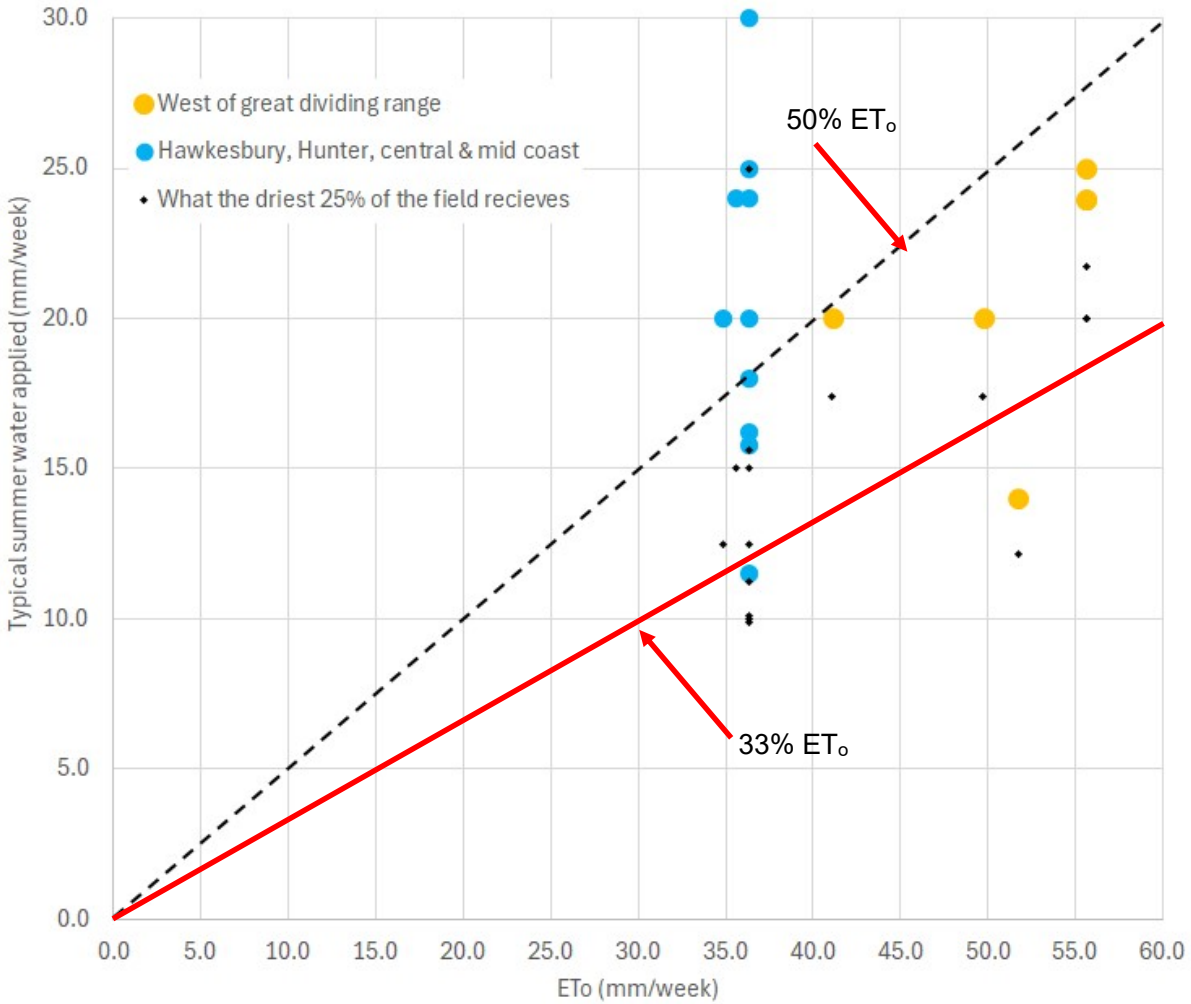



**Figure 9.2:** Apart from one farmer with brackish water, turf farmers west of the Great Dividing Range generally applied about 45% of $ET_o$ during summer. One farmer in the Hawkesbury was also using ~45% $ET_o$, with most of the other farmers east of the Great Dividing Range applying much more water, often with irrigation systems that were quite uneven.

### How much water does 25% $ET_o$ represent?

Assuming water is applied evenly (SC 1.2), 25% $ET_o$ in non-rain periods represents (Table 9.1):

- 12.3 (Taree) to 17.7 mm per week (Dubbo) for average summer conditions with no rain
- 13.1 (Taree) to 21.7 mm per week (Dubbo) for typical drought summer conditions.

The values in table 9.1 should be increased by 33% for sites irrigated with big gun travellers. These systems typically cannot apply less than 8.2 mm (turbine drives) to 14.4 mm (piston drives) per watering event (Appendix C). To apply the weekly volumes in Table 9.1 requires less frequent watering events e.g. watering every 5 days with a piston drive to apply 20.6 mm per week.

**Table 9.1:** Turf watering requirements for non-rainfall days in summer for various locations.

| Location | Average summer week | Typical drought summer week |
|---|---|---|
| Dubbo | 17.7 mm | 21.7 mm |
| Tamworth | 15.9 mm | 19.3 mm |
| Wagga | 16.3 mm | 19.3 mm |
| Bathurst | 12.8 mm | 16.8 mm |
| Singleton | 13.0 mm | 14.9 mm |
| Taree | 12.3 mm | 13.1 mm |
| Hawkesbury | 12.3 mm | 13.2 mm |

### Impact of watering less

Based on modelling, if Farm A reduced their watering regime in the drought so that 25% $ET_o$ plus SC was applied that this would result in a net benefit of $26.59 for every dollar spent on additional climate monitoring equipment.

Reducing the irrigation volume applied to closer to 25% $ET_o$ plus SC could also be used to reduce power consumption during drought periods when turf growth maximisation may not be required (e.g. quieter sales period).

### How far can the turf be pushed?

Turf is likely to struggle to remain green if irrigation volumes below 22% $ET_o$ plus SC are used based on observations of turf health on compacted sports fields in the 2019 drought (Figure 9.3).

**Figure 9.3:** This sports field was just remaining green despite its driest quartile only receiving 22% $ET_o$ in the 2019 drought (this soil is similar to that observed on many turf farms).

## 9.5 Cost effectiveness of drought mitigation measures

Modelling using 20 years of daily weather data was used to identify the most cost-effective measures that should be implemented by 6 turf farmers that had inadequate water supply in the 2019 drought. The most cost-effective means for mitigating drought (in order from most to least cost effective) were found to be (Table 9.2):

- Reducing the watering regime to 25% of $ET_o$ (Farmer A)
- Purchasing additional bore water via temporary transfer (Farmers C & D)
- Installing a dam to mitigate shortfalls in water supply (Farmer F)
- Purchasing a bore licence and installing a bore (Farmer B)
- Installing a more efficient irrigation system (Farmers A & E)
- Amending the soil prior to planting (all farmers)

The cost effectiveness of these measures declined if the drought coincided with a period of water restrictions that reduced home lawn sales. However, even when a 75% decline in the home lawn market was assumed in drought, 12 out of these 13 activities still had a net monetary benefit for every dollar spent. Payback periods for implementing these drought mitigation measures are presented in Appendix B.

**Table 9.2:** Cost benefit analysis model results for implimenting various drought mitigation measures by six turf farmers that had inadequate water supplying during the 2019 drought.

| **Drought minimisation measure** | **Net benefit for every dollar spent for the 6 farms that had inadequate water supply during the 2019 drought** | | | | | |
|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** |
| Purchase a bore licence and install a bore | | $6.48 | | | | |
| Purchasing additional bore water via temporary transfer | | | $23.81 | $25.62 | | |
| Installing a dam to mitigate shortfalls in bore water flow rates | | | | | | $11.64 |
| Install a more efficient irrigation system | $2.27 | | | | $3.29 | |
| Amending the soil prior to planting | $1.49 | $1.35 | $1.83 | $3.30 | $1.50 | $1.61 |
| Changing the watering regime so the driest quarter receives 25% of $ET_o$ | $26.59 | | | | | |

# 10 Conclusions

The study presents the results of assessments on 1053 hectares used for turf farming and irrigation system assessments on 11 turf farms (some farms have multiple types of irrigation system). This study found that turf farmers located in:

- **Coastal areas (east of the Great Dividing Range):** more commonly used irrigation systems that water unevenly (54% have big gun irrigators), with most farmers applying 46 to 70% of $ET_o$ during summer
- **West of Great Dividing Ranges:** more commonly used irrigation systems that water evenly (63% have centre pivots and 15% have lateral moves), with most farmers applying 40 to 50% of $ET_o$ during summer

These results are not surprising given drought occurs more often in central NSW relative to areas east of the Great Dividing Range. The most cost-effective means for reducing the impact of drought were evaluated for six turf farmers that had inadequate water during the 2019 drought. The most cost-effective solutions involved scheduling irrigation more accurately and purchasing additional bore water via temporary transfer during drought.

The study evaluated the lifecycle costs of various irrigation system types, with the lowest costs associated with centre pivots and well-designed pop-up sprinkler systems (~16 m radius), with the third lowest being the Turbine drive T300 soft hose traveller.

Pumping represented a significant proportion of the costs associated with watering, especially for high pressure systems that apply water unevenly. These results suggest pumping costs could be a catalyst for adopting more efficient irrigation systems, even in areas where water is not limiting

# Appendix A: Irrigation system set up costs

The cost to purchase and install various types of turf farm irrigation systems were estimated by Neale Tweedie (Hawkesbury Valley Irrigation & Grech's Turf). These costs:

- have been calculated using an area to be irrigated of 9 Hectares (22.2 acres), with centre Pivot system calculated over 12.5 hectares to make the system cost viable
- assume a paddock for the design purpose is 150m wide and 600m in length.
- assume an additional 100m of pipe mainline is required to reach the pump station
- exclude pump station purchase and installation costs

The application rate and minimum watering event sizes for these irrigation systems are provided in Appendix C.

**TRAVELLERS : Piston Drive T250 Soft Hose, 75mm x 200m.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | | |
| Suction Friction Loss | 1.5 | | | | |
| Static Head | 13 | | | | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 6 | 1000 | 6000 | |
| Pressure Head at Nelson 100 Irrigator Gun using 8 lps with 0.86" jet (21.8mm) | 45 | 3 | 32500 | 97500 | |
| Friction loss in 75mm Layflat hose at 8 lps over 200m = 2.5m/100m | 5 | | | 0 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m = 1.5m / 100m | 7.5 | 500 | 45 | 22500 | |
| Mainline Friction in 100mm Pn9 Mainline at 8 lps over 65m = 1.5m /100m | 1 | 268 | 22 | 5896 | |
| **TOTAL Head at 24 lps** | **85.5** | | | $134,116 | **$14,902** |

**TRAVELLERS : Turbine drive T300 Soft Hose, 75mm x 200m.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | | |
| Suction Friction Loss | 1.5 | | | | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 6 | 1000 | 6000 | |
| Pressure Head at Nelson 100 Irrigator Gun using 12 lps with 0.96" jet (24.5mm) | 45 | 2 | 40000 | 80000 | |
| Friction loss in 75mm Layflat hose at 12 lps over 200m = 3.5m/100m | 10 | | | 0 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m = 1.5m / 100m | 7.5 | 500 | 45 | 22500 | |
| Mainline Friction in 100mm Pn9 Mainline at 12 lps over 65m = 1.5m /100m | 1 | 268 | 22 | 5896 | |
| **TOTAL Head at 24 lps** | **90.5** | | | $116,616 | **$12,957** |

**TRAVELLERS : Poly Reel 90mm x 300m with High Pressure Gun.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine for Gun to achieve 100m/minute and 6mm application | 90 | 2 | 53000 | 106000 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m | 7.5 | 400 | 45 | 18000 | |
| Mainline Friction in 100mm Pn12 Mainline at 12 lps over 65m | 1 | 134 | 36 | 4824 | |
| **TOTAL Head at 24 lps** | **125.5** | | | $134,044 | **$14,894** |

**TRAVELLERS : Poly Reel 75mm x 200m with High Pressure Gun. 3 Machines at 8 lps (35m)**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine for Gun to achieve 100m/minute and 5mm application | 69 | 3 | 38454 | 115362 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m | 7.5 | 400 | 45 | 18000 | |
| Mainline Friction in 100mm Pn12 Mainline at 12 lps over 65m | 1 | 402 | 36 | 14472 | |
| **TOTAL Head at 24 lps** | **104.5** | | | $153,054 | **$17,006** |

**BOOM TRAVELLERS : Poly Reel 90mm x 300m with Low Pressure Foldable Boom.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine for Gun to achieve 100m/minute and 10mm application | 66 | 2 | 89400 | 178800 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m | 7.5 | 400 | 45 | 18000 | |
| Mainline Friction in 100mm Pn9 Mainline at 12 lps over 65m each side of main | 1 | 134 | 22 | 2948 | |
| **TOTAL Head at 24 lps** | **101.5** | | | $204,968 | **$22,774** |

**BOOM TRAVELLERS : Poly Reel 110mm x 300m with Low Pressure Foldable Boom.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 3 | 740 | 2220 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine for Gun to achieve 100m/minute and 10mm application | 41 | 2 | 99693 | 199386 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m | 7.5 | 400 | 45 | 18000 | |
| Mainline Friction in 100mm Pn9 Mainline at 12 lps over 65m each side of 150 main | 1 | 134 | 22 | 2948 | |
| **TOTAL Head at 24 lps** | **76.5** | | | $225,554 | **$25,062** |

**POP UPS: Small spaced at 15.9x 15.9m.**

| Item | Pressure (m) | Number | $ per item | Total ($/9 ha) | Cost per hectare) |
|---|---|---|---|---|---|
| Operate 4 x 100m lines on 63mm poly at once. 6 sprinklers per line = 24 sprinklers = 24 lps | | | | | |
| Suction Lift | 5.5 | | | | |
| Suction Friction Loss | 1.5 | | | | |
| Static Head | 13 | | | | |
| Head loss in valves | 2 | 27 | 1000 | 27000 | |
| Head loss in fittings | 5 | 10 | 600 | 6000 | |
| Pressure at Sprinkler at one lps per head | 41 | 330 | 138 | 45540 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m = 1.5m/100m | 7.5 | 600 | 45 | 27000 | |
| Mainline Friction in 100mm Pn9 Mainline at 12 lps over 65m | 1 | 390 | 22 | 8580 | |
| Friction loss at 6 lps in 100m of 2' Rural Pn6 Poly pipe =11m /100m with SF of 0.36 >3.96 | 4 | 4555 | 14 | 63770 | |
| Head loss in filter | 5 | 1 | 2000 | 2000 | |
| Automatic Controller | | | | 3000 | |
| 13 Core cable | | 2000 | 10.3 | 20600 | |
| 4mm Single Core cable | | 2000 | 3.1 | 6200 | |
| **TOTAL HEAD at 24 lps** | **85.5** | | | $182,890 | **$20,321** |

**POP UPS: Large spaced at 24 x 24 m.**

| Item | Pressure (m) | Number | $ per item | Total ($/9 ha) | Cost per hectare |
|---|---|---|---|---|---|
| Operate 1 x 120m line on 100mm pvc at once. 6 sprinklers per line x 3lps = 18 lps | | | | | |
| Suction Lift | 5.5 | | | | |
| Suction Friction Loss | 1.5 | | | | |
| Static Head | 13 | | | | |
| Head loss in valves | 2 | 25 | 1200 | 30000 | |
| Head loss in fittings | 5 | 25 | 400 | 10000 | |
| Pressure at Sprinkler at 3 lps per head | 55 | 156 | 421 | 65676 | |
| Mainline Friction in 150mm PN12 Mainline at 18 lps over 500m = 0.6m/100m | 3 | 700 | 45 | 31500 | |
| Friction loss at 18 lps in 140m of 100mm Pn9 PVC Sprayline pipe =8m /100m with SF > | 3 | 3500 | 22 | 77000 | |
| Head loss in filter | 5 | 1 | 2000 | 2000 | |
| Automatic Controller | | | | 3000 | |
| 13 Core cable | | 1200 | 10.3 | 12360 | |
| 4mm Single Core cable | | 1200 | 3.1 | 3720 | |
| **TOTAL HEAD at 24 lps** | **93** | | | $219,176 | **$24,353** |

**SPRINKLERS ON ALUMINIUM PIPES.**

| Item | Pressure (m) | Number | $ per item | Total ($/9 ha) | Cost per hectare |
|---|---|---|---|---|---|
| Operate 3 x 108m lines on 80mm Aluminium at once. 12 sprinklers at 40 lpm ea = 24 lps | | 625 | 280 | 175000 | |
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 27 | 1000 | 27000 | |
| Head loss in fittings | 5 | 10 | 600 | 6000 | |
| Pressure at Sprinkler at 36 lpm per head | 30 | | | 0 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 500m = 1.5m/100m | 7.5 | 600 | 45 | 27000 | |
| Mainline Friction in 100mm Pn9 Mainline at 12 lps over 65m (3 lines x 130) | 1 | 390 | 22 | 8580 | |
| Friction loss at 8 lps in 108m of 80mm Aluminium pipe =5m /100m with SF > | 2 | | | | |
| Head loss in filter | 5 | | | | |
| Automatic Controller | | | | 3000 | |
| 13 Core cable | | 1200 | 10.3 | 12360 | |
| 4mm Single Core cable | | 1200 | 3.1 | 3720 | |
| **TOTAL HEAD at 24 lps** | **72.5** | | | $248,580 | **$27,620** |

**LATERAL MOVE IRRIGATOR with 160m of 125mm Layflat.**

| Item | Pressure (m) | Number | $ per item | Total (9 ha) | Cost per hectare |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 2 | 1000 | 2000 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine | 25 | 1 | 180000 | 180000 | |
| Pressure Loss in 125mm layflat over 160m | 10 | 160 | | | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 550m at 1.5m / 100m | 8.25 | 550 | 45 | 24750 | |
| **TOTAL Head at 24 lps** | **70.25** | | | $209,750 | **$23,306** |

**CENTRE PIVOT IRRIGATOR 200m in Length > 12.5 hectares.**

| Item | Pressure (m) | Number | $ per item | Total (12.5 ha) | Cost per hectare |
|---|---|---|---|---|---|
| Suction Lift | 5.5 | | | 0 | |
| Suction Friction Loss | 1.5 | | | 0 | |
| Static Head | 13 | | | 0 | |
| Head loss in valves | 2 | 2 | 1000 | 2000 | |
| Head loss in fittings | 5 | 3 | 1000 | 3000 | |
| Pressure Head at inlet of Machine. | 25 | 1 | 130000 | 130000 | |
| Mainline Friction in 150mm PN12 Mainline at 24 lps over 300m at 1.5m /100m | 4.5 | 300 | 45 | 13500 | |
| **TOTAL Head at 24 lps** | **56.5** | | | $158,500 | **$12,680** |

# Appendix B: Cost benefit analysis

Techniques that could reduce the impact of drought on for six turf farm companies (17 farms) were evaluated using water balance modelling based on 20 years of daily weather data. A cost benefit analysis was then performed to determine the most cost-effective means for reducing the impact of drought for these six farmers, with these presented below.

## Farmer A

Of the 3 options evaluated for reducing the impact of drought of these turf farms, the most cost-effective was found to be more closely monitoring weather and irrigating more frequently (Table A). However, other measures such as installing an irrigation system that applies water evenly and amending the soil would also result in a net benefit for every dollar spent.

The impact of a 75% decrease in home lawn sales in drought found that watering less frequently and installing a new irrigation system still representing a net benefit for every dollar spent.

**Table A:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer A. Prices are in dollars per hectare.

| | | Drought management options | | |
|---|---|---|---|---|
| | **Parameter** | **New irrigation system that waters evenly** | **Soil amendment every 6 years prior to planting** | **Water every 4 to 5 days in dry years (instead of twice per week)** |
| No reduction in turf sale in drought | Total benefits | $42,644 | $22,346 | $23,596 |
| | Total costs | $18,750 | $3,754 x 4 applications over 25 years | $844 |
| | A dollar spent earns over a 25-year lifecycle | $2.27 | $1.49 | $26.59 |
| | Time to payback | 5 to 8 years | 7 years | 1 year |
| | Notes | | | Aim for 25% $ET_o$ plus SC in dry years |
| 75% reduction in turf sale in drought | Total benefits | $18,861 | $11,170 | $19,138 |
| | Total costs | $18,750 | $3,754 x 4 applications over 25 years | $844 |
| | A dollar spent earns over a 25-year lifecycle | $1.01 | $0.74 | $22.67 |
| | Time to payback | 24 years | Never | 1 year |
| | Notes | | | Aim for 25% $ET_o$ plus SC in dry years |

## Farmer B

Of the 2 options evaluated for reducing the impact of drought of these turf farms, the most cost-effective was found to be purchasing a bore licence and installing a bore (Table B). However, amending the soil would also result in a net benefit for every dollar spent.

The impact of a 75% decrease in home lawn sales in drought found that both these options still representing a net benefit for every dollar spent.

**Table B:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer B. Prices are in dollars per hectare.

| | | Drought management options | |
|---|---|---|---|
| | **Parameter** | **Install bore and purchase bore licence** | **Soil amendment every 6 years prior to planting** |
| No reduction in turf sale in drought | Total benefits | $80,864 | $30,924 |
| | Total costs | $12,475 | $5,910 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $6.48 | $1.35 |
| | Time to payback | 3 to 10 years (1st drought year) | 7 years |
| | Notes | | |
| 75% reduction in turf sale in drought | Total benefits | $30,728 | $30,924 |
| | Total costs | $12,475 | $5,910 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $2.46 | $1.35 |
| | Time to payback | 5 to 10 years (1st drought year) | 7 years |
| | Notes | Notes | |

## Farmer C

Of the 2 options evaluated for reducing the impact of drought on this turf farm, the most cost-effective was found to be purchasing additional bore water on the temporary transfer market (Table C). However, amending the soil would also result in a net benefit for every dollar spent.

**Table C:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer C. Prices are in dollars per hectare.

| | | Drought management options | |
|---|---|---|---|
| | **Parameter** | **Purchase bore water on the temporary transfer market water supply is limited** | **Soil amendment every 6 years prior to planting** |
| No reduction in turf sale in drought | Total benefits | $54,611 | $41,915 |
| | Total costs | $2,294 | $5,716 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $23.81 | $1.83 |
| | Time to payback | 3 to 6 years (1st drought year) | 4 years |
| | Notes | | |
| 75% reduction in turf sale in drought | Total benefits | Not applicable because Farmer C only sells into the commercial market (not home lawns) | |
| | Total costs | | |
| | A dollar spent earns over a 25-year lifecycle | | |
| | Time to payback | | |
| | Notes | | |

## Farmer D

Of the 2 options evaluated for reducing the impact of drought of these turf farms, the most cost-effective was found to be purchasing additional bore water via temporary transfer if water becomes limiting (Table D). However, amending the soil would also result in a net benefit for every dollar spent.

The impact of a 75% decrease in home lawn sales in drought found that both these options still representing a net benefit for every dollar spent.

**Table D:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer D. Prices are in dollars per hectare.

| | | Drought management options | |
|---|---|---|---|
| | **Parameter** | **Purchase bore water on the temporary transfer market water supply is limited** | **Soil amendment every 6 years prior to planting** |
| No reduction in turf sale in drought | Total benefits | $106,141 | $108,419 |
| | Total costs | $4,142 | $8,205 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $25.62 | $3.30 |
| | Time to payback | 3 to 6 years (1st drought year) | 6 years |
| | Notes | | |
| 75% reduction in turf sale in drought | Total benefits | $53,089 | $68,260 |
| | Total costs | $4,142 | $8,205 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $12.81 | $2.08 |
| | Time to payback | 3 to 6 years (1st drought year) | 6 years |
| | Notes | | |

## Farmer E

Of the 2 options evaluated for reducing the impact of drought of these turf farms, the most cost-effective was found to be installing a new irrigation system that can apply water evenly (Table E). However, amending the soil would also result in a net benefit for every dollar spent.

The impact of a 75% decrease in home lawn sales in drought found that both these options still representing a net benefit for every dollar spent.

**Table E:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer E. Prices are in dollars per hectare.

| | | Drought management options | |
|---|---|---|---|
| | **Parameter** | **New irrigation system that waters evenly** | **Soil amendment every 6 years prior to planting** |
| No reduction in turf sale in drought | Total benefits | $61,757 | $34,453 |
| | Total costs | $18,750 | $5,716 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $3.29 | $1.50 |
| | Time to payback | 6 years | 7 years |
| | Notes | | |
| 75% reduction in turf sale in drought | Total benefits | $33,800 | $28,939 |
| | Total costs | $18,750 | $5,716 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $1.80 | $1.27 |
| | Time to payback | 10 years | 9 years |
| | Notes | | |

## Farmer F

Of the 2 options evaluated for reducing the impact of drought of these turf farms, the most cost-effective was found to be installing a 40 ML dam (Table F). However, amending the soil would also result in a net benefit for every dollar spent.

The impact of a 75% decrease in home lawn sales in drought found that both these options still representing a net benefit for every dollar spent.

**Table F:** Cost benefit analysis over a 25 year lifecyle for measures that can be used to reduce the impact of drought and water supply shortfalls for Farmer F. Prices are in dollars per hectare.

| | | Drought management options | |
|---|---|---|---|
| | **Parameter** | **Construct a 40 ML dam** | **Soil amendment every 6 years prior to planting** |
| No reduction in turf sale in drought | Total benefits | $127,326 | $44,672 |
| | Total costs | $10,943 | $6,937 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $11.64 | $1.61 |
| | Time to payback | 3 to 10 years (1st drought year) | 11 years |
| | Notes | | |
| 75% reduction in turf sale in drought | Total benefits | $1,397,023 | $1,559,809 |
| | Total costs | $426,768 | $6,937 x 4 applications over 25 years |
| | A dollar spent earns over a 25-year lifecycle | $3.27 | $1.44 |
| | Time to payback | 5 to 10 years (2nd drought year) | 11 years |
| | Notes | | |

# Appendix C: Irrigation system application

**Table C:** Irrigation system application rates and minimum watering event size.

| | System | Instantaneous application rate (mm per hour) | Minimum watering event size (mm) |
|---|---|---|---|
| Big guns | Piston Drive T250 Soft Hose, 75mm x 200m. 3 Machines at 8 lps. Rad of 35m | 7.5 | 14.4 |
| | Turbine drive T300 Soft Hose, 75mm x 200m. 2 machines at 12 lps. Rad of 40m | 8.6 | 10.8 |
| | Poly Reel 75mm x 200m with High Pressure Gun. 3 Machines at 8 lps. Rad of 35m | 7.5 | 8.2 |
| | Poly Reel 90mm x 300m with High Pressure Gun. 2 Machines at 12 lps. Rad of 40m | 8.6 | 10.8 |
| Pop-ups | Small spaced at 15.9 x 15.9m. Installed. Rainbird Pop up at 40m. | 14 | 0.5 |
| | Large spaced at 24 x 24m on a 100mm Sprayline. | 18.75 | 0.5 |
| Sprinklers on aluminium pipes | | 8.3, 16.6 | 0.5 |
| Booms | Poly Reel 90mm x 300m with 50m wide Low Pressure Foldable Boom. | 123 | 8.6 |
| | Poly Reel 110mm x 300m with 50m wide Low Pressure Foldable Boom | 123 | 8.6 |
| Lateral move: Poly Lined with 160m of 125mm Layflat, Installed with GPS | | Varies | 2 |
| Centre pivot 200m in length | | Varies | 2 |