Barriers to Fish Passage in the Queensland Murray-Darling Basin Phase II: Validation of the “Keller” method for determining discharge at weir drown-out.

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Evaluating Barrier Passability for Fish in the Queensland Murray-Darling Basin using Discharge at Weir Drown-out

Janice Kerr, Andrea Prior, James Fawcett, Doug Harding and Tess Mullins
Environmental Flows Assessment Program

Cotswold Weir on the Condamine River.
Barriers in the Queensland Murray-Darling Basin
Barriers in the Queensland Murray-Darling Basin
Barriers in the Queensland Murray-Darling Basin
Weir Drown-out

Surat Weir, Surat, Queensland. Photo: A. Prior.
Weir Drown-out

Surat Weir, Surat, Queensland. Photo: A. Prior.
Modelling risk to fish from altered flows including barriers

Photo: Hyrtl’s tandan congregating below Cunnamulla Weir
Modelling risk to fish from altered flows including barriers
Design and assessment of weirs for fish passage under drowned conditions

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1. Introduction

The objective of this paper is to describe the basis of a computer program which has been developed and incorporated in a simple-to-operate spreadsheet for the determination of the hydraulic characteristics of a drowned weir that are important to fish movement. The key output of the program is the flow rate under drowned conditions. The program has been verified through laboratory experiments.

In aquatic systems, in-stream structures such as dams, weirs and road crossings can act as barriers to fish movement, particularly upstream movements, along waterways (Rosen, 1977; Cadwallader, 1978; Kingsford, 2000; Frazer and Page, 2006; Krock and Hartung, 2008; Sturberg et al., 2008; Iyon et al., 2010). There is a growing array of technological fish passage solutions for the movement of fish across structures such as weirs and dams (Clay, 1996; Luttrell and Marmulla, 2004; Stuart et al., 2004; Barrett and Mullen-Cooper, 2007).

However, for the majority of existing weirs in Australia, fishways have not been installed and fish have to rely on drowned conditions to move upstream (Stagg and Harris, 1994;
Screen shots illustrating the spreadsheet designed to calculate the stream discharge at weir drown-out by Keller, Peterken & Berghuis (2012).
“Keller” spreadsheet

Screen shots illustrating the spreadsheet designed to calculate the stream discharge at weir drown-out by Keller, Peterken & Berghuis (2012).
Sites

Legend
- Towns
- Validation Weirs
- Streams
- Condamine-Balonne Catchment
- Queensland Murray-Darling Basin
- Queensland
- Australia

- Sites:
  - Fairview Weir
  - Balgownie Weir
  - TOOWOOMBA
  - Warwick
  - Elbow Valley Weir
  - Goondiwindi
Surveying

Fairview Weir, Oakey Creek, Queensland. Photos: James Fawcett
Depth Loggers

Upstream logger pole, Elbow Valley Weir, Condamine River, Queensland.
Results

Elbow Valley
Results

Elbow Valley

Drown-out

Gauge Height (m)

Elbow Valley
Drown-out (Rating Table)
Drown-out (Normal Depth)
Logger install date
Barrier Height U/S
Drown-out Thresholds

Elbow Valley Weir, Condamine River
# Drown-out Thresholds

<table>
<thead>
<tr>
<th>Location</th>
<th>Emu Vale</th>
<th>Elbow Valley</th>
<th>Balgownie</th>
<th>Fairview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth Over Weir (m)</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>ND Drown-out discharge (m³/s)</td>
<td>3.37</td>
<td>4.97</td>
<td>4.04</td>
<td>4.19</td>
</tr>
<tr>
<td>RT Drown-out discharge (m³/s)</td>
<td>2.51</td>
<td>4.49</td>
<td>1.49</td>
<td>1.25</td>
</tr>
<tr>
<td>Measured drown-out threshold (m³/s)</td>
<td>2.55</td>
<td>3.69</td>
<td>1.81</td>
<td>2.12</td>
</tr>
</tbody>
</table>
Drown-out Thresholds

Drown-out thresholds

- Emu Vale
- Elbow Valley
- Balgownie
- Fairview

- ND
- RT
- Measured

Department of Natural Resources, Mines and Energy
## Daily Flow Exceedance

<table>
<thead>
<tr>
<th>Location</th>
<th>Emu Vale</th>
<th>Elbow Valley</th>
<th>Balgownie</th>
<th>Fairview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keller Method (ND) (%)</td>
<td>2.64</td>
<td>3.49</td>
<td>1.55</td>
<td>3.46</td>
</tr>
<tr>
<td>Keller method (RT) (%)</td>
<td>3.45</td>
<td>3.95</td>
<td>2.78</td>
<td>8.59</td>
</tr>
<tr>
<td>Measured (%)</td>
<td>3.41</td>
<td>5.03</td>
<td>2.42</td>
<td>5.28</td>
</tr>
</tbody>
</table>

- **Keller Method (ND) (%)**
- **Keller method (RT) (%)**
- **Measured (%)**

### Loggers

- **Drown-out Threshold (ML/day)**

---

*Department of Natural Resources, Mines and Energy*
Compare Frequency of Drown-out

Fairview

No. events per year

Rating Table - WRP  Normal Depth - WRP  Depth Logger - WRP

## The Wilcoxon Rank-Sum Test

Compared the frequency of drown-out events (Depth over weir 0.5 m) measured using depth loggers, “Measured”, to:
- Normal Depth Threshold
- Rating Table Threshold

<table>
<thead>
<tr>
<th></th>
<th>Emu Vale</th>
<th>Elbow Valley</th>
<th>Balgownie</th>
<th>Fairview</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W_s$</td>
<td>1958</td>
<td>1958</td>
<td>915</td>
<td>1314</td>
</tr>
<tr>
<td>$SE_{ws}$</td>
<td>119.83</td>
<td>119.83</td>
<td>67.64</td>
<td>88.79</td>
</tr>
<tr>
<td>$n$</td>
<td>44</td>
<td>44</td>
<td>30</td>
<td>36</td>
</tr>
</tbody>
</table>

### Normal Depth vs Measured Depth

<table>
<thead>
<tr>
<th></th>
<th>$W_{ND}$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1929</td>
<td>1822.5</td>
<td>762</td>
</tr>
<tr>
<td>$Z$-score$_{ND}$</td>
<td>-0.24(NS)</td>
<td>-1.13 (NS)</td>
<td>-2.26 (*)</td>
<td>-1.66 (NS)</td>
</tr>
</tbody>
</table>

### Rating Table vs Measured Depth

<table>
<thead>
<tr>
<th></th>
<th>$W_{RT}$</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1959.5</td>
<td>1866</td>
<td>880.5</td>
</tr>
<tr>
<td>$Z$-score$_{RT}$</td>
<td>0.01 (NS)</td>
<td>-0.77 (NS)</td>
<td>-0.51 (NS)</td>
<td>-1.91 (NS)</td>
</tr>
</tbody>
</table>

$P=0.05$

“*” significant
“NS” = not significant
$W$ is the Wilcoxon rank-sum statistic
$W_s$ is the mean
$SE_{ws}$ is the SE of $W$
Balgownie
Modelling fish population viability

• Water Planning Ecology (DES) uses the RAMAS meta-population model to predict the effects of changes in water resource management on the population viability of golden perch.

• This model requires information on the spatial distribution of stream connectivity at various flow magnitudes.
  • Estimates connectivity at the reach scale
  • Assesses risks to fish population viability

• Weir drown-out thresholds inform the connectivity component of the modelling.
Passability Scores

• Drown-out can be used to derive passability scores for modelling connectivity*
• Must be species specific.
• Must consider:
  – Upstream and downstream passage
  – Required duration, frequency, season, velocity
  – Size and life stage

Next steps – fish movement study

- Fish movement study
  - 62 acoustic receivers over 400km of river
  - Tag 120 fish: golden perch and Murray cod
  - Do instream barriers with and without fishways impede bi-directional migration?
  - When a fish does cross a barrier, what is the discharge?
  - Does this correlate with drown-out thresholds?
- Weir Drown-out
  - Repeat Keller method validation with 2-4 m high weirs.

Murray cod (Maccullochella peelii). Photo: A. Prior.
Summing Up

• We have validated the use of the Keller method with the Rating Table method option for use with low weirs.

• Drown-out thresholds vary with preceding and downstream flow conditions and flows that alter channel morphology

• Opportunities for movement do not guarantee fish will move, more work is required.
Questions