



Pilot project « Walphy » : Walloon experimentation of river restoration



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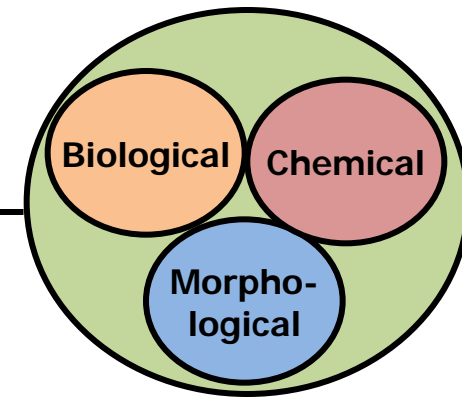


I. Context & objectives of the project

Context : Water Framework Directive (2000/60/CE):
Water bodies are required to achieve the « good ecological status » by 2015



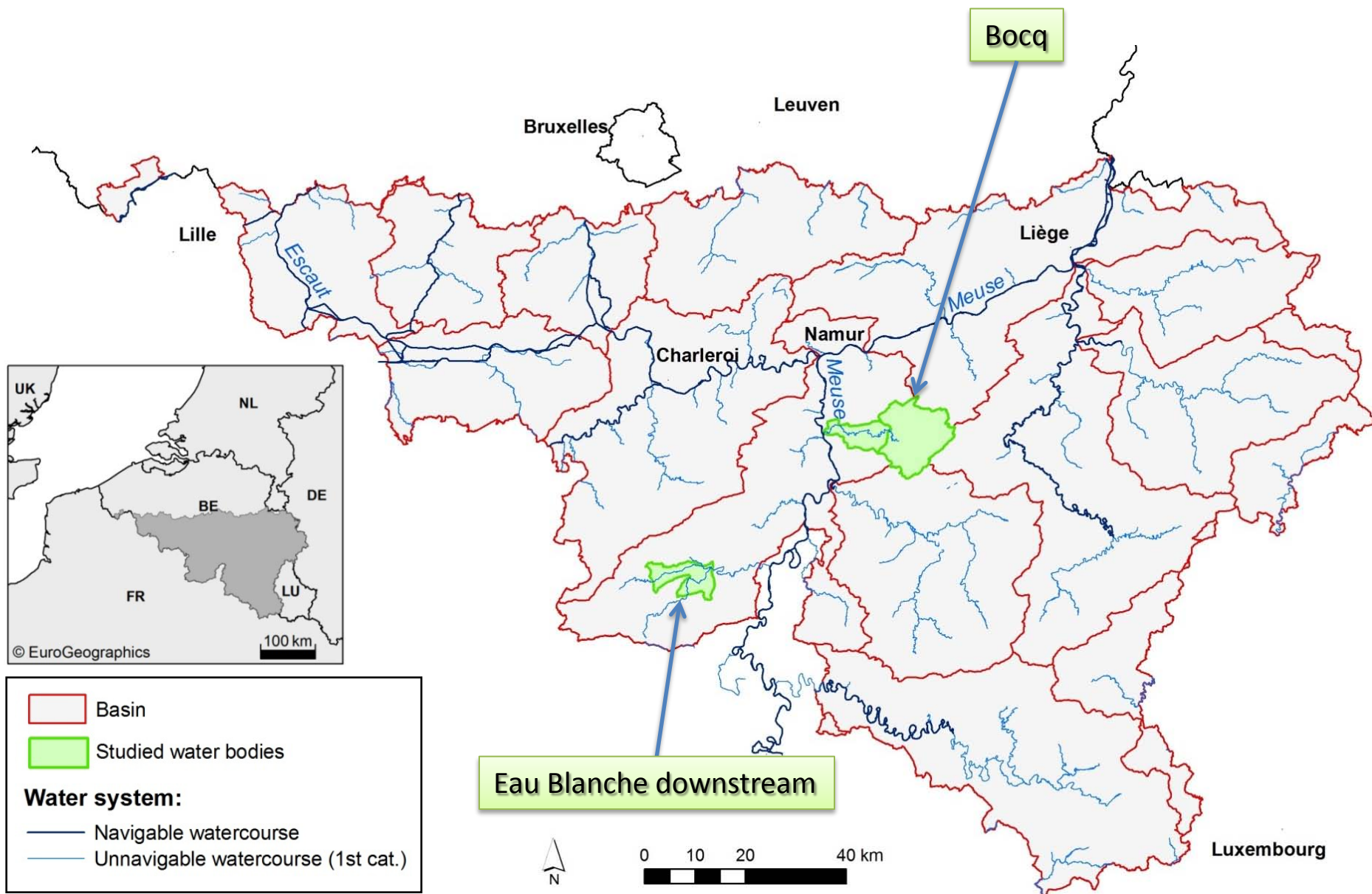
Ecological status



Pilot project « Walphy » - Design of a decision tool for hydromorphological restoration of water bodies in Walloon Region (LIFE07 ENV/B/000038)

Objectives:

- To develop a structured approach aiming at improving morphological quality of the upstream Meuse basin in order to achieve the “good ecological status” (WFD)
- To carry out experimental river restoration works on several risk water bodies
- Ecological and geomorphological monitoring of the restored river systems
- To develop a useful and suitable methodology to determine and schedule river restoration works in Wallonia

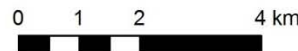
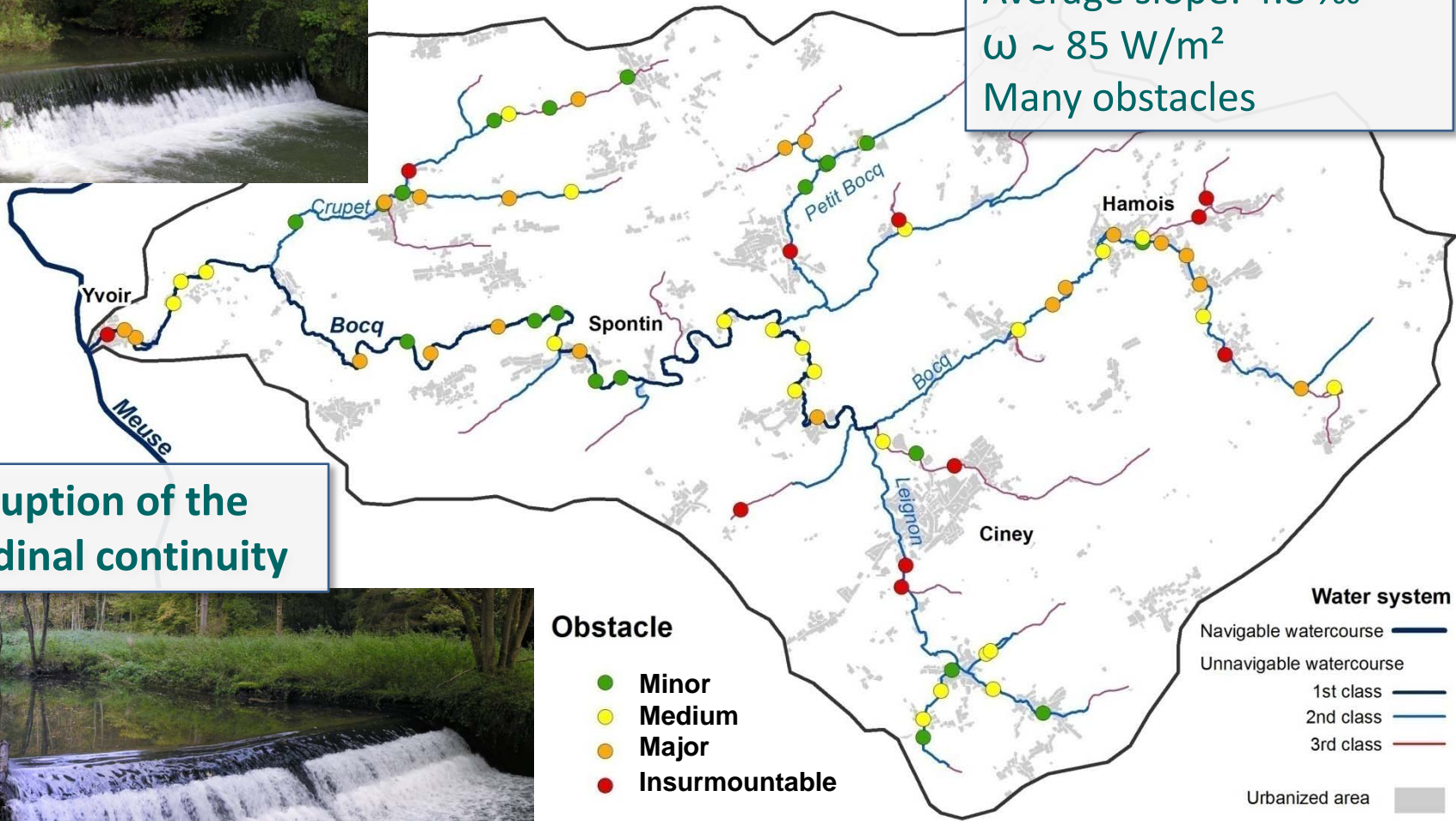
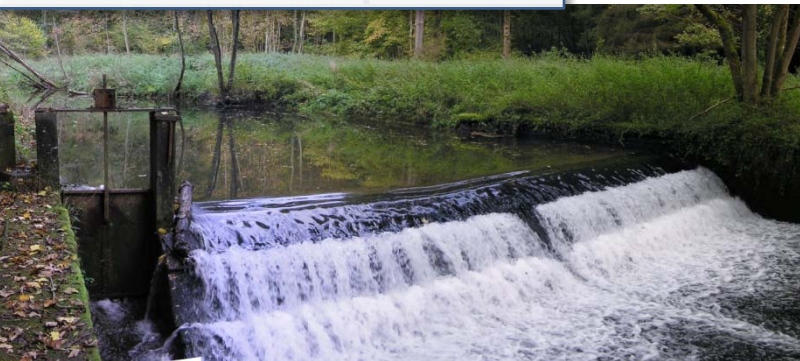


II. River restoration work

Bocq :
 Catchment area: 233 km²
 Average slope: 4.8 ‰
 $\omega \sim 85 \text{ W/m}^2$
 Many obstacles

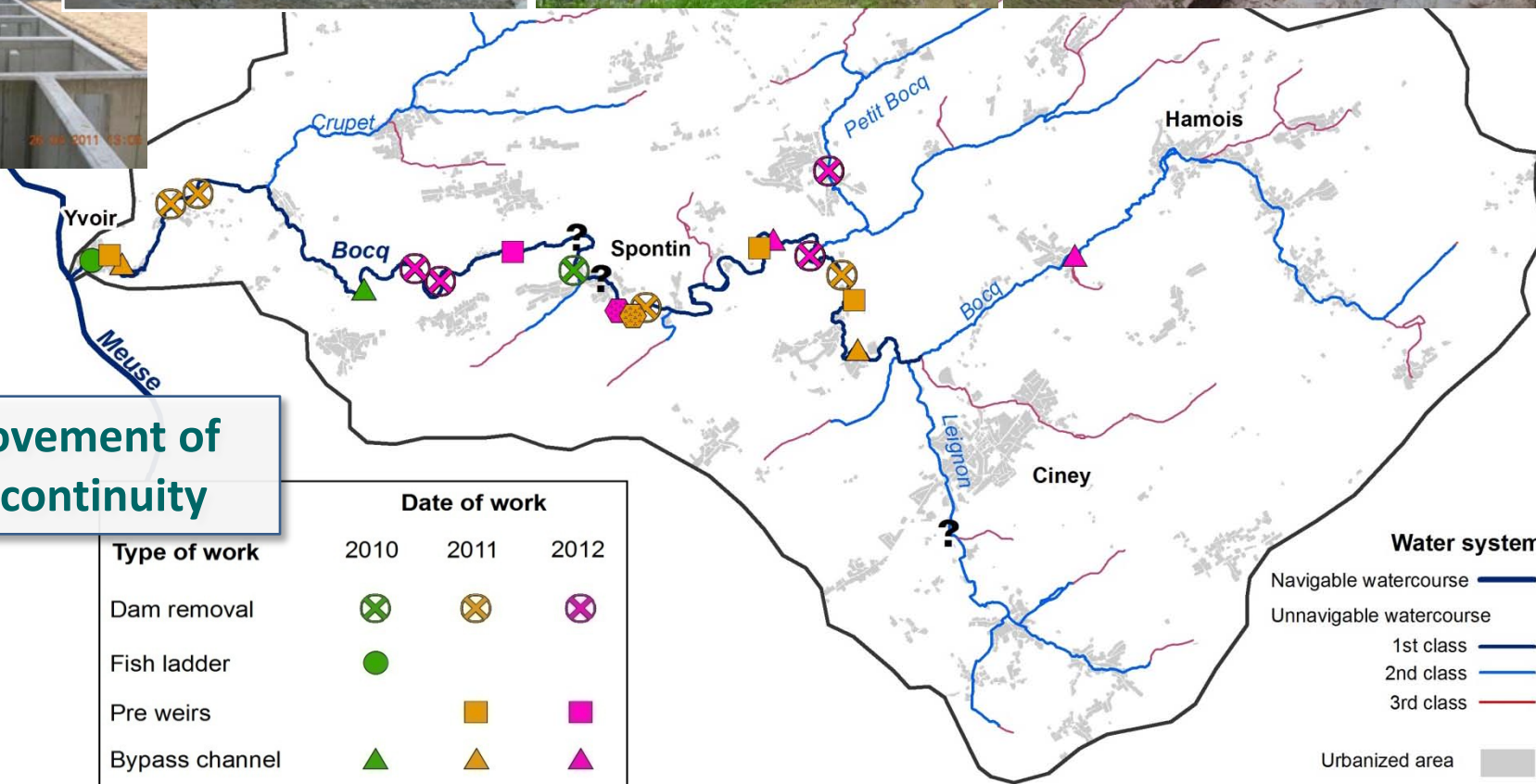


➔ **Disruption of the longitudinal continuity**



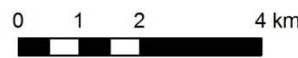
Source : SPW, 2007





➔ Improvement of the river continuity

| Type of work | Date of work | | |
|----------------|--------------|------|------|
| | 2010 | 2011 | 2012 |
| Dam removal | | | |
| Fish ladder | | | |
| Pre weirs | | | |
| Bypass channel | | | |
| Rock ramp | | | |
| Undetermined | | | |



- Water system**
- Navigable watercourse
 - Unnavigable watercourse
 - 1st class
 - 2nd class
 - 3rd class
 - Urbanized area

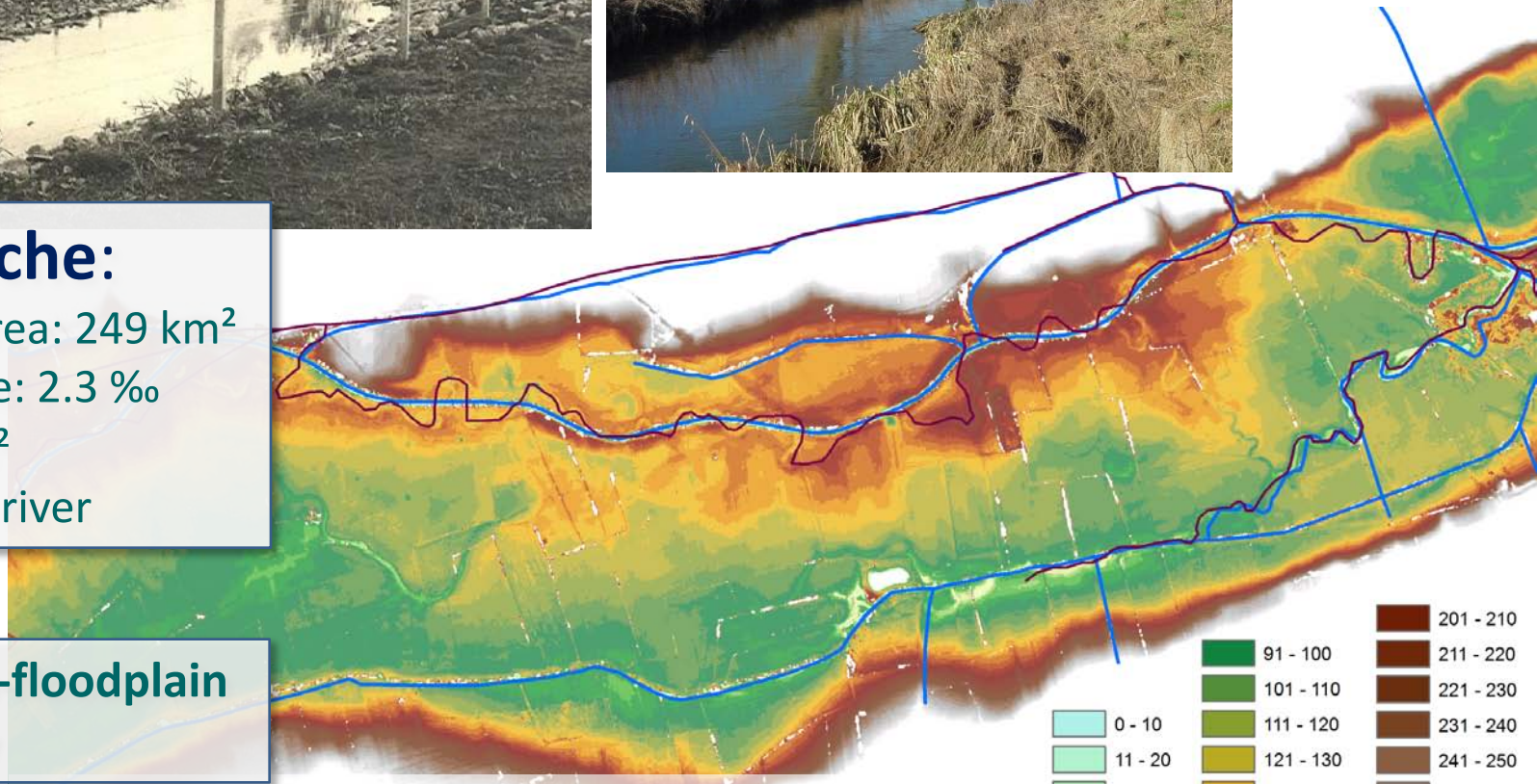




Eau Blanche:
 Catchment area: 249 km²
 Average slope: 2.3 ‰
 $\omega \sim 20 \text{ W/m}^2$
 Straightened river



Poor stream-floodplain connectivity



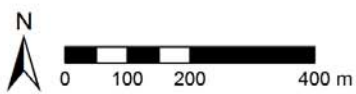
MNT – LIDAR (LAsER Detection And Ranging), 2001

Elevation above water level (cm)

Violet: Watercourse from 1910 (IGM, 1948)

Blue: Current watercourse (SPW, 2004)

| | | |
|---------|-----------|-----------|
| 0 - 10 | 91 - 100 | 201 - 210 |
| 11 - 20 | 101 - 110 | 211 - 220 |
| 21 - 30 | 111 - 120 | 221 - 230 |
| 31 - 40 | 121 - 130 | 231 - 240 |
| 41 - 50 | 131 - 140 | 241 - 250 |
| 51 - 60 | 141 - 150 | 251 - 260 |
| 61 - 70 | 151 - 160 | 261 - 270 |
| 71 - 80 | 161 - 170 | 271 - 280 |
| 81 - 90 | 171 - 180 | 281 - 290 |
| | 181 - 190 | 291 - 300 |
| | 191 - 200 | 301 - 310 |
| | | 311 - 320 |



Varied restoration techniques

Flow deflectors and gravel re-introduction

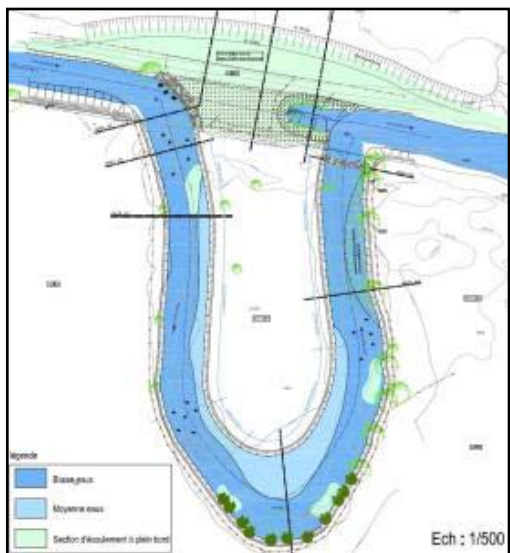
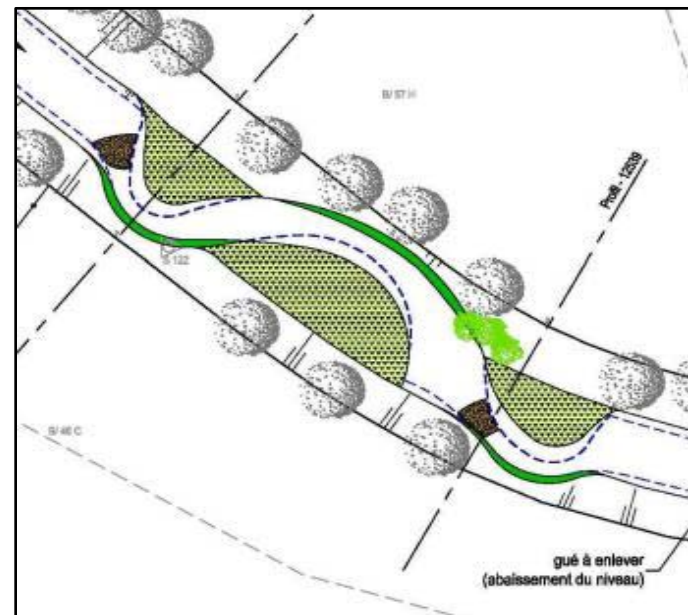


Woody debris



Low level berm

Meandering channel



Reconnecting remnant meander

III. Monitoring: data collection and analysis

Good ecological status (WFD)

Monitoring process

Monitoring process

Biology

Chemistry

Morphology

- Macrophytes index (IBMR)
- Macroinvertebrates indexes
- Electrofishing & fishes index (IBIP)

Seq-Eau index
(Agences de l'Eau, FR)

- Microhabitat survey
- IAM index (Téléos, 1999)
- Tronçon index (Téléos, 1999)

Geomorphology

- Topographic survey and cross sections
- Sediment transport
- Clogging of the gravel bed
- Flood effect on restoration works

Aim : assessing the success of restoration projects

Biology:

Macrophytes: IBMR index (Haury *et al.*, 1998) based on:

- cover,
- ecological amplitude,
- trophic level of taxa.

- Feedback:**
- For long-term monitoring
 - Reflects the quality of water and substrates



Macroinvertebrates: indexes based on:

- abundance,
- diversity,
- species richness,
- specific pollution sensitivity index,
- habitat quality,...

Multiple indexes
 ↓
 Optimized data analysis



Electrofishing and IBIP index (Didier, 1997, Kestemont *et al.*, 2001)
 based on:

- abundance,
- density,
- species richness,...



Morphology:

Microhabitat mapping

a) Water depth model

Field survey of the stream channel:

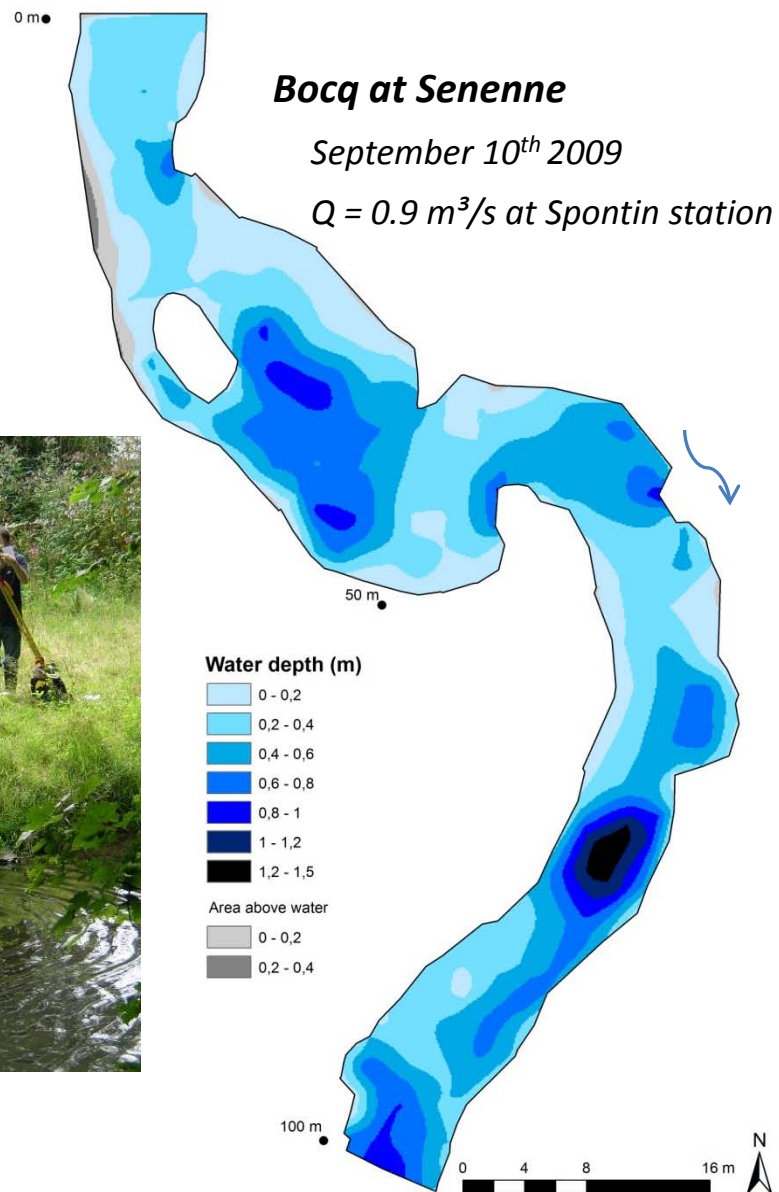
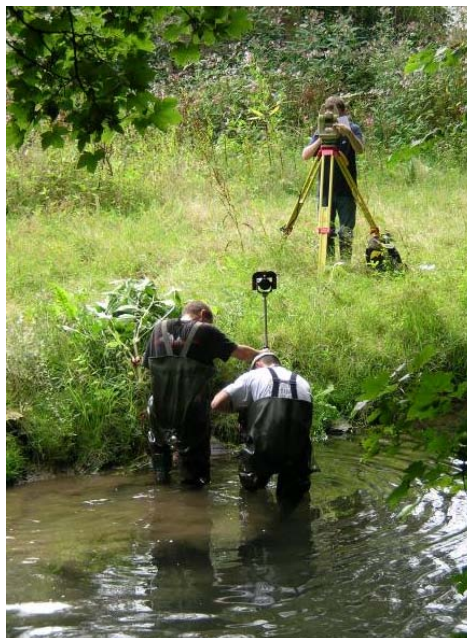
- Stream bed boundary
- Stream bed elevation
- Water surface elevation



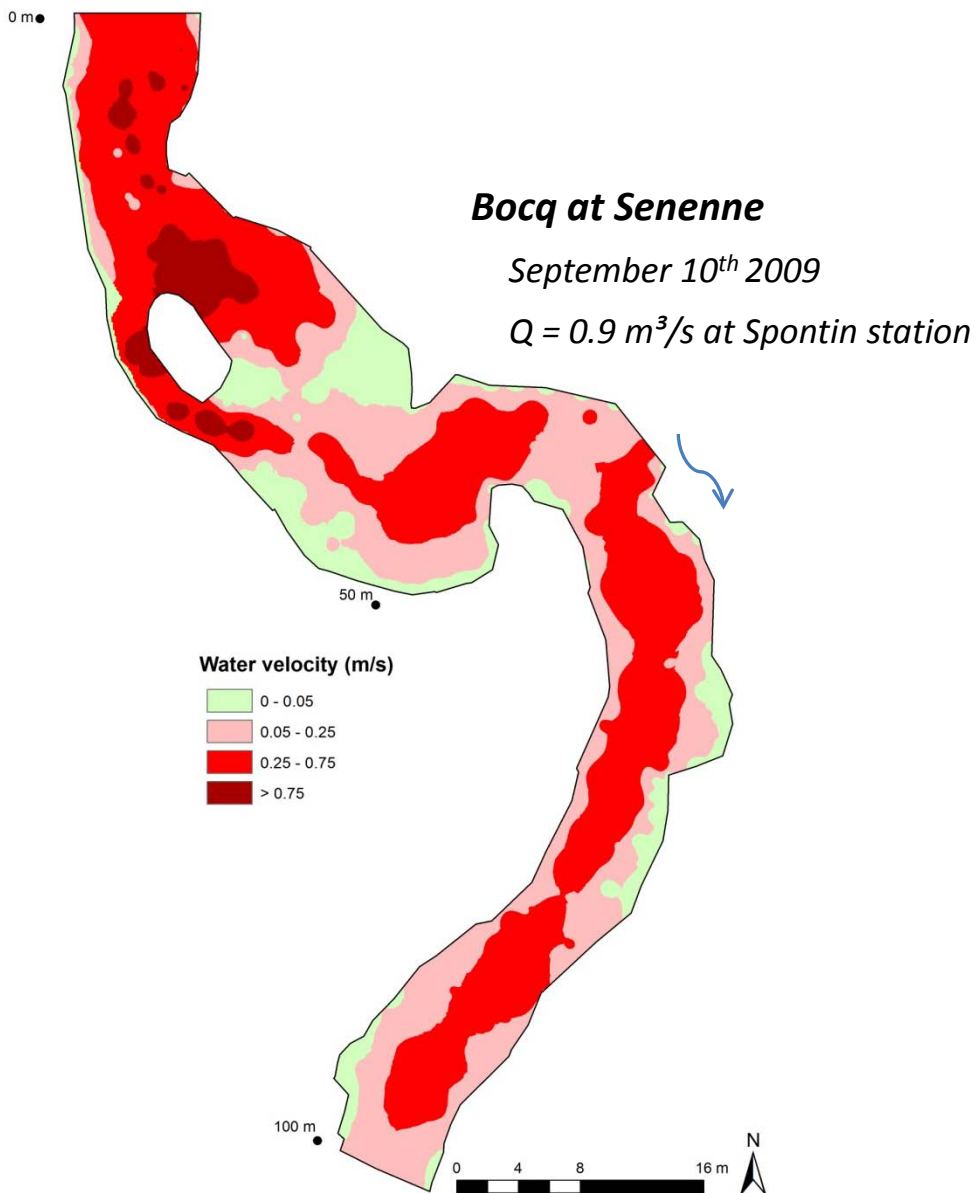
- Stream bed DEM
- Water surface DEM



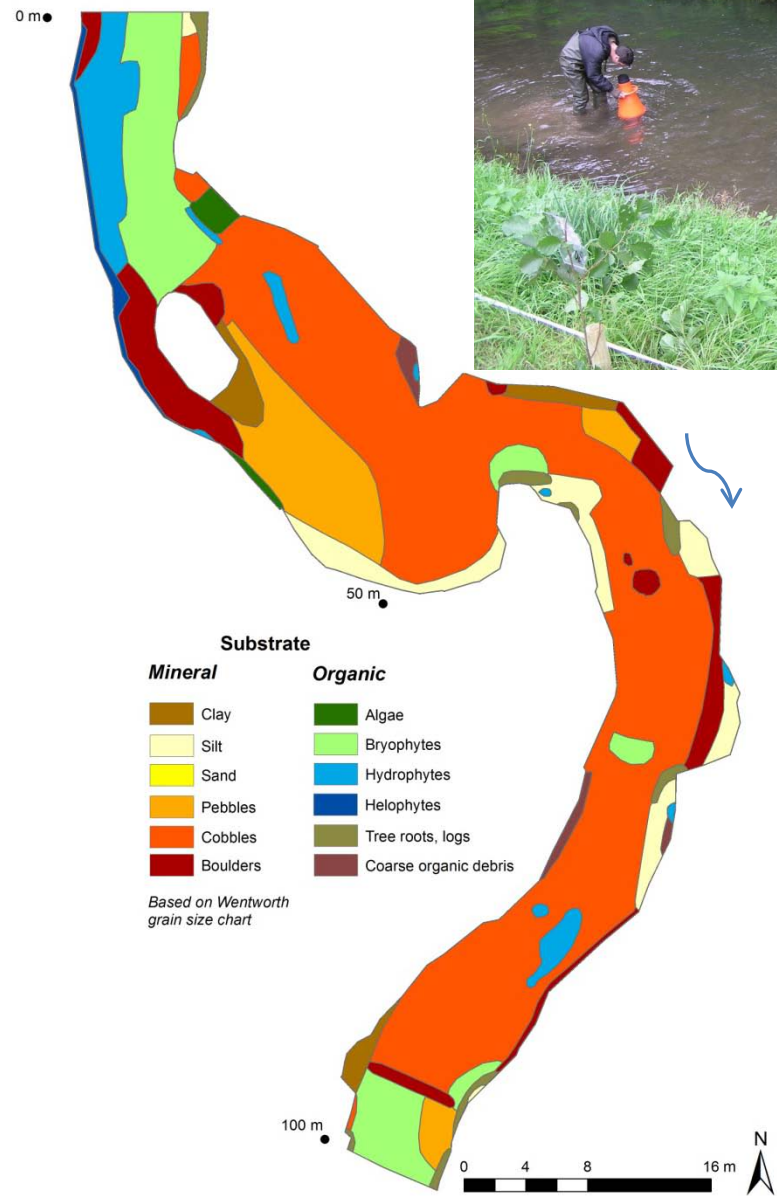
Water depth model



b) Water velocity model

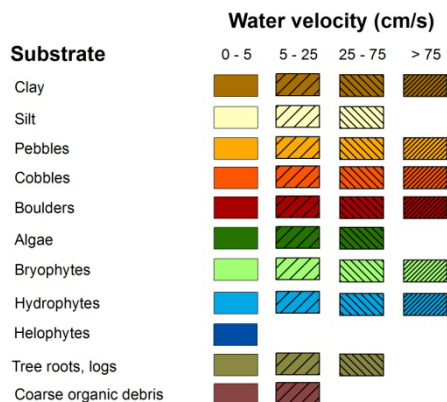


c) Dominant substrate class



Morphology:

Microhabitat mapping

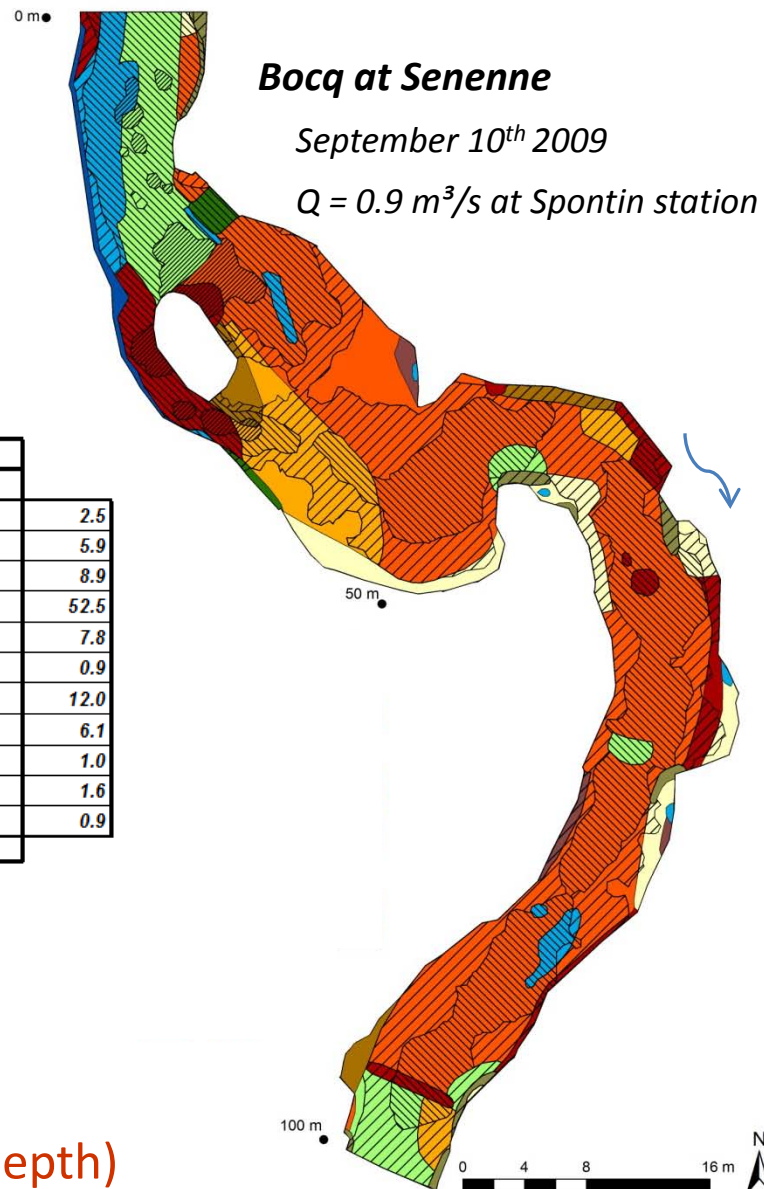


| Area (%) | WATER VELOCITY | | | | |
|-----------------------|----------------|-----------------|------------------|-------------|------|
| | v < 5 cm/s | 5 < v < 25 cm/s | 25 < v < 75 cm/s | v > 75 cm/s | |
| Clay | 1.2 | 0.9 | 0.3 | 0.1 | 2.5 |
| Silt | 3.5 | 2.1 | 0.3 | | 5.9 |
| Pebbles | 1.9 | 4.9 | 2.0 | 0.2 | 8.9 |
| Cobbles | 3.3 | 19.9 | 28.2 | 1.2 | 52.5 |
| Boulders | 0.6 | 2.2 | 3.6 | 1.5 | 7.8 |
| Algae | 0.2 | 0.1 | 0.6 | | 0.9 |
| Bryophytes | 0.2 | 2.8 | 7.3 | 1.7 | 12.0 |
| Hydrophytes | 0.2 | 1.0 | 4.6 | 0.3 | 6.1 |
| Helophytes | 1.0 | | | | 1.0 |
| Tree roots, logs | 0.4 | 1.0 | 0.2 | | 1.6 |
| Coarse organic debris | 0.5 | 0.4 | | | 0.9 |
| | 12.8 | 35.3 | 47.1 | 4.9 | |

Bocq at Senenne

September 10th 2009

Q = 0.9 m³/s at Spontin station



Feedback:

- Good accuracy of the mapping
- Time consuming (field survey)
- Influence by the season (vegetation growth)
- Influence by the discharge (water velocity and depth)

Taken into account when monitoring (before and after restoration work)

Morphology:

Morphodynamic attractivity index (IAM) (Teleos, 1999)

$$IAM_{calculated} = \left(\sum_1^n (Si * Attract.(subs.)) \right) * Var(subs.) * Var(he) * Var(v)$$

Si = Area of the *i* substrate

Attract. = attractivity of the *i* substrate for the fish

n = Number of substrate

Var(subs.) = Number of substrate

Var(he) = Number of depth class

Var(v) = Number of water velocity class

“IAM calculated” compared to “IAM reference”

| Substrate | Attractivity |
|--------------------------------|--------------|
| Root wads, woody coarse debris | 100 |
| Undercut banks | 90 |
| Hydrophytes | 80 |
| Boulders (with fish caches) | 60 |
| Cobbles | 50 |
| Helophytes | 40 |
| Root mats | 40 |
| Boulders (without fish caches) | 30 |
| Mix of pebbles and cobbles | 25 |
| Pebbles | 20 |
| Organic debris | 10 |
| Sands | 8 |
| Clay and silt | 4 |
| Mud | 3 |
| Concrete surface and slab | 1 |
| Affluents, spring | +25% |

Feedback:

- Easily calculated from the microhabitat mapping
- Same remarks as for the microhabitats
- Provides fish habitat predictions
- Index with a fish orientation
- Useful for monitoring

Morphology:

Tronçon index (Teleos, 1999)

| Heterogeneity (H) | | Attractivity (A) | | Connectivity (C) | | Stability (S) | | PHYSICAL QUALITY | |
|-------------------|---------|------------------|---------|------------------|---------|------------------------------|-----------|--------------------------------------|---------------|
| score of 111 | | score of 90 | | score of 130 | | score from -60 to +40 | | = (H + A) x C x K Score of 30 600 | |
| A | ≥ 50 | A | ≥ 45 | A | ≥ 65 | Sedimentation | > +10 | A | ≥ 6 500 |
| B | 40 - 49 | B | 34 - 44 | B | 49 - 64 | Balance | -10 / +10 | B | 3 500 - 6 500 |
| C | 28 - 39 | C | 23 - 33 | C | 33 - 48 | Erosion | -25 / -10 | C | 1 500 - 3 500 |
| D | 14 - 27 | D | 11 - 22 | D | 16 - 32 | Strong erosion | -60 / -25 | D | 400 - 1 500 |
| E | ≤ 13 | E | ≤ 10 | E | ≤ 15 | <i>Gives a K coefficient</i> | | E | < 400 |



| K | -60 < S < -26 | -25 < S < -11 | -10 < S < 9 | 10 < S < 40 |
|--------|---------------|---------------|-------------|-------------|
| H ≥ 50 | K = 0.85 | K = 1 | K = 1.25 | K = 0.75 |
| H < 50 | K = 0.85 | K = 1 | K = 0.85 | K = 0.75 |

Heterogeneity

Sinuosity, diversity of width, depth, flow, substrate, presence of backwaters,...

Attractivity

Spawning ground, hiding places, presence of backwaters,...

Connectivity

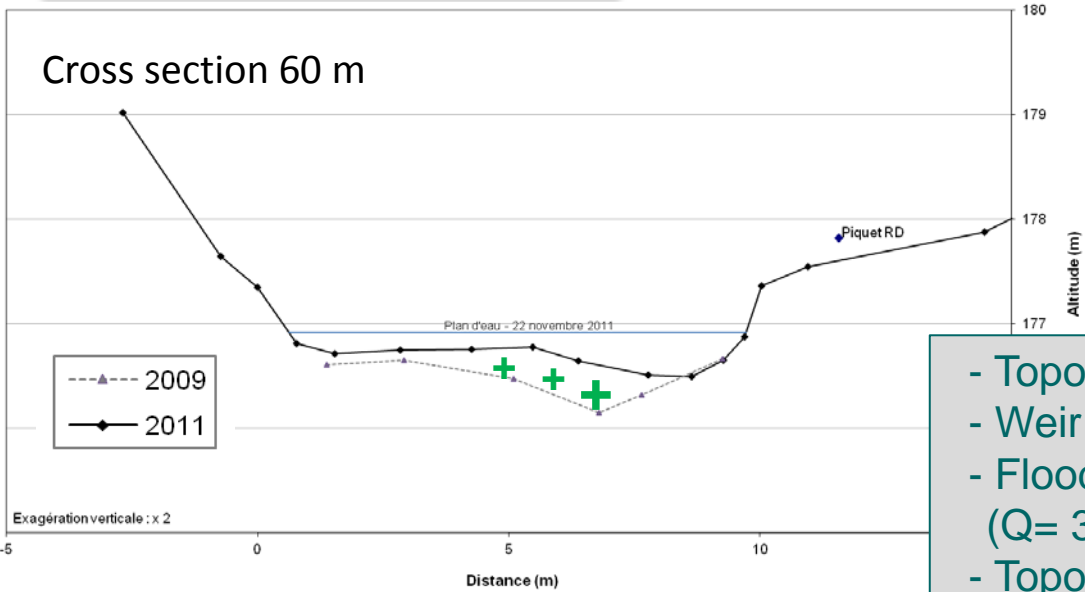
Obstacles, banks, riparian areas,...

Feedback:

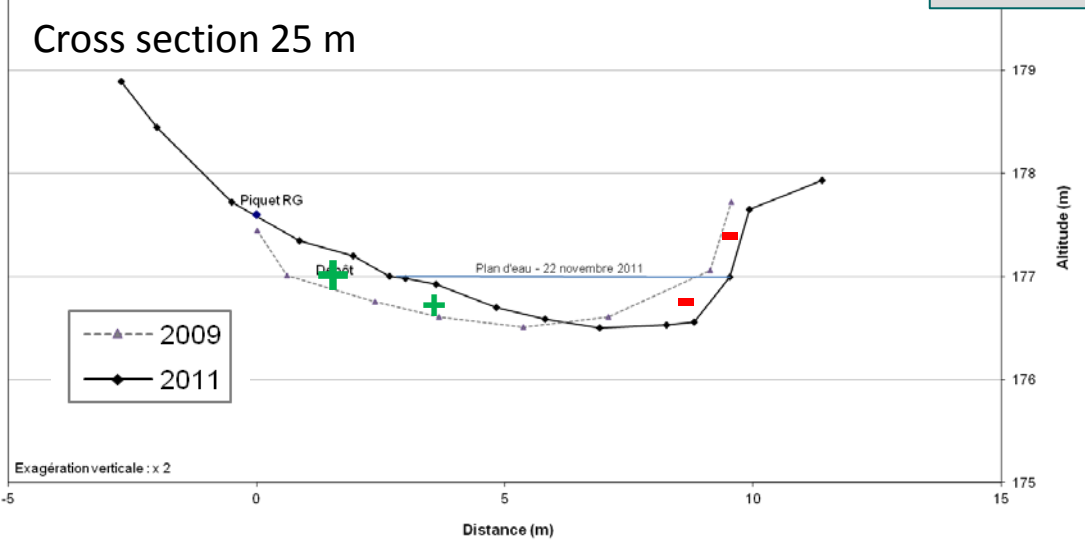
- Uneasy-to-use codage file
- Semiquantitative method
- Index with a fish orientation
- Useful subindexes to define problems (pre project) and for monitoring

Geomorphology: Topographic survey and cross sections

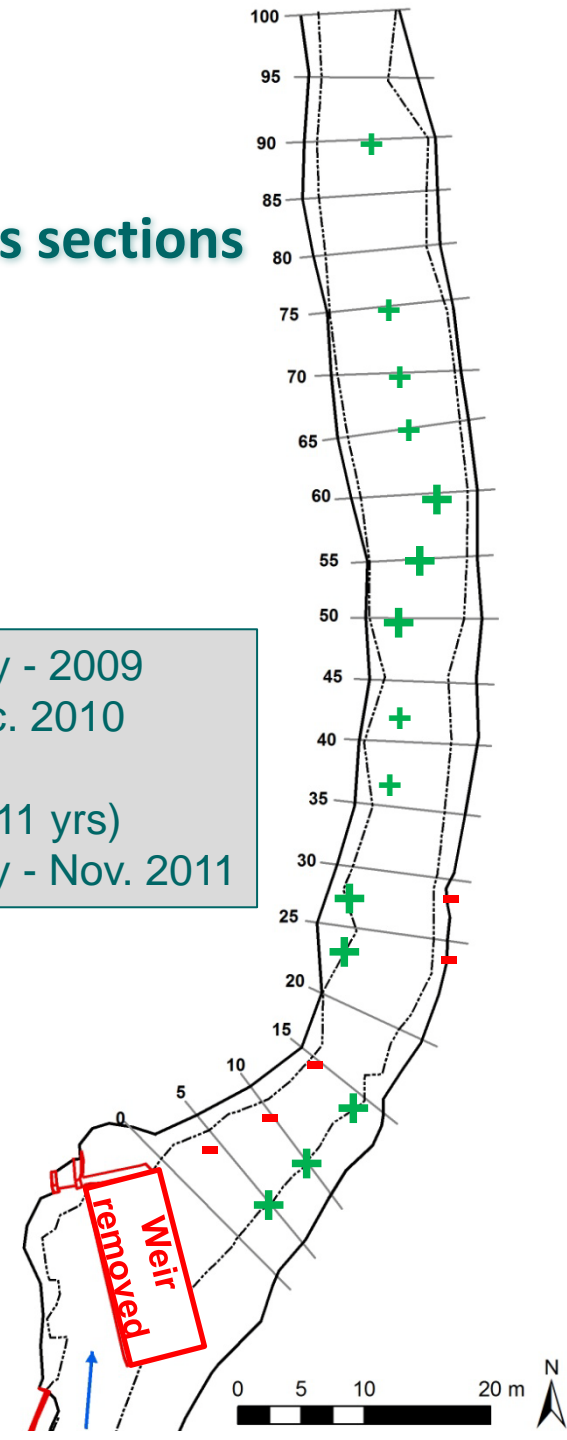
Cross section 60 m



Cross section 25 m



- Topographic survey - 2009
- Weir removal - Dec. 2010
- Flood - 7/01/2011 (Q= 33,8 m³/s ; T~ 11 yrs)
- Topographic survey - Nov. 2011



Geomorphology: Sediment transport

Evaluating bedload mobility using traced pebbles and PIT-tags

PIT tagged pebbles placed in rivers at:

- reference reaches
- reaches impacted by obstacle (e.g. upstream of weir)
 - ➔ enable to highlight restoration of free movement of sediment
- reaches with spawning gravel reintroduction
 - ➔ enable to characterize the mobility of new spawning gravel

Feedback:

- Allows particles with b-axis of 20 mm to be traced
- Do not contain a battery
- Great recuperation rate (more than 80%)
- Requires expensive equipment
- Provide useful information (bedload movement discharge, distances travelled, granulometric indexes)



Geomorphology: Clogging of the gravel bed

Sediment traps buried into the gravel bed on:

- reference reaches
- reaches impacted by restoration work
- reaches with gravel reintroduction

Feedback:

- Susceptible to loss (flood, scour,...)
 - Cannot be used in water deeper than 0.8m
 - Time-consuming (laboratory analysis)
 - Installation does not provide natural conditions (breaking of the armour layer)
- ➔ Suitable to evaluate short period of work



Wooden stakes inserted into the gravel bed on:

- reference reaches
- reaches with gravel reintroduction

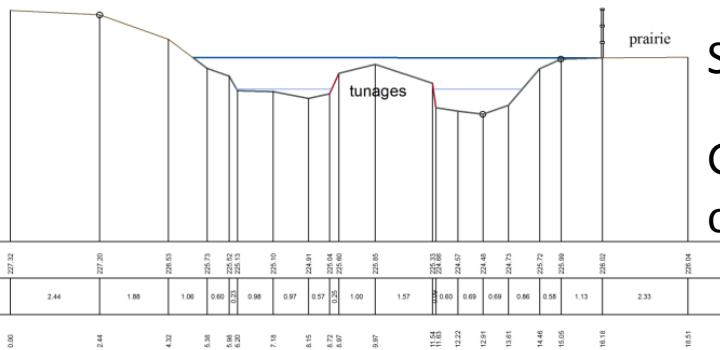
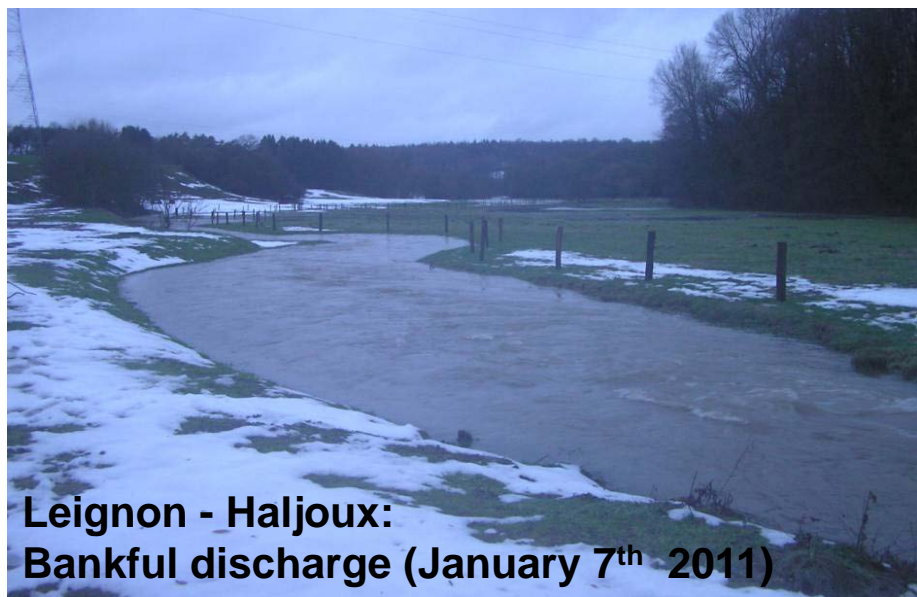
Feedback:

- Qualitative method
- Simple technique to implement



Geomorphology: Flood effect on restoration works

Restoration works and their stability and resistance to erosion: related to flood characteristics (discharge, recurrence, specific stream power, shear stress)



Slope of the water surface
+
Geometrical characteristics
of the wetted cross-section
+
Discharge



- Specific stream power
- Shear stress



Thank you for your attention

DCENN : Francis Lambot – Bernard de le Court – Louis-Michel Petiau - Olivier Desteucq – Pierre Joye

ULg / LHGF : Alexandre Peeters – Eric Hallot – François Petit

FUNDP / URBE : Gisèle Verniers – Jean-Pierre Descy