River Bed Stabilization by Initiated Natural Morphological Development – Prediction and Reality
CONTENT

1. Where, Why, What, When?
2. Forecasting of natural river development (physical and numerical models)
3. What has happened since initiation of the natural process?
4. Comparison: Prediction – Reality
5. Conclusions
WHERE?

Lower Salzach, 15 km downstream of the city of Salzburg
Catchment area = 6 112 km² (gauging station Laufen)
Mean flow = 250 m³/s
HQ100 = 3 100 m³/s
WHY? (THE PROBLEM)

Erosion of the river bed (up to 5 meters in a 50 km long river stretch, in more than 100 years)

Implications are:

• Cut off of surrounding wetlands (Nature 2000 areas)
• Hostile river banks
• Falling groundwater table
• Risk of accelerated erosion in fine sediments below of the gravel river bed, especially during floods
• Risk of flood damages
WHY? (AIMS OF THE PROJECT)

1. Turn the erosion process in a stabilization and if possible in a controlled sedimentation process
2. Flood protection
3. Ecological improvement of river and wetlands (aquatic and terrestrial with cross-links)

Photo: P. Stockhammer, 2004
WHAT? (THE CONCEPT FOR 30 RIVER-KM)

Dried wetlands

Old bed

100 m (current)

Existing river bed

Bed erosion

Graphic: BAW-IWB
WHAT? (THE CONCEPT FOR 30 RIVER-KM)

Graphic: BAW-IWB
WHAT? (THE CONCEPT FOR 30 RIVER-KM)

Lateral erosion
To wetlands

Old bed

New bed

Ramp with boat lane

To wetlands

Rising river bed and water level

Step pool ramp
(slope 2 % or less)

Existing river bed

100 m (current)

130 m (future bed width)

Space for free morphological dynamic

Lateral erosion

Graphic: BAW-IWB

Enough space to fine bed material like sand and silt
WHAT? (THE CONCEPT FOR 30 RIVER-KM)

Lateral erosion
To wetlands

New bed
To wetlands

Ramp with boat lane

Lateral erosion
Space for free
morphological dynamic

Rising river bed and water level

Step pool ramp
(slope 2 % or less)

Enough space to
fine bed material
like sand and silt

Please note: the project presented here is only one step of this concept

Graphic: BAW-IWB
WHAT? (IMPLEMENTATION OF THE CONCEPT)

Build a Ramp + remove the bank protection downstream, for about 3 km, on both sides.

WHEN?


Free morphological dynamic in limited areas (left and right respectively 30 to 40 m), maximum bed width about 200 m (doubled)
SALZACH WITH RAMP

Bank protection removed

Photo: Province Upper Austria 2010-10-06
FREE NATURAL BANK EROSION – PREDICTION

1. Physical Model Tests
   (Austrian Federal Water Management Agency + TU Wien)

2. Numerical Modelling
   Model “Uferlos“ (“Boundless”),
   developed by Tobias Hafner at TU München;
   Background for the calculations: Physical Model Test Salzach + additional bank erosion experiments.
PHYSICAL MODEL TESTS

- Model-Scale 1:50,
- Model-Area 53 x 10 m,
- 18 morphological years were simulated (floods with different peaks),
- Homogeneous bed load (1 grain size distribution for the whole model)
FINE SAND ON TOP OF THE GRAVEL

Photo: M. Hengl
BANK EROSION – PREDICTION from MODEL TESTS

Result is based on:
floodplains with 3 m gravel layer and fine sand above

Flow guidance measures to enhance bank erosion

Source: WRS, 2001
PREDICTION – NUMERICAL MODEL

Based on: ÖWAV, 2012

HQ x…return period of a flood (x…years)
OBSERVATIONS – GAUGE at LAUFEN

Discharge (cubicmeters per second) vs. Time (hours)

HQ 100
HQ 30
HQ 1

Discharge (cubicmeters per second)
Time (hours)

2010-06-03
2013-06-02

HQ x…return period of a flood (x…years)
OBSERVATIONS – CROSS-SECTIONS (1)

Note: Vertical length 6 times higher than horizontal

km 51,000

2005
March 2010
October 2010
August 2013

Same scale for vertical and horizontal length
OBSERVATIONS – CROSS-SECTIONS (2)

Photo: M. Hengl (June 2012)
COMPARISON OBSERVATION – PREDICTION

- Constructed widening
- After flood 2010
- After flood 2013

Graph showing:
- Bank erosion (meter) vs. Duration (years)
- Measured data
- Model tests
- Numerical model

1 year
3 years
0 1 2 3 4 5 6

Data points:
- 1 year: 0, 5, 10, 15, 20, 25, 30, 35
- 3 years: Measured data points
- Model tests: 1 year, 3 years
- Numerical model: 1 year, 3 years

Legend:
- ▲ Measured
- Green line: Model tests
- Blue line: Numerical model

2016-10-12
INFLUENCE ON RESULTS – PRESENT

Wooden piles of an old bank protection

Photo: M. Hengl (1 month after flood 2013)
INFLUENCE ON RESULTS – IN THE FUTURE

Emerging vegetation

Photo: M. Hengl (June 2016, 3 years after the flood 2013)
CONCLUSIONS (1 of 2)

1. Free lateral bank erosion can be predicted (the effort is still high).

2. Models can describe only parts of the natural processes.

3. Forecasting quality depends on available data (especially geology of bank erosion zone).
CONCLUSIONS (2 of 2)

4. Currently uncertainties can be covered only by expert knowledge.

5. Natural morphological development depends on the hydrology – no flood, no development!

Natural River Development = Benefit for

- Flood Protection AND
- Ecology AND
- Recreation AND …
THANK YOU.

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