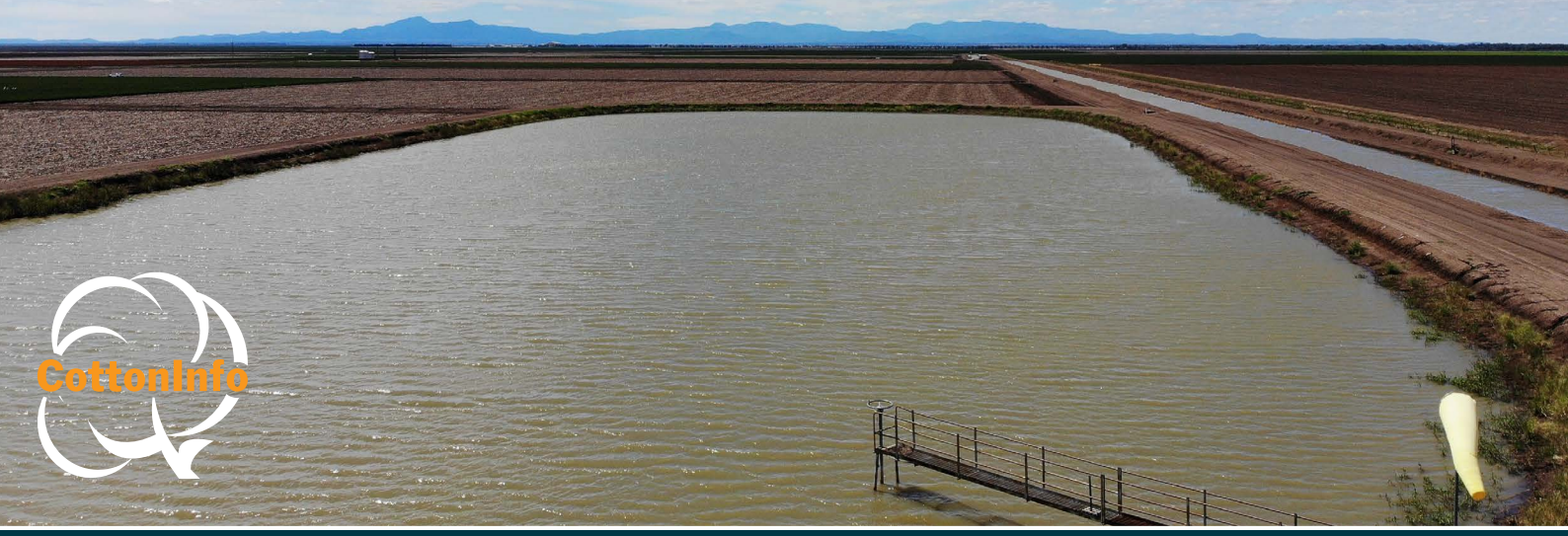

On-farm storage:

Minimising evaporation & seepage losses

On farm storages are the largest source of water loss on most irrigated farms.

If you live in the Moree district in north west NSW for example, and have held water in your farm storage for twelve months, you could be losing as much as two metres of water from the storage surface due to evaporation.

In a 20 hectare storage, this would amount to 400 megalitres. In fact keeping water in this storage for just the month of January, when the water level can drop by as much as 300 mm, could mean a loss of up to 60 megalitres.

Calculating storage losses:

Potential monthly evaporation can be easily determined by using the Monthly Evaporation Calculator developed by the National Centre for Engineering in Agriculture. The calculator is available online on the University of Southern QLD website at: http://readyreckoner.nceaprd.usq.edu.au/

The Monthly Evaporation Calculator allows you to specify the location and surface area of the storage to generate the potential volumetric monthly evaporation (Figure 1).

Using the Calculator can give an almost instant estimate of the losses you can expect in coming months. This information will assist in making effective decisions about how to best manage your water. The calculation is based on 30 years of climate data (1961-1991). Actual evaporation will vary due to changes in water surface area and the weather conditions that occur.

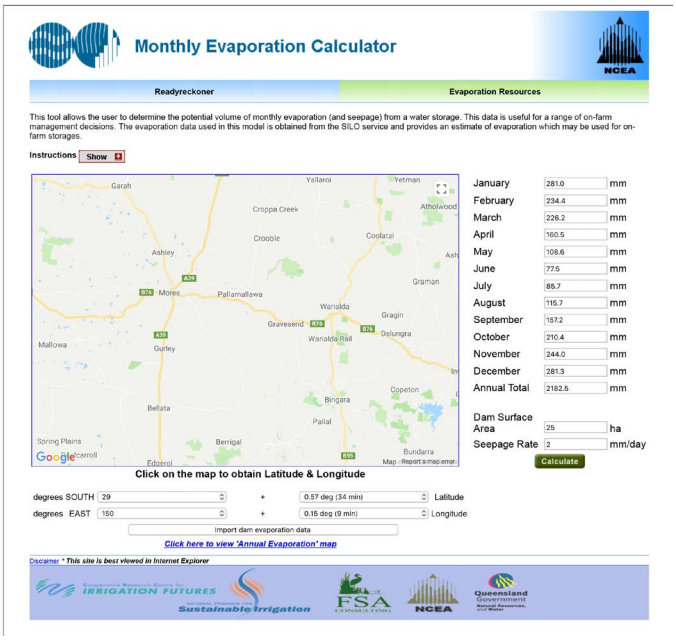

Figure 1: Using the online Monthly Evaporation Calculator, specify the location of your farm, then click "import farm evaporation data" and enter your dam surface area to calculate megalitres of water lost.

Result

Months	Evaporation		Seepage		Total Monthly Loss	
January	72.6	ML	15.5	ML	88.1	ML
February	60.6	ML	14	ML	74.6	ML
March	58.6	ML	15.5	ML	74.1	ML
April	41.6	ML	15	ML	56.6	ML
May	28.1	ML	15.5	ML	43.6	ML
June	20.1	ML	15	ML	35.1	ML
July	22	ML	15.5	ML	37.5	ML
August	29.9	ML	15.5	ML	45.4	ML
September	40.6	ML	15	ML	55.6	ML
October	54.6	ML	15.5	ML	70.1	ML
November	63.3	ML	15	ML	78.3	ML
December	72.7	ML	15.5	ML	88.2	ML
Annual Total	564.7	ML	182.5	ML	747.2	ML

Figure 2: Seepage rates, if known, can also be entered in the Monthly Evaporation Calculator to create a table of evaporation and seepage losses in megalitres.

Metering to estimate seepage:

Modern storage meters have increased in accuracy with the inclusion of highly accurate pressure sensitive transducers. The transducer is installed under the water and is able to measure very small changes in water level.

An accurate analysis of seepage and evaporation can usually be calculated from approximately 20 days of quality data recorded during a period when there is no water flow into or out of the storage.

The meter will measure the depth, volume and surface area when there is no water being pumped in or out of the dam, creating a pattern of volume records that will demonstrate a slope of loss (Figure 3).

Alternatively a radar sensor can be used to measure storage volumes, with an accuracy of +/-5mm. Evaporation can be measured when used in conjunction with on-farm weather stations.

A meter can be used to determine the amount of water pumped into a storage and at what rate. Similarly the meter can measure the amount of water used during an irrigation event, during a pumping event after rainfall, or when pumping water from the tail water return system back into the storage.

Using the meter to measure both inflow and outflow rates during a pumping event is also a good way to check the performance of your pumps.

What is an acceptable level of seepage?

It is almost impossible to eradicate all seepage loss. A well-constructed dam with heavy clay will generally lose a millimetre or less per day.

A storage meter can accurately analyse seepage and evaporation (Image: P. Verwey)

Figure 3: Storage Meter data measuring storage volume continuously over time (J. Purcell, Aquatech Consulting Pty Ltd).

A dam that is silty and sandy can lose 2-5 millimetres per day. Once seepage loss exceeds 5 millimetres per day, intervention is recommended (Table 1).

Research undertaken in a 2011 Cotton Storages Project[1] gathered data from 136 on-farm water storages which were evaluated for seepage and evaporation.

Table 1: Rates of storage seepage and triggers for intervention

<1mm/day	Excellent
<2mm/day	Good
2-5mm/day	Acceptable, not worth fixing
5-10mm/day	Probably worth investigating with a view to repairing
>10mm/day	Start remediation investigation ASAP

(**Source:** Aquatech Consulting)

Most storages in the study (120 of 136 storages) recorded seepage of less than 4 mm per day, a rate that could be considered low, with the majority of these (89 storages) recording seepage of less than 2 mm per day. A single outlier existed for a storage that was known to leak very badly where seepage of 38 mm per day was confirmed.

A summary of the research results is provided below (Table 2):

Table 2: Summary of key data

	Mean	Minimum	Maximum
Seepage (mm/day)	2.3	0	38.1
Evaporation m/year	1.52	1.03	2.18
Dam Factor (k_{dam})	0.97	0.67	1.31
Storage Size (ML)	1950	75	14,000
Storage Size (ha)[1]	44	1	303
Water Depth (m)[2]	3.5	1.0	9.1

(**Source:** Cotton Storages Project 2011, Storage Seepage & Evaporation, Cotton Catchment Communities CRC)

[1] Area data not available for the 4 storages located in Central Queensland
[2] Depth of water in storage at the time of equipment installation, not the depth of the storage

Managing storages to minimise evaporation:

Simple management options include transferring water between storages to combine water from multiple storages into a single source, or move water from a large, partly full storage into a smaller storage. These strategies will reduce the surface area subject to evaporation and the wetted area of the storage exposed to seepage.

On average it will cost about $1.10 per megalitre to pump water from one storage to another, making storage transfers a cheap management option. The aim is to reduce the total surface area of water to minimise the potential for water loss due to evaporation.

You might even consider applying water to fields in preparation for the next season's crop rather than leaving it to evaporate in the storage.

Remediation strategies to reduce storage losses:

The Evaporation and Seepage Ready Reckoner (http://readyreckoner.nceaprd.usq.edu.au/readyreckoner.aspx), on the USQ website, can be used to determine the cost effectiveness of various evaporation and seepage remediation options.

Structural works to reduce evaporation include dividing large storages into cells, to reduce the overall surface area[2].

Increasing the wall height of a storage, while maintaining the stored volume, is an effective strategy to reduce evaporation losses[3].

An on farm water storage split into cells to reduce evaporation (Image: J. Montgomery)

Problem seepage sites can be identified using EM (Electromagnetic Magnetic induction) surveys and physical inspection using test holes or by excavating soil pits. Once a seepage problem is identified the next challenge is to determine the nature of the seepage loss.

Most seepage problems occur in discrete locations rather than uniformly across the storage floor. Such problems are often due to the presence of small sections of sand or gravel in the soil.

Remediation techniques include clay lining and compaction. Where good natural clay is available close to the site, clean the area where seepage occurs then cover with about 0.5 to 0.75 metres of compacted wet clay.

Bentonite is a type of clay which has significant shrink-swell characteristics that results in very low permeability when wet, and can be used to help seal a seeping storage floor. Bentonite suppliers should provide advice regarding the best method for specific applications and soil types.
Common methods of application are:

- Pure Blanket: a layer of pure bentonite of around 10mm is used with a protective compacted covering of soil
- Mixed Blanket: Bentonite is incorporated into the existing soil at a rate of around 50 to 150 t/ha depending upon the existing soil characteristics.
- Broadcast: Bentonite is applied to the surface of a storage which contains water and allowed to settle to the bottom.

Further information:

- View the *On-farm storages: minimising evaporation and seepage losses* video, featuring Jim Purcell of Aquatech Consulting www.youtube.com/watch?v=uOWO4T7iLXI
- Contact CottonInfo irrigation technical lead & NSW DPI research and development officer irrigation, Ali Chaffey: 0439 326 601, ali.chaffey@dpi.nsw.gov.au

Thanks to Jim Purcell, Aquatech Consulting, Narrabri for providing information for this article. Information in this fact sheet has also been sourced from the following:

- ReadyReckoner, Economic Ready Reckoner - Evaporation Mitigation Systems (2009). NCEA USQ, http://readyreckoner.nceaprd.usq.edu.au
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- Storage Seepage & Evaporation: Final summary of results (Cotton Storages Project 2011), Cotton CRC http://eprints.usq.edu.au/23245/1/87551_NCEA-Storage_Seepage_%26_Evaporation_8pp_Bklet_PRF.pdf

The Australian Government is providing more than $13 billion for implementation of the Murray-Darling Basin Plan and associated activities, with the vast majority (more than $8 billion) being made available for modernising infrastructure and water efficiency improvements. The Sustaining the Basin: Irrigated Farm Modernisation Program is funded from this initiative.

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1. Storage Seepage & Evaporation: Final summary of results http://eprints.usq.edu.au/23245/1/87551_NCEA-Storage_Seepage_%26_Evaporation_8pp_Bklet_PRF.pdf
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