Should you install pipes and risers or an open channel system?

Farm surface irrigation upgrades compared

State Government Victoria

Printed by (name of printer, suburb)
ISBN XXXXXXXXXXXXXXX

Accessibility
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Introduction

This paper provides information to assist irrigators answer the key question: Which system – an open channel system or a pipe and riser system – is the best for my situation?

The answer is not as straight forward as it looks. Recently there has been increased interest in pipe and risers system with the roll out of programs like Farm Water. Upgrading farm irrigation supply channels to pipes and risers can potentially improve the efficiency of water use on farm through lower seepage and evaporation losses. However irrigators need to examine their own unique set of circumstances before deciding which infrastructure is best for their situation.

Information provided includes:

- The pros and cons of both systems
- The costs and benefits of both systems on a case study farm
- Important factors to consider in the decision making

Pros and cons of pipe and risers systems and open channel systems

The pros and cons of pipe and riser and channel systems are shown in Table 1 below.

The information provided in Table 1 provides some guidance for you to consider your options. For example if you already have an efficient channel system, then the benefits of converting to a pipe and riser system will not be as significant. However, if you have experienced a blow out in your channels or if you have a channel system which is inefficient, does not drain out, is difficult to manage and requires redevelopment then you might want to consider a pipe and riser option.

It is important to understand the soil types on a property as it can have a major impact on the type of irrigation system that is best suited for the property. Earthen channel delivery systems can operate quite variably depending upon soil type. It is estimated that between 1-5 % of delivered water through open channel systems can be lost through leakage, seepage and evaporation (RMCG 2009). Channel construction can be difficult on some soil types, particularly sandy and cracking soils, so pipe and riser systems can be a better option. However, on very sandy soils adoption of a surface irrigation system, whether it is an open channel system or a pipe and riser system, might not be the best approach. In such cases a pressurised spray or drip system may be more appropriate.

Another factor that needs to be considered is the energy cost. Unlike a channel system, pipe and riser systems usually require water to be pumped. This means there is greater exposure to increasing energy costs, and this needs to be factored in to the decision making process.

Table 1 Pros and cons

Pipe and riser	Channel system
Pros	Pros

• Greater control over irrigations
  ○ Can irrigate the farthest bay from the irrigation supply point without having to fill long sections of farm channel
  ○ Water can be applied to bays instantaneously from different sources (eg. from GMW channel or farm re-use system)
• Reduced seepage and evaporation losses
• Gain land which could have been occupied by farm channels
• Improved access within farm
• Eliminated channel maintenance costs
	• Use of gravity to convey water
	• In most cases pumping is not required, particularly if the channel system is well designed
	• Construction cost is usually cheaper than a pipe and riser system
	• The development of a channel system can be staged and could make financing easier
	• Channel system can be linked to adjoining neighbouring properties with minimal changes, if a purchase is planned in future

Pipe and riser	Channel system
Pros continued	Pros continued
• Easy to install in winter with little disturbance • Irrigation of higher ground more of an option than with an open channel system • Able to irrigate closer to when a crop requires it e.g. directly following grazing • Increased ability to distribute effluent evenly across a property	• Often easier for the operator to make repairs if anything goes wrong compared with the pipe and riser system • Major flows (>20 ML/d) can be used with minimal channel alteration
Cons	Cons
• Significant capital cost – higher than the channel system in majority of cases • Higher operating cost – because water usually needs to be pumped • Reliance on the availability of power (electricity/diesel and working pump) in order to irrigate • Repair costs can be significant when they occur, usually requiring contractors to complete the works • Some concern about the long term durability of poorly designed/ constructed systems	• On sandy undulating soil types or cracking clays, channel construction will be difficult • Blow out of channels on sandy soil types • Require regular repair, maintenance and weed control • May need to fill up channel systems to irrigate different sections of a property • Some water losses occur in the channel system (seepage, leakage and evaporation)

Costs and benefits – pipe and riser vs channel system

Another key question to ask is *"do the extra benefits of the pipe and riser system outweigh the extra costs"*? The cost of both systems are discussed below in the context of a case study farm.

Recently a landowner in northern Victoria has installed an automated pipe and riser system which consisted of 2000 metres of 355 mm PN 4 PE 100 polyethylene pipe serving 77 ha of land. The area is served by thirty one 355 mm automated risers. The irrigation water is sourced through a 450 mm Magflow meter and is directed through 1.5 kilometres of farm channel to a 7 ML farm drainage reuse sump. From the sump the water is pumped through the pipe and riser system at the rate of 15 ML/d.

The actual cost of this investment was collected from the landowner and is presented in Table 2 under the pipe and riser column (for a detailed benefit cost study of an automated pipe and riser system, read a separate DEPI case study entitled '*Irrigation supply system modernisation enables transformational change on farm' 2015*).

For the same case study area, a hypothetical case was developed with the help of a local irrigation designer to examine the option of installing an automated open channel with the capacity to deliver 15 ML/d to serve the 77 ha project area. A detailed costing for the automated farm channel system for the project area is provided in *Appendix* A. The comparative costs and benefits of the two systems are provided in Table 2.

Capital costs

The total infrastructure cost for the channel system is $188,000 compared to $282,000 for the pipe and riser system. The difference is an additional cost of $93,000 for a pipe and riser system compared to an open channel system. Other farm improvement costs such as laser grading, power connection and decommissioning works are same for both the systems.

Table 2 Comparison of costs and benefits of a pipe and riser and a channel system

Description of costs	Pipe and riser	Channel
Capital costs		
Installation of automated channel system or Pipe & Riser system	$281,975	$188,277
Farm improvement costs (power connection, laser grading, sump construction, construction of connecting channel from supply outlet to sump, cost of extra 4 outlets at the end of the system and fencing)	$307,042	$307,042
Other costs (backfilling of decommissioned GMW channel, other decommissioning works such as removal of old structures, old channels and fences)	$85,200	$85,200
Pasture related costs (production forgone during construction and pasture re-establishment)	$138,937	$138,937
Annual costs		
Pumping cost	$7,090	$3,545
Channel spraying cost	$0	$1,600
Channel de-silting cost	$0	$1,370
Extra O&M cost (2 % of the capital cost)	$5,640	$3,765
Annual extra benefits		
Production benefits from extra land gained (extra 2 ha)	$2,700	$0
Water savings from evaporation loss in channel system (4ML)*	$260	$0
Water savings from leakage and seepage (15ML)*	$975	$0

*** Estimation of water losses from evaporation, leakage and seepage depend on several factors like soil type, evaporation rate in a particular year and water retention in a farm channel system. Leakage and seepage losses could end up in on-farm groundwater reserves and some of which can be accessed through groundwater pumping.**

It needs to be noted that in the above case study, pumping is also required for the open channel system scenario. Water from the supply outlet is designed to drain into a 7ML farm drainage reuse sump and from the sump, the water is pumped to the project area.

In most situations installation of an automated open channel system may not require the purchase of a pump and motor system, further reducing the cost of an open channel system. The comparative costs for an automated pipe and riser system, automated open channel system and automated open channel system without a pump and motor are presented in Table 3 below.

Table 3: Comparative costs

Description	Installation cost	Per hectare cost
Automated pipe and riser system	$281,975	$3,660
Automated open channel system	$188,277	$2,445
Automated open channel system excluding pump and motor	$153,277	$1,990

It costs $3,660 per hectare for the installation of a pipe and riser system compared to $2,445 per hectare for the open channel system, a difference of $1,215 per hectare. When the cost of a pump and motor is not included then the cost further reduces to $1,990 per hectare, a difference of $1,670 per hectare compared to the pipe and riser system.

In the above example for a pipe and riser system, the landowner has spent an extra $93,000 compared to a pump operated open farm channel system and an extra $128,000 compared to an open channel system which does not require

a pump and motor to operate. Farmers in a similar situation should ask whether it is worth spending extra money on a pipe and riser system considering the extra upfront cost and annual benefits such as production increase and costs such as pumping, spraying and de-silting.

Considering the extra cost for a pipe and riser system, the analysis showed that the case study farmer would have to generate an extra 0.5 to 1 tDM/ha/year to financially justify the extra cost over the cost of the open channel system.

Other factors

There are other factors that also need to be considered when deciding between the two systems.

Maintenance costs

The maintenance cost with an open channel system includes regular spraying and de-silting. These costs will be eliminated with the installation of the pipe and riser system. However, the maintenance and repair costs for a pipe and riser system, such as pump repairs can be costly and may require contractors to complete the work.

Extra land gain

With pipe and riser system, the irrigator can gain productive use from the land which could have been occupied by farm channels. In the case study farm, an extra 2 hectares of land is gained from the pipe and riser system, which can bring extra production benefits of $2,700 per year.

Evaporation, seepage and leakage losses

In an open channel system some water will be lost and is not recoverable due to evaporation, leakage and seepage. In the example above, 4 ML of water per year is lost due to evaporation based on an average evaporation of 4mm/day over the irrigation season.

Water is also lost due to leakage and seepage in an open channel system. This loss can be calculated based on the number of days water stays in the channel per irrigation, final infiltration rate of Moira and Naring soil types of the project area and the length, width and bed depth of the channel. The calculated leakage and seepage loss is 15ML per year.

Where a pipeline is installed in place of a channel system in the above example, there is a water savings of 19 ML per year just from evaporation, leakage and seepage. This loss due to seepage and leakage could vary depending on the way the channel system was compacted during the construction stage of the project.

Fencing cost

Fencing is required to keep animals out of open channel systems. This may not be necessary for a pipe and riser system. The cost of fencing will vary depending on the site, conditions and type of materials used. Generally the cost of fencing could range from $4,000 to $5,000 per kilometre. Fencing costs should be included as part of the capital cost of constructing an open channel system.

Pumping cost

Pipe and riser systems usually require water to be pumped, resulting in additional energy costs. In the above farm case study, the water needed to be pumped for both the pipes and risers and the channel system. However, the head or pressure requirement for the channel system is far less than the pressure required for the pipe and riser system. Both systems require water to be lifted from the reuse system. For the pipe and riser system however, there is an additional friction loss through the pipe system to deliver irrigation water to paddocks.

The pipe and riser system in the example is designed to operate at 14 metres of total dynamic head. A pipe and riser system at a total head of 14 metres typically requires around 56 kWh of energy per ML applied. If the electricity tariff is 20 cents per kWh then the pumping cost for 56 kWh/ML is $11.20/ML. Similarly if the tariff is 14 cents per kWh then the pumping cost is $7.85/ML.

For a channel system, a pumping head of 4 metres may be required. For this, it will require around 16 kWh of energy to pump a ML of water. In this situation, if the electricity tariff is 20 cents per kWh then the pumping cost is $3.20/ML. Similarly if the tariff is 14 cents per kWh then the pumping cost is $2.25/ML.

In the above example, the irrigator will be paying an extra $5.60 to $8.00 per ML of water depending on the electricity tariff to push water through the pipe and riser system.

The use of a diesel pump in the above situation is again different in terms of the cost per ML of water pumped. For a pipe and riser system, with diesel fuel costing $1.40/litre, a farmer would normally pay $0.90/litre after claiming GST and

rebate. At a specific fuel consumption of 0.3 litre/kWh, pumping at 56 kWh/ML would require 17 litres of diesel fuel per ML pumped, costing $15/ML.

For a channel system with a low pumping head of 4 metres, with diesel fuel costing $1.40/litre and farmers paying $0.90/litre after claiming GST and the diesel rebate, the farmer will require 5 litres of diesel fuel per ML pumped costing $4.50/ML.

In this scenario the irrigator will be paying an extra $10/ML to deliver water through the pipe and riser system using diesel fuel.

Energy costs will be a significant ongoing operating cost for pipe and riser systems. As the cost of energy rises in the future, savings of energy in terms of operating cost will become more and more attractive.

Trade-off between capital and operating cost

Irrigators need to be aware of the trade-off between capital and operating costs at the design stage of the investment decision. Pipe and riser systems operating at lower pressure will cost proportionally less to run.

The selection of pipe sizes involves a compromise between the capital cost and the operating pressure, the latter of which affects the ongoing operating costs. Operating costs are directly related to the size of the pipes used in the system.

Small diameter pipes cause higher friction losses and increase operating pressures and hence costs. Irrigators who are planning to install a pipe and riser system need to be aware of this and be involved in deciding what they are prepared to pay upfront in capital cost and the ongoing operating costs.

Automation

Automation systems for opening and closing of outlets are available for both open channel and pipe and riser systems. Irrigators need to understand how different systems work before deciding which system is best for a particular irrigation layouts.

There are fixed automatic irrigation units in available for both systems where each structure has its own unit to operate it automatically. Fixed systems are more suited to areas where irrigation systems are permanent and irrigation occurs frequently. Both systems now also have the ability to be automated with “portable” units which can be moved around the property during irrigation and can significantly cut down costs. The cost varies with types of automation. The costs are comparatively similar for channel and pipe and riser systems.

Intangible benefits and costs

Intangible benefits of new technology such as convenience, flexibility and lifestyle benefits are usually not included in a financial analysis but also need to be considered while making decisions on technology adoption.

It is thus important to consider all the reasons, financial as well as non-financial, before making decisions on your irrigation infrastructure investment.

Whole farm plan preparation

It is important to prepare a detailed Whole Farm Plan when considering irrigation upgrades. Whole Farm Plans provide a means of ensuring the irrigation system is well designed and this reduces the risk of something going wrong or not lining up with long term plans. The Whole Farm Plan can also help stage the development of the farm.

Getting a second opinion on the design of a pipe and riser system can help to reduce any concerns about its future durability and performance.

Take home message

Before you make decisions on your irrigation infrastructure, you need to consider all the issues discussed above and other factors relevant to your situation. Talk to irrigation suppliers and irrigation designers for their suggestions. Talk to other farmers who have implemented a similar system in your local area.

References

RMCG 2009. ‘Goulburn Murray Integrated Farm Modernisation Program: Background Report to Support the Farm works Guidelines’ (Bendigo: RMCG Consultants for Business, communities and Environment).

DEDJTR 2015. ‘Irrigation supply system modernisation enables transformational changes on farm’ (Tatura: Department of Economic Development, Jobs, Transport and Resources).

Appendix A

Table 1: Cost estimate for an open channel system on a case study farm

Item		Rate	
Channel Earthwork			
Fill requirement (preparing pad)	4 cu m/ m length	$4/cu m	$34,288
Formation (forming channel)		$3/m	$6,429
Subtotal (A)			**$40,717**
Bay outlets			
29 outlets		$500/outlet	$14,500
Installation cost for 29 outlets		$400/outlet	$11,600
2 drop box outlets		$530/outlet	$1,060
Installation cost for 2 drop box outlets		$400/outlet	$800
Subtotal (B)			**$27,960**
Maxiflow culverts			
3 Maxiflow culverts	Across two laneways, one needing two way culvert	@2,000/unit	$6,000
Installation cost		$600/unit	$1,800
3 Slide door and winch		$300/unit	$900
Subtotal (C)			**$8,700**
Channel checks			
2 channel checks		$850/unit	$1,700
Installation cost		$400/unit	$800
Subtotal (D)			**$2,500**
Butterfly valve (355mm) at pump site			
2 Butterfly valves		$3,000/unit	$6,000
Installation cost		$300/unit	$600
Subtotal (E)			**$6,600**
Automation			
Base station		$6,000	$6,000
31 outlets		$1,600/outlet	$49,600
2 channel checks		$1,600/check	$3,200
3 slide doors auto for Maxiflow		$1,600/unit	$4,800
2 automation of butterfly valve		$1,600/unit	$3,200
Subtotal (F)			**$66,800**
Electric pump			
Pump cost (includes installation and shed)			$35,000
Subtotal (G)			**$35,000**
Grand Total			**$188,277**

- **All the figures are Ex GST**
- **Automated P&R for the same area is about $282,000.**

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