



# Hydromorphological Monitoring of a Sediment Replenishment Operation: The Case of the Saint-Sauveur dam in the Buëch River (Southern Alps. France)

**1 - Research context**

**2 - Why restore the Buëch River - How to restore ?**

**3 - Monitoring of the restoration operation**

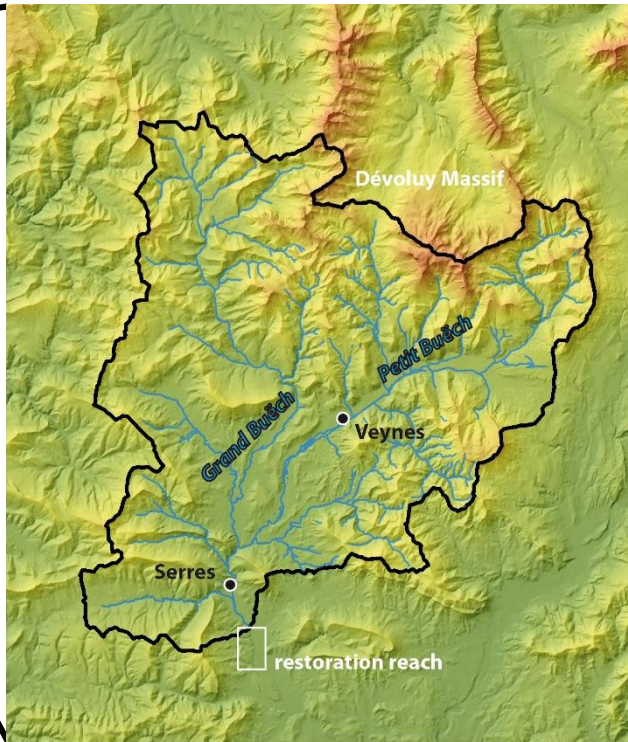
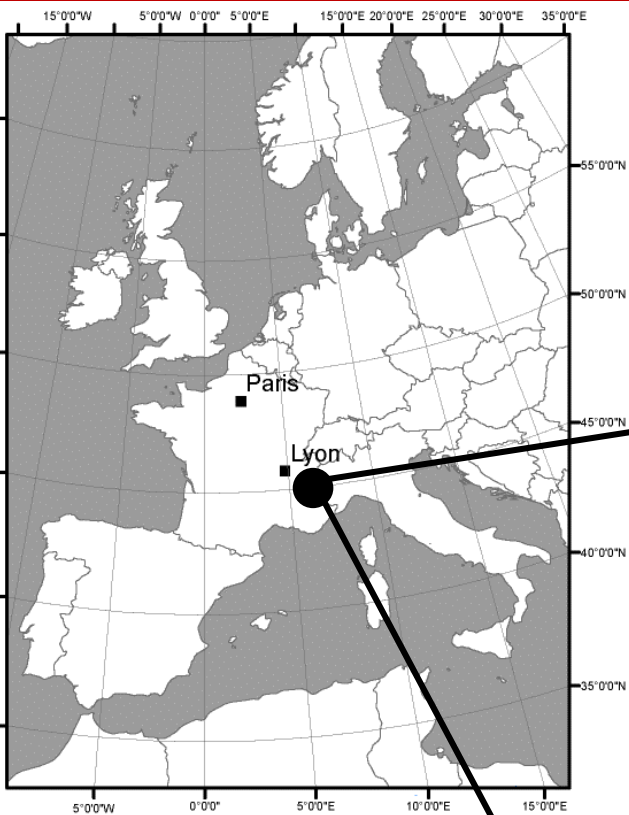
**4 - Preliminary results after a  $Q_{10}$  flood**

**5 - Feedback and prospects**



# 1 - Research context

## Location



- French Alps
- Rhône catchment
- Right bank tributary of the Durance River

Geology dominated by sedimentary rocks with black marls

A hot spot of the alpine biodiversity  
 → Mosaic of ecological habitats

Multiple economic uses (irrigation, hydro-electricity, hunting, fishing, tourism ...)

# 1 - Research context

## Study site

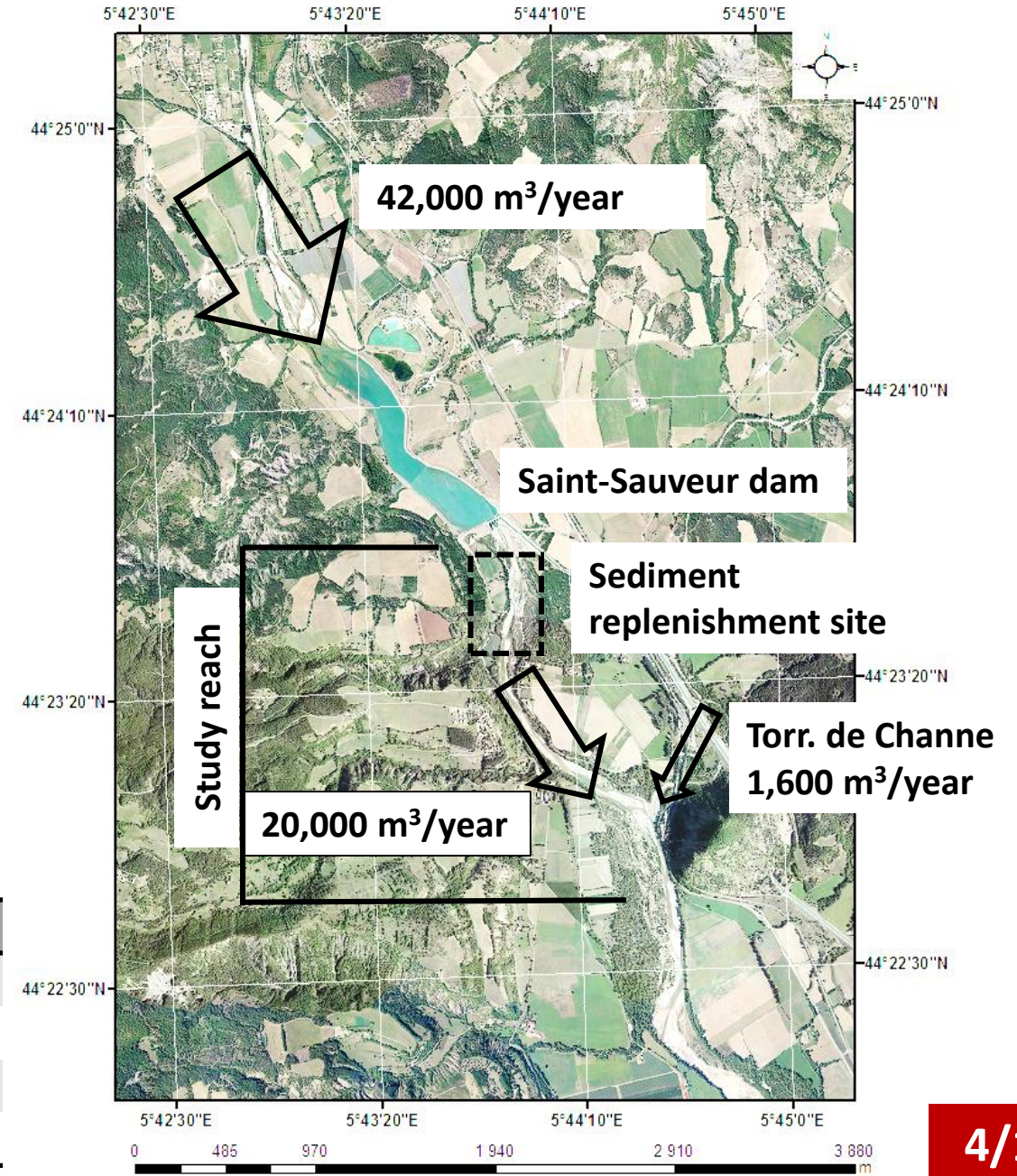


1



2

Drainage area (km <sup>2</sup> )	836
Length of the study reach (km)	2.2
Active channel width (m)	180
Channel slope (m/m)	0.009
Planform morphology	Braided/wandering patterns





Human alterations of the physical fluvial corridor :

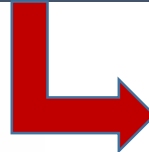
Gravel mining

> 3 million m<sup>3</sup> in the upper catchment

> 6 million m<sup>3</sup> in the lower catchment

Dam was built between 1991 and 1992 => dredging of 600,000 m<sup>3</sup> of sediment

Sedimentary transport continuity has been strongly impacted



Rapid channel responses :

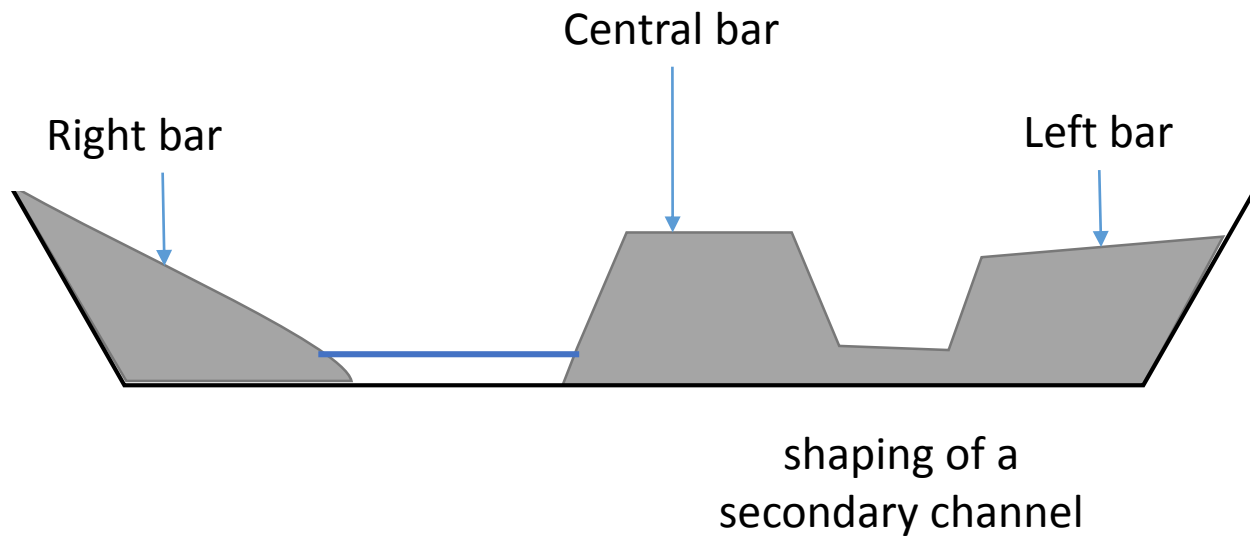
- Alluvial fan is aggrading upstream the reservoir
- Contraction and degradation of the active channel with downstream propagation
  - Marly bedrock outcrops are observed along the degraded reach
  - A shift from a braided to a wandering pattern

### Replenishment operation

September 2016 : 1 million euros

- Dredging the alluvial fan of the Saint Sauveur reservoir (50,000 m<sup>3</sup>)
- Sediment replenishment downstream of the dam (44,000 m<sup>3</sup>)

#### Schematic cross section of the replenishment operation



End of the operation



EDF ©

EDF	Right bank	Left bank
Volume (m <sup>3</sup> )	12,256	31,189
Total (m <sup>3</sup> )	43,445	

## Local monitoring

### Objective

Capture the geomorphological and biological responses of the degraded reach to the artificial gravel recharge

1

Field data:

- Granulometry
- Marl outcrops
- Flood marks
- Time lapse photo

2

Topographic survey:

- Sequential LiDAR
- Drone survey
- Terrestrial and classical topography

3

Hydrological survey:

- Floodgates hydrology
- Overflow wear hydrology

## Morphological change





## Morphological change



## Morphological change

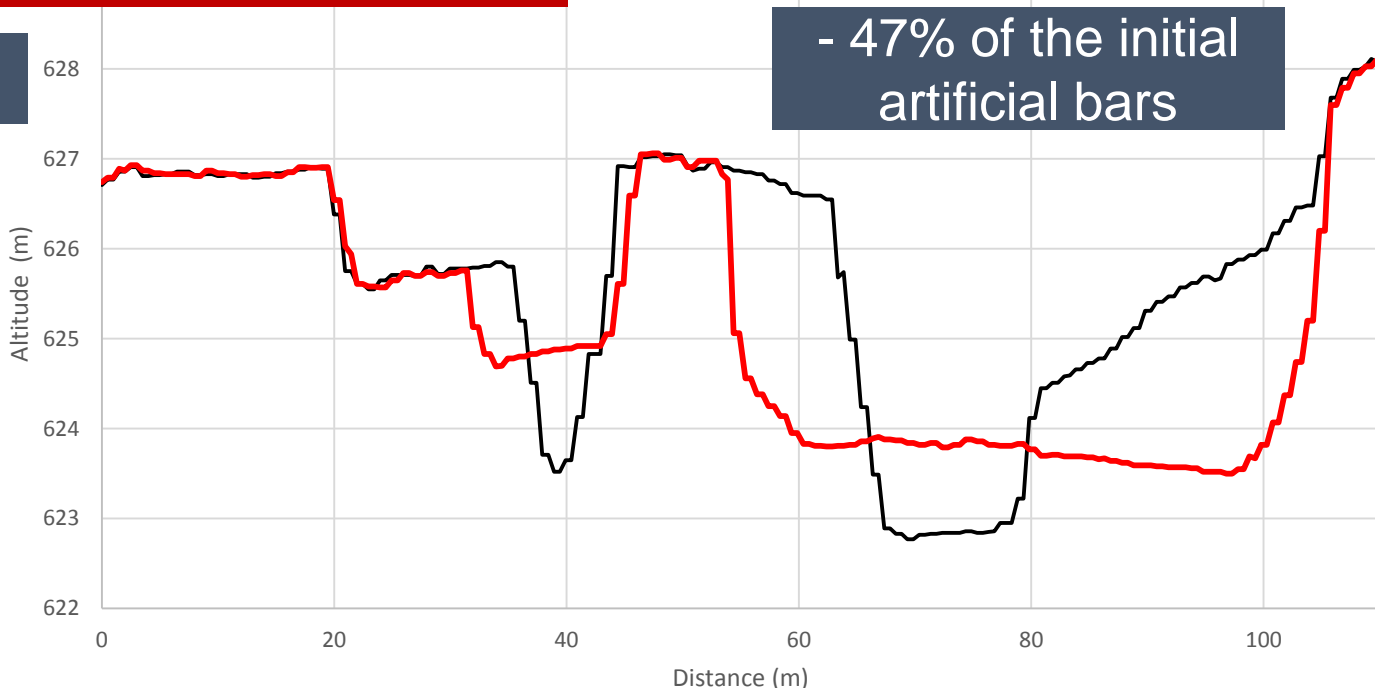


## Morphological change

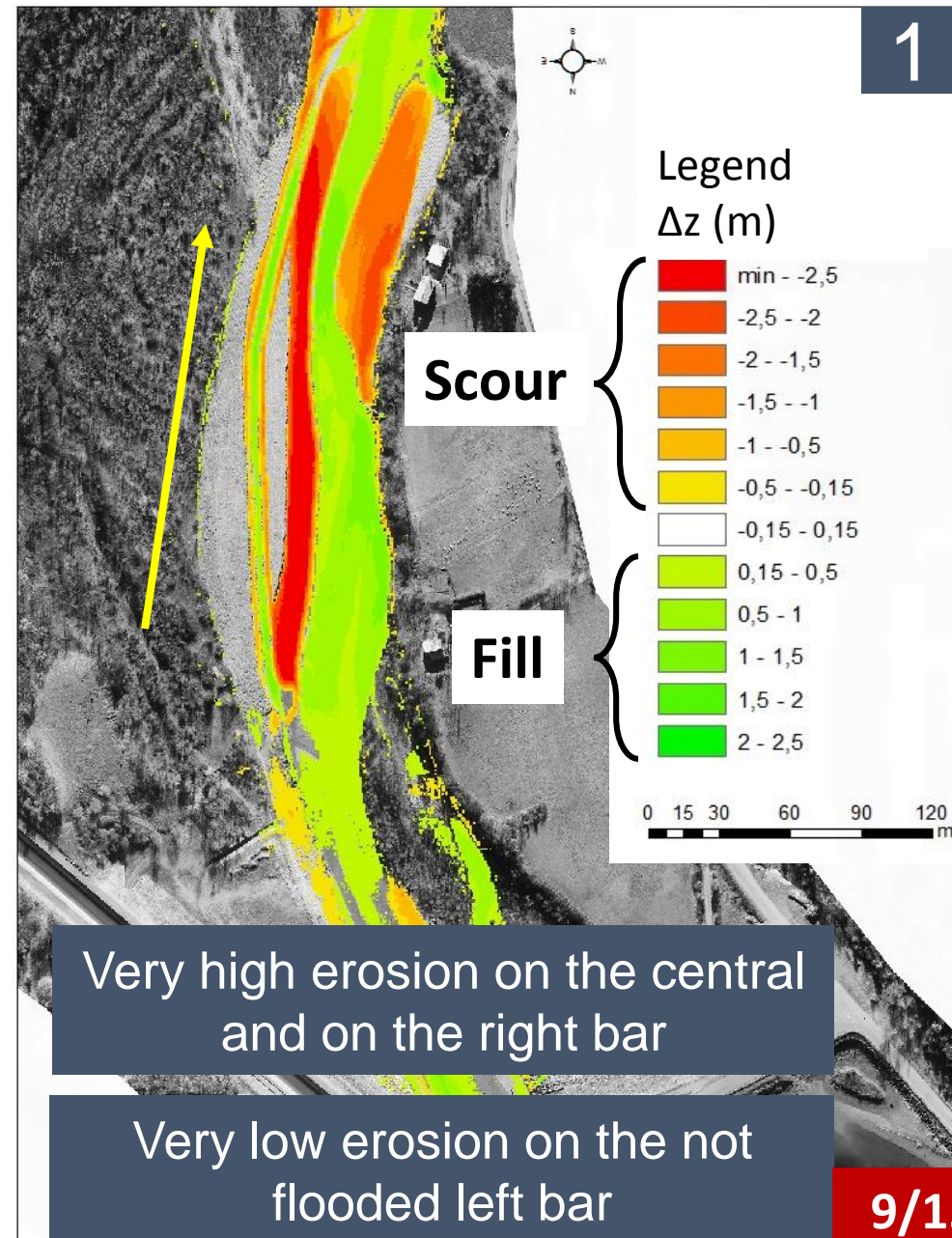
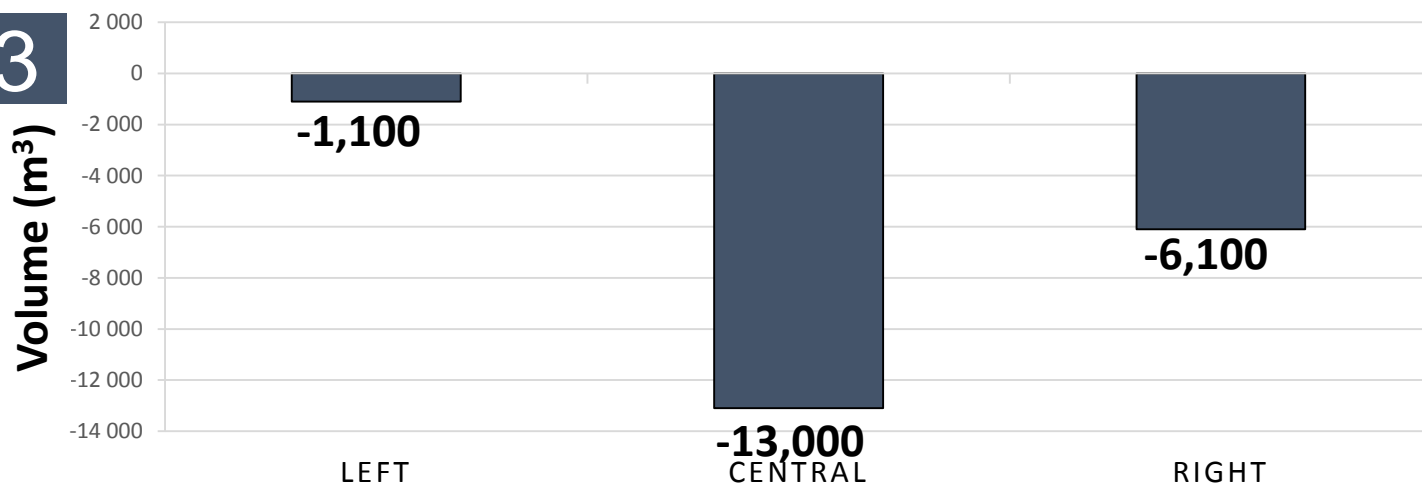


## Volumetric change

2

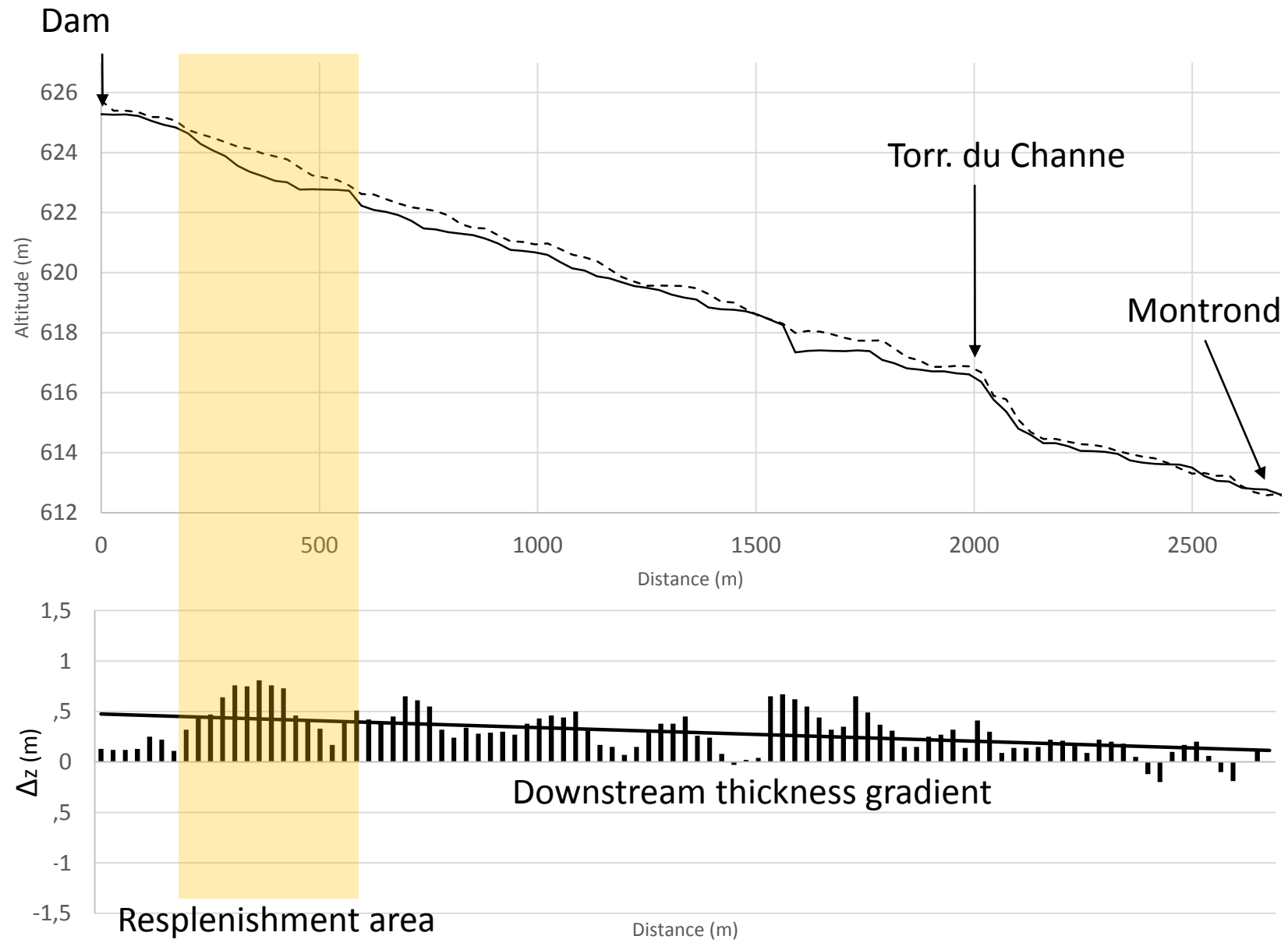


3



## Longitudinal evolutions

### The main channel



Vertical adjustments

Cross section spacing = 25 m

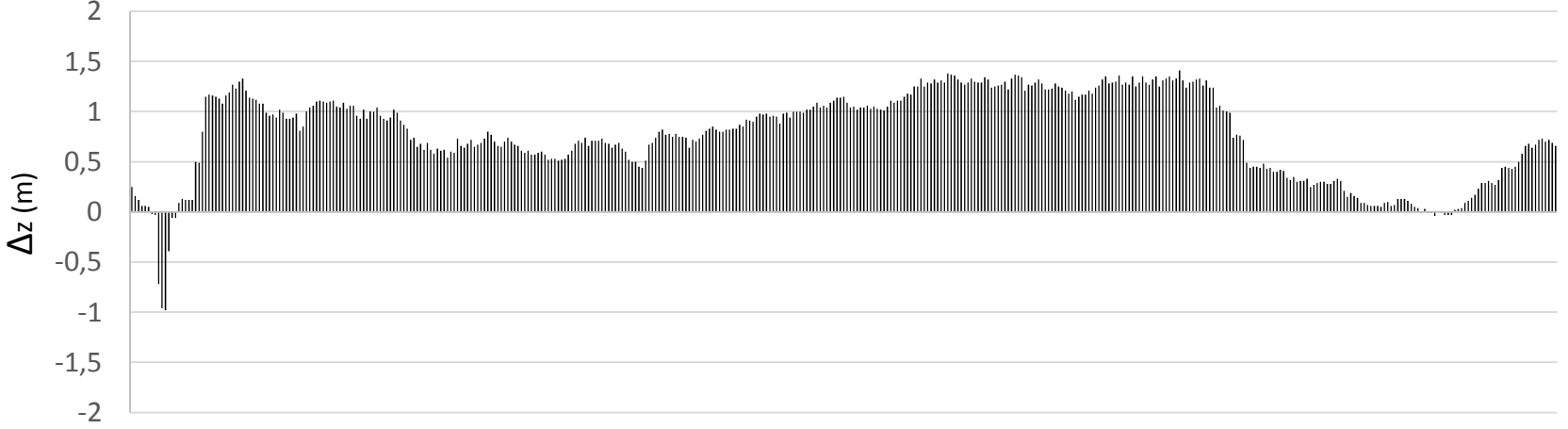
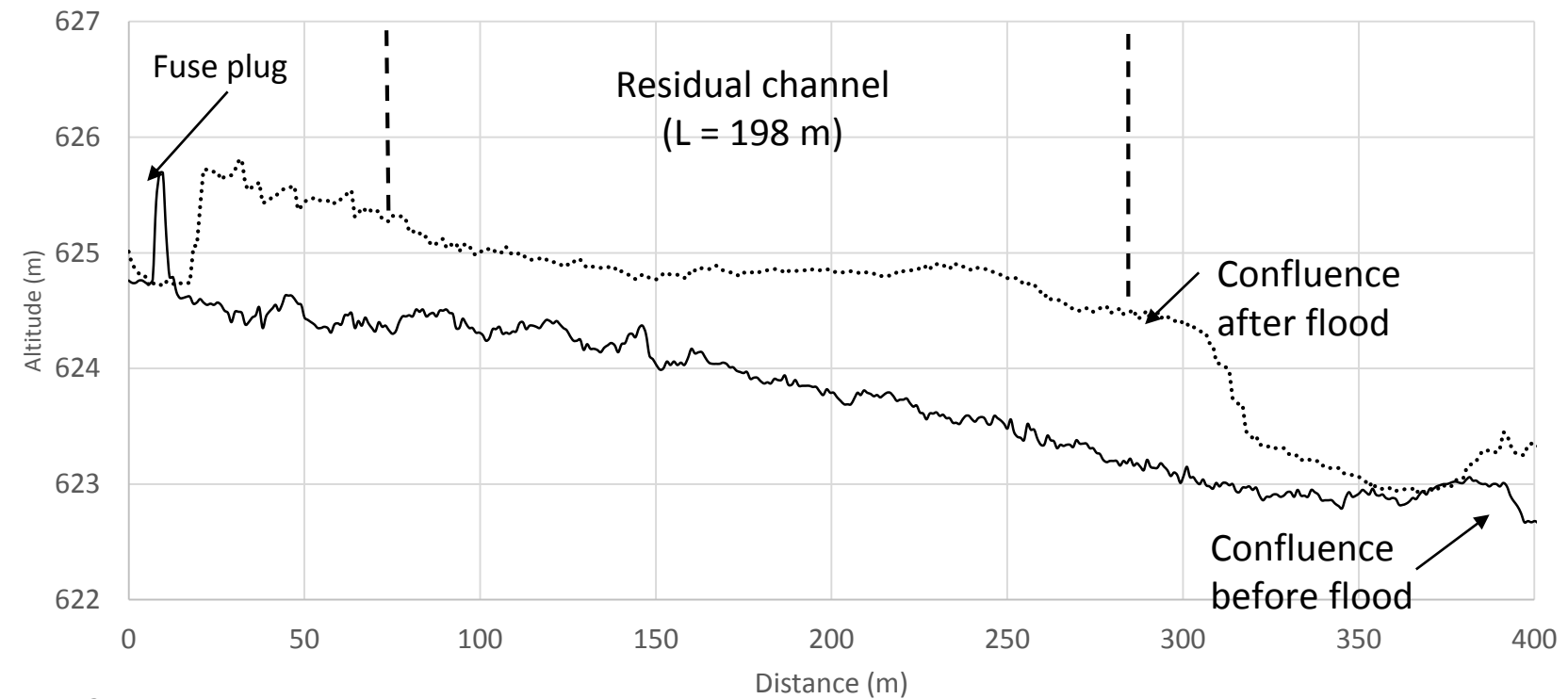
Difference between the min value of each cross section

	$\Delta z$ (m)
Min	-0.20
Max	0.81
Average	0.30
SD	0.22

An important aggradation of the main channel

## Longitudinal evolutions

### The secondary channel



Vertical adjustments  
 1 point/m  
 Difference between before and after flood values

	Before flood	After flood	Evolution (%)
length (m)	380	198	-48
Slope (%)	0.54	0.20	-63

	Δz (m)
Min	-0.98
Max	1.41
Average	0.78
SD	0.43

## Sedimentary budget

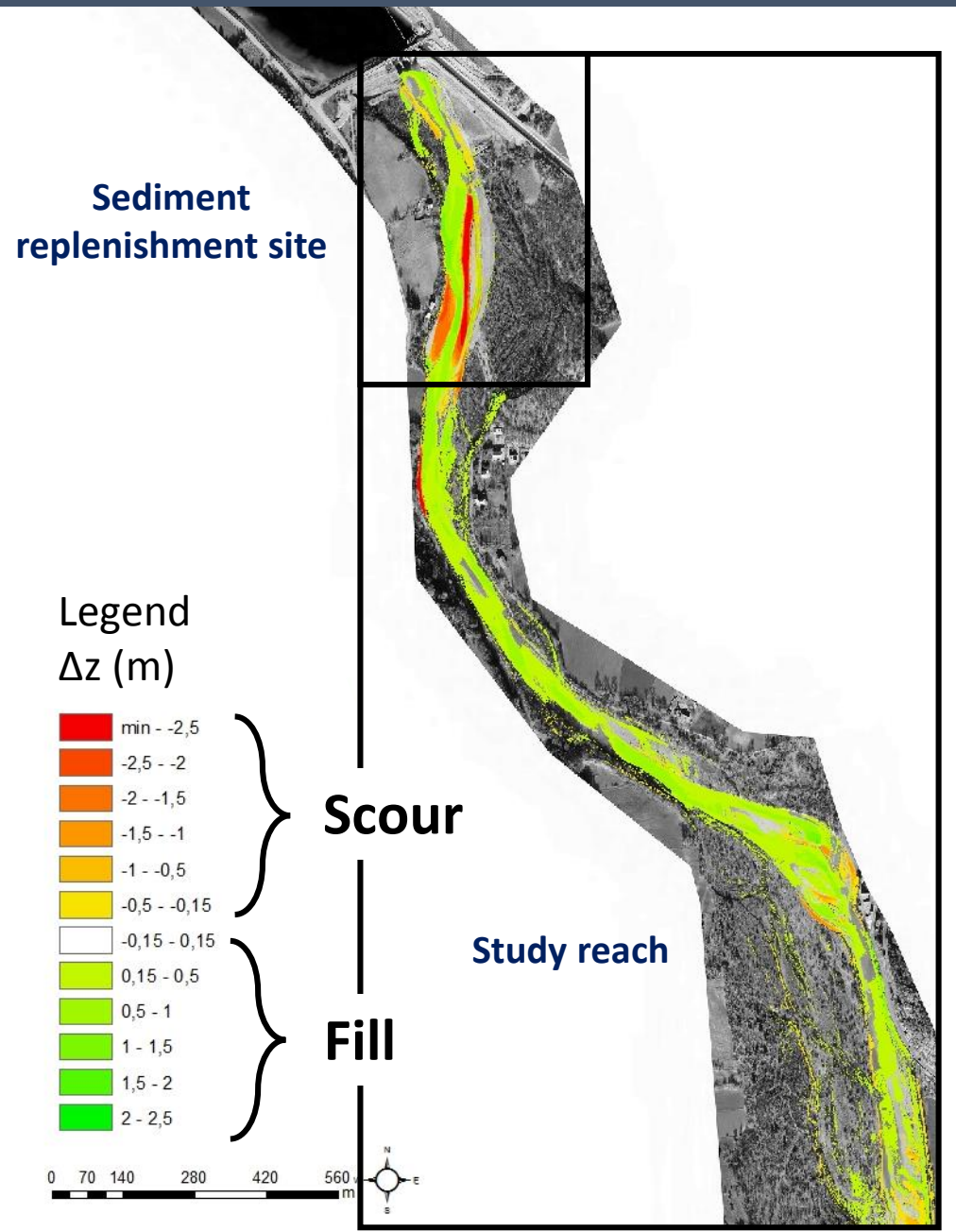
$$I = \Delta S + O$$

### Reach scale

$$\Delta S = + 25,300 \text{ m}^3$$

RMS	0.0202 m
SD	0.0203 m
N	42

Accuracy = ± 7,800 m<sup>3</sup>



## Sedimentary budget

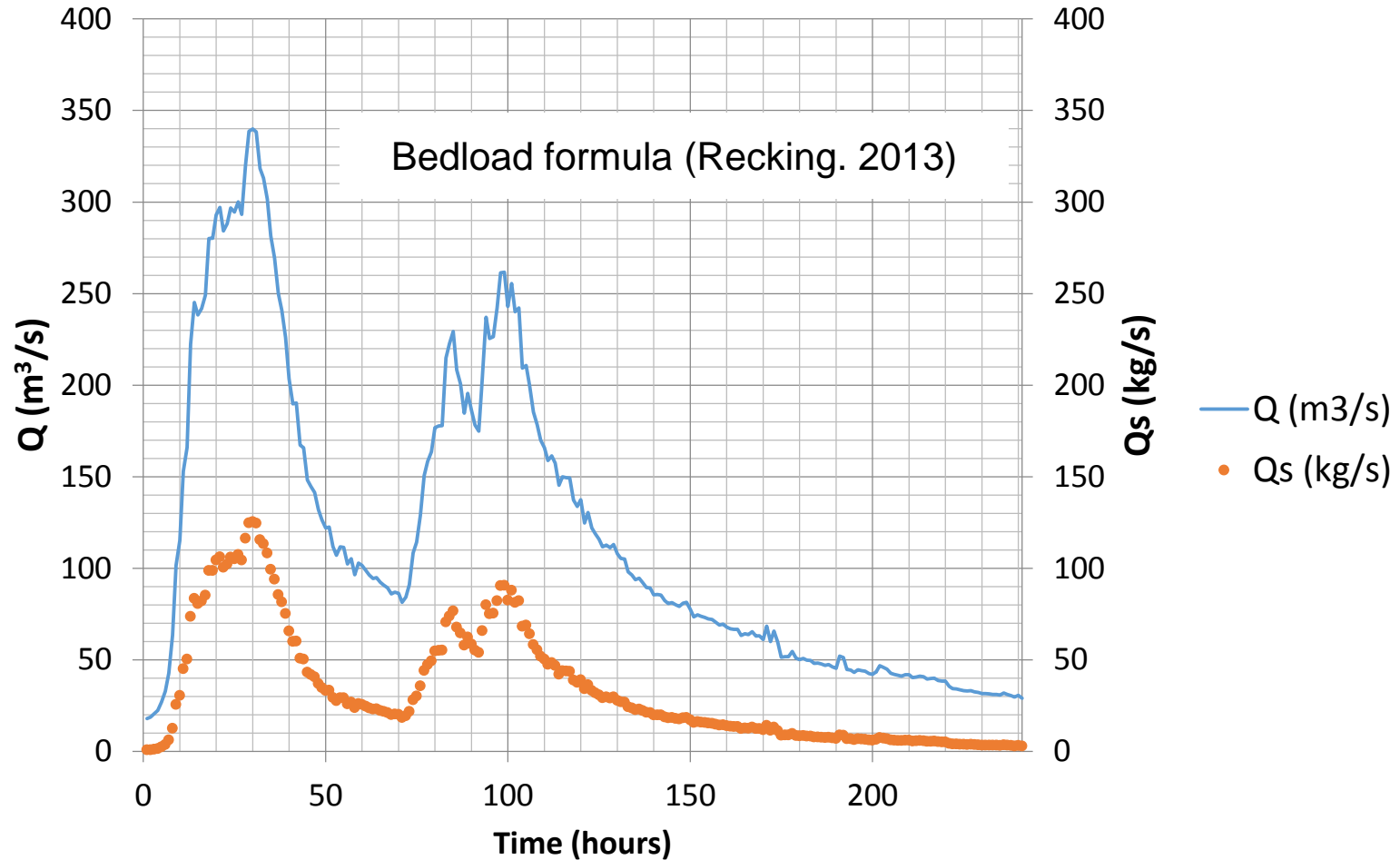
$$I = \Delta S + O$$

- Wolman granulometry after flood
- 1 cross section
- 1 longitudinal profile
- Flood marks
- Bedload formula integration in the hydrogram

Parameter: Q <sub>max</sub>		
d	1.23	m
S	0.00319	m/m
W	70.00	m
R	1.19	m
U	2.19	m/s
τ	37.15	N/m <sup>2</sup>
τ*	0.055	d84
τ <sub>c</sub> *	0.023	d84
τ* / τ <sub>c</sub> *	2.43	d84

$D_{50} = 20.8 \text{ mm}$

$D_{84} = 40.9 \text{ mm}$

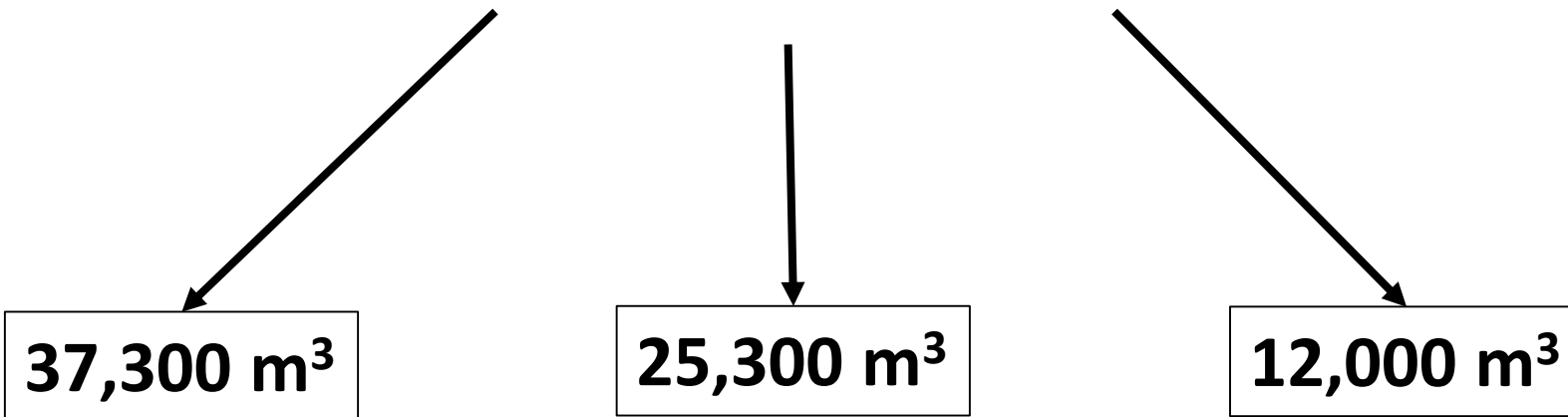


$O \text{ (bedload)} = 12,000 \text{ m}^3$



Sedimentary budget

$$I = \Delta S + O$$



90% of the mean annual sediment supply upstream the dam

190% of the mean annual bedload downstream the dam

What is the accuracy of this sedimentary budget ?

### Hydromorphological feedback

The replenishment operation is successful in a particular hydrological context

- Global bed aggradation
- Bed scour limitation → ok

What about braided pattern ?

- No braided channel formed in the replenishment site
- But bed aggradation will increase active channel submersion frequency
- We can hope for a positive feedback loop

The contribution of the secondary channel is a little disappointing

- Now it is perched by the main channel
- No development of aquatic habitat
- The decrease in energy due to this channel has probably limited the erosion
- Especially for the left bar

Next step is to quantify bed level evolution in low flow without hydraulic transparency

LiDAR data will complete the monitoring in no flood context

Time lapse photo will be used to quantify spatial adjustments

**Thank you for your attention**

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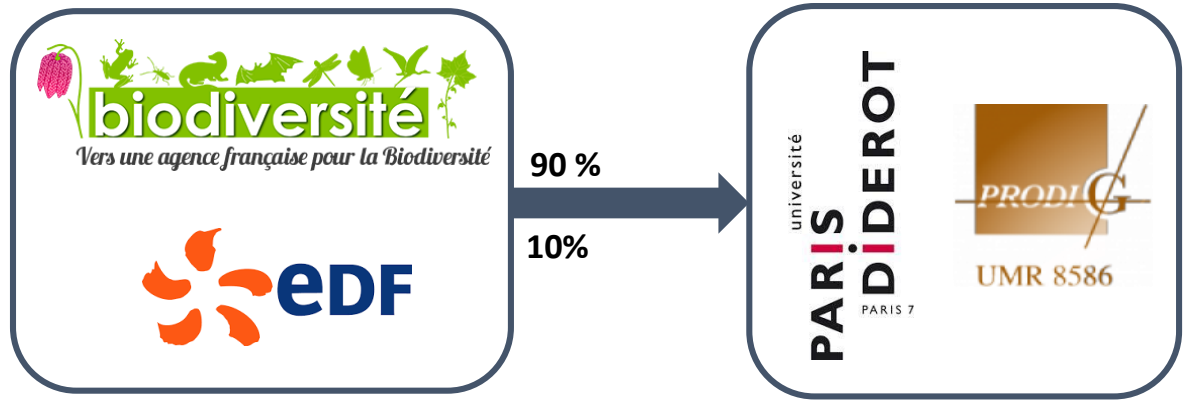
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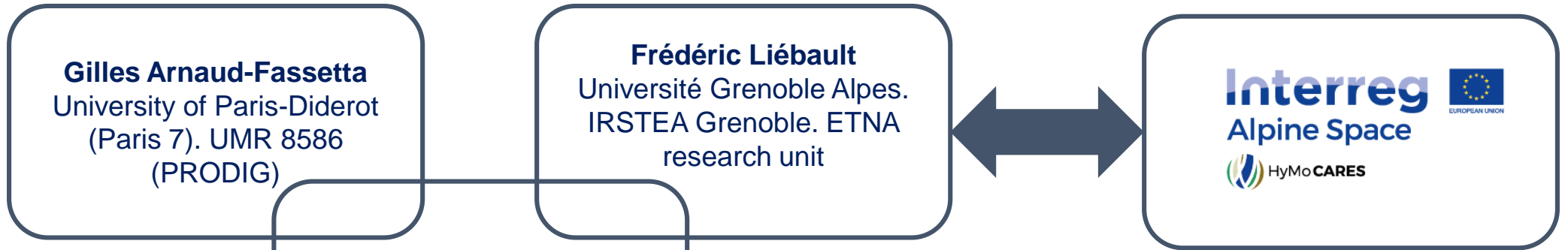
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## Team project

### Funding



### Direction



HyMoCARES - HydroMorphological assessment and management at basin scale for the Conservation of Alpine Rivers and related Ecosystem Services

### Phd student