CASE STUDY

ASSESSING OPTIONS FOR EVAPORATION MITIGATION

TAYLOR FAMILY PRODUCE, AMIENS

The Taylor family are a fourth-generation vegetable farming family. Their enterprise operates across sites in south-east Queensland with production farms in Redland Bay, the Granite Belt and Kalbar in the Fassifern Valley. This geographic spread allows them to spread their risk and to continually provide product lines to market. They supply five main products: iceberg lettuce, wombok, celery, broccoli, and silverbeet.

The family recognise the importance and value of high security water to their production system and have developed an interconnected series of water storages on their farm at Amiens. These storages have been designed and constructed to limit water loss from the beds and banks. However, Managing Director Ray Taylor accepts that evaporation is a significant loss of water on farm and has begun investigations into options to reduce this loss to improve their water security.

The farm office and packing shed are located on Robertson Road, Amiens, with the growing beds and nursery towards the north of the site. The farm slopes generally from north to south, and the on-farm storages are numbered one through four down the hill.

On-farm water storage

Dam 1 captures runoff from the growing areas and is able to overtop to Dam 2. Dam 2 is the primary irrigation storage and is maintained at a high water level for the majority of the year though pumping from Dam 3 and Dam 4. These two final dams collect overland flow water, and the water level changes significantly through the season and across each year. Water can be transferred between all dams. The on-site irrigation manager uses this strategy to minimise the stored water surface area to reduce seepage and evaporation.

	Dam 1	Dam 2	Dam 3	Dam 4	Total
Surface area (ha)	0.25ha	0.59ha	3.3ha	3.1ha	7.2ha
Depth (m)	~5m	~7m	~10m	~7m	-
Approximate volume at full supply area (ML)	12.3ML	41ML	330ML	217ML	600ML
Total direct rainfall (not including overland flow and recycling)	764mm 1.8ML	764mm 4.4ML	764mm 25ML	764mm 24ML	55ML
Total maximum evaporation	1,692mm 4.1ML	1,692mm 9.7ML	1,692mm 57ML	1,692mm 54ML	125ML
Net loss	-2.3ML	-5.3ML	-32 ML	-30ML	-70ML

The table above shows that the storages at the Taylor family's Amiens farm is receiving a long-term average direct rainfall of 55ML (not including overland flow and any recycling) and are losing a maximum of 125ML per year to evaporation. (Seepage losses can also be significant and investigations should be undertaken to identify the volumes lost to both seepage and evaporation.)

Ray Taylor suggests that the water in level in Dam 3 and Dam 4 vary seasonally, as shown over, and there are some periods when the storages are completely dry.

Australian Government Department of Agriculture, Fisheries and Forestry
Future Drought Fund
University of Southern Queensland
qcwt queensland college of wine tourism
SQNNSW Innovation Hub
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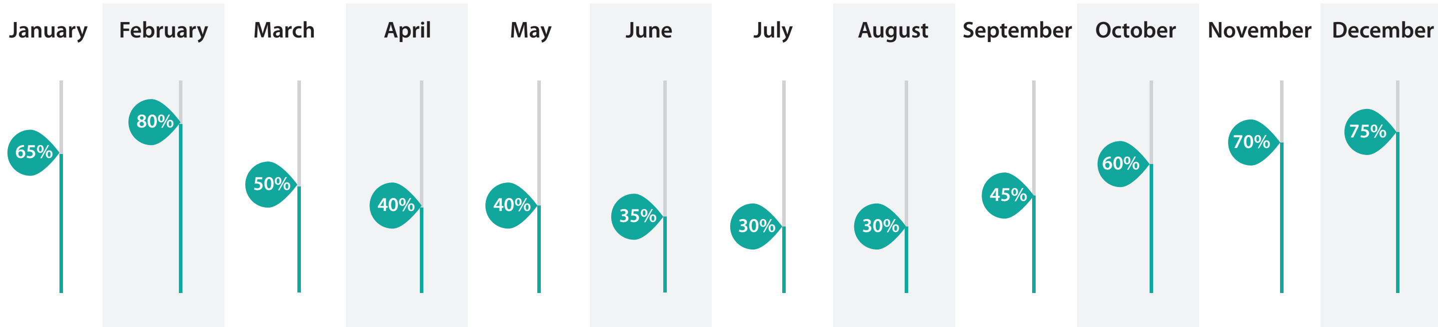
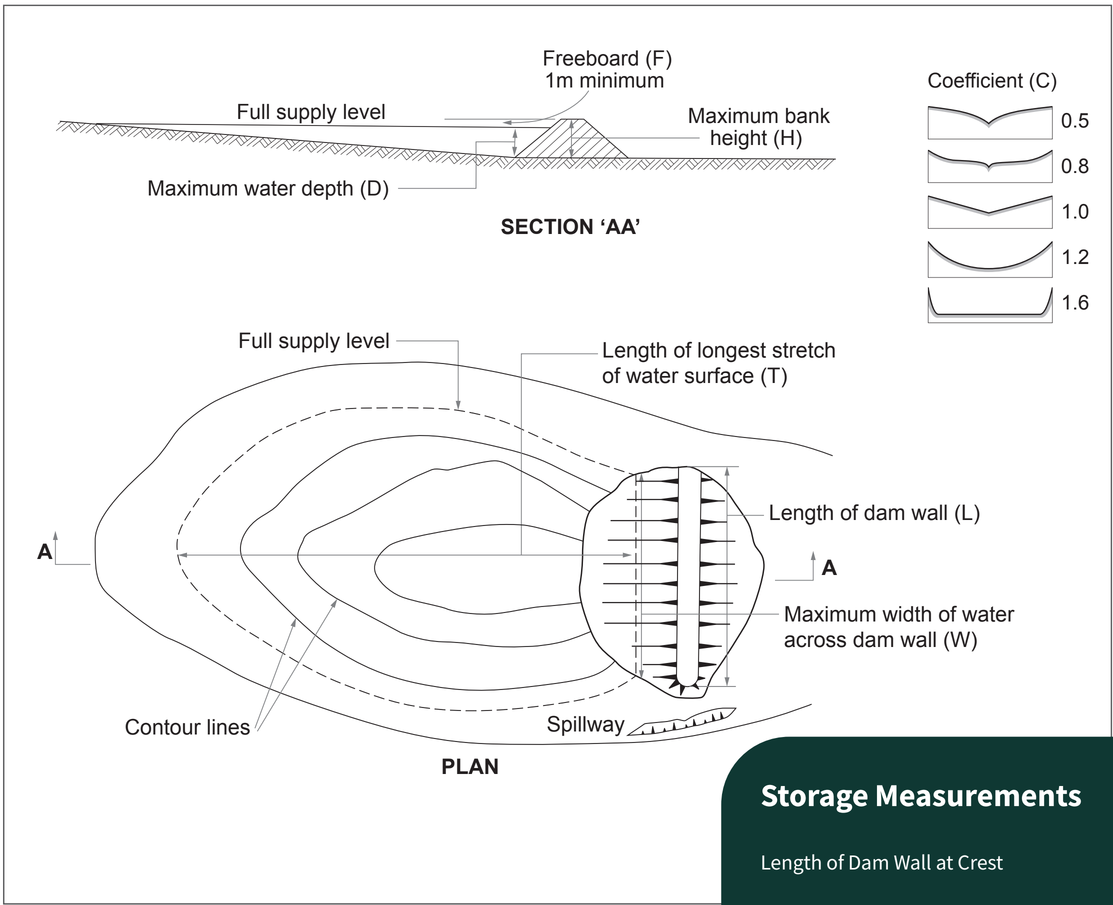


The Taylor family are innovators and keen to investigate a range of options to reduce their water loss. They have requested quotes for two different products (suspended shade cloth and floating modular covers) but were not aware of their magnitude of the loss or the potential savings from each product.

The advantage of having several on-farm storages is that the Taylors can choose to cover the storages with the greatest loss first. The Taylors have selected to investigate Dam 2 (as it is the primary irrigation storage and is usually full year-round) and Dam 3 (as it has the largest surface area and has the largest evaporation losses).

To understand how the surface area open to evaporation varies with depth of water in each of the Taylors dams, a numerical model (shown below) is used to calculate a "Storage Depth and Surface Area Curve".



Storage Measurements

Length of Dam Wall at Crest	L1	130 **metres**
Maximum Bank Height (H)	H	8 **metres**
Gully Cross-Section Coefficient at Dam Wall (C)	C	1.5 **coefficient**
Maximum Width of Water Across the Dam Wall (W)	W	130 **metres**
Maximum Depth of Water at the Dam Wall (D)	D	7 **metres**
Length of Longest Stretch of Water Surface (T)	T	85 **metres**
Gully Cross-Section Coefficient where Water Stored (C)	C	1.5 **coefficient**

Evaporation mitigation technologies

The size and construction on the four storages at Taylors Family Produce are suitable for a range of commercially available evaporation mitigation technologies (EMTs). Each EMT has a unique set of criteria that must be considered, as each storage is managed differently (see back page).

The four most relevant categories of EMT for Taylors' storages are: suspended covers, floating modular covers, floating continuous covers, and chemical monolayers.

1. SUSPENDED COVERS

Shade cloth covers, usually suspended above the top water level surface of the storage with a permanent structure and cable stays. The permeability of shade cloth allows rainfall to enter the storage.

2. FLOATING MODULAR COVERS

Floating modular covers vary in size, shape and construction. There are a number of commercial systems available. Modular systems use individual objects (modules) as barriers to reduce the surface area of water available for evaporation. They usually cannot achieve 100% coverage of the water surface and as such they allow rainfall to enter the water storage.

3. FLOATING CONTINUOUS COVERS

A continuous floating cover usually floats on the water surface or can be secured to the storage banks (or both). Covers currently available allow rainfall to enter the storage whilst also significantly reducing evaporation.

4. CHEMICAL MONOLAYERS

Monolayers are chemicals that can be applied to the water surface. Chemical monolayers act as a barrier to reduce the rate of evaporation. The application of chemical can be carried out manually but may be applied through an automated system.

Economics of evaporation mitigation

The evaporation savings of each EMT are variable depending on the storage and installation, but all have been proven effective at reducing losses from water storages. In addition to the site-specific characteristics, the critical value that farmers and irrigators must consider is the cost per megalitre of water ($/ML) saved for each EMT.

The online software tool, *https://evapadvisor.com/* can be used to undertake a site-specific economic assessment of EMTs at any location in Australia. This tool was used to assess the economics for a generic cover at both Dam 2 and Dam 3. with details summarised below.

The following tables indicate that a range of EMTs can be considered for the storages. Assumptions of capital cost and product efficiency are key determinants of product performance and affordability. For example, capital cost per unit area could reduce as storage size increases, given economies of scale. Product efficiency in reducing evaporation will depend on the specific design configuration and material used. For example, shade covers used for evaporation reduction come in a range of cloth densities (70% to 95%) affecting evaporation reduction performance, cloth weight and structural support cost. Floating continuous and modular covers vary in size, shape and design, and therefore product efficiency and cost. Chemical monolayers require sophisticated automated application strategies to achieve their potential in evaporation saving. A site-specific quote is essential and should be used to refine the economic analysis.

The decreased cost to save water on Dam 2 when compared with Dam 3, highlights the benefit of maintaining a high water level in a dam covered with a system of high capital cost.

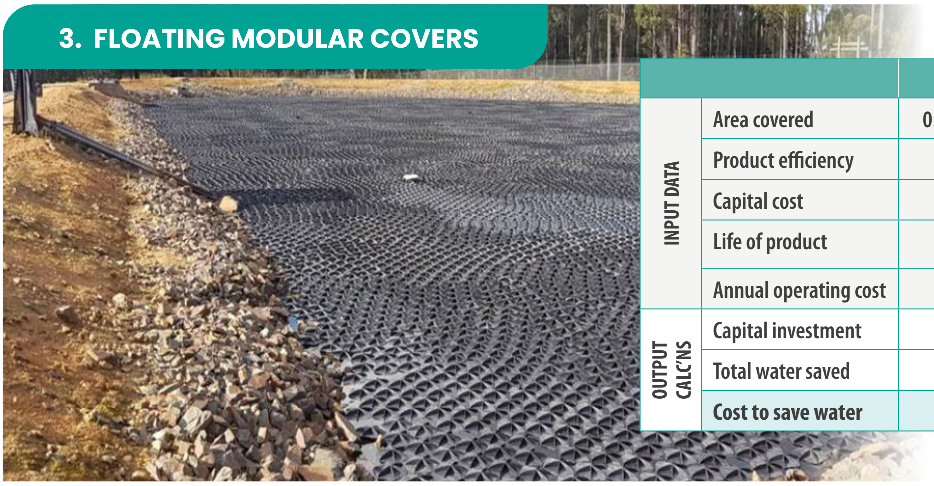
1. SUSPENDED COVERS

		DAM 2	DAM 3
INPUT DATA	Area covered	0.6 ha (100% of storage area)	3.3 ha (100% of storage area)
	Product efficiency	80%	80%
	Capital cost	$18/m^2	$18/m^2
	Life of product	30 years on structure 15 years on shade cloth	30 years on structure 15 years on shade cloth
	Annual operating cost	9c/m^2 (0.5% of capital)	9c/m^2 (0.5% of capital)
OUTPUT CALC'NS	Capital investment	$99,450	$620,100
	Total water saved	7.5 ML/annum	33 ML/annum
	Cost to save water	**$1,047/ML**	**$1,487/ML**

2. FLOATING CONTINUOUS COVERS

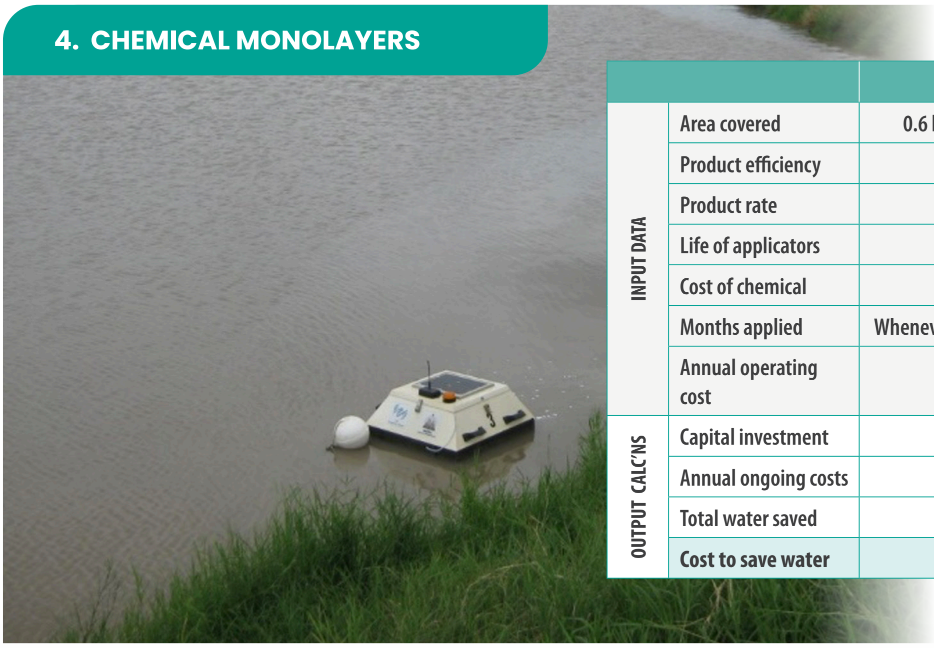
		DAM 2	DAM 3
INPUT DATA	Area covered	0.6 ha (100% of storage area)	3.1 ha (90% of storage area)
	Product efficiency	95%	95%
	Capital cost	$16/m^2$	$16/m^2$
	Life of product	10 years	10 years
	Annual operating cost	16c/m² (1% of capital)	16c/m² (1% of capital)
OUTPUT CALC'NS	Capital investment	$88,400	$496,080
	Total water saved	8.9 ML/annum	39 ML/annum
	Cost to save water	$1,430/ML	$1,820/ML

3. FLOATING MODULAR COVERS



		DAM 2	DAM 3
INPUT DATA	Area covered	0.6 ha (100% of storage area)	3.1 ha (90% of storage area)
	Product efficiency	70%	70%
	Capital cost	$25/m²	$25/m²
	Life of product	15 years	15 years
	Annual operating cost	12c/m² (0.4% of capital)	12c/m² (0.4% of capital)
OUTPUT CALC'NS	Capital investment	$138,125	$861,250
	Total water saved	6.5 ML/annum	29ML/annum
	Cost to save water	$2,166/ML	3,068/ML

4. CHEMICAL MONOLAYERS



		DAM 2	DAM 3
INPUT DATA	Area covered	0.6 ha (100% of storage area)	3.3 ha (100% of storage area)
	Product efficiency	30%	40%
	Product rate	10L/ha/week	10L/ha/week
	Life of applicators	15 years	15 years
	Cost of chemical	$15/L	$15/L
	Months applied	Whenever evaporation is >4mm/day	Only December - March
	Annual operating cost	1c/m²	5c/m²
OUTPUT CALC'NS	Capital investment	$1,381	$8,613
	Annual ongoing costs	$193	1,206
	Total water saved	2.1 ML/annum	7.1 ML/annum
	Cost to save water	$1,381/ML	$1,457/ML

Summary

Mitigation Technology	Strengths	Weaknesses	Opportunities	Threats
Structural Modification (increased wall height)	» One-off cost for long-term reduction in evaporative and seepage losses » Improves water management options for reducing evaporative loss » Easy to quantify water saving » No ongoing maintenance cost	» High up-front labour and mechanised plant costs » Requires additional infrastructure (pumps, pipes etc.) » Construction cost increases significantly with embankment height » May increase seepage rate	» Technical and practical design and construction experience is readily available » Opportunity to combine two shallow storages into one deep storage of same volume	» Regulatory limitations may restrict wall height » Farm distribution layout and conveyancing losses may offset water savings
Structural Modification (Storage cells)	» Allows water depth to be maximised while reducing surface area » Reduced wind action » Easy to quantify water saving based on reduced area » Particularly useful for reducing losses during periods of low water availability	» Lose volume (unless combined with increased wall height or external cells) » Effective if each cell is emptied completely » System has addtional operational costs (labour, energy)	» Technical and practical design and construction experience is readily available » Multiple cell management may be an advantage for the deployment of floating PV cells	» Farm distribution layout and conveyancing losses may offset water savings
Suspended Continuous Covers (eg. NetPro, Superspan, Canvacon)	» High evaporation reduction potential » Not affected by fluctuating water levels » Permeable, flexible cover allows rain ingress and debris removal » Easy access for pumping, water quality testing and maintenance » Low ongoing operating costs	» High up-front capital and specialist installation costs » High cable tension and support requirements limit option to storages < 5ha surface area (< 15ha with in-dam support) » Anchorage may be difficult in some soil types	» Cover selection for > 90% light exclusion substantially inhibits algal growth, improving potable water quality » Existing expertise and experience available for design and installation	» Specialist engineering skills required for design and installation
Floating, Continuous Covers (eg. Aquaguard, Daisy Dam Covers, Elite Pool Covers, Aquacon, Fabtech, Enviro Dam Covers, Layfields)	» Highest average evaporation reduction potential » Lowest variability in evaporation mitigation performance » Relatively easy to install and remove » Guidelines and Standards are available for cover selection	» High capital and maintenance costs » High winds can damage cover » Multiple small drainage holes required and may reduce efficacy » Use of covers limited to < 2ha » Debris build-up may damage fabric and cause submergence » Tethering may be required to stabilise cover » Access to storage basin may be difficult	» Reduces light penetration and potentially reduces algal growth » Applicable for use on treated waste water storage dams	» Adversely affects aquatic ecology and wildlife access » Cover must be removed for storage basin maintenance » Water saving will not be realised when sorage is dry

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Mitigation Technology	Strengths	Weaknesses	Opportunities	Threats
Floating, Modular Covers (eg. Aqua Armour, AquaCap, E-EvapCap, Hexa-Cover, Evapo-Control, NeoTop)	» Progressive purchase spreads cost over time » Individual modules can be repaired or replaced » Lightweight, easy to install » Long-term evaporative reduction is proportional to the surface area covered	» Very high capital cost » Difficult to completely cover surface area » Limited to storages < 10ha » Modules may stick in mud » Attached algae may affect water quality » Modules physically disrupt wildlife	» Easy to install and maintain » Reduced light transmission may improve water quality	» Modules may be beached by high wind and wave action
Floating, Photovoltaic Covers (eg. Ciel et Terre, FloatPac Solar, Global NRG Afloat Solar, DNV GL, Suntrix Solar)	» Reduces land footprint of solar power generation » Provides on/off-grid power for pumping etc » Long-term evaporative reduction is proportional to the surface area covered	» No guidelines available to reduce risk associated with power conveyance over water » Very high capital cost and technical expertise required for design and installation	» Off-grid power will reduce pumping costs » Reduced panel temperature improves power generation efficiency	» Very few case studies documented to-date » Greater safety risks in conveying power over water » Floats often sold separately to PVs
Mono-Molecular Chemical Films (eg. WaterSavr)	» Bidodegradable, ultra-thin film with low environmental impact » Low capital outlay and intermittent application for medium to large storages » Autonomous applicators improve cost-effectiveness » Low risk investment for ephemeral storages as product applied only when needed » Potentially viable system for large storages (> 10ha)	» Requires repeat application under specific wind conditions » Products are susceptible to indirect photo degradation » Very limited range of commercially available products and applicators » Low and highly variable evaporation reduction potential » Monitoring of presence of product and performance is very difficult » Not suitable in windy locations	» Monolayer film can be applied to small, medium or large storages up to 100 ha » Food-grade compounds degrading in 2-3 days minimises adverse impact on ecology and recreation » Application can be reserved for critical water management times » Products can potentially be matched to suit different water	» Technical advice is required to select the product, the number of applicators and timing of application required for a specific water storage » Environmental quality concerns » Actual performance and water saving is less certain
Multi-Molecular Chemical Films (eg. WaterGuard by Aquatain)	» As above for mono-molecular » Longer half-life than monolayer » Requires fewer repeat applications	» As above for mono-molecular » Thick slick at surface may reduce oxygen diffusion » Physical slick may adversely affect aquatic ecology » Very limited product range	» As above for mono-molecular » Product may be applied by aircraft » Application can be reserved for critical water management times	» As above for mono-molecular » Mode of operation is different to monolayers, with greater environmental risk

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