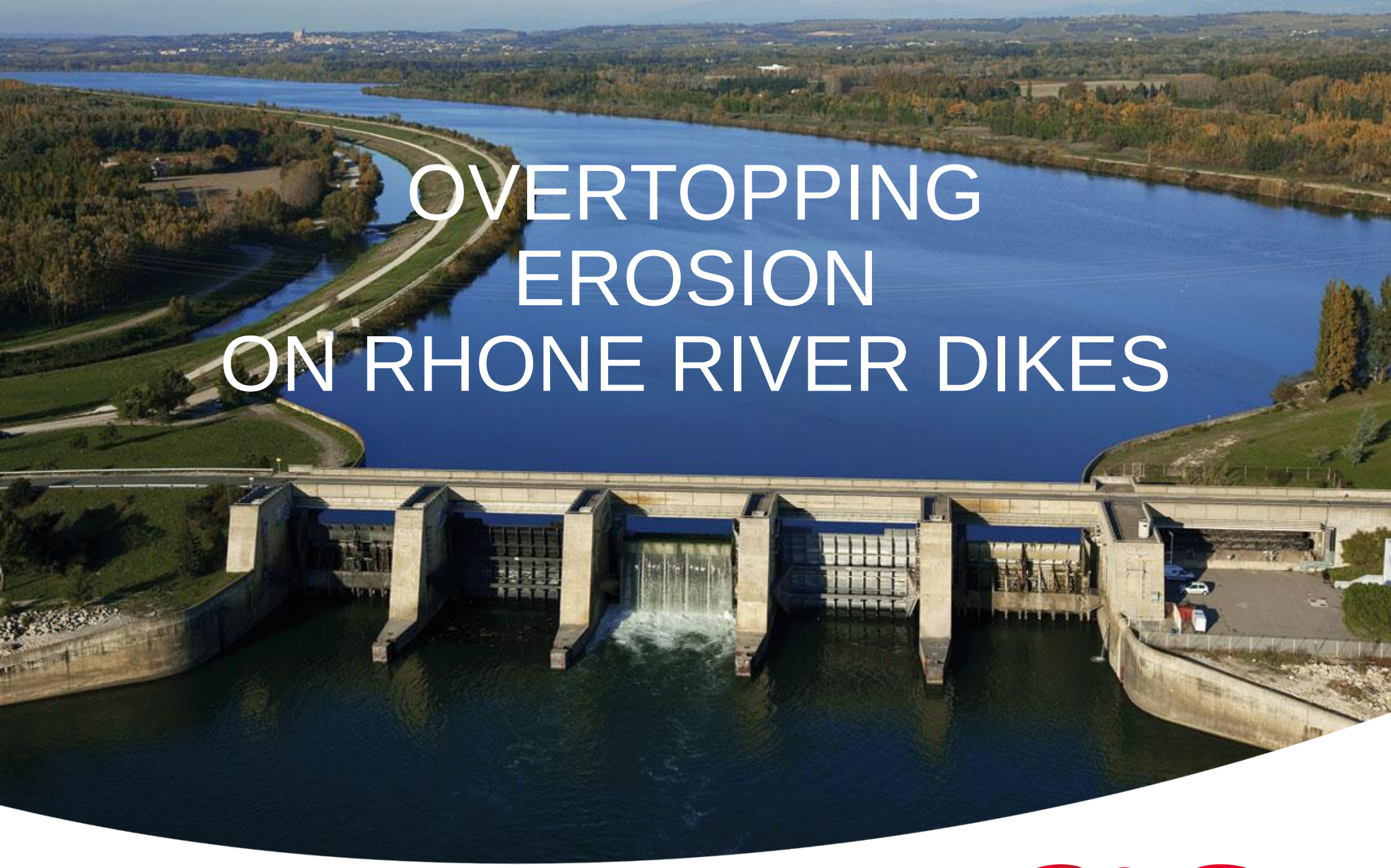
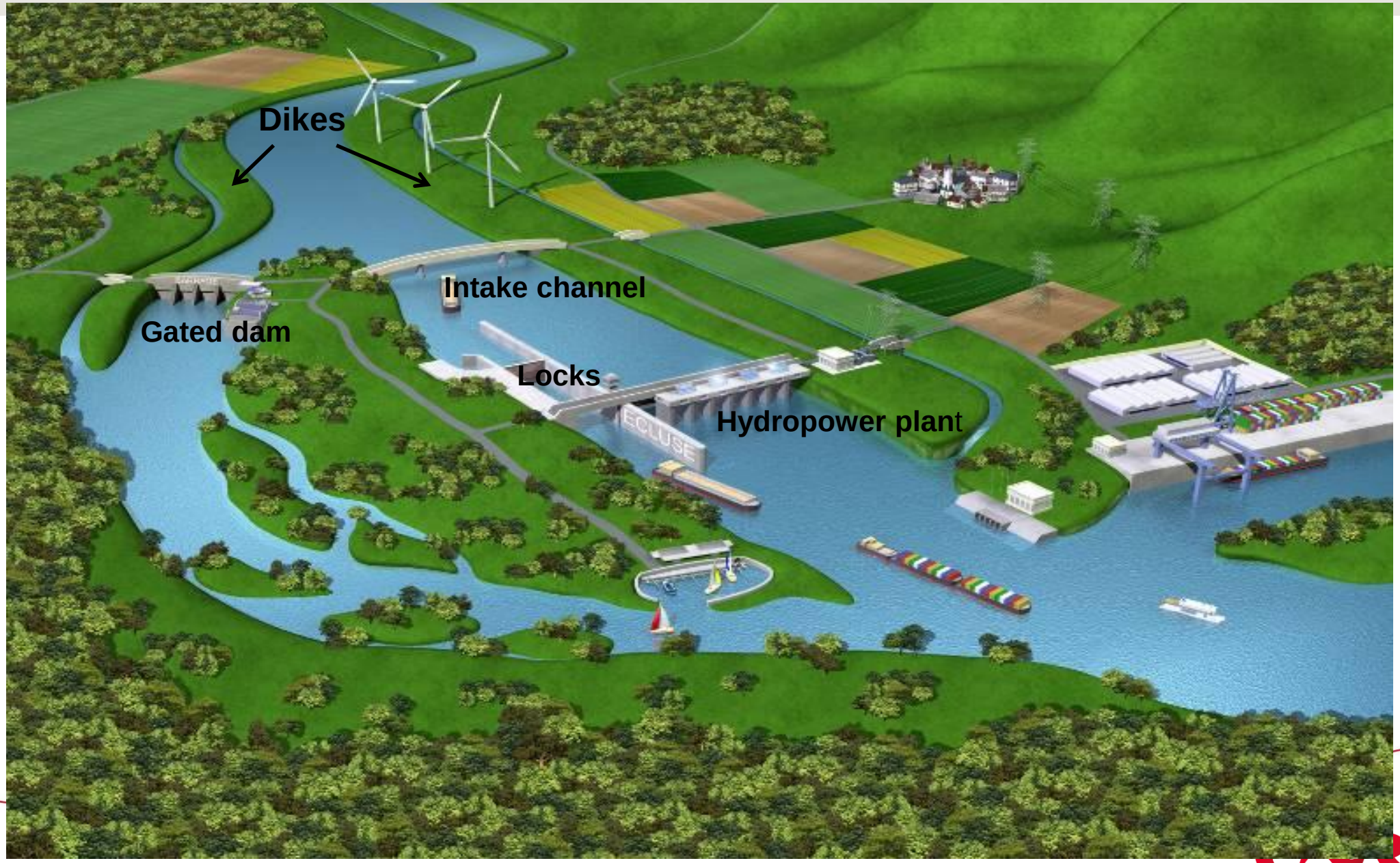


OVERTOPPING EROSION ON RHONE RIVER DIKES

L'énergie au cœur des territoires

TYPICAL DEVELOPMENT ON THE RHONE RIVER



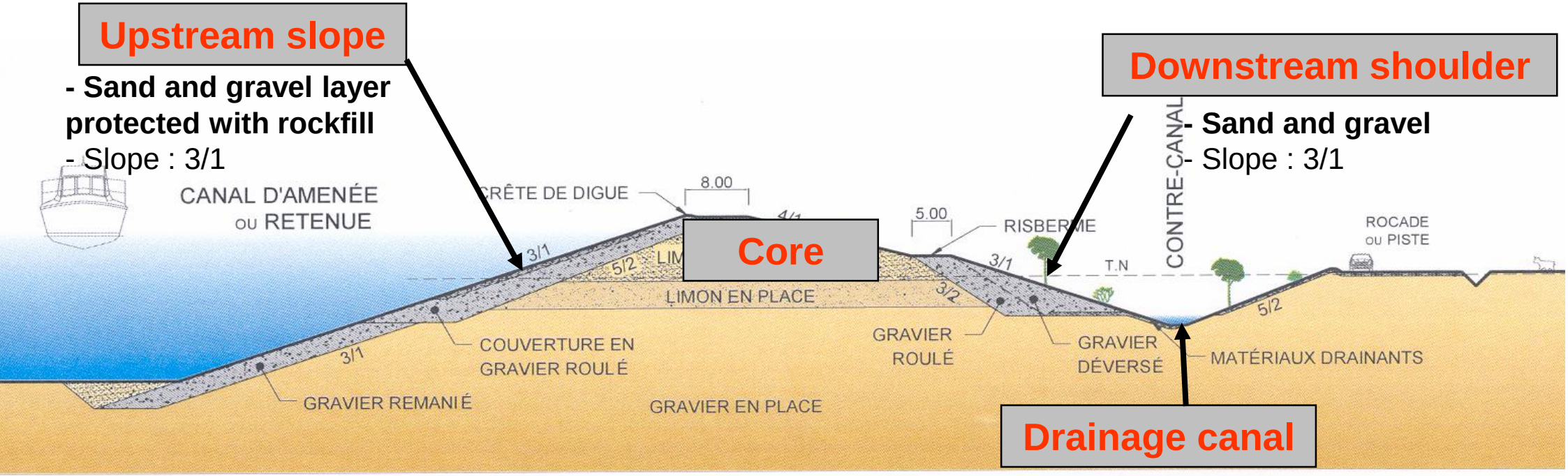
400 KM OF DIKES ALONG THE RHONE RIVER

- **19 Hydropower Plants**

- **For each HPP :**
- 20 Km of dikes
- From 10 to 15 meters heads

CNR DIKES GEOMETRY AND STRUCTURE

- the structure of our zoned dikes is mostly the same, from upstream to downstream:
  - an upstream shell (rockfill)
  - a filter layer (sand and gravel)
  - the core
  - a downstream shoulder for drainage and filtering (sand and gravel)

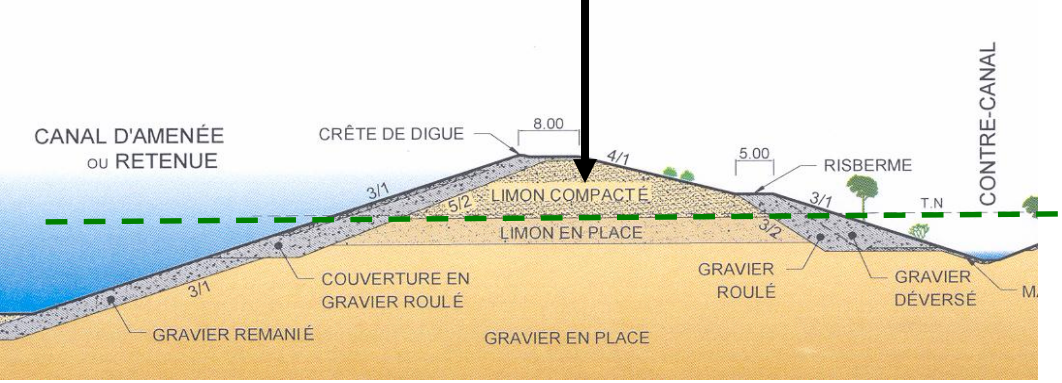


TWO TYPES OF CORE

- The dikes are made with the soil extracting during the intake channel digging. The characteristics of the core can change, depending on the height of the silts layer on site during the works.

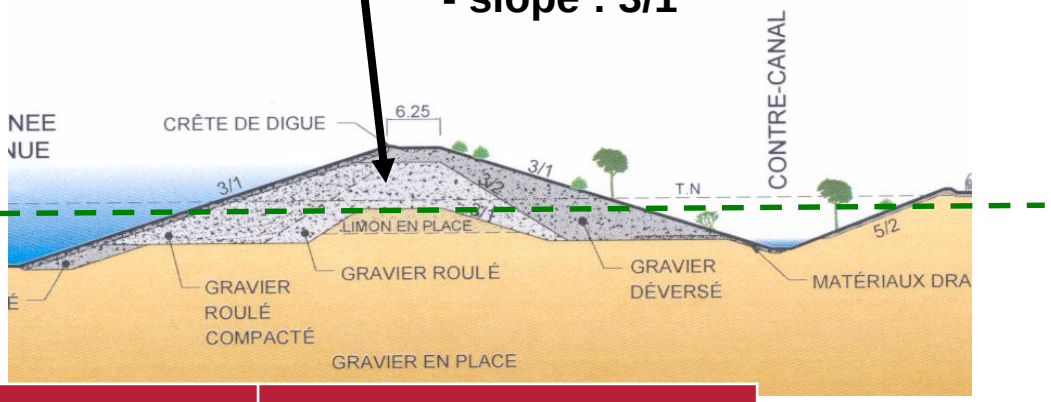
Silty core

- **slope : 4/1**



Sand and gravel core

Sand and gravel bank on natural silt layer
- slope : 3/1

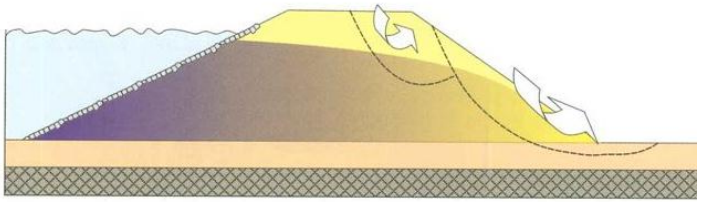


	Silt	Sand and gravel
γ (kN/m^3)	21	19
C' (kPa)	0	0
ϕ' (°)	25	35

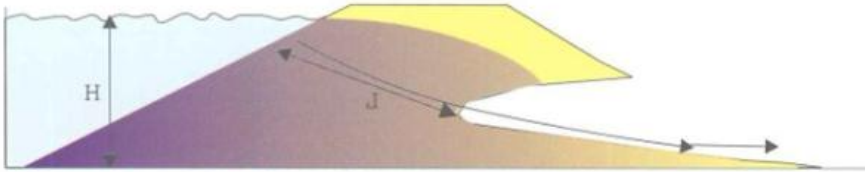
THE CNR DIKES DESIGN CRITERIA

CNR dikes were built between 1955 and 1985. The design deals with :

- **slope stability**

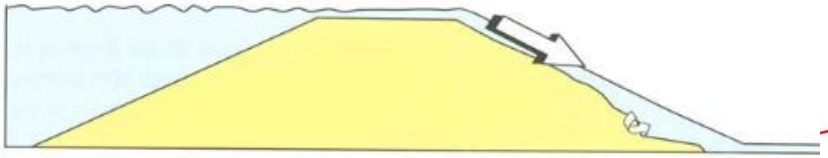


- **internal erosion** (the length of the dike is function of the hydraulic head, dealing with “Lane law”)

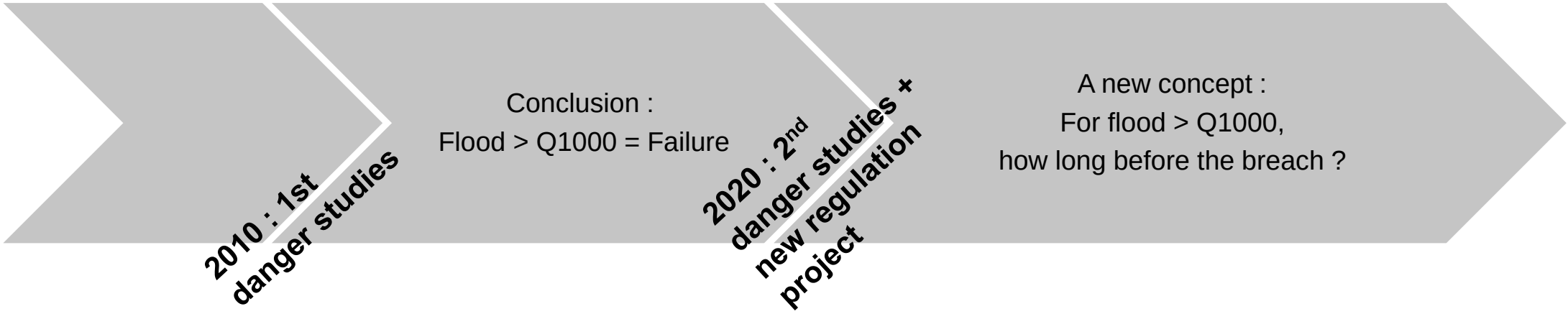


- **external erosion**

- **Overflow** (the dam crest level correspond to the millennial flood)



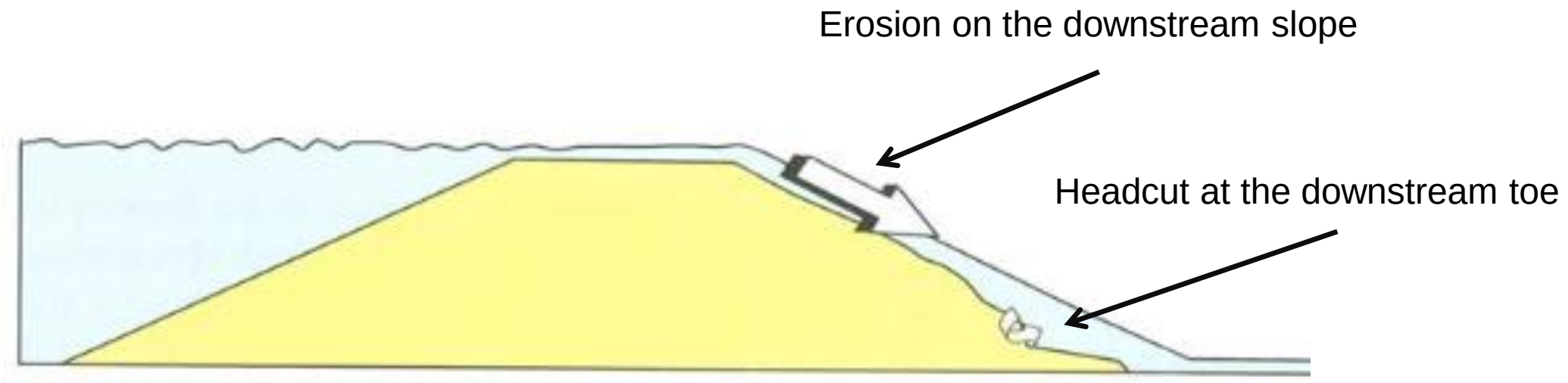
EVOLUTIONS OF THE FRENCH REGULATION



With the French dams regulation we have to study every ten years the consequences of events that exceeds the design assumptions : it is the “danger study”

- **In 2010**, our conclusion about floods that exceed the millennial flood was that dykes are not designed to resist to overtopping and failure occurs.
- **We have a new regulation project in France,** and the approach for the next danger studies in 2020 may be different. The question is how long the dike submitted to overtopping can resist before the breach ? Therefore, we have to study the behavior of our dikes if overtopping happened.

ASSESSMENT OF THE BEHAVIOR OF THE DIKE SUBMIT TO OVERTOPPING



➢ **Erosion mechanism on the downstream slope => useful approaches exist :**

- Hydraulic parameters : velocity flow and shear stress estimation on the downstream slope with the Navier-stockes law, including the turbulent character of the flow using the Reynolds tensor

- Soil parameters : erodibility parameters (critical shear stress and erosion coefficient) are determined using the EFA (Erosion Function Apparatus) or the JET erosion test .

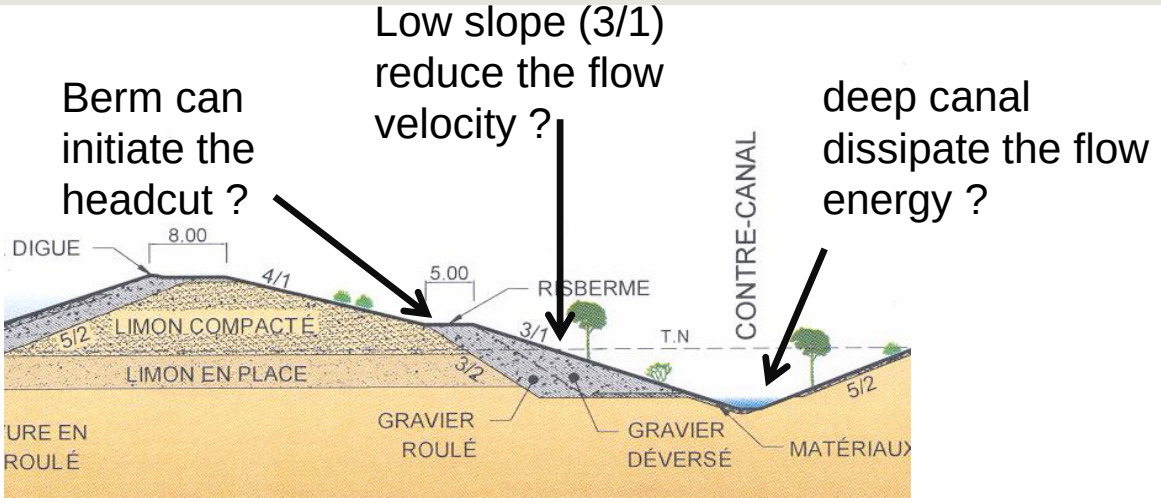
➢ **Headcut at the toe** => need of tools and method for engineers to assess the dike's behavior :

- Research programs, large scale tests in Norway, numerical simulation SIMBA, …..work in progress !

ASSESSMENT OF THE BEHAVIOR OF THE DAM SUBMIT TO OVERTOPPING

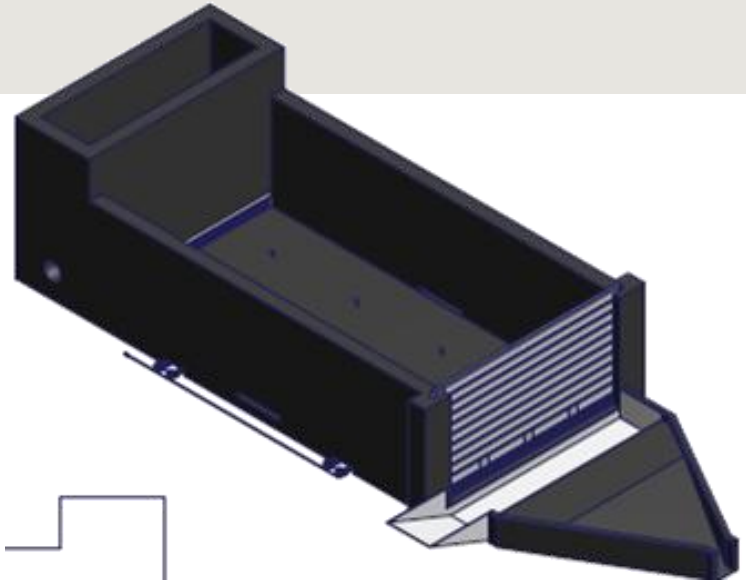
Two main questions for CNR in 2020 :

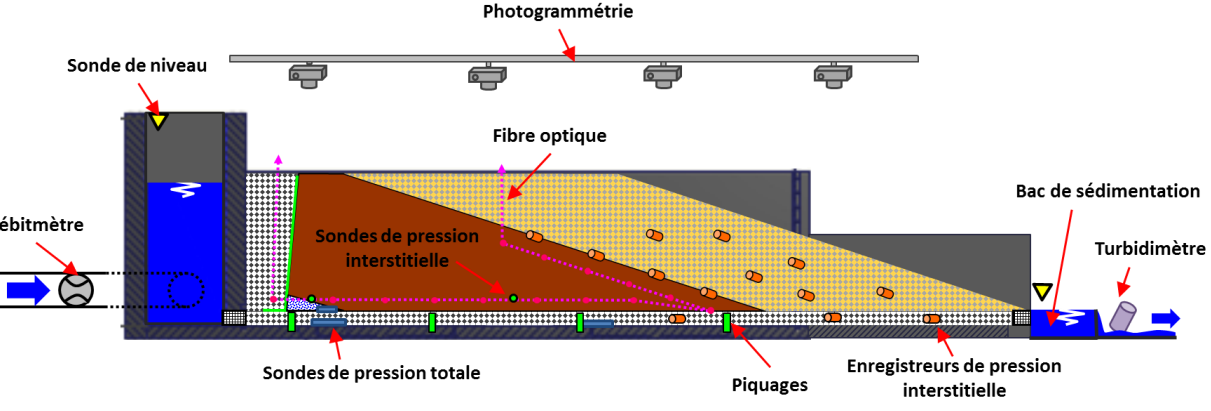
- **What is the influence of the geometry of our dikes on the development of the breach ?**

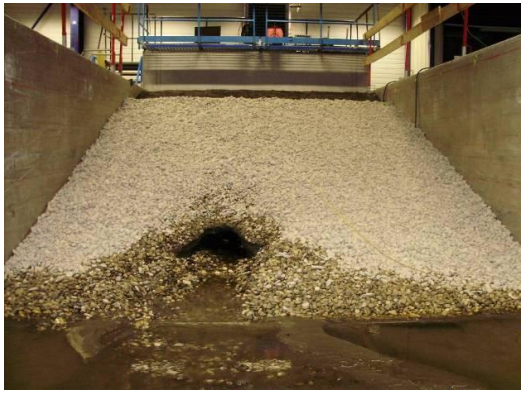


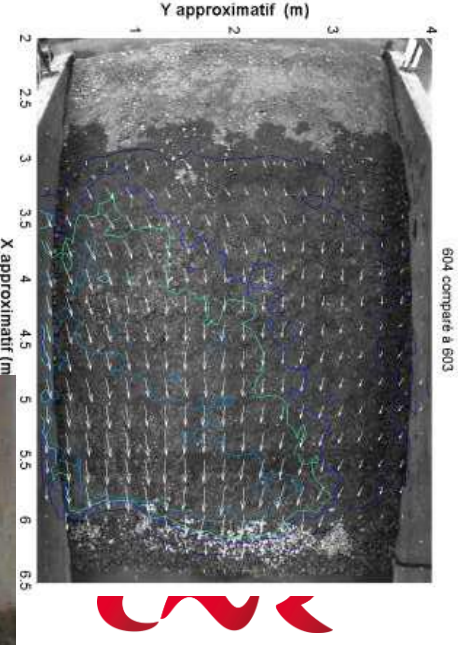
- **What is the duration of the whole process (erosion + headcut) ? How they combine to lead to breach ? Simultaneous process or different stages ?**

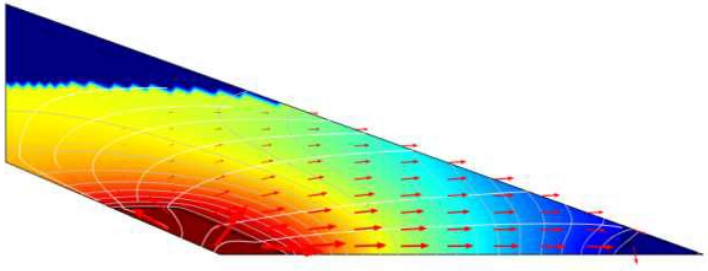
CNR PHYSICAL MODEL LABORATORY











THANK YOU FOR YOUR ATTENTION

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