# A COMPREHENSIVE APPROACH TO ESTIMATE HYDROKINETIC RESOURCES ON THE TANANA RIVER AT NENANA, ALASKA


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Annual Conference
Chena Hot Springs

# OUTLINE

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- ➢Our Approach
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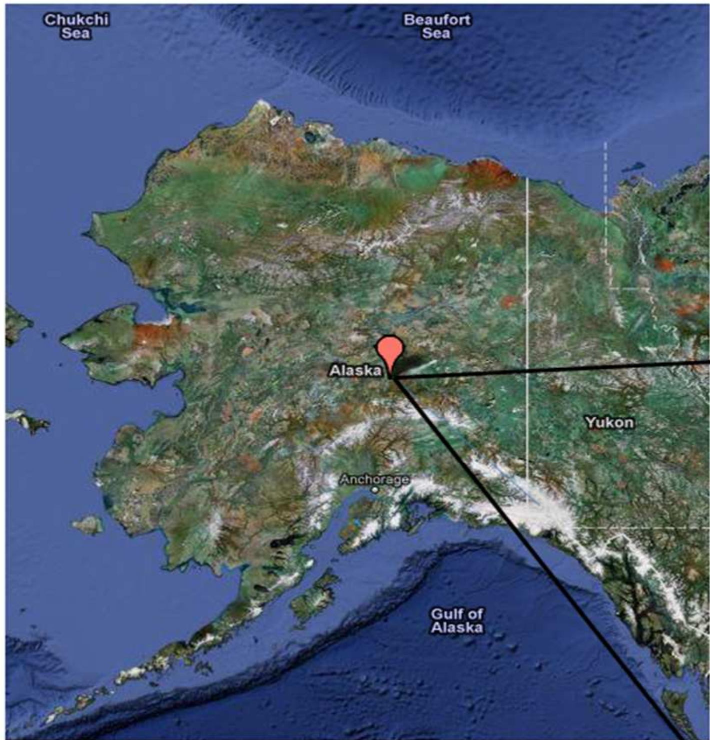
    - ▪Bathymetric Surveys
    - ▪ADCP Measurements
      - oTurbulence Measurements
    - ▪ Sediment Transport
    - ▪ Bed forms
  - ✓Numerical Modeling
    - ▪Power Density
- ➢Conclusions

# Study Site




Tanana River near Nenana

- ❑ Glacier-fed river
- ❑ Open water: May to October
- ❑ Average discharge: 1500 $m^3/s$
- ❑ Bed sediment: sand/gravel

# Bathymetric Surveys

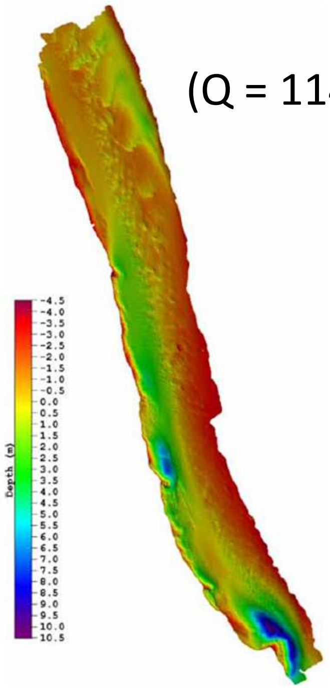
2009 and 2010

Conducted by Terrasond

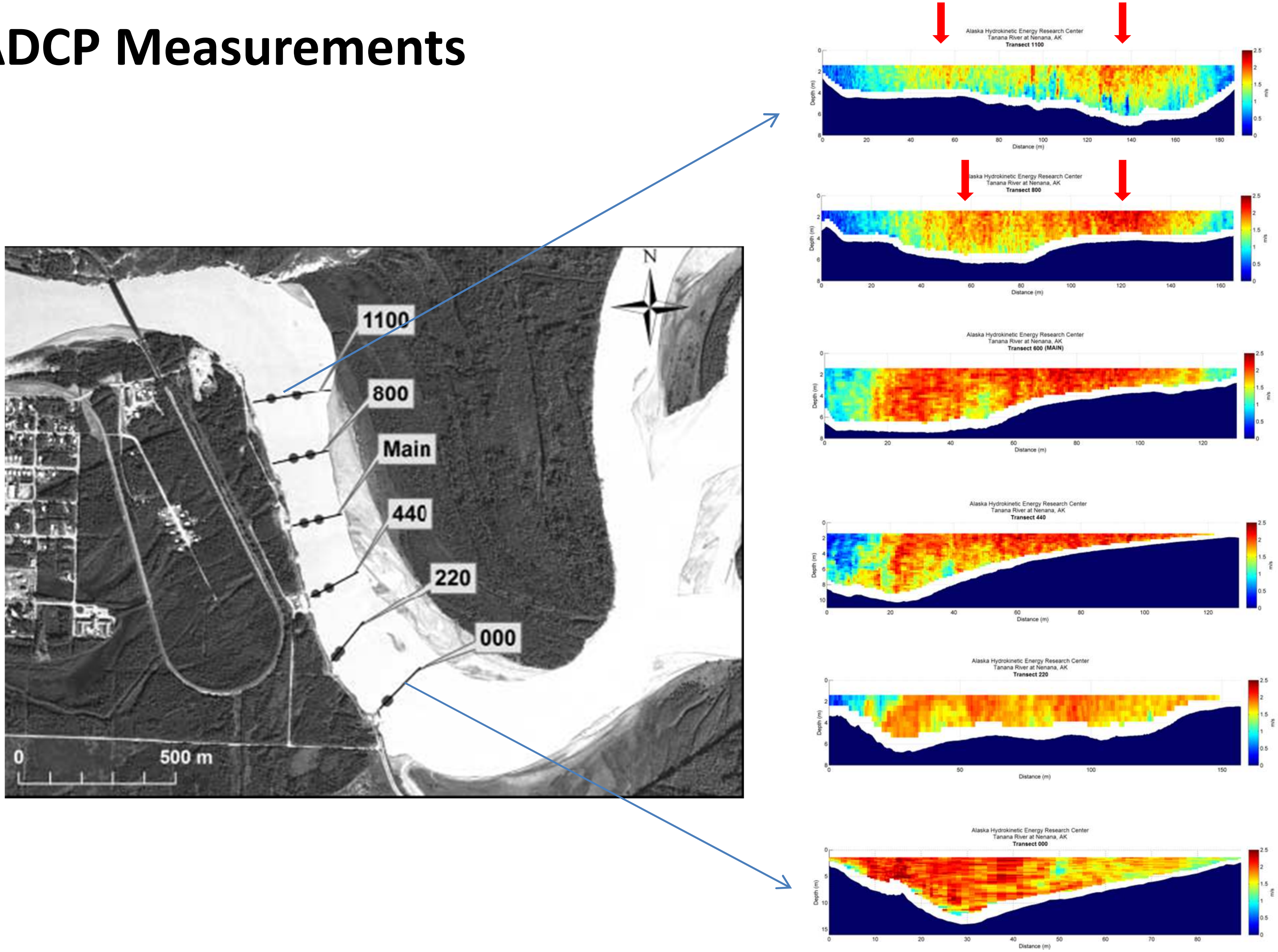
MV Irish Eyes


- Multibeam Echo sounder
- GPS – RTK
- ADCP

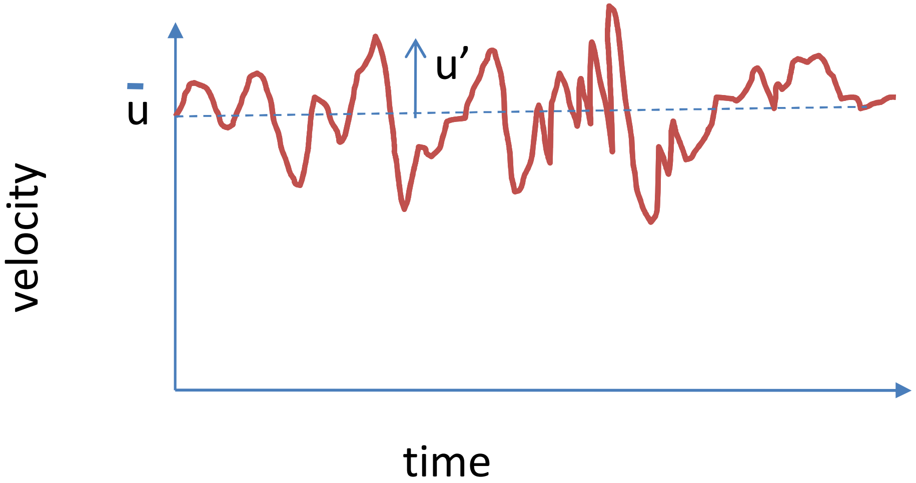
(Q = 1141 $m^3/s$)



# ADCP Measurements



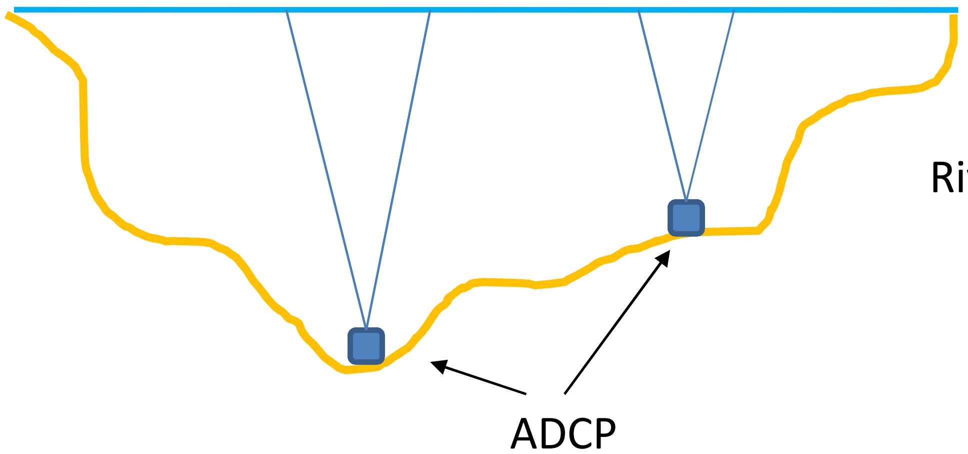
# Turbulence




$$u = \bar{u} + u'$$

$$v = \bar{v} + v'$$

$$w = \bar{w} + w'$$



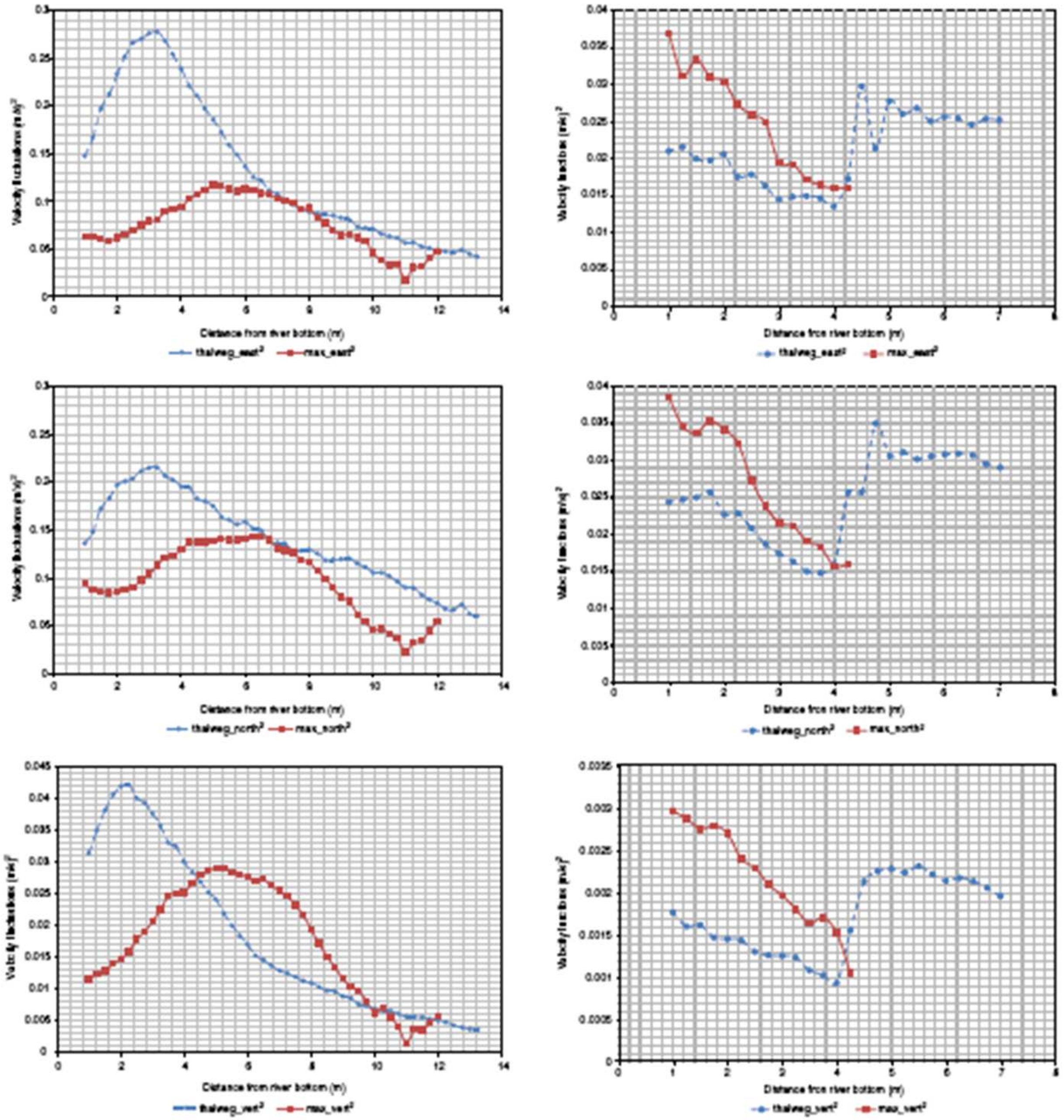

River cross-section

# Turbulence

Average velocity fluctuations

Transect 000

Transect 1100



east

north

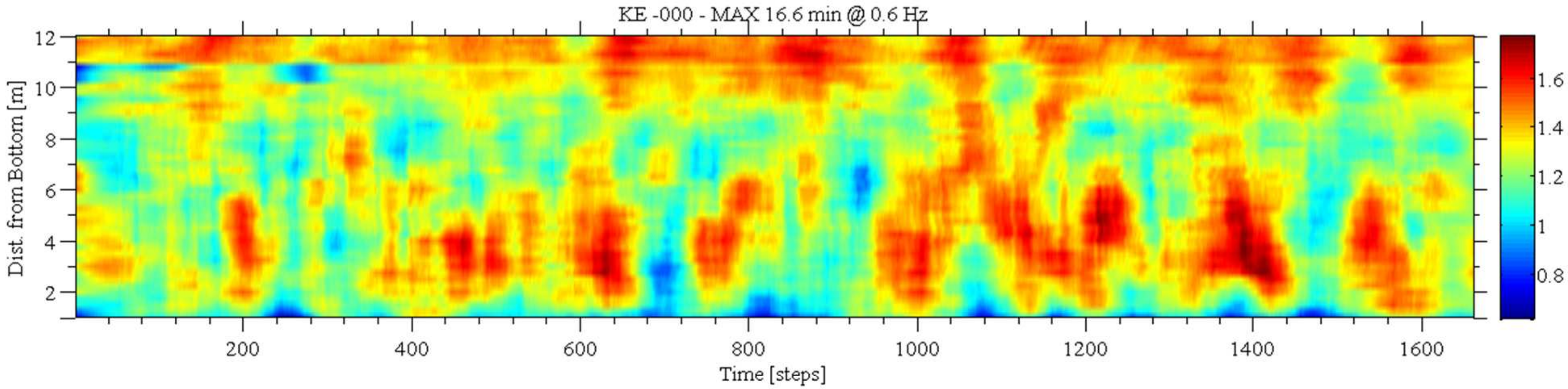
vertical

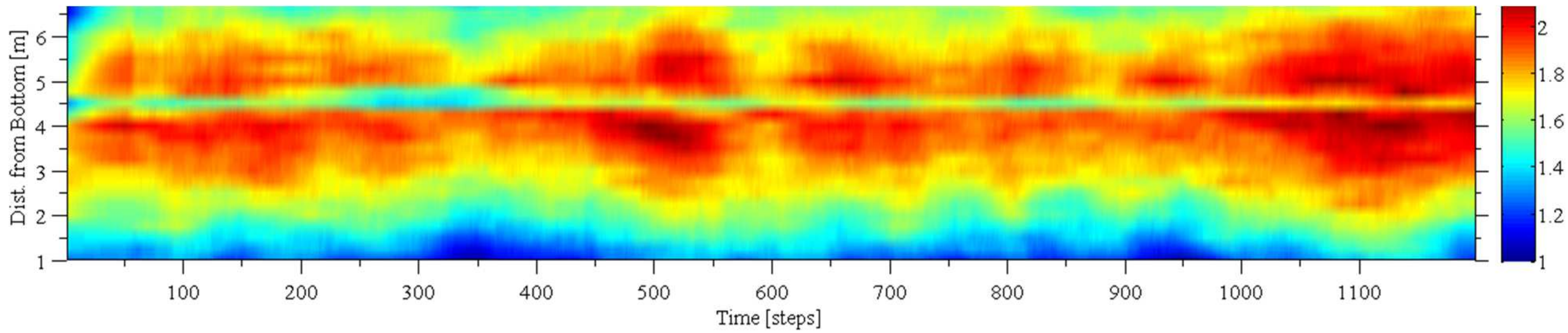
thalweg

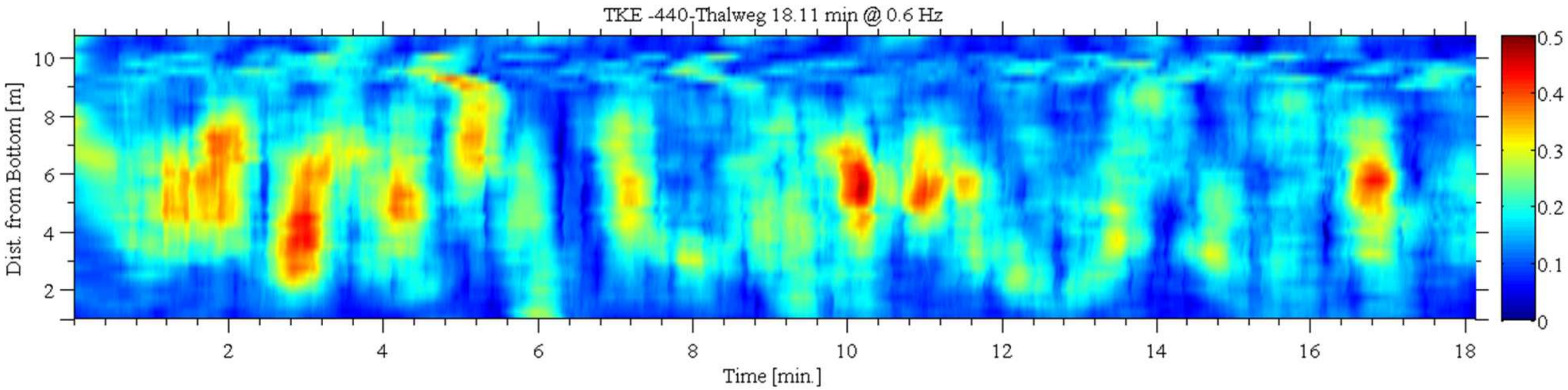
maximum

# Turbulence – New results

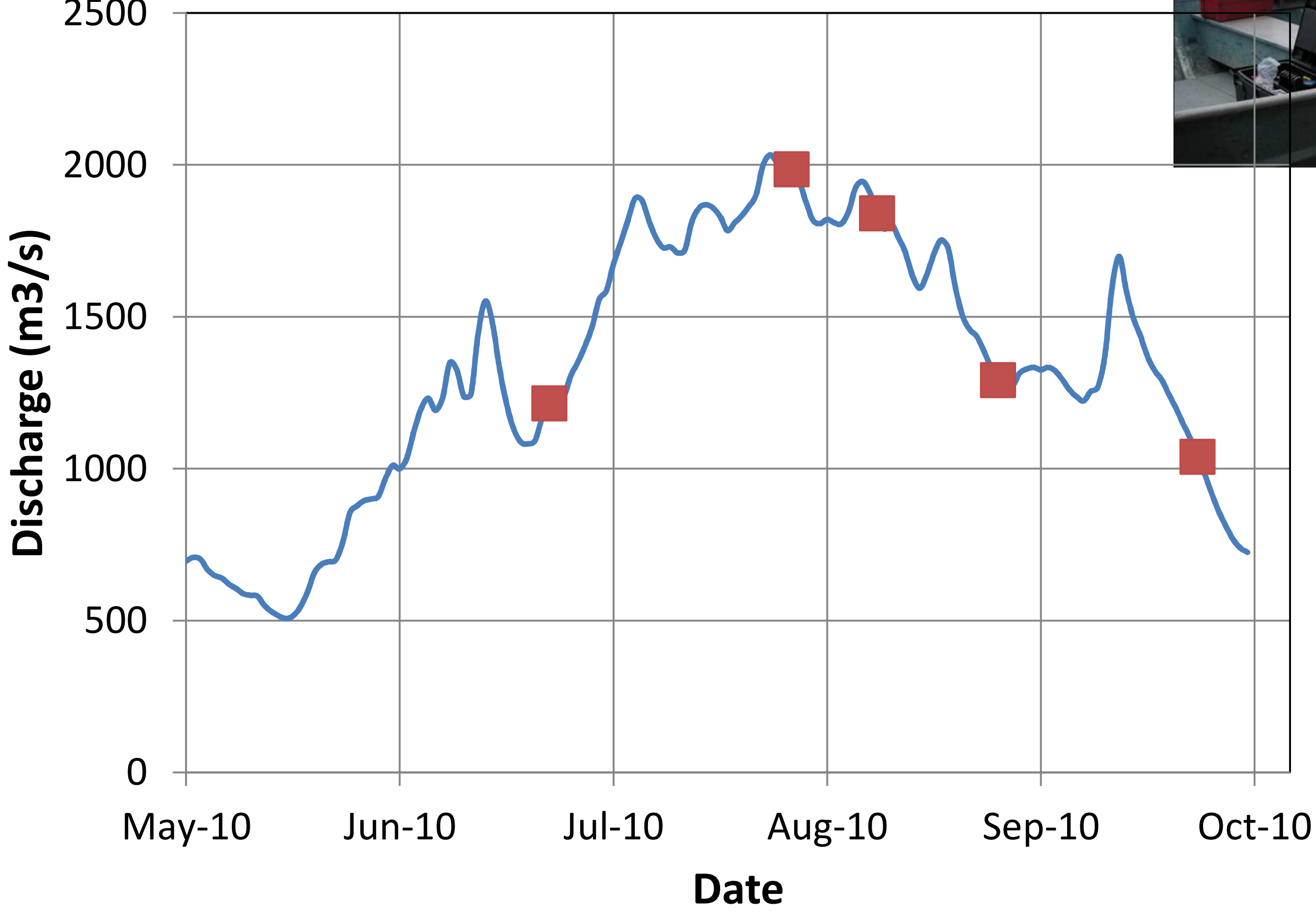
Casey Walsh



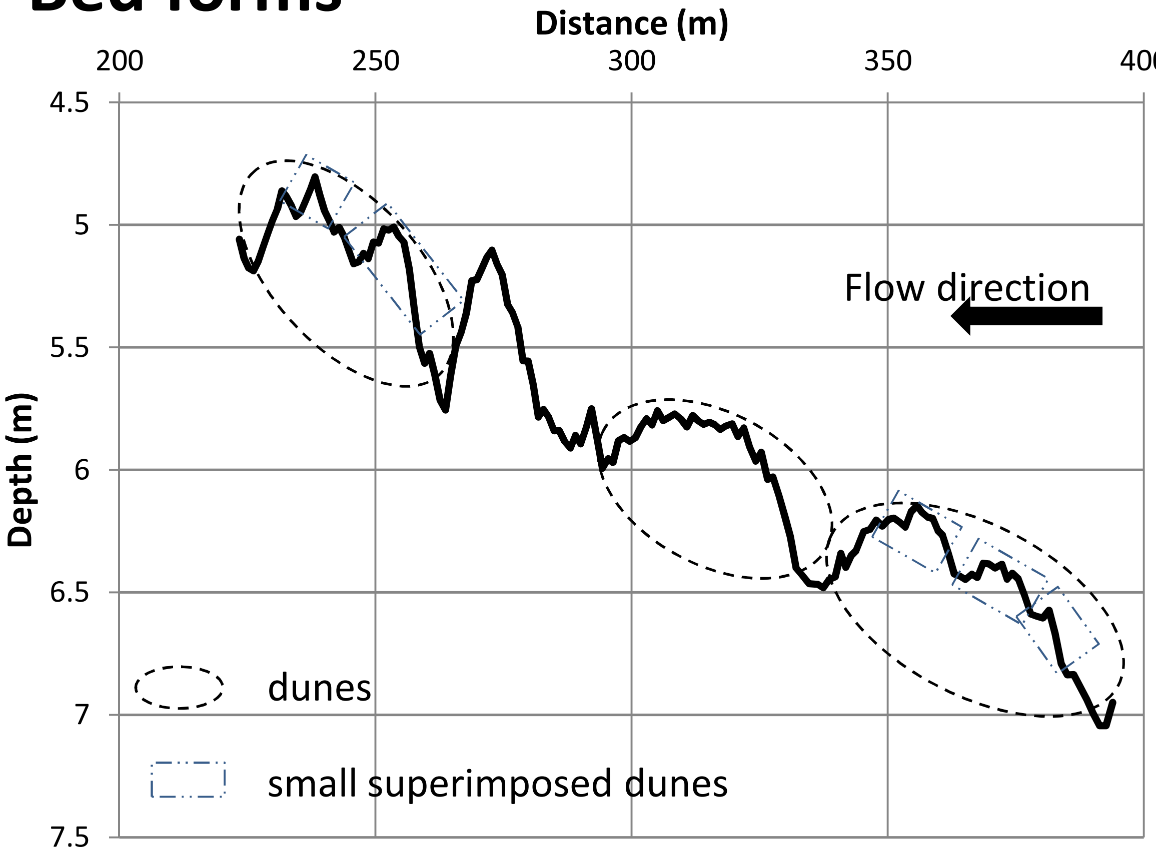



# Hydrograph




USGS data

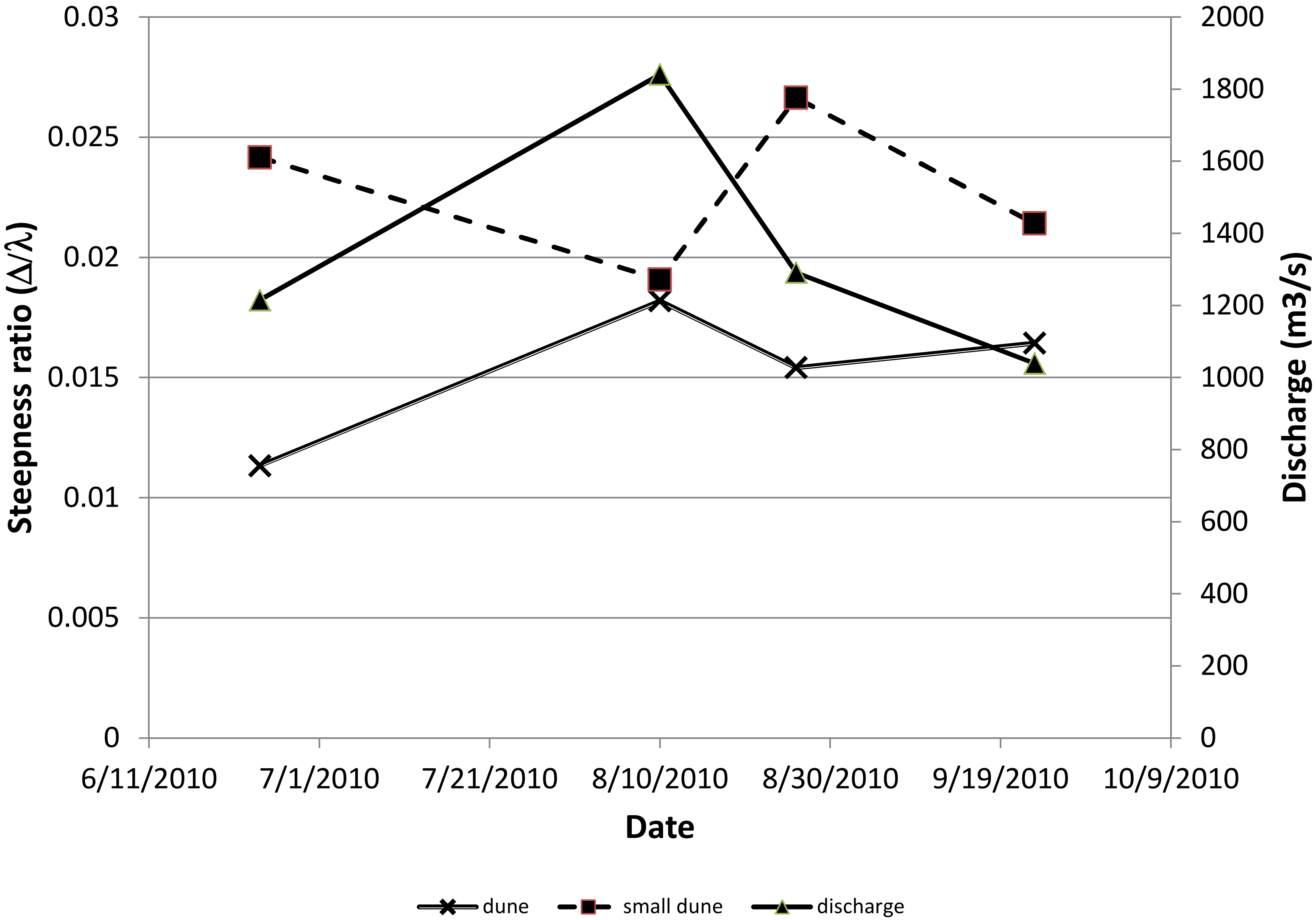
# Bed forms



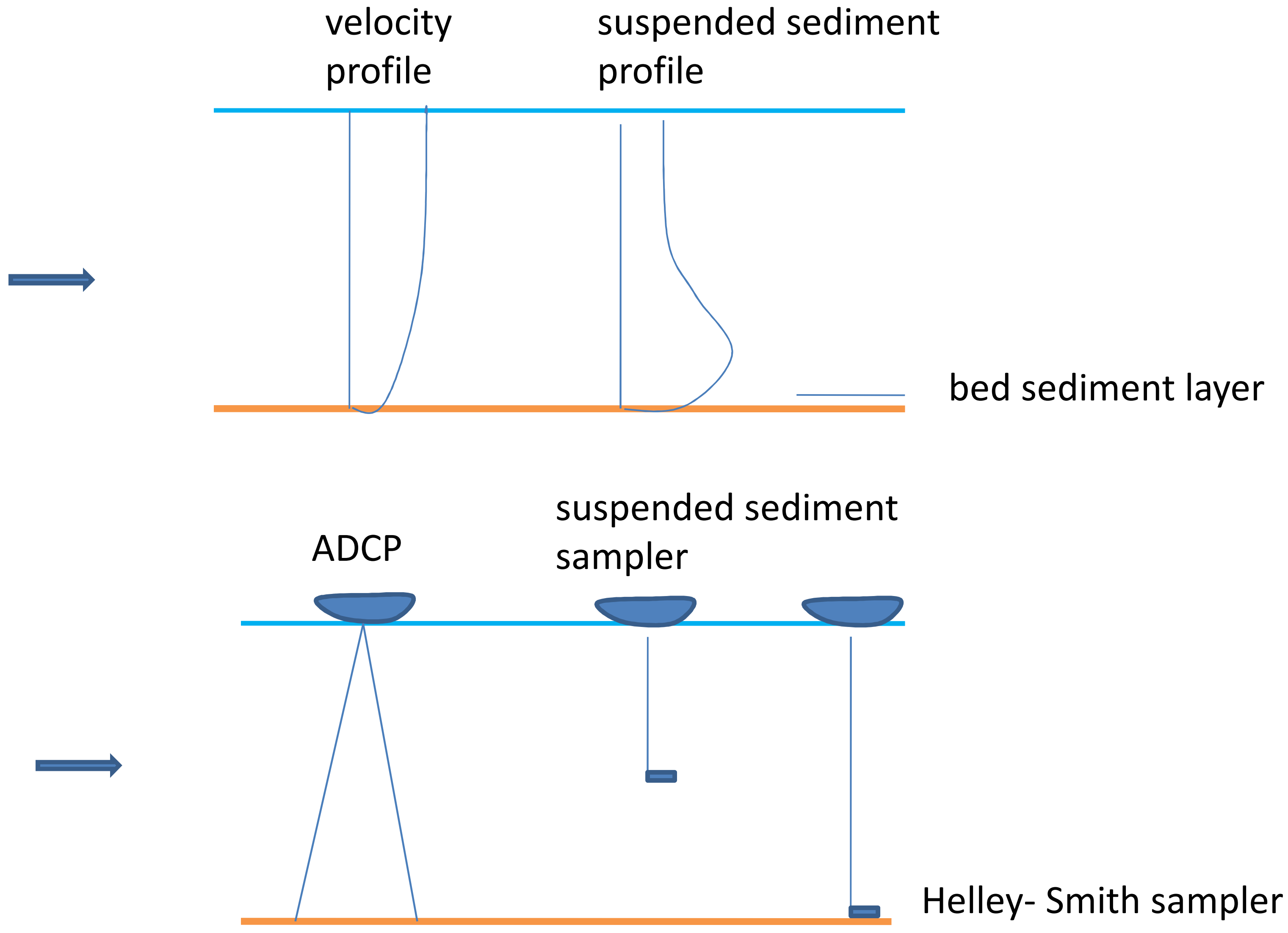

**Steepness ratio of dunes and small superimposed dunes**

| Date | Dunes | | | Small Superimposed Dunes | | |
|---|---|---|---|---|---|---|
| | Minimum | Average | Maximum | Minimum | Average | Maximum |
| 24 June 2010 | 0.007 | 0.010 | 0.013 | 0.008 | 0.024 | 0.042 |
| 9 August 2010 | 0.007 | 0.018 | 0.031 | 0.011 | 0.019 | 0.030 |
| 26 August 2010 | 0.008 | 0.016 | 0.030 | 0.010 | 0.027 | 0.056 |
| 23 September 2010 | 0.008 | 0.017 | 0.029 | 0.013 | 0.021 | 0.040 |

# Bed forms

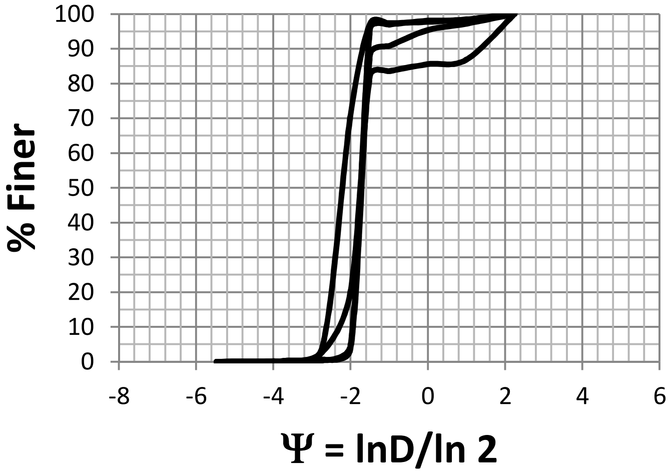

0.03
0.025
0.02
0.015
0.01
0.005
0
Steepness ratio (Δ/λ)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Discharge (m3/s)
6/11/2010
7/1/2010
7/21/2010
8/10/2010
8/30/2010
9/19/2010
10/9/2010
Date
dune
small dune
discharge

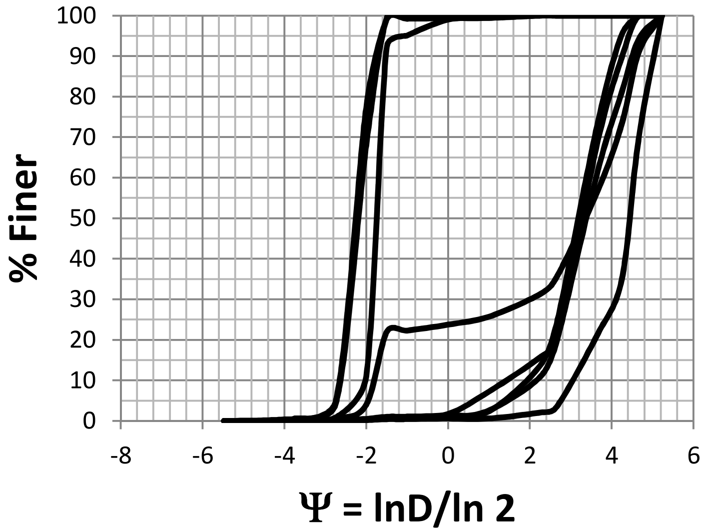
# Sediment transport

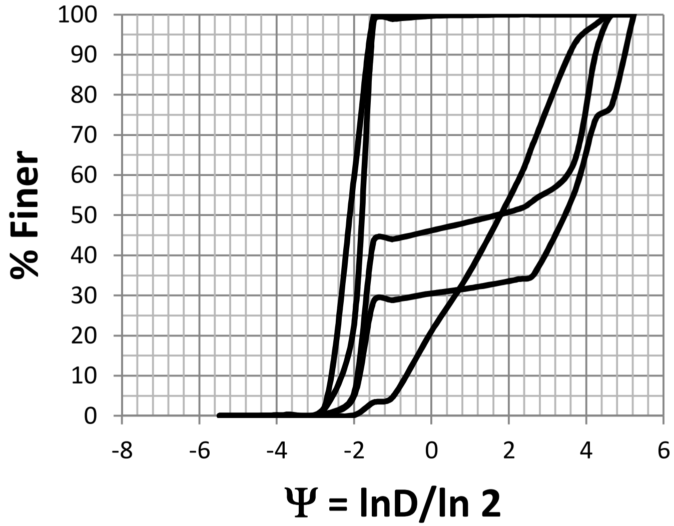


# Sediment transport

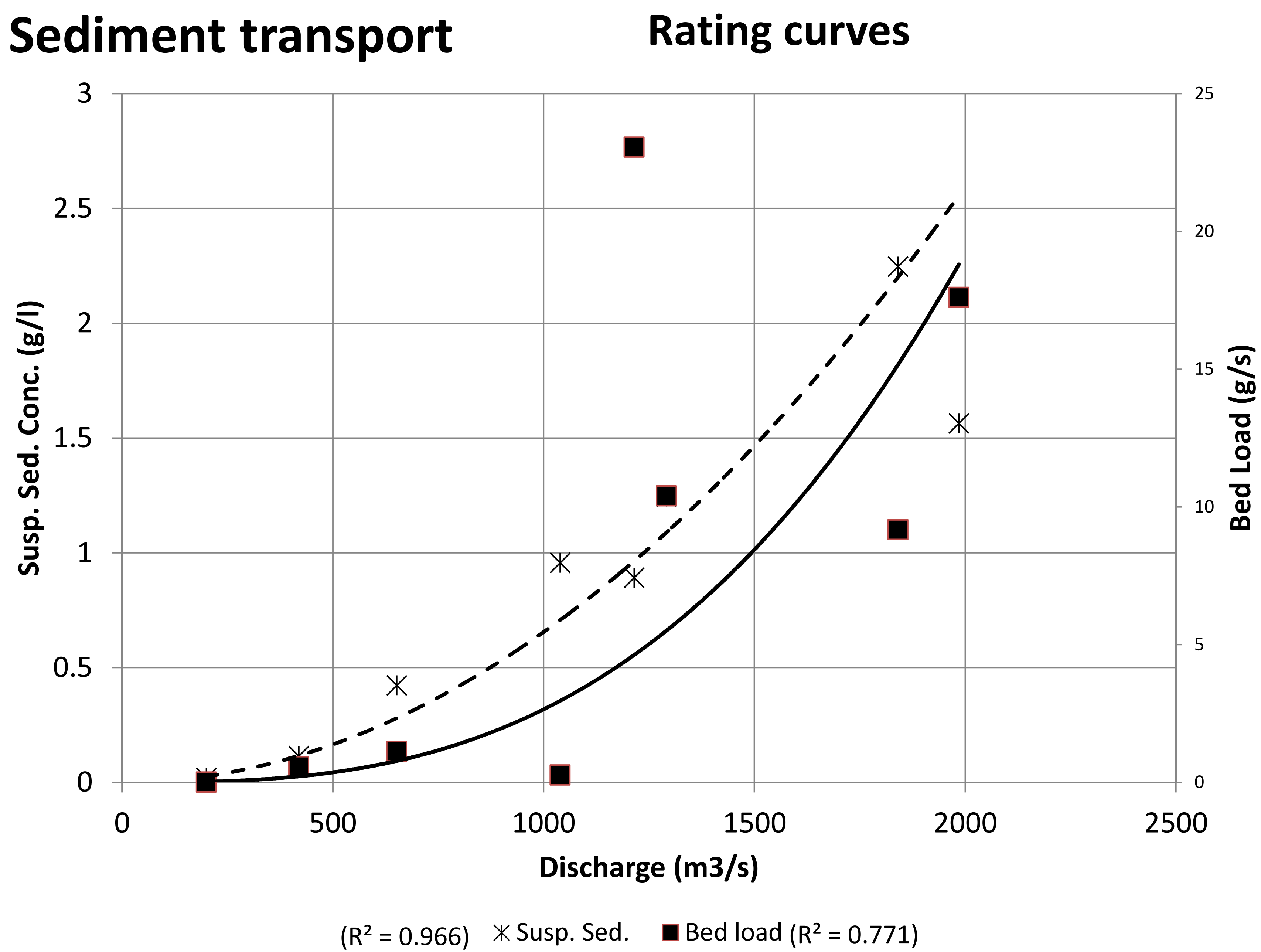
Uniform sand




Bi-Modal distributions
(sand and gravel)

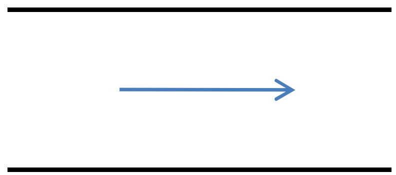


Sediment transport
Rating curves
Susp. Sed. Conc. (g/l)
Bed Load (g/s)
Discharge (m3/s)
0
0.5
1
1.5
2
2.5
3
0
5
10
15
20
25
0
500
1000
1500
2000
2500
($R^2$ = 0.966) Susp. Sed.
Bed load ($R^2$ = 0.771)

# Numerical Modeling

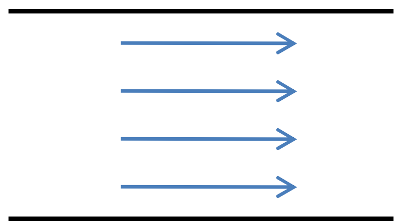
- One-dimensional
  - Advantage: Very simple – Provides average information along the cross-section and depth – Only looks property variations downstream.
  - Disadvantage: Very simple – Many processes are not represented.
- Two-dimensional
  - Advantage: Provides information in the downstream and transversal directions.
  - Disadvantage: Does not provide information on secondary flows.
- Three-dimensional
  - Advantage:  Can account for processes involving all the directions (x, y, and z).
  - Disadvantage: Very computational demanding.

Top View



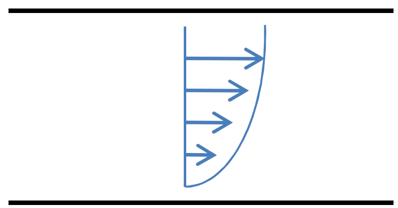
1-D

Top View



2-D

Lateral View



3-D

**Numerical Modeling**

# CCHE2D Model

- Developed by the National Center for Computational Hydroscience and Engineering (NCCHE), University of Mississippi (http://www.ncche.olemiss.edu).

- Depth-integrated two dimensional model for studying steady/unsteady flows in open channels with irregular cross-sections, topography, and bank protection structures

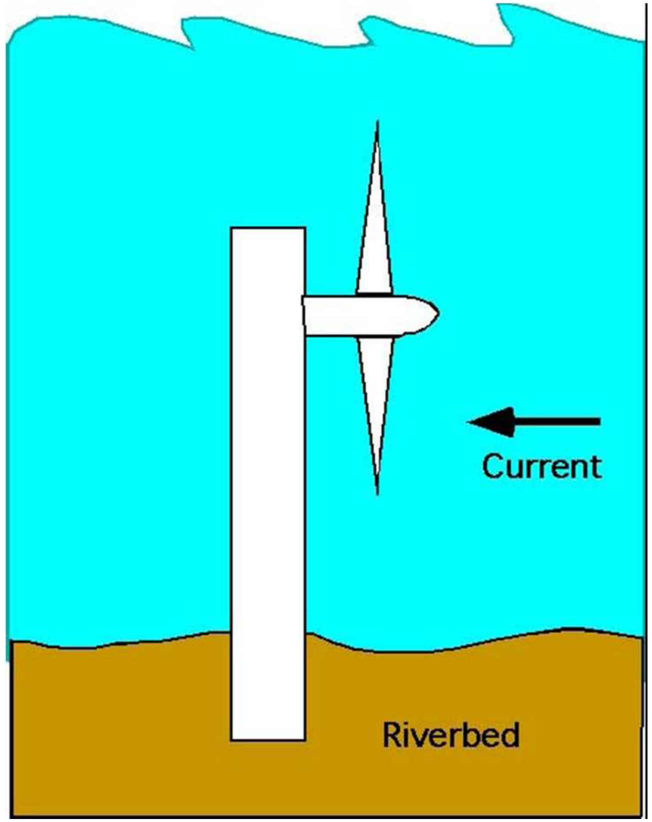
# Numerical Modeling

## Power Density

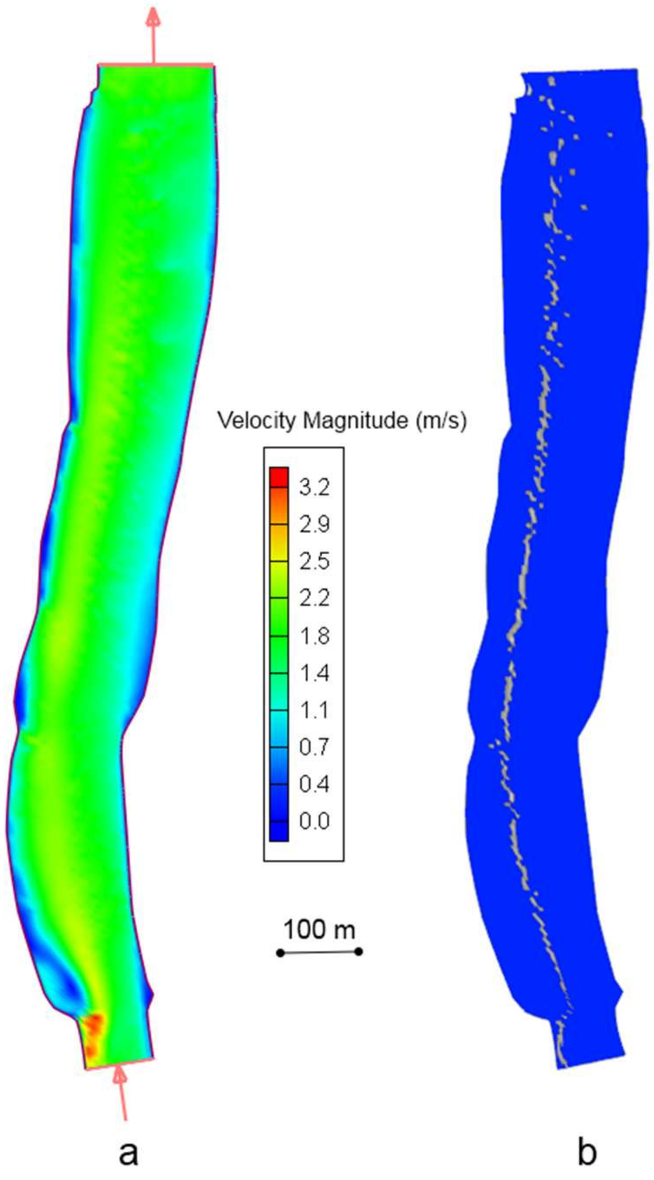
Basic Equation

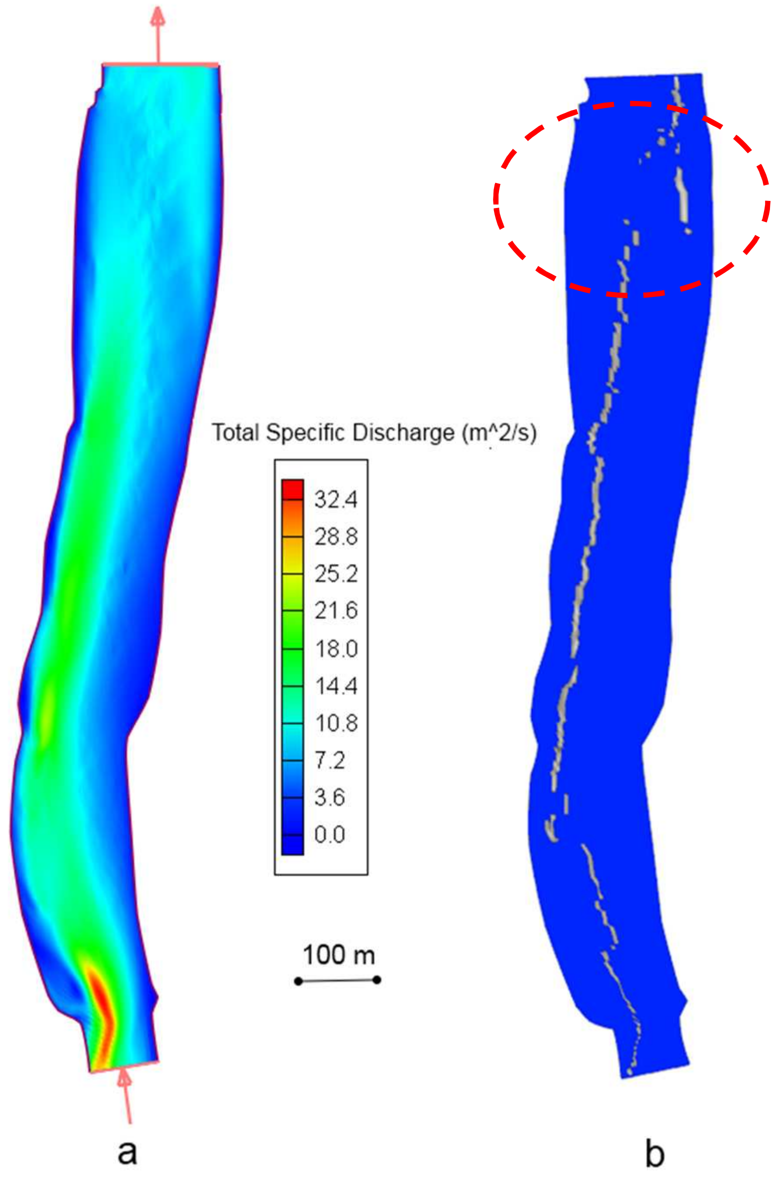
$$Ke = \frac{1}{2}\rho V^3$$

*Ke*: power/area
*ρ:* water density
*V:* velocity

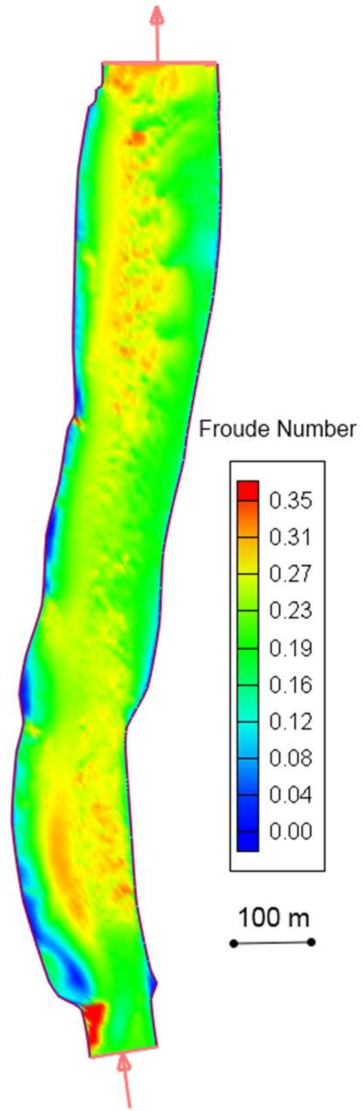


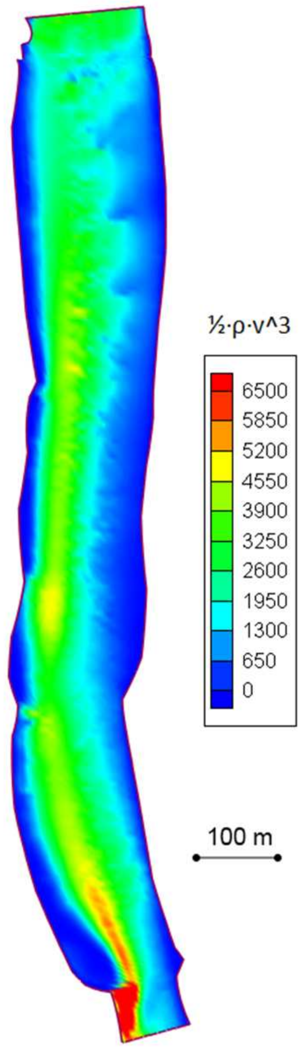
# Numerical Modeling



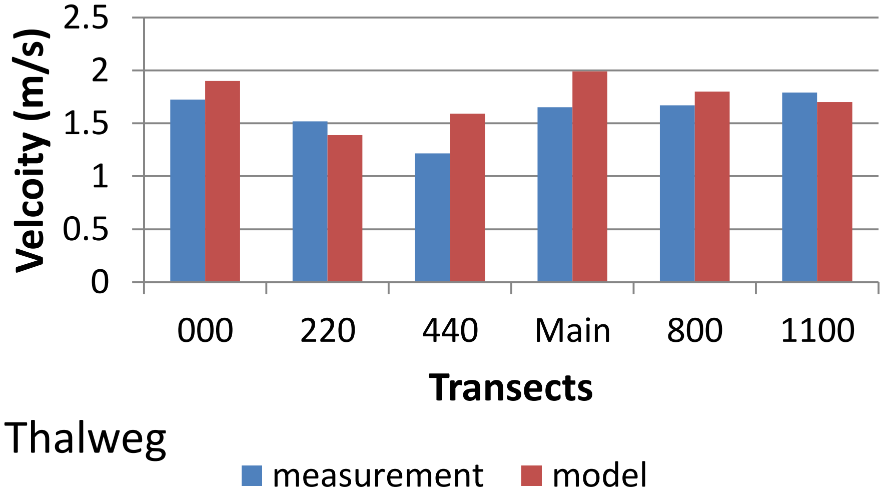
# Numerical Modeling



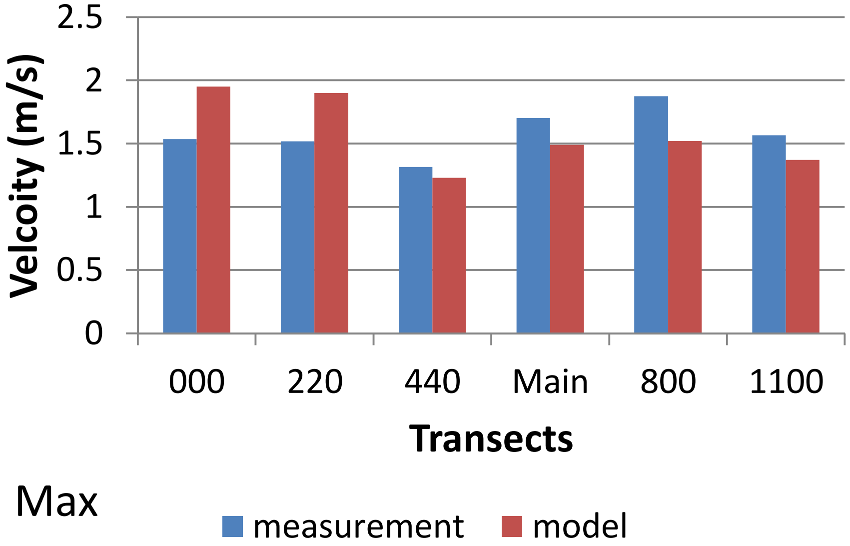



# Numerical Modeling

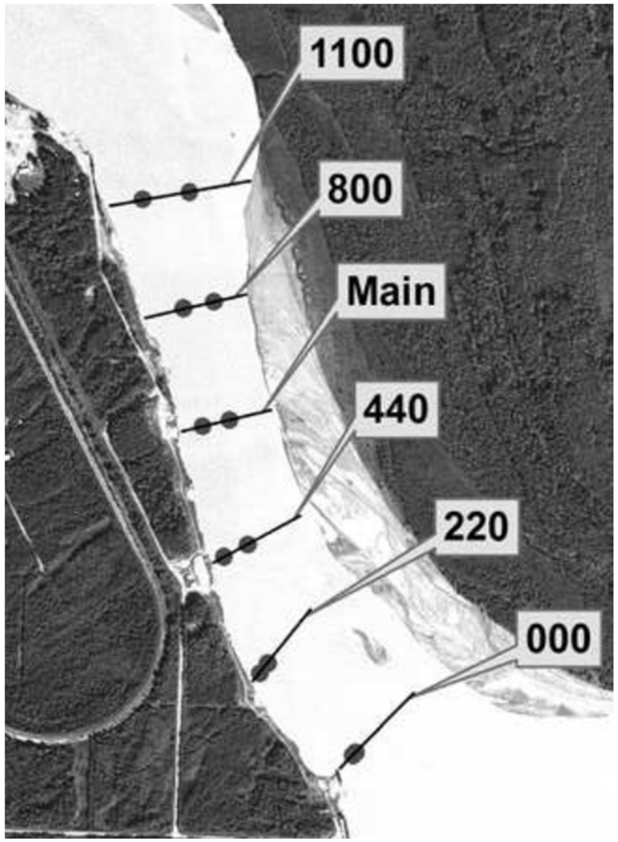
Validation




Thalweg



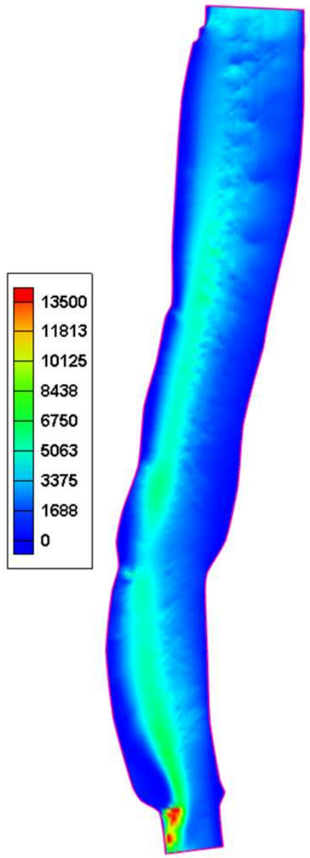

Max

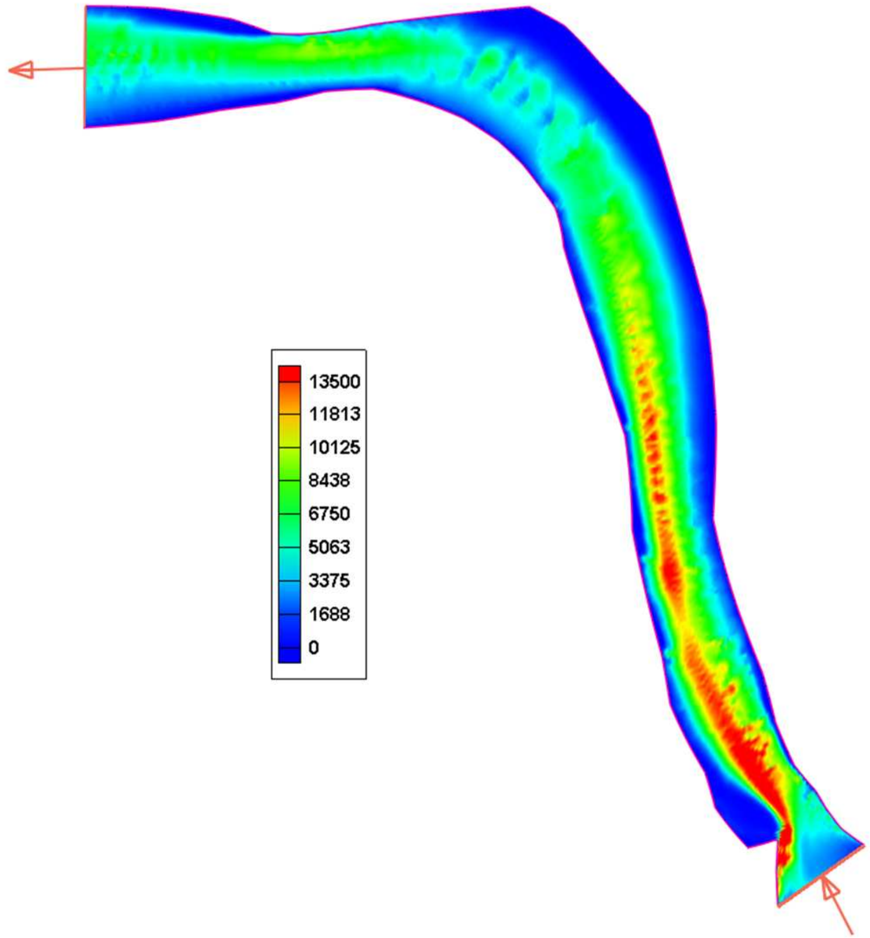



Average difference between modeled and measured velocities is around 3 percent.

# Numerical Modeling

Power Density (Watts/$m^2$)




Maximum power density = 6,500 W/$m^2$
(Q = 1,141 $m^3$/s)

Maximum power density = 13,500 W/$m^2$
(Q = 1,784 $m^3$/s)

# Conclusions

Approach involves

- Field measurements
  - Hydraulic parameters
- Numerical modeling
  - Power density
- Analysis
  - Channel stability

THANKS !