Using the ELAM for forecasting fish passage on the Mississippi River
(or other locations using CFD and ELAM)

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ERDC, USACE, ITL

Gaurav Savant
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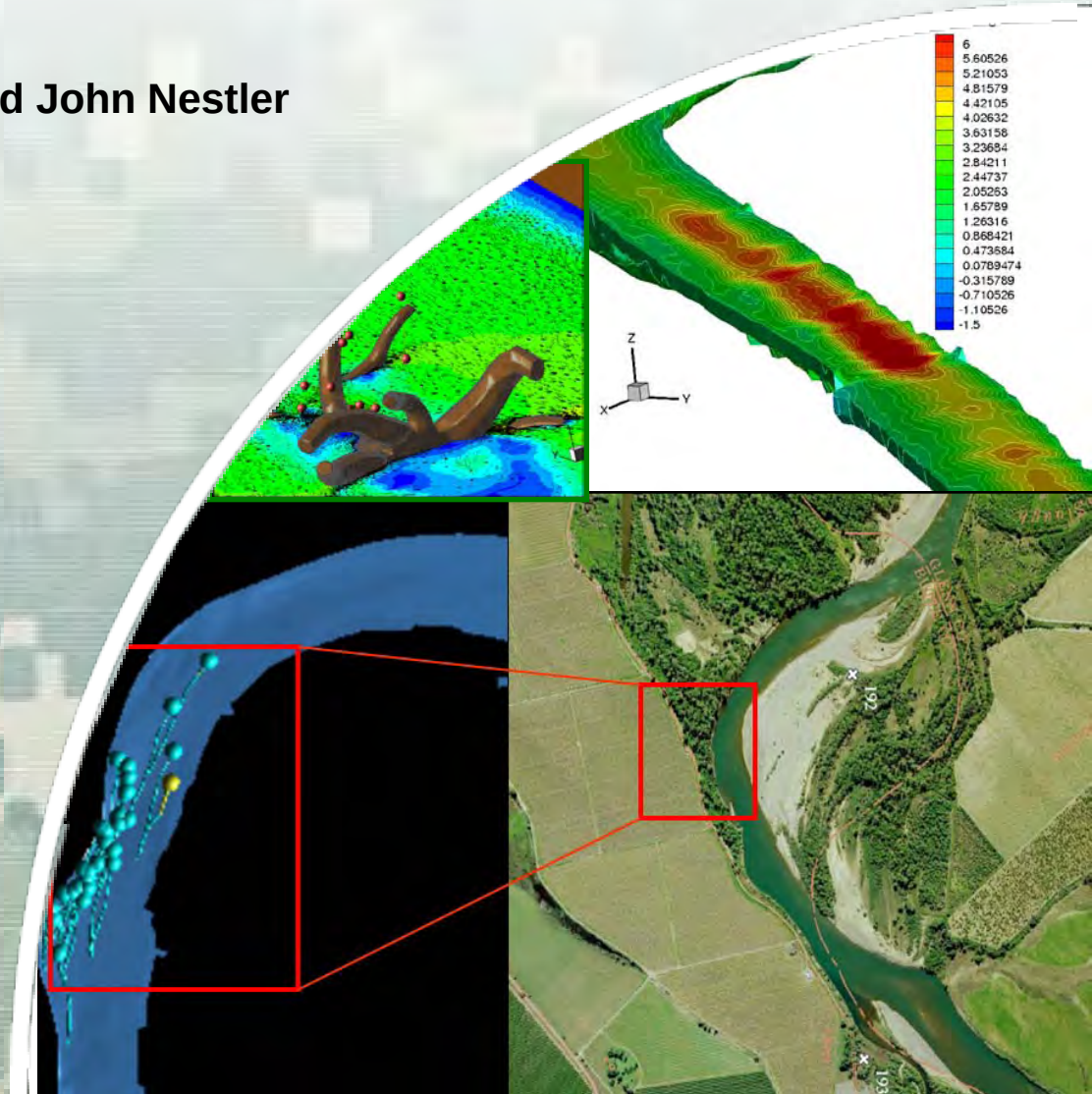
Aaron Buesing
St. Paul, USACE



US Army Corps of Engineers
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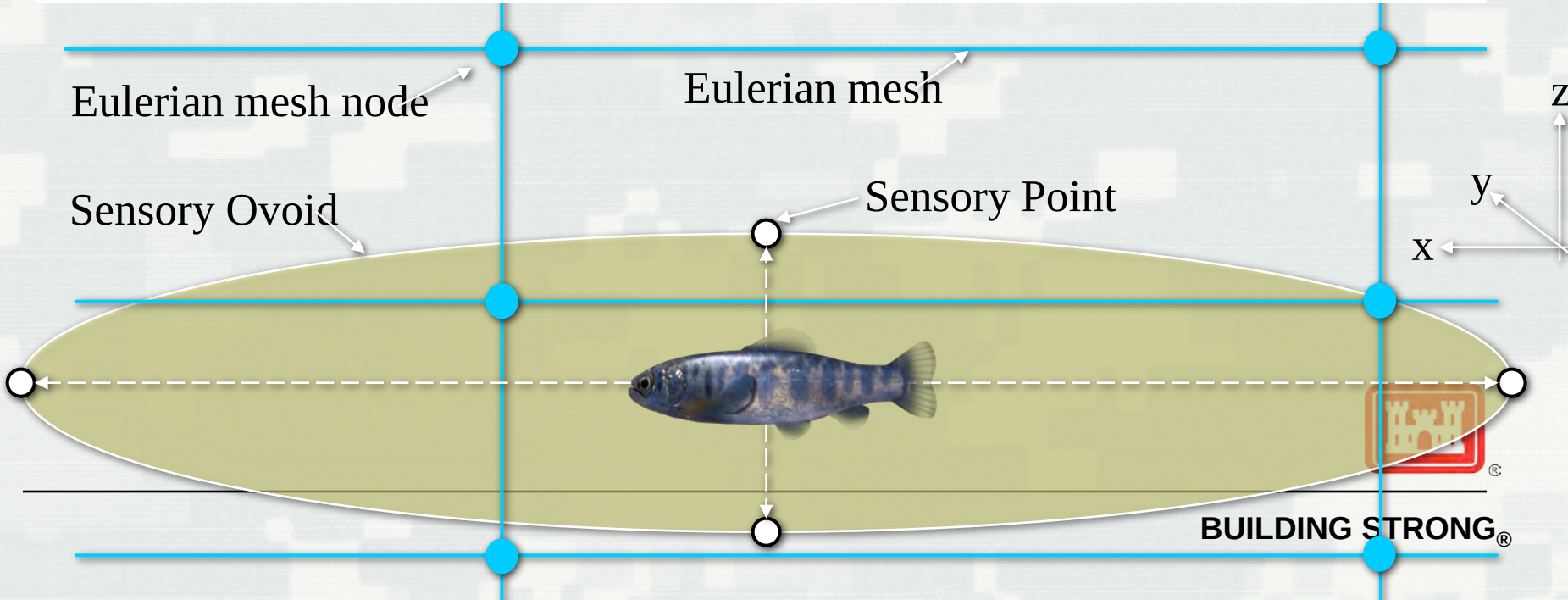
Forecast movement

Important Attributes of the ELAM

- temporal & spatial scaling of each process optimally simulated,
- information transformed as needed to meet requirements of linked processes,
- distribution of processes to frameworks partially function size of domain
- venue for inter/trans-disciplinary education & integration, and
- maximum fidelity to “real world” using “first principles”.



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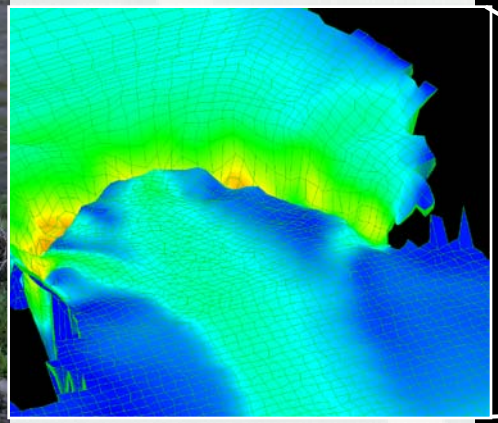
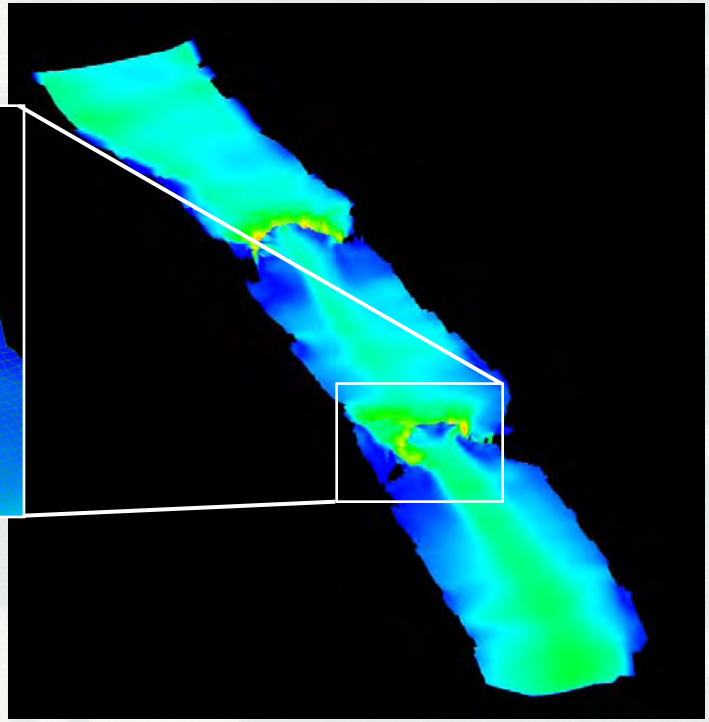
Small rivers

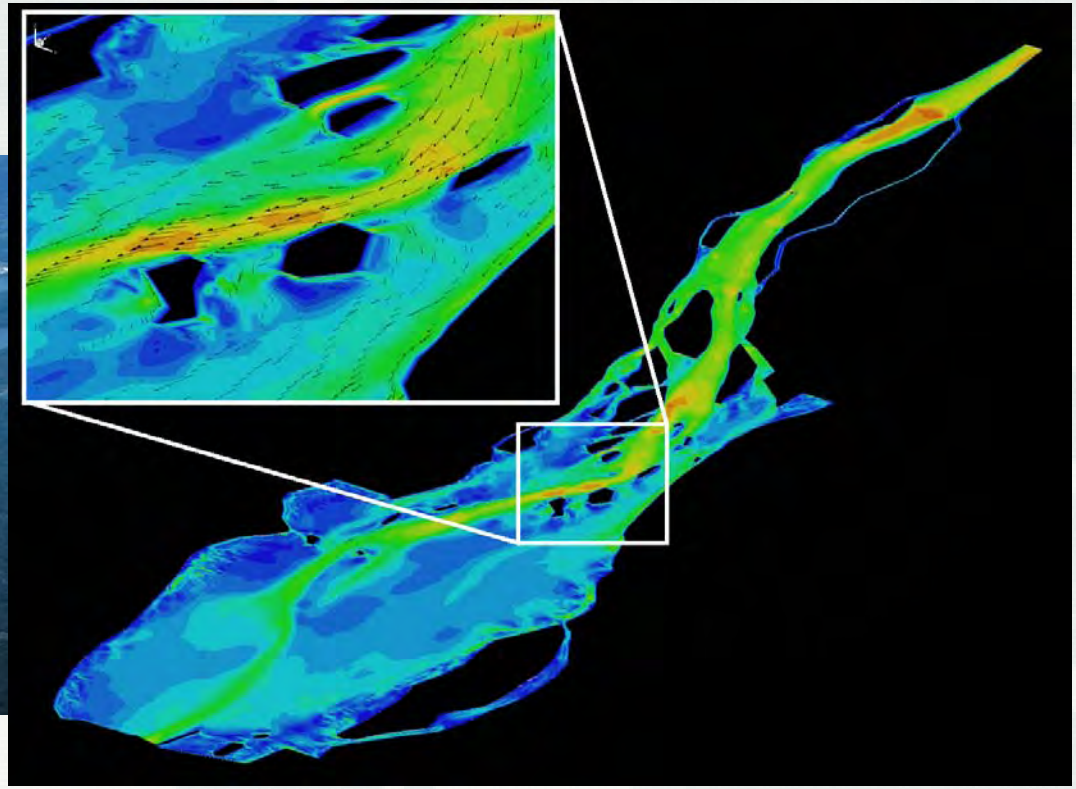




Little Snake River

Photo and CFD courtesy of Dr. Yong Lai

Large rivers



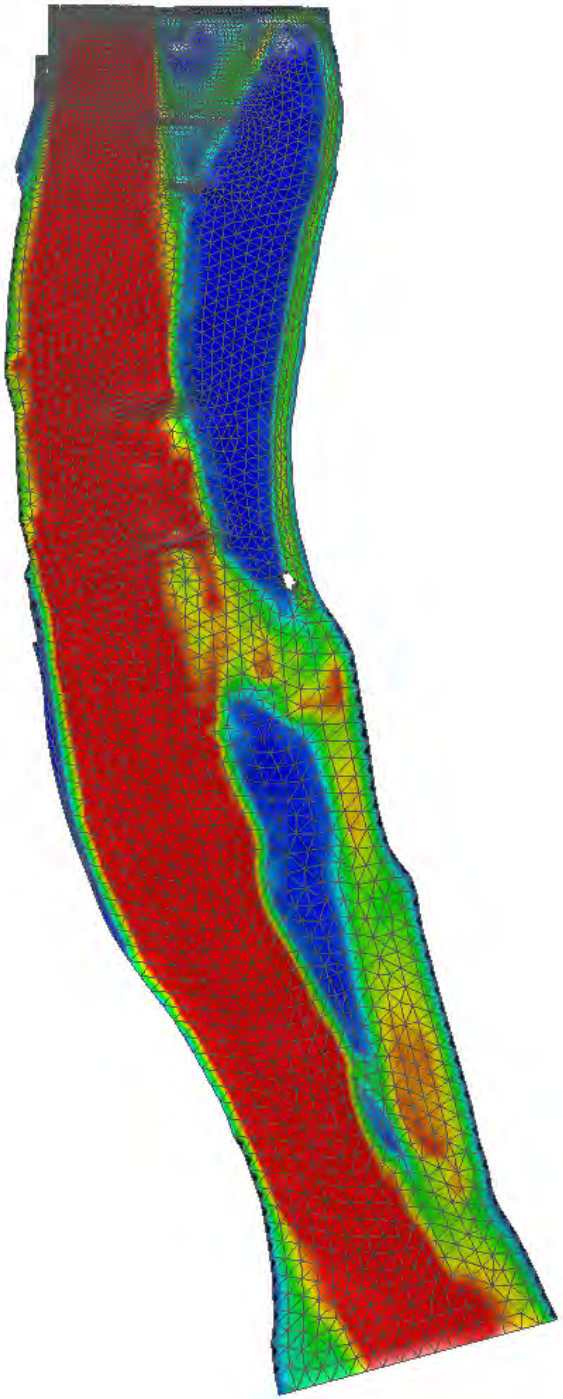
Mississippi River

CFD courtesy of Dr. Larry Weber
Photo courtesy of USGS

Location

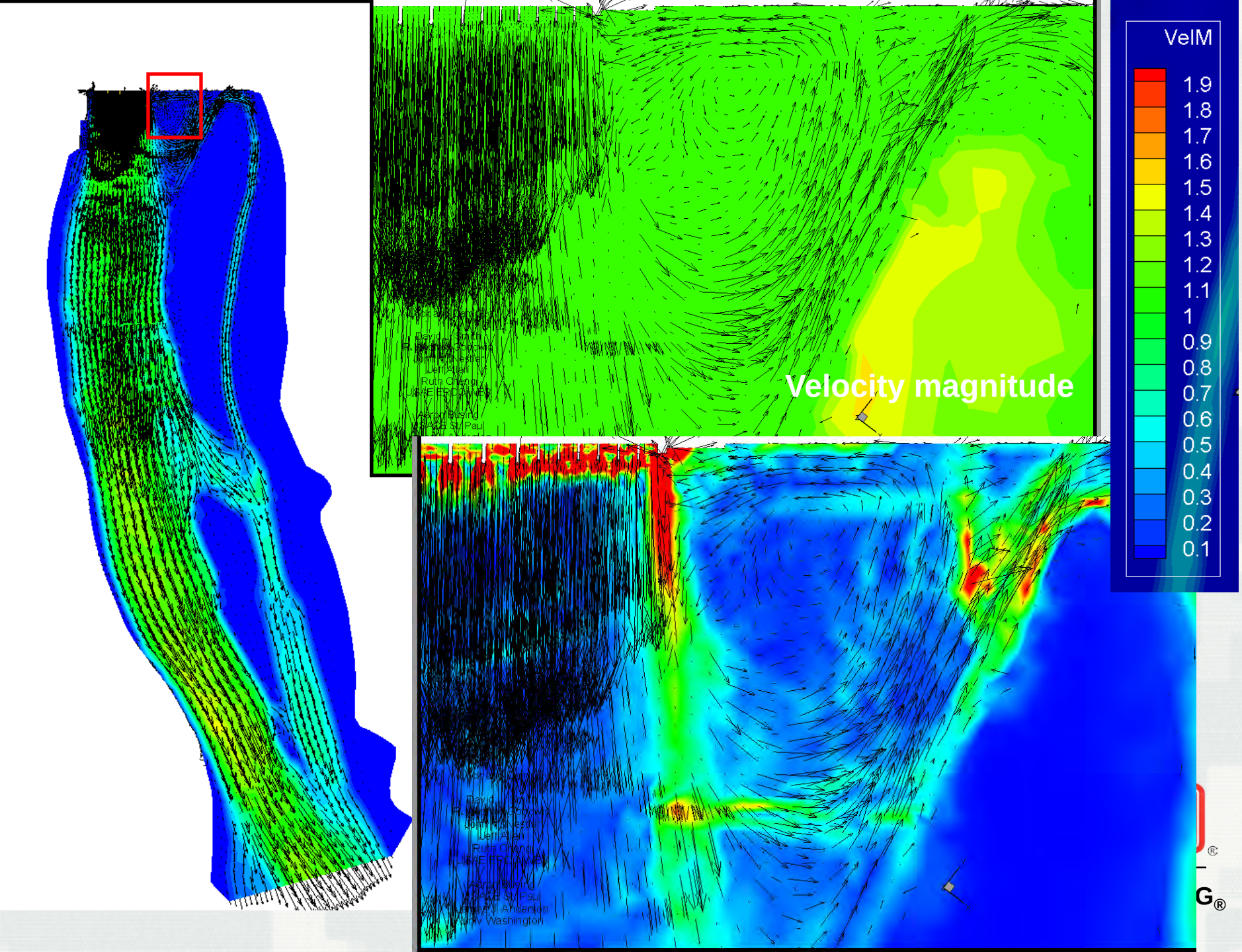
- Located near Saverton, Missouri at rivermile 301.2
- Dam and lock are 2900 feet wide

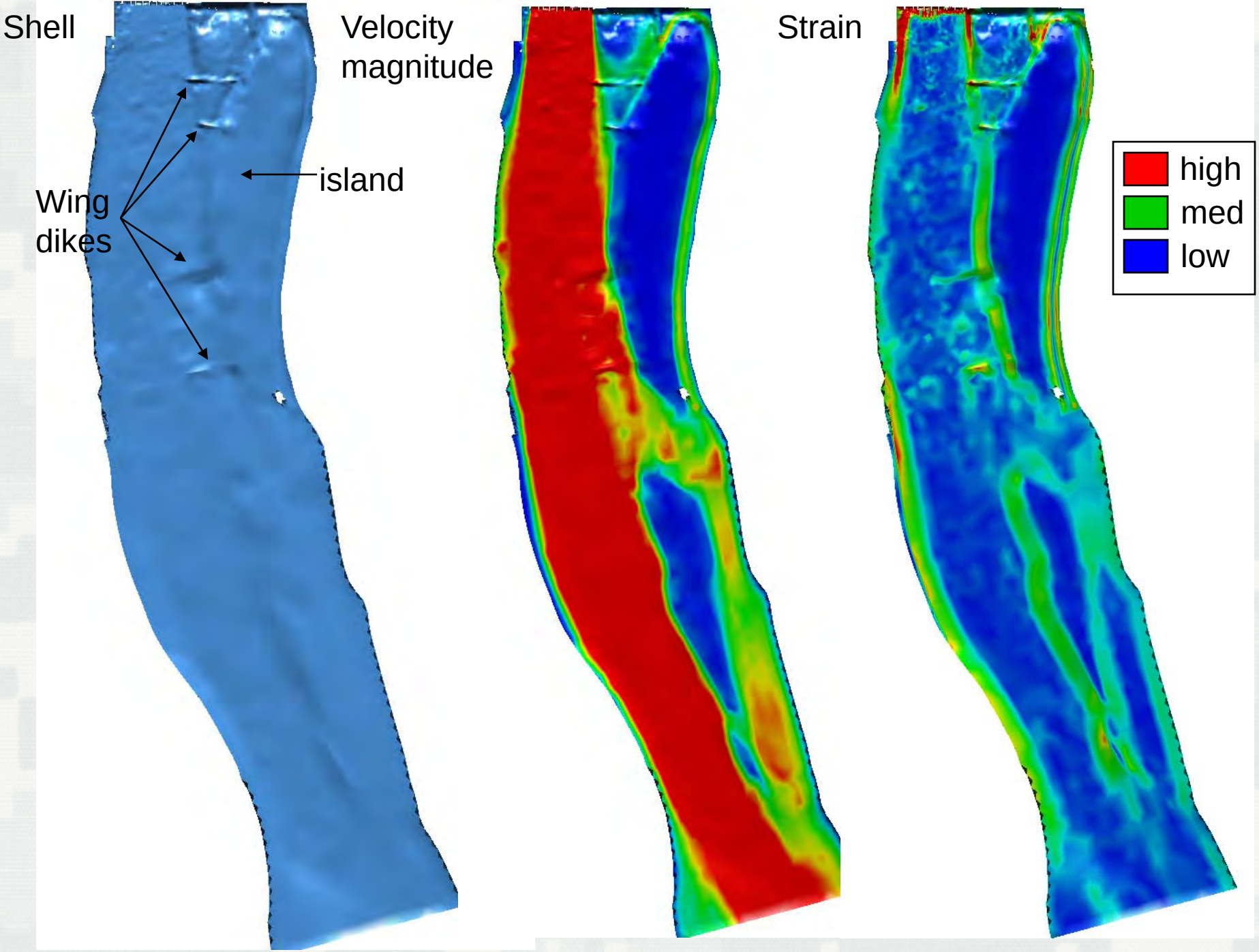
Dam
Browns Island
Wing dikes
Jim Young Island
Taylor Island
current
Image USDA Farm Service Agency
© 2009 Europa Technologies
© 2009 Tele Atlas
©2007 Google™
Pointer 39°37'35.38" N 91°12'56.63" W elev 455 ft
Streaming 100%
Eye alt 19108 ft



Domain

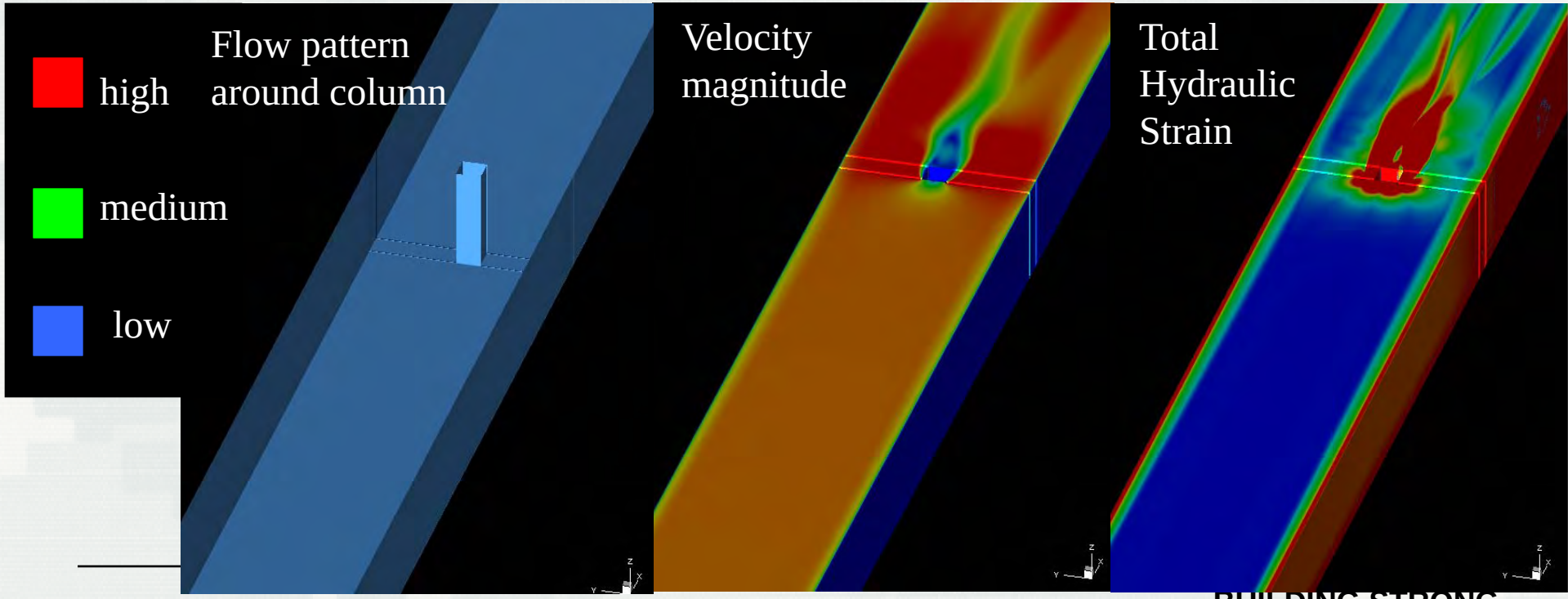
- 2D ADH
- May 23, 2007 conditions
- Element size from ~4 m to 90 m
- Converted to 3D by adding one layer and formatting per ADH and ELAM-NFS formats
- Fish movement simulated using pNFSSIM


Velocity magnitude
VelM
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


Shell
Velocity magnitude
Strain
Wing dikes
island
high
med
low

Why do you need total hydraulic strain?

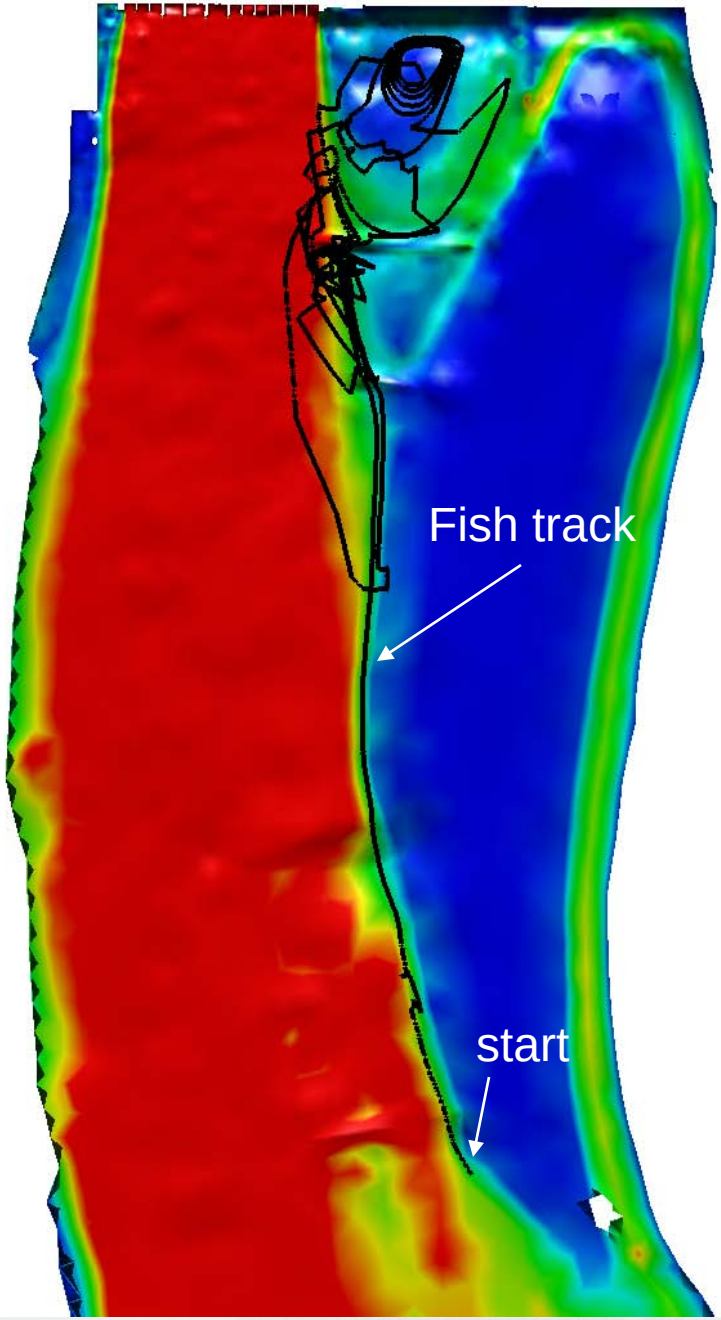
- Coupled with velocity magnitude, allows fish to distinguish between bed and form resistance

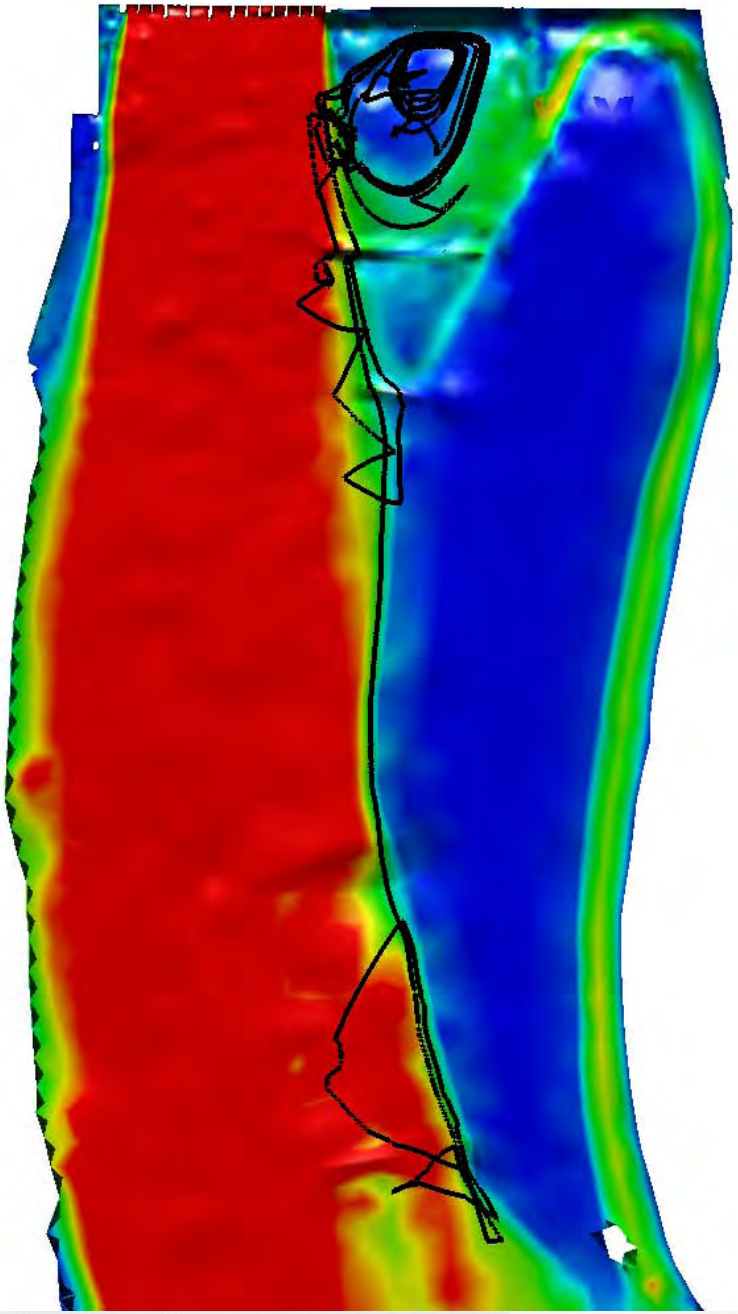


Rules

- Default – swim upstream
- If free shear is detected
  - Swim toward decreasing velocity or into the velocity vector until deactivated
- Iterate at each time step and respond to changing conditions in the CFD.
- No pressure or wall-based behaviors because of 2D information field.

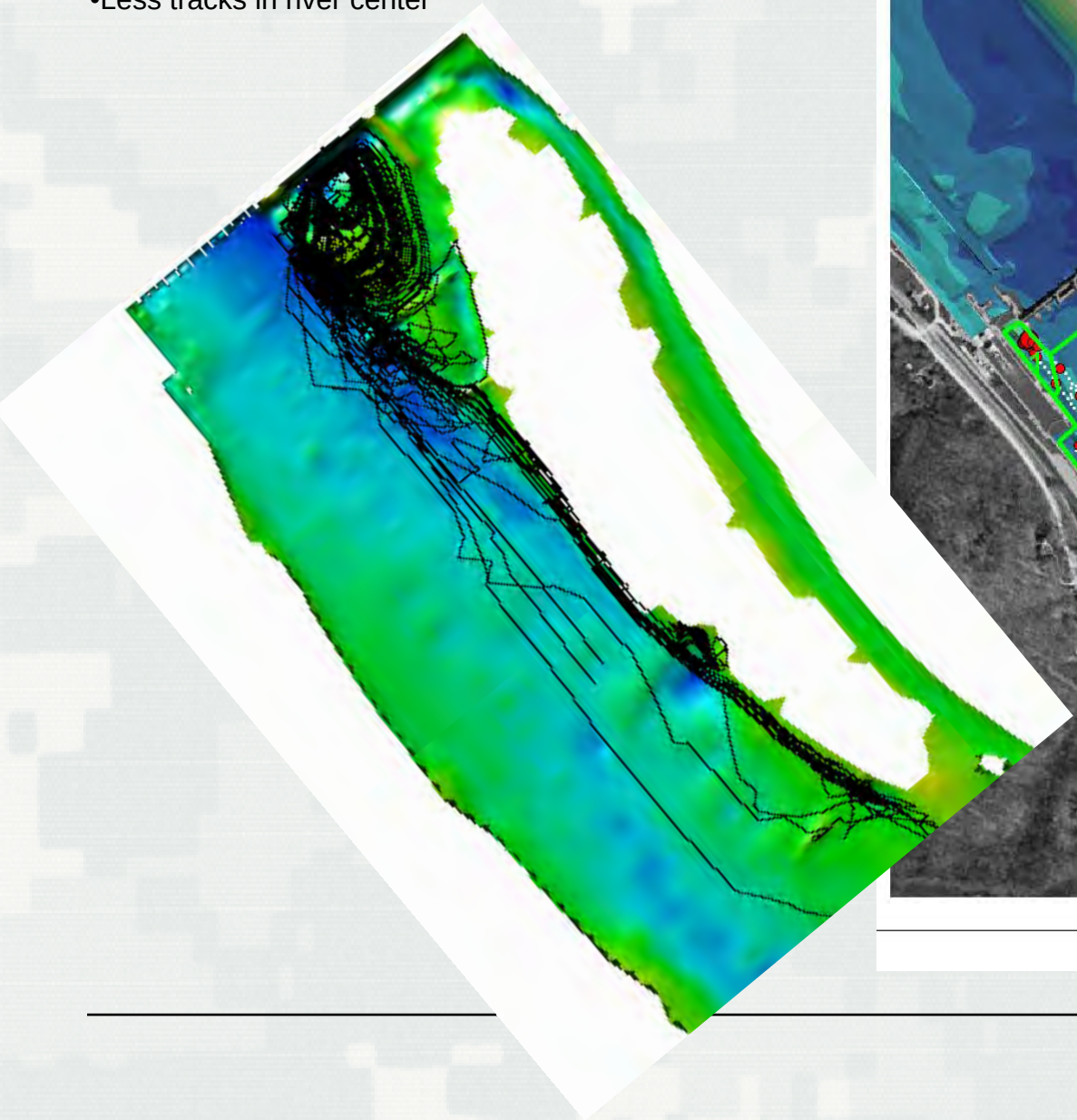
Upstream movement
and velocity magnitude
of one fish per domain



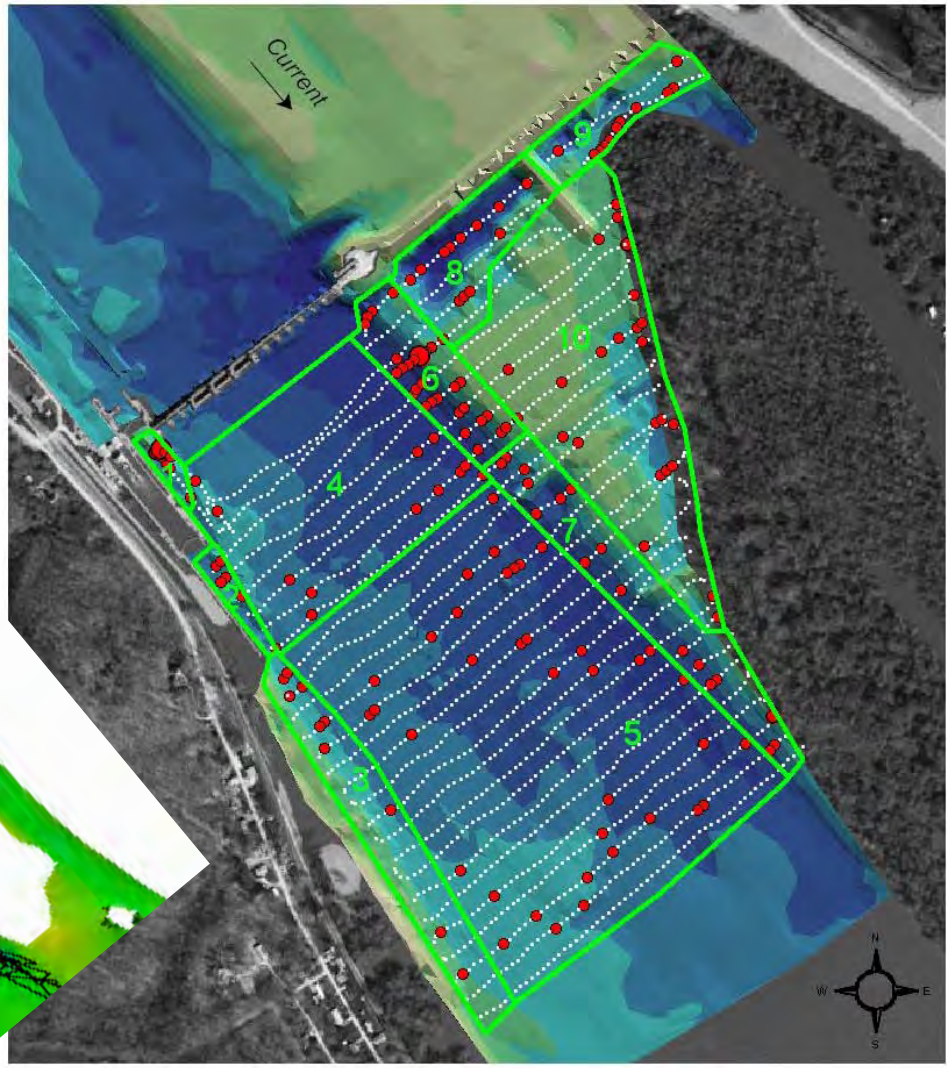


Similarities with acoustic survey

- Upstream tracks concentrated in Zone 6 and 7
- Tracks concentrated in Zone 8
- Less tracks in river center

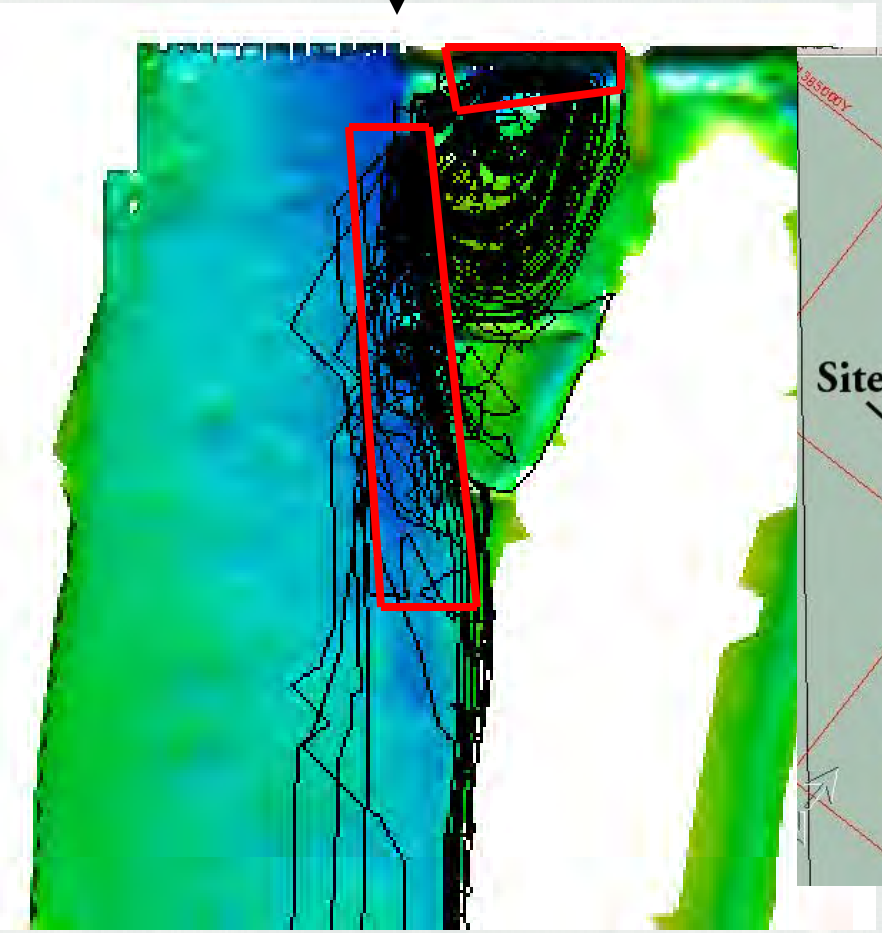


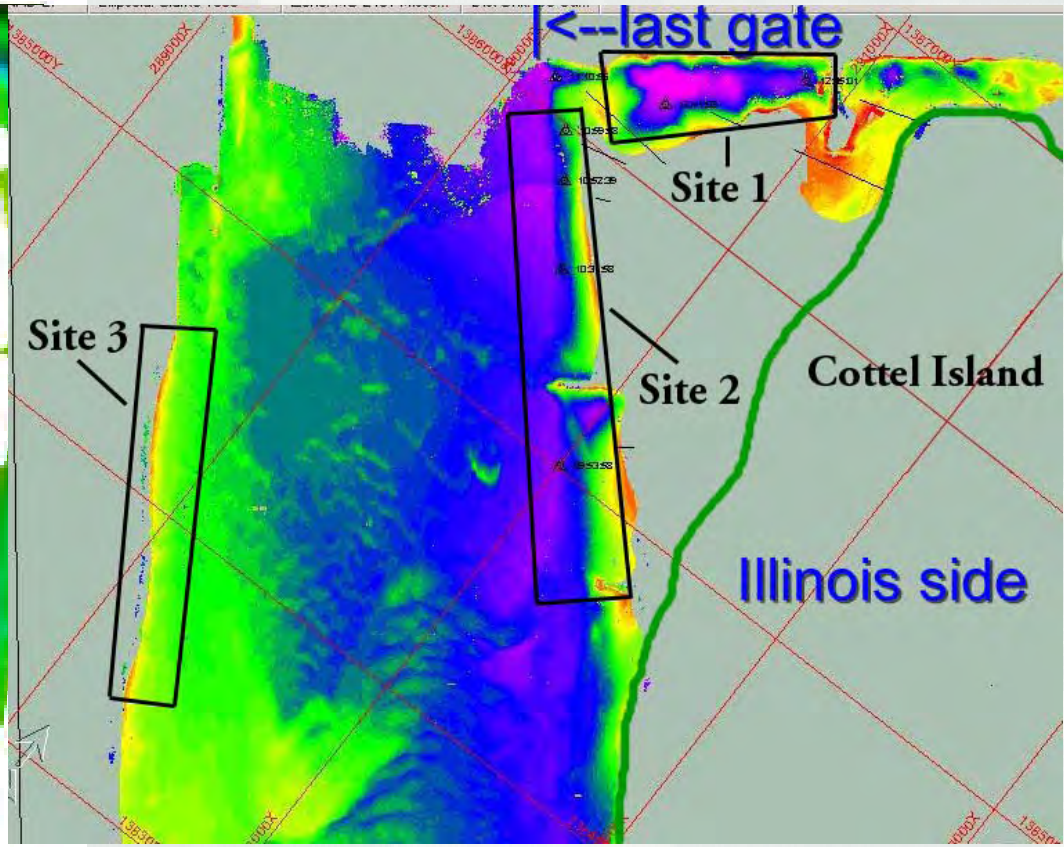
Survey 05/09/2006



Site 1 and 2 had greatest fish density, dominated by shovelnose sturgeon, *Scaphirhynchus platorynchus*
Site 1 is a deep hole where most sturgeon are caught
Note concentration of fish tracks in Site 1 and Site 2

Last gate



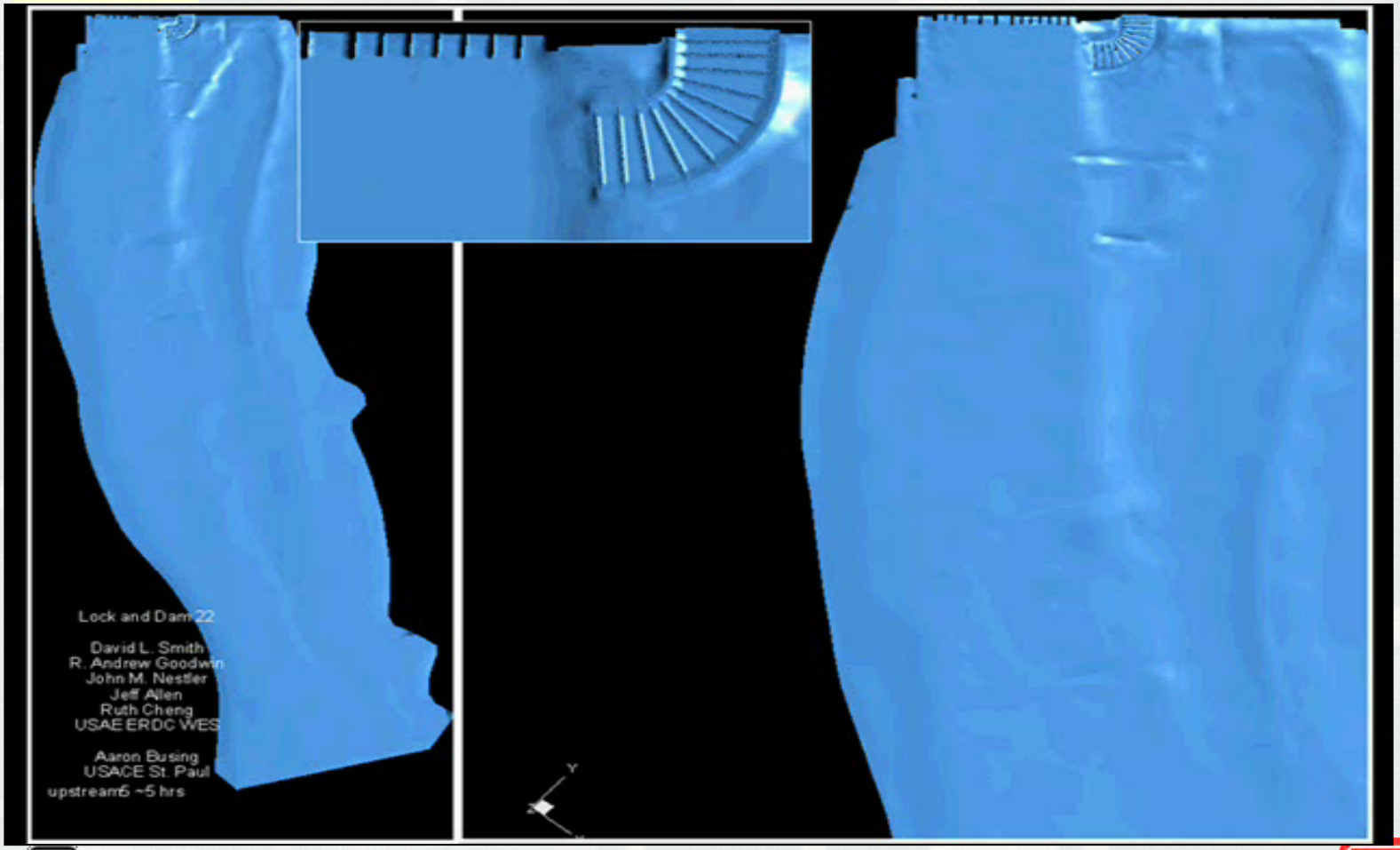


animation

Click to activate...

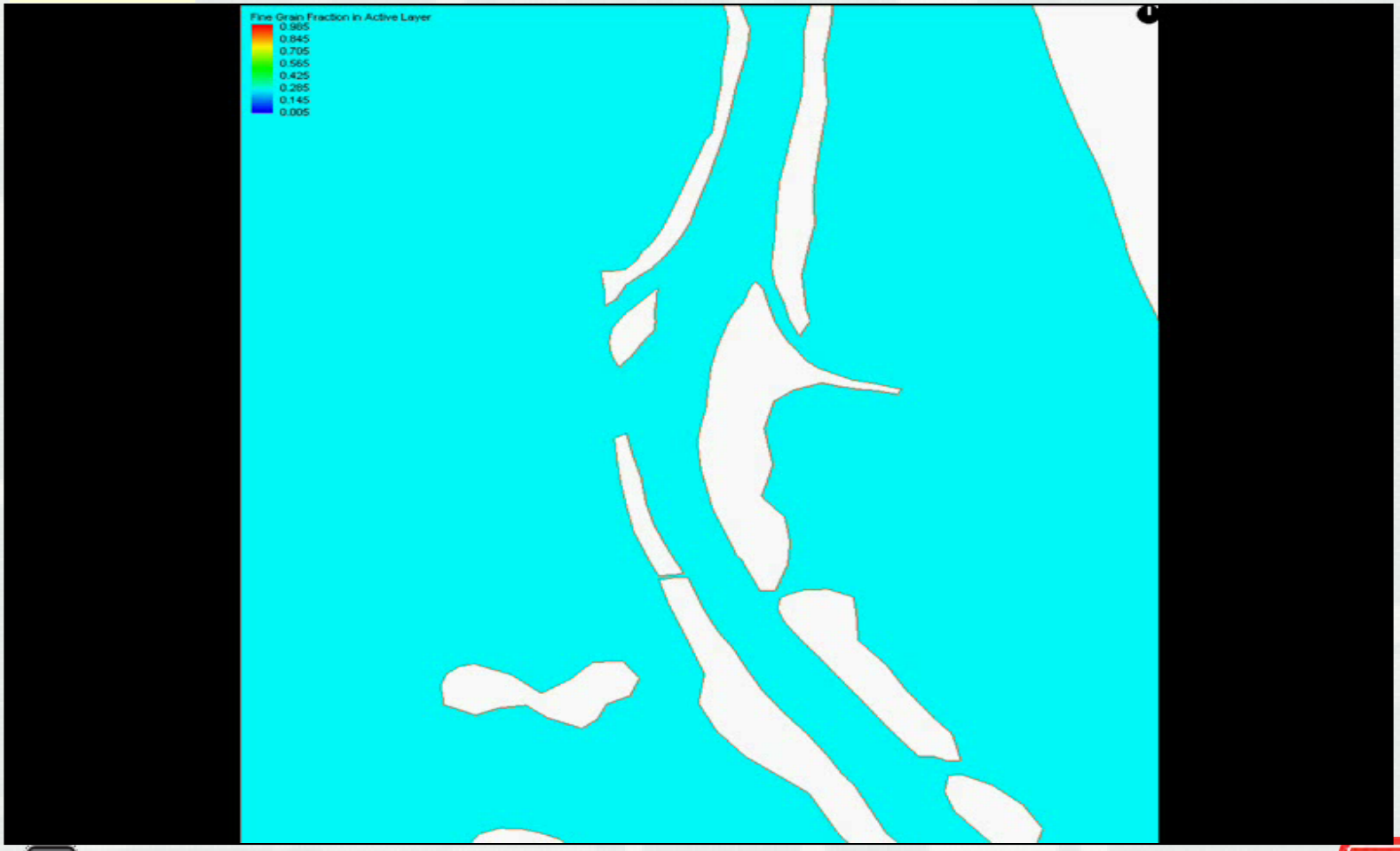
animation

Click to activate...



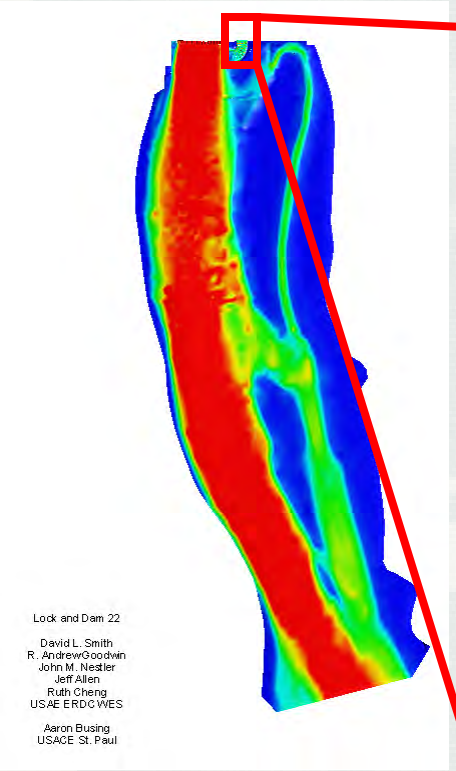
animation

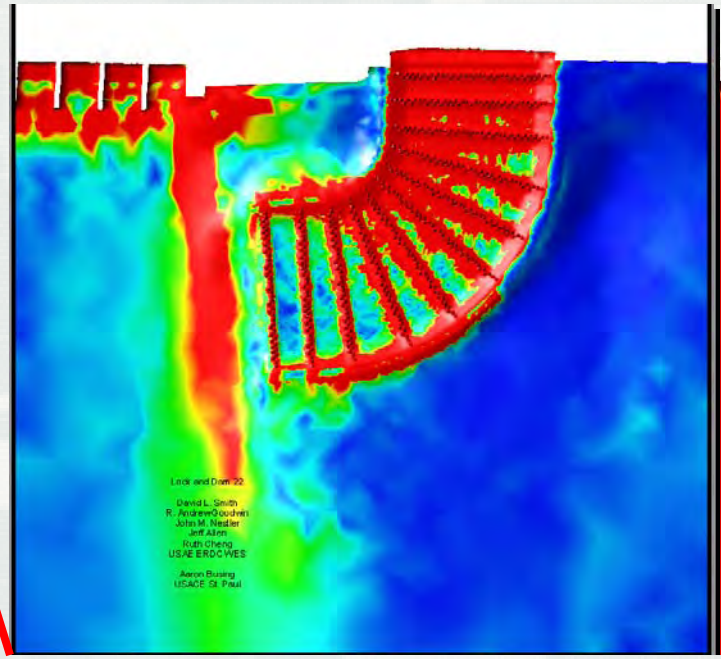
Click to activate...

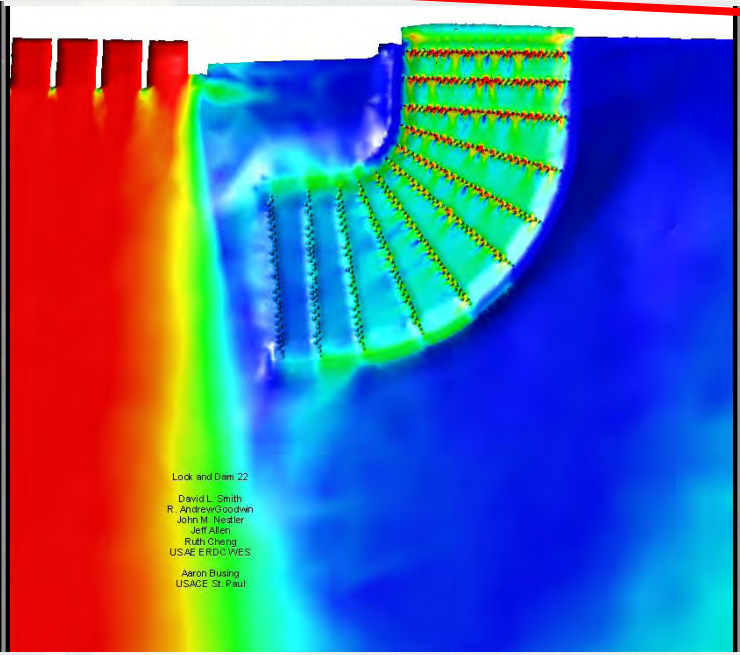


Strain

Velocity







Lock and Dam 2
David L. Smith
R. AndrewGoodw
John M. Nestler
Jeff Allen
Ruth Cheng
USAE ERDC WES
Aaron Busing
USACE St. Paul

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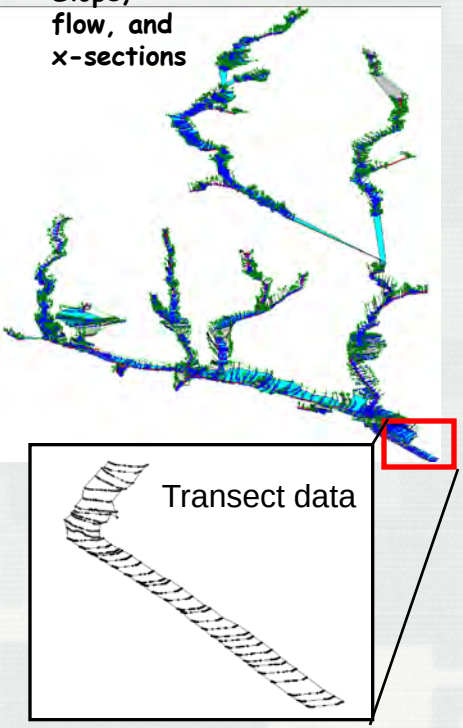
Making it better

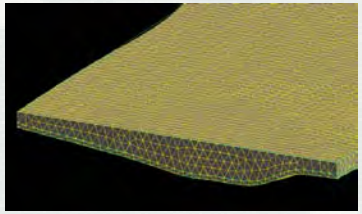
SHAPE – Stream Habitat Analyses Package → *MultiD high fidelity ecological simulations from readily available data*

Start with a HEC-RAS model

Slope, flow, and x-sections

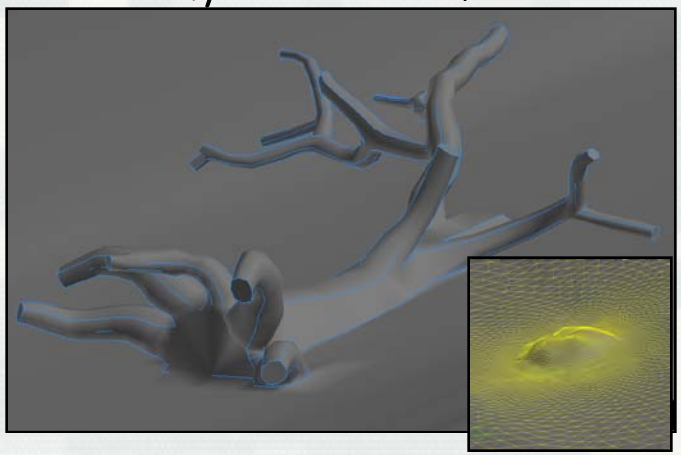


Develop MultiD environment



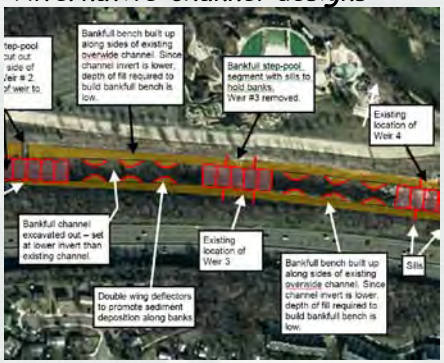
Model bathymetry between transects

Add important habitat features

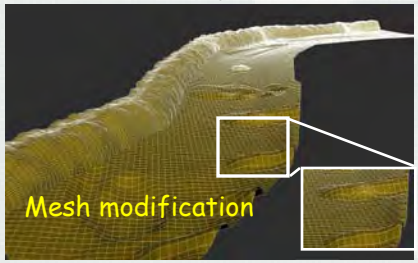


Consider desired future conditions

Alternative channel designs

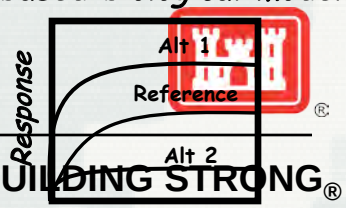


Meanders, bank protection, engineered log jams



Supplement with aerial photos → *Highlight important habitat features (LWD, etc)*

Analyze multiD simulation with risk-based biological model an



Δ Flow, channel morphology etc

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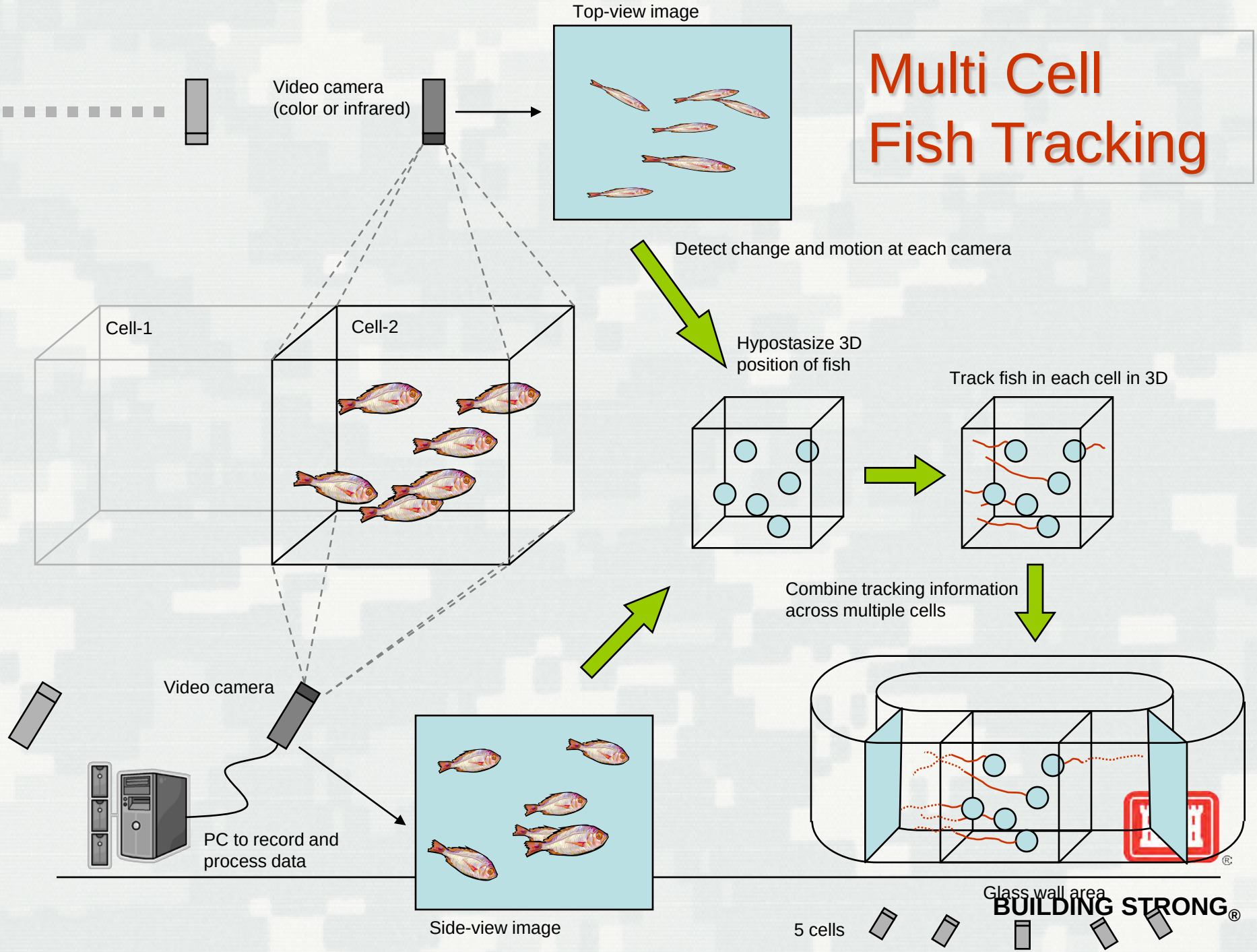
Multi Cell Fish Tracking



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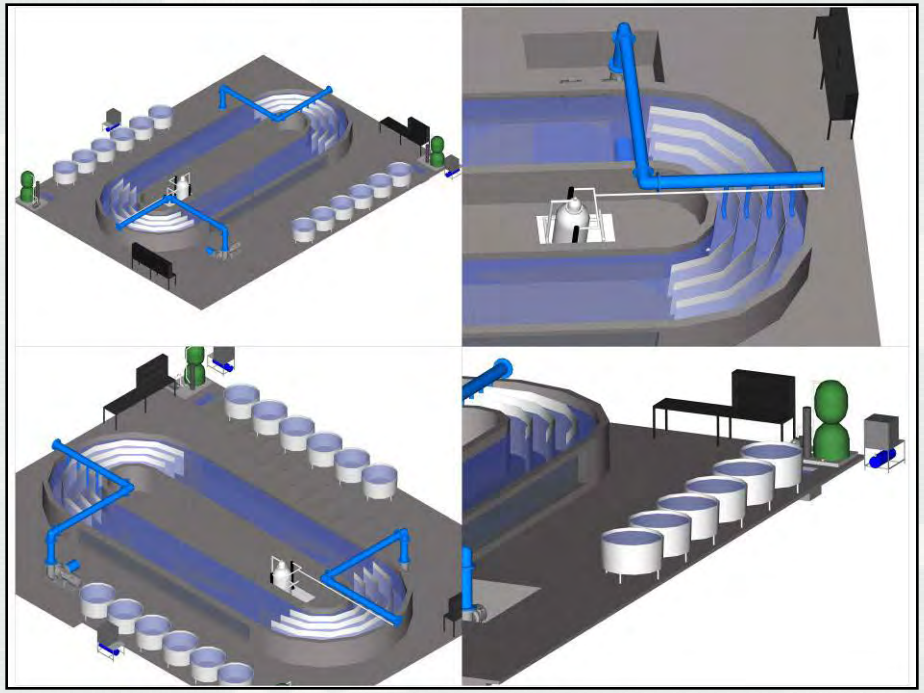
Why a large flume?

- Provides link between laboratory data and variable field conditions when coupled with modeling
- Provides scientific creditability that can withstand public scrutiny
- Will allow development of dynamic barrier operational specifications
- Manage fish movement and navigation

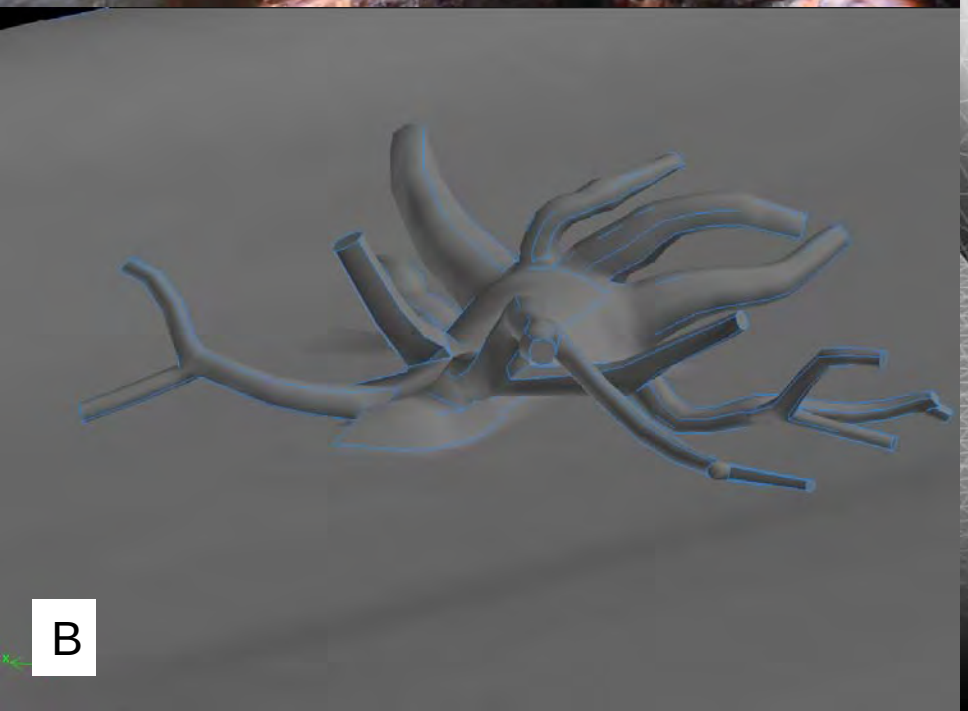


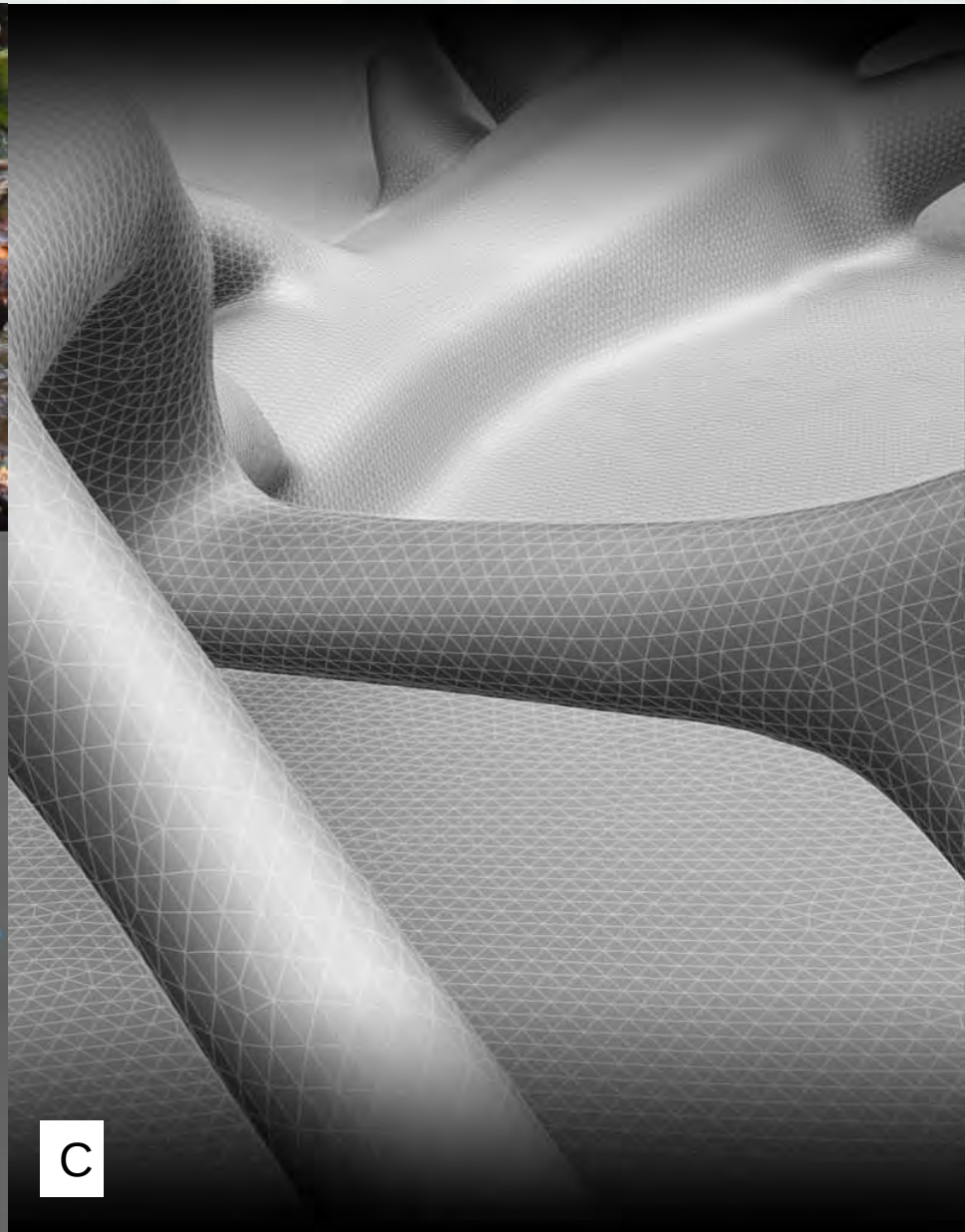
3D model of actual design

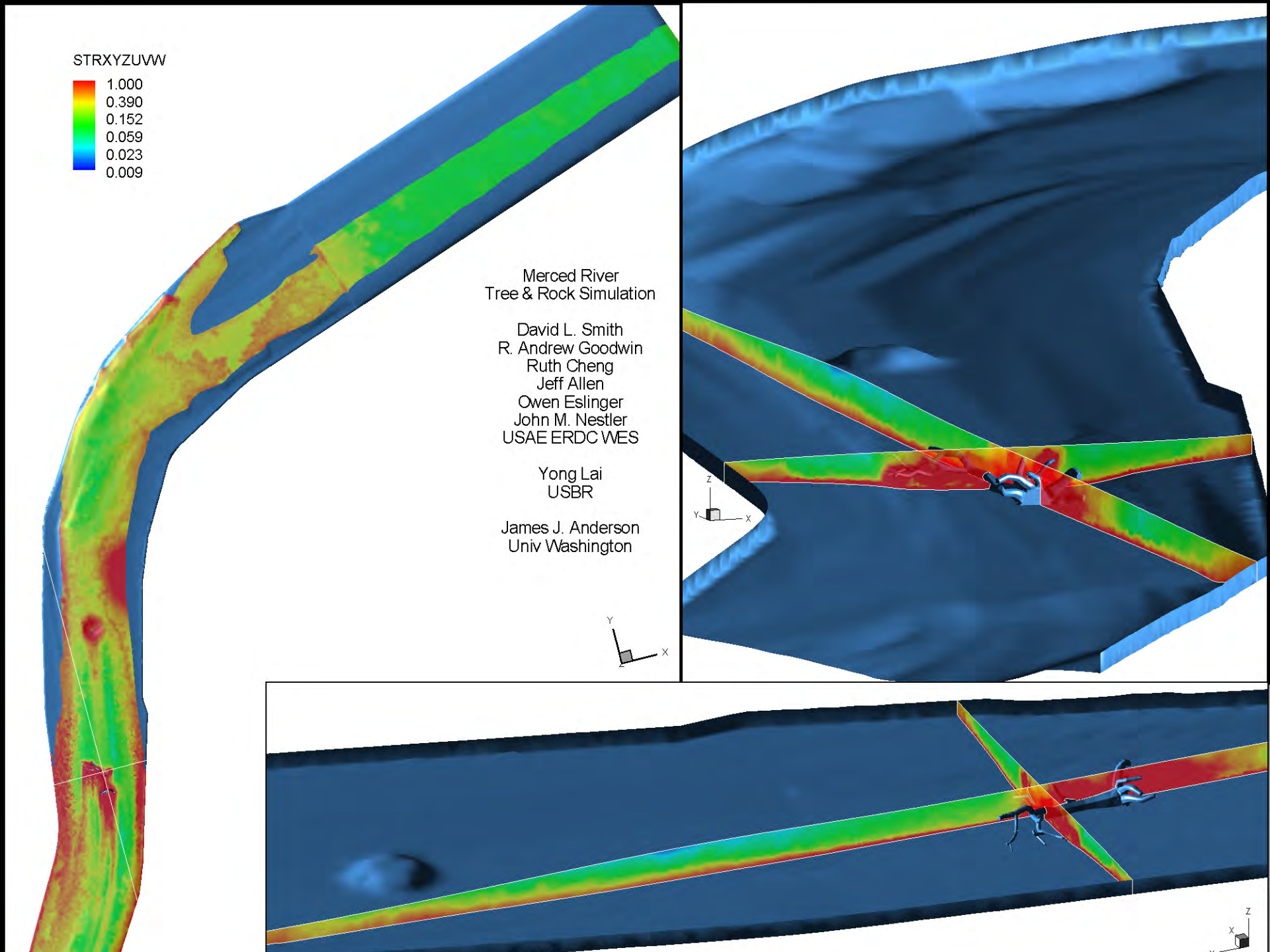
References

- **Lock and Dam 22: Acoustic fish surveys of the tail water area 2005 – 2007 provided by Mark Cornish**
- Region 3 Fisheries Data Series, FPR-2007-X, **Fisheries Monitoring at Lock & Dam 22: March – May 2007**

Complex Features: Embedment & Meshing






STRXYZUVW
1.000
0.390
0.152
0.059
0.023
0.009
Merced River
Tree & Rock Simulation
David L. Smith
R. Andrew Goodwin
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Owen Eslinger
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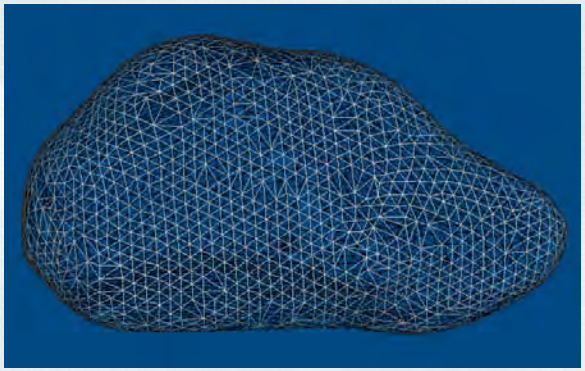
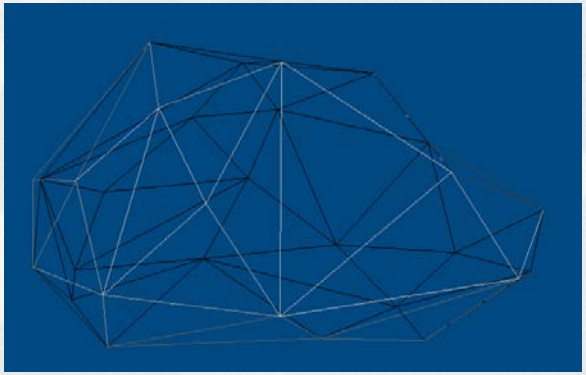
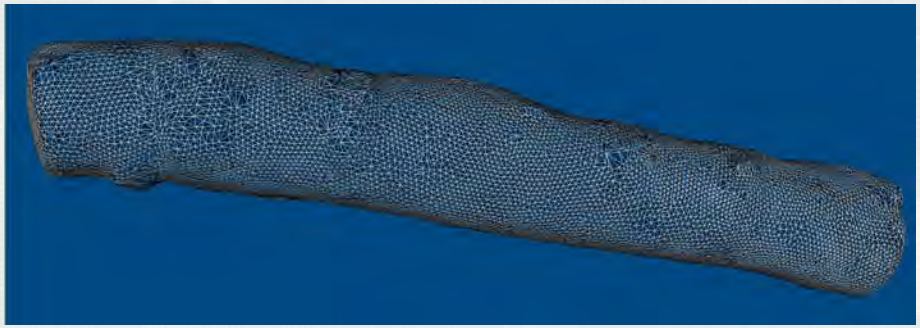
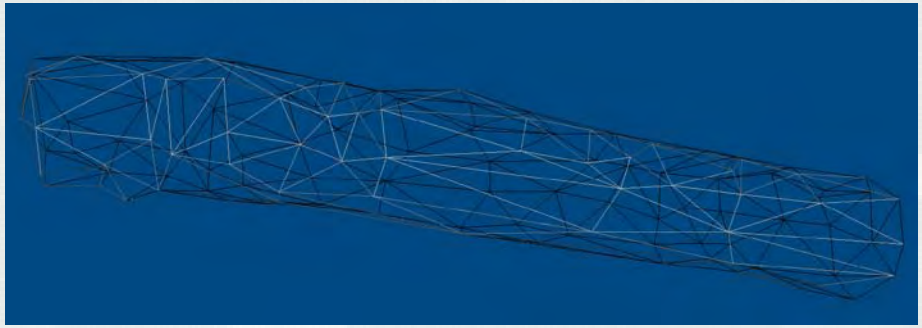
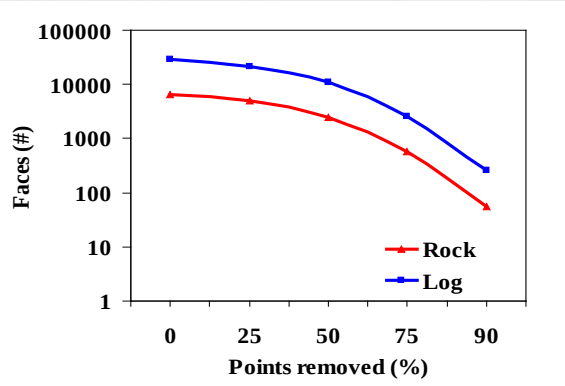
USAE ERDC WES
Yong Lai
USBR
James J. Anderson
Univ Washington

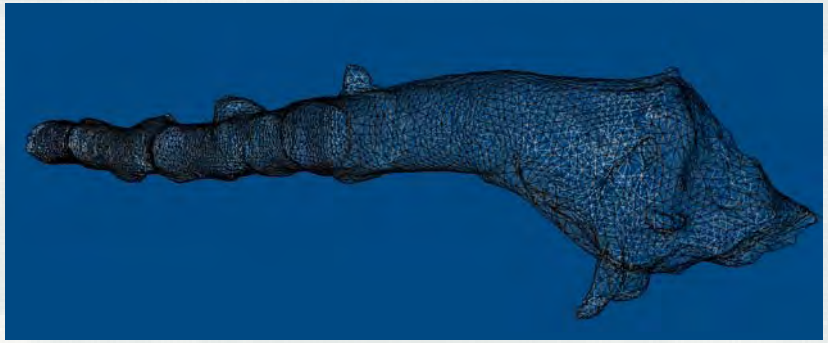


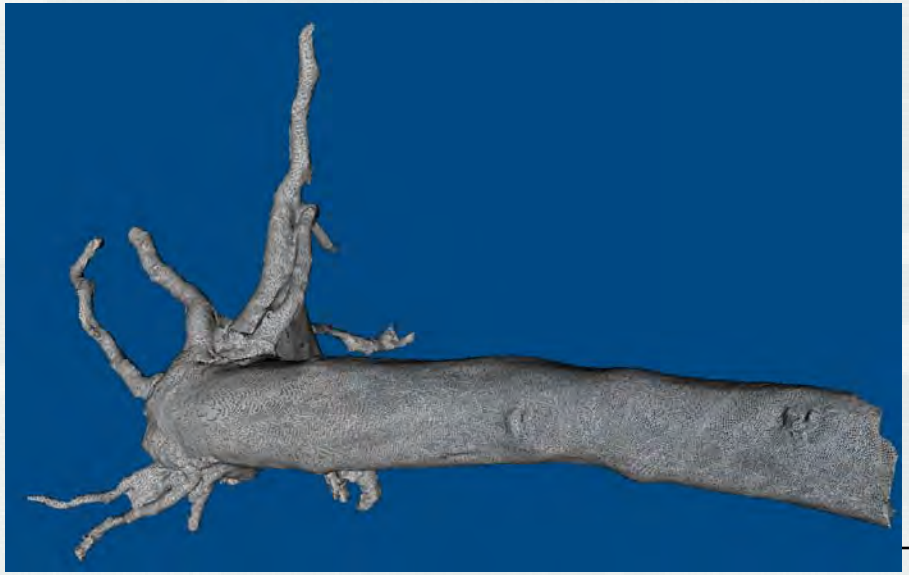




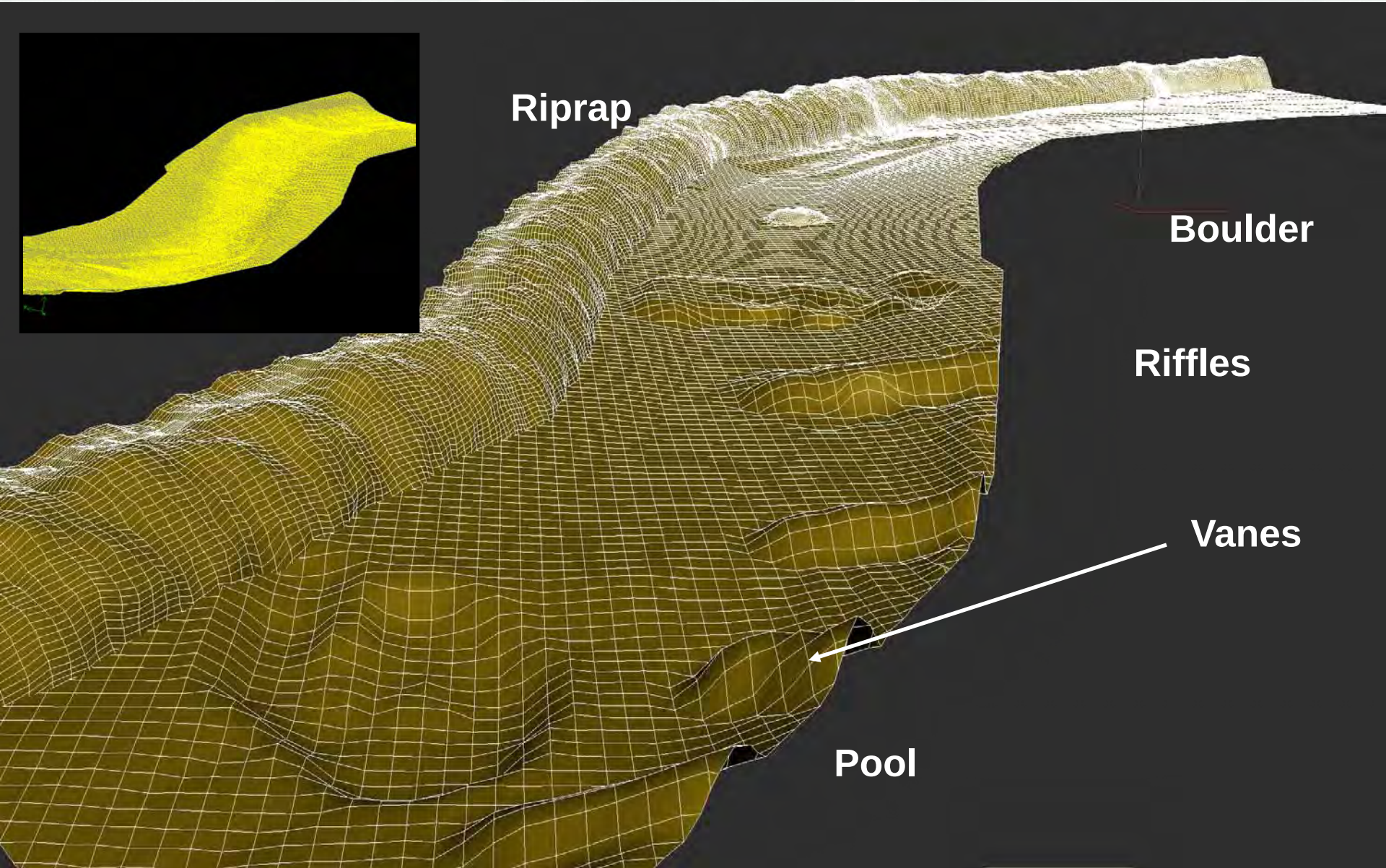


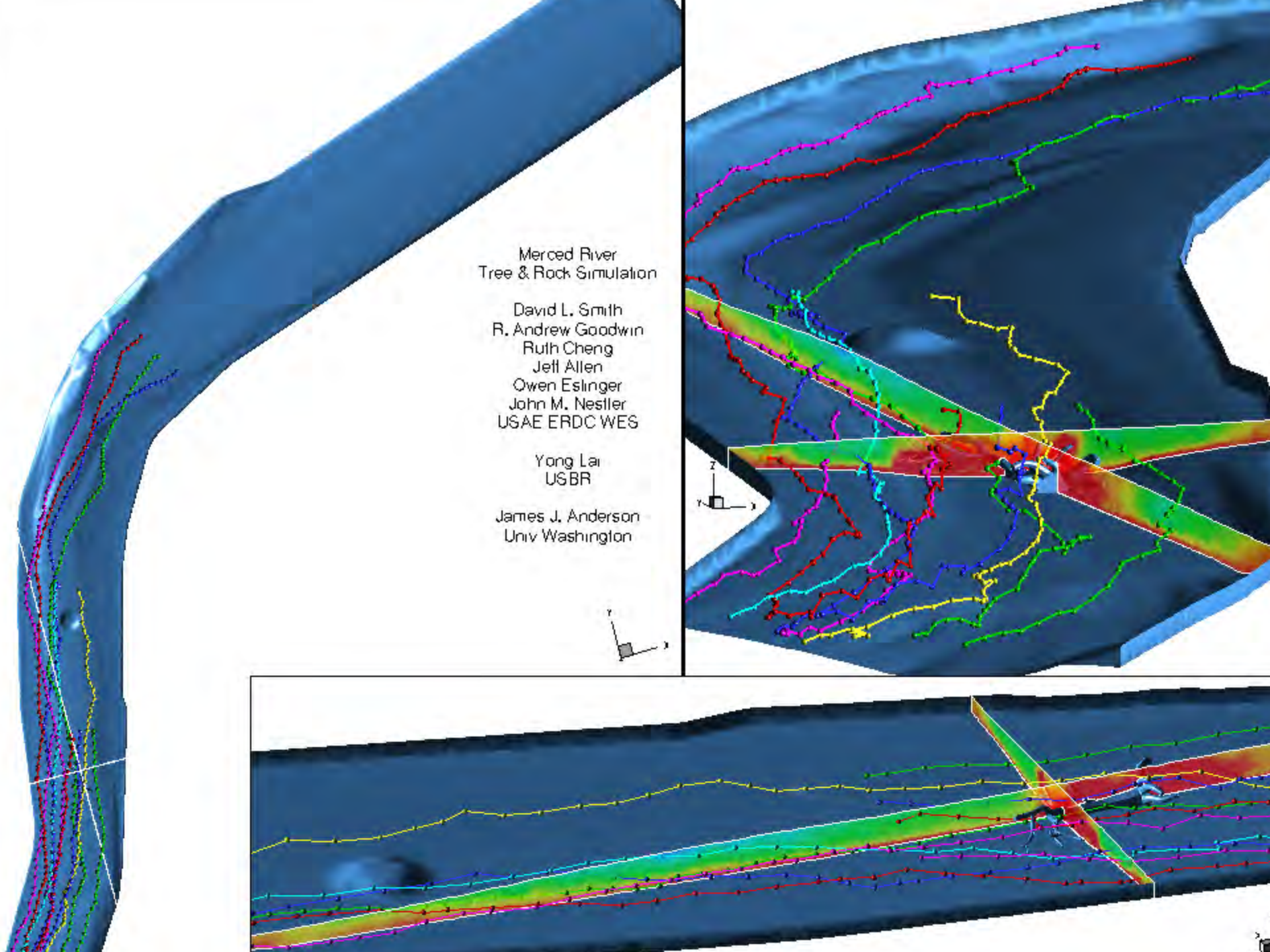

100000
10000
1000
100
10
1
Faces (#)
0
25
50
75
90
Points removed (%)
Rock
Log





Mesh manipulation

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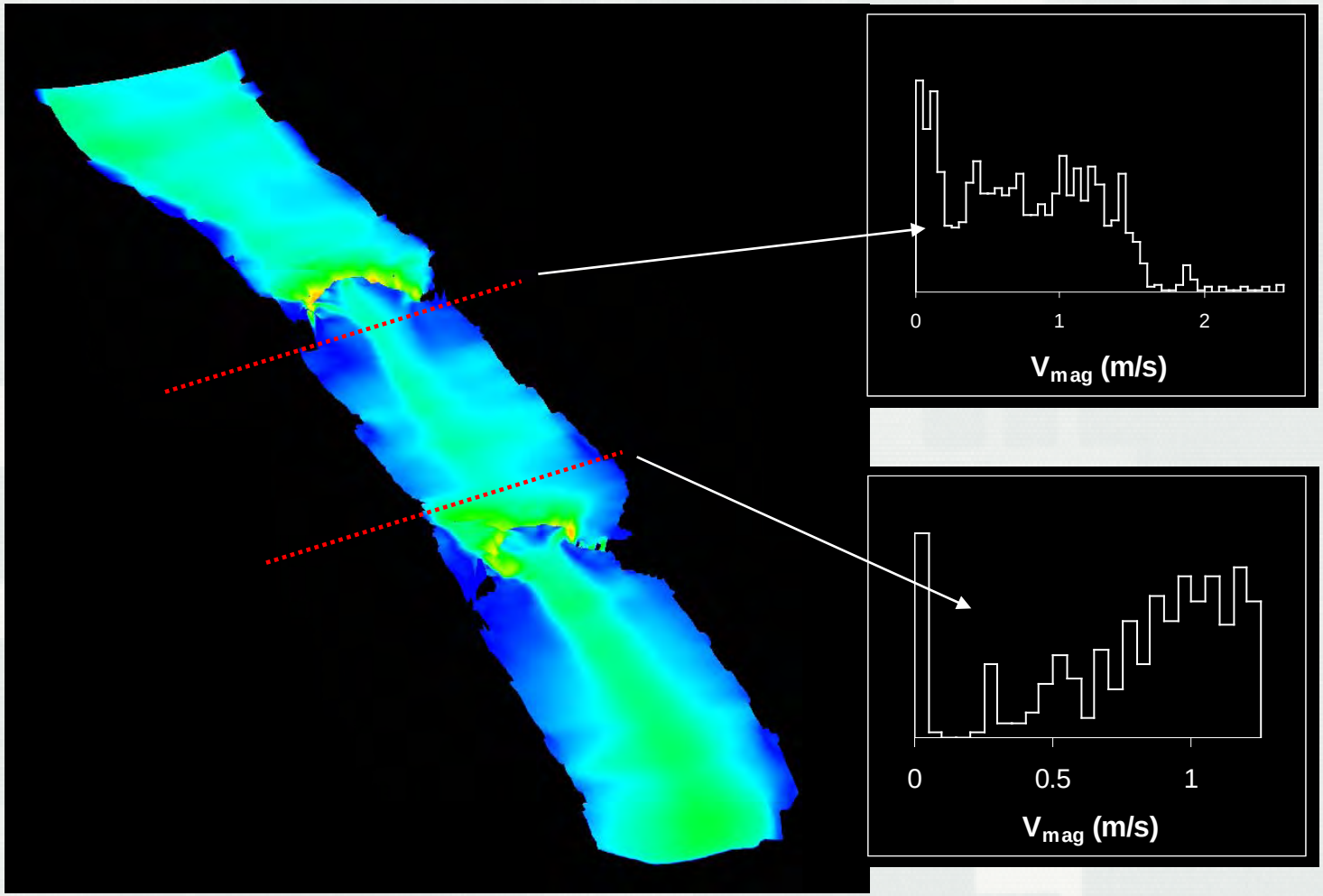
USAE ERDC WES
Yong Lai
USBR
James J. Anderson
Univ Washington

Information from CFD



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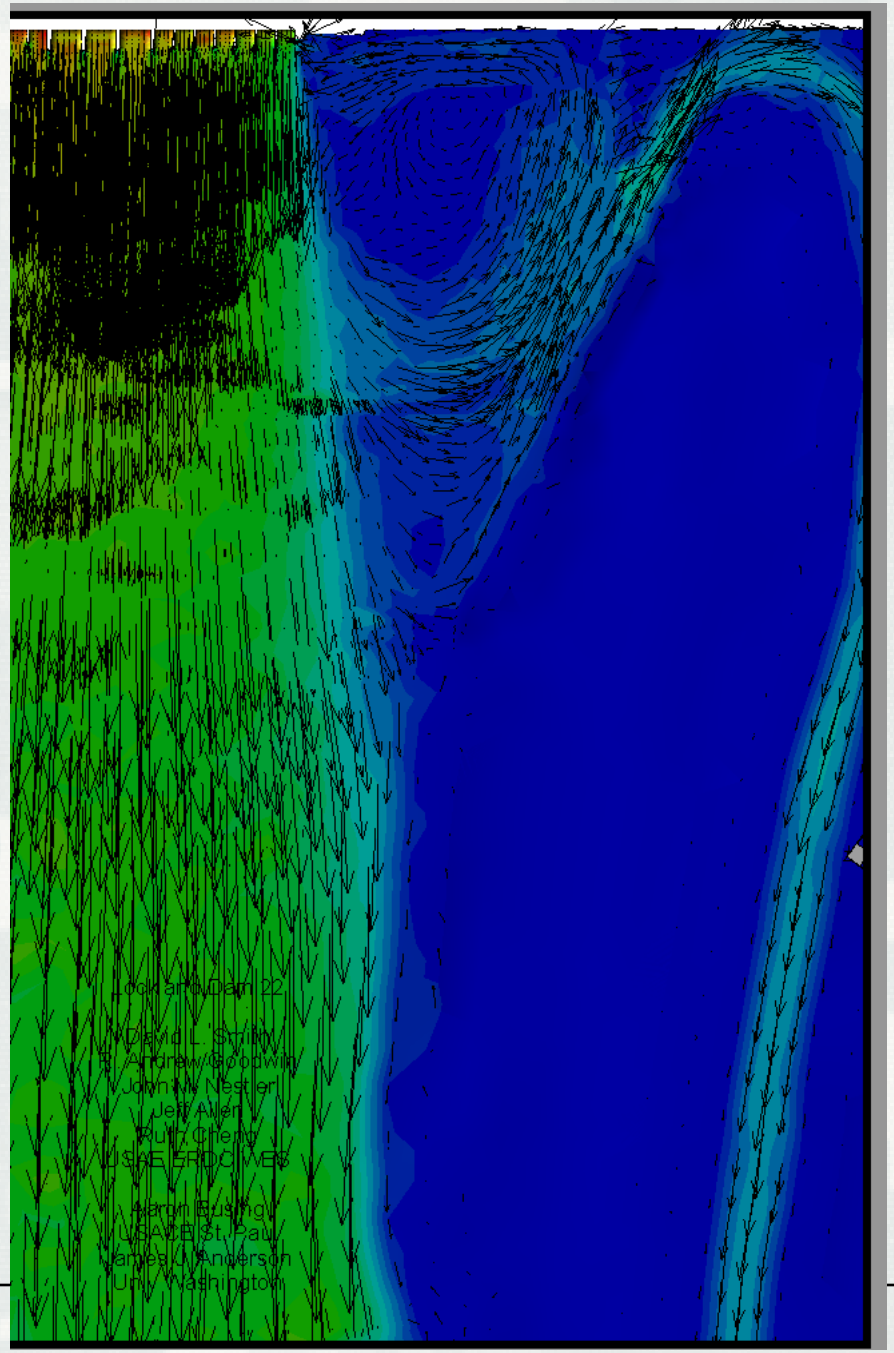
Mean = 0.749 m/s
S.D. = 0.514 m/s
Min = 0 m/s
Max = 2.542 m/s

N = 414
Mean = 0.793 m/s
S.D. = 0.363 m/s
Min = 0 m/s
Max = 1.238 m/s



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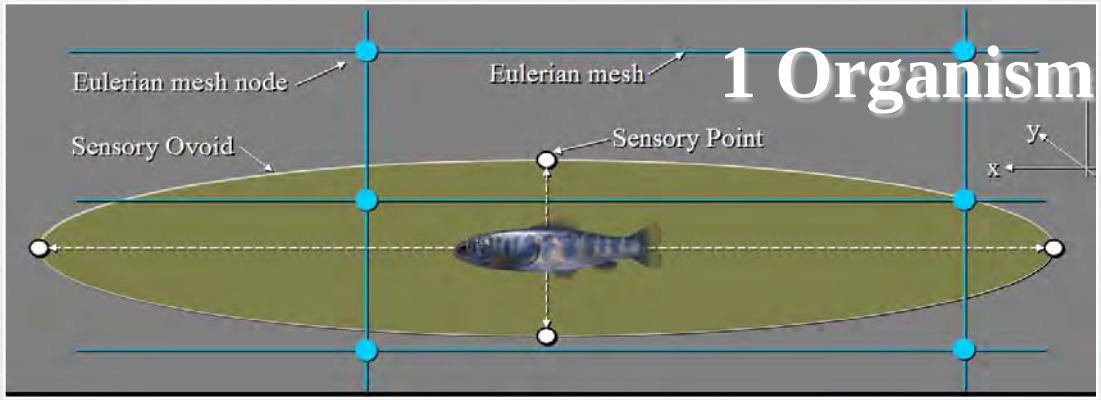
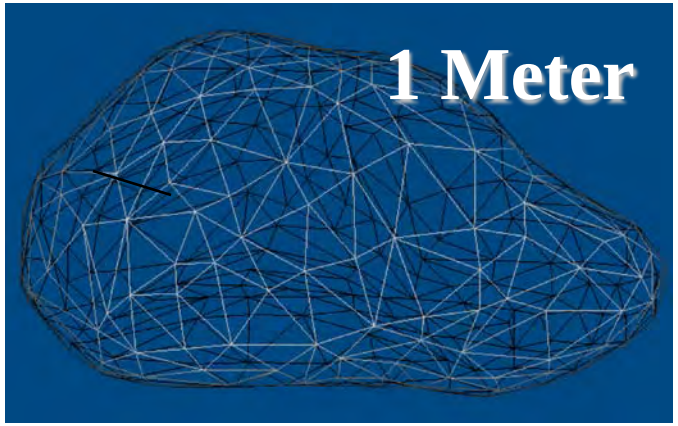
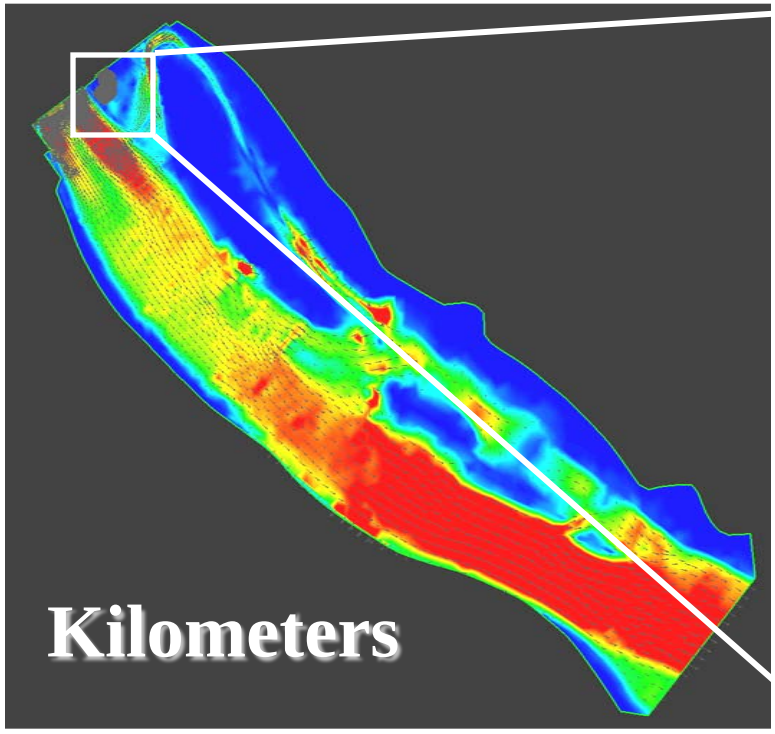
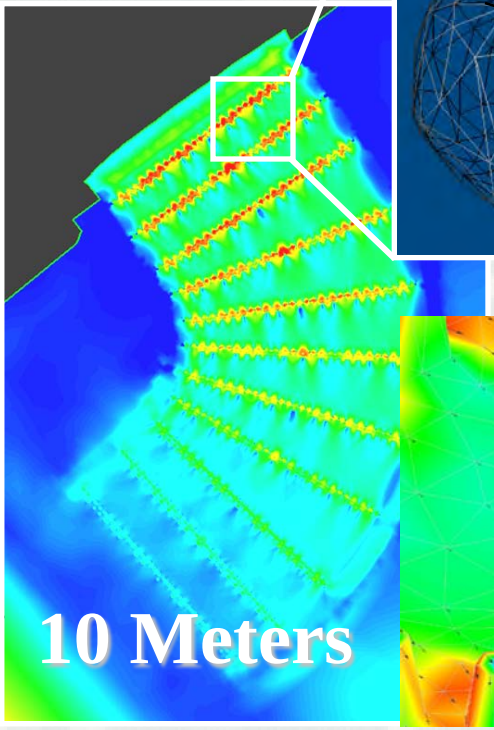
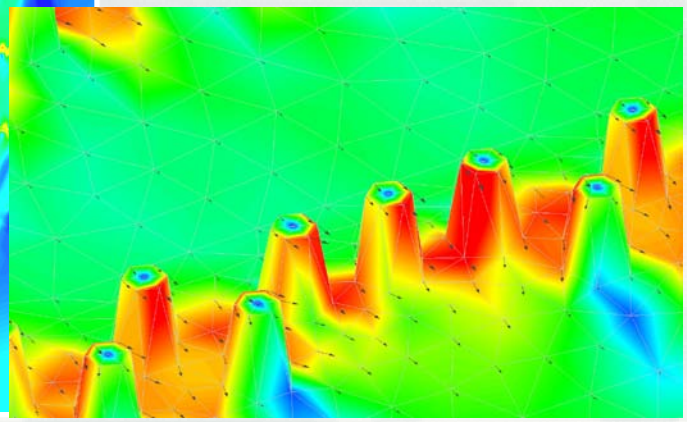

1 Organism
Eulerian mesh node
Eulerian mesh
Sensory Ovoid
Sensory Point
y
x


1 Meter


Kilometers


10 Meters