Application Systems for Optimal Management of Monolayer Films

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Water Loss Project

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INTRODUCTION

• Recent focus on evaporation suppression has been driven by drought and water scarcity
• Commercial structural solutions are available
• Cost and performance issues remain
• Monolayer systems provide opportunity
MONOLAYER SYSTEMS

- Monolayers - chemical films one molecule thick (2nm)
- Formed at a phase boundary of the water air interface.
- Long chain molecules with hydrophilic base and hydrophobic stem.
- Typically long-chain fatty alcohols (e.g., Hexadecanol C16 and Octadecanol C18), self-spreading on contact with water.
- Natural long-chain components of plant material, thus biodegradable by microbial and photochemical processes.
- Disruption of structure and packing of molecule by wind and wave.
- Require tightly packed molecules to achieve surface pressure of greater than 30mN/m across water body.
Monolayer Systems

- Monolayer systems must consider
  - Product
  - Application of Product
FOCUS OF THIS PAPER

• Development of application systems for optimal management of monolayer films

• Deployment at Logan’s Dam (Gatton)
DEPLOYMENT PLANNING FOR THE APPLICATION SYSTEM

• Scale of storage – surface area/shape
• Local topography and microclimate
• Climate (evaporation, rain, temp, wind)
• Water quality and biological factors
• Product selection and characteristics
• Economics – Value of water
• “Universal Design Framework for Monolayer Application”
EVALUATING MONOLAYER MOVEMENT BY WIND

- Video Camera
- 5.8m Diameter Water Tank
- Fan
- 2.7m Wide Air Duct
EVALUATING MONOLAYER MOVEMENT BY WIND

\[ y = -0.0009x^2 + 0.2106x - 0.0088 \]

\[ R^2 = 0.94898 \]

- Spreading rates (0km/h wind speed)
- Dispersion angles (range of wind speeds)
- Drift rates (for a range of wind speeds)
MODELLING SPREADING OF MONOLAYER ON STORAGE

Maximum Surface Coverage Achieved (wind direction from the East)

Time Taken to Achieve Maximum Coverage (wind direction from the East)
MODELLING SPREADING OF MONOLAYER ON STORAGE

Distribution of Wind Speed Occurrences

Coverage of Logans Dam 6 Hr Continuous Application Period

- UQ, Gatton wind speed data (16/07/02 - 02/07/10)
MODEL LIMITATIONS

• The model is unable to account for dynamic wind conditions. Specifically:
  – Wind speed and direction are assumed constant both across the storage and throughout the period of application for any individual simulation.
  – Each wind speed and direction condition is considered separate and every simulation starts from zero coverage.

• Any product that reaches a downwind shore is beached and permanently lost.

• The effect of wave submergence is not considered.

• Any biological degradation effects are not considered.

• Application rate is constant and therefore can be considered analogous with loss rate (once steady-state has been reached). As product beaches, it is applied at the same rate.
• Nine liquid based floating applicators
• Decision rules to control dosage
  – On site conditions
  – Required dosage for each applicator (wind direction and velocity)
  – Frequency and rate
APPLICATION SYSTEM DEVELOPMENT AND DEPLOYMENT

Monitoring
Of the prevailing weather conditions and the presence of monolayer

Control System
For real-time analysis to calculate how much monolayer to apply and when to apply it

Application
Of monolayer by the application points within the reservoir
Floating Monolayer Application System

- 9 Applicators deployed at Logan’s Dam (16Ha)
- Dosage Rate
  - 1.75L/Ha/Day = 28 L/day
- Semi-continuous dosing
  - 292ml / 15 min
- Dosing commenced
  - Monday 21st March
Floating Monolayer Application System

- **On-Site Co-ordinator**
  - Wind speed & direction inputs
  - Smart decisions for maximum effectiveness
  - Dosage divided between applicators positioned upwind
  - Dosing stops at wind speeds greater than 25km/h
RESULTS FROM LOCAL TRIALS

• Application Period 21-29 March 2011
Product Management Issues

Installation of a floating containment grid:

- Monolayer is largely contained within each cell and is available to re-spread
Monolayer Performance

- Scintillometer and Eddy Covariance measurements and modelling have been undertaken by CSIRO and the University of Queensland to determine monolayer performance.
CONCLUSIONS

• Improved formulations of monolayer products are a prerequisite for reliable water savings.
• Smart application systems for monolayer deployment capable of adjusting the rate and location of monolayer application according to weather conditions will assist in achieving required savings.
• Improved formulations are being developed by CRC Polymers for trials at Logan’s Dam.
• Revised application strategies will need to be calibrated for future monolayer products
  – in particular the frequency and rate of dosing.
Urban Water Security Research Alliance

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THANK YOU

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