

Aligned with your needs.

Flume Erosion Test Configuration CFD Results

November 24, 2009





Objectives

- Average velocity in flume tests set to approximately 0.12 ft/s, which is the tumbling velocity for small pieces of fiberglass
- Flume TKE adjusted with presence of “turbulence inducers” with a target of approximately $3.5e-3 \text{ ft}^2/\text{s}^2$
- Flume Turbulent Kinetic Energy (TKE) levels during erosion testing are not directly measured, but can be estimated using CFD
- Plant specific analysis bounded by flume results
 - Average values of velocity and TKE are calculated for areas of non-transported debris as determined by Debris Transport Calculations
 - Weighted average applied to the velocities and TKE of non-transported debris areas



Executive Summary

- Base flume configuration inadequate for velocity and TKE objective
- Configuration 1 does not meet TKE objective
- Configuration 2 an improvement over Configuration 1
- Configuration 3 has closest TKE to objective and smallest deviation

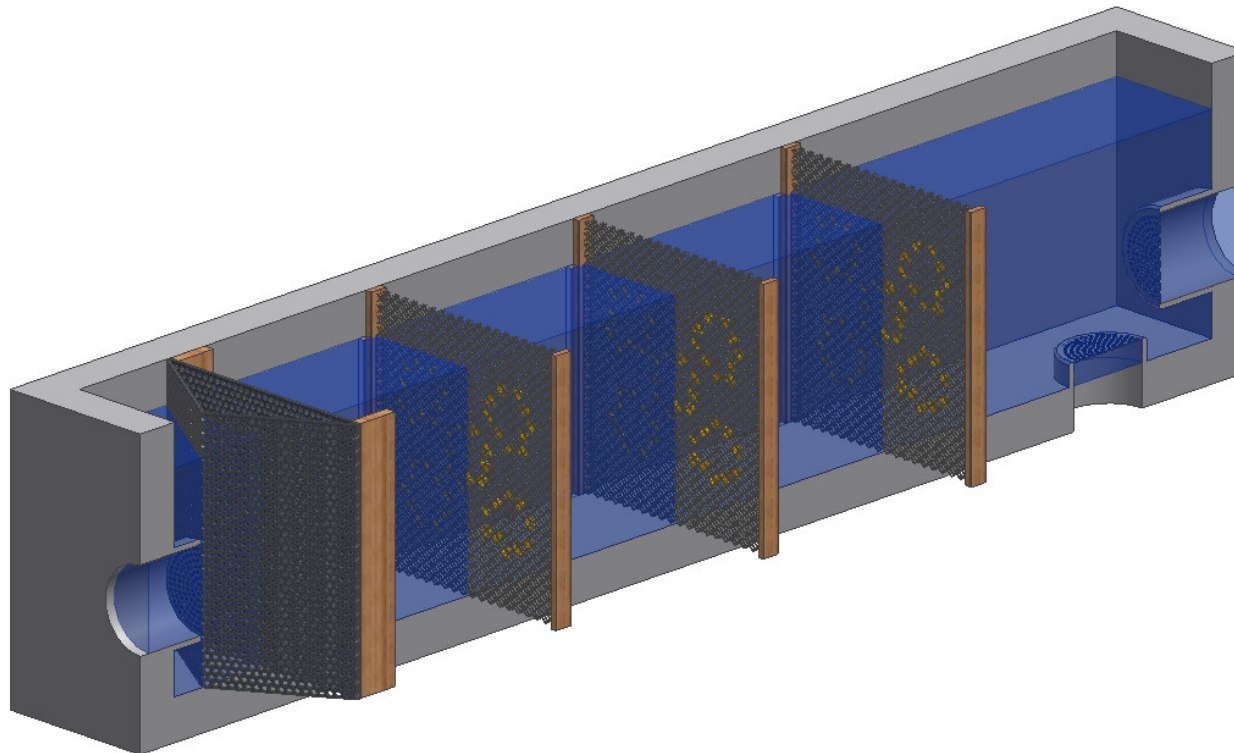
Statistics for each sample group

	Base		Config1		Config2		Config3	
	Vel	TKE	Vel	TKE	Vel	TKE	Vel	TKE
Average	0.117	3.05E-03	0.138	2.92E-03	0.143	3.36E-03	0.135	3.65E-03
StdDev	0.063	1.86E-03	0.032	2.18E-03	0.048	2.17E-03	0.029	1.74E-03



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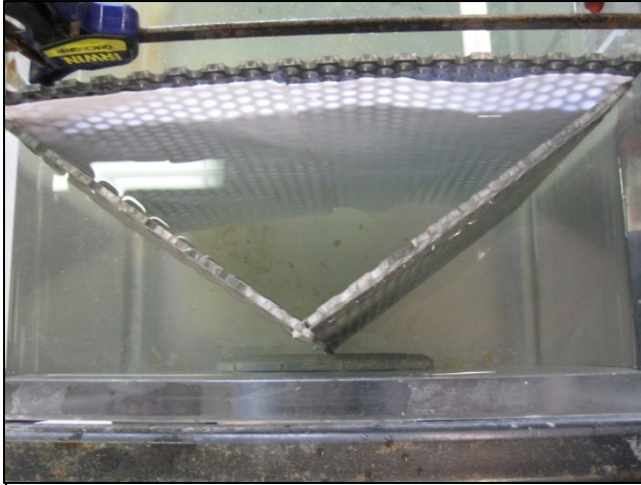
Base Flume Configuration





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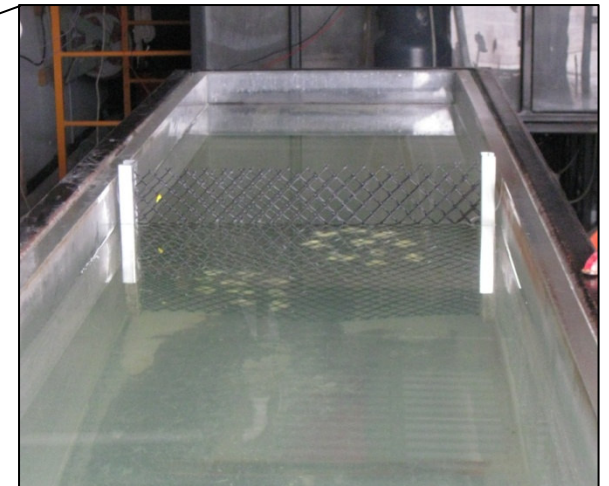
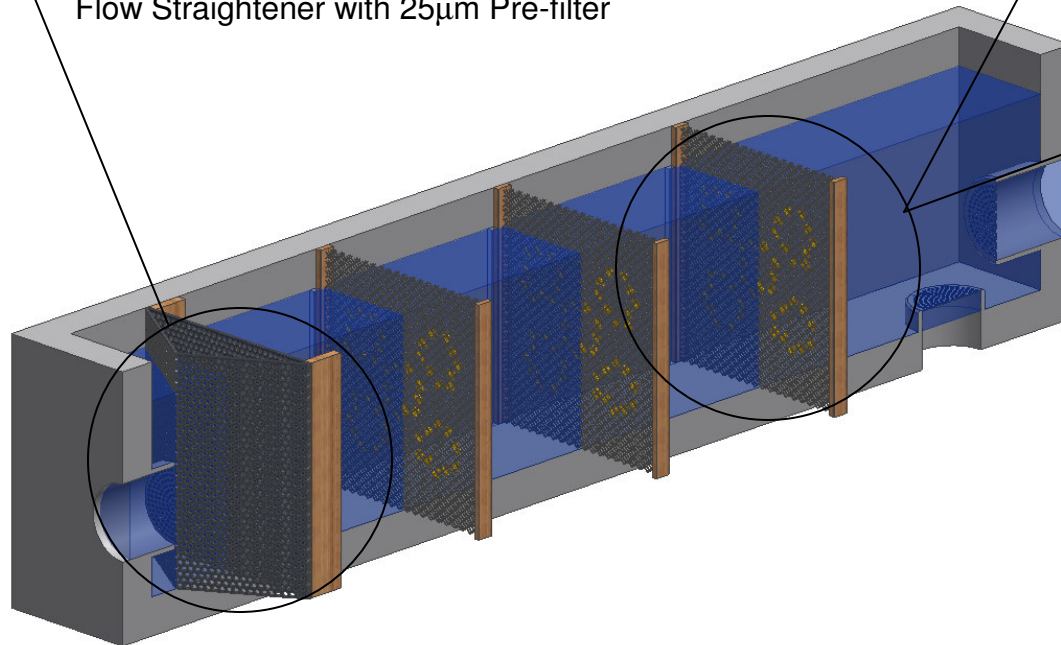
Base Test Flume Configuration



Flow Straightener with 25µm Pre-filter



Rack with Sample Groups



Rack in Test Configuration

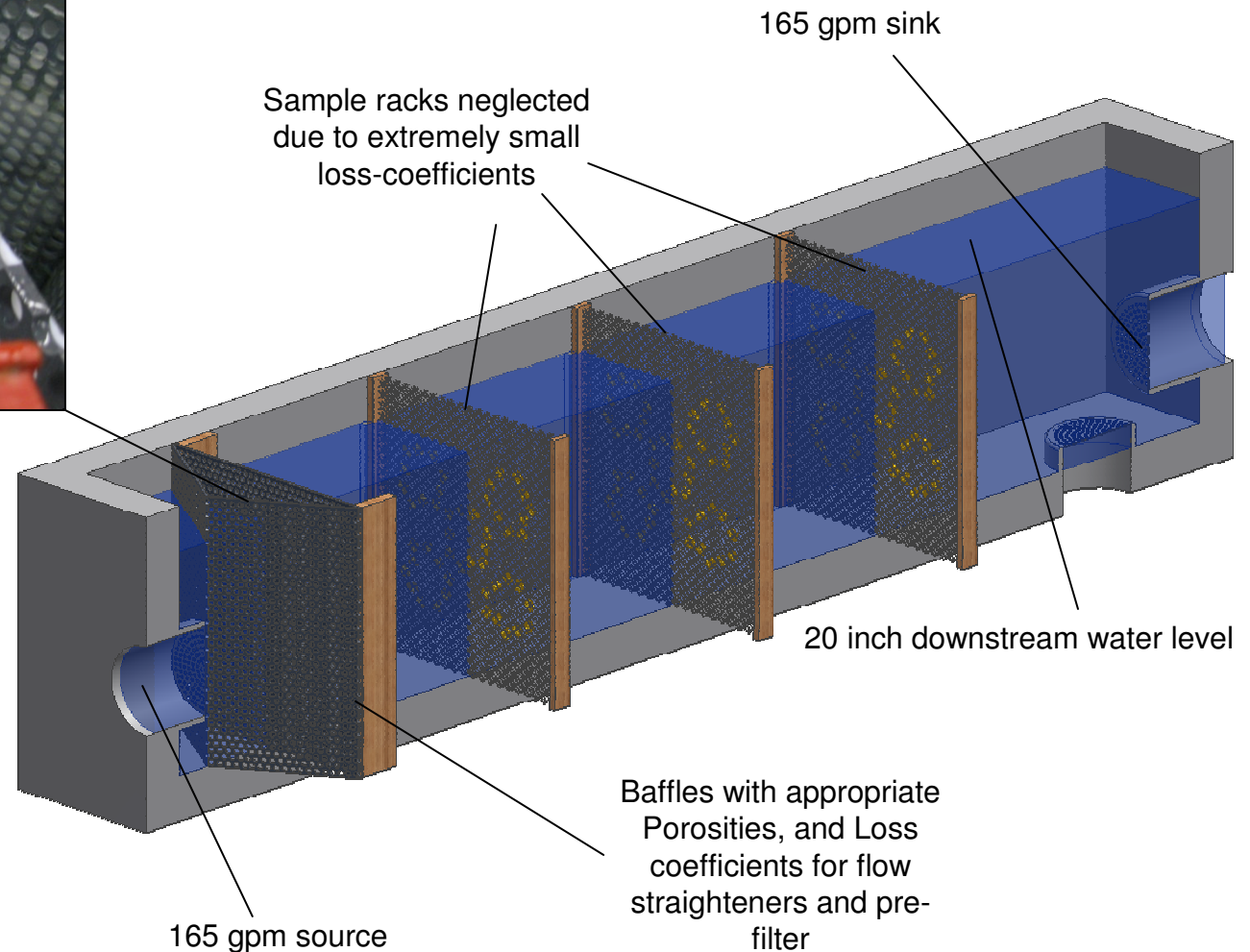


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Base CFD Model of Flume Small Fiberglass Erosion Test



Head of water expected through pre-filter

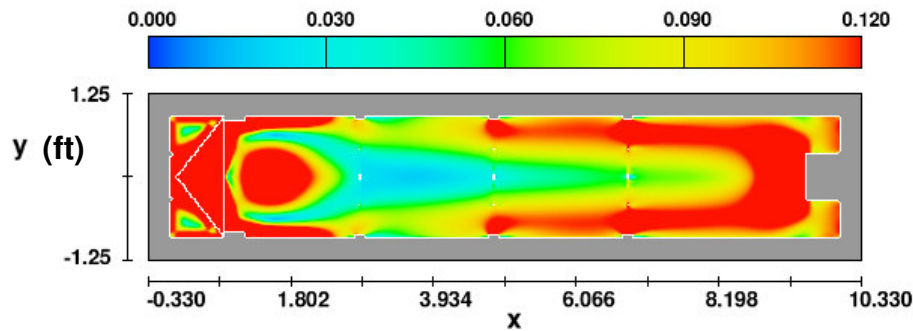




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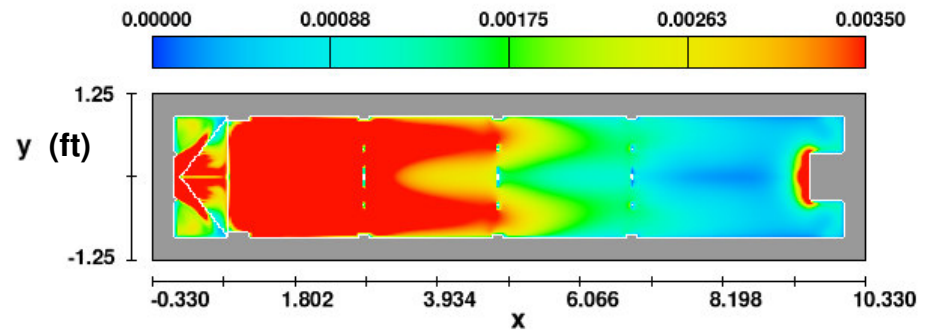
Flume Velocity and Turbulence for Base Case

Velocity Plan View
velocity magnitude contours



FLOW-3D t=214.40443 z=8.350E-01 ix=2 to 426 jy=2 to 51
09:18:12 11/05/2009 mcpb hydr3d: version 9.3.2 win32-ifi 2008
Base Case Flume Configuration

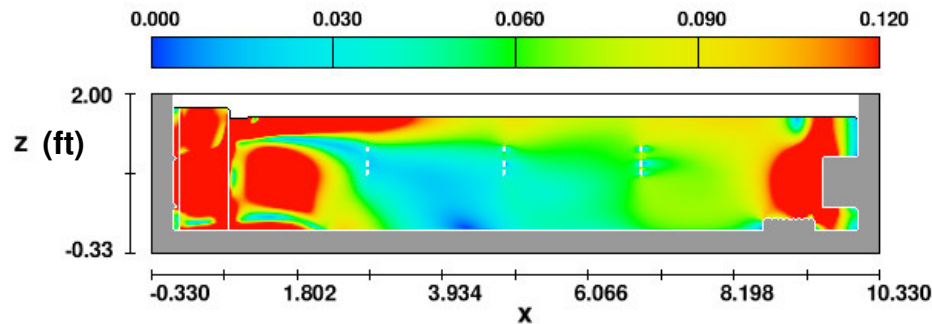
TKE Plan View
turbulent energy contours



FLOW-3D t=214.40443 z=8.350E-01 ix=2 to 426 jy=2 to 51
09:18:12 11/05/2009 mcpb hydr3d: version 9.3.2 win32-ifi 2008
Base Case Flume Configuration

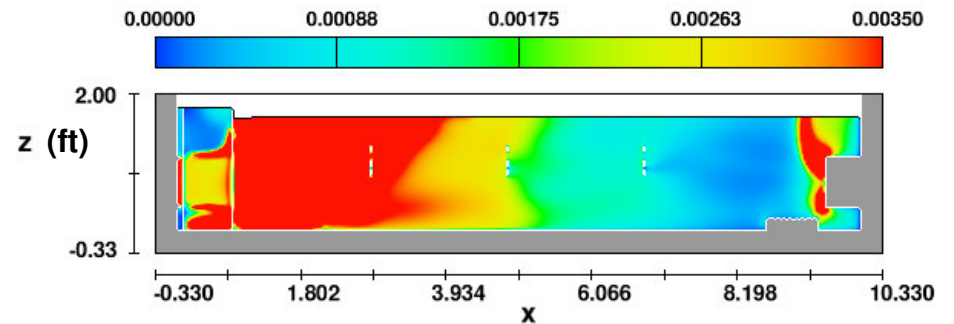
1

Velocity Section View
velocity magnitude contours



FLOW-3D t=214.40443 y=1.250E-02 ix=2 to 426 kz=2 to 94
09:18:12 11/05/2009 mcpb hydr3d: version 9.3.2 win32-ifi 2008
Base Case Flume Configuration

TKE Section View
turbulent energy contours



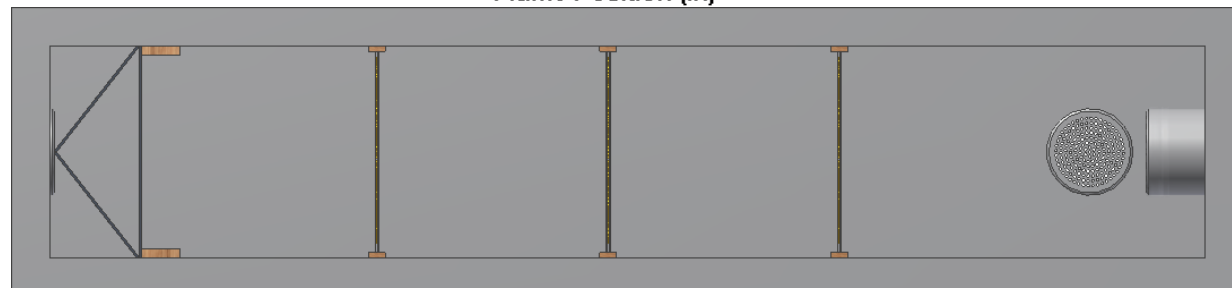
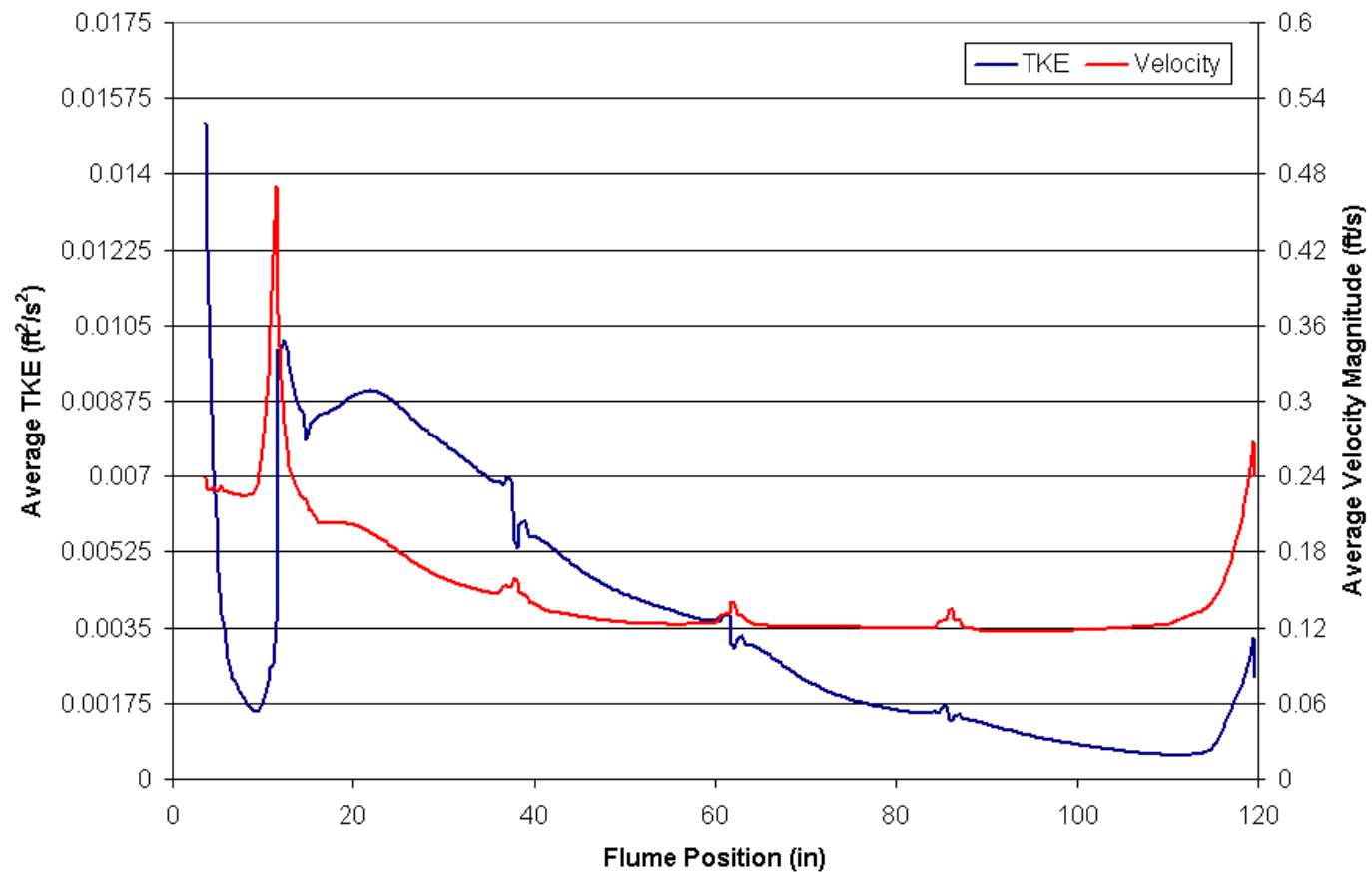
FLOW-3D t=214.40443 y=1.250E-02 ix=2 to 426 kz=2 to 94
09:18:12 11/05/2009 mcpb hydr3d: version 9.3.2 win32-ifi 2008
Base Case Flume Configuration

1



Aligned with your needs.

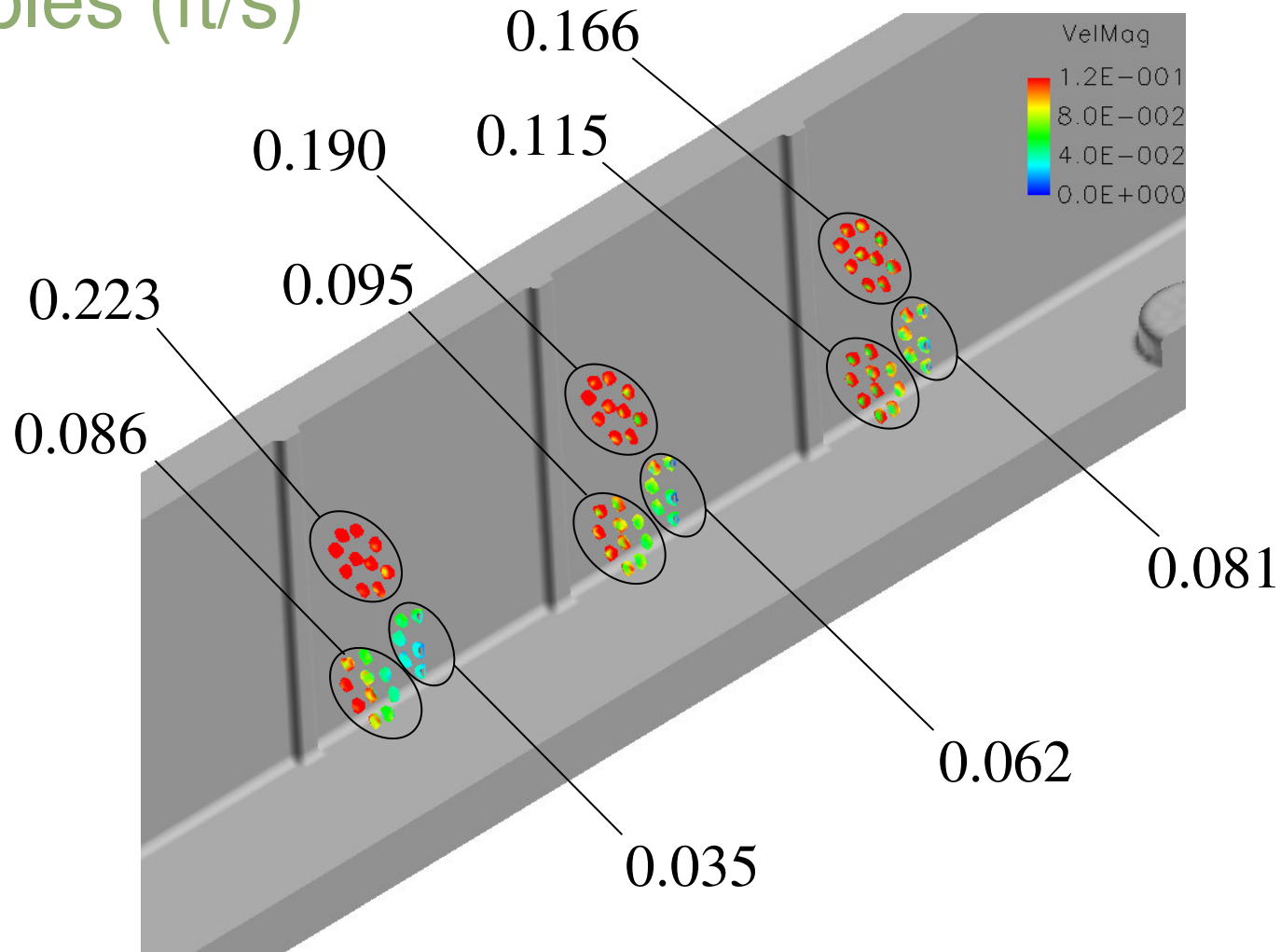
Average TKE/Velocity Across Flume Width for Base Case





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Base Case Average Velocity at Debris Samples (ft/s)

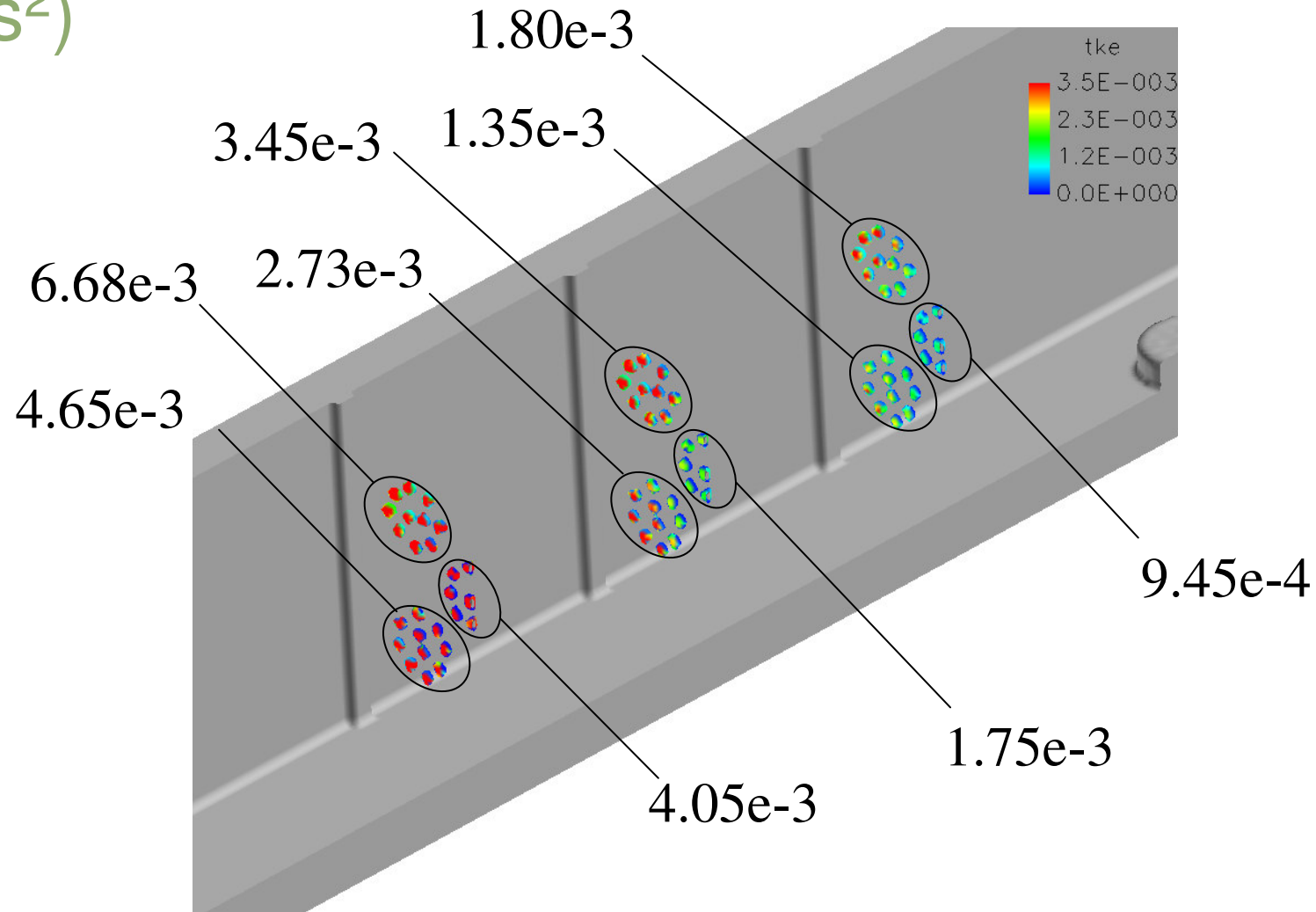


Note: The velocity values shown were determined for each sample group by taking the average velocity magnitude in a rectangular plane circumscribing each sample group.



Aligned with your needs.

Base Case Average TKE at Debris Samples (ft²/s²)

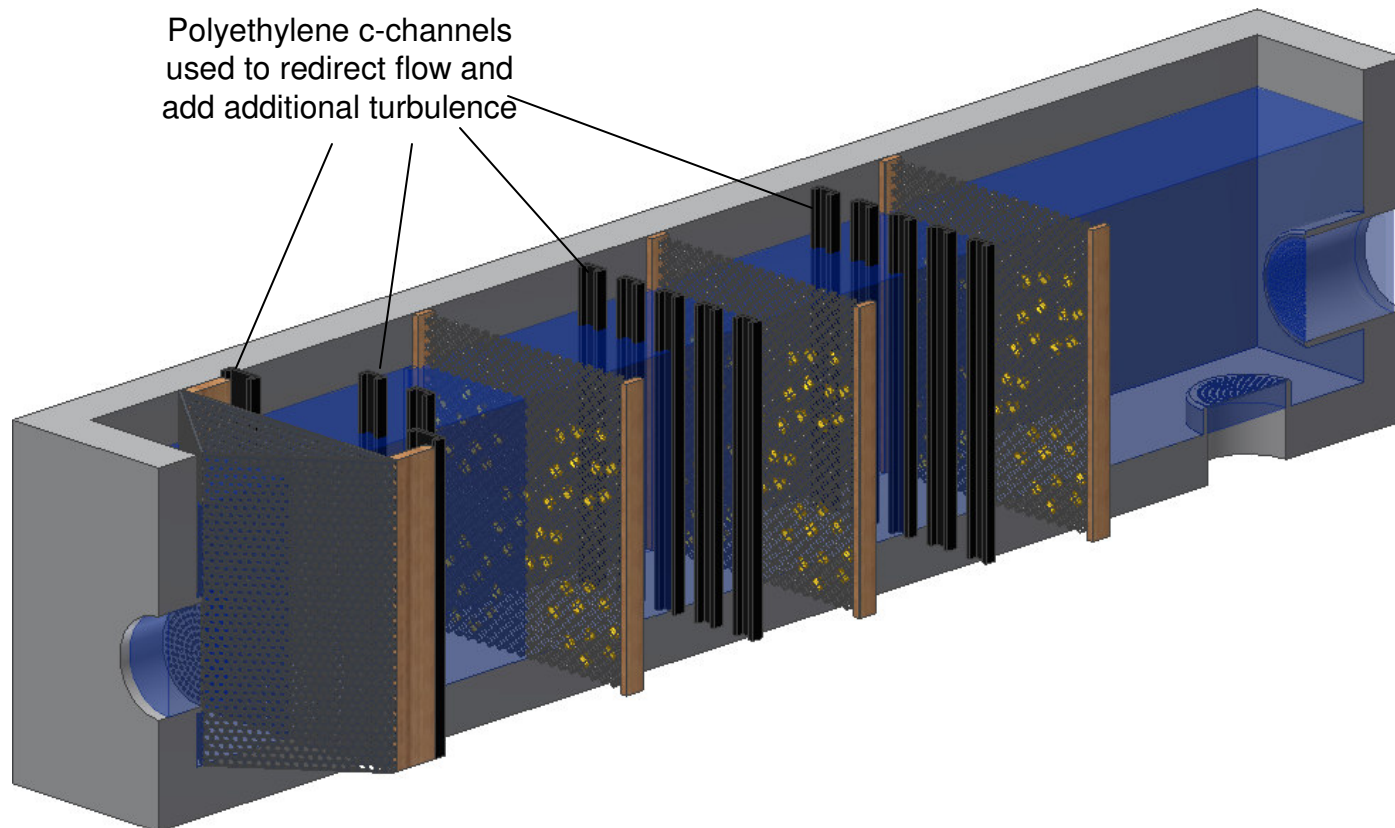


Note: The TKE values shown were determined for each sample group by taking the average turbulent energy in a rectangular plane circumscribing each sample group.



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Flume with Turbulence Inducers (C-Channels) Configuration 1



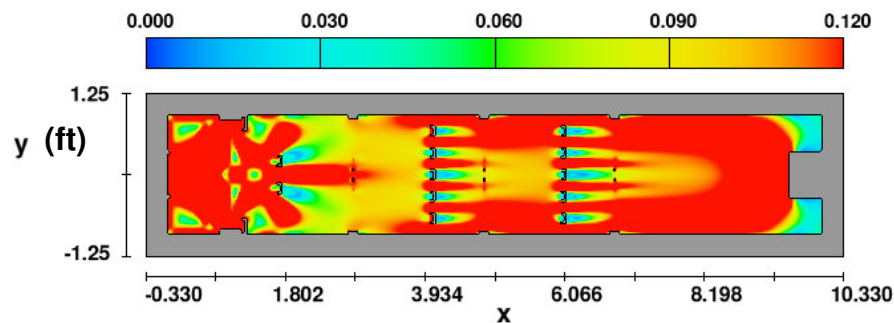


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Flume Velocity and Turbulence for Configuration 1

Velocity Plan View

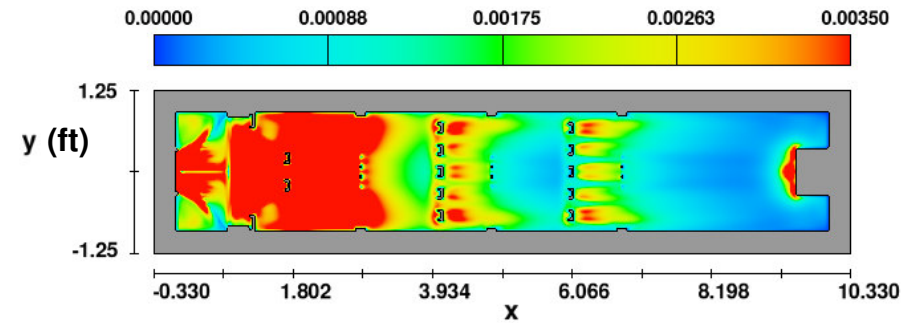
velocity magnitude contours



FLOW-3D t=424.31207 z=8.350E-01 ix=2 to 426 jy=2 to 51
15:49:10 11/12/2009 onmc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 6

TKE Plan View

turbulent energy contours



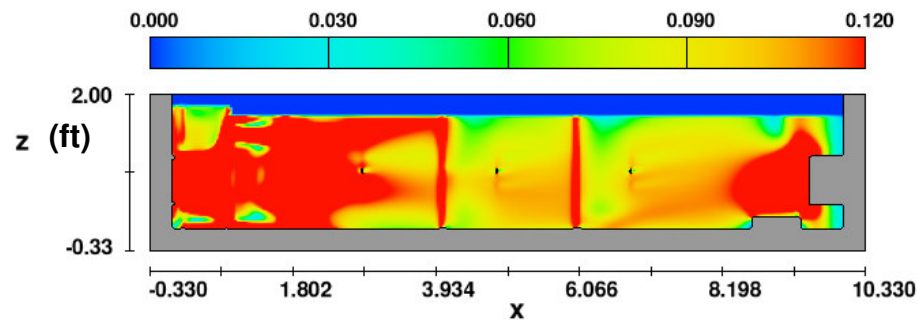
FLOW-3D t=424.31207 z=8.350E-01 ix=2 to 426 jy=2 to 51
15:49:10 11/12/2009 onmc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 6

1

1

Velocity Section View

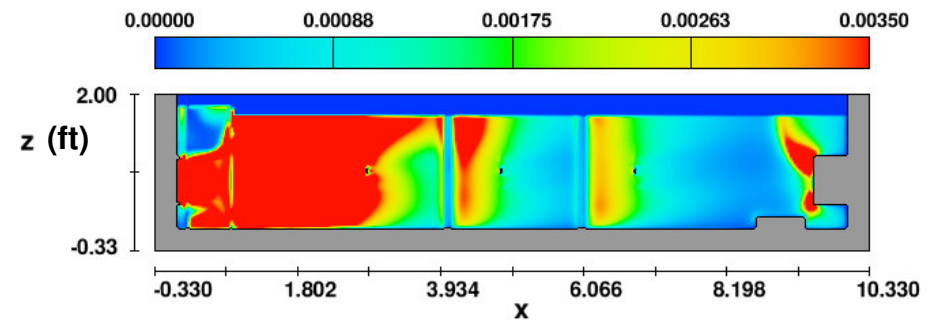
velocity magnitude contours



FLOW-3D t=424.31207 y=8.750E-02 ix=2 to 426 kz=2 to 94
15:49:10 11/12/2009 onmc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 6

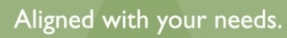
TKE Section View

turbulent energy contours

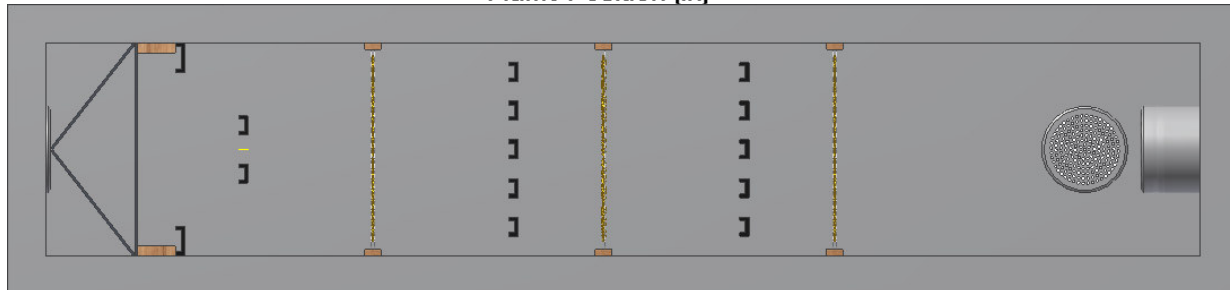
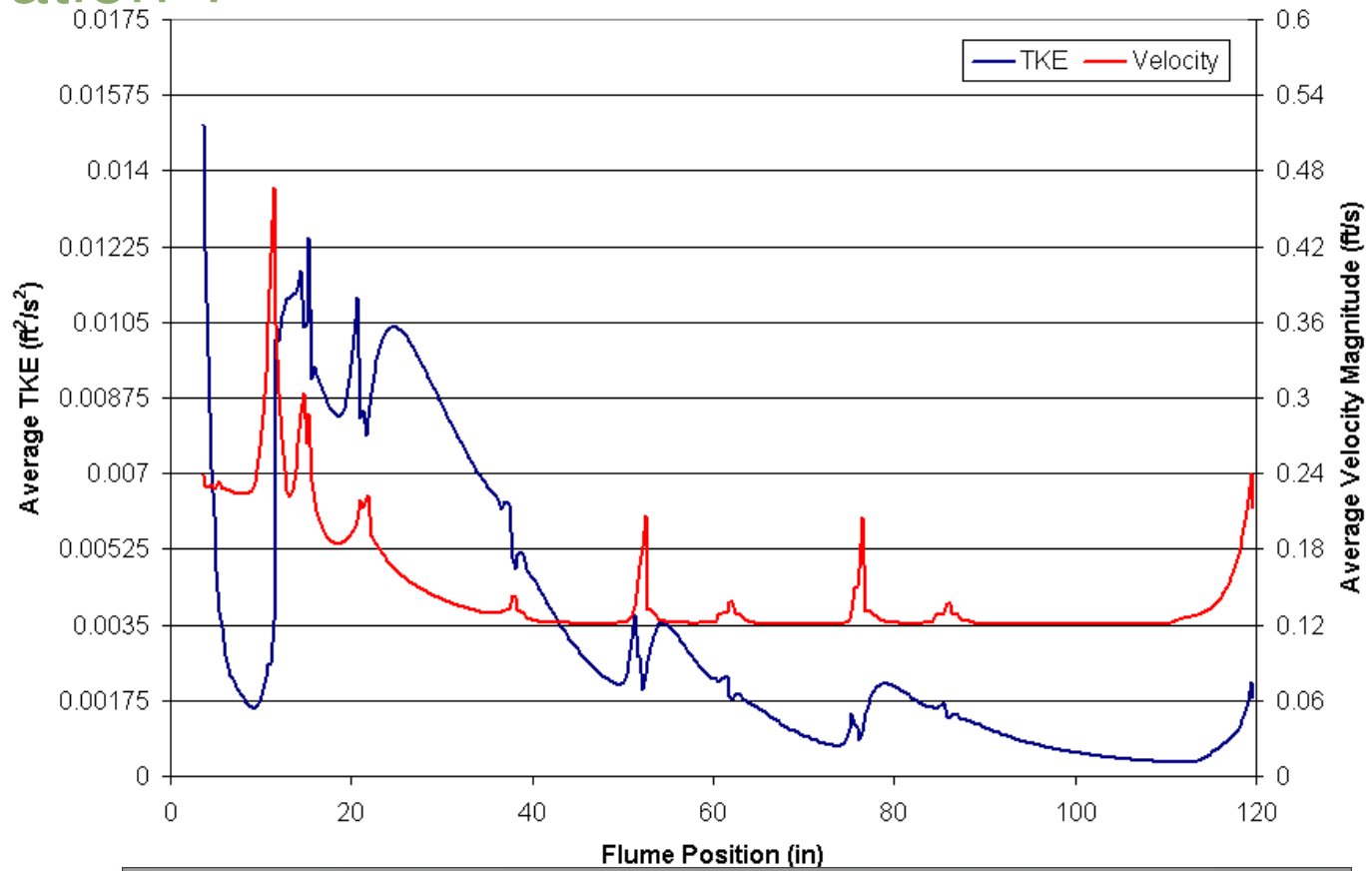


FLOW-3D t=424.31207 y=8.750E-02 ix=2 to 426 kz=2 to 94
15:49:10 11/12/2009 onmc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 6

4



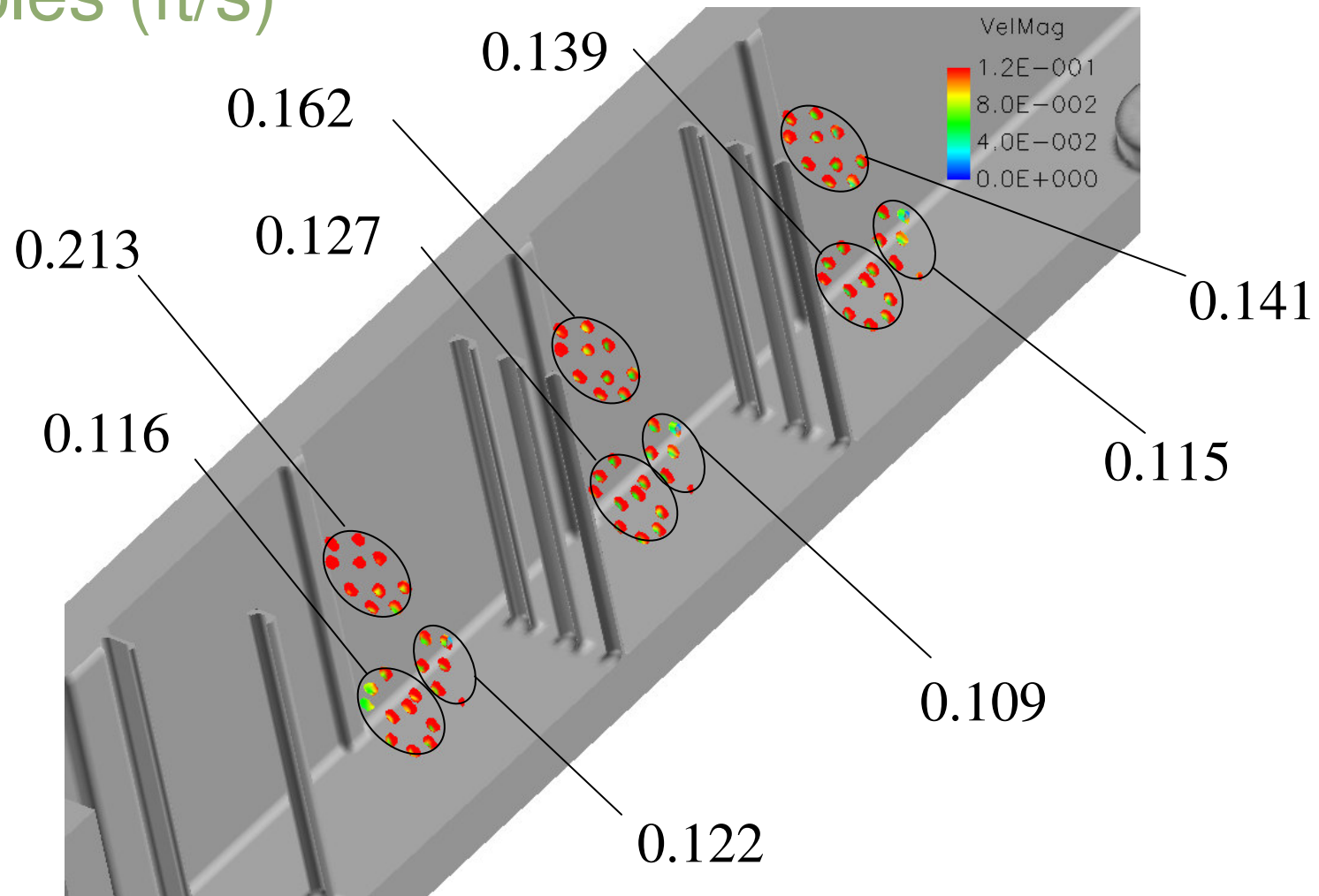
Average TKE/Velocity Across Flume Width for Configuration 1





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Configuration 1 Average Velocity at Debris Samples (ft/s)

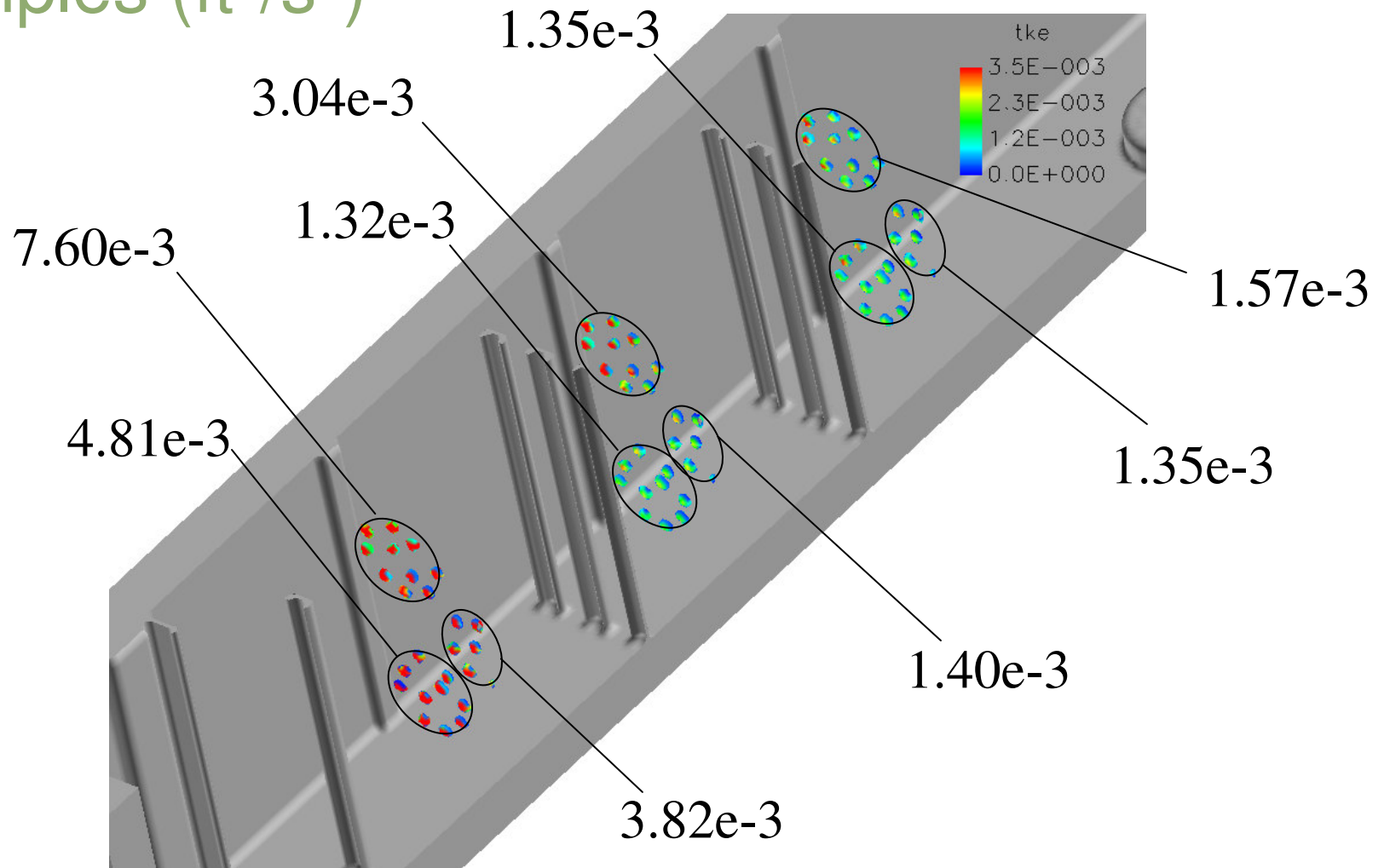


Note: The velocity values shown were determined for each sample group by taking the average velocity magnitude in a rectangular plane circumscribing each sample group.



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Configuration 1 Average TKE at Debris Samples (ft²/s²)

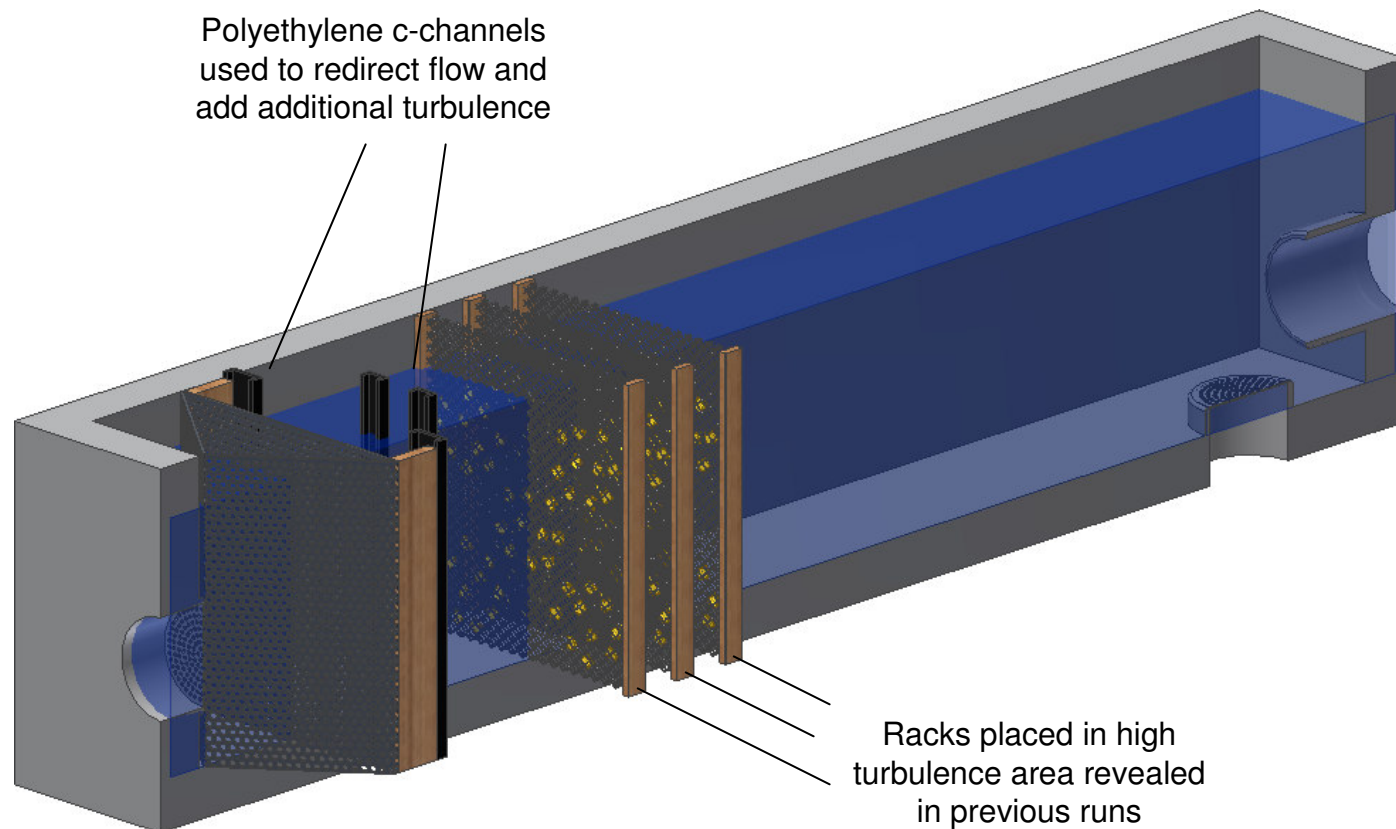


Note: The TKE values shown were determined for each sample group by taking the average turbulent energy in a rectangular plane circumscribing each sample group.



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Flume with Turbulence Inducers (C-Channels) Configuration 2



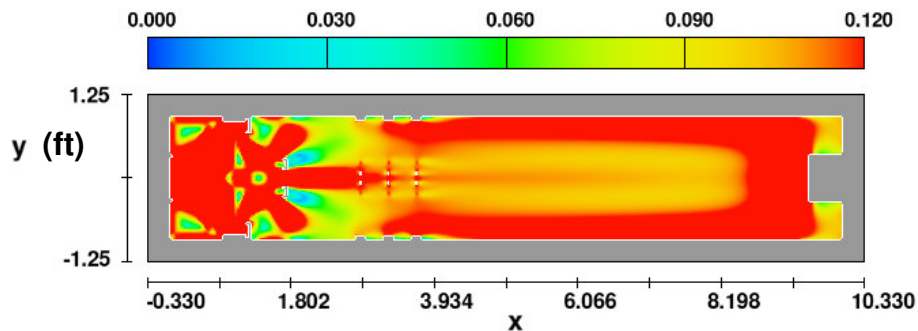


Aligned with your needs.

Configuration 2 Flume Velocity and Turbulence

Velocity Plan View

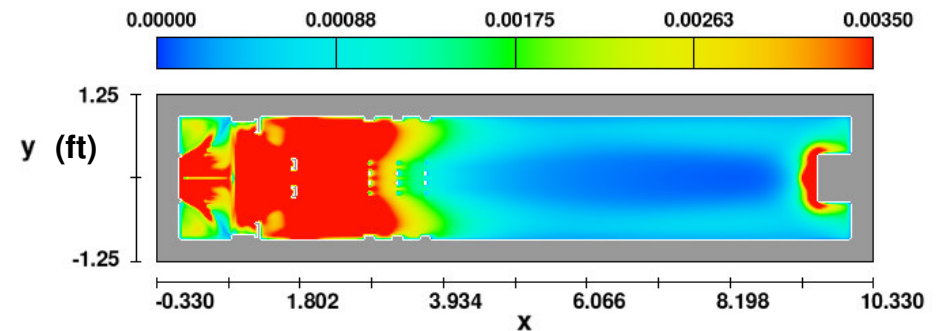
velocity magnitude contours



FLOW-3D t=120.87911 z=8.350E-01 ix=2 to 426 jy=2 to 51
14:22:31 11/16/2009 ykc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 7

TKE Plan View

turbulent energy contours

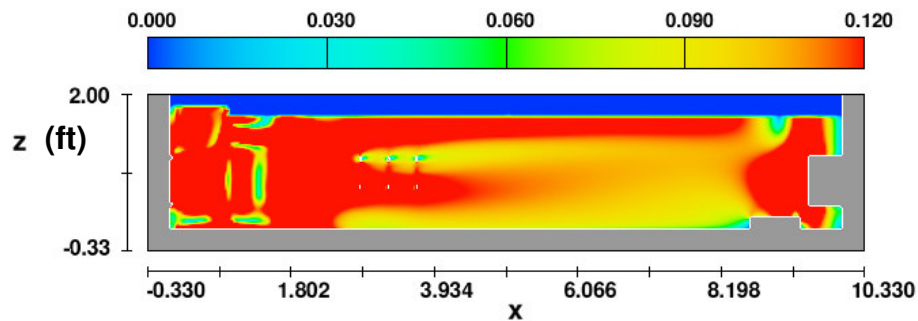


FLOW-3D t=120.87911 z=8.350E-01 ix=2 to 426 jy=2 to 51
14:22:31 11/16/2009 ykc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 7

1

Velocity Section View

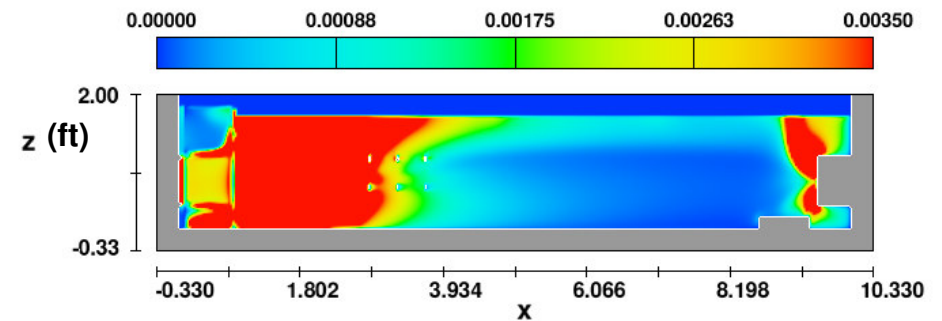
velocity magnitude contours



FLOW-3D t=120.87911 y=1.250E-02 ix=2 to 426 kz=2 to 94
14:22:31 11/16/2009 ykc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 7

TKE Section View

turbulent energy contours



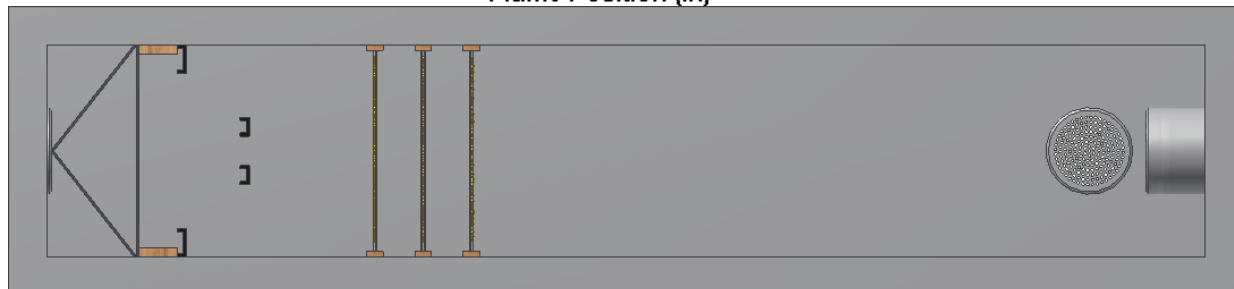
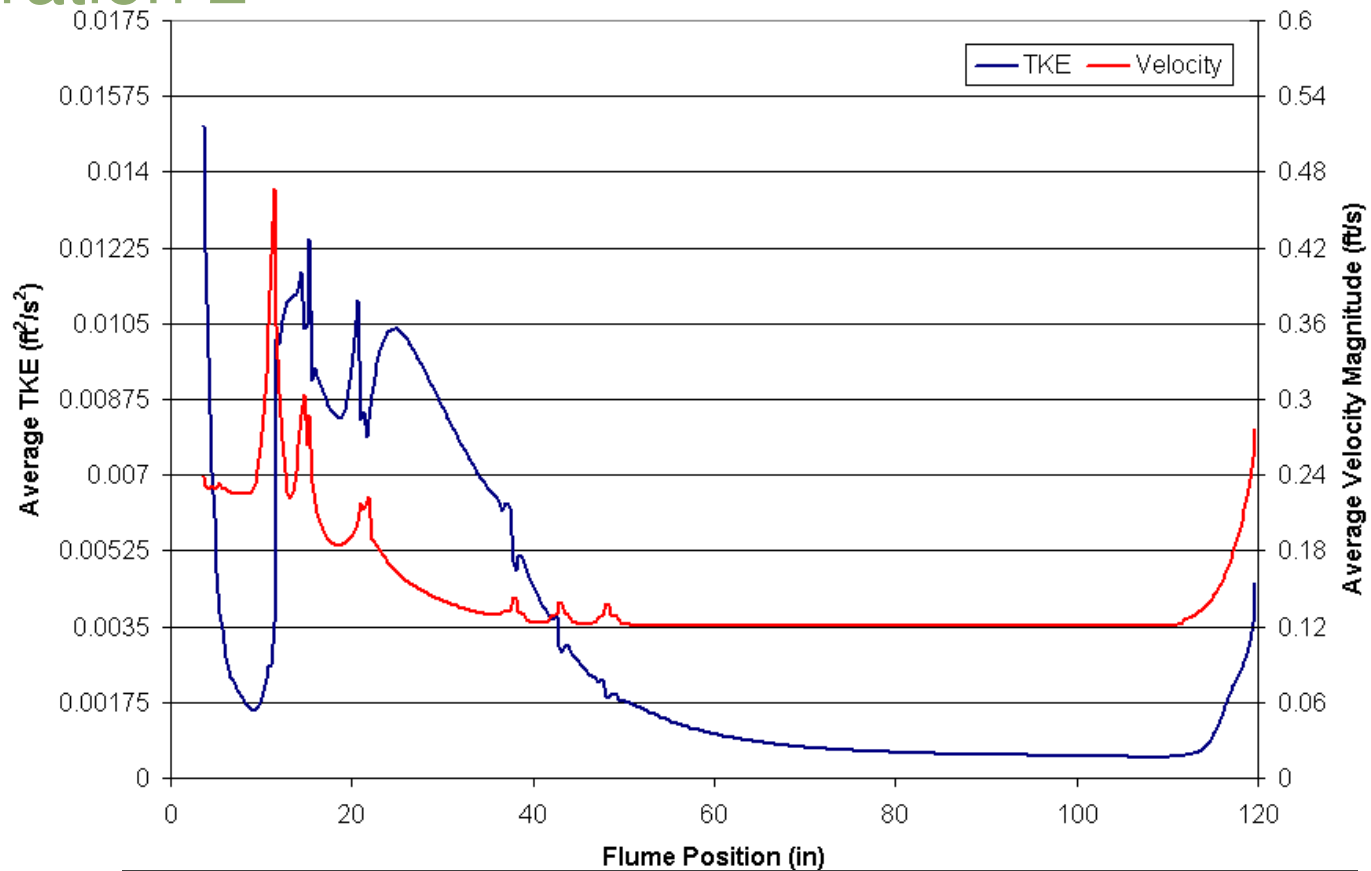
FLOW-3D t=120.87911 y=1.250E-02 ix=2 to 426 kz=2 to 94
14:22:31 11/16/2009 ykc hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 7

1



Aligned with your needs.

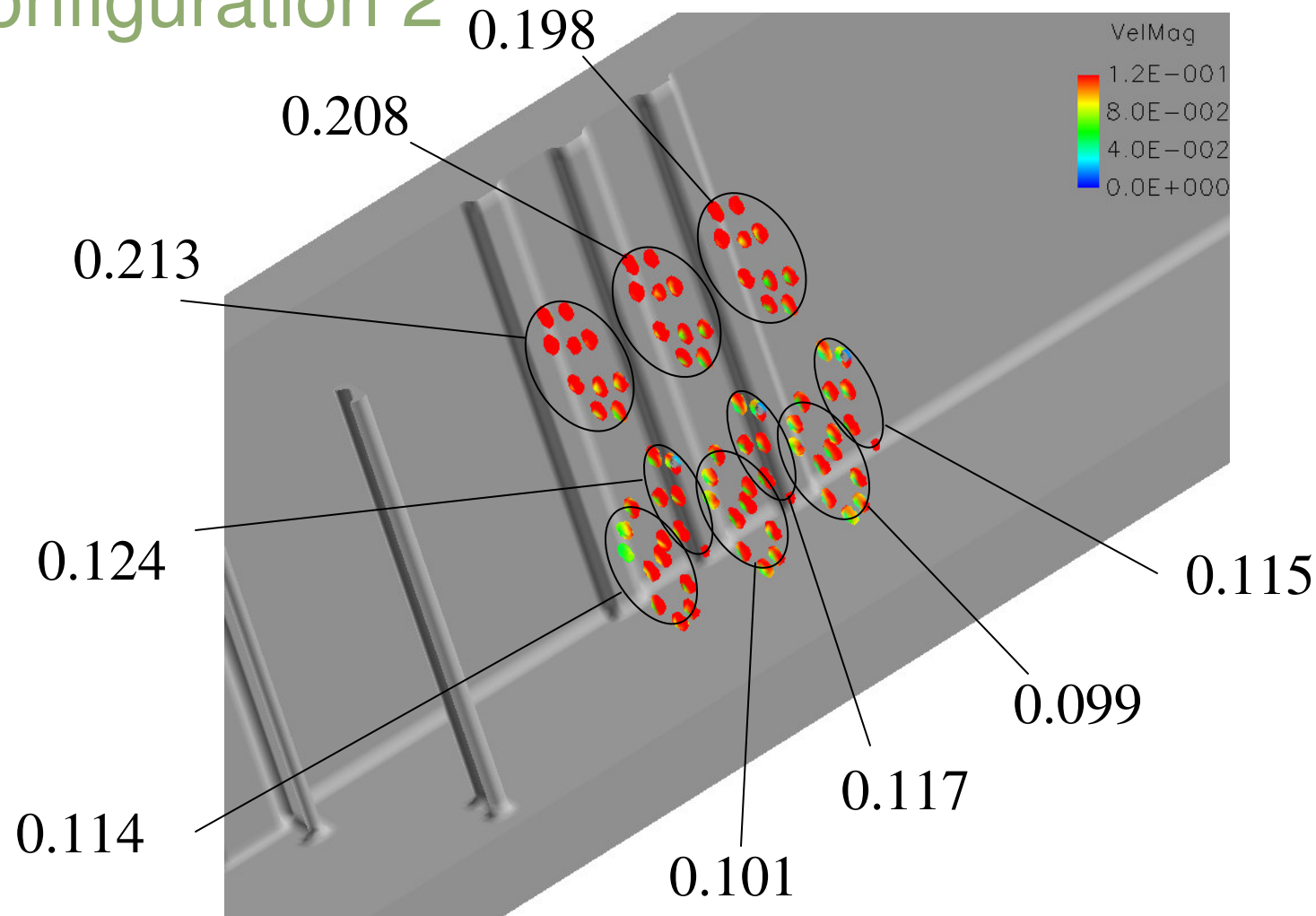
Average TKE/Velocity Across Flume Width for Configuration 2





Aligned with your needs.

Average Velocity at Debris Samples (ft/s) for Configuration 2

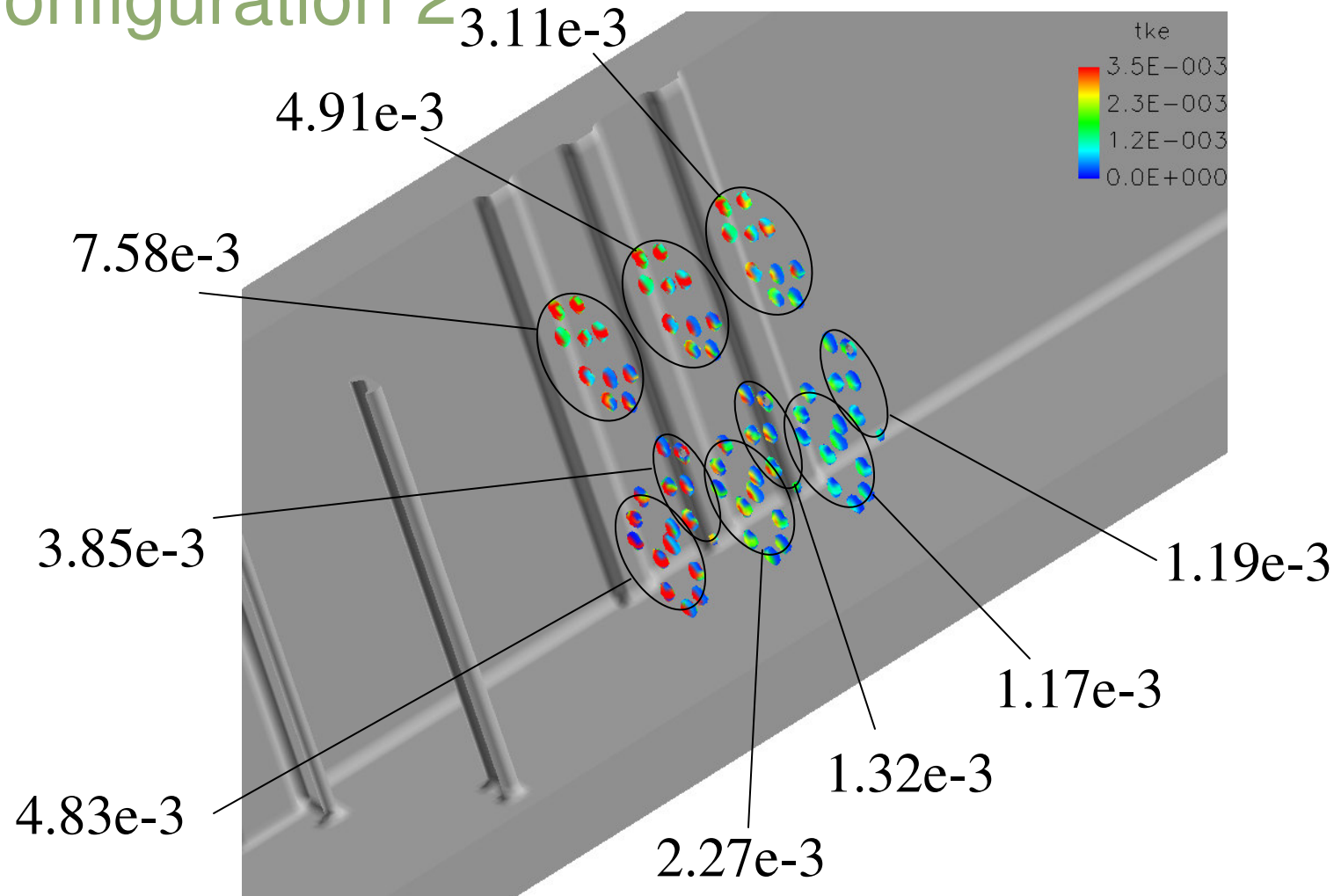


Note: The velocity values shown were determined for each sample group by taking the average velocity magnitude in a rectangular plane circumscribing each sample group.



Aligned with your needs.

Average TKE at Debris Samples (ft²/s²) for Configuration 2

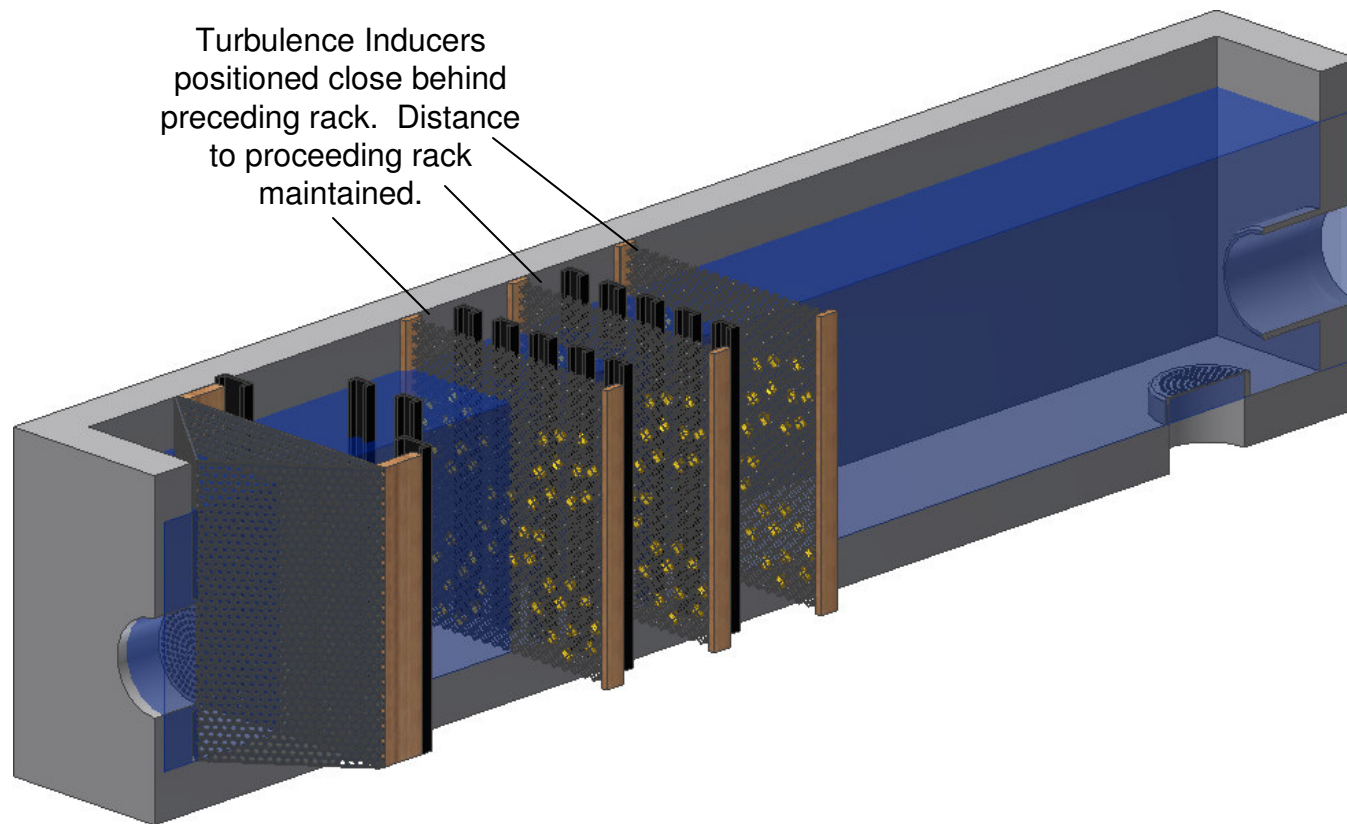


Note: The TKE values shown were determined for each sample group by taking the average turbulent energy in a rectangular plane circumscribing each sample group.



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Flume with Turbulence Inducers (C-Channels) Configuration 3

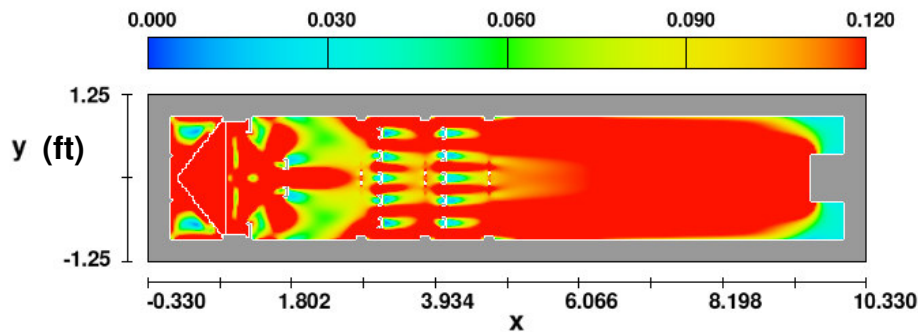




Aligned with your needs.

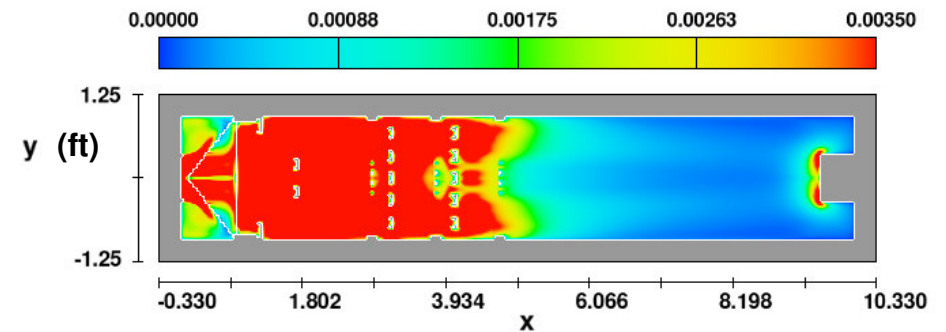
Configuration 3 Flume Velocity and Turbulence

Velocity Plan View
velocity magnitude contours



FLOW-3D t=150.00235 z=8.350E-01 ix=2 to 426 jy=2 to 51
15:05:28 11/20/2009 apli hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 9

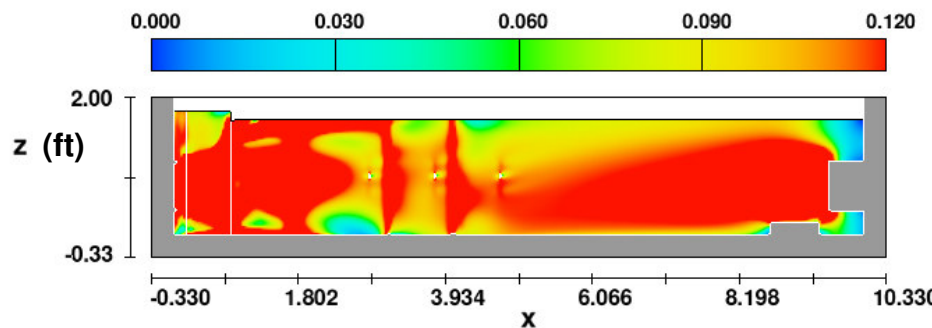
TKE Plan View
turbulent energy contours



FLOW-3D t=150.00235 z=8.350E-01 ix=2 to 426 jy=2 to 51
15:05:28 11/20/2009 apli hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 9

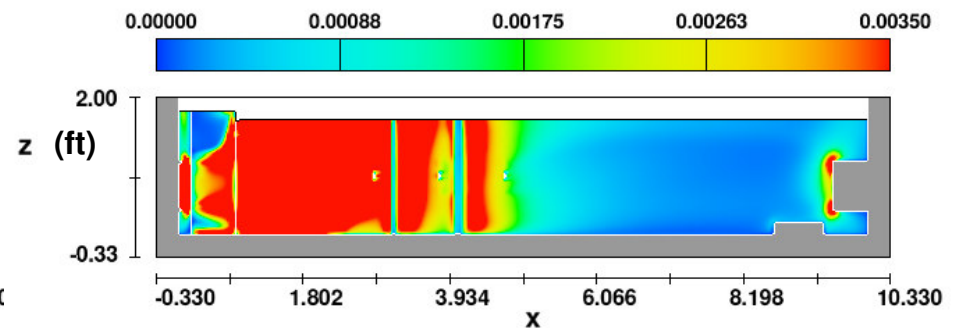
1

Velocity Section View
velocity magnitude contours



FLOW-3D t=150.00235 y=8.750E-02 ix=2 to 426 kz=2 to 94
15:05:28 11/20/2009 apli hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 9

TKE Section View
turbulent energy contours



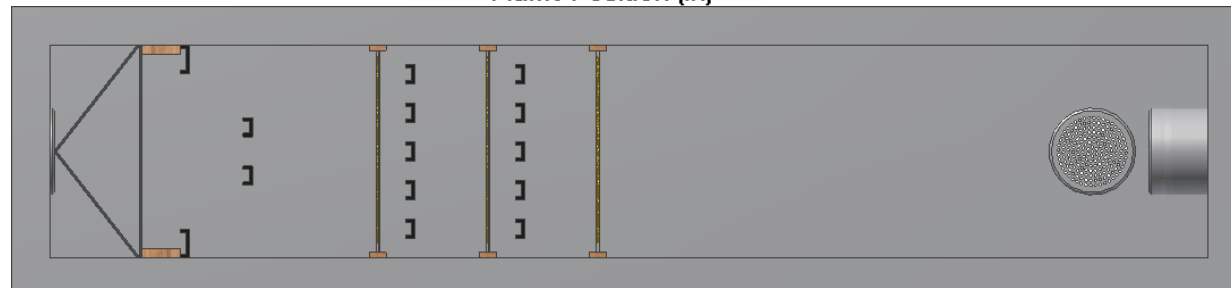
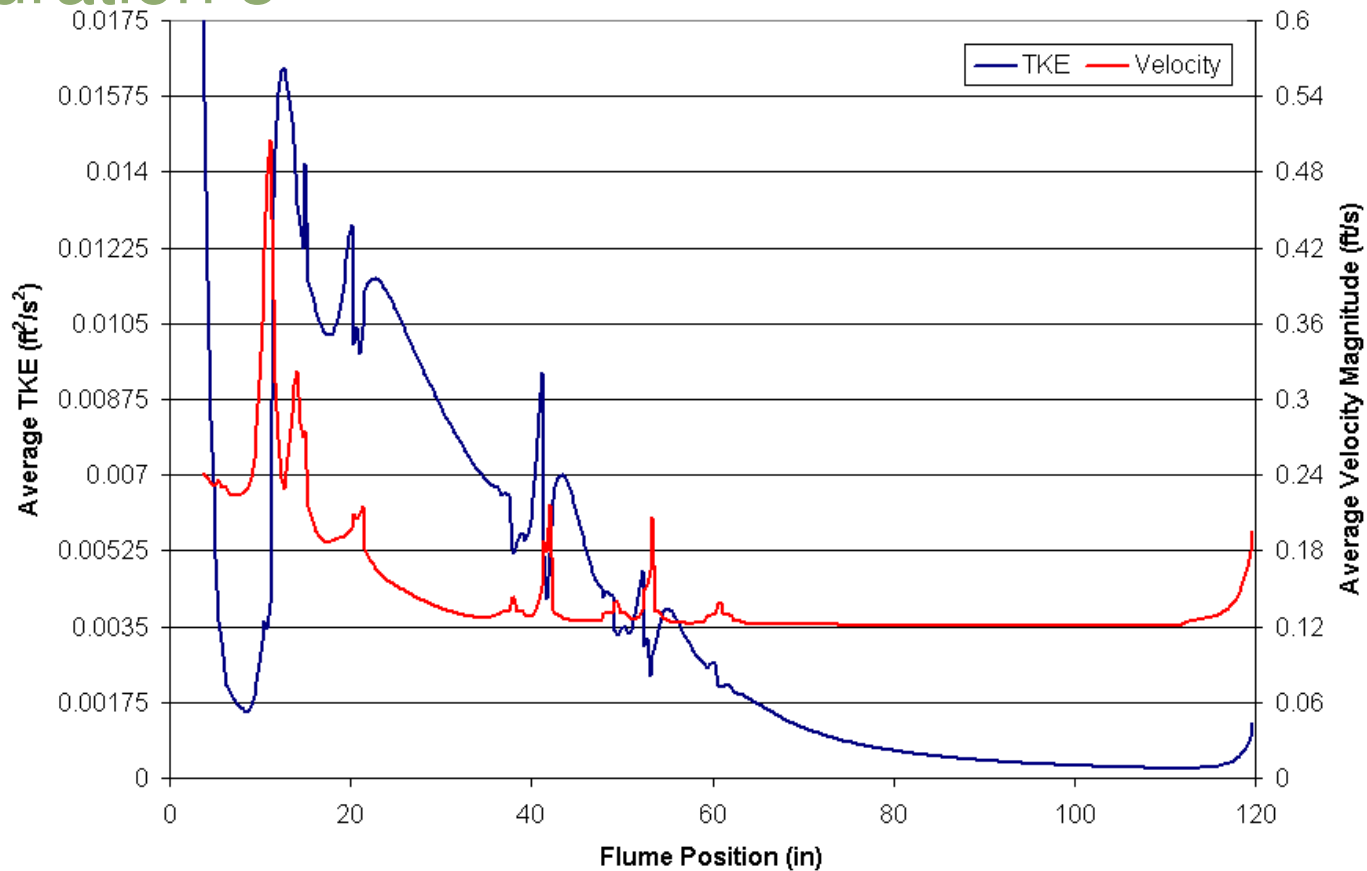
FLOW-3D t=150.00235 y=8.750E-02 ix=2 to 426 kz=2 to 94
15:05:28 11/20/2009 apli hydr3d: version 9.3.1 win64 2008
Flume with C-Channels 9

4



Aligned with your needs.

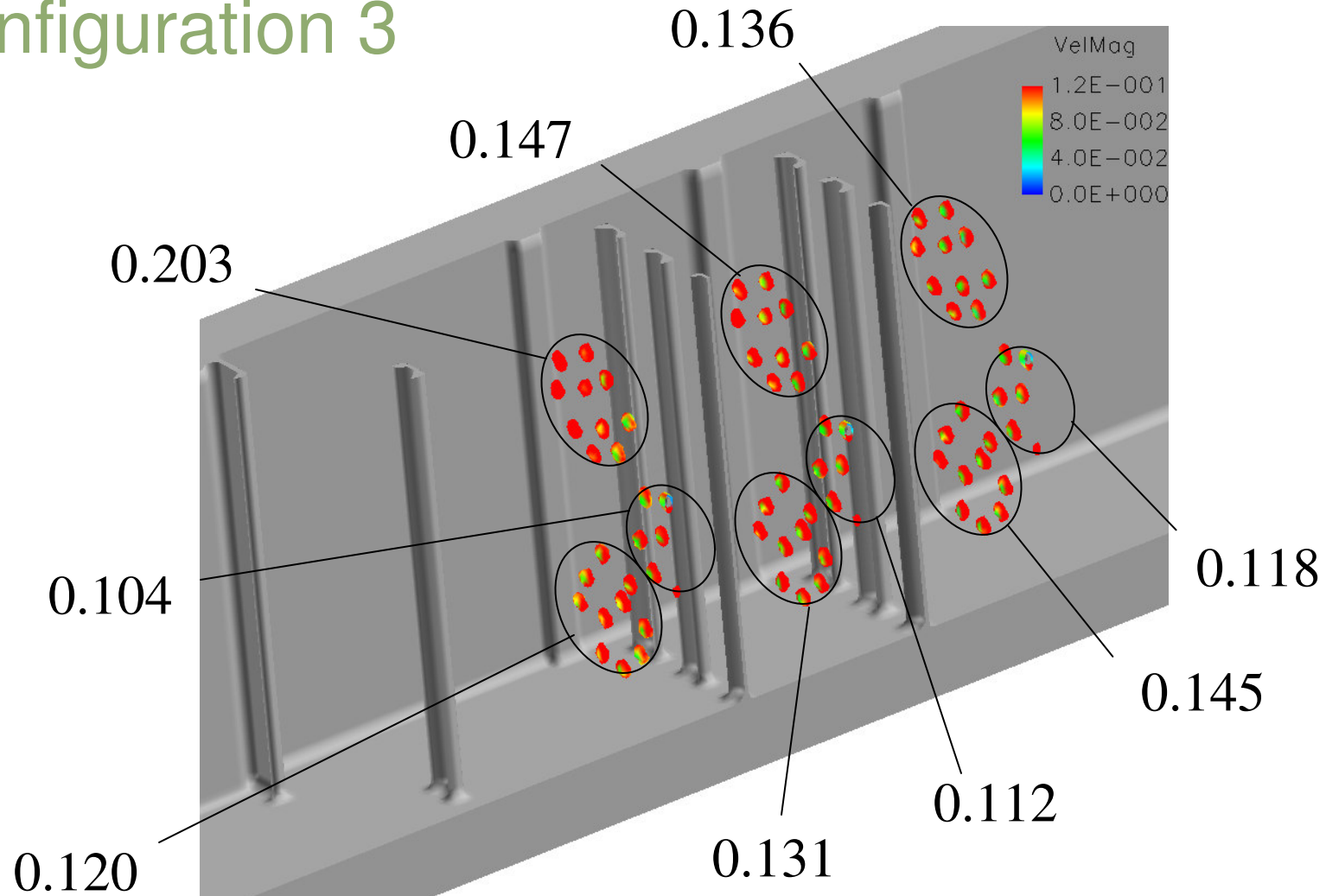
Average TKE/Velocity Across Flume Width for Configuration 3





Aligned with your needs.

Average Velocity at Debris Samples (ft/s) for Configuration 3

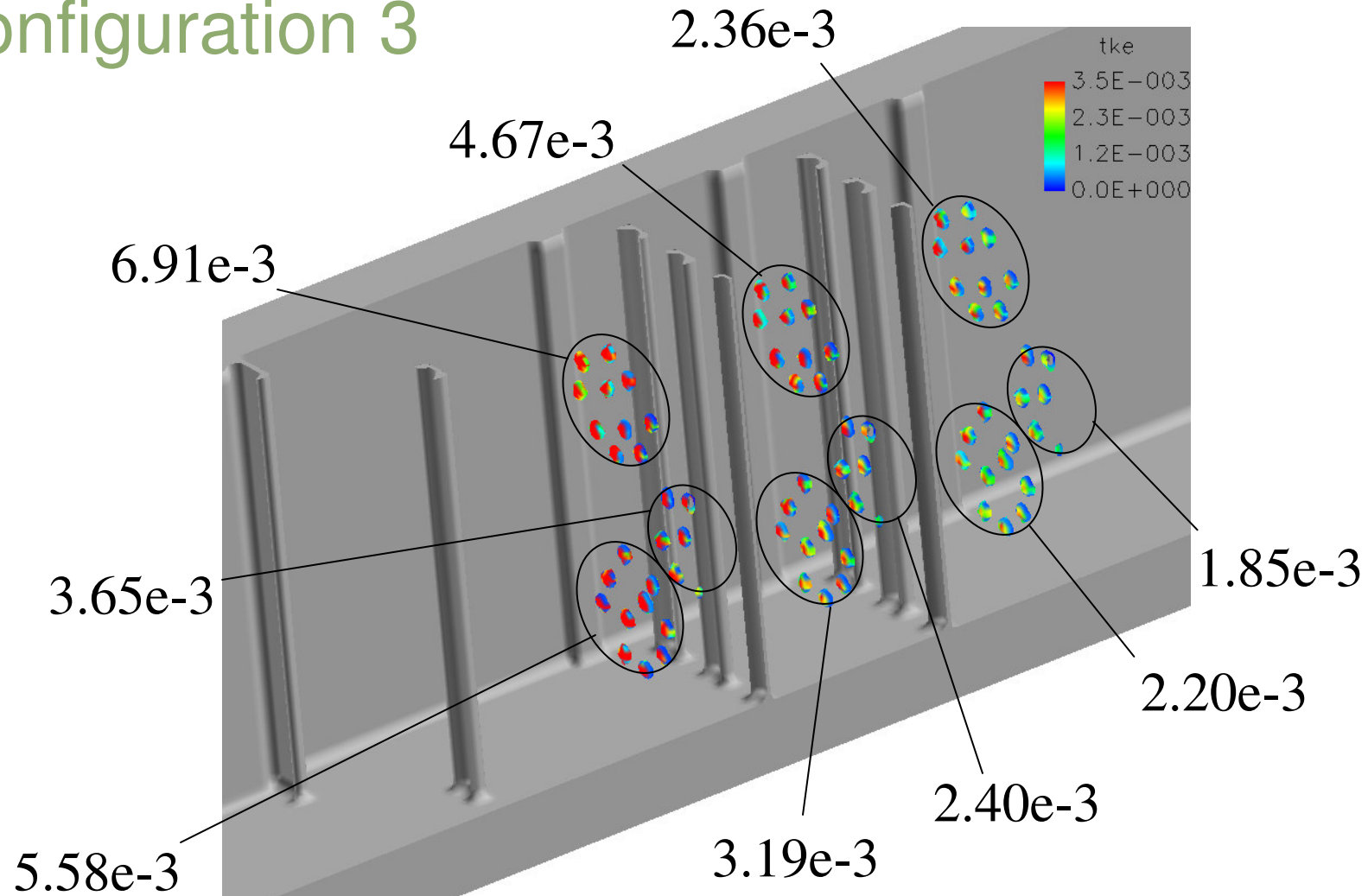


Note: The velocity values shown were determined for each sample group by taking the average velocity magnitude in a rectangular plane circumscribing each sample group.



Aligned with your needs.

Average TKE at Debris Samples (ft²/s²) for Configuration 3



Note: The TKE values shown were determined for each sample group by taking the average turbulent energy in a rectangular plane circumscribing each sample group.