Referee's Comments on

"A dynamic rating curve approach to indirect discharge measurement"

by F. Dottori, M. L. V. Martina, and E. Todini

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General Comments

I enjoyed reading this article. It is a good idea, and it is time it was exploited and tested. And frankly, used. It has been around for a while, and the authors really should refer to Herschy (1985, Chapter 8), who calls it the Stage-Fall-Discharge method. A more scientific explanation is given in Chapter 3 of Fenton & Keller (2001) "The use of surface slope in determining flow". That document refers to an International Standards Association Standard also. There seems also to be an American Standard *ASTM D5541-94(2008) Standard Practice for Developing a Stage-Discharge Relation for Open Channel Flow* that describes it.

For my own taste the article was a little bit unscientific. The variety of methods were presented with not much explanation or scientific justification, and I felt that I had not been given much insight into them. Maybe that is my problem. Having said that, I am sure that the method they advocate, the Stage-Fall-Discharge method really is much better than any of the others they tested.

I think that the method that the authors suggest could be placed on a stronger and simpler theoretical footing. For example consider the momentum equation in the form

$$\frac{\partial Q}{\partial t} + \left(gA - \beta\frac{Q^2B}{A^2}\right)\frac{\partial \eta}{\partial x} + 2\beta\frac{Q}{A}\frac{\partial Q}{\partial x} = \beta\frac{Q^2B}{A^2}\bar{S} - gA\frac{Q^2}{K^2}, \tag{1}$$

where this follows the notation of Fenton & Keller (2001, equation B.7). In Appendix B.2 of that report it is shown that almost all terms of the equation are of the order of the square of the Froude number $F^2 = Q^2B/gA^3$, leaving only two terms and giving the equation

$$Q = K\sqrt{-\frac{\partial \eta}{\partial x}}, \qquad \text{(F\&K, Eqn 2.4)}$$

where the *only* approximation made is that $F^2 \ll 1$. Now consider equation (23) of the paper under review. If the dynamic terms are ignored, it is clearly an approximation to equation (F&K, Eqn 2.4). It seems that there might be some room for simplification in the authors' approach to the problem. In particular, it is inconsistent to include terms like the dynamic terms in β, when terms of similar magnitude have already been omitted. A legitimate approximation to (F&K, Eqn 2.4) is something like

$$Q = K_2\sqrt{-\frac{\eta_2 - \eta_1}{x_2 - x_1}}.$$

Of course this does not require iteration. This would make the paper easier to read and understand, which are both desirable virtues. Complication is not.

There is one method they did not test, although it is in the paper they referred to (Fenton 1999), and is a more sophisticated version is presented where a differential equation for the discharge is obtained.

Although Fenton found that it gave very little better results then an explicit approximation for the *one* example he presented, it should probably be tested in a paper that purports to examine all.

Having said that, I think the authors are in a position to come up with a method that might solve most of the problems. Rather than considering the presence of the time derivative a problem, I think they should turn it to their advantage. That is, turn equation (1) into an ordinary differential equation and solve it:

$$\frac{dQ}{dt} = \beta\frac{Q^2 B}{A^2}\bar{S} - gA\frac{Q^2}{K^2} - \left(gA - \beta\frac{Q^2 B}{A^2}\right)\frac{\eta_2(t) - \eta_1(t)}{x_2 - x_1}. \quad (2)$$

Now, there is *no* essential analytical approximation being made. All the dynamic terms are included, and they are calculating the spatial derivative accurately, which otherwise is the only real problem. All terms on the right side are either able to be calculated, $B(\eta(t))$ for example, or are part of the problem, namely $Q(t)$. I think this could work quite well.

I think the authors have not considered the problem of calibration of the $K(\eta)$ as well as they might.

Overall, I thought a bit more hydraulics and a bit less statistics would have helped.

Specific Comments

Page 868

- Line 14 – "Chow (1959)" – please include a page number. I think it should be compulsory for all book references in all papers to come with specific locations included. I can't believe that we don't all do it.

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- DyRaC – I HATED the name. It is ugly and it is not necessary. Call it anything, like Stage-Fall-Discharge or something, but please not a name that means nothing. And, I will point out, the very characteristic of the authors' method and equation (F&K, Eqn 2.4) here is that it is *not* dynamic - it is based on an approximation where dynamic effects have been neglected.
- I don't like the use of z for the free surface. I think of it as an independent variable. Maybe η, ζ, ...?

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- Line 2: Reference to (21) - equation number seems wrong

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- Line 21: reference to Eq. (14) – it was presented without much explanation.

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- line 25: "Eq. (23) was always used instead of Eq. (25)" The incorrect equation numbering is frustrating.
- Also, I really do not like the style, favoured by the ASCE, of using "Eq. (123)" – writing it as a sentence to read is much nicer: "equation (123)"

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- What hasn't been explained or tested is how roughness would be estimated.
- Is equation (25) not just a complicated way of calculating the mean?

References

Fenton, J. D. (1999) Calculating hydrographs from stage records, *in Proc. 28th IAHR Congress, 22-27*

August 1999, Graz, Austria, published as compact disk.

Fenton, J. D. & Keller, R. J. (2001) The calculation of streamflow from measurements of stage, Technical Report 01/6, Cooperative Research Centre for Catchment Hydrology, Melbourne. http://www.catchment.crc.org.au/pdfs/technical200106.pdf

Herschy, R. W. (1985) *Streamflow Measurement*, Elsevier.