NATIONAL PROGRAM FOR Sustainable Irrigation

Research Bulletin 5

October 2006

# New Tools for Measuring Evaporation from Farm Dams

## Evaporation losses from farm dams are a major potential area of real water savings.

While it is difficult to accurately measure the water losses from evaporation on farm dams, a scoping study funded by the National Program for Sustainable Irrigation estimated the loss is as high as 7,000 gigalitres per year from Queensland's section of the Murray-Darling Basin alone (Watts, 2005). The total amount extracted in the whole of Australia from our waterways for all purposes is around 20,000 gigalitres per annum – so it is easy to see why potential savings are worth pursuing.

This bulletin describes the results of a modelling study of evaporation from farm dams and a 'ready reckoner' in the form of a spreadsheet that:

Calculates the cost of installing an evaporation reduction system

Calculates how much water is saved from evaporating.

## Systems for reducing evaporation

Systems that reduce evaporation from farm dams need to:

- Reduce the amount of energy available to cause evaporation,
- Restrict the boundary layer at the water surface, or
- Modify the wind and humidity above the water surface.

The state of the current evaporation reduction systems was summarised by Watts (2005).

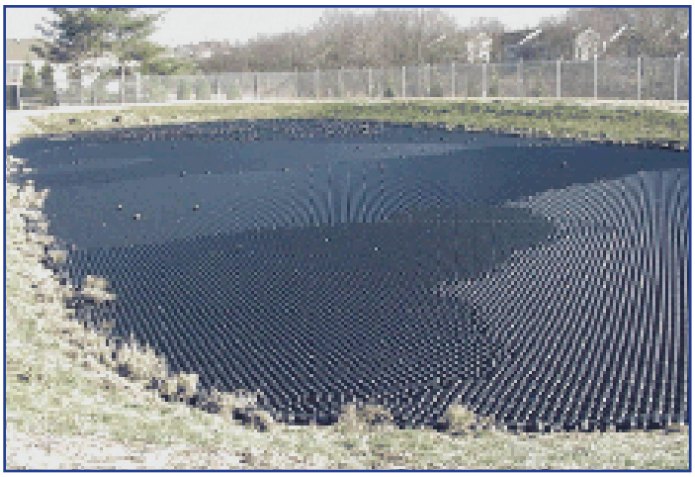
In brief:

1. Monolayers (a chemical film over the water surface) have a long history and, despite many attempts, have not been shown to be viable and effective in the long term (Brown 1988). Retreatment is required every two to four days, depending upon the amount of turbulence on the water surface (NPSI, 2005). Their evaporation reduction efficiency varies from 0% to 40% but the reasons for this variability have not been fully studied. However, monolayers may be the only solution for dams with a large surface area.
2. Emergent or floating vegetation does not offer an effective solution.
3. Various floating, modular devices are effective (60% to 90% reduction) and offer viable solutions in some circumstances. However, there are cost and practical limitations.
4. Complete (air-tight) surface covers are expensive and pose significant practical problems for larger dams (including unknown ecological effects).
5. Shade cloth is probably the best-bet option at this stage. It provides a significant evaporation reduction (70%) and is not reliant on a 'perfect' seal over the dam surface. Rainfall can easily enter the dam. If further practical design work can reduce capital costs, then shade cloth covers will become viable in an increasing number of situations.

Examples of various covers are shown in Figure 1 a,b,c.

a. Shadecloth

b. Impermeable cover



c. Modular cover

***Figure 1.*** *Examples of evaporation mitigation systems. a. Shadecloth cover. b. Impermeable (plastic) cover. c. Modular cover.*

## Night time evaporation

A modelling study by Hipsey (2006) explored the likely contribution of night-time evaporation to the total evaporation from an area.

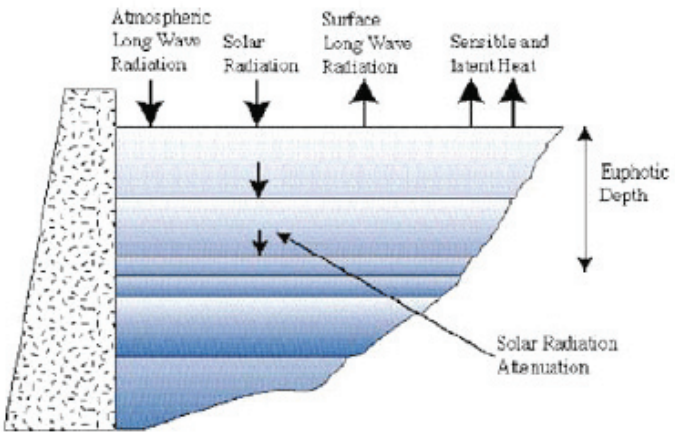
Using a Dynamic Reservoir Simulation Model (DYRESM), ten test (modelled) dams in 4 different climatic regions suggest that, irrespective of a dam's size or the climatic region it is located in, between 35-45% of the total annual loss of water through evaporation was during the night, i.e. in a climate where potential evaporation is approximately 1.5 m / year the night time fraction equates to roughly 0.6 m / year.

Although the magnitude of the variation differed between regions, all simulations showed significant seasonal variability in the night time fraction of evaporation. In particular, it was predicted that the night time contribution increased considerably during the winter months, with all sites showing the fraction increasing to 55 – 70%.

Overall however, the analysis concluded that the fraction of evaporation occurring during the night time is largely insensitive to climate or dam shape. Evaporation mitigation strategies should therefore target the driving mechanisms causing the evaporative flux by reducing wind speed, and limiting solar heating.

The overall volume lost through evaporation as a fraction of the total dam water balance can be minimized through careful storage design (i.e. minimizing the surface area to volume ratio).

***Figure 2.*** *Surface thermodynamic processes modelled by DYRESM.*



All simulations showed significant seasonal variability in the night time fraction of evaporation. In particular, it was predicted that the night time contribution increased considerably during the winter months, with all sites showing the fraction increasing to 55 –70%. This increase correlated well with an increase in the number of low wind hours and local instability over the water surface suggesting an increased frequency of free convective losses is responsible. Nonetheless, it is emphasised that despite the winter increase in the night time evaporation fraction, the overall magnitude and importance of the night time losses decreases from summer to winter, as does the day time component.

Hipsey (2006) concludes that the study has highlighted several key design considerations for farm dams. First, availability of necessary meteorological data is important for evaporation flux estimates. In this study, the focus was mainly on relative differences, but for actual design projects, access to accurate solar radiation and cloud cover (or long wave radiation) data will improve evaporation predictions. Secondly, night time evaporation should always be accounted for in water balance investigations and during the design of evaporation amelioration strategies. In particular evaporation estimation methods that rely solely on solar radiation, or use night time water level decline to calculate seepage, will be erroneous. Finally, the results highlight that evaporation rates are not significantly impacted by storage configuration, although the overall volume lost through evaporation as a fraction of the total dam water balance can be minimised through careful storage design, for example through siting the dam to minimize its exposure to winds from the dominant direction. It should also be noted that although a large fraction of evaporation occurs outside of sunlight hours, mitigation strategies that reduce solar radiation input would still be effective over the entire day since the surface water temperatures will be lower.

## The economics of reducing evaporation

A simple computer spreadsheet model has been developed (Heinrich and Schmidt, 2006) that enables the user to enter the dimensions of various types of dams (tanks), the pan evaporation data (linked from another website), the seasonal variation in the capacity of the dam, and the costs of any evaporation mitigation technologies. The spreadsheet then calculates the amount of evaporation saved (to the nearest 100 000 litres), and the cost of doing so. A detailed manual, including case studies from around Australia, provides a helpful reference document so that users can check that their own data entries are within plausible orders of magnitude.

To calculate the amount of water saved and the cost of saving the water, the user enters information on the following areas:

- Storage Type and Geometry
- Evaporation
- Average Amount of Water Stored per Month
- Average Percentage of Years that the Storage Contains Water
- Seepage Information, and
- Evaporation Mitigation System Information.

***Figure 3.*** *An example of the data entry required by the spreadsheet for a rectangular water storage.*

| | | | | |
|---|---|---|---|---|
| 5 | | Step 1 - Select Storage Type (click on adjacent cell) | Rectangular Ring Tank | SHOW INPUT PARAMETERS |
| 6 | Clear 'Storage' Data Fields | | | |
| 7 | | Complete the required fields for your Storage Type (Unnecessary fields do not need to be left blank) | | |
| 8 | | Enter Storage Data (Rectangular Ring Tank) | | |
| 9 | For further guidance on any of these Storage parameters, see the relevant diagram on the 'Diagrams' sheet | Length @ Centreline | 500 | metres |
| 10 | | Width @ Centreline | 200 | metres |
| 11 | | Corner Radius @ Centreline | 40 | metres |
| 12 | | Storage Wall Crest Width | 8 | metres |
| 13 | | Average Bank Height | 5 | metres |
| 14 | | Batter Slope of the Storage Inside Wall | | in 1 |
| 15 | | Batter Slope of the Storage Outside Wall | | in 1 |
| 16 | | Full Supply Volume | | ML |
| 17 | | Freeboard | | metres |

While most information can be obtained from measurements of the dam or estimates (such as seepage), information on the evaporation at a site is able to be imported from the SILO database, created by the Queensland Department of Natural Resources, Mines and Water. The evaporation for any site in Australia can be downloaded and saved to the user's computer. The only information required is the location (latitude and longitude) of the water storage in question, which can be readily obtained by going to the Geoscience Australia website which has a location finder tool (at www.ga.gov.au). Links to these sites are available from the front page of the Ready Reckoner.

Up-to-date costs of particular evaporation mitigation systems can be obtained from suppliers and added in to the spreadsheet. The spreadsheet provides, for the first time, a tool that enables irrigators to determine the economics of evaporation mitigation technologies for their particular situation.

## References


Heinrich, N. and Schmidt, E. (2006). Economic Ready Reckoner for Evaporation Mitigation Systems Reference Manual.NPSI Final Report USQ11. 113 pp. **http://www.lwa.gov.au/downloads/publications_pdf/ER061197.pdf**

Hipsey, M. R. (2006). Numerical investigation into the significance of night time evaporation from irrigation farm dams across Australia.NPSI Final Report UWA45. 46 pp. **http://www.lwa.gov.au/downloads/publications_pdf/ER061198.pdf** Full report: **http://www.lwa.gov.au/downloads/publications_pdf/ER061199.pdf**

NPSI, (2005). Controlling evaporation losses from farm dams.NPSI Fact Sheet 2005/4. 2 pp. **http://www.lwa.gov.au/downloads/publications_pdf/PF050873.pdf**

Watts, P. J. (2005). Scoping study - Reduction of Evaporation from Farm Dams. Final report to the National Program for Sustainable Irrigation.NPSI Final Report FSA1. 79 pp. **http://www.lwa.gov.au/downloads/publications_pdf/ER050936.pdf**



**NPSI Research Bulletin 5 (October 2006)**

**New Tools for Measuring Evaporation from Farm Dams**

This research project is supported by the National Program for Sustainable Irrigation – a Program that focuses on research that will drive the development and adoption of sustainable irrigation practices in Australian agriculture.

NPSI is managed by Land & Water Australia on behalf of its fourteen partners. The partners include irrigators, water authorities, research agencies, state and Commonwealth departments and commodity groups.

Product code: PK061214
ISBN: 1921253215


NATIONAL PROGRAM FOR Sustainable Irrigation