Why and How to flush a reservoir without environmental impacts

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Compagnie Nationale du Rhône

L'ENERGIE A L'ETAT PUR

Why allow sediment to pass dams?

Effect of sedimentation
- upstream of the dam (reservoir) - downstream of the dam

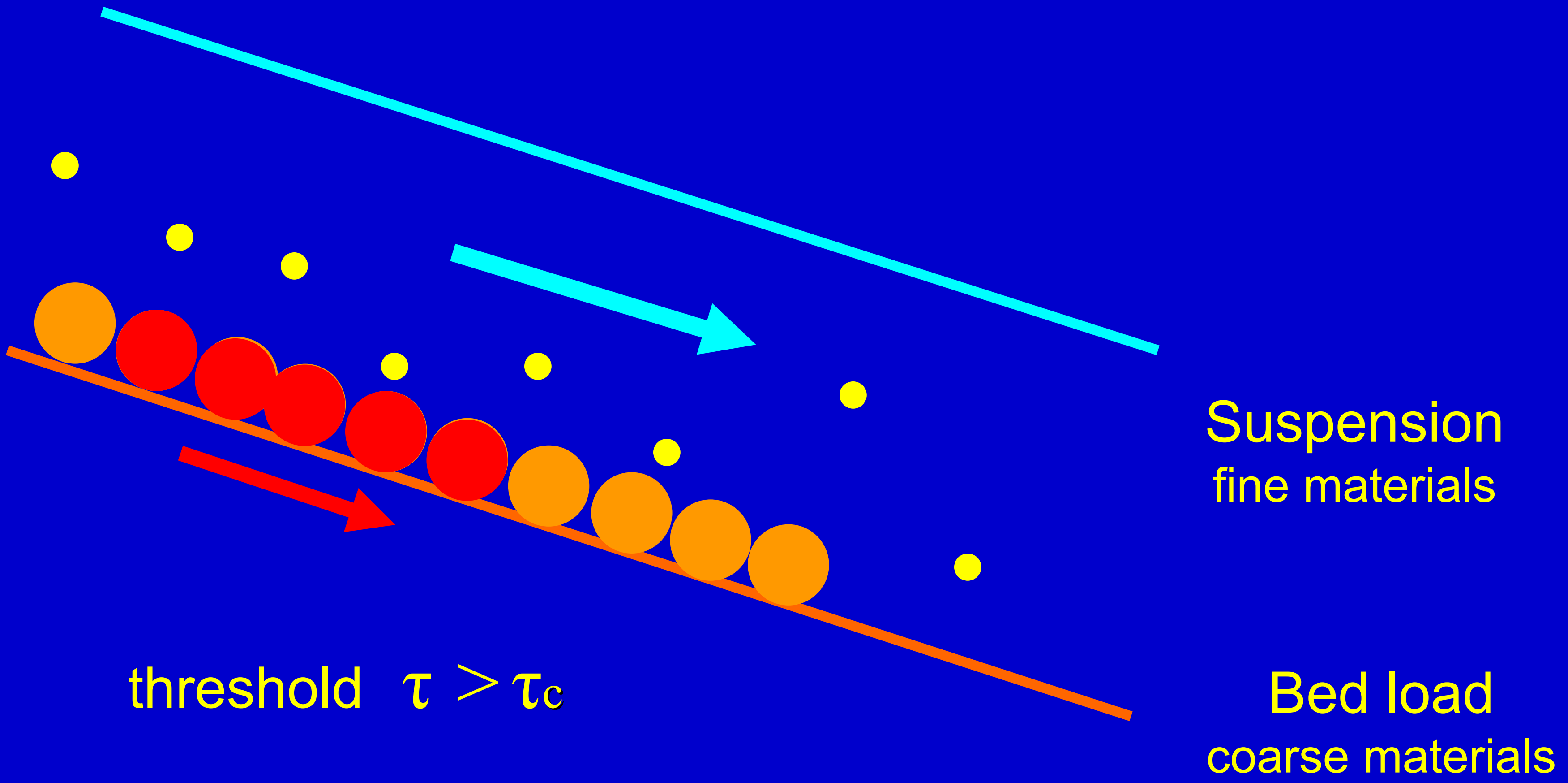
Is it better to let sediment stay in the reservoir?

‘Hard Flushing’ or ‘Environmentally Friendly’ flushing ?

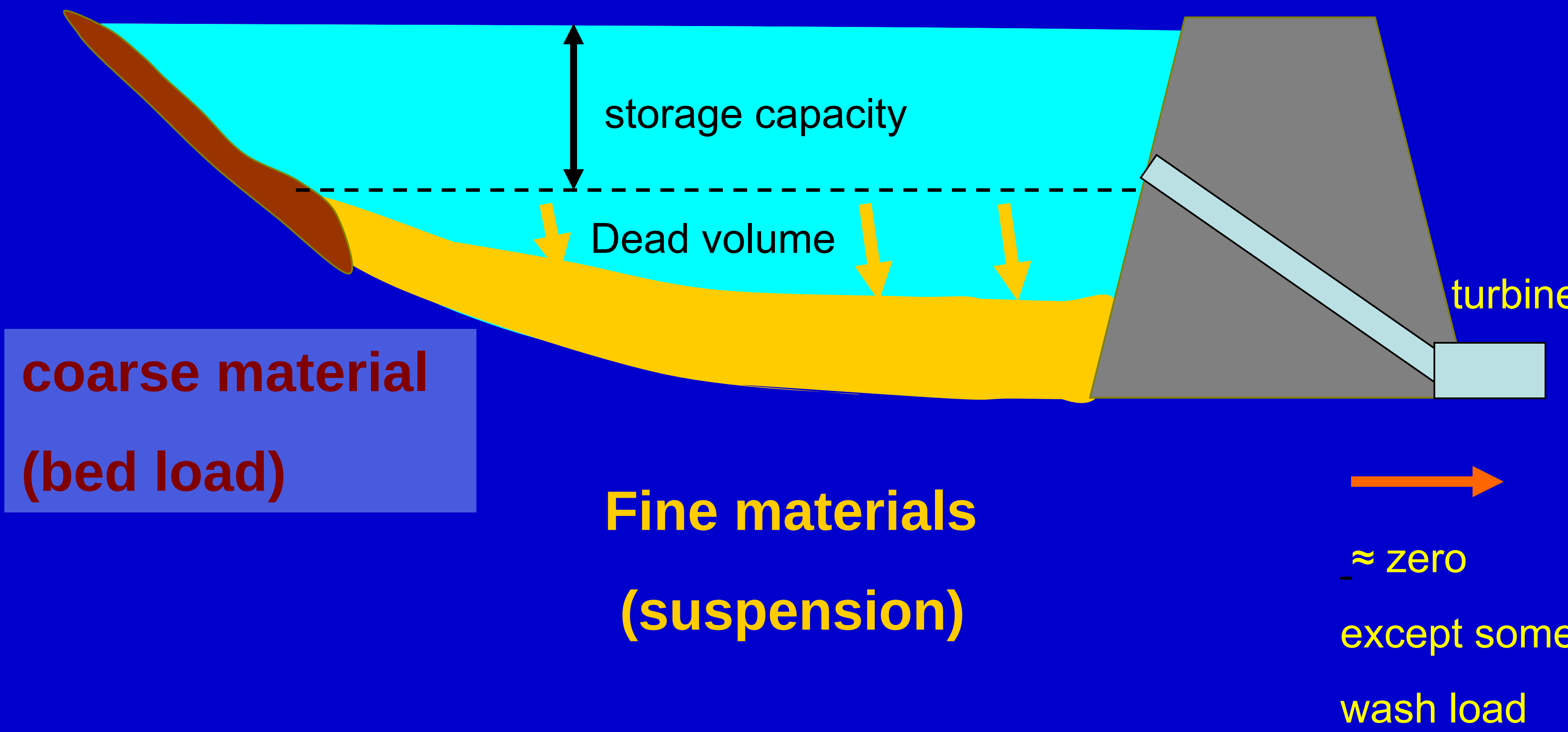
How to flush the sediment while minimizing environmental impacts?

Is there an incentive for hydropower plant owners to flush ?

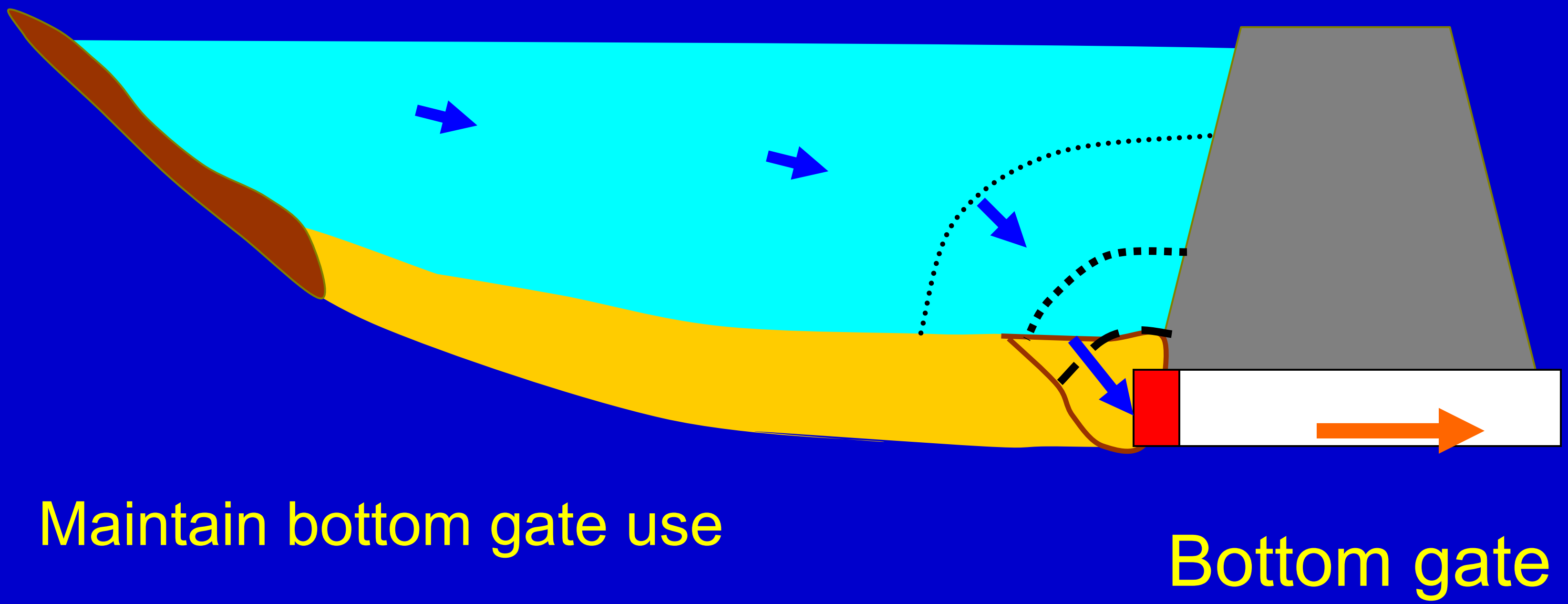
Material transportation in rivers



Sedimentation in a reservoir



Bottom gate flushing



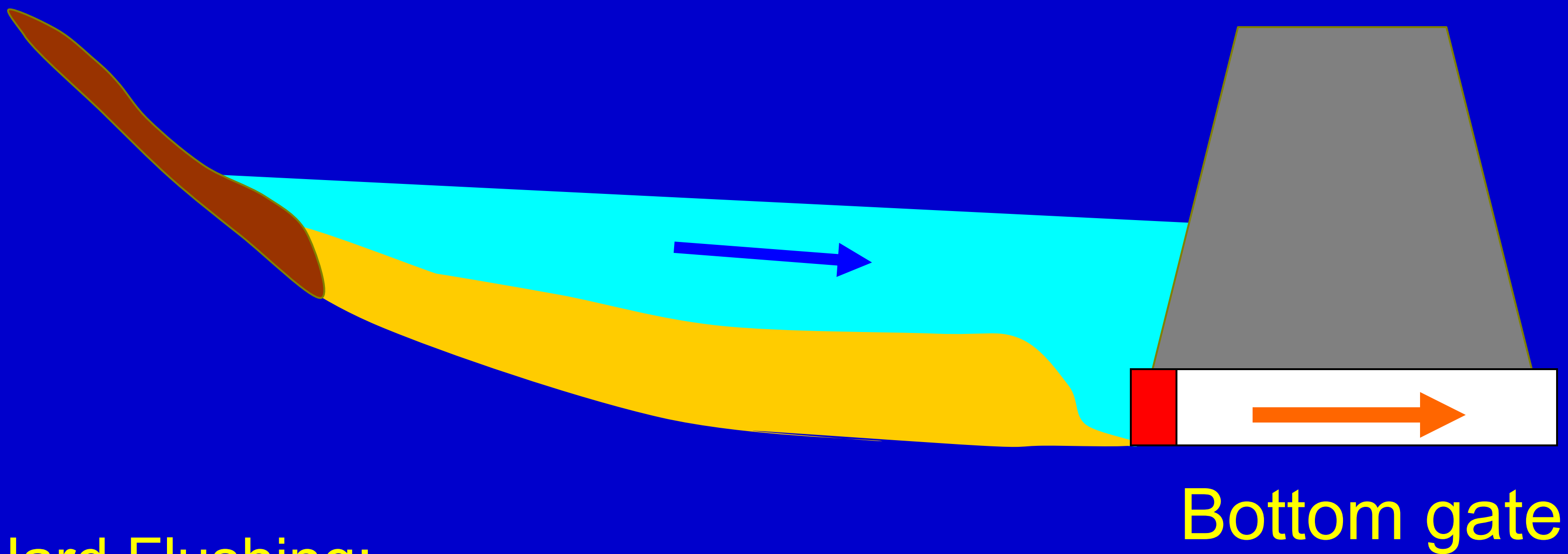
Maintain bottom gate use

Necessary for security

Uncontrolled concentration downstream

Best practice: operation during a flood

Hard flushing



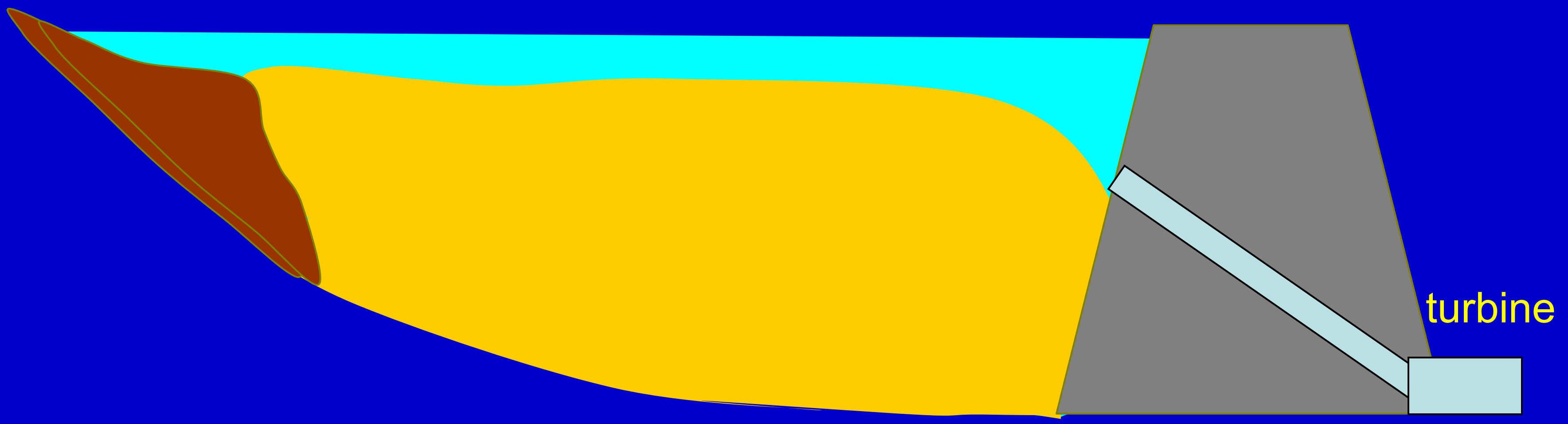
Hard Flushing:

High and uncontrolled concentration downstream

Destruction of the biodiversity downstream

Best practice : no flushing ?

NO flushing



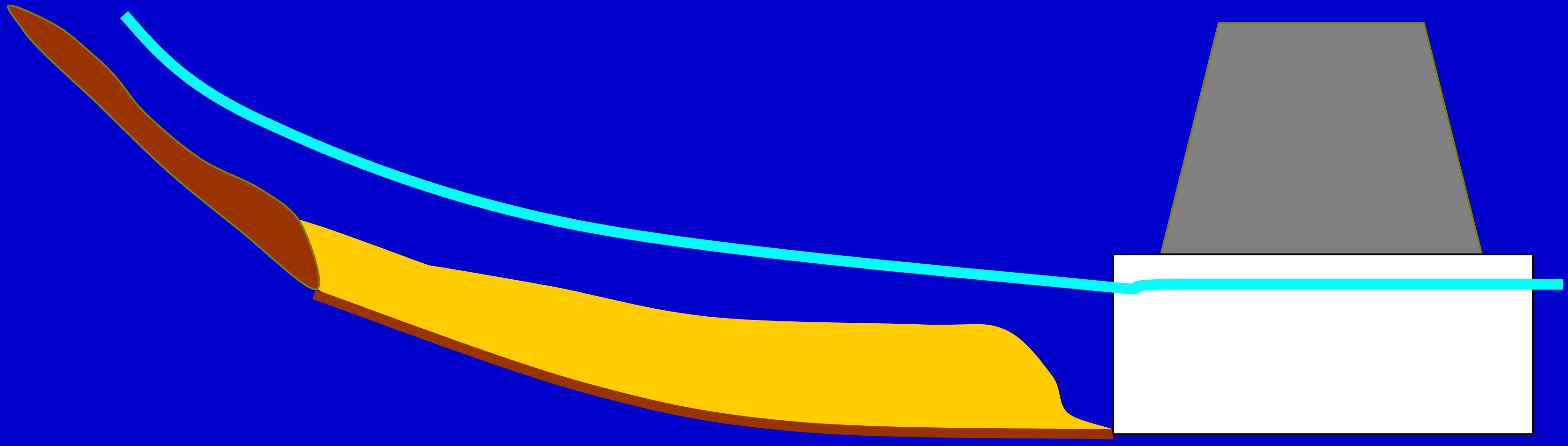
No Flushing :

No more storage capacity

Fine sediment reaches the turbine

Pipes and turbine damages by erosion

Flushing the coarse materials ?



Flush the coarse materials = bed load

Flush the fine materials First

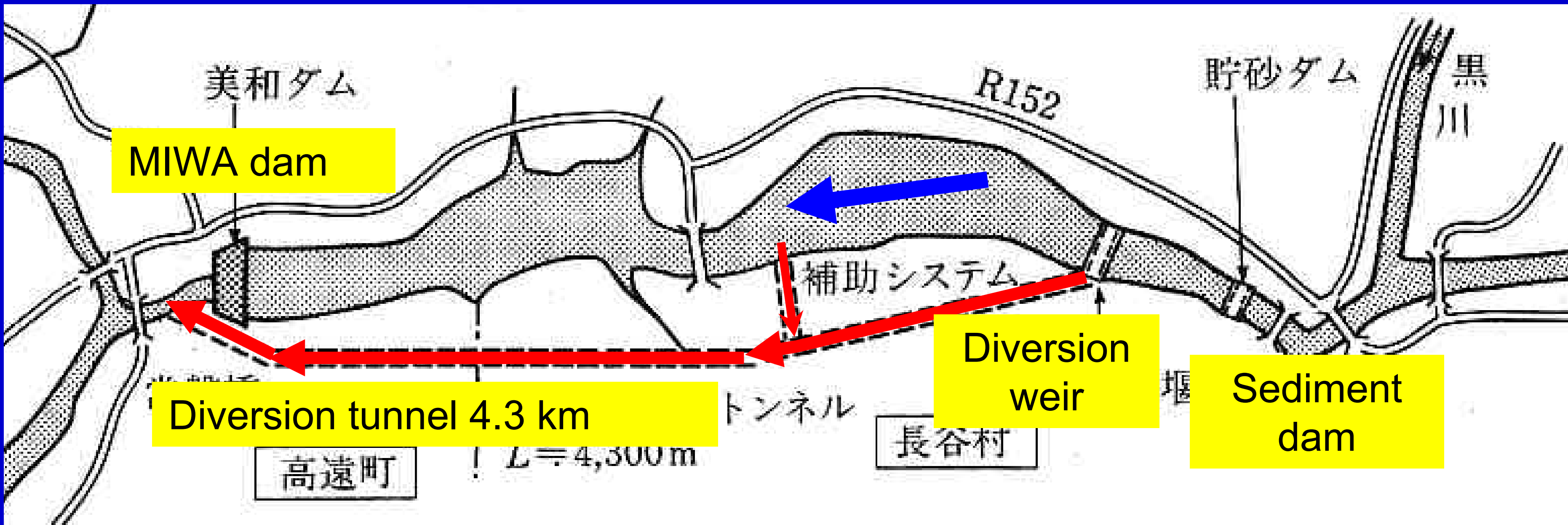
Flood is needed

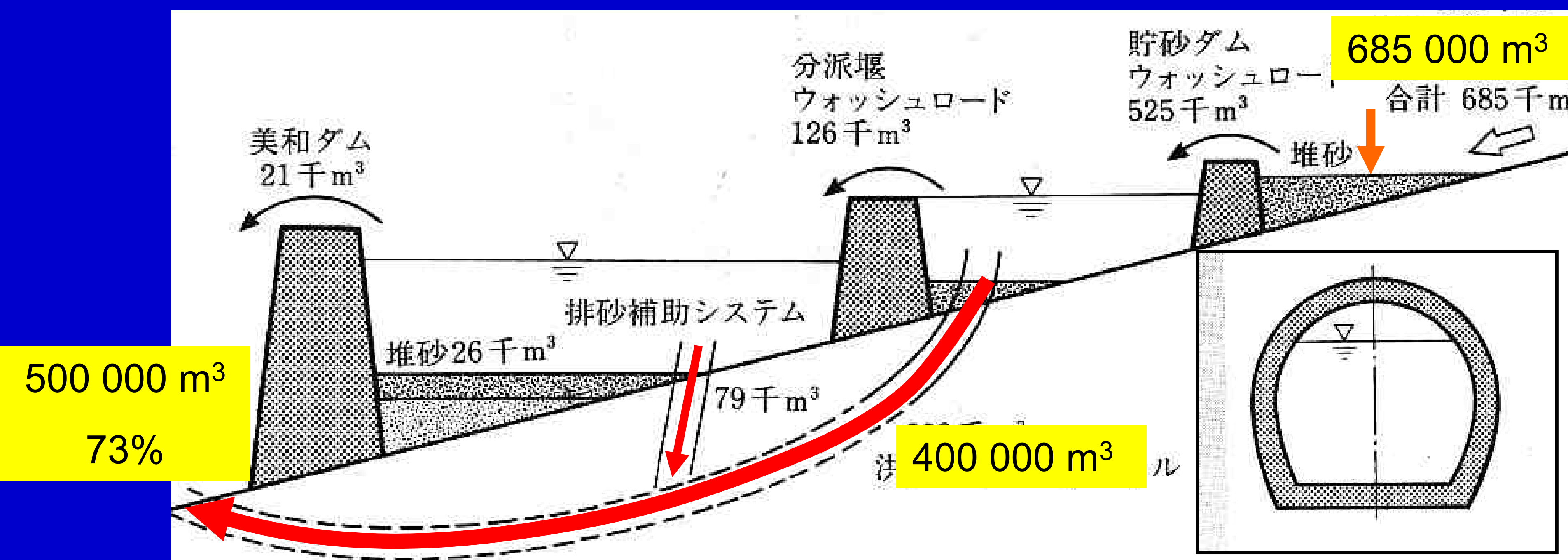
Appropriate bottom gate

Miwa dam Japan

- Construction completed in 1959 Reservoir 37 million m^3
- In 1972 Sedimentation reached 10 million m^3 in 1982: + 4 million m^3
- objective: preserve the volume of the reservoir - no regard to environment

Miwa dam Japan – bypass tunnel





Genissiat dam Rhone river France

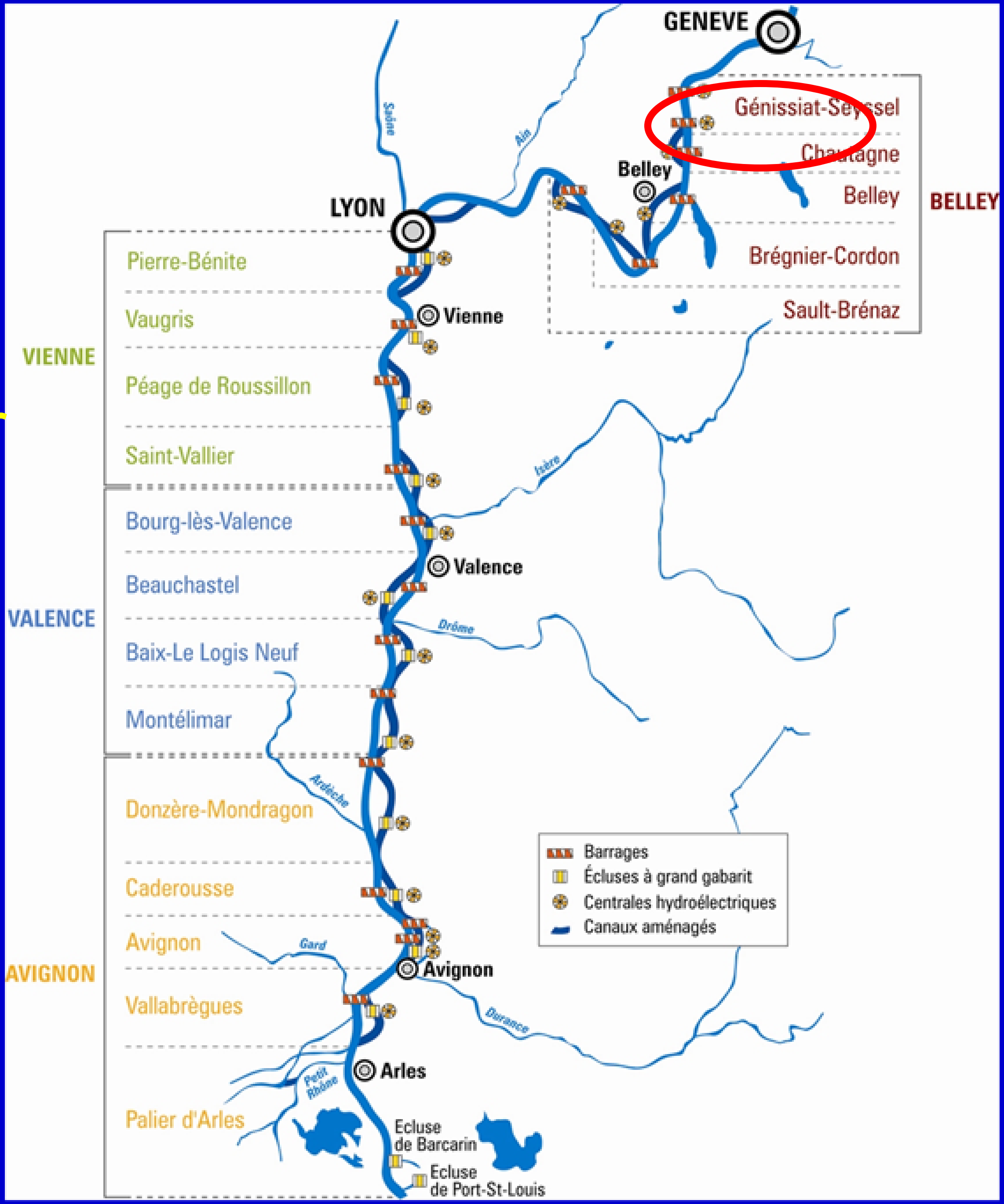
Environmentally Friendly Flushing ©

to send downstream only the concentration of sediment that the environment can withstand

Hard flushing: to send as much sediment as possible downstream

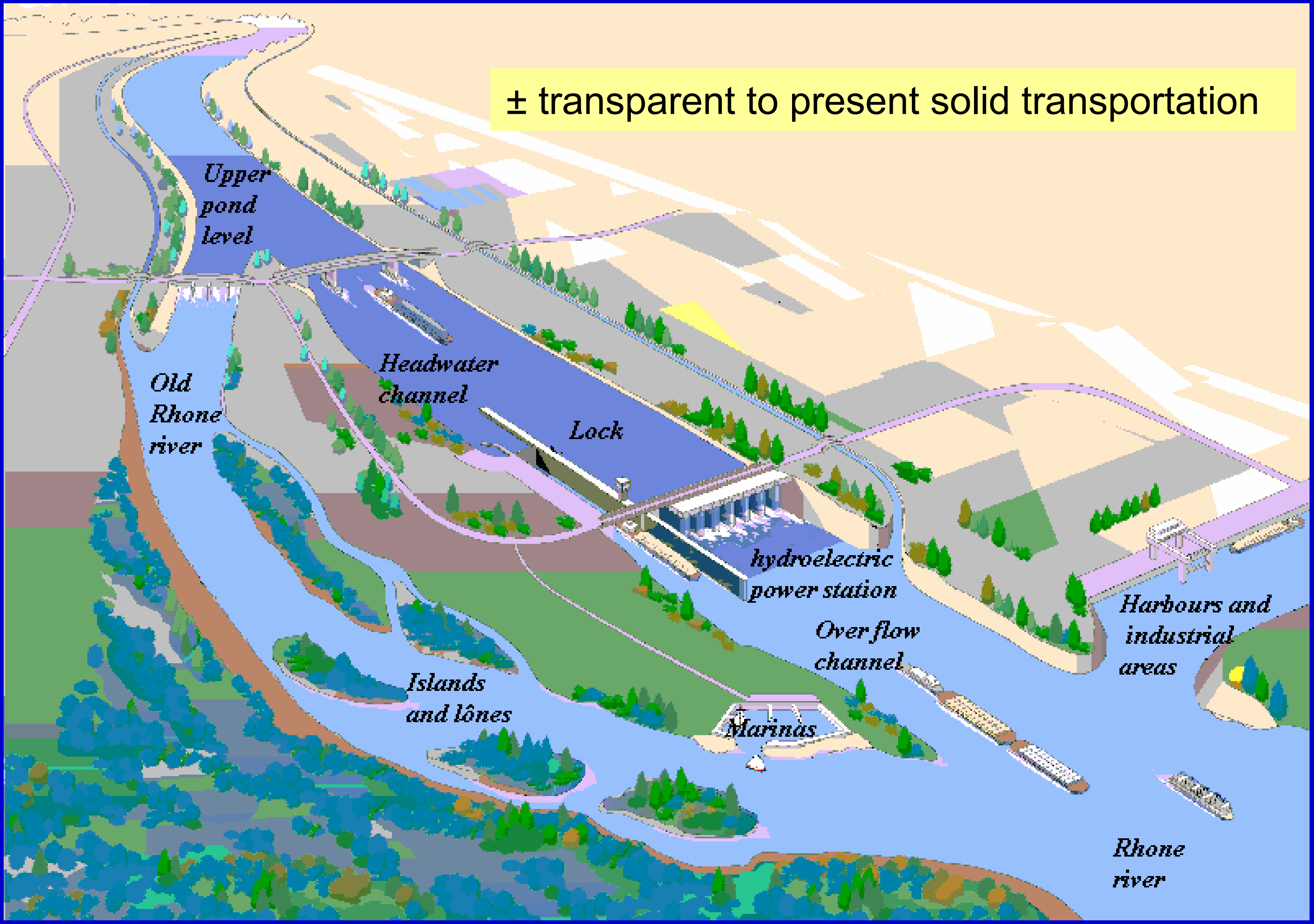
CNR developments along the Rhone river France

- 1 dam
- 17 run of the river developments

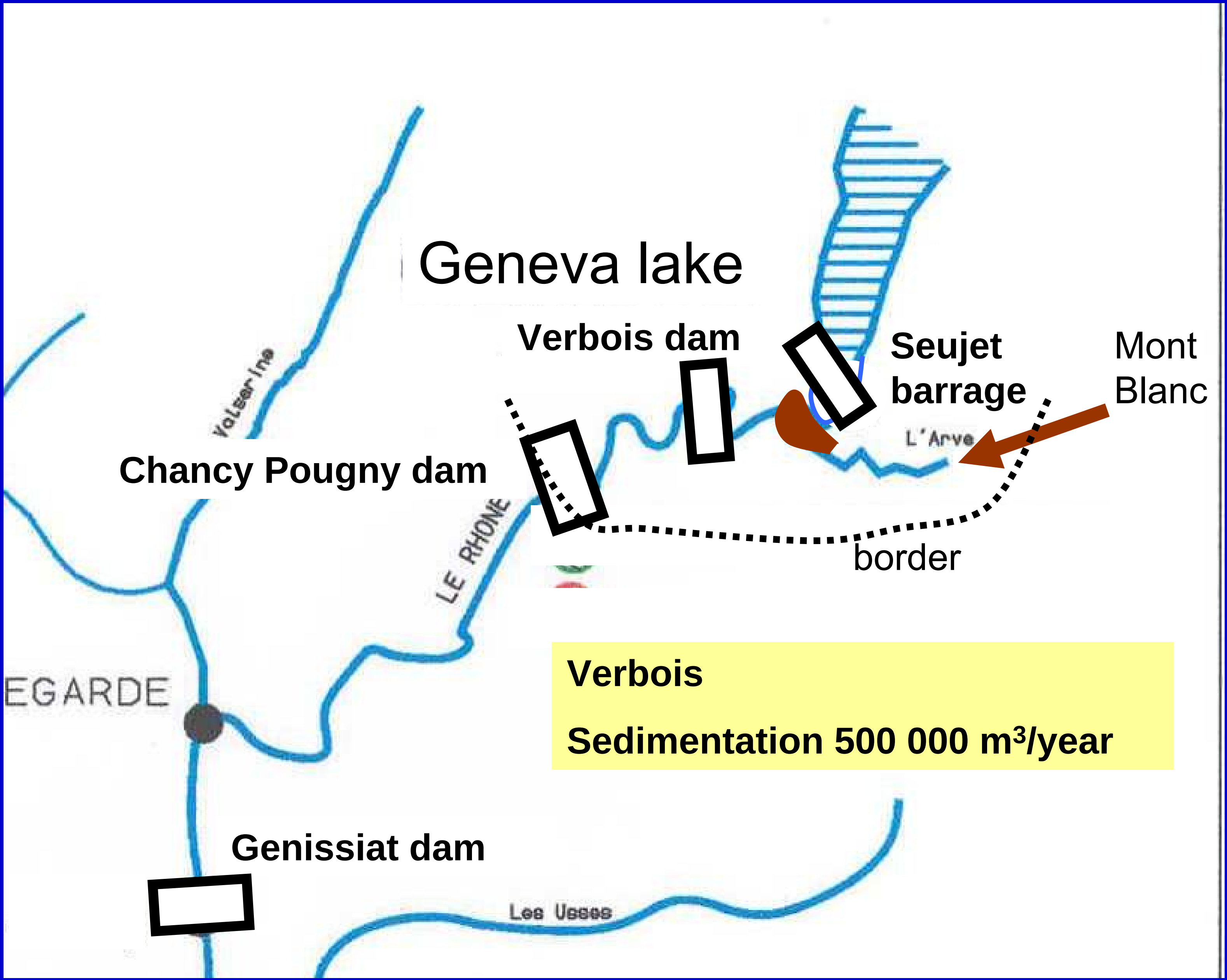


Mediterranean sea

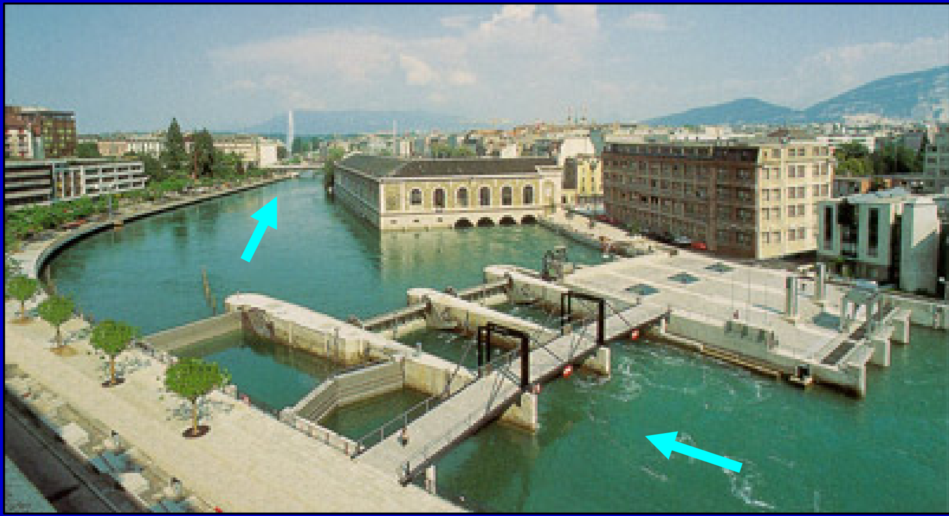
Run of the river development scheme



Upper Rhone river France - Switzerland

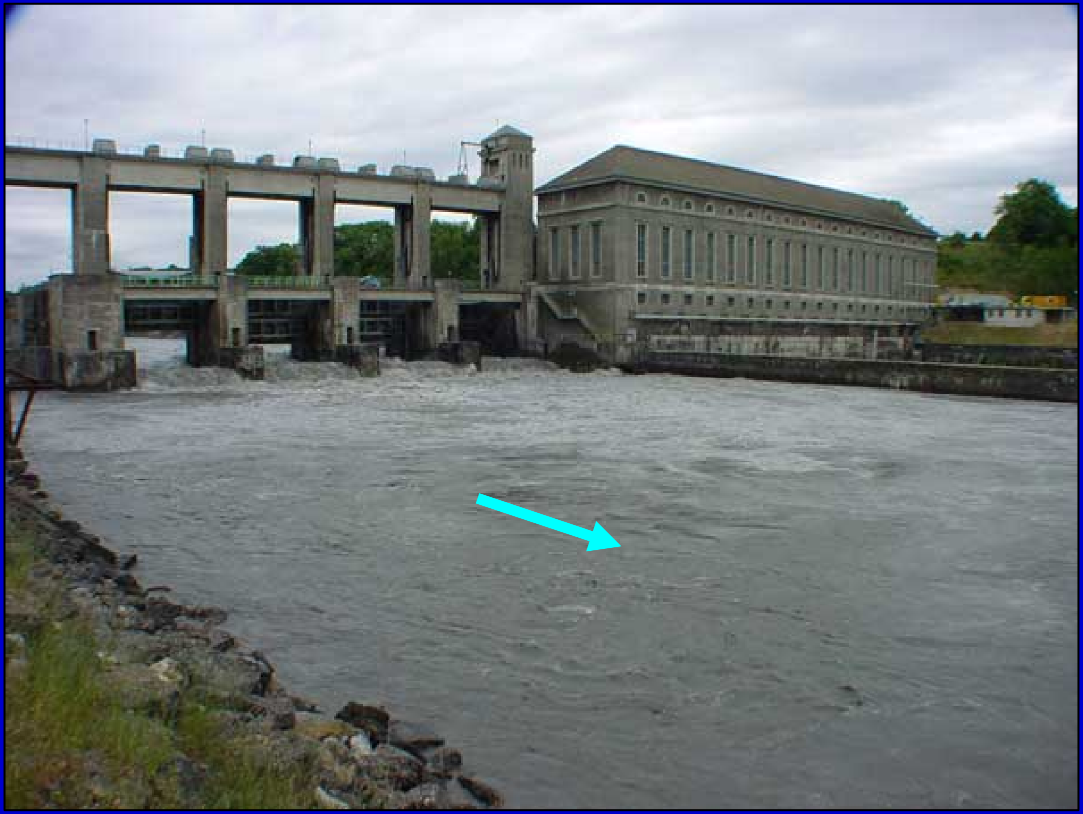


Geneva lake Switzerland



Seujet barrage

Verbois dam Switzerland



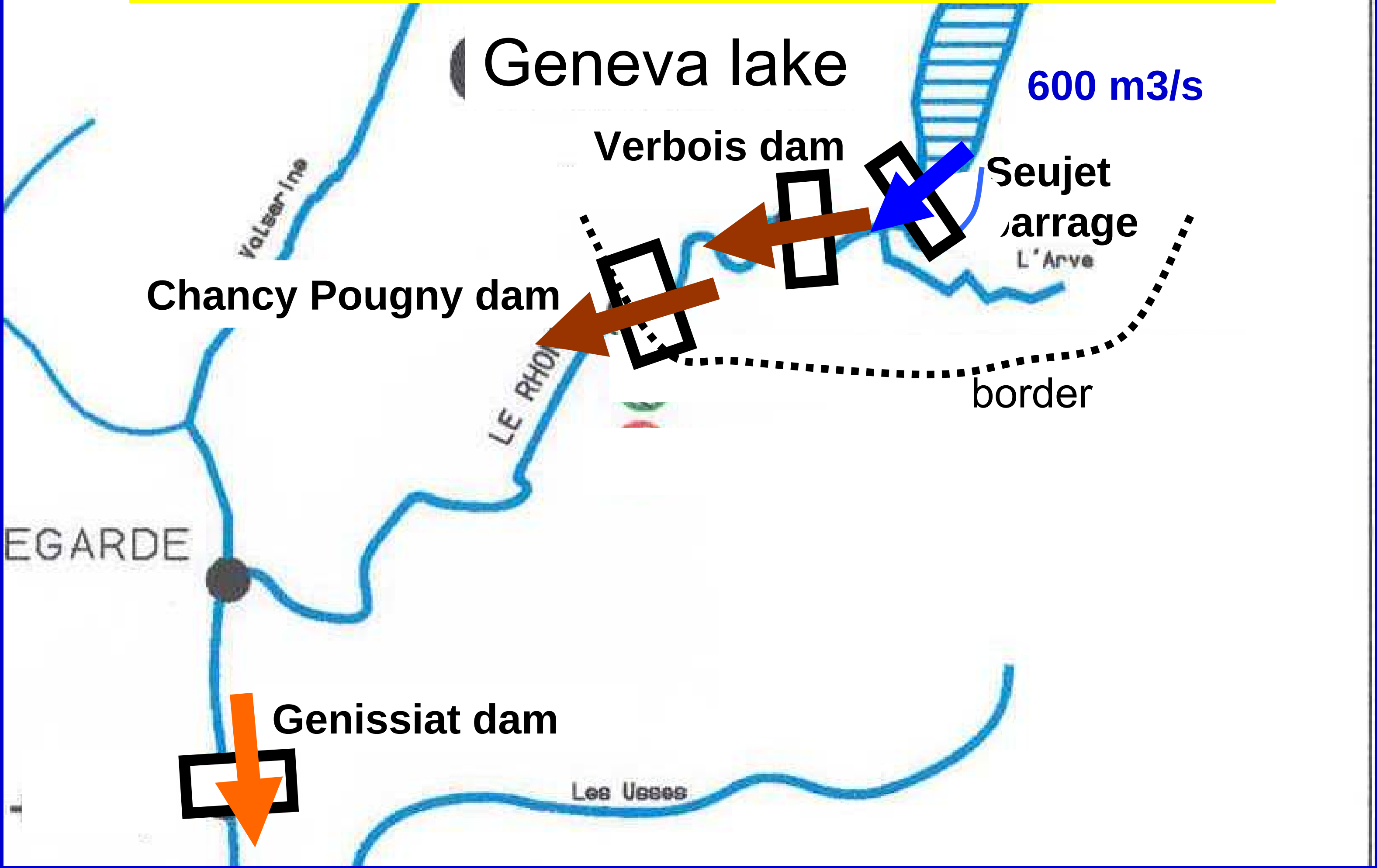
Chancy Pougny dam

Switzerland – France border

Genissiat dam France

Upper Rhone river France - Switzerland

Flushing Verbois-Chancy-Genissiat dams organized every 3 years since 1970 duration 1 week



Rhone river - Genissiat dam

Head 67 m

6 turbines 66 MW 125 m^3/s

Total volume 52 millions m^3

Used volume 12 millions m^3

1 bottom gate

1 mid depth gate

1 spillway

Longitudinal narrow reservoir

Steep cliffs

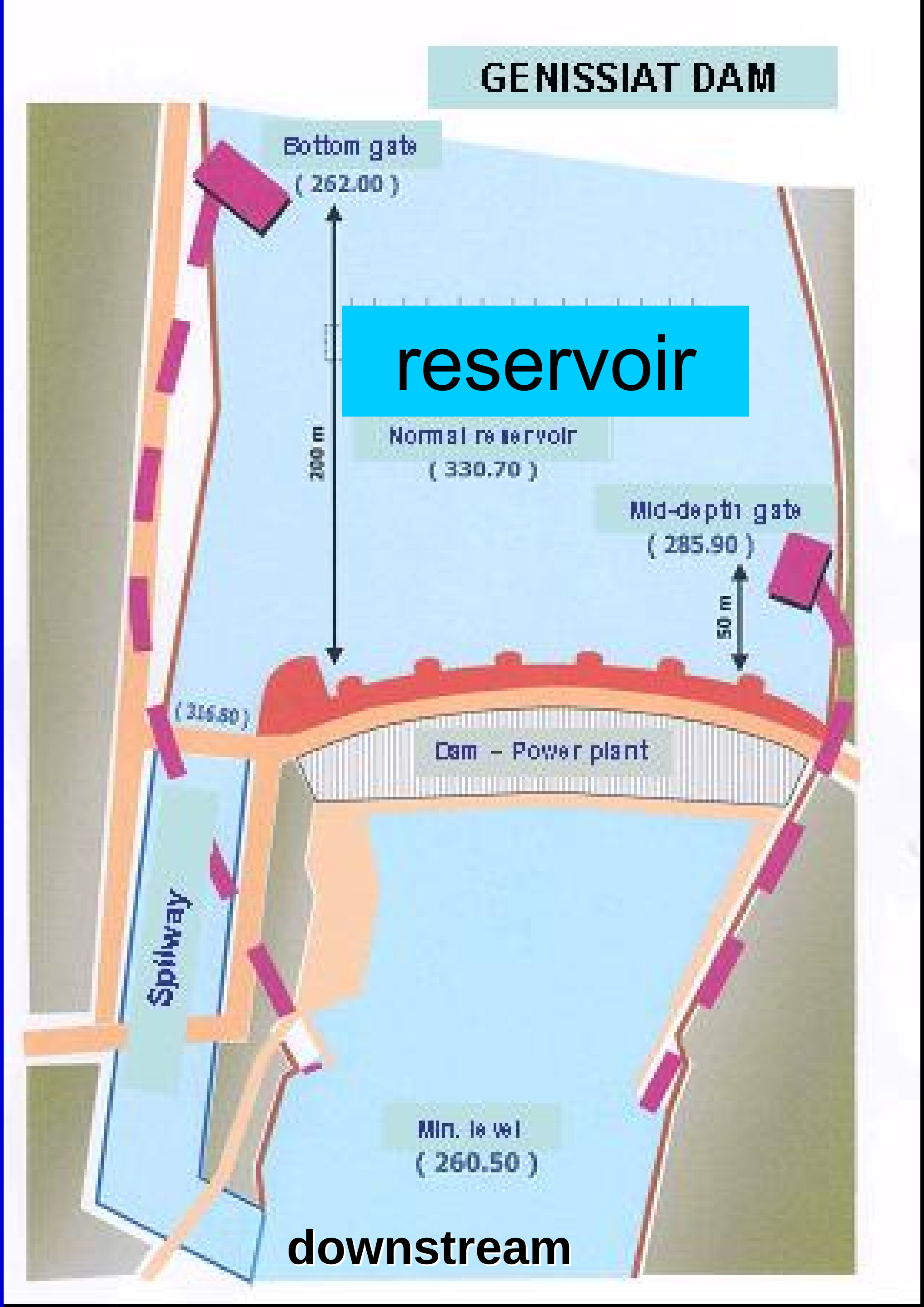
General purpose

Prolong the life time of the Genissiat reservoir

Transit of the sediments sent by Swiss dams

3 main issues of the flush

1. Guarantee acceptable concentrations downstream
2. Guarantee the biodiversity of the old Rhone river Chautagne, Belley, Bregnier-Cordon run of the river developments downstream
3. Guarantee 125 m^3/s for cooling the Bugey nuclear power station downstream



GENISSIAT DAM
Bottom gate
(262.00)
reservoir
200 m
Normal reservoir
(330.70)
Mid-depth gate
(285.90)
50 m
(316.80)
Dam – Power plant
Spillway
Min. level
(260.50)
downstream

Downstream concentration limits to be respected:

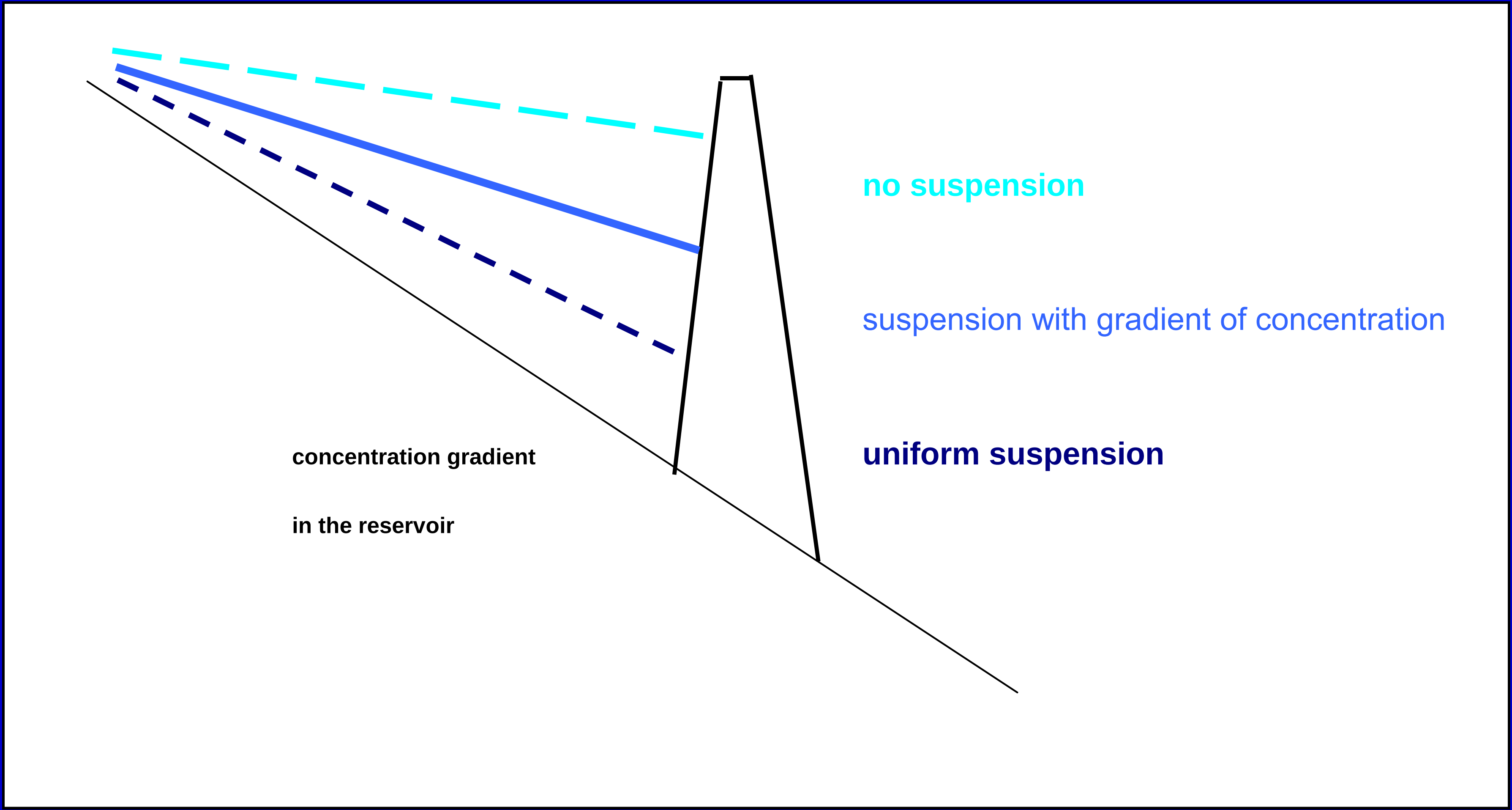
- 5 g / l	**average**
- 10 g /l	6 hours max
- 15 g /l	30 minutes max

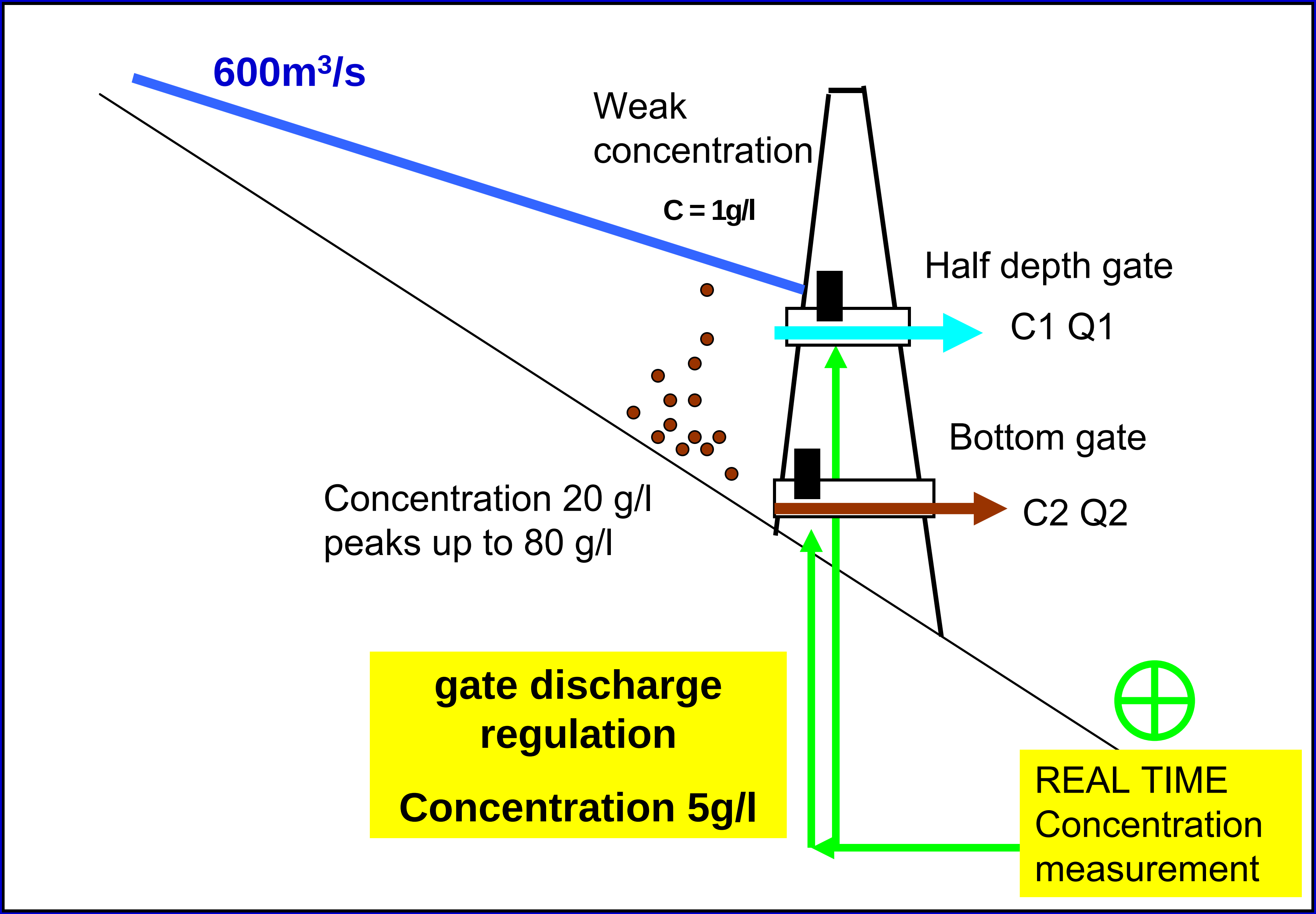
Monitoring in real time

- Water levels
- Suspension concentration
- Water quality, oxygen, Water Temperature, Bacteriology (bath areas), Toxicology (sediments)
- Clogging of spawning area

+ Before and after the flush : Electrical fishing

gradient of concentration in the reservoir




600m³/s
Weak
concentration
C = 1g/l
Half depth gate
C1 Q1
Bottom gate
C2 Q2
Concentration 20 g/l
peaks up to 80 g/l
gate discharge
regulation
Concentration 5g/l
REAL TIME
Concentration
measurement

Suspension concentration measurement - γ ray device

Continuous measurement:

Gamma ray densimetry

- Bottom gate

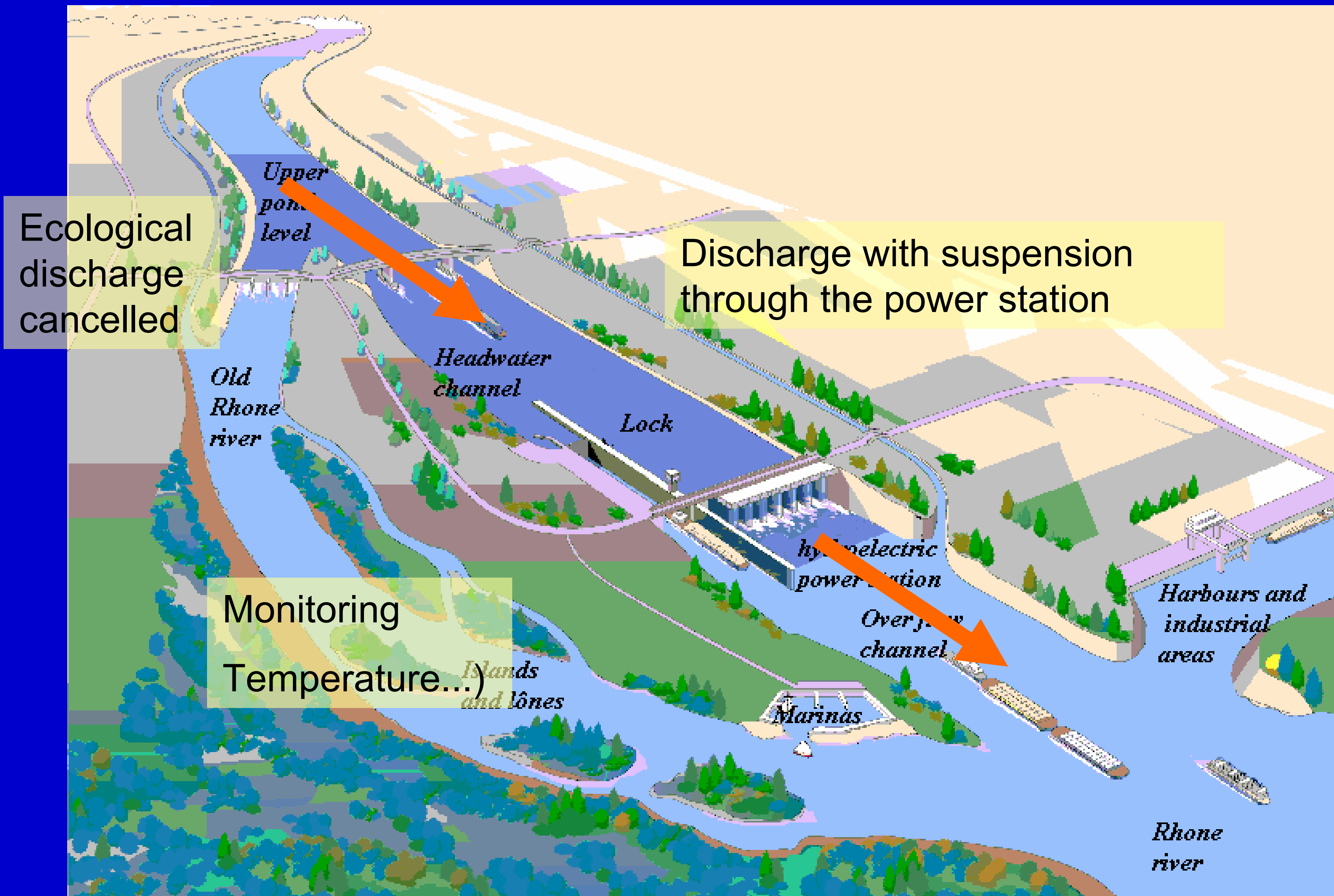
- Mid depth gate

- 6 km downstream

by authorized specialists

+ ponctual measurements: picnometer (density measurement) - pancake (quick drying)

Run of the river development management downstream



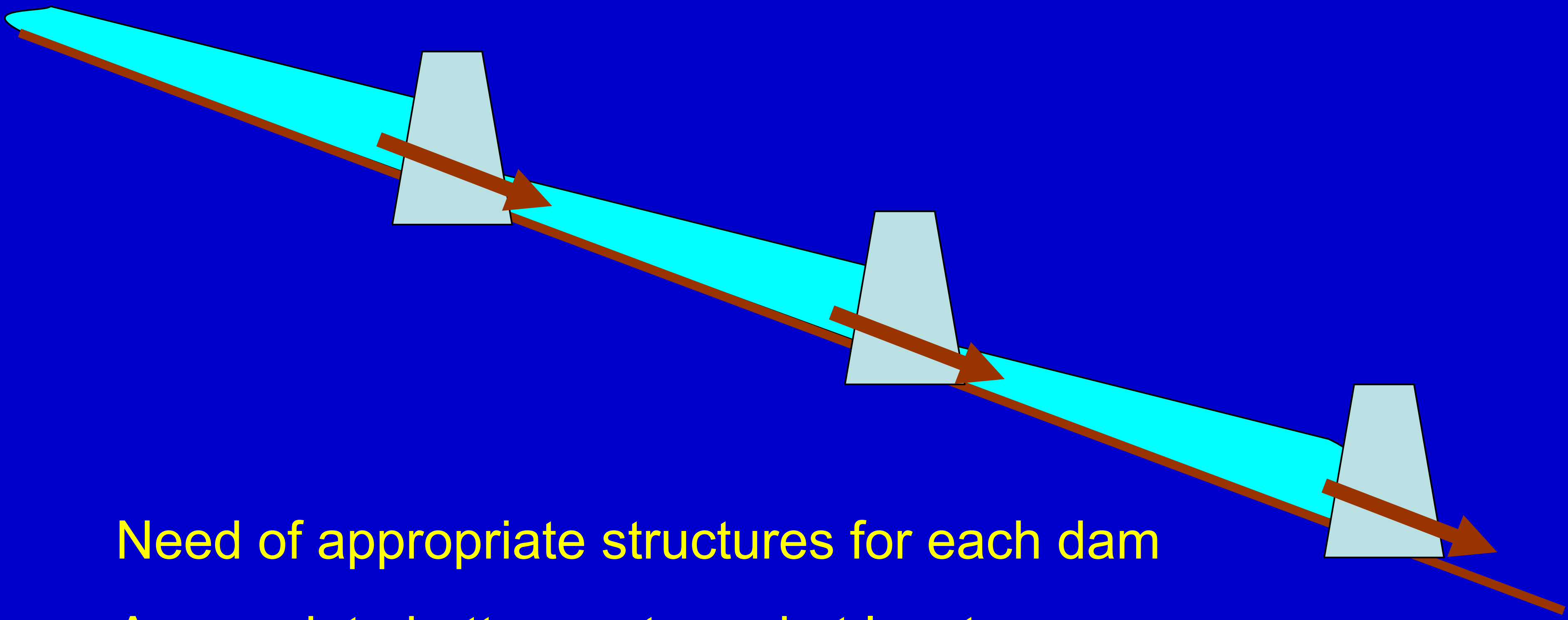
2003 Genissiat reservoir flushing assessment

- **no damage to the environment**

- **Heavy organization**
  – 2 country close cooperation
  – 80 people involved during 1 week
  – lot of monitoring over 150 km
  – 30 year experience

- **Efficient**
  - output ≈1 600 000 tons > input
  – Cost 1.5 M€ -loss for energy- staff
  – Dredging cost effectiveness very good ≈1 € /ton

Flushing a cascade of dams

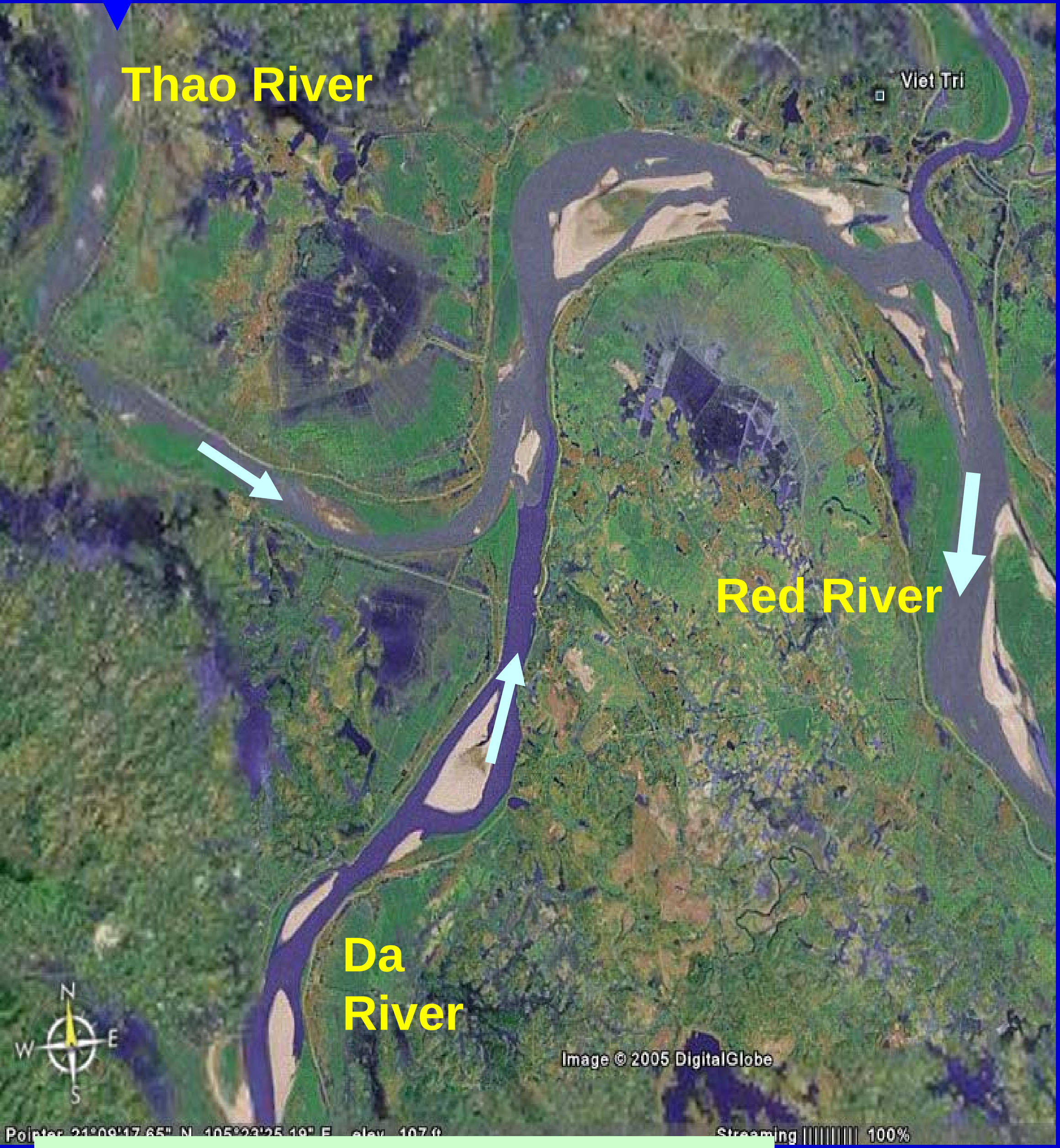


Need of appropriate structures for each dam

Appropriate bottom gate and at least
mid depth gate for the downstream dam

Impact of dams downstream

Downstream effect of dams on river morphology



Hoa Binh dam - capacity 5 Billion m^3

Hydraulics

Decrease of the floods downstream (morphogenic discharge)

Material transportation

Siltation in the reservoir

Bed <u>aggradation</u> (sedimentation) downstream of the dam

despite embankments

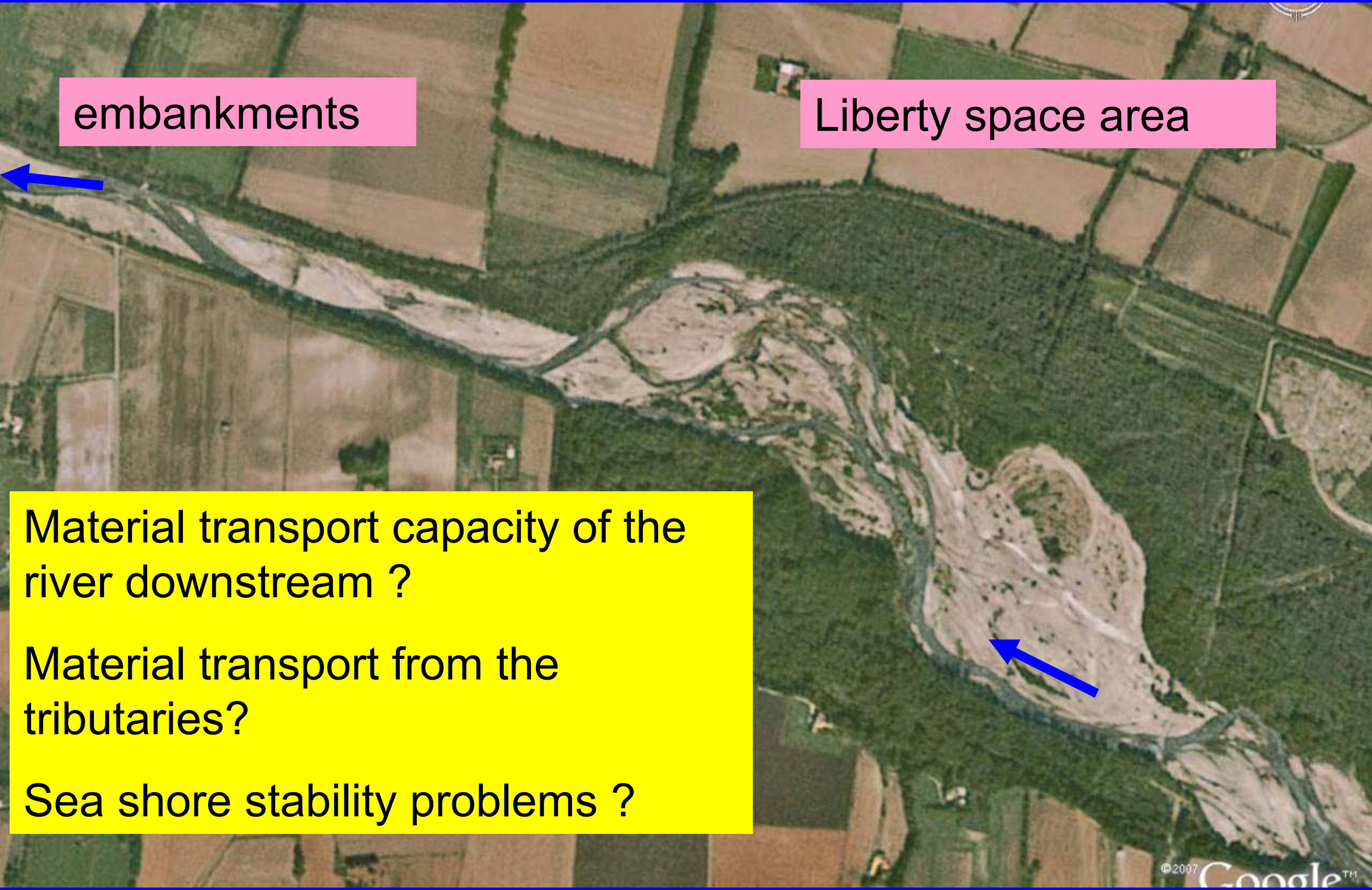
Dams should be transparent:

- to sediment transport

  (suspension and bed load)

- to morphogenic floods (average floods)

River downstream



Material transport capacity of the river downstream ?

Material transport from the tributaries?

Sea shore stability problems ?

Drome River - Rhone river tributary - France

Conclusion

- **Flushing a reservoir is complicated**

Appropriate structures to be included in the design

Take into account:

  - effect of the reservoir on flood mitigation
  - existing morphology and environment downstream

Comprehensive morphological view needed - upstream - downstream

- **'Environmentally friendly flushing'©**

Important organization with real time monitoring

Advantages:

Maintain the storage capacity of the reservoir

Cost effective alternative to dredging

Respects environment and morphological equilibrium of the river

For the Mekong river

Thanks

Xiexie nimen

Xin cam on

Kop Khun kha

Khob jai

Tjé zu bé

Or kun

Merci