Nature of Cross Currents at River Confluences:

Spur Dikes as Control Measures for Enhanced Navigation Safety

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INTRODUCTION

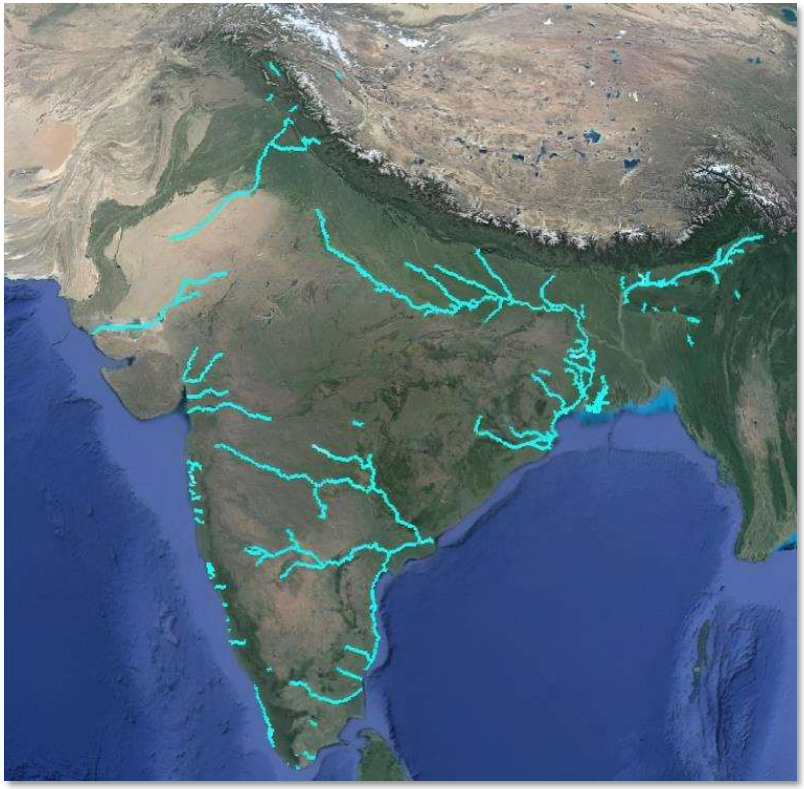


Figure 1. Proposed 111 National Waterways in India

Figure 2. Convergence of the bifurcated Ganga river

INTRODUCTION

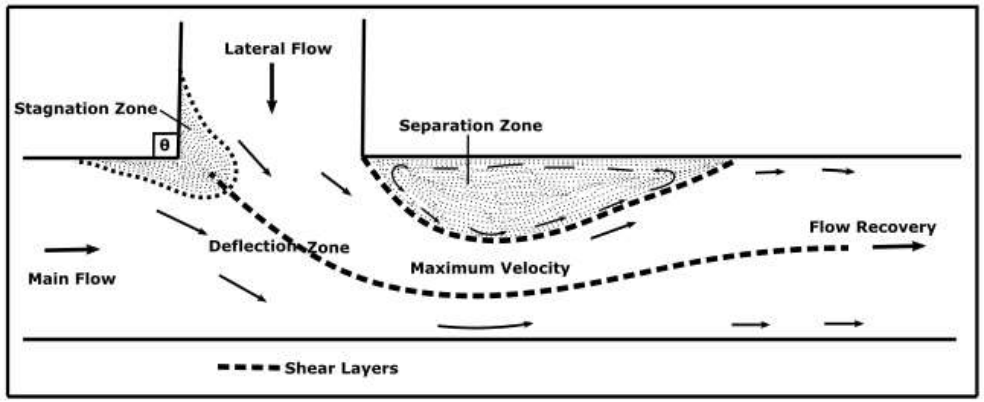


Figure 3. Hydrodynamic zones at a river confluence

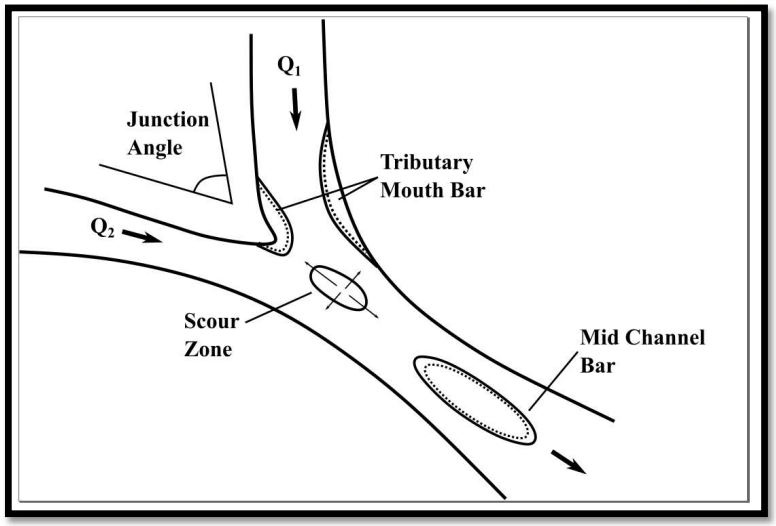
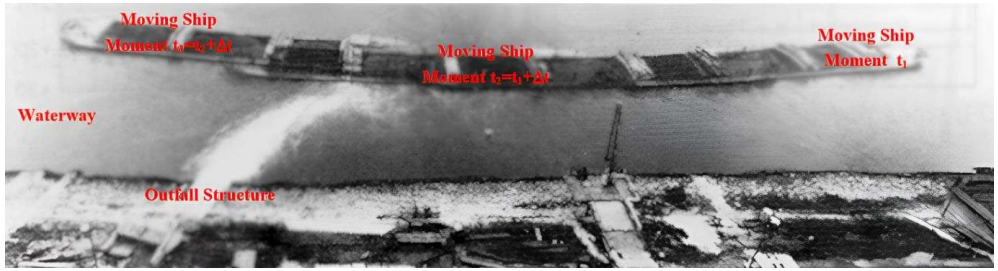


Figure 4. Conceptual model of morphological features at a river confluence

- Sediment **bar formation** in the separation zone and mid-channel post confluence → **Fairway Maintenance**
- High intensity turbulence; Increased **transverse velocities** → **barge maneuvering**

INTRODUCTION



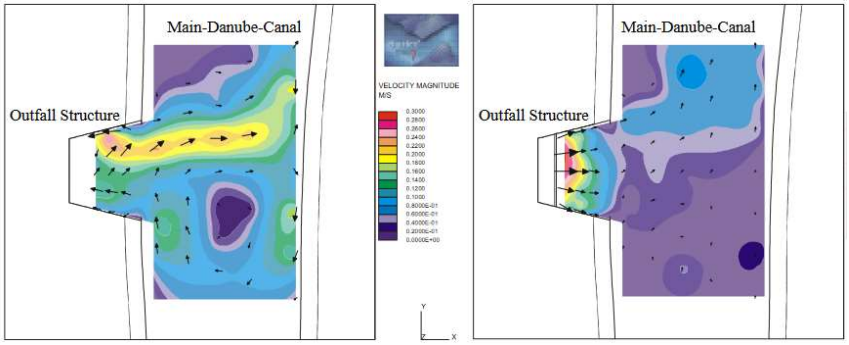


Figure 5. Hydrodynamic zones at a river confluence

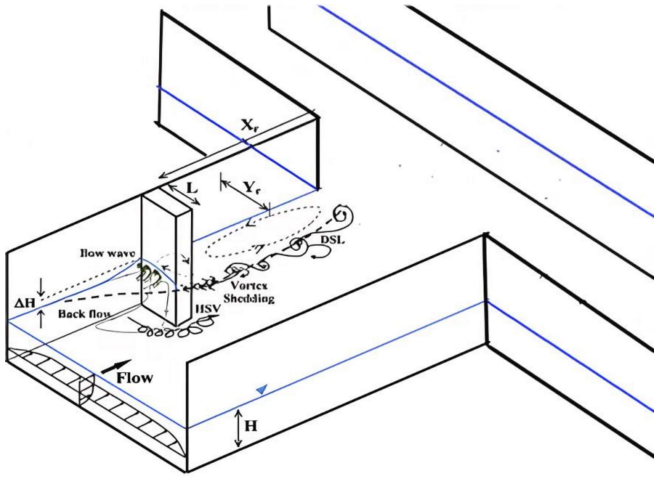


Figure 6. Hydrodynamic zones at a river confluence

Methodology

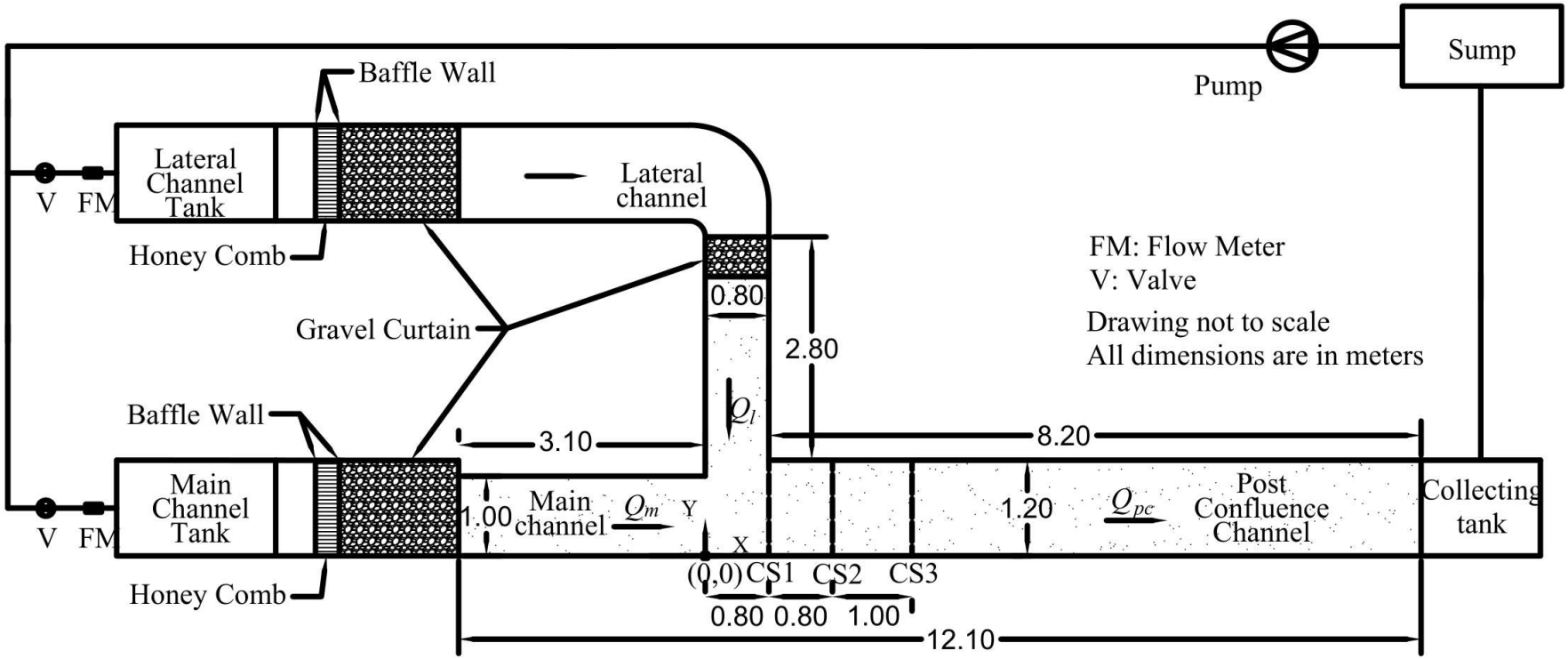


Figure 7. Schematic of Experimental setup

Methodology

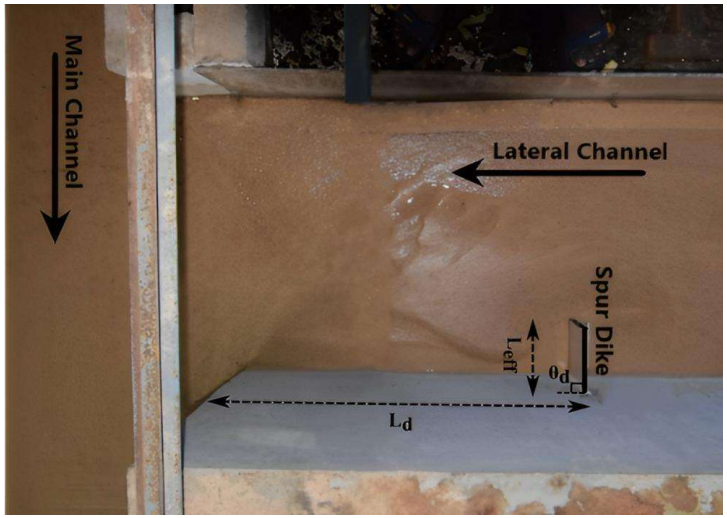


Figure 8. Close view of spur dike in the test section

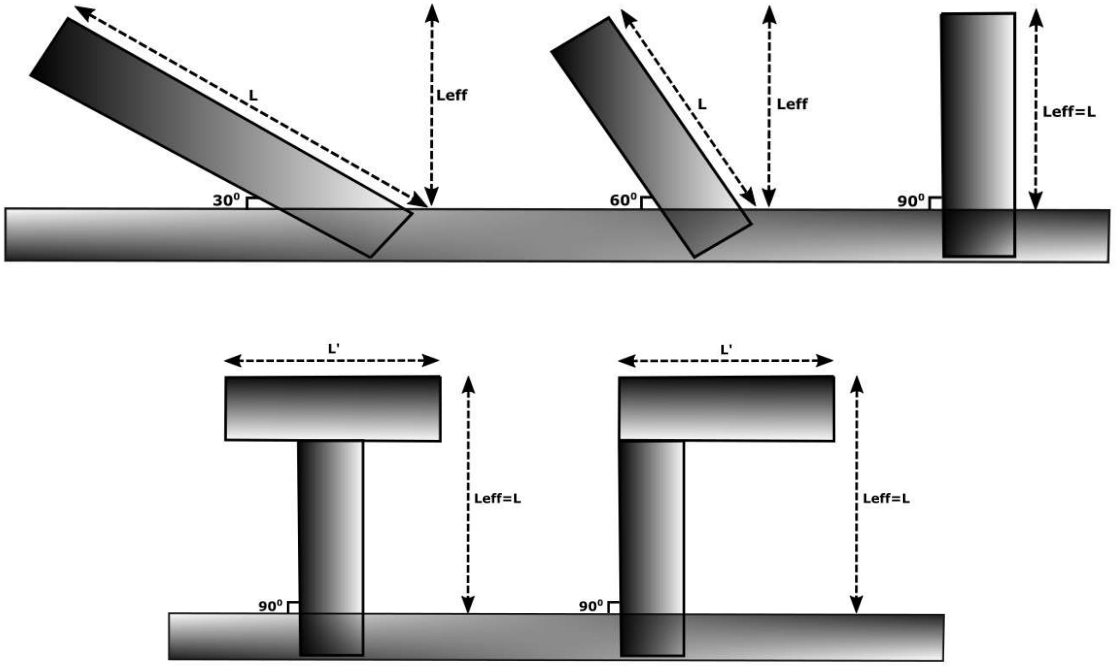


Figure 9. Spur dike models used in the present study

Methodology

Table 1. Experimental parameters

Variables	Values
Confluence angle (θ)	90º
Discharge ratio (Q_r)=(Q_l /Q_m)	0.2, 0.4, 0.6, 0.8
Dike angle (θ_d)	30º, 60º, 90º
Dike length (L_{eff}/W_L)	10%, 20%, 30%
Dike location (L_d /L_{eff})	2, 4, 6, 8
Wing length (L'/L_{eff})	0.5, 1, 1.5

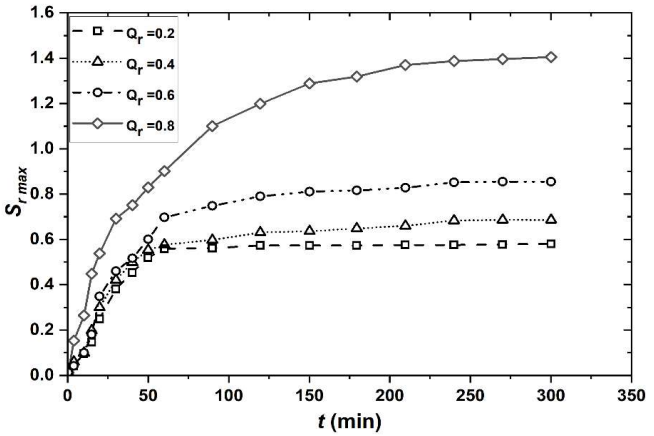


Figure 10. Temporal variation of scour depth

Results

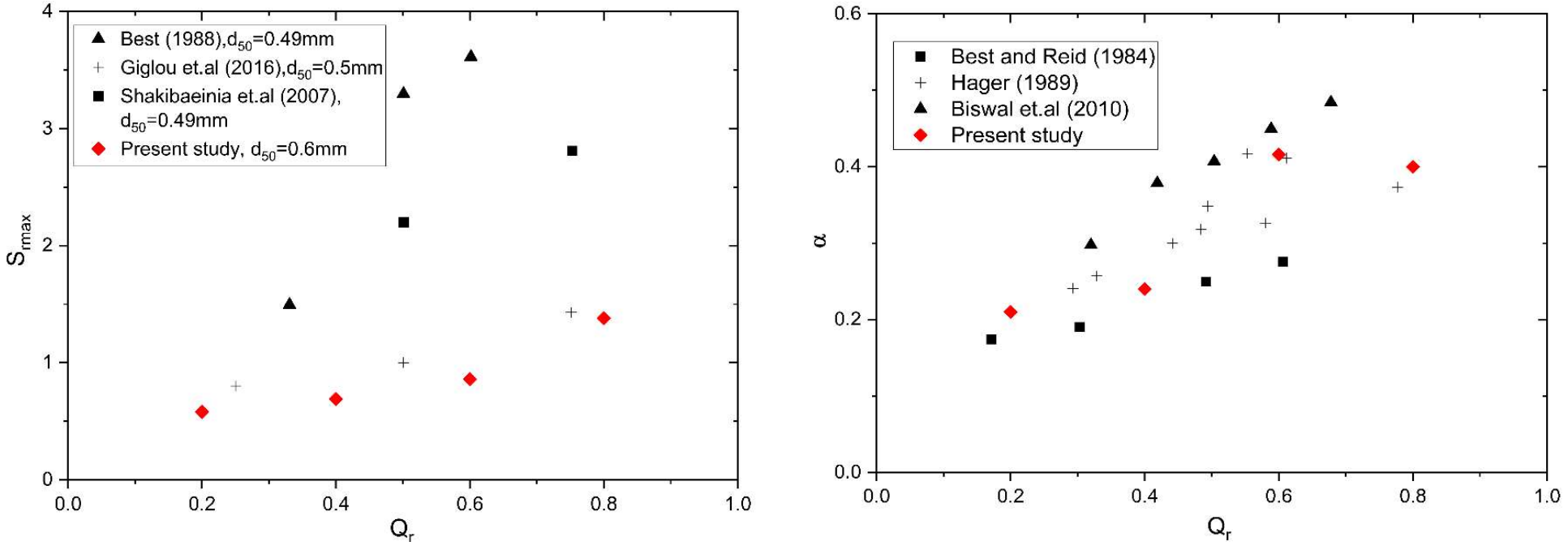


Figure 11. (a) Maximum scour depth ratio ($S_{r\,max}$), (b) Separation zone index (α)

Results

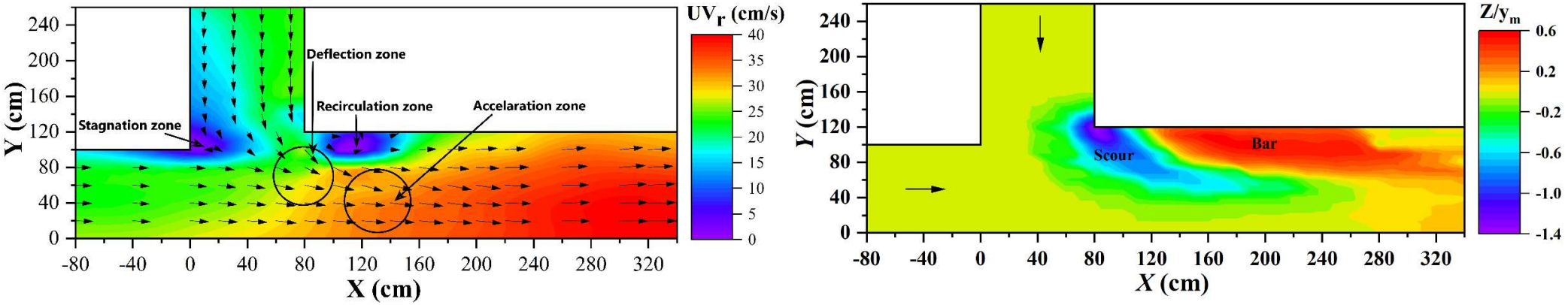


Figure 12. (a) Near bed U-V resultant vector plot and the (b) resulting bed contour Q_r of 0.8

Q_r	Scour	Bar		
	$(S_d/y)_{max}$	(B_h/y)	W_b/W_{pc}	V_b (m^3)
0.8	1.39	0.59	0.58	0.052
0.6	0.98	0.45	0.41	0.039
0.4	0.79	0.34	0.23	0.028
0.2	0.70	0.22	0.08	0.019

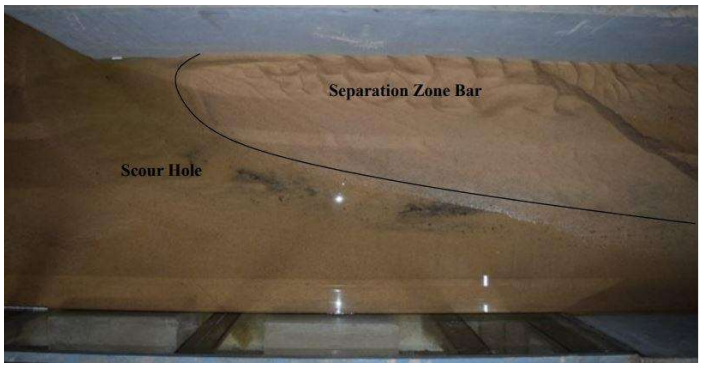


Figure 13. Near equilibrium confluence morphology

Results

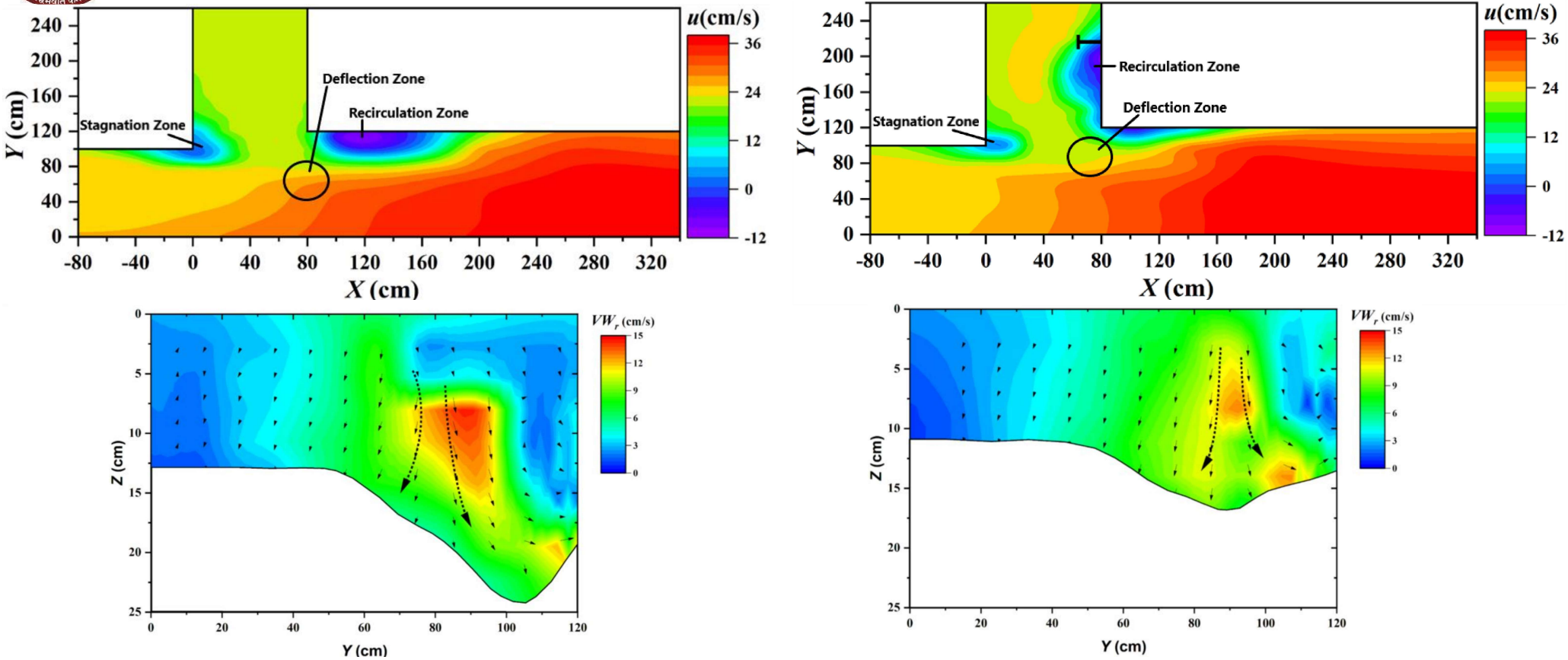


Figure 14. (a) Near-surface velocity contour at Q_r= 0.8 for the Base case and T-1 configuration, along with their corresponding cross-sections at X=100 cm.

Results

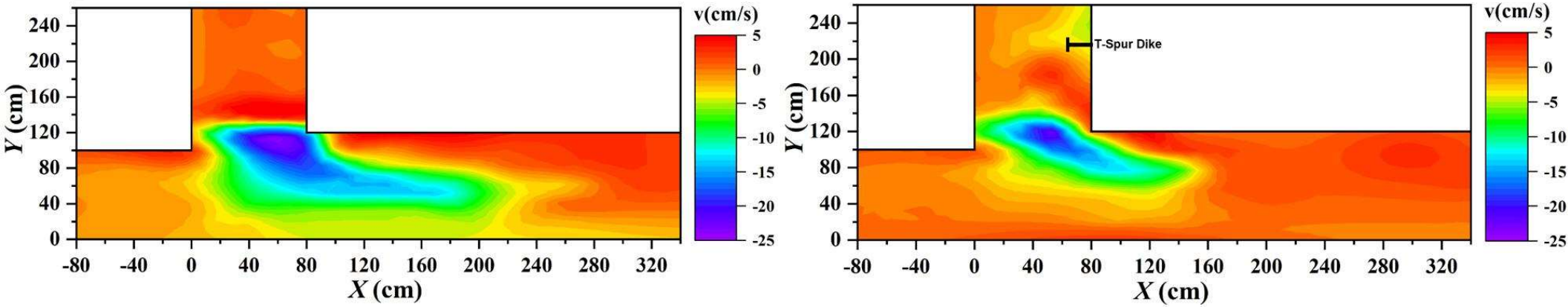


Figure 15. Cross currents at Q_r= 0.8 for the Base case and T-1 configuration.

Maximum permissible cross current velocity – 4 cm/s (Pulima, 1983; BAW 2011; PIANC WG 141, 2019)

Table 3. Cross current extent at river confluence

	Base case		*T-1*	
Q_r	W_c	L_c	W_c	L_c
0.8	0.58	2.61	0.29	1.16
0.6	0.42	1.83	0.26	0.92
0.4	0.38	1.24	0.24	0.70
0.2	0.32	0.86	0.19	0.57

Future

"Experimental study on Influence of vessel movement on Hydro-morpho-sedimentary process at river confluence"

- Vessel induced sediment resuspension
- Fish swimming behavior and migration patterns
- Modelling of fish behavior at river confluence and vessel influence

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Acknowledgments

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Questions??