Optimising the design, installation and operation of a monolayer application system on a farm dam via a 'Universal Design Framework'

Gavin Brink[1,2*], Andrew Wandel[1], Pam Pittaway[2], Nigel Hancock[1,2]and Erik Schmidt[2]

[1] Faculty of Engineering and Surveying, University of Southern Queensland, West Sreet, Toowoomba, Qld 4385, Australia
[2]National Centre for Engineering in Agriculture, University of Southern Queensland, West Sreet, Toowoomba, Qld 4385, Australia
* correspondingand presenting author, brink@usq.edu.au

Summary

Monolayer technologies can potentially provide a cost effective solution for reducing evaporation losses from farm dams. As every dam will have it's own set of environmental characteristics and user requirements, this needs to be considered holistically in order to determine a suitable monolayer material, application system and application strategy. Hence, a Universal Design Framework (UDF) was developed to enable this approach and to optimise the evaporation suppressing performance of monolayer. This paper details theUDF approach.

Introduction

When a chemical monolayer film,only tens of nanometers thick,is used on a farm dam it is subject to transport and/or removal by wind, submergence by waves, damage by rain and biological degradation (Frenkiel 1965). Due to the nature and complexity of these interactions and the fact that these conditions will vary through time and between locations, a Universal Design Framework (UDF) wasdeveloped (Brink et al. 2011). The UDF recognises that every reservoir will have a unique set of user and environmental considerations that need to be considered holistically in order to determine a customised solution. Towards this objective the UDF is used in two modes; in**planning mode**, to inform monolayer material selection, monolayer application system design, including number of applicators and their arrangement on-site; and in**operational mode**, to inform the application strategies to be implemented on site on a time-step (i.e. 15 minute, 30 minute or hourly) basis according to prevailing weather conditions.

Methods and Materials

The UDF takes into account a number of key factors that influence monolayer performance. These inputs are as follows:user performance criteria,water storage factors, monthly climate data, and water quality and biological factors.Once this information has been specified by the user, it is usedinthree key analyses:

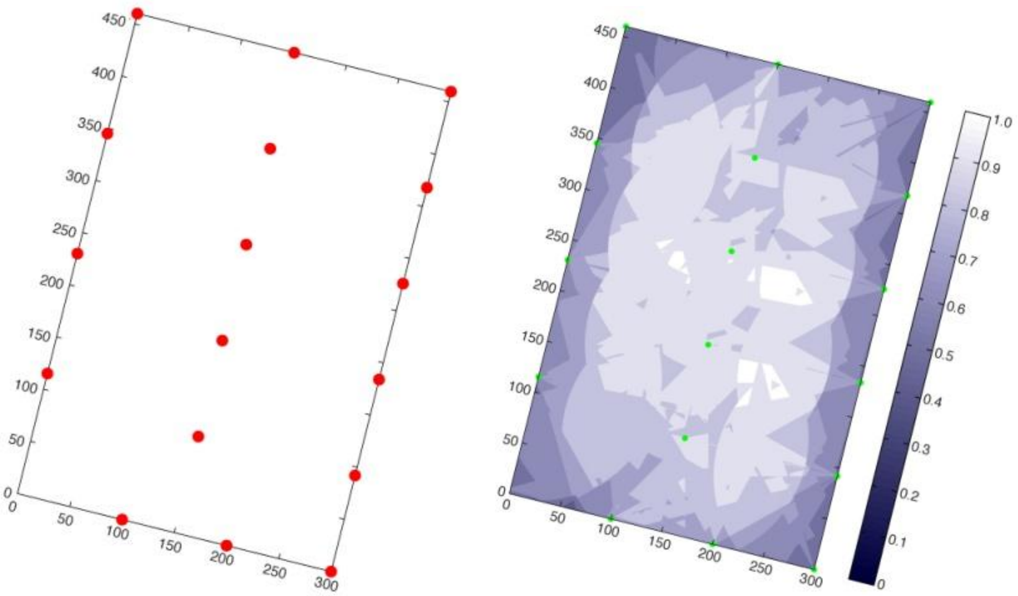
1. monolayer product is selected via a decision tablewhich allows the user to make comparisons between three previously benchmarked South East Queensland reservoirs and their own, to determine a best match monolayer material;
2. application systemdesignis determined with a simulation platform, which allows the user to model surface coverage and application rate for different wind conditions. The process is often iterative, where the number and/or location of applicators may be changed for each run until user performance criteriaare met.
3. application strategies are also determined with the simulation platform, but this time using a greater number of wind conditions. The information output by the simulation (i.e. which applicators to use and their respectiveapplication rate for

each wind condition)are used as a decisiontable to inform the real-time application strategies on-site;

To demonstrate the UDF methodology, a rectangular ring tank water storage with a 13.8 ha surface area, located in Amberley, Queensland, was selected for analysis.This dam is fairly indicative ofthe types of storages to be found throughout many agricultural areas in Australia and, due to its size (i.e. >10 ha), is particularly suited to monolayer use for evaporation mitigation (Craig 2007).

Results & Discussion

The overriding key water quality indicator at this site wasthe presence of algal bloom's, thus there isa high chance of the presence of monolayer-degrading bacteria (Pittaway & van den Ancker 2010). Therefore, the most suitable product for this storages water quality and biological characteristics is C18OH.At Amberley the majority of wind is predominately from the East and North East, therefore,the general approach is to concentrate applicator numbers near these sides of the storage(Figure 1a). In addition, many more applicators are typically required near the shore of the storage as this maximises cover, whereas, applicators within the storage generally reduce the time taken to achieve cover. After a number of simulations were run,a suitable applicator arrangement comprising 17 applicators was settled uponas this arrangement satisfied the user-specified 60% minimum surface cover at least 90% of the time(Figure 1b). Control of dosage rates from each applicator every 15minutes wasinformed by prevailing wind speed and direction.



(a) (b)

Figure 1: Thecustomised application system as determined through iterative simulations: (a) Illustration of the applicator arrangement comprising 17 applicators with more applicators on the Eastern shore than on the Western shore due toAmberley's prevailing wind conditions; (b) Contour plot detailing the distribution of cover and the percentage of time that cover is achieved by this arrangement.

Through the holistic approach provided by the UDF it is believed that the evaporation suppressing performance of monolayer will be optimised according to a user's site-specific conditions and requirements.

References

Brink, G., Wandel, A., Pittaway, P., Hancock, N. and Pather, S. (2010), A `universal design framework' for installation planning and operational management of evaporation-suppressing films on agricultural reservoirs, in `International Conference on Agricultural Engineering'.

Craig, I., Aravinthan, V., Bailee, C., Beswick, A., Barnes, G., Bradbury, R., Connell, L., Coop, C., Fellows, C., Fitzmaurice, L., Foley, J., Hancock, N., Lamb, D., Morrison, P., Misra, R., Mossad, R., Pittaway, P., Prime, E., Rees, S., Schmidt, E.,Solomon, D., Symes, T. and Turnbull, D. (2007), `Evaporation, seepage and waterquality management in storage dams: A review of research methods', Environmental Health **7**, 81-94.

Frenkiel, J. (1965), Evaporation reduction: physical and chemical principles and review of experiments, UNESCO, Paris, France.

Pittaway, P. A. & van den Ancker, T. R. (2010), `Properties of natural microlayers on Australian freshwater storages and their potential to interact with artificialmonolayers', Marine and Freshwater Research **60**, 1083-1091.