River discharge measurement uncertainty project 2023

NSW government organisations work together towards a practical methodology to quantify flowrate measurement uncertainty when using stage discharge curves.

Stage discharge curves enable continuous flow monitoring in rivers, channels and partially full pipes through development of site-specific rating curves tied to continuous water level monitoring. The approach is relied on throughout the water industry including water resource planning, river operations, water licensing and trade, regulation and compliance, irrigation, water supply, stormwater and sewerage applications.

Australian and international technical standards[1] define methods for stage discharge monitoring. However existing standards are inadequate and impractical to use in most cases to define flowrate measurement uncertainty using stage-discharge curves. Their key issues to quantify measurement uncertainty include:

- more than 15 gaugings are required within each rating curve section
- unable to apply in the extrapolated curve range (typically the high flow range).

Few water authorities quantify flowrate measurement uncertainty and instead rely on good flow measurement practices to reduce measurement uncertainty. There are, however, increasing needs to quantify flow measurement uncertainty associated with changing regulations, water trading and compliance activities.

The NSW Department of Planning and Environment[2] engaged Enviromon Pty Ltd to develop a *simplified method* to characterise flow measurement uncertainty when using stage discharge curves. A Modelling and Monitoring Hub (MaMH) project team peer reviewed this initial work before the establishment of this project to investigate alternative measurement uncertainty approaches with an emphasis on practical recommendations.

[1] *ISO 18320:2020 Hydrometry — Measurement of liquid flow in open channels — Determination of the stage–discharge relationship* and *AS3778.2.3:2023 Measurement of water flow in open channels*.

[2] The Department of Climate Change, Energy, the Environment and Water from 1 January 2024.

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Approach

The *simplified method* peer review identified opportunities to consider recent international work; align the methodology to *ISO Guide to Expression of Uncertainty (GUM)* requirements; and, review new software identified in the latest international standards, in particular, *BaRatin*.[3]

Enviromon Pty Ltd led the work to further investigate practical approaches specifically:

1. The *simplified method* which defines discharge uncertainty as the combined effect of uncertainty due to the *scatter of gaugings about the rating curve* and uncertainty in discharge due to *level measurement uncertainty*.

$$U(Q_{PD}) = \sqrt{\left[U_{Gaugings}\ or\ U_{Extrapolate}\right]^2 + \left[U(Q_{Level})\right]^2}$$

2. *BaRatin* software adopts a Bayesian approach to rating curve and measurement uncertainty definition.

Figure 1: Example BaRatin software output

The two approaches were trialled at the:

- Doctors Point gauging station on the Murray River. This station includes a stable channel hydraulic control with many gaugings to define the rating curve.
- Brewarrina Weir on the Barwon River. This station includes complex hydraulic controls with amplified gauging difficulties.

[3] Developed jointly by Istrea (France's National Research Institute for Agriculture, Food and Environment) and University of Adelaide, Australia, and is funded by the French government.

Figure 2: Doctors Point (left picture) and Brewarrina Weir (right picture) gauging station locations

MaMH organisation technical representatives were engaged for specific feedback on the work along with presentations at the *MaMH Forum 2023* and to the *Water Monitoring Standardisation Technical Committee* (November 2023).

Findings

Both approaches enable flow measurement uncertainty estimates without the need for more than 15 gaugings.

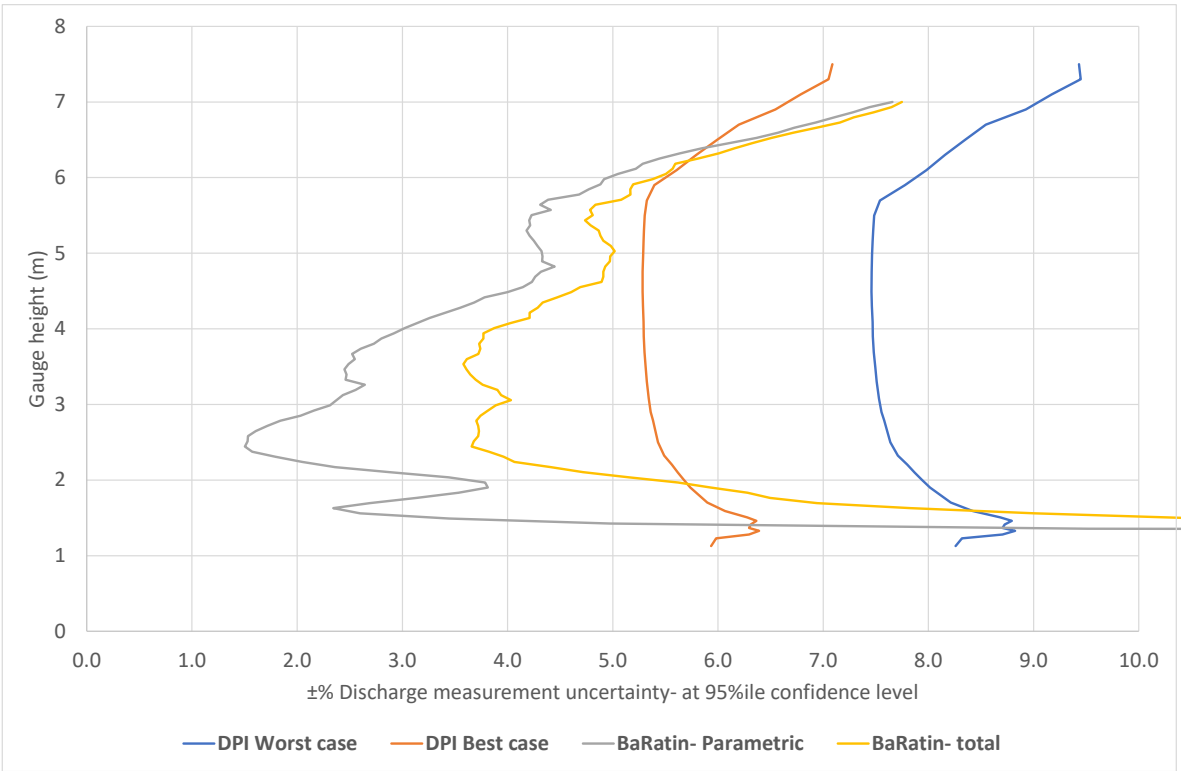

Figure 3: Doctors Point Gauging Station (Murray River) measurement uncertainties
(note: *DPI Worst case* and *DPI Best case* in this figure adopt the simplified method)

The simplified approach is MS Excel based and uses inputs which are generally available within existing hydrometric databases. It is yet to be broadly applied and aspects of its mathematical model are still be confirmed.

The BaRatin approach requires definition of a new rating curve using hydraulic model assumptions with additional site and hydraulics knowledge. It completes the uncertainty calculations using available gaugings and field observations.

Initial review of BaRatin outputs indicates there maybe improvements made to existing rating curves (which are based on gaugings only) forced through the use of hydraulic models to support the new rating curves, especially in rating curve sections where there are few gaugings available. BaRatin is is freely available, used overseas and is identified as an alternative approach in current standards[4]. However, it is externally managed software using a relatively complex statistical approach. Training is required to apply the tool.

Recommendations

The next stage recommendations include:

- Test both approaches at additional sites to demonstrate performance, methodology and limitations.
- Develop a decision framework to guide users in the approach/s to adopt considering the application's needs and available information (including gaugings), as well as point to existing standards which already adequately cover measurement uncertainty in built controls such as thin plate weirs.
- Develop support guidelines for hydraulic model setup in BaRatin and map out a skills development programme for hydrographers to be able to apply the software.
- Investigate application linkages with existing database packages such as Hydstra.

Please contact the NSW Modelling and Monitoring Hub for further information.

[4] For example, *ISO 18320:2020 Hydrometry — Measurement of liquid flow in open channels — Determination of the stage–discharge relationship* and *AS3778.2.3:2023 Measurement of water flow in open channels.*