Engineering Services for Additional Studies and Technical Assistance for New Locks PANAMA

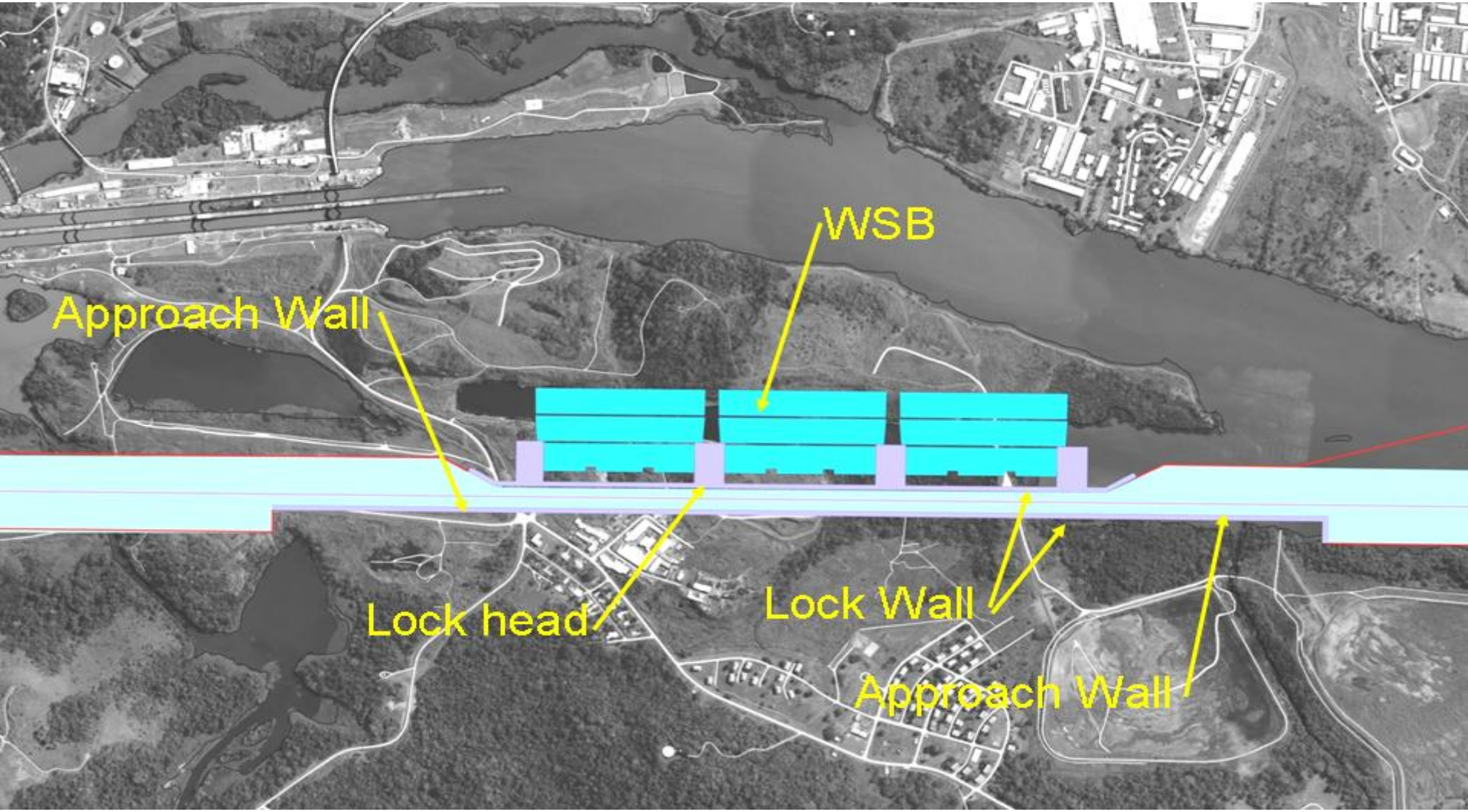
Study and 3D modelling of density and discharge currents of the third set of locks

CEDA – presentation 19 May 2011

Mark Bollen – IMDC

Pacific

Conceptual Design



Discharge and density currents

- Aim of the study
- Study approach
- Data collection
- Modeling of present situation
- Modeling of future situation
- Conclusions

Aims of this study

- To better understand flow and salt exchange between chamber and the ocean during leveling (spilling) and after opening the gates (density current);
- To determine the velocities caused by density currents that effect ship navigation;
- To recommend alternatives, that mitigate or eliminate the adverse effect of density currents on navigation and throughput;
- To generate current maps (vectors) at different water depths in the vicinity of the locks up to 5 km from the new locks for SIDMAR Ship Simulator.

Study approach

- Site visit & measurement campaign
- Analysis of field data and measurements
- Understanding of phenomena
- Set-up, limited calibration & validation of far-field model
- Set-up, calibration & validation of detailed model
- Include and extend for future siuation in Third Lane model
- Run various scenarios for design of the approach channel
- Prepare current maps

Site visit & measurement campaign

Current Measurements – RCM9

RCM-9 selflogging multi- probe

Current

Magnitude

Direction

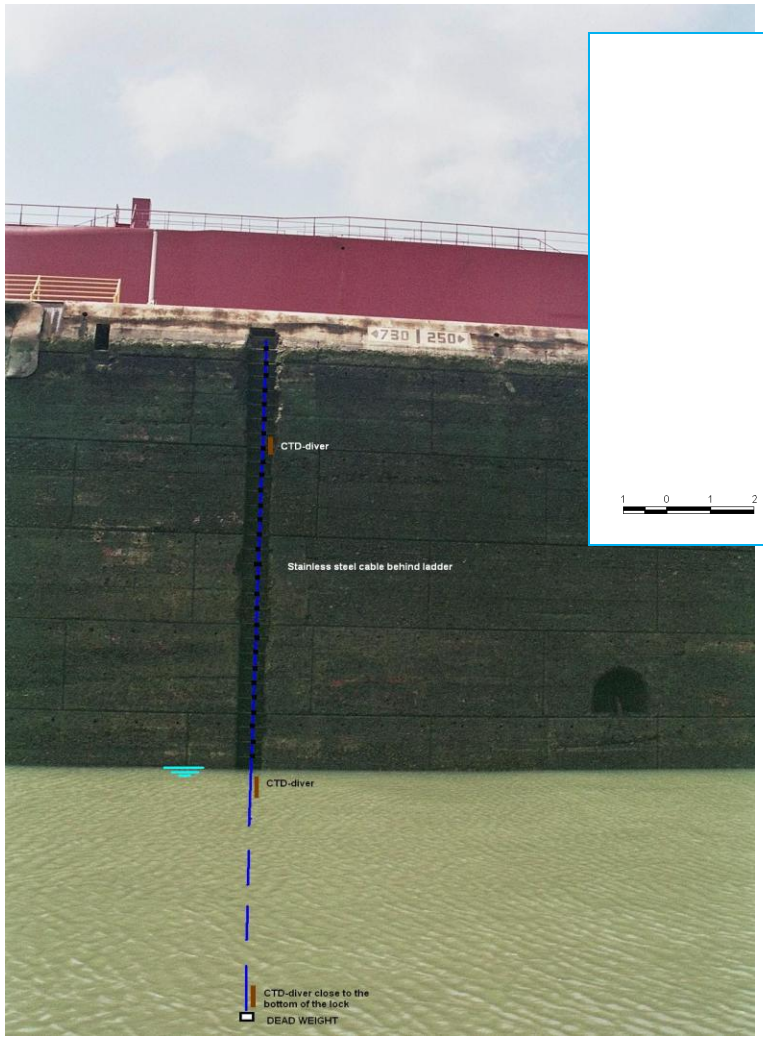
Conductivity

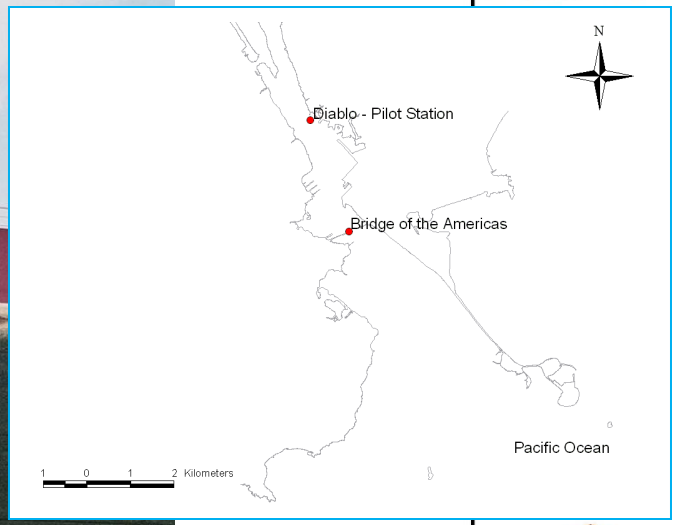
Temperature

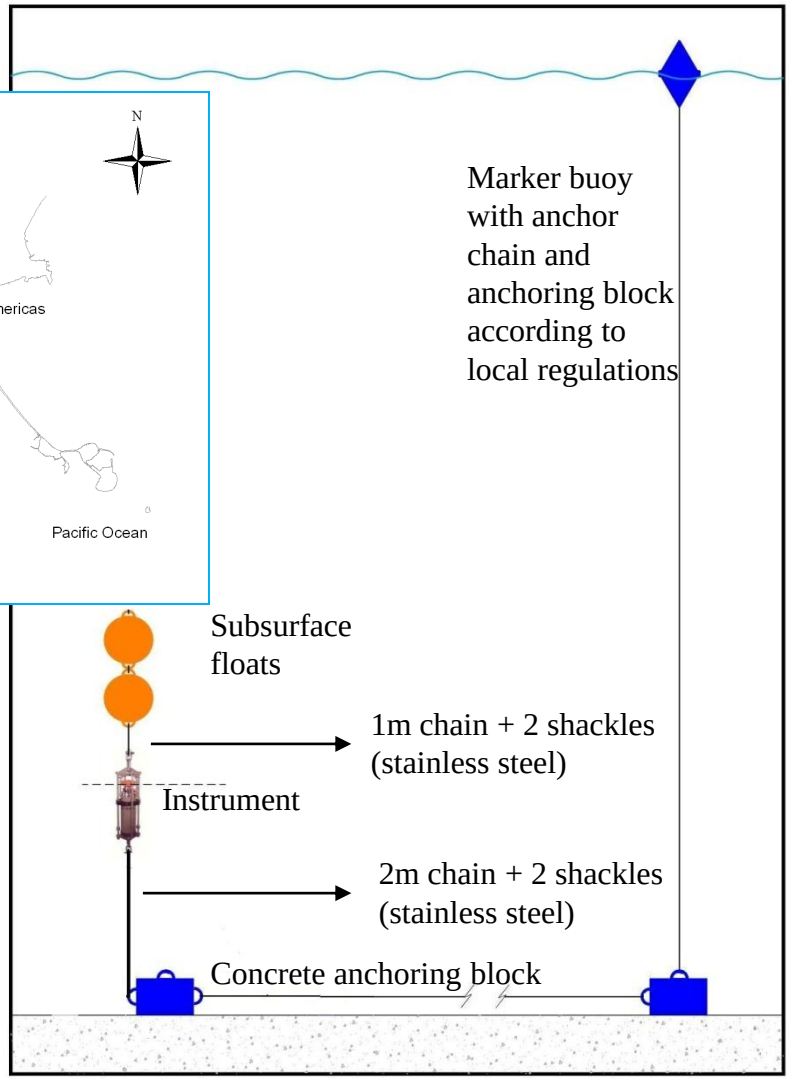
Depth

Turbidity

Stationary Measurements :Location & Schedule

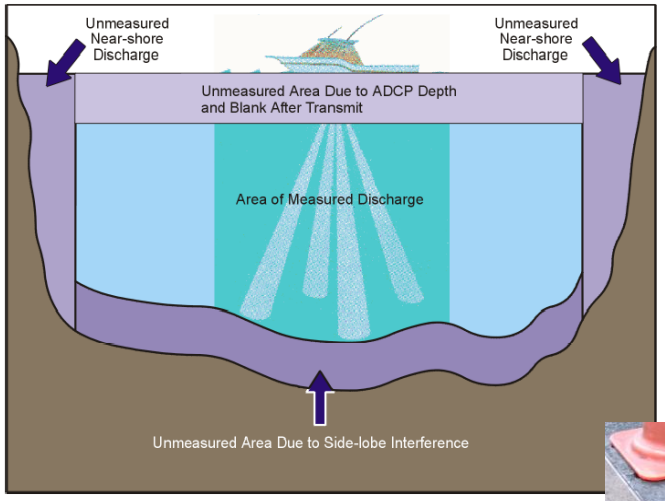






Site visit & measurement campaign

Current Measurements - ADCP



Site visit & measurement campaign

Salinity Measurements – SiltProfiler

High Frequency (100 Hz)

Wireless (acquisition &transmission)

Freefall Profiling

3 Silt sensors:

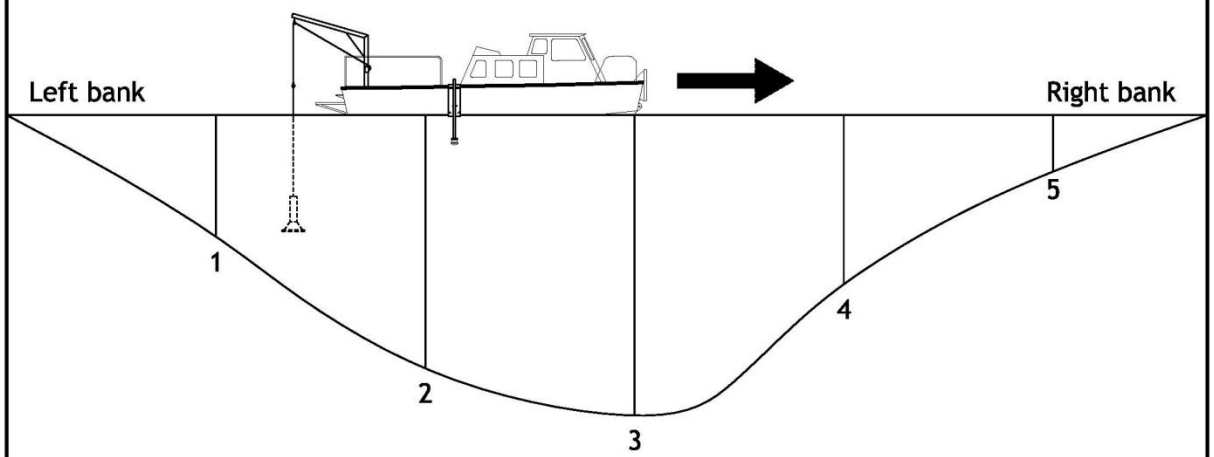
- 1 Seapoint BS sensor (0-700 mg/l)
- 2 Transmittance Extinction Sensors (500-5000 mg/l & 5000 – 35000 mg/l)

CTD sensor +backup sensor

Site visit & measurement campaign

Mobile Measurements: set-up

Throughtide measurement : velocity + salinity structure
* Duration = 12.5 Hrs (one tidal cycle)
* Location = Fixed transect (Cross section) left bank - right bank
4-5 fixed stations along transects

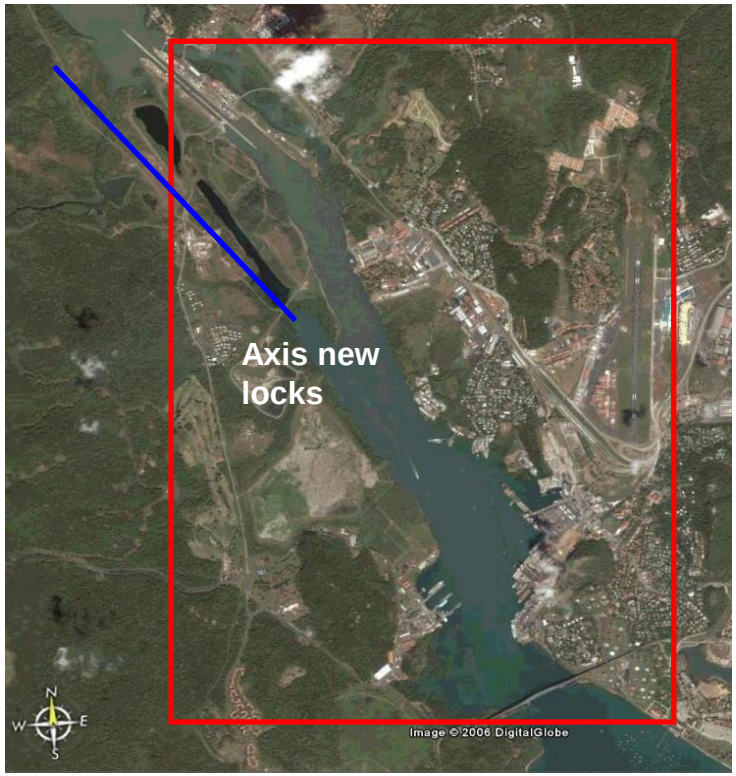


* 1 cycle - ADCP transect left to right bank
- Siltprofiles right to left bank at locations 5, 4, 3, 2, 1

Single cycle duration = approx. 30 minutes.

Far-field model

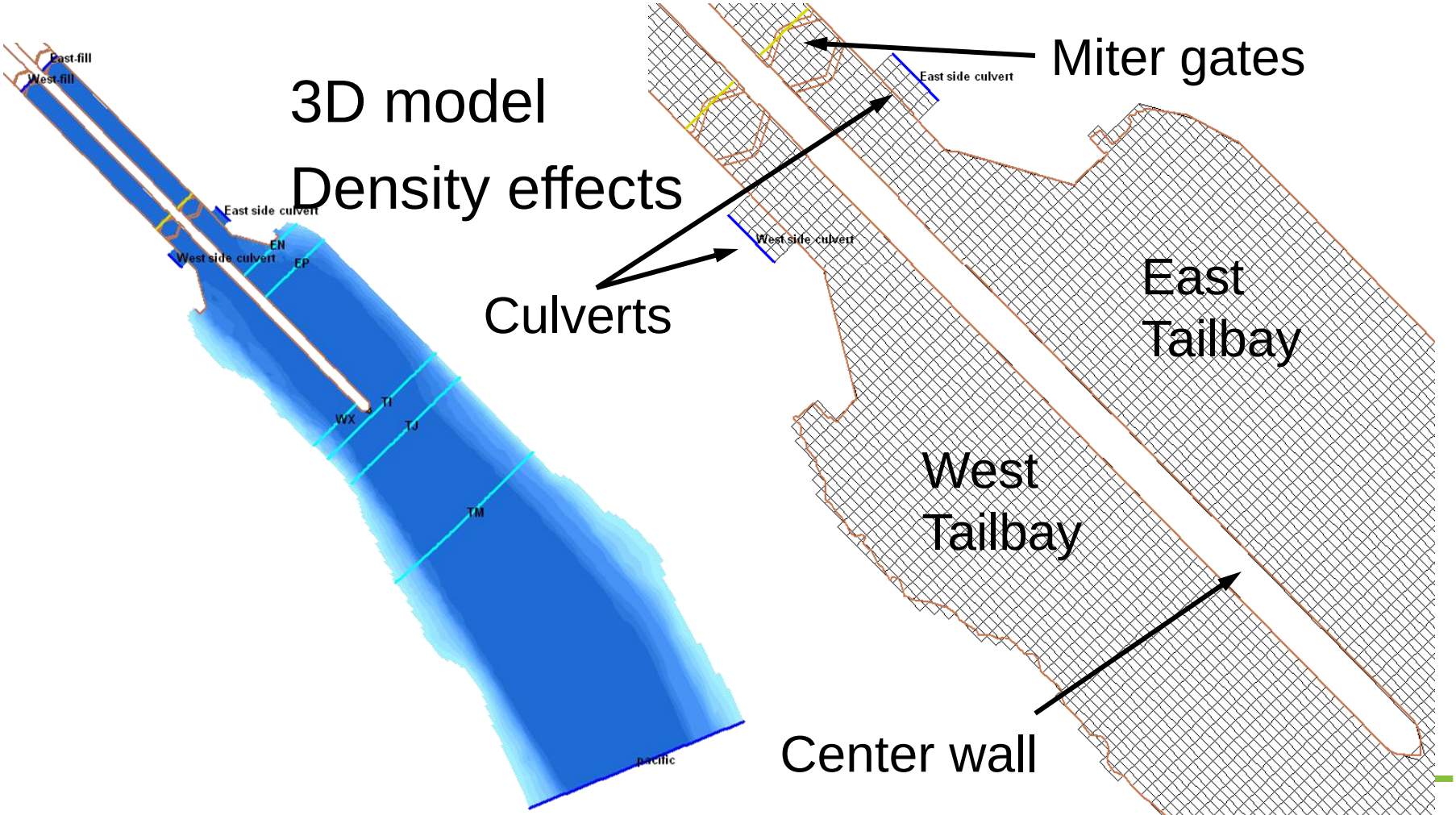
- Understanding of the flow and density structure in estuary
- In particular the <u>average</u> effect of spills and exchange currents on the far-field salinity gradients
- Compute density currents and cross-currents in far-field (up to 5km from locks; available up to Bridge of the Americas)
- Generate boundary conditions for detailed models



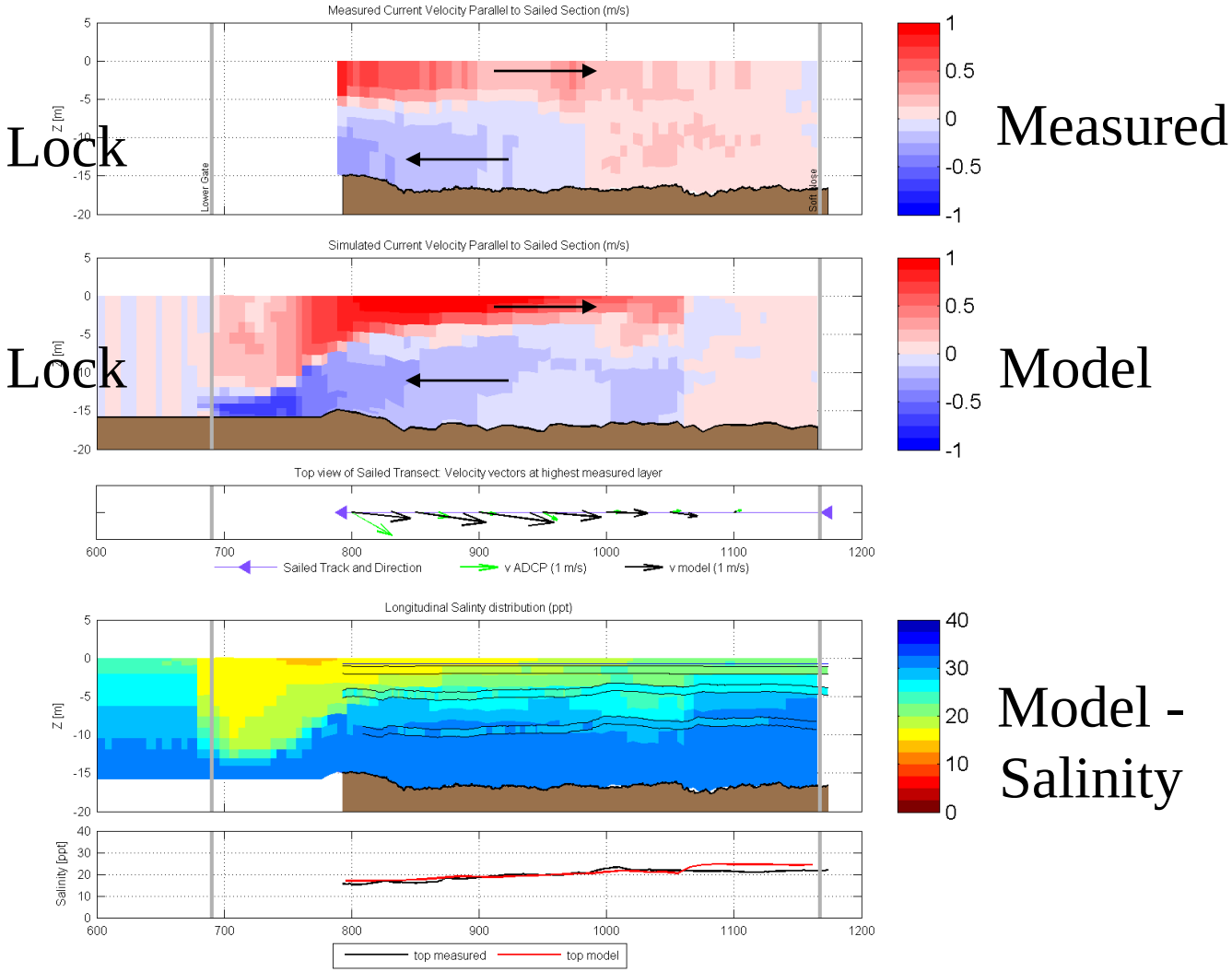
Near-field model functionality

- Understanding of local flow and density structure
- In particular the <u>momentary</u> effect of spills and exchange currents on the velocities in the vicinity of the locks
- Compute density currents and cross-currents in near-field
- Testing of alternative approach channel designs for future situation

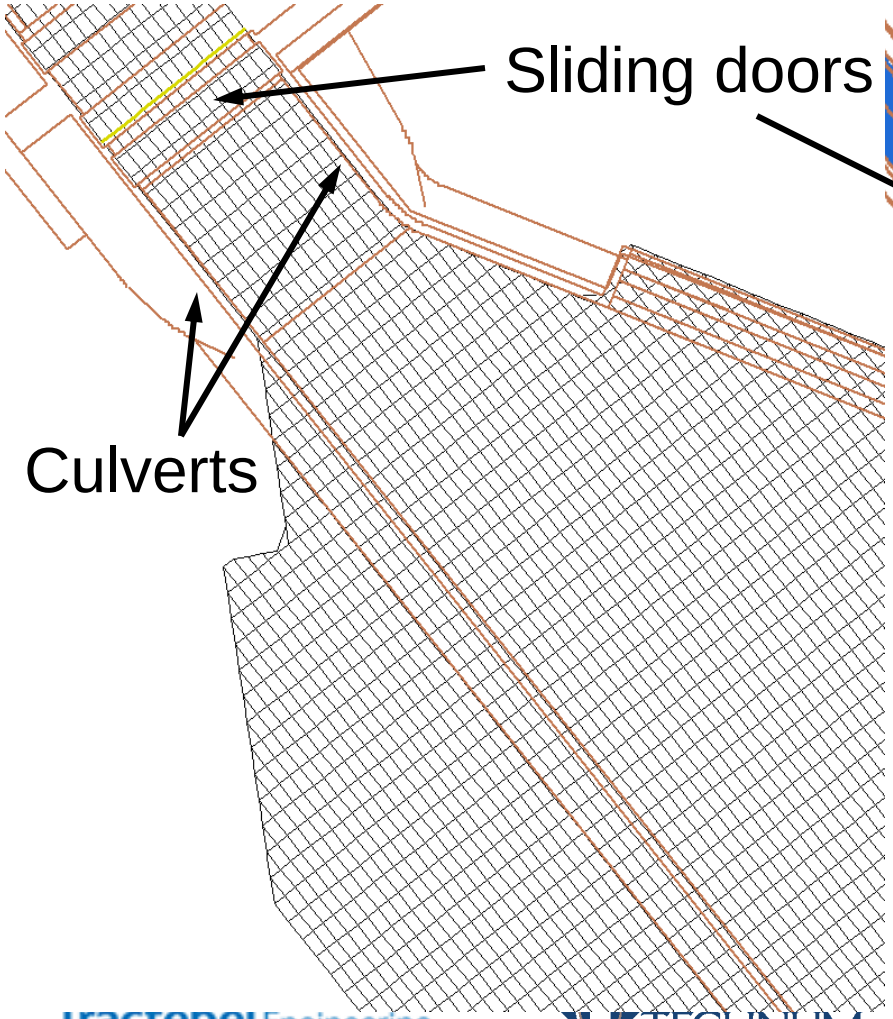
Computational grid and bathymetry

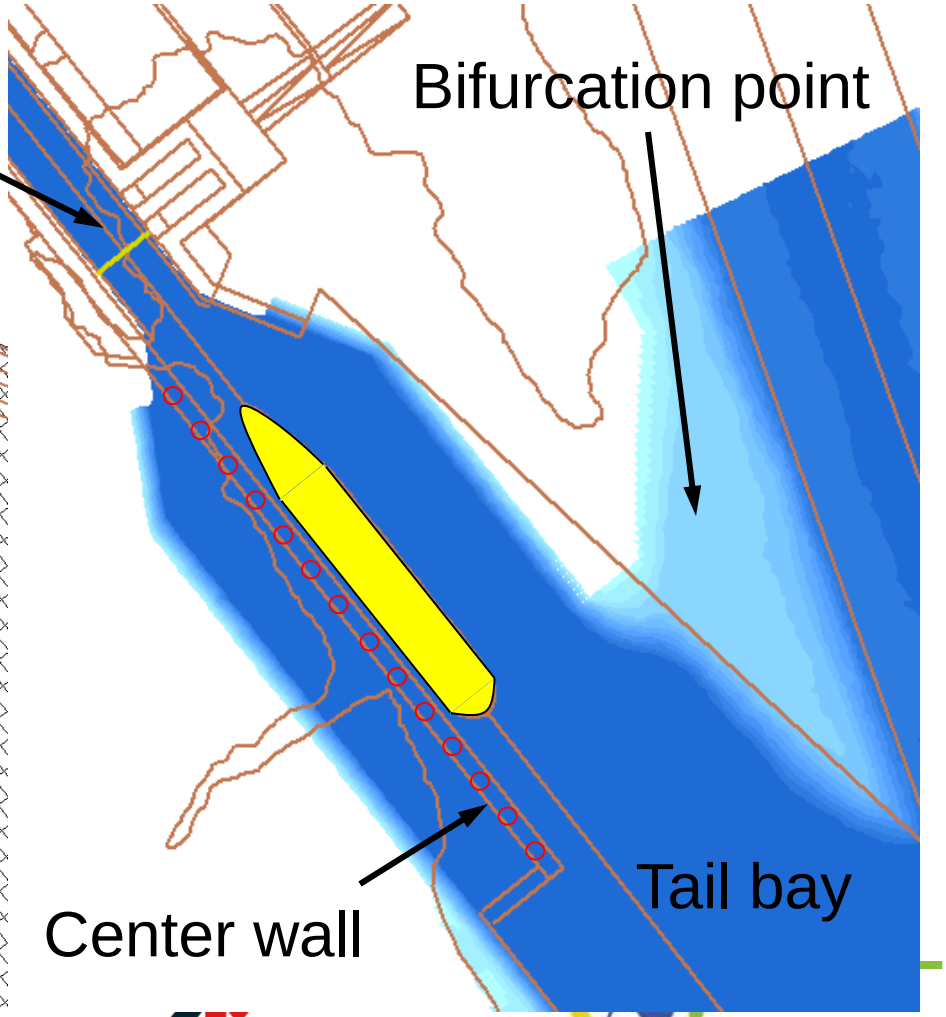


Near-Field : Longitudinal transects, spill



Model set-up third lane lock



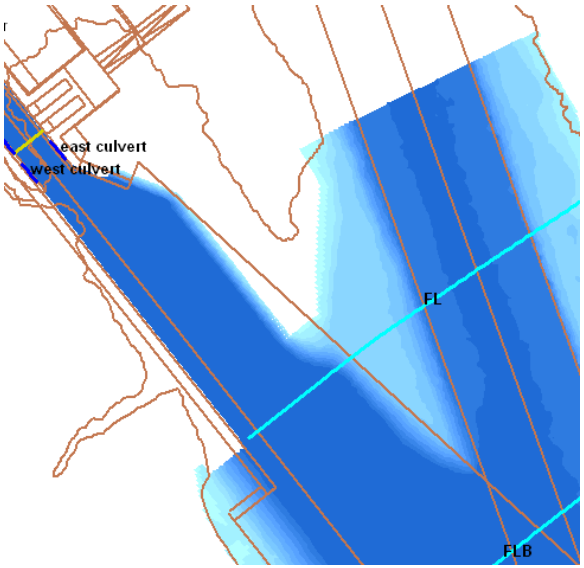


Scenarios studied

Base line scenarios

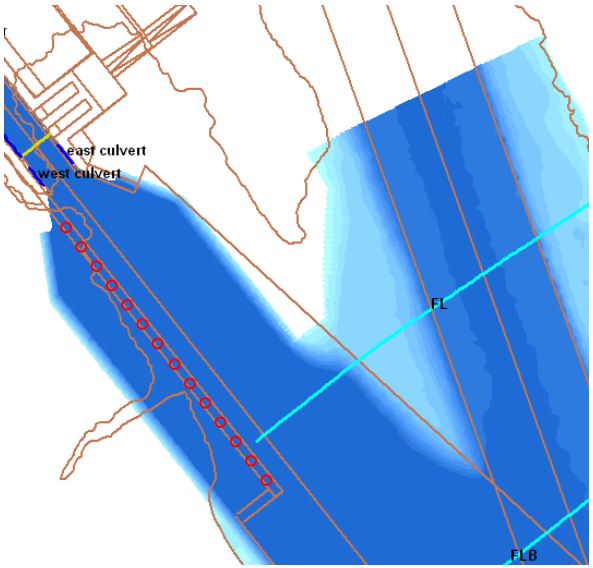
- To study the effect of the permeability of the center wall
- Invisible wall <u>without</u> and <u>with</u> Water Saving Basins

closed center wall



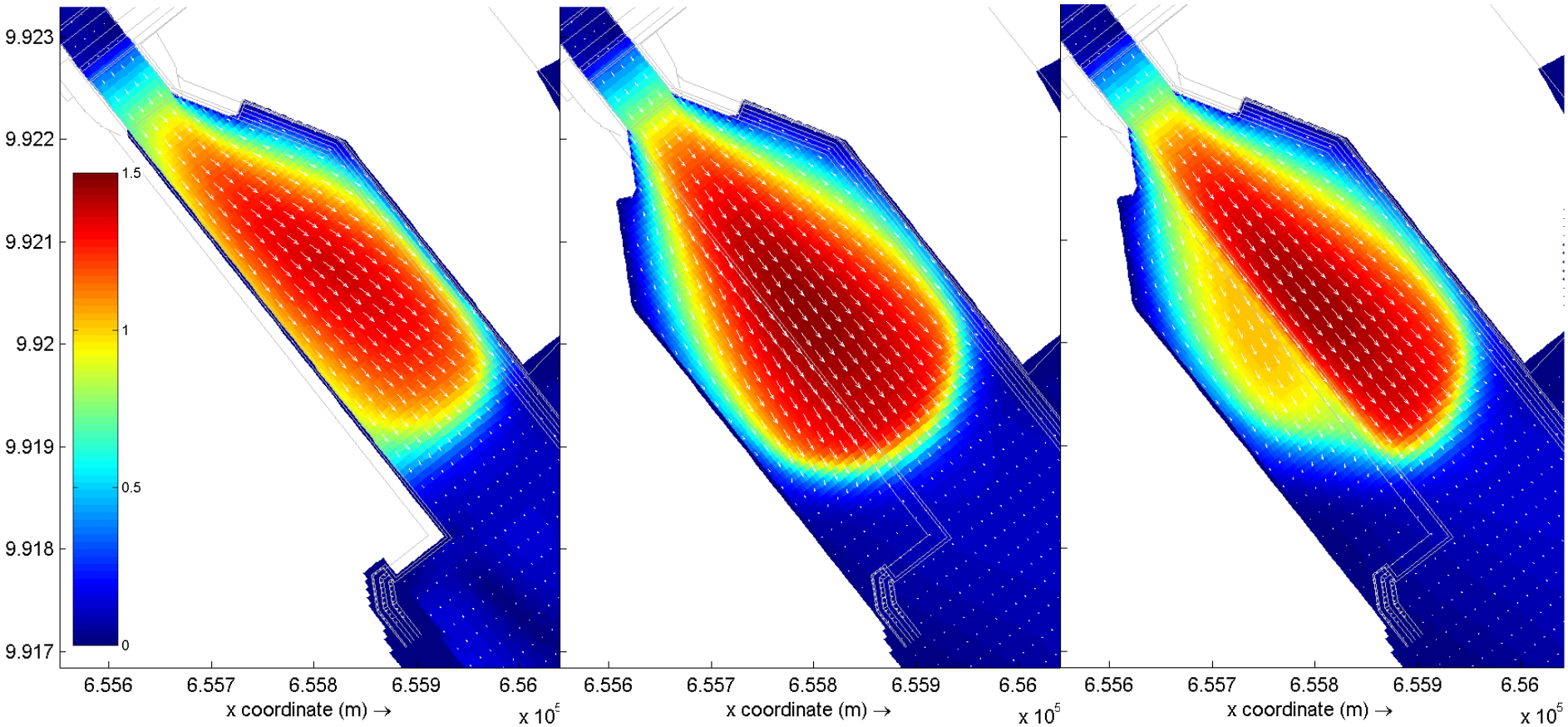
no center wall

permeable wall

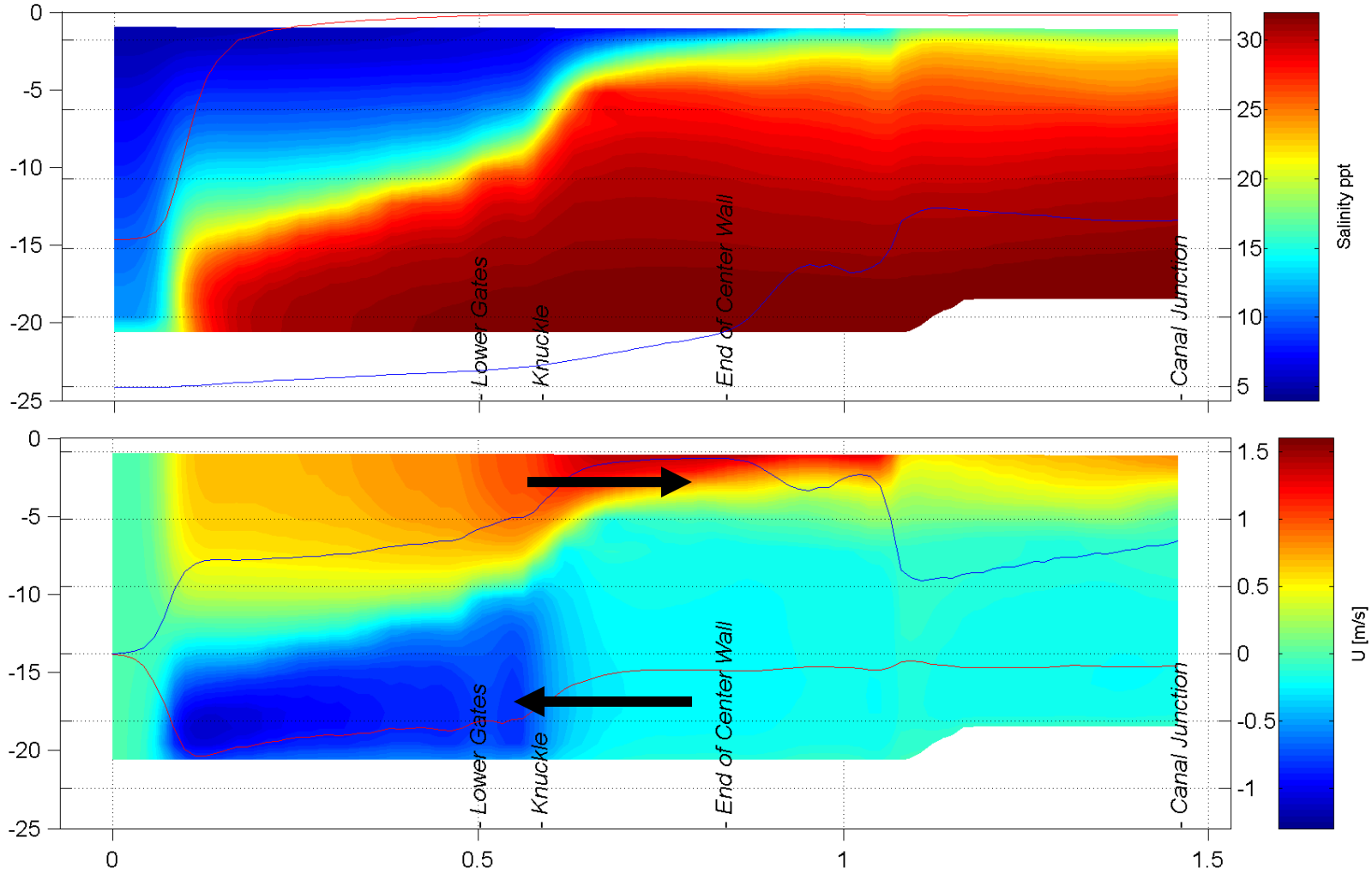


Surface velocity 10 minutes after start spill

closed center wall | no center wall | permeable wall



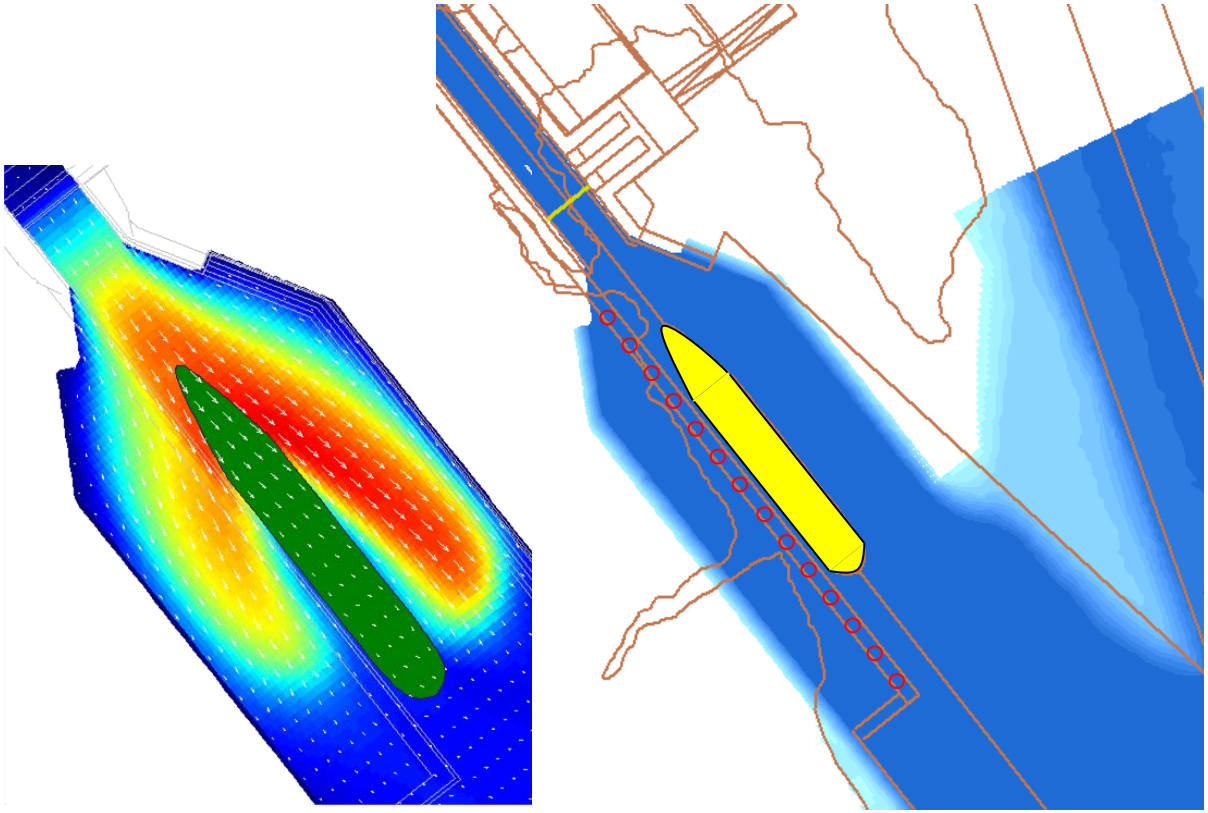
Longitudinal profile



Scenario

Ship waiting 90 meters from knuckle (stationary)

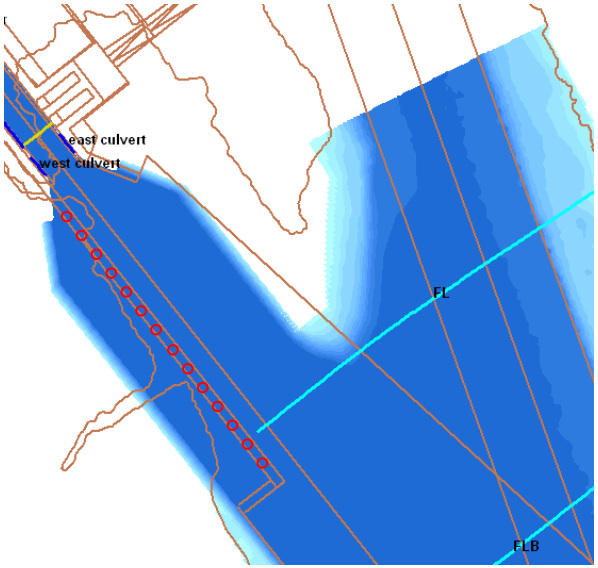
- 12.000 TEU design vessel (Flanders Hydraulics)
  - 366 m length
  - 48.8 m beam
  - 15.2 m draft



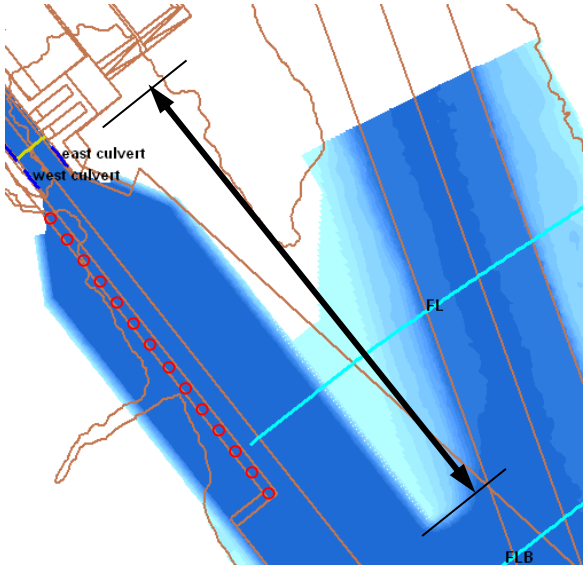
Scenarios : Shape of bifurcation point

- To create symmetrical flow in tail bay Third Lane
- To minimize impact on navigation in present channel

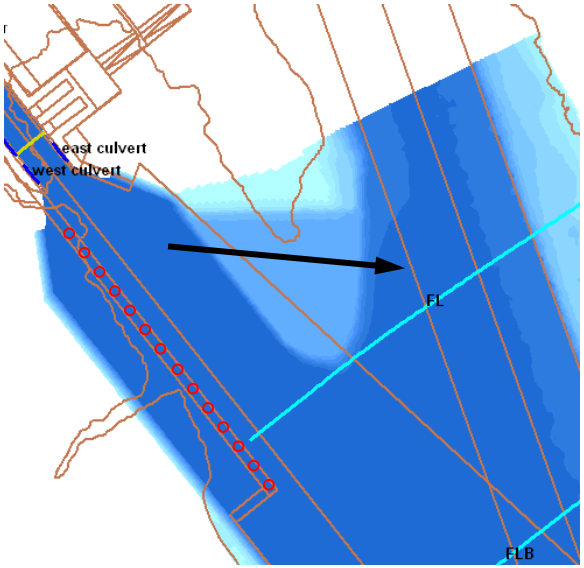
reduced



extended



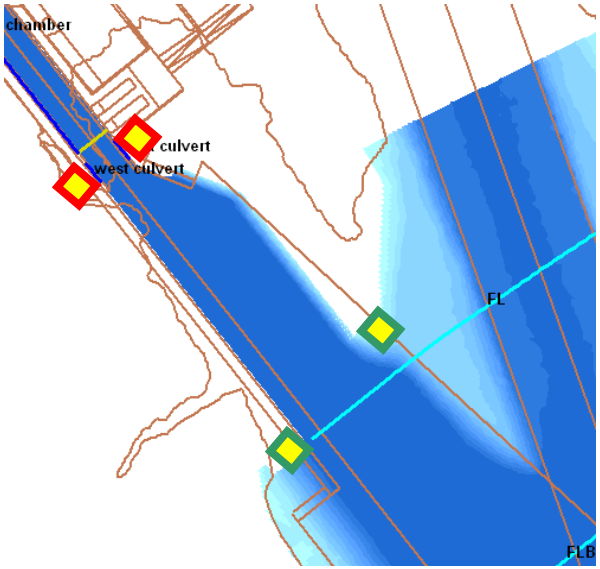
submerged (weir)



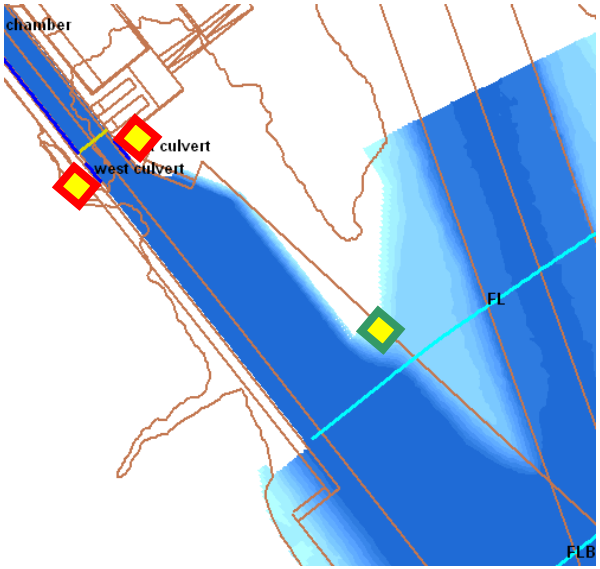
Scenarios : discharge points

- To spread-out a less confined spill discharge
- To demonstrate the effect op navigation in present channel

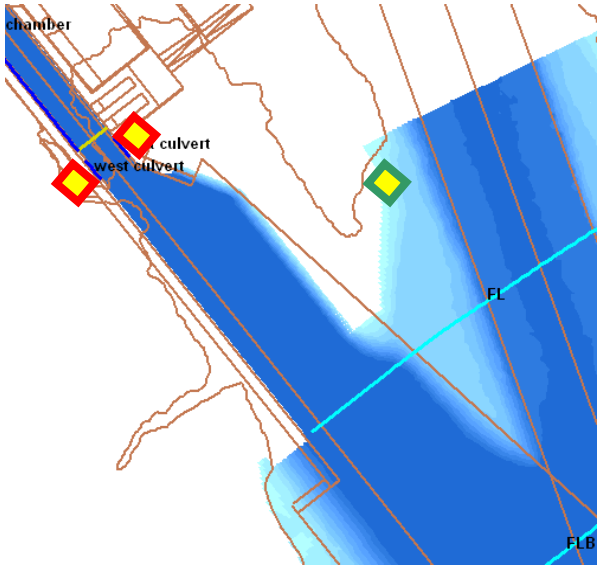
end of tailbay



east bank only

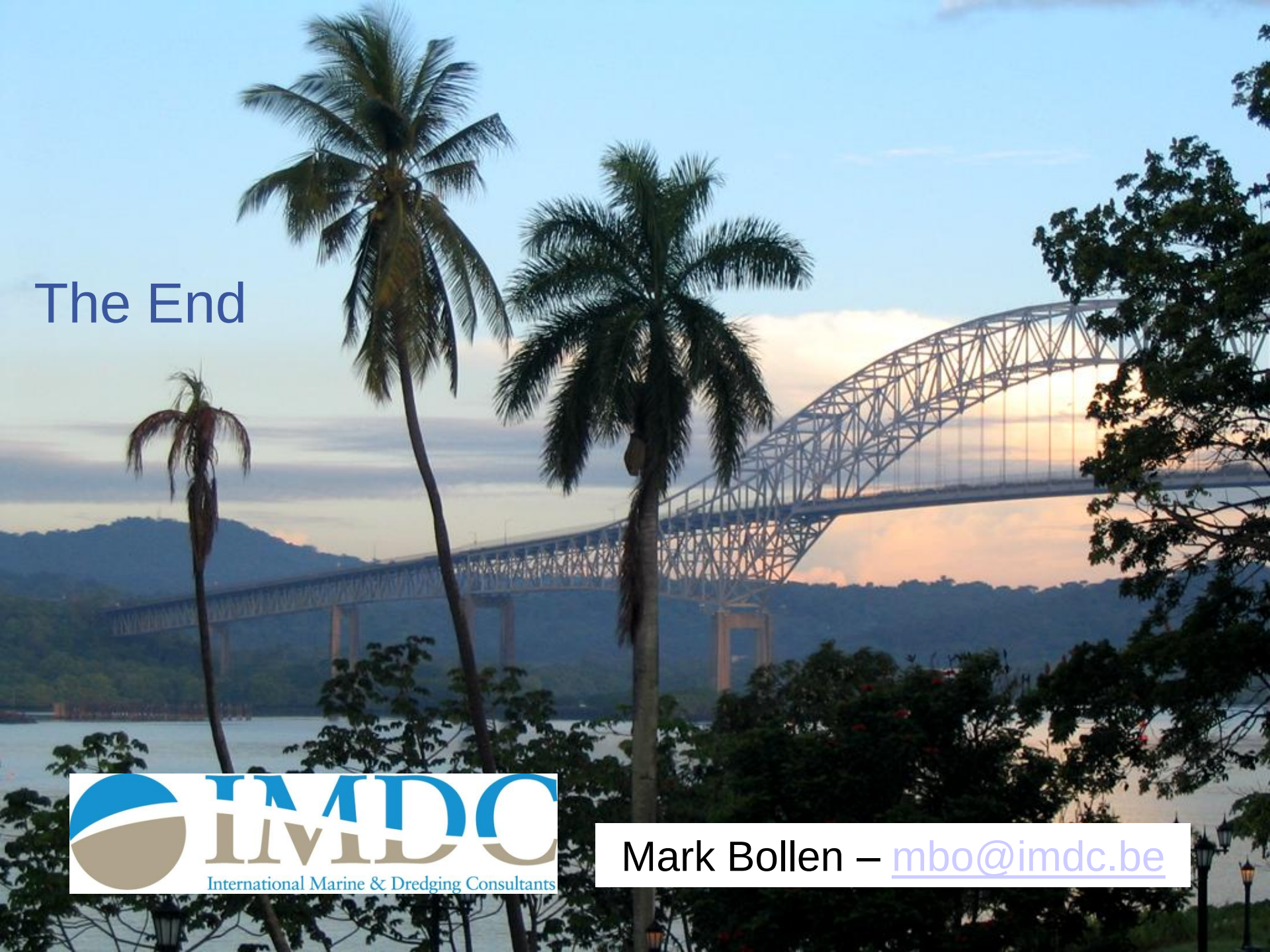


in present channel



Conclusions

- The 3D numerical model of the Third Lane approach gives detailed information on the flow structure resulting from the spill and density exchange currents;
- The model confirms that the ‘invisible’ wall leads to a symmetrical flow structure in the tailbay;
- Results of the model can be used to assess forces on the vessel while in the tailbay and the current fields can be imported in the Ship Simulator;
- Where the Third Lane approach connects to the present channel, complex flow patterns may be expected, that could negatively influence navigation to Miraflores locks;



The End

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