Australasian Hydrographer

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AUSTRALIAN HYDROGRAPHERS ASSOCIATION

AHA

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Contents

Acknowledgement of Country

The AHA acknowledges the Australian Aboriginal and Torres Strait Islander peoples of this nation. We acknowledge the traditional custodians of the lands on which our association is located and where we conduct our business. We pay our respects to ancestors and Elders past, present and emerging. The AHA is committed to honouring Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to the land, waters and seas and their rich contribution to society.

Zac Ward

From the Editor-In-Chief

Firstly, apologies for the tardiness of this edition of the Australasian Hydrographer. Not only did I totally underestimate the workload void that would be left in Jacquie's wake but also, much the same as other months we really are still struggling for member submissions, articles, photo's blurbs, etc. Hopefully the announcement by Arran and the AHA Committee below will invigorate and prompt some fresh movement into 2023 with an in-person conference of sorts. Here's to hoping.

Thanks however to those few who did reach out and offer some form of assistance and material submission. This is always much appreciated and not only is it a great opportunity to share new, exciting ideas/case studies with your fellow hydrographers but also remember that CPD Points can be obtained through material submission. I also very much enjoy reading what everyone is up to out there in the wide world of hydro & measurement.

With this edition we find ourselves going way, way back to the basics of BoS. I thought Spalshback's article on V-Notch weirs was a good formative overview on the topic of simple discharge weir theory and it seemed very timely given some interesting field applications I've seen of the Ol' sharp-crest weir of late. In order to develop and progress measurement techniques we definitely need to understand the basics and critical design aspects of what situations warrant these kind of measurement structures and techniques. There is never a one size fit's all measurement application.

Some other very relevant articles/presentations on non-contact metering and ADCP use for sediment load calculations which I found quite interesting also. As hydrographers we've always had to adapt & innovate and utilising flow measurement devices for other purposes entirely is a great display of that ingenuity.

Finally, as I write this more and more physical & social impact can be felt/seen from the declared third La Nina event overt east and as always I'd like to extend my best wishes to everyone out there either working and/or struggling through this tumultuous time. Please stay safe, stay strong and look out for your mates.

Cheers,

Zac Ward CPH


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Arran Corbett

From the President

Welcome to another edition of our journal. I am writing this piece from the Adelaide Convention Centre where I have had the pleasure of participating in the Irrigation Australia (IA) Certified Meter Installer & Validator Workshop and attending the International Congress on Irrigation & Drainage Conference/Exhibition.

The IA workshop kicked off with three presentations from Queensland, South Australia and New South Wales. These three jurisdictions have re-affirmed their commitment to the Metrological Assurance Framework 2 (MAF2). MAF2 calls for a nationally consistent compliance management approach for non-urban water meters in Australia. While this may all sound a bit out of scope for Hydrographers I would offer a different view. MAF2 is a commitment to better management of water through improved measurement. As I am sure you will agree, water measurement is very much at the core of Hydrography and I encourage you to look at this current policy drive as an opportunity.

One clear co-benefit of MAF2 is the development of Local Intelligence Devices (LIDs). These LIDs are simplified, packaged logger, power and telemetry solutions. I am confident that the efforts of manufacturers to harness emerging telemetry tech will make an impact, in time, on our existing hydrographic networks.

In other exciting news.... I am happy to share with you early confirmation of our next, in person, AHA conference & workshop. We will be meeting in May 2023 at the Penrith Panthers Club in Greater Sydney. Huge thanks to Daniel, Wally, Harry and Anthony in joining me in a sub-committee to handle planning activities. While the agenda is by no means finalised yet, we have every intention of making this upcoming event as valuable as possible to both our members and partners. To that end we are looking to put a strong emphasis on training, CPD points and interaction. If you or your organisation would like to support our sub-committee efforts please reach out to the team.

And yes - it looks like another "exciting" wet season is firing up. Early rains on the East Coast are falling on saturated ground and full storages... whilst collecting quality data and extending ratings is important, getting home safely must be the priority. Stay safe!

Best regards,

Arran

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Splashback - The V-Notch Weir

Daniel Gould, Daniel Ray and Phoebe Dalby
Splashback, Hobart TAS

Summary

Many of Splashback's clients work with water discharge as part of their environmental monitoring. These measurements of flow and discharge are often taken from V-notch weirs. Splashback's team works closely with its clients to provide them the analytical tools to help get the most out of their data. Water flow adds the required context to water quality measurements in many circumstances. Splashback has recently added an Excel function to assist in calculating the discharge from a V-notch weir. We have here provided a summary of the workings of the V-notch weir and the underlying mathematics of the equation used in the Excel function to accompany this release. It is our hope that this article will assist in the accurate use of V-notch weirs as well as give a 'on-site' context to those using the Excel function in the workplace.

Introduction

Weirs, both permanent and portable, are a common way to enable the standardised measurement of discharge for a water way [1, 2]. Their application is widespread in the field of hydrology as they allow the user to calculate the flow of water from a direct measurement of the water height. As simple as this standard measurement system sounds there are many issues that can prevent a weir measurement from being entirely accurate. There are many weir designs, here we will chiefly discuss one of the most common, the V-notch weir. The overflow section of a V-notch weir is an isosceles triangle with its vertex pointing downwards. V-notch weirs are often chosen over other weir geometries because of their greater accuracy at lower flows. In this article we aim to provide an overview of the weir, specifically the thin plate V-notch weir, and how to correctly utilise it for a discharge measurement. We then provide a derivation of the V-notch discharge equation.

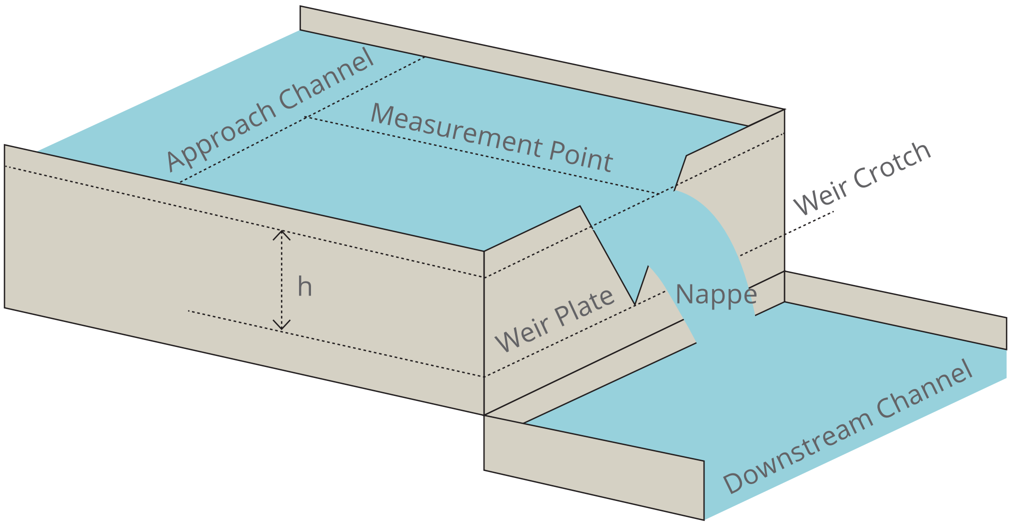
The scoping document itself is a living artefact and will be updated as new and emerging technologies enter the marketplace and start to further enhance existing infrastructure and services. Through these advancements a more responsive water environment is anticipated and will deliver new benefits to water users through open and transparent resource management.

The Standard Weir

In constructing a weir there are three important sections to consider; the approach channel upstream of the weir, the weir plate itself and the downstream channel. These all impact the weirs' ability to function as a 'standard weir'. Each of these sections have their own impact on the water flow and thus discharge of the weir [2]. Without proper consideration and construction, the weir will not provide accurate discharge data from the standard weir discharge equation, regardless of how accurate the water height measurements may be.

There are several industry standards available [3] that provide detailed requirements for the construction of a standard weir. We will not provide such detail here, but instead offer a discussion of the issues and considerations relating to weir measurement accuracy to assist those striving to obtain accurate discharge data from a weir system. Although we chiefly discuss the V-notch weir design here, many aspects of this discussion are applicable to other weir geometries.

a.



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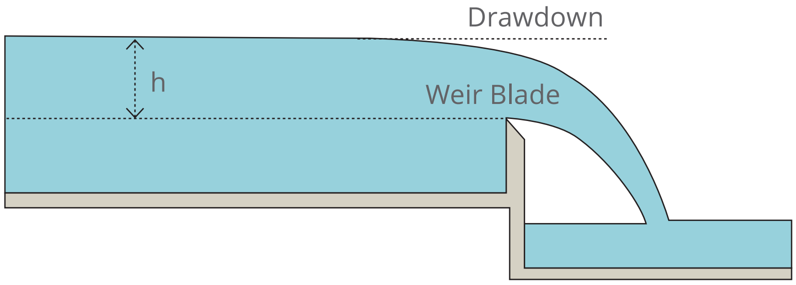


Figure 1: a) A simple diagram of V-notch weir. b) a cross section of the V-notch weir along its long axis. Several important parts of the weir have been labelled.

Approach Channel

The approach channel, the section upstream of the weir plate, is used to address the flow characteristics of the water on its approach to the weir plate. Tranquil and calm water is required in the area immediately upstream of the weir plate in order for the discharge to follow the standard discharge equation. The approach channel, being ideally a long, deep, and wide area, allows the water to assume a homogeneous velocity profile. Deviation from an ideal velocity profile is usually visible in the water body as it approaches the weir plate. Upwelling, eddies and other visible abnormalities should be reason to suspect that the weir may not follow the standard discharge equation [4].

Sand or gravel bars building up in the approach channel, or vegetation along the bank, are two possible causes of deviation from ideal conditions [5]. Additionally, eddies can form if the approach channel is not far downstream from a drop or bend, of if the flow section undergoes a rapid expansion. Eddies can concentrate the flow to a narrower section, that is, cause a deviation from ideal conditions.

Rough or turbulent conditions affect both your ability to read the effective height of the water in the weir and also disrupt the discharge relationship [4]. In general, the roughness of the surface can be improved by resolving the aforementioned causes. If the water surface is rough due to wind conditions, it's likely that the weir will still follow a standard discharge, and only your ability to take an accurate height measurement will be affected. In this case, a stilling well might be used. A wave suppressor, such as an underpass, is one method for improving the water flow characteristic. An underpass forces water through a submerged area below water level directly prior to entering the approach channel, improving the water flow characteristics, and reducing the surface roughness. Both stilling wells and wave suppressors can generally be avoided if the approach channel is constructed with the idea of tranquil and uniform flow in mind.

Weir Plate

The weir plate closes the far end of the approach channel, forming the face where the notch, or cut-away, is located. Around this cut-away is the weir blade, over which the water falls. It is named as such due to its sharp profile. The sharp blade is required so that the water flowing through the notch can achieve a smooth, ideally laminar, flow. The weir plate as well as the blade itself can have significant effect on the discharge from the weir.

If the plate is not perpendicular to the walls of the approach channel, and vertical, the resulting calculated discharge may contain non-random offsets in value. If the weir plate is not properly fixed, or its material has some flexibility, the resulting bend with respect to water height may also lead to non-random offsets in the calculated discharge. Both of these phenomena can be attributed to the flow scenario deviating from that assumed by the standard discharge equation. [1].

The weir blade, if not well kept with regular inspection, may corrode, grow algae and form precipitate or dull and become rounded. Whilst these might appear to be small issues, they too can lead to discharge error, especially at low water heights. Cleaning the weir blade, as part of maintenance, can cause changes in the discharge of the weir. Some time should be given to allow the weir to return to a steady state.

Downstream Channel

The flow of the downstream channel, if restricted, can cause large errors in discharge. Weirs should be designed and placed, such that there is a free flow of water through the notch. That is, that the nappe falls freely down from the weir opening into the downstream channel. If this is not the case the weir is deemed 'flooded', and extremely large error can be expected [2]. In general, this can be fixed by clearing some blockage downstream of the weir to avoid this backwater build-up. However, in some situations the weir opening may need to be raised.

Other large errors in discharge can occur if the nappe does not freely pass out and over the weir blade, clinging rather to the outer side of the weir plate. This clinging can be due to the weir blade becoming blunt, debris caught in the notch or the water height falling to such a level that the water velocity through the notch cannot sustain a nappe [4].

Head Measurement

While the factors discussed above may impact the discharge of the weir significantly enough to cause noticeable error, it is ultimately an accurate head measurement which governs the success or failure of the instrument. The specific procedure and location of each point of measurement for each individual weir should be known to everyone who undertakes data collection there. As we only give a general overview of measurement procedure, we recommend that staff be informed of the site-specific procedure.

A measurement of head in a weir is taken as the water height above the weir crotch. However, this height is not the water height directly above the crotch itself but rather the height at a location upstream from the weir plate. The reason for this is the section of water in and around the weir crotch has begun to fall and accelerate through the notch [1, 2]. This section of water is called the drawdown and a measurement of water height in this area does not reflect the true water height in the weir. The height change in the drawdown is directly related to the velocity gained by the water exiting the notch.

The location of the head measurement should be at a distance of 4 to 6 times the head upstream from the weir crotch to avoid the drawdown. However, going too far upstream may mean that the gradient of the stream or upstream section causes a larger head measurement. The exact location in each site should take into account these factors. The use of staff gauges along the bankside should be investigated on a case by case basis, the mis- placement of which can lead to systematic offsets in data.

When taking head data from a weir it is important to take multiple measurements over a period of time. An instantaneous measurement may reflect the discharge of a surge in water rather than the average flow. An average of several measurements should be taken over a period of time, reducing both error in the head measurement and error due to surges [4].

The V-Notch

Owing to its geometry the V-notch weir is often chosen over the rectangular weir due to its performance at both low and high flow. Low flow performance of the V-notch is greater as the smaller area closer to the vertex or crotch of the notch allows for a nappe to more readily form. Low flow of water through a rectangular notch weirs often causes the water to stick to the weir plate as the velocity of the water does not allow for the formation of a nappe.

V-notches come in a variety of internal angles, this being the angle between the weir blades at the weir crotch. The angle chosen should reflect the desired measurement range or expected flow through the weir. Weirs that measure low flow should choose a notch with a tighter angle, those with higher flow a larger angle. Common notch angles are θ = 90˚, θ = 53.13˚ and θ = 28.07˚ [3]. These corresponding to numbers that simplify the discharge equation allowing the tan(θ/2) term to take the values 1, 0.5 and 0.25 respectively.

Discharge Equation

The V-notch weir has been the subject of extensive study, constraining the equation relating its effective height to discharge to a relatively simple form [1]. The equation relating the 'Head' to the discharge of water for a V-notch weir is expressed as the following

$$Q = \frac{8}{15} C_e \sqrt{2g} \tan\frac{\theta}{2} H^{\frac{5}{2}}$$

Where Q is the discharge, g is acceleration due to gravity, Ce is the discharge coefficient, θ is the angle of the V-notch and H is the head.

In Splashback's Excel function, SBK.V NOTCH (water level, angle), we use this equation with the inputs of water height (in meters) and V-notch angle (in degrees) to generate the flow in Cumecs through the weir. This function takes any value of angle from 20º to 100º. The coefficient of discharge in this calculation is derived internally from the measurement of height and the angle with the assumption that the weir is performing in a standard way. It is important that the weir is performing as such when making the head measurements this function is applied to.

Via inspection of this equation, you can see that the accuracy of your calculated flow data is reliant on both accurate effective head measurements and an accurate value for the coefficient of discharge. The discharge coefficient is an experimentally determined coefficient dependent on a range of parameters relating to the weir and approach channel. Despite the complexity of its dependencies, the discharge coefficient has been widely investigated and now can be found in many standards on weir measurement in the form of either graphs or tables.

In forming a mathematical model of something as changeable as water flow, assumptions as to the 'state' of the system must be made. The general assumption that this model makes is that the flow of water in the approach channel is tranquil and uniform. When this is not the case the discharge of the weir no longer follows the given equation. The discussion of different conditions in the texts referenced demonstrates the sensitivity of such a system to any deviation from ideal. Bellow follows a derivation of the standard V-notch weir discharge equation.

Discharge Equation Derivation

The discharge, Q, of a fluid through an area is given by the velocity, ν, of the fluid multiplied by the area, A, through which it passes.

$$Q = \nu \times A.$$

However, in this case both fluid velocity and area are dependent on the depth of the fluid. In this calculation we cannot simply multiply the area of the V-notch by some scalar to arrive at discharge, we must integrate the velocity profile over the area with respect to height. The relationship between the waters velocity and its depth is given by

$$\nu = C_e\sqrt{2gh},$$

Where g is acceleration due to gravity and h is water depth. To account for the friction effects between the water and the area it is passing through we have multiplied by a constant Ce, this being the coefficient of discharge.

Now consider the area of the V-Notch. Each 'slice' from top to bottom will have uniform velocity across it. Figure 2 depicts our method. Each 'slice' will have the small area, dA, of,

$$\begin{aligned} \mathrm{d}A &= 2l\ \mathrm{d}h \\ &= 2(H-h)\tan\left(\frac{\theta}{2}\right)\mathrm{d}h \end{aligned}$$

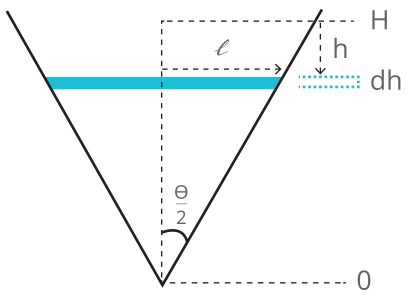


Figure 2: The V-notch area broken up into slices of dh thick- ness.

Combining this area with our expression for velocity yields the discharge of water through that slice.

$$\begin{aligned} \mathrm{d}Q &= \nu \times \mathrm{d}A \\ &= 2C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)(H-h)\sqrt{h}\ \mathrm{d}h \end{aligned}$$

Integrating this expression over the water height 0 → H yields the total discharge

$$
\begin{aligned}
Q &= \int_0^H 2C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)(H-h)\sqrt{h}\,dh \\
&= 2C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)\int_0^H (H-h)\sqrt{h}\,dh \\
&= 2C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)\left[\frac{2}{3}Hh^{\frac{3}{2}}-\frac{2}{5}H^{\frac{5}{2}}\right]_0^H \\
&= 2C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)\left[\frac{2}{3}H^{\frac{5}{2}}-\frac{2}{5}H^{\frac{5}{2}}\right] \\
&= \boxed{\frac{8}{15}C_e\sqrt{2g}\tan\left(\frac{\theta}{2}\right)H^{\frac{5}{2}}}
\end{aligned}
$$

Arriving at the standard V-Notch weir discharge equation.

1. J. Shen, Discharge Characteristics of Triangular-notch Thin-plate Weirs, pp. 1–15. Department of the Interior, Geological Survey Water-supply Paper 16I7-B (1981).
2. A. J. Clemmens, T. L. Wahl, M. G. Bos, J. A. Replogle Water Measurement with Flumes and Weirs, pp. 59–164. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, ISBN 90- 70754-55-X (2001).
3. ASTM International, Standard Test Method for Open- Channel Flow Measurement of Water with Thin-Plate Weirs, ASTM Designation: D 5242 – 92 (Reapproved 2001).
4. A. J. Peterka, “Water Measurement Procedures Irrigations Operators’ Workshop –1967, Department of the Interior Bureau of Reclamation (1967).
5. F. L. Ogden, T. D. Crouch, N. R. Pradhan,E. Kempema, Laboratory Investigation of Sedimentation Effects on V-Notch Weirs, World Environmental and Water Resources Congress 2011, pp. 4820–4827 doi 10.1061/41173(414)500 (2011).

Clamp-on Ultrasonic Water Meter Disturbance Testing

Presented at the "International Congress on Irrigation and Drainage 2022"

Dr John Awad, Dr Baden Myers, Dr John Guilfoyle & Mani Manivasakan

All project testing conducted by the Australian Flow Management Group, UniSA STEM

Introduction

There is an interest in verifying the accuracy of water meters in the field. Removing and replacing (or reinstalling) operational water meters for verification in laboratories is costly due to labour required to remove and replace meters in pipelines. In-situ verification equipment is currently expensive to develop and run. The use of 'clamp on' ultrasonic water meters – which temporarily clamp on to the outside of a pipe and use ultrasound signals to determine a flow rate – is proposed as a means of in situ verification. However, while clamp on ultrasonic water meters have been around for decades to measure water flow, their accuracy when subject to flow disturbances is poorly documented (there may be studies, but there is little data available in the public realm that we could identify).

Project Aim & Objectives

- The aim of this study was to identify the impact of several disturbance factors of the accuracy of five clamp on ultrasonic water meters.
- Evaluate the effect of the following on meter performance:
  - » various pipe sizes (200, 300 and 600 mm)
  - » various pipe materials (PVC, HDPE and Steel)
  - » Flow disturbance – ¼ plate (e.g., elbow, pump) (upstream length: 2D, 5D and 20D)
  - » Water quality (presence of sediment) on meter performance
  - » Presence of air bubbles (air volume ratios: 0.6, 1.5, 2.9, 5.9 and 11.8% of total flow)

Methodology

All meters were first tested to determine the error of measurement (determined by comparison with a conventional, calibrated reference 'magflow' meter) on the three pipe types and three pipe sizes (objective 1 and 2). Then compared to maximum permissible error (2.5% based on NMI M10-2).

The error shift compared to the baseline value was used to assess performance.

- Error shift = Abs $(\text{Error}_{\text{DN300 or DN600}} - \text{Error}_{\text{DN200}})$ Or Error shift = Abs $(_{\text{ErrorPVC or steel}} - \text{Error}_{\text{HDPE}})$

All meters were then exposed to a flow disturbance - a 1/4 plate at varying distance upstream, sediment in flow or air in flow - and their error of measurement determined in each case.

The error shift compared to the equivalent ‘no disturbance’ baseline was used to assess performance.

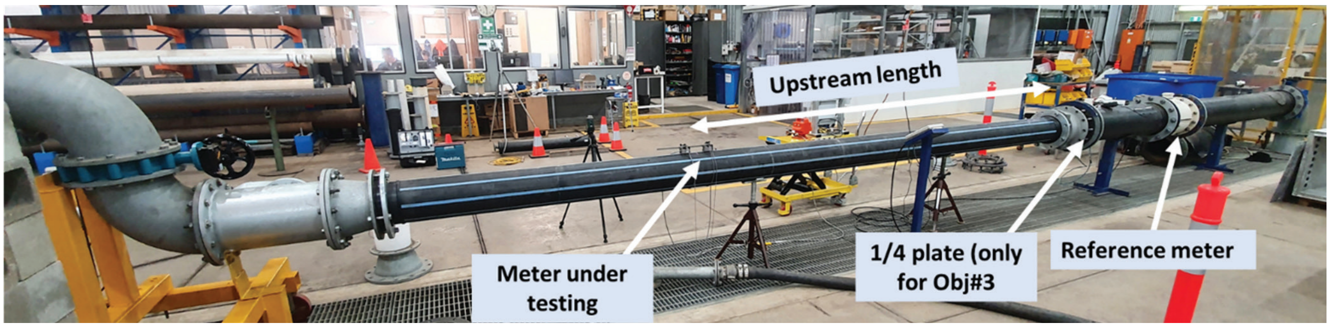
- Error shift = Abs ($Error_{with\ disturbance} - Error_{without\ disturbance}$)

To simplify the message, we used qualitative threshold terms to describe the error shift magnitude (not from standards):

Small	Medium	Large	Very large
< 2.5%	2.5% - 5%	5% - 8%	8% - 20%

Effect of Pipe Size (Obj#1) and Materia (Obj#2)

Pipe size (D, mm)	Pipe material	Upstream length nD (m)	Flow velocity (m/s)	EUT	Total number of flow tests
200	HDPE, PVC & Steel	20D (4)	0.75, 1.5, 3.0	All	54
300	HDPE, PVC & Steel	20D (6)	0.75, 1.5, 3.0	All	54
600	HDPE	17.5D (10.5)	0.75, 1.5	A, B, D, E	8

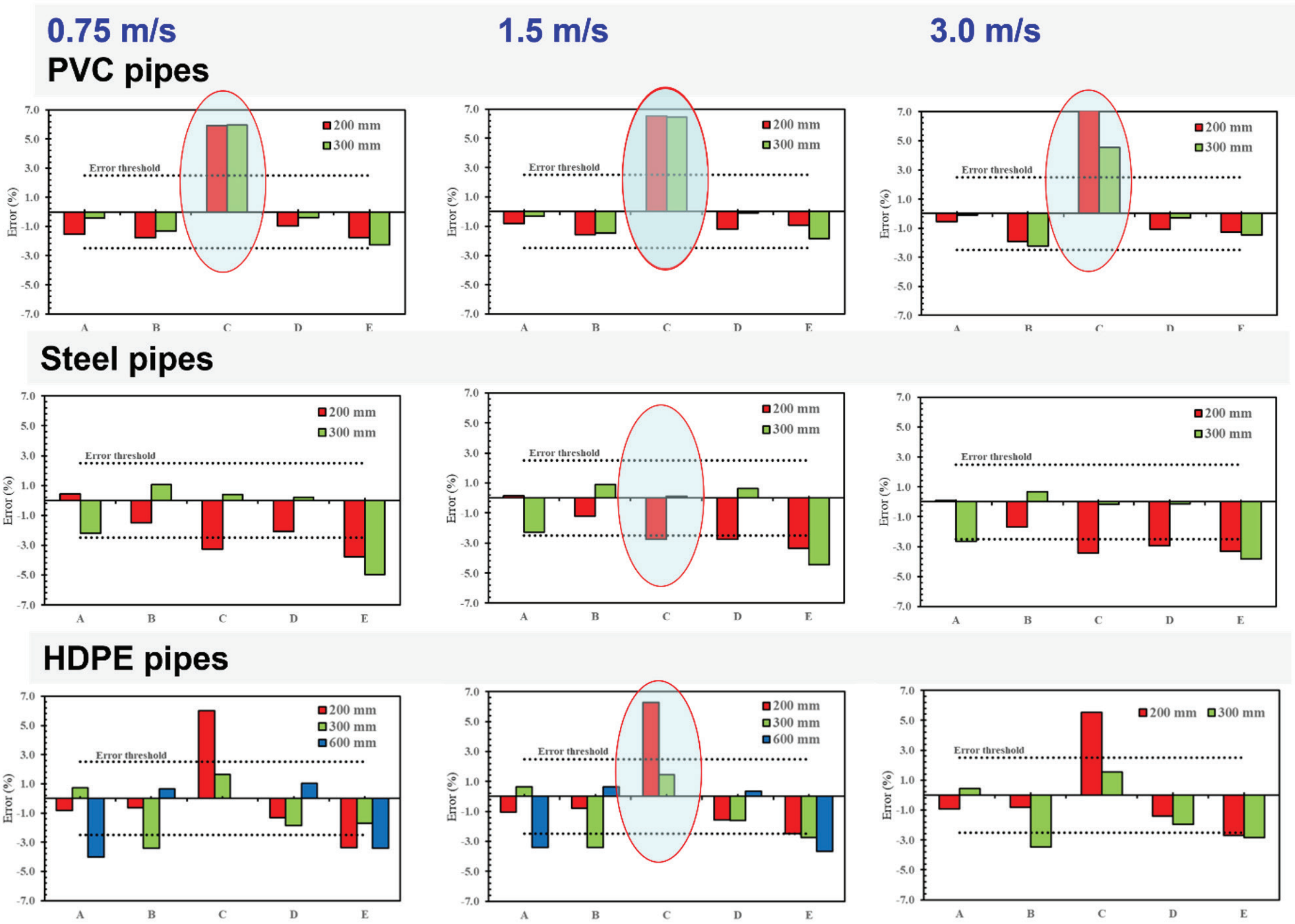


Results

Error of measurements determined for all meters

The errors of measurement for the meters without disturbance were between 4.95% and 7.39%.

Note:
There was no error correction or calibration attempted on the meters. Meter correction values were taken 'as is' straight from supplier BUT for all tests we did input appropriate data for each pipe material, diameter and wall thickness.



Obj#1 – The effect of pipe size on meter error of measurement

Changing the pipe size had an impact on the error of measurement performance of the water meters.

The impacts were considered to be of medium concern - error shift when moving from smaller to larger pipe sizes was less than 5% in all cases.

The error shift for PVC changing from 200mm to 300mm pipe was relatively smaller compared to the other to materials at all three flow rates.

200 to 300	0.07 to 2.85	0.51 to 3.67	0.04 to 4.83
200 to 600	No data	No data	0.05 to 3.16
300 to 600	No data	No data	0.92 to 4.73

Obj#2 – The effect of pipe materials on meter error of measurement

For a given pipe size, changing the pipe materials had a larger impact than changing pipe size.

The highest error shift in this case was when moving from PVC to steel.

The lowest error shift was when moving from HDPE to PVC pipe - small to medium impact on error.

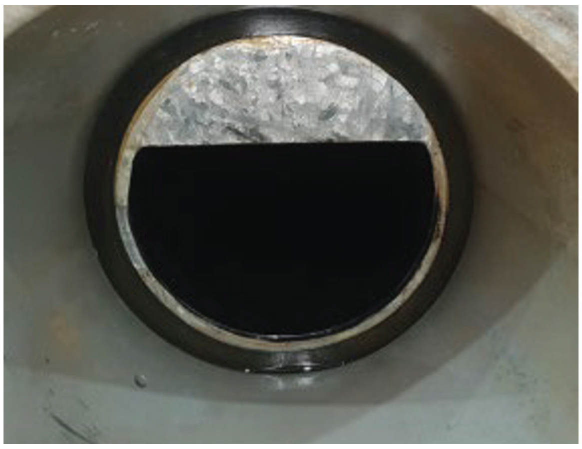
However, when moving from HDPE or PVC to steel, the error shift was up to 10.8% in some cases but the 75th percentile of the error of measurement values were less than 5% (medium concern).

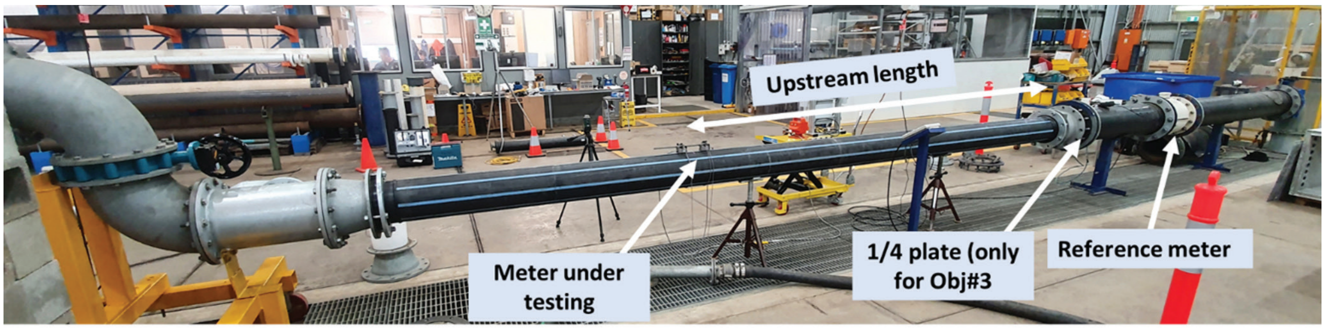
200	0.24 to 10.81	0.39 to 9.26	0.1 to 1.86
300	0.18 to 6.1	0.96 to 4.48	0.52 to 4.99

Obj#3 – The effect of the meter location relative to the source of disturbance (e.g. elbow, pump)

A 'quarter plate' was used to simulate the flow disturbance often caused by valves or other throttling devices.

Pipe size (mm)	Pipe material	Upstream length nD	Flow velocity (m/s)	EUT	Number of flow tests
200	HDPE, PVC & Steel	2D, 5D, 20D	0.75, 1.5, 3.0	All	162
300	HDPE, PVC & Steel		0.75, 1.5, 3.0	All	162
600	HDPE		0.75, 1.5	A, B, D, E	24





Error Shifts

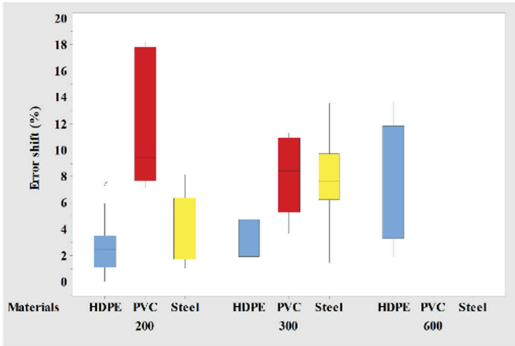
Quarter plate disturbance at an upstream length of 2D between the disturbance and the meters

The impacts at 2D were considered to be very large as the error shift was higher than 8% in most cases, and up to 18%. For all pipe sizes, the highest error shift was for PVC (up to 18%) followed by HDPE (up to 14%) then steel (up to 12%).

Upstream length (nD)	Pipe (mm)	Range in absolute value of error shift across all flow rates, %		
		PVC	Steel	HDPE
2D	200	7.15 - 18.24	1.57 - 4.93	0.04 - 7.4
	300	0.98 - 11.3	0.94 - 12.08	0.11 - 5.66
	600	N/A	N/A	1.87 - 13.66

Categories

Small	Medium	Large	Very large
< 2.5%	2.5% - 5%	5% - 8%	8% - 20%



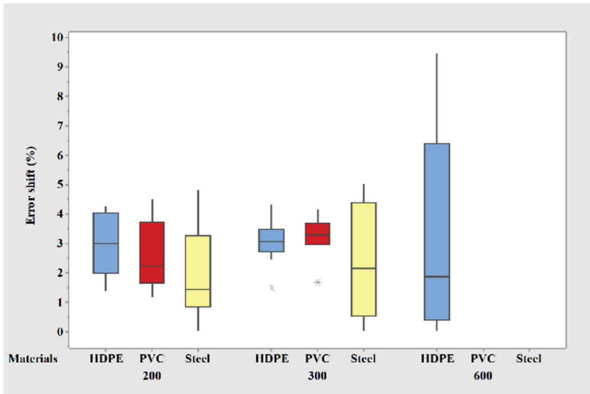
Median, 25th percentile and 75th percentile values of absolute relative error of measurement across all flow rates when exposed to 1/4 plate.

Quarter plate disturbance at an upstream length of 5D between the disturbance and the meters

The impacts at 5D were considered to be medium as the error shift was less than 5% in all but one case. No material was clearly 'better' or 'worse' (PVC: up to 4.5%; Steel: up to 5.1%; HDPE: up to 4.3%)*

No discernible relationship between the error shift and pipe size.

Upstream length (nD)	Pipe (mm)	Range in absolute value of error shift across all flow rates, %		
		PVC	Steel	HDPE
5D	200	1.19 - 4.51	0.17 - 4.8	1.39 - 4.28
	300	2.47 - 4.32	1.58 - 5.01	1.48 - 4.32
	600	N/A	N/A	0.02 - 9.46*



Small	Medium	Large	Very large
< 2.5%	2.5% - 5%	5% - 8%	8% - 20%

*Error shift determined for all meters (except meter A) tested at various flow rates were less than 3.5%. Median, 25th Percentile and 75th Percentile values of absolute relative error of measurement across all flow rates when exposed to 1/4 plate.

ALERT2 Evolution

Features at a glance

You may not have of heard of Envirada, but you will know of ELPRO and Aquamonix. We have all been busy working on the new ALERT2 products and where recently awarded the BoM national installation roll out.

The new ALERT2 hardware sets a new benchmark for remote monitoring. The roll out has begun with a number of councils and utilities starting to future proof their networks..

For more information contact the ELPRO or Aquamonix sales lines below, or follow us on Linkedin.

sales@aquamonix.com.au

sales@Elpro.com.au

www.Envirada.com

Quarter plate disturbance at an upstream length of 20D between the disturbance and the meters

The impacts were considered to be medium - the error shift was less than 3.5% in all cases.

OVERALL:

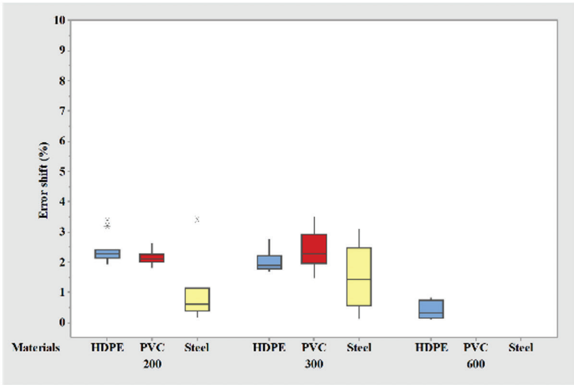
$\%errorShift_{1/4plate\_2D} > \%errorShift_{1/4plate\_5D} > \%errorShift_{1/4plate\_20D}$

No discernible relationship between the error shift and pipe size.

Upstream length (nD)	Pipe (mm)	Range in absolute value of error shift across all flow rates, %		
		PVC	Steel	HDPE
20D	200	1.8 - 2.61	0.59 - 3.37	1.94 - 3.35
	300	1.48 - 3.51	0.05 - 2.53	1.69 - 2.77
	600	N/A	N/A	0.11 - 0.83

Categories

Small	Medium	Large	Very large
< 2.5%	2.5% - 5%	5% - 8%	8% - 20%



Median, 25th Percentile and 75th Percentile values of absolute relative error of measurement across all flow rates when exposed to 1/4 plate.

Summary Slide #1

The error of measurement for the ultrasonic clamp on meters was influenced when the meters were moved from smaller to larger pipes. The impacts were of 'medium' concern (less than 5%).

For a given pipe size, changing the pipe materials had a larger impact than changing pipe size (error shift up to 10.8% in some cases). In most cases, the error of measurement values were less than 5% (medium concern).

The accuracy of ultrasonic clamp on meters were influenced by exposure to the quarter plate disturbance.

The impact decreased as the upstream length between the disturbance and the meters increased - normal.

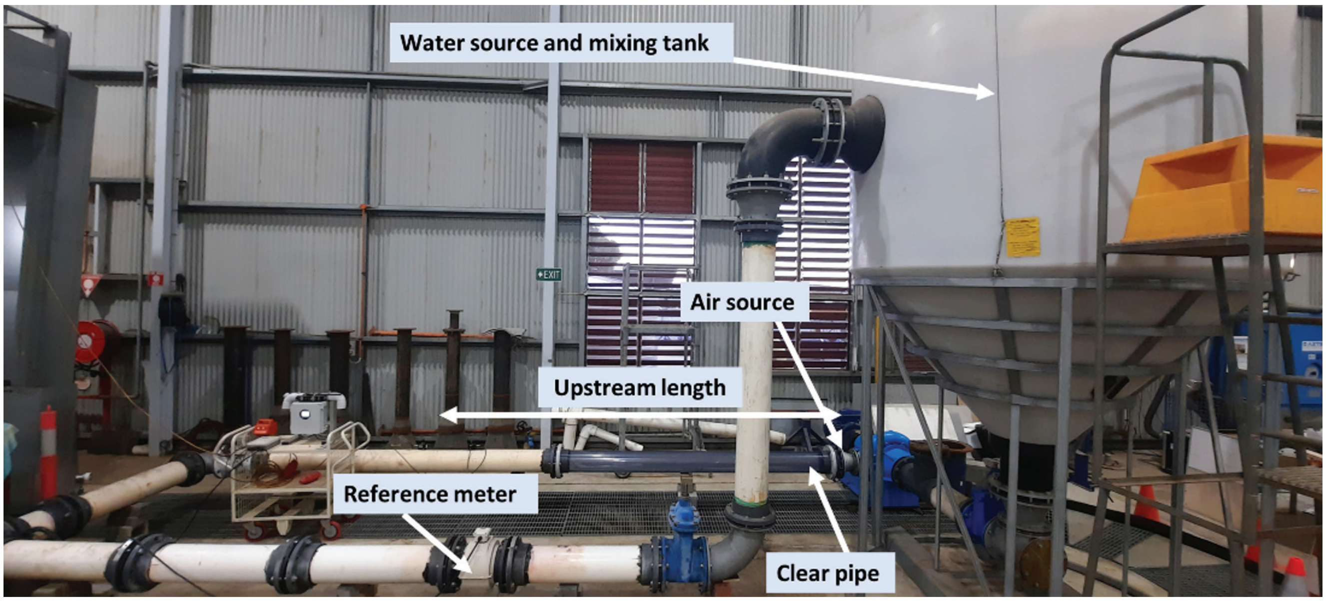
The impacts were considered to be 'very large' at 2D (error shift: 8% - 20% in most of the cases).

The impacts were considered to be 'medium' at 5D and 20D (error shift was < 5% (except one case) and < 3.5%, respectively).

If assessed for pattern approval, few meters would pass the ¼ plate disturbance test at 20D.

Obj#4 & 5: Evaluate the effect of poor water quality (sediment, Obj#4) and the presence of air (Obj#5) on meter performance

Pipe size (D, mm)	Pipe material	Disturbance source	Upstream length nD (m)	Flow velocity (m/s)	EUT	Total number of flow tests
200	PVC	No	20D (4)	0.75, 1.5, 3.0	All	15
200	PVC	With sediment	20D (4)	0.75, 1.5, 3.0	All	15
200	PVC	With air [a]	20D (4)	1.5	All	20



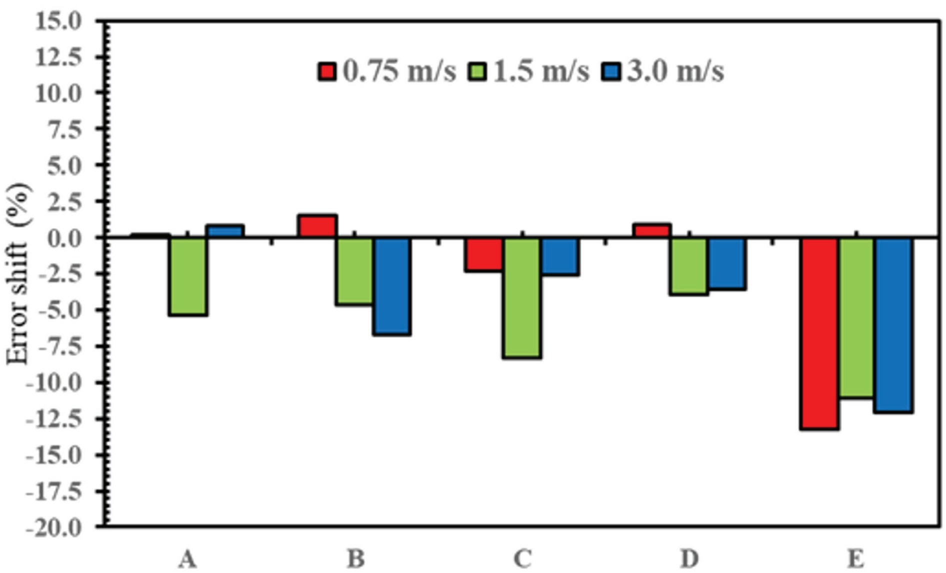
Five flow rates (1, 2, 5, 10 and 20 m3/h) corresponding to five different air water volume ratios (0.6, 1.5, 2.9, 5.9 and 11.8%).

Results

Effect of poor water quality (sediment) on meter performance

Error shift ranged from 0.22% to 13.2% with a 75th percentile of error shift of 8.3%.

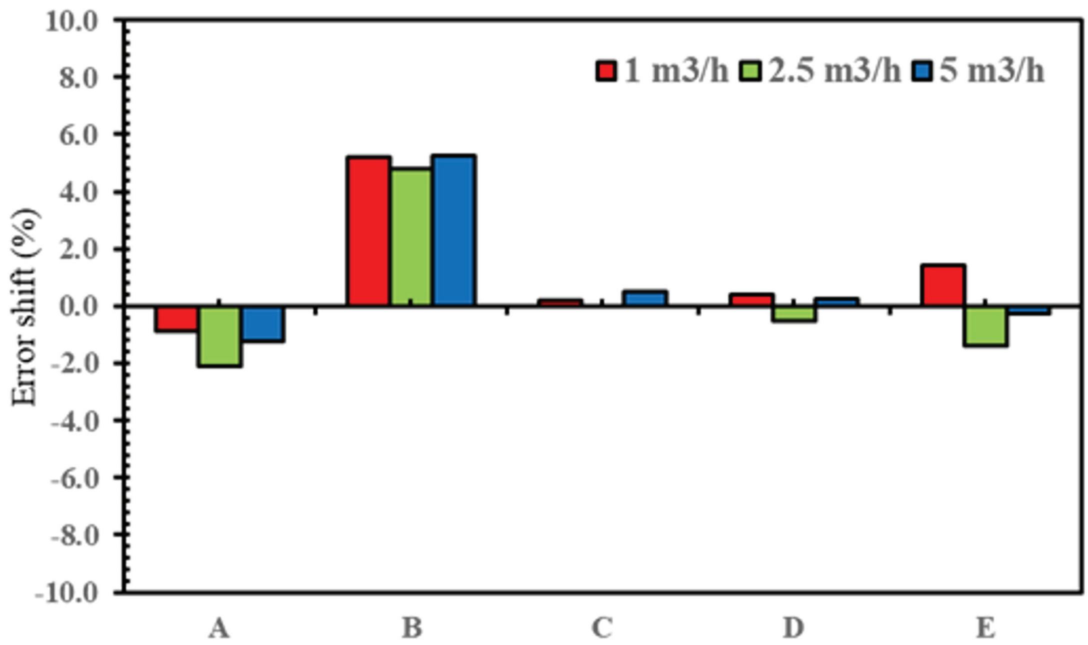
The impacts were considered to be of 'large' concern.



Effect of the presence of air on meter performance (Obj#5)

At air flow rates of 1.0, 2.0 and 5.0 m3/h (air/water ratio: 0.6, 1.5, 2.9%).

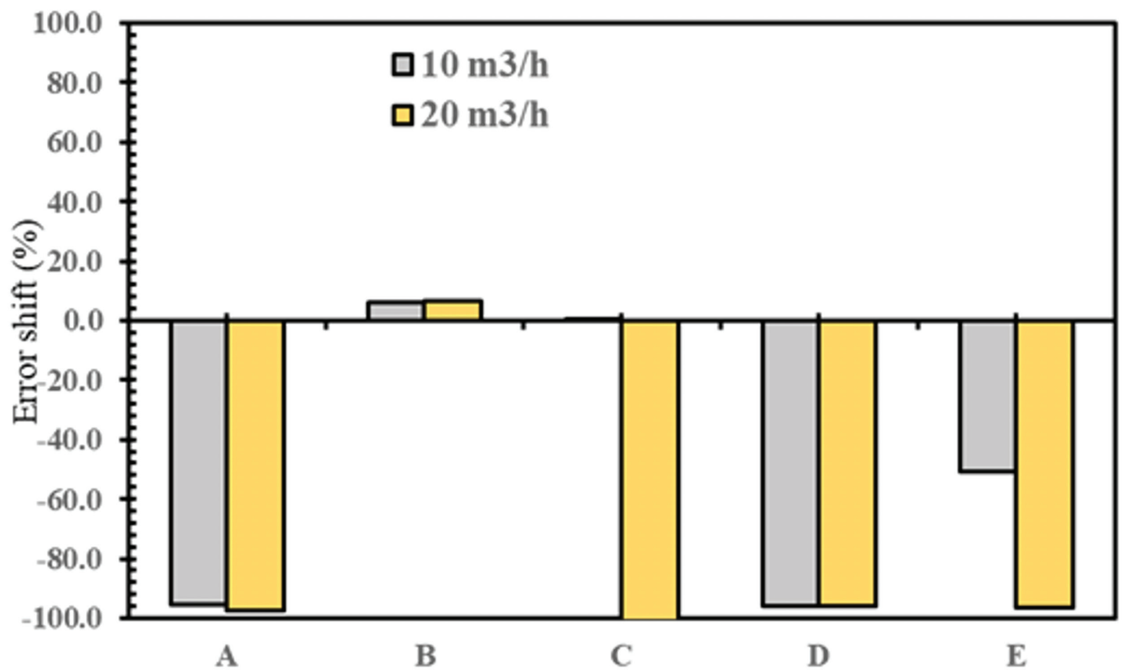
The impacts were considered to be of 'medium' concern - the error shift was less than 5% in these cases.



At air flow rates of 10 and 20 m3/h (air/water ratio: 5.9 and 11.8%).

The impacts were considered to be of 'very large' concern.

At 10 m3/h: the error shift was > 50% for most cases.



Recommendations

Pipe material matters! A calibration (or correction) factor applied following calibration of a meter in one pipe material may not be consistent for other pipe materials. As such meter accuracy testing and calibration should be conducted on specific pipe materials i.e., steel, PVC, HDPE ...

Air should be bled out of all pipe work (e.g., by using air bleed valves until no more air is leaving the valves whilst water is flowing). But is this possible in the field?

This is not intended to lambast clamp-on ultrasonic meter providers - research is also required into the performance of standard bolt-in meters when exposed to air in typical pipe networks.

Information about the typical error drift of ultrasonic clamp on meters is currently not available. Further research (or documentation of existing experience) is recommended to establish a required calibration interval for ultrasonic clamp on water meters. AFMG uses a calibration interval of 12 months at this time.

Quality of source water should be characterised prior to field verification of water meters with ultrasonic water meters. There is no simple 'in-situ' method to estimate the level of suspended solids in water, however there may be potential to develop a water quality threshold based on turbidity which can be measured with a probe.

Other factors (e.g., those included in pattern approval testing such as swirl disturbance and exposure to standard environmental conditions) were not considered in this study. It is recommended that clamp on ultrasonic meters selected for use as reference meters be pattern approved before use for in-situ meter verification.

Clamp on ultrasonic water meters have a number of parameters that need to be specified by the user (e.g., pipe wall thickness, outside diameter, pipe materials, water temperature). They also require specific positioning of measurement transducers and can have multiple transducer sets. For best results, it is essential that the users are trained in the proper use of these meters.

It is very important to get meter parameters right – therefore, meter installations should permanently record (e.g. with a stamp or information plate) parameters including outside diameter, pipe wall thickness (based on multiple measurements) and material to minimise errors in future testing.

Additional Testing

Since we completed this report, we conducted additional testing on an AFMG clamp on meter (2 transducer sets).

We tested the effect of erroneous setup parameters- wall thickness, transducer alignment and transducer distance.

Further research is recommended to develop a better understanding of the effect of these parameters on ultrasonic clamp on water meters, but based on these (limited) findings, it is suggested that multiple clamp on meter setups are tested and averaged if adopting clamp on ultrasonic water meters to verify in-situ water meters.

Pipe size (mm)	100		40	
Material	Steel		PVC	
Velocity (m/s)	3		3	
Conditions	Error (%)	Error shift (%)	Error (%)	Error shift (%)
Standard conditions	-0.55		1.9	
Changes				
Wall thickness: +5%	-0.74	0.19	0.54	1.36
Wall thickness: -5%	0.19	0.74	2.97	1.07
Transducers alignment: +5%	-1.11	0.56	2.52	0.62
Transducers alignment: -5%	-0.3	0.25	0.69	1.21
Distance between transducers: +5%	-0.64	0.09	-0.07	1.97
Distance between transducers: -5%	-0.47	0.08	0.39	1.51

Acknowledgements

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We express our gratitude to Dr Robert Keller (R. J. Keller & Associates) for his thoughtful review comments.

A final report for this work with detailed results and discussion is here:

https://www.unisa.edu.au/research/sustainable-infrastructure-and-resource-management/australian-flow-management-group/reports-and-resources/

Draft Guideline for the Monitoring of Suspended Sediment Load from Acoustic Doppler Current Profilers (ADCP's)

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Summary

A draft guideline for the monitoring of suspended sediment load using acoustic Doppler current profilers (ADCP) has been developed by a team of researchers from the Department of Environment and Science Water Quality & Investigation Unit (WQI), Queensland University of Technology, and the Department of Natural Resources, Manufacturing and Water. The aim is for the guideline to be published for use at the national level upon review and approval by the Water Monitoring Standardisation Technical Committee (WaMSTeC). ADCP are well suited for the monitoring of suspended sediment load as the instruments are routinely used to monitor discharge and suspended-sediment concentration (SSC) can be estimated from acoustic backscatter measurements recorded by ADCP. Current efforts have focused on data collection and analysis of field measurements from Queensland, Australia (Livsey et al., 2022, Livsey et al., in prep). This article outlines the process for monitoring suspended sediment load from ADCP and illustrates initial results.

The standard details the workflow needed to compute suspended sediment load from ADCP and provides methods for quantifying uncertainty in load measurements. A typical workflow is summarised below:

1. Collect simultaneous field measurements of acoustic backscatter, either from ADCP or acoustic backscattering sensors (ABS), and water samples for the measurement of SSC.
2. Post-process acoustic backscatter to correct for changes in ambient noise level, power supply voltage, near-field spreading of the acoustic beam, and attenuation of sound by water and suspended sediment.
3. Calibrate corrected acoustic backscatter to field measurements of SSC with calibration undertaken by regression between acoustic backscatter and SSC.
4. Compute suspended sediment load from the product of SSC estimated from acoustic backscatter and discharge.

Results are presented from field measurements collected on the Johnstone River near Innisfail, Queensland in 2020. The site was selected because WQI measures suspended sediment load by pairing discharge from a horizontally profiling ADCP (hADCP) with SSC measured from discrete water samples (Turner et al., 2013). At the river station, the cross-section is roughly 300 m wide and 6 m deep at mean water level with a great diurnal range of 2 m. Oscillations in tidal flow are on the order of +/- 700 m3/s with unidirectional flow occurring at high discharge (> 750 m3/s). The maximum observed event discharge is on the order of 4500 m3/s.

For brevity, results from steps 3 and 4 are provided to illustrate the workflow. Firstly, calibration of acoustic backscatter to field measurements of SSC can be undertaken by regression to SSC measured at a point (SSCpt) (Figure 1a) or to cross-section average measurements of depth-averaged, discharge-weighted SSC (SSCxs) (Figure 1b). SSCpt measurements can be analysed from discrete water samples, whereas measurements of SSCxs require boat-based sampling methods (Edwards et al., 1999). SSCxs in this work is estimated from acoustic backscatter from ABS converted to SSC (Figure 2a) and boat based ADCP measurements of discharge. Regression to SSCxs (Figure 2b) should be undertaken if significant vertical or cross-channel variability in SSC is expected. At the river station, significant variability in SSC was observed (Figure 3), so acoustic backscatter from the hADCP was regressed to SSCxs. After calibration, time-series estimates of SSCxs from acoustic backscatter can be multiplied by discharge to compute suspended sediment load (Figure 4). Suspended sediment load estimates from the ADCP are within 10 percent of sediment load measurements reported by WQI.

Figures

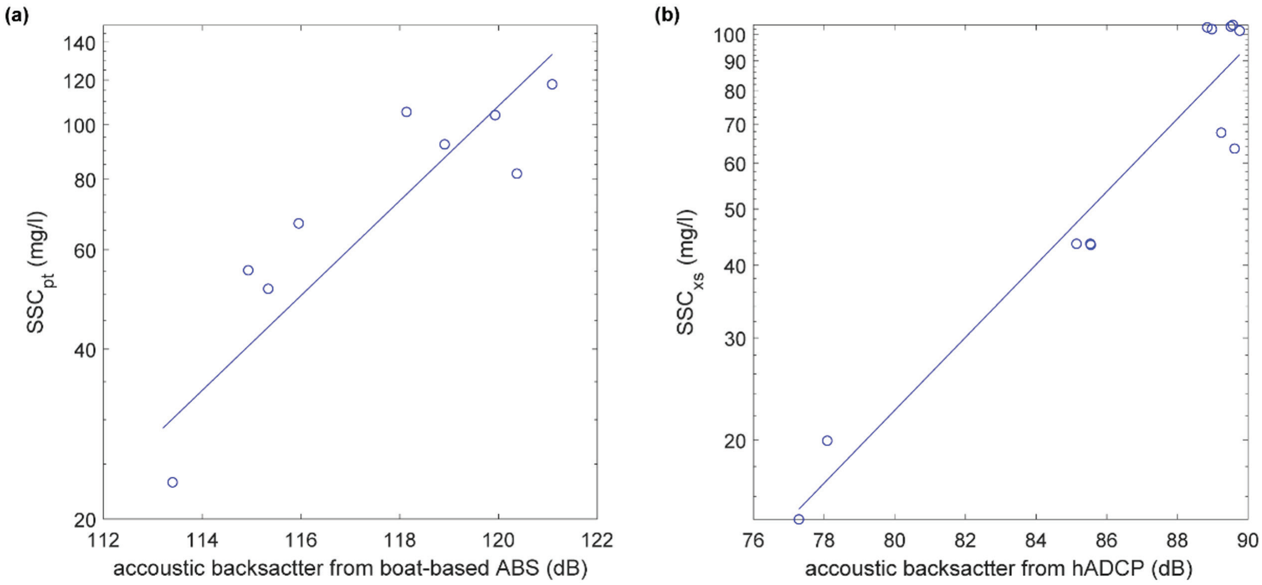

Figure 1. (a) Point-based measurements of SSC (SSCpt) from US-P61 sampler and acoustic backscatter from boat-based acoustic backscatter sensor (ABS); best-fit ordinary least squares regression line shown (R2 = 0.81, p-value < 0.001, n = 10) (b) Cross-channel average measurements of depth-averaged, discharge-weighted SSC (SSCxs) and acoustic backscatter from horizontally profiling ADCP (hADCP); best-fit ordinary least squares regression line shown (R2 = 0.92, p-value < 0.001, n = 12). See figure 2 for example of cross-channel acoustic backscatter and SSC from boat-based ABS. See figure 4 for timeseries of SSCxs estimated from regression in (b).

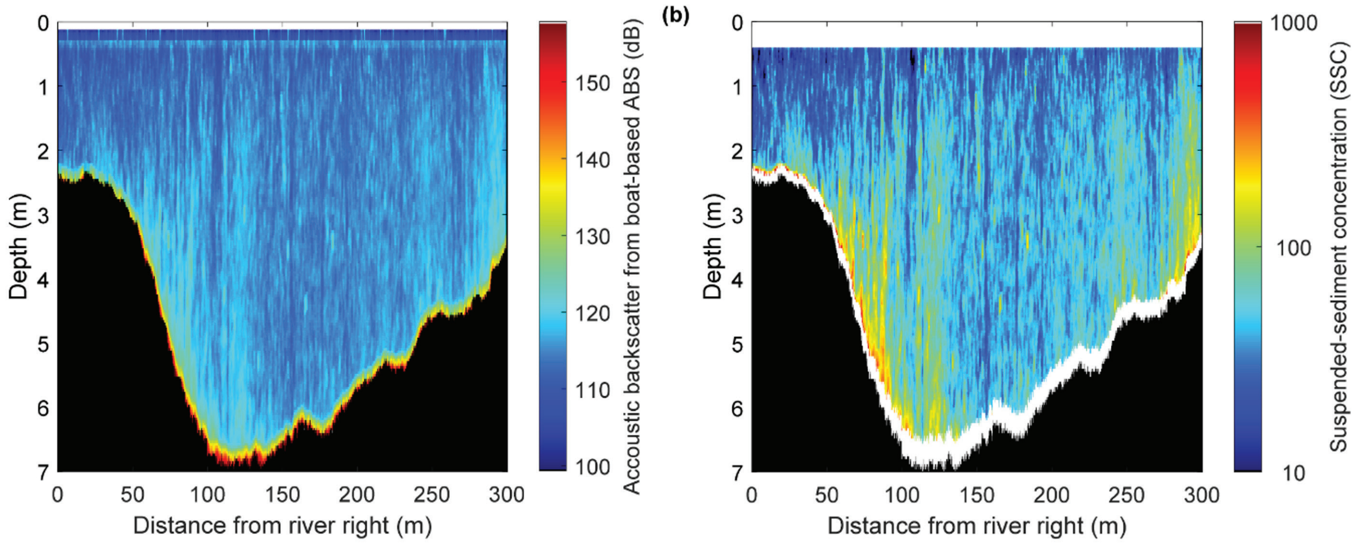

Figure 2. Cross-channel acoustic backscatter from boat-based ABS (a) converted to SSC (b) from regression shown in figure 1a. White region in panel (a) is from 0.1 m draft on ABS mount. White regions in panel (b) are a result of excluding near-surface and near-bed acoustic backscatter anomalies caused by surface interference and side-lobe interference, respectively. Depth to side-lobe interference is the cosine of the angle of the acoustic beam from vertical. Although ABS is oriented vertically, a conservative estimate of 15 degrees was used to account for possible movement from vertical while the boat was moving. Use of ABS greatly reduce data lost to side-lobe interference as the acoustic beam is oriented vertically and ADCP commonly use acoustic beams slanted at 30 degrees from vertical.

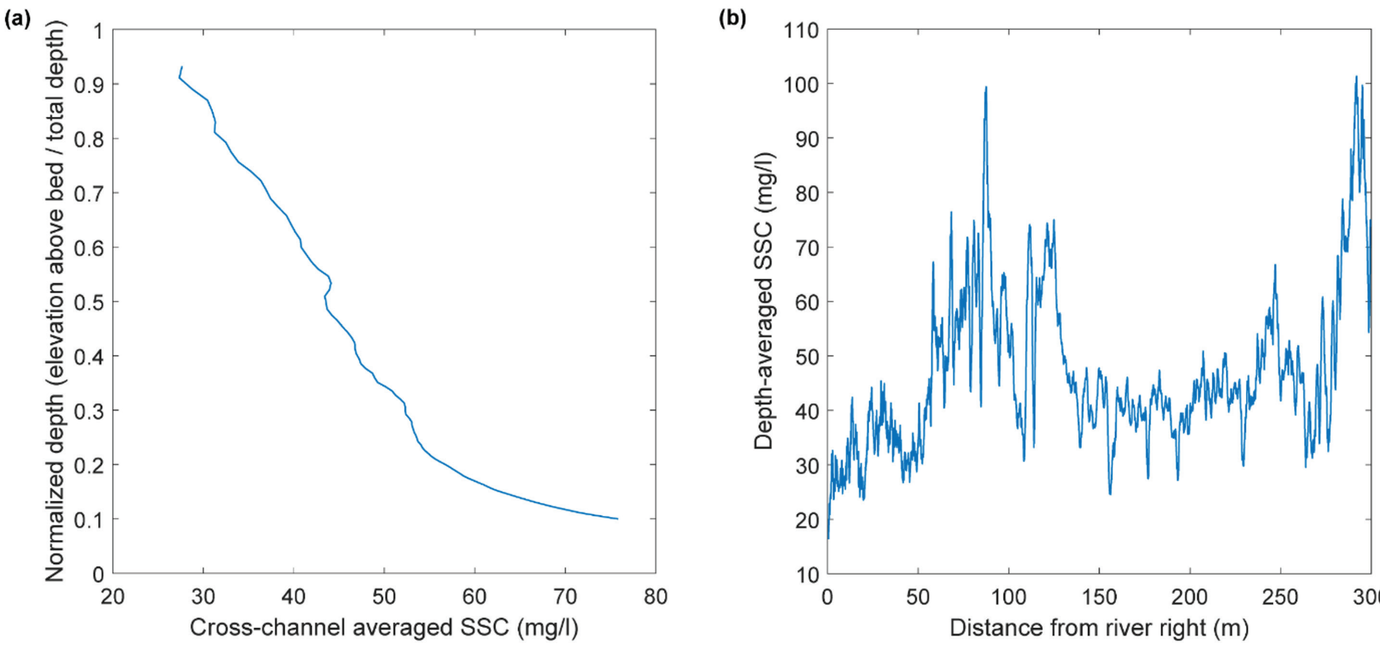

Figure 3. Cross-channel average SSC (a) and depth-averaged SSC (b) computed from figure 2b. Cross-channel average SSC was computed after normalising depth for all measurements across the channel. Depth was normalized by dividing elevation above the bed by total depth.

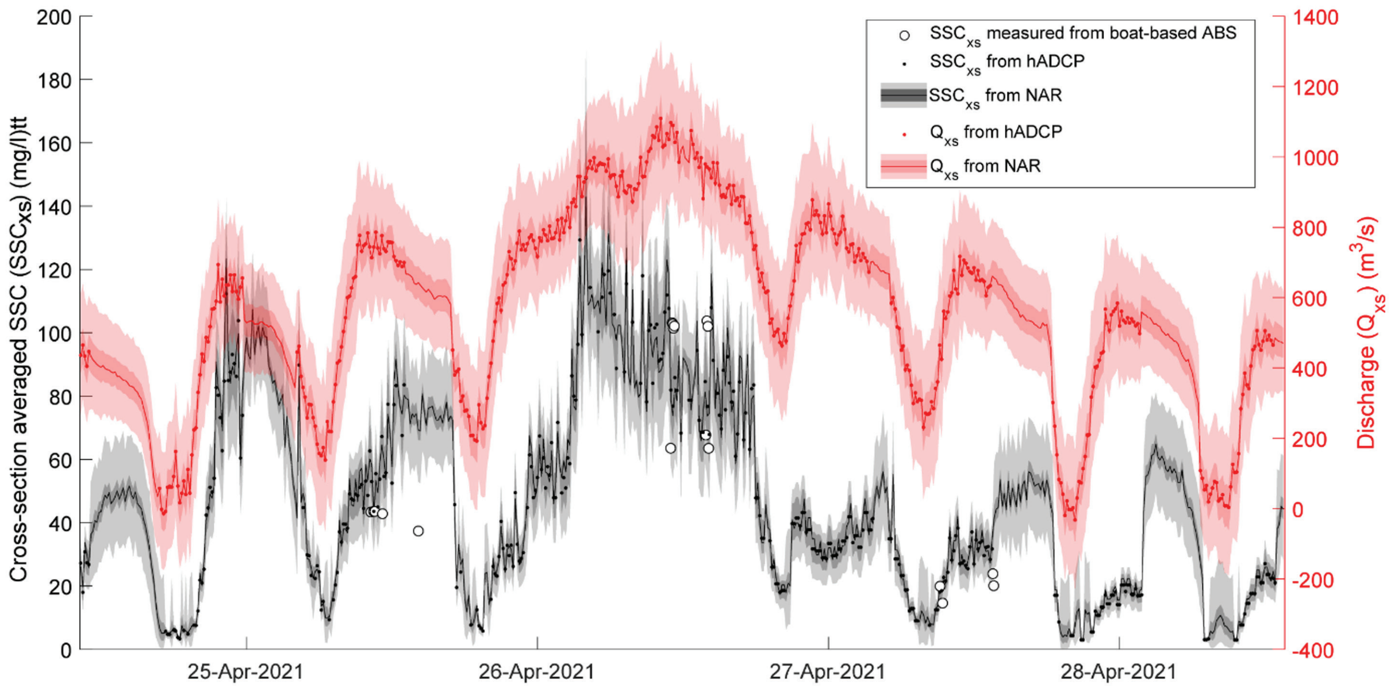

Figure 4. Timeseries of cross-channel average of depth-averaged, discharge-weighted SSC (SSCxs) and total cross-channel discharge (Qxs) from horizontally profiling ADCP (hADCP). Subscript "xs" denotes cross-section estimated or measured quantities. Gaps in observations, the result of out of water readings at low tide were in-filled using nonlinear autoregressive neural networks (NAR). Dark and light shaded regions indicate uncertainty of NAR models at one and two standard deviations, respectively. The Qxs NAR model uses stage at Innisfail and discharge observed at upstream stations. The SSCxs NAR model uses the Froude number and tidally filtered Qxs. NAR were used to infill data gaps as NAR model nonstationary processes between the response and target variable (e.g., a change in sediment erodibility that would affect the relationship between the Froude number and SSCxs).

Acknowledgements

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