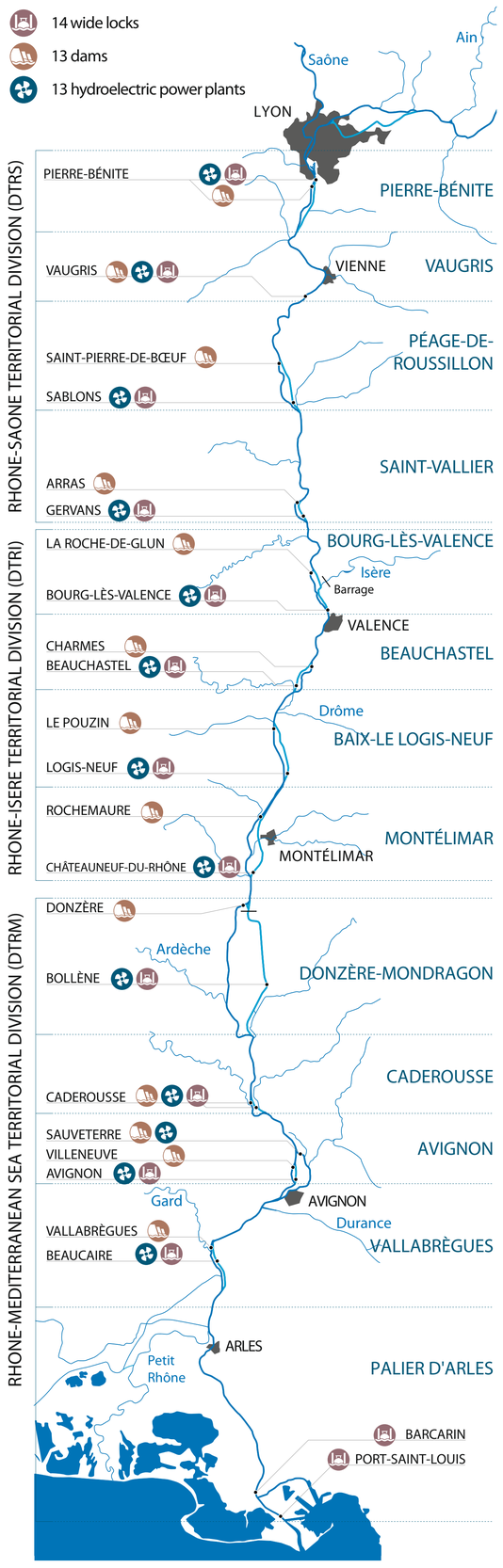
Colloque TSMR – CFBR

Transport sédimentaire : rivières et barrages réservoirs

15 au 17 mars 2022 – Saclay

Bathymetric monitoring of the Rhône River bed

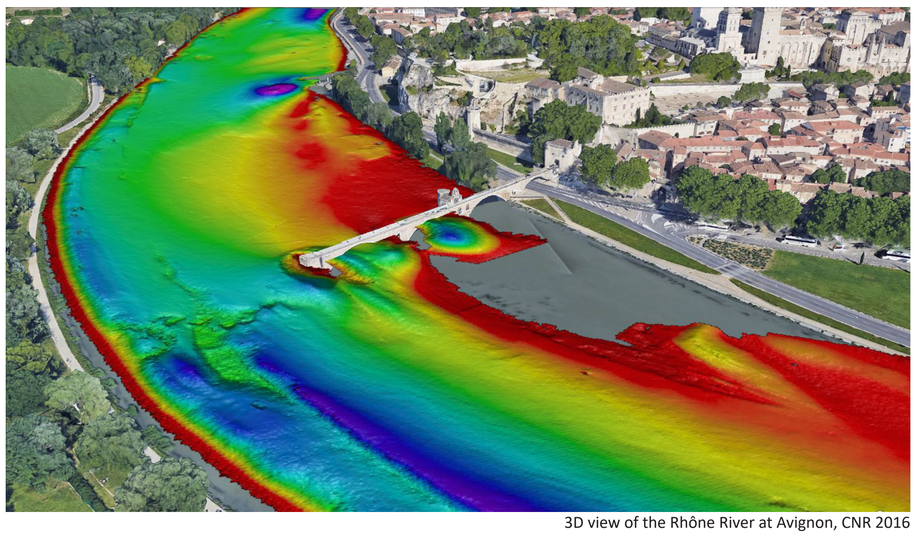
Diachronic analysis of hydromorphological evolutions



Context

CNR operates and develops the Rhône River in the context of three missions entrusted by the State: generating electricity, developing navigation and promoting agricultural activity in the Rhône valley.

Downstream of Lyon, a chain of 14 wide-gauge locks, 13 dams and 13 hydroelectric power stations was commissioned in stages from 1952 to 1980. Thanks to these developments, CNR ensures wide-gauge commercial navigation (12m wide by 190m long convoys) from the Mediterranean Sea to Lyon, 24 hours a day, 355 days a year, i.e. 330km of waterway with a guaranteed minimum depth of 3m.



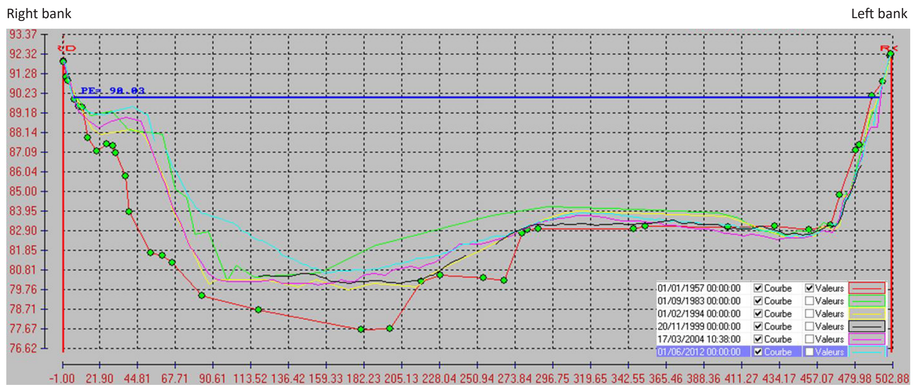
3D view of the Rhône River at Avignon, CNR 2016

To guarantee optimal navigation conditions in all circumstances, CNR has developed a supervisory system of the navigable channel:

- bathymetric monitoring with a hydrographic boat dedicated to this mission (Frédéric Mistral);
- additional measurements by the teams of CNR's Territorial Divisions (DTRS, DTRI and DTRM).

The bathymetric survey of the Rhône is also used as a tool to verify that the flow sections necessary for flood flows are maintained.

In order to optimise the Frédéric Mistral's missions, CNR has initiated a global reflection on Rhône River bed evolution since the implementation of hydroelectric developments.



Example of cross profiles – Logis-Neuf reservoir, CNR 2012

Hydromorphological analysis of bed evolution

The principle of the study is to analyse bathymetric evolutions of the riverbed since the commissioning of CNR's developments downstream of Lyon. By combining detailed analysis and global analysis of evolutions, the hydromorphological study:

- highlights logics of adjustment of the Rhone River sedimentary transit;
- allows to estimate evolution trends over the mid/long term.

The hydrogeomorphic analysis of each reach proceeds in three steps.

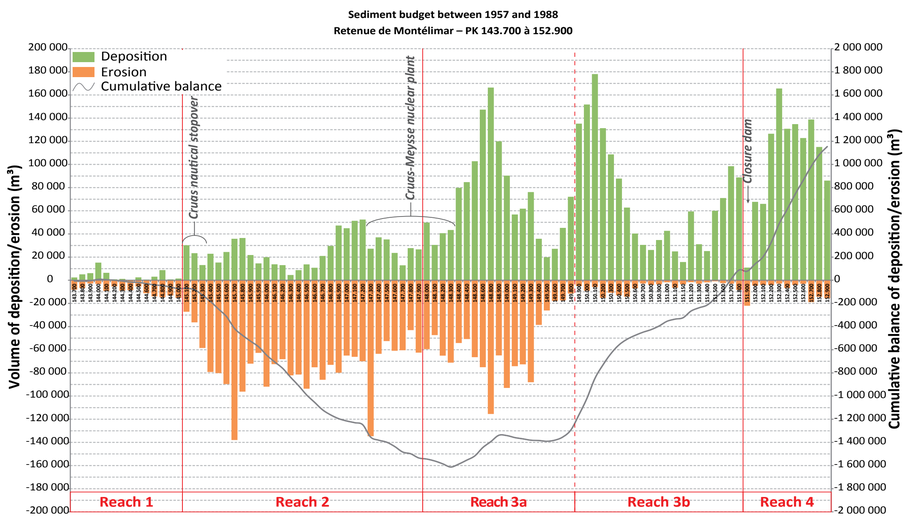
Step 1: Characterization of control and response variables
⇨ *Morphologically homogeneous reaches*

Step 2: Identification and ranking of disturbances (floods, dredging...)
⇨ *"Disturbed" and "undisturbed" periods*

Step 3: Comparison of bathymetric surveys framing each period
⇨ *Evolution trends by period*

➡ **Definition of reaches with homogeneous behaviours**
– During either "disturbed" or "undisturbed" periods
– Over mid/long term period

➡ **Distinction between initial adjustments and current sediment dynamics**



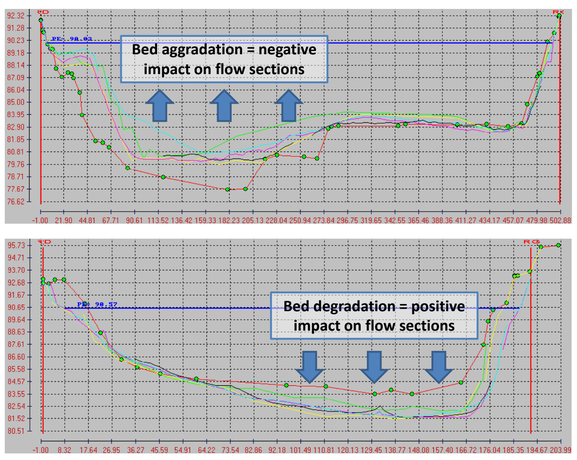
Sediment budget between 1957 and 1988 – Montélimar reservoir

Application to CNR issues

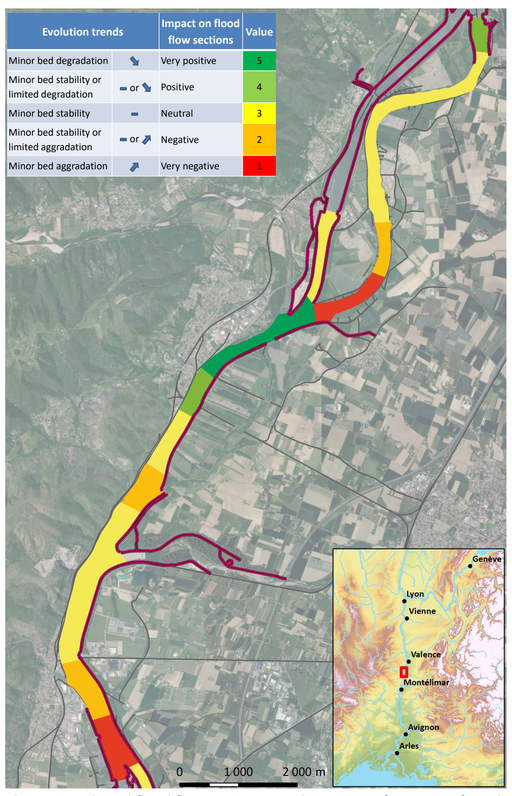
Secure flood flow sections

As concession-holder, CNR must ensure the safe passage of floods. Hydromorphological analysis of riverbed evolutions helps to identify sectors with a general tendency to aggradation and wich therefore risk to compromise flood flow sections sustainability.

Evolution trends can be combined with hydraulic model results for greater accuracy or can be used to validate the results of a hydro-sedimentary model.



Effects of evolution trends on flood flow sections



Evolution trends and flood flow sections: synthesis map of Logis-Neuf reach

Maintain the guaranteed fairway

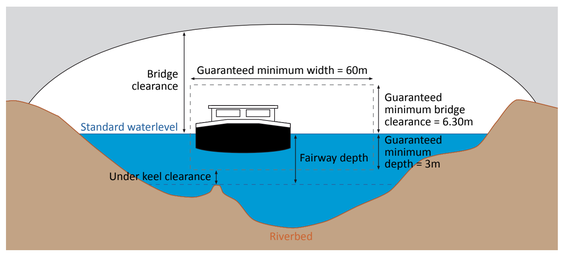
CNR is responsible for ensuring optimal navigation conditions. Hydromorphological analysis of riverbed evolutions can provide a risk assessment of non-compliance of guaranteed minimum depth.

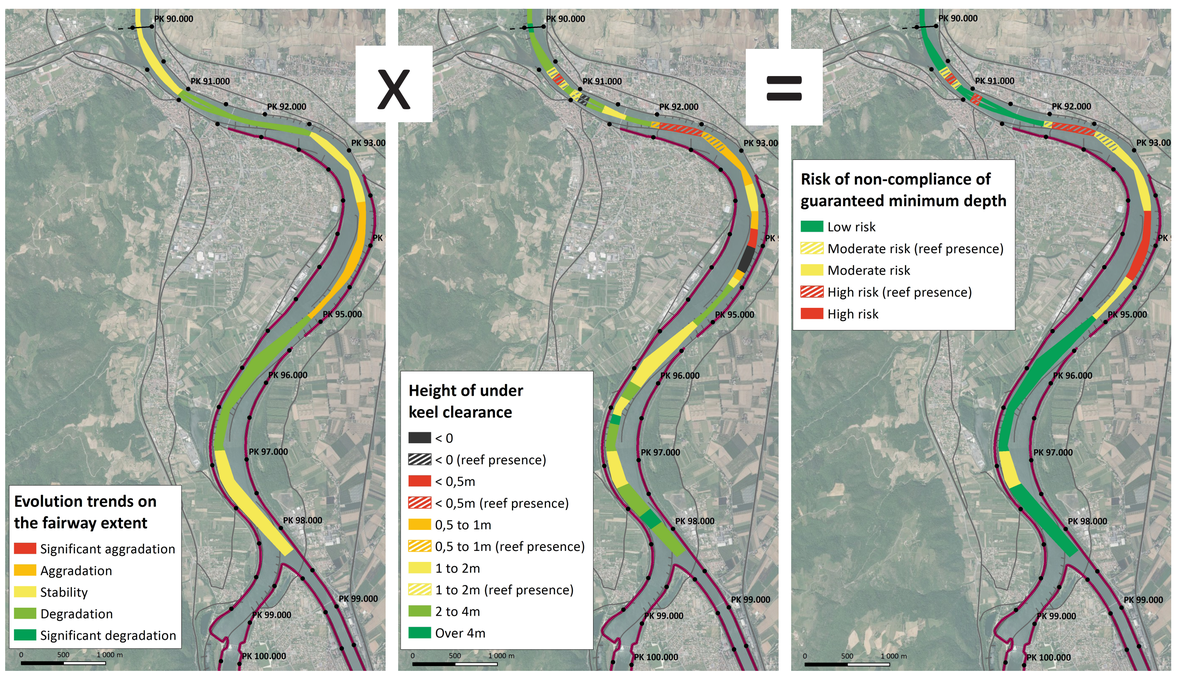
It is obtained by crossing evolution trends in the fairway extent (="hazard") and the sensitivity of the fairway, induced by the height of under keel clearance (="vulnerability"). The influence of reefs, which artificially limit the height of under keel clearance, is also taken into account.

Visual representation of this risk quickly reveals the most sensitive sectors regarding navigation issues, to monitor in priority after major floods.

Evolution trends \ Under keel clearance	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Non-compliance risk of minimal draught





Scope of application

The study, initially focused on optimizing the Frédéric Mistral's activity, has revealed the need for a broader vision to include other issues:

- Restoration of sediment dynamics on bypassed reaches (Vieux-Rhône);
- Dam gates reliability, impacted by upstream deposition;
- Adjustments to guaranteed fairway («reefs» removal, beacons displacing, etc.);
- Management of coarse sediments generated by tributaries dredging operations (availability of dredge-spoil dump sites and sediment transport potential in reservoirs).

Several operational applications can be considered:

- Prioritise areas to be monitored after a major flood;
- Steer the necessary adjustments of the guaranteed fairway;
- Locate suitable and unsuitable areas for dredge-spoil dumping.

Authors

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