

**ICSE6 2012**

**BED EROSION ON THE RIVER  
GALET AND ITS IMPACT ON  
RAILWAY INFRASTRUCTURE**

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## ***ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure***

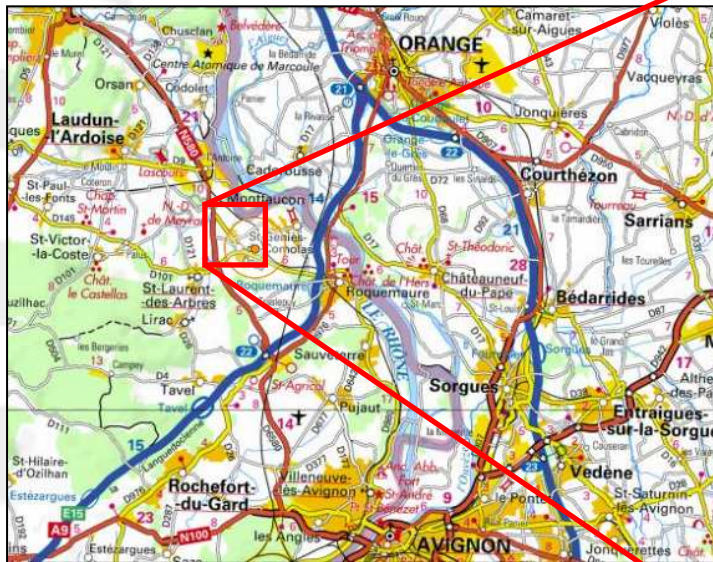
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- **Introduction**
- **River Galet**
  - Catchment characteristics
  - History of flooding
  - Geomorphology
- **Hydromorphology study**
  - Ground Investigation
  - Hydraulic Model
- **Conclusions**

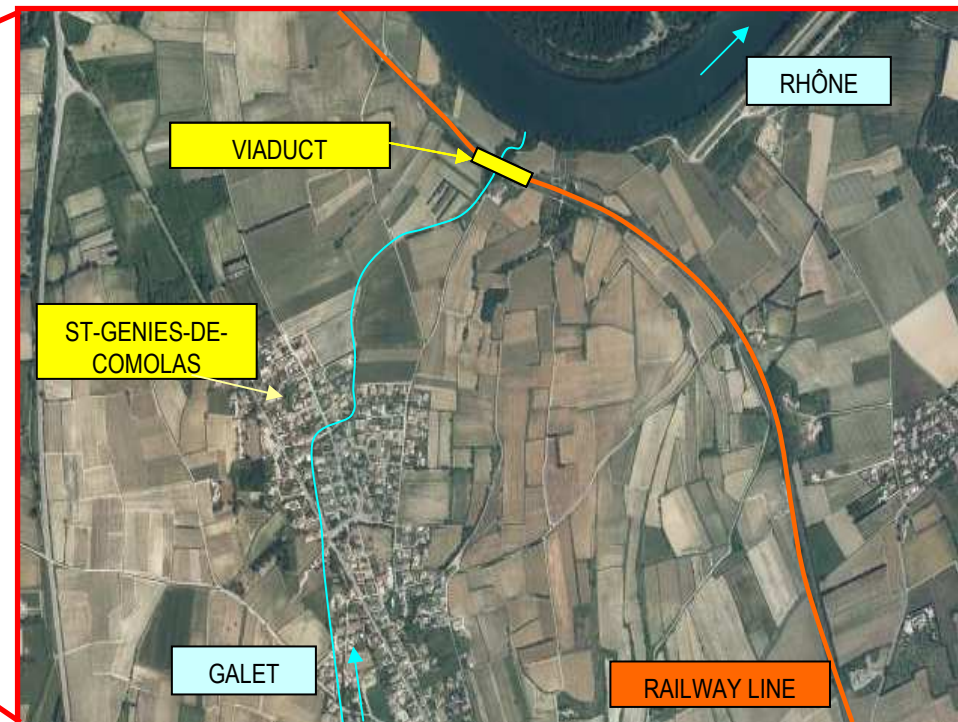
# ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

## ■ Introduction

- The Galet viaduct is situated on the railway line between the towns of Givors and Grezan in the Languedoc-Roussillon region of France (Gard, 30).



Source: CartoExplreur

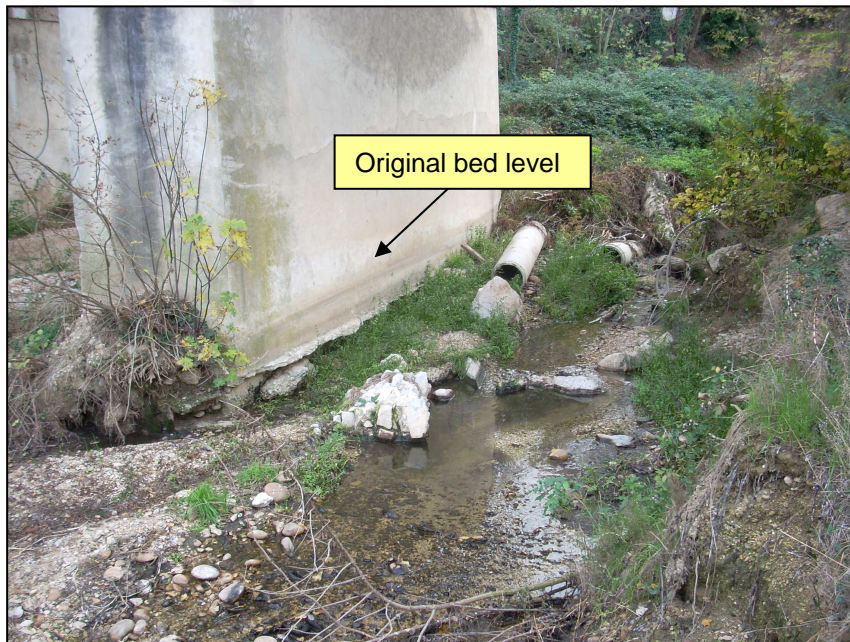




## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ Introduction

- An inspection of the viaduct railway in 2008 following flooding in the Galet catchment identified generalised bed lowering of the Galet exposing the foundations of the structure.





# ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

## ■ River Galet

### ➤ Catchment Characteristics

#### • Physical characteristics

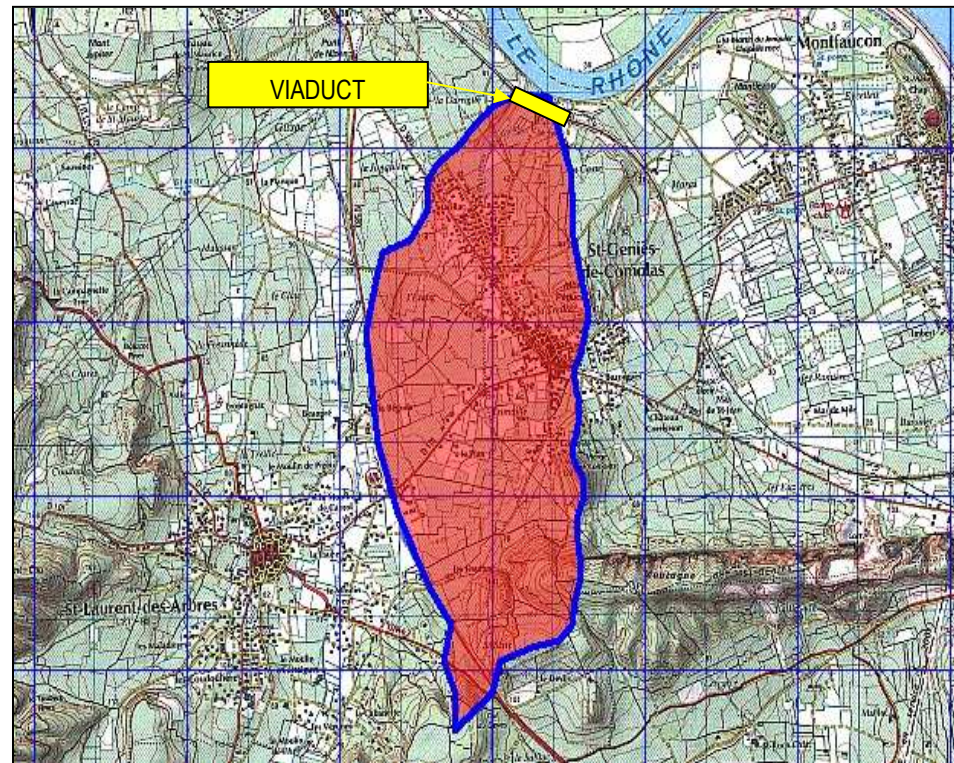
- ◆ Surface area =  $3.5\text{km}^2$
- ◆ Watercourse length =  $3.5\text{km}$
- ◆ Average slope 3%
- ◆ Land cover predominantly agricultural (vineyards)

#### • Rainfall

- ◆ Rainfall intensities of 200-400mm (upto 800mm) in a few days
- ◆ Peak intensities of 125mm in 15 minutes have been recorded

#### • Flow estimation (ungauged catchment)

- ◆  $Q_{100} = 70\text{m}^3/\text{s}$
- ◆  $= 20\text{m}^3/\text{s}/\text{km}^2$

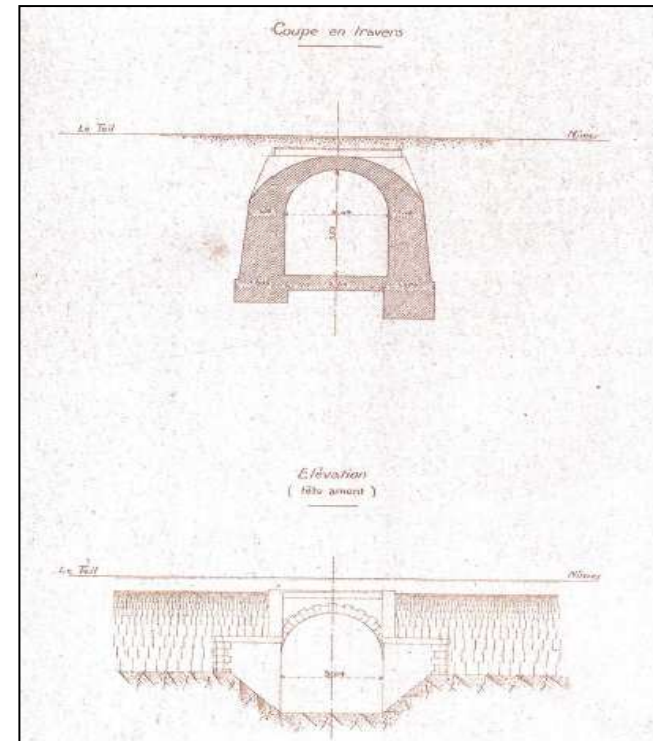


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## ■ River Galet

### ➤ History of flooding

- 23 september 1924
  - ◆ Original structure comprised a single 3m span arch.
  - ◆ Structure destroyed by the flood of 23 september 1924
  - ◆ Breach of 60m formed in the railway embankment
  - ◆ River bed scoured by up to 6m downstream
- 30 september 1958
- 22 september 1993
- 8 september 2002
- 1 december 2003
- 11 september 2008
- ?? October 2011

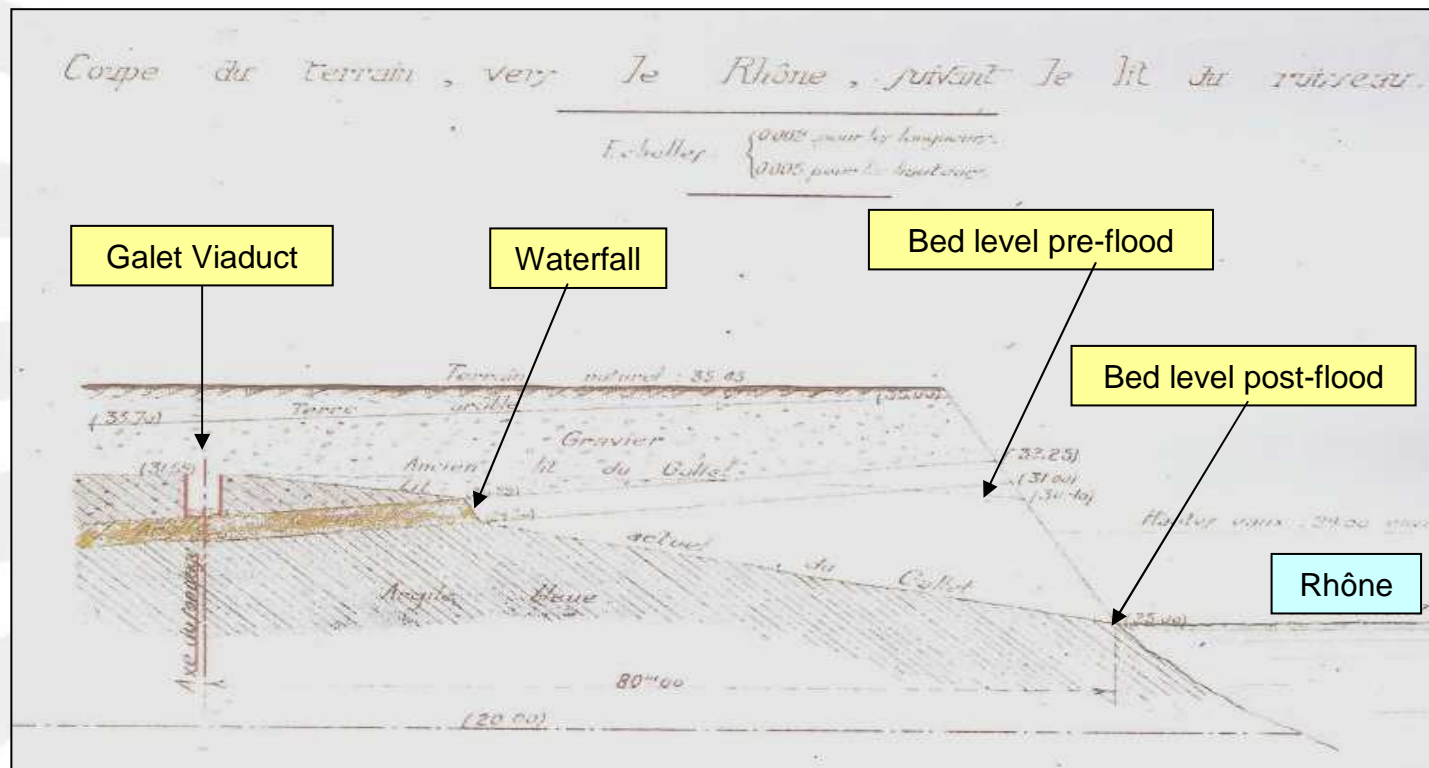


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## ▪ River Galet

### ➤ History of flooding

- Profile of the River Galet post flood of 23 september 1924



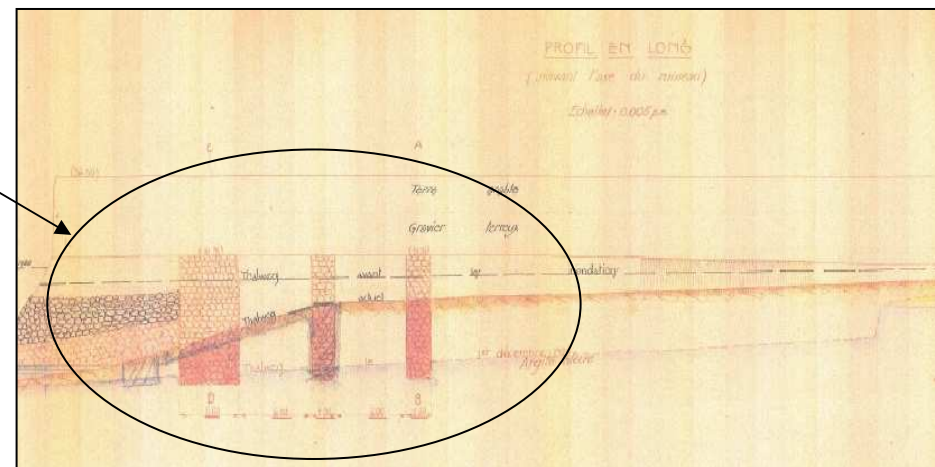
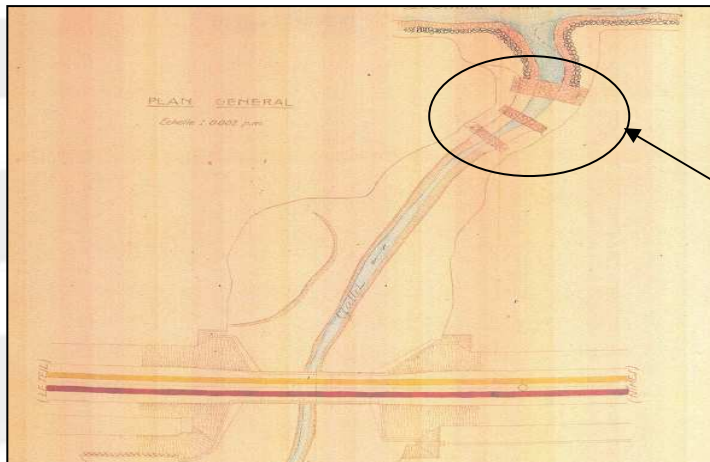
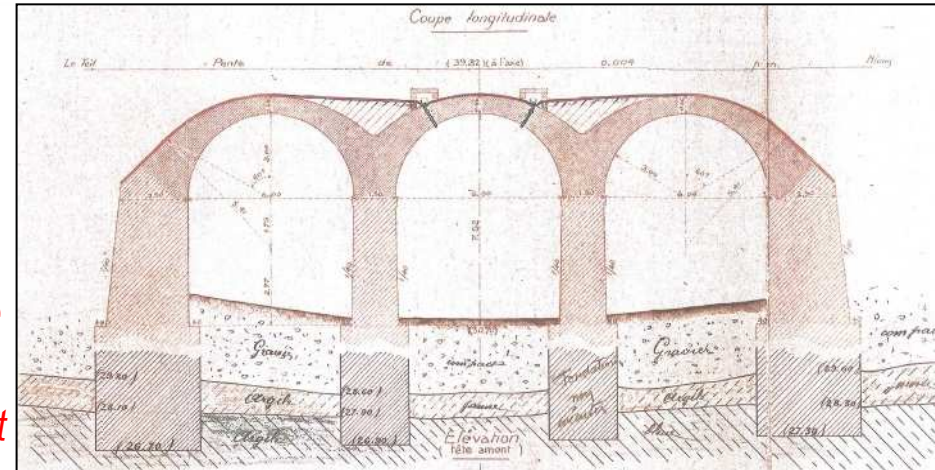


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## ■ River Galet

### ➤ History of flooding

- Rebuilding of the railway viaduct in 1926
  - ◆ 3 arches each of 6m span
  - ◆ Construction of 3 weirs at the confluence of the Galet and the Rhône
  - ◆ Artificial raising of the river bed between the weirs and the new viaduct (imported fill material)

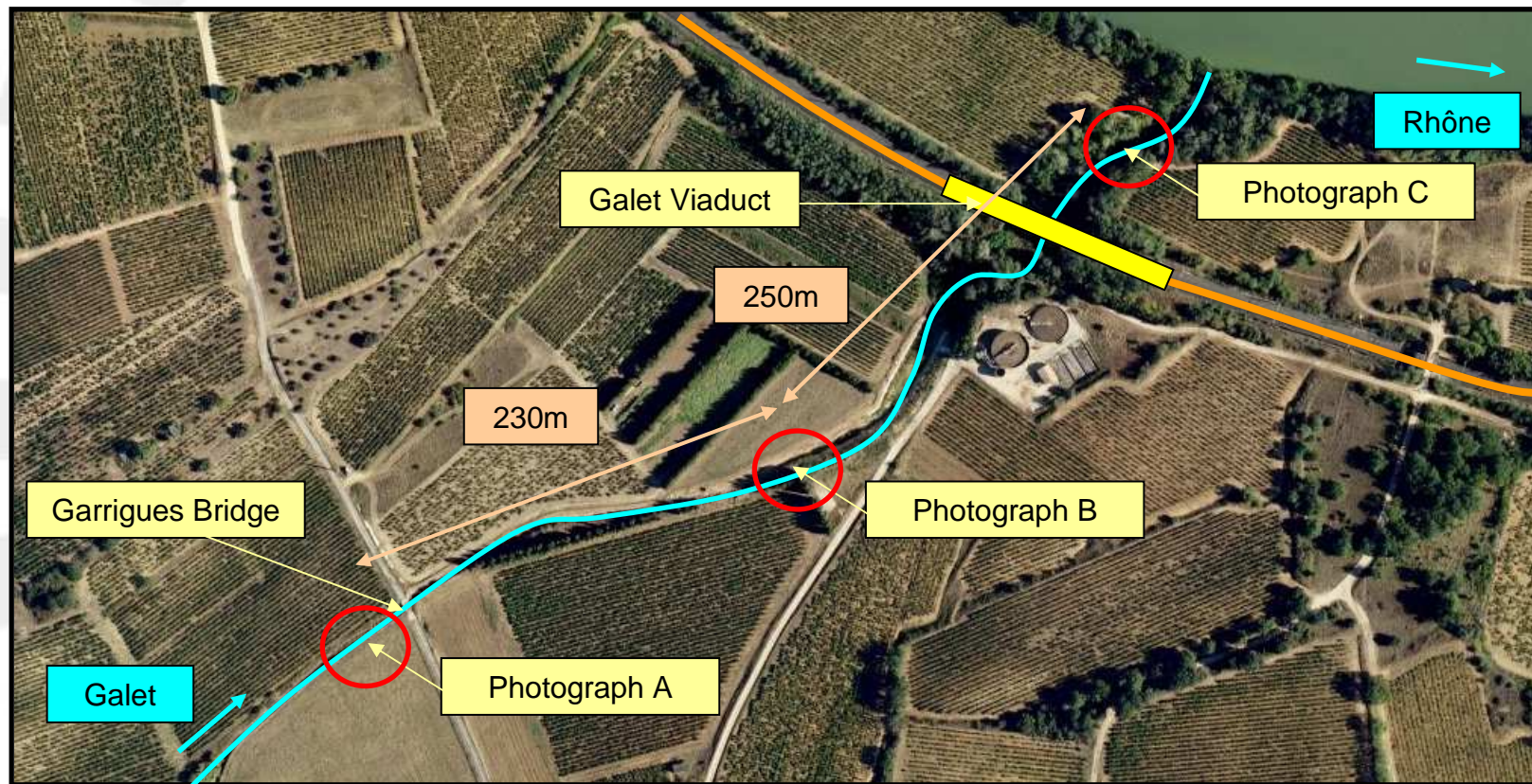




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### ■ River Galet

#### ➤ Geomorphology



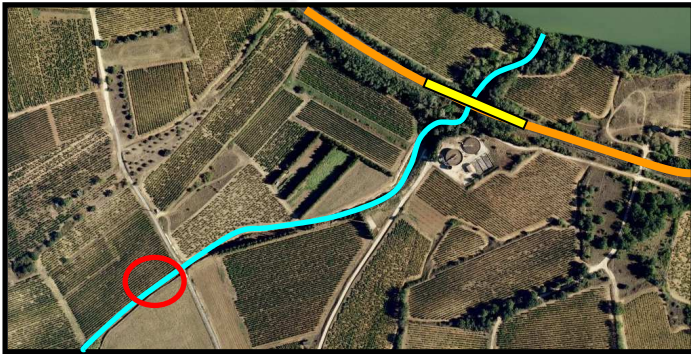
Source: CartoEplorateur



## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology



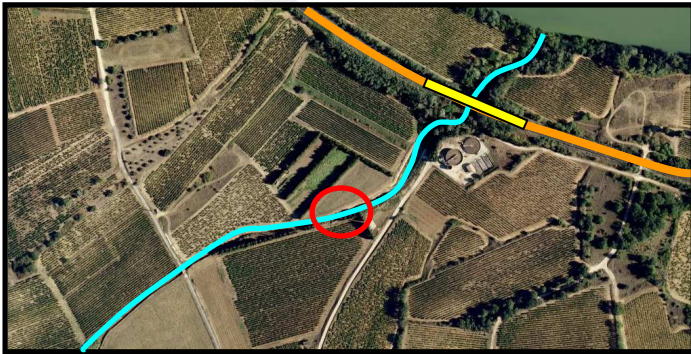
#### ➤ Photograph A – Upstream of Garrigues Bridge



## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology



#### ➤ Photograph B – Reach between Garrigues Bridge and the Galet Viaduct

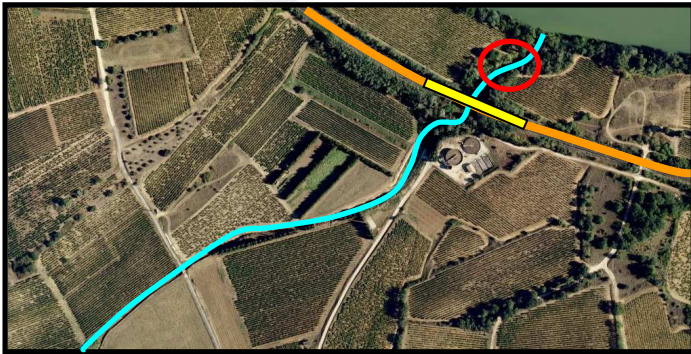




## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology



#### ➤ Photograph C – Reach downstream of the Galet Viaduct





## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

- Geomorphology
  - Observation of river bed changes



Viaduct pier base 2008



Viaduct pier base 2011

## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology

- Observation of river bed changes



Waterfall downstream of viaduct 2008

Concrete block



Waterfall downstream of viaduct 2011



## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology

- Observation of river bed changes



Reach between Garrigues Bridge and the Galet Viaduct (bank protection placed in 2002/3)



## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ River Galet

#### ➤ Geomorphology

- Observation of river bed changes



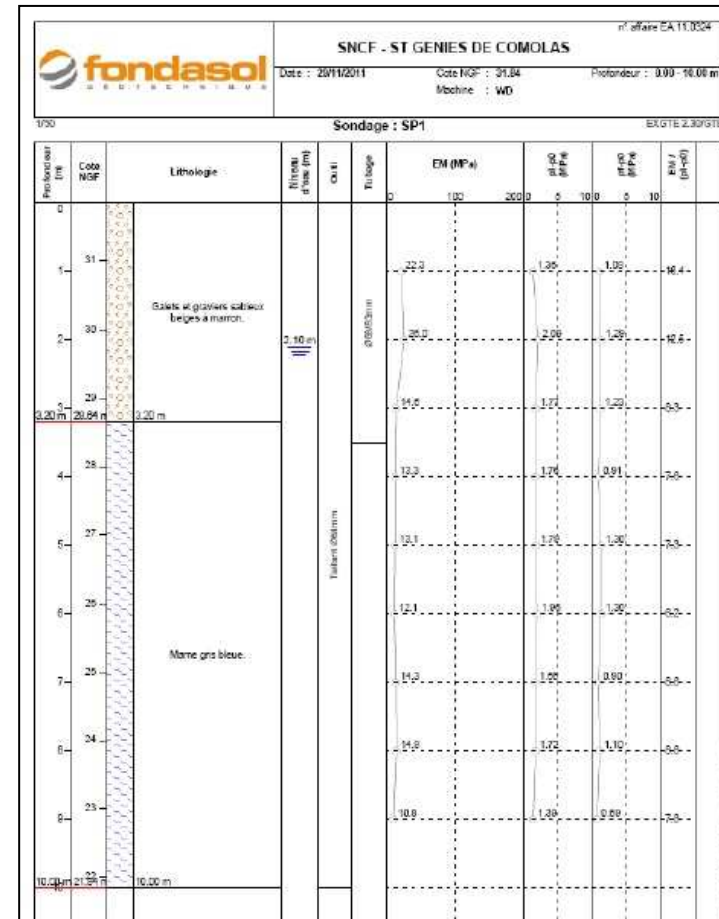
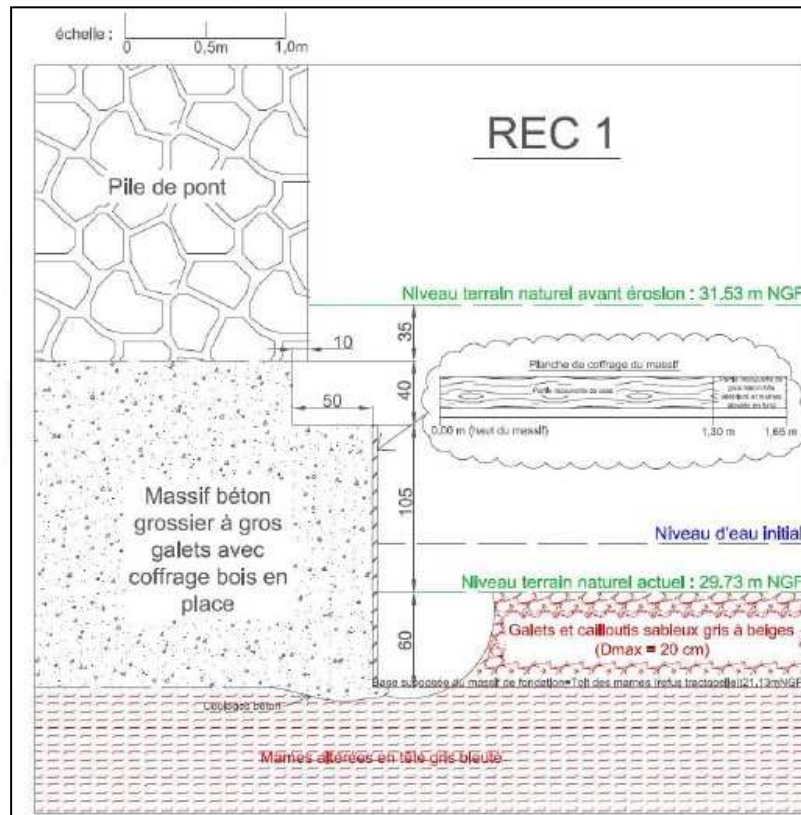
Immediately downstream of Garrigues Bridge 2008



Following works in 2011

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- Hydromorphology study
  - Ground Investigation

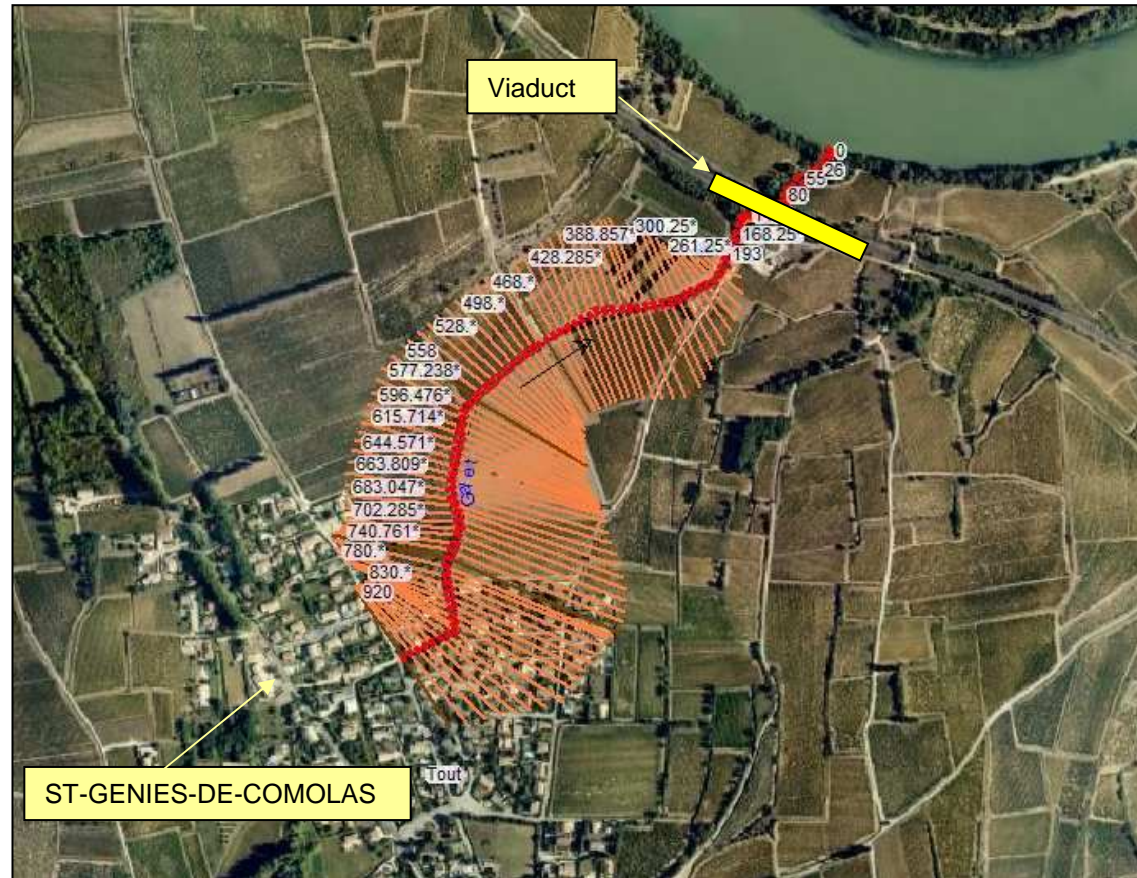




## ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

### ■ Hydromorphology study

- Hydraulic model
  - HEC RAS 1D
  - River length  $\approx 1\text{km}$
  - Run in steady state and sediment transport mode

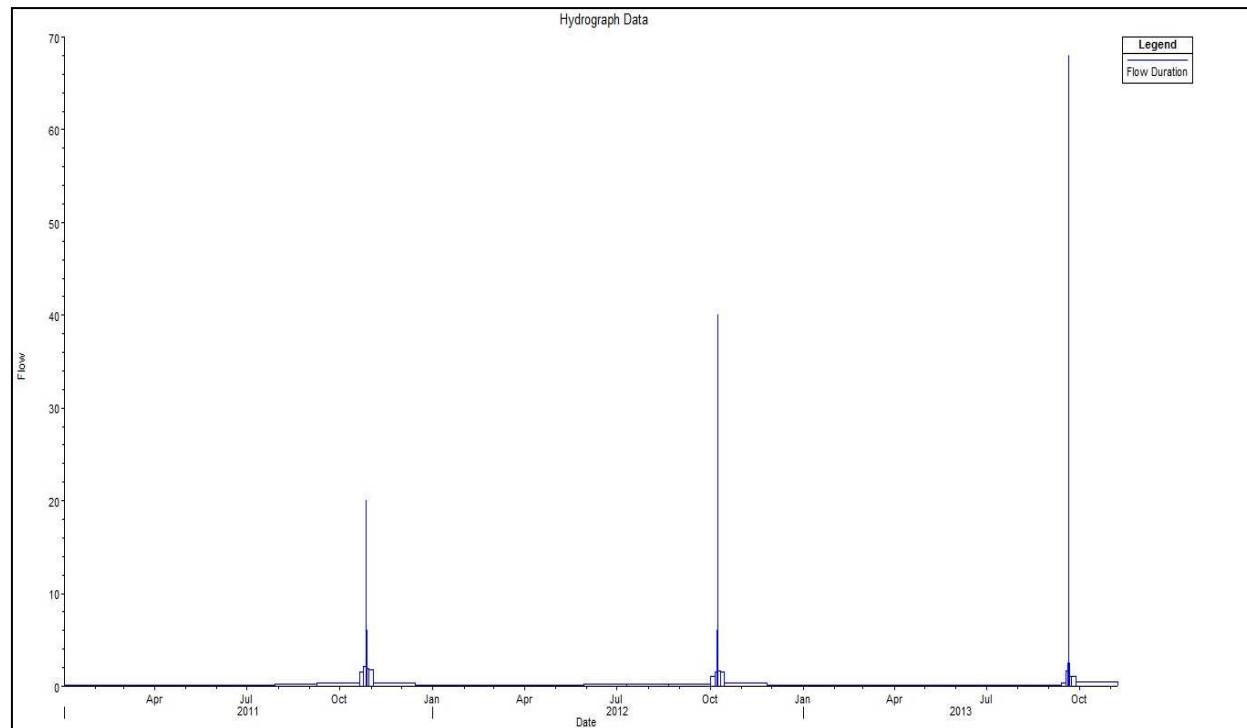


# ICSE6 : Bed Erosion on the River Galet and its Impact on Railway Infrastructure

## ■ Hydromorphology study

### ➤ Hydraulic model

- HEC RAS 1D
- River length  $\approx 1\text{km}$
- Run in steady state and sediment transport mode
- 3 year simulation:
  - ♦ Yr 1 – 1 flood  $20\text{m}^3/\text{s}$
  - ♦ Yr 2 – 1 flood  $40\text{m}^3/\text{s}$
  - ♦ Yr 3 – 1 flood  $68\text{m}^3/\text{s}$

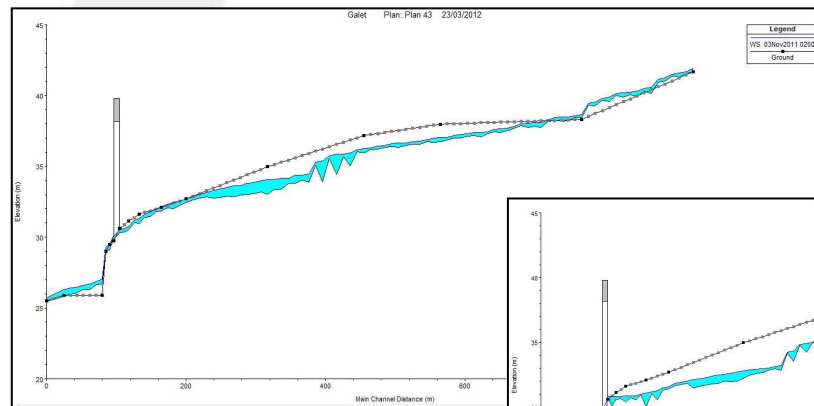


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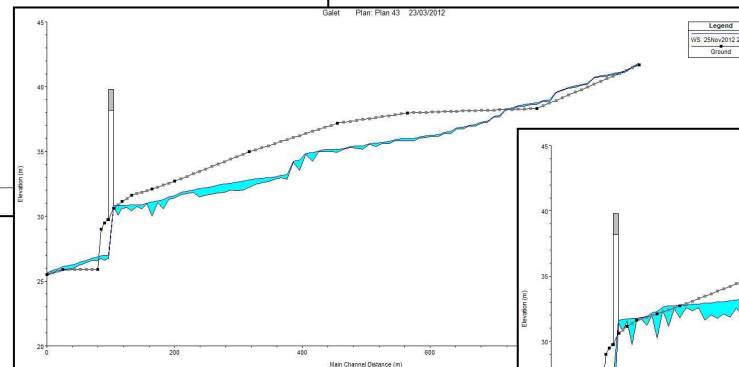
## ■ Hydromorphology study

### ➤ Hydraulic model

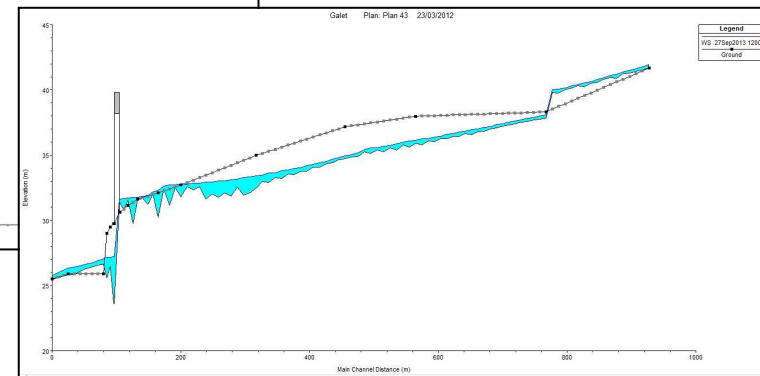
- Results of sediment transport modelling (series of 3 floods of  $20\text{m}^3/\text{s}$ ,  $40\text{m}^3/\text{s}$  and  $68\text{m}^3/\text{s}$ ) reflect well observations made on the ground



After  $20\text{m}^3/\text{s}$



After  $40\text{m}^3/\text{s}$



After  $68\text{m}^3/\text{s}$



# Bed Erosion on the River Galet and its Impact on Railway Infrastructure

## ■ Hydromorphology study

### ➤ Hydraulic model

- 4 Solutions for stabilising the river bed adjacent to the Galet Viaduct were integrated into the model:

1. *Reconstruction of the weirs at the confluence of the Galet and the Rhône*
2. *Construction of a single weir immediately downstream of the existing waterfall*
3. *Construction of a series of low weirs between the existing waterfall and the confluence of the Galet and the Rhône*
4. *Use of rock armour to protect the bed and banks of the Galet from further erosion between the existing waterfall and the confluence*

## ***Bed Erosion on the River Galet and its Impact on Railway Infrastructure***

### **■ Conclusions**

- The River Galet is undergoing important and ongoing bed modification (lateral and vertical erosion)
- The Galet Viaduct is at risk of destabilisation without rapid intervention to control the erosion of the river bed
- Of the bed stabilisation options considered, the construction of single weir downstream of the existing waterfall is the optimal medium term option
- The proposed bed stabilising works adjacent to the Galet Viaduct will have a limited impact in terms of reducing bed erosion in the reach between the railway viaduct and Garrigues Bridge
- The reach upstream of Garrigues Bridge is at risk of erosion