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# Impacts of hydraulic releases from a hydroelectric power plant on bedload velocity and bed alteration in the Warche River (Belgium)

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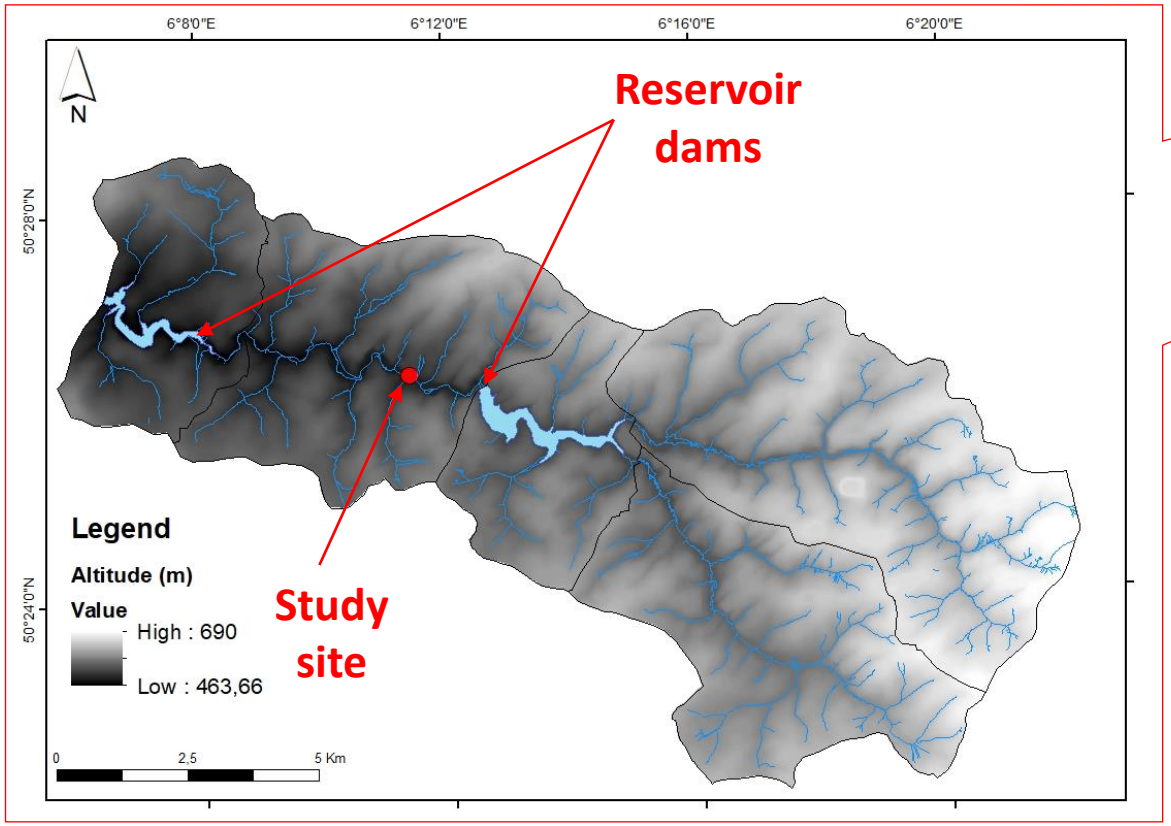
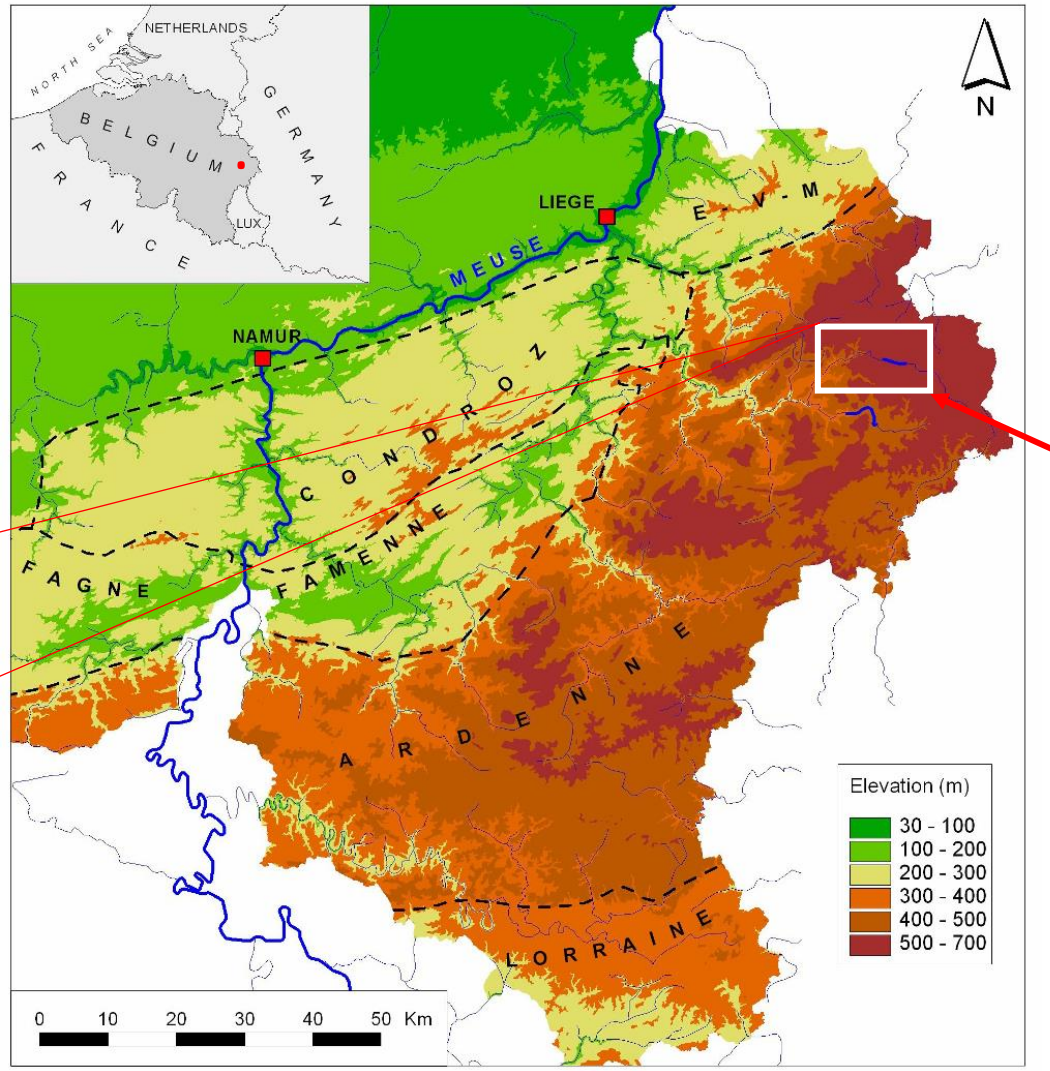
# Geographical context of the Warche river

- South part of Belgium, in Wallonia part
- Western part of the Rhenish shield
- Ardenne Region
- Altitude about 550 m
- Sector between 2 reservoirs

http://www.lmg.ulg.ac.be



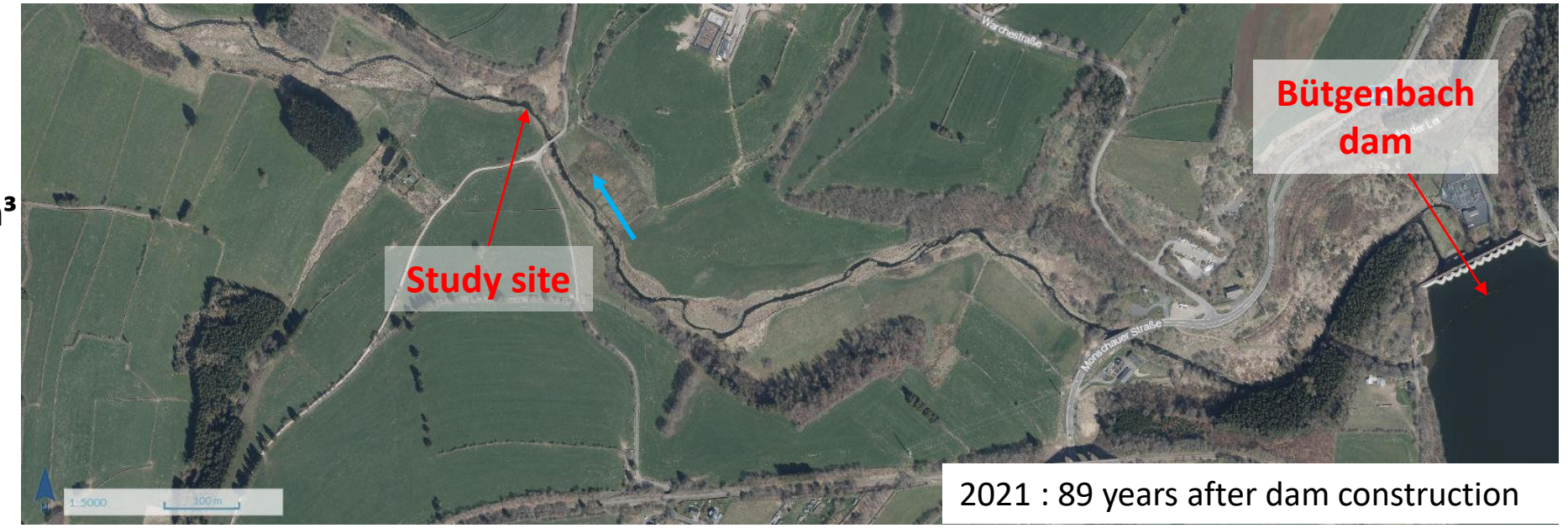




Location of the study area within the Ardenne Massif

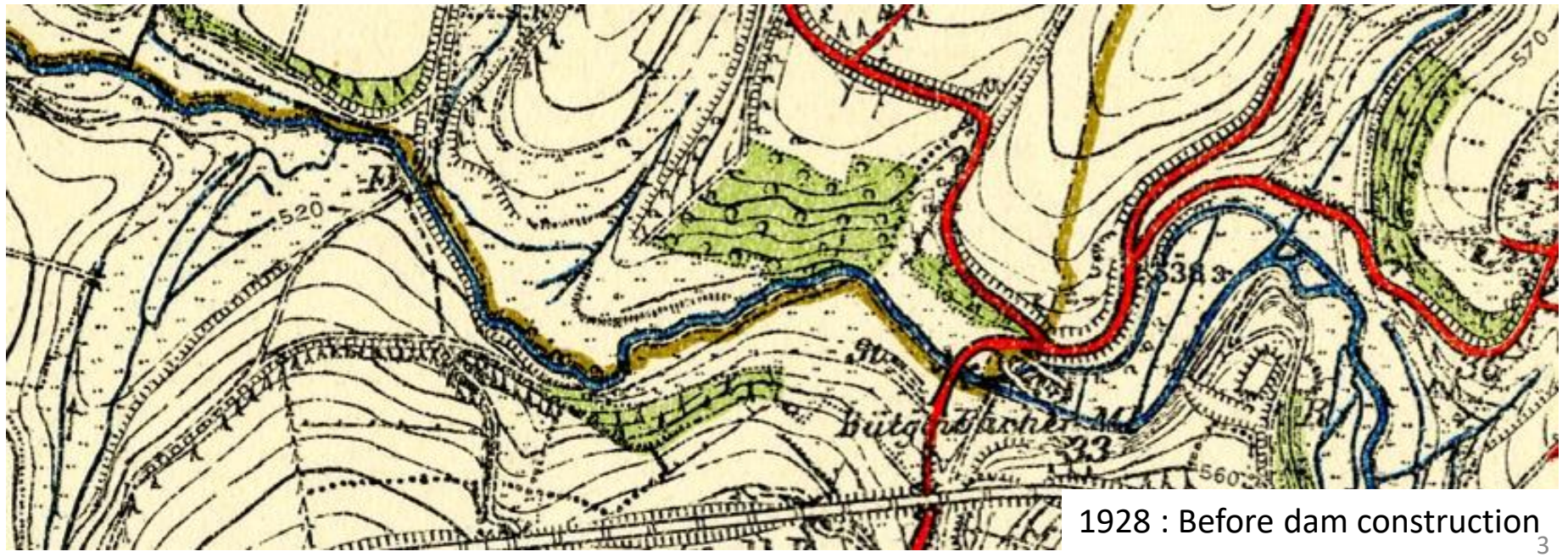
# Warche river characteristics : downstream Bütgenbach hydropower plant

- Commission date : **1932**
- Reservoir surface = **120 ha**
- Reservoir volume = **11 million m³**
- Production : **200,000 kW/year**
- Hydropeaks of **10 m³/s** reached almost **daily**

| Characteristics of the study site | |
|---|---|
| **Watershed size** | 96 km² |
| **Average slope** | 2.9 ‰ |
| **Average width** | 5.5 m |
| **Average width $Q_b$** | 13 m |
| **Bankfull discharge** | 10 m³/s |
| **Specific power (for the $Q_b$)** | 22 W/m² |




2021 : 89 years after dam construction




1928 : Before dam construction

# Hydrological impacts of the Bütgenbach dam :

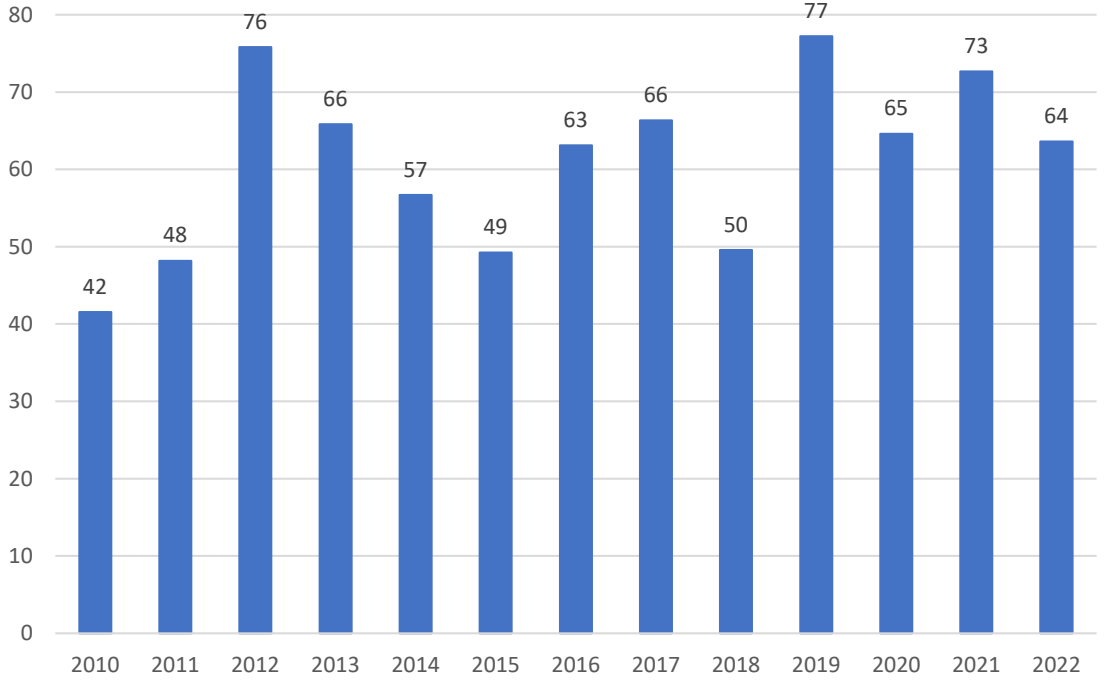
In medium-sized rivers (100-500 km²) in the Ardenne region in non pertubated conditions :

- Bedload mobilisation begins at 0.6 $Q_b$ with a recurrence of **0.3 year**
- The duration of the mobilisation ≈ **8-12 days/year**

Houbrechts *et al.*, 2006

- Bedload velocity for similar specific power : **2km/century**

Houbrechts *et al.*, 2015




Cumulative hydropeak duration (in days of 24h) /year since 2010

**BUT in the Warche River** :

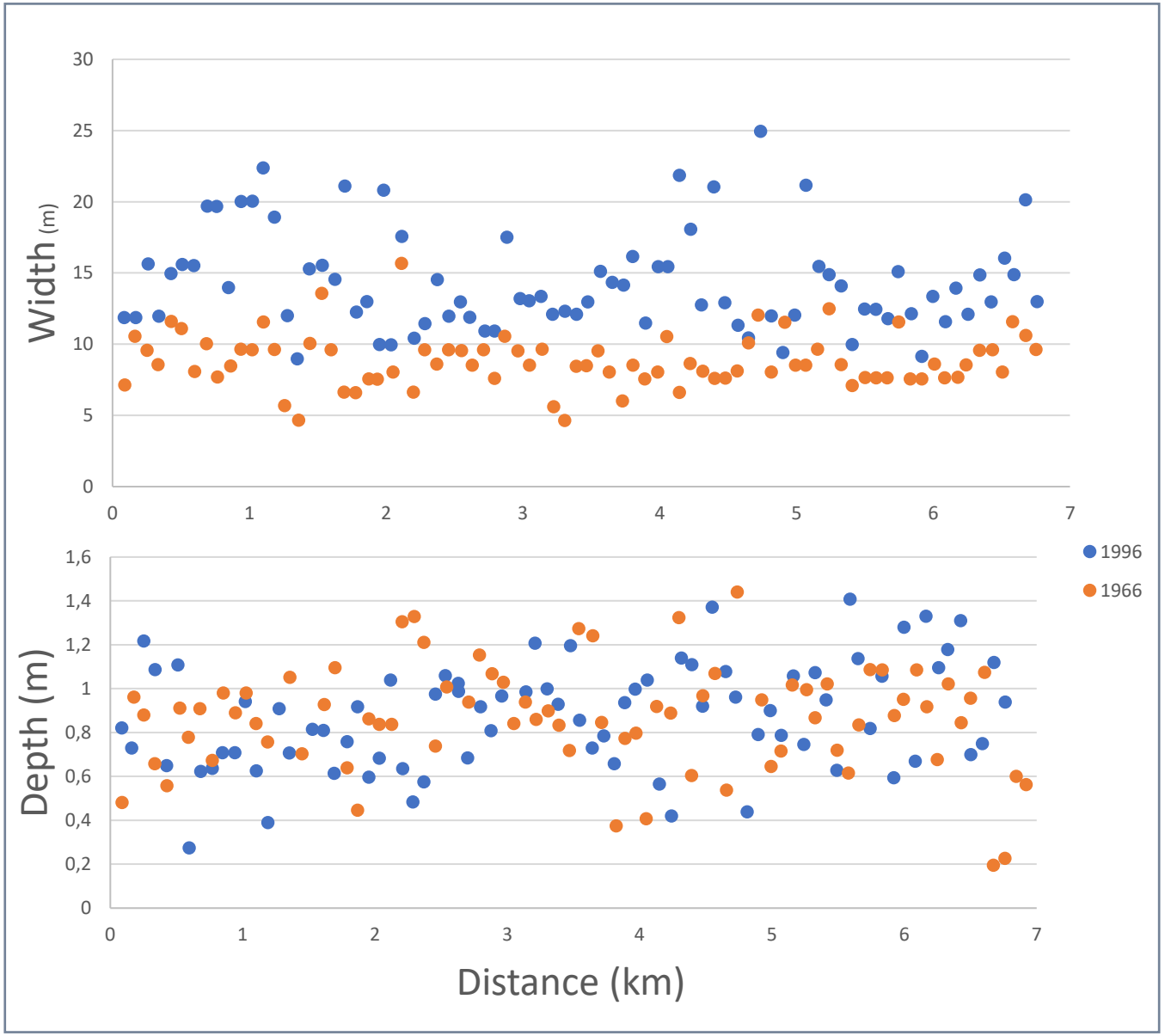
Hydropeaks of **10 m³/s = $Q_b$** reach almost **daily** (≈ **200 - 300 times/year)**

Mean duration of hydropeaks : **10 h**

➔ **Multiplication** of the **$Q_b$** recurrence by **<u>100 times</u>**

**<u>But the dam also helps to reduce flood peaks > $Q_b$</u>**

# Preliminary study on the Warche river




Graphs based on Assani and Petit (2003)

**Previous observation:**

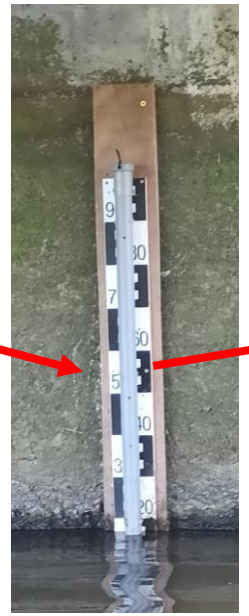
- **Increase** of the **riverbed width** between 1966 and 1996
- **No bed level evolution** between 1966 and 1996
- The **bed incision** occured **probably between 1932 and 1966**
- **Impact over 7 km** after **30 years (1932-1966)**

Assani and Petit (2003)

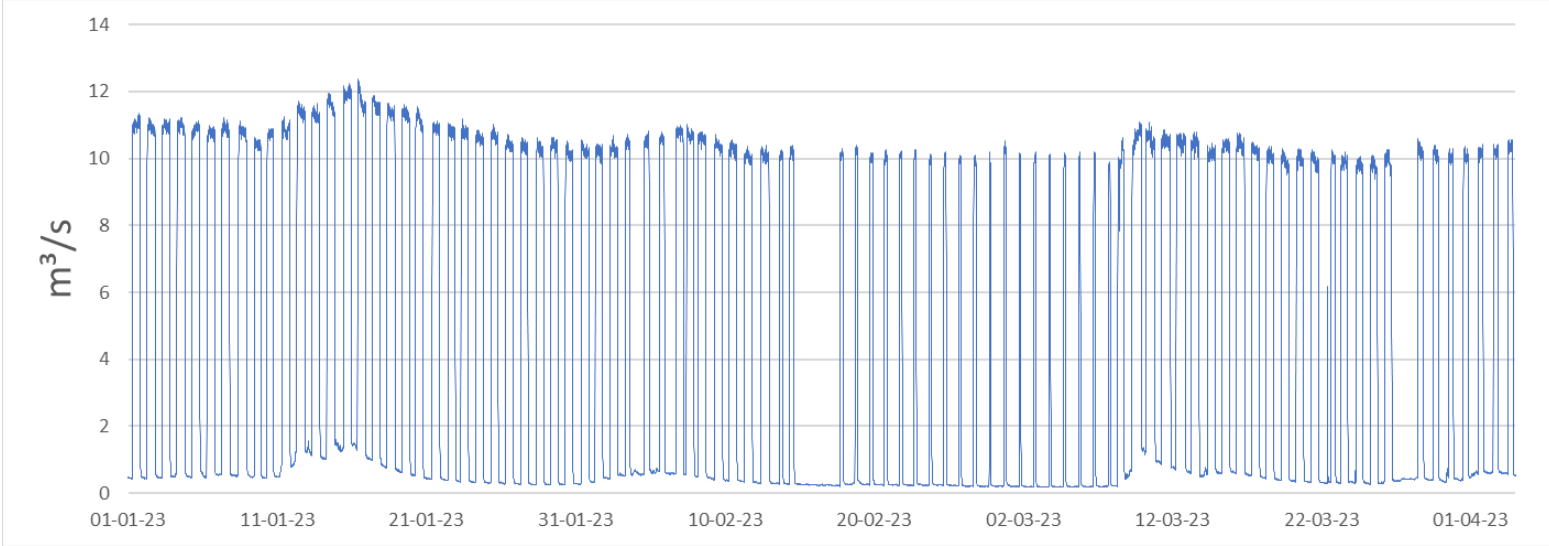
➔ **The aim of the present study :**

**To quantify bedload velocity pebbles marked with PIT Tags to understand how morphological changes propagate downstream**

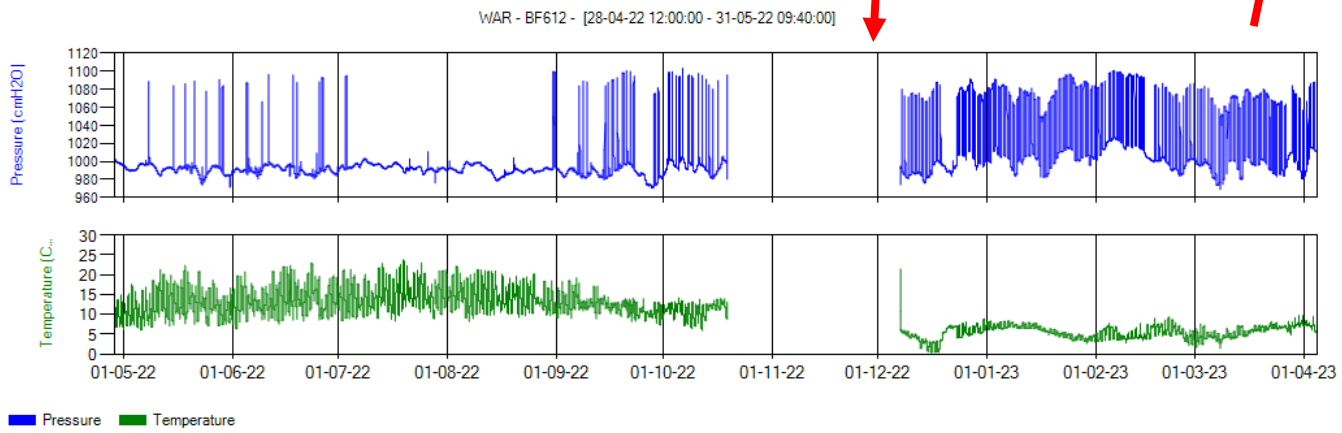
# Methodology : hydrological data




January – April 2023




+ Atmospheric
pressure (barometer data)




Hydrological study

- ➢ Diver to collect water level data
- ➔ Pressure of the water + temperature
- ➢ IRM
- ➔ Atmospheric pressure

➔ **Water level height at gauging station**

# Methodology : sedimentological data


http://www.ti-rfid.com

**PIT Tag method**

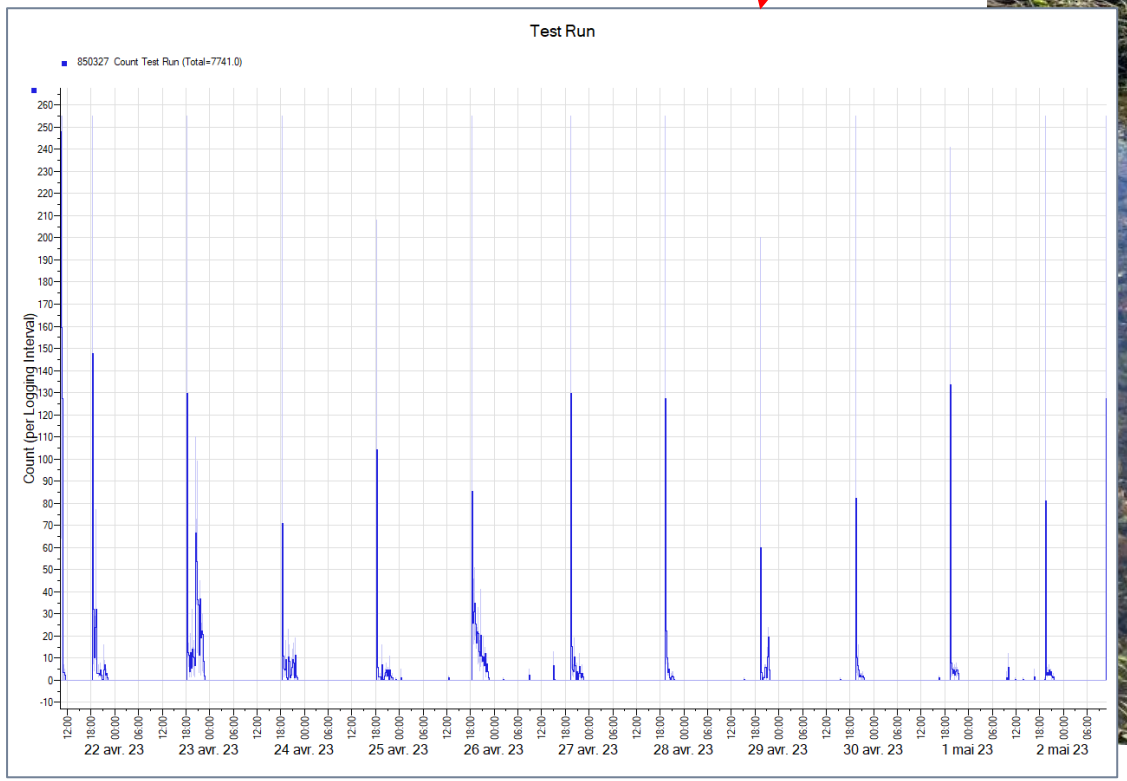
- RFID peebles (n=164)
- 6 surveys

Located by :

- Theodolite Leica TC 600
- RTK GPS

**Impact plate method**

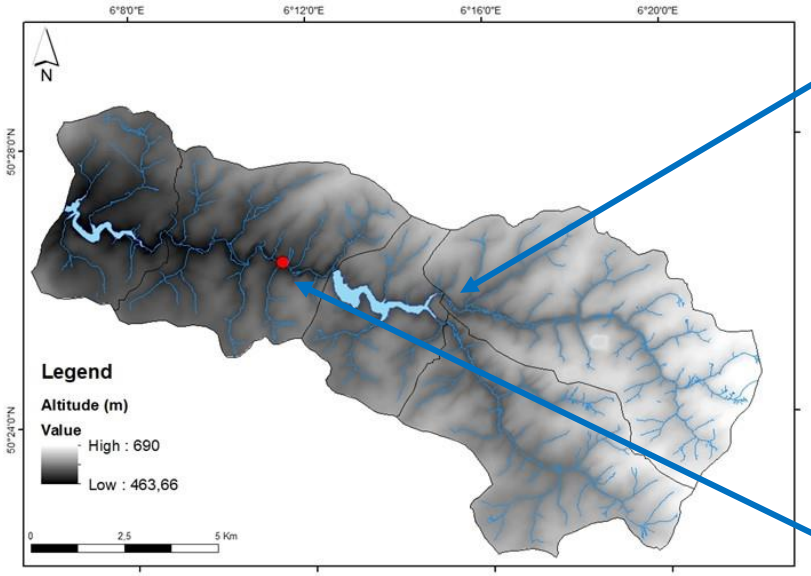
- 2 plates
- Sensibility = 10 mm



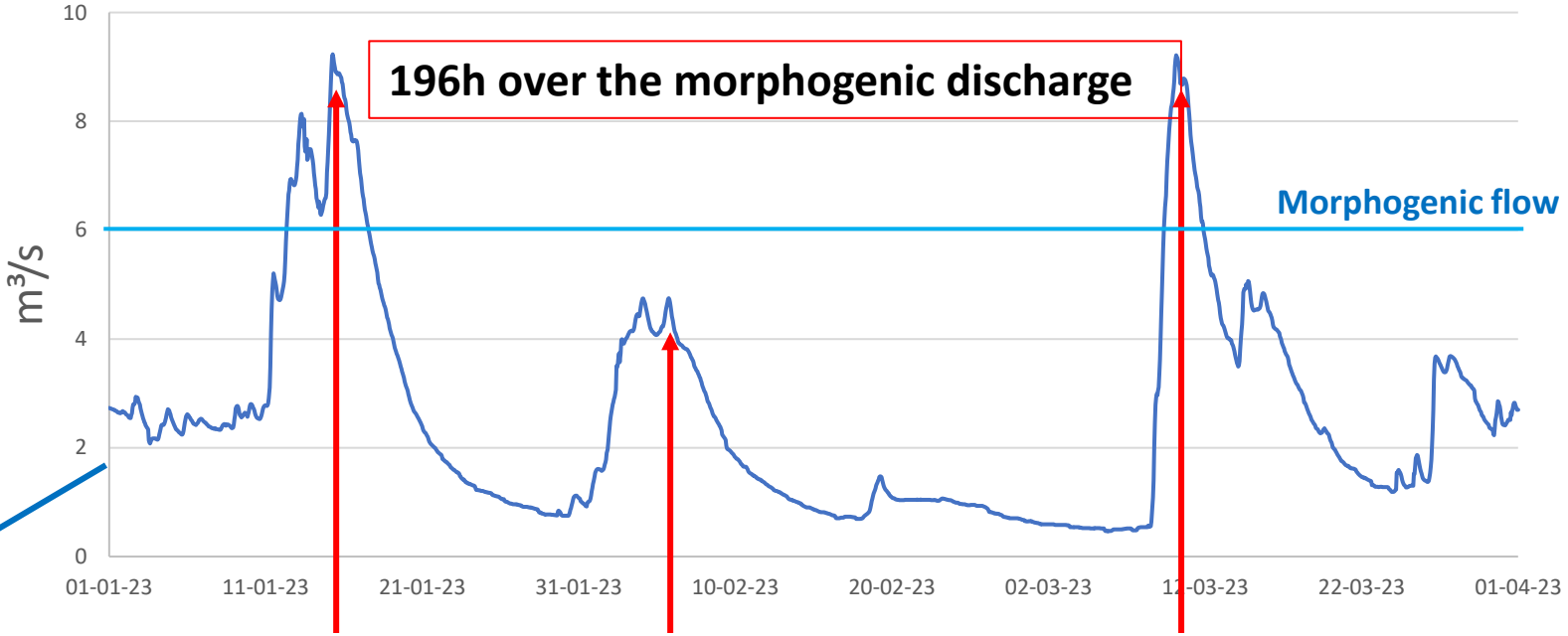

# Results : impact of the Butgenbach dam on the hydrological regime

In 3 months (01/01/2023 – 01/04/2023) :

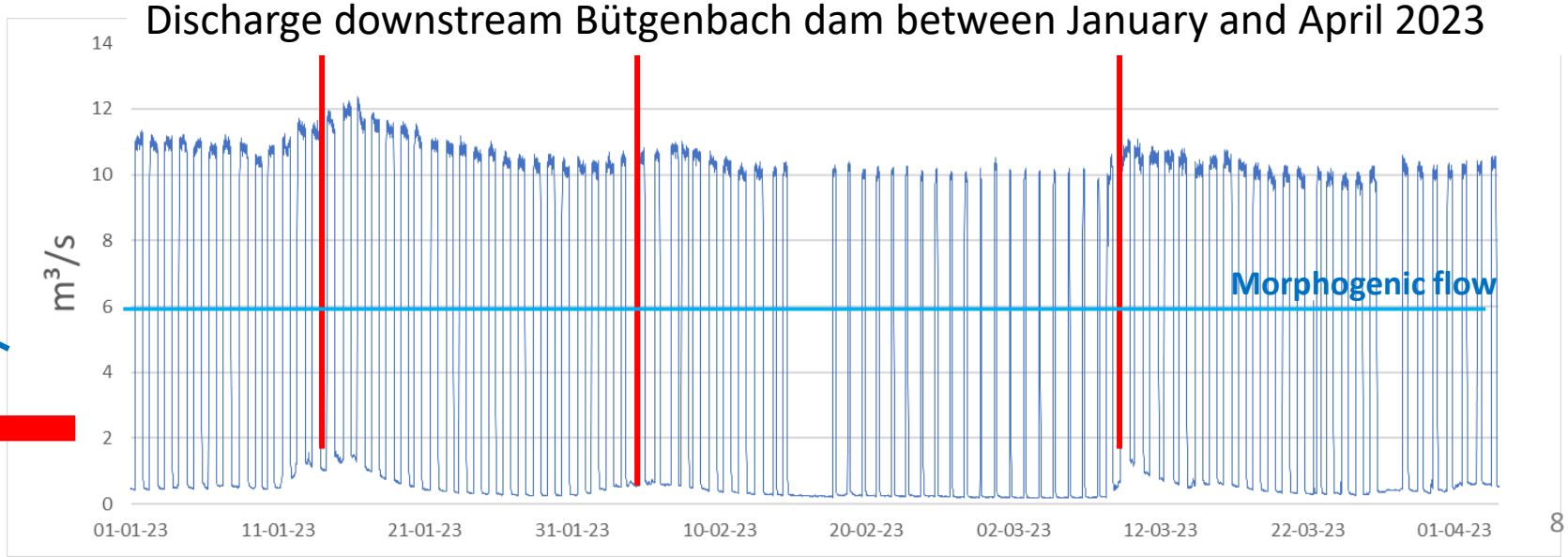
➔ 929 h of hydropeak (Q > 10 m³/s) downstream
➔ 0 h (Q > 10 m³/s) upstream
➔ Increase of the morphogenic flow but no major flood event (only [0.6; 1] $Q_b$)




Natural discharge usptream of the dam between January and April 2023




Discharge downstream Bütgenbach dam between January and April 2023

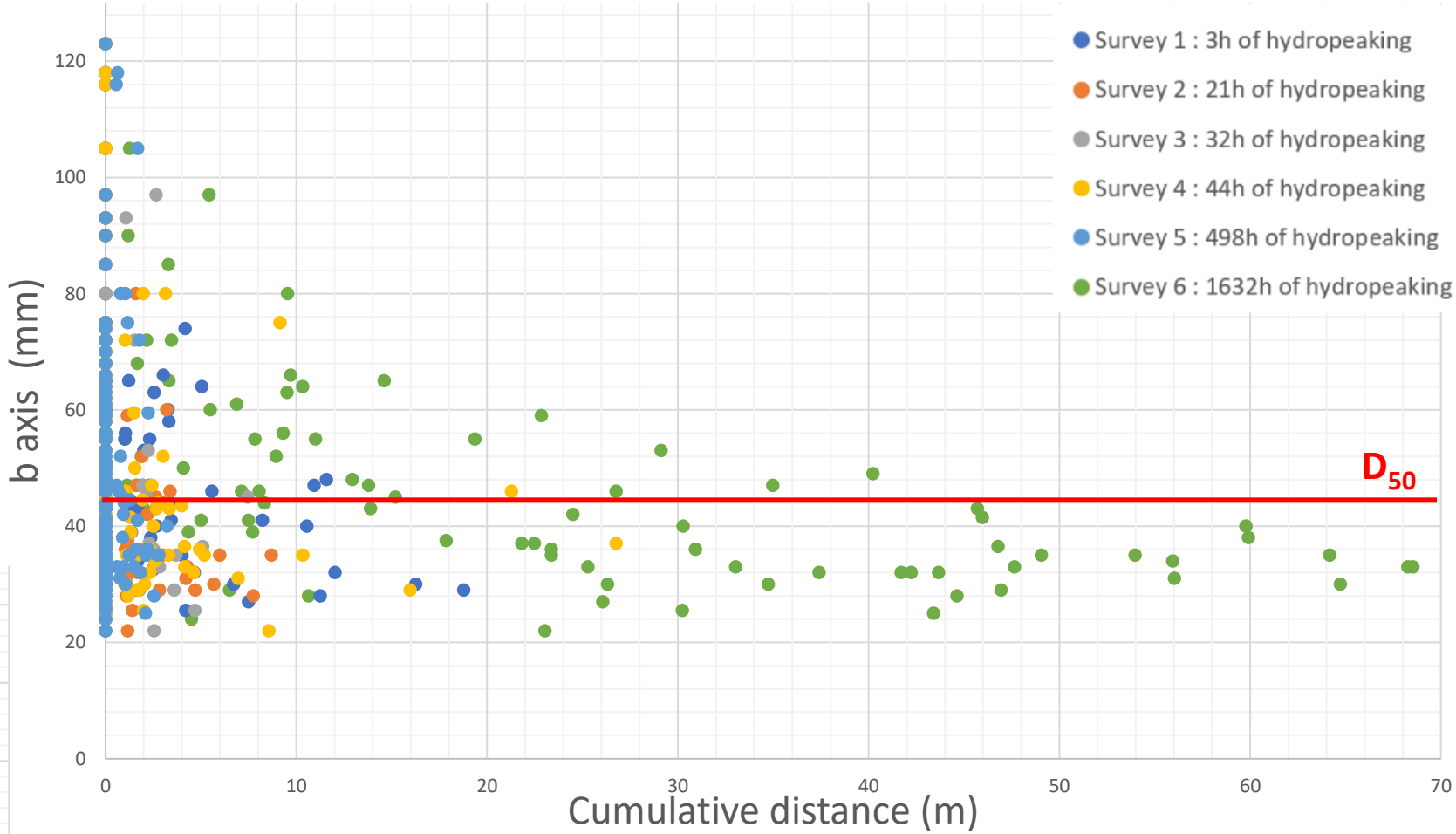


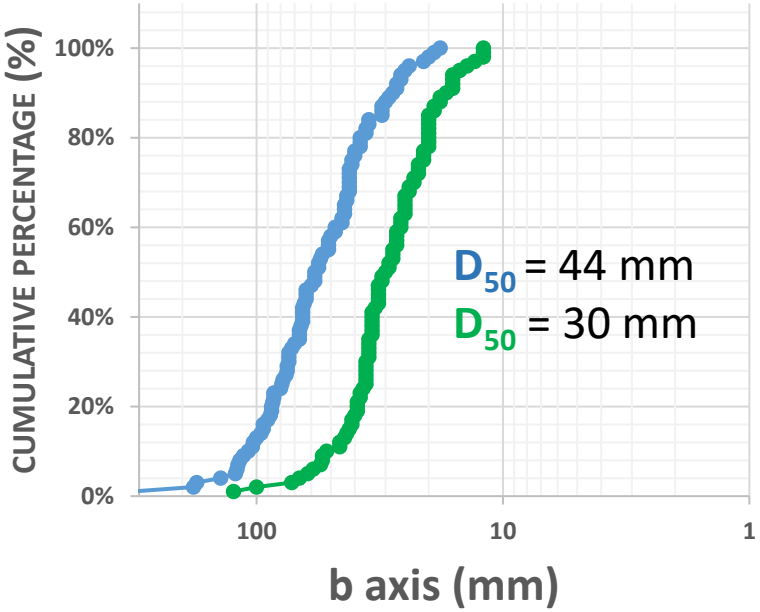

**929h of hydropeaking at 10 m³/s**


8

# Results : the mobilisation of the RFID pebbles

- Effective competence of hydropeaks around the $D_{50}$
- Last survey most of the mobilisation around the $D_{10}$
- Around 60% < 10m
- Increase of the sediment size downstream the dam

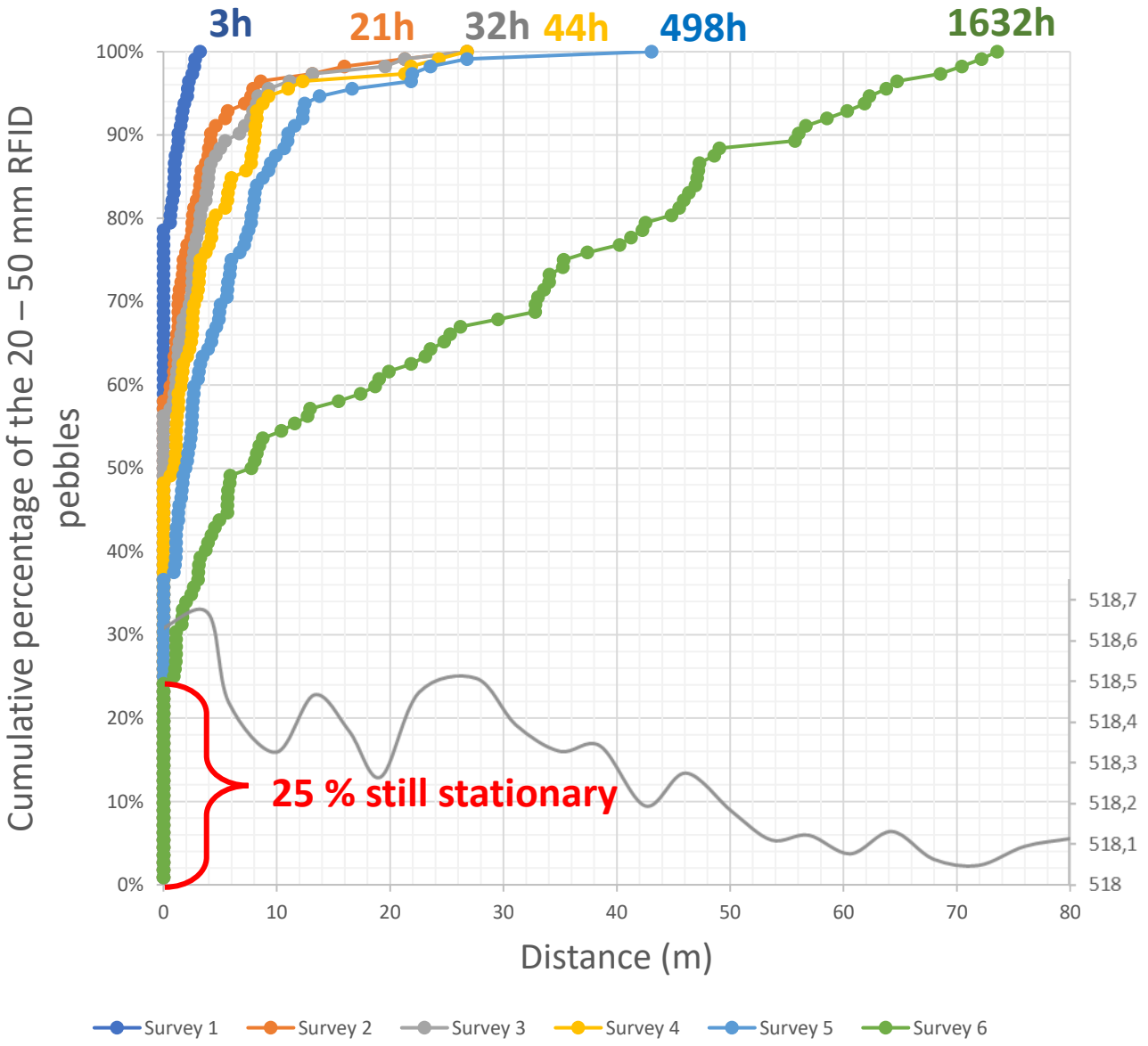


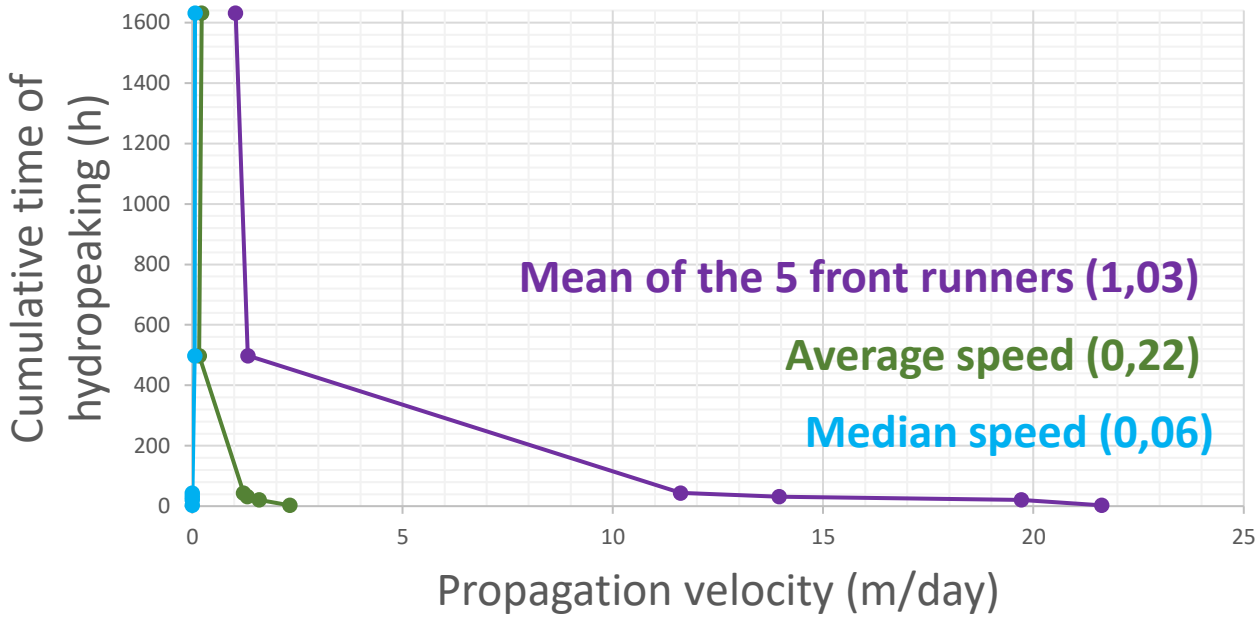



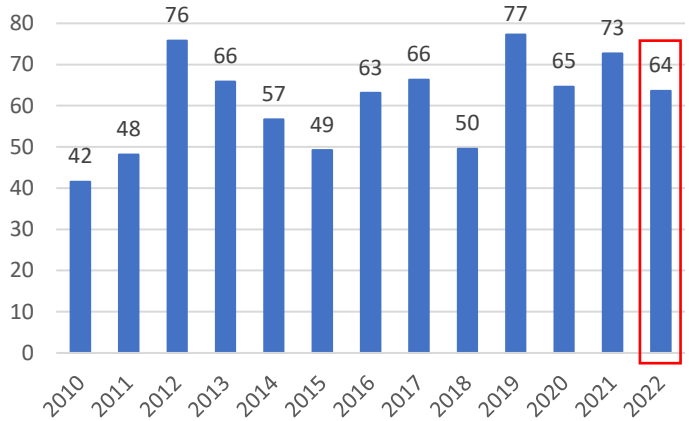

Donwstream the dam

Upstream the dam

# Results : the mobilisation of the RFID pebbles



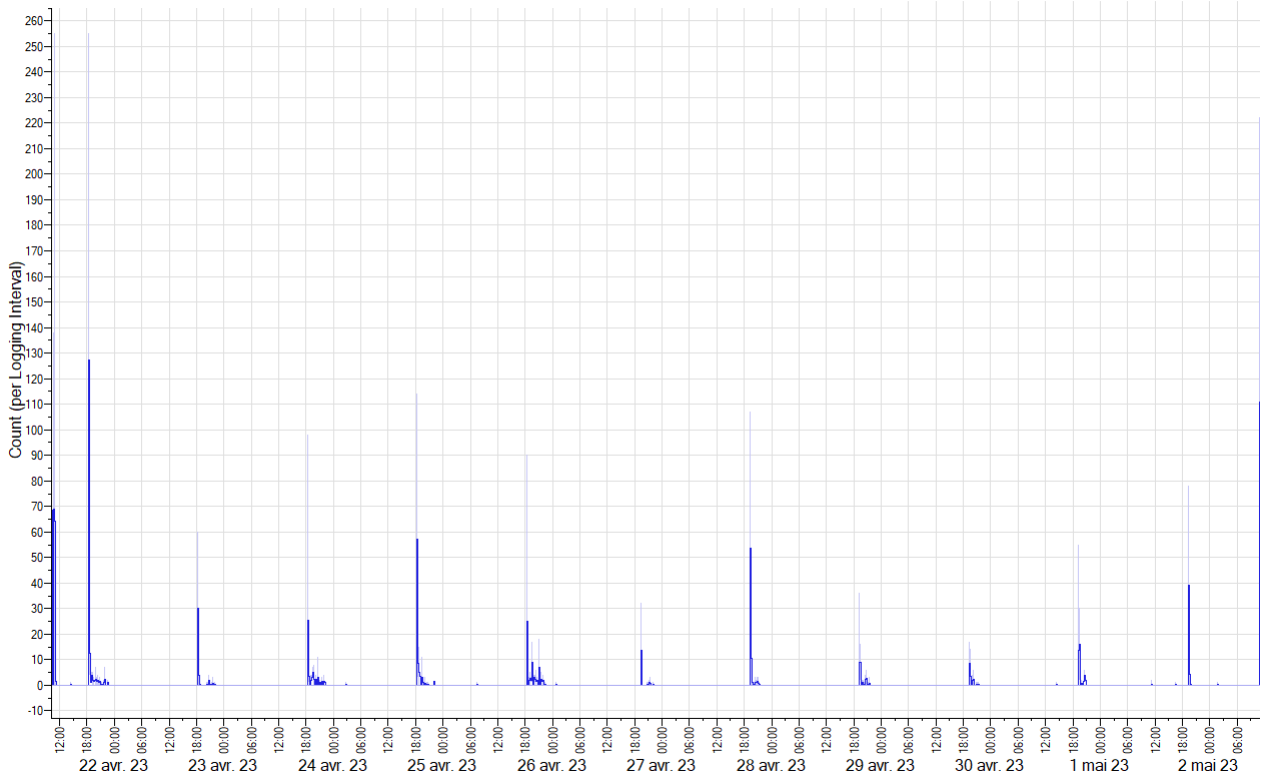

Cumulative hydropeak duration (in days of 24h) /year since 2010

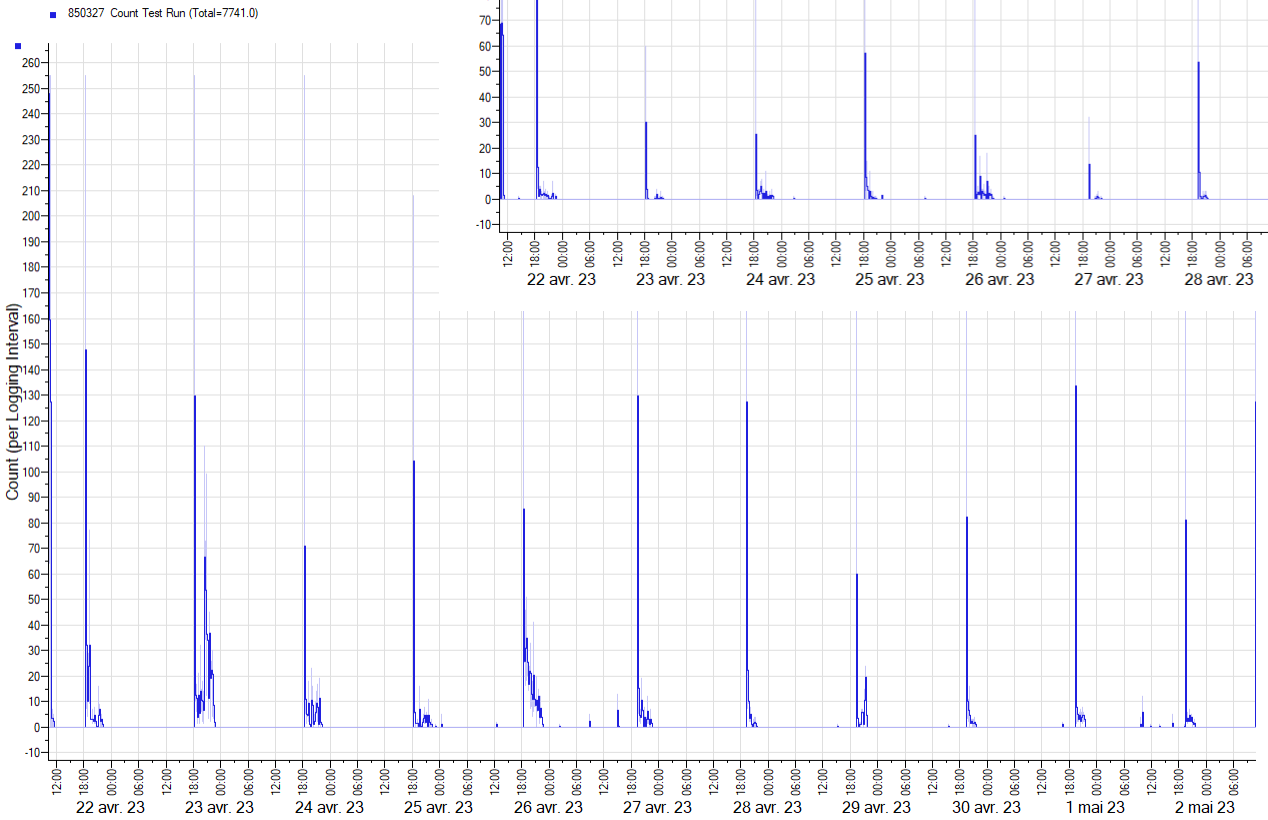
In 2022
64 days of hydropeaking
➔ **4.2 m/ year**
➔ **14.2 m/ year**
➔ **65.3 m /year**

<u>Since 2010</u> : average duration = **61 days**
➔ **3.6 m/year**
➔ **13.4 m/year**
➔ **62.8 m/year**

**<u>So</u>** in 91 years :
➔ 0.3 km
➔ 1.2 km
➔ 5.7 km

# Results : the impact plates : data from 10 mm





- Mobilisation of sediment around 10 mm still occured
- Can explain a probable paving of the bed

# Conclusion

- **Over representation** of the **morphogenic flow** (929h dowsteam VS 196 h upstream)
- **Reduction** of the **major flood** events

- **Increase** the graine size of the bed **dowstream** ➔ probable **paving** of the bed material
- **Selective transport and trapping into the reservoir = Lack of small particles** but not an absence thanks to **the widening of the river**

- **Average distance :** 1.2 km/91 years or **1.3km /century**

➔ Sediment deficit due to the presence of the dam would be about **1.2 km**

➔ In the Ardenne rivers, propagation velocity is more around **2 km/century** for similar specific power (Houbrecths *et al.*, 2015)

➔ Only 10-12 $m^3/s$ discharge and **no major flood event**

**Necessity to study what will be going on for a major flood event**


Thank you for your attention