Bay-Delta Geometry: The Shape of Things and Salinity Mixing

Chris Enright
Suisun Marsh Branch
DWR

Regional Scale

The session so far has focused on the tidal excursion length scale (Mildred Island, Franks Tract, Honker Bay)

- What are the regional hydrodynamics and mixing impacts of estuary geometry changes?
- What are the mechanisms?
- Primer

Change Geometry, Change Region Scale Hydrodynamics

- Levee breach modeling has shown that tidal propagation can be modified on estuary scale.
- Projects that change geometry will interact and should be analyzed together.
- What other processes are modified?
- Projects require systematic physical process analysis (numerical modeling).

Estuary Geometry Changes

Goal	Geometry Change
Conveyance/Navigation	Channel dredging, widening, new connections
Levee Integrity	Levee setbacks, habitat berms
Habitat Restoration	Island flooding or partial flooded island reclamation
Salinity reduction	Flood *or* reclaim polders! (redistribute tidal energy dissipation)

“Unintended” Geometry Changes:

Catastrophic levee breaches due to

- Seismic events
- Flood runoff
- Subsidence
- Sea-level rise
- ENSO

The Salinity Regime Is Not a Given.

- Fateful decisions in the past
- Designs for the future

Key Ideas

Changing estuary geometry:

- Affects tidal propagation. (Balance of momentum, surface slope, friction forces)
- Changes the way the estuary dissipates tidal energy (increase, decrease, redistribute) through mixing.

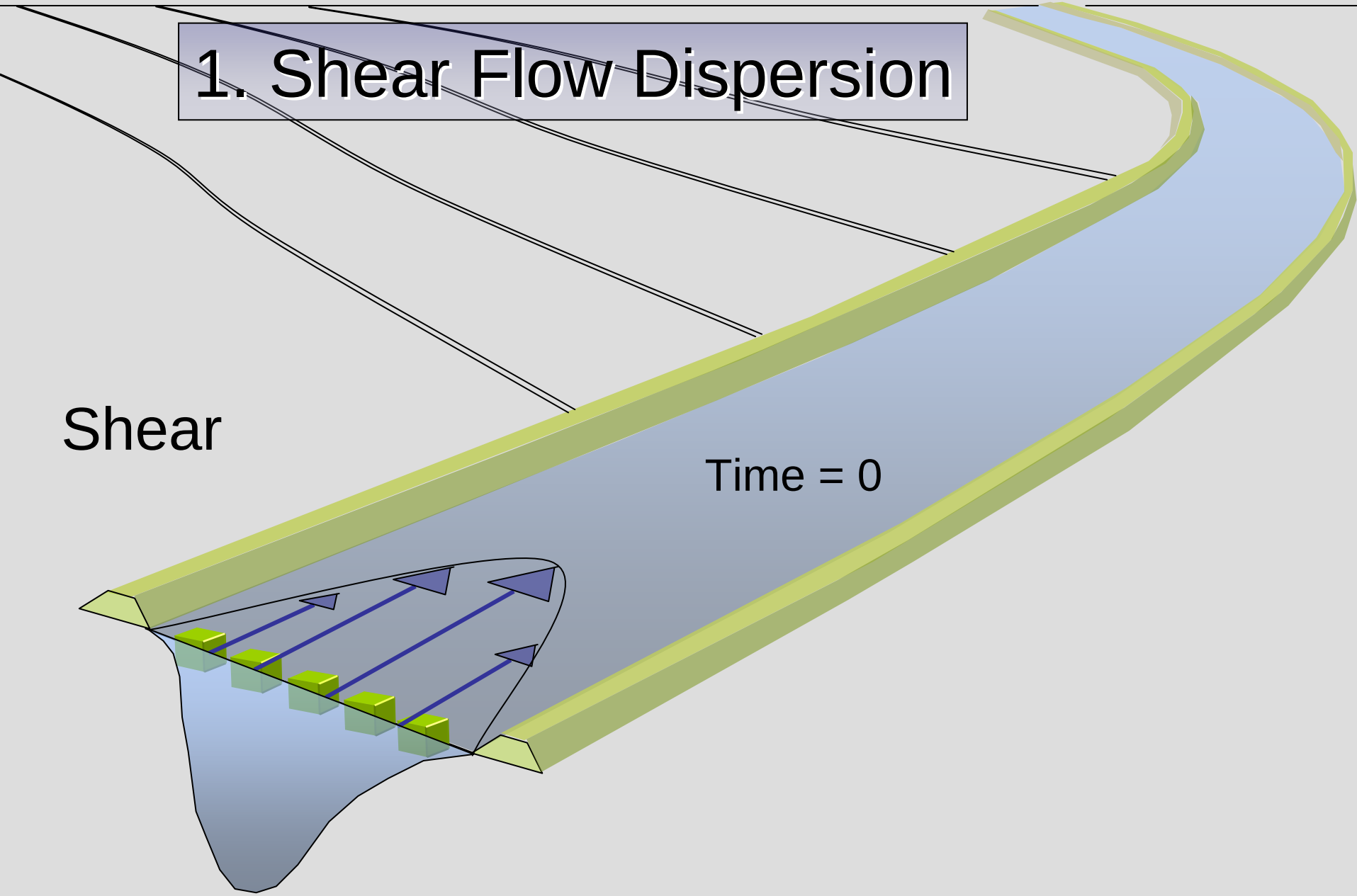
Forces That Cause Mixing

- Tides
- River flow
- Meteorology
- Density gradients
- Earth rotation

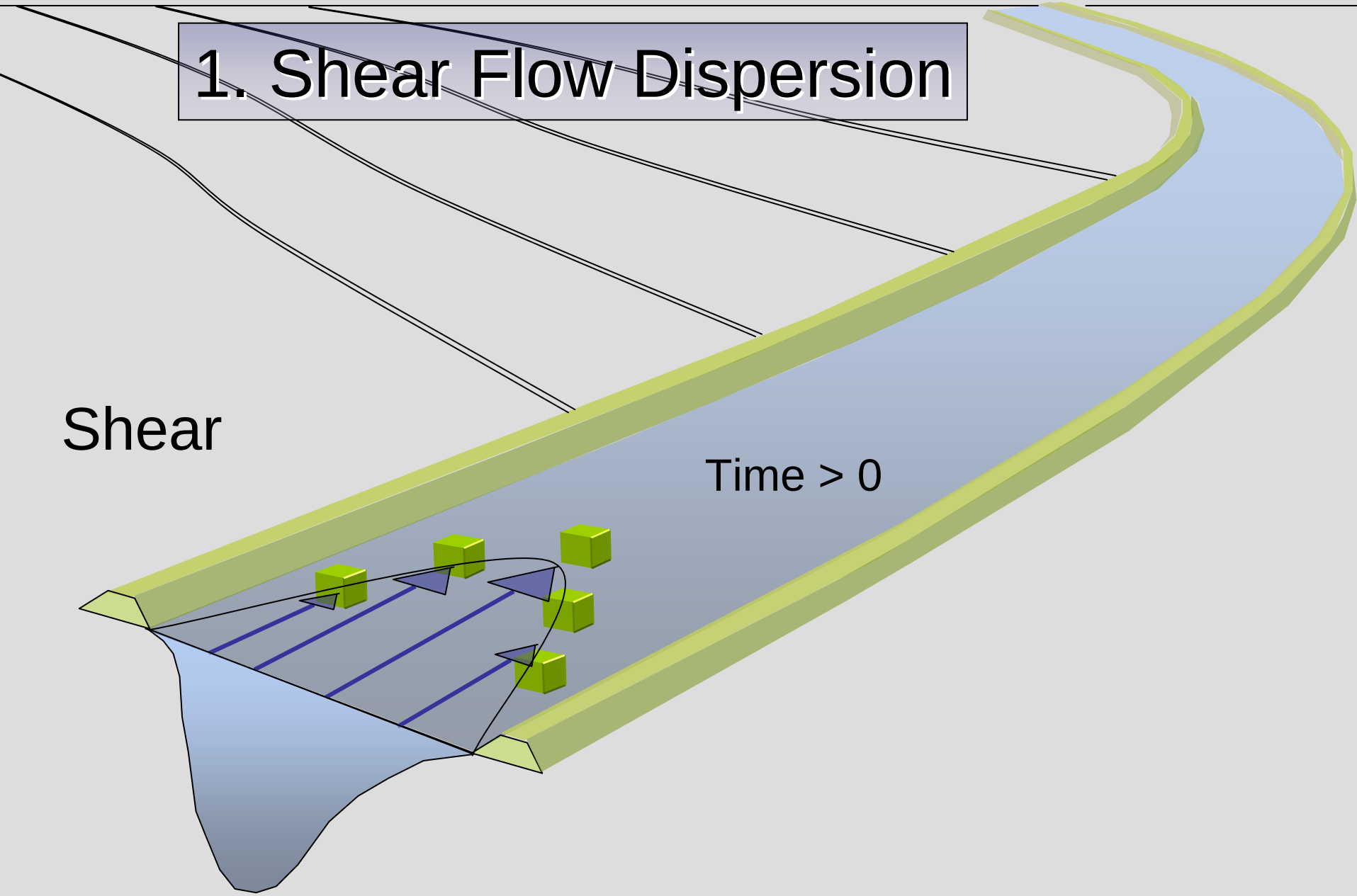
Tide Causes Mixing By:

1. Shear Flow Dispersion
2. Interaction of tidal wave with bathymetry
   - Tidal Trapping
   - Tidal Pumping

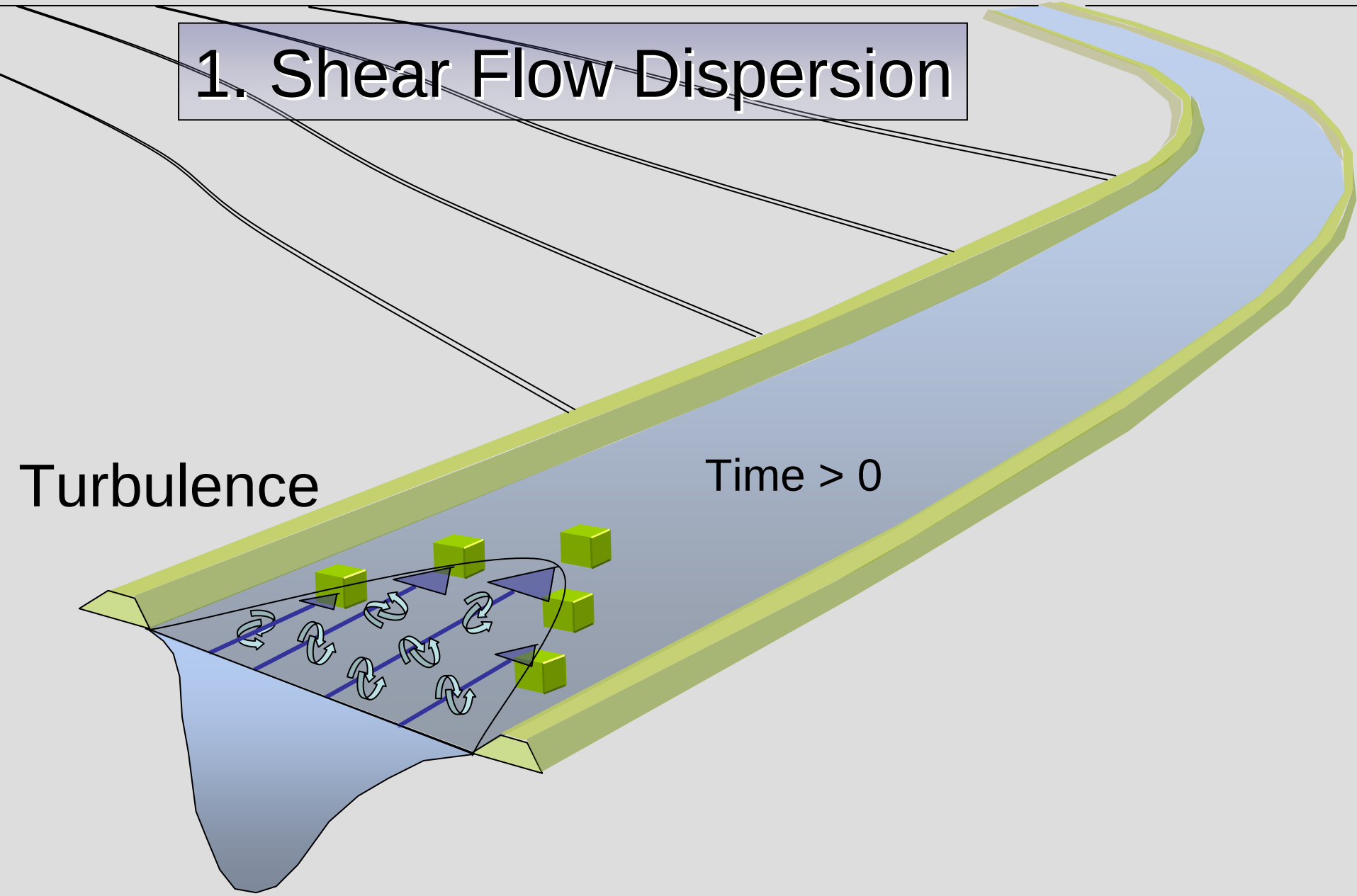
1. Shear Flow Dispersion



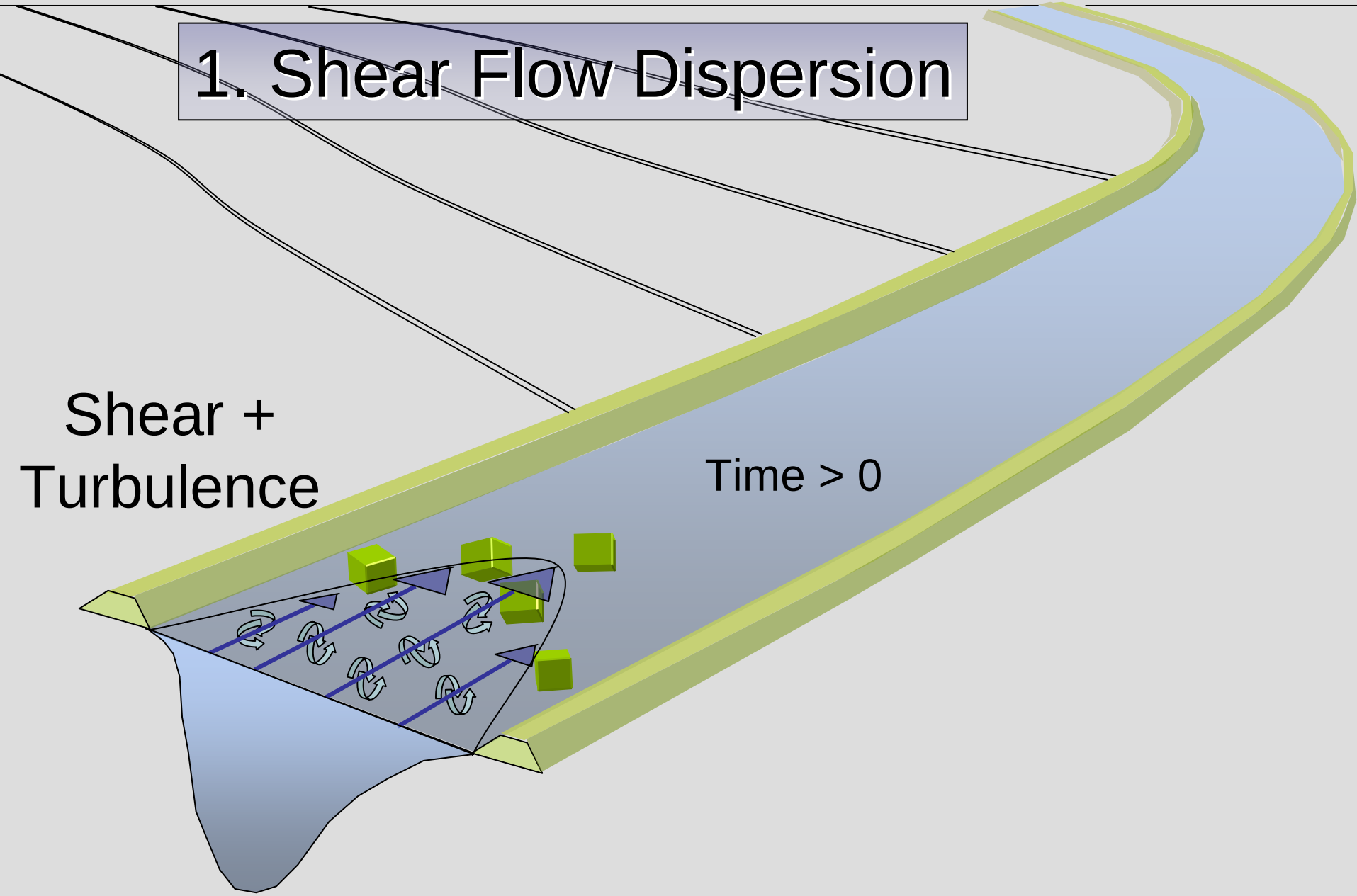
1. Shear Flow Dispersion



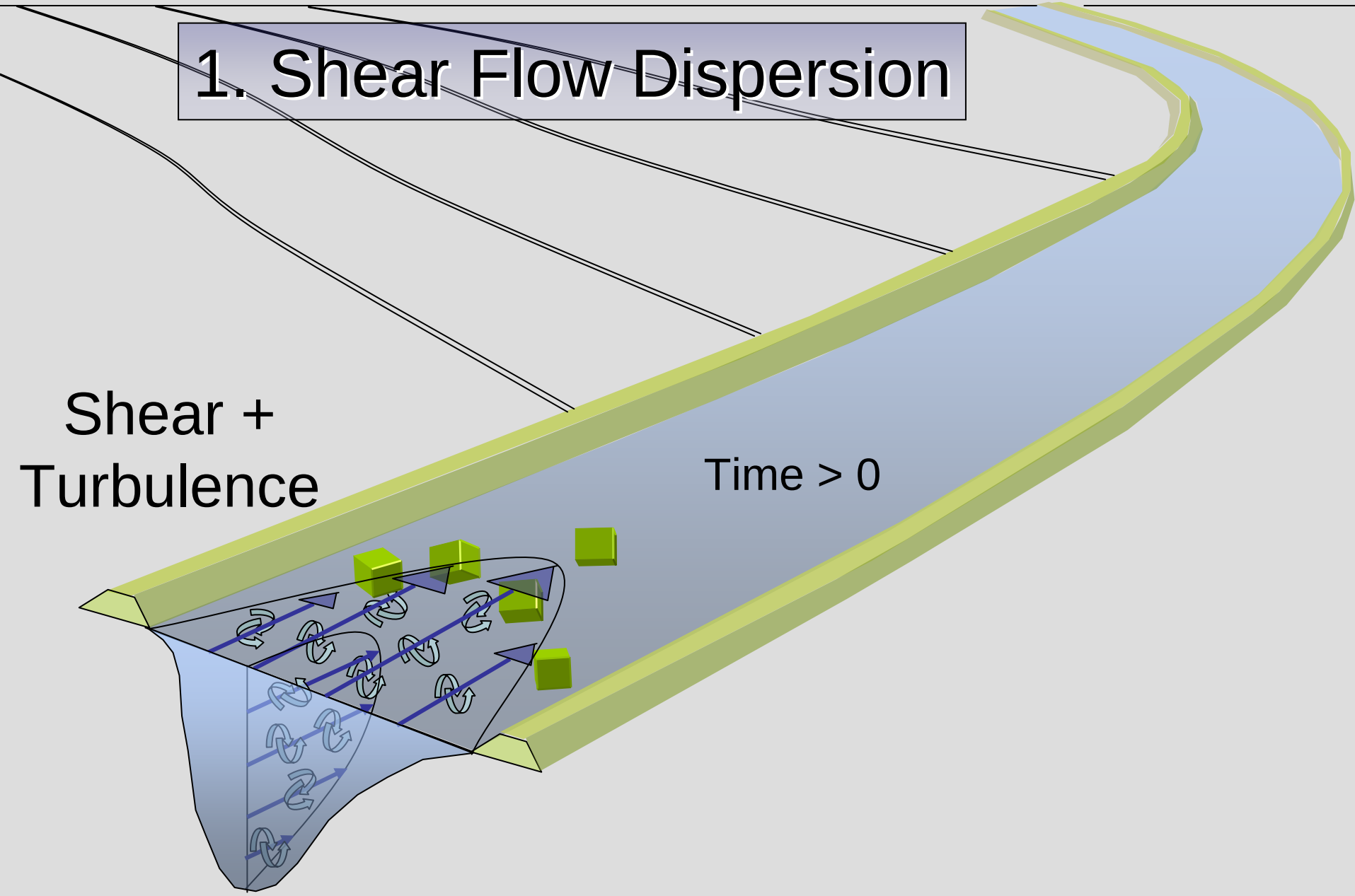
1. Shear Flow Dispersion



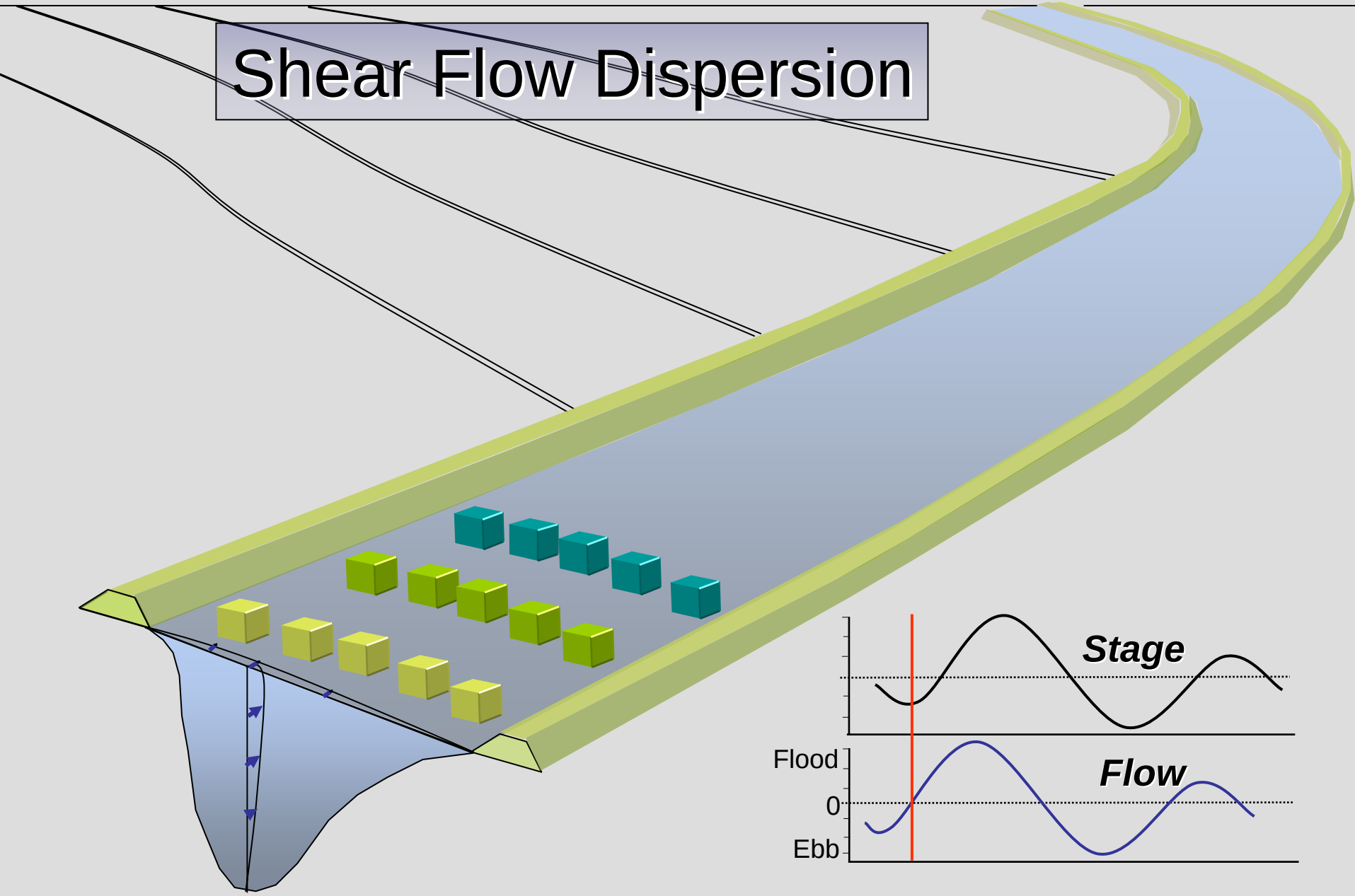
1. Shear Flow Dispersion



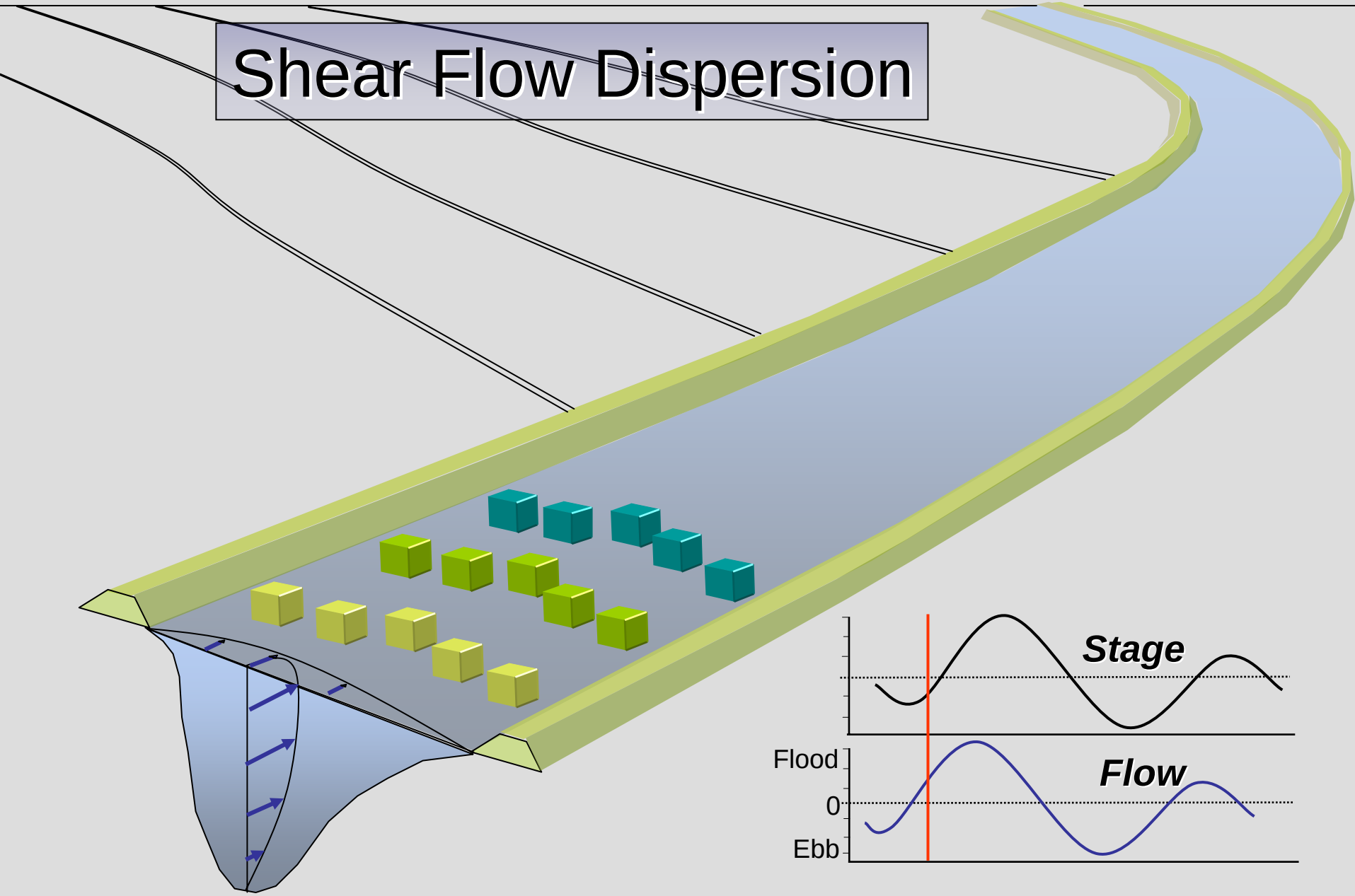
1. Shear Flow Dispersion



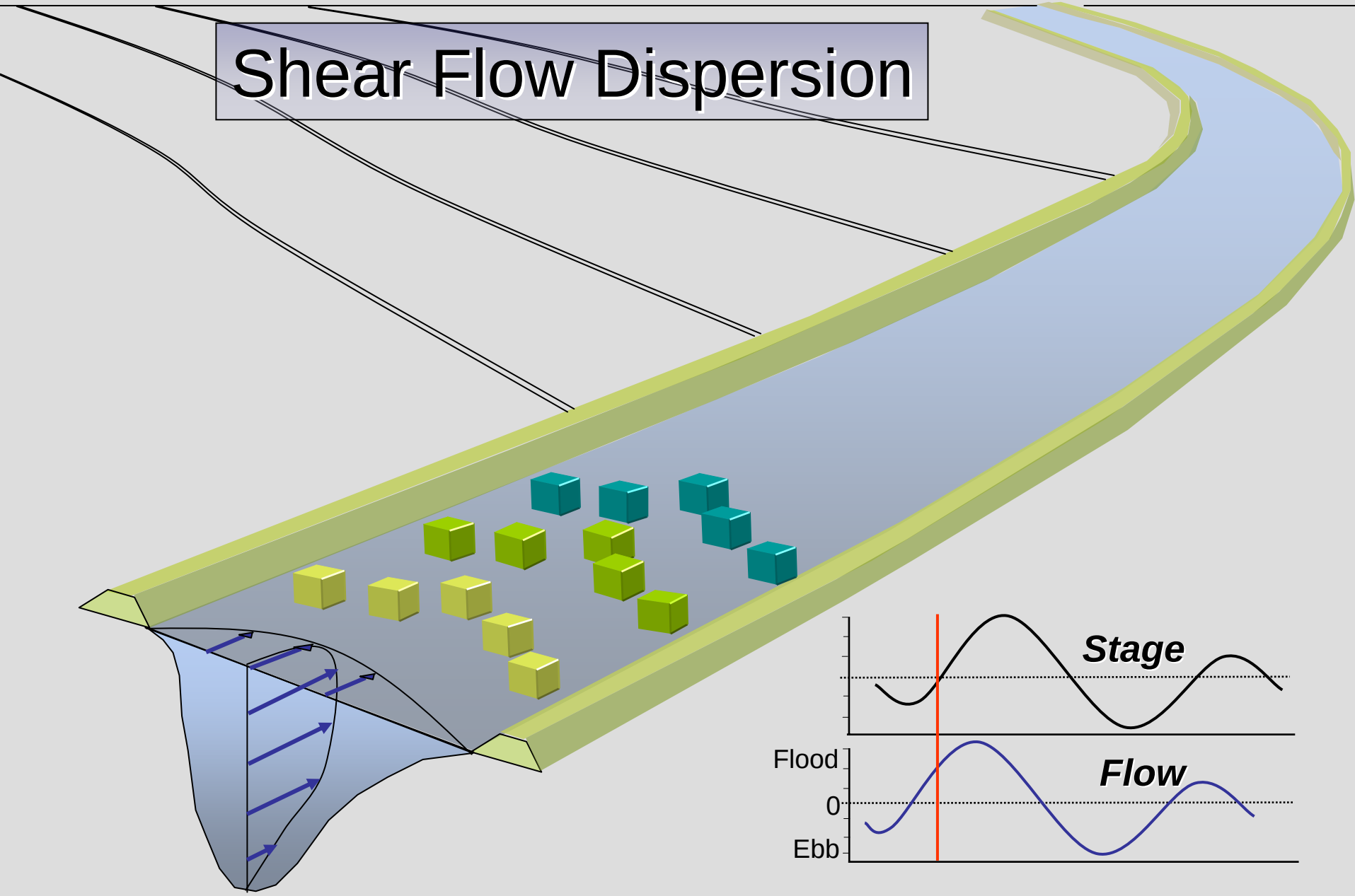
Shear Flow Dispersion



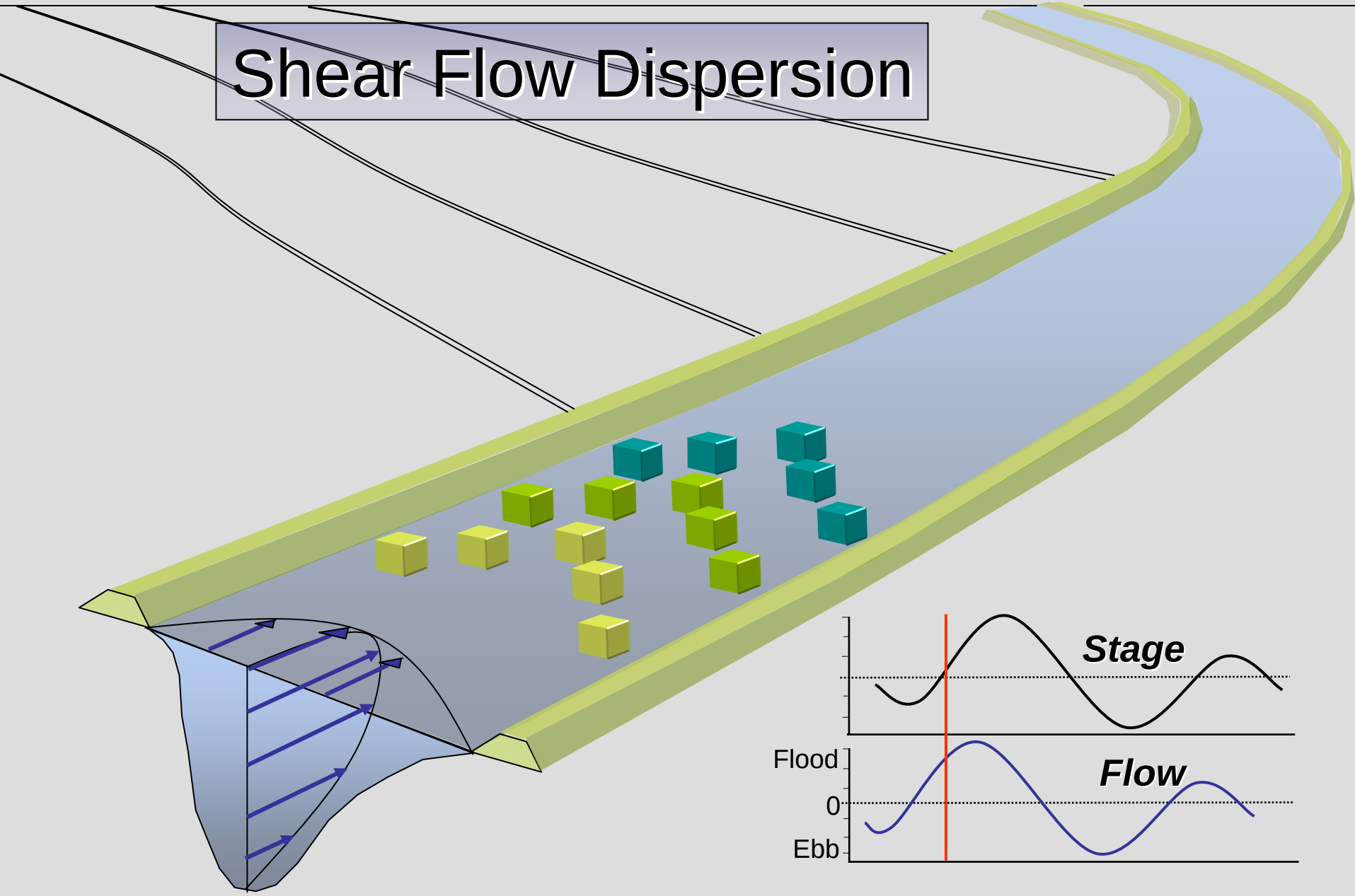
Shear Flow Dispersion



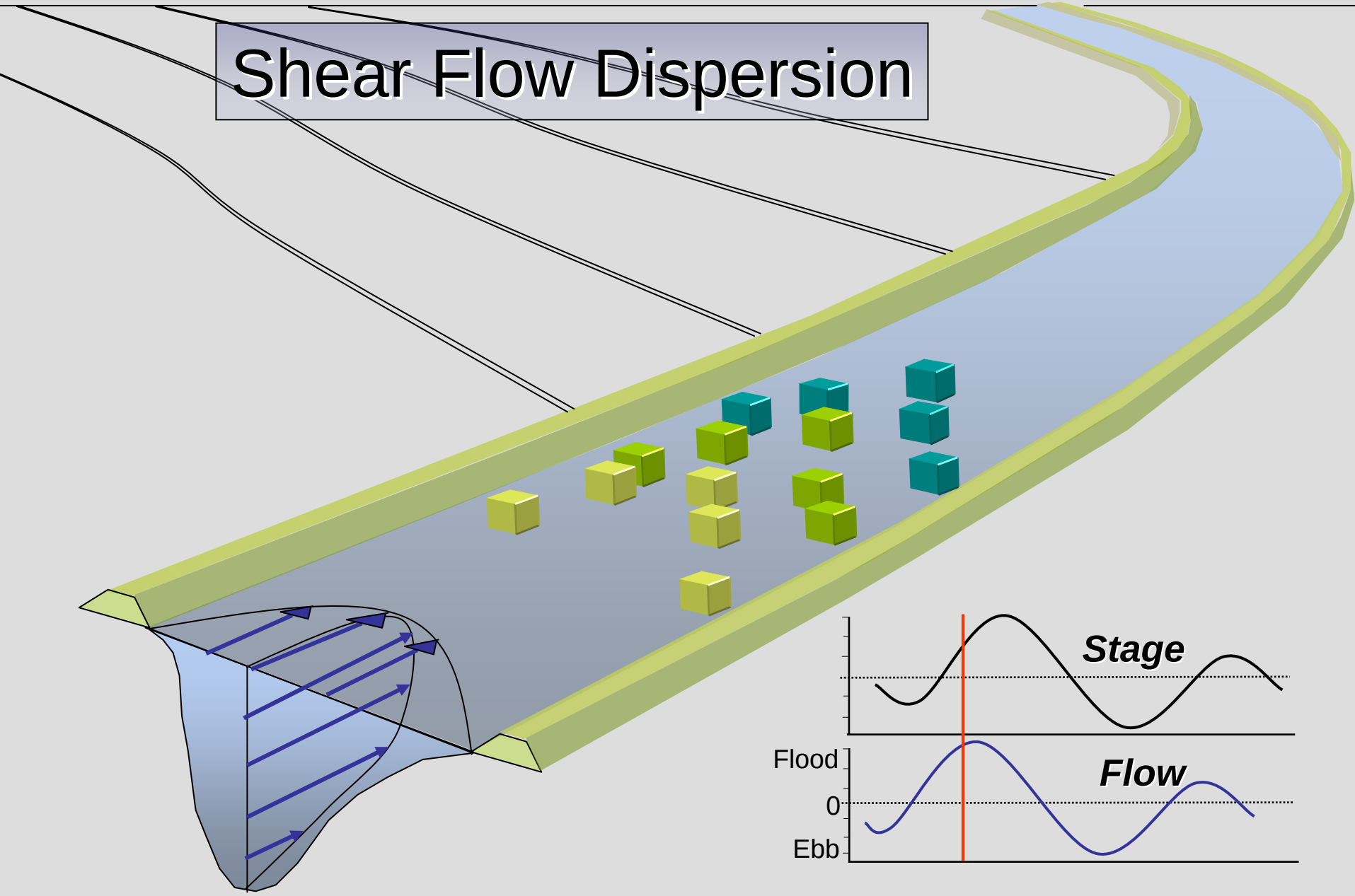
Shear Flow Dispersion



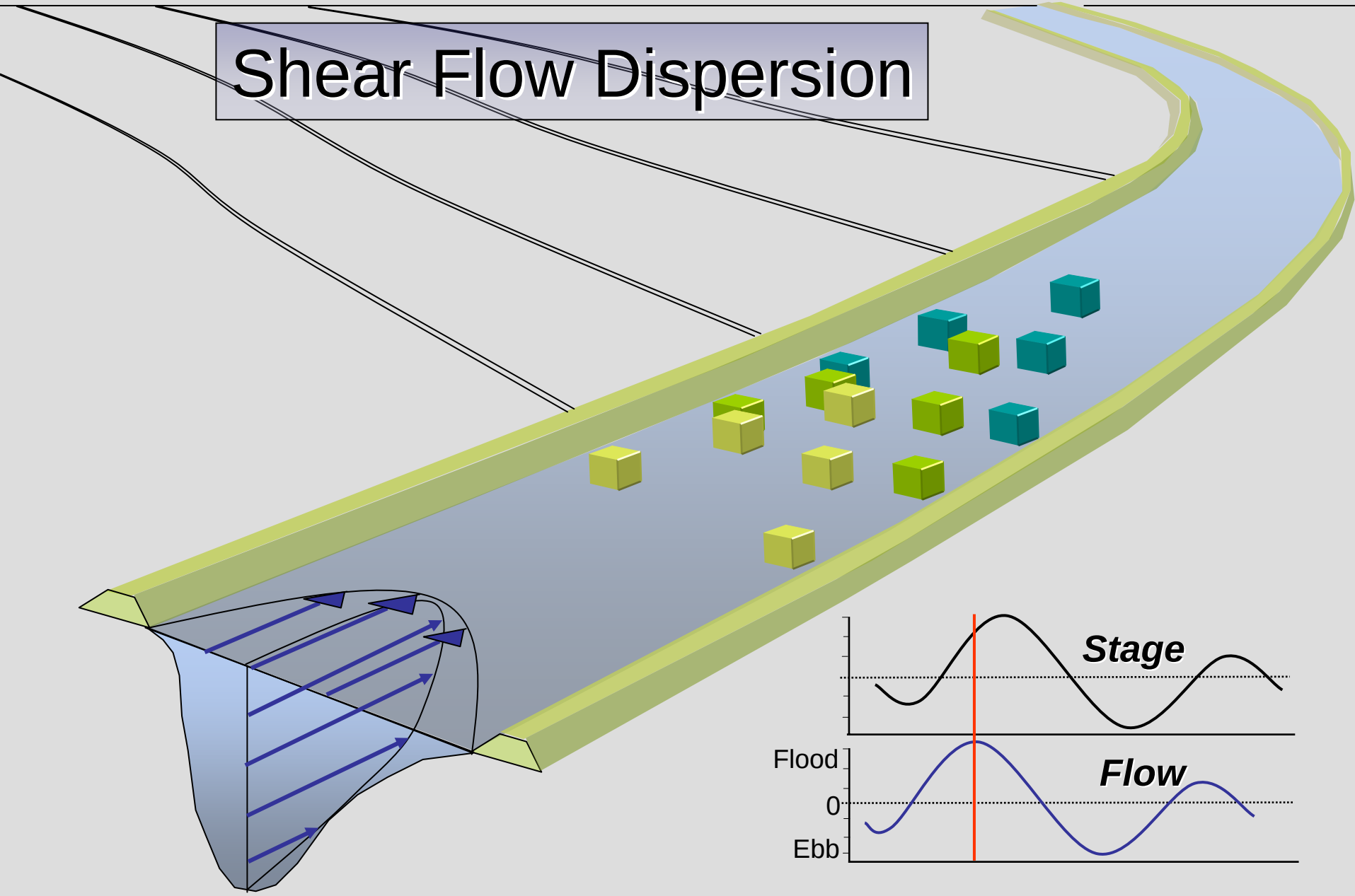
Shear Flow Dispersion



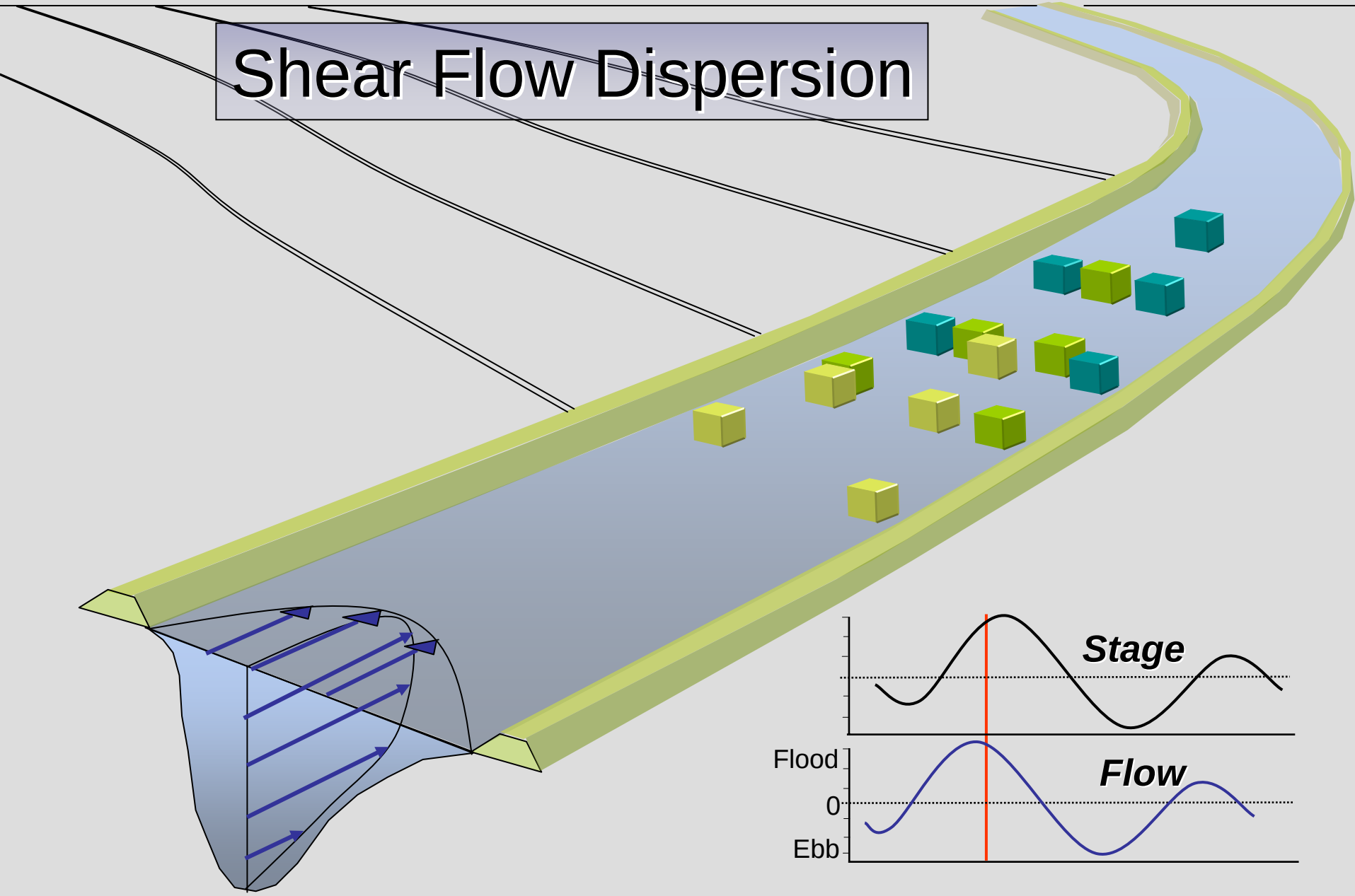
Shear Flow Dispersion



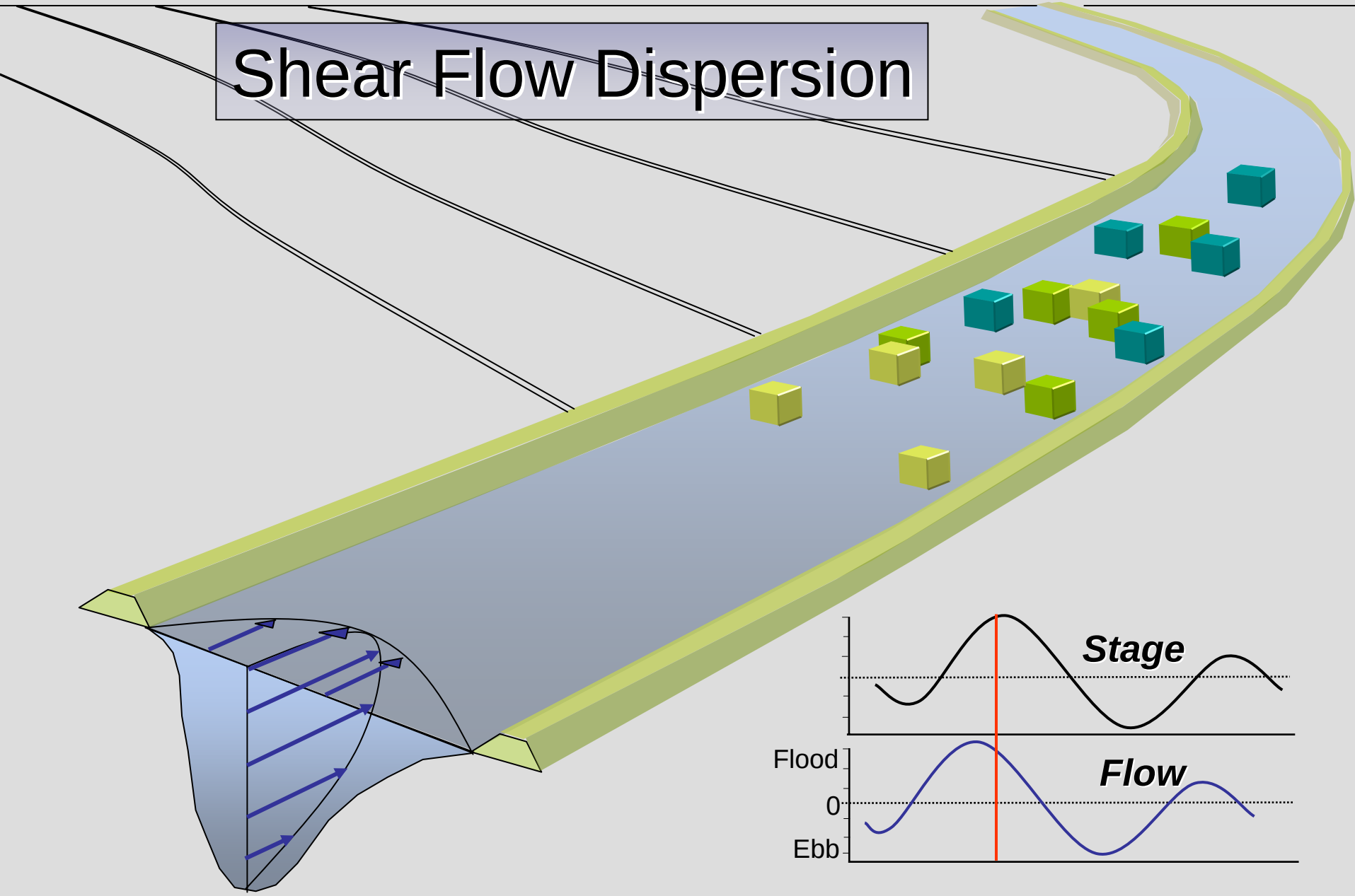
Shear Flow Dispersion



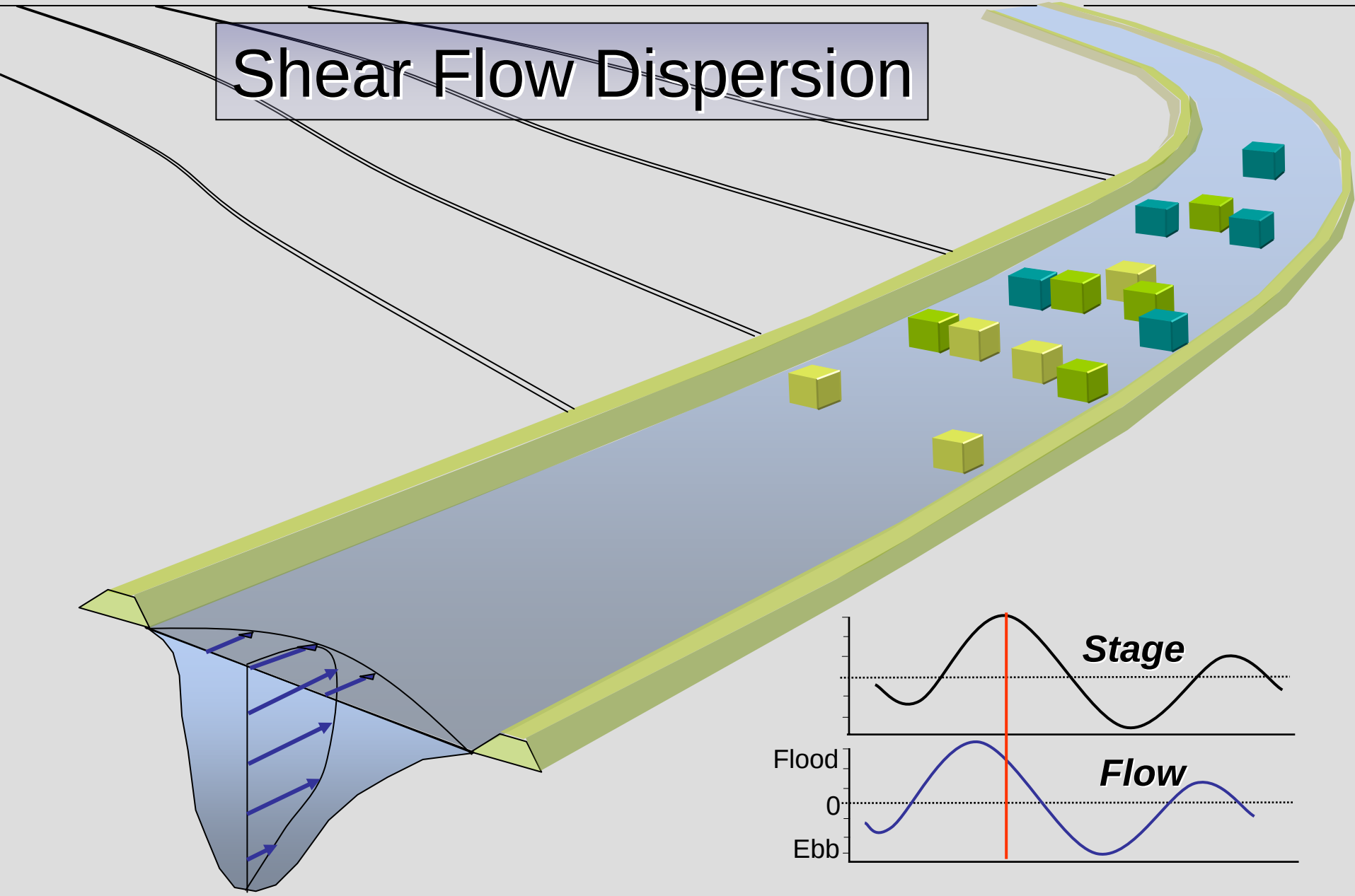
Shear Flow Dispersion



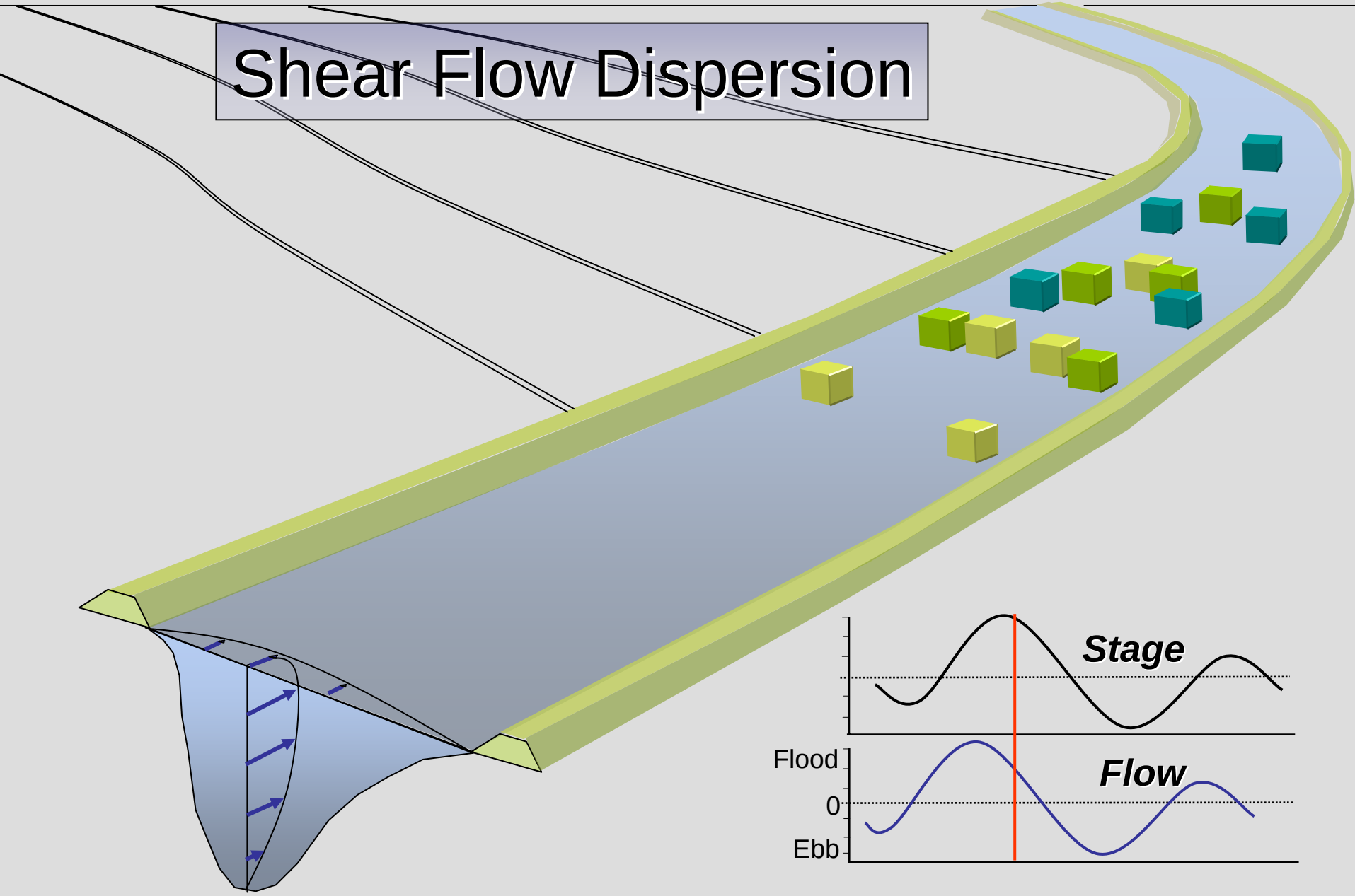
Shear Flow Dispersion



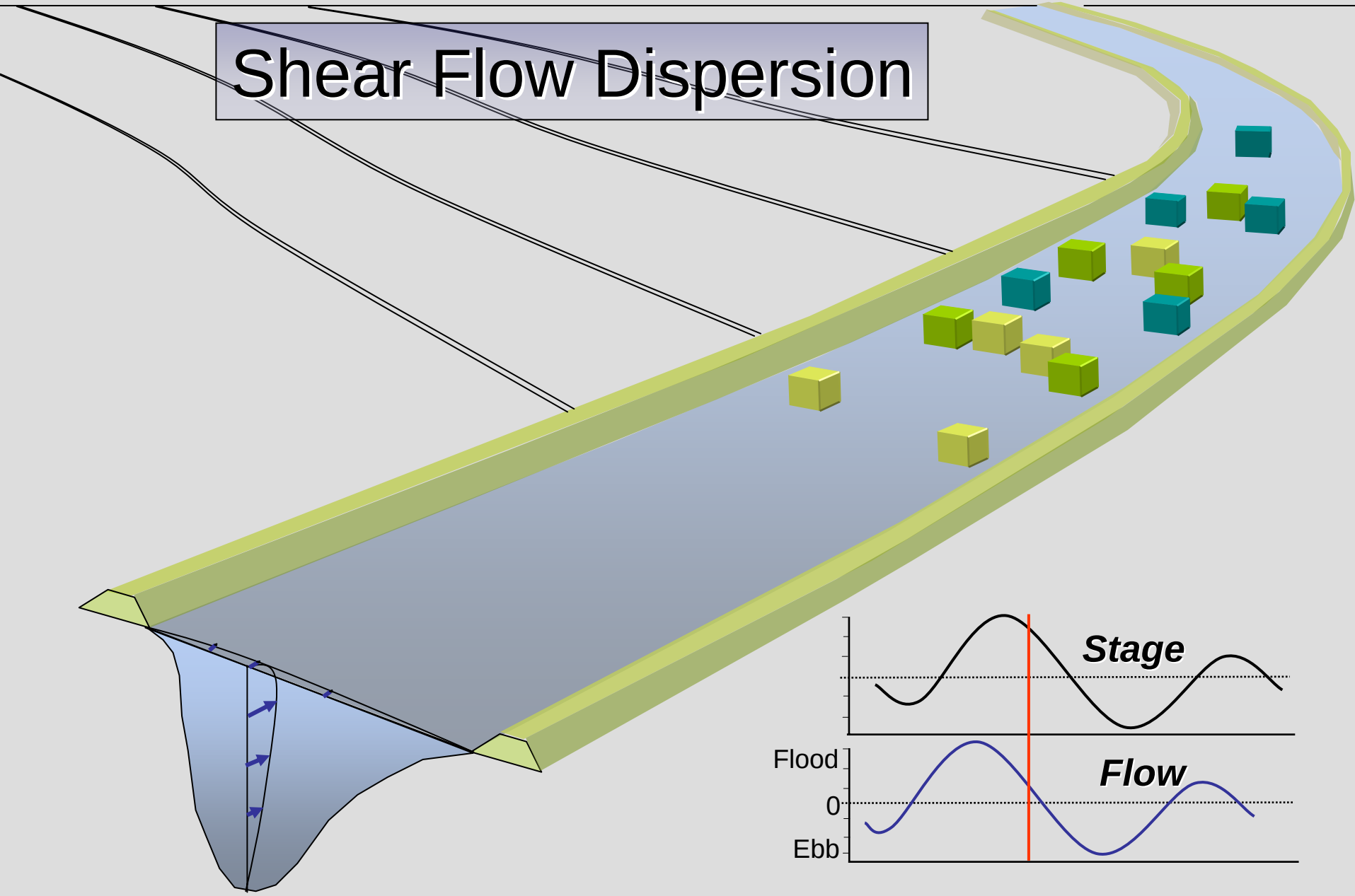
Shear Flow Dispersion



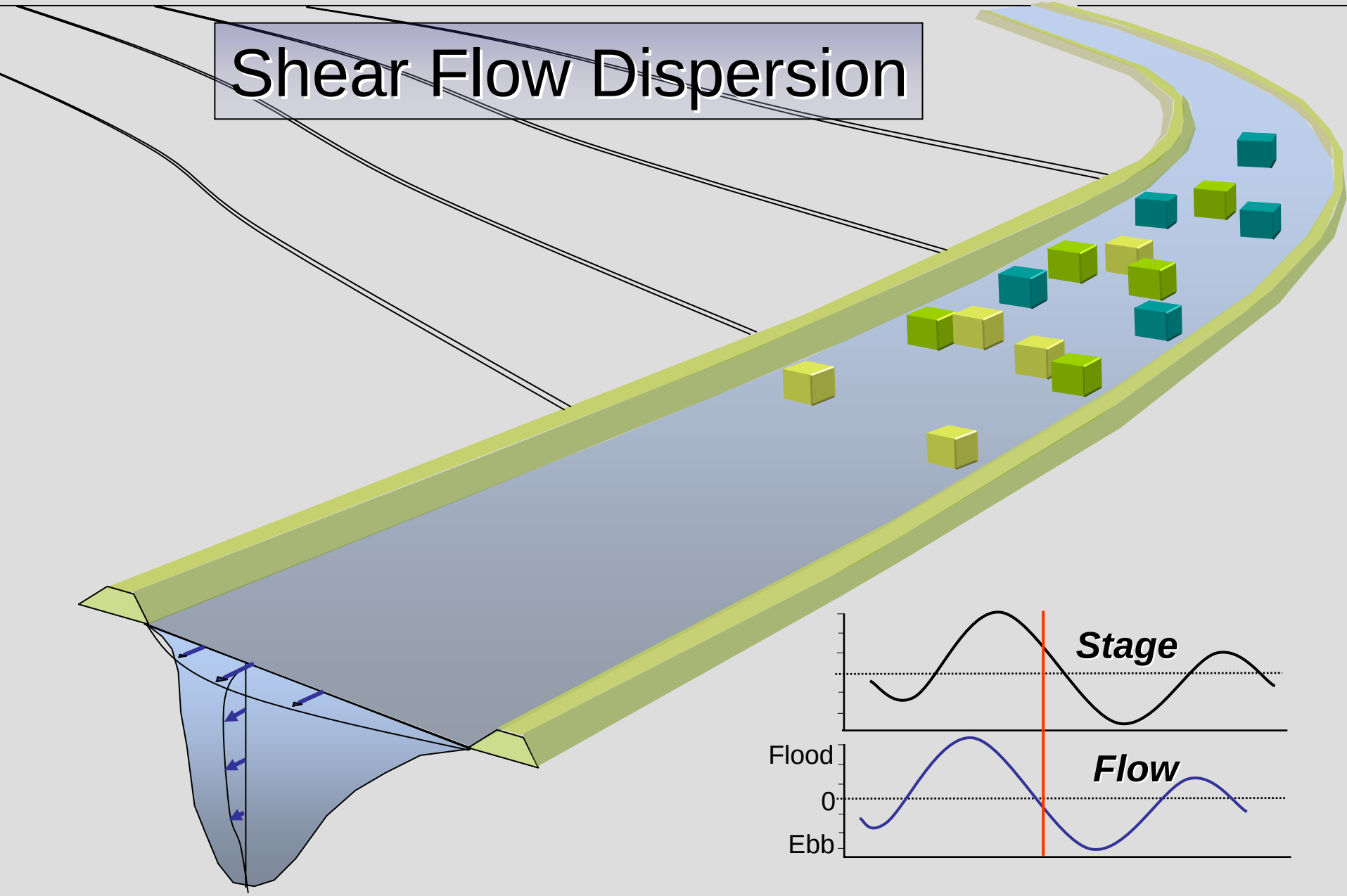
Shear Flow Dispersion



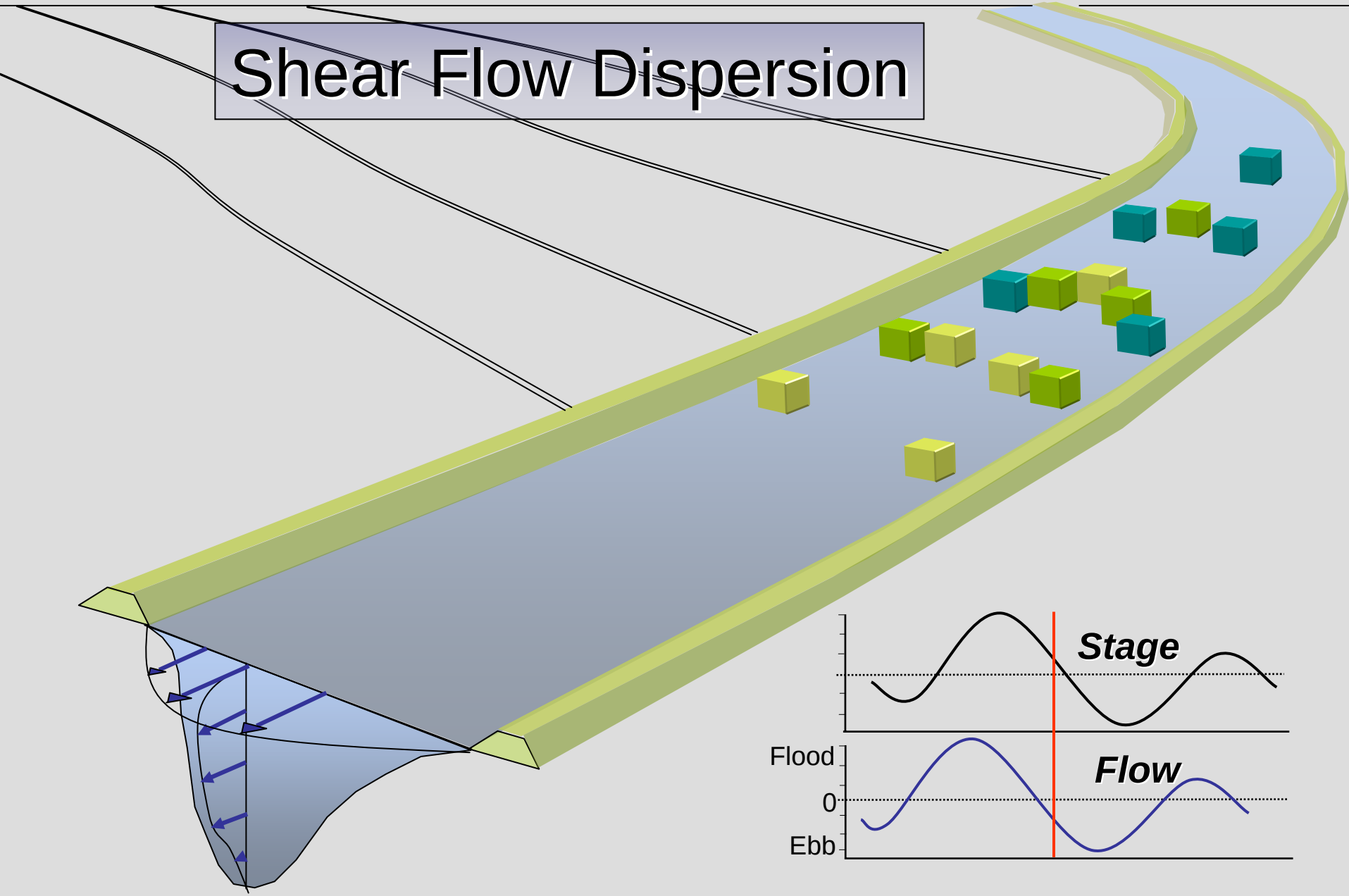
Shear Flow Dispersion



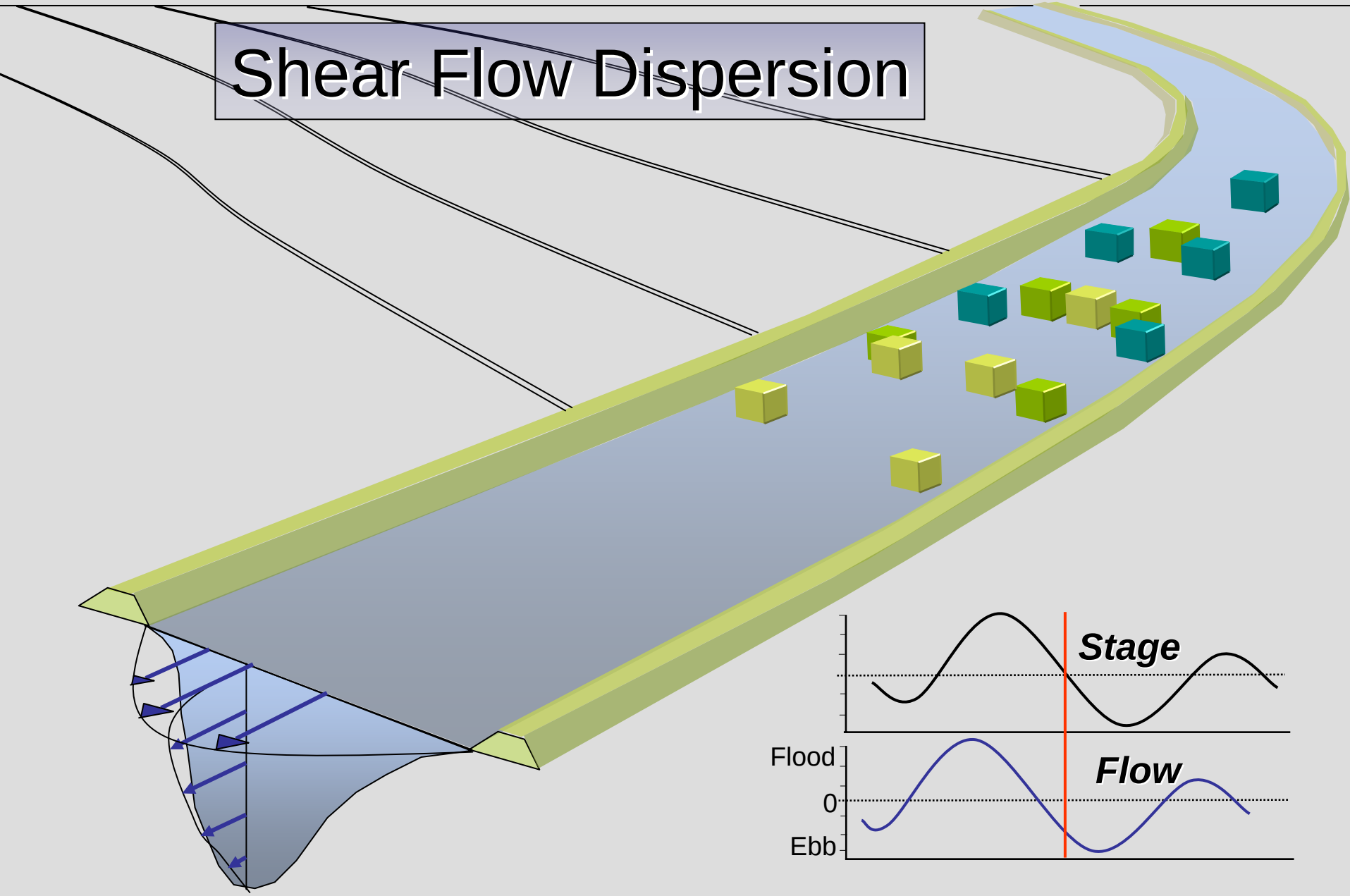
Shear Flow Dispersion



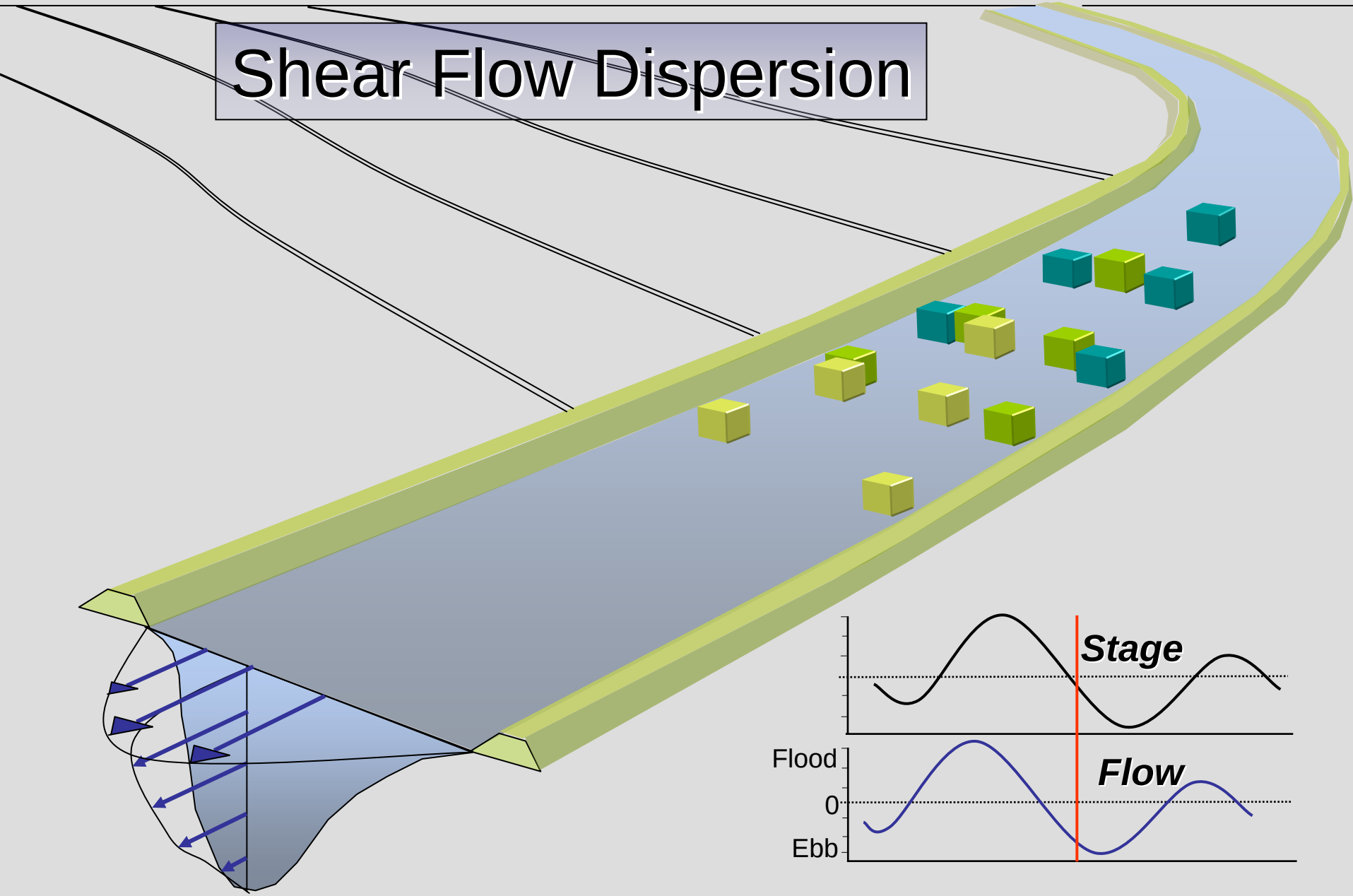
Shear Flow Dispersion



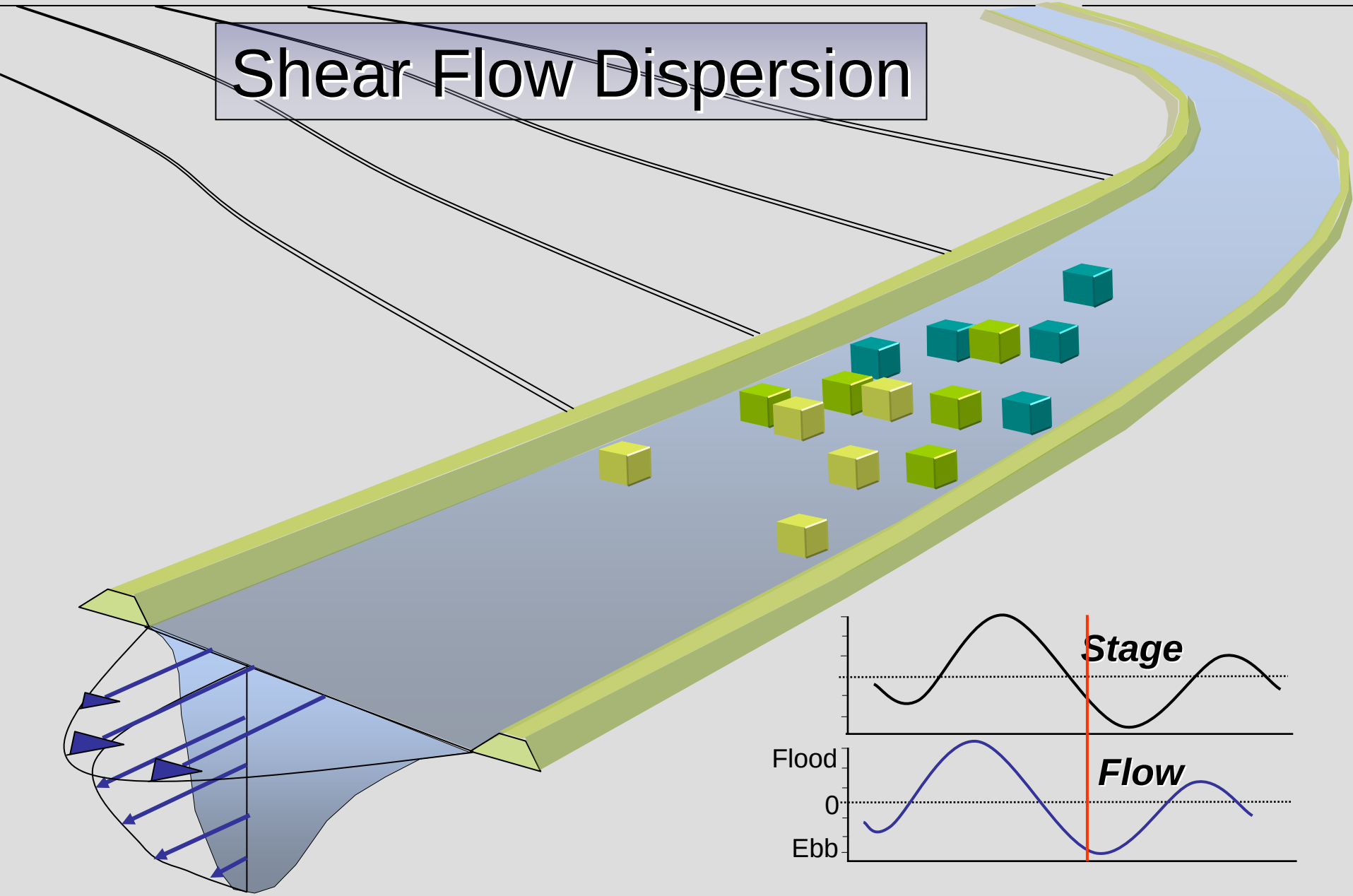
Shear Flow Dispersion



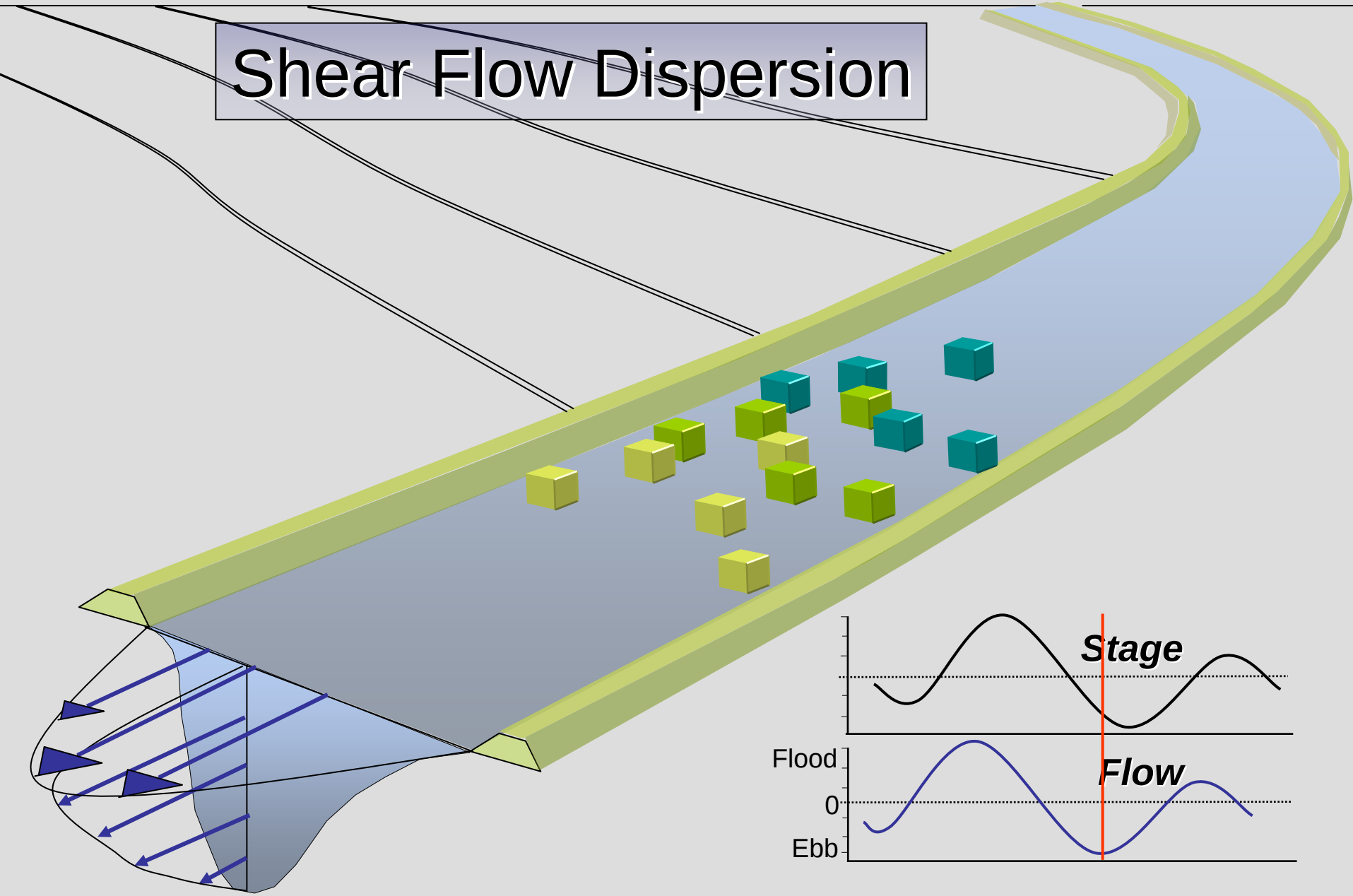
Shear Flow Dispersion



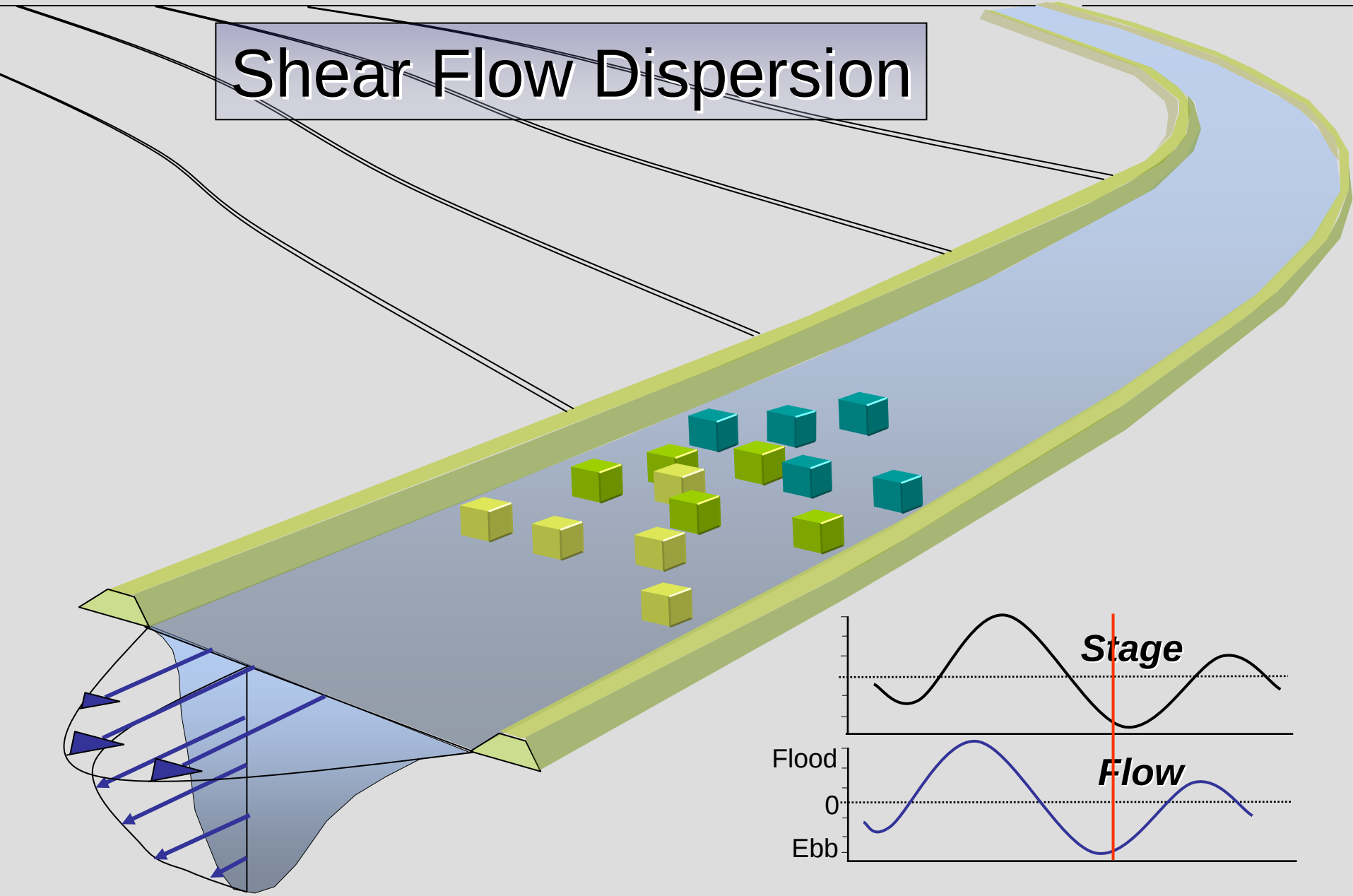
Shear Flow Dispersion



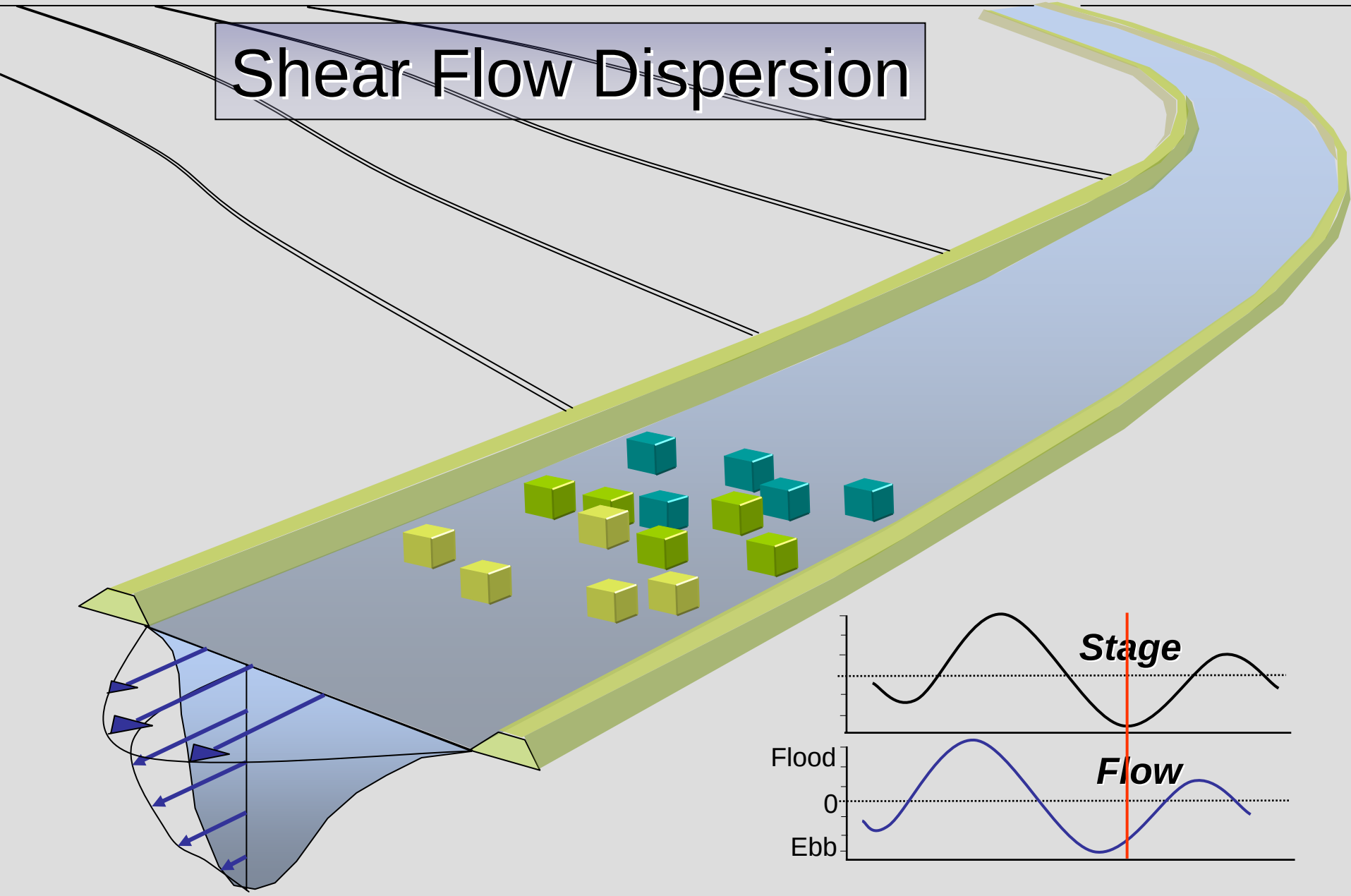
Shear Flow Dispersion



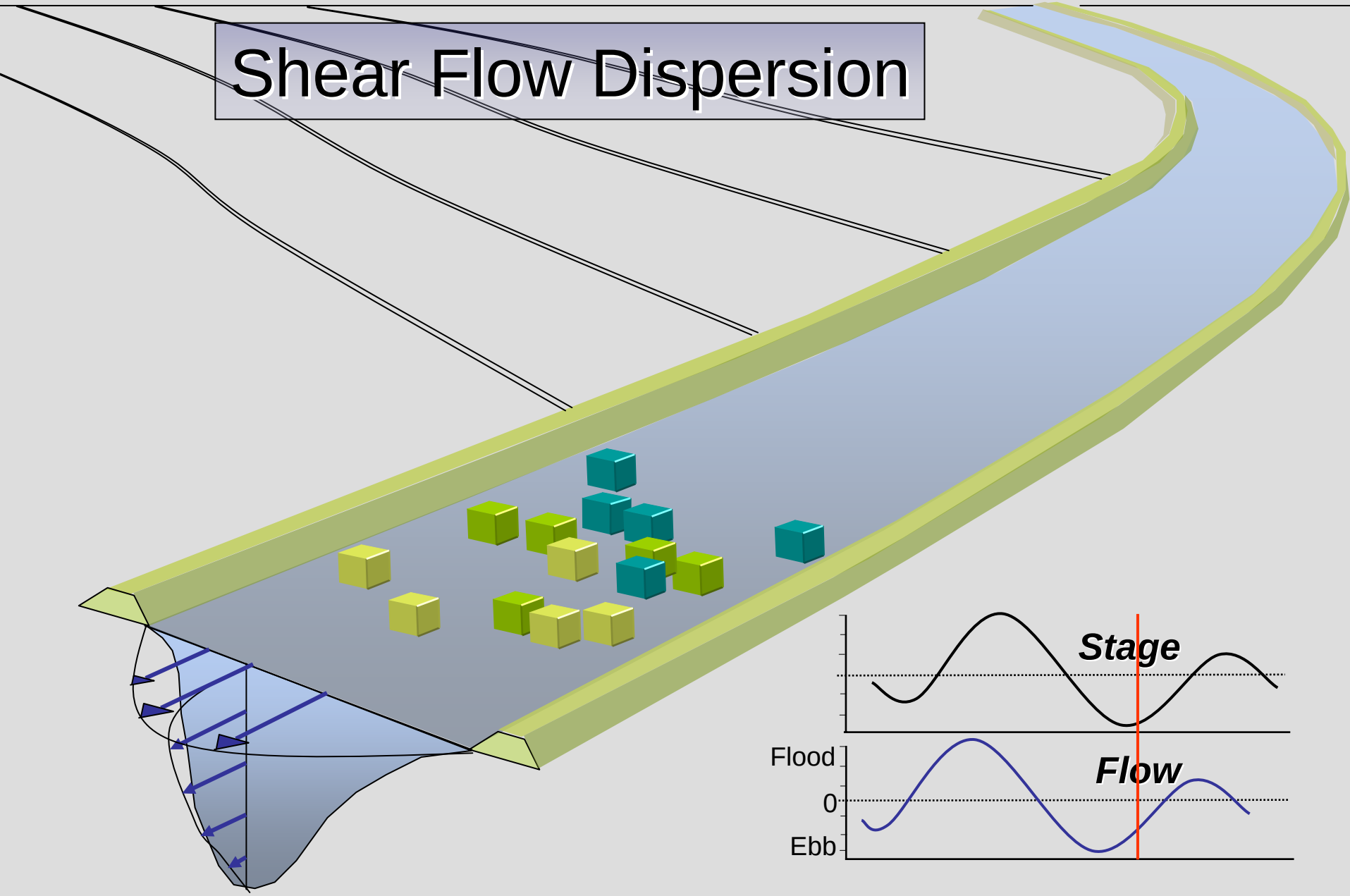
Shear Flow Dispersion



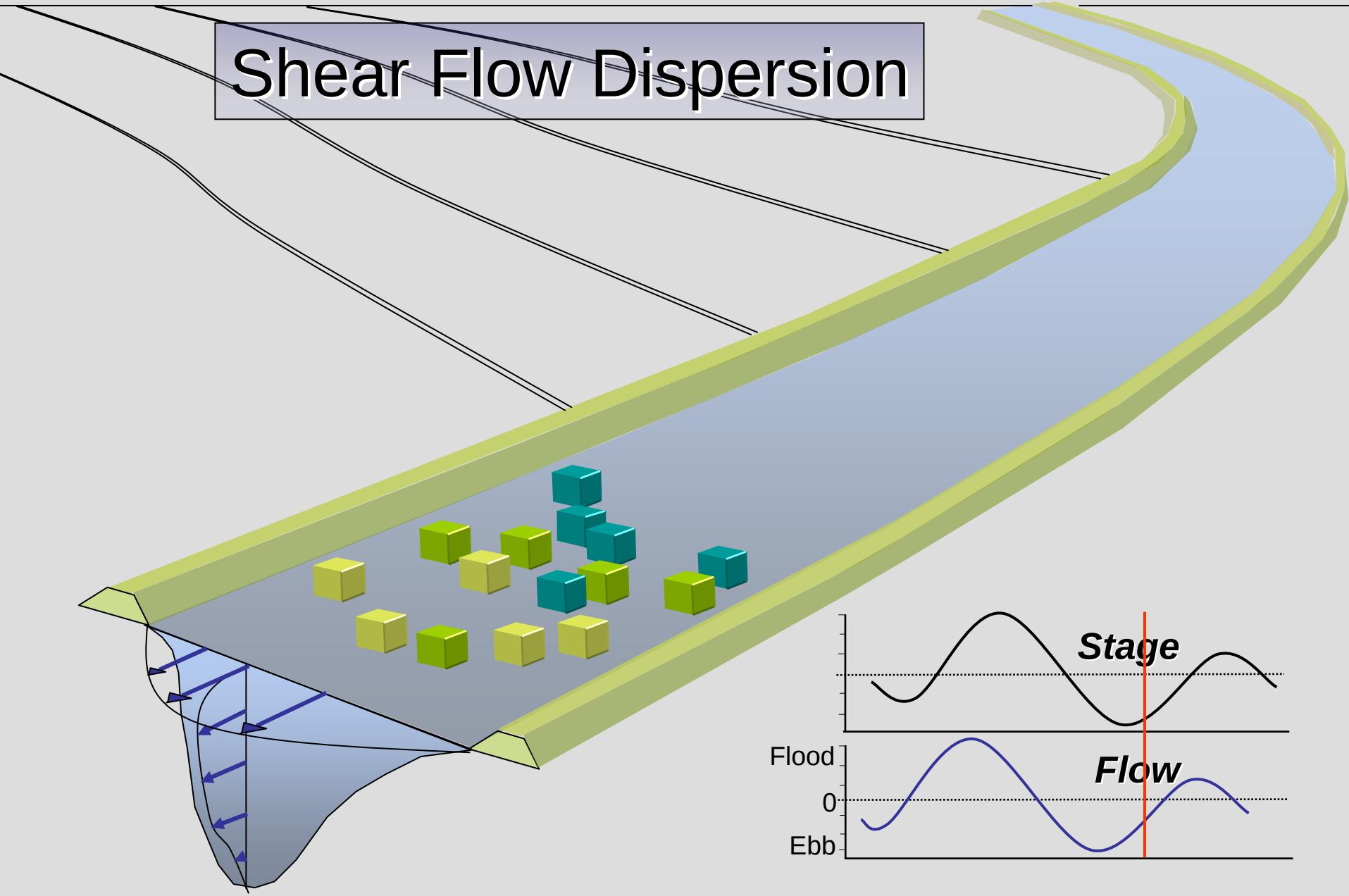
Shear Flow Dispersion



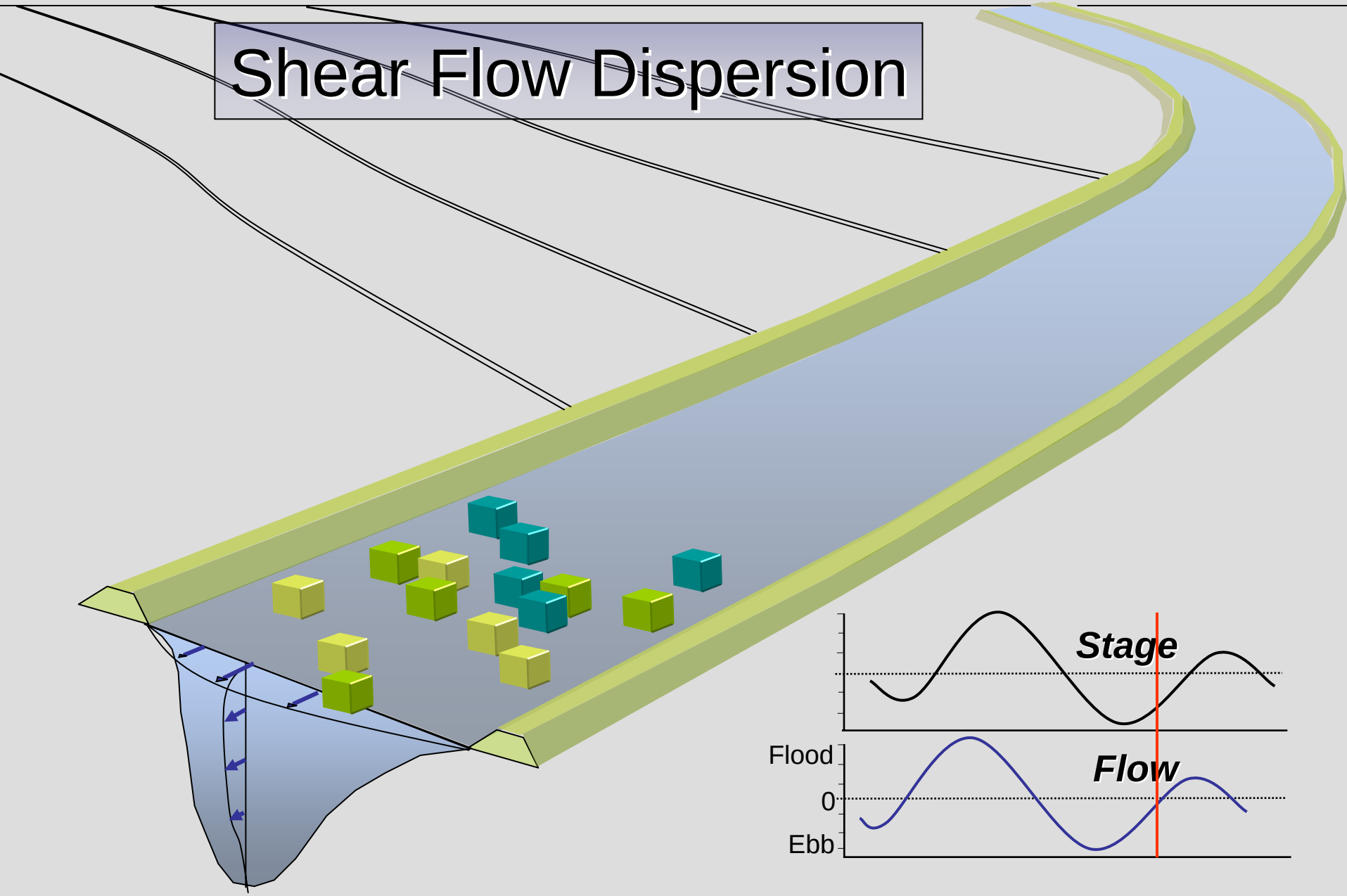
Shear Flow Dispersion



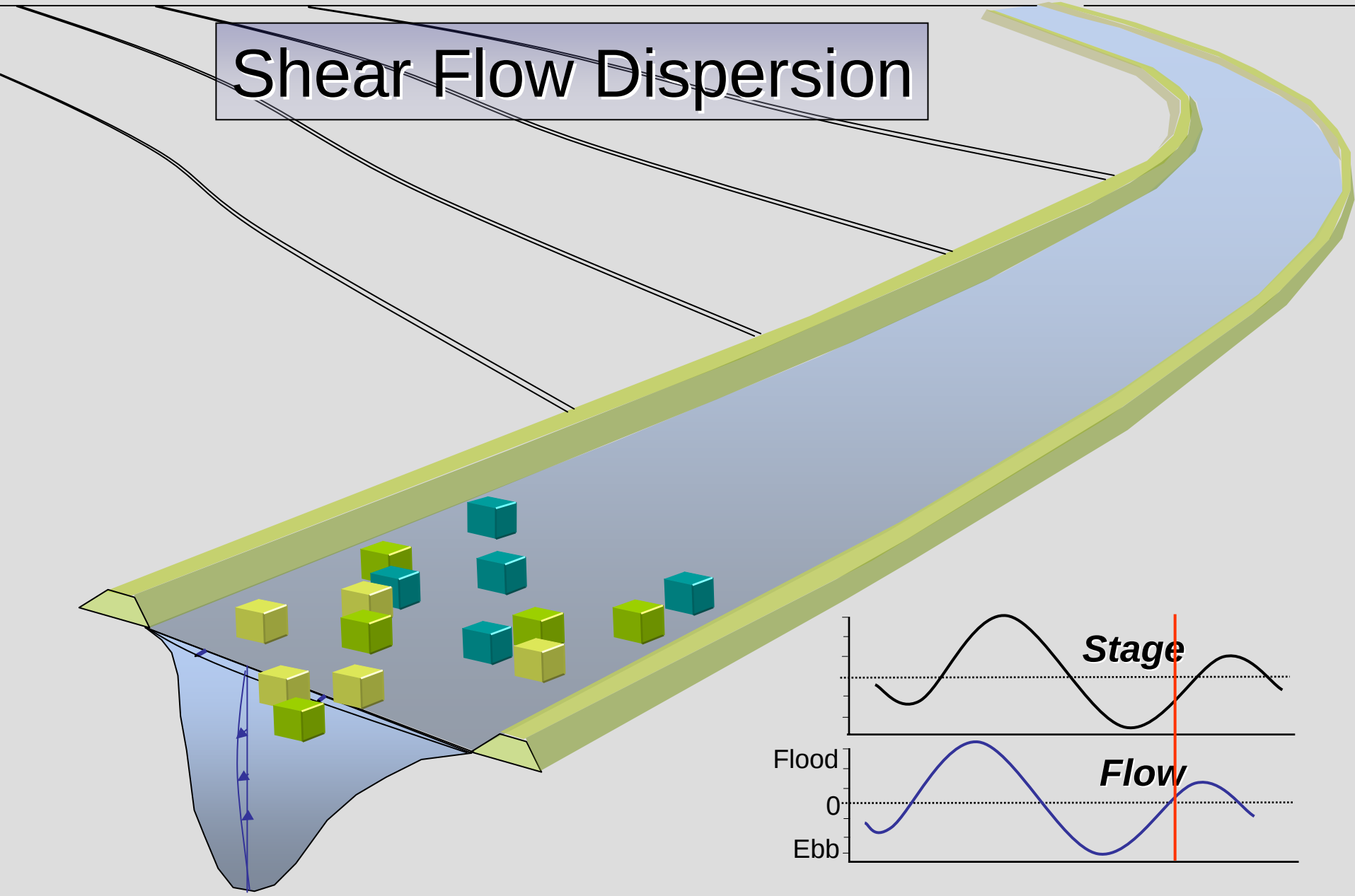
Shear Flow Dispersion



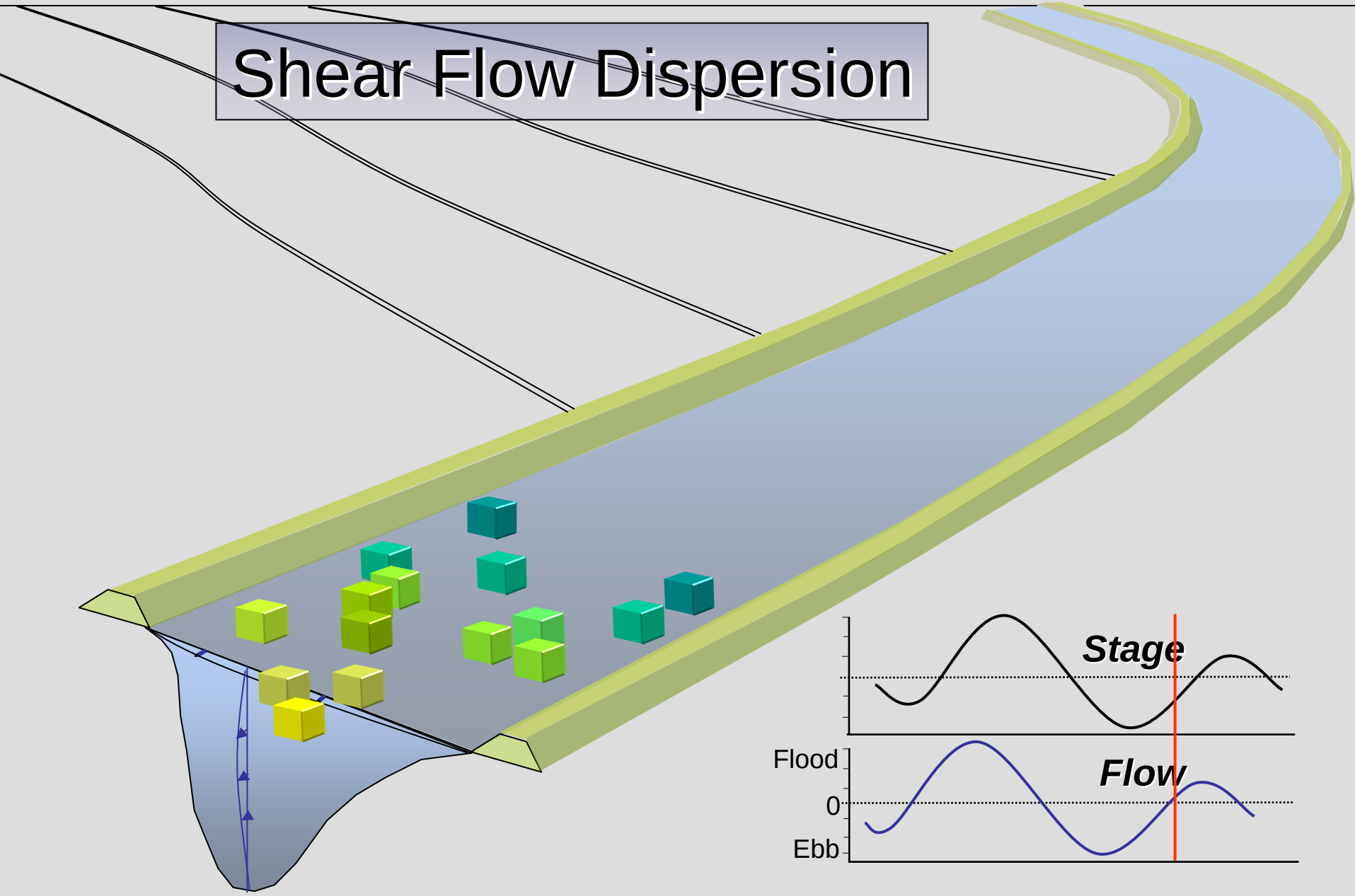
Shear Flow Dispersion



Shear Flow Dispersion

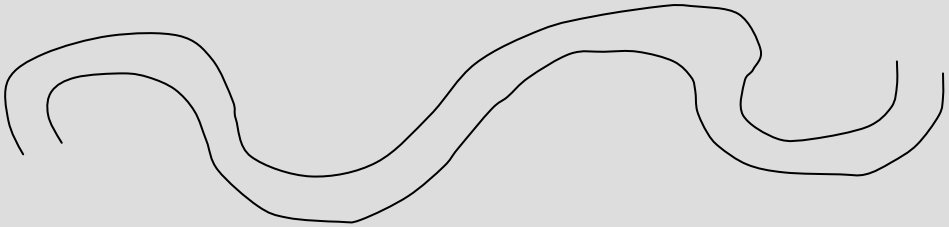


Shear Flow Dispersion

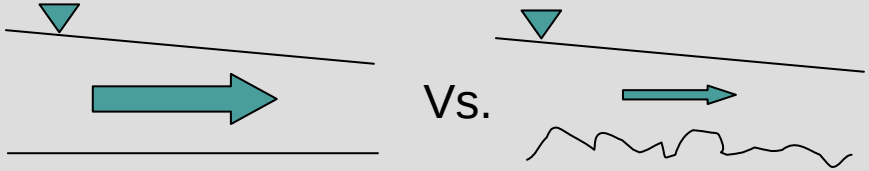


Mixing Due to Shear Flow Dispersion is Enhanced by :

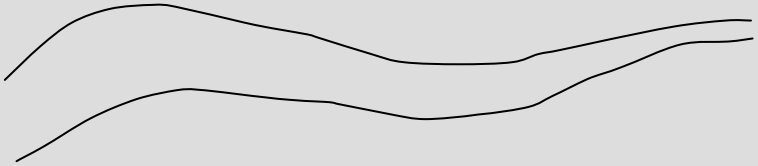
- Sinuosity



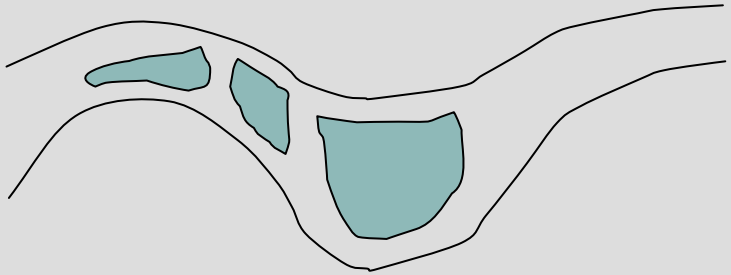
- Bottom roughness



- Channel convergence

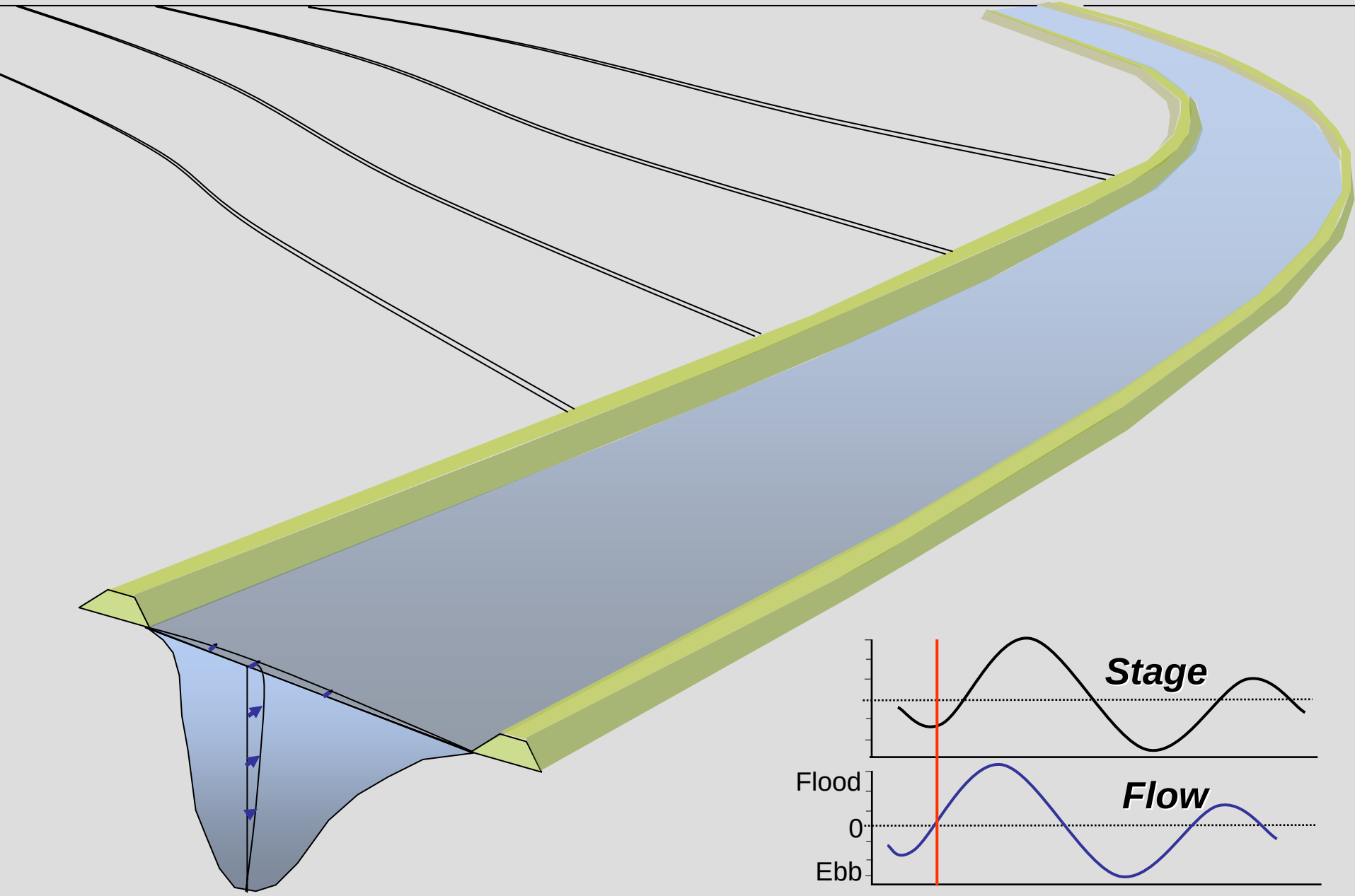


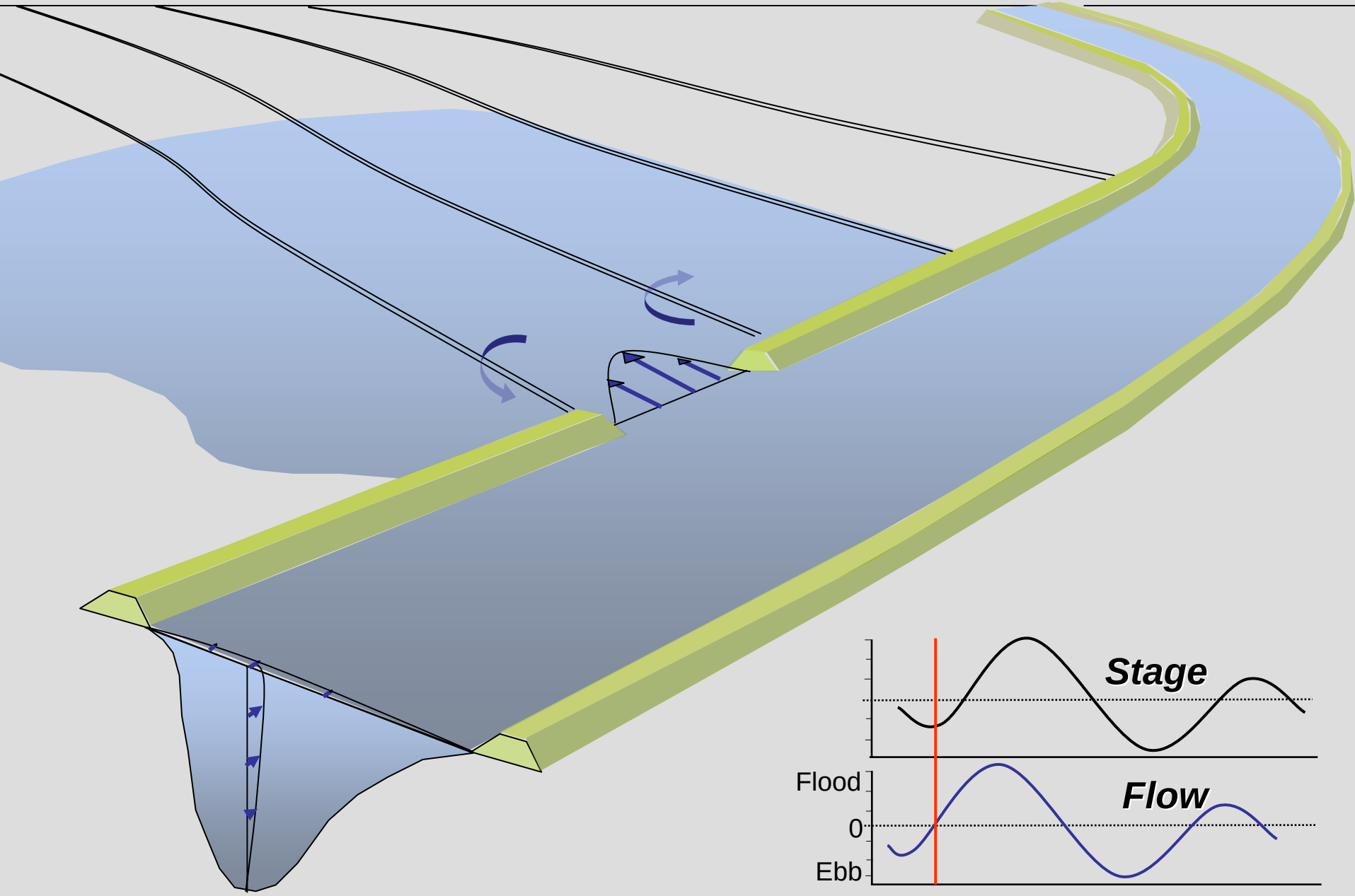
- Channel irregularities

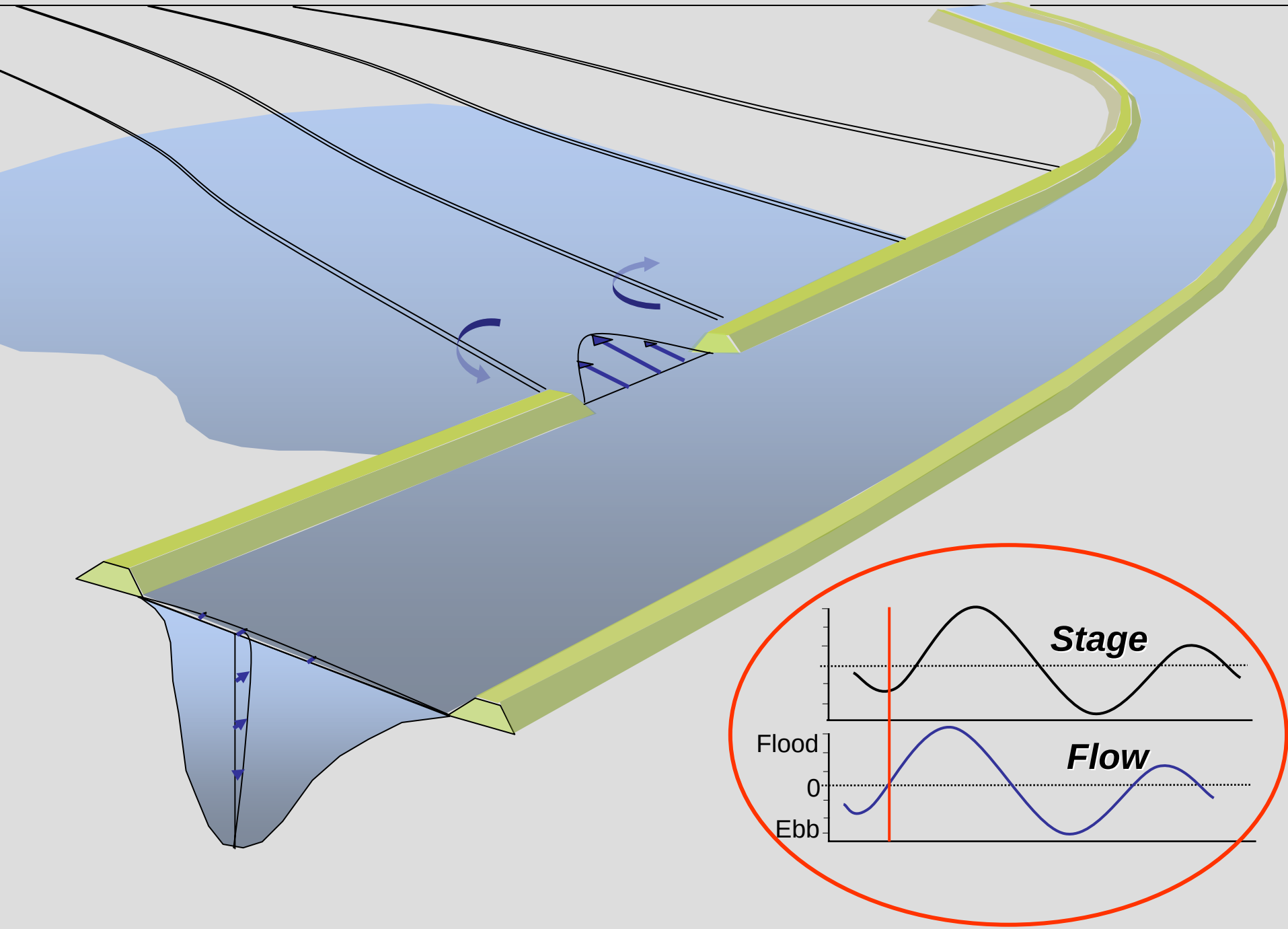


2.Tidal Trapping

- Differential tidal propagation in geometric irregularities

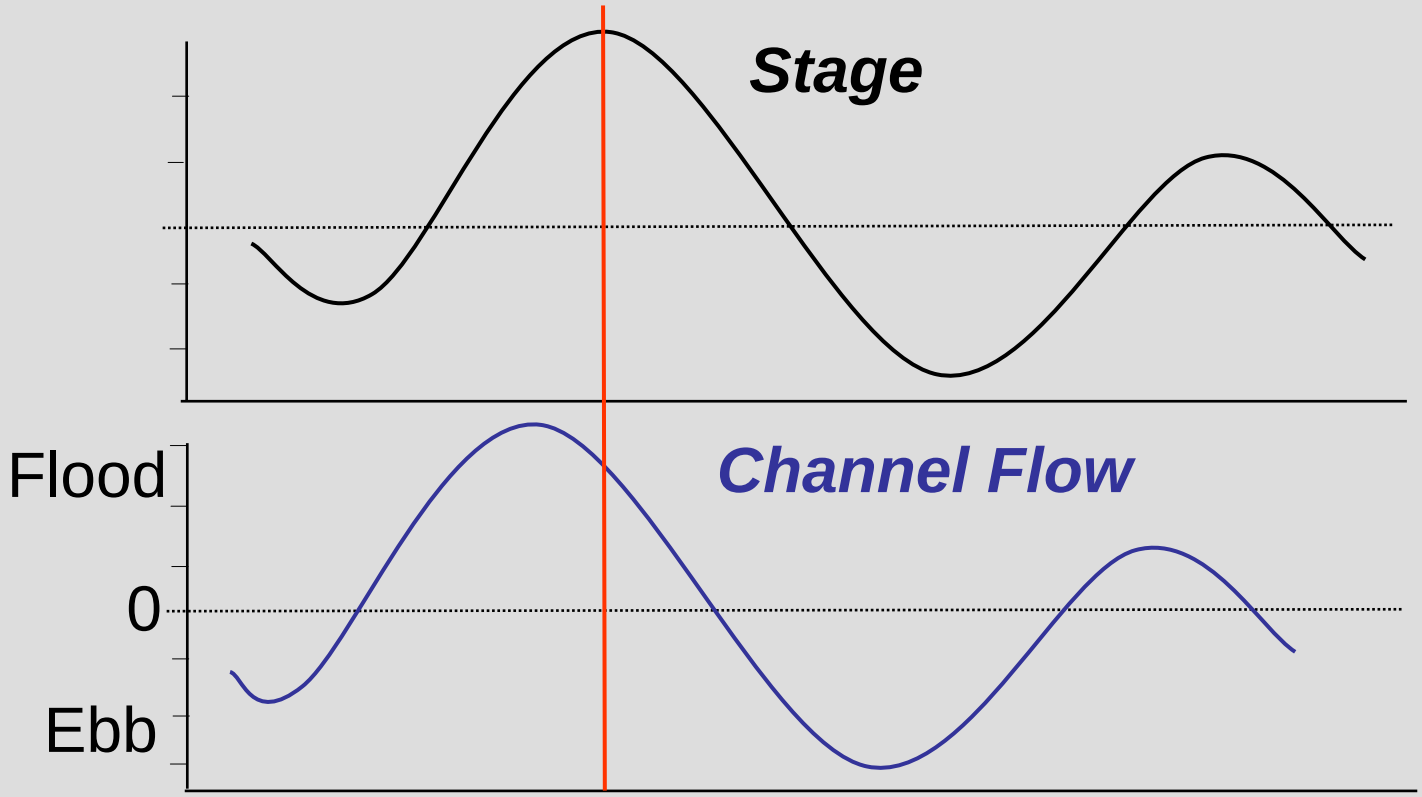

Stage
Flood
Flow
0
Ebb


Stage
Flood
Flow
0
Ebb


Stage
Flood
Flow
0
Ebb

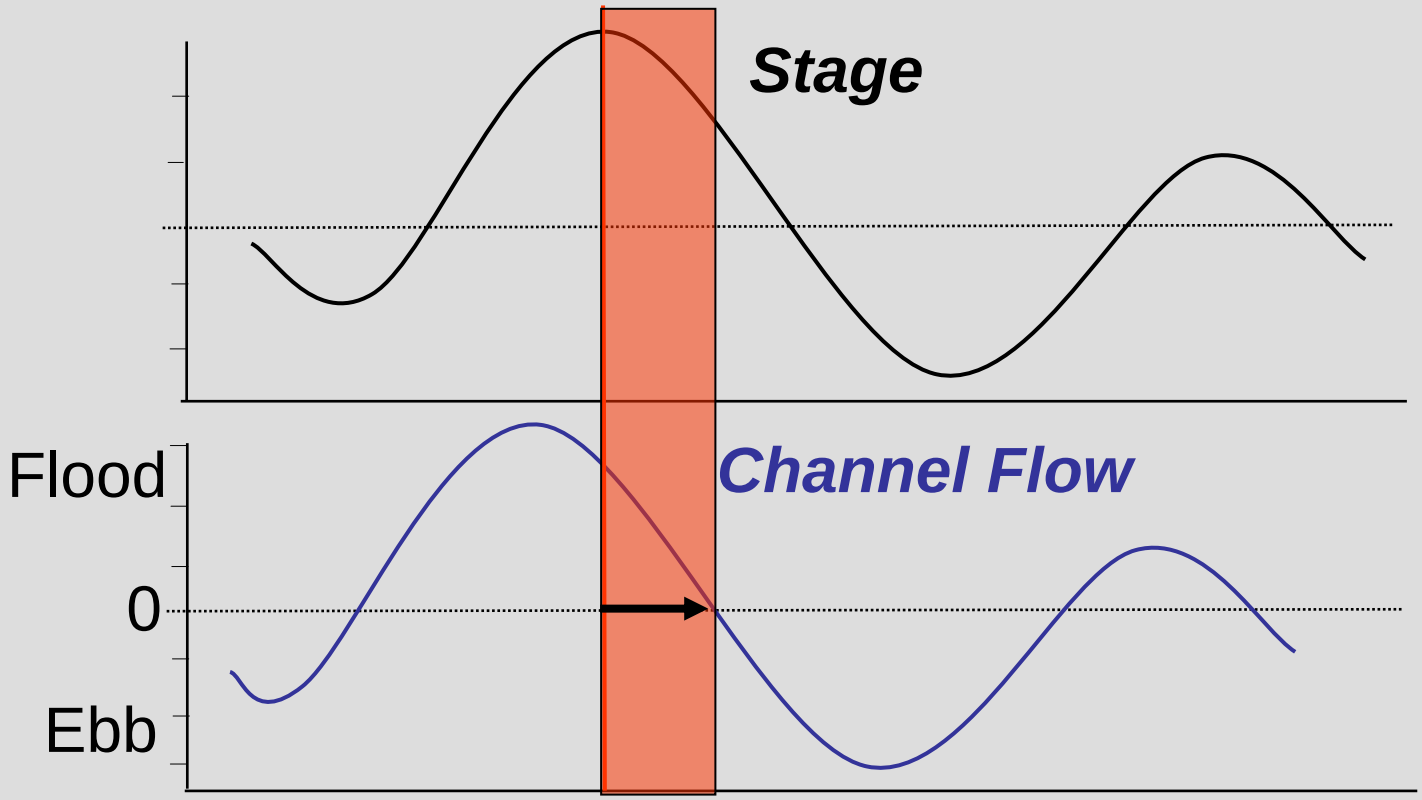
Tidal Trapping

- Timing of tidal stage and tidal flow:



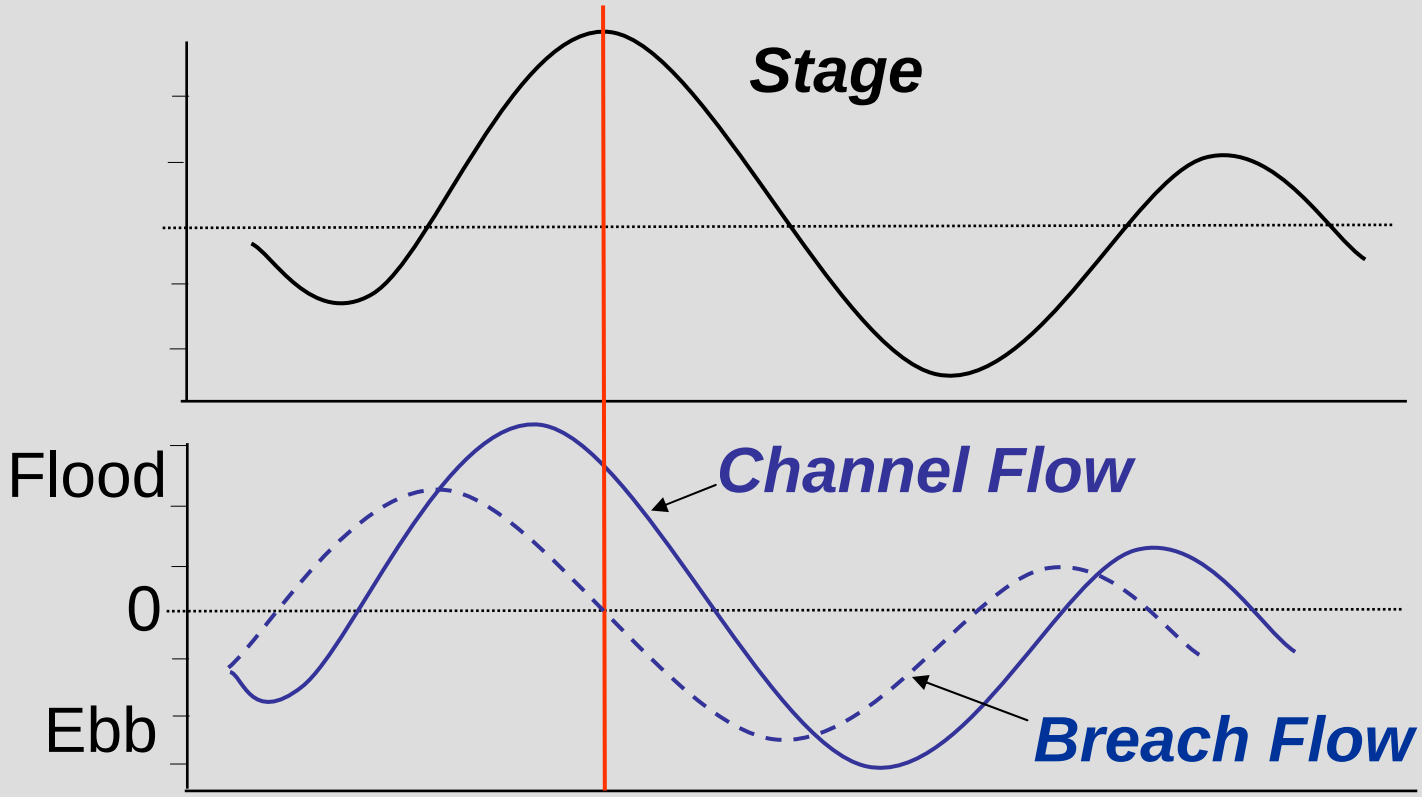
Tidal Trapping

- Timing of tidal stage and tidal flow:



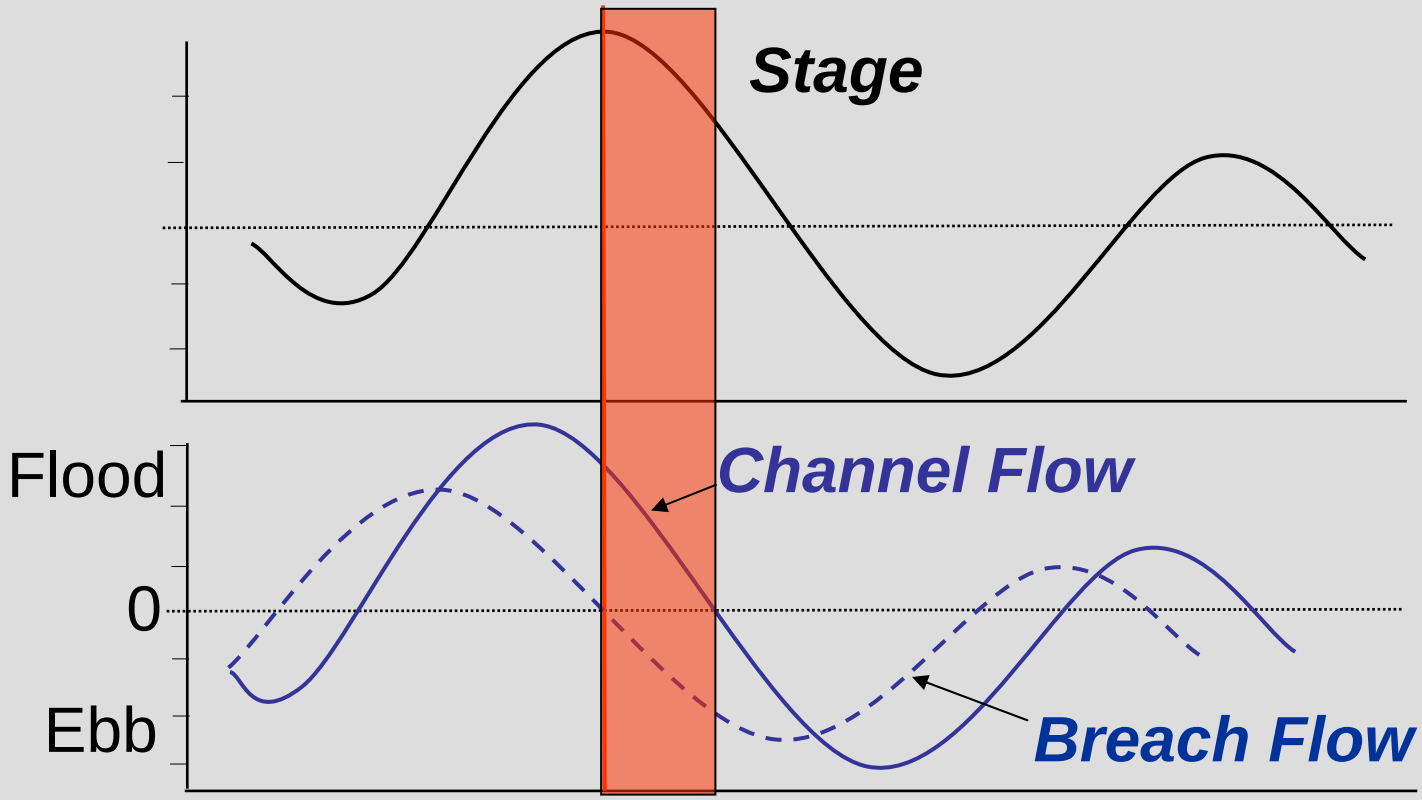
Tidal Trapping

- Timing of tidal stage and tidal flow:

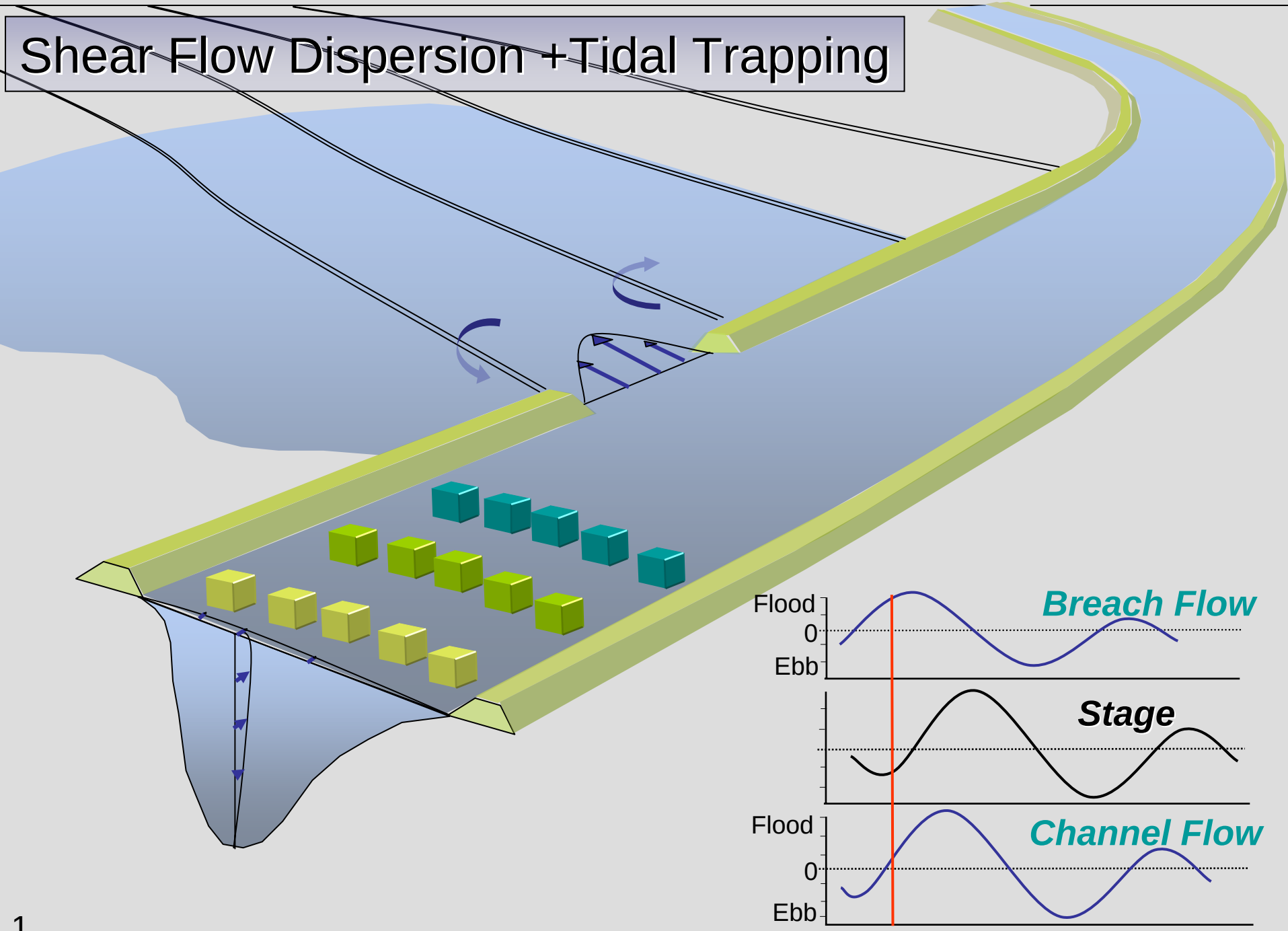


Tidal Trapping

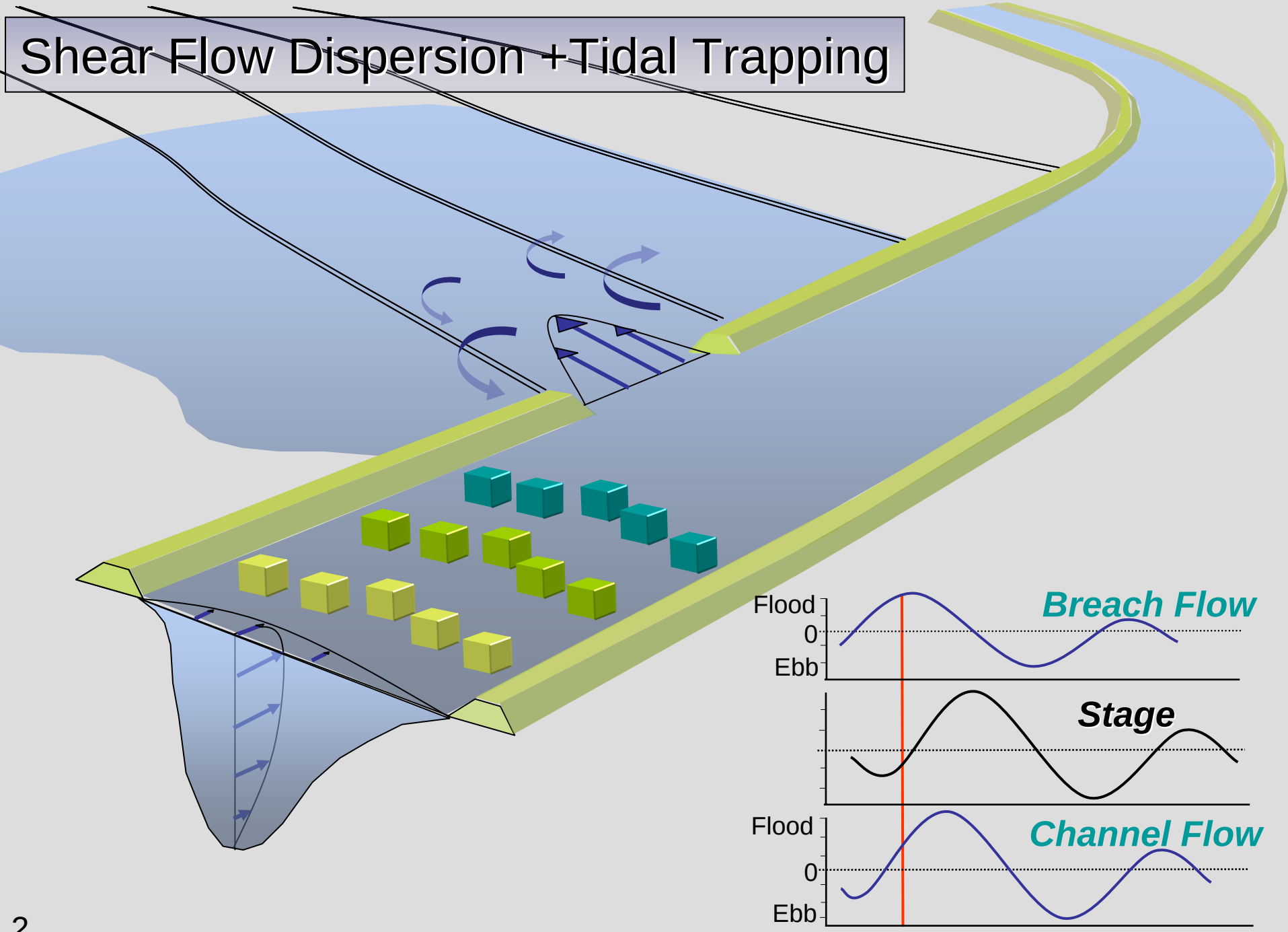
- Timing of tidal stage and tidal flow:



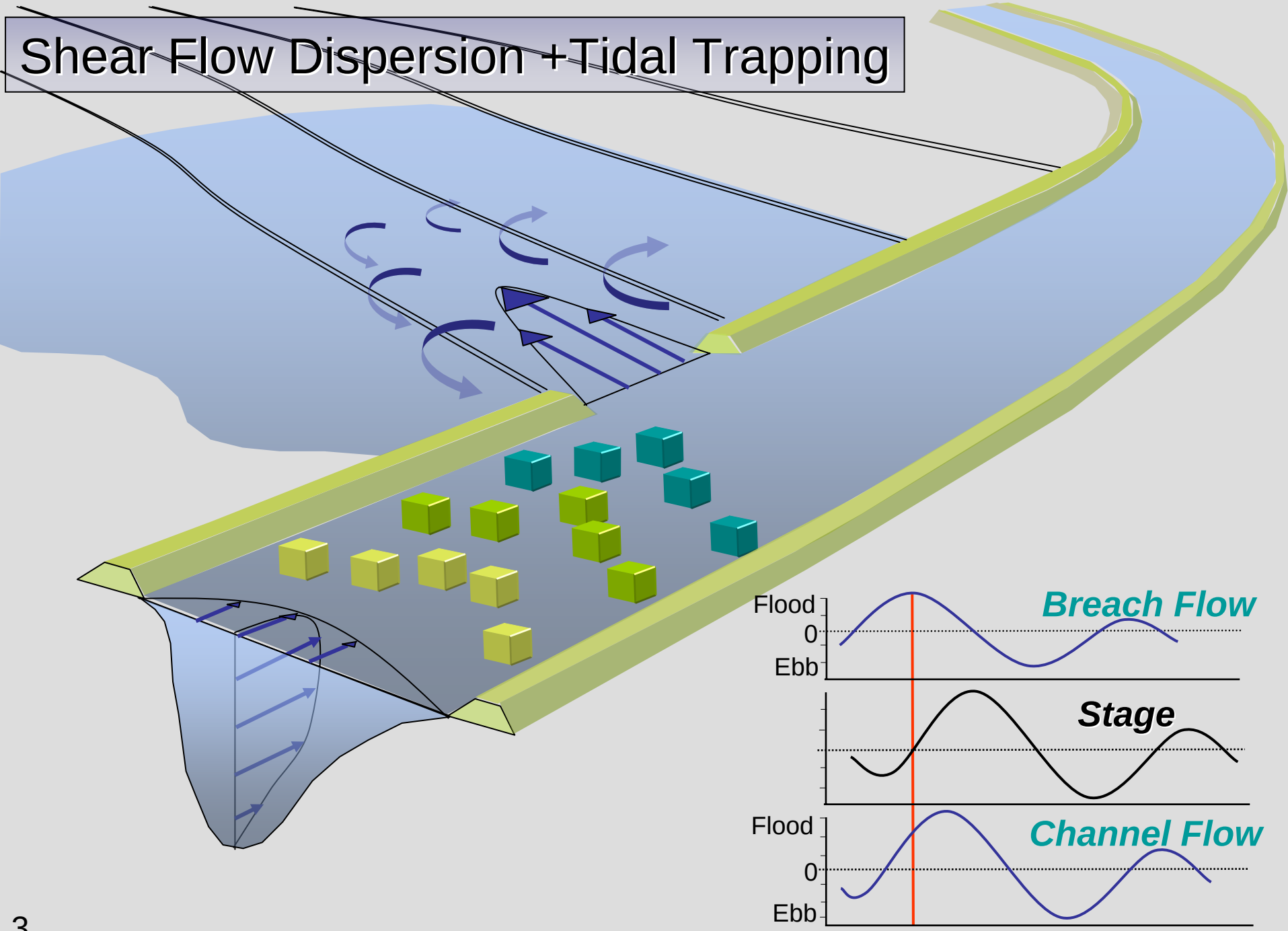
Shear Flow Dispersion +Tidal Trapping



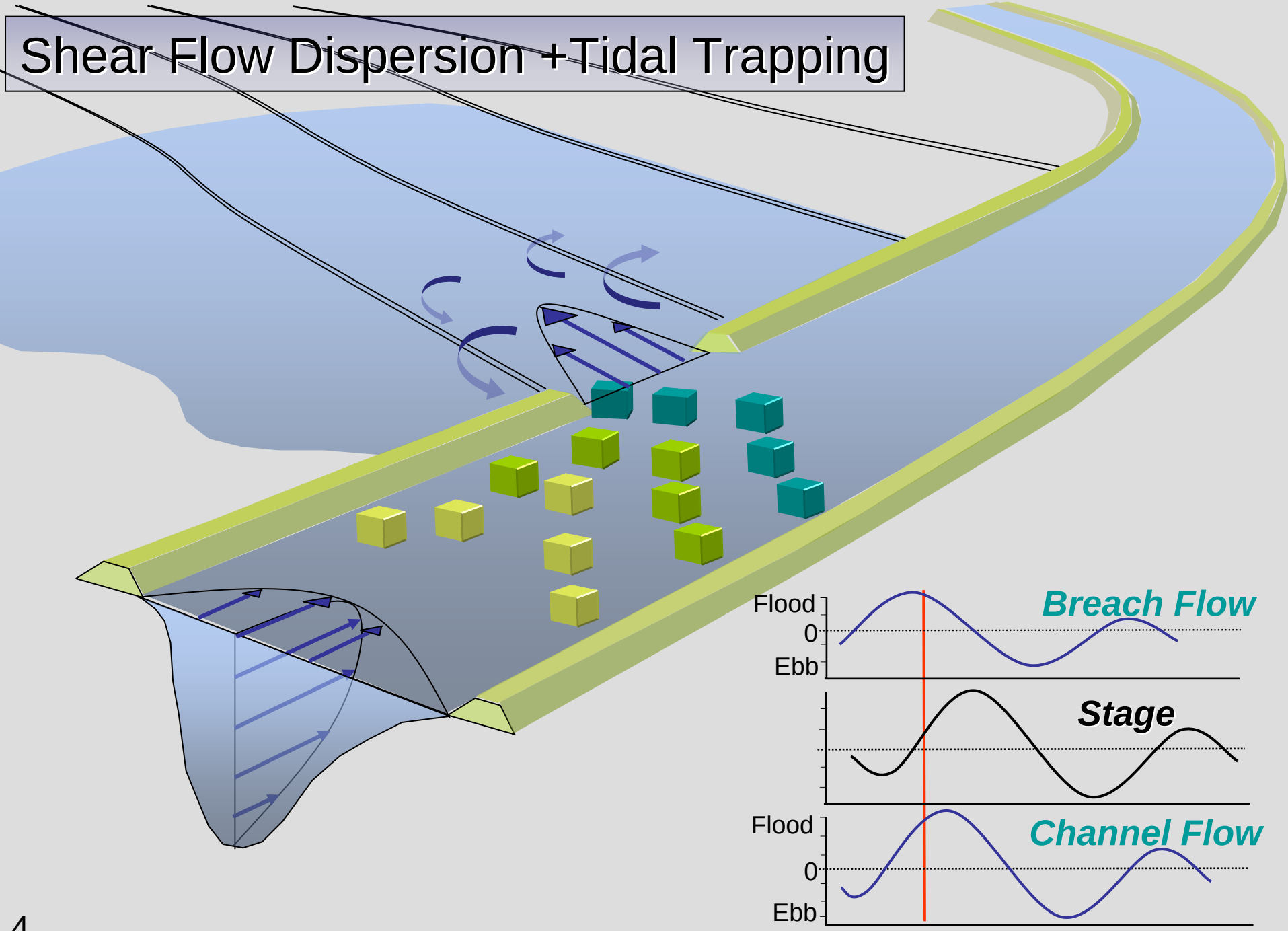
Shear Flow Dispersion +Tidal Trapping



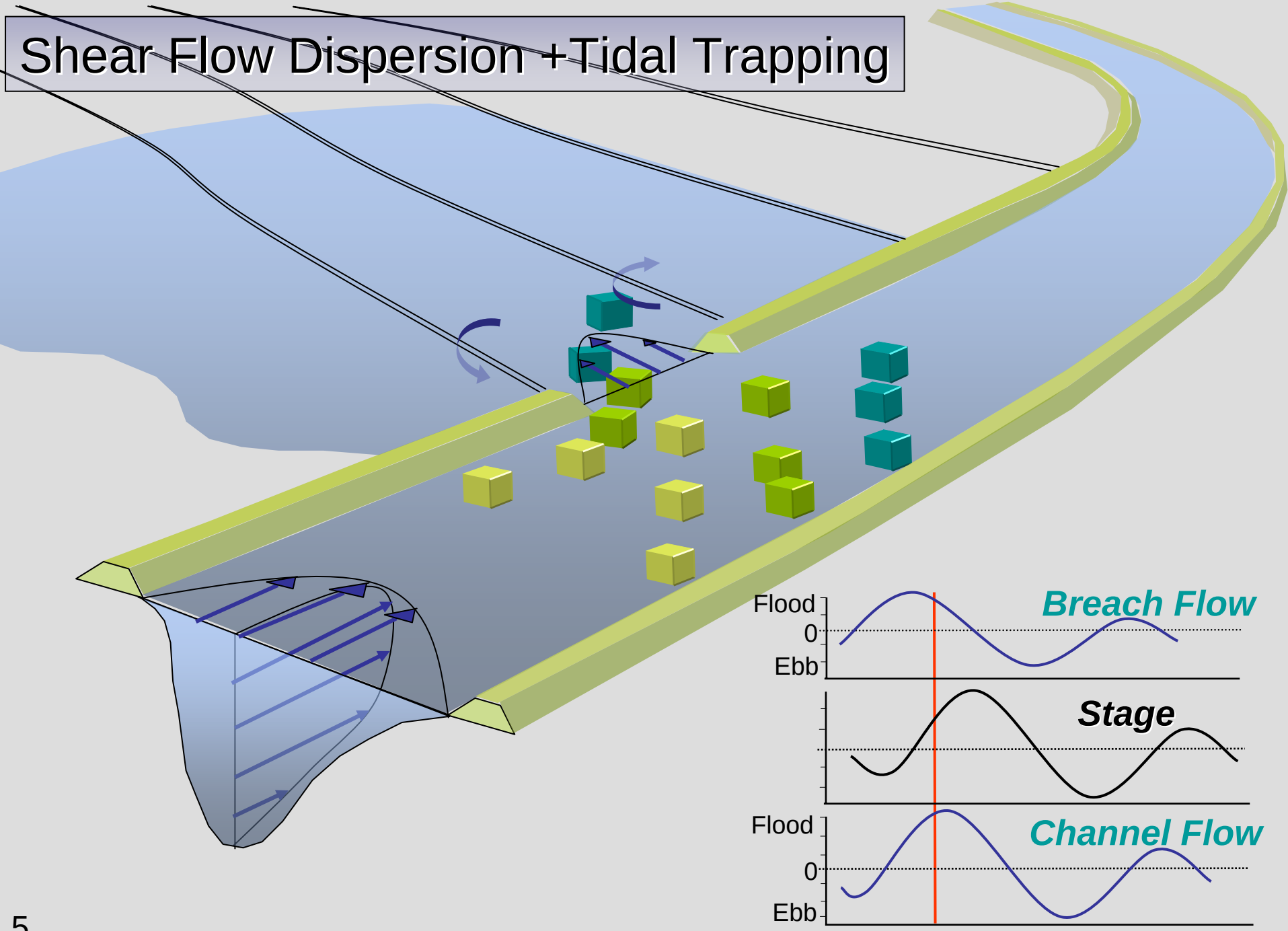
Shear Flow Dispersion +Tidal Trapping



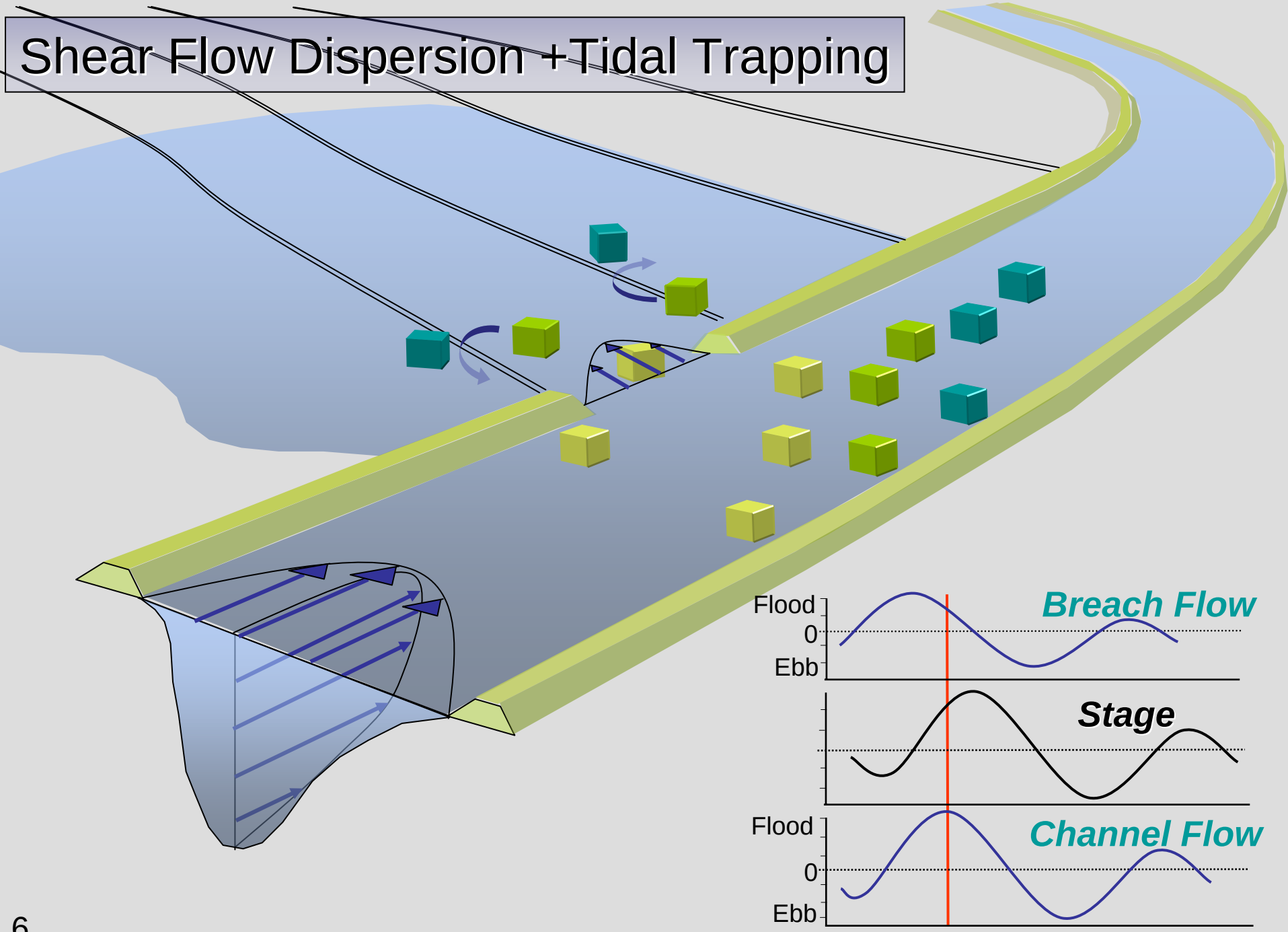
Shear Flow Dispersion +Tidal Trapping



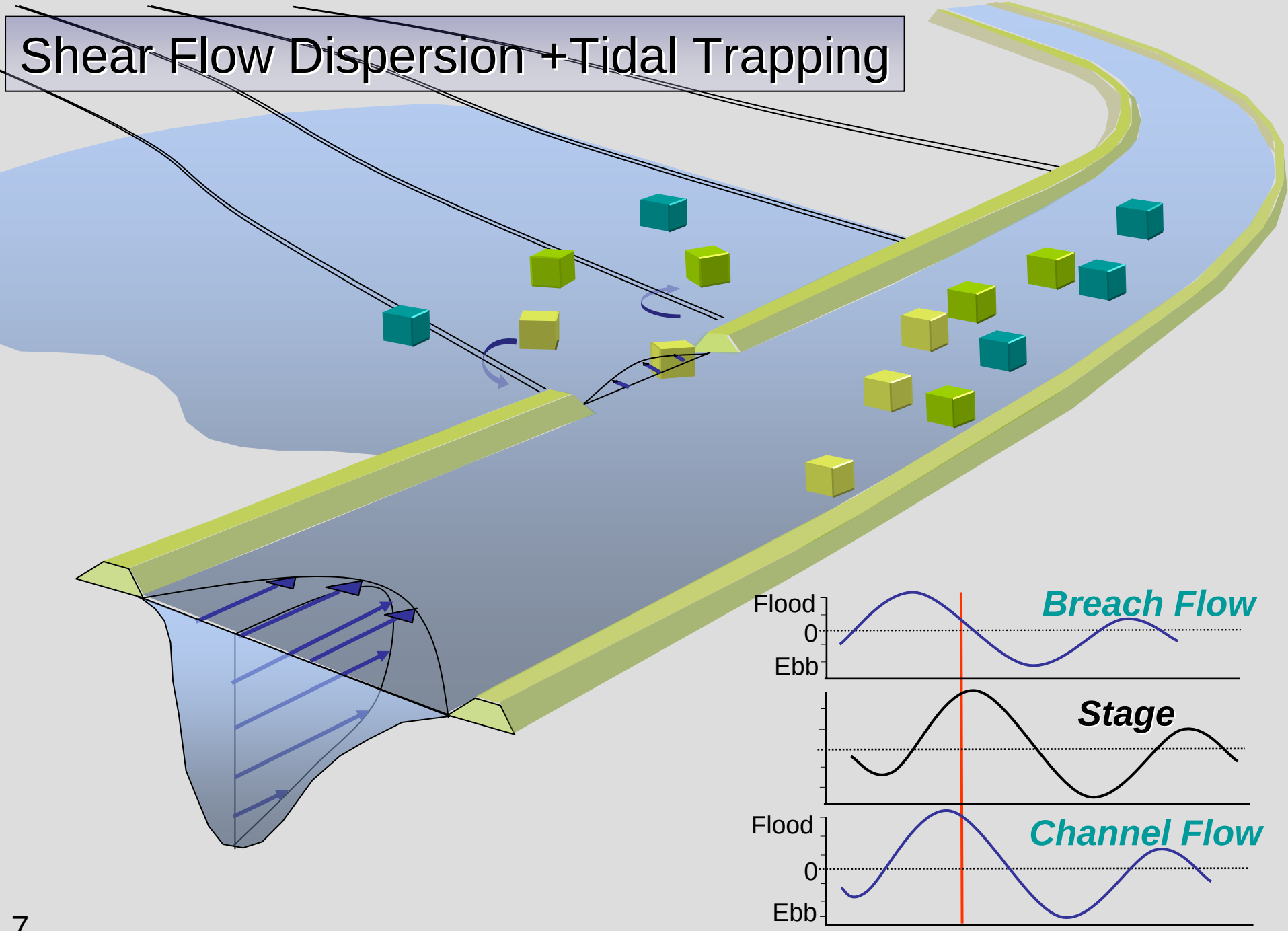
Shear Flow Dispersion +Tidal Trapping



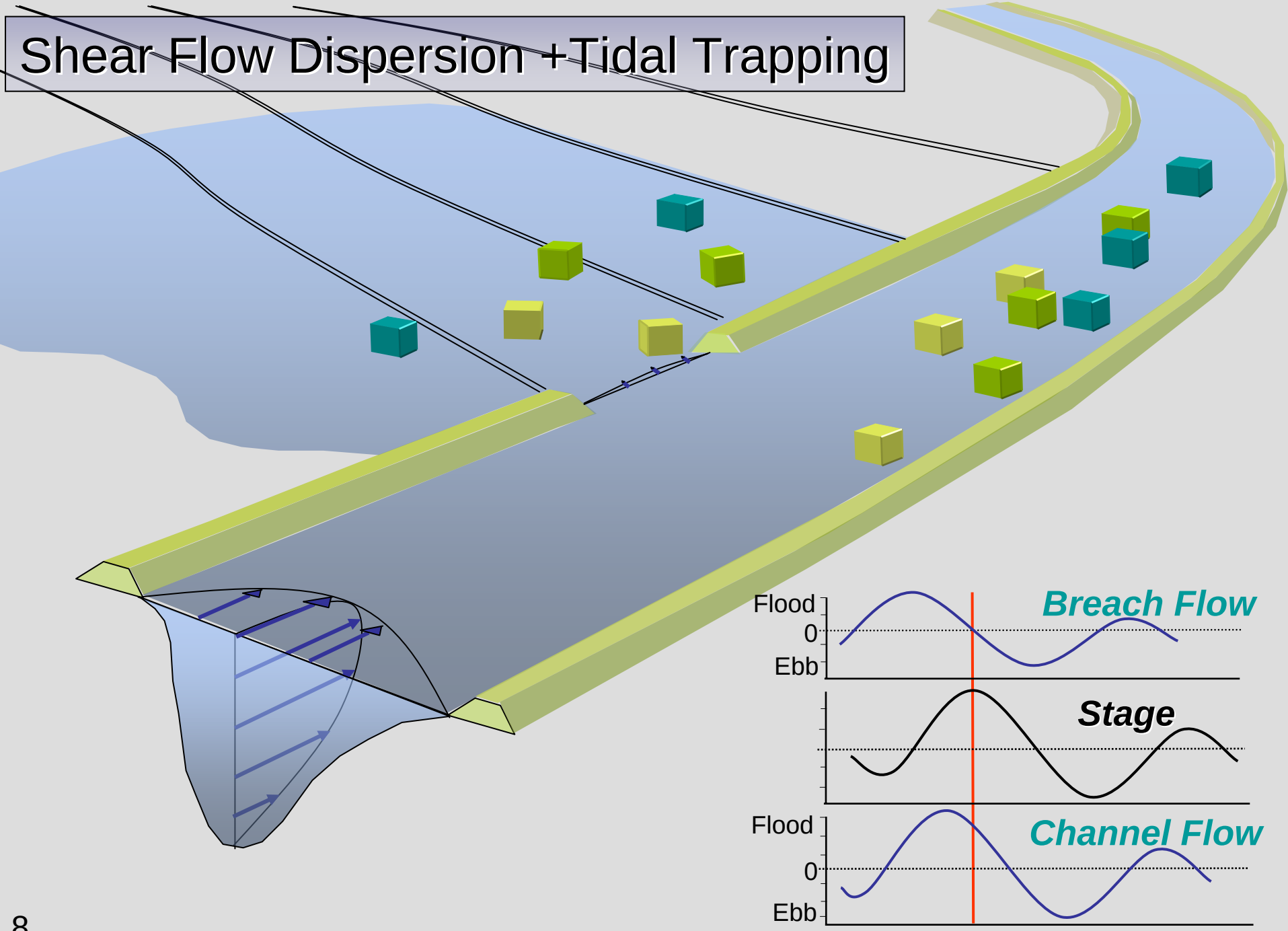
Shear Flow Dispersion +Tidal Trapping



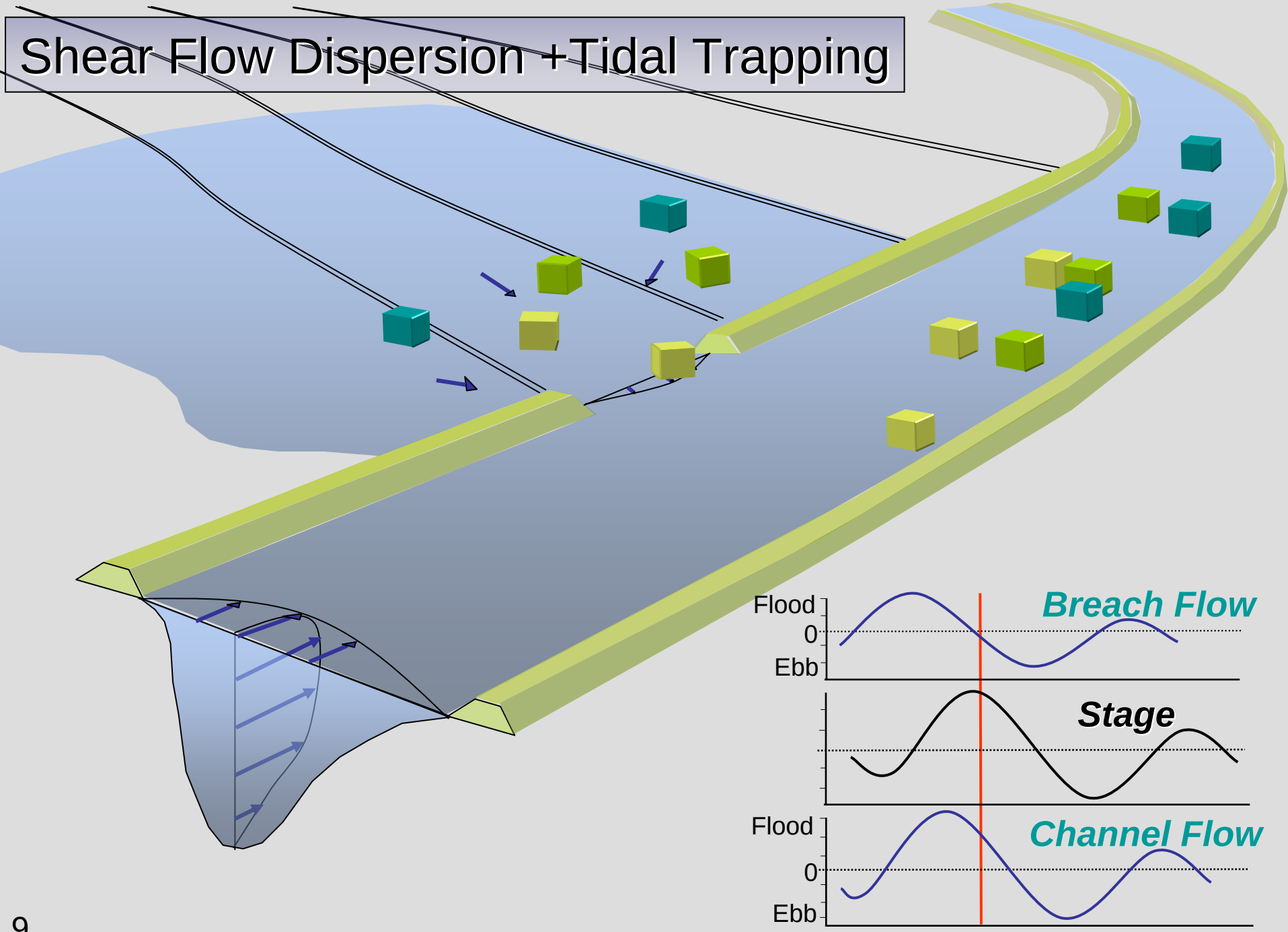
Shear Flow Dispersion +Tidal Trapping



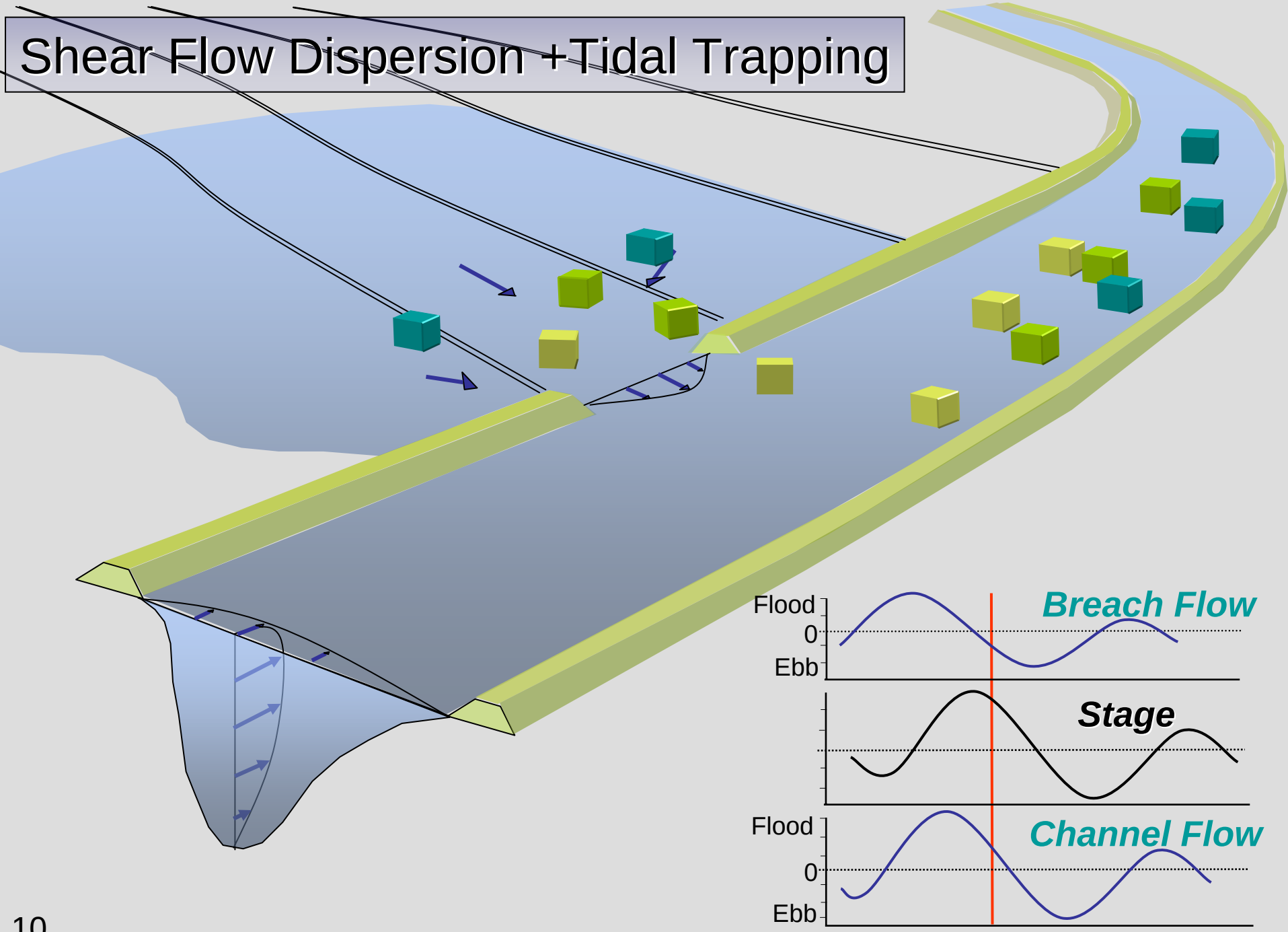
Shear Flow Dispersion +Tidal Trapping



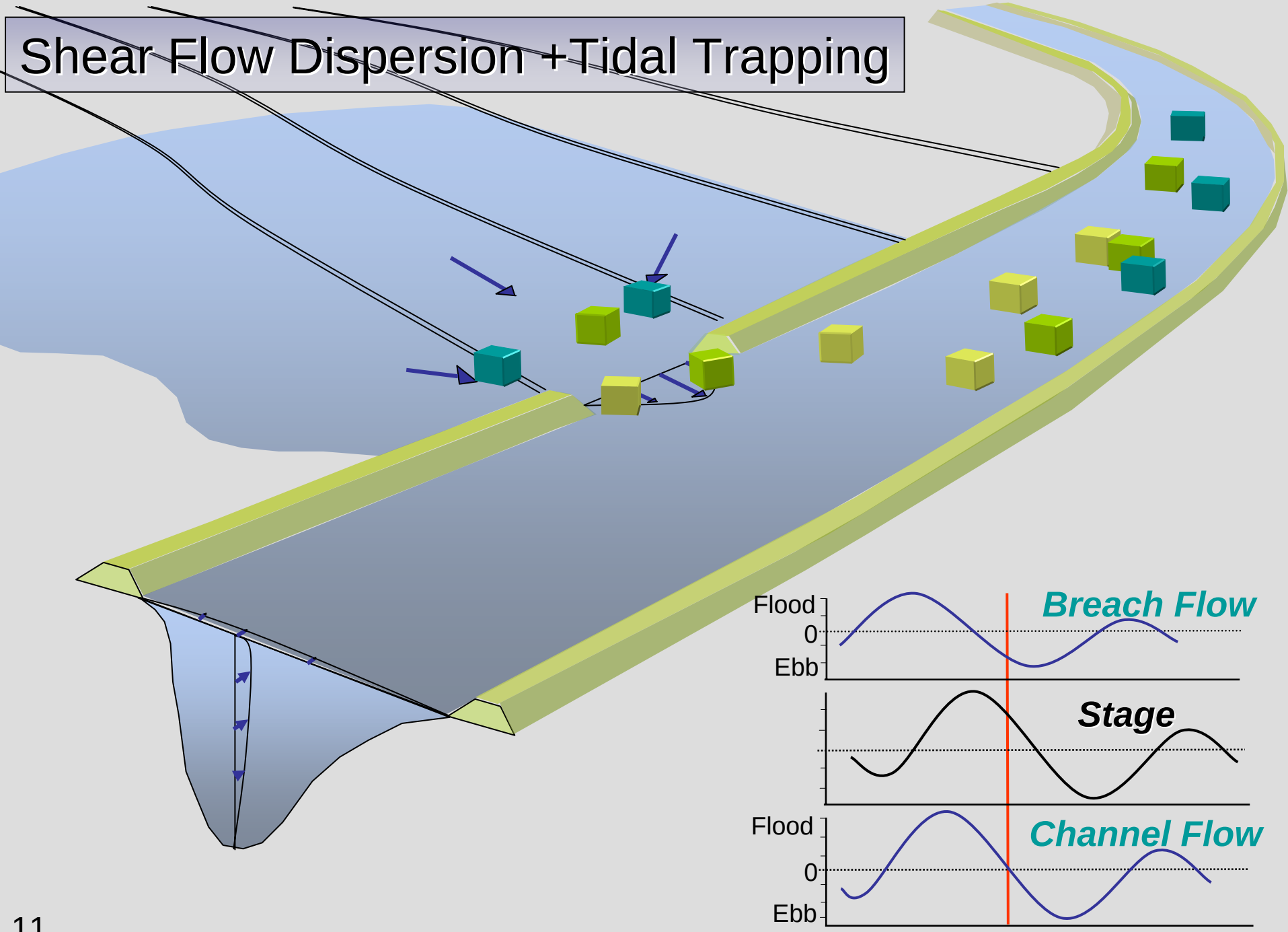
Shear Flow Dispersion +Tidal Trapping



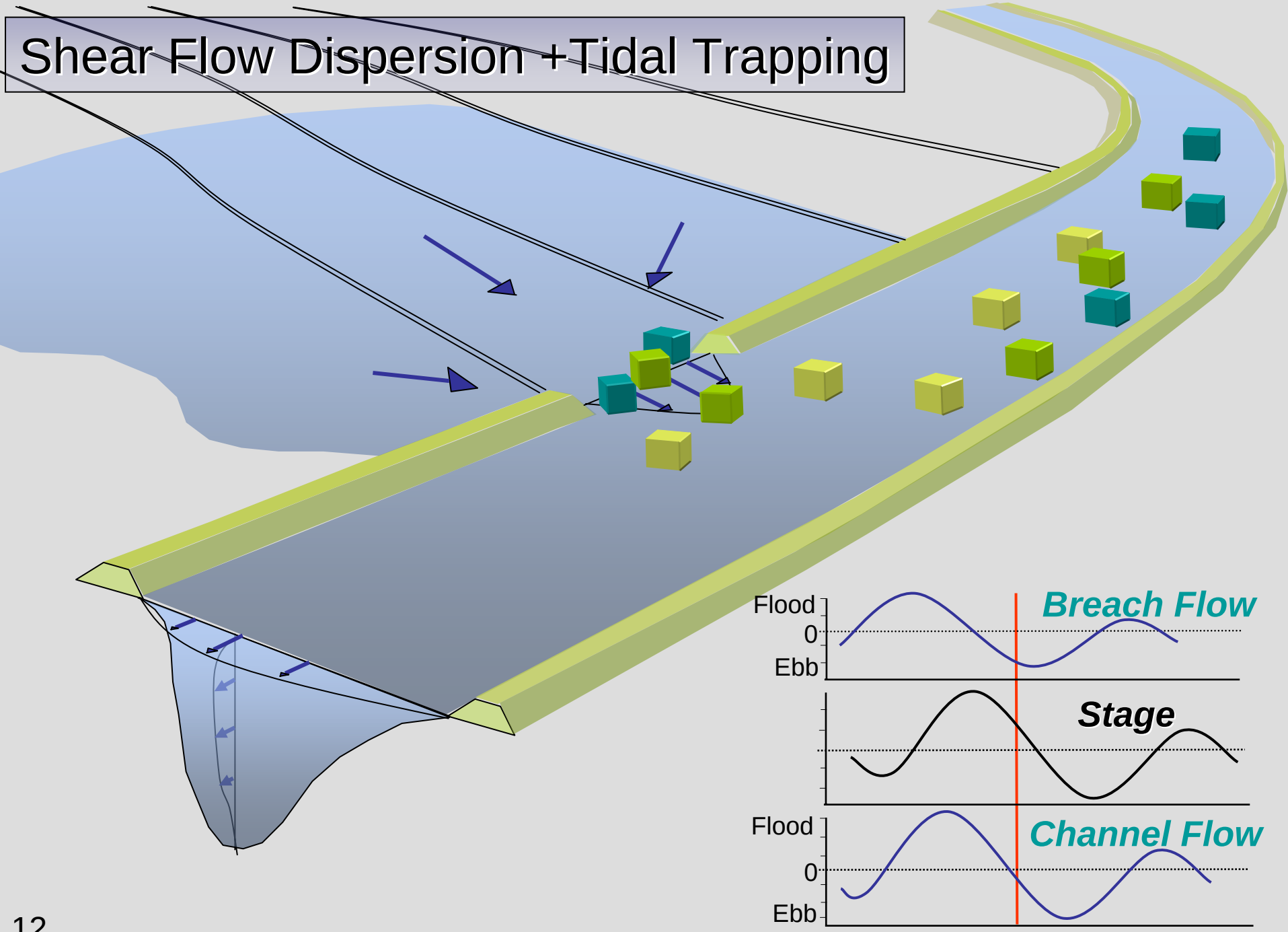
Shear Flow Dispersion +Tidal Trapping



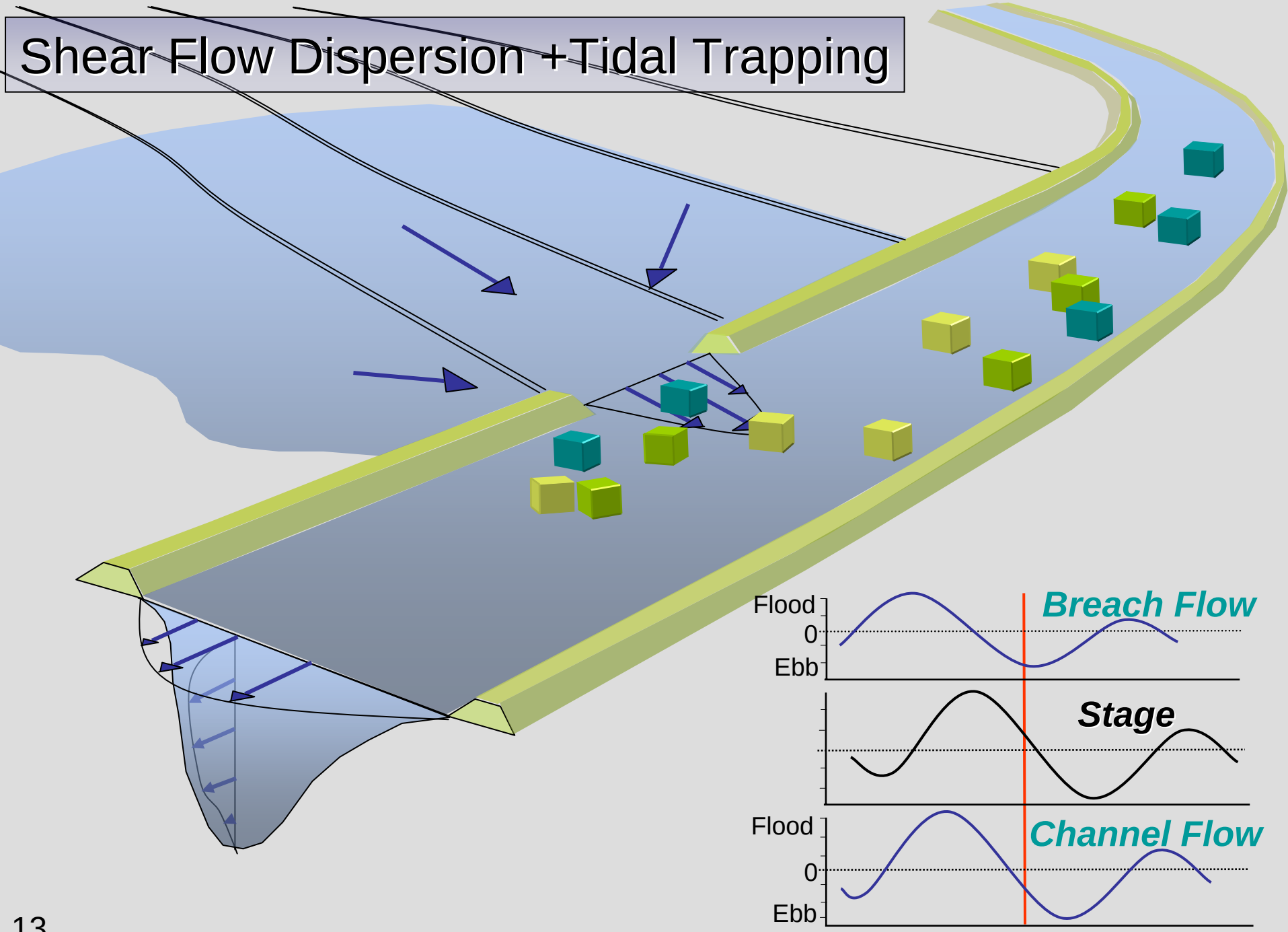
Shear Flow Dispersion +Tidal Trapping



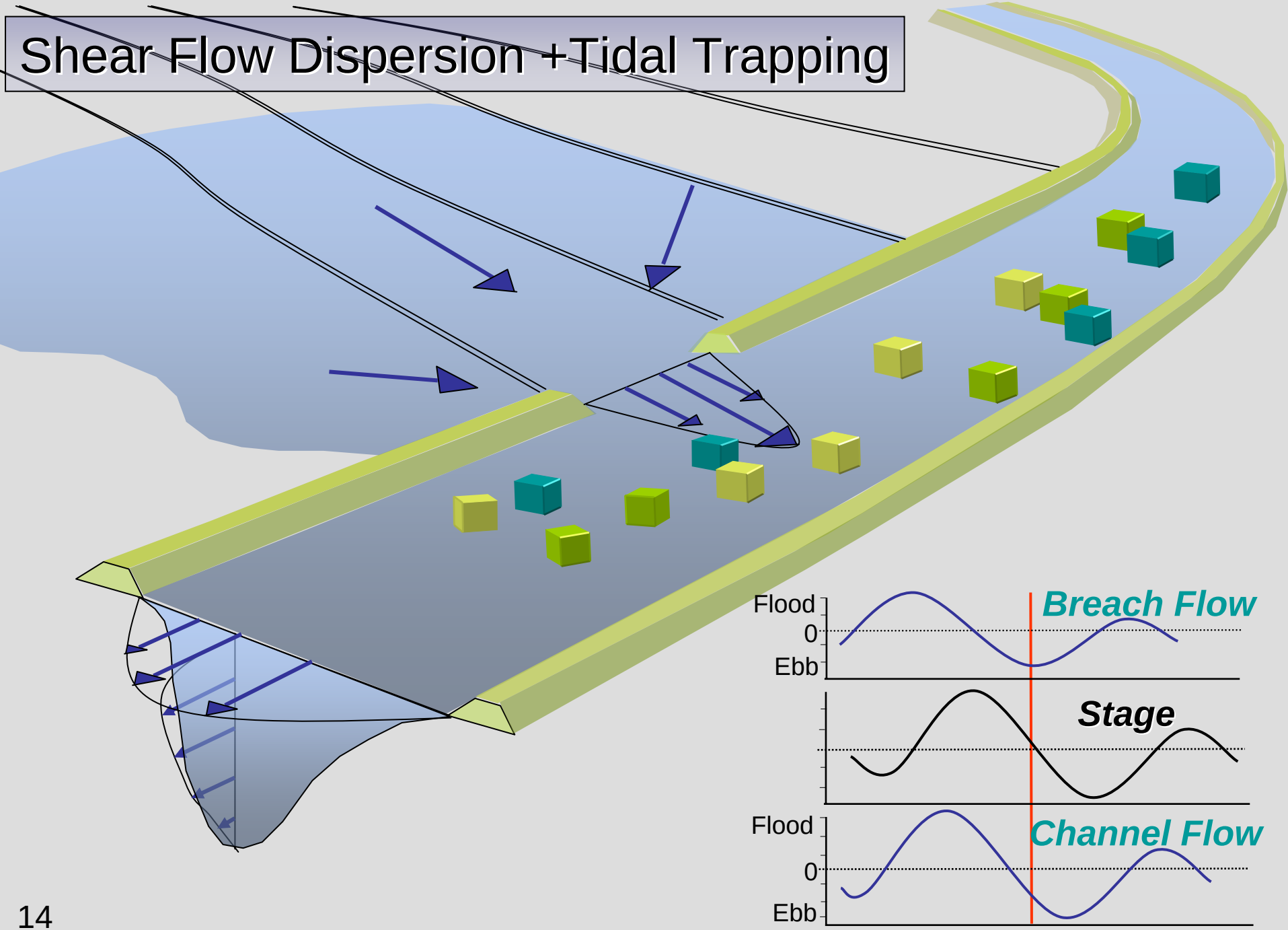
Shear Flow Dispersion +Tidal Trapping



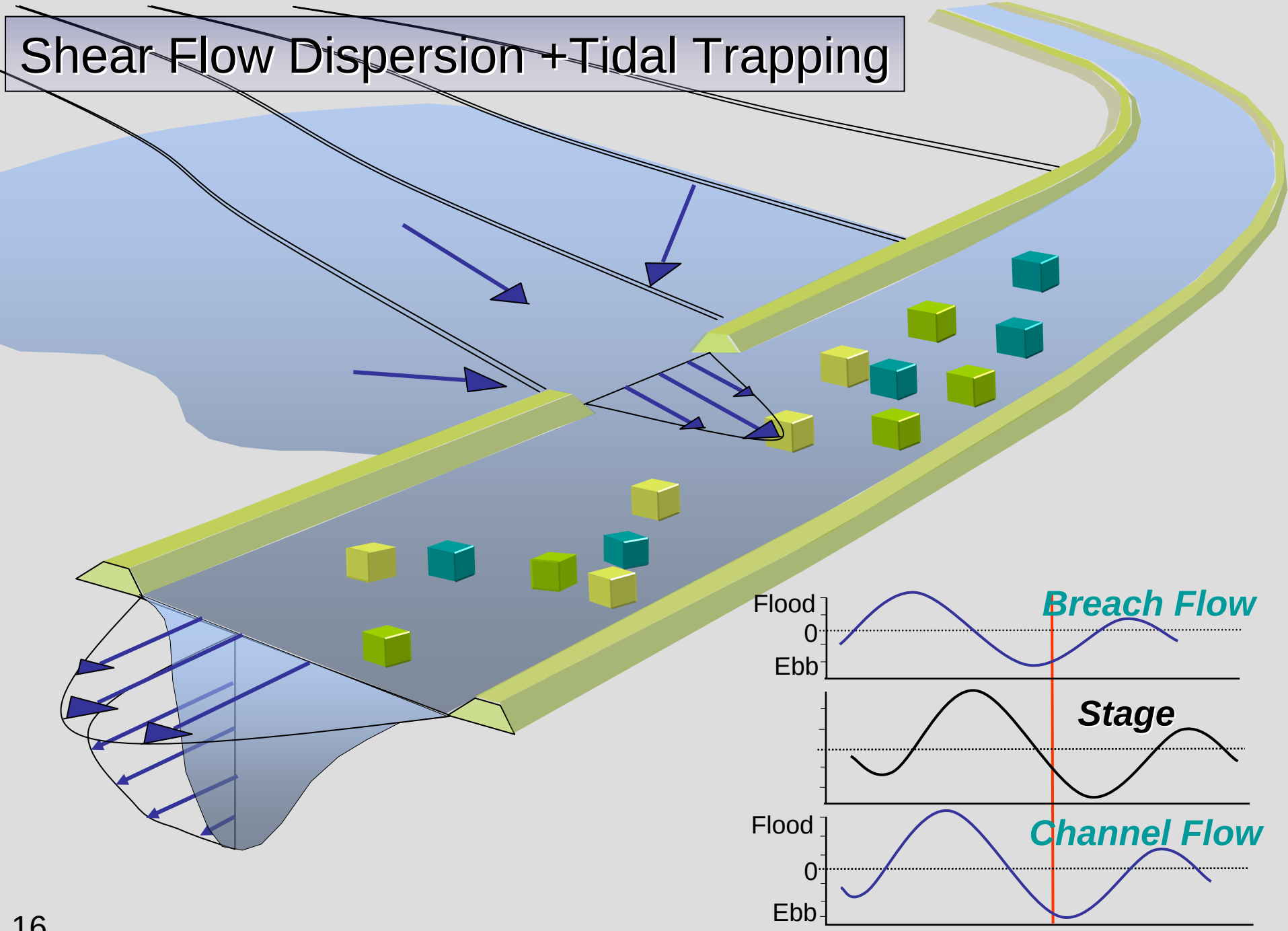
Shear Flow Dispersion +Tidal Trapping



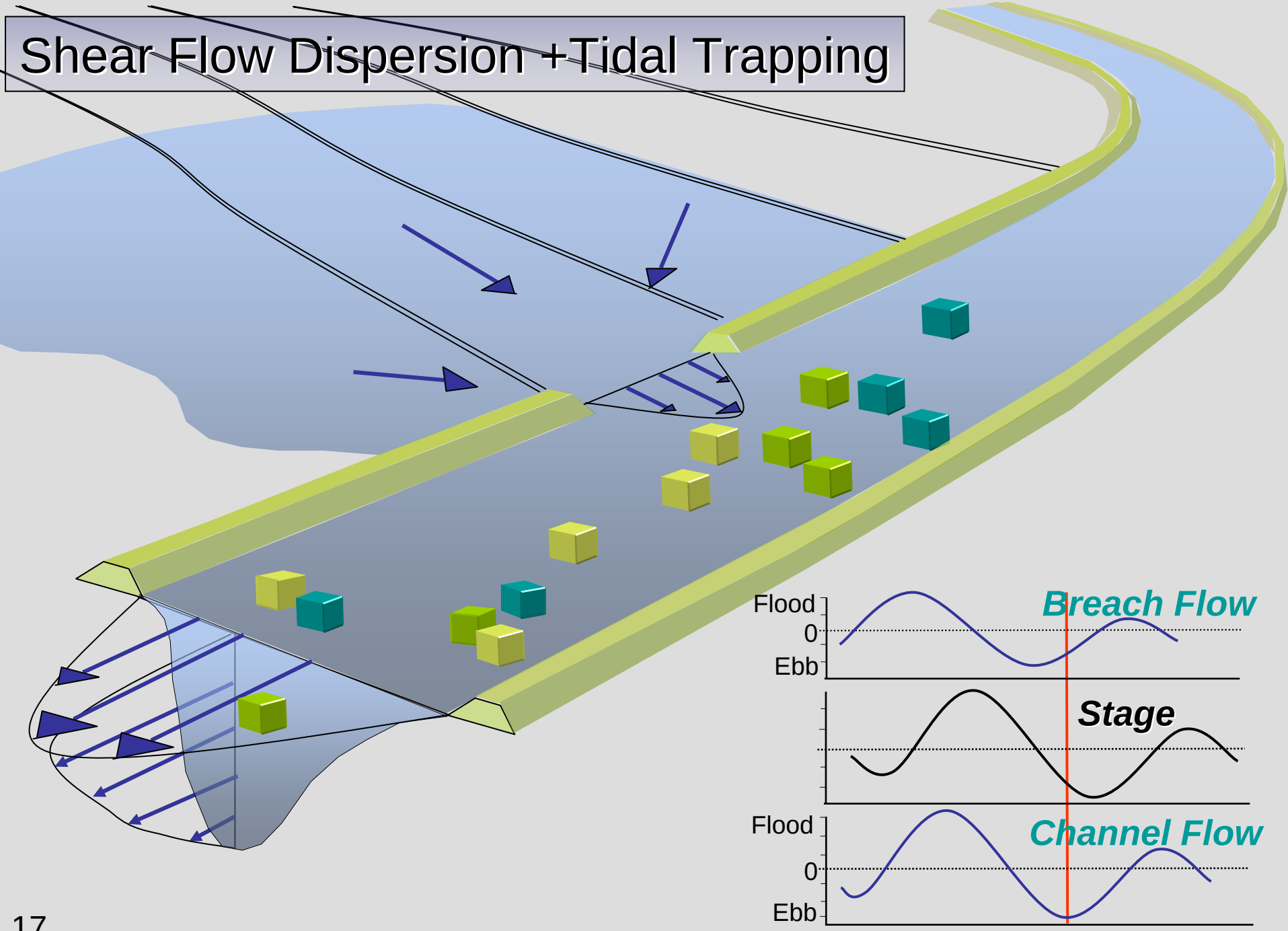
Shear Flow Dispersion +Tidal Trapping



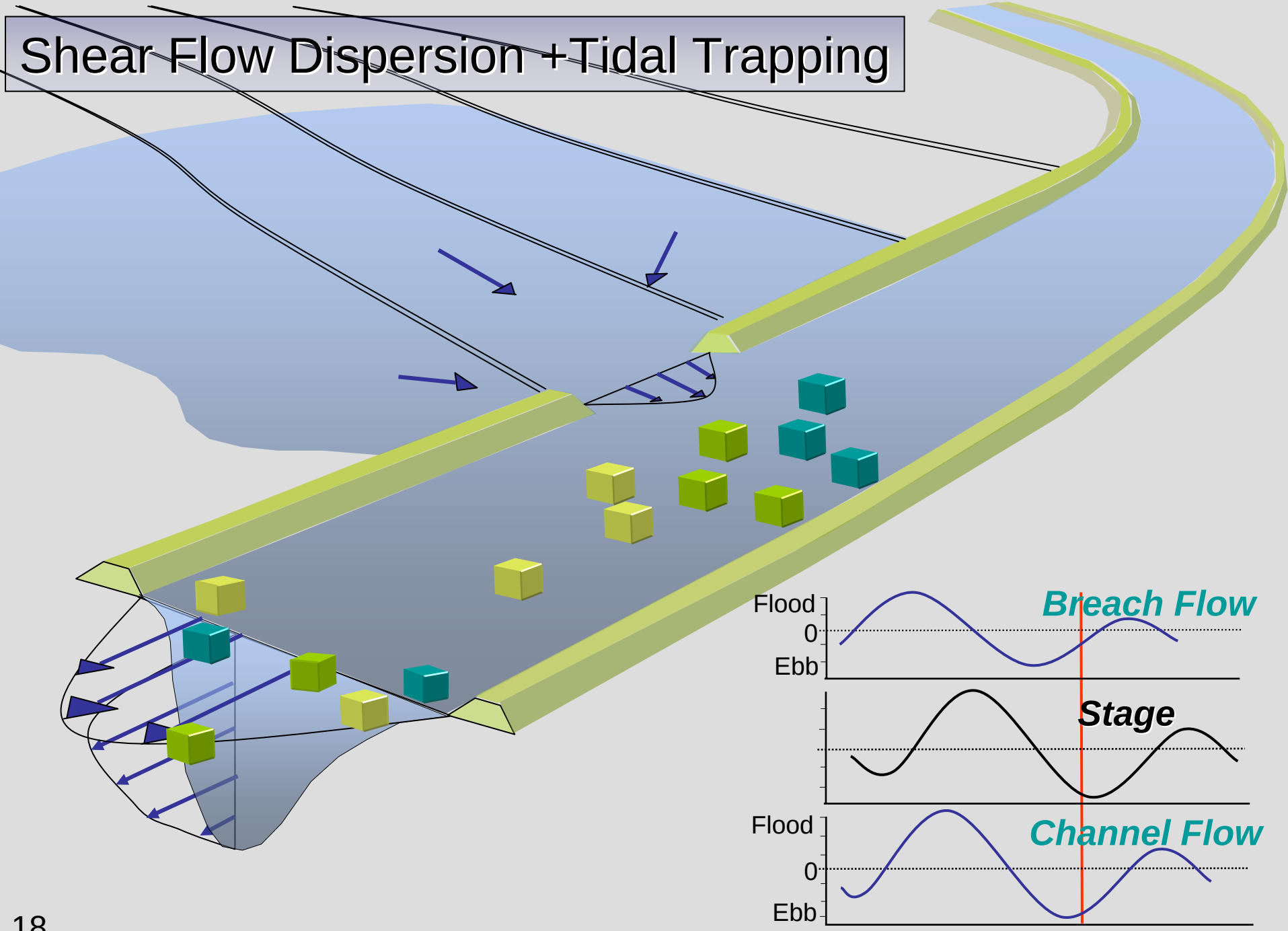
Shear Flow Dispersion +Tidal Trapping



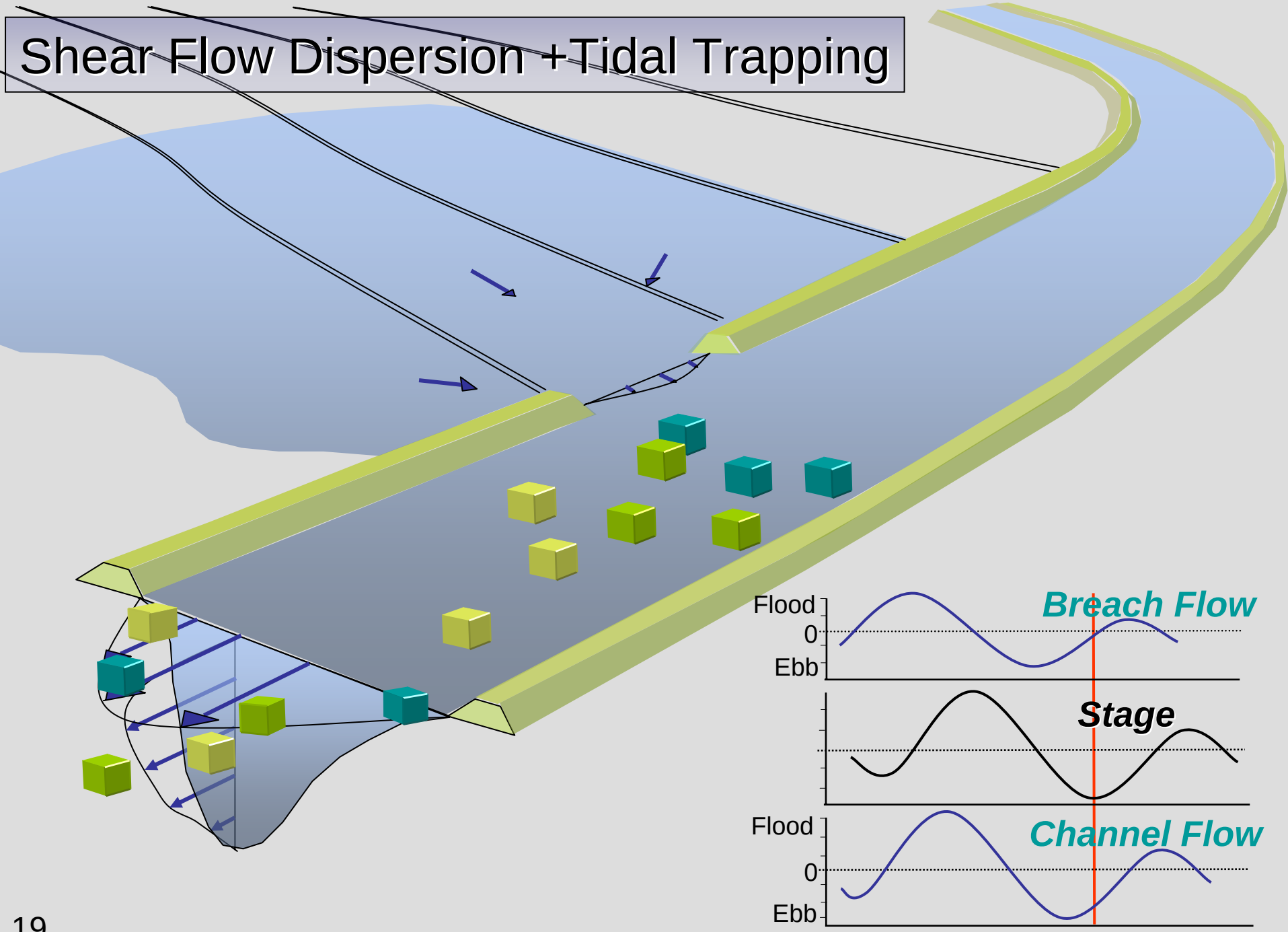
Shear Flow Dispersion +Tidal Trapping



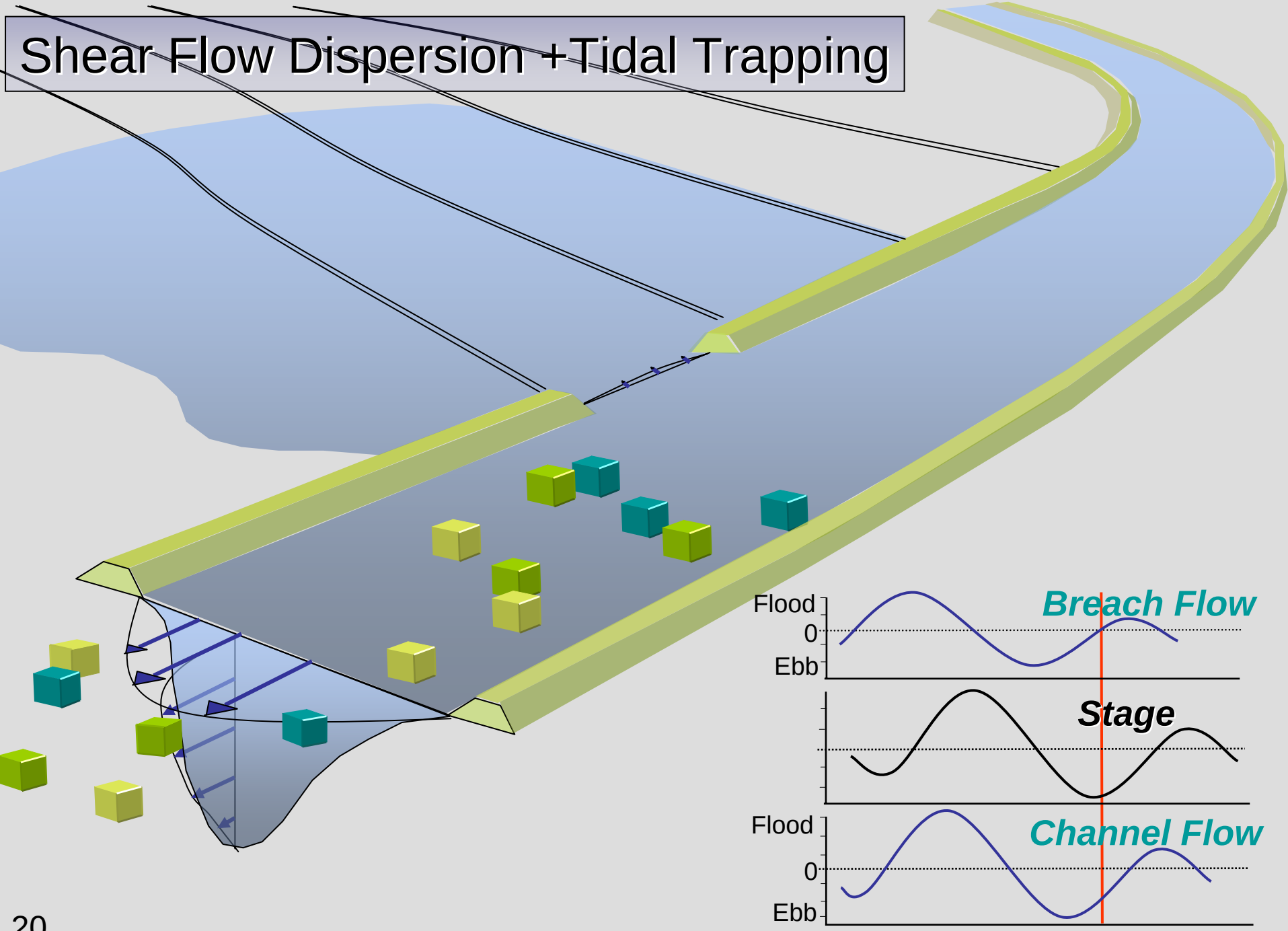
Shear Flow Dispersion +Tidal Trapping



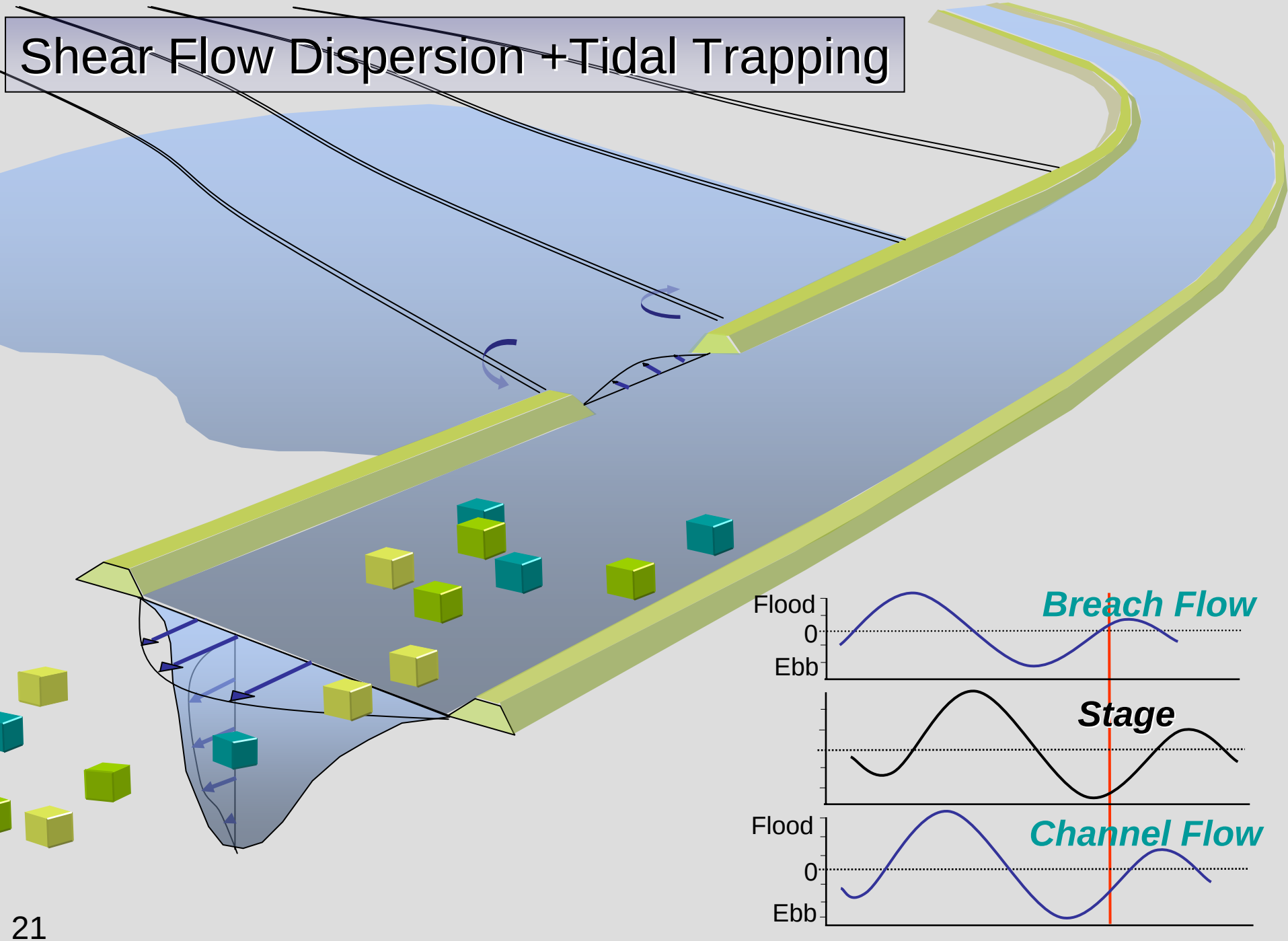
Shear Flow Dispersion +Tidal Trapping



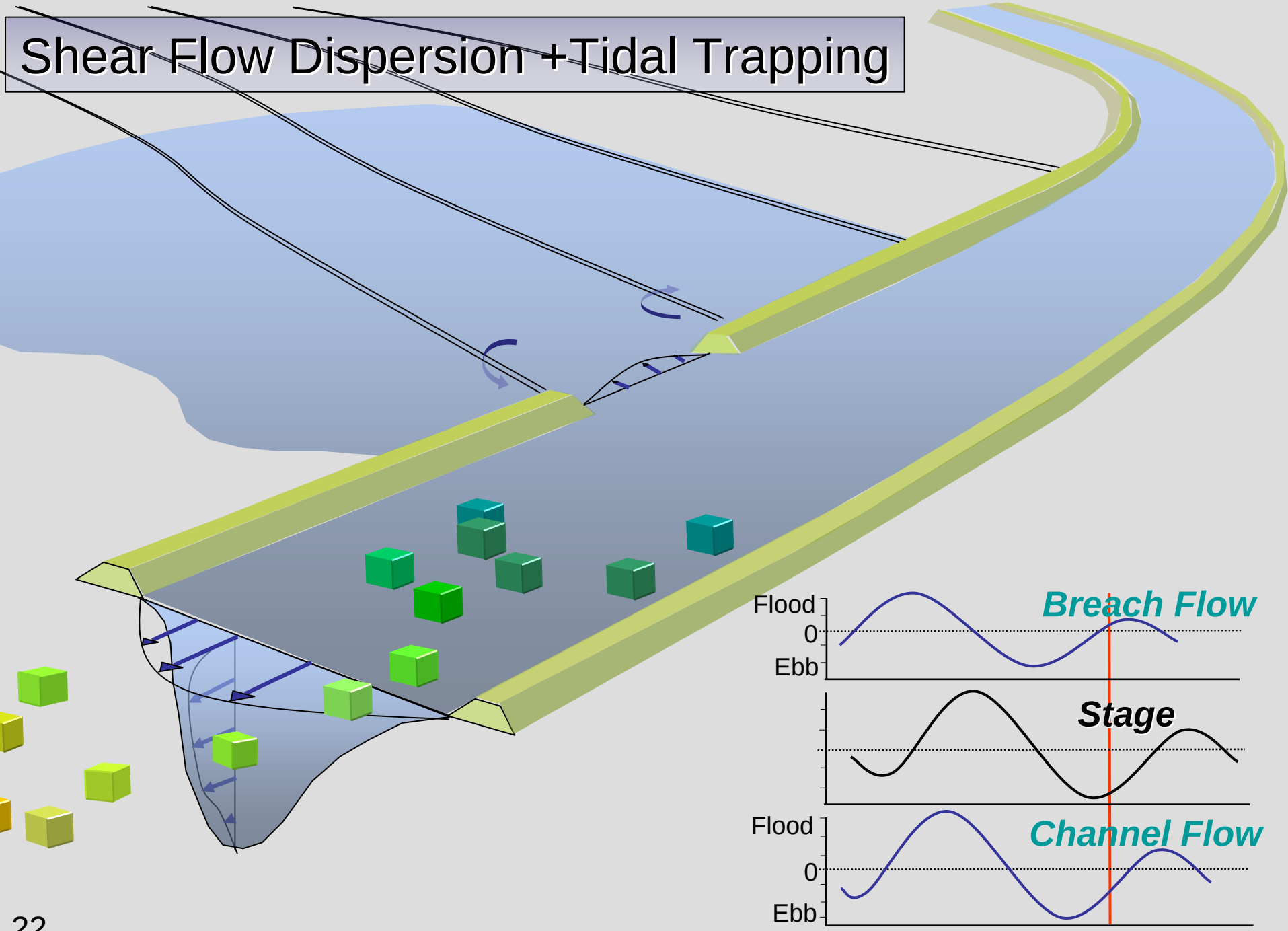
Shear Flow Dispersion +Tidal Trapping



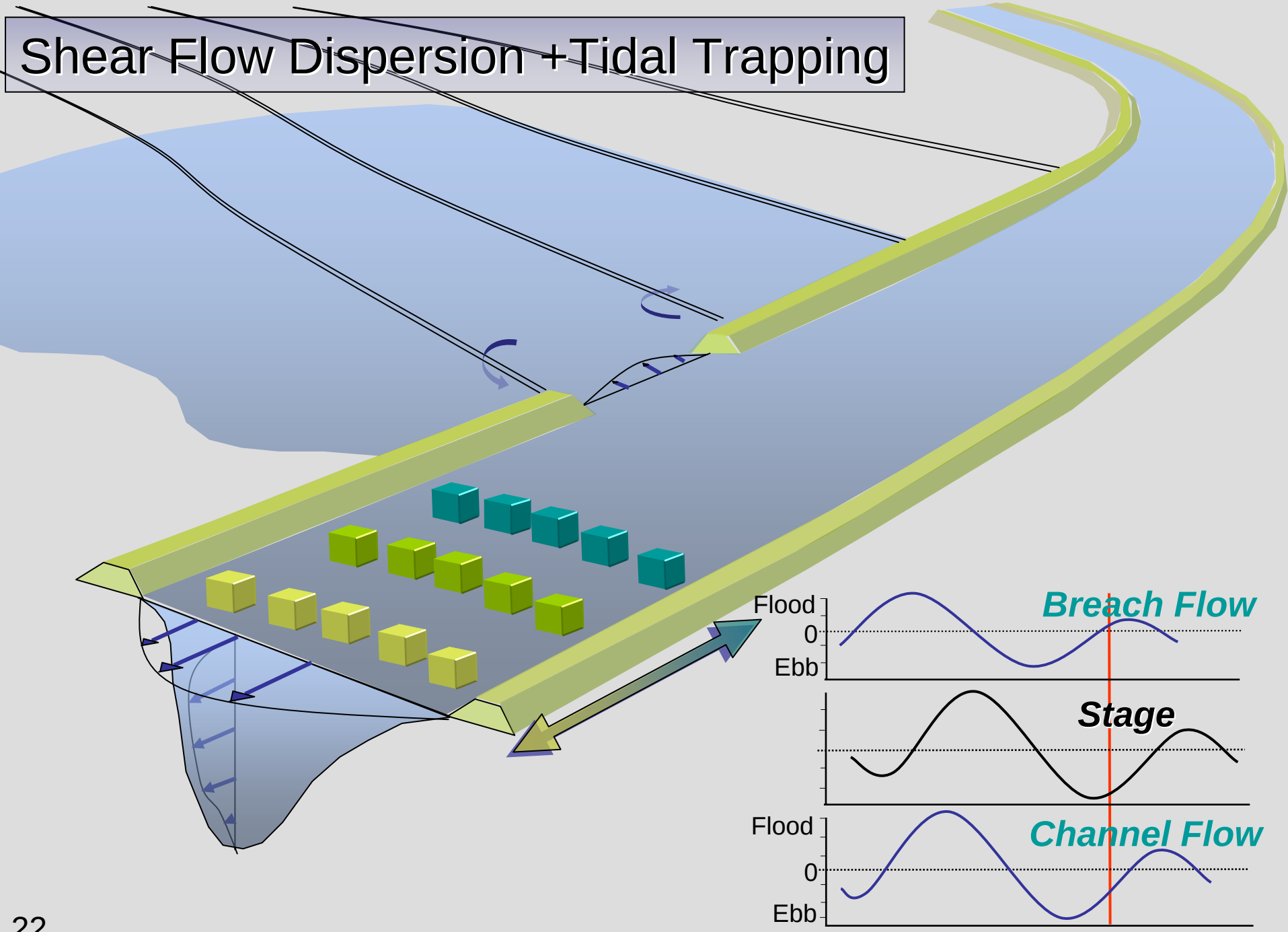
Shear Flow Dispersion +Tidal Trapping



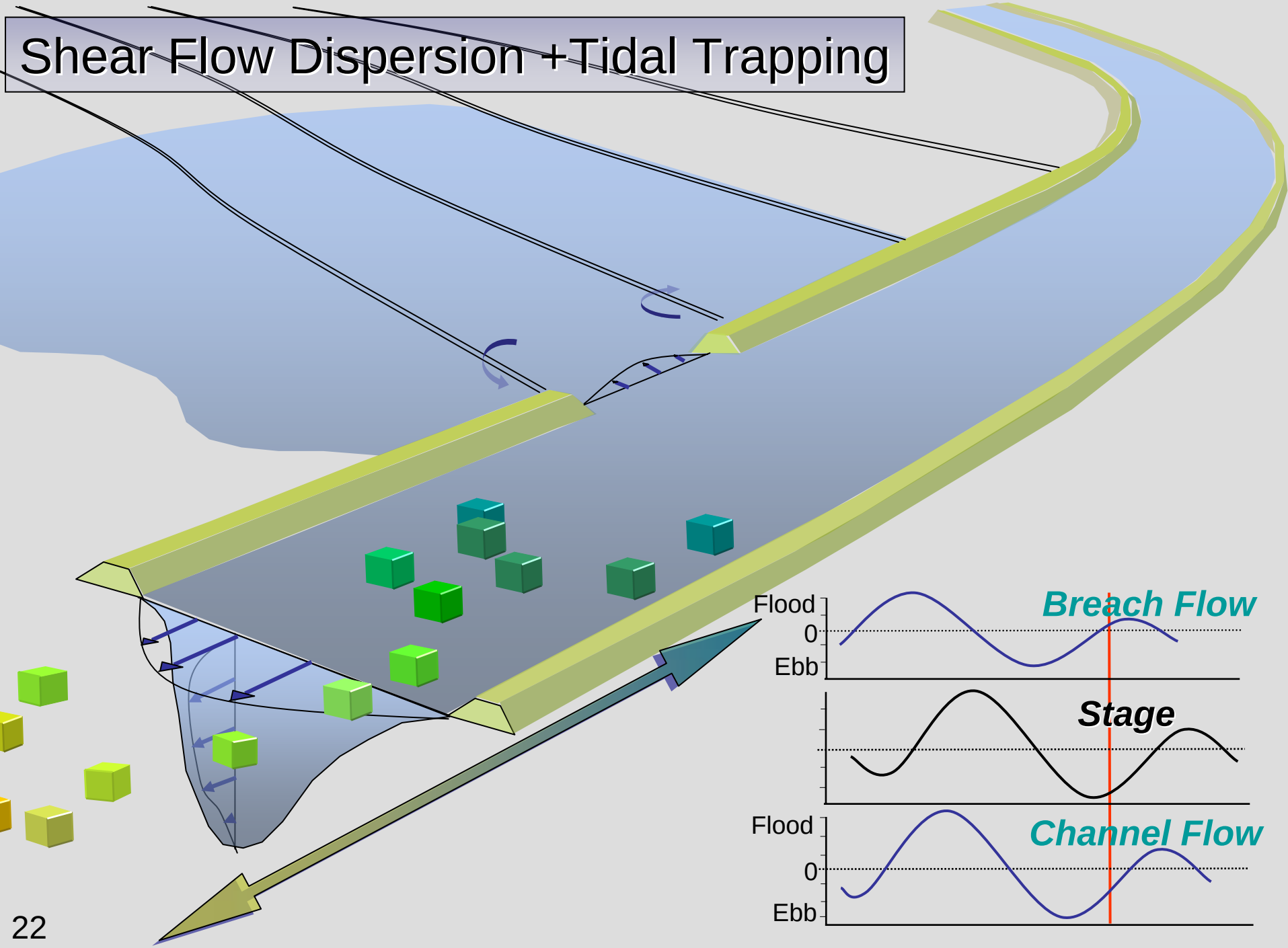
Shear Flow Dispersion +Tidal Trapping



Shear Flow Dispersion +Tidal Trapping



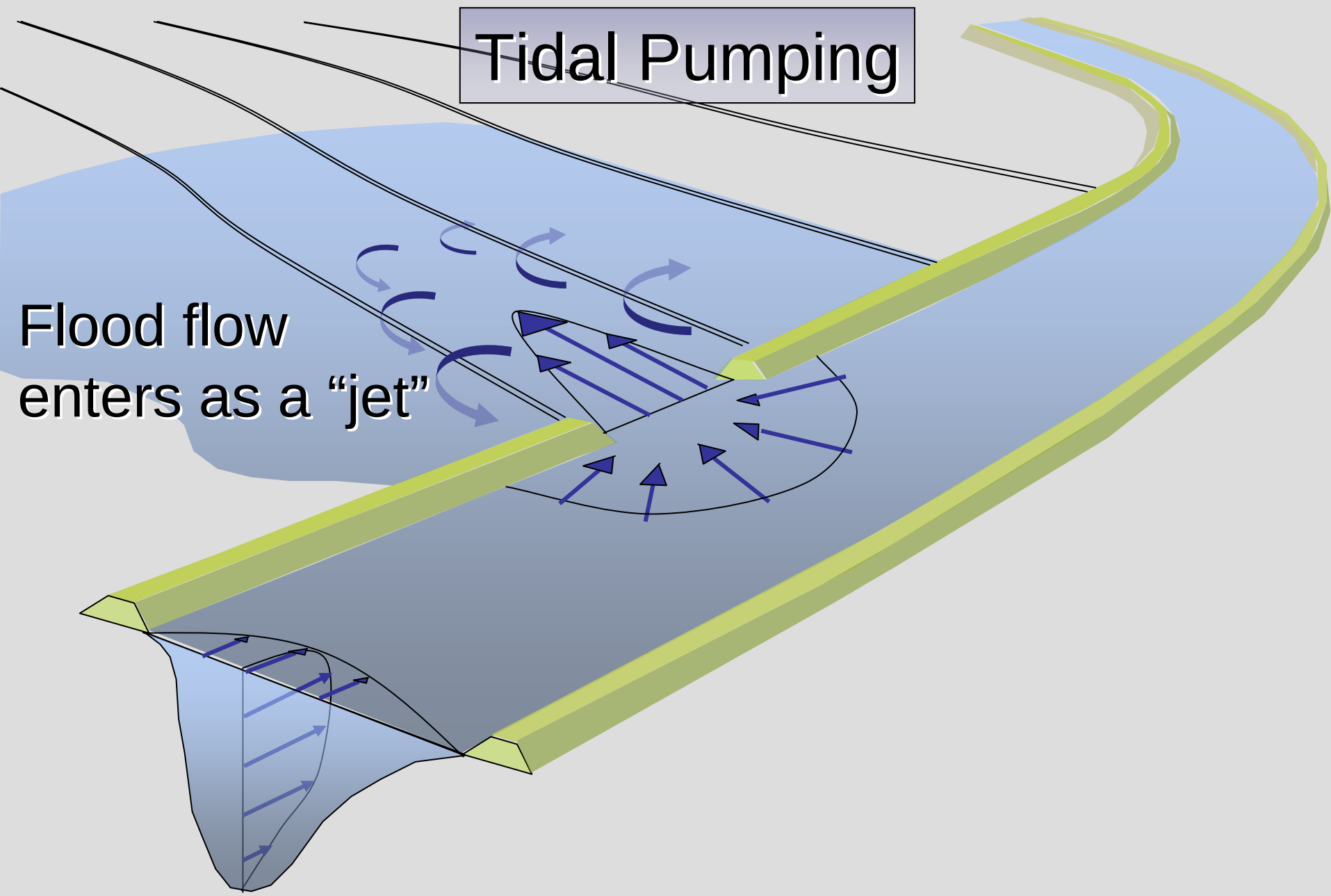
Shear Flow Dispersion +Tidal Trapping



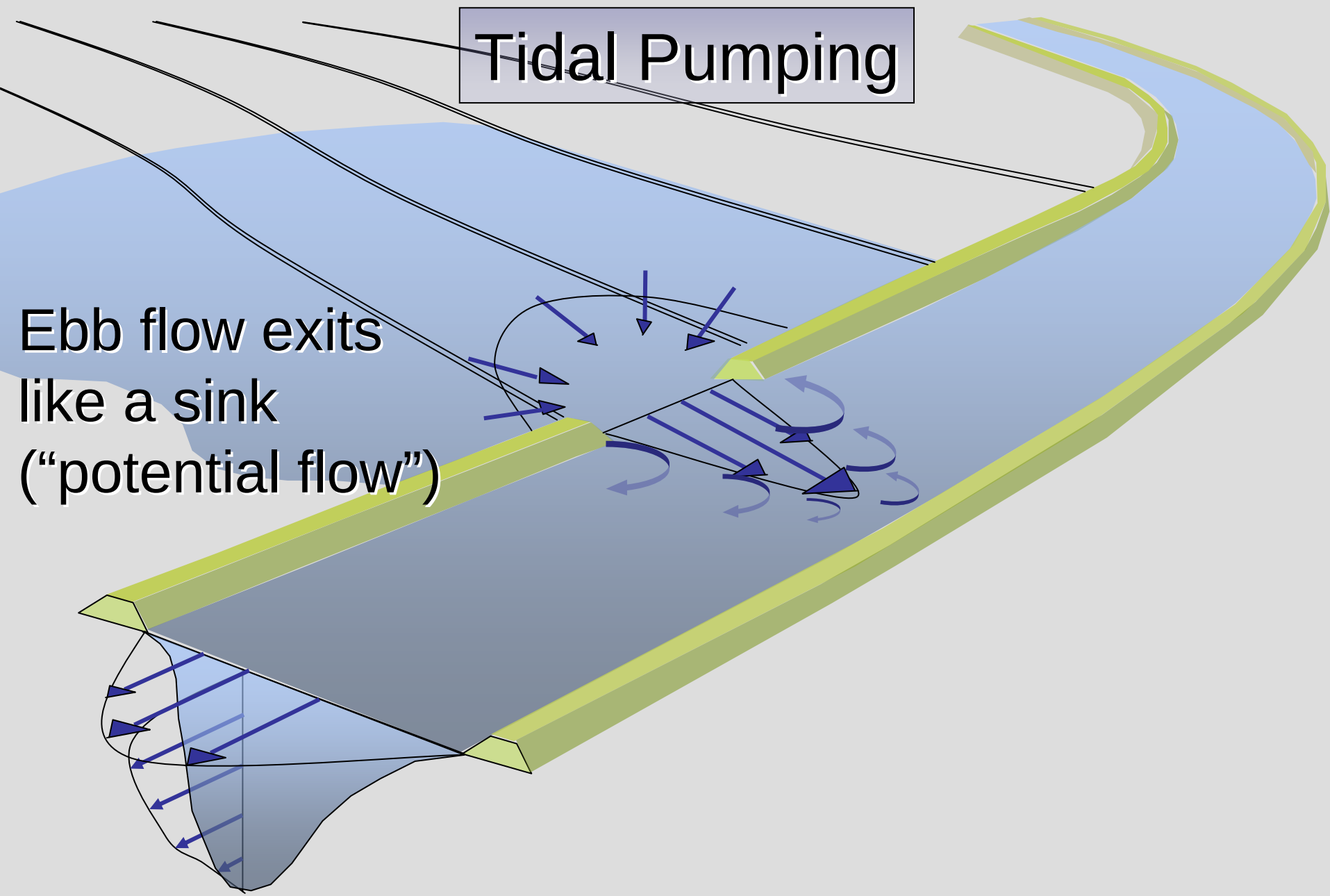
2.Tidal Pumping

- “Net” flow caused by tidal flow asynchrony

Tidal Pumping

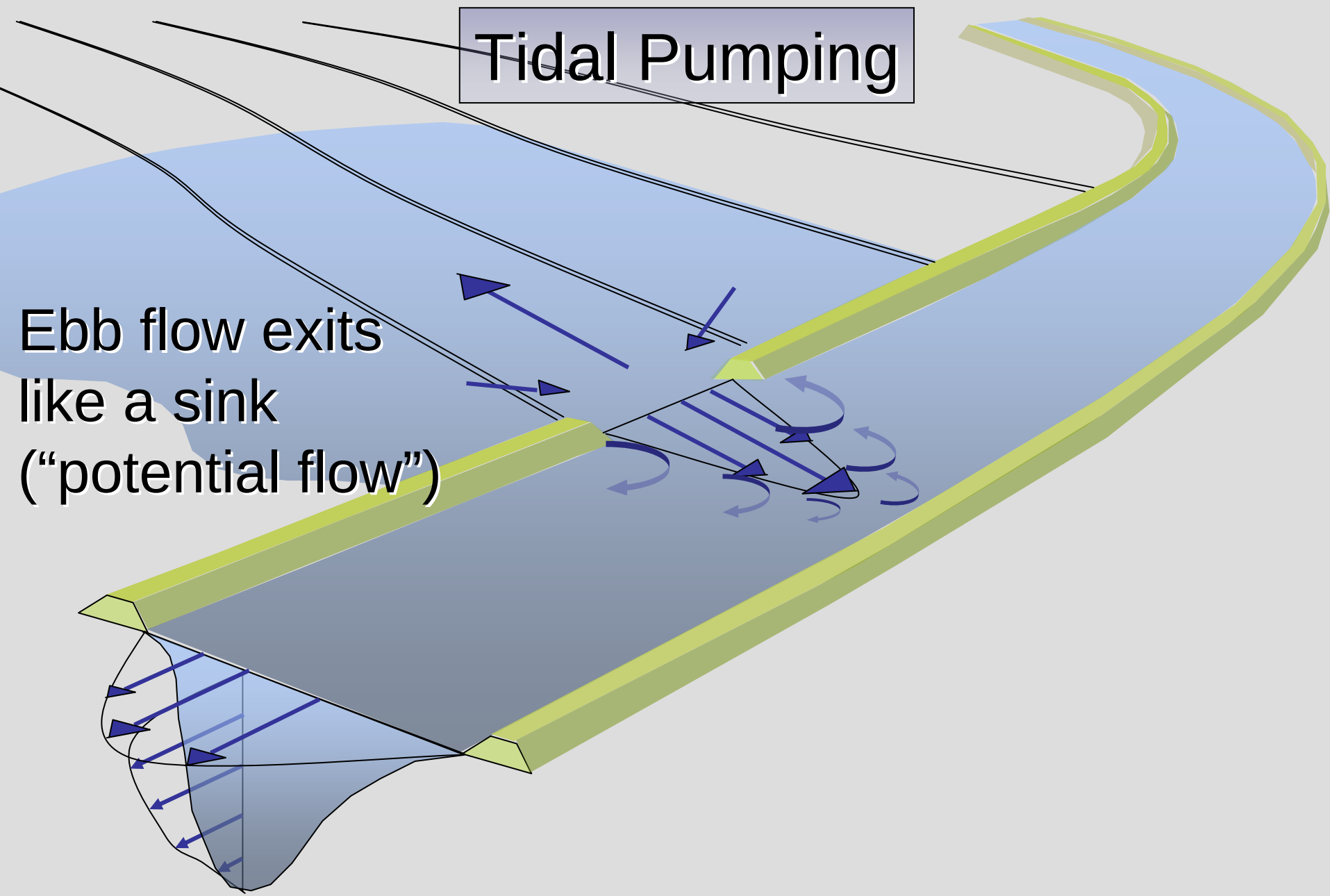


Tidal Pumping



Ebb flow exits like a sink (“potential flow”)

Tidal Pumping

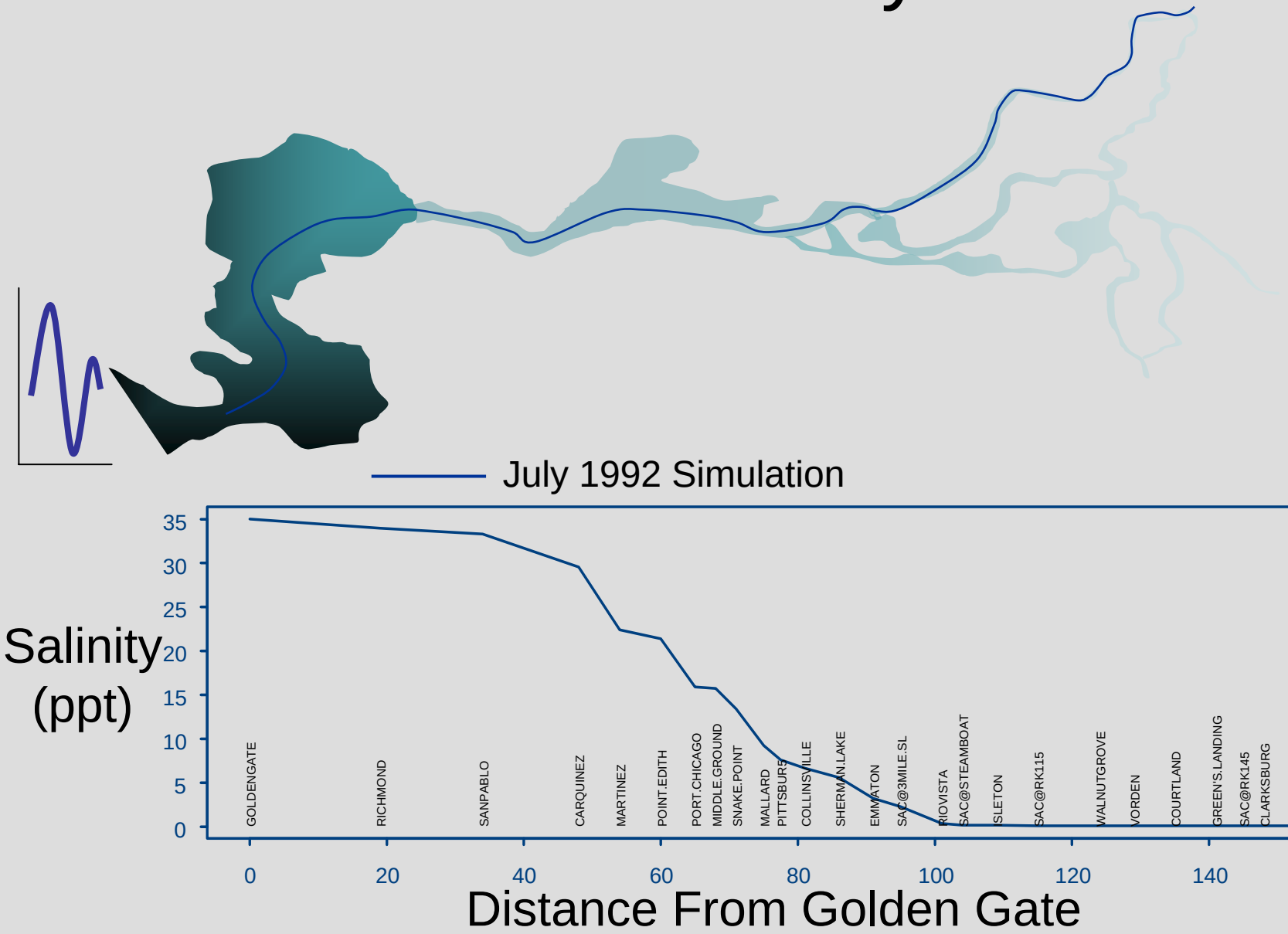


Ebb flow exits like a sink (“potential flow”)

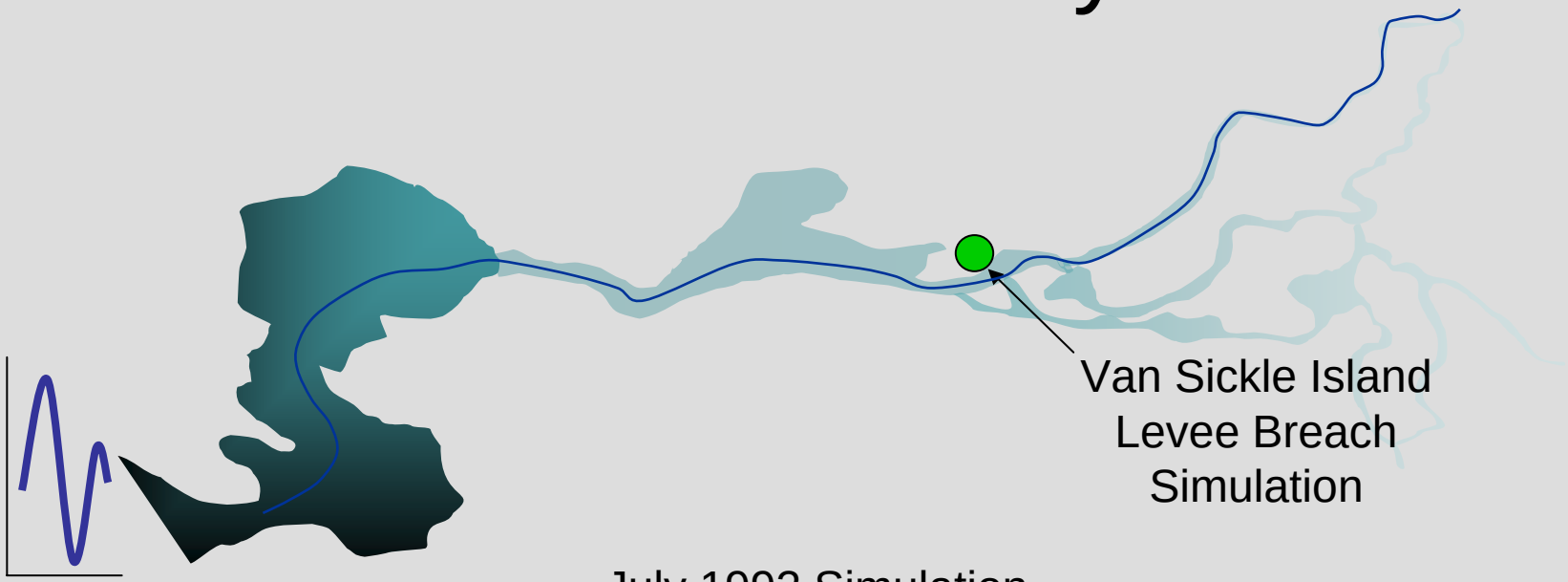
Region Scale Impacts

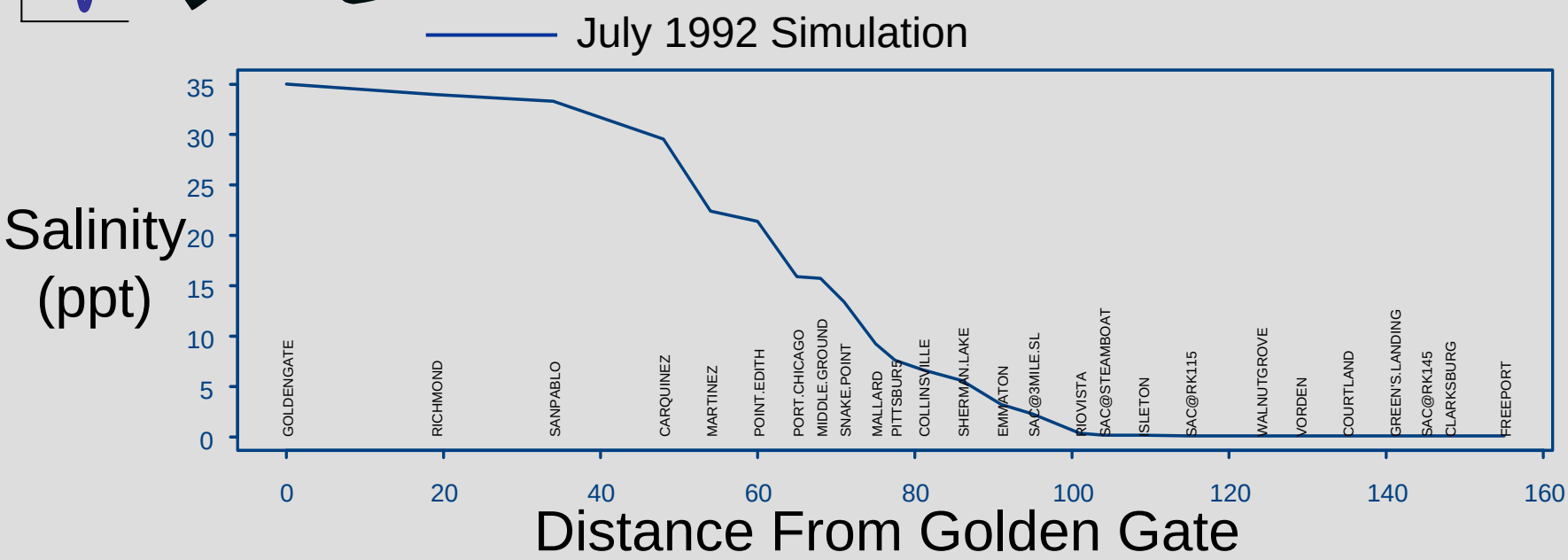
- Local flattening of salinity gradient indicates mixing and energy dissipation
- Mixing increases the internal potential energy of the water column. That energy was extracted from the ocean tidal wave.

Simulated Salinity Gradient

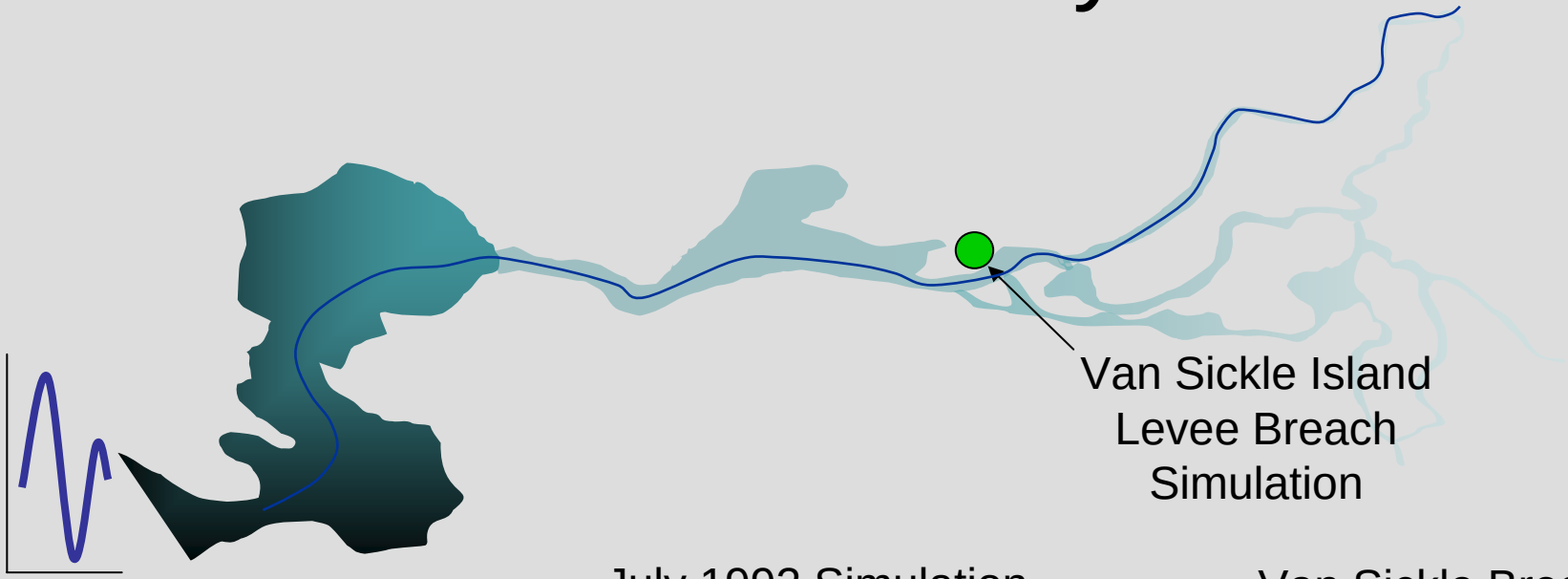


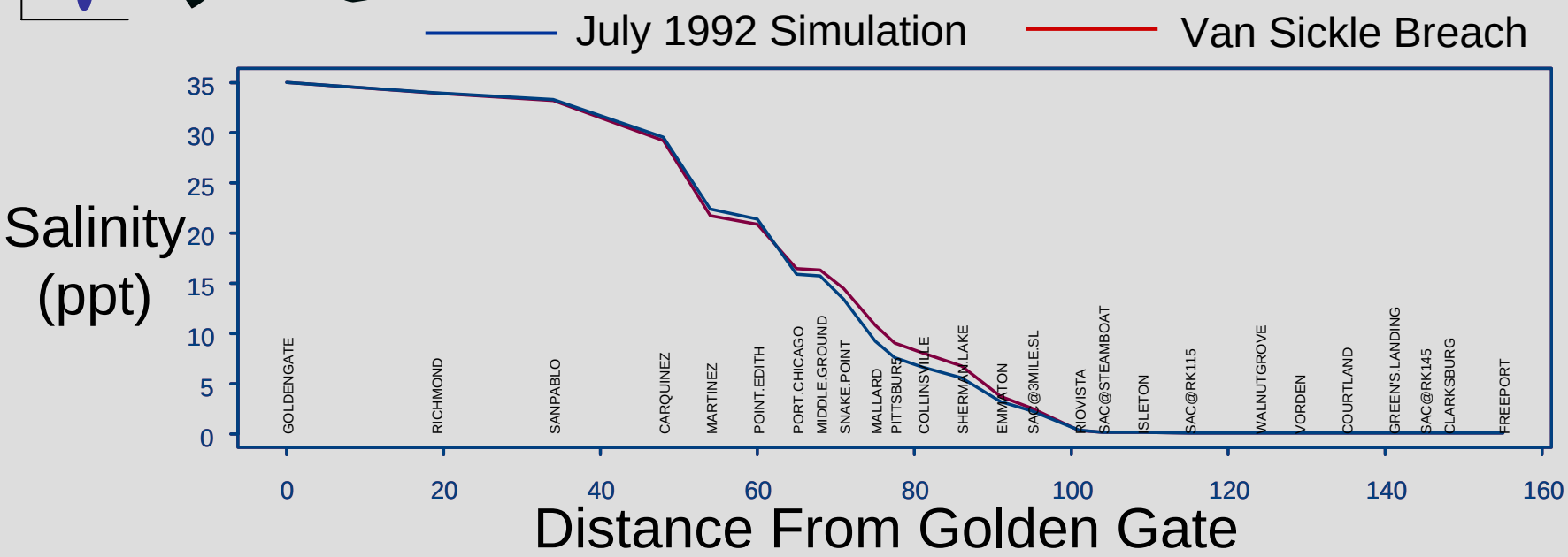
Simulated Salinity Gradient



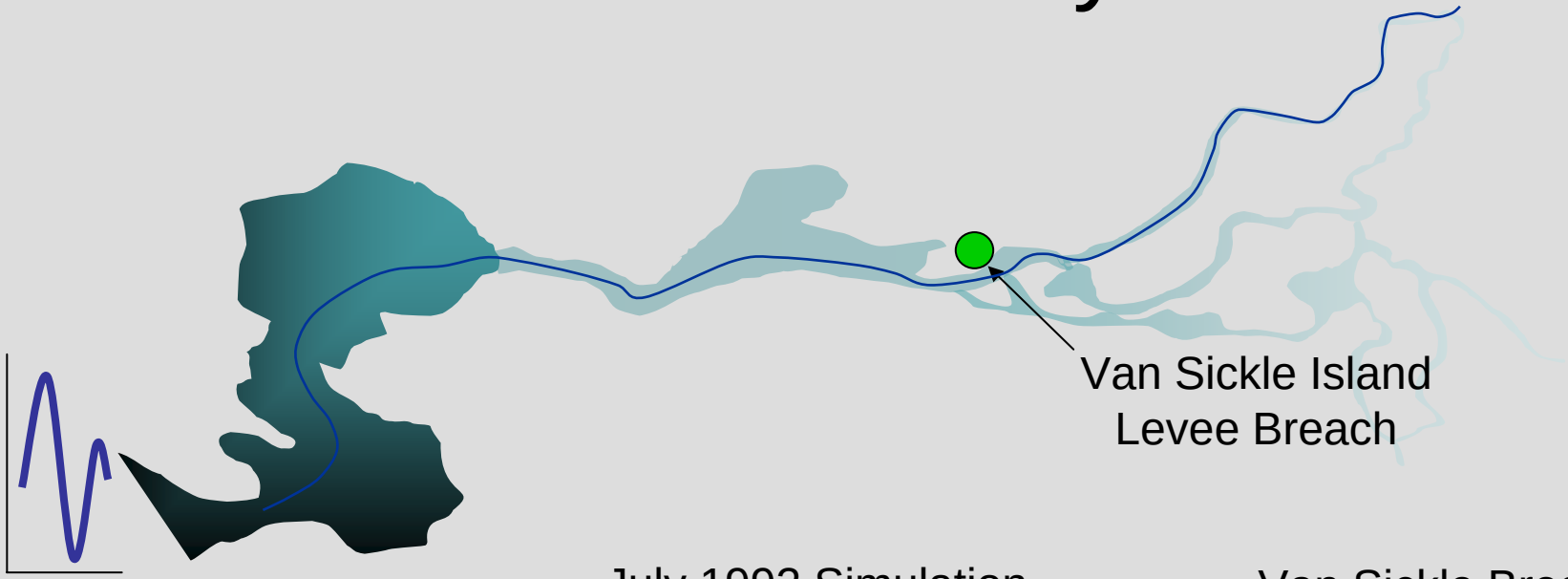


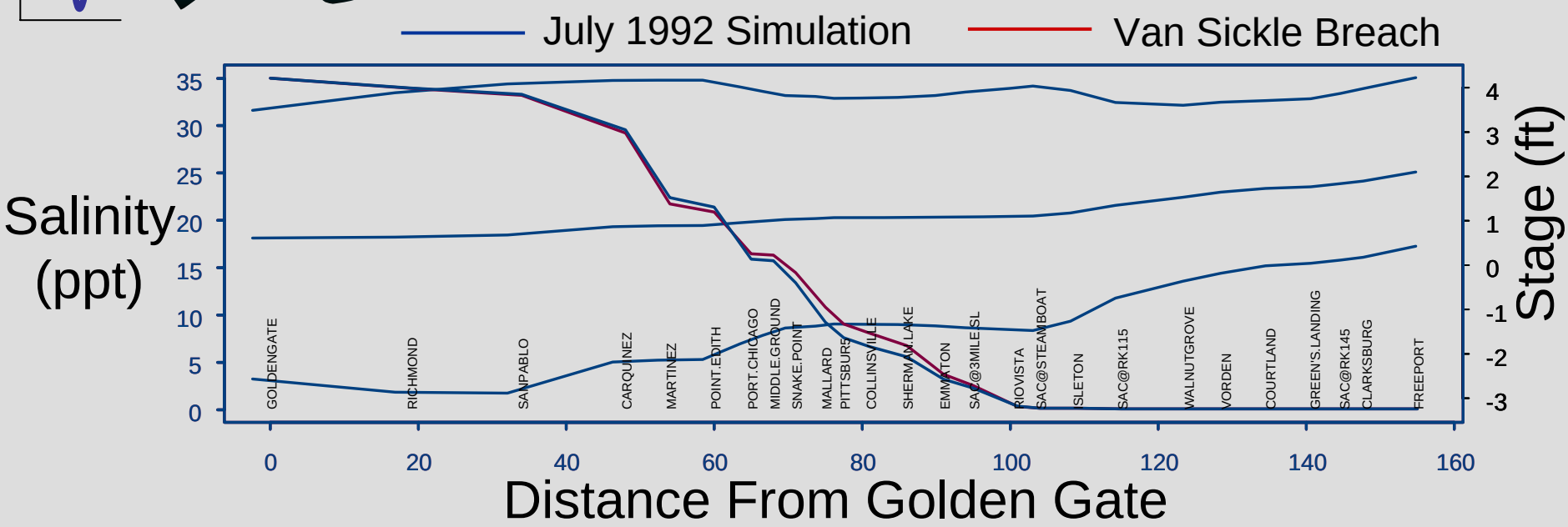
Simulated Salinity Gradient



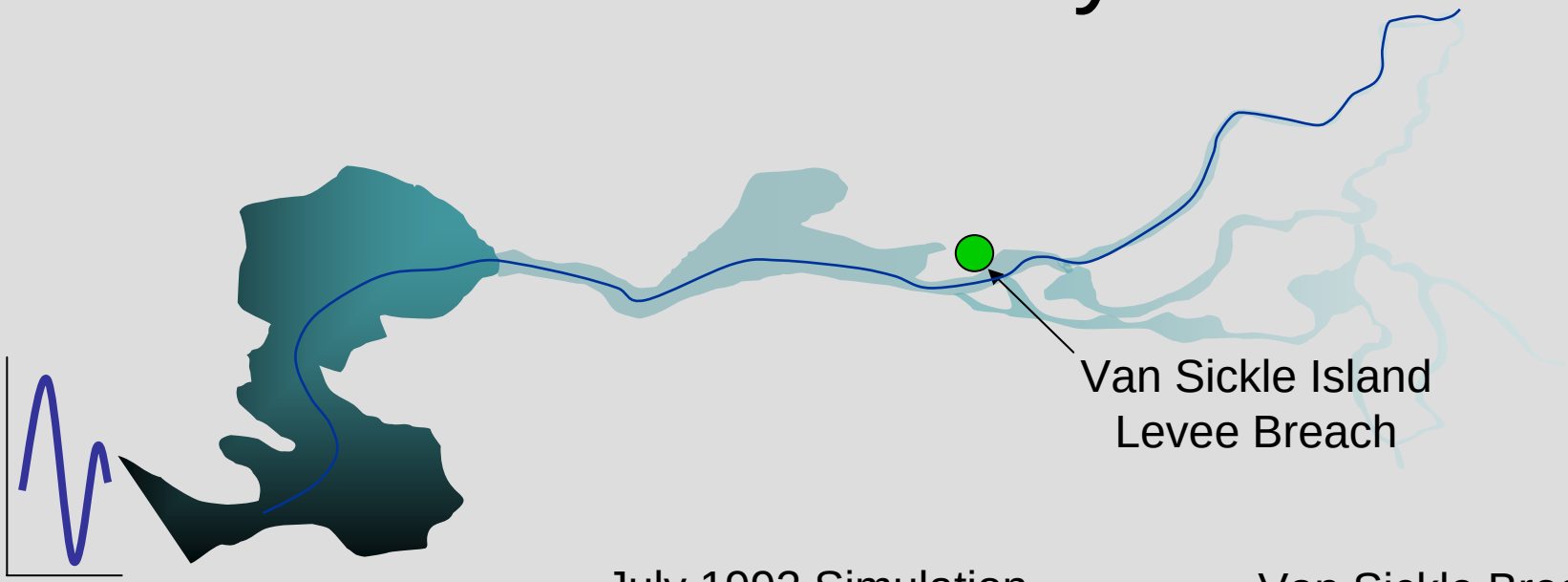


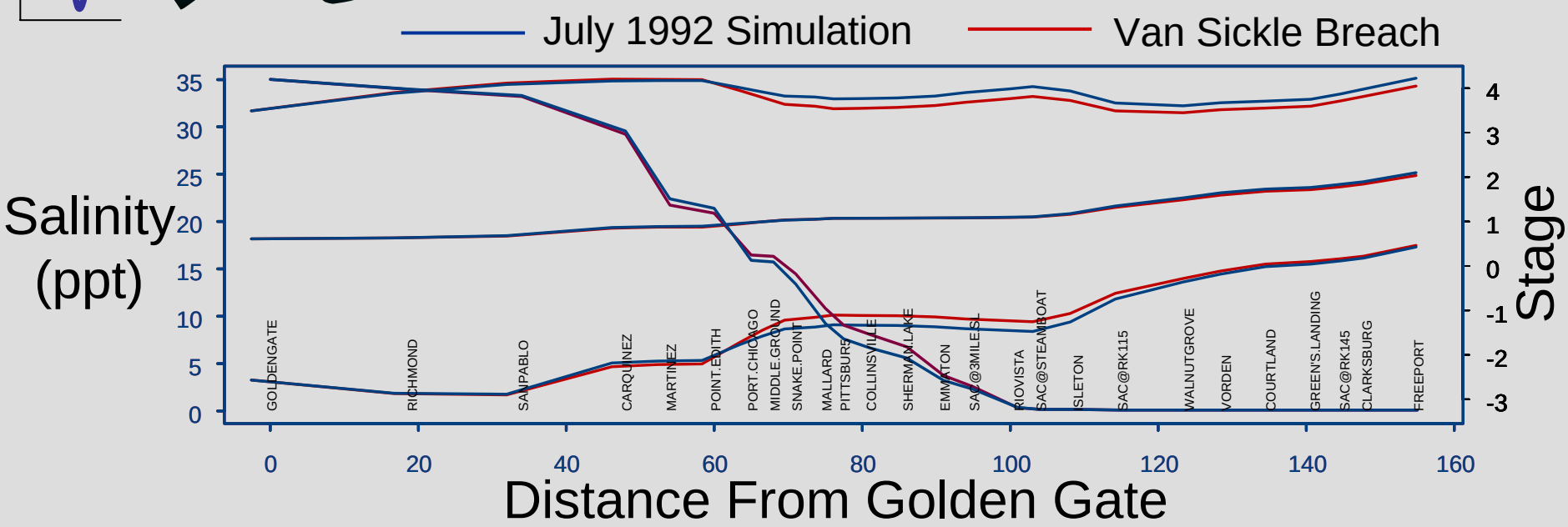
Simulated Salinity Gradient



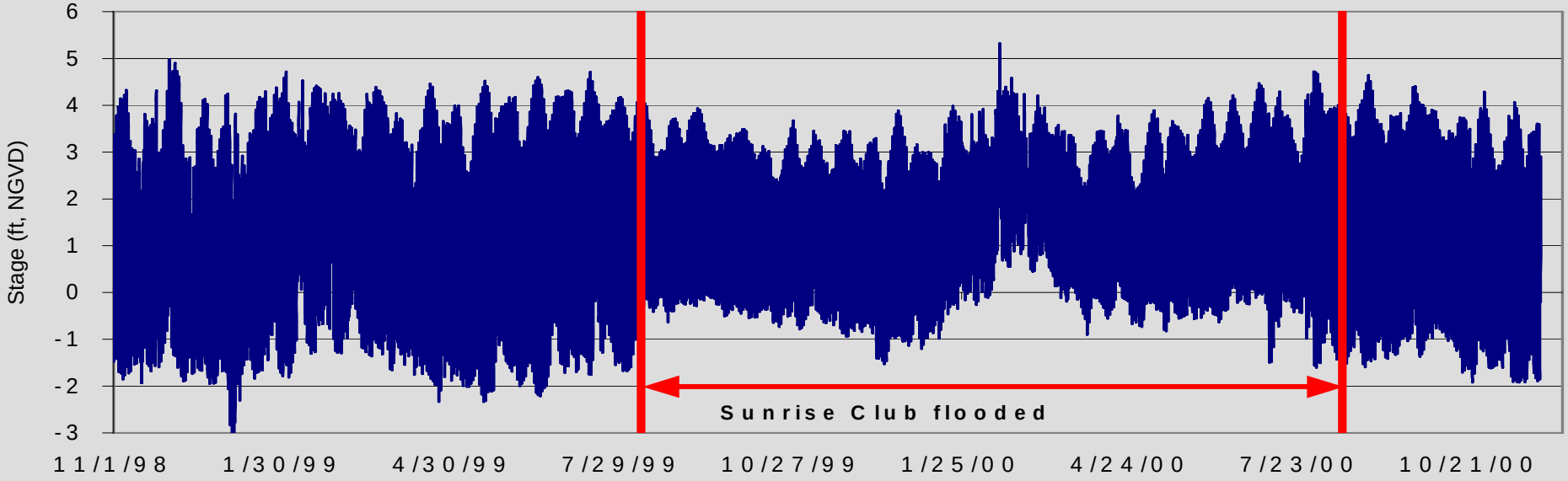


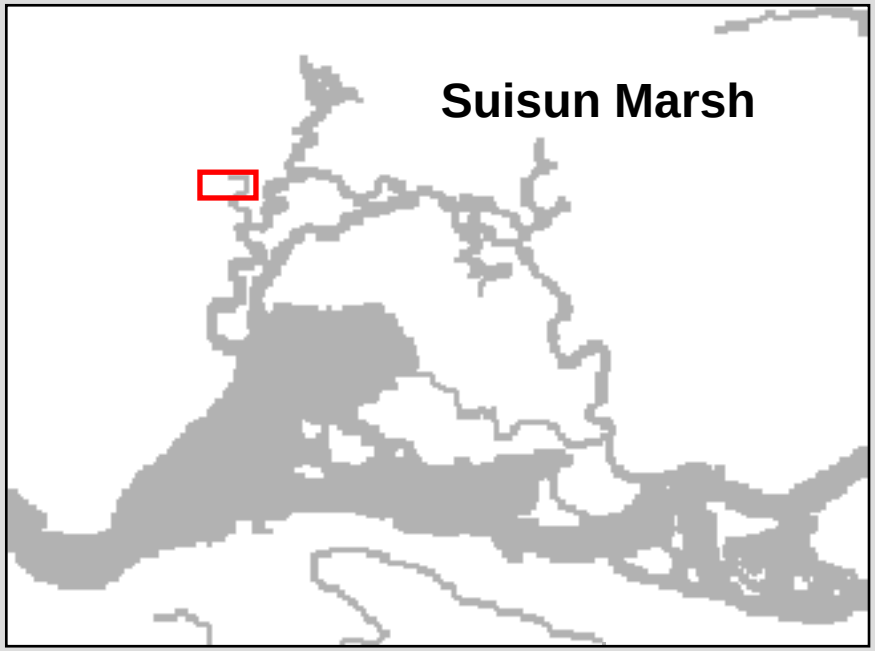
Simulated Salinity Gradient





Tidal Range Reduction Due to Levee Breach





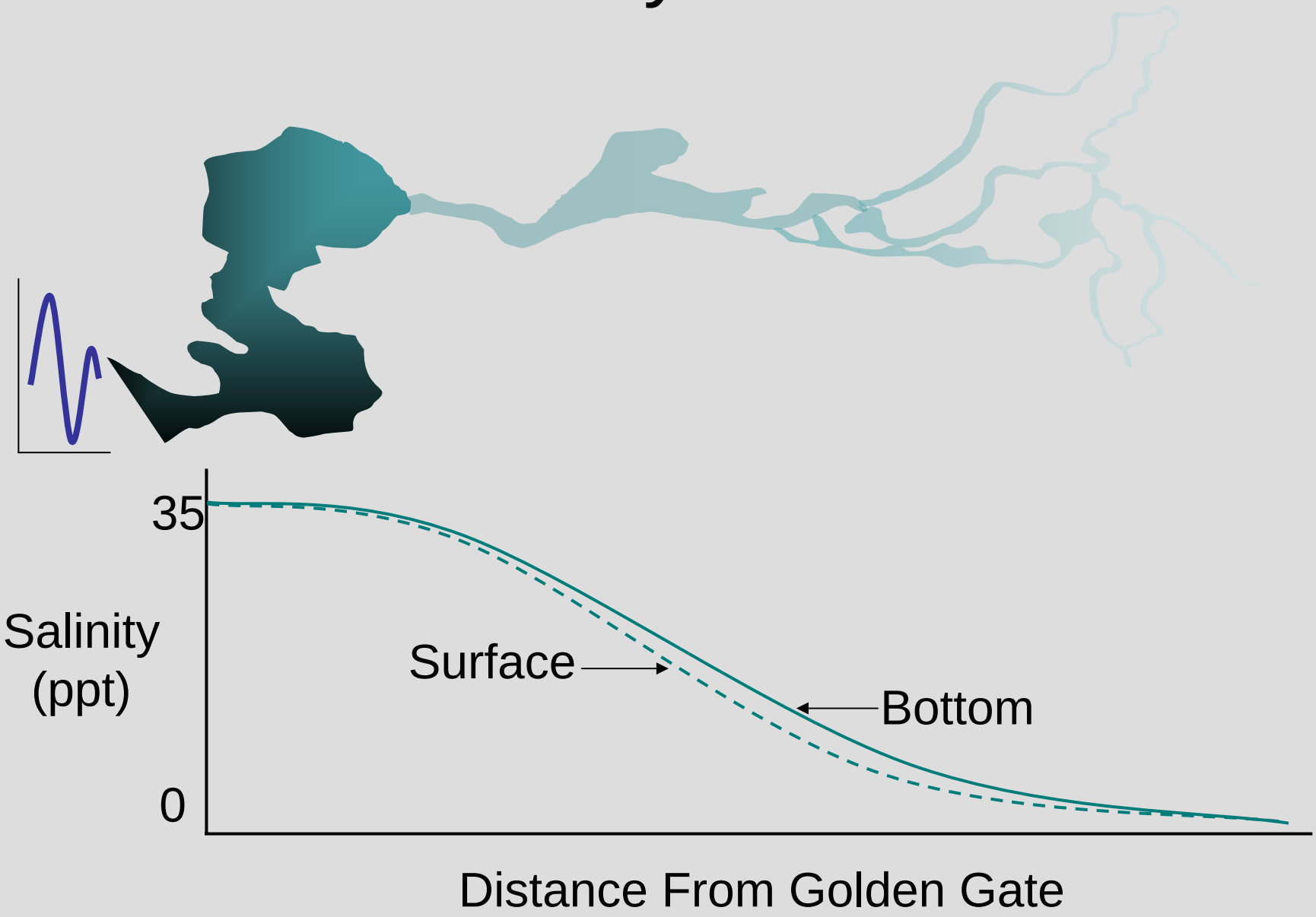
Impacts of Tidal Range and Salinity Gradient Modification: 2 Examples

1. Increase frequency/magnitude of gravitational circulation?
2. High marsh plants

Conclusions

- Tidal propagation can be modified on estuary scale.
- Projects that change geometry will interact and should be analyzed together.
- Need full Bay-Delta models with demonstrated tidal propagation accuracy.
- Process field studies (feedback with models)

Thank You

- Jon Burau
- Steve Culberson
- John DeGeorge
- Lisa Lucas
- Richard Richele
- Beth Schwehr

Salinity Gradient