Estimation of seepage losses from automated irrigation distribution channels during periods of shutdown

A dissertation submitted by

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ABSTRACT

Irrigated agriculture is the largest water consumer all over the world as well as in Australia. Therefore, managing water more effectively in irrigation distribution systems is one of the most important and urgent challenges facing Australia. The correct estimation of conveyance water losses from an irrigation system is vital for the proper management of the system. The loss of water due to seepage, leakage and evaporation from irrigation channels constitutes a substantial part of the usable water. The scarcity of water resources and inefficiency of irrigation infrastructures convinced the Australian government to pursue modernization and automation of irrigation distribution supply networks in major irrigation districts of the country. The automation includes installation of automatic control structures with remote monitoring, one example of which is the total channel control technology (TCC) of Rubicon Water. Main objectives of using automation are to supply water near-on-demand and to control channel water levels. TCC includes supervisory control and data acquisition (SCADA) technology which will result in integrated databases of real time measurements of flow and water levels for the whole system. This data has the potential to be used to identify sections of channel with high rates of seepage or leakage. Pondage tests are acknowledged as the best direct method for seepage measurement, and the recorded water level data from automated systems during periods of gate closure can be treated as pondage test data. A comprehensive review of seepage studies identified examples of the successful application of TCC data from a limited number of selected channels during certain periods of season. However, no study was located that used TCC data collected over the whole irrigation district or for whole irrigation seasons to estimate seepage and leakage losses during periods of gate shut down. Given that Coleambally Irrigation Corporation Limited was the only scheme able to provide data for three irrigation seasons, this study aimed to estimate seepage and leakage losses for the entire channel network of CIA using TCC data during periods of gate closure. Using Microsoft SQL server, a database containing the TCC data in the form of individual tables was created. A model consisting of the database and code written in C# was developed to identify all pondage conditions for any given pool in the network, to sort the pondage data into rejected and accepted samples based upon set criteria. Linear regression was used to give an estimate of the seepage rate for any gauge in a pool during a pondage condition. The
model was tested for the 2010/11 irrigation season and identified 1073 pondage conditions for different pools on the network, among which 295 were rejected as they did not meet the specified criteria. The model was also applied for 2009/10 and 2011/12 seasons and average seepage rates for each pondage and pool were estimated.

The results clearly showed that seepage losses from the CIA are significant, with approximately 20% of the estimated seepage rates in all three seasons greater than 0.5 mm/hr (12 mm/d). A number of cases with significantly high loss rates were observed during each season. The median seepage rate for 2011 was lower in comparison with the other two seasons, while the median seepage rates were similar between the 2009 and 2010 seasons.

A number of pools with several pondage conditions were identified and the possible factors affecting the estimation of seepage rates were evaluated. These include, duration of gate shut down, surface water elevation at the start of the pondage condition and its relation to supply level of the channel at each gauge, accumulated depth of rainfall during the pondage period, seasonal variations in seepage rate, number of water level measurements in the pondage, suspected unauthorized water usage, noise associated with measurements and leakage through macro pores in banks of the channels.

Pools with very high rates of water loss indicative of leakage were addressed and the application of a polynomial trend line rather than linear regression for modelling the seepage rate in those samples was assessed.

Given that higher loss rates occur at higher channel water elevations similar to operational levels, the corresponding seepage estimates were used to:

- identify pools with high loss rates which require remediation works, and
- give an estimate of the possible water loss during normal operation in each channel.

The loss rates at occurring at higher channel water elevations were compared with seepage estimates from an earlier study in the CIA which identified several locations potentially with high seepage losses. Results of the comparison showed a good agreement in those pools with moderate seepage losses. On the other hand, in pools where the present study indicated high loss rates and possible leakage at higher channel water elevations, the loss rates estimated from the TCC data were greater than in the earlier study.
CERTIFICATION OF DISSERTATION

I certify that the ideas, designs, experimental work, software code, results, analyses and conclusions presented in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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## ABBREVIATION

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
</tr>
<tr>
<td>AWS</td>
<td>Automated Weather Station</td>
</tr>
<tr>
<td>ANCID</td>
<td>Australian National Committee on Irrigation and Drainage</td>
</tr>
<tr>
<td>CIA</td>
<td>Coleambally Irrigation Area</td>
</tr>
<tr>
<td>CICL</td>
<td>Coleambally Irrigation Corporation Limited</td>
</tr>
<tr>
<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
</tr>
<tr>
<td>EM</td>
<td>Electro Magnetic</td>
</tr>
<tr>
<td>FoES</td>
<td>Faculty of Engineering and Surveying</td>
</tr>
<tr>
<td>GMW</td>
<td>Goulburn-Murray Water</td>
</tr>
<tr>
<td>LOC</td>
<td>Level Of Confidence</td>
</tr>
<tr>
<td>LOCP</td>
<td>Level Of Confidence Pool</td>
</tr>
<tr>
<td>NCEA</td>
<td>National Centre for Engineering in Agriculture</td>
</tr>
<tr>
<td>NMPP</td>
<td>Number of Measured Points per Pondage</td>
</tr>
<tr>
<td>NMPPP</td>
<td>Number of Measured Points Per Pool</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>Post</td>
<td>After remediation</td>
</tr>
<tr>
<td>Pre</td>
<td>Before remediation</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control And Data Acquisition</td>
</tr>
<tr>
<td>SDR</td>
<td>Sequential Decline Ratio</td>
</tr>
<tr>
<td>SKM</td>
<td>Sinclair Knight Merz</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>TCC</td>
<td>Total Channel Control</td>
</tr>
<tr>
<td>TDR</td>
<td>Total Decline Ratio</td>
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<tr>
<td>USQ</td>
<td>University of Southern Queensland</td>
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PUBLICATION ARISING FROM THIS RESEARCH


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