Measuring the flow in a small irregular river using LS-PIV

Contents

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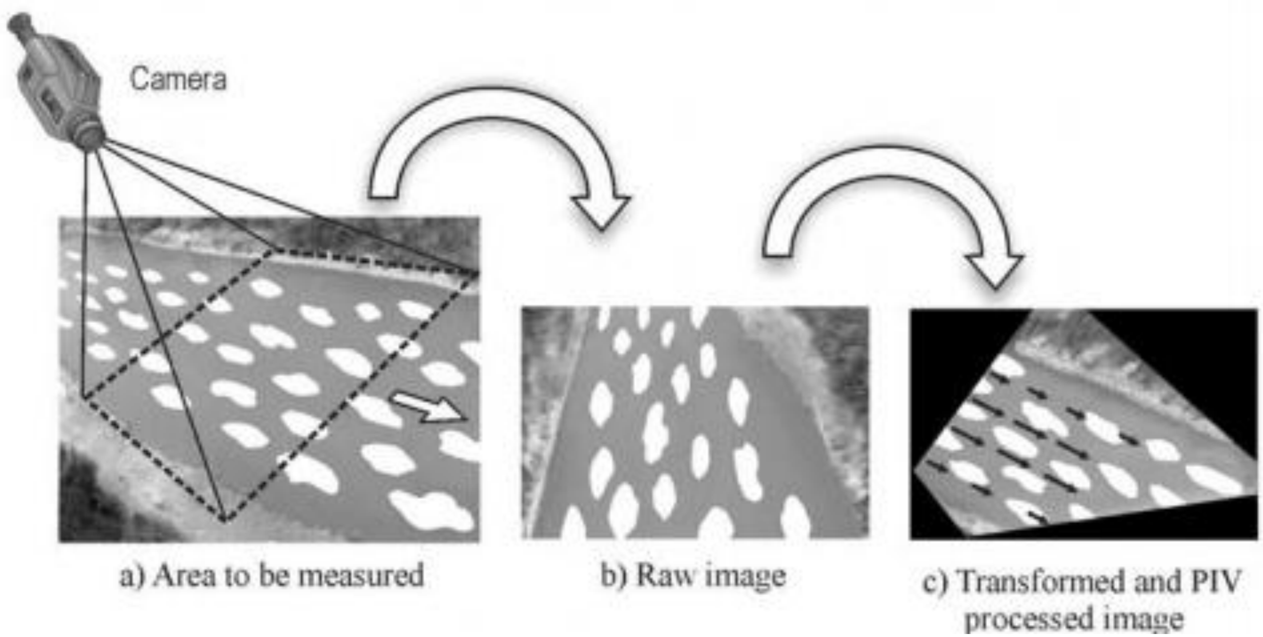
Definition of LS-PIV

- Non-intrusive approach used to measure the 2-D velocity field on the water surface.

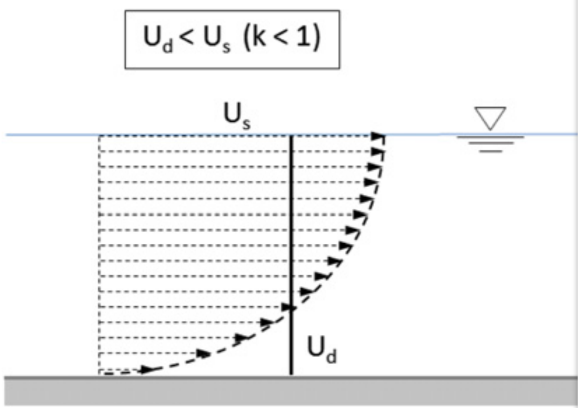


Definition of LS-PIV

- There are 3 types:
  - Large-scale Particle Image Velocimetry (LS-PIV)
  - Space-tome Image Velocimetry (ST-IV)
  - Controlled-surface Wave Image Velocimetry (CS-WIV)

The challenge

- Can we determine the discharge by simply looking at the patterns on the water surface?

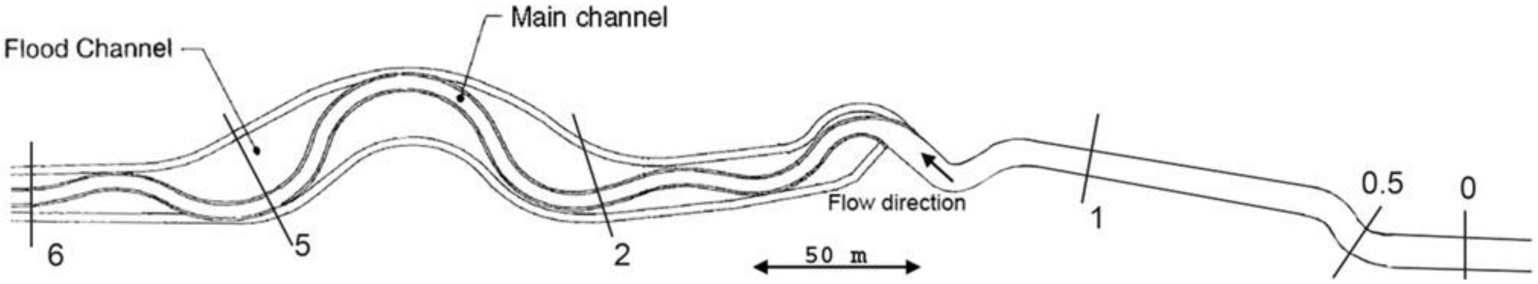


$$k = \frac{U_d}{U_s}$$

$$\frac{U(z)}{U_s} = \left(\frac{z}{h}\right)^{1/7} \Rightarrow k = 0.875$$

Experimental site

- “Man made” river
- Width = 5m; bank-full depth = 0.75m



Experimental site

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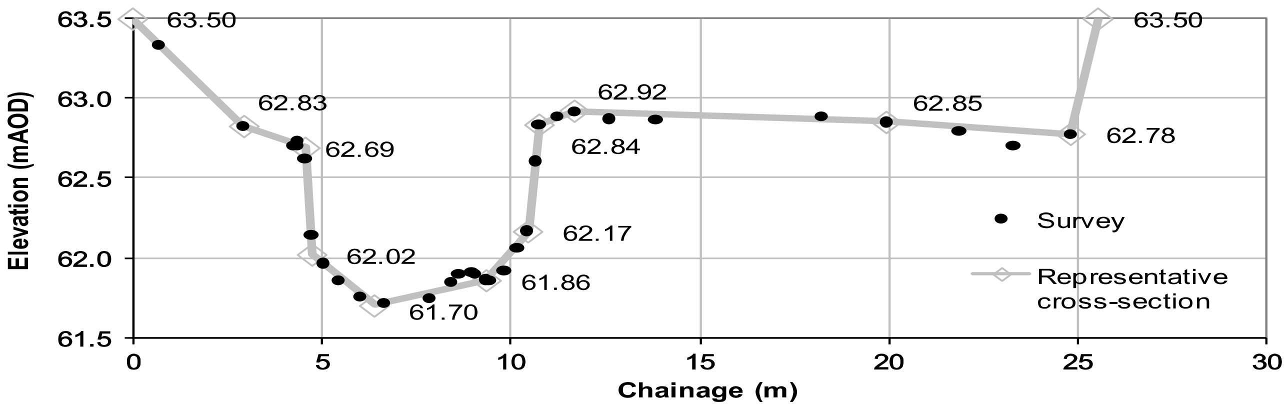
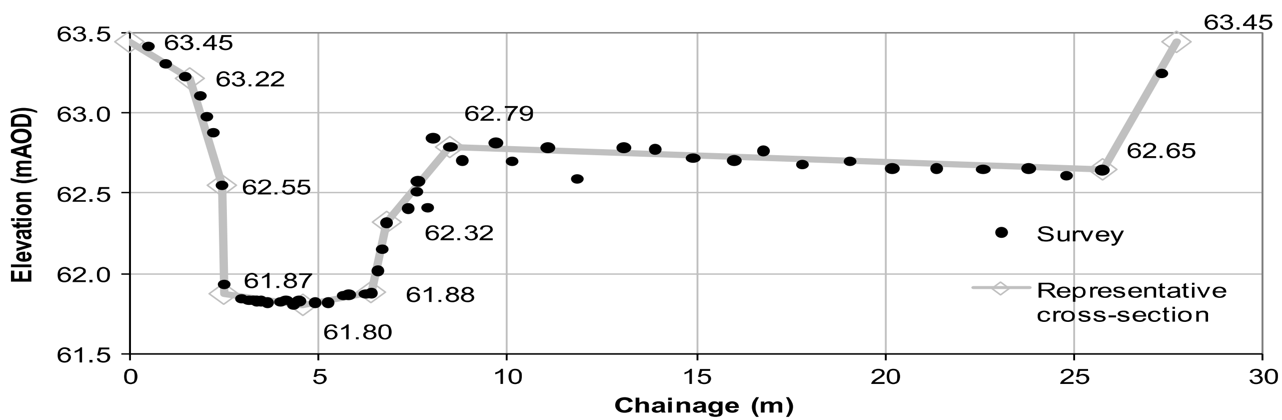


(a) Cross section 2.



(b) Cross section 5.

Fig. 3. Cross sectional profiles.

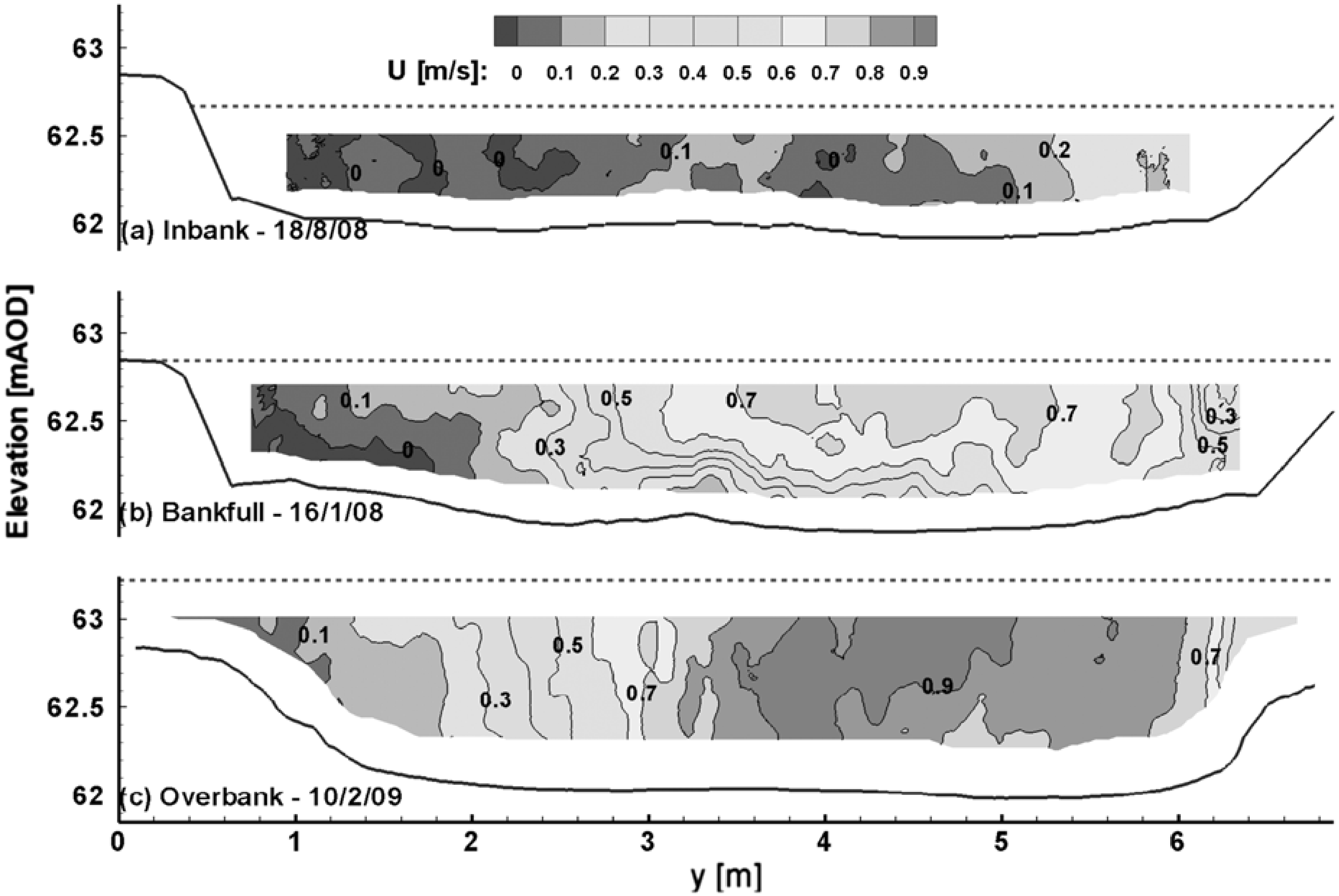
Data collected

- Event 1: bank-full (Q ~2.0 m^3/s)
- Event 2: in-bank (Q ~0.34 m^3/s)
- Event 3: over-bank (Q ~4.5 m^3/s)

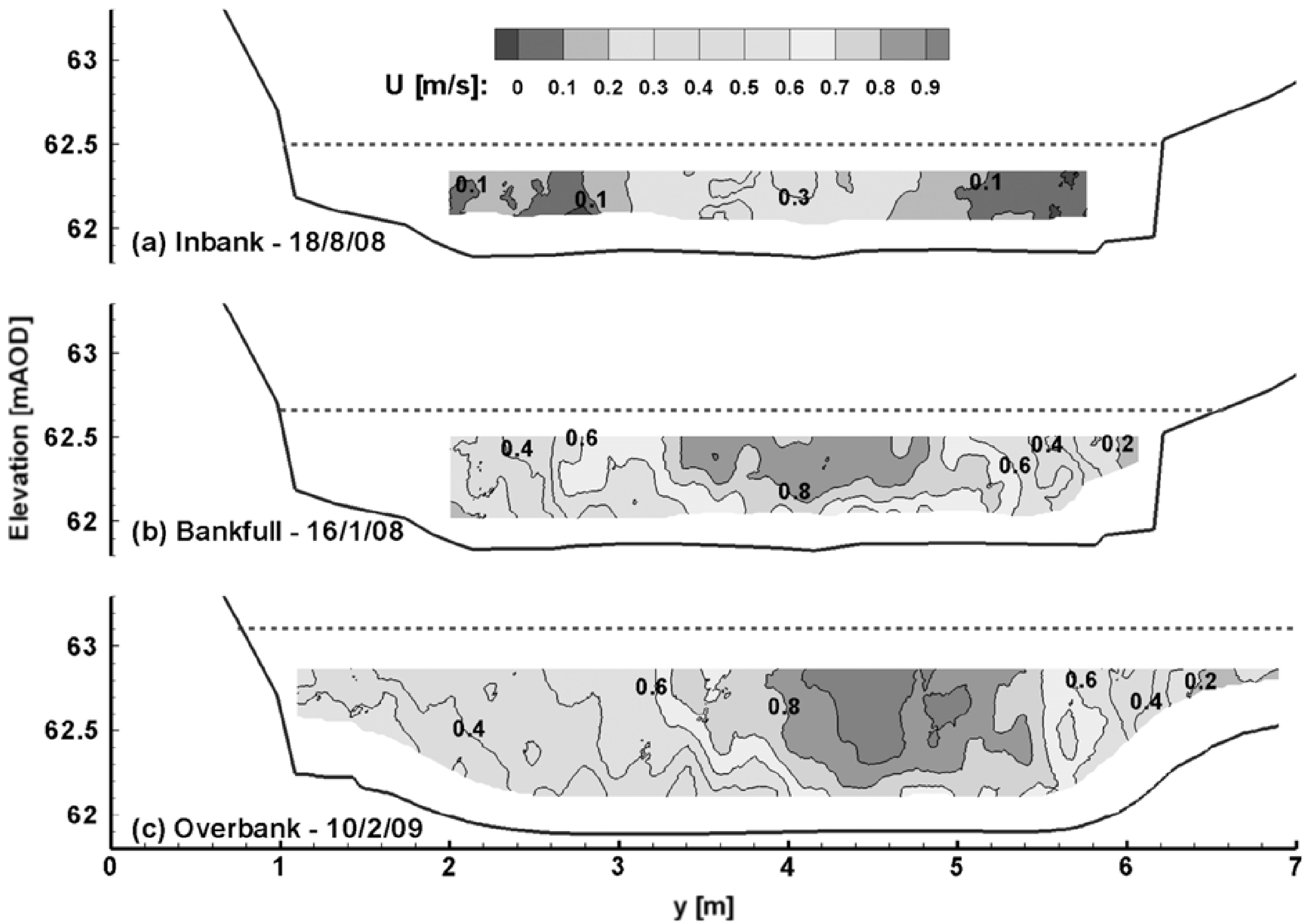
Data collected

- How does the position of maximum velocity vary with lateral distance?

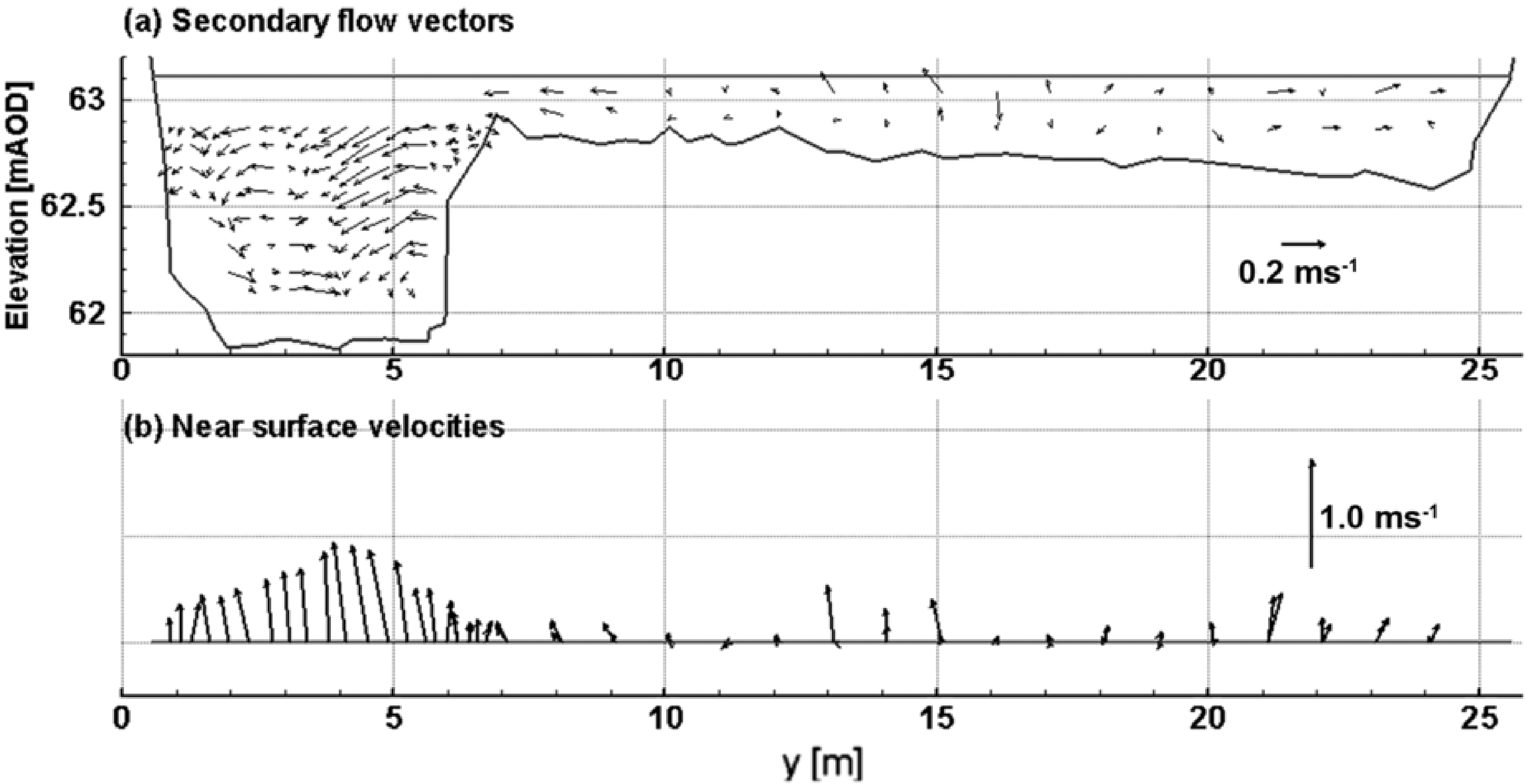
ADCP & ADV data – cs 2



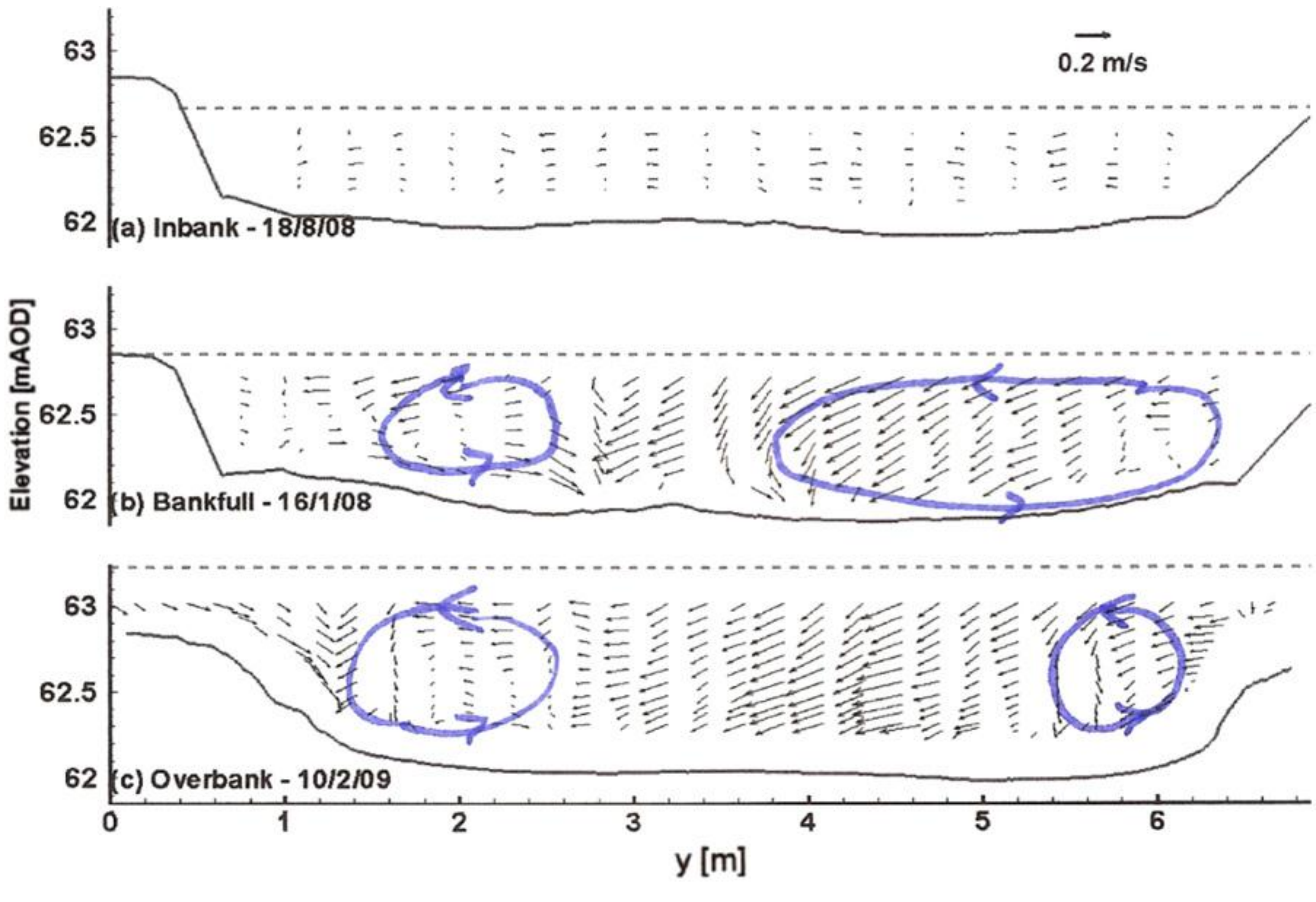
ADCP & ADV data – cs 5



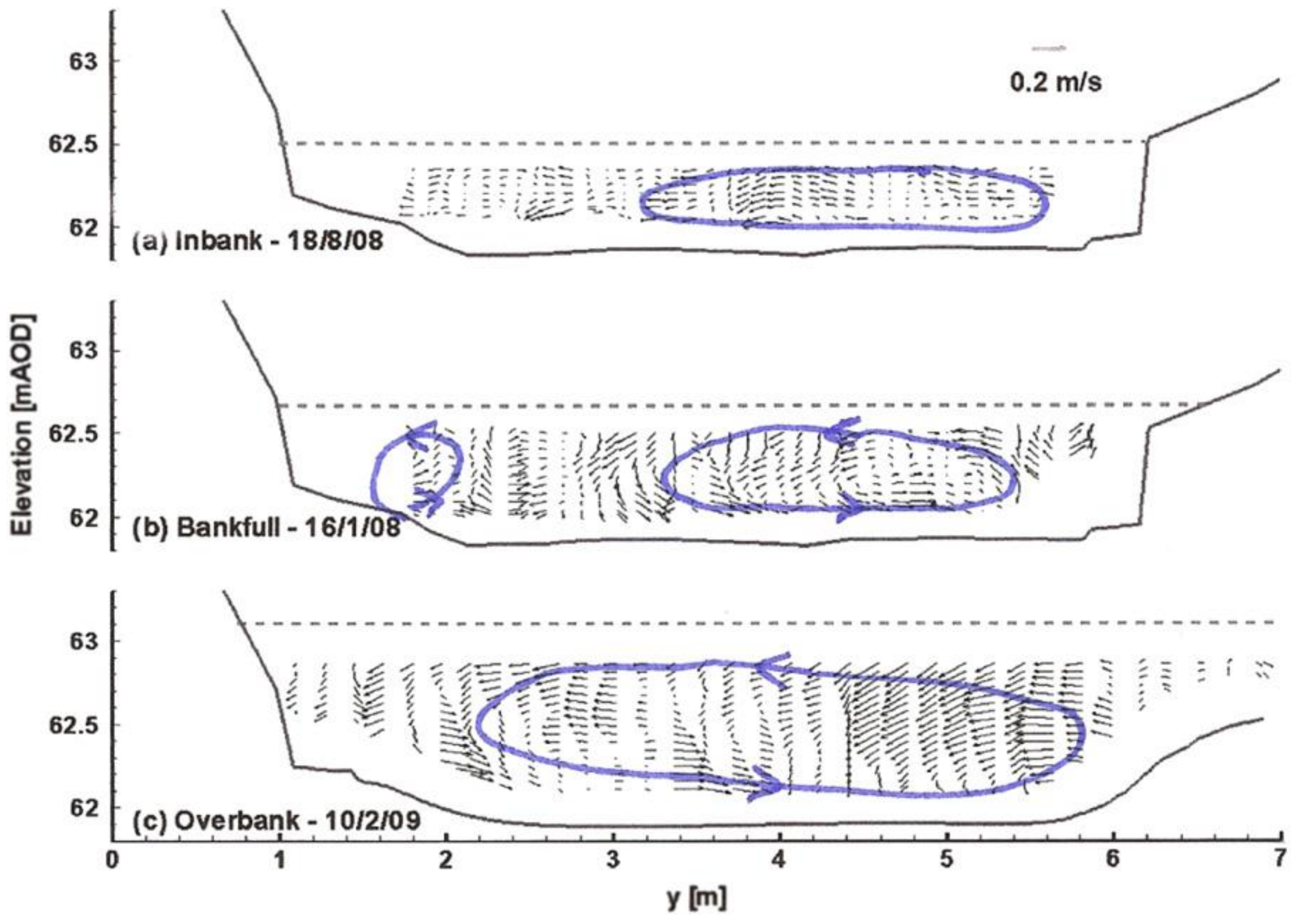
Velocity vectors for cs 5



Secondary flow – cs 2

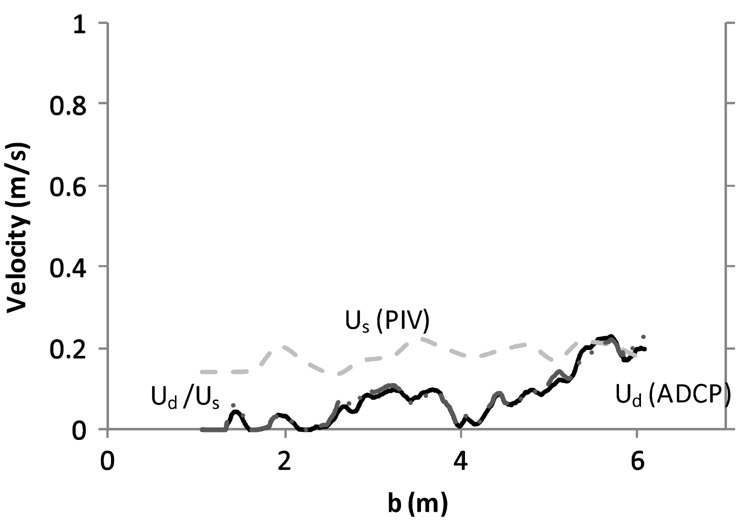


Secondary flow – cs 5

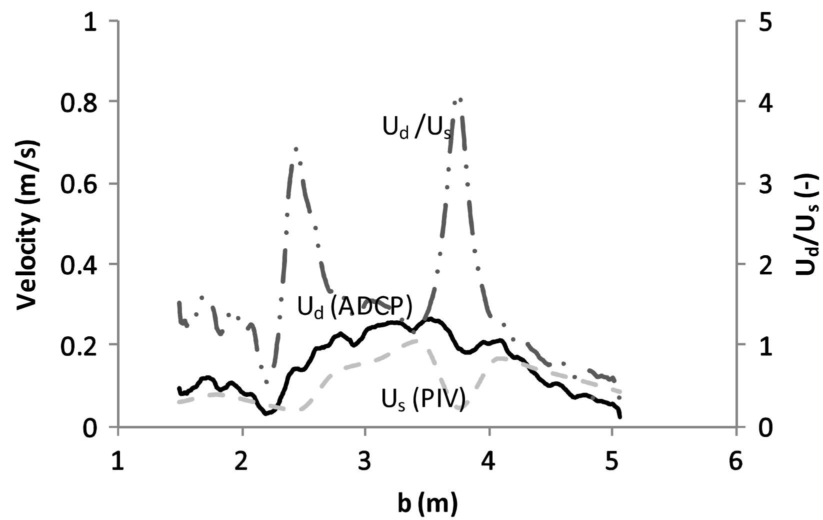


Surface velocity

Relationship between U_d / U_s in-bank flow

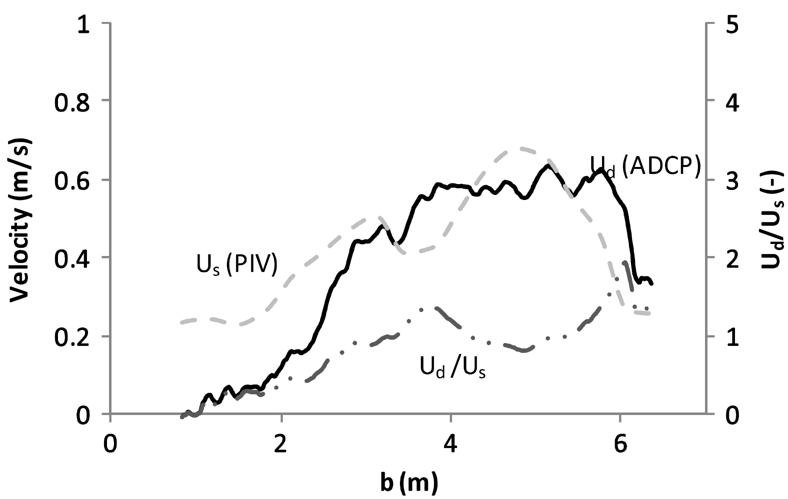


(a) Section 2.

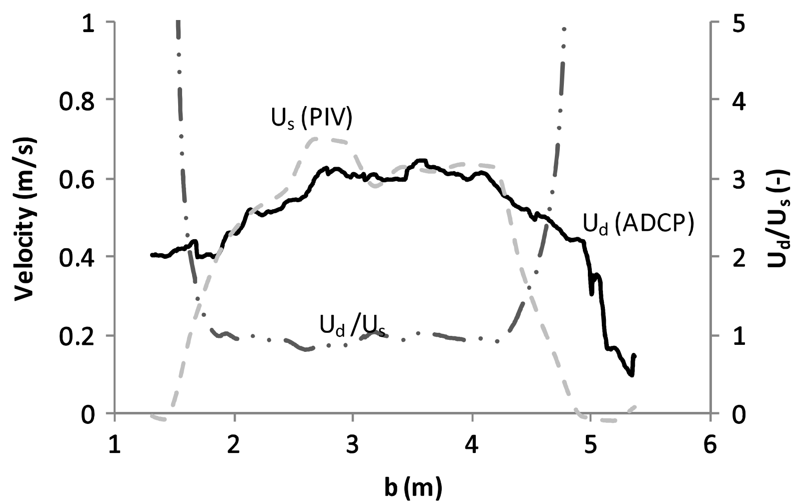


(b) Section 5.

Relationship between U_d / U_s bank-full case

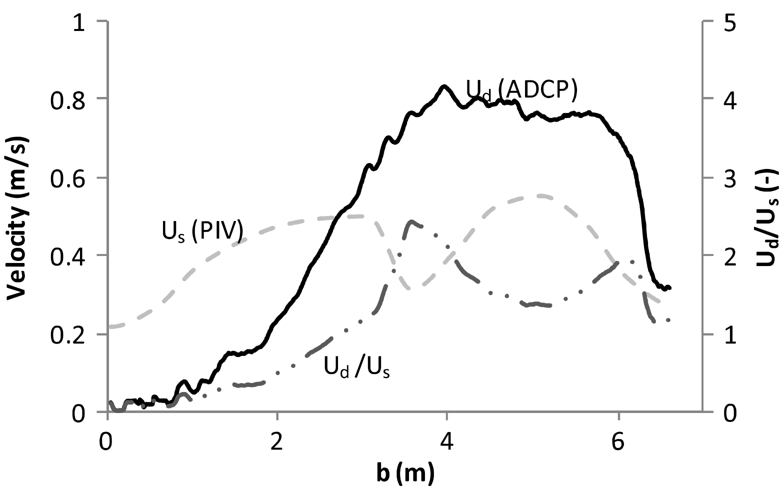


(a) Section 2.

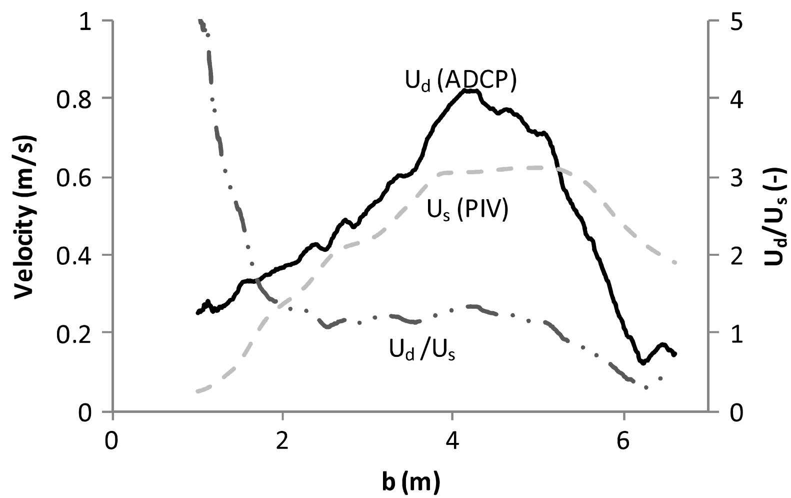


(b) Section 5.

Relationship between U_d / U_s over-bank case



(a) Section 2.



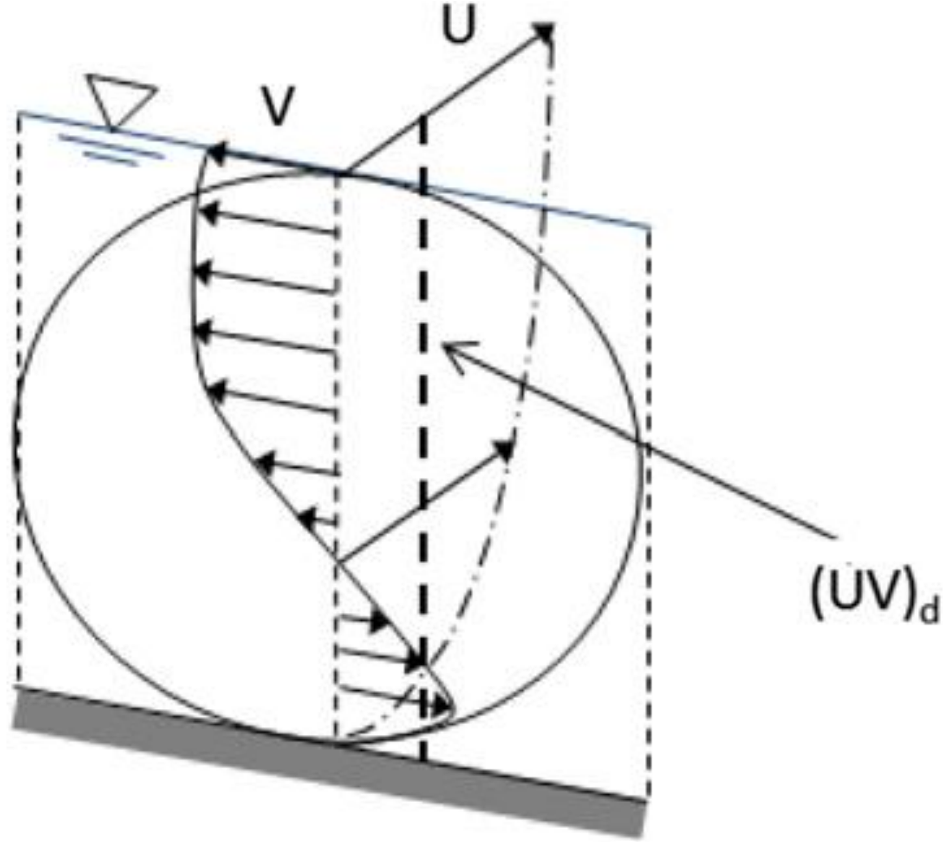
(b) Section 5.

Average value of U_d / U_s

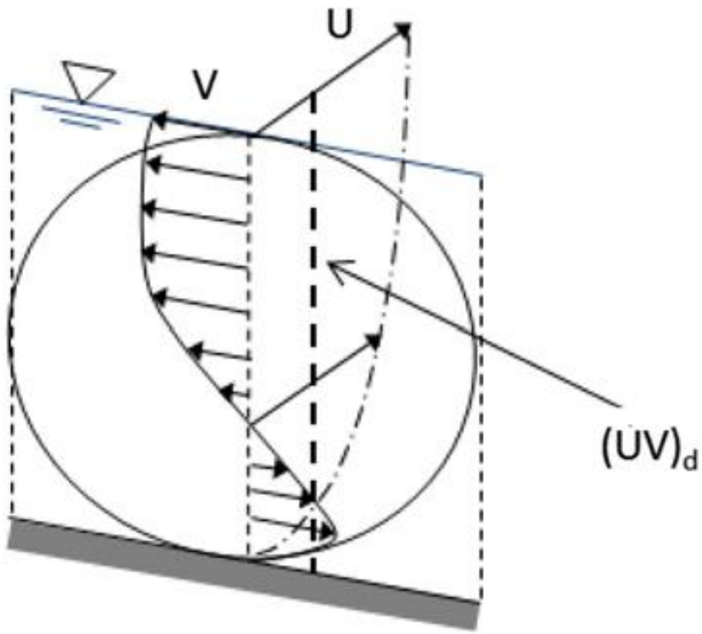
Event	Cross section 2	Cross section 5
Inbank (18/8/2008)	0.397	1.175
Bankfull (16/01/2008)	0.862	1.028
Overbank (10/2/2009)	0.989	1.066

(c.f. 0.875)

Quantifying the effect of second flow on U_d / U_s



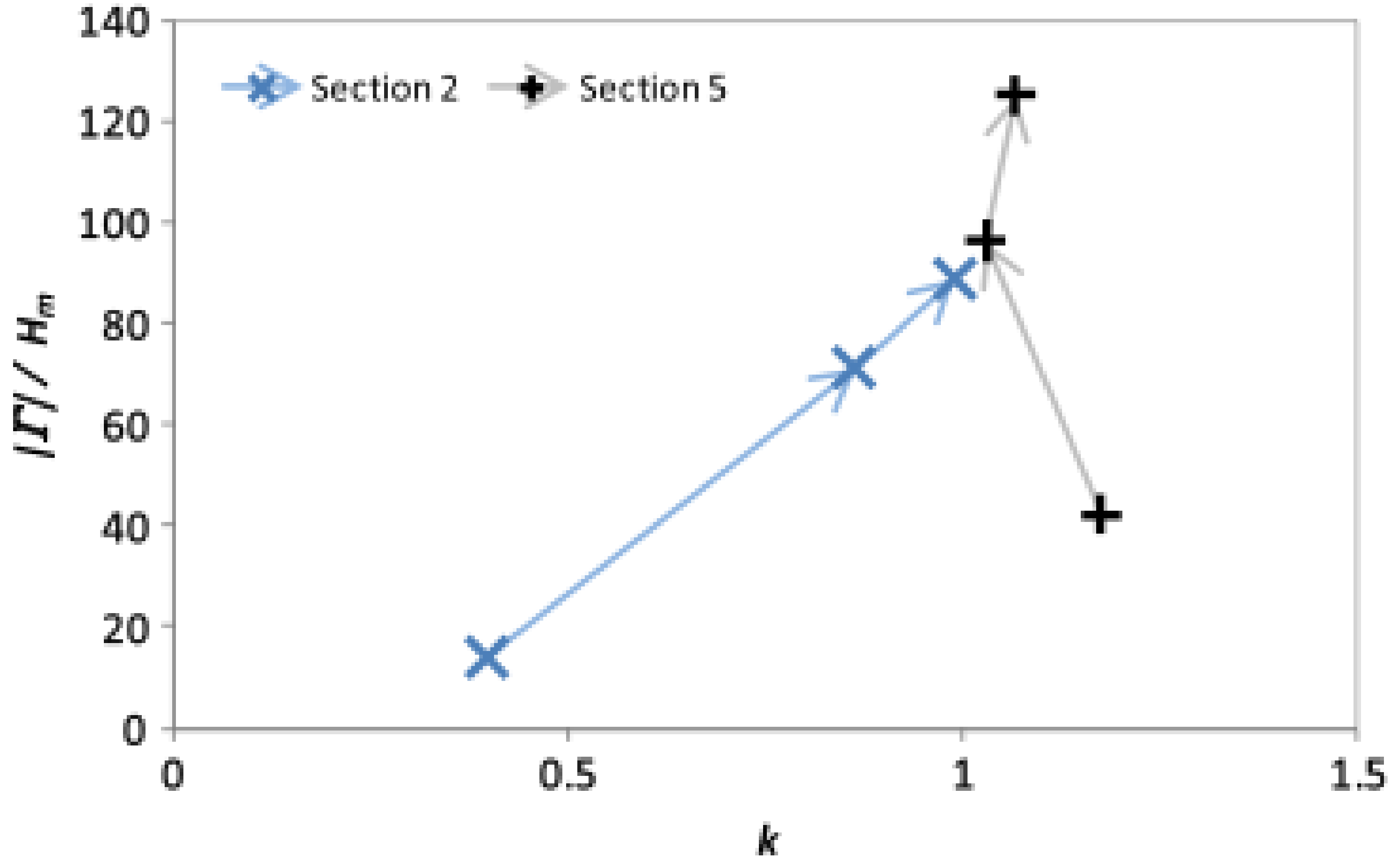
Quantifying the effect of second flow on U_d / U_s



- Assume channel can be discretized in linear elements.

$$\Gamma = \frac{\partial}{\partial y}\left[H\rho\,(UV)_d\right]$$

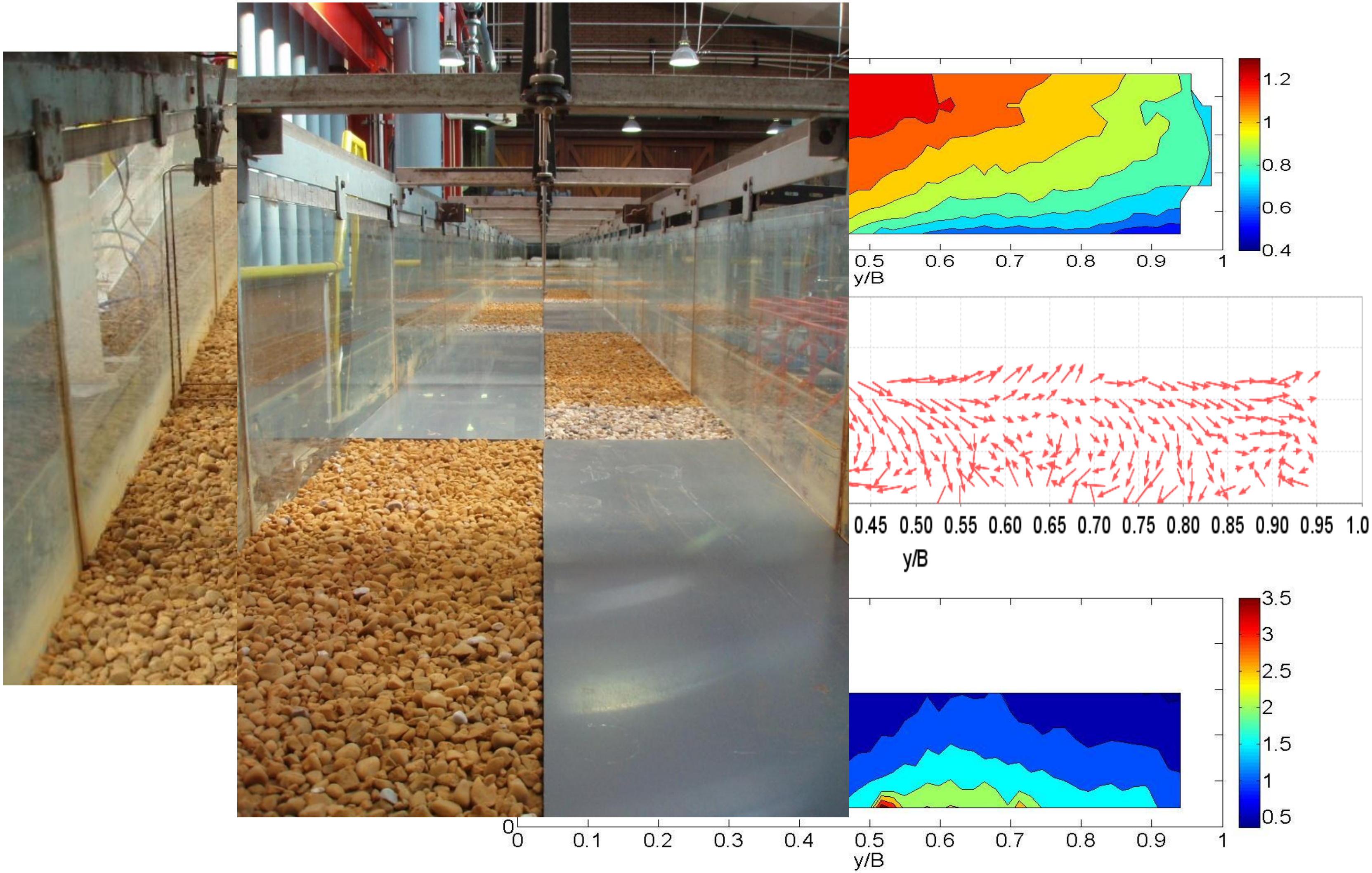
Secondary flow vs. k



Conclusions

- The ratio of the depth averaged velocity to the surface velocity (k) can vary significantly between cross sections.
- k varies with Q and is highly dependent on the structure of the local velocity field.
- For practical purposes, a value of k=1.0 is not an unreasonable starting point for discharge estimation, providing that a cross section is chosen where there is significant mixing.

Roughness distributions



Roughness distributions