

# Final Technical Results Report

## 2024

### Understanding return on investment of sub-surface water management options for waterlogged areas in the Western Region

**Project code:** SCN2005-001SAX

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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 serious threatening process for growers across WA, with real implications to crop health and farm profitability. The Subsurface Drainage Return on Investment trial aimed to assist growers in making informed decisions around the efficacy of subsurface drainage in reducing impacts of waterlogging on crop production systems and increasing farm profitability through yields.

Two subsurface drainage demonstration sites were established in the high rainfall zones of Neridup, and Dalyup in the Esperance Port Zone. Monitoring began in 2021 and collected data on perched water levels, yield improvements and environmental factors. The 2021 and 2022 harvests were record breaking for the area, as a result of high rainfalls, and although Neridup and Dalyup both experienced significant waterlogging, the drains performed well and produced substantial yield benefits. The drains also presented yield benefits in 2023 despite it being a decile 1 – 3 year for the trial.

The time until return on investment for subsurface drainage is determined to be between 9 – 12 years and is expected to provide internal rates of return to growers between 12 – 16%. This project finds subsurface drainage to be a profitable and effective management tool to address waterlogging. Further research and expertise is required to support broadscale adoption.

## EXECUTIVE SUMMARY

Waterlogging is a serious threatening process for growers across WA, with real implications to crop health and farm profitability. The low lying, shallow sandy soils, and high rainfalls particularly in the Esperance and Albany Port Zones which comprise the South Coast region are highly susceptible to waterlogging, and the impacts are realised not only in yield losses, but also in a decline in the health of the farm system (Department of Primary Industries and Regional Development (DPIRD), 2022).

Subsurface drainage systems have long been used to combat waterlogging in agricultural landscapes. The buried pipe sits to the depth of the clay layer within the subsoil, the layer at which perched water becomes trapped in the root zone of the crop, leading to crop drownings and reduced soil health. Subsurface drainage supports the effective drainage of excess water away from the root zone, improving soil health and crop yields.

This investment aims to assist growers in making informed decisions around the efficacy of subsurface drainage in reducing impacts of waterlogging on crop production systems and increasing farm profitability through yields. To accurately understand the profitability of this management technique, the projects primary output is a time to return on investment, and cost benefit analysis, comprised of installation and maintenance costs against realised increases in yields, resource efficiencies and longer-term improvements in the farm systems health.

The project took a grower led approach to emulate real world conditions of how a grower might design and implement subsurface drainage on farm. This strategy ensures that the learnings from the project were easily understandable, accessible, and actionable for other growers. On ground demonstration and peer to peer learning, ensured that the project could deliver activities that supported the primary objectives and desired outcome.

Two subsurface drainage demonstration sites were established in the high rainfall zones of Neridup, and Dalyup in the Esperance Port Zone (EPZ). The Neridup subsurface drainage network is comprised of nine (9) lengths of subsurface drainage installed at 36m intervals across an 8ha area. The pipes ran laterally between two pre-existing drains, which were installed by the landholder in 2018. Dalyup consisted of a total of 33 individual pipes that averaged 450m - 700m in length and covered an expanse of 65.5 hectares.

Monitoring began in 2021 at the Neridup trial site, with Dalyup joining after the first year, and ran until February 2024. The first two years of the trial saw decile 8 – 10 annual and growing season rainfall. The 2021 perched water table data for Neridup showed significant inundation in the rainfalls with the influence of La Nina driving wet conditions for much of subsoil up to 10cm from the surface. The waterlogged, undrained control site at Neridup was consistently the most responsive to rainfall, and results of this monitoring demonstrated that the presence of the drains could effectively move perched water away from the root faster than in an undrained waterlogged area.

This had a significant effect on the yields of the trial paddocks. Yield improvements observed because of the drains ranged from 1.13 - 1.49t/ha for wheat, 1.36t/ha for barley and 0.07 - 0.72t/ha for canola (Petersen, 2024). The results of the project have identified an intrinsic link between the yield improvements observed from the drains, and the relationship between rainfall and crop growth stages.

The yield improvements were impressive for both Dalyup and Neridup, but produced a greater internal rate of return, and a faster return on investment (ROI) for Dalyup, as this drainage design was cheaper on a per hectare basis. Whilst Dalyup is estimated to meet its ROI in 9 years, Neridup is expected to pay itself back in 12 years (Petersen, 2024). These ROIs are within at least half the lifetime of the drains themselves and very little maintenance costs are expected. Further, subsurface drainage appears to be robust against a range of future scenarios and is expected to provide positive internal rates of return to growers between 12 – 16% (Petersen, 2024).

This project directly engaged with over 50 farming enterprises and 20 advisors from across the South Coast and worked with national and international partners to deliver on ground demonstrations, educational media (videos and podcasts) and support the research of other related projects from across Australia. The result of this extensive engagement has grown widespread interest in this management tool, and many growers across the EPZ are now directly considering or planning for the installation of subsurface drainage on their own farms.

The momentum and engagement realised throughout this trial indicates that subsurface drainage will only increase in prevalence for growers who are impacted by waterlogging on the South Coast, and across Australia. Related work in the field is exploring the role of subsurface drainage in drought conditions and establishing the role of subsurface drainage in future proofing farming systems against a changing climate is critical in building a resilient industry. The growing interest of farmers in surface water management and subsurface drainage will require increased provision of trusted advisors, that can support the planning, design and implementation of drainage systems under best practice principles. Cohesive industry effort to provide this expertise should be prioritized, so that broadscale adoption of this technique can be supported with appropriate advice to ensure long term sustainability. Additionally, this report recommends further research into the performance of subsurface drainage across a broader range of farming environments to support the validity of the conclusions drawn.

## BACKGROUND

Waterlogging is a serious threatening process for growers across WA, with real implications to crop health and farm profitability. Approximately 3 million hectares of agricultural land in Southwest WA is moderately, to highly prone to waterlogging (Department of Primary Industries and Regional Development (DPIRD), 2022).

The low lying, shallow sandy soils, and high rainfalls particularly in the Esperance and Albany Port Zones which comprise the South Coast region (Figure 1) are highly susceptible to waterlogging, and the impacts are realised not only in yield losses but in a decline in the health of the farm system as well (Department of Primary Industries and Regional Development (DPIRD), 2022).

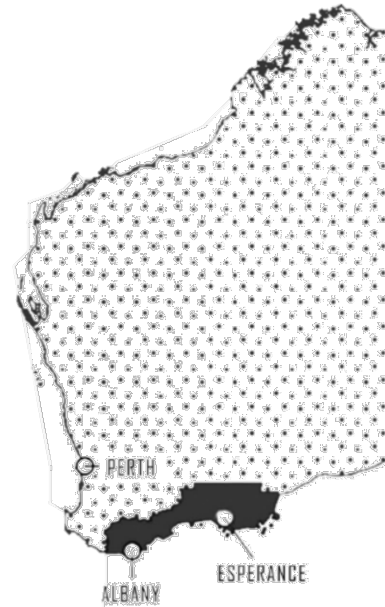
Whilst Australia's climate continues to dry, the risk of waterlogging is not negated. A warming climate can retain greater volumes of water vapor in the air, contributing to the increased intensity and frequency of short-duration, heavy rainfall events (Bureau of Meteorology , 2022).

To build resilient farming systems it is imperative that growers address the increased climate variability affecting the South Coast, and cope with heavy rainfall events and changing rainfall availabilities throughout the growing season.

Subsurface drainage systems have long been used to combat waterlogging in agricultural landscapes. The buried pipe sits to the depth of the clay layer within the subsoil, the layer at which perched water becomes trapped in the root zone of the crop, leading to crop drownings and reduced soil health. Subsurface drainage supports the effective drainage of excess water away from the root zone, improving soil health and crop yields.

Although an old technique, subsurface drainage systems have had little adoption in broadacre agricultural landscapes with climates similar to the South Coast. Growers in this region, have little real-world examples of this management technique to inform their surface water management decisions on farm.

The Subsurface Drainage Return on Investment project was designed to give South Coast growers affected by waterlogging an understanding of the effectiveness of subsurface drainage in alleviating waterlogged soils in their landscapes. It sought to establish the return on investment of subsurface drainage and the timeframes associated for that return. A solid understanding of subsurface drainage's further costs and benefits was viewed as critical to support more informed management decisions for growers and advisors across the South Coast.



**Figure 1. The South Coast Region of WA. Image Credit: South Coast NRM**

## PROJECT OBJECTIVES

### Outcomes & Objectives

This investment aimed to assist growers in making informed decisions around the efficacy of subsurface drainage in reducing impacts of waterlogging on crop production systems and increasing farm profitability through yields. To accurately understand the profitability of this management technique, the projects primary output was a time to return on investment (ROI), and cost benefit analysis, comprised of installation and maintenance costs against realised increases in yields, resource efficiencies and longer-term improvements in the farm systems health.

The outputs and objectives were aimed to be achieved through grower participation in the planning, development, monitoring, and maintenance of the drainage installation trial sites. Data (cost of implementation and maintenance, water movement, establishment, biomass, yield etc.) from within the zone of influence and outside this zone at each site was to be collected over time. The collective data from all trial sites was to be analysed to provide a robust understanding of the influence of subsurface drainage on waterlogging for South Coast farming systems.

The projects outcome statement was,

*By 2024, 45% of growers whose properties are affected by waterlogging will have a good understanding of the yield benefits and time to return on investment of installation of on-farm subsurface drainage and ability to implement on-farm.*

This outcome was supported by the following project objectives:

- By 15 March 2024, subsurface drainage installation trials on waterlogged sites will give growers knowledge and ability to implement drainage on their properties to increase crop productivity on the affected areas.
- By 15 March 2024, key learnings and analysis of ROI of the trial sites will be extended to growers and advisers in the Western Region so that they have the knowledge and ability to implement on-farm subsurface drainage and have a good understanding of time to return on this investment.
- By 15 March 2024, Pre and post surveys will assist in determining if the project has increased grower knowledge and ability to implement on-farm subsurface drainage and whether this has led to on-farm practice change that addresses areas of the farm impacted by waterlogging.

## Assumptions

To assist in evaluating the success of the project in achieving its desired outcomes and objectives, the following assumptions were established for the trial:

- The Esperance Port Zone (EPZ) spans 5.4 million hectares of which 28% or 1.5 million hectares is arable, and the average agricultural property size is 3,400 hectares. (Department of Primary Industries and Regional Development, 2021)
- Of those 1.5 million hectares of arable land, a conservative, 5% is impacted by high to severe waterlogging equating to 54,000 hectares of severely waterlogged land. (Department of Primary Industries and Regional Development (DPIRD), 2022).
- This means that there's roughly 15 farms impacted by severe waterlogging in the EPZ, 45% of this is roughly 7.

These assumptions were limited in their validity as the information is dependent on models and publicly available knowledge. The source used to understand the extent of waterlogging across the region only provides viable information on cases of high to severe waterlogging and therefore, the assumptions cannot quantify the extent of low or moderate waterlogging that many more growers would experience.

Additionally, on ground observations tell us that waterlogging can occur in highly targeted patches on farm, and these small, but severe areas of waterlogged country may occur at scales that are not detected by modelling systems. Therefore, it is highly likely that the extent of waterlogging used in this assumption (5%) is conservative, and the true extent of waterlogging within the EPZ is likely much higher.

## Limitations

Subsurface drainage systems are highly intrinsic to the immediate surrounding environment and performance is strongly influenced by design, soil type and elevation. The results of this project are therefore highly nuanced to the participating trial paddocks and not truly representative of all broadacre cropping systems across the South Coast region.

Additionally, the Dalyup and Neridup trial sites vary significantly in design and environmental factors and although this provides a unique insight into design and performance, does limit comparability. Further, the trial only collected three years of data for the Neridup trial, and only two years of data for the Dalyup trial and time is a significant limitation in the validity of results and the project's understanding of rainfall patterns and the influence of annual climate variability on the drains.

## METHODOLOGY

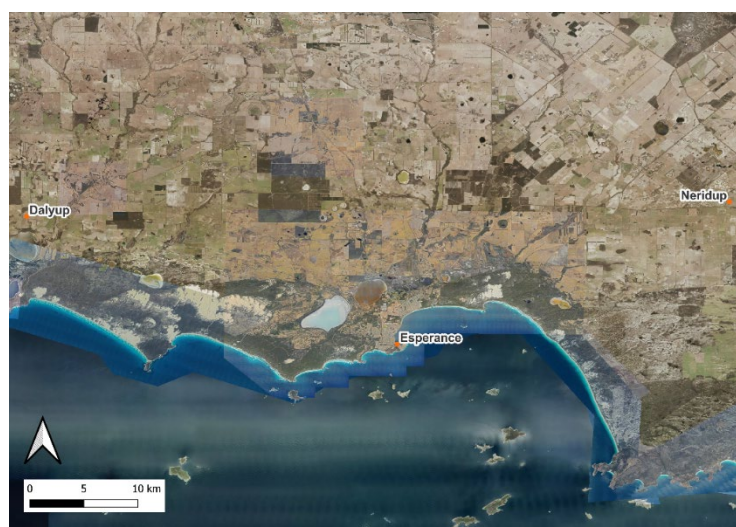
As a demonstration trial, the project's strategy was to emulate real world conditions of how a grower might design and implement subsurface drainage on farm. This strategy ensures that the learnings from the project were easily understandable, accessible, and actionable for other growers. On ground demonstration and peer to peer learning, ensured that the project could deliver activities that supported the primary objectives and desired outcome.

The locations of the drain systems were informed by growers using their observations, historical yield performances and biomass imagery. Both trials designed subsurface drainage systems to discharge perched water into existing surface water management infrastructure. Consideration was taken to create as little interference with growers' regular regimes as possible.

### Trial Design

Two subsurface drainage demonstration sites were established in the high rainfall zones of Neridup, and Dalyup in the EPZ, see Figure 2. A third site was identified in late 2021, however, due to labour shortages, installation was delayed, and rescheduled for early 2024.

Neridup is viewed as the primary trial site and was the focus of the project's monitoring regime and design. During the first year of monitoring, the project established a technical advisory group (TAG) to guide the project's outcomes. One member of the TAG, another local farmer from Dalyup had also installed subsurface drainage on farm, and the TAG saw immense value in including this system into the monitoring and evaluation of the project. The TAG agreed that with such varied systems, and implementation approaches, understanding the differences in yield benefits between these two sites could value add to the knowledge and validity of the trials results. Dalyup was incorporated into the project in 2022, with the landholder providing the installation of the drainage system in-kind. Dalyup did not receive any direct support from the project in the establishment of a monitoring regime.

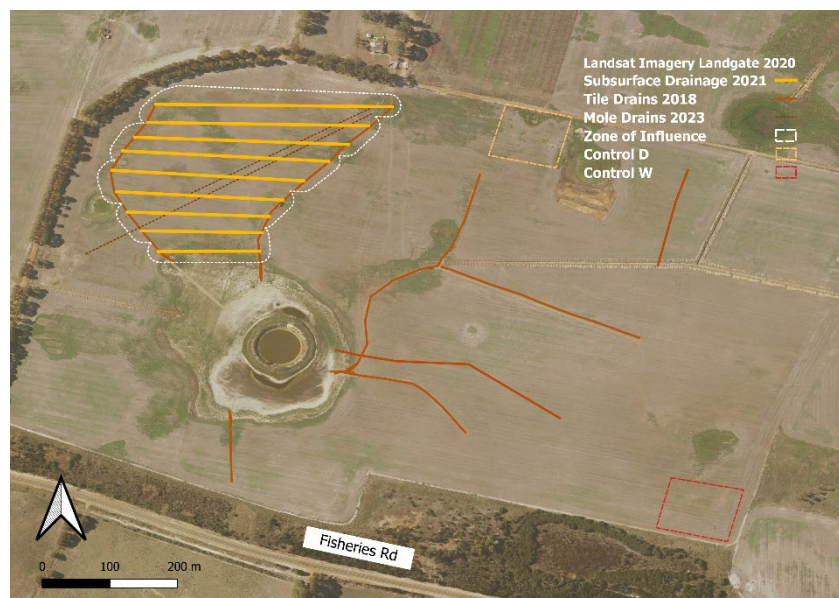


**Figure 2. Trial locations of the Subsurface Drainage Return on Investment Trial in the Esperance Port Zone, South Coast NRM, 2024.**

The design of any subsurface drainage network is highly dependent on the soil profile and elevation of a paddock. The interval spacing for both Dalyup and Neridup followed recommendations of N.R. Fausey in the “encyclopedia of soils in the environment,” 2005 which notes that highly permeable soils, such as the gravel/sandy mix of the Esperance Sandplain can withstand spacing of up to 50m (Fausey, 2005). Both trials utilised a spacing of 36m which was determined to be the optimal spacing to maximise draw down effect and value for money. The subsurface drains were buried to the depth of the clay layer which traps perched water in the root zone. For both Neridup and Dalyup the clay layer was present between 600 – 800mm below ground level.

### Neridup Trial Design

The Neridup subsurface drainage network is comprised of 9 lengths of subsurface drainage installed at 36m intervals across an 8ha area. The pipes ran laterally between two pre-existing drains, which were installed by the landholder in 2018 (Figure 3).



**Figure 3. Neridup Subsurface Drainage Trial Design, South Coast NRM, 2024.**

The drains installed in 2018 were installed either side of a severely waterlogged patch and were up to 350m apart at the widest point. This spacing failed to have a drawn down effect on the perched water in the subsoil and was unable to reduce the severity of waterlogging in this area. The 8ha area between the two pre-existing tile drains was therefore selected by the landholder to test whether the addition of intersecting polypipe between the existing drains could effectively create the draw down effect required to remove the perched water.

To support the infiltration of perched water into the drains, the pipe was infilled with a limestone aggregate before the topsoil was placed over top of the drains. In addition to the drains, two 1ha control sites were established in the paddock, one that was on free-draining soils and the other in similarly waterlogged soils (Figure 3). The 8ha trial drains were installed by contractor, Surface Water Management.

In 2023, the landholder supplemented the space between the slotted poly-pipe by installing mole drains running at perpendicular angles to the tile drain. Mole drains are comprised of unlined soil “pipes” that when installed create small fissures in the earth that provide a direct pathway for water to follow, out of the subsoil and into the drain (DPIRD, 2020). Water will move through the Neridup drainage system to a dam at the terminus of the drains. In high water events, overflow from this dam will travel via a pre-existing open drainage system to a lake in the neighbouring paddock.

### Dalyup Trial Design

The Dalyup trial paddock is dissected by a raised sandhill running east to west, which prevents water from an uphill wetland (top left of paddock) from moving to lower elevations at the south end of the paddock where an existing surface drain lies (Figure 4). The landholder installed a total of 33 individual pipes that averaged 450m - 700m in length and covered an expanse of 65.5 hectares. The pipes extend to the base of the sandhill and are designed to draw water across the sandhill and into the surface drain at the base of the paddock.



**Figure 4. Dalyup Subsurface Drainage Trial Design, South Coast NRM, 2024.**

To the western edge of the trial paddock, some different spacings were trialled by the landholder, however it was conferred that 36m seemed to be optimal for this soil profile and elevation. Testing the spacing of the drains contributes to gaps in knowledge around best practice subsurface drainage design. The landholder completed the install, using a soil-max tile drain machine and materials purchased from a United States distributor, Farm-X. Unlike Neridup, the Dalyup pipe was covered by a perforated sock to facilitate flow into the pipes, rather than a limestone aggregate.

As the Dalyup trial was included in the project following strong grower engagement as an additional deliverable, the trial did not establish formal control zones, but rather, compares the results of the drains zone of influence against the undrained portion of the paddock.

## Monitoring Regime

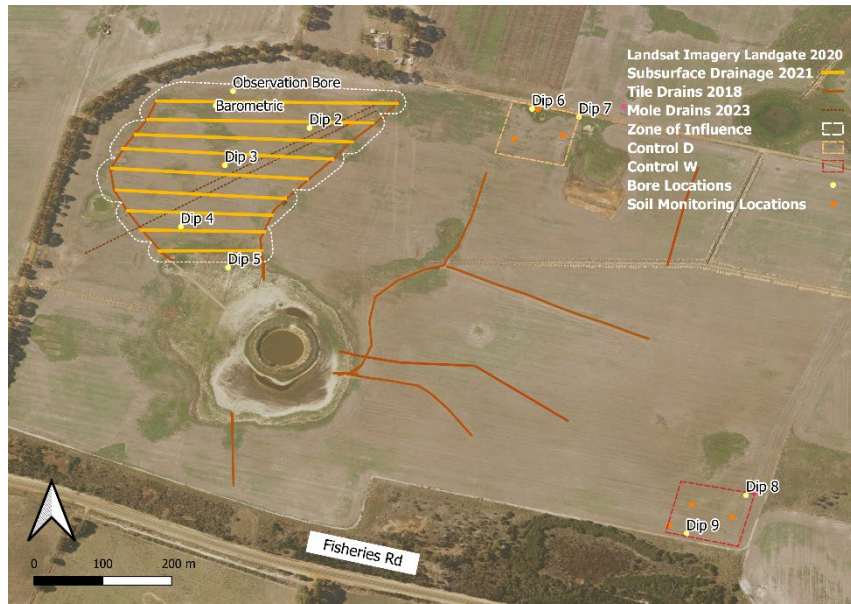
The monitoring regime collected data on key farm operational factors including, biomass, yield, weed and disease presence, soil moisture and salinity, perched water levels, drain rate of flow and establishment and tiller counts, to provide real world understanding of the outcomes and potential benefits of subsurface drainage in alleviating waterlogging.

Monitoring of the Neridup site began in February 2021, and ended in February 2024. Monitoring of the Dalyup trial site began in February 2022, and ended in February 2024.

To appropriately determine what parts of the paddock were affected by the drains, the project established a zone of influence. The zone of influence was determined by adding a buffer to the perimeter of the drainage network with an extent of half the spacing width. For both trial sites, the spacing of the drains was 36m, creating an 18m buffer around the drains (Figure 3 and Figure 4).

### Neridup Monitoring Design

Evenly dispersed across the trial area are five strategically placed dip wells and one observation bore created using class 18, 50mm PVC pipe, which house freshwater level monitor loggers as shown in (Figure 5). The loggers recorded the depth of perched water in the paddock using a time series analysis at hourly intervals.



**Figure 5. Neridup Subsurface Drainage Trial Monitoring Regime, South Coast NRM, 2024.**

Following damage caused to the dip wells by the landholder's direct seeder in 2022, the wells were shortened and buried to sit 100mm below the surface of the paddock. To assist in locating the dip wells, they were fitted with metal caps, and a metal detector was used in conjunction with georeferencing to identify the loggers during data collection.

Soil moisture content and salinity samples were recorded before seeding, and directly after harvest, each monitoring year. Three soil samples were taken from each trial plot (drained, control dry and control waterlogged), at depths of 200mm. Soil moisture content was determined as a percentage by weighing soil samples before and after a 12-hour period of baking, while soil salinity samples were used by diluting the soils with di-ionised water and taking conductivity readings (Moore, 1998). Weed and disease prevalence within the trial site was assessed by South East Agronomy Services prior to the installation of the drainage system, and at the end of each subsequent harvest.

### Dalyup Monitoring Design

Dalyup primarily focused on collecting yield results and biomass imagery through farm machinery and remote sensing. Additional data collected for the Dalyup trial included biomass imagery, drainage rate of flow and water quality samples.

## Statistical analysis and/or modelling

Project delivery partners, South Coast NRM and Stirlings to Coast Farmers Group (STCF) collaborated on the data analysis and interpretation for the EPZ and APZ trial sites. Advanced Choice Economics was contracted to conduct a benefit cost analysis (BCA) and determine a time to return on investment (ROI) for all four trial sites, and then amalgamate these findings to draw a broader conclusion on the effectiveness and profitability of subsurface drainage in alleviating waterlogging and improving crop yields.

The BCA is determined using a discounted cashflow methodology and utilises installation and maintenance costs as key data. To understand the methodologies used to complete the BCA and determine the ROI, please view Advanced Choice Economics’ final project report, in appendix A. This report directly delivers on the second objective of the project.

## Project Governance

The project was delivered by South Coast NRM, with the project team consisting of a project officer, project manager and executive guidance (Table 1).

**Table 1. Project Team for the Subsurface Drainage ROI Trial.**

Name	Role	Responsibility
Sophie Willsher	Regional Agricultural Landcare Facilitator	Lead project officer
Kylie Fletcher	Land & Water program manager	Project manager
Johanna Tomlinson	Executive Manager Operations	Executive guidance

The South Coast NRM project team was responsible for the delivery of all key project tasks, including the administration, extension, monitoring, and reporting of project activities. The team was supported by South Coast NRM’s human resources, administration, finance and communications policies and personnel.

To assist in the guidance of the project, South Coast NRM were supported by a Technical Advisory Group (TAG) consistent of local growers, technical experts, and service providers. The TAG was responsible for ensuring that the project officer delivered key activities in a way that would produce the most value for growers and advisors across the South Coast. The project team reported to the Grains Research and Development Commission (GRDC) annually on the progress of the project in the form of an annual report. GRDC were responsible for all final approvals of project reports and key communication activities, including the webpage and media materials.

## LOCATION

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	-33.733197	122.232213	Esperance
Trial Site #2	-33.744228°	121.520019°	Esperance

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)	Benefiting GRDC agro-ecological zone	
Understanding return on investment of sub-surface water management options for waterlogged areas in the Western Region	Western Region Choose an item. Choose an item.	<input type="checkbox"/> Qld Central <input type="checkbox"/> NSW NE/Qld SE <input type="checkbox"/> NSW Vic Slopes <input type="checkbox"/> Tas Grain <input type="checkbox"/> SA Midnorth-Lower Yorke Eyre <input type="checkbox"/> WA Northern <input type="checkbox"/> WA Eastern <input type="checkbox"/> WA Mallee	<input type="checkbox"/> NSW Central <input type="checkbox"/> NSW NW/Qld SW <input type="checkbox"/> Vic High Rainfall <input type="checkbox"/> SA Vic Mallee <input type="checkbox"/> SA Vic Bordertown-Wimmera <input type="checkbox"/> WA Central <input checked="" type="checkbox"/> WA Sandplain

## RESULTS

### Climate

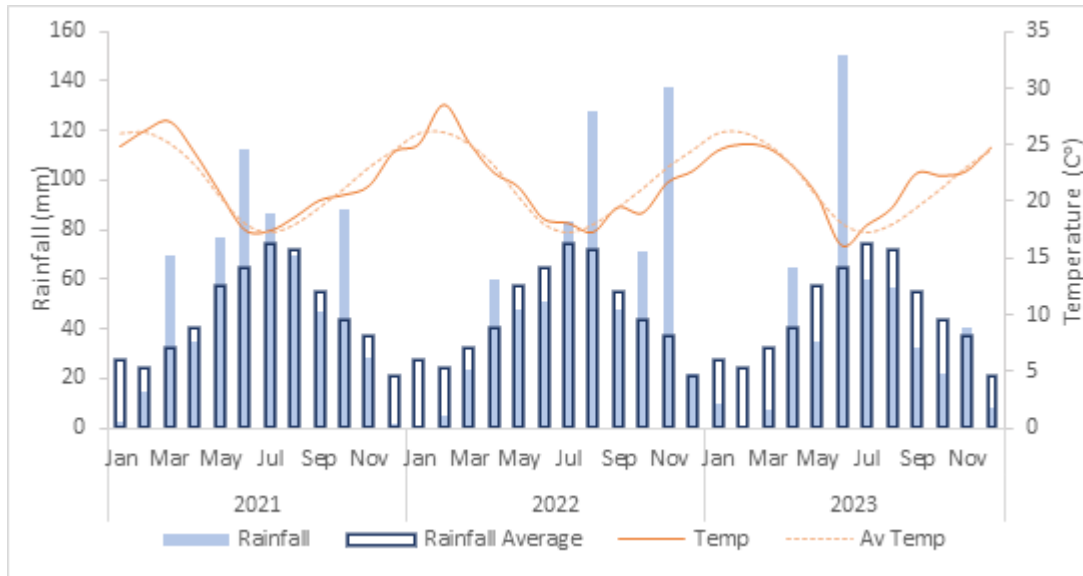
The average rainfall for the Esperance region is 621mm, with the Neridup and Dalyup catchments receiving slightly less annual rainfall on average of (~554mm and 557mm respectively) (Bureau of Meteorology, 2023).

In 2021, both Neridup and Dalyup had a decile 8-9 growing season, with Neridup's annual rainfall reaching 630.7mm and Dalyup's 573.2mm (Figure 6 and Figure 7). This increased rainfall can be largely attributed to the arrival of La Nina in late 2020, bringing increased rains across Australia (Bureau of Meteorology, 2020).

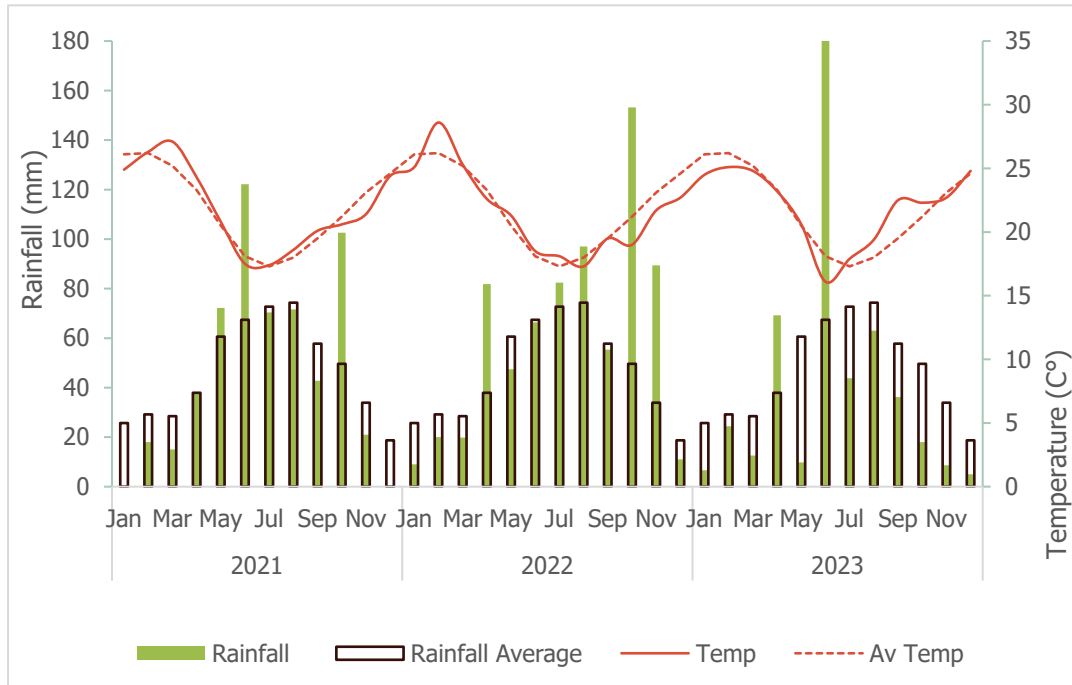
La Nina persisted into 2022, and both Neridup and Dalyup recorded decile 10 annual and growing season rainfalls, reaching 677mm and 732mm respectively (Bureau of Meteorology, 2020). An Environmental Scorecard produced by the Australian National University and Australia's Terrestrial Ecosystem Research Network (TERN) identified 2022 as the highest year of inundation across the South Coast NRM region (Walpole to Cape Arid) since the year 2000 (Australian National University, 2023).

The arrival of El Nino, coupled with a negatively charged Indian Ocean Dipole, led to drying conditions for the South Coast in 2023, decreasing Neridup's annual rainfall to 487.2mm (decile 2-3) and Dalyup's to a very below average rainfall (decile 1) to 479.4mm, more than 200mm less than the previous year (CSIRO, 2023). Although 2023 was in general, significantly drier, Neridup and Dalyup were fortunate to receive much of this rainfall during the growing season (Figure 6 and Figure 7) (Bureau of Meteorology, 2024). For both Neridup and Dalyup, the month of June 2023, retained the highest volume of rainfall of any month during the trial period, totalling 150.6mm and 182.2mm respectively.

Climate projections for WA will see the average annual temperature continue to rise, against declining winter rainfalls (Climate Services for Agriculture, 2024). The intensity of rainfall events is likely to increase, resulting from the increased water vapor held in the air as the atmosphere warms (Bureau of Meteorology, 2022). As the climate change continues to bring about increased uncertainty and variability, the need to manage water resources on farm, and maximise yield potential is increasingly critical.



**Figure 6. Monthly Climate Data for Neridup, Esperance 2021 - 2023. Sourced, Bureau of Meteorology, 2023**

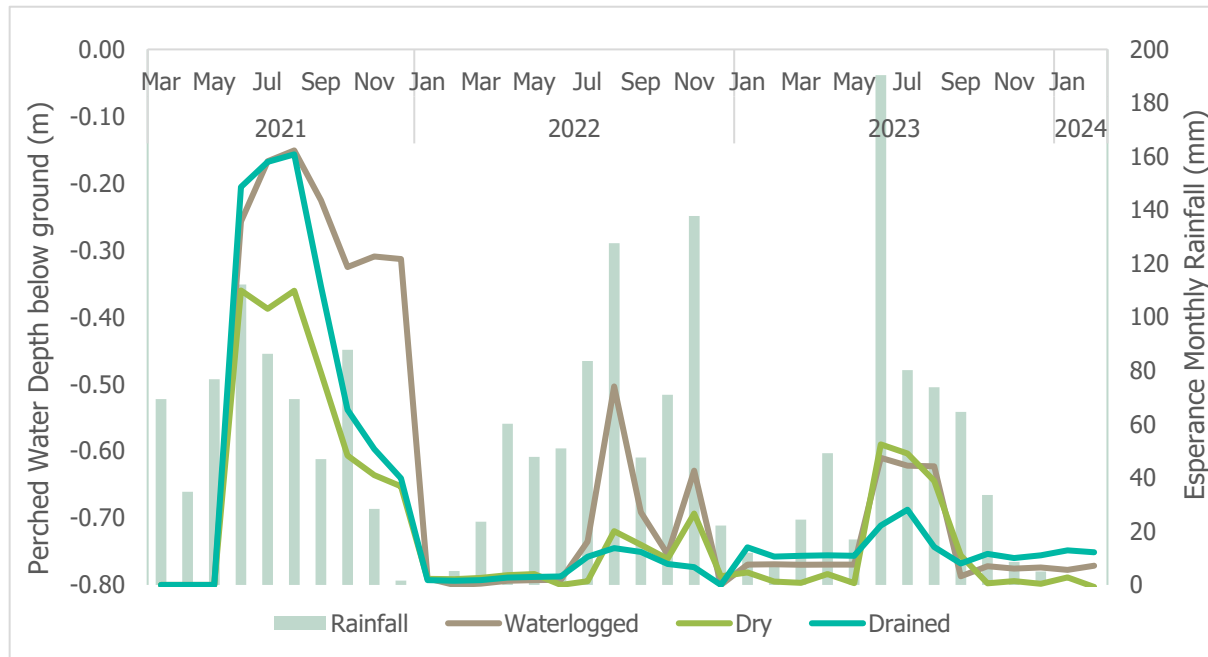


**Figure 7. Monthly Climate for Dalyup, Esperance, 2021 - 2023. Sourced, Bureau of Meteorology, 2023.**

## Waterlogging & Drainage Activity

### Neridup's Perched Water Table

Perched water levels at the Neridup trial site were significantly higher across all monitoring sites in 2021 than in 2022 and 2023, elucidating the intricate relationship between annual rainfall patterns, crop type and crop growth stages (Figure 8).



**Figure 8. Perched water levels and annual rainfall in the Neridup subsurface drainage trial site. South Coast NRM, 2024.**

2021 saw the most inundation of any year in the perched water table at Neridup (Figure 8), and the drained site responded to the early rainfall, much the same as its waterlogged control site. However, even though the drained site's perched water table rose to 10cm below the surface, it was able to remove this excess water away from the crop much faster than the equally inundated, waterlogged control site. In the subsequent years, the drains worked far better thanks to later rainfall and more mature plants, so much so that the drained site's perched water table sat at levels lower than even that of the dry control site throughout 2022 and 2023.

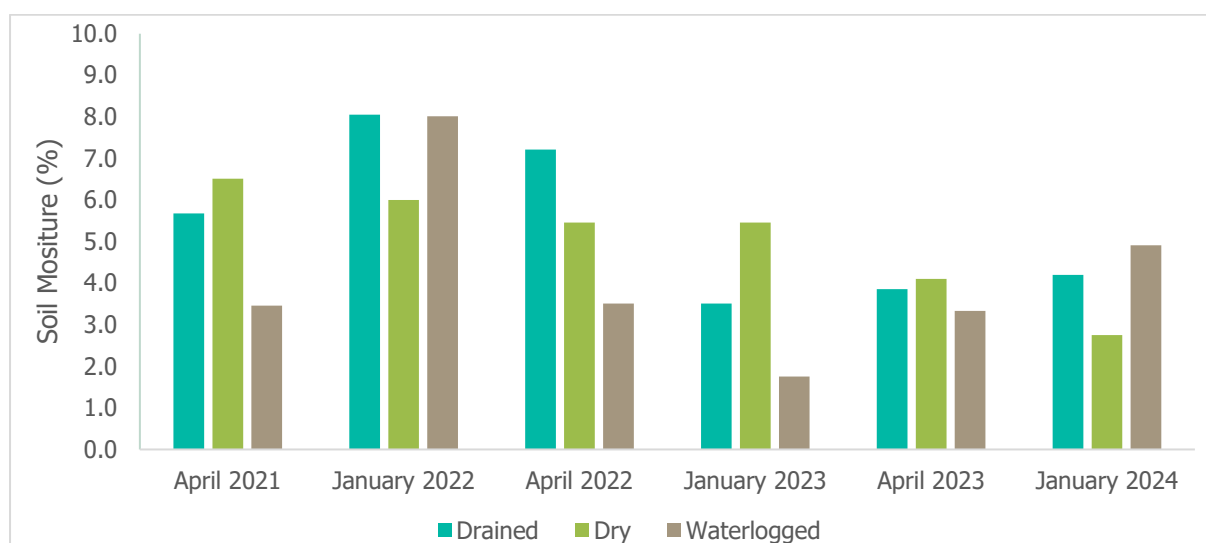
With most rain falling before seeding in 2021, all sites in Neridup saw a rise in perched water tables, with both the drained and waterlogged control site inundating soils up to 10cm below ground level. The dry control site was lower, only reaching up to 50cm below surface. Whilst the drained site was able to remove the perched water relatively quickly, the waterlogged control site maintained a perched water table at depths of 30cm below the surface all the way through to December 2022 (Figure 8).

Rainfall fell a little later in 2022, and perched water tables remained much lower than the previous year across all monitoring sites. The waterlogged control site was still responsive to high rainfalls in

later 2022, particularly in July and November, where the perched water table reached 50cm and 60cm below ground level respectively (Figure 8).

2023 had a lower annual rainfall but observed much of this rainfall between June and September. Both control sites were responsive to the increasing rainfall particularly in June, with their perched water tables sitting 65cm below ground level until August. The perched water table at these sites were quick to drain away as rainfall declined in the spring months. The drained site had a consistent marginal perched water table between 75 - 80cm below ground level across the whole year of 2023.

### Neridup's Soil Moisture



**Figure 9. Soil moisture content at pre-seeding and post-harvest in the Neridup subsurface drainage trial site. South Coast NRM 2024.**

Soil moisture content of the Neridup trial sites at pre-seeding and post-harvest, support the perched water table data observed above. The persistent perched water table throughout 2021 in the drained and waterlogged control sites are evident by January 2022, where soil moisture levels peaked at 8% (Figure 9). The significant decline in perched water levels after 2021 are reflected by soil moisture levels in both control sites, at pre-seeding 2022, although the drainage site remains relatively high. The soil moisture pattern of the Neridup trial site follows the annual rainfall patterns experienced by the paddock and declines from 2021 to 2023 across all monitoring sites, as the climate dries.

In each year the waterlogged control site had the lowest soil moisture content prior to seeding (Figure 9). This likely is exhibiting the impacts of increased weed presence in this area, where weeds are accessing any excess soil moisture, particularly over summer periods where crop competition is absent. The presence of weeds is encouraged by poor crop survival because of continued waterlogged conditions in this part of the paddock.

Soil salinity was also measured throughout the trial and remained under 100 ECe mS/m across also sites within the Neridup trial, which is well below the 200 ECe mS/m threshold for sand to clayey sand soils that characterise Neridup (Moore, 1998).

## The performance of subsurface drainage

The drains were able to effectively remove perched water at rates  $\sim 0.3 - 0.4\text{m/s}$  during high rainfall events (between 20 – 40mm). On some sample occasions, no flow was observed, as a result of flooding of the exit points of the drains. At Dalyup, the backlogging of discharged water at the exit of the pipe, forced the excess water back up through the pipe's perforations, pushing the surrounding sandy soils away from the drain and causing some localized erosion (Figure 10). This was not observed at the Neridup site, despite the Neridup exit point being flooded on multiple occasions. Further investigation into the use of limestone aggregate over perforated sock may point to this difference.

Anecdotally, the excess water sitting in the end point of the Dalyup drain was exposed to sunlight and led to some algal growth. Whilst growth was minimal, and assumed to be limited to the end points of the drain that were exposed to sunlight, the threat of algal blockages in subsurface drainage has been observed in other studies and represents a potential maintenance cost. Nutrients play an important role in the likelihood of algal growth in drainage systems, and this is explored in greater detail in the water quality investigations conducted by the TAG which are detailed in appendix B.

Ensuring that discharged perched water is moved away from the end point of the drains effectively, by use of other surface water management techniques is important in preventing localized erosion, and the likelihood of algal growth.



**Figure 10. Localised erosion of the subsoil from the Dalyup subsurface drainage system. South Coast NRM 2024.**

## Water Quality

Following the commencement of the trial in 2021, the Esperance TAG saw a critical gap in knowledge pertaining to the relationship between water quality and varying water management techniques on farms. Particularly, the TAG sought to understand whether water discharged from the subsurface drainage system was of improved quality to that of surface water travelling across the paddock as runoff.

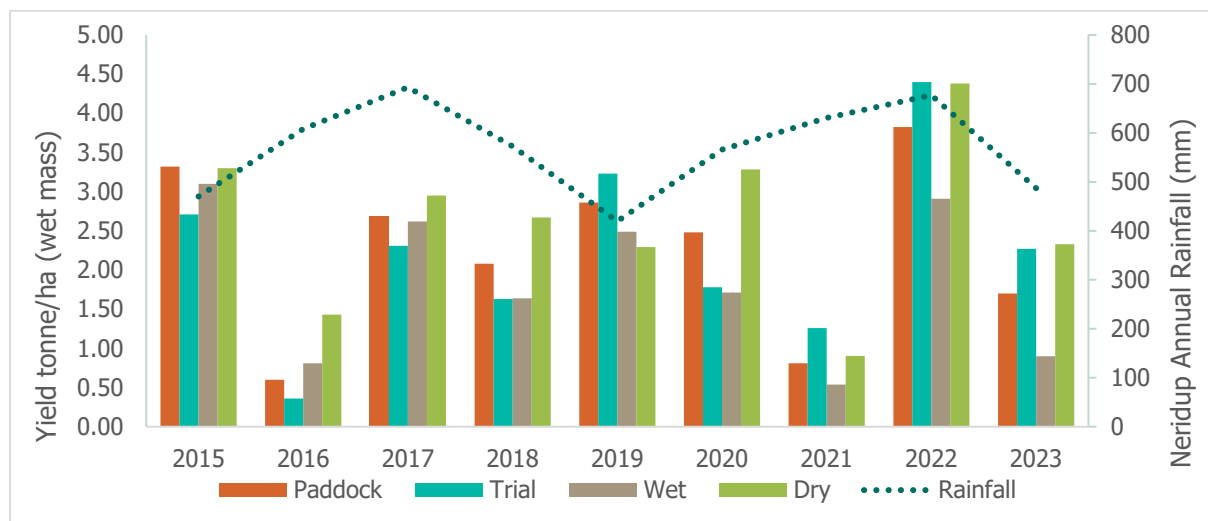
The intended outcomes of this research may inform management decisions around using surplus water on farm, such as for livestock or spray water, but also to inform on the potential on and offsite environmental impacts of discharged water into native vegetation, riparian systems, or natural waterways. For the full methods and results of this analysis, please refer to Appendix B.

## Yield

Esperance growers experienced two record-breaking harvests in 2021 and 2022, with total crop production for the Shire in 2022 exceeding of 4.2 million tonnes (Grain Industry Association of Western Australia, 2023). However, these yields were not sustained in 2023 and Esperance growers, much like the rest of WA, felt the impacts of the much lower rainfalls. The total grain production in the 2023 Season in Western Australia of 14.5 million tonnes was nearly 50 per cent lower than the record years of 2022 and 2021 (Grain Industry Association of Western Australia, 2024).

Although the 2023 season was starkly different to the prior years, the results observed across the EPZ showed extremely positive yield benefits due to the drains in all years, and crop types. Yield improvements observed ranged from 1.13-1.49t/ha for wheat, 1.36t/ha for barley and 0.07-0.72t/ha for canola (Petersen, 2024).

## Neridup



**Figure 11. Yield data from the Neridup Subsurface Drainage trial site from 2015 - 2023. South Coast NRM, 2024.**

In the year following the installation of the drains, the Neridup site saw a yield benefit from the drains of 56% above the paddock average. Even greater were the benefits from the waterlogged control site, which yielded a 0.54t/ha average, whilst the drained site averaged 1.26t/ha (Figure 11).

In 2022, growing wheat, the drained site yielded an average of 4.4 t/ha, nearly double that of the control waterlogged site, which averaged 2.8 t/ha. This return is also slightly improved from the control dry site which yielded 4.0 t/ha (Figure 11).

In 2023, growing barley, the Neridup site as a whole saw far lower yields, but still observed impressive benefits from the drained site of 0.5t/ha greater than the paddock average, and a 1.37t/ha improvement from the waterlogged, undrained control (Figure 11).

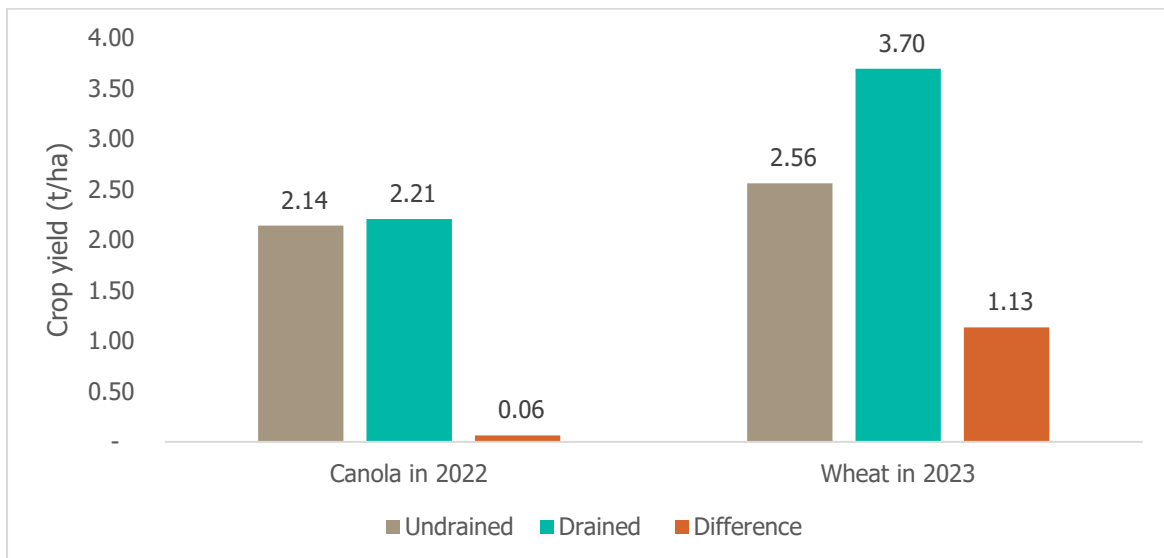
On average, before the drain was installed, the site where subsurface drainage was installed yielded 8% lower than the waterlogged control and 26% lower than the dry control. After the drain was installed, this site performed 112% better than the waterlogged control and 12% better than the dry control. Further, the *Benefit Cost Analysis of Subsurface Drains for Managing on Farm Waterlogging*

in the *Esperance Port Zone* report, produced by Advanced Choice Economics for this project estimates that the drained site yielded 35% higher than the paddock average throughout the trial. The full report can be read in appendix A.

### Dalyup

Dalyup grew canola in 2022, and wheat in 2023. Crop yields were higher for the drained site compared with the undrained area of the trial in both years (Figure 12). The 2022 canola yields in the drained area were slightly higher than in the undrained area, with an average yield of 2.21t/ha in the drained site compared to 2.14t/ha in the undrained.

The following year, wheat yields increased by 44% within the drained area, and overall, yields were significantly higher than the previous year. This is consistent with the performance of the canola and wheat crops observed in the Neridup trial in the same years.



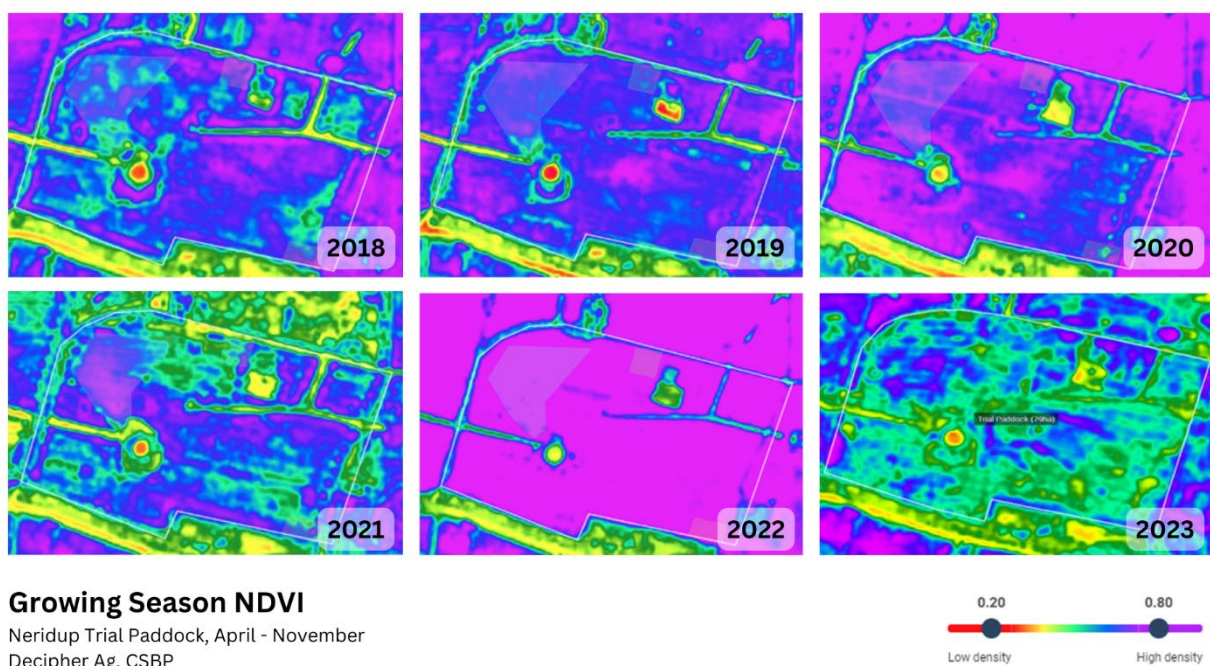
**Figure 12. Yield data from the Dalyup Subsurface Drainage trial site in 2022 and 2023. Advanced Choice Economics, 2023.**

### Crop Extent & Vigour

Crop extent and vigour can be measured in remote sensing, using the Normalised Difference Vegetation Index (NDVI). NDVI is a measure of the difference between the visible light absorbed by plants, and the solar energy they reflect, which is used to determine the density and condition of vegetation (Bureau of Meteorology , 2024 ). The NDVI scale ranges from -1 to +1, where -1 indicates complete absence of vegetation (such as a car park), and +1 indicates dense vegetation (GISGeography, 2024). Understanding the NDVI of the trial paddocks throughout the growing season (April through to November) can help understand the health and abundance of the crop and is used to validate the results of the perched water table, yields, and weed and disease presence in this project.

In general, the presence of subsurface drainage does appear to improve the extent and vigour of crops in the drainage zone of influence across both Neridup and Dalyup, which is observed through positive NDVI's in the drainage zone of influence. This project utilised CSBP's Decipher Ag platform to view NDVI, which classifies standard plant density from a scale of 0.2 as low density to 0.8 as high density.

This is particularly evident for Neridup (Figure 13) where NDVI improves from mid density (0.4) to higher density (0.8) in 2021 directly following the install of the drains. The waterlogged control site consistently has the lowest NDVI, save for in 2022, where the whole trial paddock overall had a very high NDVI (Figure 13). The NDVI is supportive of the Neridup yield results and particularly the difference between the drained and waterlogged control sites.

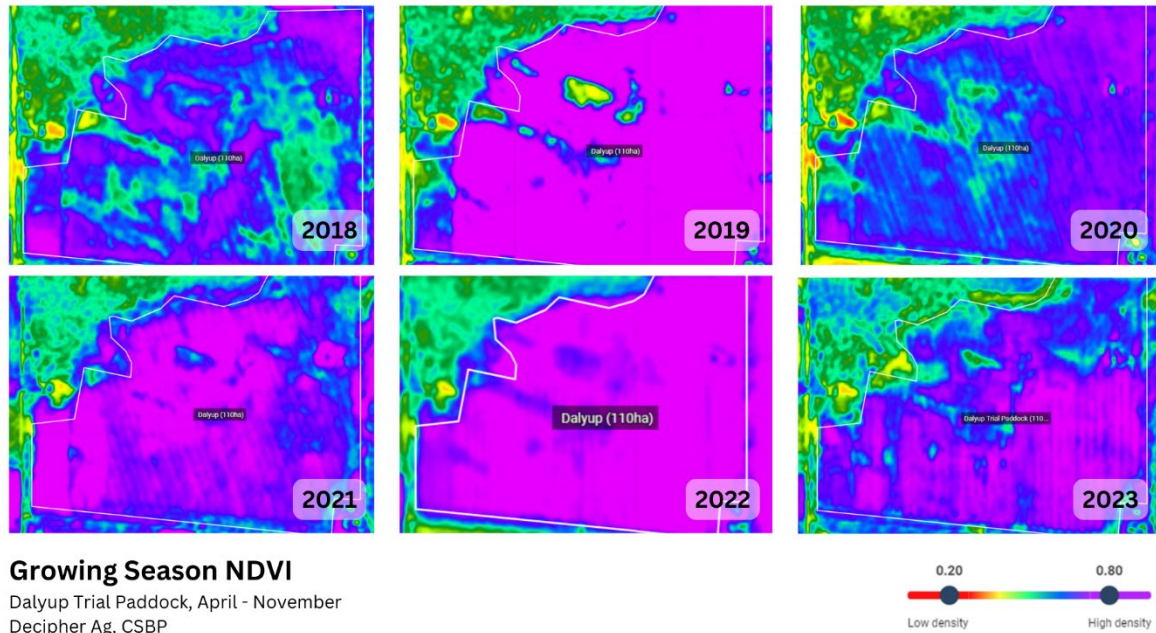


**Figure 13. Normalised Difference Vegetation Index for the Neridup Subsurface Drainage trial site. Sourced: Decipher, CSBP 2024.**

The Dalyup trial had high NDVIs between 0.6 – 0.8 across the paddock for most years, except in 2018 and 2020 (Figure 14). The impact of the drains is evident in 2023, where the NDVI drops off at the edge of the drain's zones of influence, to the northern end of the paddock (Figure 14).

The type of plant cannot be determined through the NDVI assessment, and it is possible that high NDVI but low yields in the waterlogged, undrained sites of Neridup and Dalyup are a result of higher weed presence in these areas. This supports that the low soil moisture content of the waterlogged

control site at Neridup during the post-harvest to pre-seeding period could be a result of increased weed presence during times of low competition.

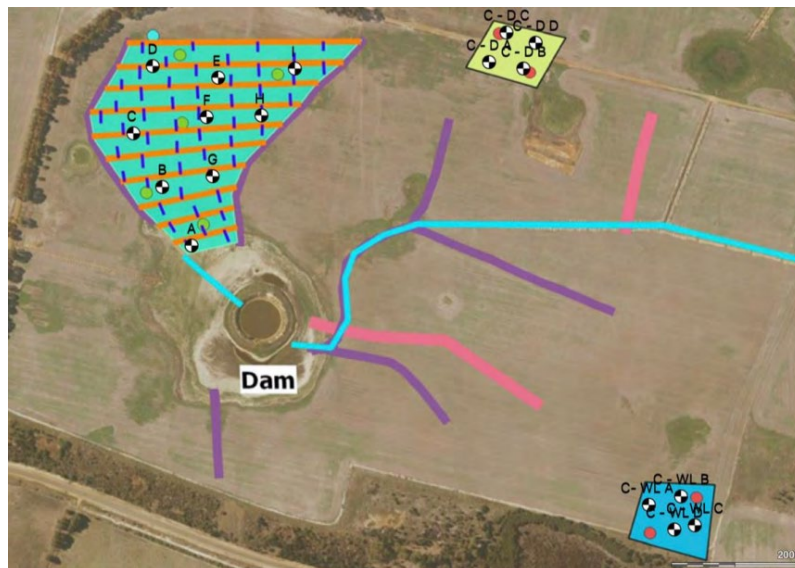


**Figure 14. Normalised Difference Vegetation Index for the Dalyup Subsurface Drainage trial site. Sourced: Decipher, CSBP 2024.**

### Weed & Disease

Weed assessments are an effective tool in evaluating the effect of waterlogging on broadacre crops where excess water causes abiotic stress on crops, inhibiting healthy growth patterns and therefore give opportunity for weeds to thrive in the absence of competition from crops.

Weed and disease assessments were conducted at the Neridup trial site each year post harvest, by South East Agronomy Services. Nine random sample sites within the drained area were observed for weed presence, including species and density, along with four sample sites in each control zone (Figure 15).



**Figure 15. Weed and disease monitoring regime at the Neridup Subsurface Drainage trial site. South East Agronomy Services, 2021.**

Over the three monitoring years, the waterlogged control site consistently saw greater weed burden than that of the drained or control dry site. In the third year of monitoring, the positive effects of the drains showed solid stubble in conjunction with a lack of weed burden in the drained site, which was not observed in the control dry site. The root disease results provided have given no conclusive evidence as to any differences in root disease activity between the drained site and controlled sites.

Due to the timing of the assessment, summer sprays reduced the presence of weeds across the paddock as a whole, but the influence of waterlogging in promoting weed and diseases was still observed. The full results of the weed and disease assessments for each year of the trial are included as Appendix C.

## Cost Benefit Analysis and Return on Investment

The cost benefit analysis (CBA) and return on investment of the Dalyup and Neridup subsurface drainage systems is explored in detail in the *Benefit Cost Analysis of Subsurface Drains for Managing on Farm Waterlogging in the Esperance Port Zone* report, produced by Advanced Choice Economics (appendix A).

With their highly variable designs, the Neridup and Dalyup sites installation costs varied significantly. While the Dalyup drainage system was more expensive in total, as a result of the purchase of a Soil Max machine and the relevant equipment, it was cheaper on a per unit length and area basis, primarily due to lessened labour and transport costs (Petersen, 2024). The total costs and cost per unit area is summarised in Table 1 below and further explored in Advanced Choice Economics full economic analysis (appendix A).

**Table 2. Installation costs of the Dalyup & Neridup Subsurface Drainage trial sites. Advanced Choice Economics 2024**

Site	Total cost (\$, ex. GST)	Cost per unit area (\$/ha, ex. GST)
Dalyup	167,437	2,990
Neridup	41,500	5,188

The return on investment of subsurface drainage from the Dalyup & Neridup trial is estimated between 9 – 12 years, a little longer than the 3 – 5 years assumed by survey respondents at the beginning of the trial. Further, subsurface drainage appears to be robust against a range of future scenarios and is expected to provide positive internal rates of return to growers between 12 – 16% (Petersen, 2024).

The cost benefit analysis for the Albany Port Zone trial sites, led by Stirlings to Coast Farmers Group also suggests that sub-surface drains are likely to be a cost-effective way for growers to manage soils that are susceptible to waterlogging in farming systems of the APZ. A summary of the CBA and ROI are provided by Stirlings to Coast Farmers Group’s final technical report.

A final executive summary examining the economic outputs of all four trial sites across the APZ and EPZ has also been provided by Advanced Choice Economics. This analysis determines that the net present value of the trial drains ranged between \$1,900 - \$10,200/ha for the four sites, with a return on investment between 31 - 460% and an internal rate of return of 12-110% (Petersen, 2024).

The time to break-even is estimated to be between 2 and 12 years, higher profitability is associated with a greater zone of impact compared to the drained area, greater crop yield responses to the drain and minimising installation costs (Petersen, 2024). This executive summary is attached as Appendix F.

## Stakeholder Engagement

South Coast NRM delivered 88 specific communication and engagement activities, and directly engaged with over 50 farming enterprises and over 20 advisors and technical experts from across the South Coast. The project has maximised opportunities to communicate to stakeholders, which has resulted in considerable interest across the region. Many growers across the EPZ are now directly considering or planning for the installation of subsurface drainage on their own farms, as a result of engagement. The confidence of South Coast growers in subsurface drainage, without the final economic analysis being publicised is testament to the timely, and locally led way that this project has been implemented.

Key successes of the projects communications and engagements are listed below. The full list of engagements is attached in Appendix D.

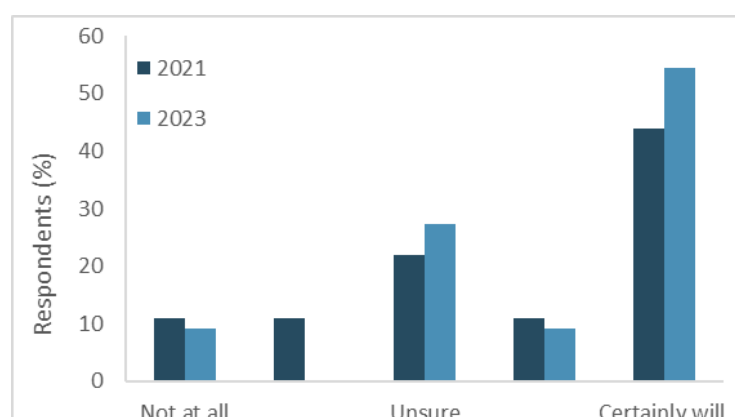
- Hosting three field days throughout the project,
  1. **February 2021:** The Neridup installation day, delivered with subsurface drainage provider Surface Water Management, receiving over 30 attendees.
  2. **March 2023:** The Dalyup installation demo day, hosted in partnership with Farm-Xport and Soil Max, from California, USA. 45 - 50 growers and industry representatives attended.
  3. **August 2023:** The Neridup “Brekky in the Paddock,” field day with trial economist, Advanced Choice Economics presenting the preliminary return on investment, where over 40 growers and industry representatives attended.

- Through GRDC, producing a drainage installation video and podcast with Anvil Media which were released in June 2023. The video has received over 1000 views directly on YouTube.
- Through the Esperance TAG, filming a grower focused video with Rosie Henderson, an Esperance based videographer, that has had over 250 views in its first month of launching. This video focused on showcasing the landholders personal experience of subsurface drainage.
- Presenting a poster on the project at the National NRM Knowledge Conference hosted by NRM Regions Australia, between the 31st of October and 2nd of November 2022, viewed by the 400+ in attendance. The focus on this poster was to explore the intrinsic link between agriculture and natural resource management.
- Developing a Subsurface Drainage Guide Booklet, that details all the critical considerations for installing subsurface drainage. The booklet can be accessed via [demo day booklet](#).
- Supporting relevant projects across Australia including,
  1. The Gillamii Centre's project investigating maximising water harvest potential through the principles of subsurface drainage in low rainfall areas.
  2. Supporting another investment by GRDC into mapping the risk of waterlogging across Australia led by AgVic and the University of Tasmania.

## Knowledge Change Survey

The pre and post event surveys aimed to understand how growers' knowledge changed throughout the trial, as a result of extension and engagement activities. Both surveys were circulated directly following community field days and received low response rates. Of the 22 respondents, only two respondents had completed both the pre and post survey, and as a result, quantifying the degree of knowledge change over time is a challenge due to inconsistent sample pools.

Responses reflect that growers have gained a more realistic picture of subsurface drainage, with a greater understanding of the profitability and difficulty to install demonstrated. The perceived benefits of subsurface drainage have been consistent from the beginning to the end of the trial, with survey results showing that most respondents were certain to install subsurface drainage on farm (Figure 16). This shows that subsurface drainage is widely regarded as a highly effective tool, and growers are confident to invest in this management tool. For the full survey report, please see Appendix E.



**Figure 16. Respondents' likelihood to install subsurface drainage assuming a positive payback period in 2021 and 2023. South Coast NRM 2024**

## DISCUSSION OF RESULTS

The result of this trial clearly demonstrates that subsurface drainage is effective in removing perched water away from the root zone, alleviating waterlogging conditions and improving crop yields. The results strongly infer that there is an intrinsic link between drainage performance, and the annual rainfall patterns and crop type and growth stages.

### The Influence of Crop Type and Growth Stage

#### Canola

Canola was sown in 2021 at the Neridup trial site. This crop is highly susceptible to waterlogging, in part as a result of its limited water uptake capacity (Schillinger & Paulitz, 2018). Early rainfall in 2021, inundated the subsoil during crop establishment (March through to June). At this time, temperatures were relatively warm (varying between 17.5°C to 24°C between April and July) encouraging the growing plants to have high metabolic activity and therefore require lots of oxygen (Moore, 1998). As the perched water table rose, the seedlings oxygen supply was limited to the top 10cm of soil (Figure 8). The increased inundation, paired with the seedling's high metabolic needs and limited ability to uptake excess water, may have contributed to anaerobic conditions in the subsoil between April and July 2021. Without the support of the plants to take up excess water, the drains struggled to remove the significant water load in the subsoil until rainfall started to decline in July 2021.

The waterlogged control site experienced the same inundation during early crop growth stage, but without the support of the drains, failed to remove the excess water via plant uptake and led to a persistent perched water table for the remainder of the year. This translated to significant yield improvements for the canola plants in the drainage zone of influence, yielding 141% higher compared to the undrained site (Petersen, 2024).

Dalyup's canola harvest further demonstrates the significant influence of the annual rainfall x crop growth stage relationship when it grew canola in 2022. 2022 saw some pre-seeding rainfall but received the bulk of its annual rainfall after July. This later rainfall allowed the canola plants to mature and increase their water uptake capacity before being inundated, unlike Neridup's canola in 2021. Additionally, cooler winter temperatures suppressed the plants metabolic activity, reducing their oxygen needs as the rainfall entered the subsoil (Moore, 1998). As a result, canola under drained conditions at Dalyup saw a 26% yield improvement compared to undrained conditions, an impressive yield benefit although a much smaller margin compared to Neridup.

#### Wheat

Wheat was sown in 2022 at Neridup, which is a far more tolerant crop to waterlogging. Wheat both has a greater capacity for water uptake, and particular waterlogging adaptations that allow it to access oxygen in anaerobic environments (Schillinger & Paulitz, 2018) (Moore, 1998). The development of aerenchyma in the wheat plants, provides a "continuous gas-filled channel where oxygen can diffuse from the base of the stem to the root tip" that ensures that wheat plants can supplement aeration in waterlogged soils (Moore, 1998).

With the later July rainfall, the wheat plants were able to make greater use of the perched water table and allowed the drainage system to transmit perched water more effectively during periods of high rainfall. For Neridup, this reduced the severity of waterlogging across the paddock as a whole but increased the aerobic conditions of the subsoil in the drainage zone of influence from 10cm in the previous year to over 50cm during the growing season (Figure 8). Wheat's tolerance to waterlogging produced a 109% improvement from the waterlogged yields, totalling 4.4t/ha in the drainage zone of influence (Petersen, 2024).

Dalyup grew wheat in 2023, and although observed positive yield improvements of 44% from the undrained conditions, likely suffered from the lower performing harvest felt by much of the state. It is possible that the performance of wheat observed at Neridup the previous year wasn't demonstrated at Dalyup due to a lack of rainfall overall.

## Barley

Barley was only grown once during this trial in 2023 at Neridup. This crop has been observed to develop aerenchyma like wheat in wild barley types but is widely regarded as a highly susceptible crop to waterlogging (Manik, Zhao, Johnson, & Zhou, 2022). 2023 was a lower decile year both in annual and growing season rainfall and the presence and severity of waterlogging was far less overall. So much so, that Neridup and Dalyup saw much lower yields across the trial paddocks in general. Despite this, Neridup still observed a yield improvement of 109% for barley under drained conditions.

## The profitability of Subsurface Drainage

The Neridup and Dalyup subsurface drainage systems produced significant yield improvements for crops growing under drained conditions compared to crops in waterlogged, undrained conditions. Impressively, at Neridup, the drainage site even produced greater yields than the non-waterlogged control site and the paddock average, showing that subsurface drainage can access unrealized yield potentials in areas that are not necessarily affected by waterlogging.

Results of the yield improvements across all monitoring years suggest that the optimal performance of subsurface drainage is not realised until rainfall reaches higher-than-average deciles (between 8 – 10). Yield improvements were still observed in 2023 despite significantly lower decile annual rainfall but didn't produce the greater than 100% yield increase from the waterlogged baseline that was observed in 2021 and 2022. As discussed above, greater understanding of crop types and the annual rainfall and crop growth stage relationship could provide further insight into accessing the optimal performance of this waterlogging management tool.

The lower decile year does indicate that subsurface drainage can still provide positive benefits to the farm in drier years. This addresses an important concern from growers, that during dry periods the drains may move perched water away from the crop too quickly and further exacerbate drought conditions, and lead to yield penalties. With other projects across the South Coast applying subsurface drainage in low rainfall areas to increase water harvesting potentials, this concern is important, but not necessarily supported by this project's findings.

Although the ROI was not as short as originally anticipated, the minimal maintenance costs and the lengthy lifetime of the drains (assumed at 20 years for analysis although this could exceed 30 years) means the drains will likely break even within half of their lifetime. Additionally, this management

tool was determined to be robust against a range of future scenarios, meaning that subsurface drainage can be viewed as a relatively safe, and effective tool for a range of farming systems and against an uncertain future.

Installation costs and future grain prices are considered the greatest influencers on the economic benefits of the drains even when yields are lower, and as demonstrated through this project, installation costs can vary drastically. The approach taken by Dalyup, for the landholder to purchase their own machinery and install the drainage system themselves was cheaper on a per hectare basis, largely because they could do as much area as desired once the machine was purchased.

Regardless of the approach, thorough planning and engagement with trusted advisors is critical to the effectiveness and overall profitability of this management tool. Although Neridup was more expensive on a per hectare basis, this system was designed and installed by a technical expert, and Neridup did receive the greatest benefits in terms of yield overall. This is an observation, that requires further research, and greater appreciation to all the nuances between these sites should be given.

## The benefits of a grower led approach

The design of this project as a grower-led, demonstration trial has enabled growers across a variety of climates and cropping systems in the EPZ and beyond to engage with this trial. The role of the grower led TAG meant that outcomes of this project were relevant to local growers and the results of this trial could be easily translated to individuals own farming systems.

The communications and engagement from South Coast NRM with support from the TAG and GRDC have been positive in driving local, national and international recognition of the project and has promoted the leading work of South Coast NRM, GRDC and growers across the South Coast in the waterlogging space. At a project level, the results of the survey indicate that the project successfully delivered on its key outcome to increase the knowledge and understanding of subsurface drainage as a tool to alleviating waterlogging for growers and advisors.

At the conclusion of this project, there is much anecdotal evidence from South Coast NRM, the TAG, GRDC and partners that many growers within the EPZ are engaged with experts and are actively planning their subsurface drainage systems. This is an important success for the project, as the cost benefit analysis and return on investment figures have not been determined prior to this report. Peer to peer extension has led to greater confidence in this management tool and the ongoing adoption of this practise.

## CONCLUSION

The Subsurface Drainage Return on Investment trial has provided foundational knowledge and understanding for South Coast growers affected by waterlogging, of the effectiveness of subsurface drainage in alleviating waterlogged soils in their landscapes. Extension and engagement of the project has led to greater confidence in subsurface drainage as a tool to alleviate waterlogging and has driven early adoption across the EPZ.

The project aimed to increase the knowledge of 45% of growers (or 15 individual farms) affected by waterlogging in the region, and successfully engaged with over 50 individual farming enterprises. Although this target was limited by its assumptions, this reach reflects the immense success of the project, and the widespread engagement it has achieved.

Whilst a key deliverable, the cost benefit analysis and return on investment did not appear to be a critical factor in whether or not a grower might consider this management tool for their farming system. The survey, and anecdotal evidence demonstrate that this tool already has widespread engagement and adoption across the EPZ. The established return on investment and cost benefit analysis of the Dalyup and Neridup trials will support growers and advisors to make informed decisions on the design and implementation of this tool.

The three-year trial ran over an extraordinary few years in terms of climate and harvest records for the South Coast region. The drains continuously performed well under all rainfall conditions and resulted in considerable yield improvements. The variability between trial years elucidates the central influence of the relationship between annual rainfall patterns and crop type and growth stages on the drain's performance, and yield improvements overall.

The performance of this management tool in high rainfall decile years was impressive, but observations in lower decile years, along with surrounding studies being conducted in low rainfall areas suggests this tool could play a role in both waterlogging and drought conditions. Further investigating the role of subsurface drainage across a range of climates may help support farming systems in becoming more resilient to a changing climate.

The project recognised that a key limitation to the results of this trial was the highly nuanced nature of subsurface drainage. This management tool is highly dependent on environmental factors, including soil type and elevation, as well as the now observed rainfall and crop type dynamic. In addition, the profitability of this tool is determined by the costs of installation, which also can be highly variable. As a result, the findings and conclusions of this report are highly specific to the Neridup and Dalyup trial sites. Growers and advisors using information within this report to inform their surface water management decisions should use this information as generalized only and consider their own circumstances before implementing subsurface drainage on farm.

This project was delivered at a pivotal time for broadacre agriculture and provides industry with important insights into the opportunities with respect to subsurface drainage in a broadacre agricultural setting in areas where waterlogging is impacting on yield and profitability. The project partners are confident that the data generated from the project provides sound information to support application on farm for further assessment of the opportunity and integration into the farming systems.

## IMPLICATIONS

The momentum and engagement realised throughout this trial indicates that subsurface drainage will only increase in prevalence for growers in the South Coast, and across Australia who are impacted by waterlogging. Related work supported by South Coast NRM is exploring the role of subsurface drainage in drought conditions and how subsurface drainage can contribute to a resilient grains industry across the South Coast region.

Extension of this trial has already facilitated new thinking on best practise surface water management on farm. Consideration of the surface water management landscape is reinforcing the understanding that drainage tools, including subsurface drainage, are highly intuitive to the area and must be designed with careful consideration to the specific area. More so, continued messaging around the integration of multiple surface water management tools to maximise resource efficiencies will support the development of a sustainable, enduring surface water management landscape in broadacre agriculture.

The growing interest of farmers in surface water management and subsurface drainage will require increased provision of trusted advisors, that can support the planning, design and implementation of drainage systems under best practice principles. Cohesive industry effort to provide this expertise should be prioritised, so that broadscale adoption of this technique can be supported with appropriate advice to ensure long term sustainability.

## RECOMMENDATIONS

Several recommendations are drawn from the findings of this project, that will support the interests of the growers, advisors, technical experts and relevant bodies who have engaged with this project.

- **Testing the performance of subsurface drainage across a greater range of farming systems.** This will test the findings of this report and provide validity to the results observed, including the economic analysis.
- **Extending the scope of future trials to consider the end use of drained water.** Particularly, how this water might be used on farm for spray or stock water, and what are the efficiencies and cost savings associated with this activity. Additionally, this would tie in with the work of others in determining the role of subsurface drainage in increasing water harvesting capacity on farm for low rainfall areas.
- **Greater research into the crop type and rainfall relationship to maximise the efficacy of subsurface drainage.** Particularly, from these results, understanding how to build drainage systems to support early inundation as observed in 2021.
- **Cohesive industry effort** to promote surface water management and subsurface drainage as a viable career choice for early professionals and tertiary students to meet the demands of the industry for trusted advisors and expertise going forward.

## APPENDICES

The list of supporting appendices below are attached to this final technical report.

Appendix A: Benefit Cost Analysis of sub-surface drains for managing on farm waterlogging, produced by Liz Petersen, Advanced Choice Economics.

Appendix B: Water Quality and Surface Water Management Techniques Background Paper, produced by Sophie Willsher, South Coast NRM.

Appendix C: Weed and Disease Assessments for the Neridup trial site, produced by Luke Marquis, South East Agronomy Services.

Appendix D: Communications & Engagement Register, South Coast NRM

Appendix E: Growers perceptions of Waterlogging & Subsurface Drainage Survey Report, produced by South Coast

Appendix F: Executive Summary of Findings: Benefit cost analysis of sub-surface drains for managing on-farm waterlogging in the Albany and Esperance Port Zones, produced by Liz Petersen, Advanced Choice Economics.

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