The Evolution of Water Control in modern farming systems:

A Case Study of D & S Turner, Brookton, WA

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Introduction

Darrell and Suzanne Turner's W.I.S.A.L.T.S. journey began after Darrell's father David became a firm believer of the W.I.S.A.L.T.S. method. Their family's first introduction to Harry Whittington's work was in early 1970's when Harry established a bank from one of their waterholes to the Aldersyde-Kweda road. They witnessed the bank running water and to this day it still does.

It was in the mid 1980's that the first test of major renovations began, Tom Mills (W.I.S.A.L.T.S. Quairading) came and surveyed an 8km bank. This bank was constructed as a double push dozer bank which had a good result initially, this confirmed to Darrell and his father that they were on the right track. However, over time the clay broke down and the bank began to leak in the sandy areas, which created other problems. To counter this problem, W.I.S.A.L.T.S. decided to test whether lining the sand seams with a plastic barrier would stop the leak.

The majority of work began in the mid 1990's with the installation of banks and plastic in the deeper sand areas. This method proved more effective than the traditional double push method, however, there were still some issues with water moving around the edges of plastic. By the late 1990's after a W.I.S.A.L.T.S. discussion with Harry and Laurie Adamson (W.I.S.A.L.T.S. Quairading) it was decided that plastic should be used in all the banks as it gave a more effective and durable seal. At this time Darrell began working with Noel Powell, purchasing a shared excavator to make this labour-intensive job more efficient. From 1998 – 2005 Darrell and Noel worked together to install many kilometres of plastic lined banks on their farms and properties throughout the district.

Recently Darrell has begun filling in the banks and leaving the plastic lining. This has allowed machinery to operate over the plastic barriers and the paddocks could be worked as normal without the obstacle of the banks.

The results from installing Interceptor Barriers (plastic lined trench with-out a surface bank) gave a significant reduction in waterlogged areas and a more even distribution of water over the landscape. It stopped the water accumulating in seepage areas (sand plain seeps) and retained the water higher in the landscape for the crop to use. The recent filling in of banks has also eliminated weed problems caused by the banks.

The plastic lined method has also helped to stem water flow from neighbour's properties (see case study 1). This has allowed areas to remain productive and prevent or slow the spread of salinity.

Darrell's rational for installing Interceptor Barriers are driven by increases in productivity with environmental benefits as a bonus.

The vision for the future is a continuation of installing plastic barriers starting at the top of the hill and a program to fill in the old banks to take advantage of GPS technologies and weed control. With knife points, stubble retention and 100% cropping there is no longer a need to manage surface water flow.

Farming Enterprise

Darrell and Suzanne's farm is located 35km east of Brookton near Aldersyde (see below map). It has an average annual rainfall of 400mm with 300mm falling during the growing season.

They farm consists of approximately 6000Ha of owned and leased land with an enterprise mix of approximately 4000Ha of Wheat and barley, 1000Ha of Lupins and 500Ha of both Canola and Hay.

Darrell has always had an interest in soil health and has maintained a regular liming program along with being an early adopter of no-till seeding. The farm has been continuously cropped since 1996.

Figure 1: Showing approximate location of Darrell and Suzanne's farm.

Figure 2: Aerial Photo of farm facing south.

Soils classification

The soils on the farm are typical of the area. The farm predominantly consists of sandy surfaced duplex soils with varying depth to clay or gravel. There are also clay river flats and shallow duplex soils associated with the valley floor and the Avon river flood plain. The soils in the district are characterised by the Department of Primary Industries and Regional Development (DPIRD) as being in the Ancient drainage system with the sandplain soils described as aeolion sandplain of the Kweda district (Kweda 259Ke – Bulletin 4807). See below figure 3 which identifies the different soils of the region, map courtesy of DPIRD.

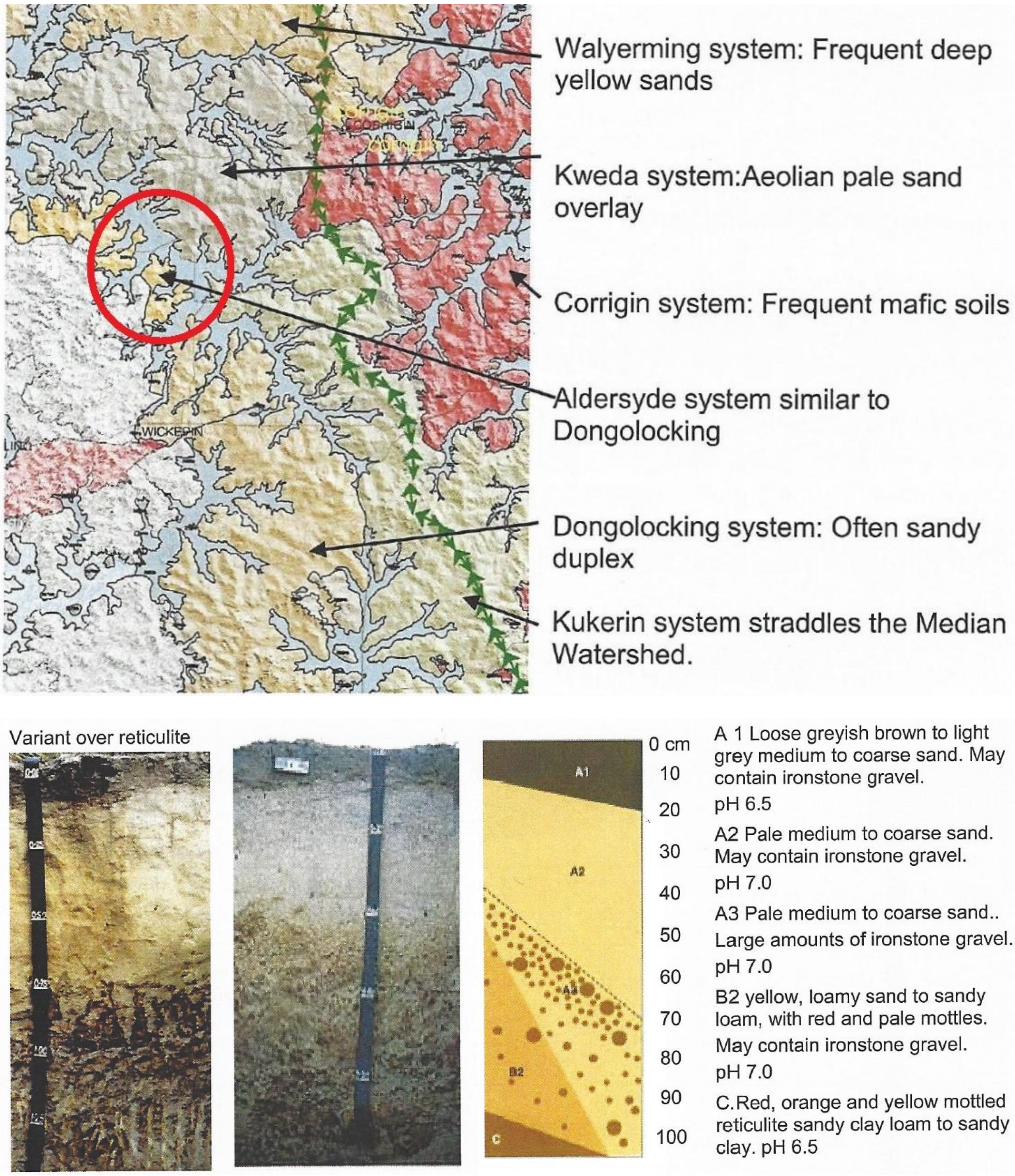

Figure 3: Different soil and landscapes of the southern Avon River catchment (Source: DPIRD)

Converting Interceptor Banks into Interceptor Barriers

Now that Darrell has found that surface water management is no longer required in a no-till no sheep system he has begun filling in the dozer banks and leaving the plastic barriers in place.

Figure 4 shows where W.I.S.A.L.T.S. banks were filled in leaving the plastic barriers in place. This has allowed the machinery to work over the barriers and removed the weed infestation from the banks.

Figure 4: Image showing where a plastic lined dozer bank has been filled in. Plastic can be seen on the surface.

Figure 5: Aerial image showing where the two main banks have been filled in (but remain visible from air) and machinery now operated over the Interceptor barriers.

Modern Interceptor Barrier

The plastic barriers have evolved using W.I.S.A.L.T.S. principals, however, rather than relying on a double push bulldozer bank to intercept the perched water above the impermeable C horizon, Darrell used an excavator to dig a trench and install plastic sheeting to stop water accumulating in seepage zones.

Trenching in a plastic barrier between the free draining sandy surface and the less permeable C horizon holds water higher in the landscape. This allows it to be used by crops rather than accumulating and causing transient waterlogging and eventually salinity in lower areas.

The simplest way to explain the concept is to compare the installation of multiple plastic barriers across the landscape acting like "Chinese rice terraces" holding the water high in the landscape.

The plastic barriers are installed on the level (like Rice paddies), as the original W.I.S.A.L.T.S. banks were and the sites for the barrier installation are also chosen using the W.I.S.A.L.T.S. principals. Starting in the top of the landscape, using divining and landscape shape to identify where natural barriers are closer to the surface (see Figure 7 Diagram). Natural barriers are often on the contour. Also see case study 4, Figure 17 showing paddock elevation image and position of natural barrier and positioning of bank.

Usually the trenches to the hard, impermeable C horizon are less than 2m deep. This works well with 2m roles of plastic sheeting. The liner is to be fitted to the downhill side of the trench and the bottom of the plastic is to have a 300-400mm return on the bottom of the plastic (effectively forming an L shape) facing up the slope, this helps to seal the barrier and minimise water leaking between the plastic and the clay layer.

Figure 6: This image shows barriers being installed, water can be seen perched above the C horizon (approx. 1.6m) has seeped into the trench.

Evolution Time Line of the W.I.S.A.L.T.S. Interceptor Bank to modern Interceptor Barrier

70's Harry Whittington developed the Double push dozer banks

Late 70's- 80's David Turner – implemented the W.I.S.A.L.T.S. system of Double push dozer banks

Mid 90's Darrell 1st started experimenting with plastic lined banks targeting deeper sand patches

1996 The farm became 100% cropping with no live stock or pasture.

1998 Darrell began doing whole plastic lined banks jointly with Noel Powell.

2005 – Darrell began the process of filling in double push banks without plastic and only inserting plastic barriers with a single push bank.

2015 – Begun filling in plastic lined banks that can be worked over.

Ongoing – Installing Interceptor Barriers above sites where water accumulation is a problem.

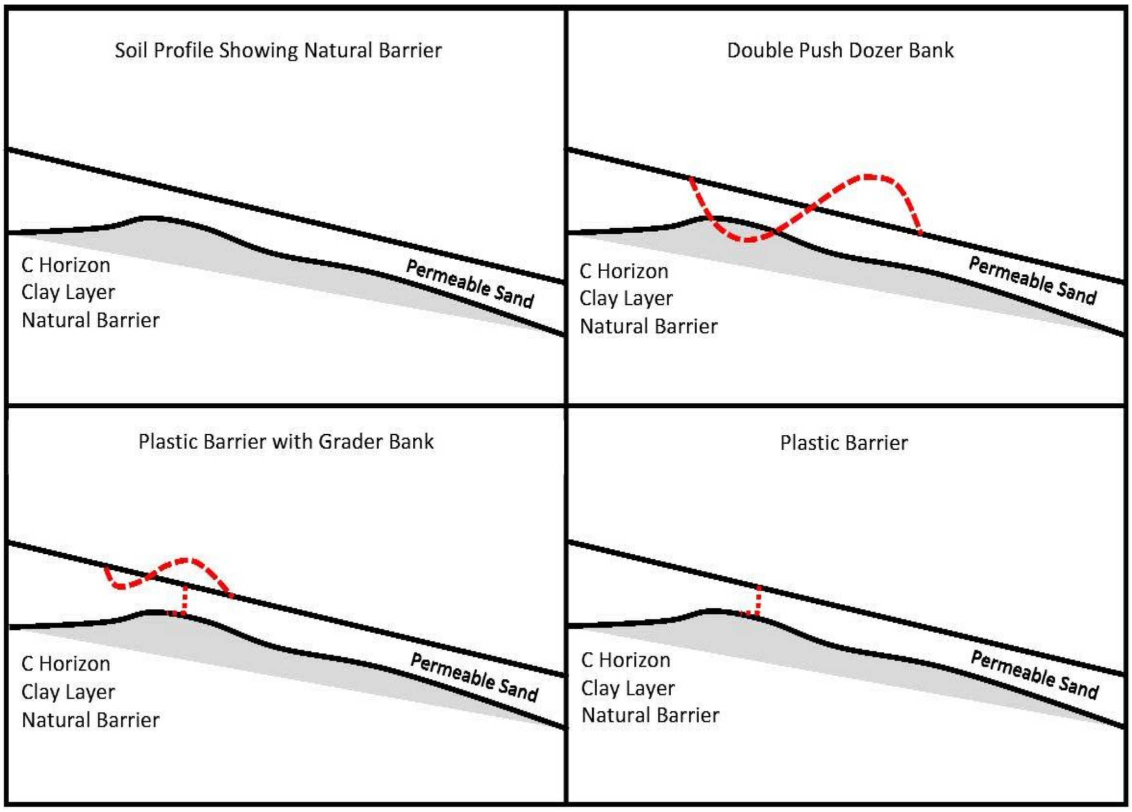

Figure 7: Schematic diagram showing site selection, the traditional W.I.S.A.L.T.S. banks, the grader bank + barrier and the Plastic Barrier

Darrell's Modern Adaptation

Where there are deep sand seams (>2m deep) plastic can be purchased in 6m roles that can be installed in 6m sections) this is usually only required over short distances.

Darrell found that his first installed barriers would have a problem with water accumulating or overflowing at the end of the barrier. This problem could be avoided by running the plastic up the slope at the end of the barrier approximately 5m. This creates a dam effect and prevents water spilling off the end of the barrier creating wet patches.

To date Darrell has installed about 15km of plastic barriers across his farm, constructed from 2m plastic rolls with the occasional section of 6m used vertically where the clay layer was deeper than 2m.

Figure 8 shows how the interceptors are installed on the contour and can hold perched water in the landscape like rice paddies. Most of these were originally interceptor banks and Darrell is progressively filling in the banks and replacing them with Interceptor Barriers. This removes the above ground obstruction and allows easy working of the paddock and also prevents weed problems on the banks.

Figure 8: Showing image of Interceptor Banks installed on Darrell's farm during the 90's. Some of these banks are now filled in and replaced with Interceptor Barriers allowing easy working of paddocks.

Costs of installing Interceptor Barriers

Excavator ($150-hour)

Plastic ($1000 km)

Work on $6-7000/km with full contract. It can be installed significantly cheaper with your own equipment.

Can install roughly 400m per day depending on depth of C horizon

Darrell feels that the banks paid for themselves within two years with improved productivity above the Interceptor Barrier by allowing the crop to access the subsoil moisture that is stored and also by preventing waterlogging in the zones that accumulated the excess water. These benefits are over and above the prevention or delaying the progress of salinity.

Darrell estimated he has reclaimed over 100ha of waterlogged and saline land that is now highly productive. At current land prices this is worth $360,000 in land value alone.

This does not include the savings in lost land if no action was taken.

Darrell feels that his deep white sands have become more productive. He thinks there is less water moving through the subsoil leaching nutrients that are now available to the crop where they are applied.

Darrell has installed 15km of Interceptor Barriers (plastic lined trenches). If we assumed, it was installed with full contract at the higher end of the cost range ($7000/km) this would have cost $105000 to install. Ignoring productivity gains from preventing waterlogging Darrell has improved or recovered 100ha of land valued at $360 000.

Plastic installation tips.

- Start in the top of the landscape (not the bottom).
- Install plastic sheet on bottom side of trench.
- Fold sheeting along the bottom of the trench forming an uphill facing L to reduce water leaking below plastic.
- Curl the ends of the barriers up the slope to stop water draining out the end of the level barrier (approximately 5m).
- Where depth to impermeable layer is >2m use 6m roles of plastic installed in sections.
- Safety is critical with deep trenches.

The Adoption of the W.I.S.A.L.T.S. Method and the need for Evolution

In the 70's and 80's when the original W.I.S.A.L.T.S concept was developed, the farming system in WA was very different to that of today. Most farms were a sheep dominated enterprise and where cropping was undertaken, growers used small scale machinery (combine seeders 6m width).

This meant that the dissecting of paddocks with large banks was less of an issue with small hand driven machinery and because of the low intensity of cropping growers were less concerned about harbouring weeds on the banks.

Also in a livestock dominated system, surface water management is critically important to stop water erosion as the bare pasture paddocks that are compacted by livestock readily run water.

Alternatives at the time did not offer the same waterflow control benefits that the W.I.S.A.L.T.S. method did. Deep drains were a popular concept at the time which theoretically would help to drain excess water away from areas of accumulation into creeks and rivers. The land around Darrell's property feeds into the Avon river catchment. This land around the catchment is fairly flat so when the Avon river floods this will cause water to run back down the drain as opposed to into the river from the waterlogged areas. The result of this would be further more severe waterlogging.

In today's farming system with large scale machinery (20m seeders) and continual cropping, having surface banks is crippling to productivity and efficiency of plant operations. Large gains in efficiency have been achieved with auto steer machinery and by reducing the amount of cornering required to seed a paddock. Good paddock hygiene is critical in a cropping system to ensure long term sustainability.

Key Problems with W.I.S.A.L.T.S. Banks

- Breaking up paddocks reduces machinery efficiency and increases overlap.
- Banks harbour weeds and make hygiene difficult.
- Surface water management is no longer required with no-till and stubble retention, each furrow acts as a mini bank to slow the velocity of surface water flow and increase water infiltration.
- Double push dozer banks are expensive to install and are also expensive to fill in.
- Darrell's comments – when W.I.S.A.L.T.S. were first installed they worked well for the first few years. Then over time they began to leak. Inserting the plastic barriers was a game changer.
- In Darrell's soil types, the main problem with the Dozer bank was that the depth to the impermeable C horizon varied across the paddock. Sand seams or deep sand areas would end up collecting the water from the bank and causing additional wet areas in paddocks.

Figure 9: Image of dozer banks with burden of wild radish that can continually contaminate the paddock.

Benefits and Problems of the new Interceptor Barrier

Interceptor Barrier's - the Challenges

- **Safety -** Inserting plastic into a 2m trench can be dangerous. Great care needs to be taken when installing the plastic. Safety cages are required for deep excavation (deeper 1.4m)
- Installing Interceptor Barriers is an expensive exercise (approximately $6-7000/km). Darrell feels that he recoups his money in 2-3 seasons through productivity gains alone.
- The method is expensive and fairly labour intensive. This is an obstruction to initial entry but also acts as a restriction to the amount of work which someone undertakes. The problem with not completing a full project is that not all the benefits are likely to be seen. With incomplete banks it is likely that water will continue to accumulate in the areas where it is undesired, albeit at a slower rate. Remember works should always begin at the top of the catchment and install the lower ones last.
- Darrell and Suzanne have now expanded the farm and are time poor which makes it difficult to undertake ongoing works as fast as they would like. Even though they own the equipment.
- Interceptor Barriers are extremely effective on duplex soils where there is an impermeable C horizon in the top 1-3m of the soil surface. On some sandplain soils the clay or rock can be too deep to insert the barriers.
- It will be important to maintain good sub-soil health to allow crop roots to access the moisture at depth that the interceptor Barriers have held in the landscape.

Interceptor Barrier's - the Benefits

- Interceptor Barriers are ideal for the modern cropping system.
- Once installed paddocks can be worked as normal with no loss in arable area. Most other rehabilitation techniques involve sacrificing arable land.
- Interceptor Barriers will not prevent growers undertaking soil amelioration techniques such as deep ripping or spading as the barrier is doing all the work at depth not in the top 500mm of soil.
- Interceptor Barriers are effective in wet and dry seasons. If it is a very wet season trees can become waterlogged and water can still end up in recharge.
- Interceptor Barriers have no influence on overland water flows, however with no-till and retained stubble surface flow is minimal. Often in extreme rainfall events banks become overwhelmed and water can burst the banks resulting in accumulation of the full banks water in one site creating an erosion problem.
- Water is retained up-slope for crop to use. The water flow is not accelerated off the paddocks.
- Interceptor Barriers are a one-off expense. Once installed there is no ongoing cost (either financial, maintenance, agronomic or environmental).
- Once installed it is likely that the Interceptor Barriers will have a very long life span. The plastic will last a long time in the cool, low UV environment.

Other alternative water management options

Trees

Darrell believes trees are useful in un-arable areas for biodiversity. Darrell has undertaken extensive revegetation surrounding saline areas and on deep white sand to use water or minimise recharge. However trees on arable land are not an option as they harbour weeds and break up the paddock as well as loosing productive land and neighbouring crop competition. Trees though providing some benefit to controlling water levels are unable to extract water fast enough to reduce the impact of inflows.

Surface Banks

In full cropping system surface water management is no longer needed. Grader/surface banks also remove water (our most limiting resource) off the paddocks faster and without the opportunity for a crop to use it.

Darrell has also found that the Avon river flood plains are higher than some of his surrounding paddocks. So in order to run surface water into the river, shallow drains will need to be dug as you get closer to the river. If this was done when the river was in flood the water would flow back up the drainage lines onto the paddocks.

Deep Drainage

Deep drains can be used to drain saline land. This is an illegal practice to dispose of saline water into water ways. Darrell feels it is far better to retain the water in the paddocks where it can be used by crops.

Paddock Case Studies

Case Study 1: Mears Paddock This is a flat low-lying paddock that was been inundated from water from the neighbouring paddock to the south (see google earth image figure 13). The natural drainage lines were beginning to go salty and the paddock was regularly waterlogged in winter. It was under threat of becoming un-arable from salinity and waterlogging.

In 1998 Darrell decided to stop the below ground water from entering his paddock. As he felt that his farming system (continual cropping) could deal with the water that landed on the paddock but could not remove the water coming from upslope. An excavator trench was dug on the southern boundary of the paddock down to the clay layer (average 2.5m but maximum depth 4m) and a plastic liner was laid to impede water flow. This trench intercepted many below ground water channels that gushed fresh water.

At the same time a double push dozer bank was removed from the middle of the paddock as it was ineffective due to leaking and also divided the paddock up not allowing GPS working.

A grader bank was installed above the plastic to divert the surface water from spreading across the paddock.

The productive area of the paddock has increased to 80Ha from 65Ha prior to the works. Waterlogging now only occurs in the wettest years. While there is still salinity in the drainage channels, this has not spread and has receded since the barrier was installed. It is obvious to see the extent of salinity spread in the neighbouring paddocks. Especially when comparing the areas north and south of the trench (Figures 12 and 13).

Figure 10: Showing trench being prepared to insert the plastic liner.

Figure 11: showing water gushing from the side wall of the trench prior to plastic insertion.

Figure 12: This 2002 photo shows the barrier in the centre dividing Mears (left) to the neighbouring (right). Since the photo was taken salinity has continued to spread on the right.

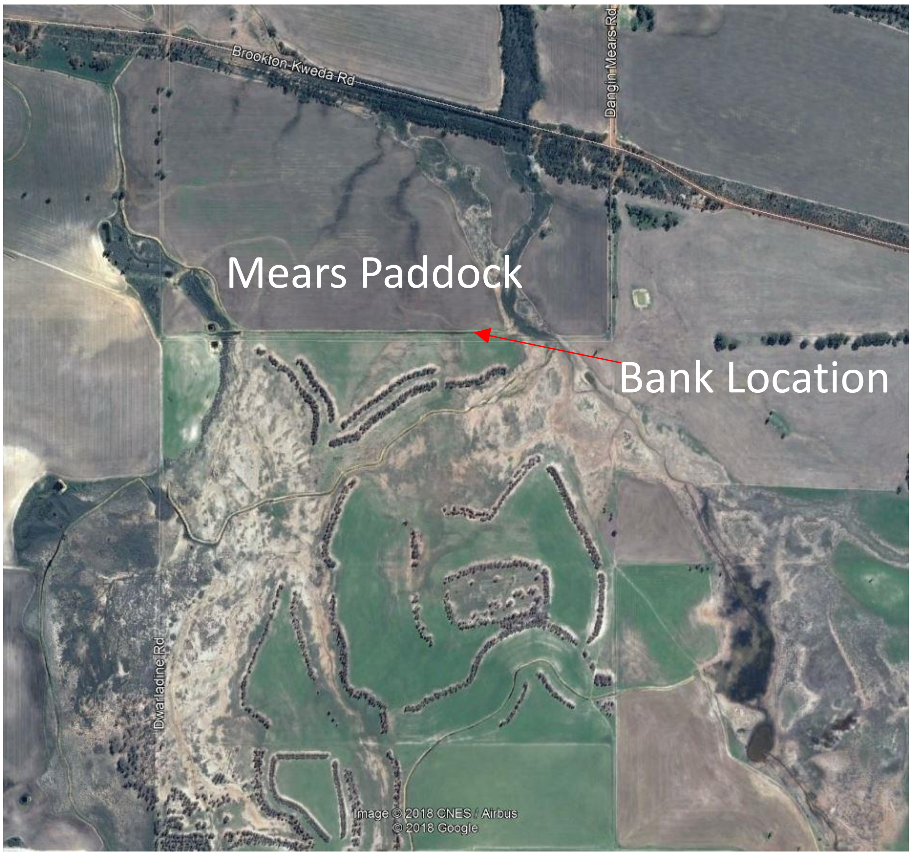

Figure 13: An Aerial photograph of the location of the bank in Mears paddock and the benefits it has had in halting the spread of salinity from the neighbouring paddock (2016 google earth image)

Case Study 2: 3 in 1 Paddock

The Banks in the 3 in 1 paddock were installed during the transition period where the method of plastic lining was beginning to be implemented. All the banks in this paddock are the double push dozer type with the exception of some installation of plastic barriers where the depth of the sand was greater.

Darrell notes that the banks are currently harbouring too many weeds and their positions within the paddocks is hindering the efficiency of his machinery operations. As a result the goal is to eventually remove the banks over the next few years and replace them with more Interception Barriers so he can maintain their positive benefit whilst better managing his machinery and weeds.

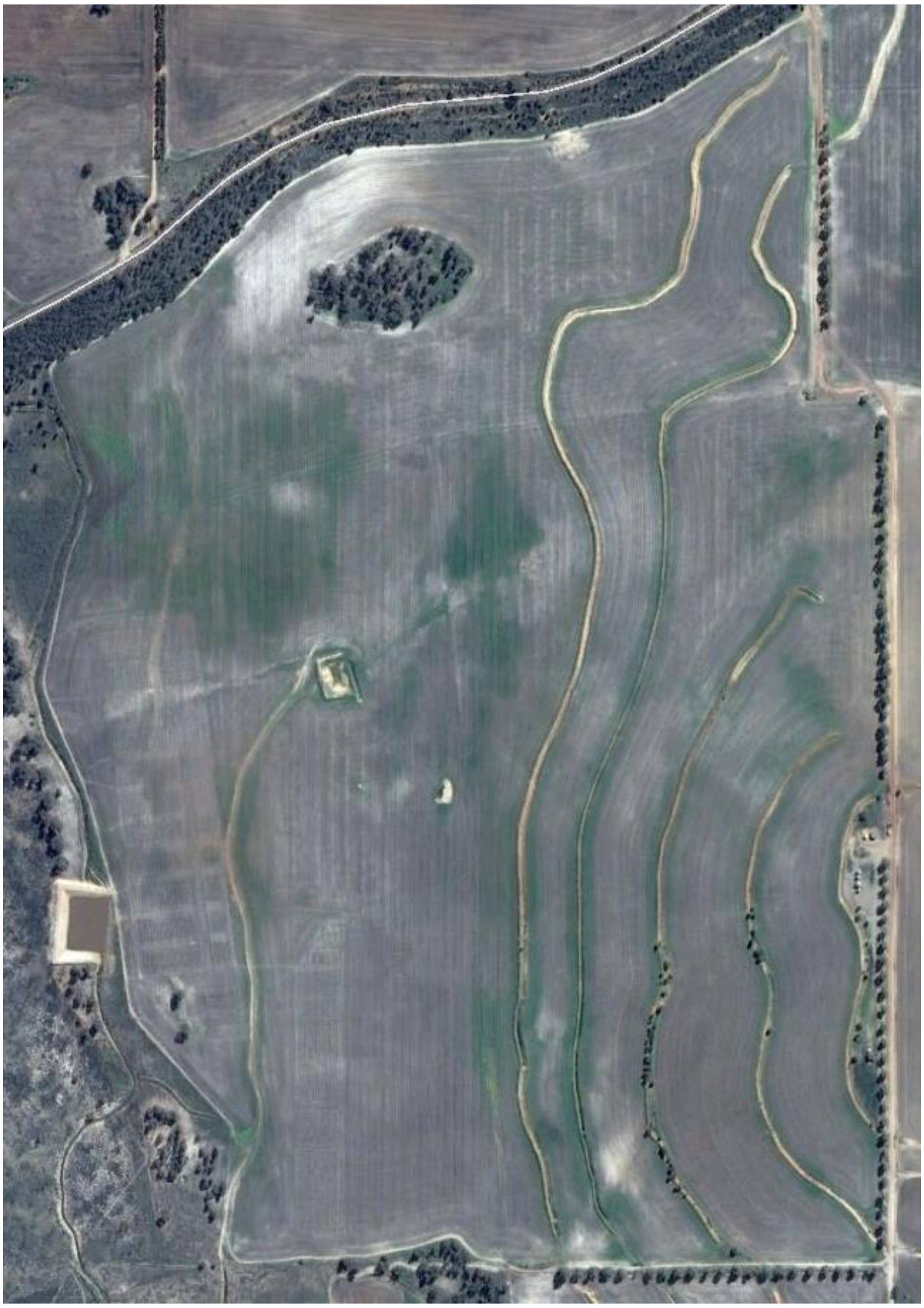

Figure 14: Aerial photograph of the location of the banks in the 3 in 1 paddock.

Case Study 3: N 34 Paddock

Before the installation of the banks paddock 34 used to get extremely wet on top of the hill. The level of moisture was to such an extent that many of the areas were un-trafficable. Plastic lined banks were installed in the 2001 and proved to be extremely effective at preventing waterlogging. Darrell has noticed that since he's changed his system to a practice of no-till and no sheep, surface water management is no longer an issue.

In the future Darrell plan's to fill in the banks and leave the plastic barriers in place so he still maintains the positive benefits of groundwater flow as overland flow is no longer an issue.

Figure 15: The distribution of the plastic lined banks in the landscape: Darrel plans to smooth out the banks in the paddock and maintain the plastic beneath the surface.

Figure 16: This image shows the placement of the banks on the landscape. Historically the steep elevation of the paddock led to significant overland flows. The introduction of no-tillage systems has made this problem obsolete

Case Study 4: Deep Well Paddock

The middle bank seed in figure 17 has a plastic barrier installed. This has now been filled in allowing easier working of the paddock with modern tillage and paddock management equipment.

The top and bottom banks are double push dozer banks (without plastic). These are no longer needed to manage surface water and they leak under waterlogging conditions. They will be filled in in the near future. Darrell believes the plastic barrier is doing most of the work in managing waterlogging.

Removing the banks will allow for better weed control and increased efficiency in his cropping operation.

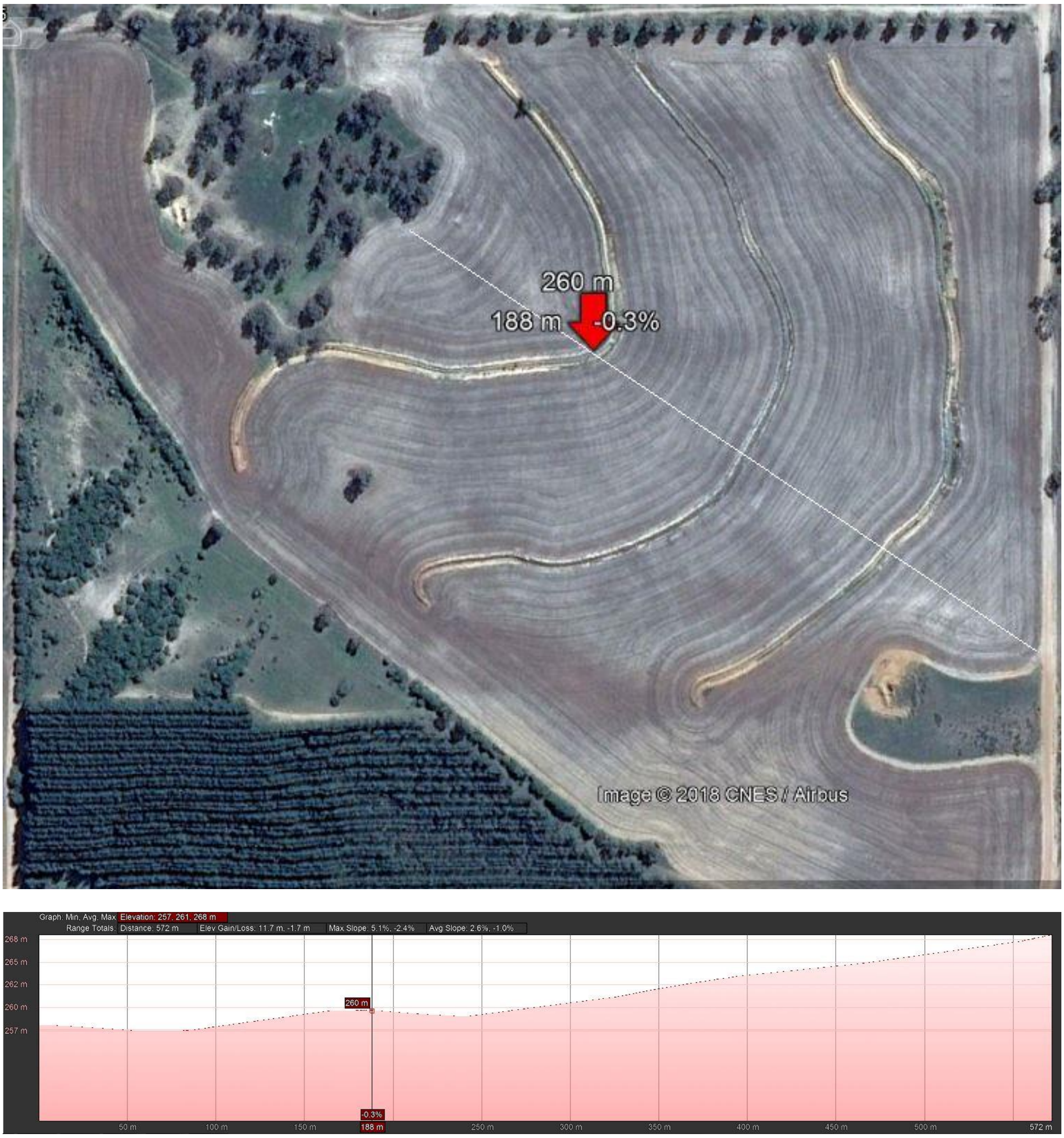

Figure 17: An aerial photo of the positions of the banks in the paddock and an elevation transect down the slope. The arrow marks the position of the banks relative to the elevation of the paddock depicted in the image below the aerial photo. The natural rise in the landscape has helped the bank to capture water. Note that Darrell has revegetated the unproductive deep white sands with Pinus Radiator plantations. These pine trees have grown well on this site and they prevent the recharged of ground water and will hopefully generate a return in the future.

Figure 18: This photos shows the banks acting like “Chinese Rice Paddy” terracing to hold water in the landscape. Photo shows use of trees on deep white sand recharge area (low arability). The centre bank has now been filled in.

Darrell and Suzanne's Plans with ongoing work

Darrell plans to fill in all banks across his farm where surface run off water is no longer an issue. He will continue installing Interceptor Barriers on his farm, targeting areas with seepage patches, waterlogging or salinity lower in the landscape. His drive for continuing this investment is for productivity gains and the environmental benefits (such as reducing the spread of salinity) are an additional bonus.

Darrell and Suzanne have been early adopters of lime. Most of the farm has a surface pH above 5.5, which is the critical level for allowing lime to leach and ameliorate subsoil pH.

Darrel intends to conduct trials to evaluate the benefits of deep ripping and deep ploughing on his sand plain soils to incorporate lime, remove subsoil hard pan and bury non-wetting surface soil. This will ensure that subsoils are not hostile to crop root growth and will allow crops to access the moisture stored above the Interceptor Barriers.

Figure 19: Darrell and Suzanne feel that the work they are undertaking will benefit the generations to come.

Glossary

W.I.S.A.L.T.S.– Whittington Interceptor Sustainable Agriculture Land Treatment Society Inc

Interceptor Barrier – A plastic liner trenched to the impermeable C horizon that is placed on a level contour. There is no bank or surface water management on the surface so farm implements can freely work over the barrier.

Interceptor bank – A large bank installed by a double push with a bulldozer installed on the level to hold water.

Contour bank – a smaller bank installed on a grade to flow water off a paddock or to a dam, installed by a grader.

DPIRD – Department of Primary Industries and Regional development (Formerly Dept of Ag).

C Horizon – this is the term used to describe the impermeable sub soil. Where water freely moves through the surface layers of the soil and sits above the impermeable layer. This is most commonly clay or rock on Darrell's farm.

Perched Water – water that has leached through the surface layers of the soil.

Recharge Water – Recharge areas are permeable and allow water to percolate to the aquifer. If the recharge tubes have been filled by fine sediments moving with the water, that will create an obstruction thus preventing the water reaching the aquifer, it will them move down slope above the C horizon.