2018 Natural Channels Conference – Guelph, ON

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W.K. Annable

Field Based Correction of Environmental Flow Estimates Affected by Aquatic Vegetation Growth at Gauged Sites

UNIVERSITY OF WATERLOO
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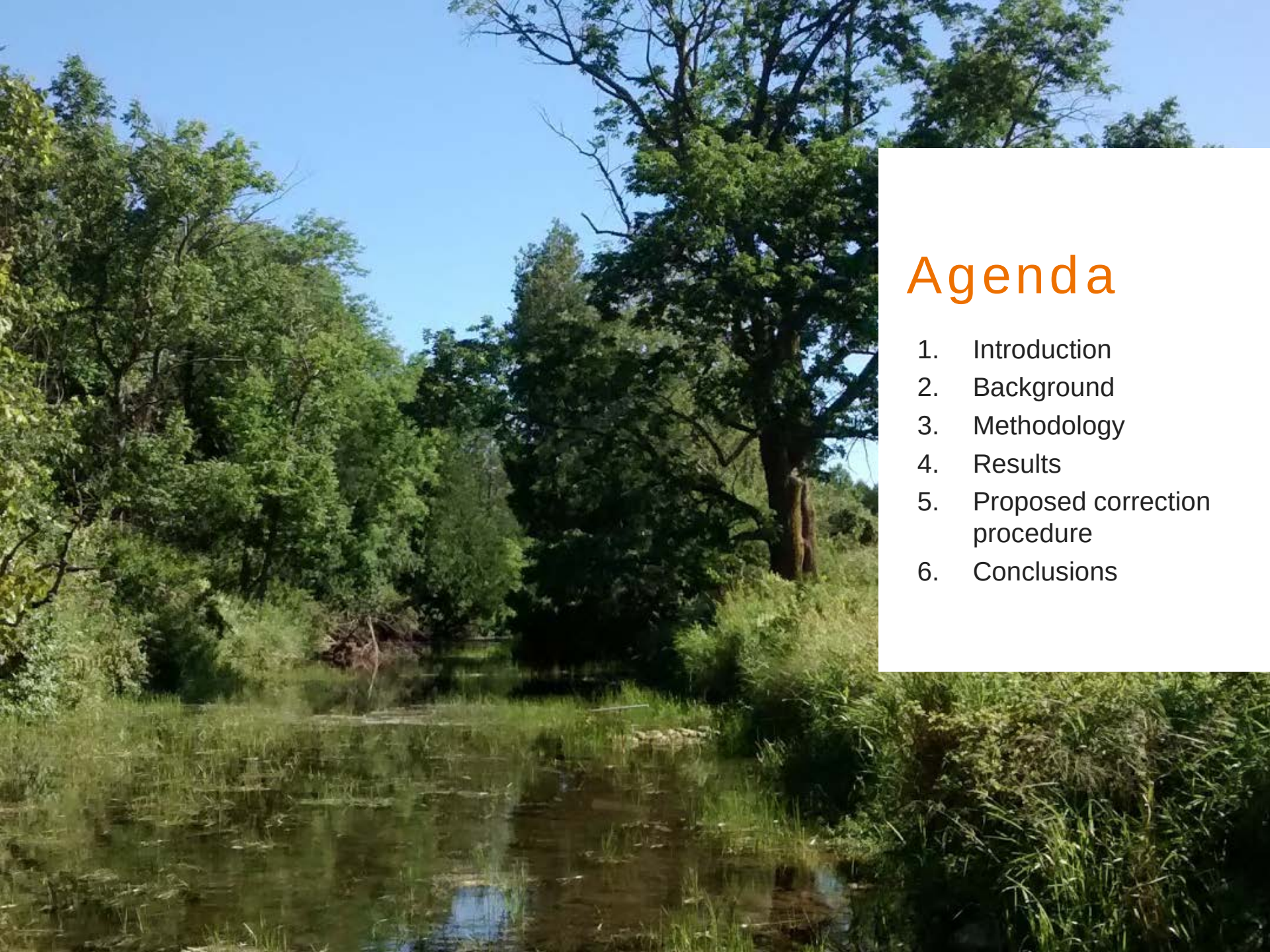
Stantec



Agenda

1. Introduction
2. Background
3. Methodology
4. Results
5. Proposed correction procedure
6. Conclusions

Introduction

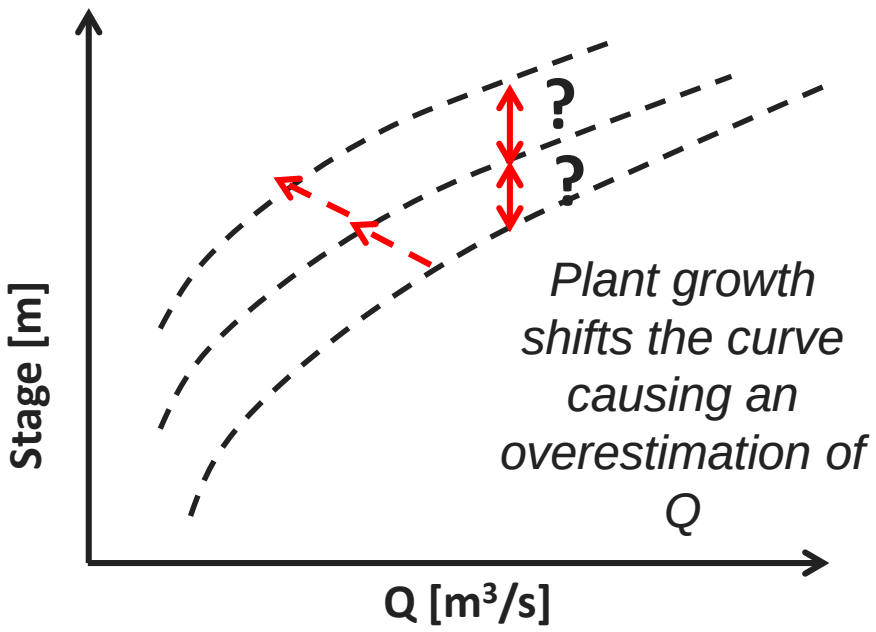
Issue and Study goals

Flow records and Streamgauging

- Only “direct” source of flow data
- Multiple uses (and end-users)
- Measure water levels at gauging stations
- Obtain flow from a rating curve

Effects of aquatic vegetation

- Vegetation increases flow resistance
- Increases water level for the same Q
- Q estimated through a conventional rating curve will be overestimated
- Errors are generally higher at low flow



Dangers of low flow overestimation

- Uneven water apportionments
- Flawed water allocation protocols
- Inconsistent low flow indices
- Wrongful evaluation of habitat suitability
- Defective Drought and Climate change impact assessments

Both long- and short-term issues!

Klamath River, Oregon, USA [2002] – *waterwatch.org*

Study goal

Improve the estimation of low flows at gauged sites

And develop techniques:

- To map aquatic plants
- To quantify temporal changes in flow resistance
- Repeatable, time-efficient

Background

Previous studies findings and limitations

Vegetation vs Flow resistance

- First studies in 1930s on agricultural drains
- Lab studies from the 1960s
- Field studies from the 1980s

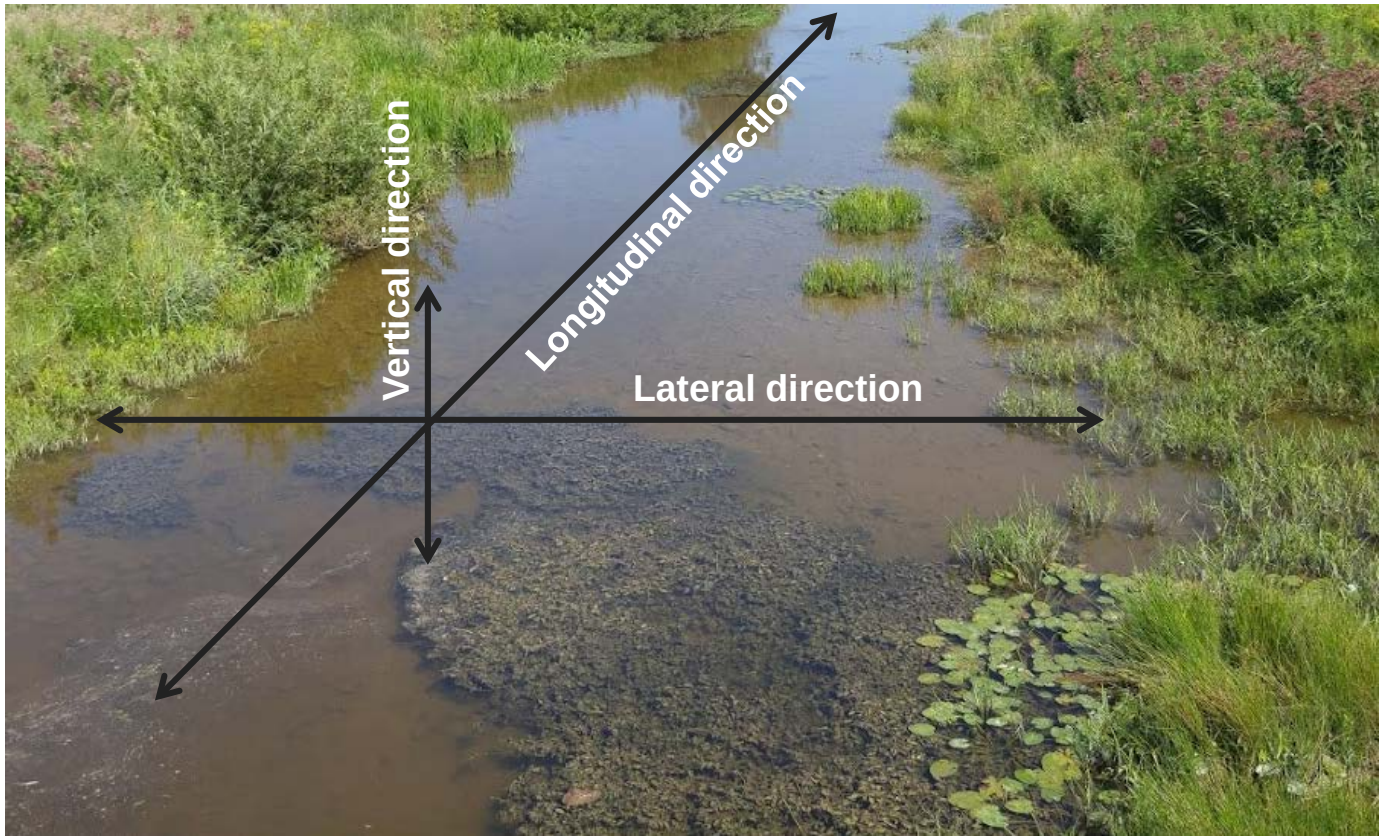
Experiments in Stillwater, OK (ca. 1985) photo by N. Kouwen

Lab experiments at UWaterloo (2011)

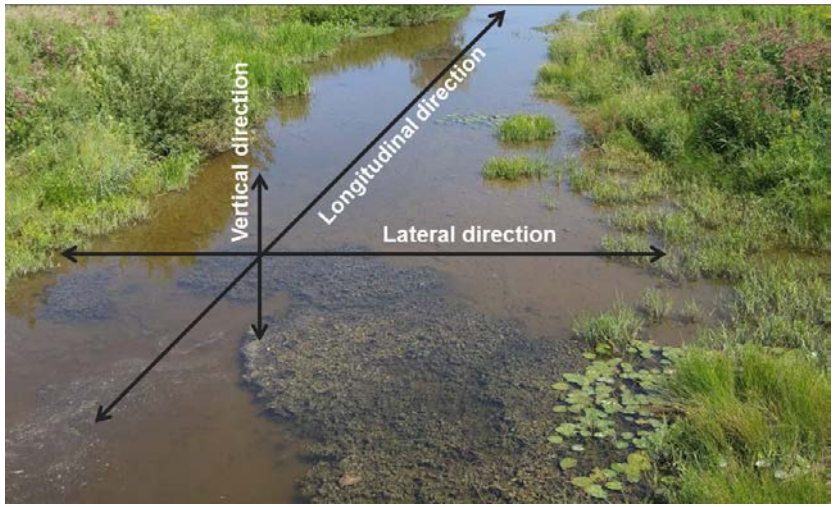
Overall consensus

Vegetative flow resistance α Spatial distribution of vegetation

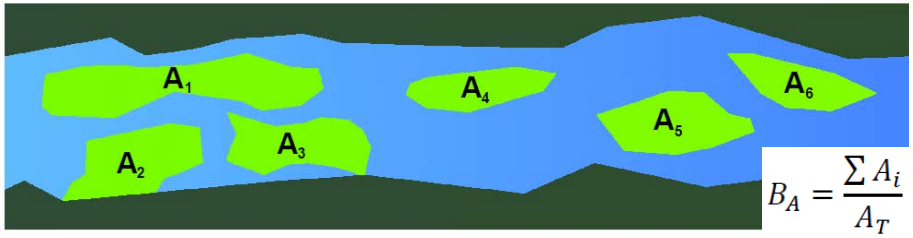
(Kouwen et al. 1969; Green, 2005; Nikora et al., 2008; Nepf, 2012)



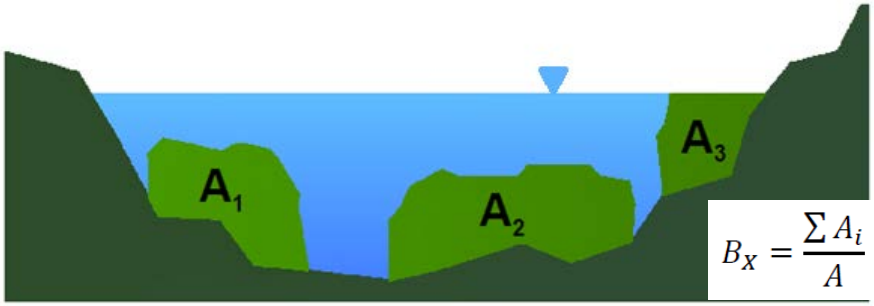
Field metrics



Longitudinal+Lateral=Aerial cover (B_A)



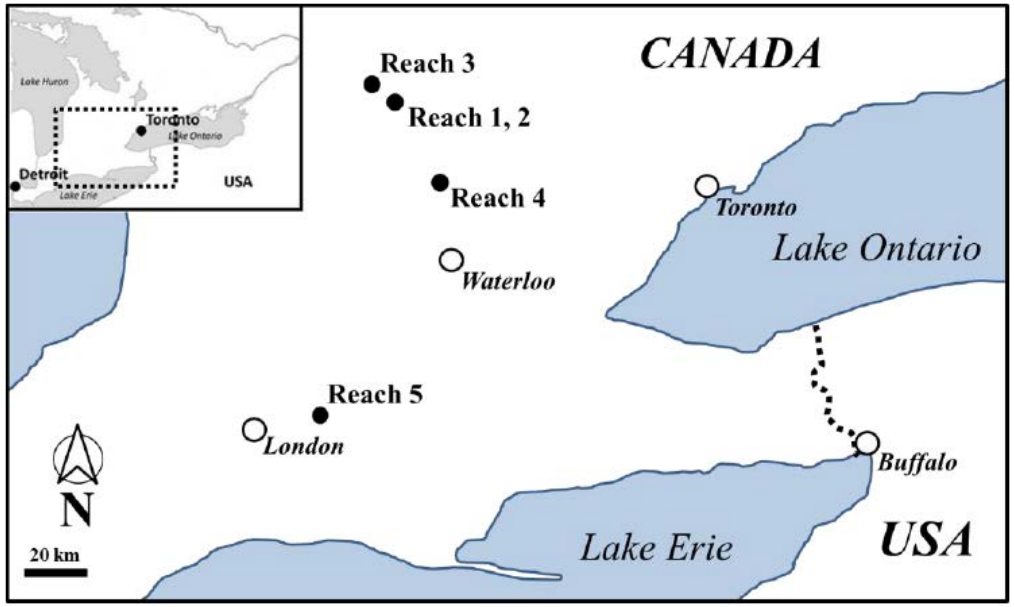
Vertical+Lateral=Blockage factor (B_X)



Methodology

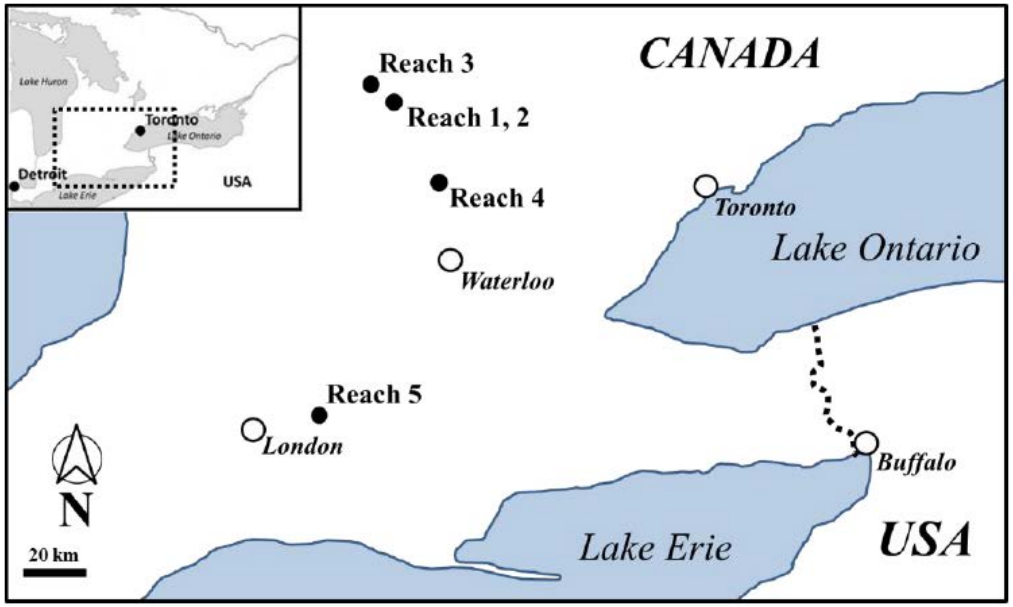
Data collection and analysis

Study Sites



- Five reaches in Southern Ontario
- Avg Width ~ 7 – 12 m
- Length ~ 106 – 149 m
- Drainage Area ~ 46 – 145 km^2
- Both submergent and emergent species

Study Sites



Reach 1, Moorefield Creek

Reach 3, North Maitland River

Reach 4, Canagagigue Creek

Site measurements

- Flow measurements
- Continuous depth measurements
- Vegetation surveys

Site measurements

- Flow measurements
  - To develop a rating curve
- Continuous depth measurements
  - At vegetated locations
  - At non-vegetated locations

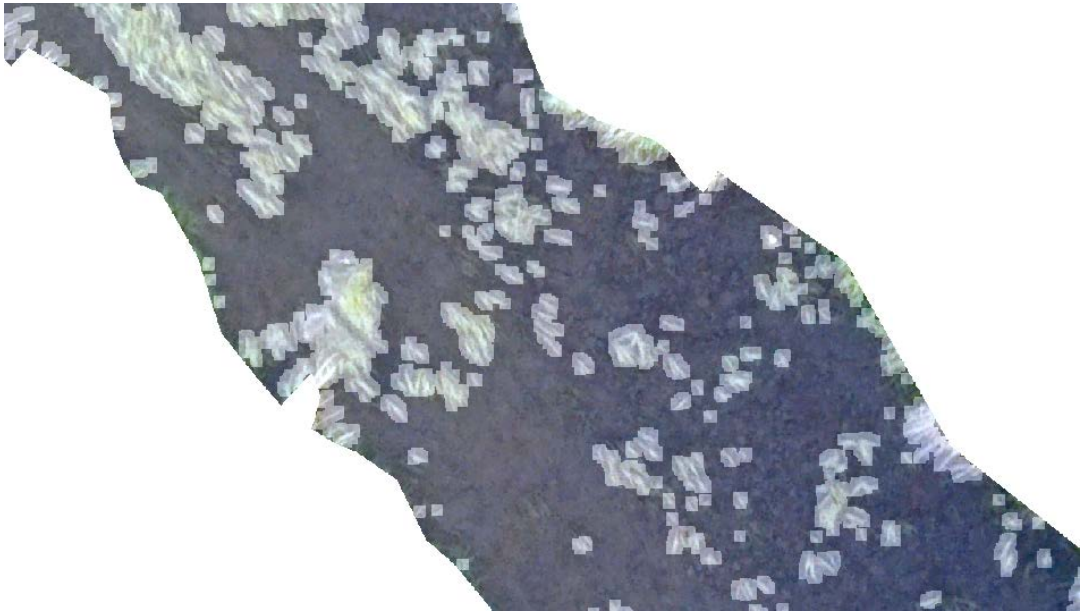
Site measurements

- Vegetation surveys
  - To map aquatic vegetation
  - Discrete (in channel); Repeated 7-10 times per year
  - Aerial – with drone

Results

Study Main Findings

Post-processing UAV photos with MATLAB®



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Assessing the accuracy of vegetative roughness estimates using unmanned aerial vehicles [UAVs]

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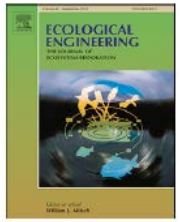
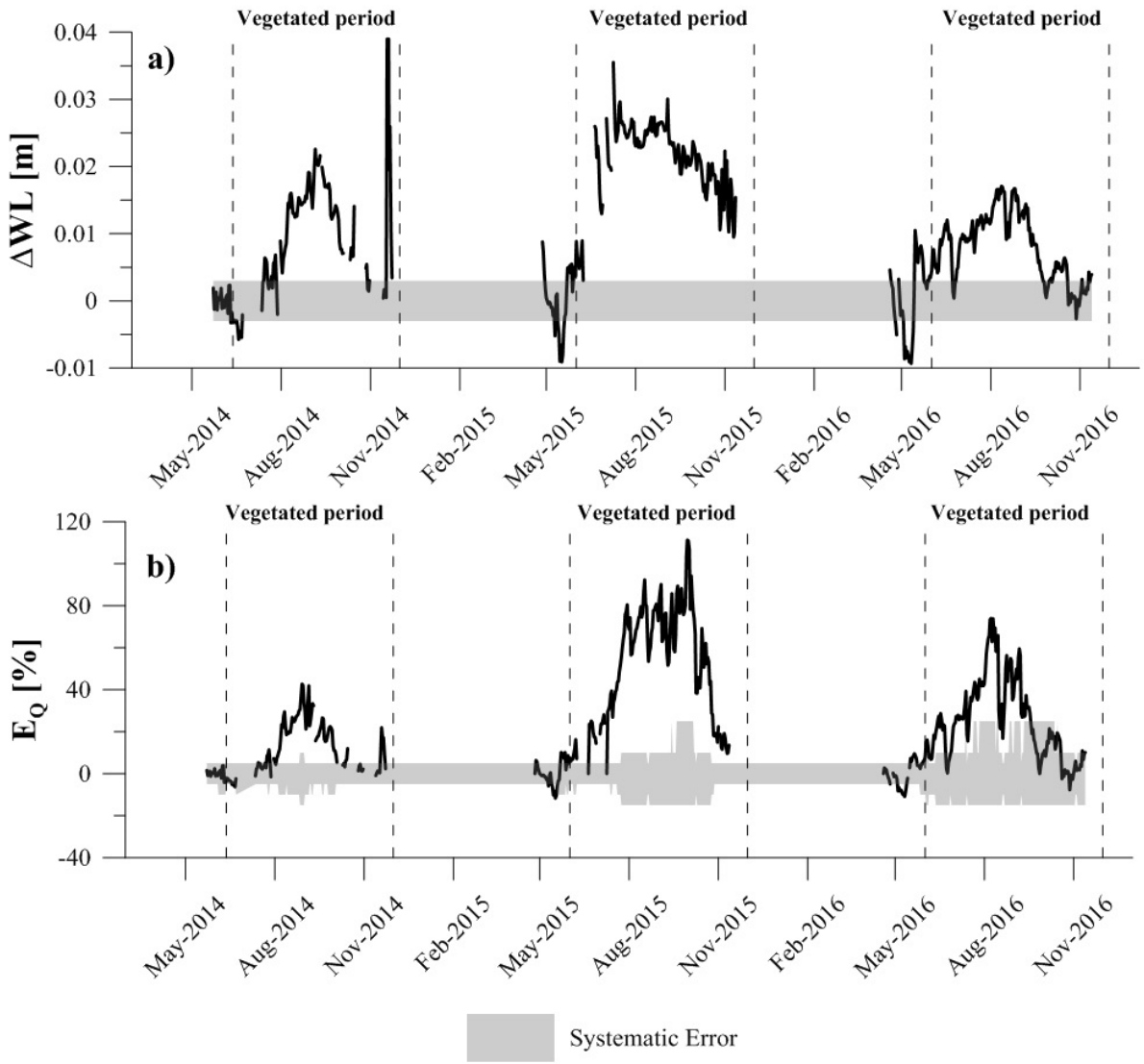


Temporal effects of aquatic vegetation

Increase in water level (for a constant Q)

Increase in Discharge Error



Spatial effects of aquatic vegetation

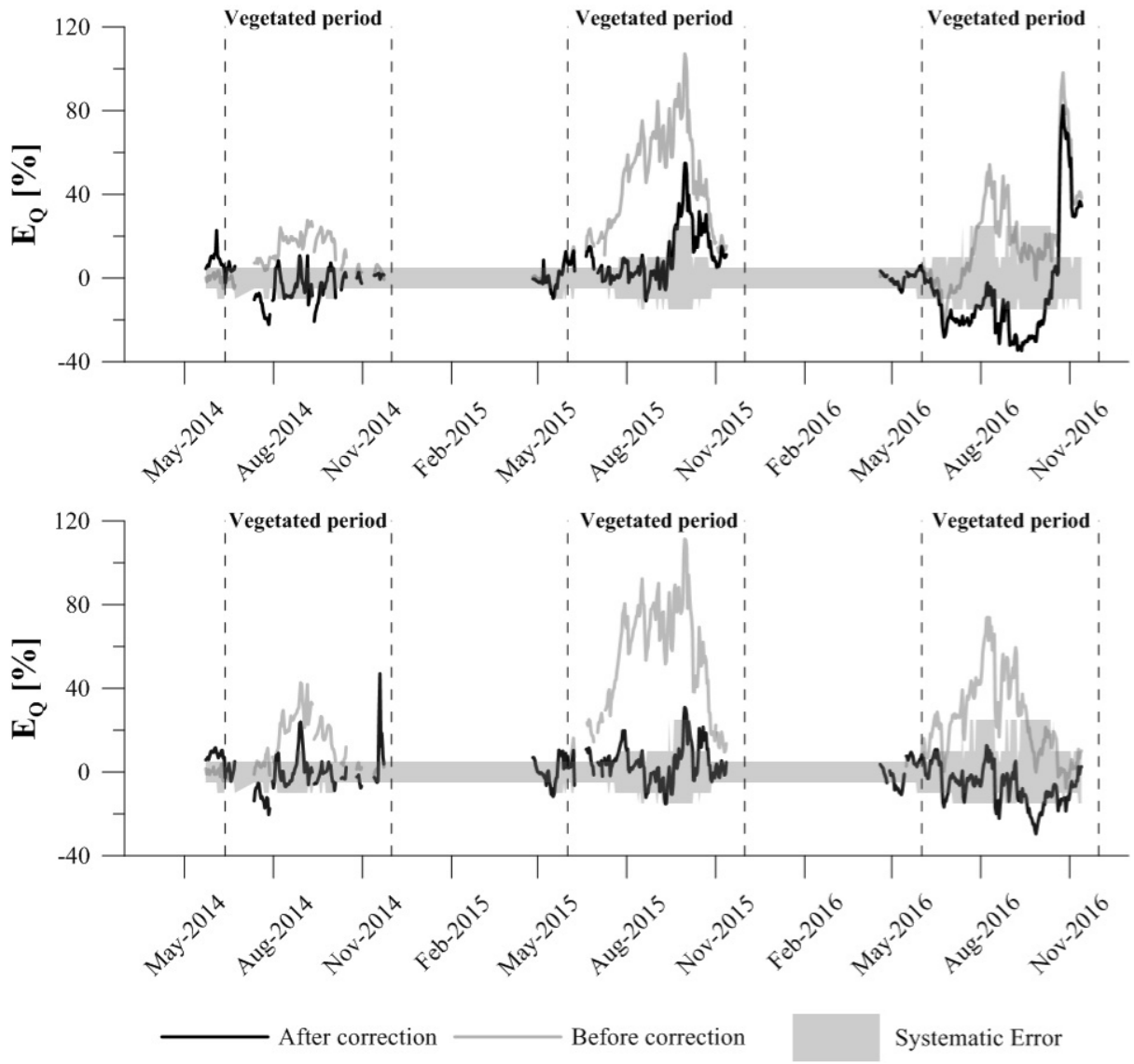
It is not the average distribution of plants that causes flow resistance to increase.

Rather, it’s where vegetation is the most dense that affects flow resistance.

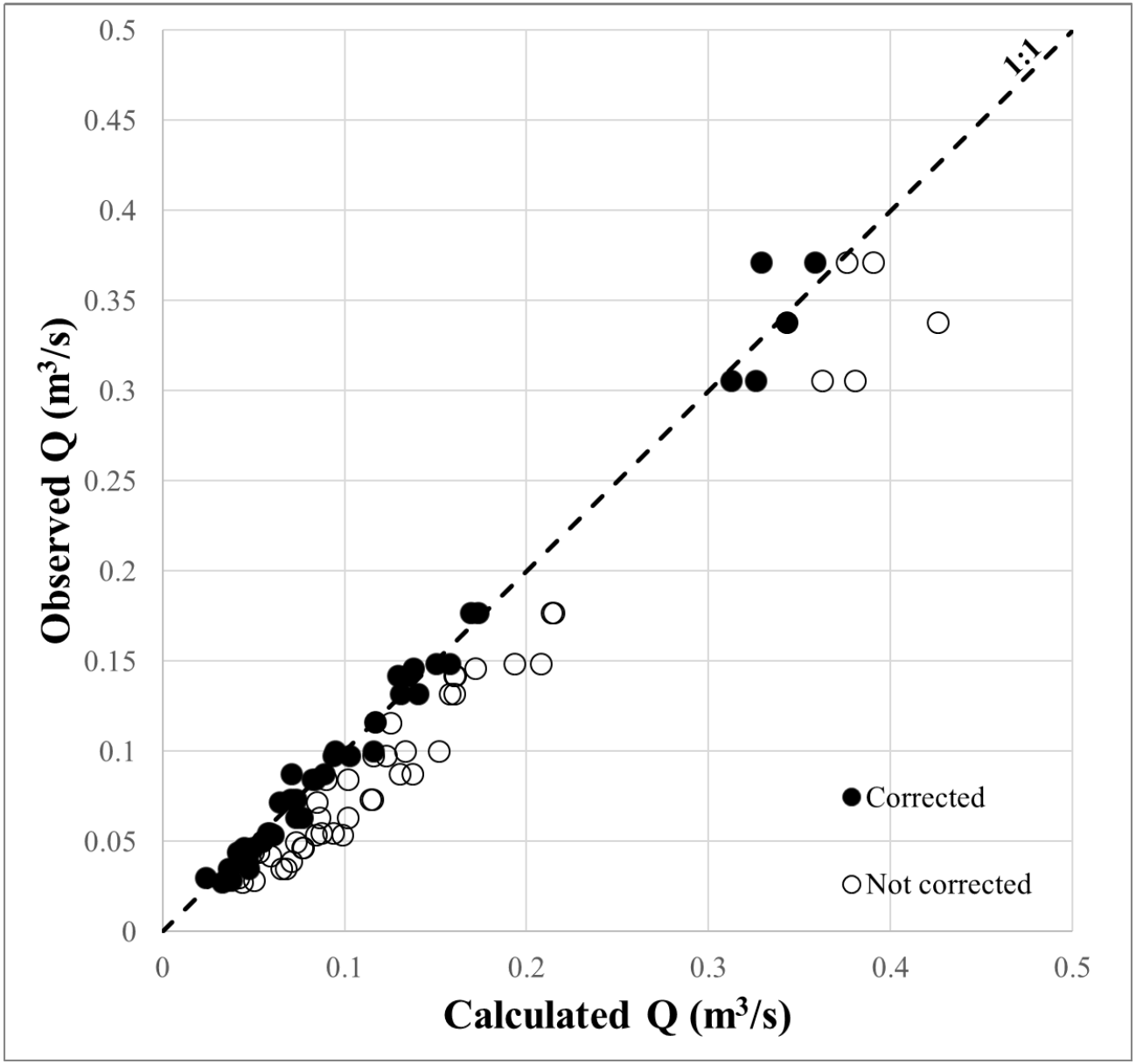
Proposed correction procedure

How do we correct these errors?

Correcting flow estimates



Correcting flow estimates



Correcting flow estimates

- Before correction
  - ~1,550 m^3/day overestimated (on average)
- After correction
  - ~37 m^3/day overestimation (98% reduction)
- One survey per month is enough to capture growth
  - Comparable to frequency used by streamgauging agencies

Conclusions

In summary…

Summary

- Successfully mapped aquatic plants distribution using cost-effective aerial photogrammetry techniques
- Not accounting for vegetation growth can cause overestimations above 100% of the actual flow
- Correction procedure is able to reduce the error by 98% on a yearly basis.
- Better low-flow records are possible using these methods.

Lower Darling River, Australia [2015] – *abc.net.au*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Stantec
JTB Environmental Systems Inc.
Fluvial Geomorphology Natural Channel Design Coastal Processes Erosion Control
THANK YOU – QUESTIONS?

References

- Green, J. C. (2005). Comparison of Blockage factors in modelling the resitance of channels containing submerged macrophytes. *River Research and Applications*, 671-686.
- Kouwen, N., Li, R.-M., & Simons, D. B. (1981). Flow resistance in vegetated waterways. *Transaction of the ASAE, 24*(3), 684-690, 698.
- Nepf, H. M. (2012). Hydrodynamics of vegetated channels. *Journal of Hydraulic Research, 50*(3), 262-279. doi:10.1080/00221686.2012.696559
- Nikora, V., Larned, S., Nikora, N., Debnath, K., Cooper, G., & Reid, M. (2008). Hydraulic resistance due to aquatic vegetation in small streams: field study. *Journal of Hydraulic Engineering, 134*(9), 1326-1332. doi:10.1061/(ASCE)0733-9429(2008)134:9(1326)