Final Technical Results Report

2024

Understanding return on investment of sub-surface water management options for waterlogged areas in the Western Region (Albany Port Zone)

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REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES ☐ NO ☒
Results are incomplete	YES ☐ NO ☒
Commercial/IP concerns	YES ☐ NO ☒
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ABSTRACT

Waterlogging is a common problem within the southwest region of Western Australia, with approximately 3 million hectares of land ranked with moderate to high susceptibility to waterlogging. Left unmanaged, waterlogging can lead to soil structural decline and has the potential to create nutrient deficiencies & toxicities, cause root death/reduced plant growth, or, in the worst case, result in the death of the plant. Subsurface drainage is one control method in the mitigation of waterlogging. However, research in this space in a modern context is limited, and recent studies on the potential return on investment are unknown.

Established in early 2021, the Stirlings to Coast Farmers (SCF) Sub-Surface Drainage project investigates methods of managing waterlogging within the Albany Port Zone through the use of slotted pipe buried at depth at two demonstration sites (Cranbrook & Perillup). Both demonstration sites had a control (undrained) and a treatment (drained) measure, and a range of monitoring activities have been conducted throughout 2021, 2022 and 2023, including plant counts, biomass, soil and yield analysis through to harvest 2023. Measurements taken from the trial informed the ability for growers to better understand the potential returns on investment, as a measure to increase overall farm profitability.

EXECUTIVE SUMMARY

Waterlogging is a common problem within the southwest region of Western Australia, and it has been estimated that approximately 3 million hectares of land within the area have a moderate to very high susceptibility to waterlogging or inundation. Left unmanaged, waterlogging can lead to soil structural decline, has the potential to create nutrient deficiencies & toxicities (such as Iron & Manganese toxicity), cause root death/reduced plant growth, or, worst case, result in death of the plant (DPIRD 2019). In some instances, poor crop growth and competition can additionally lead to greater weed breakouts.

Under this research project, two subsurface demonstration sites were established in the Albany Port Zone, with demonstration sites located West of Cranbrook (2021) and at Perillup (2022). Each paddock was comprehensively surveyed by RTK GPS, and elevation data and production data were utilised to inform the final sub-surface drainage design.

At each of the demonstration sites, Drainage Downunder installed a 100mm slotted pipe at depth in the pre-selected trial area. The process involved running a mechanical chain-saw-styled trencher through the grounds sub-surface to leave a trench, inserting the slotted pipe into the ground, and then in-filling above the pipe with a Limestone caprock to allow water permeability. The drainage was designed with GPS elevation data & laser to ensure that there was sufficient fall in the pipe to allow the water to flow freely without impediment.

Each of the trial sites comprised of sub-surface drainage (slotted pipe) installed at depth across a minimum area of 2 hectares. A 'control' region prone to waterlogging (no pipe installed) and a non-waterlogging site located upslope are utilised within the same paddock to enable the ability to do a comparative yield analysis. This project enabled growers to become aware of the technical requirements of designing and planning for sub-surface drainage, as well as the data generated being used to help demonstrate the potential returns on investments generated throughout the project.

A wide range of field measurements was collected throughout the project to measure differences in plant counts, yield, weed burdens, and NDVI tracked to demonstrate the production-side benefits of implementing sub-surface water management (SSWM). The results from implementing sub-surface drainage were significant for 2021 & 2022; however, due to seasonal conditions, the benefits of drainage were reduced but still positive.

Previous yield increases in 2021 acknowledged a 47% yield increase (Flinders Barley) in Cranbrook, along with a 72.5% yield increase in 2022 (45Y98 Canola). At the Perillup demonstration site, a 39% yield improvement (45Y95CL Canola) between drained/un-drained was achieved in 2022. However, for 2023, the seasonal conditions were not as favourable, and the benefits of implementing sub-surface drainage were limited to -10kg/ha to +420kg/ha in Dennison Wheat in Cranbrook & +180kg/ha in DS Bennett in Perillup for the 2023 growing season.

The 2021 season ended up being a 99 percentile year for rainfall at the Cranbrook demonstration site, and the 47% yield increase in the drained regions was a great result, however, the 2023 season experienced a very dry start, waterlogging through June and July, and at the Perillup site, heat/water stress during flowering/grainfill was exhibited.

Overall, the benefits-cost analysis showed promising responses for both sites. Dr Petersen, Advanced Choice Economics reported that the '*results of the Benefit Cost Analysis suggest that sub-surface drains are likely to be a cost-effective way for growers to manage soils that are susceptible to waterlogging in the Albany region of Western Australia*.' It is also important to highlight and note '*that the results from the sensitivity analysis found that the cost-effectiveness of sub-surface drainage is robust to a wide range of realistic changes to future economic and environmental conditions*' (Petersen, 2024). The project identified that the potential payback period was approximately 2 years for the Cranbrook demonstration site and 7 years for the Perillup site, and earlier payback periods are more likely to occur when the field of influence generated by the sub-surface drainage can be maximised.

One other component of the drainage trial was carrying out a survey on grower perceptions of water management and sub-surface drainage. Overall, survey responses were positive and showed that ultimately, growers were open to trialling subsurface drainage as a method of managing waterlogging. Responses from survey participants identified that many growers are currently implementing water management solutions in the Albany port zone, however, they are often relying upon more than one management technique or technology to manage waterlogging, with shallow & trafficable drains the most common method. This is not surprising, as the costs to implement surface drainage are relatively cheap and approximately half the price of sub-surface drainage; however, the efficacy of these drains at a sub-surface level is quite limited and waterlogging still can occur.

Grower knowledge of the use of sub-surface drainage has grown through the project, with 6 survey respondents having implemented this process on their own properties. Growers within the region are readily adopting sub-surface drainage as a method of managing waterlogging, with some survey participants adding an additional 2 to 70 kilometres of slotted pipe at depth, since the project inception, with the larger amount contributing due to the yield responses seen from 2021 and 2022 seasons.

There still remain some significant barriers to adoptions, namely around a better understanding of the return on investment over multiple seasons/crop types and the need for further demonstrations to build grower confidence. Legislative requirements for implementation are the least likely barrier to adoption, with survey responses showing that 78% of the responses rated this barrier as a disagree or neither agree/disagree. Given this, continued research across a range of crop types and soil types will be beneficial to driving adoption moving forward.

All of these learnings combined, in conjunction with positive values seen in the sensitivity analysis conducted with the BCA, should help give farmers increased confidence to investigate the implementation of sub-surface drainage on their own farms, even if applied on a relatively small scale. Petersen (2024) and the trial author, however, does acknowledged that all results listed here ultimately will need to be validated over additional sites and a greater time frame, differing seasons, and crop types (including legumes) to ensure that trial results are robust and accurate under a wider range of conditions.

BACKGROUND

Waterlogging is a common problem within the southwest region of Western Australia, particularly in the wetter months of winter, and typically occurs when rainfall exceeds the ability for soils to drain away soil moisture (DPIRD 2019). Under these conditions, the excess water within the root zone creates anaerobic conditions (conditions without free oxygen) and prevents the plant from performing gaseous exchange with the atmosphere or biological activities with the oxygen in the soil, air & water (DPIRD 2019). Left unmanaged, waterlogging can lead to soil structural decline and has the potential to create nutrient deficiencies & toxicities (such as Iron & Manganese toxicity), cause root death/reduced plant growth, or worst case, result in death of the plant (DPIRD 2019).

Overall, it has been estimated that approximately 3 million hectares of land within the southwest agricultural region of Western Australia have moderate to very-high susceptibility to waterlogging or inundation, which represented an estimated annual opportunity cost of $35m between 2009/10 and 2013/14 (DPIRD 2019). Early research undertaken by McFarlane and Wheaton (1990) identified that direct yield losses of up to 2.5 tonnes/hectare could occur within cropping operations, and pasture production can also be affected (Moore 2001).

There are methods available that farming operations can utilise to minimise and mitigate against the effects of waterlogging, including the use of either surface water management or subsurface water management methods. Surface drainage/management options available to growers include options such as raised beds, evaporation basins, & interceptor drains, while sub-surface options include slotted pipe, mole drains & pumping options (Ritzema, Satyanarayana et al. 2008, DPIRD 2019). Practice changes & management decisions such as fertiliser/nutrient management and species selection are temporary solutions also available to manage waterlogging, but their efficacy is often determined by seasonal conditions & rainfall events (Moore 2001; DPIRD 2019).

Unfortunately, the challenge with the implementation and adoption of some of these water management methods, is that they often impact farming operations; whether that be due to potential reductions in machinery movements/machine productivity or simply due to the cost of implementation of the drainage method utilised (Bennett 2014). Subsurface drainage methods are typically less invasive than surface management options and offer added benefits such as better trafficability without the loss of machine/operations productivity (Kornecki, Fouss et al. 2001).

PROJECT OBJECTIVES

This investment aims to assist growers and advisors in making informed decisions around the installation of sub-surface drainage as a tool to reduce the impacts of waterlogging on crop production areas to increase overall farm profitability.

Key objectives of this trial project include:

- An understanding of the requirements of implementing a sub-surface drainage solution:
  - Contractor & site selection.
  - Drainage design options,
  - Installation techniques, and
  - Sub-surface drainage maintenance requirements
- An understanding of the legislative agreements required when implementing sub-surface drainage for the discharge of water.
- An understanding of the differences in the "zone of drainage influence" across the drainage trial site, according to classified soil types.
- An understanding of how to calculate Return on Investment when implementing Sub-Surface Drainage Solutions.

METHODOLOGY

Site Specifics - Trial Site 1 – Cranbrook:

A sub-surface demonstration site was established west of Cranbrook, at the Preston Family Farm. In January 2021, the grower's paddock was elevation mapped utilising high accuracy, Real-Time Kinematic (RTK) GPS survey equipment to record the digital elevation levels across the landscape. This data was imported and analysed through Geographic Information System (GIS) & Precision Farming software to create water catchment maps and water flow/accumulation maps to help determine and shape the final trial site location/installation process. The final trial layout was designed to capture accumulated soil moisture and alleviate the soil from excess soil moisture at depth.

In February 2021, Drainage Downunder installed a slotted pipe at depth in the pre-selected trial area. The process involves running a mechanical 'chain-saw styled trencher' through the ground sub-surface to leave a trench, inserting the slotted pipe into the ground, and then in-filling above the pipe with Limestone caprock to allow water permeability. Careful consideration was taken in regard to ensuring that there was sufficient fall in the pipe to allow the water to flow freely without impediment. A control, "non-drained" site was located adjacent to the sub-surface drainage installation site, allowing a comparative analysis throughout the project duration.

Stirlings to Coast Farmers installed a weather station and soil moisture probes in 2021 to record seasonal conditions and soil volumetric water content across both treatments. The soil moisture probes installed are EnviroPro 80cm Soil Moisture Probes, buried at a depth of 30cm below the soil surface, recording soil volumetric water content in 8x 10cm increments from 30 – 110cm below the surface level.

Across the demonstration site the soil type is relatively uniform & consistent across the demonstration site, with sand (50cm) over a clayey duplex profile. This soil type and location is prone to waterlogging due to the distinct textural and horizontal changes in the soil profile at 50cm, where infiltration is limited due to a relatively compacted, impermeable clay layer.

Figure 1: Visual diagram of the trial design at the Preston family farm at Cranbrook, Western Australia, where red lines represent primary drains (100mm slotted pipe) and blue lines represent secondary drains (100mm slotted pipe)

Site Specifics - Trial Site 2 – Perillup:

In 2022, Stirlings to Coast Farmers implemented a second drainage demonstration site in the locality of Perillup, with the Allison family. Again, the paddock was mapped utilising high accuracy, RTK GPS equipment to create surface elevation and contour maps to guide final trial-site layout and installation designs. The installation of the drainage medium was conducted by drainage contractors, Drainage Downunder, utilising the same installation method covered at the Cranbrook trial site.

The trial design for the Perillup demonstration site is distinctly different to that of the Cranbrook site and comprises numerous parallel sub-surface drainage runs, along with herringbone-shaped drainage designs within the same system. The total length of drainage installed equates to approximately 5.9 kilometres and covers a geographical area of approximately 25 hectares. A small subset region of the installation is being monitored under this project. Located North of the drainage demonstration site, is the control treatment, where no sub-surface drainage has been installed. A high-accuracy weather station was also installed at the Perillup demonstration site, to record seasonal conditions throughout the year.

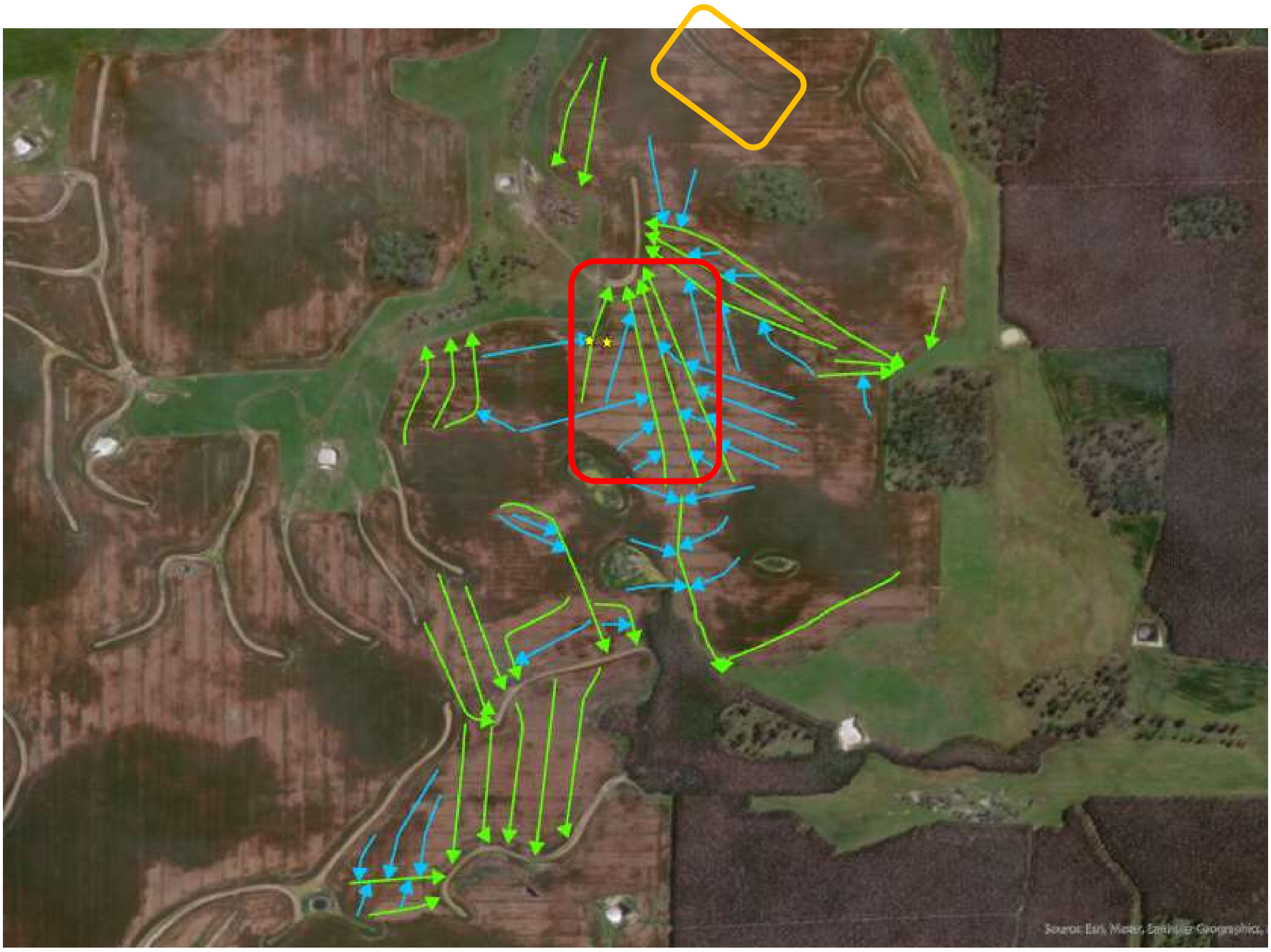

Figure 2 Visual diagram of the sub-surface drainage design at the Allison family farm at Perillup, Western Australia, where green lines represent primary drains (100mm slotted pipe) and blue lines represent secondary drains (100mm slotted pipe). Note that the red square is monitored under this project report, and the orange polygon located at the northern end visually represents the 'control' treatment area.

Data Collection, Analysis & Interpretation

Across both demonstration sites, a wide range of production and geographic data was collected to measure treatment responses against the use of sub-surface drainage methods. These measurements and data sources are further detailed & explained below:

Elevation & Topographical Datasets

High-accuracy, survey-grade RTK elevation data was collected by Trimble GPS equipment traversing the paddock in 12-metre, parallel swaths. Areas that were depressed or with minimal slope experienced a crosshatch-styled data collection pattern to ensure that data quality & accuracy were maximised. Data was imported into ArcGIS Professional and analysed to create elevation, aspect, watershed, streamflow, contour maps (10cm, 25cm, 50cm, 100cm contour increments) and flow-direction layers. These layers, in conjunction with yield data and grower knowledge, were imperative in the forming of the final sub-surface drainage designs.

Satellite NDVI

Satellite biomass data was collected and analysed throughout the main growing periods to compare differences between treatments. As per the approved trial protocol/agreement, the Normalised Difference Vegetation Index (NDVI) indices was utilised for monitoring during 2021 – 2023. Satellite data was captured via the Sentinel-2 platform provided by the European Space Agency and processed through ArcGIS; however, due to seasonal conditions in 2021 and significant cloud-cover issues affecting multiple datasets, Planet Laboratories daily 3x3 metre resolution imagery was utilised instead.

Soil Health & Plant Health

Prior to each seeding period, a comprehensive soil sampling program was undertaken to identify the current soil nutritional levels prior to seeding. Comprehensive Plant tissue analysis was also completed during the cropping seasons (between each treatment type) to monitor plant health status and identify any potential nutritional deficiencies. All comprehensive analysis was undertaken by APAL Laboratories Perth/Adelaide.

Yield Analysis

Where existing yield data was already available, this data was utilised to inform drainage designs. Post drainage installation, simple yield analysis was performed annually for the seasons of 2021 (Cranbrook site only), 2022 & 2023 (Cranbrook & Perillup sites) for both drained & undrained treatments through the use of Precision Farming Software (SMS Advanced).

Weather Monitoring

Each demonstration site was equipped with a Metos 3.3 Weather Station which recorded trial-site climatic conditions in approximately 5-minute time increments. Recorded parameters included temperature, relative humidity, rainfall, solar radiation, windspeed/direction & soil Volumetric Water Content (%VWC) conditions at 30 – 110cm depth in 8x 10cm increments at the Cranbrook Demonstration Site.

Cost Benefit Analysis

Aside from the in-field data collection, a comprehensive cost-benefit analysis was completed by Dr Elizabeth Petersen (Advanced Choice Economics Pty Ltd) across both demonstration sites, financially supported by South Coast Natural Resource Management (SCNRM). The Cost-Benefit Analysis took into consideration the known yield benefits, installation costs, field of influence, as well as estimated returns based on predicted future yields, planned rotation, genetic yield improvement and annual repair & maintenance costs. From this, we were able to predict the impacts of sub-surface drainage over a 20-year period across a range of factors, including the Net-Present Value (NPV), Benefit Cost Ratio (BCR), Return on Investment (ROI), Internal Rate of Return (IRR) & breakeven period.

Grower Surveys

A range of growers in the Albany Port Zone (APZ) were surveyed at the start and finish of the project to baseline measure subsurface drainage knowledge levels and return on investment perceptions. Growers were surveyed via the SurveyMonkey platform, with data later discussed in this report.

TRIAL LOCATIONS

Where field trials have been conducted, provide the following location details in the table below: latitude and longitude, or nearest town. (Add additional rows as required.)

Site #	Latitude (decimal degrees)	Longitude (decimal degrees)	Nearest town
Trial Site #1	-34.31683	117.35817	Cranbrook, WA
Trial Site #2	-34.57211	117.31826	Perillup, WA

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC agro-ecological zone/s, indicate which in the table below:

Research	Benefiting GRDC region (select up to three)	Benefitting GRDC agro-ecological zone	
Water Management	Western Region Southern Region Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☒ Tas Grain ☒ SA Midnorth-Lower Yorke Eyre ☐ WA Northern ☐ WA Eastern ☐ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☒ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☒ WA Central ☒ WA Sandplain

RESULTS

Trial Site 1 – Cranbrook:

Site Background Information

The first season, 2021, was a well above average year for rainfall, with nearly 750mm of rain falling throughout the year and approximately 600mm of that falling within the growing season, both significantly higher than the average annual farm rainfall value of 480mm. The barley plants were underwater for a considerable amount of time during the year, and in particular, throughout the early stages of growth (figure 3).

This sadly resulted in some issues in managing plant nutrition and weed control due to inundation and the inability of vehicles to traverse the paddock. Early fertiliser applications were unable to be performed at the optimal time and were delayed to later in the growing season. There were considerable differences in trafficability across the paddock, with extreme difficulty in physically walking across the paddock within the control region in June & early July, compared to what felt like solid ground within the drained regions.

1st June 2021

7th July 2021

Figure 3: Early waterlogging experienced at the Cranbrook Demonstration Site in 2021.

When investigating plant establishment levels and tiller counts at the site, Stirlings to Coast Farmers found that there were significant levels of variation within the treatment plots themselves, and also significant variations between the drained & undrained regions. Overall, we found that there were up to 30% more tillers in the drained region, when compared to those measured in the control. These differences appeared to be accounted for by a completely inundated, water-logged crop resulting in less viable plants and significantly higher levels of ryegrass weed populations in the control section. Weed control throughout 2021 was challenging given the wet season and the poor competition levels between the barley crop, which was trying to compete with the evident ryegrass weed population under waterlogging conditions.

The following year, 2022, was the second year of field measurements for the Cranbrook demonstration site, with seasonal conditions finishing above average rainfall, with waterlogging conditions evident at the demonstration site. Annual rainfall equated to 569mm for the year, with a growing season rainfall recorded of 454mm (Table 2, Figure 5). 2022 seasonal rainfall amounts typically track below-median rainfall levels to mid-June and result in an above-median rainfall season experience thereafter.

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The 2022 growing season rainfall levels led to waterlogging conditions being experienced in the control section of the drainage trial. Drone imagery captured on the 5th of October 2022 visually captured a significant reduction in healthy biomass in the control region, and relatively healthy biomass levels were visible where drainage had been installed (red lines), as shown in Figure 4.

Figure 4: Drone imagery capturing waterlogging conditions experienced on 5th October 2022 and a visible reduction in plant health evidenced in the control region to the left of the drainage lines. (Source: Stirlings to Coast Farmers Inc.)

Despite a well-below-average rainfall prior to seeding (and following on from a high-rainfall year in 2021), plant establishment for the canola seedings was good, and grass weed control was well maintained throughout much of the growing period. Plant counts were conducted in late June at the rosette stage, with slightly higher plant counts per metre squared experienced in the drained region (47 plants/m2), compared to 38 plants/m2 found in the control.

2023 was the third and final year of field measurements for the Cranbrook demonstration site. Despite a drier start and finish to the season, the seasonal conditions again finished with above-median rainfall. Annual rainfall equated to 573mm for the year, with a growing season rainfall recorded of 443mm. Unlike the previous years, 2023 had limited periods of waterlogging experienced in the control (undrained) trial compared to the drained regions. Plant establishment levels were good, and differences between drained and undrained regions were non-existent in terms of germination and tillering.

Table 1: Trial site summary for Cranbrook Demonstration Site.

	Annual Rainfall	Growing Season Rainfall
2021 – Barley (Flinders)	749mm	598mm
2022 – Canola (45Y98)	569mm	463mm
2023 – Wheat (Dennison)	573mm	443mm

Rainfall Graph – Cranbrook Demonstration Site

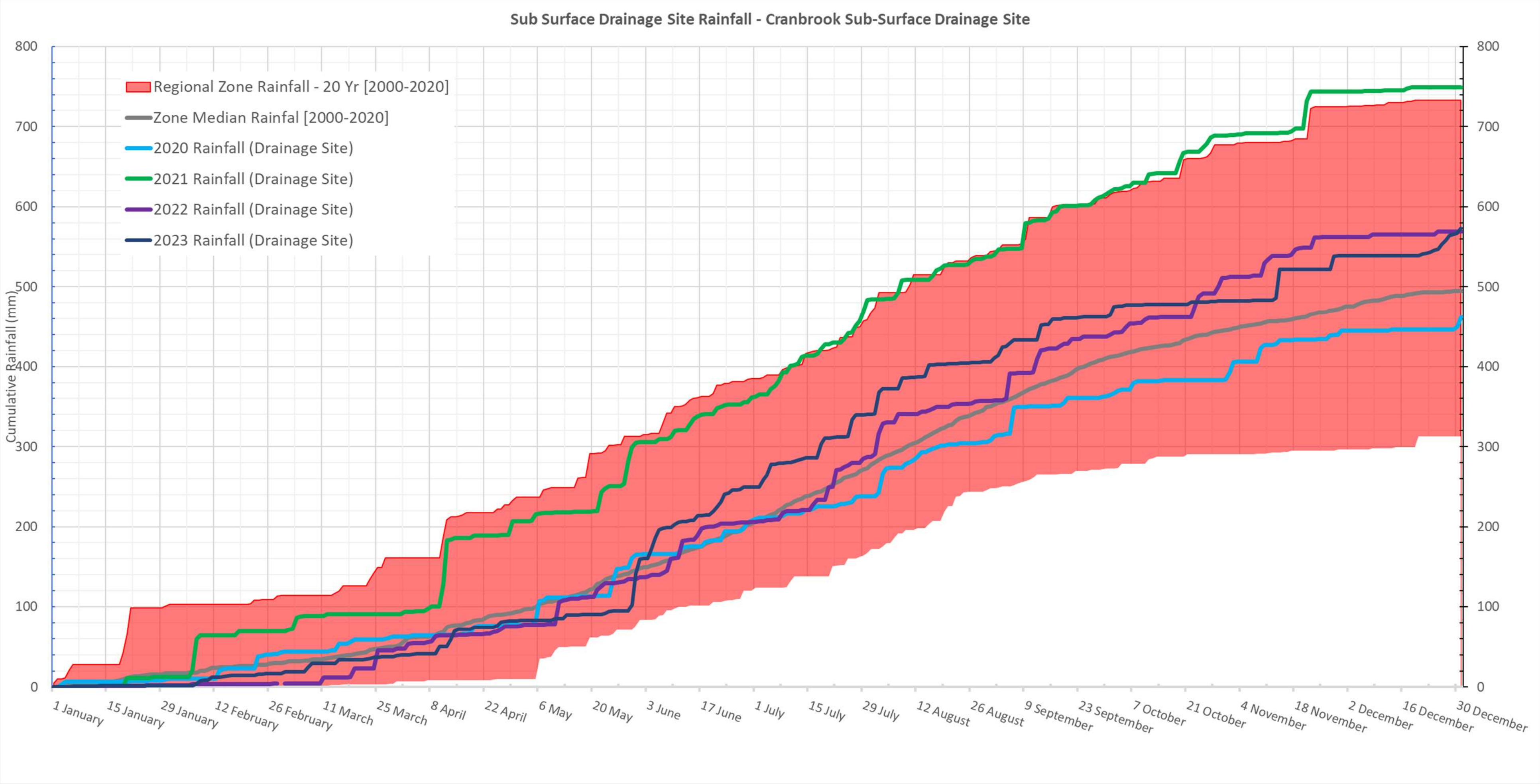

Figure 5: Annual site rainfall values against modified LongPaddock SILO Rainfall Data (Source: SILO, Stirlings to Coast Farmers)

NDVI Analysis

NDVI satellite imagery was captured throughout the 2021, 2022 & 2023 growing seasons, utilising high-resolution 3m satellite imagery sourced from Planet Laboratories, an imagery sensing company. Throughout the seasons, it was highly evident where the installed pipework was located due to the increased biomass levels recorded when compared to that of the control region located in the southeastern corner of the paddock, as shown as an example in (Figure 6).

When comparing individual plots throughout the 2021 season in particular, Stirlings to Coast Farmers found that the waterlogged control section had the lowest NDVI readings throughout the season, with the exception of the final reading captured in mid-October (Figure 7). These NDVI values were heavily inflated in the control region later on in the season due to the significant levels of ryegrass, which had emerged due to poor plant establishment & competition.

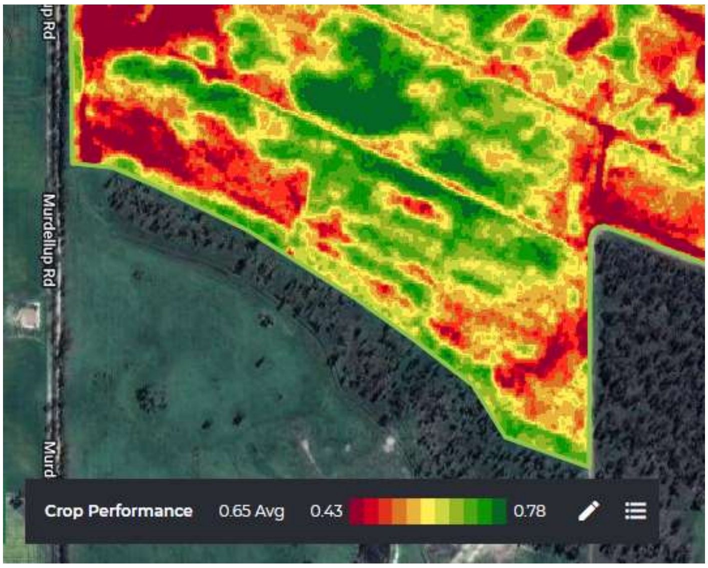

Figure 6: NDVI Satellite Imagery captured 12th August 2021 outlining higher biomass levels where sub-surface drainage pipes had been installed. (Source: Planet Laboratories)

Again, satellite imagery captured throughout the 2022 growing season showed significant evidence of where the installed subsurface pipework was located due to continuously higher biomass levels recorded compared to that of the control region located in the southeast corner of the paddock.

Overall, the 2023 growing season rainfall levels led to waterlogging conditions being experienced in the control section of the drainage trial. NDVI imagery captured via Satellite indicated marginally higher biomass where sub-surface drainage existed in the paddock, with NDVI values of 0.6 to 0.75 in drained, compared to NDVI values of 0.45-0.7 in the undrained regions for 17th July 2023 (Figure 8).

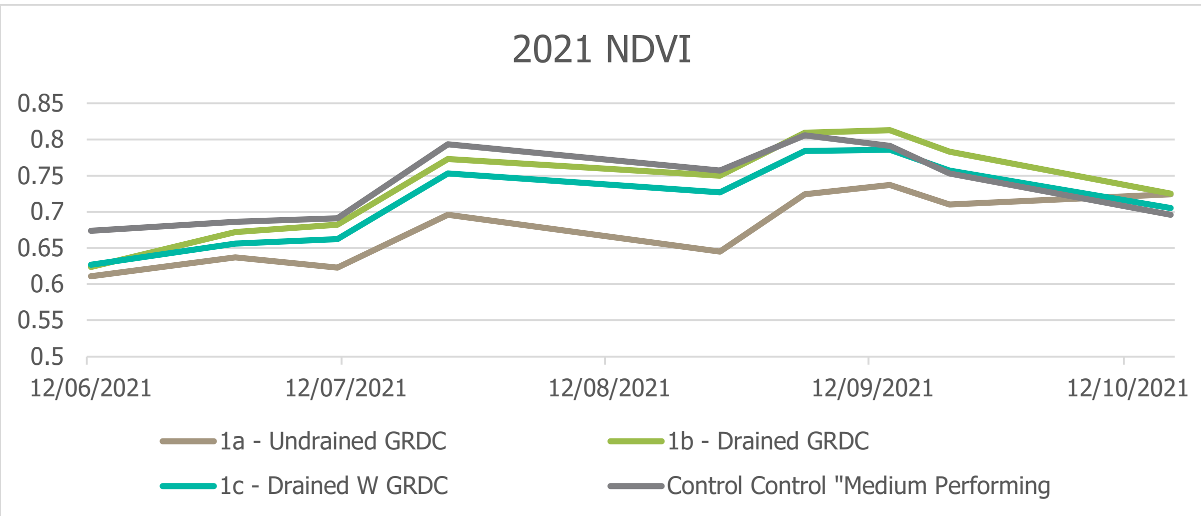

Figure 7: 2021 NDVI Values for the Cranbrook Demonstration Site (Source: Planet Laboratories)

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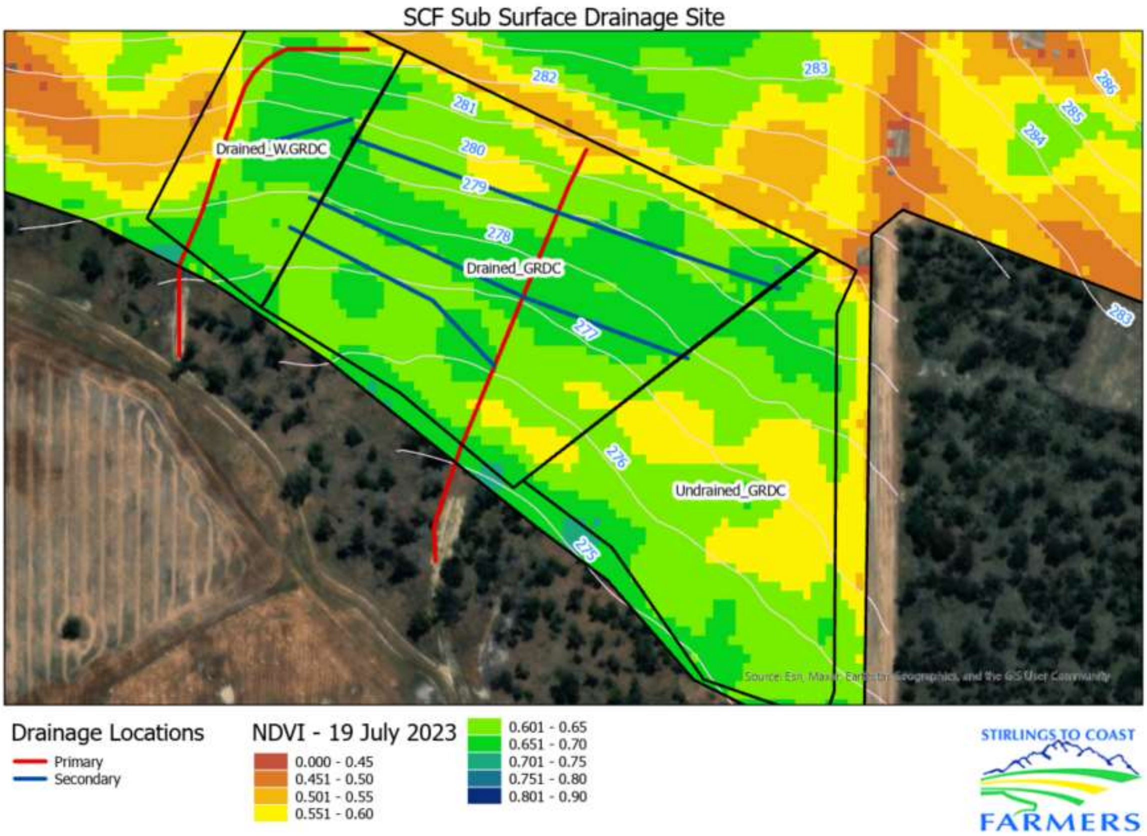


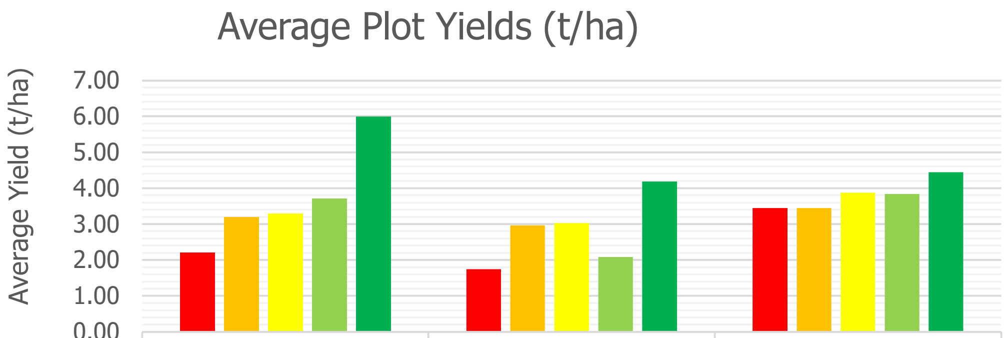
Figure 8: 2023 NDVI Imagery for the Cranbrook Demonstration Site - 19th July 2023 (Source: Planet Laboratories)

Yield Analysis

In mid-December 2021, the Flinders Barley paddock was harvested by the Preston family. Overall, yields were approximately 1 t/ha higher in the drained regions (3.20 – 3.29t/ha) compared to the control treatment (2.21 t/ha) in a 99-percentile rainfall year. Two additional areas were also assessed at harvest where there was no drainage installed, and where it was unlikely to suffer from waterlogging. These areas across a deemed medium-performing (mid-slope) and high-performing (up-slope) soil landscape represented what the maximum potential yield might be should a particular area not express the yield penalty effects from waterlogging. When we compared the drained GRDC trial regions against these non-waterlogging medium-performing areas, there was a potential additional 410-500kg per hectare yield opportunity, should waterlogging be effectively managed. Should the drainage trials soil type be more reflective of a non-waterlogging high-performing soil, then there was a significant additional potential yield opportunity of up to 2.8t/ha available, as visually shown in Figure 9 below.

Following on from very cool, ideal finishing conditions for canola, in mid-December 2022, the paddock was harvested by the Preston family. Overall, the canola yields were approximately 1.25 t/ha higher in the drained regions (ranging from 2.97 – 3.02 tonnes/ha) compared to the control treatment (1.74t/ha). Following on from the previous year's two additional (high & medium-performing) non-waterlogging monitoring areas, Stirlings to Coast Farmers identified that there was an additional 1.17t/ha potential yield opportunity in the 'higher performing' soil. Unfortunately, the previously planned 'medium performing' soil didn't perform as well as seen in 2021, recording a yield value of 2.08 tonnes to the hectare, which was below the recorded yield values in the drained site.

In the final year of data collection, 2023, there generally was a positive benefit experienced to implementing sub-surface drainage, as an average across both trial sites, however, the yield benefit wasn't as high as prior years. The control region where subsurface drainage wasn't installed, averaged a total yield of 3.45t/ha, compared to 3.44t/ha and 3.87t/ha recorded where subsurface drainage had been installed. When we compared the drained GRDC trial regions against the non-waterlogging higher-performing area, then there was an additional potential yield opportunity for up to 0.58t/ha more yield (Figure 9). Sadly, the results weren't as positive for 2023 compared to previous seasons, which is namely due to a distinct change in rainfall distributions and heat stress during flowering/grain fill, which is further explained in the discussion section.



	2021 (Barley - Flinders)	2022 (Canola - 45Y98)	2023 (Wheat - Dennison)
Control GRDC	2.21	1.74	3.45
Drained GRDC	3.20	2.97	3.44
Drained (W. GRDC)	3.29	3.02	3.87
Control - Mid Slope	3.70	2.08	3.84
Control - Upper Slope	5.99	4.19	4.45

Figure 9: Average plot yields (tonnes/ha) per year, compared to production zone/drainage trial location. (Source: Stirlings to Coast Farmers & Preston Farms)

Simplistic Financial Analysis – 'back of envelope' Potential Return on Investment Calculation

As part of the extension process, we wanted growers to be able to hypothesise what the potential return on investment might be, if they were able to add additional subsurface drainage to a paddock. A case example was created for the Cranbrook demonstration site, which encompassed adding another 3.5kms of pipe to the existing drainage layout to minimise waterlogging in approximately 20 hectares on the bottom ¼ of the paddock and 7 hectares in the high-performing soil in the north-eastern corner (as shown in Figure 10).

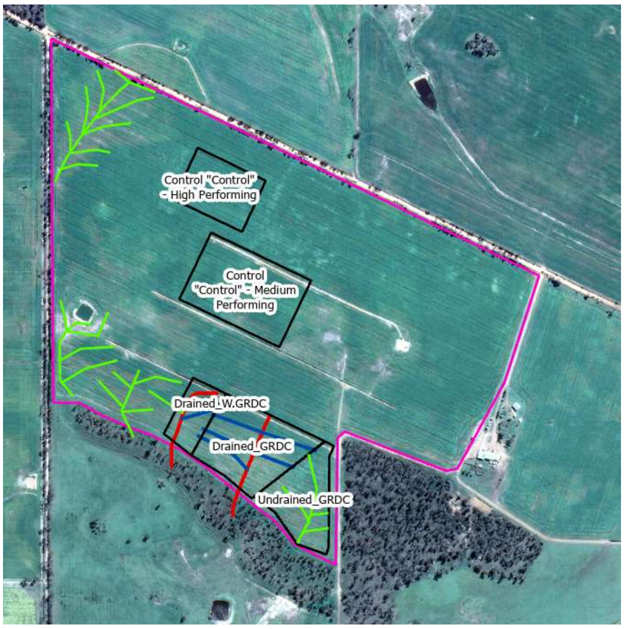


Figure 10: Hypothesised potential sub-surface drainage layout to be utilised in a simplistic ROI calculation

Working on an assumption of $15,000/kilometre to install the pipe, and the nearest neighbouring yield multiplied by the long-term median grain prices, we could estimate the potential lost yield opportunity ($/ha) & potential return on investment.

Previous return on investment results from back-of-envelope calculations included:

- In 2021, a potential payback period of approximately 3.8 years to occur, pending a median barley grain sale price ($250/t) being achieved and similar yield differences exhibited,
- In 2022, a potential payback period of 1.5 years to occur, pending a median canola price of $580/t was achieved and/or
- In 2023, an estimated potential payback period of 8.6 years would occur under a dry-finish Wheat, on an assumed $300/t median grain price.

Financial Analysis – Benefit-Cost Analysis

In early 2024, a Benefit Cost Analysis (BCA) was conducted by Dr Elizabeth Petersen from Advanced Choice Economics Pty Ltd for the Cranbrook demonstration site. The BCA comprised of understanding the economic costs for implementation, potential repairs & maintenance costs spread over a very conservative twenty-year lifetime period, considering crop rotations and considering any additional input costs (fertiliser and chemical) that may be required due to increased productivity for the area under drainage.

Table 2: Cranbrook demonstration site implementation costs as utilised for the BCA analysis. (Source: Petersen & Stirlings to Coast Farmers 2024)

	West Cranbrook
Length of drain (km)	1.40
Area of drain (ha)	5
Zone of influence (ha)	16
Unit drain installation cost ($/km)	15,000
Total cost of drain installation ($)	21,000
Total cost of drain installation ($/ha of drains)	4,200
Total cost of drain installation ($/ha of impact)	1,313

Overall, when considering the future cash streams and benefits from implementing sub-surface water management, there is an upward-trending zig-zag pattern which represents positive financial benefits moving forward, with the peaks exacerbated by higher-returns from Canola within the rotation and lower revenue years where cereal crops are grown within the rotation (Figure 11). In all scenarios, the cashflow return is positive.

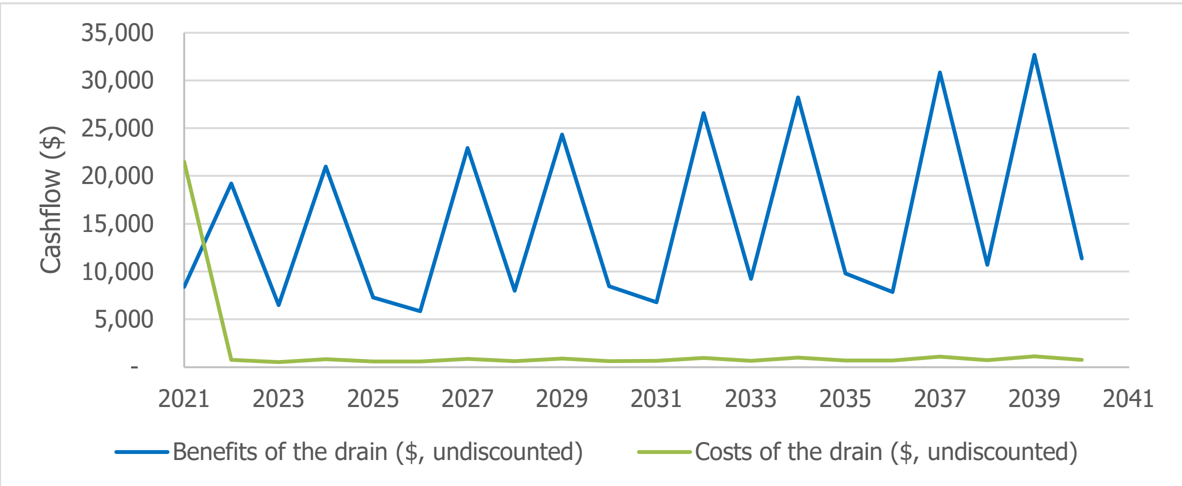


Figure 11: Undiscounted stream of benefits and costs of the sub-surface drains for the Cranbrook demonstration site. (Source: Petersen, 2024)

Further investigation completed by Petersen also identified that the cumulative cash flow with discounting (at an assumed 7% rate) and without discounting factors showed that the project was cost-effective, with the break-even period expected to have occurred in 2022 (second year of installation).

Petersen also noted that with the current values derived from the BCA under a 20-year horizon, the benefit-cost ratio equated to an estimated 5.6, which indicates that every dollar spent by the Cranbrook grower, equates to a $5.60 return, or 460% profit on investment. An Internal Rate of Return (IRR) was estimated to be 110%, providing a 110% annual rate of growth, which is significantly higher than current interest rates (Table 3).

Table 3: Benefit-Cost Analysis results table for the Cranbrook demonstration site over a 20-year time period. (Source: Petersen, 2024).

	Total area ($)	Per hectare ($/ha)
Present value of the benefits ($)	199,700	12,500
Present value of the costs ($)	35,700	2,200
Net present value ($)	164,000	10,200
Benefit cost ratio	5.6	
Return on investment	460%	
IRR	110%	
Time to breakeven (year)	2022 (second year after installation)	

Trial Site 2 – Perillup:

Site Background Information

2022 was the first year of measurements for the recently installed demonstration site at Perillup, with rainfall values exceeding 709mm for the year, and 534mm for the growing season, recorded at the site-based weather station. Soil conditions for sowing were relatively dry despite the previous seasons' rainfall, and germination was patchy initially dependent on soil type within the paddock. Overall, rainfall typically tracked below the median 20-year average until late July, when the season turned around and tracked above median conditions (Figure 12, Table 4).

The trial site was relatively inaccessible to any vehicle other than a quadbike, and fertiliser and chemical applications were made via air (helicopter) throughout the year due to the damp, seasonal conditions. Given the cool conditions leading from spring into summer, the canola crop experienced extremely optimal finishing conditions, with desiccation occurring in late November/early December, and harvesting beginning just prior to Christmas. Plant establishment counts were collected in early June at the demonstration site, where minimal differences were observed between the drained and undrained regions, with an average total of 49 plants per metre squared observed in the drained region, and 47 plants per metre squared seen in the undrained regions.

For the 2023-year period, *similar to the Cranbrook trial site*, there also was a dry start recorded/experienced, with a rather dry finish recorded throughout the maturity of the crop phase. Growing season rainfall equated to 529mm for 2023, with annual rainfall equating to 639mm for the year. Rainfall was heavily distributed from June to August, with rainfall plateauing from September to November. Overall, soil conditions for sowing were relatively dry in early (4th) April despite the previous seasons' rainfall, and germination was patchy initially dependent on soil type within the paddock.

When assessing plant counts, there were approximately 8% more plants in the drained region, compared to the control. Overall, rainfall generally tracked below the median 20-year average until the June period.

Table 4: Trial site summary for Perillup Demonstration Site

	Annual Rainfall	Growing Season Rainfall
2021 – Barley (RGT Planet)	796.6 mm	634.4 mm
2022 – Canola (45Y95)	709.4 mm	569.6 mm
2023 – Wheat (DS Bennet)	639.8 mm	539.2 mm

Rainfall Graph – Perillup Demonstration Site

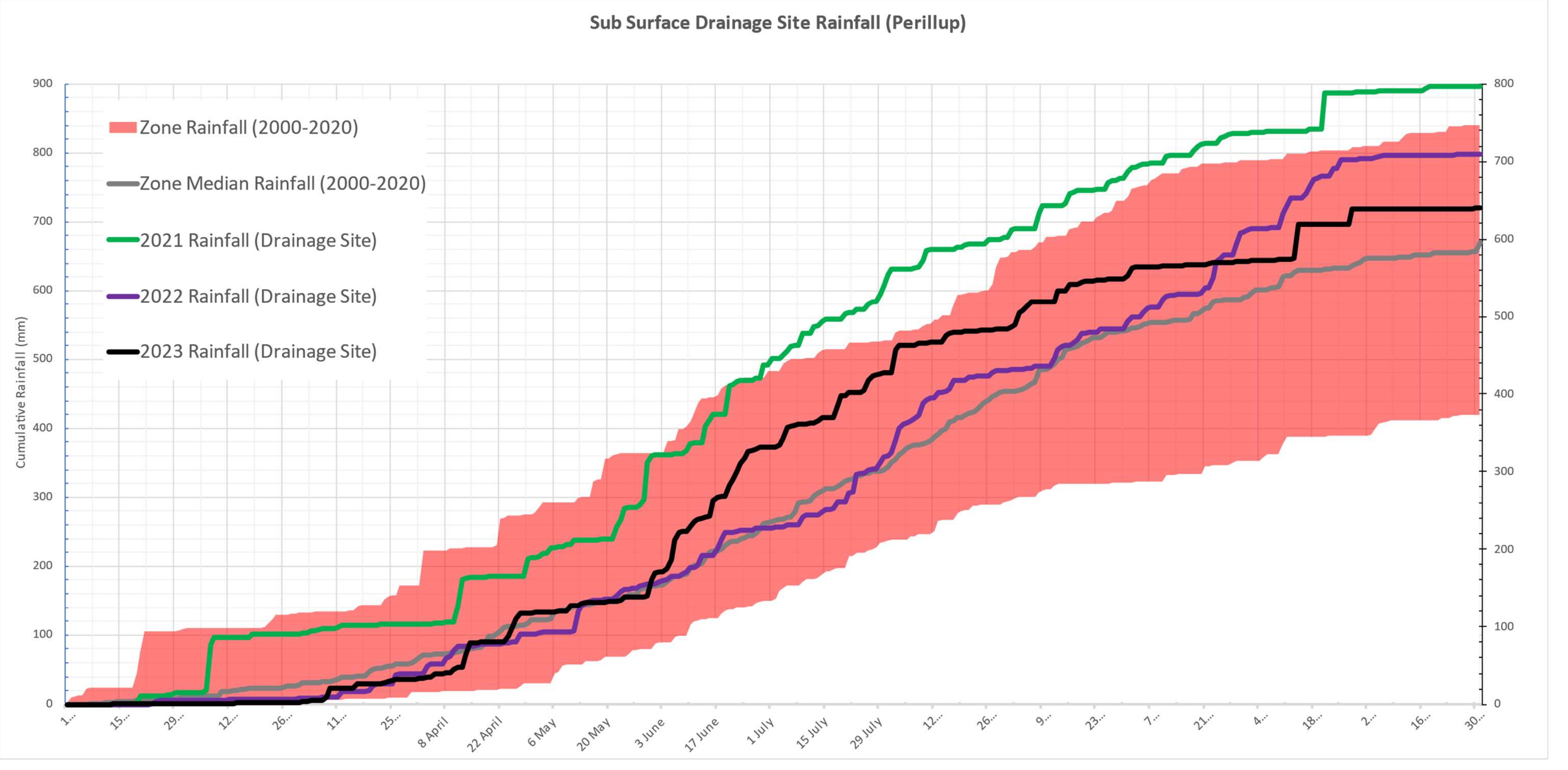
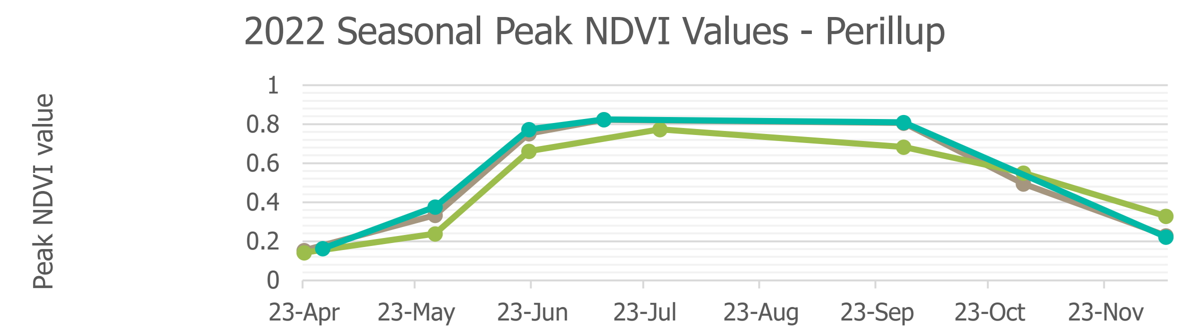


Figure 12: Annual site rainfall values against modified LongPaddock SILO Rainfall Data (Source: SILO, Stirlings to Coast Farmers)

NDVI Analysis

Following the same protocol as the Cranbrook Demonstration Site, NDVI satellite imagery was captured and analysed throughout the 2022 & 2023 growing seasons, utilising high-resolution 3m satellite imagery sourced from Planet Laboratories. In 2022, throughout the growing season, and indicated slight differences in NDVI values were recorded in the drained area, when compared to the un-drained plot between June & end of September 2022 timeframe, with NDVI values approximately 0.1 – 0.2 NDVI units less seen in the control, indicating that there was lower photosynthetic activity in these areas. When comparing the drained NDVI values to the control (up-slope) regions where waterlogging potential is limited, the values were typically much closer to each other, typically within 0.04 – 0.05 NDVI units higher than the drained treatment (Figure 13).



	23-Apr	28-Apr	28-May	22-Jun	12-Jul	27-Jul	30-Sep	1-Nov	9-Dec
Drained	0.154		0.334	0.752	0.824		0.807	0.495	0.228
Control - Undrained	0.142		0.238	0.662		0.774	0.684	0.55	0.329
Control - Upslope		0.164	0.377	0.774	0.825		0.809		0.223

Figure 13: 2022 Seasonal NDVI Values utilising Planet Laboratories daily 3x3m Imagery.

Yield Analysis

The 45Y95 CL canola was harvested on 20th December 2022, and yield data was cleaned to derive yield values for the undrained control, drained region and upslope (non-waterlogging) controls within the paddock. Yield benefits for the installed sub-surface drainage medium overall were extremely positive for the 2022 season, with a 5.2t/ha yield level recorded in the drained region of the paddock and 3.74 tonne/ha recorded in the undrained control. The upslope control located nearby, within the same paddock, yielded slightly higher than the drained regions, achieving a final average yield of 5.42 tonnes per hectare. This equated to a yield increase of approximately 40% against the undrained treatment.

In the following year, 2023, the DS Bennett wheat crop was harvested in December, with the yield benefits for the installed sub-surface drainage region positive, but minimal. A final yield value of 5.13t/ha was recorded in the drained region, and 4.95 tonne/ha was recorded in the undrained control. The upslope control located nearby, within the same paddock, interestingly yielded less than the drained/undrained, with a final yield of 4.22t/ha. This was noted due to differences in the soil type and water-holding capacity of the soil. Sadly, the results, again, weren't as positive for 2023 compared to previous seasons, which is namely due to a distinct change in rainfall distributions and heat stress during flowering/grain-fill, which is further explained in the discussion section.

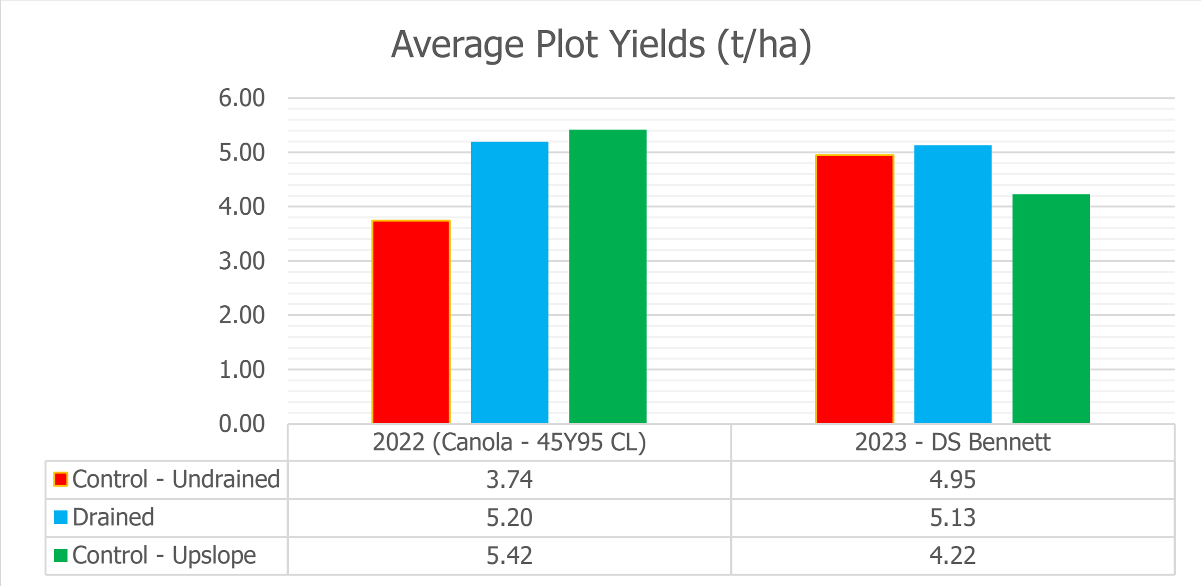


Figure 14: Recorded yields for Perillup Sub-Surface Drainage Demonstration Site.

Financial Analysis – Cost Benefit Analysis & Return on Investment

In early 2024, a Benefit Cost Analysis (BCA) was conducted by Dr Elizabeth Petersen from Advanced Choice Economics Pty Ltd for the Cranbrook demonstration site. The BCA comprised of understanding the economic costs for implementation, potential repairs & maintenance costs spread over a very conservative twenty-year lifetime period, considering crop rotations and considering any additional input costs (fertiliser and chemical) that may be required due to increased productivity for the area under drainage.

Table 5: Perillup demonstration site implementation costs as utilised for the BCA analysis. (Source: Petersen & Stirlings to Coast Farmers 2024)

	Perillup
Length of drain (km)	10.83
Area of drain (ha)	37
Zone of influence (ha)	64
Unit drain installation cost ($/km)	15,000
Total cost of drain installation ($)	162,450
Total cost of drain installation ($/ha of drains)	4,391
Total cost of drain installation ($/ha of impact)	2,538

Overall, when considering the future cash streams and benefits from implementing sub-surface water management, there is an upward-trending zig-zag pattern that represents positive financial benefits moving forward, with the peaks exacerbated by higher returns from Canola within the rotation and lower revenue years where cereal crops, or when Faba Beans are grown within the rotation (Figure 15). This was very similar to the Cranbrook demonstration site; however, it was not as aggressive between the rotations. In all scenarios, the cash flow return is positive.

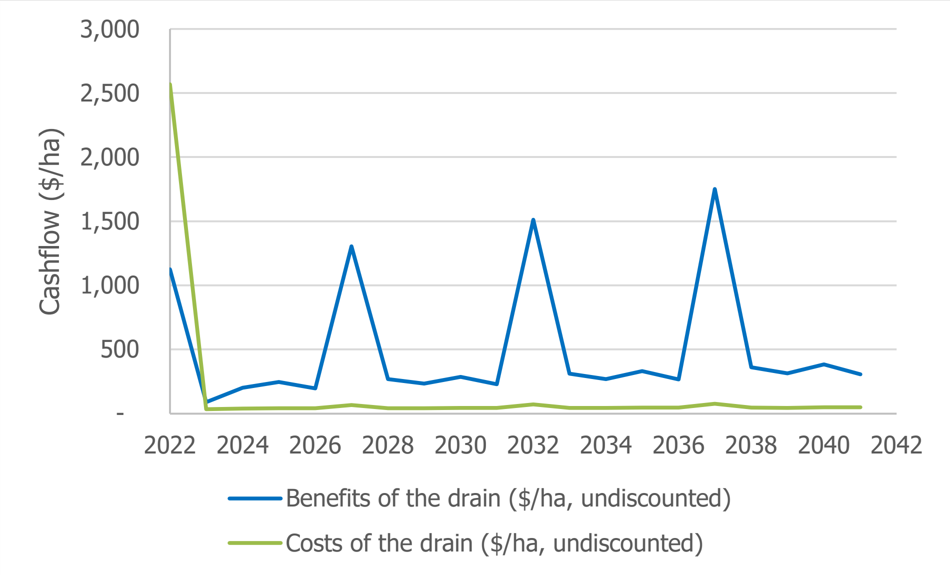


Figure 15: Undiscounted stream of benefits and costs of the sub-surface drains for the Perillup demonstration site. (Source: Petersen, 2024)

Further investigation completed by Petersen also identified that the cumulative cashflow with discounting (*at an assumed 7% rate*), and without discounting factors, showed that the project was cost-effective, with the break-even period expected to have occurred in 2028 (seven years after installation).

Petersen also noted that with the current values derived from the BCA under a 20-year horizon, the benefit-cost ratio equated to an estimated 1.8, which indicates that every dollar spent by the Cranbrook grower, equates to a $1.80 return, or an 84% profit on investment. An Internal Rate of Return (IRR) was estimated to be 21%, providing a 21% annual rate of growth, which is significantly higher than current interest rates (Table 6).

Table 6: Benefit-Cost Analysis results table for the Perillup demonstration site over a 20-year time period. (Source: Petersen, 2024).

	Total area ($)	Per hectare ($/ha)
Present value of the benefits ($)	**411,000**	**6,400**
Present value of the costs ($)	**223,200**	**3,500**
Net present value ($)	**187,800**	**2,900**
Benefit cost ratio	1.8	
Return on investment (%)	84%	
IRR (%)	21%	
Time to breakeven (year)	2028 (7 years after installation)	

In addition to the above results, a sensitivity analysis was completed by Petersen (2024) at the Perillup site to determine whether the results are sensitive to key assumptions. Each of the key assumptions is adjusted one at a time, with all other assumptions held the same. Each key assumption is adjusted to a realistically low and a realistically high value, as indicated in the legend of the figures presented below.

Petersens' analysis reported that the Net Present Value (NPV) remained above $0 in all scenarios, which indicated that sub-surface drainage is likely to be cost-effective under a range of future economic conditions. As shown in Figure 16, the results are least sensitive to changes in maintenance and additional agronomic costs. The results are most sensitive to future expected prices, yields and productivity improvements.

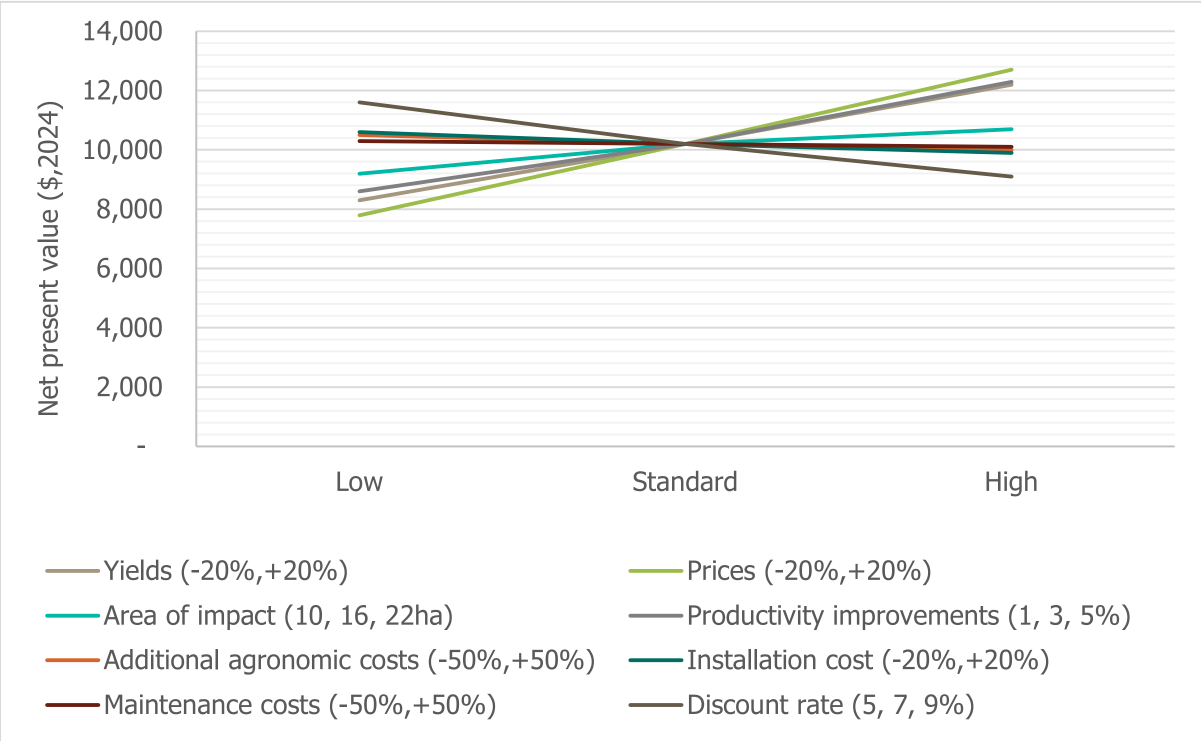


Figure 16: Sensitivity analysis of the sub-surface drains for Perillup site (Source: Petersen, 2024)

Grower Surveys

In total, 25 grower members from the Albany Port Zone were interviewed by Stirlings to Coast Farmers in the pre & post-project surveys to determine knowledge levels and experiences with the implementation of water management techniques. The survey was also utilised to help quantify some of the losses experienced due to waterlogging, and what water-management changes have been implemented since the program was launched.

Of those surveyed, their associated farm sizes typically varied from 450 – 8000 hectares in operation, representing a total land mass of 87,850 hectares in the Albany Port Zone and an average landholding of approximately 3,200 hectares each. Across 19 of the survey responses, cropping was the dominant farming enterprise (>50%). When taking into consideration all participants captured pre and post project, there was an overall survey average of 61% of the dedicated landmass dedicated to cropping activities.

Duplex soils (sand over clay and/or sand over gravel) were the dominant soil types for the region surveyed, accounting for approximately 66% of the responses, followed by forest gravels (15%). There was one response for loamy soils, one response for clayey soils and a final response for others where there were high levels of sheet granite. No responses were recorded for waterlogging on sand-plain dominant soils in the Albany Port Zone (APZ).

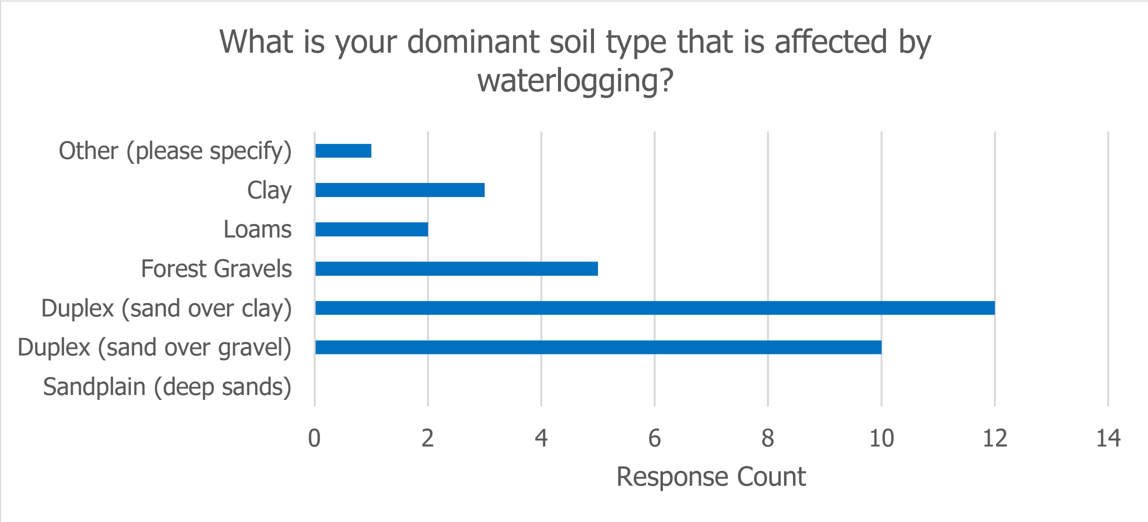


Figure 17: Distribution of dominant soils affected by waterlogging in the Albany Port Zone.

The majority of interviewed members have implemented at least one water management methodology, except for a single survey participant who is yet to implement any technique or technology. Most survey participants have implemented shallow or trafficable drains, followed closely by interceptor/deep drainage, often strategically placed to direct flows away from shallow/trafficable drains. Nine survey participants have also utilised vegetation as a method of managing waterlogging. Four participants recorded "other" in their tried technologies/techniques, offering solutions such as summer cropping, varying seed/fertiliser rates and raised beds as alternatives (Figure 18).

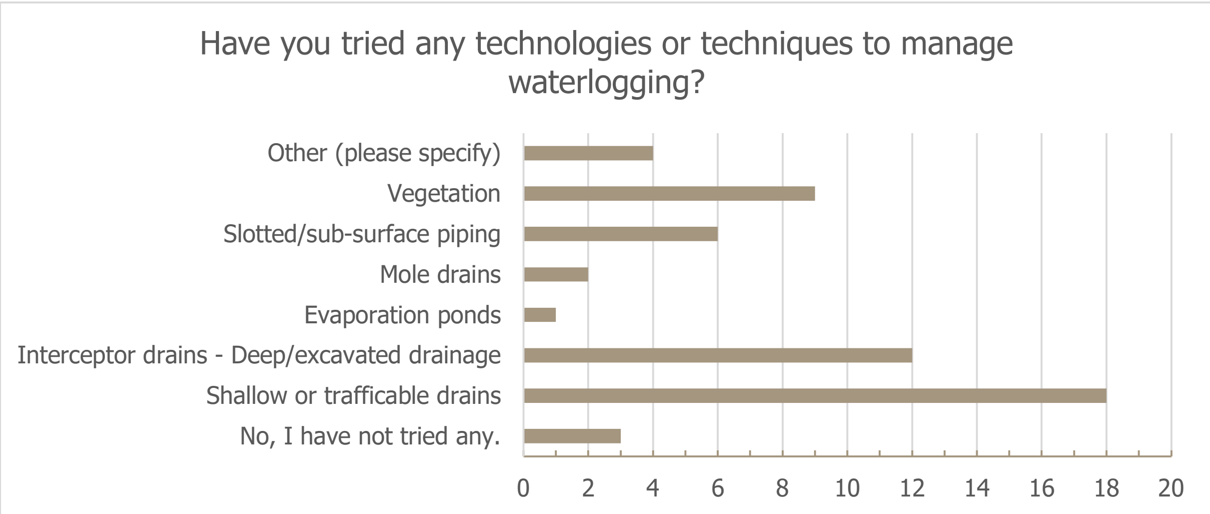


Figure 18: Grower survey responses for types of waterlogging management employed within the Albany Port Zone.

Growers were asked what timeframe they would anticipate for a return on investment/cost recovery of the installation would be, should they implement sub-surface water management. The initial pre-project survey responses were more widely distributed, with responses across all three timeframes, with the majority (46%) believing it would take approximately 3-4 years and 38% believing it would take 5+ years to receive a return on investment. Following on in the post-project survey, all responses were confined to the 3–4-year period and 5+ year period answers. As noted in the pre-project survey, for many, this question was hard for respondents to answer, as the payback period is ultimately reliant upon sufficient rainfall levels to create/induce waterlogging scenarios.

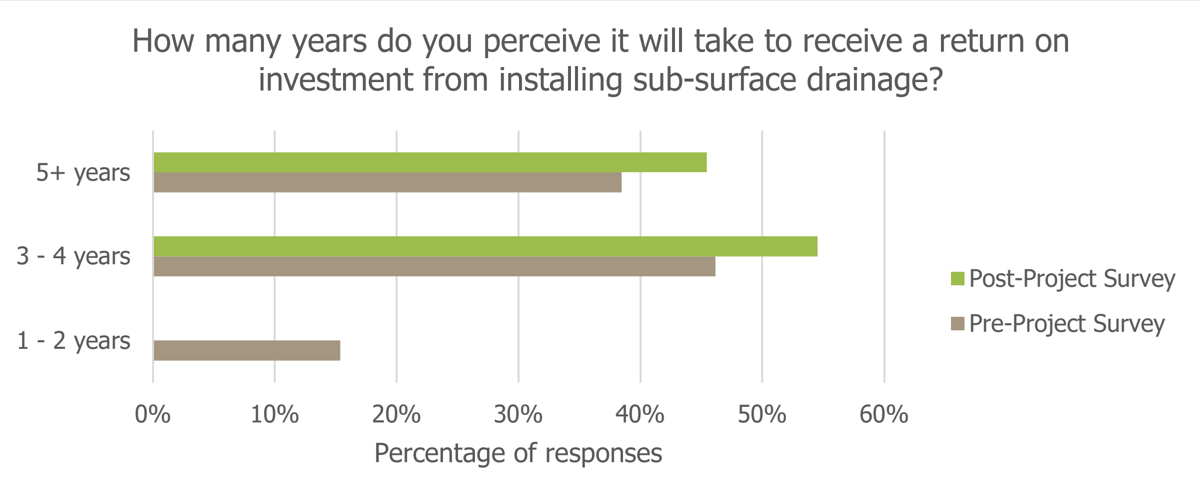


Figure 19: Grower perceptions of the potential return-on-investment period acquired through sub-surface drainage installation.

Survey participants were asked the following questions: "On a scale of 1 to 5 and assuming a positive payback period was experienced, how likely would they be to install sub-surface drainage at the current moment?". In the pre-project survey, the majority of responses were rated 'not quite sure', closely followed by 'no, never at all' and 'unlikely to implement'. When growers were surveyed at the end of the project, there was an increase in the likelihood of implementing sub-surface drainage, with the most common response of 'likely to implement' accounting for 45% of the responses, 'not quite sure' ranking 36% of responses and 'certainly will implement' accounting for 18% of the responses.

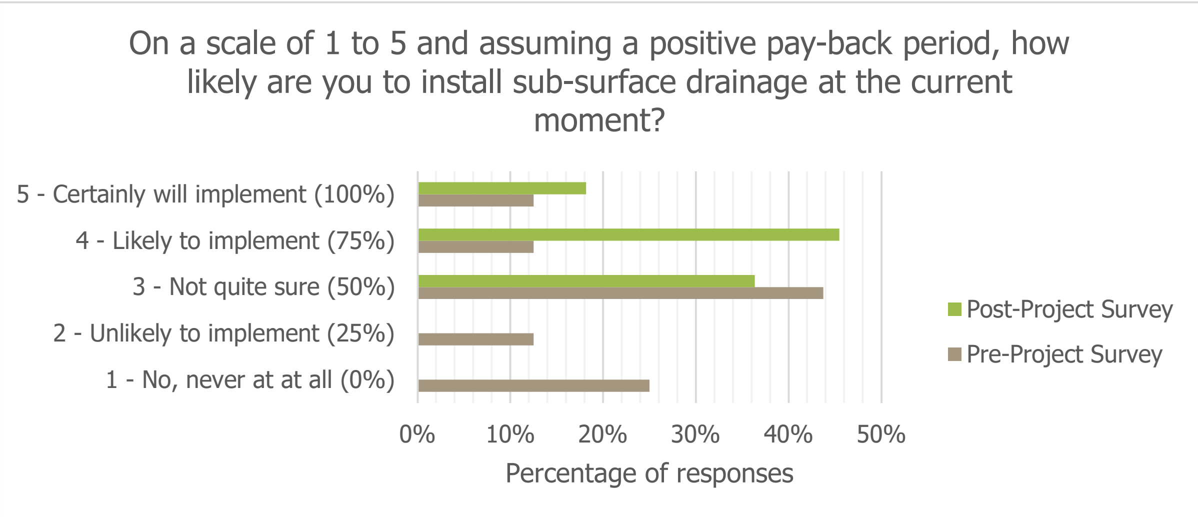


Figure 20: Grower likelihood of implementing sub-surface drainage solutions given a positive pay-back period.

Growers were recently surveyed at the Stirlings to Coast Farmers 2023 Trials Review Day to gain additional information as to what may be the continuing barriers to adopting sub-surface water management both now and into the future. Of 29 responses collected from growers/industry, 89% of respondents agreed that a 'continued understanding of ROI over multiple seasons' would build confidence in adoption, with 72% of respondents wanting further demonstrations to build grower confidence. 47% of respondents also wanted a better understanding of the types of sub-surface water management available and a better understanding of the efficacy/response over time.

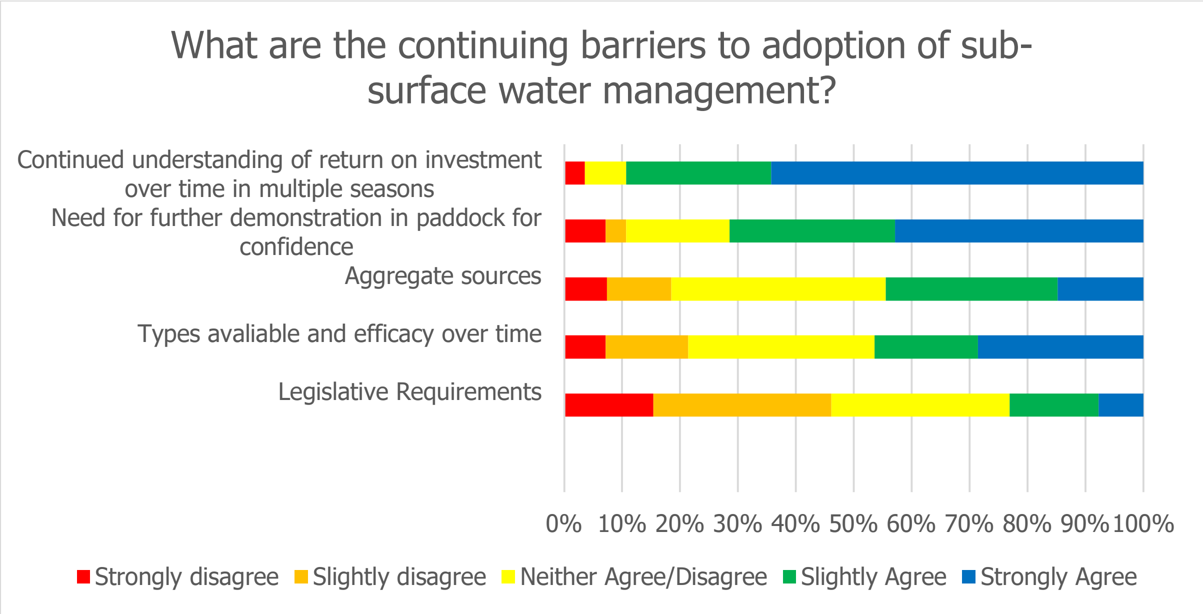


Figure 21: Identification of the key challenges to the adoption of sub-surface water management (n=29)
Source Dataset: SCF Trials Review Day Survey

DISCUSSION OF RESULTS

Farm Production Results

The use of Sub Surface Drainage has shown a general positive effect on final yields obtained across both demonstration sites throughout 2021- 2023; however, the responses have been highly seasonal. Previous yield increases in 2021 acknowledged a 47% yield increase (Flinders Barley) in Cranbrook, along with a 72.5% yield increase in 2022 (45Y98 Canola). At the Perillup demonstration site, a 39% yield improvement (45Y95CL Canola) between drained/un-drained was achieved in 2022. However, for 2023, the seasonal conditions were not as favourable, and the benefits of implementing sub-surface drainage were limited to -10kg/ha to +420kg/ha in Dennison Wheat in Cranbrook & +180kg/ha in DS Bennett in Perillup for the 2023 growing season. 2023 represents the final year of monitoring for these trial sites under the GRDC research project.

All three seasons resulted in an above-median rainfall value; however, their distributions throughout the year were completely different. 2021 saw rainfall track above median rainfall throughout the whole year, after the 21st of January 2021, whilst 2022 started drier for both sites, tracked near median rainfall throughout April to late September, then tracked above median rainfall thereafter.

2023 saw a very dry start at both demonstration sites, followed by below median rainfall levels to April (Perillup) and to June (Cranbrook), with the season's rainfall plateauing for both trial sites from mid-late September, which is the critical flowering and beginning of the grain-fill period for Wheat. It is assumed that rainfall within this later period of the year would have led to an improved yield potential overall and shown a larger potential difference between treatments. These dry events effectively capped the yield potential of the crop, rather than the biomass itself, which was determined & grown throughout the year.

Whilst yields were generally improved across all treatment locations through the implementation of sub-surface water management, it is also an important consideration to select varieties that can better mitigate drought/heat stress during critical grain fill periods (as experienced in 2023) to maximise yield potential in these types of seasons. This may include the use of a longer-season wheat variety if early soil moisture is available and it is anticipated to finish well; however, if the season starts dry and ends dry, a shorter-season variety may be more beneficial to have for yield production in the mix.

Despite the dry start to 2023, the results ultimately showed the opportunity to help identify what might be anticipated to occur in a year, where heat stress is exhibited at the critical grain-fill period, and the effect on potential yield under drained and un-drained management scenarios. Results from 2023 should help build some confidence that although there is a financial cost in implementing the drainage itself, there were no significant financial and/or production-based disadvantages to the crop, where sub-surface drainage has been implemented in Cranbrook & Perillup in these instances.

Benefit-Cost Analysis

Analysing the financial benefits of implementing sub-surface drainage conducted by Dr Elizabeth Petersen from Advanced Choice Economics, it was evident that the implementation of subsurface drainage has had positive effects, not just only on the productivity of the paddock itself, but also positive financial outcomes from the installation too.

Dr Petersen reported that the '*results of the Benefit Cost Analysis suggest that sub-surface drains are likely to be a cost-effective way for growers to manage soils that are susceptible to waterlogging in the Albany region of Western Australia.*' It is also important to highlight and note 'that the results from the sensitivity analysis found that the cost-effectiveness *of sub-surface drainage is robust to a wide range of realistic changes to future economic and environmental conditions'* (Petersen, 2024).

Overall, the report also identified that the Cranbrook site was found to have higher profitability than the Perillup site, with this higher profitability associated with a greater zone of impact compared with the drain area and greater crop yield responses to the drain (Petersen, 2024). Whilst the cost of installation is perceived to be quite high per kilometre, moving forward, it will be important for landholders to maximise the efficacy of installed pipework to maximise the field of influence/zone of impact of the sub-surface drainage as much as possible, and to maximise the potential area covered, effectively too.

Whilst the results are generally overall very positive, and notwithstanding the BCA reports authors' opinion, there is still a perceived potential that the net benefits from implementing sub-surface drainage are still likely understated. Following on from the lived experience & data collected in 2021 at the Cranbrook demonstration sites, it was highly evident that the drained site allowed for greater management opportunities throughout the season, particularly in terms of potential weed control or in allowing for nutritional management according to plant requirements, in high-rainfall seasons. Quantifying the ability to better time these applications and to better manage the soils structural components is likely to lead to improved yields, farm-wide & plant efficiencies, as well as improved environmental benefits, all of which are quite difficult to calculate when 'stacked' on top of each other.

It is also of the view of the BCA reports author and Stirlings to Coast Farmers that for more robust, stronger accuracy results to be generated within the Albany Port Zone, further investigation needs to be conducted. Petersen noted that the *'results need to be validated with further trial sites, over a longer period of time to consider a range of years and where the yield responses of different crop types are repeatedly tested.'*

Current results were based on estimates that yield responses to sub-surface drainage ranges between 0.2 – 0.9t/ha for Wheat, which was based on a relatively poor finish to the 2023 season & heat stress. Despite seeing benefits in Barley within the cereal phase of around 1.5t/ha from implementing sub-surface drainage, this was achieved in a 99-percentile year and was an extreme outlier, being nearly double the annual average farm rainfall.

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Grower Surveys

Overall, survey responses were positive and showed that growers were open to trialling subsurface drainage as a method of managing waterlogging. Responses from survey participants identified that many growers are currently implementing water management solutions in the Albany port zone, however, they are often relying upon more than one management technique or technology to manage waterlogging, with shallow & trafficable drains the most common method. This is not surprising, as the costs to implement surface drainage are relatively cheap and approximately half the price of sub-surface drainage; however, the efficacy of these drains at a sub-surface level is quite limited and waterlogging still can occur.

Growers, during the progress of the project, had actively increased their adoption of slotted pipes & sub-surface drainage, with 6 survey participants having implemented this process on their own properties. Growers within the region are readily adopting sub-surface drainage as a method of managing waterlogging, with some survey participants adding an additional 2 to 70 kilometres of slotted pipe at depth, since the project inception, with the larger amount contributing due to the yield responses seen from 2021 and 2022 seasons. This was evident in Figure 20, with a shift in responses to an increased likelihood of implementing sub-surface drainage in the post-project survey.

Feedback from survey participants was that the perception of the payback period, at times, was hard for growers to quantify. Whilst they all acknowledged that yield benefits were able to be seen, the variability in seasons made it hard for growers to quantify what their potential payback period might be, as the results were derived from 3 above-median rainfall years. This was seen in Figure 19, as the post-project surveys had extended their anticipated timeframes beyond the original 1-2 years for some (pre-project survey) and replaced these responses into 3-4 and 5+ year timeframes in the post-project survey.

There still remain some significant barriers to adoptions, namely around a better understanding of the return on investment over multiple seasons/crop types and the need for further demonstrations to build grower confidence. Legislative requirements for implementation are the least likely barrier to adoption, with 78% of the responses rating this barrier as a disagree or neither agree/disagree. Given this, continued research across a range of crop types and soil types will be beneficial to driving adoption moving forward.

CONCLUSION

In conclusion, implementing sub-surface drainage has resulted in improved production results at both demonstration sites located in Cranbrook & Perillup, with initial economic payback period based on an estimated 2-to-7-year period, dependent upon trial site location and the associated field of influence.

The two demonstration sites had exceptional yield responses in 2021 & 2022, with values circa of 47% yield improvement in Barley, 39 – 73% yield improvement in Canola, and with a lesser yielding 3.7-12.2% achieved in 2023 with Wheat in a heat-stressed environment. It is important to note that despite 2023's limited yield response due to seasonal conditions (heat stress), there were no significant differences or negative effects on final yield between the drained & undrained trials, when the season finished drier, with no significant rainfall events within the period between flowering & grain-fill. NDVI values captured throughout the seasons showed that drainage performed well during the season, leaving higher levels of biomass/NDVI detected.

Growers also learned through the project how to calculate a simplistic 'back of envelope' potential ROI analysis, utilising the case study at Cranbrook that measured and analysed yield in the drained and un-drained regions, calculating the 'lost yield opportunity', and took into consideration installation costs, zone of influence, median grain prices and potential payback periods, prior to being introduced to a full Benefits Cost Analysis (BCA) completed externally in 2024.

These learnings, in conjunction with positive values seen in the sensitivity analysis conducted with the BCA, should help give farmers an increased confidence to investigate the implementation of sub-surface drainage on their own farms, even if applied on a relatively small scale. Petersen (2024), however acknowledged that "*our results need to be validated with further trial sites, over a longer period of time to consider a range of years with low to high growing season rainfall, and where the variety of crop types are repeatedly tested*", particularly if results are to be extended into different regions or environments.

IMPLICATIONS

Approximately 3 million hectares of land located within the southwest agricultural region of Western Australia has a moderate to very-high susceptibility to waterlogging or inundation, representing an estimated $35 million opportunity cost between 2009/10 and 2013/14 (DPIRD, 2019). Water management techniques such as sub-surface drainage can help alleviate some of these challenges and minimise the yield penalties that farmers often experience in wetter periods, but also creates opportunities for farmers to improve their on-farm operations, increase productivity in terms of grain yield, increase productivity in terms of machine efficiency and run-time operation, minimise soil degradation, and maximise the ability to appropriately apply fertilisers and chemicals at the right time.

Despite the upfront installation costs of sub-surface drainage in the magnitude of $15,000+ per kilometre, positive yield responses were seen across both demonstration sites across the project, with cereal yields being increased by up to 47% and up to 72.5% in canola at Perillup in ideal finishing conditions. Calculations derived through the benefit-cost analysis assessment showed that the return on investment was 84% (Perillup) and 460% (Cranbrook), with individual break-even periods as short as 2 years from Cranbrook and 7 years for Perillup.

Whilst results are promising, caution will, however, need to be exercised, given the short duration of this project, to ensure that the results seen at Cranbrook and Perillup are not outliers and are reflective across a wider range of seasons and crop rotations. Extreme caution should be taken when trying to extrapolate these results to other geographical regions and rain-fall zones, as results are highly site-specific.

RECOMMENDATIONS

This report ultimately highlights the potential for sub-surface drainage to be an effective medium in managing waterlogging under a range of environmental conditions. Results showed that payback periods could be as little as 2 years in some scenarios and that the models still performed well under varying sensitivities. Whilst the results from the trial have shown positive findings, it is, however, recommended by Stirlings to Coast Farmers that further investigations & research work be conducted on the following matters to ensure that trial results are robust and accurate under a wider range of environmental conditions, seasons & locations, including:

- Timing & length of Trial – *to ensure that sufficient data is collected across a wide range of seasons and crop types, including conducting additional research into grain legumes to determine their potential yields under drainage solutions.*
- Rubble Sources & Quality – *Farmers within the Great Southern region are experiencing issues in sourcing appropriate limestone rubble aggregate, that is often used in the installation process. Alternative sources such as gravels and blue-metal can be used, however, some iron-based gravels can react in anaerobic conditions. Chemical testing of the pisolites from field samples will ensure that aggregates remain compatible with drainage systems, and not compound the effects of waterlogging.*
- Tile Plow vs 'trenched with rubble' styled drainage – *There has been a growing interest in the use of a lower-cost, direct-burial tile-plough drainage installation method (not tested under this project), however, their efficacy against the more expensive 'trenched with rubble aggregate' drainage has not been ascertained under local conditions. Further research side-by-side in terms of flow rates, the lifecycle, applications/suitability in varying soil types & maintenance requirements of the pipe & effective* field of influence would be highly beneficial.

EXTENSION ACTIVITIES

Presentations

- Stirlings to Coast Farmers 2021 Trials Review Day (2022)
- GRDC Gairdner NGN Workshop (2022) – SCF GRDC Subsurface Drainage Trials – *Learnings from our first year at Cranbrook*
- GRDC Kojonup Grains Research Update (2022)
- GRDC Grower Research Updates Albany (2023)
- DeltaAg Wellstead Trials Review Day (2023)
- Stirlings to Coast Farmers Trials Review Day (2024) – *Drainage Dollars*

Field Walks (SCF Organised & Managed)

- SCF Spring Field Day – Cranbrook (2020)
- Preston Installation Demonstration Day – Cranbrook (2021) – 30 Attendees from lower, Great Southern region.
- Preston Information Day – Cranbrook (21st September 2021) – *24 Attendees from Bruce Rock region.*
- Amerillup Installation Demonstration Day – Perillup (3rd February 2022) – *27 Attendees from lower Great Southern region.*
- Stirlings to Coast Farmers Winter Field Walk/BBQ Day (2023)
- Agronomy Australia Conference – *Planned Field Trip (24th October 2024)*

Site Visits (Host Managed)

- Frankland Rural
  - Nutrien Wheatbelt Agronomy Walk – Perillup (20th September 2023) - 10 agronomists
  - SCF is aware of at least two additional agronomist groups visiting – including Farm & General Esperance.
- Amerillup Pastoral Co
  - Estimated 40 farmers and agronomists have visited the site outside of SCF events -

Reports, Videos, Print Articles & Social Media

- 2020 Sub-Surface Drainage Article – Link
- Sub-Surface Drainage Handbook - Link
- 2021 Drainage Installation Day Article – Link
- 2021 Spring Newsletter Article – Link
- Trials Review Booklet (2021 Season) – Link
- Trials Review Booklet (2022 Season) – Link
- Trials Review Booklet (2023 Season) – *in production*
- GRDC Groundcover - Learning important lessons from 2022's Big Wet – May/June 2023 – Link

Media

- Albany Advertiser - Farmers to learn keys to sub-surface drainage to combat waterlogging - 16 February 2021 – Link
- ABC WA Country Hour – 2nd July 2021
- ABC Great Southern Mornings – 2nd July 2021
- Farm Weekly – South Coast NRM & Stirlings to Coast Farmers help develop waterlogging strategies – 22nd March 2022 – Link
- Farm Weekly – Drainage helps reduce crop waterlogging – 4th July 2022 – Link
- ABC WA Country Hour – 5th July 2022

Podcasts & Videos:

- SCF Sub-Surface Water Management Options – Drainage – Link
- SCF Subsurface Drainage Project Updates – 2021 – Link
- GRDC Video – Rising interest in sub-surface drainage – Link

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GLOSSARY AND ACRONYMS

BCA	Benefit-Cost Analysis, or sometimes otherwise known as a cost-benefit analysis, is a process which compares the estimated costs and benefits associated with a project decision to determine whether it makes financial sense form a business perspective.
DPIRD	Department of Primary Industries and Regional Development
IRR	Internal Rate of Return (or sometimes referred to as 'yield rate') is a method of calculating an investment's rate of return. The term internal refers to the fact that the calculation excludes external factors, such as any cost of capital, inflation or financial risk. capital, or financial risk.
NDVI	Normalised-Difference Vegetation Index
RTK GPS	Real-Time Kinematic Global Positioning System – Utilises highly accurate GPS satellite and ground-based equipment to improve the accuracy (x,y,z) of data collected across a paddock.
SCF	Stirlings to Coast Farmer's Inc.
SCNRM	South Coast Natural Resource Management
SSWM	Sub-surface water management

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