AN EXPERIMENTAL STUDY ON DOWNSTREAM FISH GUIDANCE EFFICIENCY

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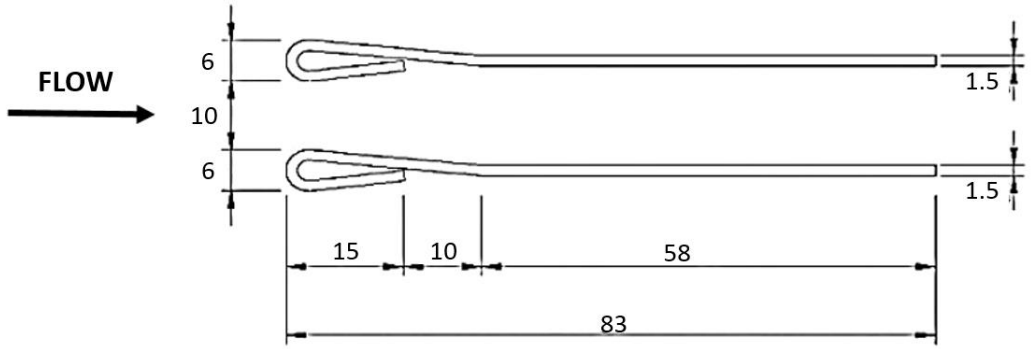
Fish-friendly Oppermann Fine Screens (Win-win Solution)

- ✓ 10 mm bar spacing → max. fish protection
- ✓ Streamlined bar profile → min. head loss

3-D Profile

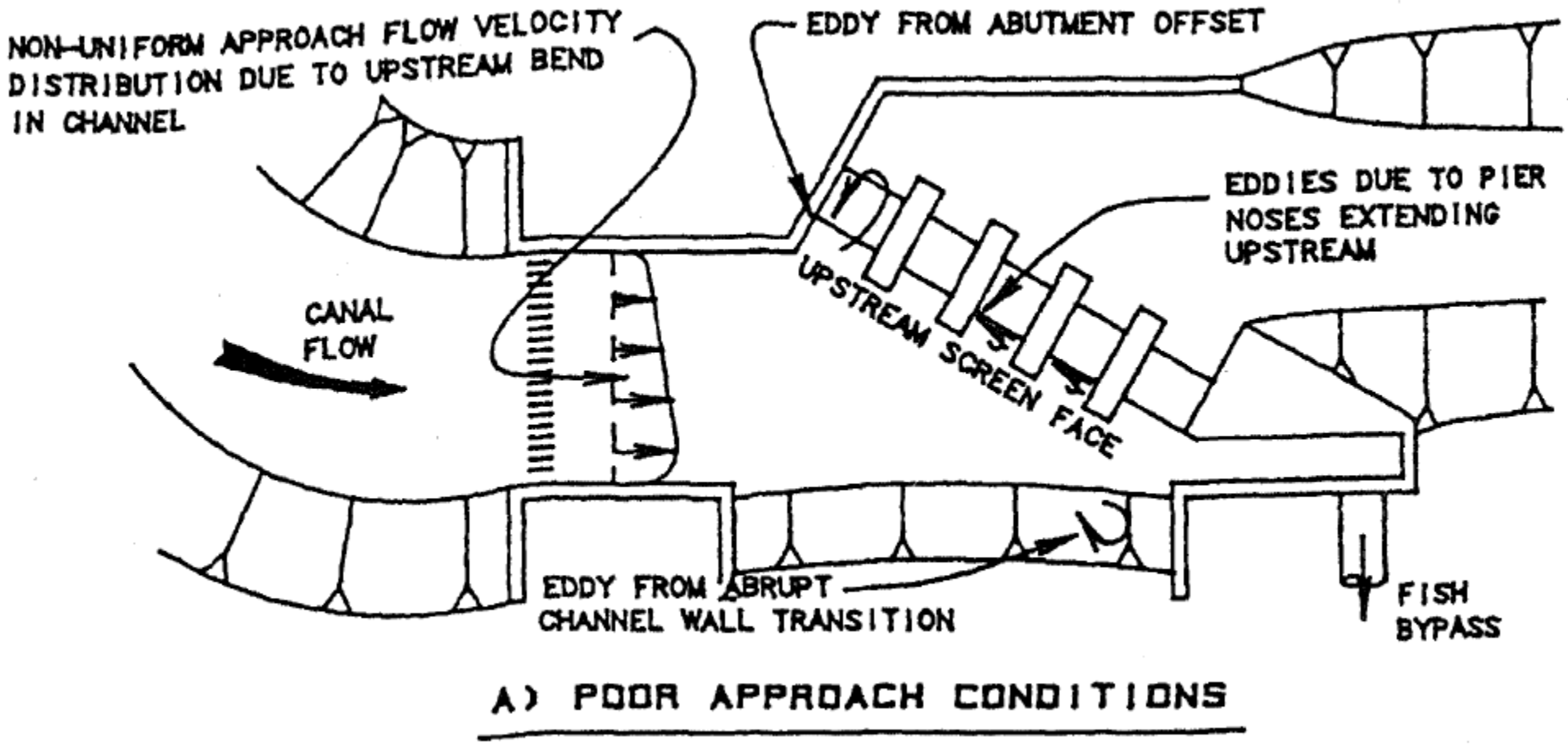
(a)



(b)

* all dimensions in mm

Poor Approach Flow Conditions (ASCE, 1995)



ETHOHYDRAULIC EXPERIMENTS

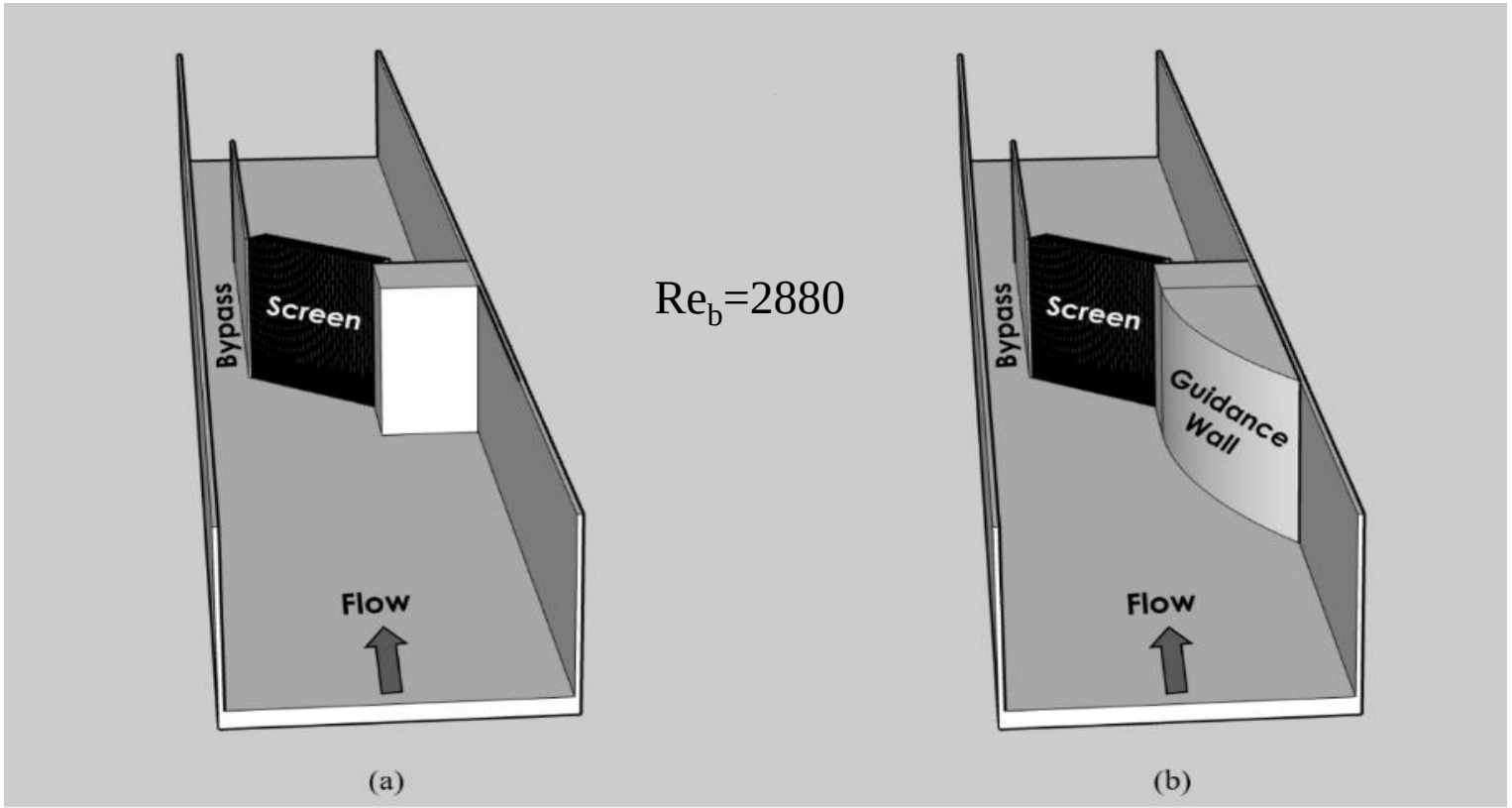
Ethohydraulic Laboratory: Live-fish Tests

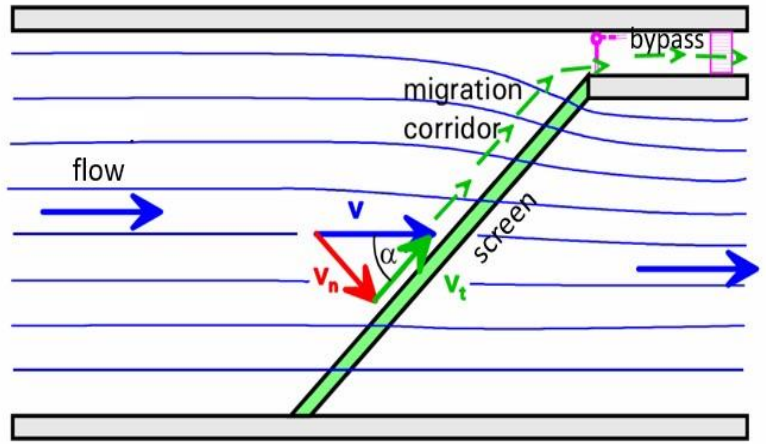
- 8 m long & 0.8 m wide

Freshwater Fish Biology and Ecology Laboratory

- Preserving the fish species

EXPERIMENTAL SETUP





Three-dimensional model of the experimental setup showing the 45° angled Oppermann fine screen and the bypass channel. (a) without, and (b) with guidance wall.

EXPERIMENTAL CONDITIONS

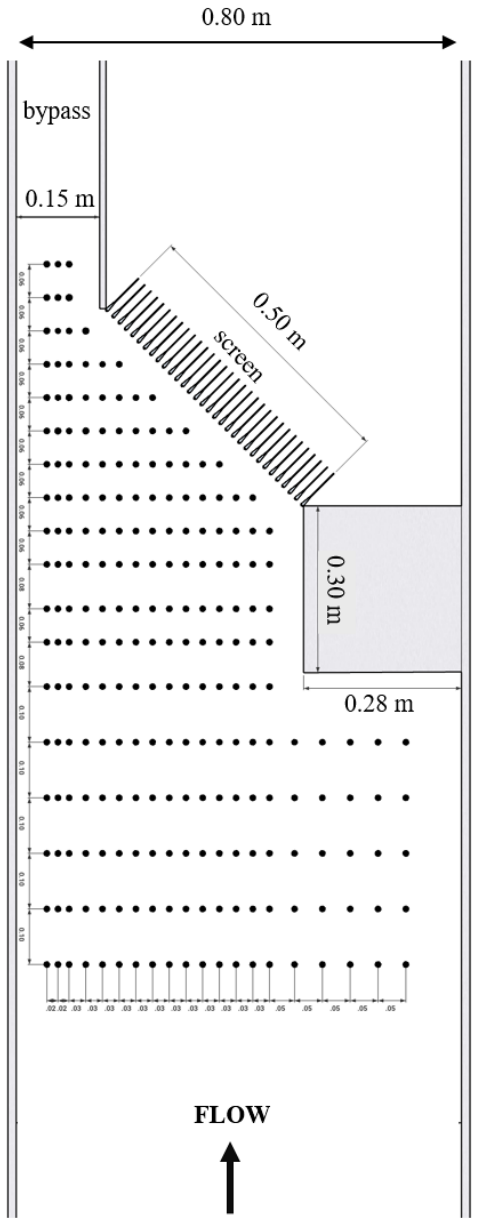
Table 1. Hydraulic and geometric conditions of with and without guidance wall experiments.

b (m)	s (m)	B_s (m)	B_b (m)	B (m)	Q *(L/s)*	h (m)	V (m/s)	Re (-)	Fr (-)	S_0 (-)	α *(-)*
0.010	0.006	0.50	0.15	0.8	85	0.22	0.48	106250	0.328	0 %	45°

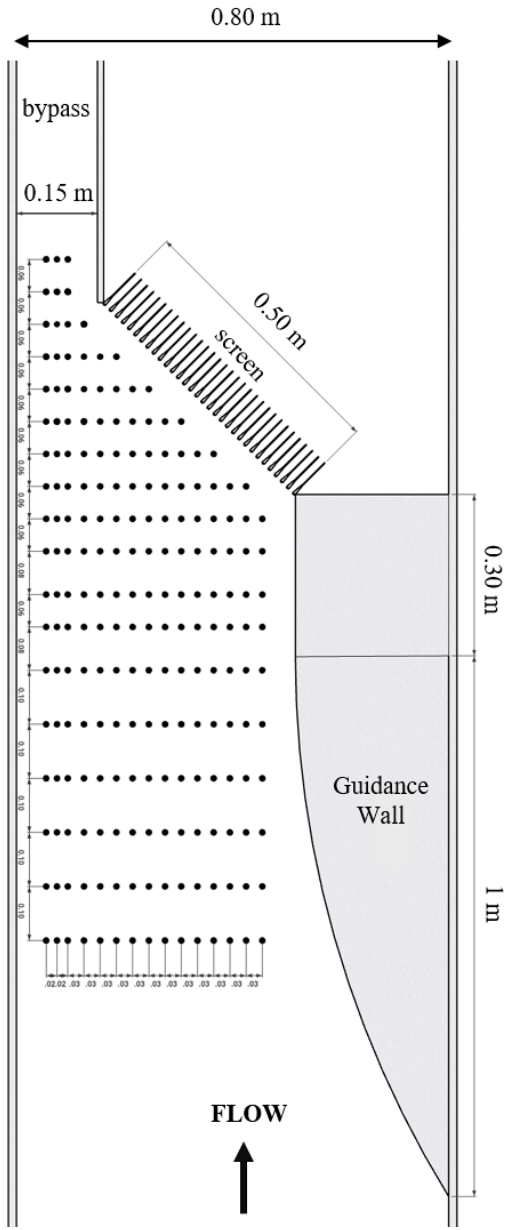
NOTE: b=clear bar spacing,s=bar thickness, B_s=total width of the screen, B_b=total width of the bypass channel, B=total channel width, Q =total discharge, h =average flow depth, V =approach flow velocity, Re =approach Reynolds number, Fr=approach Froude number, S_0=channel bottom slope, α=horizontal screen angle.

ADV Measurement Grid: Without and With Guidance Wall

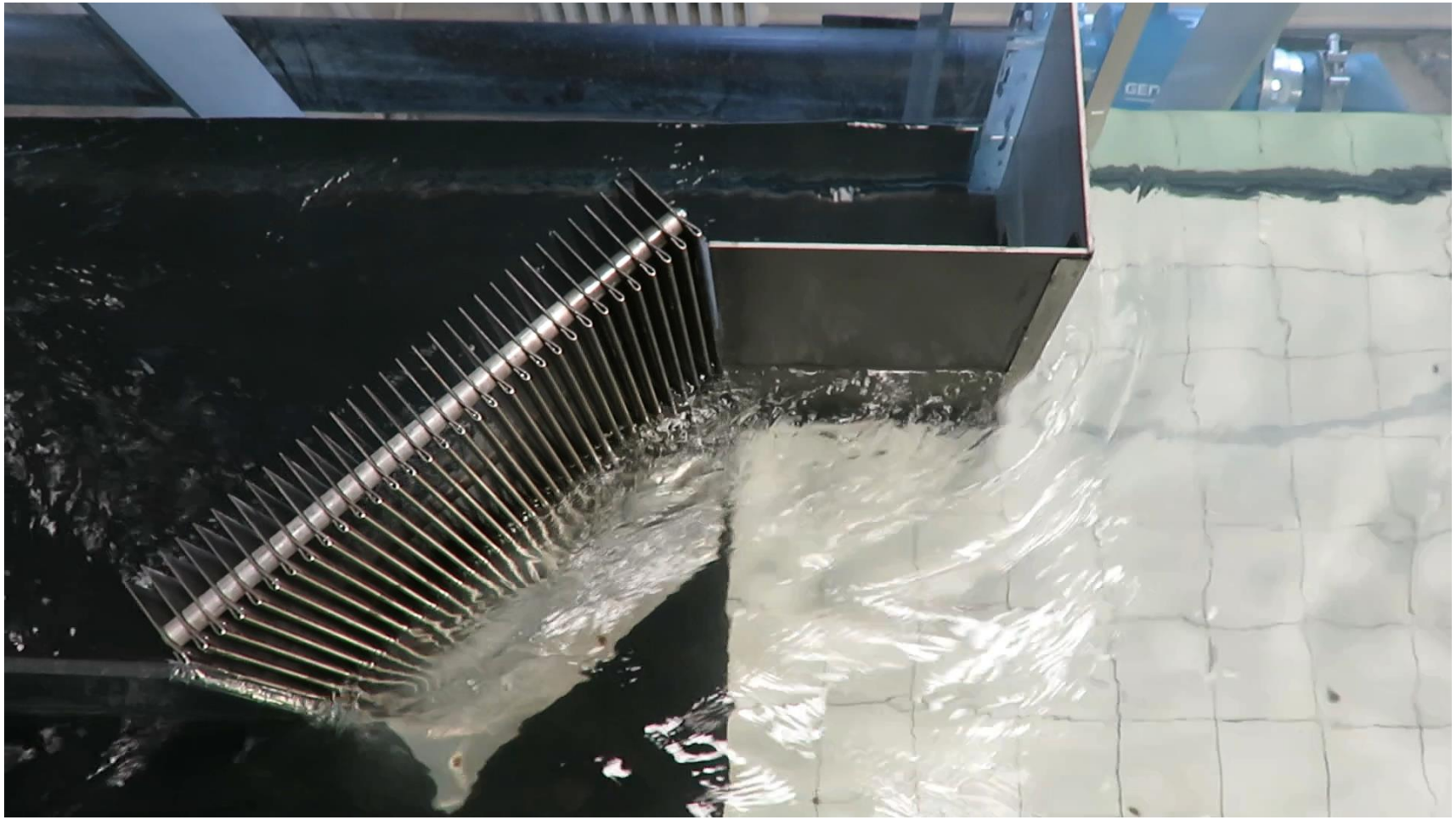
- 235 points



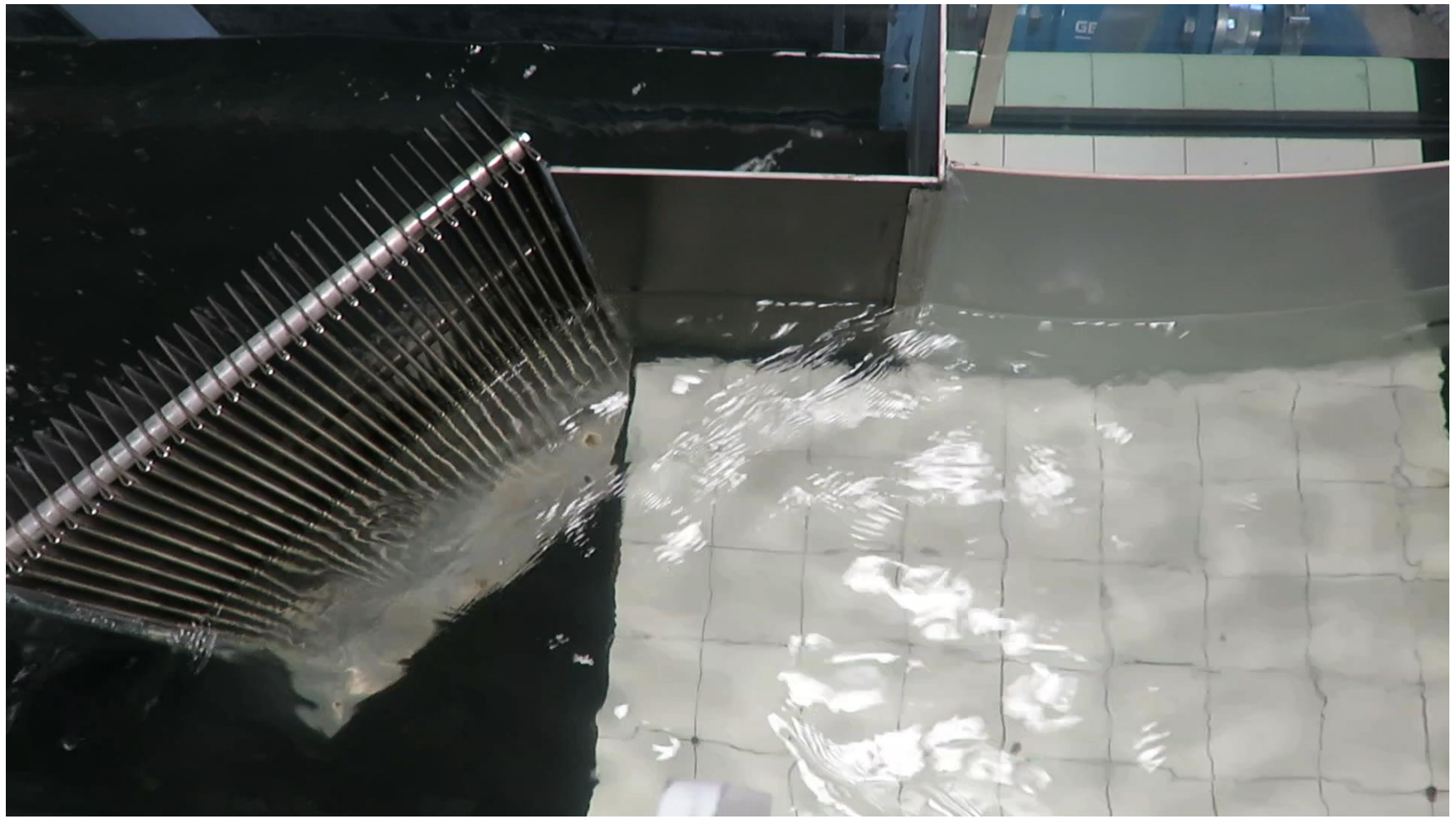
- 210 points



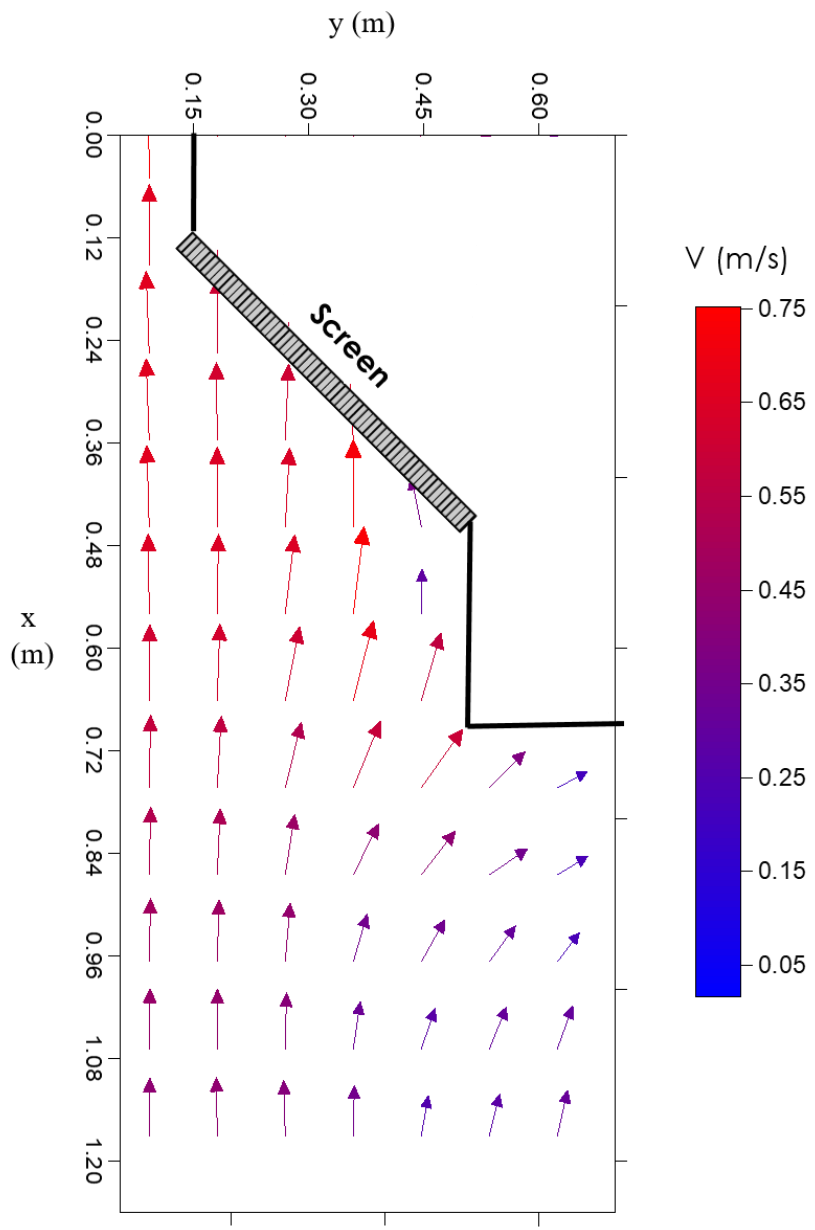
Flow Field: Without Guidance Wall

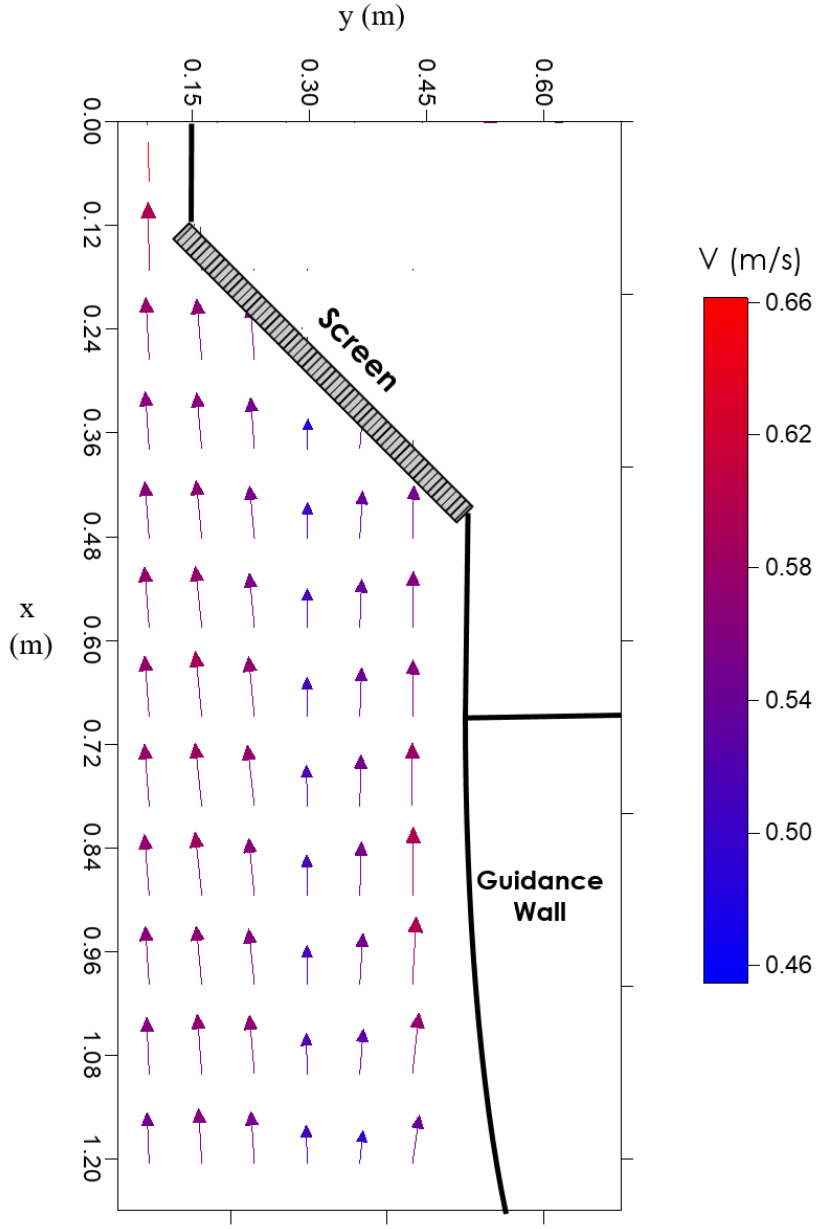


Flow Field: With Guidance Wall

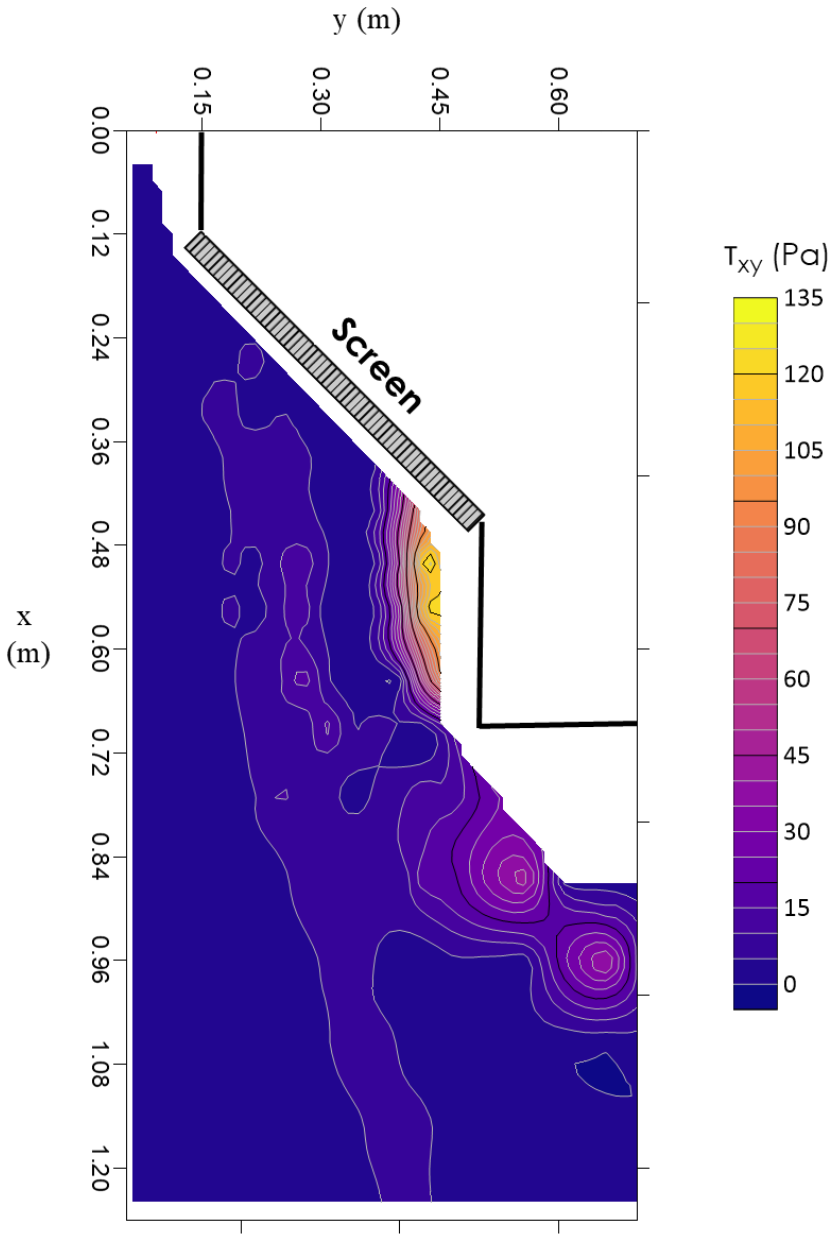


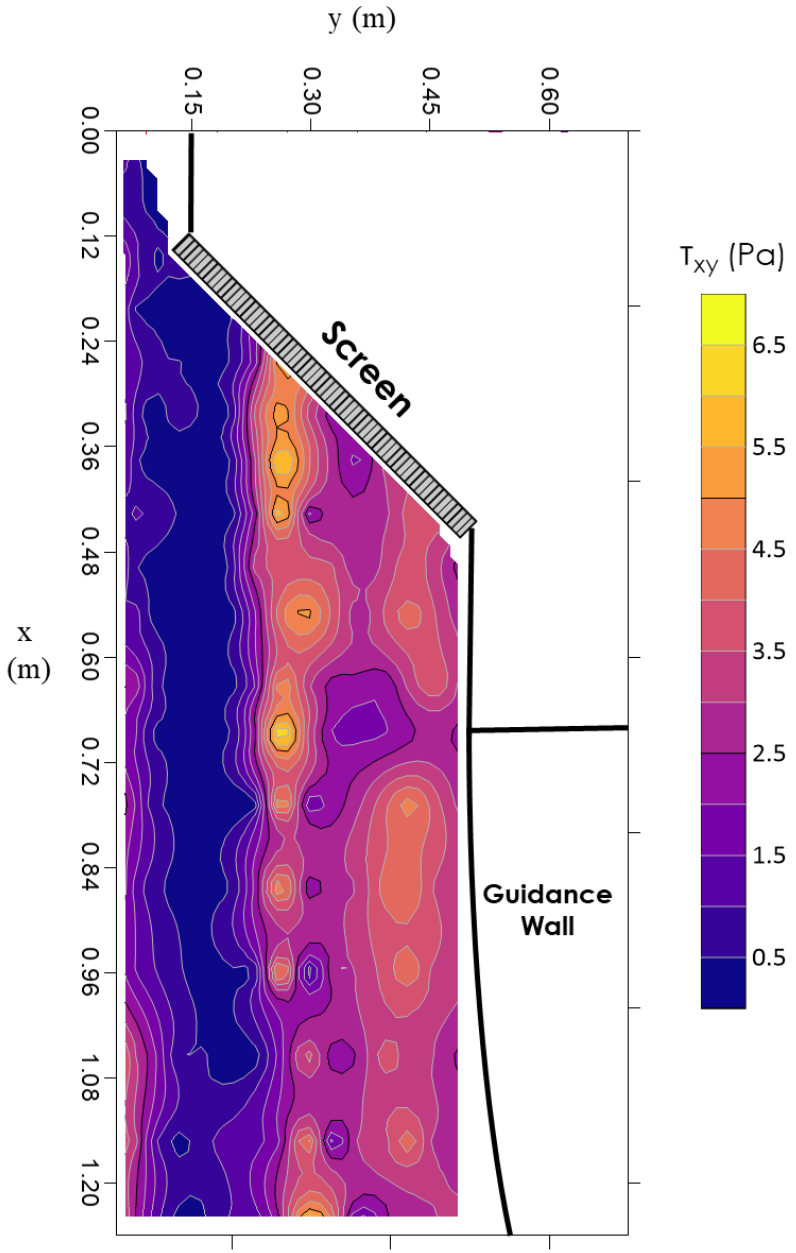
Flow Field: without and with guidance wall





Shear Stress: without and with guidance wall





3D CFD Modeling of the Setup

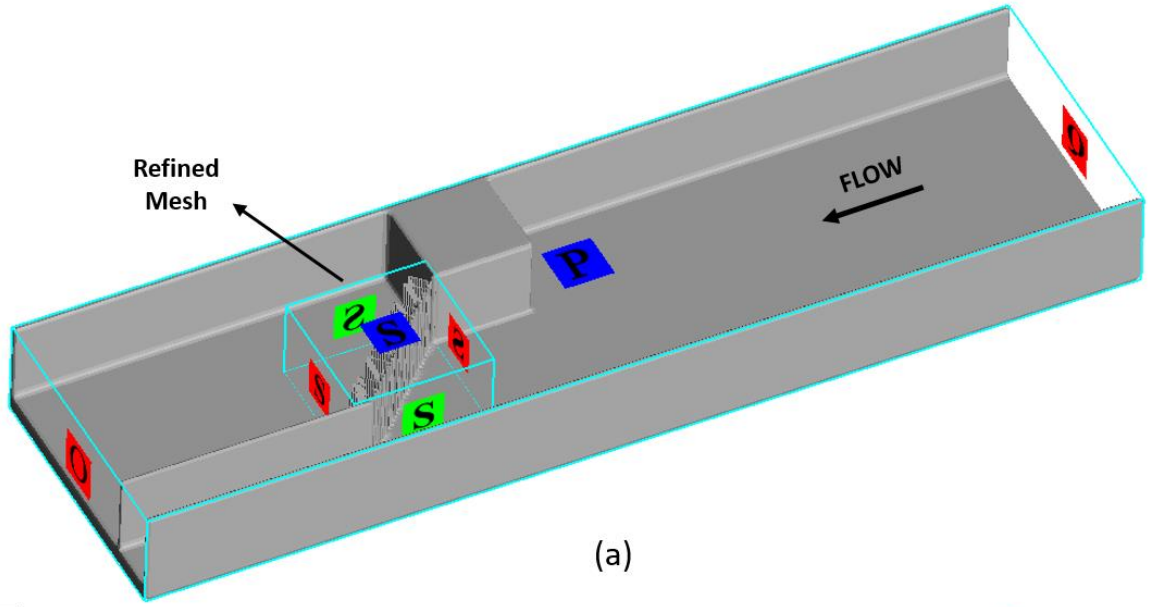
Boundary Conditions

- Q = Volume Flowrate
  - ✓ Q = 90 L/s
  - ✓ Fluid elevation = 0.22 m
- S = Symmetry
- P = Specified Pressure
  - ✓ Patm= 0
- O = Outflow

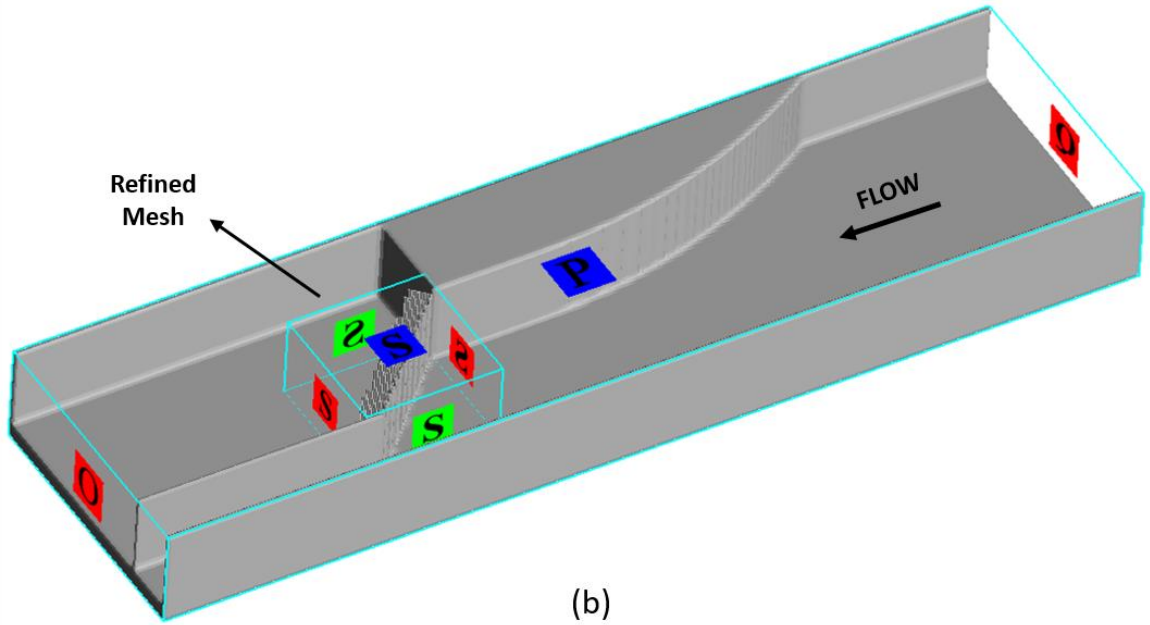
Simulation Duration → **180 seconds**

Turbulence Model → **Large Eddy Simulation**

Grid Size → **0.01 m & refined mesh = 0.005 m**

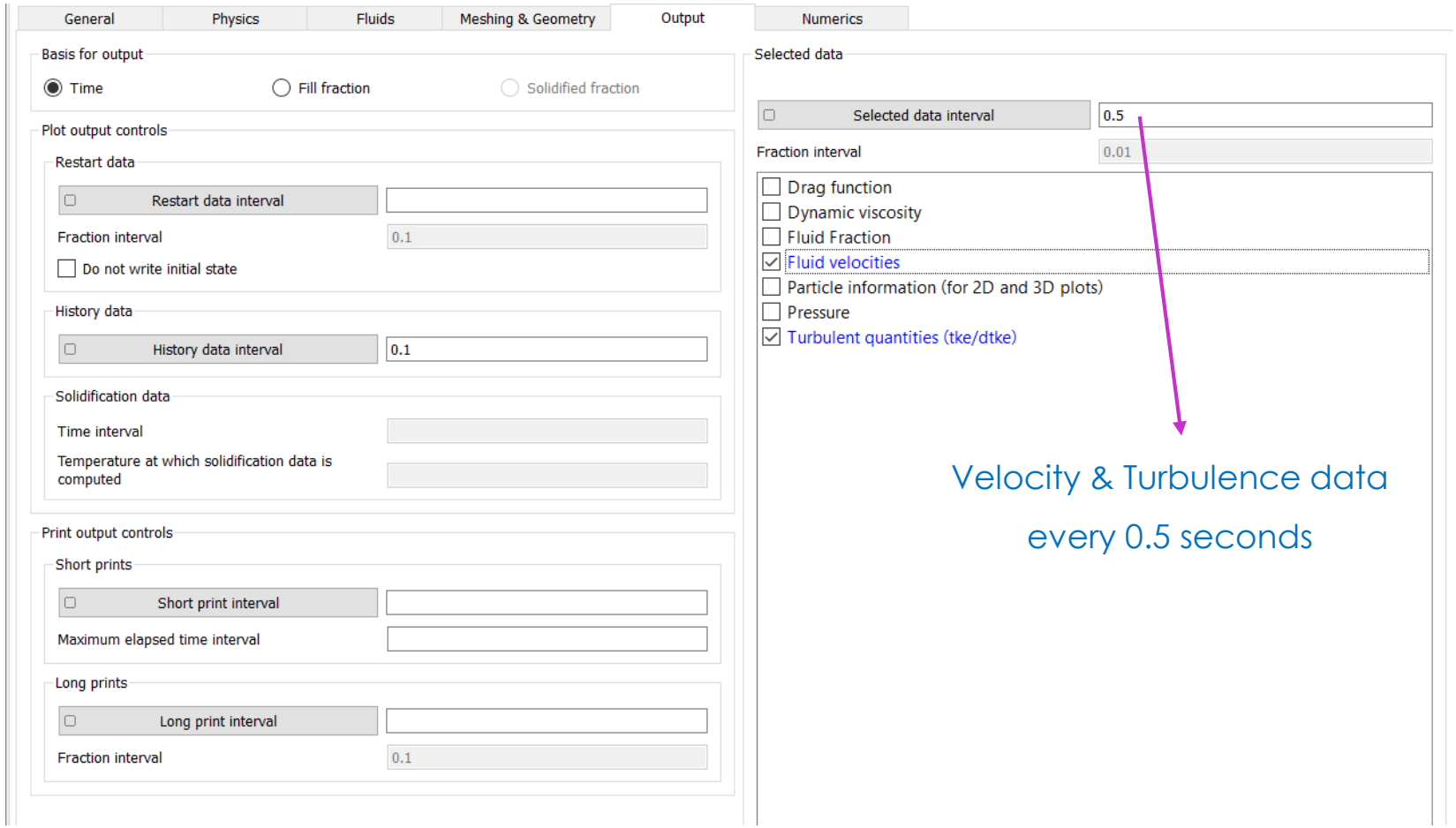


(a)

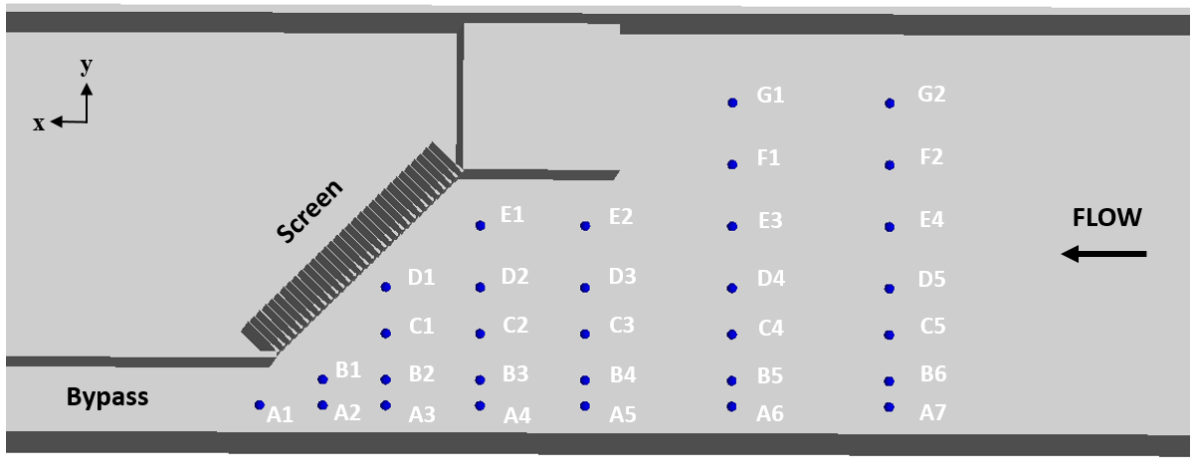


(b)

Numerical Output

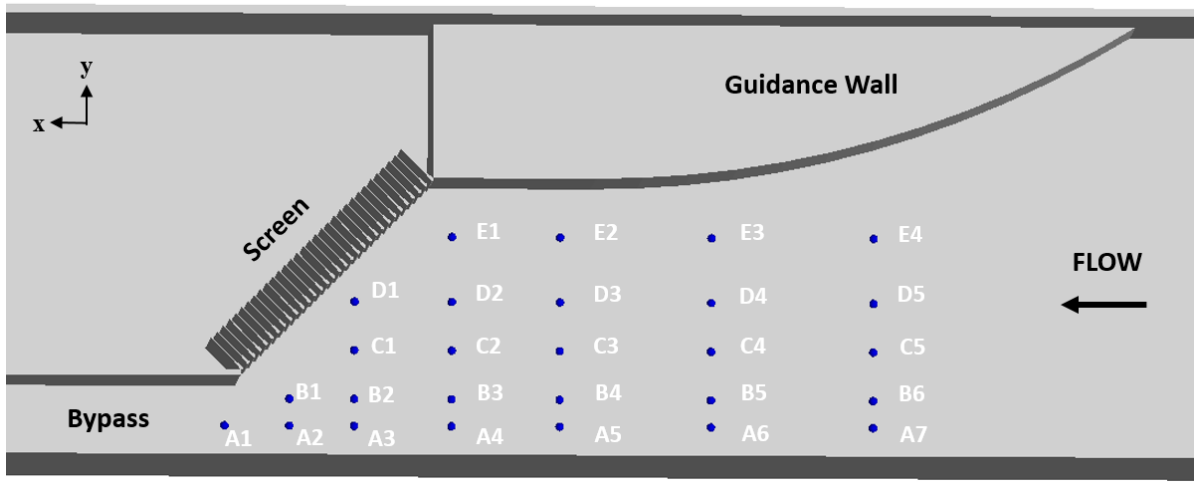


CFD VALIDATION



n = 31 points

- **LES** is employed for both simulations.



n = 27 points

Mean Absolute Percentage Error (MAPE) Values

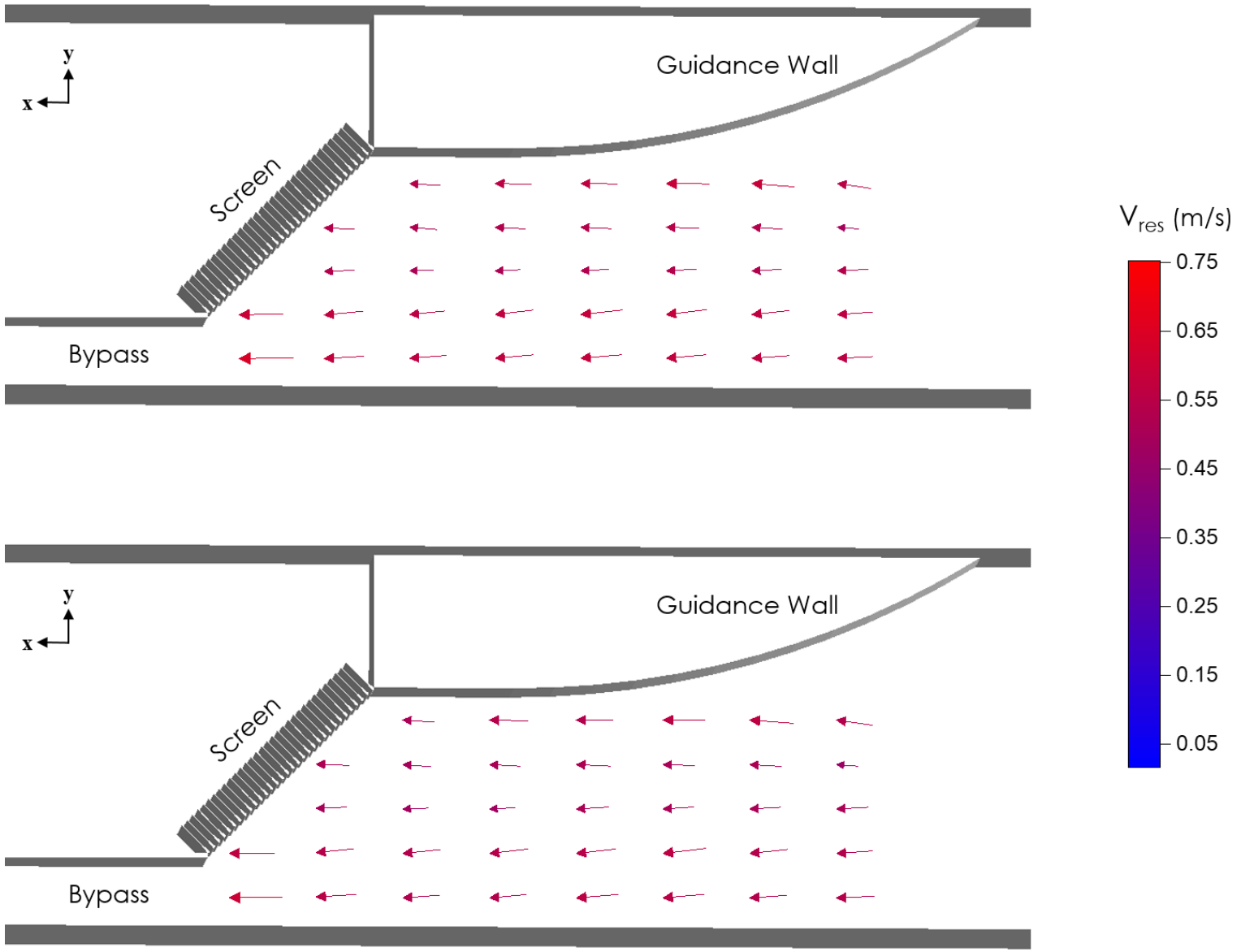
$$\% \text{ Error } = \left| \frac{\text{Numerical Result - Experimental Result}}{\text{Experimental Result}} \right| \times 100 \longrightarrow \text{MAPE} = \frac{1}{n} \sum \% \, Error$$

Parameter	Without Guidance Wall	With Guidance Wall
V_{res} (m/s)	MAPE = 5.7 %	MAPE = 3.8 %
T_{xy} (Pa)	MAPE = 9.2 %	MAPE = 6.6 %

Flow Field Comparison: With Guidance Wall

Experimental flow field

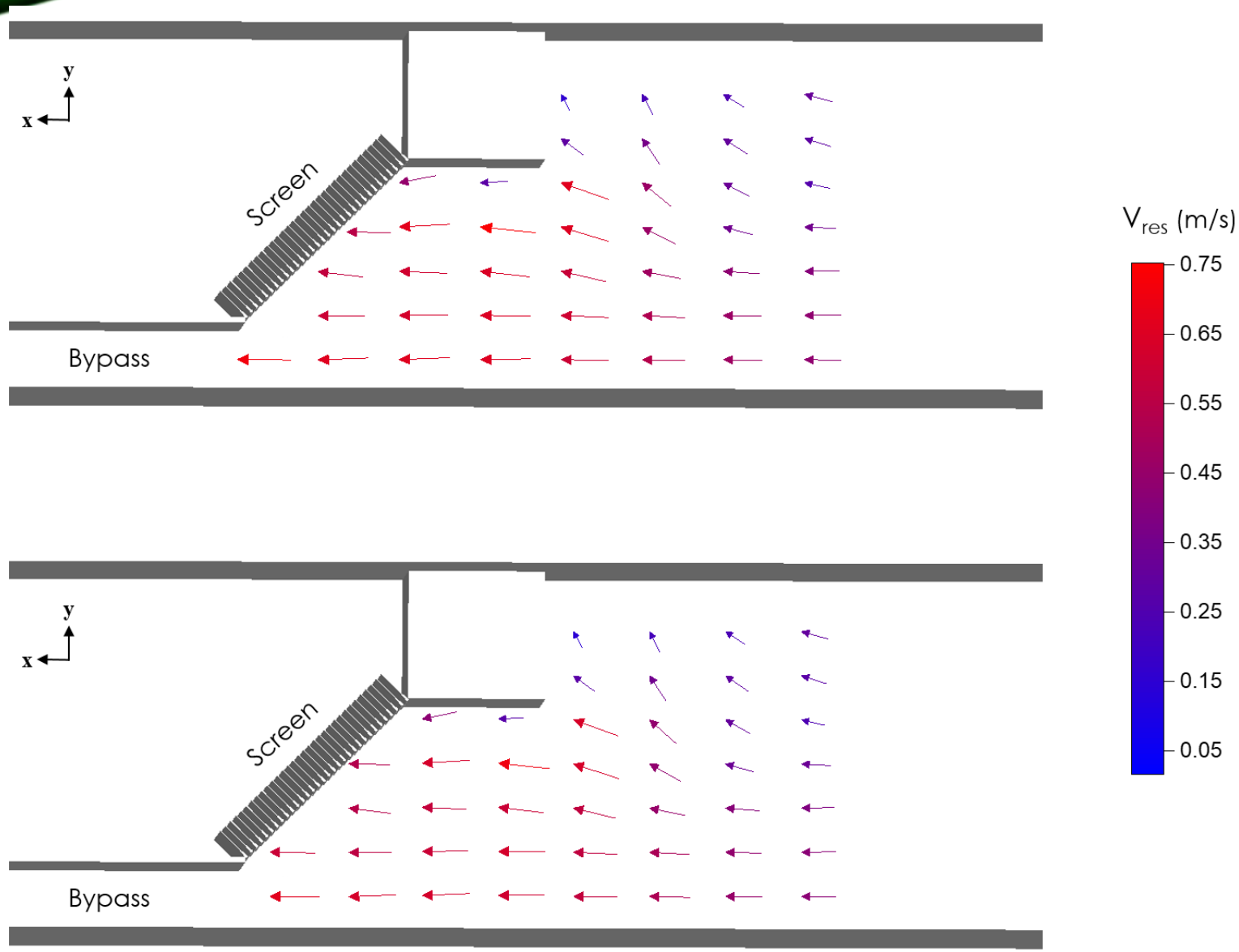
Numerical flow field



Flow Field Comparison: Without Guidance Wall

Experimental flow field

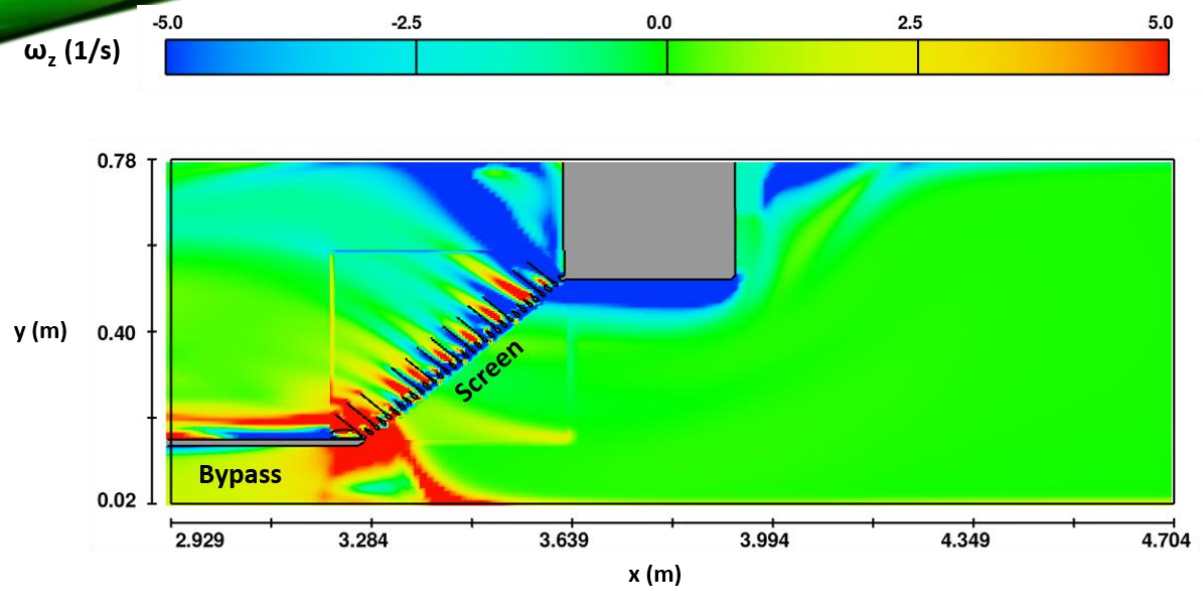
Numerical flow field



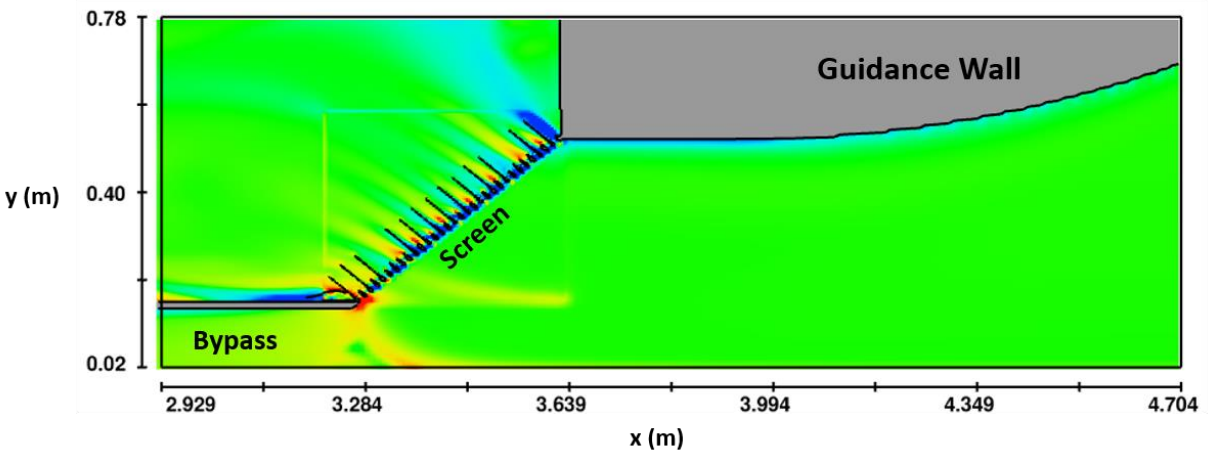
Vorticity Field Comparison

For both cases:

- ✓ z = 0.05 m and a = 45°
- ✓ Outer mesh size = 0.01 m
- ✓ Refined mesh size = 0.005 m
- ✓ Turbulence Model = LES



❖ **Without guidance wall**



❖ **With guidance wall**

FIELD STUDY: FISH SAMPLING

SAMPLING LOCATION → Kirmir Stream – Ankara - Turkey

Alburnoides kosswigi collected from Kirmir Stream

Migratory fish species tested in experiments

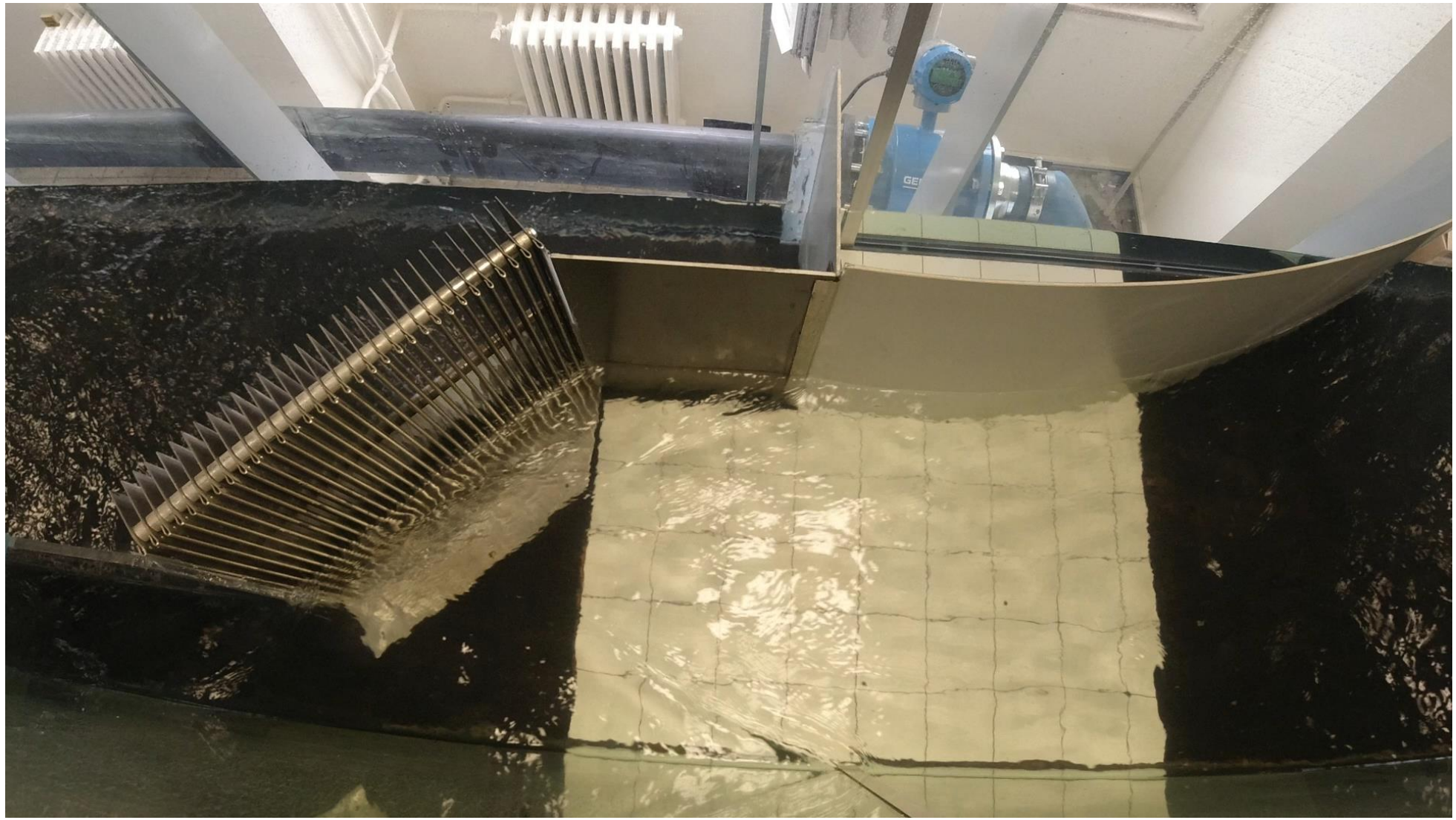
Species	Family	Total Body Length Interval (mm)	Total Individuals
Chondrostoma colchicum	Leuciscidae	104 – 202	30
Alburnus escherichii	Leuciscidae	89 – 126	30
Alburnoides kosswigi	Leuciscidae	73 – 98	11

Small-bodied fish

Passage Efficiencies

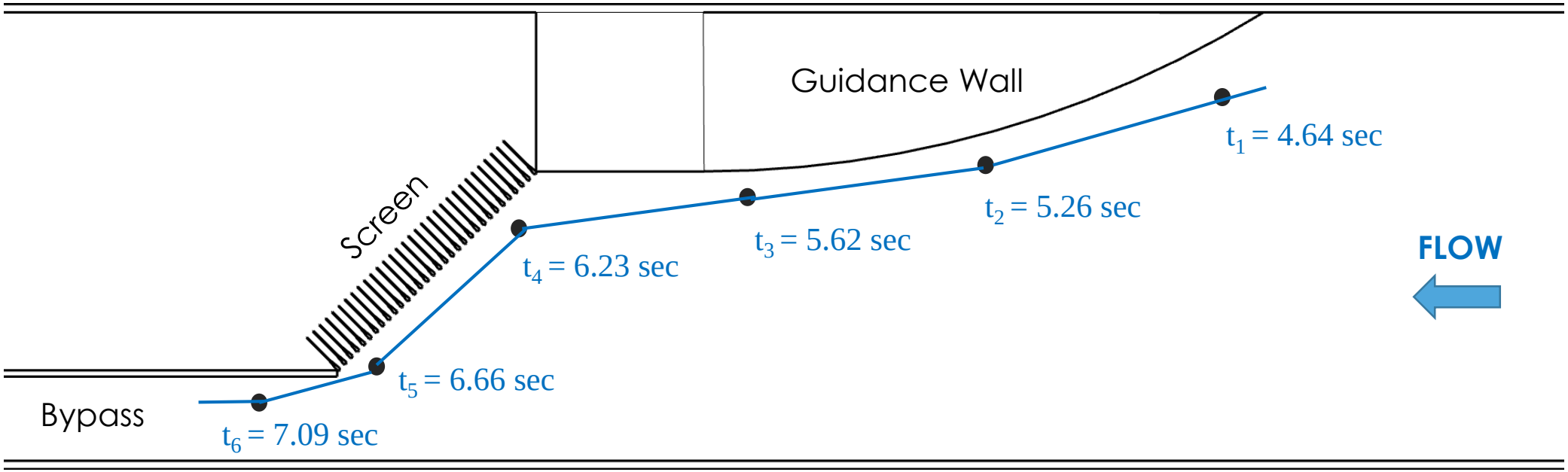
	Without Guidance Wall	With Guidance Wall
	70 %	83 %
	63 %	90 %
	45 %	73 %

Chondostroma – Total Body Length = 15.4 cm

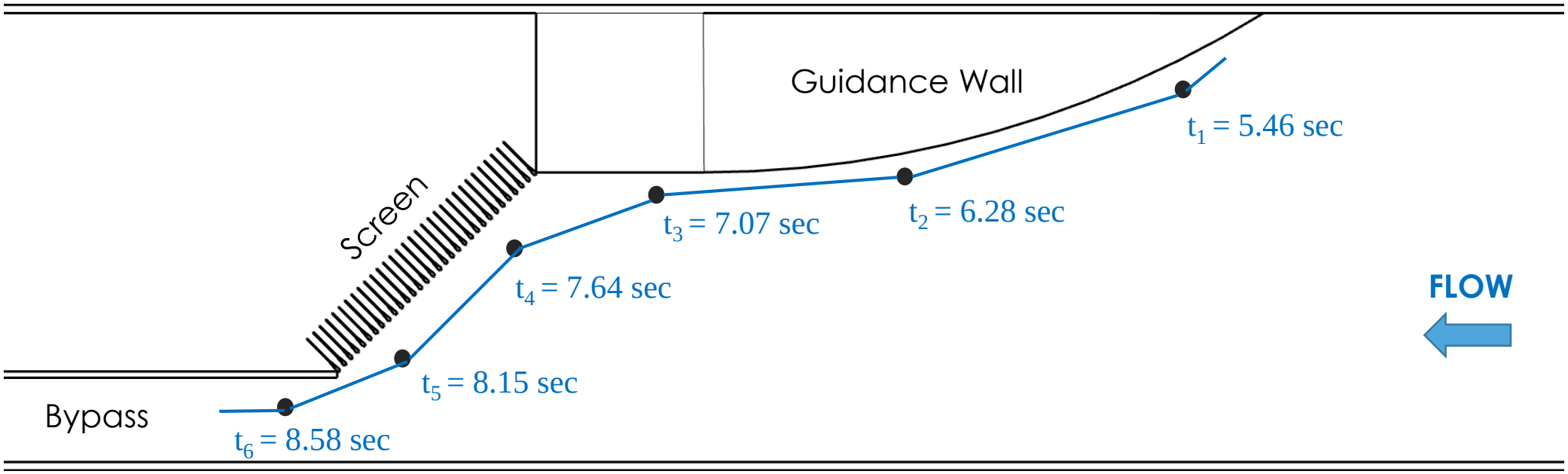


Alburnus – Total Body Length=10.5 cm

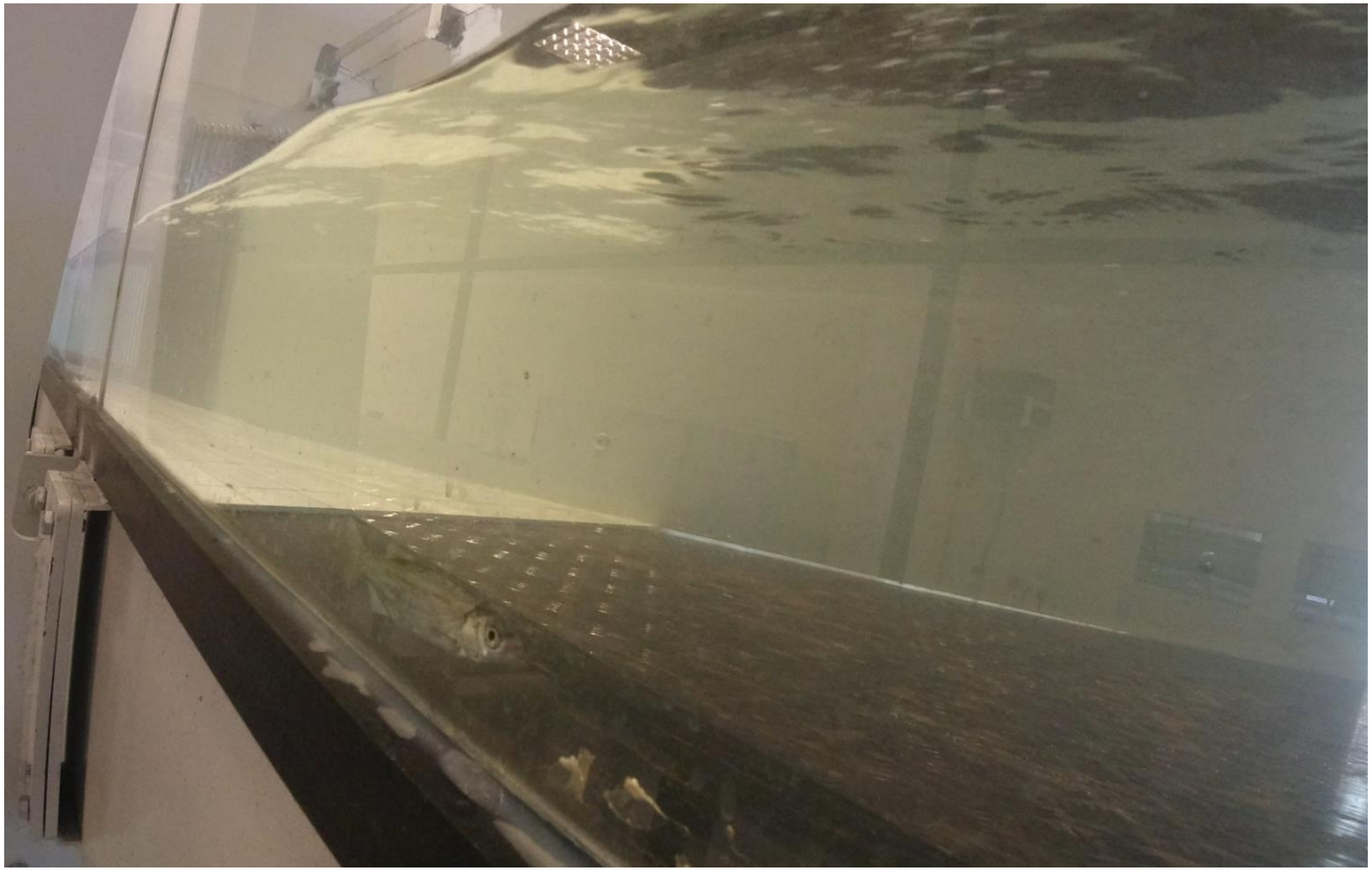
Fish Trajectory: Chondostroma



Fish Trajectory: Alburnus



Chondostroma – Without Guidance Wall



SUMMARY

- Poor approach flow conditions were enhanced by the guidance wall for downstream fish migration.
- The presence of guidance wall created much reduced lateral shear stress near the channel bottom with a more homogenous flow field in the upstream region.
- The guidance wall was shown to increase the tangential velocities along the screen axis, which is essential for effective guiding for fish toward the bypass.
- For all tested fish species, passage efficiencies were increased when the guidance wall was used.
- None of the tested individuals passed between the screen bars, leading to provide maximum protection even for small-bodied fish.

THANK YOU…