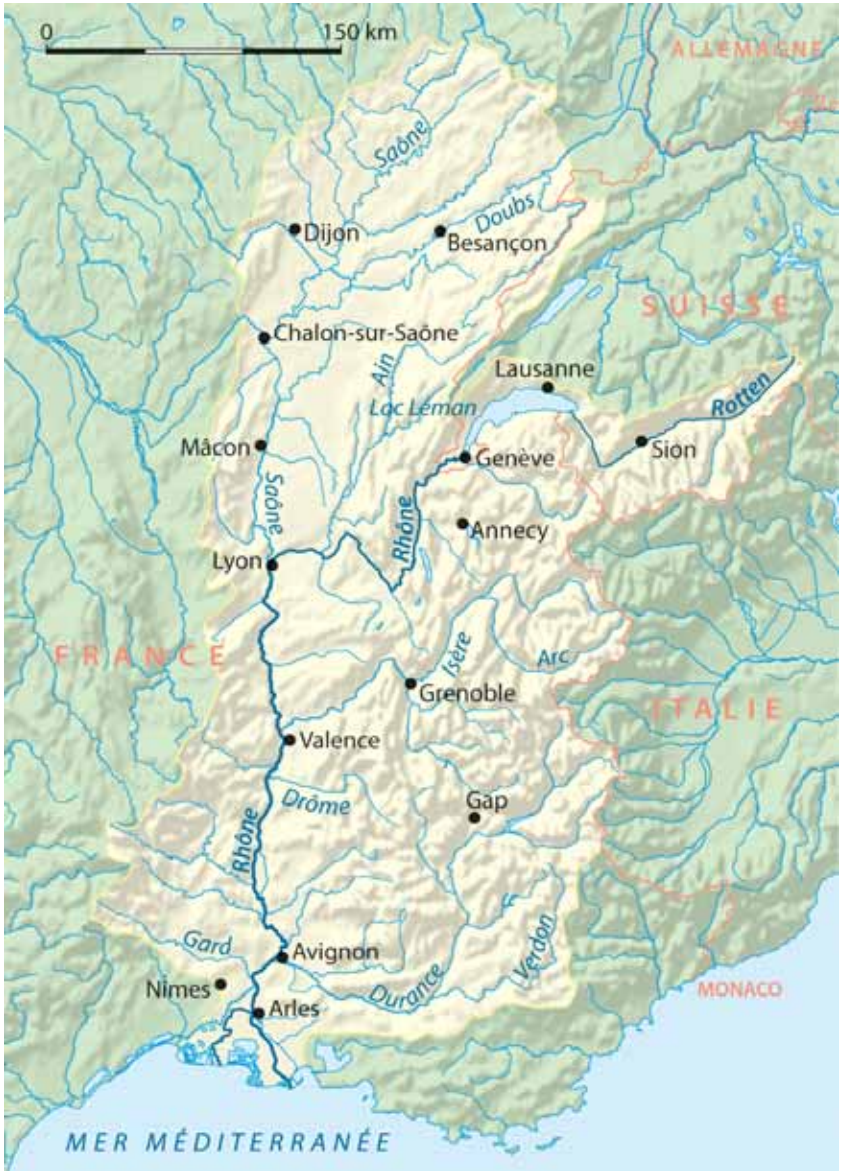
Hydropower and navigation development on the Rhône river (France)



Impacts and environmental management

- Morphological changes on the Rhône river: impacts of training works and new sediment balance (Year 1800 – Year 2000)
- Main operational issues of cascades of dams: hydraulics behaviour, sediment transport, flood protection and river morphology issues
- Experience in addressing barriers to fish migration on the Rhône river basin

Vincent PIRON,
Head of International Department
v.piron@cnr.tm.fr

“Hydropower and navigation development on the Rhône river (France) – impacts and environmental management”

- Morphological changes on the Rhône river: impacts of training works and new sediment balance (Year 1800 – Year 2000)

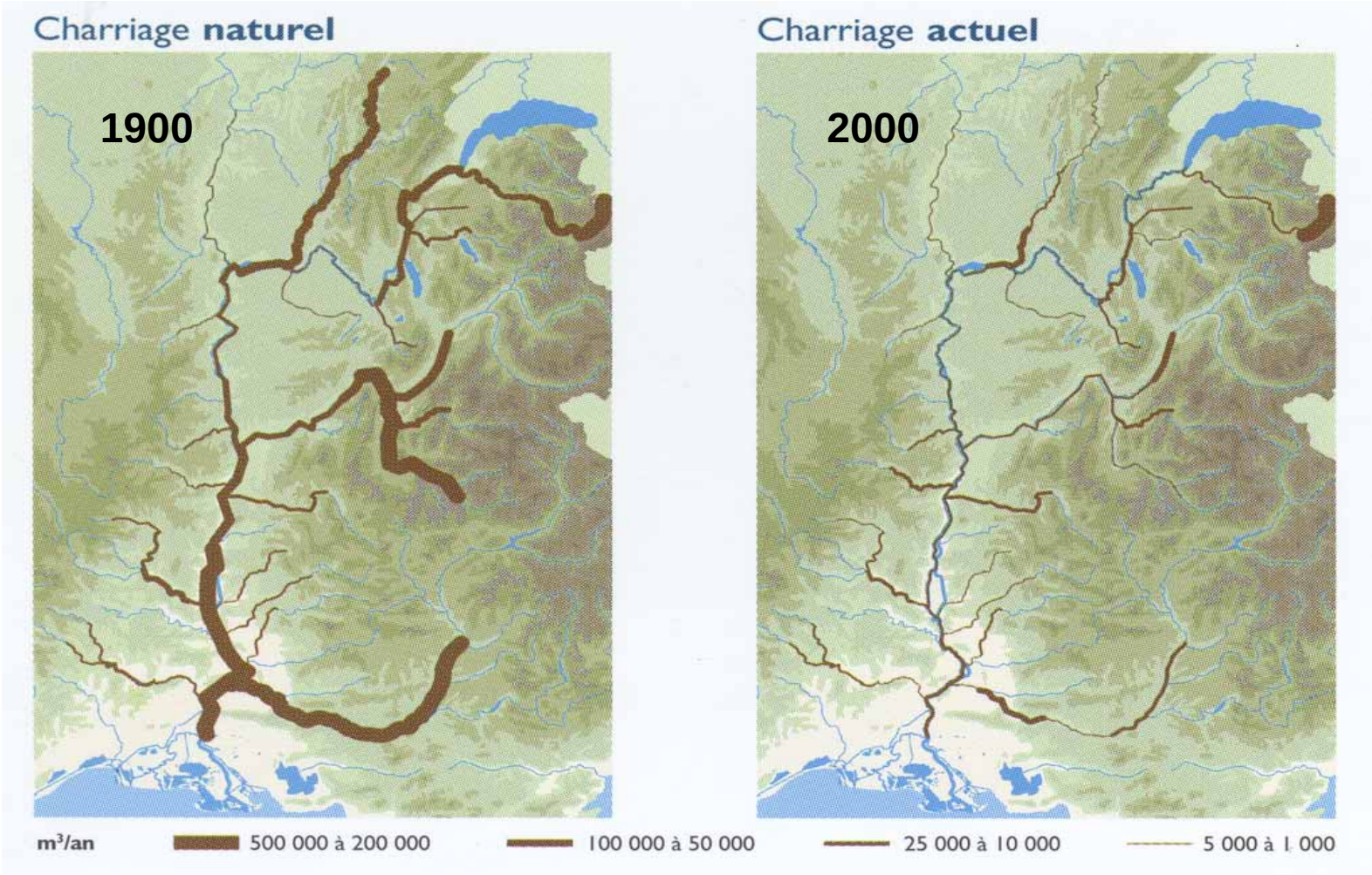
An evoluting system: the Rhône River in Lyon (18th c.)

- A wall protects the city against the river (right bank)

- The medieval bridge had to be lengthened, i.e. adapted to the aggravation and the lateral expansion of the braided pattern

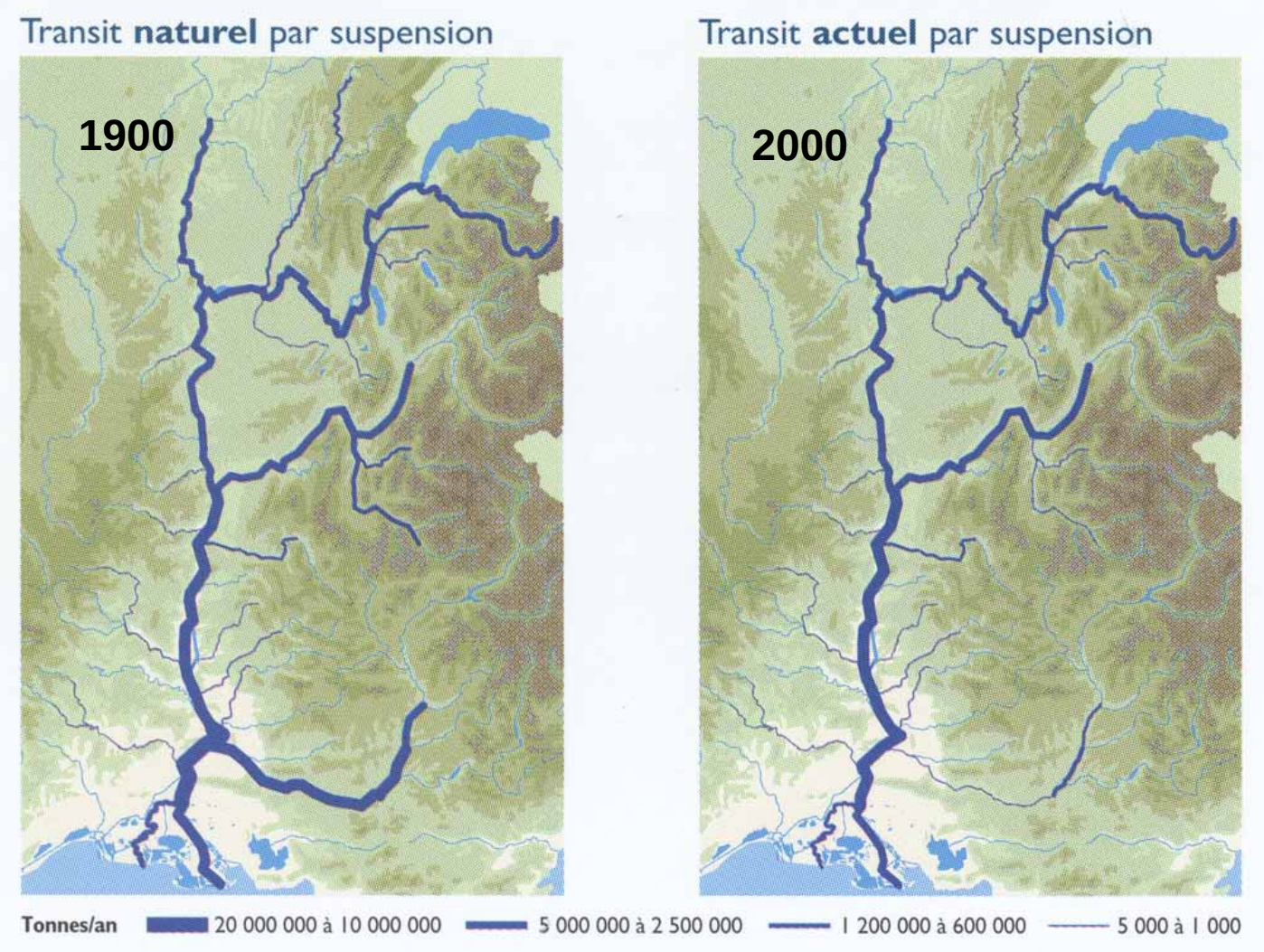
45 - Détail d'un plan de Lyon au XVIIIe s. A.M.L. 3 S 313 .

Transit of bedload



A severe reduction of inputs and transit along the main axis (IIRS, SOGREAH)

Sediment transport
Wash load - Suspended sediments



Limited decrease of inputs and transit (IIRS, SOGREAH)

The reafforestation of the Alps (1860-1910)

1900 Ph. Eaux et Forêts

2005 Ph. JP Bravard

Spontaneous reafforestation (ca 1500 m) in Die Mtns

Reconquest of *Pinus* and *Fagus*over abandoned pastures

1900

1950

2003

River training for navigation was performed between the 1840's and the 1920's, i.e. during the late period of braiding

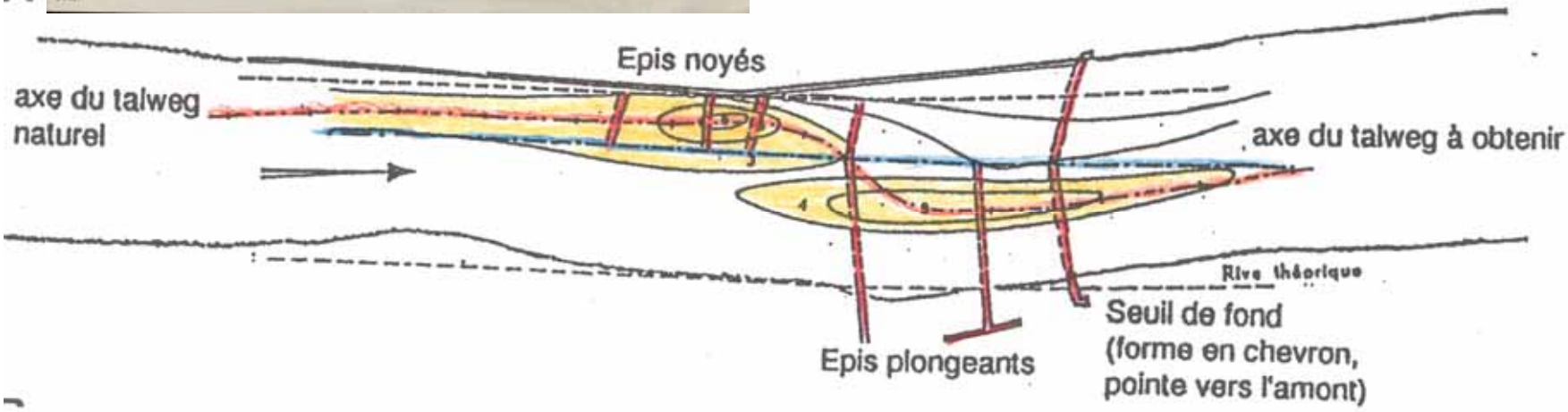
The remains of Sauge islands, Brangues, Haut-Rhône ca 1985: close to the former landscape (ph. JP Bravard)

Steam boat at Aix-les-Bains ca 1900 (postcard)

Training works : the 1880-1920's

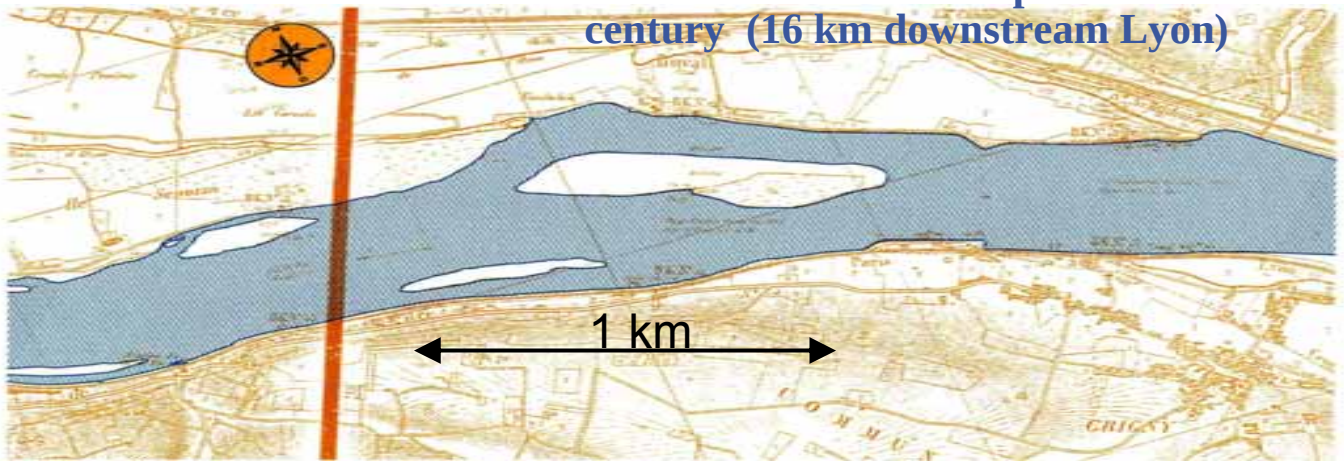
Red : natural talweg

Blue: talweg designed for navigation

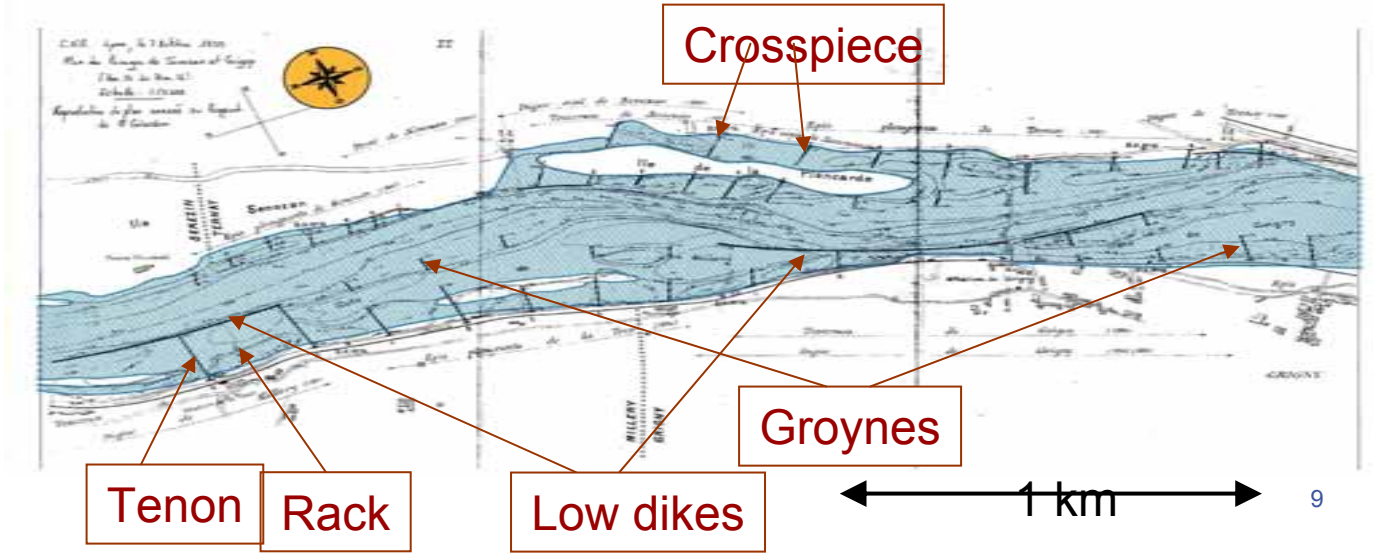


Compagnie Nationale du Rhône

Extract from « carte des Ponts et Chaussées » - 2nd part of 19th century (16 km downstream Lyon)

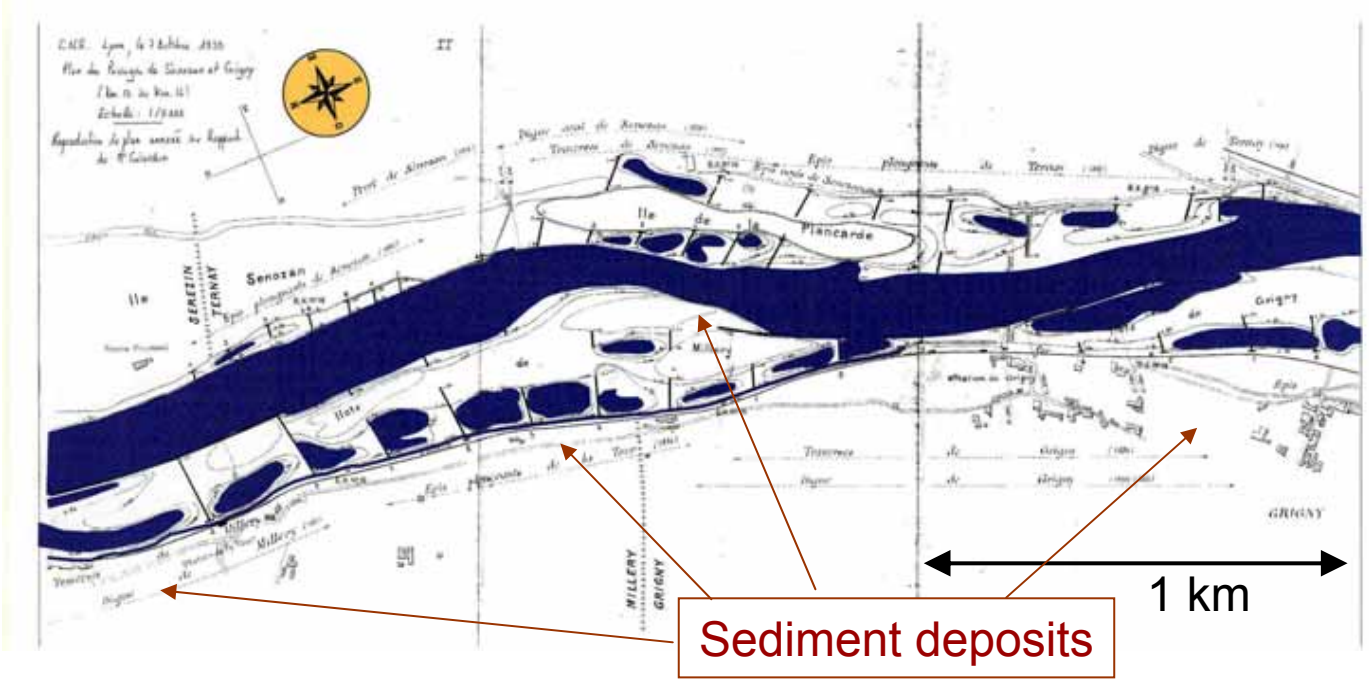


Layout of the training works carried out between 1870 et 1887 (extract from Mr. Girardon publication, La Haye 1894)

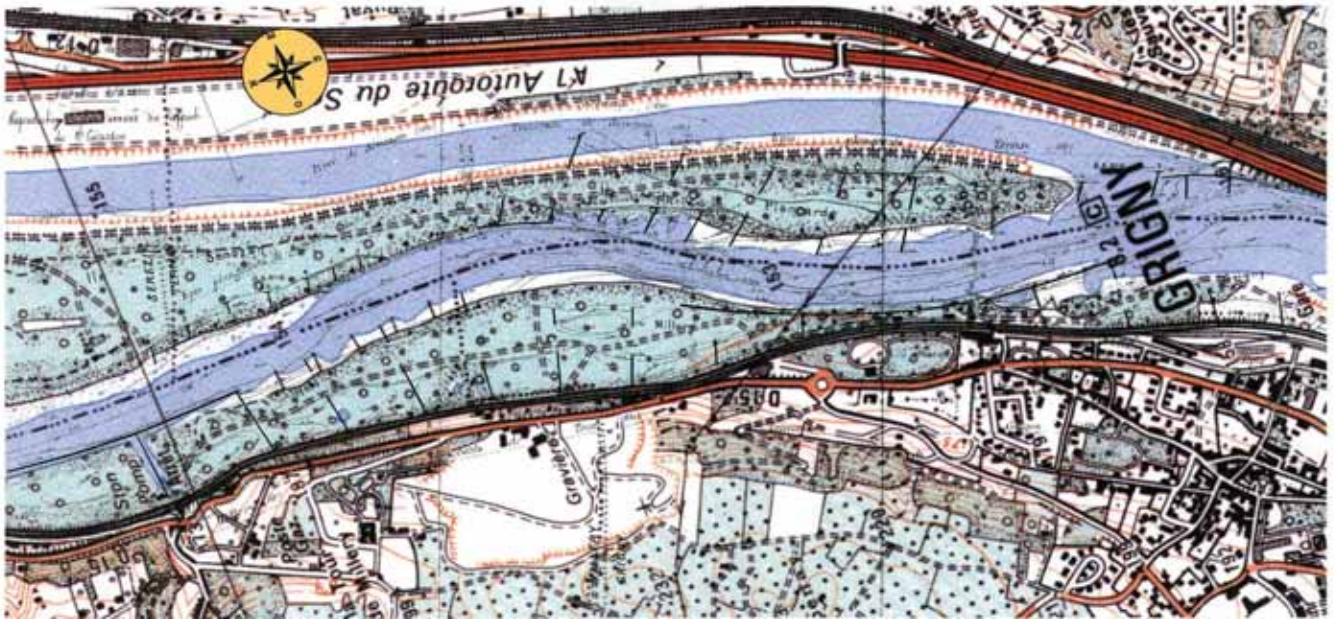


Compagnie Nationale du Rhône

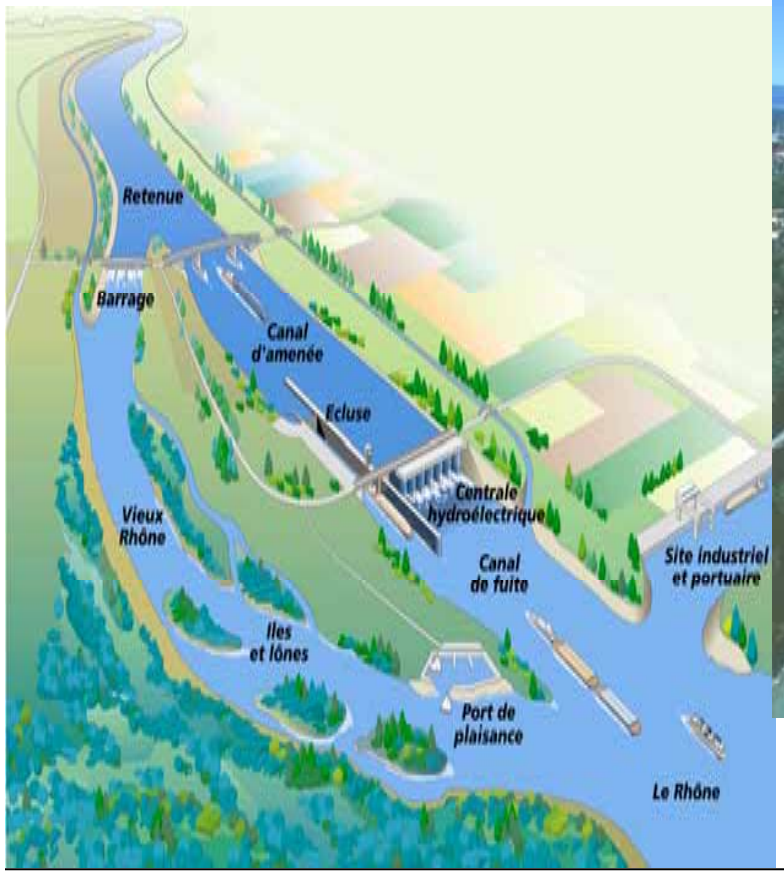
Water course conditions at the time of Girardon publication (La Haye 1894)

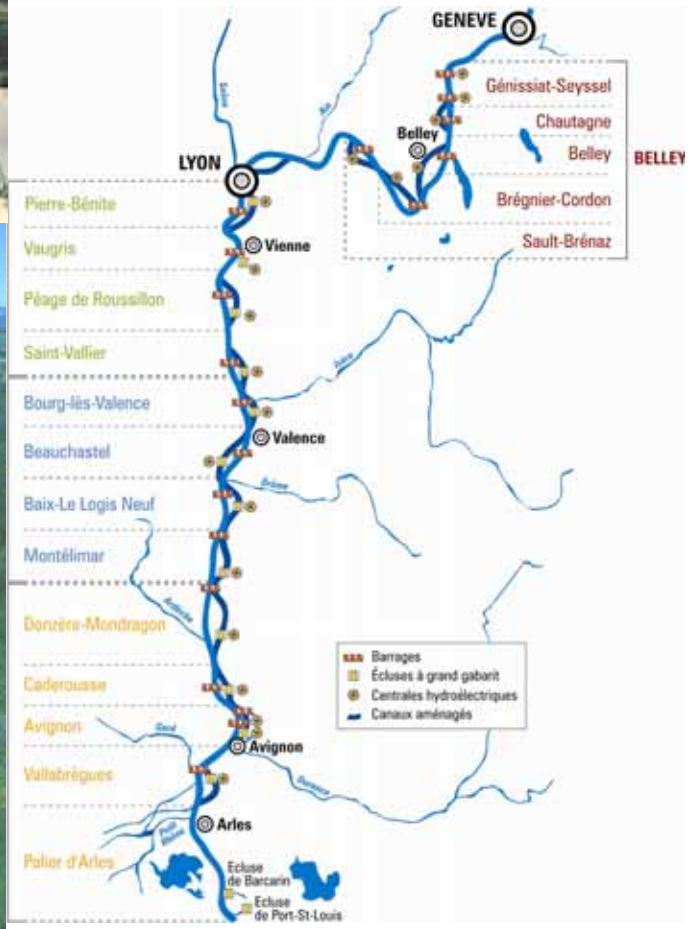


Current water course conditions, including the tailrace canal of Pierre Bénite HPP



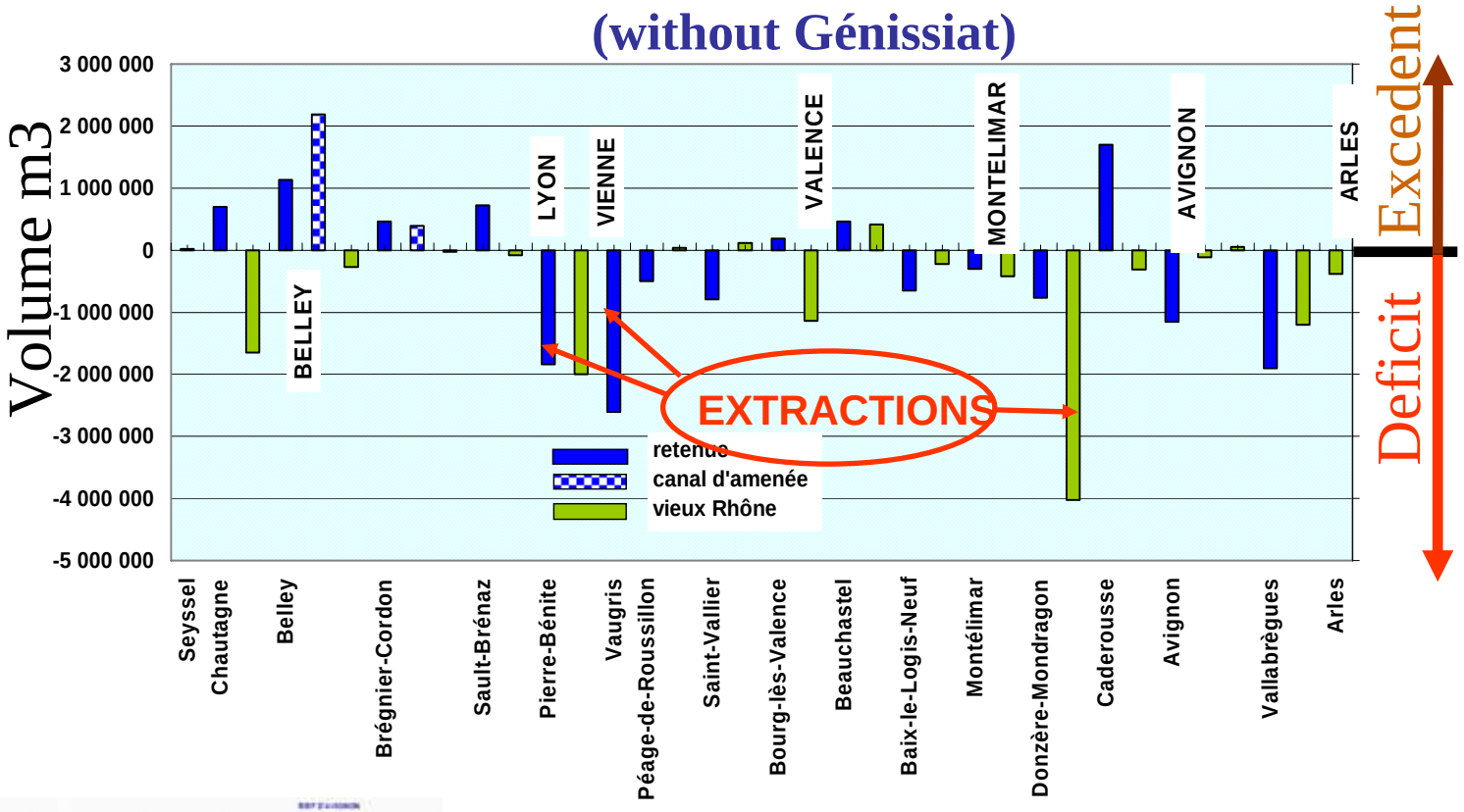
CNR development schemes along the Rhone

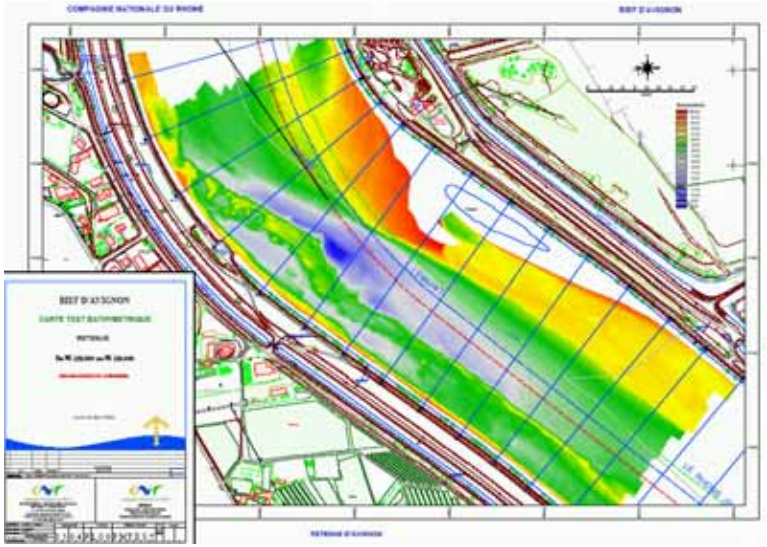


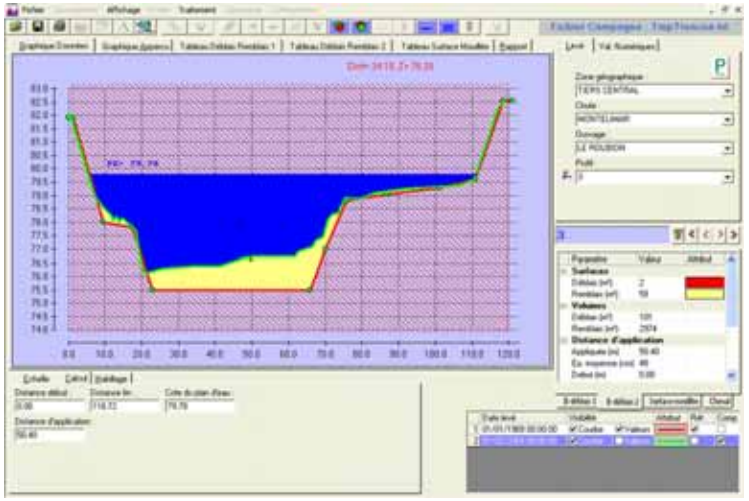


Typical layout of a development scheme

Rhone River: sediment balance along the system of reservoirs (without Génissiat)

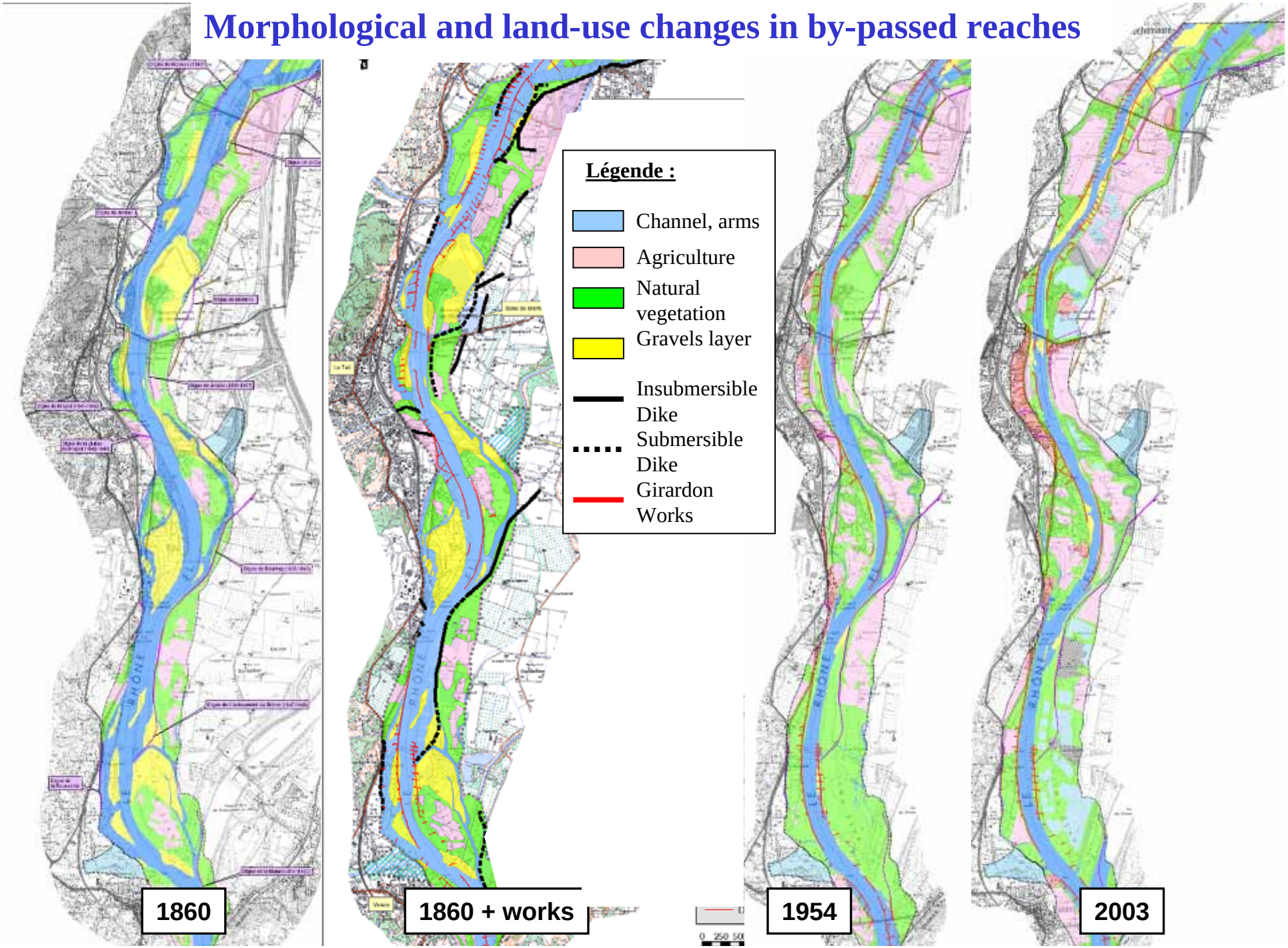






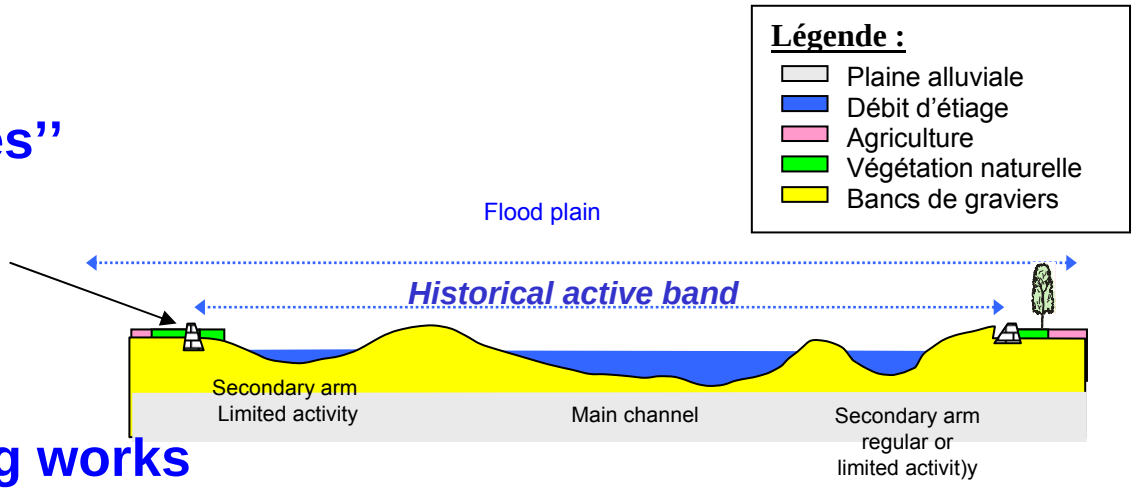
Hydrography & Bathymetry surveys

Morphological and land-use changes in by-passed reaches

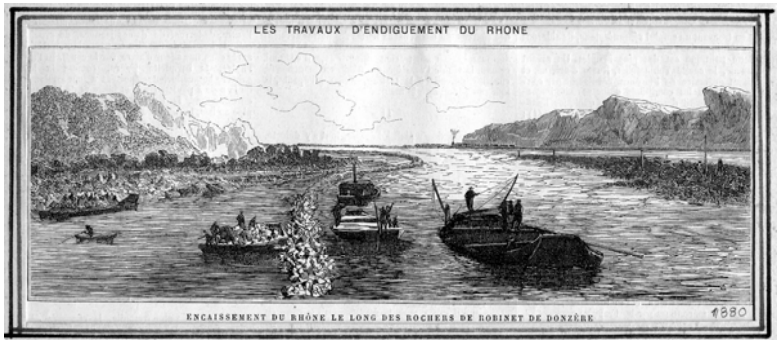


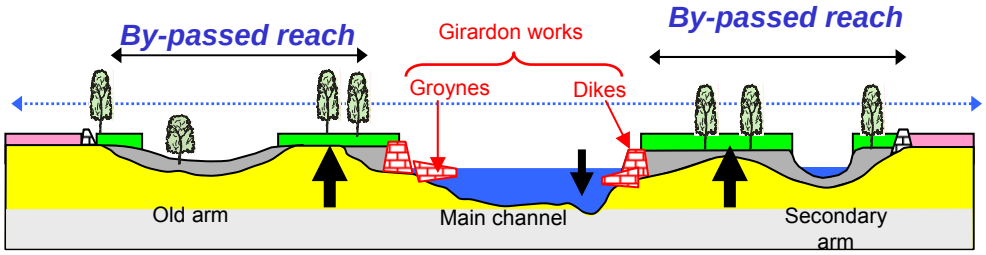
Synthesis of morphological evolution on the Rhône River

- **before 1850 : « farmers dikes''**

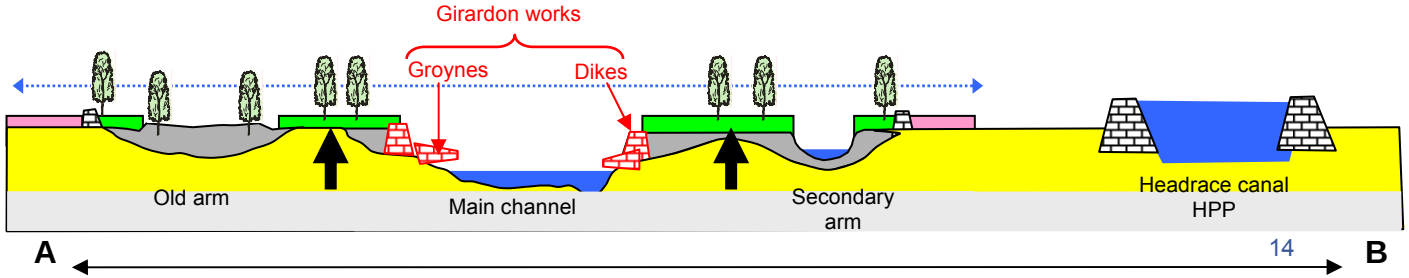


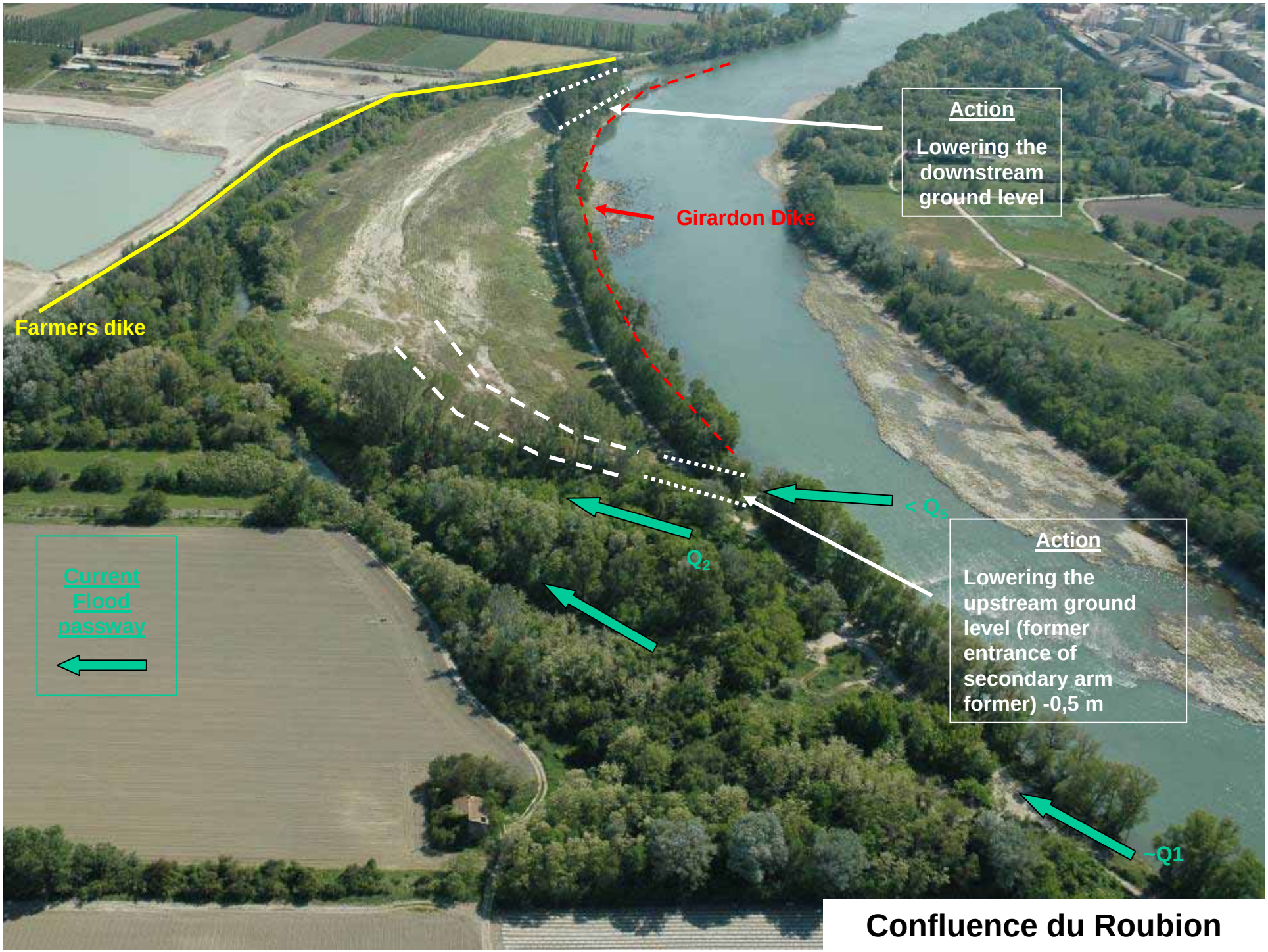
- **XIX & XX : Girardon training works**





- **1952-1980 : hydropower developments CNR (+ impact of dams on tributaries)**





Confluence du Roubion

Rhone Delta mobility / instability

(as per CEREGE – European Center for Research and Education in Geosciences of the Environment)

► Delta advance during the last Small Glacial Period (XVI - XIX centuries)

Due to:

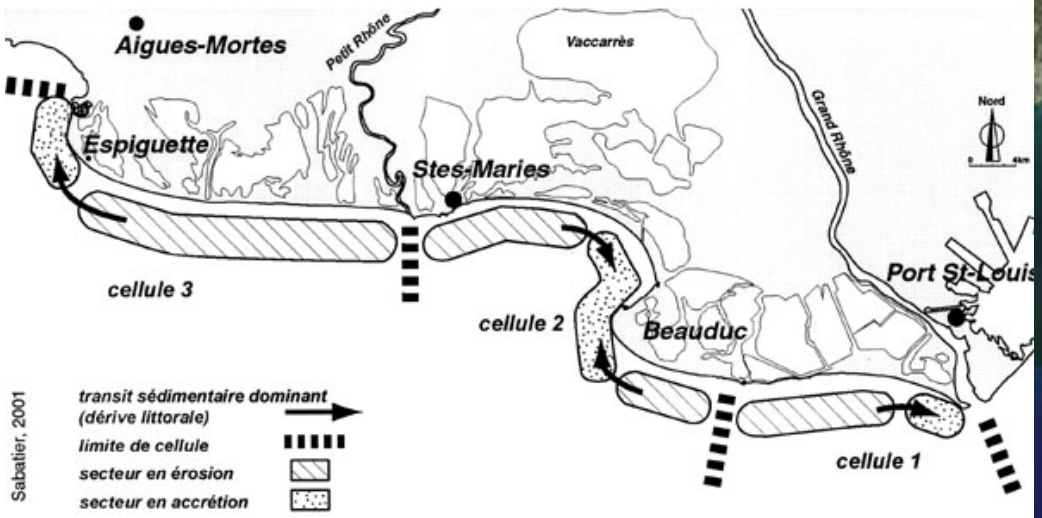
► climate change and agriculture development in the basin that induced huge erosion and sediment transit

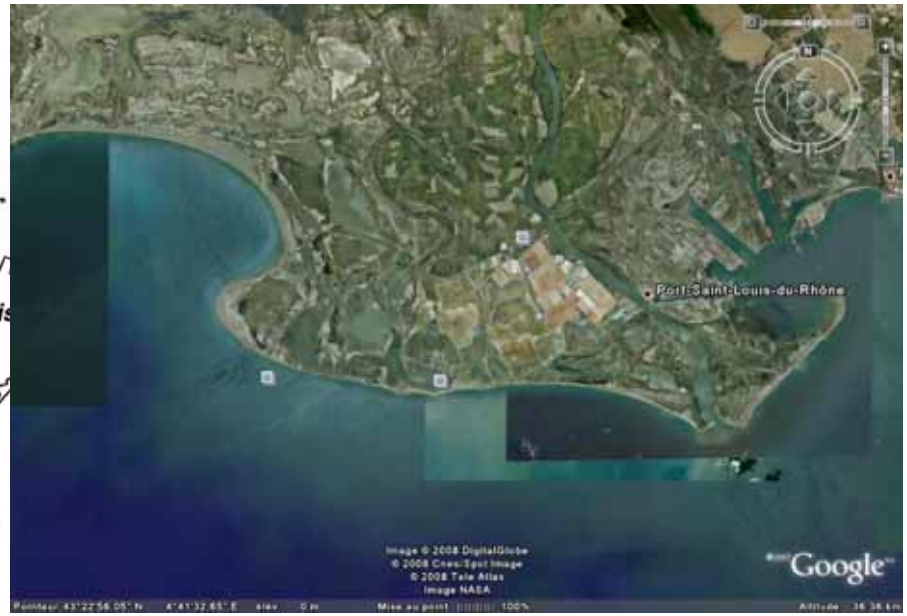
► Delta recession during the XX th century: 4 m/year during last 50 years

Due to:

► Sediment transport deficit (natural climate change, decrease of agricultural areas, training works for navigation and lately hydropower)

► Rise in sea level: 2 mm/year since 1905

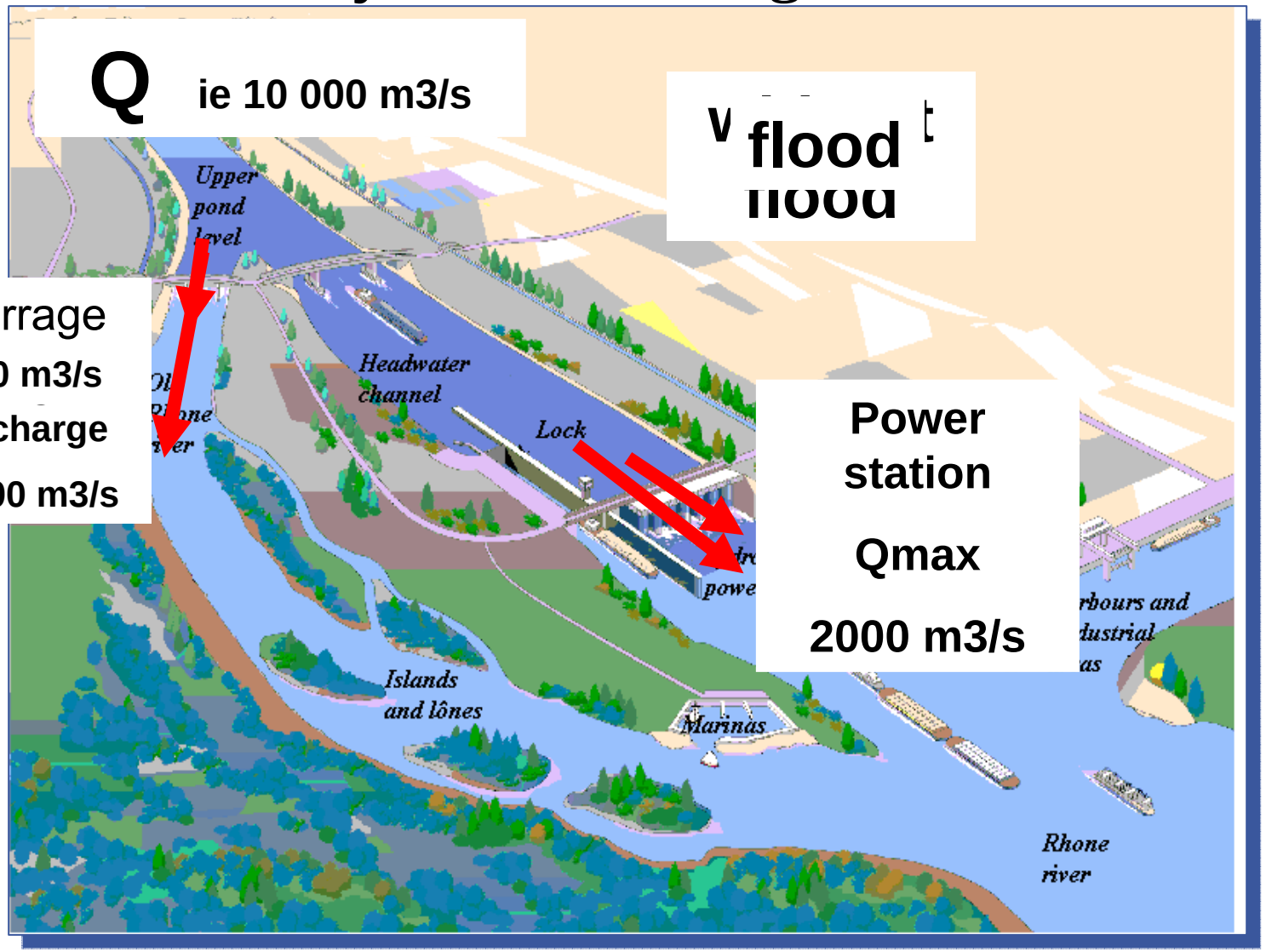




“Hydropower and navigation development on the Rhône river (France) – impacts and environmental management”

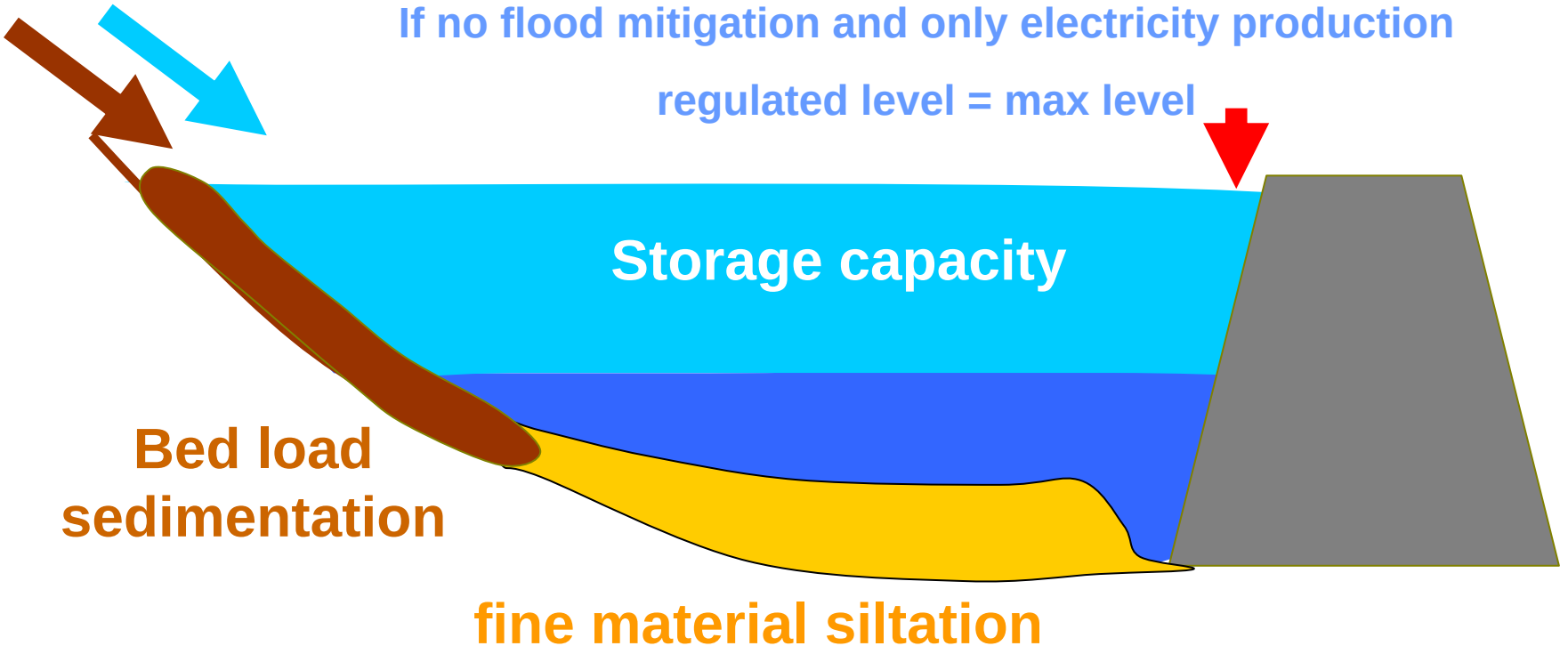
- Main operational issues of cascades of dams: hydraulics behaviour, sediment transport, flood protection and river morphology issues

Runoff the river development
Hydraulic management



Runoff the river development

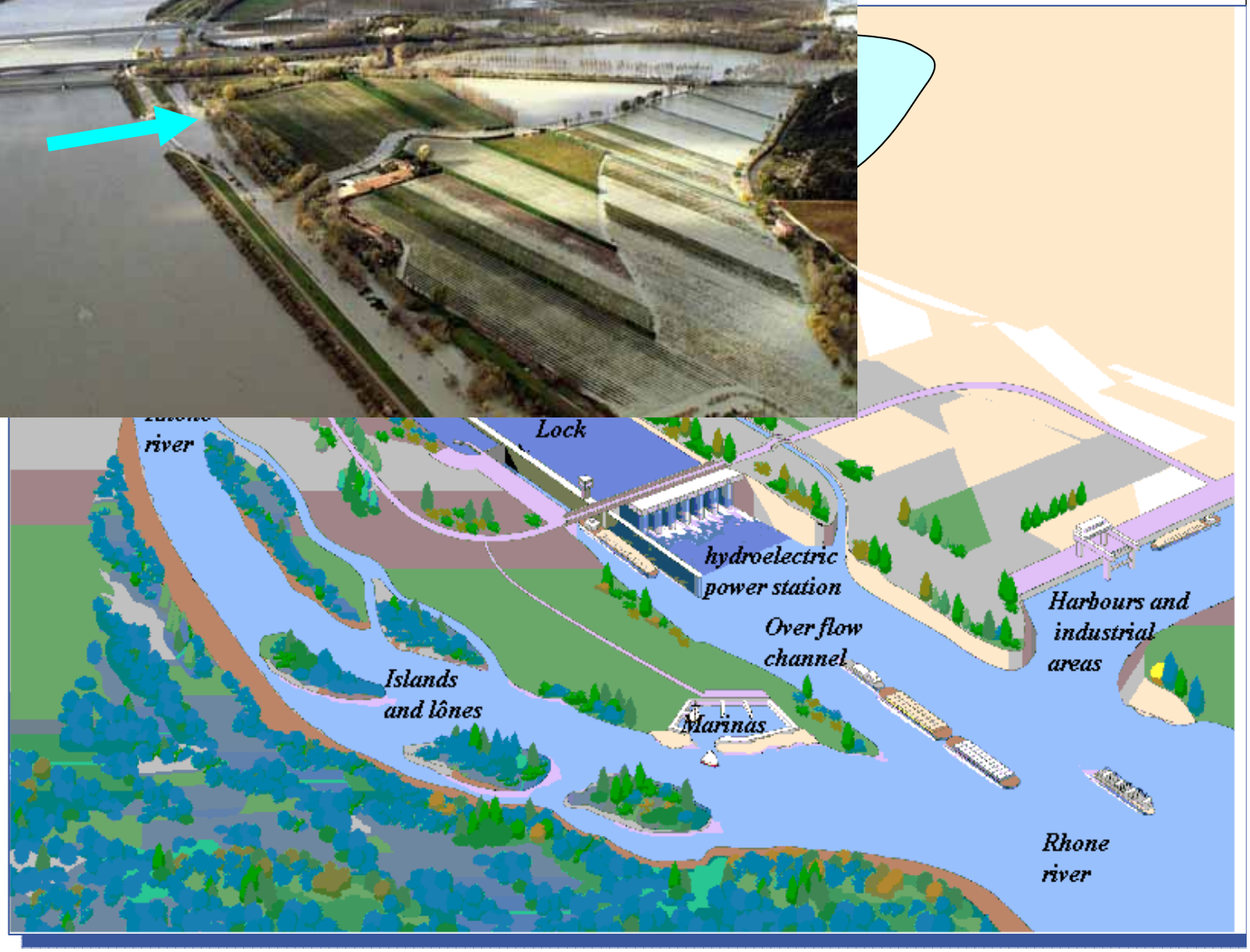
not a dam with a reservoir

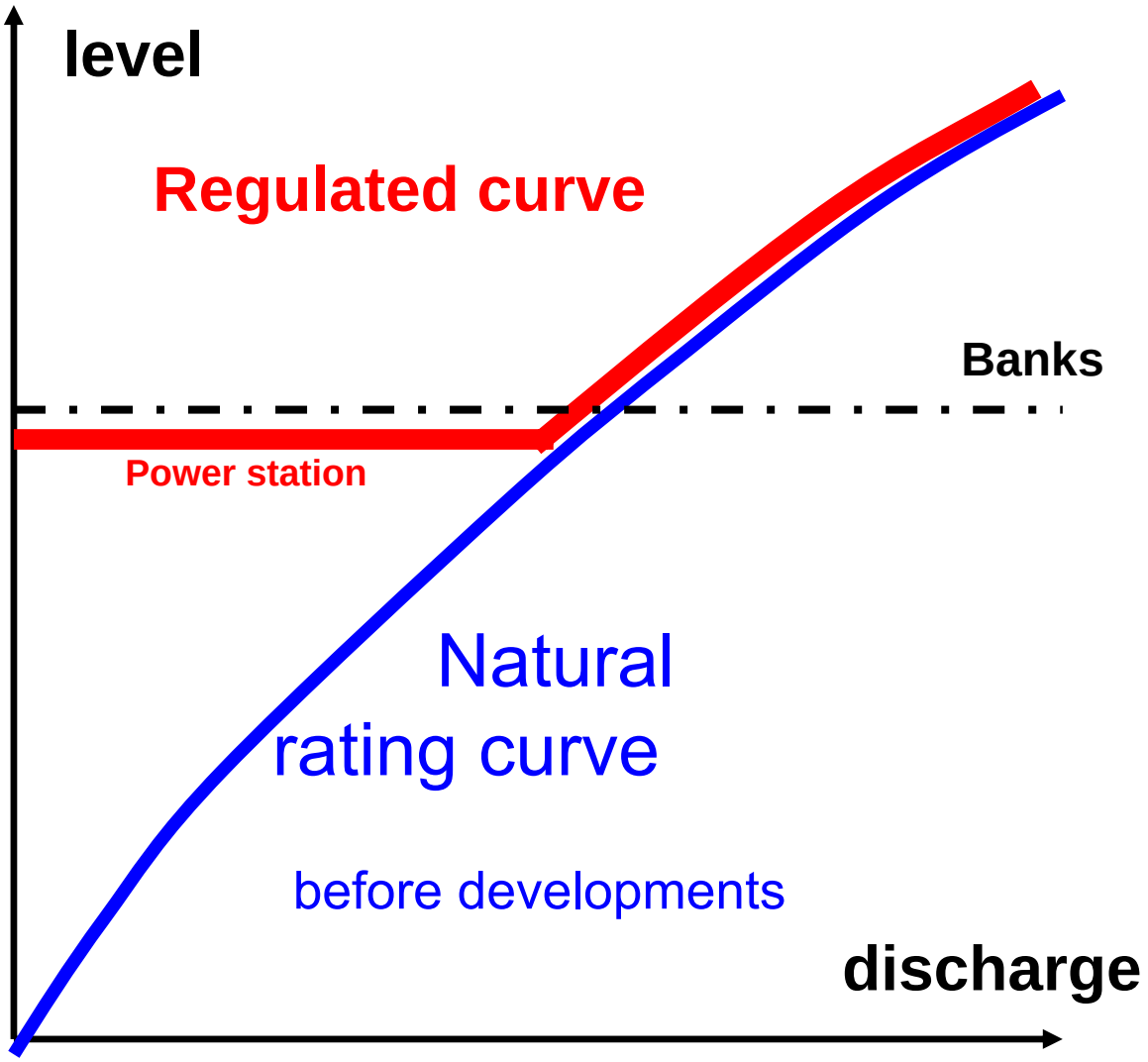


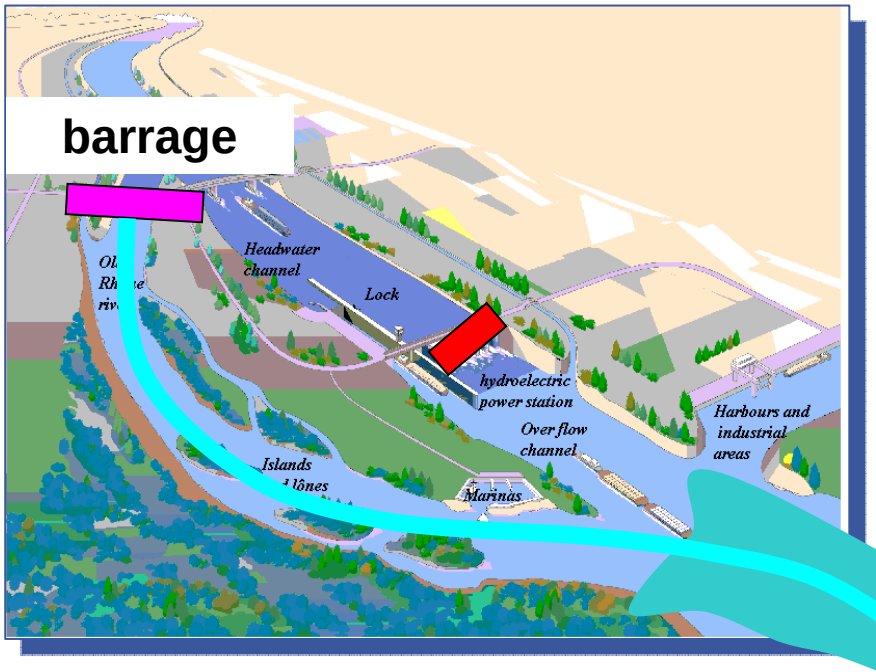
CNR runoff the river development

Compagnie Nationale du Rhône

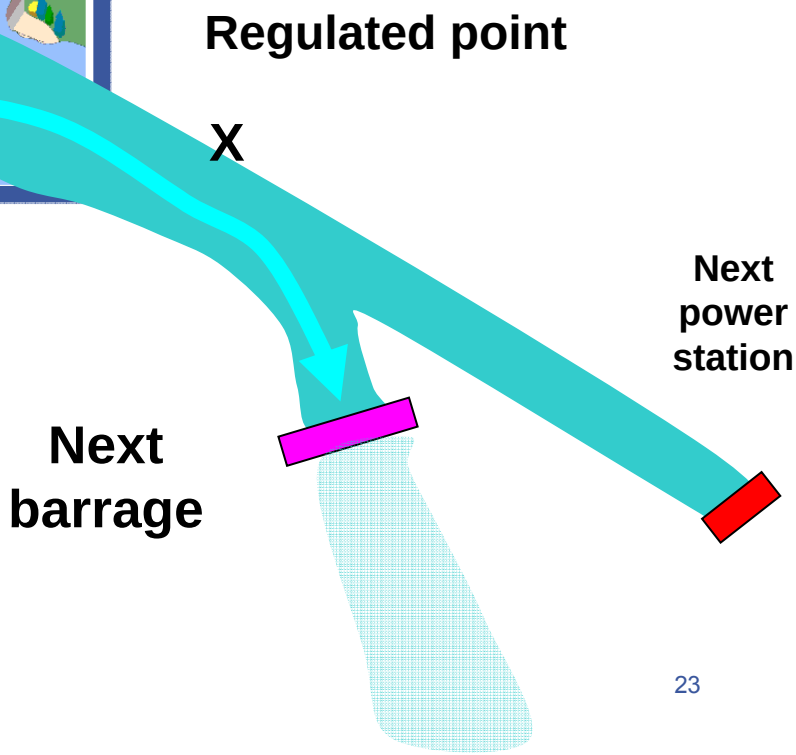
the barrage

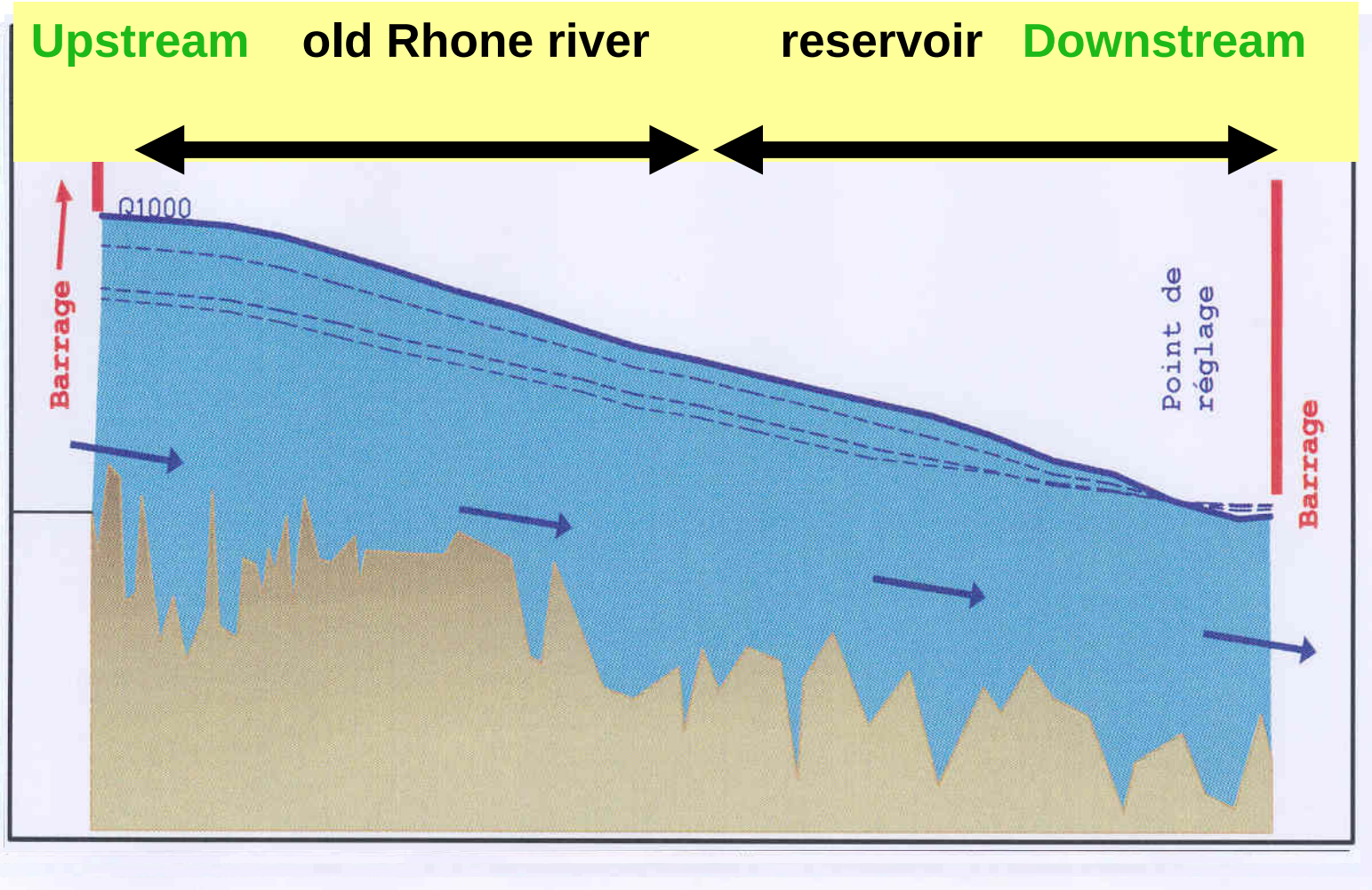



level
Regulated curve
Banks
Power station
Natural
rating curve
before developments
discharge



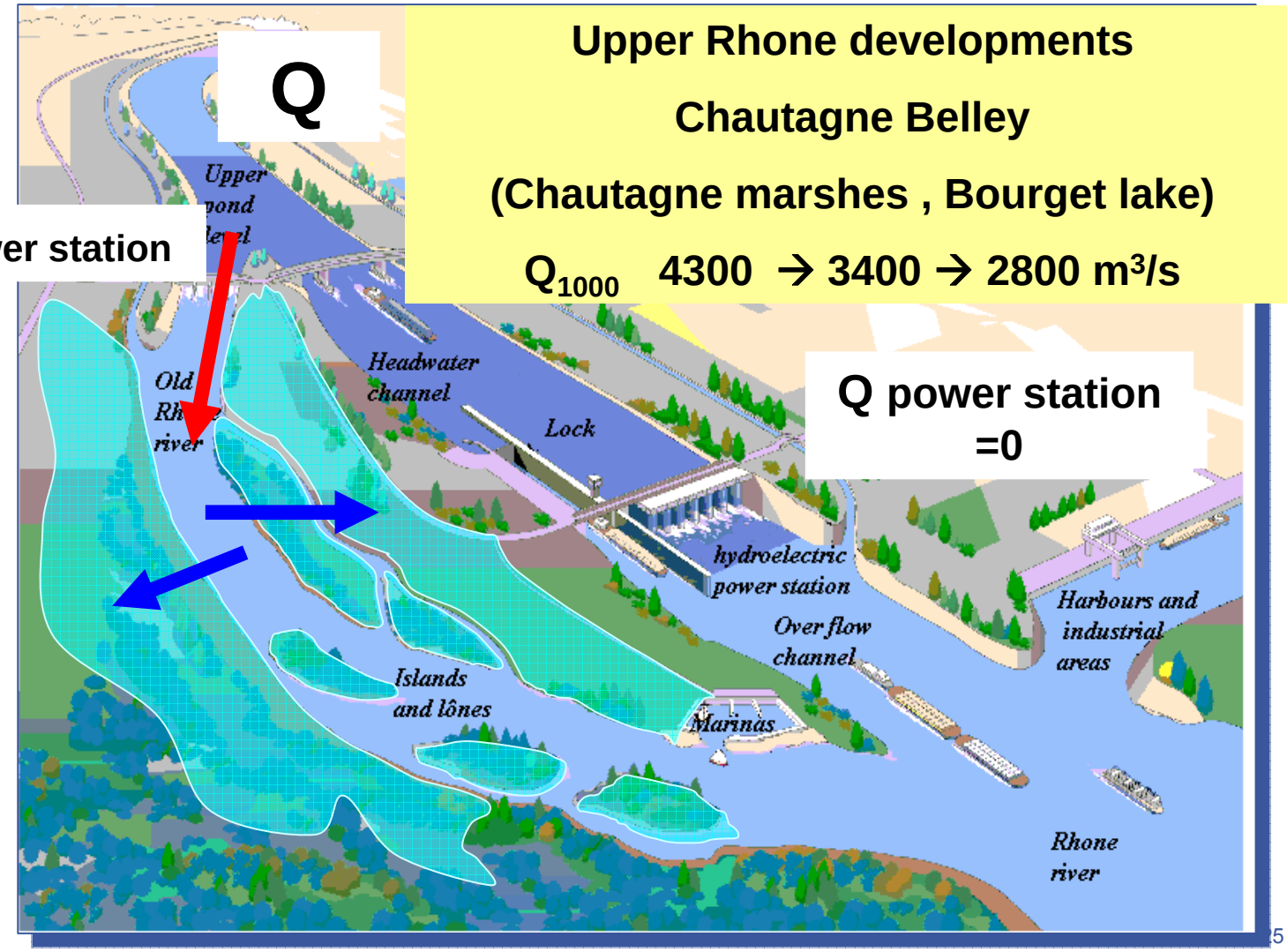
Water level simulation from barrage to next barrage




Upstream
old Rhone river
reservoir
Downstream
Barrage
Q1000
Point de réglage
Barrage

Flood management - old Rhone river

Q – Q power station



Upper Rhone developments

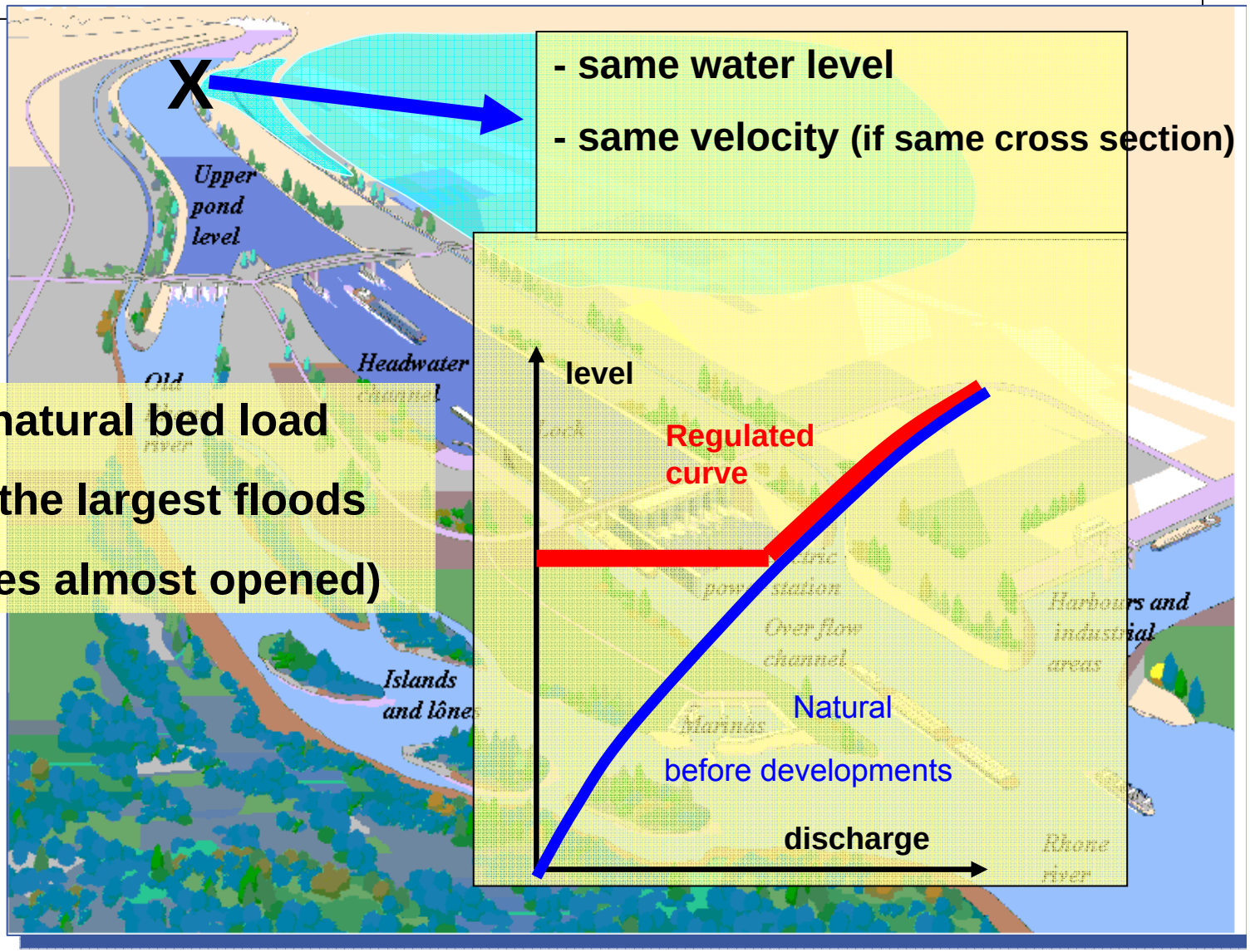
Chautagne Belley

(Chautagne marshes , Bourget lake)

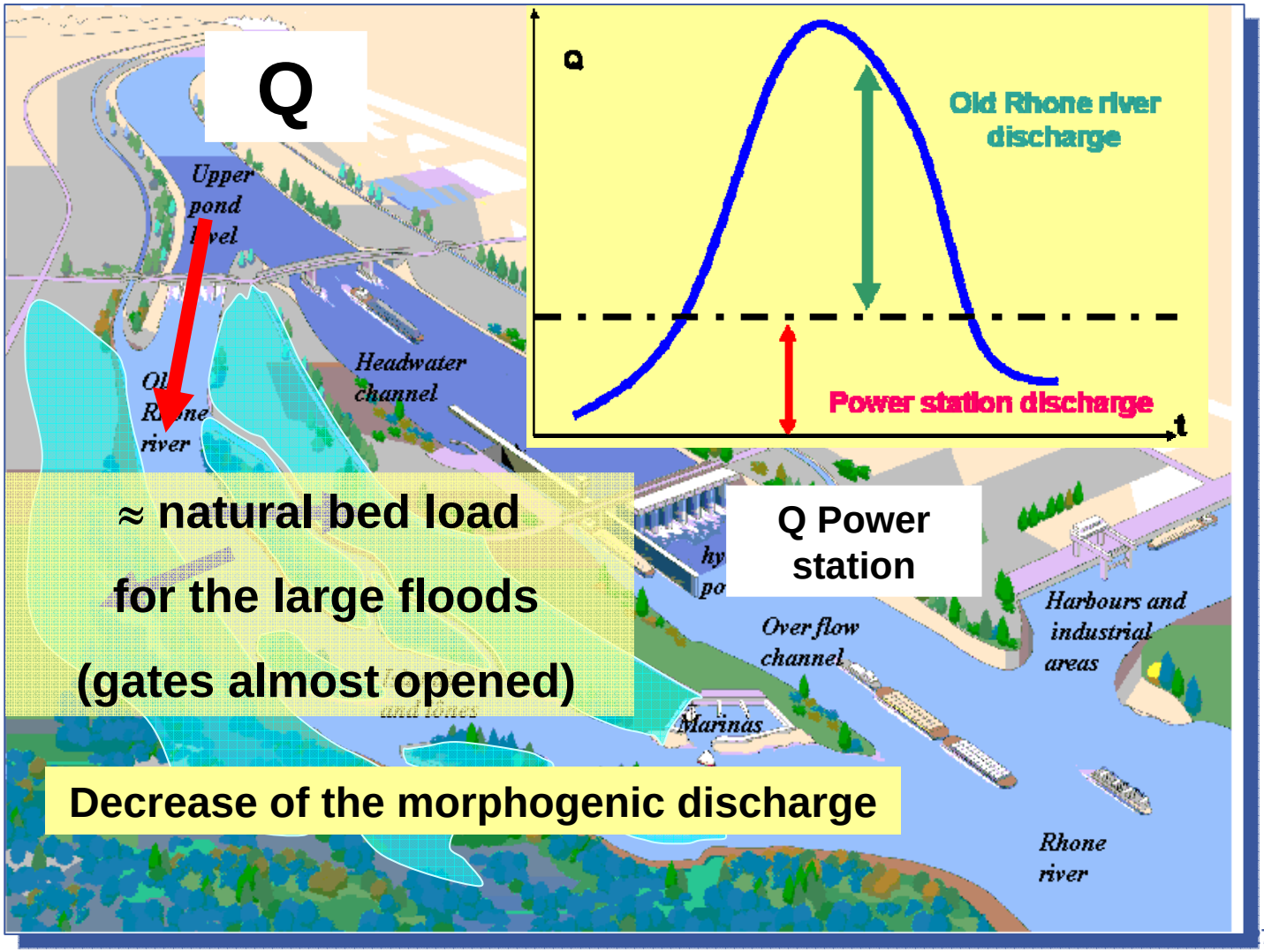
Q_{1000} 4300 → 3400 → 2800 m³/s

Q power station =0

bed load management - Upstream the barrage



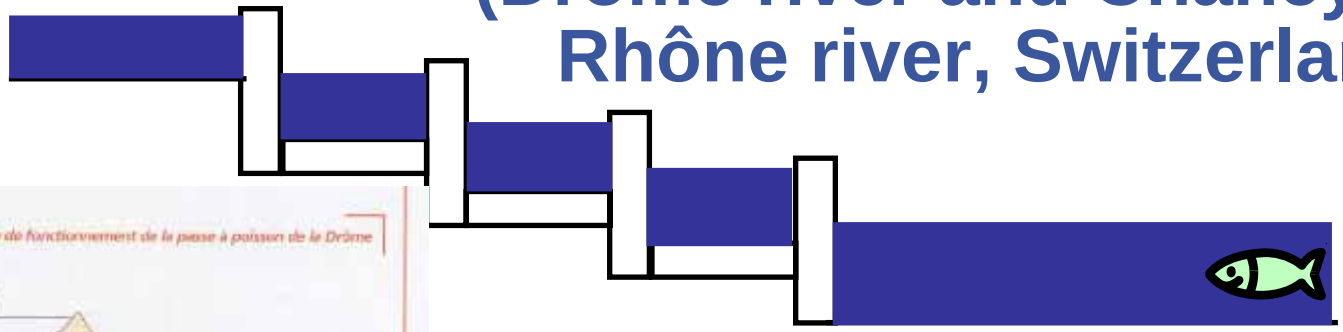
Bed load management - old Rhone river

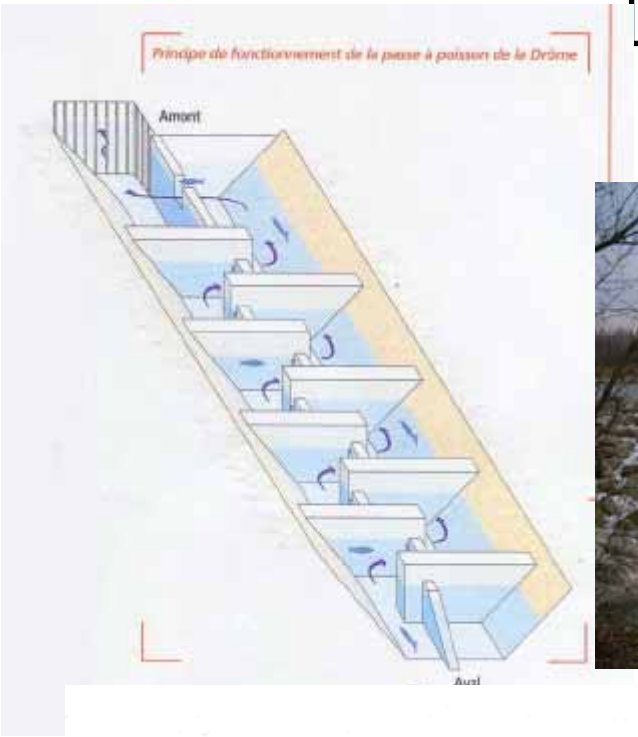


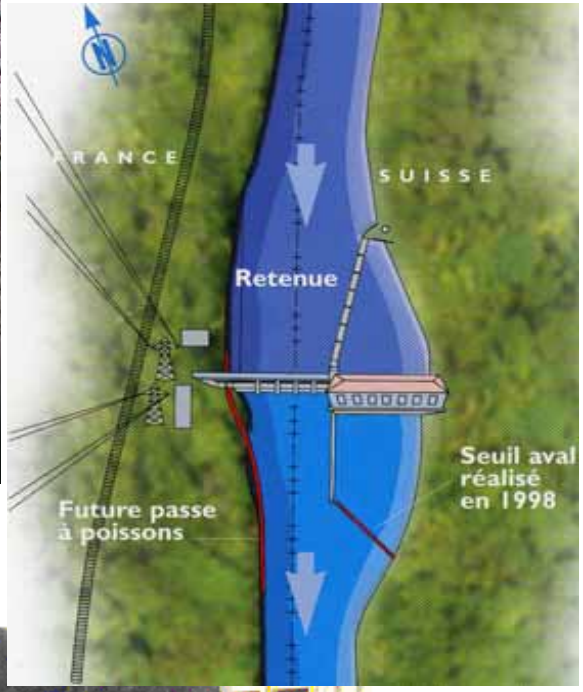
“Hydropower and navigation development on the Rhône river (France) – impacts and environmental management”

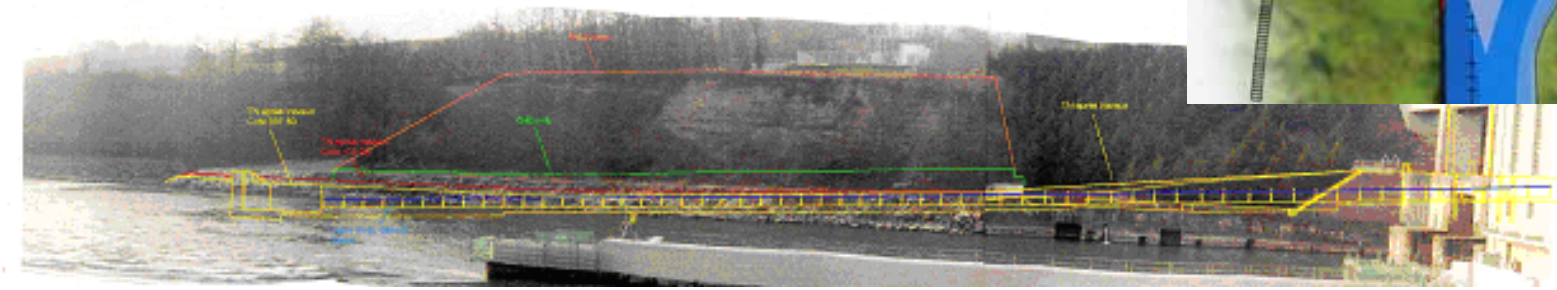
- Experience in addressing barriers to fish migration on the Rhône river basin

Multi pools pass (Drôme river and Chancy HPP Rhône river, Switzerland)



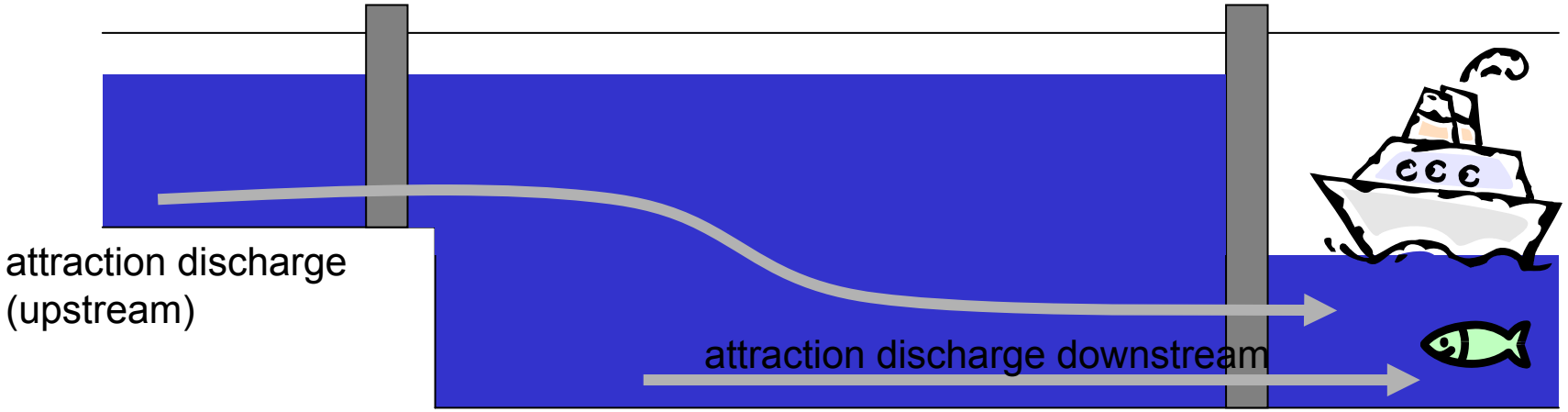


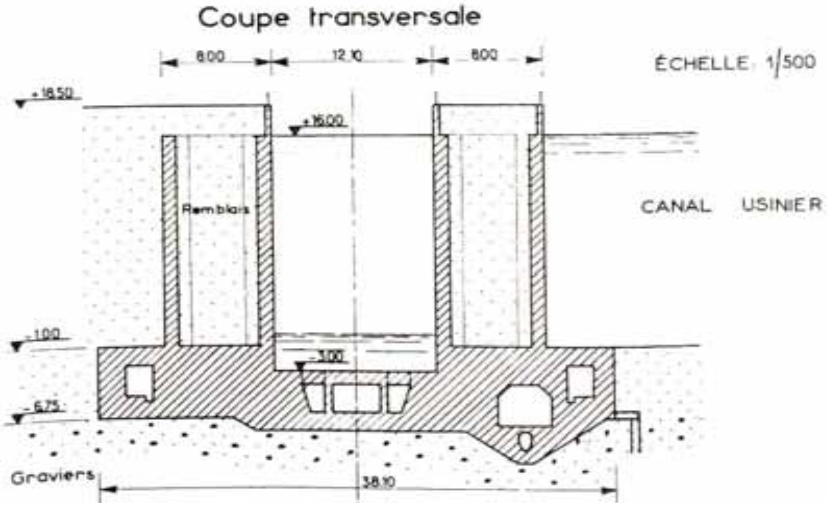




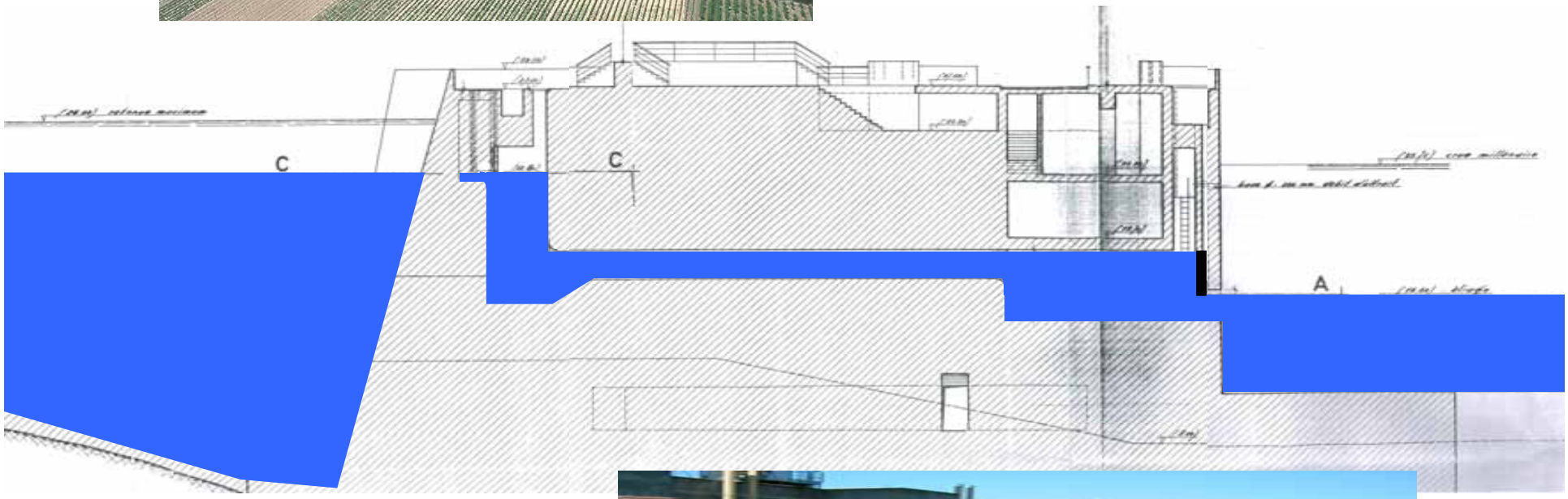
Ship locks

(CNR Beaucaire)

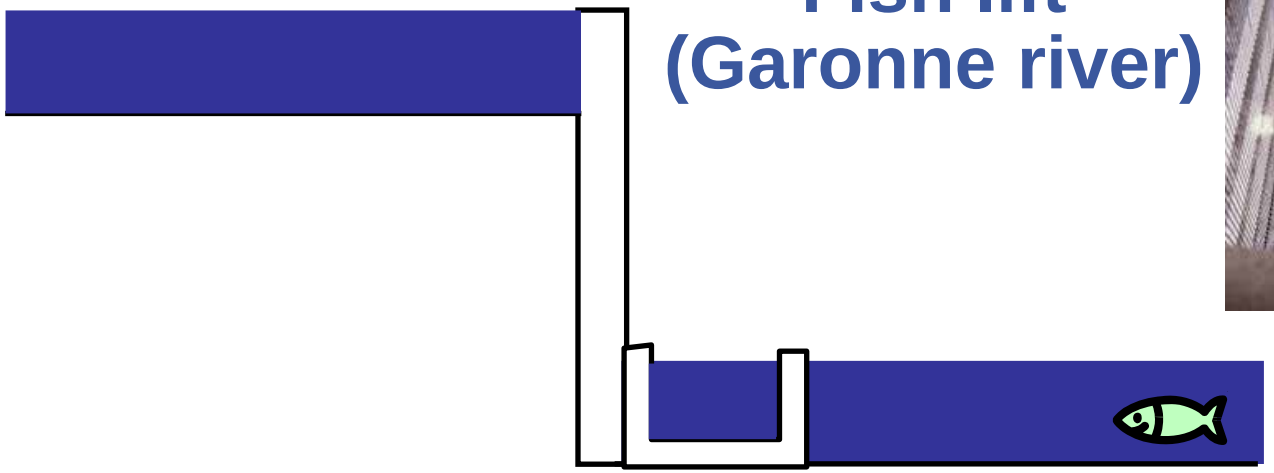


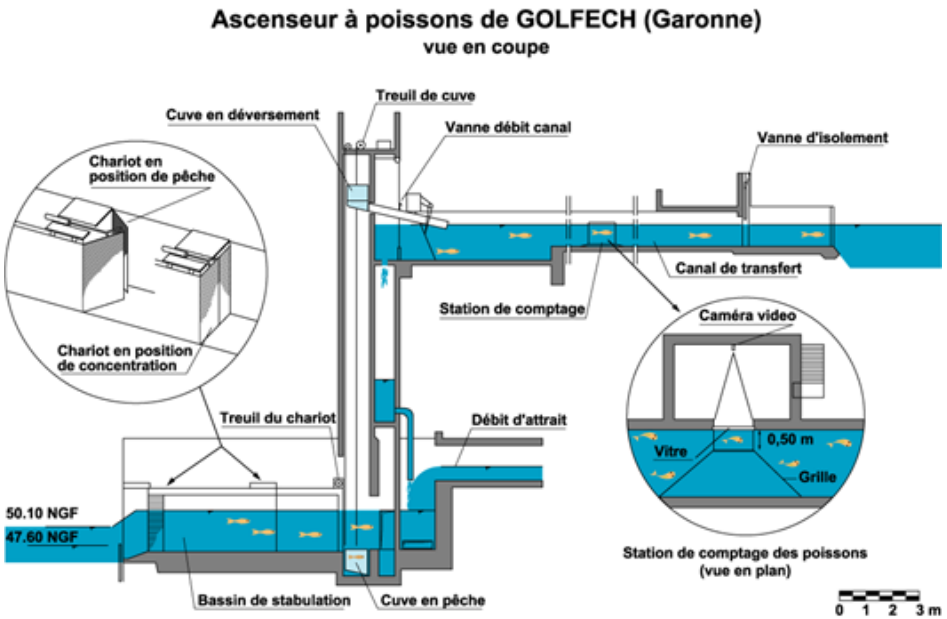


Fish lock
(CNR Sauveterre barrage)

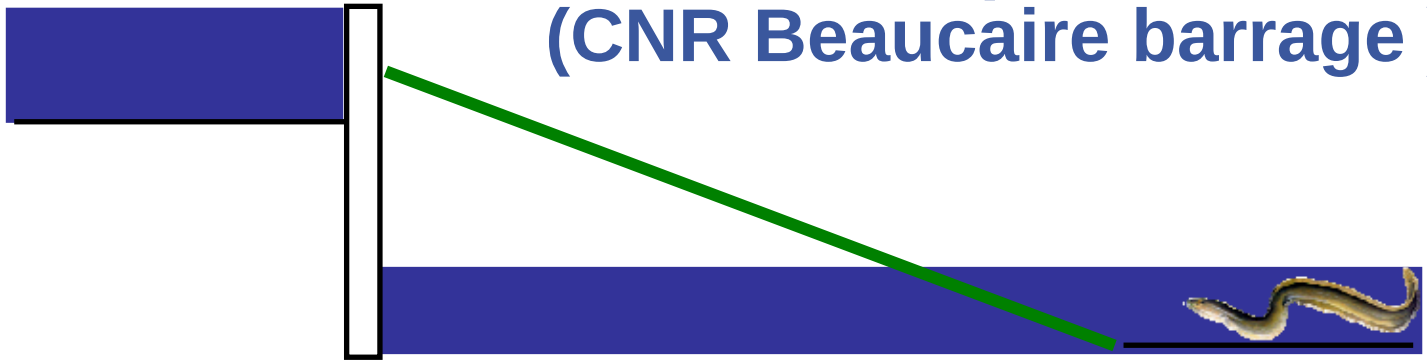


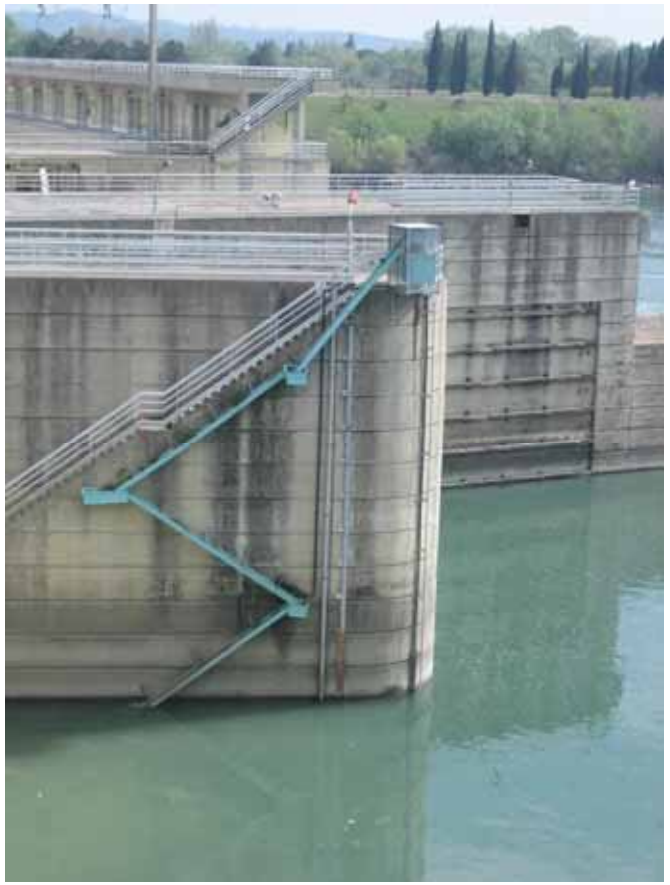
Fish lift (Garonne river)



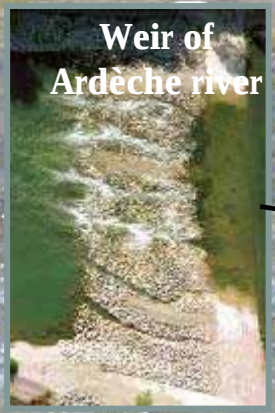


Eel pass
(CNR Beaucaire barrage)

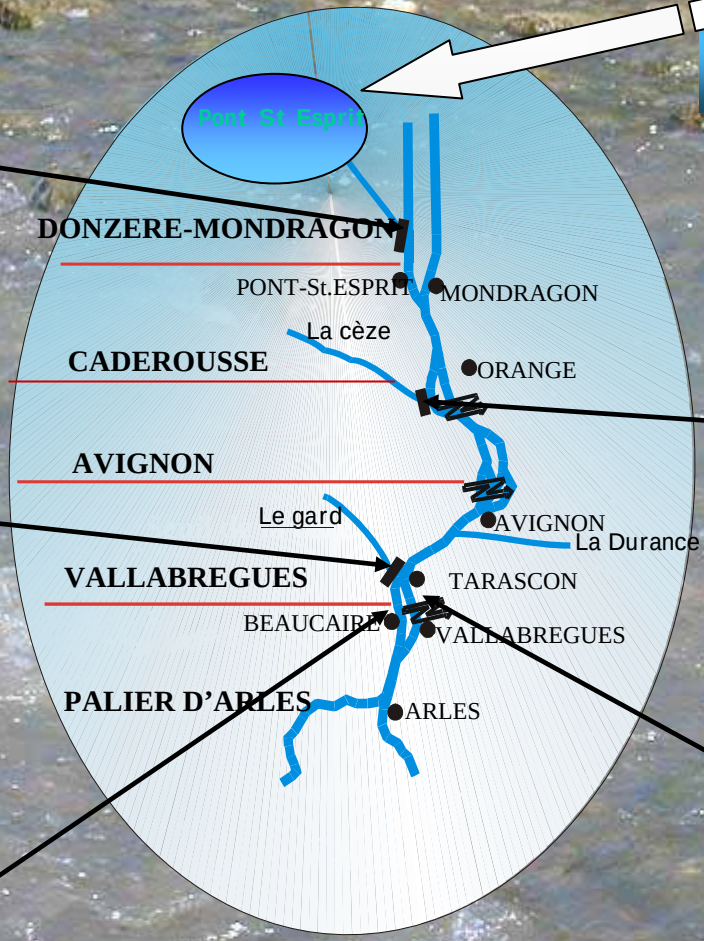




Restoration of the migratory Fish Axis

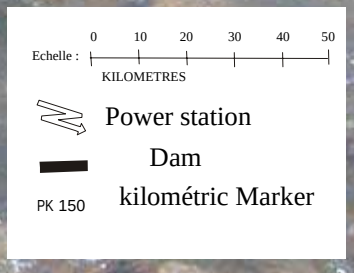


Target 1 : Alose(*Alosa sp.*)
up to the Ardèche River



TARGET 1 : FINANCIAL COST (2000)

Weirs	Beaucaire	Gardon	Cèze	Ardèche	Total (M€)
Costs	1.7	0.9	0.3	0.2	3.1
Lock	Vallabrègues	Avignon	Caderousse		
Costs	0.4	0.4	0.4		1.2



Restoration of the interstream fish circulation

82 lateral identified obstacles

40 on the drainage channels

26 on the tributaries

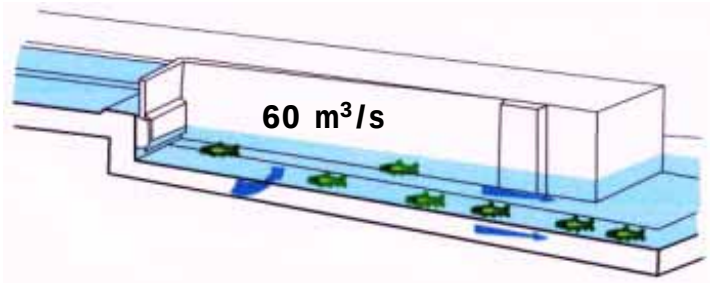
16 on the secondary arms

Cost of the restoration of the fish circulation

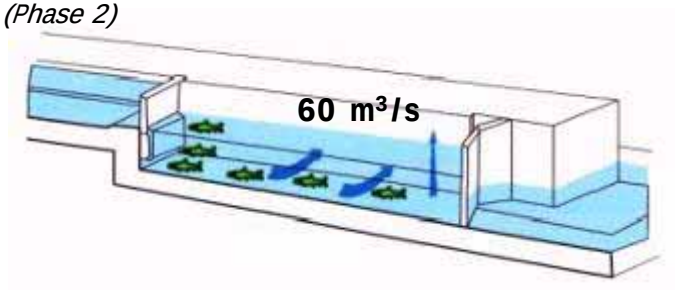
5 M €

Attraction process in the lock

1 - *(Phase 1)*

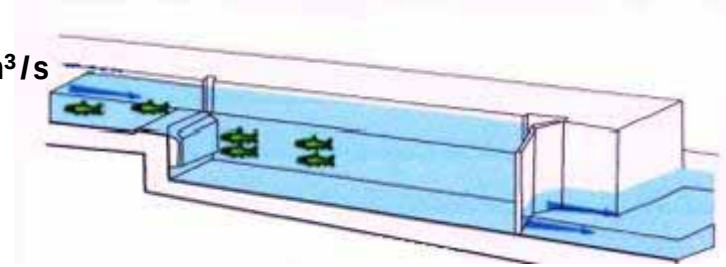


2 - *(Phase 2)*



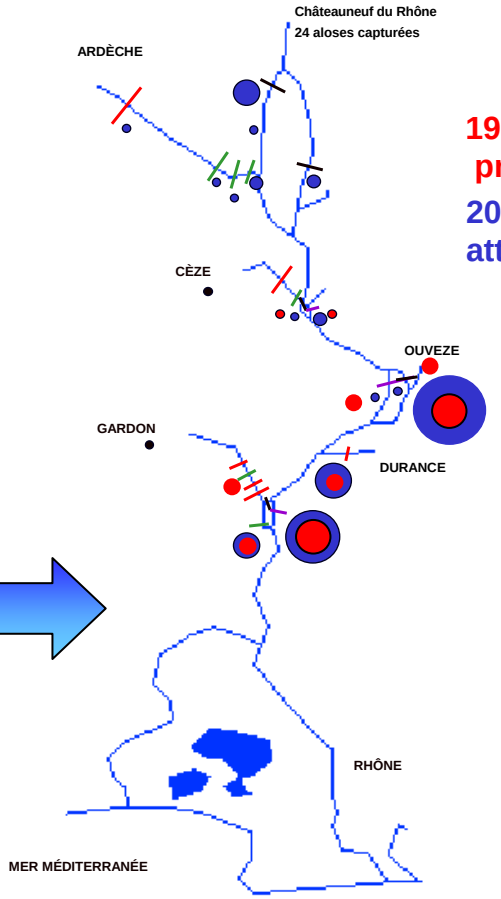
3 - *(Phase 3)*

5 m³/s



2 x 2.5 m³/s

Results of the attraction process



1997 : Before the attraction process

2004 : Results of the attraction process

Captures

- 1 à 10 aloses
- 11 à 50 aloses
- 51 à 100 aloses
- 101 à 200 aloses
- 201 à 400 aloses
- 401 à 600 aloses
- 601 à 1000 aloses

- Seuils non équipés
- Seuils équipés
- Aménagements CNR franchissables (aménagement de l'écluse de navigation)
- Aménagements CNR non franchissables

Données fournies par l'association M.R.M.
Financements : CNR, Agence de l'eau et Ministère de l'environnement.