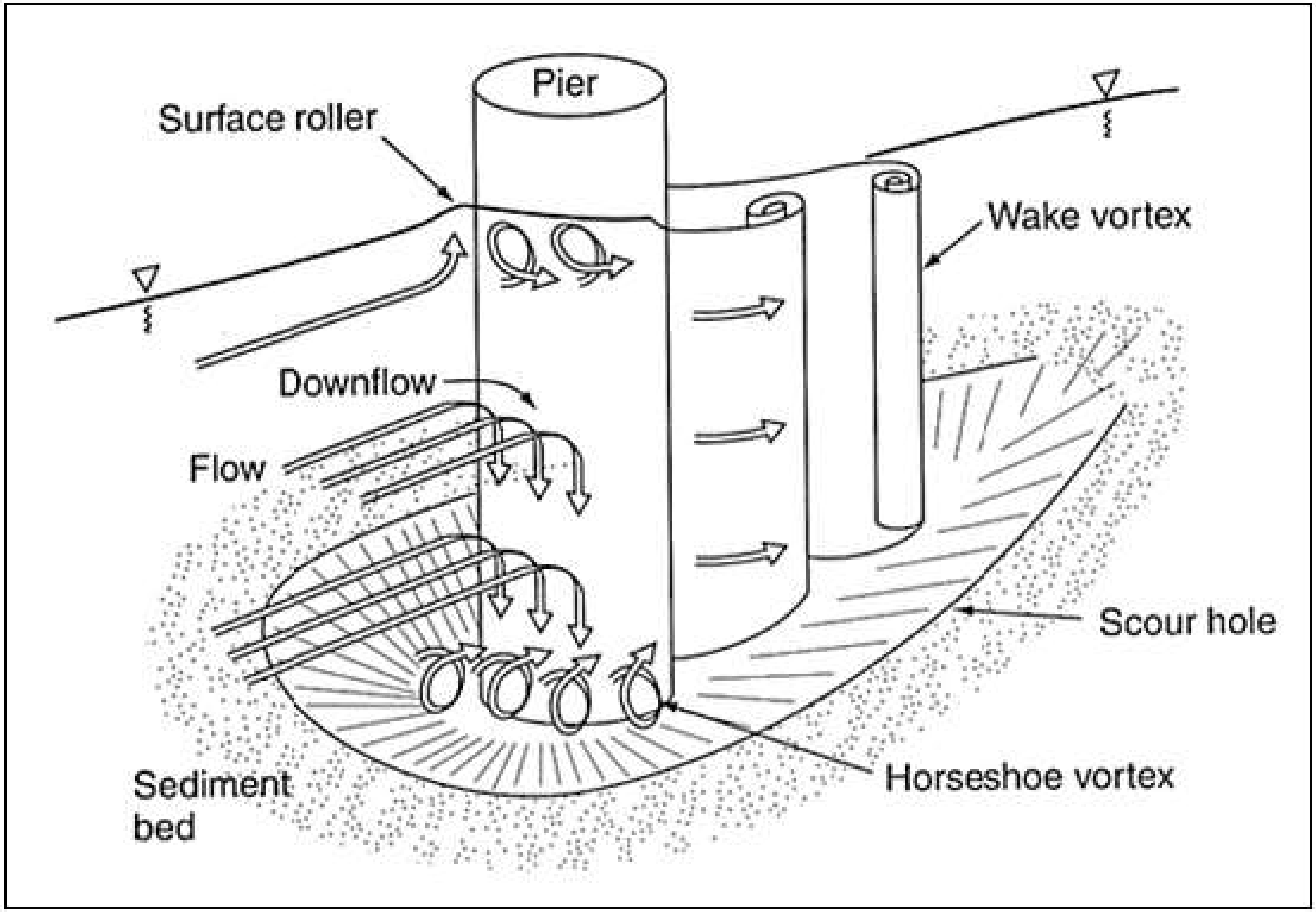
Contraction (constriction) scour

Factors that can cause contraction scour are:

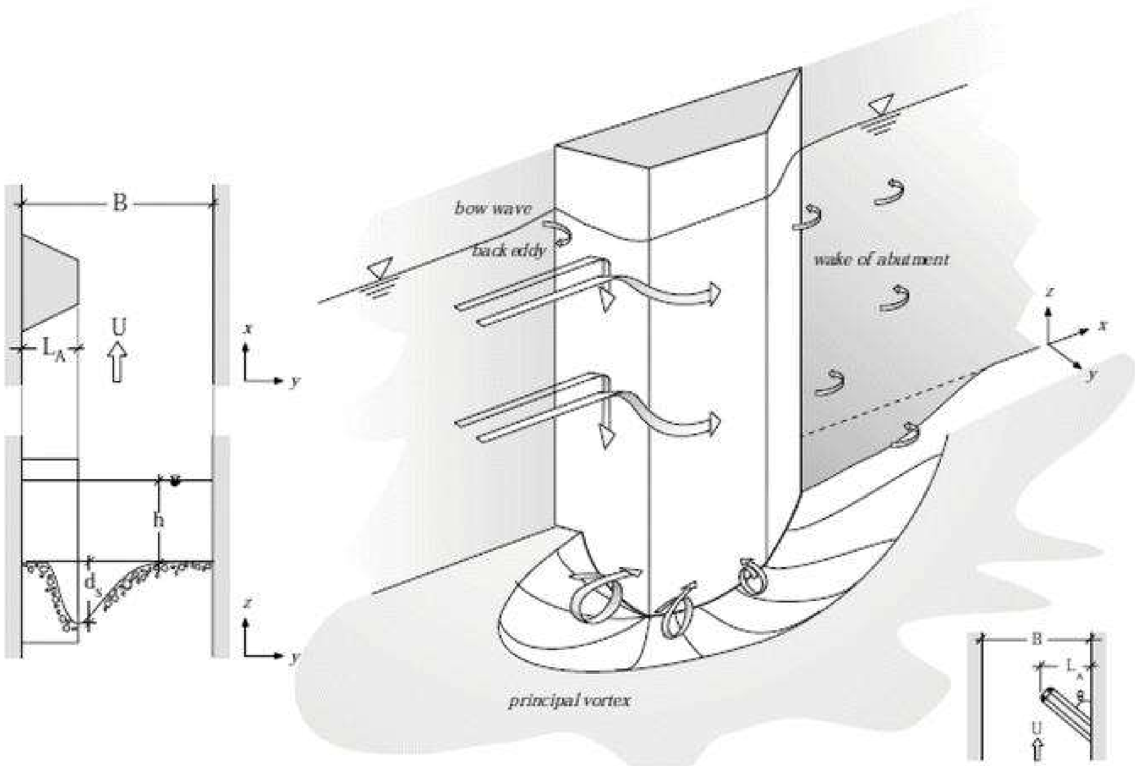
- natural stream constrictions
- long highway approaches to the bridge over the floodplain
- natural berms along the banks due to sediment deposits
- debris
- vegetative growth in the channel or floodplain
- ice formations or jams



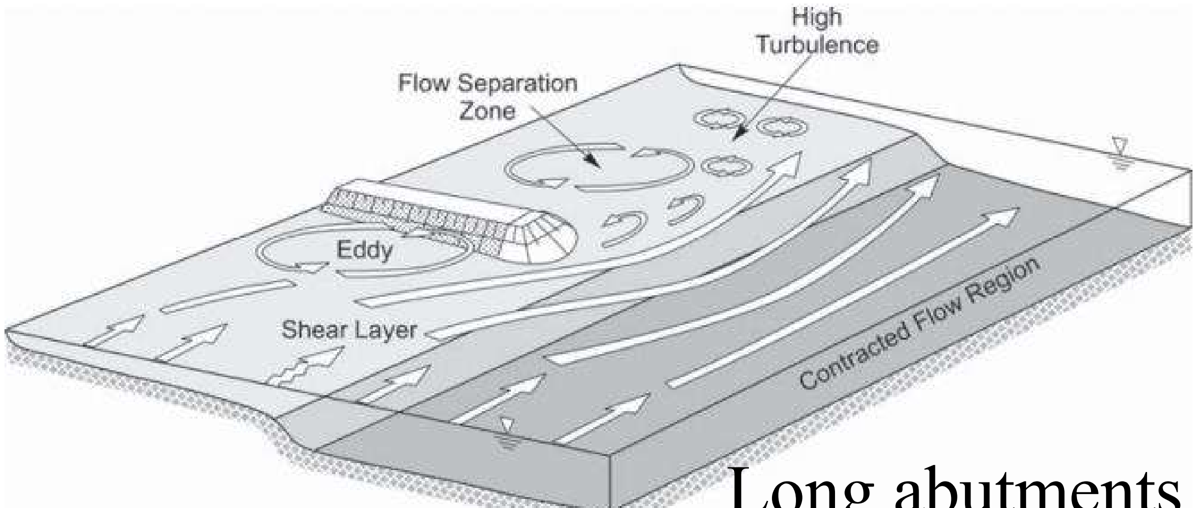
Local scour (at piers)



Local scour (at abutments)



Narrow abutments

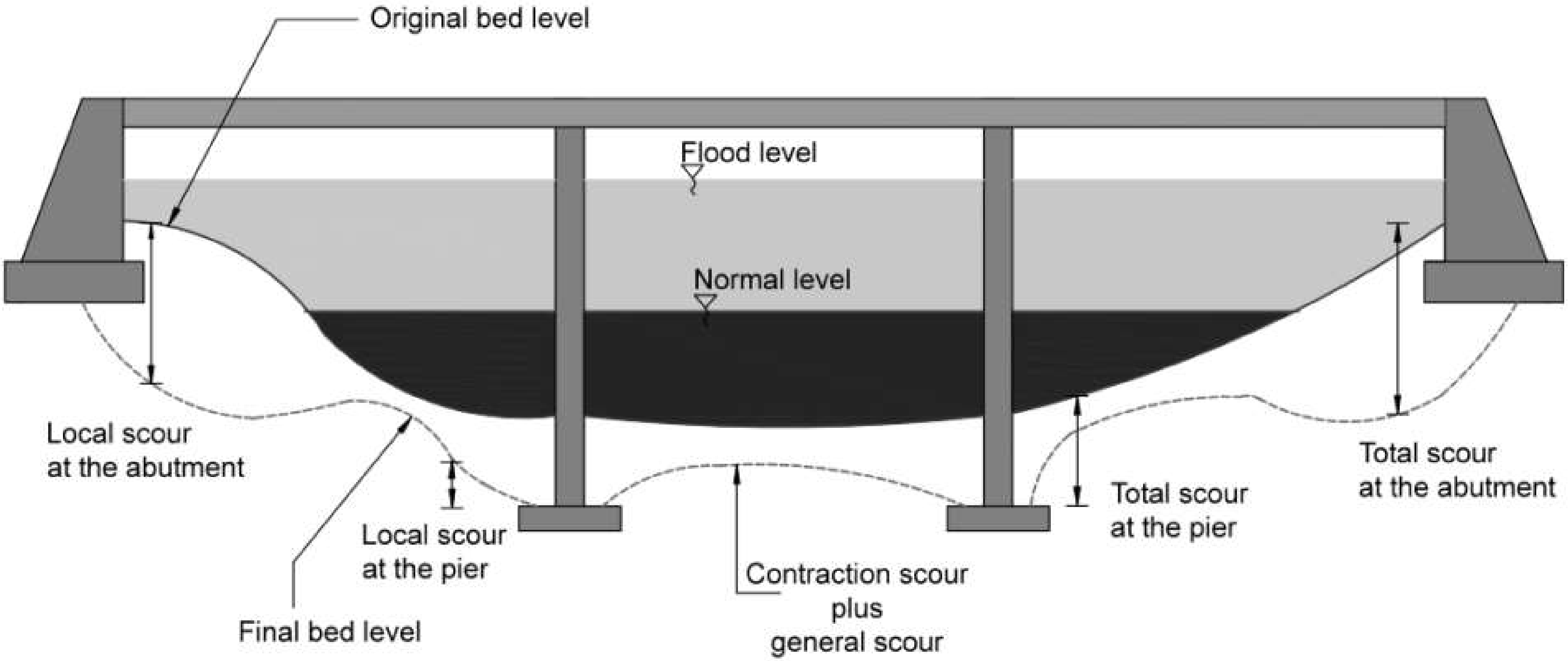


Long abutments

Local scour

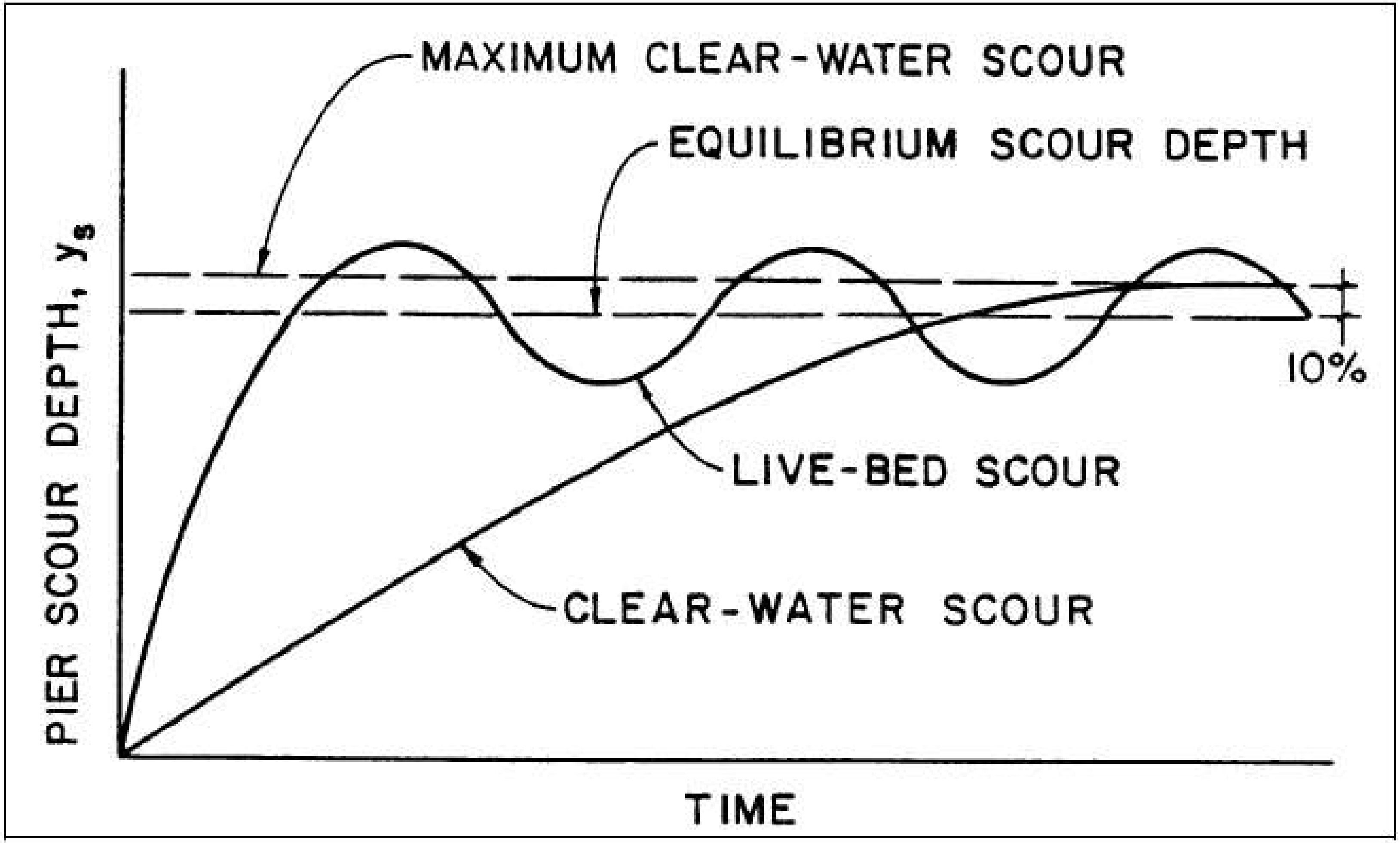
- Factors which affect the magnitude of local scour depth at piers and abutments are:
  - velocity of the approach flow
  - depth of flow
  - width of the pier
  - discharge intercepted by the abutment and returned to the main channel at the abutment
  - length of the pier
  - size and gradation of bed material
  - angle of attack of the approach flow to a pier or abutment
  - shape of a pier or abutment
  - bed configuration
  - Ice formation or jams and debris.

Total bridge scour



Total scour = Natural scour + Contraction scour + Local scour

Types of scour



Types of scour

- Two conditions for contraction and local scour:
  - Clear-water scour: no movement of the river bed material
  - Live-bed scour: transport of bed material from upstream; of cyclic nature
- Typical clear-water scour situations include:
  - coarse-bed material rivers
  - flat gradient rivers during low flow
  - local deposits of larger bed materials
  - armored river beds
  - vegetated channels
- Critical velocity equations are used to determine the velocity that distinguishes between clear-water and live-bed scour.

Debris Accumulation

Debris Accumulation

- Debris against bridges can significantly affect hydraulics, scour and risk of failure.
- Debris can be classed as large woody debris, small vegetation or urban debris.
- Floating debris vs non-floating debris.
- Debris accumulation reduces the flow area and increases flow velocity in the vicinity of a structure.
- Can increase contraction scour or cause erosion of the riverbed and banks.
- Increased effective width of the pier, increased flow velocities resulting from the constriction can also increase local scour.
- Changes in flow patterns arising from debris can change the angle of attack at piers and abutments.
- Debris can also lead to increased drag and hydrodynamic forces and impact forces resulting from debris colliding with the piers and/or deck
- Debris accumulation can result in scour depth increase of up to 50%!!

Debris Accumulation

- The debris load depends on:
  - the length of contributing channel upstream of the structure
  - catchment topography
  - geology
  - potential for soil erosion
  - land use adjacent to the channel
- Risk of debris accumulation can be explained through:
  - the debris load (*source*)
  - mobilisation and transportation (*pathway*)
  - interaction with the structure (*receptor*)
- Certain bridge features are more likely to accumulate debris such as:
  - pile groups or closely spaced piers
  - exposed pile footings
  - open truss superstructures

Factors influencing scour

Factors influencing GENERAL SCOUR (GEOMORPHIC/HYDROLOGIC, FLOOD FLOW TRANSPORT, BED SEDIMENT)

Factors influencing LOCALISED SCOUR (FLOOD FLOW TRANSPORT, BED SEDIMENT, BRIDGE GEOMETRIC)

GEOMORPHIC/HYDROLOGIC	
Catchment Characteristics	Precipitation
	Physical characteristics: -topography/slope -size -shape
	Vegetation
	Soils: -type -erodibility
River Characteristics	Valley setting
	Stream channel: -width variability -bankfull width -floodplain(s) extent -cross-sectional shape -channel slope -degree of incision
	Hydraulic controls
	Plan form: -straight -sinuous/meandering -braided/anabranched -bar development
	Channel boundaries: -bank material -bank stability (slope) -vegetative cover

FLOOD FLOW TRANSPORT		
Flood frequency		
Hydrograph	flow rate	Q
	duration	T
Flow velocity	mean	V
	lateral distribution	
	secondary currents	
Flow depth	main channel depth	y
	lateral distribution	
Sediment transport	sediment transport rate	Q_s
	bed-form magnitude	
	form of sediment transport	
Debris load		

BED SEDIMENT	
median size	d_{50}
nonuniformity	σ_g
cohesion	C
vertical stratification	
areal distribution	
bed-rock: -erodibility -level	

BRIDGE GEOMETRIC		
Bridge opening	degree of contraction	
	superstructure submergence	
Bridge piers	type	
	position in main/flood channel	
	shape	*Sh*
	size, length, width (diameter)	l, b, D
	alignment	θ
Bridge abutments	type	
	position in main/flood channel	
	shape	*Sh*
	size, length	L
	alignment	θ
Bridge location with respect to channel bends		
Scour protection measures	revetments, retards, spurs, check dams, channelisation, bridge modifications, etc.	