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The Effect of Turbulence in Hydropower Dam Fish Passageways on Pacific Lamprey Passage

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THE EFFECT OF TURBULENCE IN HYDROPOWER DAM FISH PASSAGEWAYS ON PACIFIC LAMPREY PASSAGE

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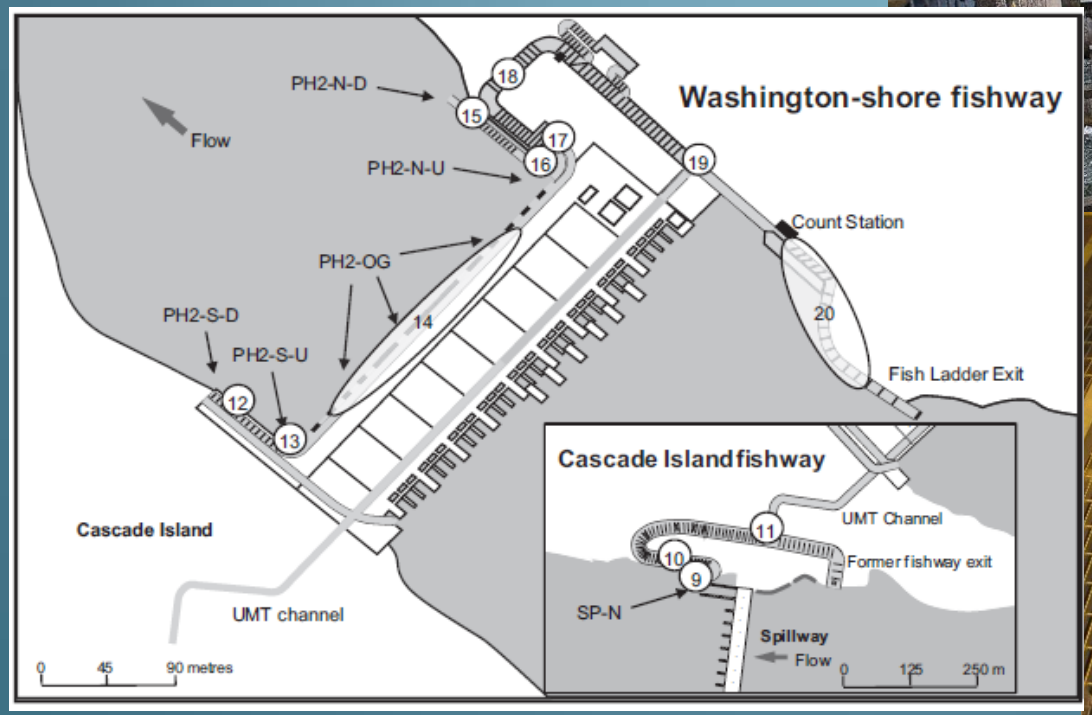
CENTER FOR ECOHYDRAULICS RESEARCH

University of Idaho
College of Natural Resources

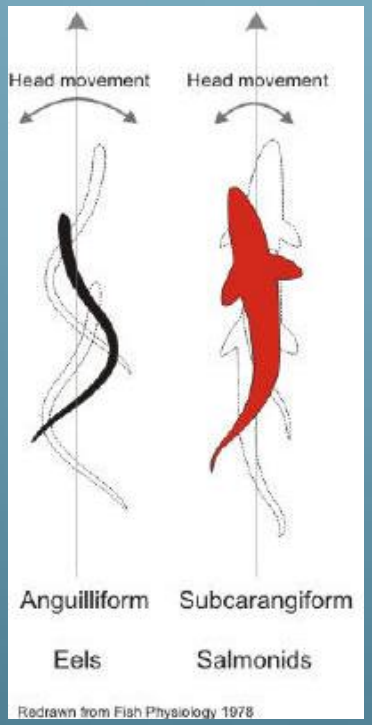
SERPENTINE WEIR PASSAGE

- *Lamprey passage is very low through serpentine weirs. (25-30%)*
- *Turbulence or Distance through slots.*
- *Flume designed as a representation of serpentine.*



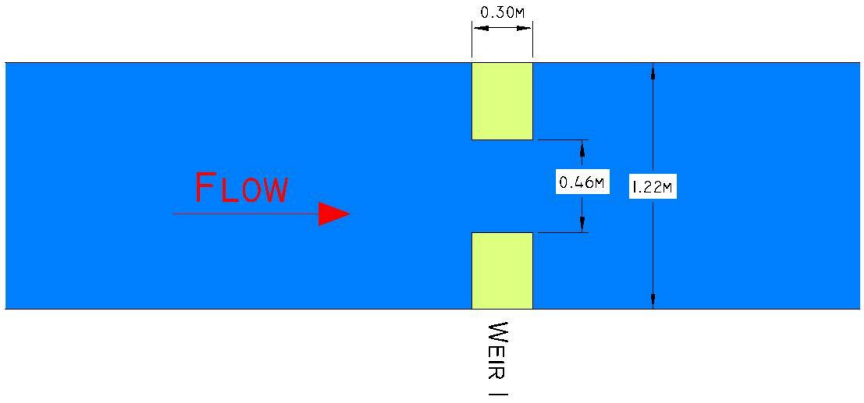
LAMPREY OBSTACLES

- Salmonids are subcarangiform swimmers and move quickly through turbulent conditions.
- Anguilliform swimmers may be more affected by turbulence.
- In high flow/ turbulence conditions, Lamprey go into burst and attach mode.

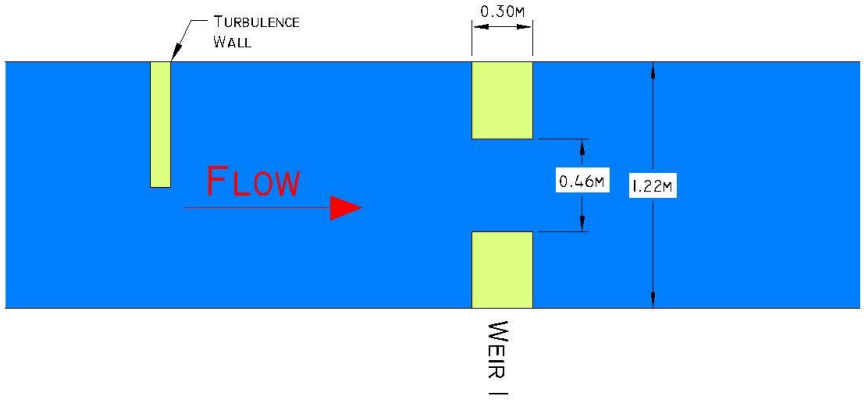


FLUME SETUP

FLUME CONTROL TREATMENT



FLUME TURBULENCE TREATMENT

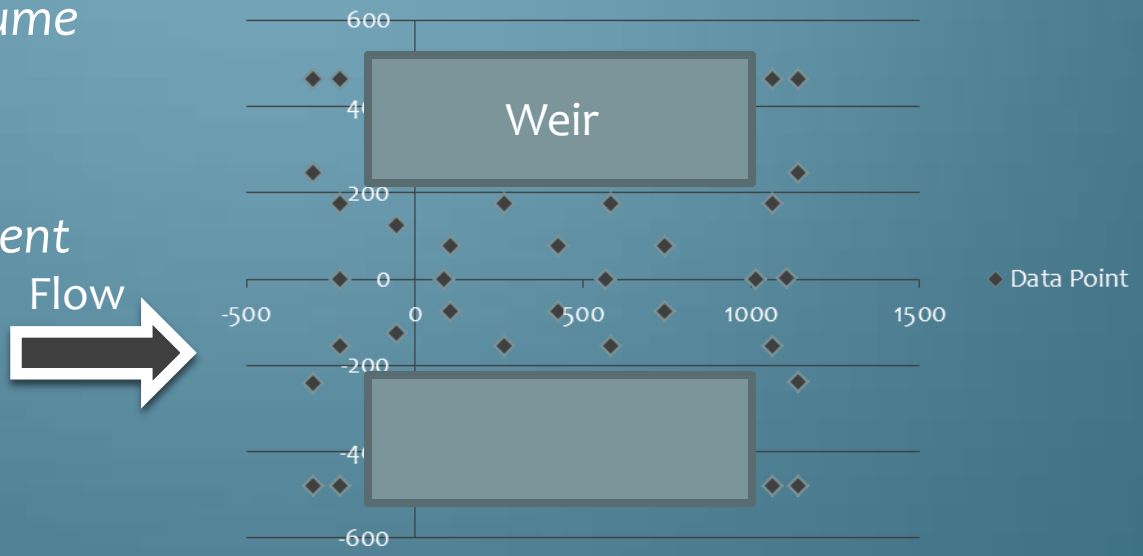


Flow Setting	Velocity (m/s)
High Flow	2.4
Medium Flow	1.8
Low Flow	1.2

SAMPLING

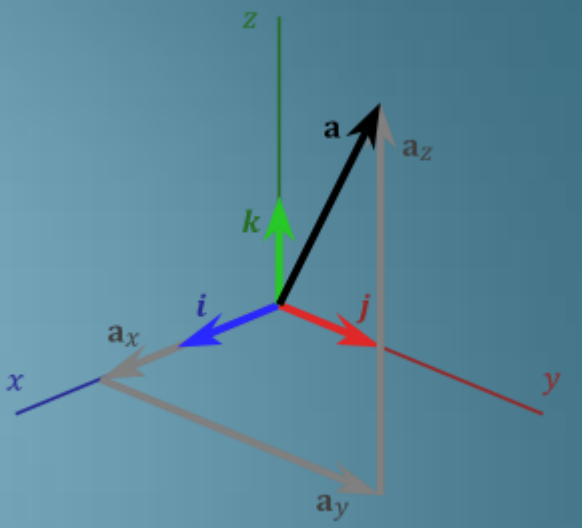
- *Developed Robot for precise measurements within the flume.*
- *Sontek Micro ADV used for measurements.*
- *Measurements taken at 3 elevations (0 cm, 30cm, and 65 cm)*
- *Control Treatment*
  - *Assumed symmetry within flume.*
  - *Took 17 measurements per elevation for ½ of the flume*
- *Turbulence treatment – 33 measurements per elevation*
- *4000 samples per measurement*

Flow

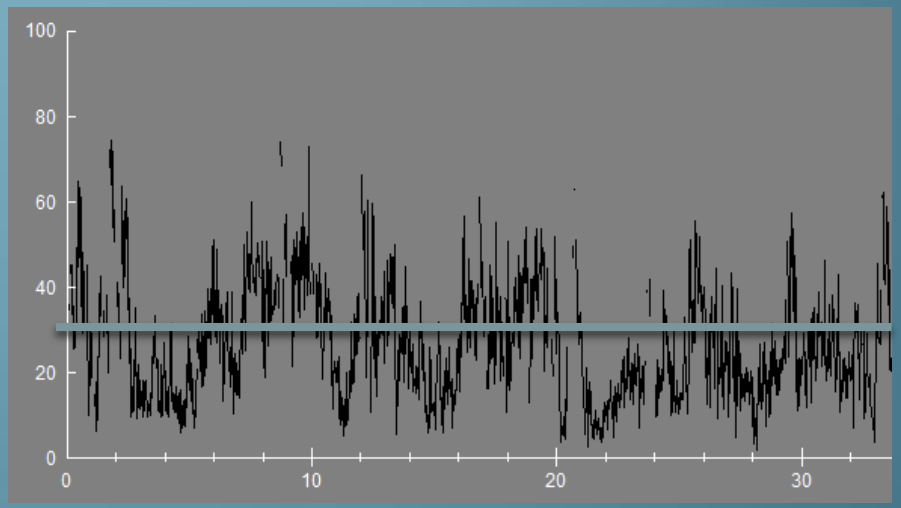


VELOCITY AND TURBULENCE

- *Average Velocity is computed as the magnitude of the resultant of the three average velocity components.*
- *The root-mean-square error of the turbulent velocity fluctuations about the mean velocity are computed for use in determining turbulence intensities and levels of turbulent kinetic energy.*



- $RMS[V_x'] = \sqrt{\overline{(V_x')^2}} = \sqrt{\frac{\sum V_x{}^2 - \frac{(\sum V_x)^2}{n}}{n-1}}$
- $RMS[V_y'] = \sqrt{\overline{(V_y')^2}} = \sqrt{\frac{\sum V_y{}^2 - \frac{(\sum V_y)^2}{n}}{n-1}}$
- $RMS[V_z'] = \sqrt{\overline{(V_z')^2}} = \sqrt{\frac{\sum V_z{}^2 - \frac{(\sum V_z)^2}{n}}{n-1}}$



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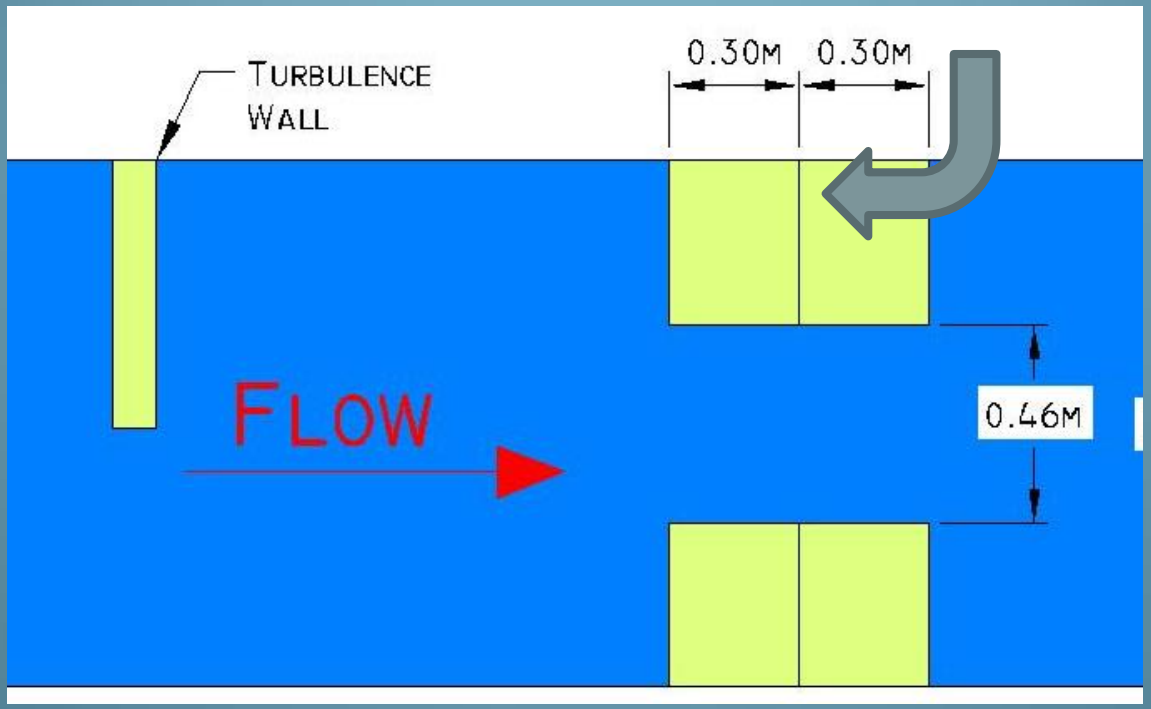
- *Turbulence is temporal not spatial.*
- *Turbulence is then normalized by the average velocity of the slot to calculate intensity. (COV)*
- *Velocity at high flow is 2x velocity at low flow. Intensity will be 2 standard deviations different.*

ROBOT FLUME MEASUREMENTS

Go link below for video of flume.

http://youtu.be/xXxp-E4nmj4

LAMPREY VIEW IN FLUME

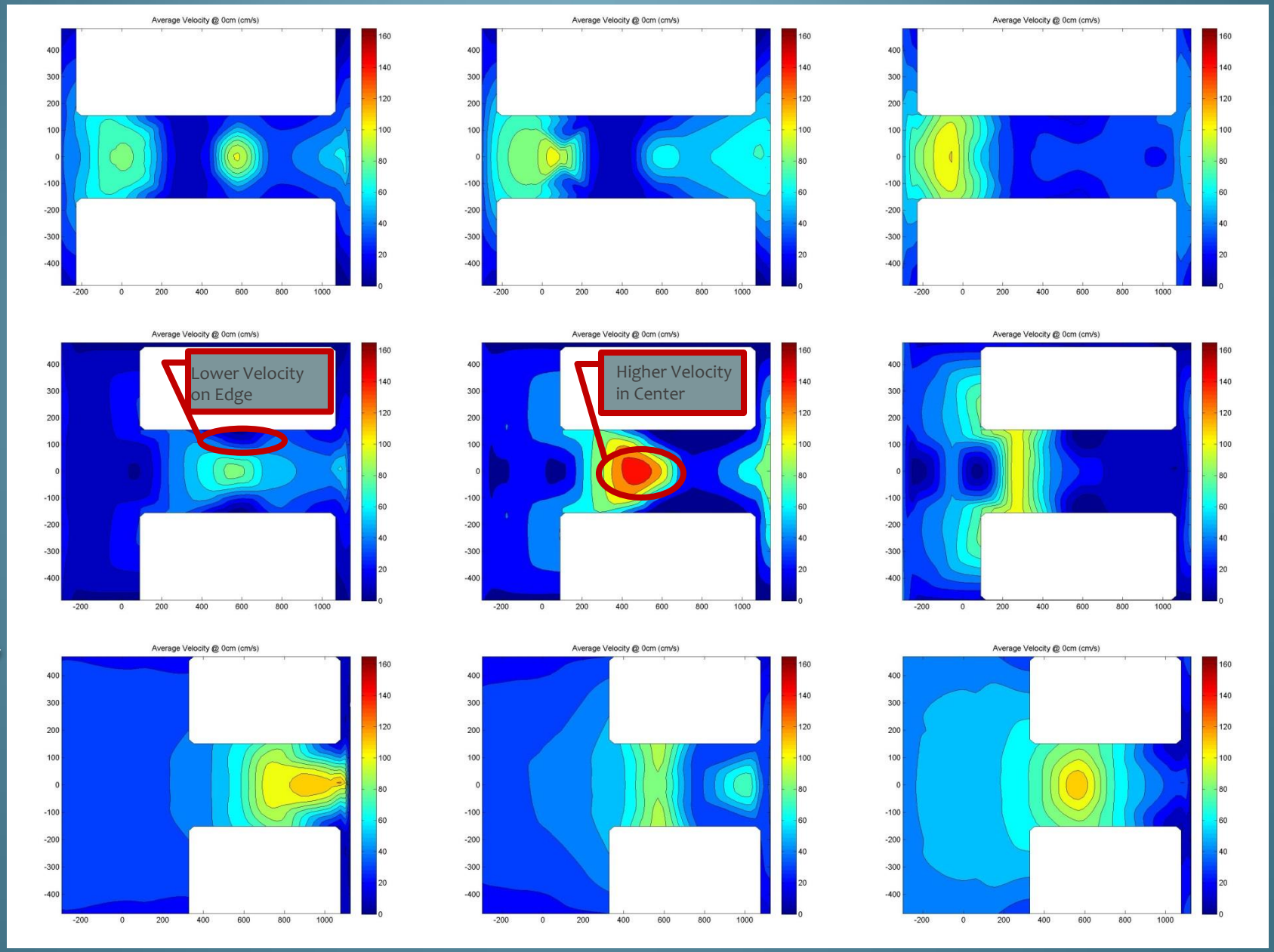


LAMPREY VIEW IN FLUME

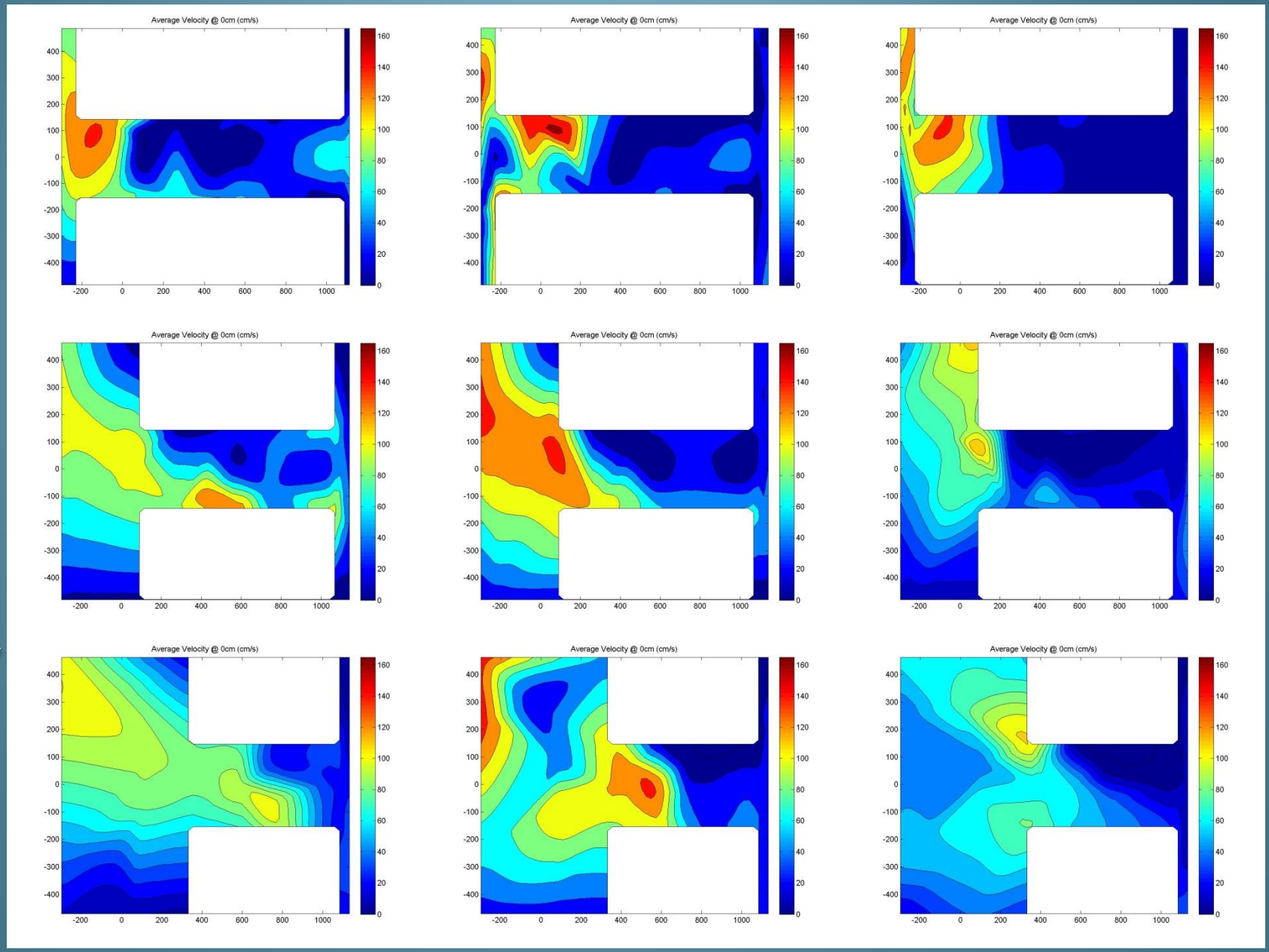
Go link below for GoPro video underwater.

http://youtu.be/KX8Ldo9VPGg

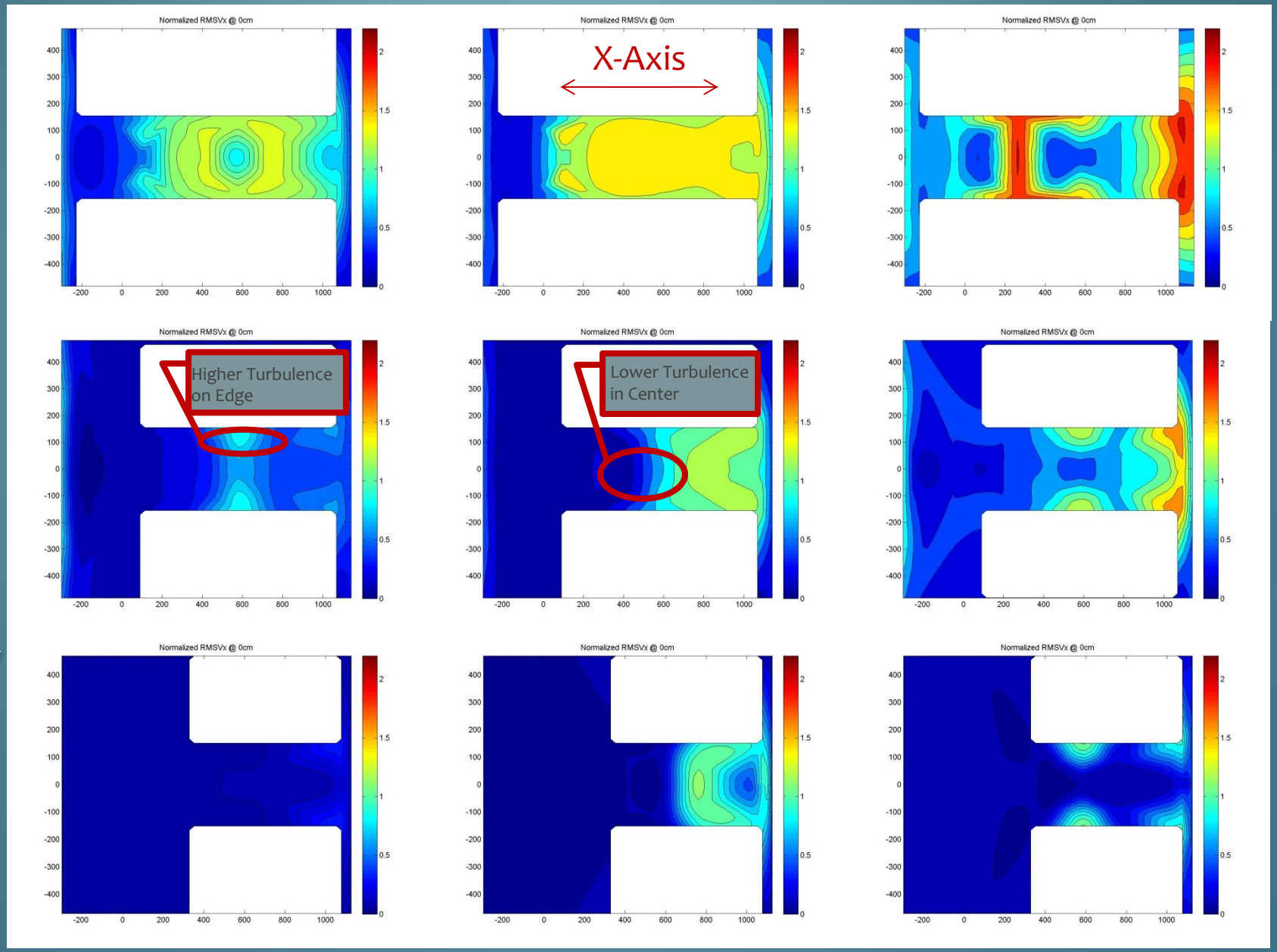
Average Velocity at Floor with Control Treatment



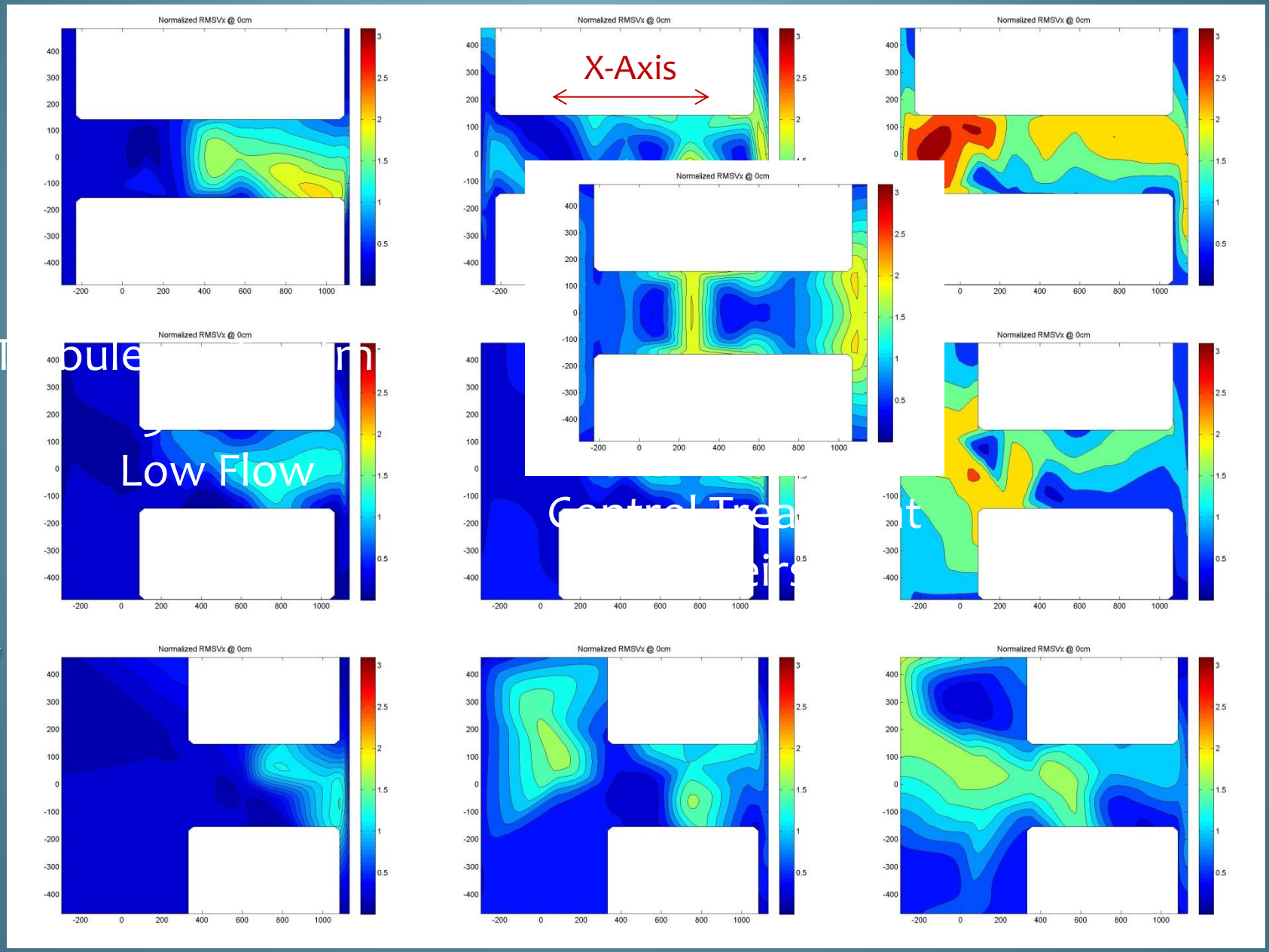
Average Velocity at Floor with Turbulence Treatment



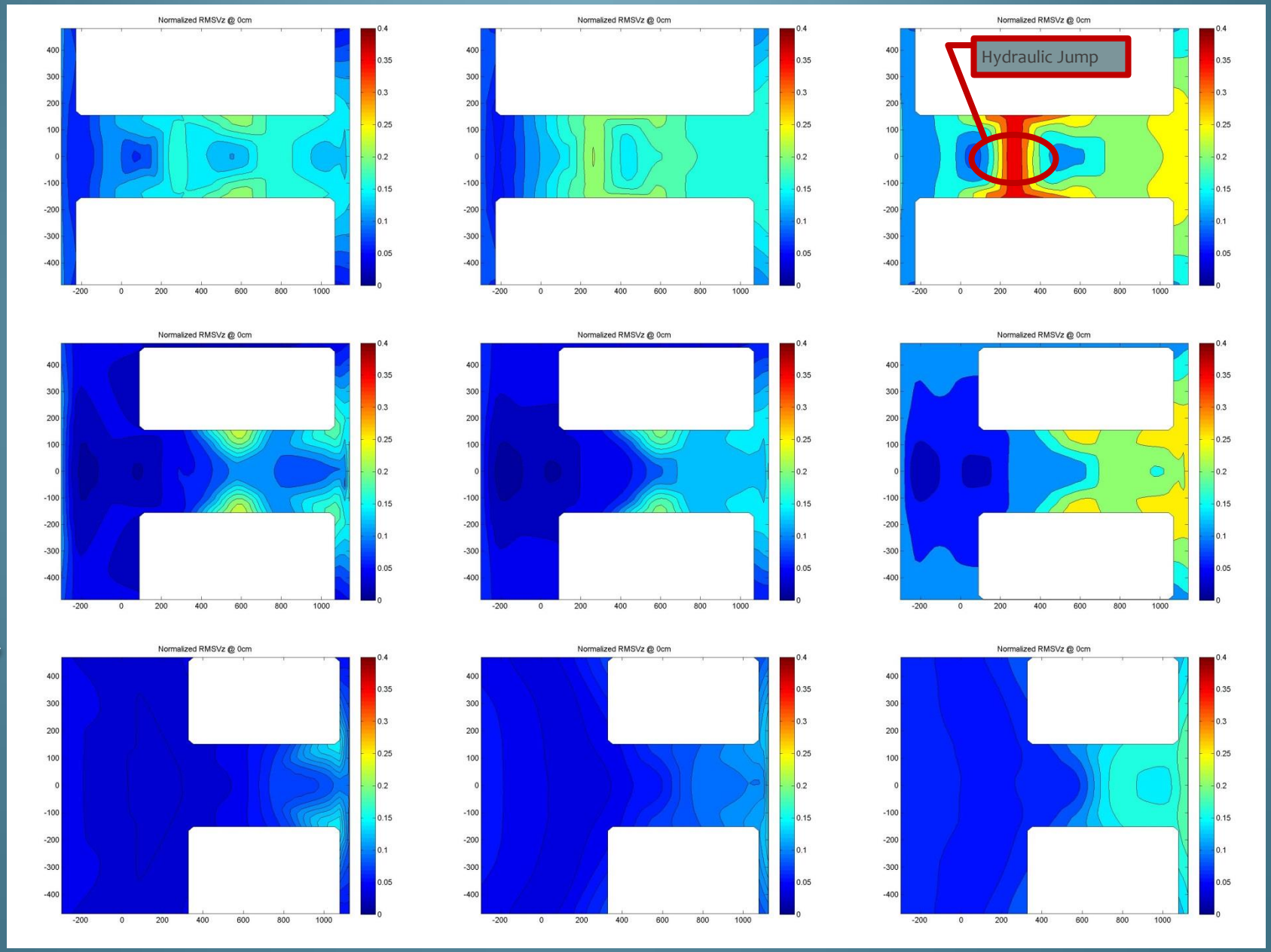
Normalized Turbulence X at Floor with Control Treatment



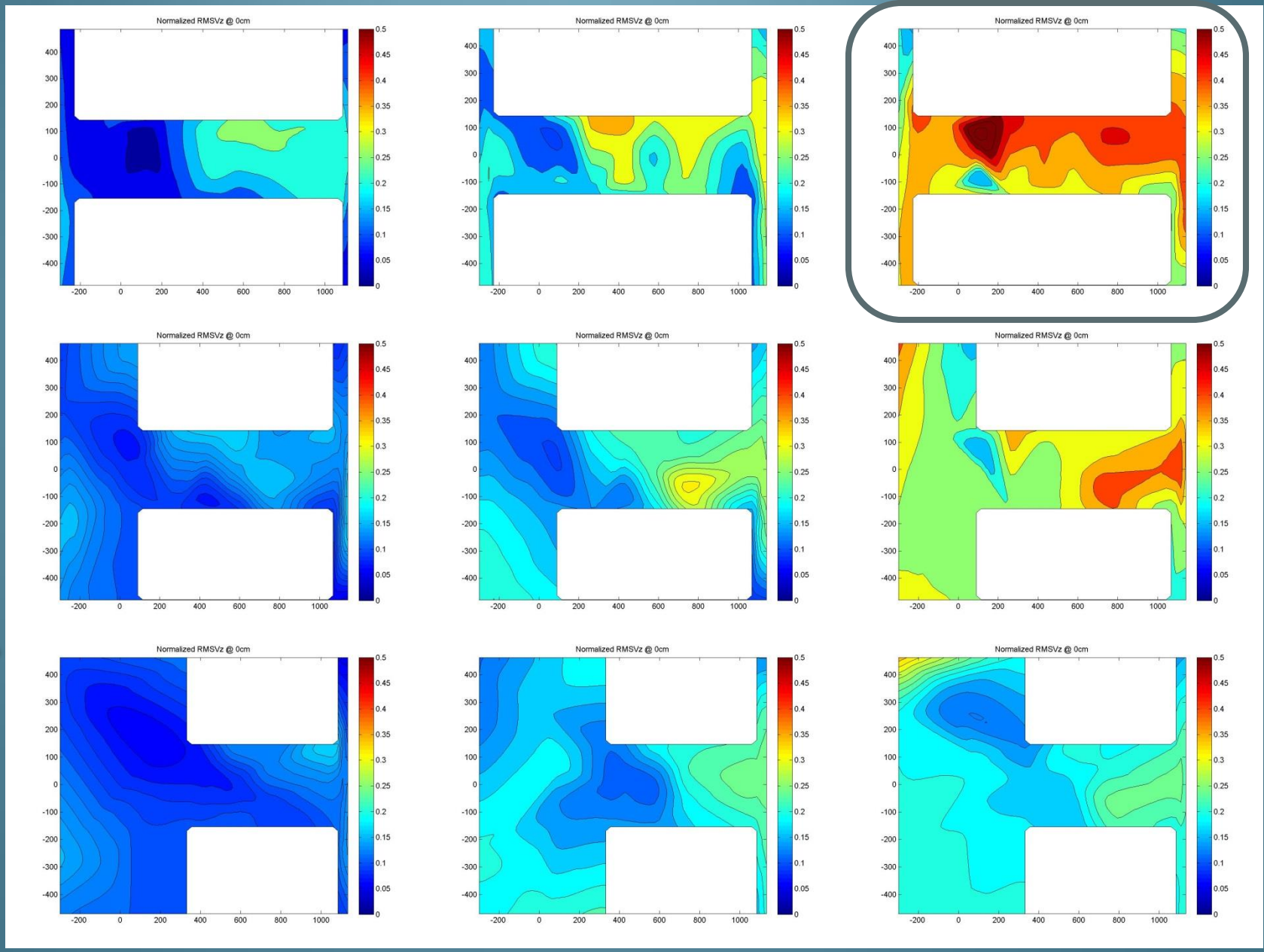
Normalized Turbulence X at Floor with Turbulence Treatment



Normalized Turbulence Z at Floor with Control Treatment



Normalized Turbulence Z at Floor with Turbulence Treatment



Results

- *Flows are more turbulent in the control treatment near the walls due to shear.*
- *Turbulence treatment creates vortices similar to serpentine weirs.*
- *Higher flows intensify turbulence in all cases.*
- *Number of Weirs and Discharge do not affect velocity at bottom.*
- *Heterogeneous flow in turbulence treatment.*
- *Z-axis turbulence may cause detachment of fish.*
- ***Velocity is lowered by introducing structures that increase turbulence.***

What's Next?

- *Monitoring Lamprey behavior in flume.*
- *1/3 of Experiments Complete*
- *Appear to be no differences observed in success across all weir and flow conditions for turbulence treatment.*
- *Preliminary results show Lamprey are holding attachment much longer with the turbulence treatment.*

CONTROL

Video of Lamprey swimming in Control Treatment

http://youtu.be/mHDXdJfjU1c

TURBULENCE

Video of Lamprey swimming in Turbulence Treatment

http://youtu.be/gvWRCPIwbCU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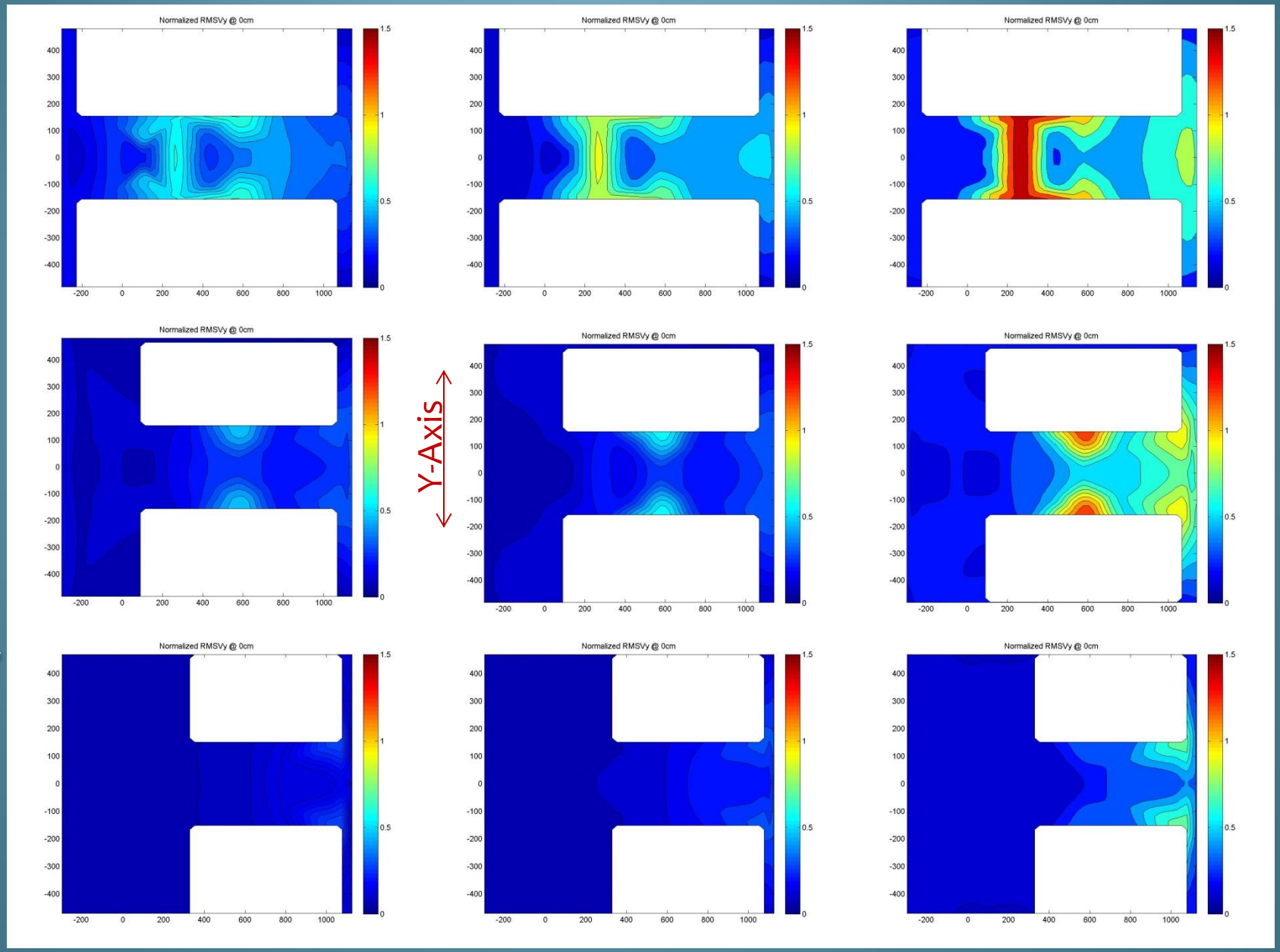
Normalized Turbulence Y at Floor with Control Treatment



Normalized Turbulence Y at Floor with Turbulence Treatment