"Modelling sediment supply towards, and sedimentation processes in unnavigable watercourses"

SEDNET – 08/10/2013

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IV Results

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lne. Departement Leefmilieu, Natuur en Energie

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I Motivation for study

- Predict dredging works

- 1,400 km watercourse management
- Estimated annual inflow: 150,000 m³
- Budget : approx. 5 million € /year
- Treatment cost (2012): 30€/m³

	2007	2008	2009	2010	2011	2012
Total volume (m³)	155.613	164.995	138.116	56.804	124.281	195.260
Total budget (euro)	7.251.961	5.682.751	4.273.747	2.464.204	2.591.090	5.879.741
Average treatment cost (euro)	47	34	31	43	21	30

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I Motivation for study

- Location sediment ponds

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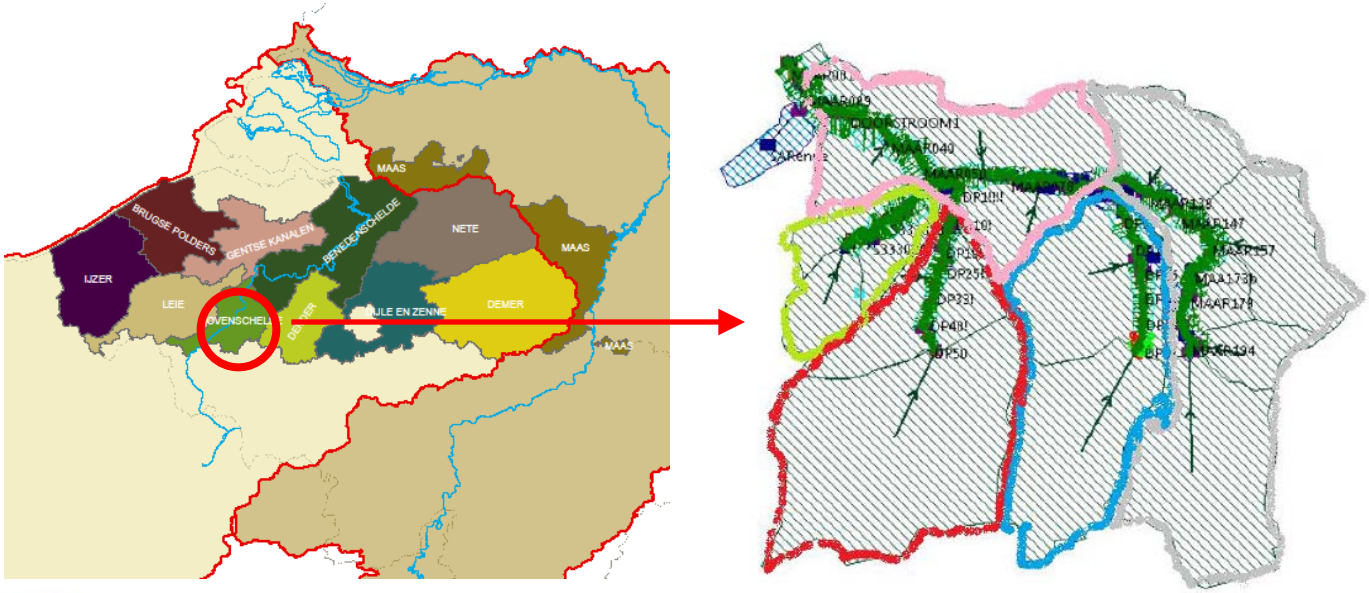
I Outline study

- Sediment export (=erosion) – hydrological modelling
  - ✓ soil conservation measures
  - ✓ = Watem/Sedem, LISEM (KULeuven)
  - ✓ Input sediment load into hydraulic models
- Connecting soil to river – connectors
  - ✓ Sewerage network, ditches, roads
- Sediment tranport – hydraulic modelling
  - ✓ river restoration scenarios
  - ✓ Infoworks RS (detailed), Infoworks ICM (simplified) = 1D
  - ✓ Deposition, erosion & resuspension

I Outline study

- Both models:
  - First application of detailed model for 7 catchments
  - Then simplify model
  - Application of simplified model for all catchments

- In this presentation: first test resuts for catchment Maarkebeek



IICalibration data

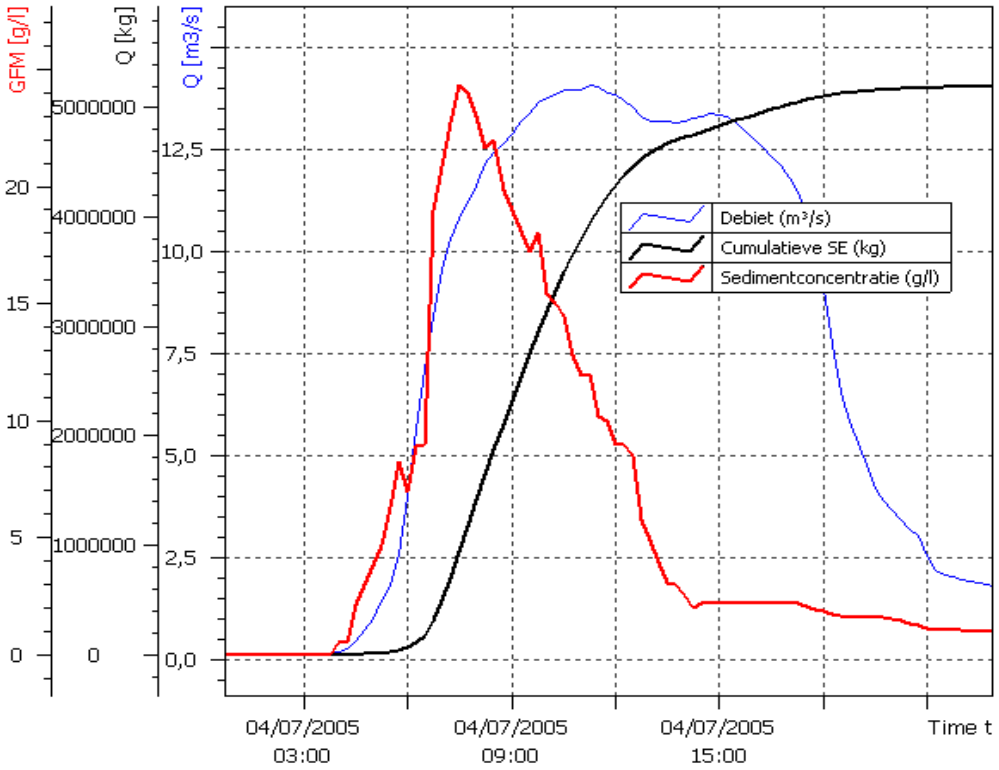
- Sediment transport data:

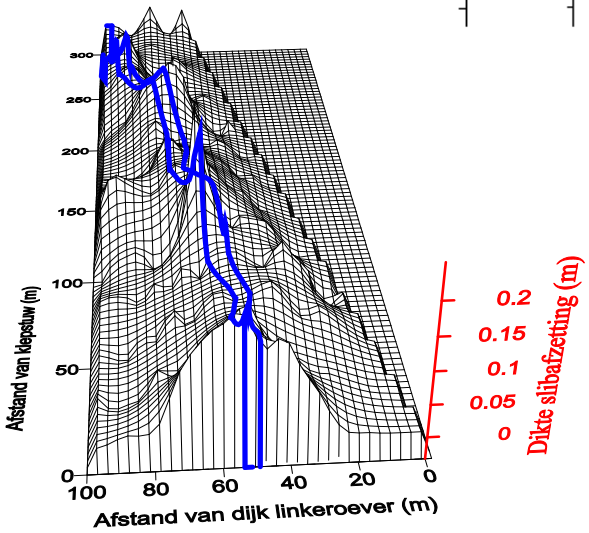
100 years 15’ SSC data (100-1000

- Bathymetrical data of

10 sedimentation zones &

5 retention basins





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III Challenges tackeled so far - River

Sediment continuity equation

$$(1-\lambda)\,W\,\frac{\partial z}{\partial t}+\frac{\partial G}{\partial x}=0 \qquad (1)$$

where:

λ = bed porosity

W = water surface width

z = bed elevation

t = time

G = sediment transport rate (m^3/s)

x = distance in flow direction

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III Challenges tackeled so far - River

Replacing spill units

Mode 4 - Free weir flow under gate

Condition	$h_o \geq 0.001$ $h_2/h_1 \leq m$ $0.005(L - r) < h_1 < 1.5\, h_o$ $h_2 < h_o$
Equation	$Q = C_d\, C_{vm} (2/3)^{1.5} \sqrt{g}\, b\, h_1^{1.5}$ (3) where: $C_d = [\,1 - \delta (L - r)/b\,][\,1 - (\delta / 2h_1)(L - r)\,]^{1.5}$ $r = 0.1$ $\delta = 0.01$ g = gravitational acceleration (m/s^2)
Fixed Modular Limit Equation	$Q = C_{vm} (2/3)^{1.5} \sqrt{g}\, b\, h_1^{1.5}$ (3a)

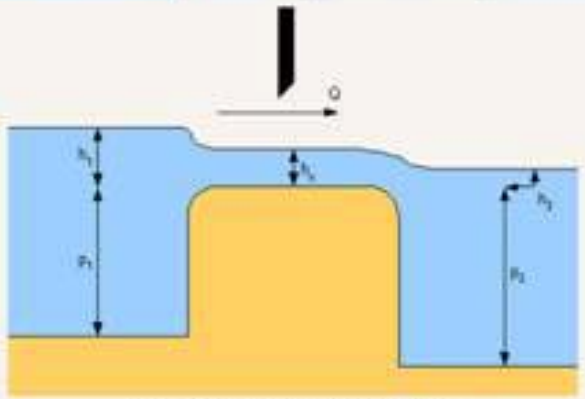

Figure 5: Vertical Sluice Gate (Mode 4)

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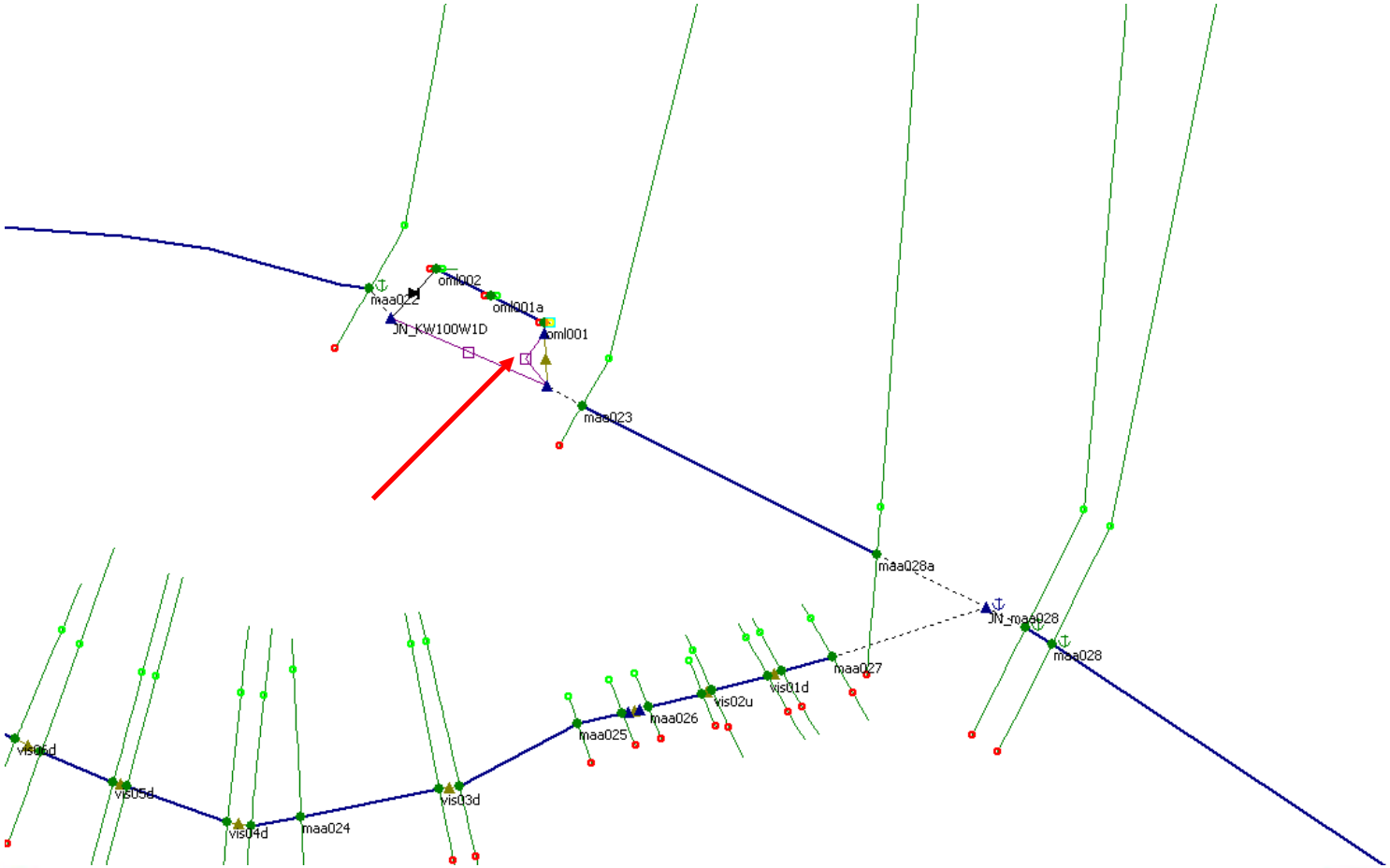
III Challenges tackeled so far - River

Stability

III Challenges tackeled so far - River

Stability



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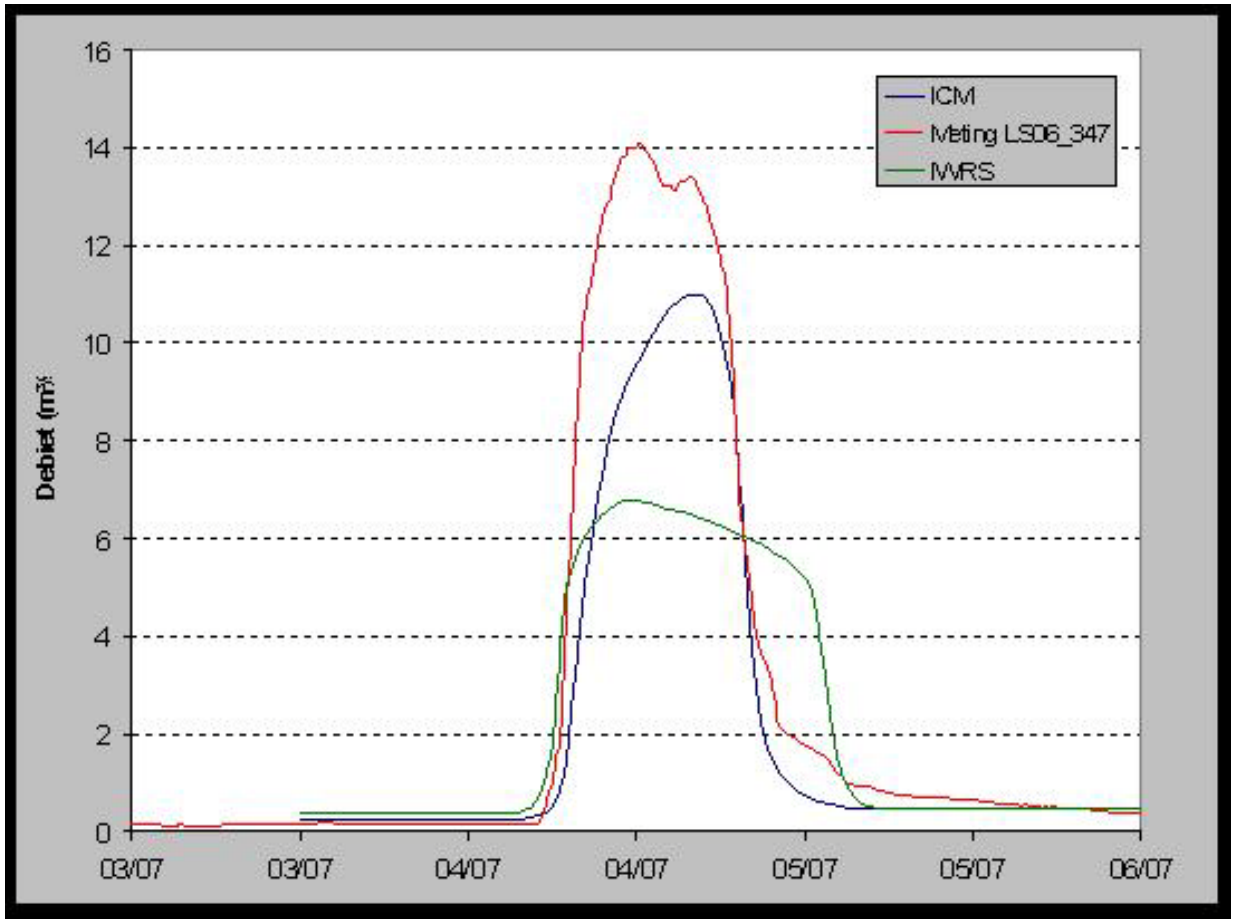
III Challenges tackeled so far - River

In bank model vs model including flood areas



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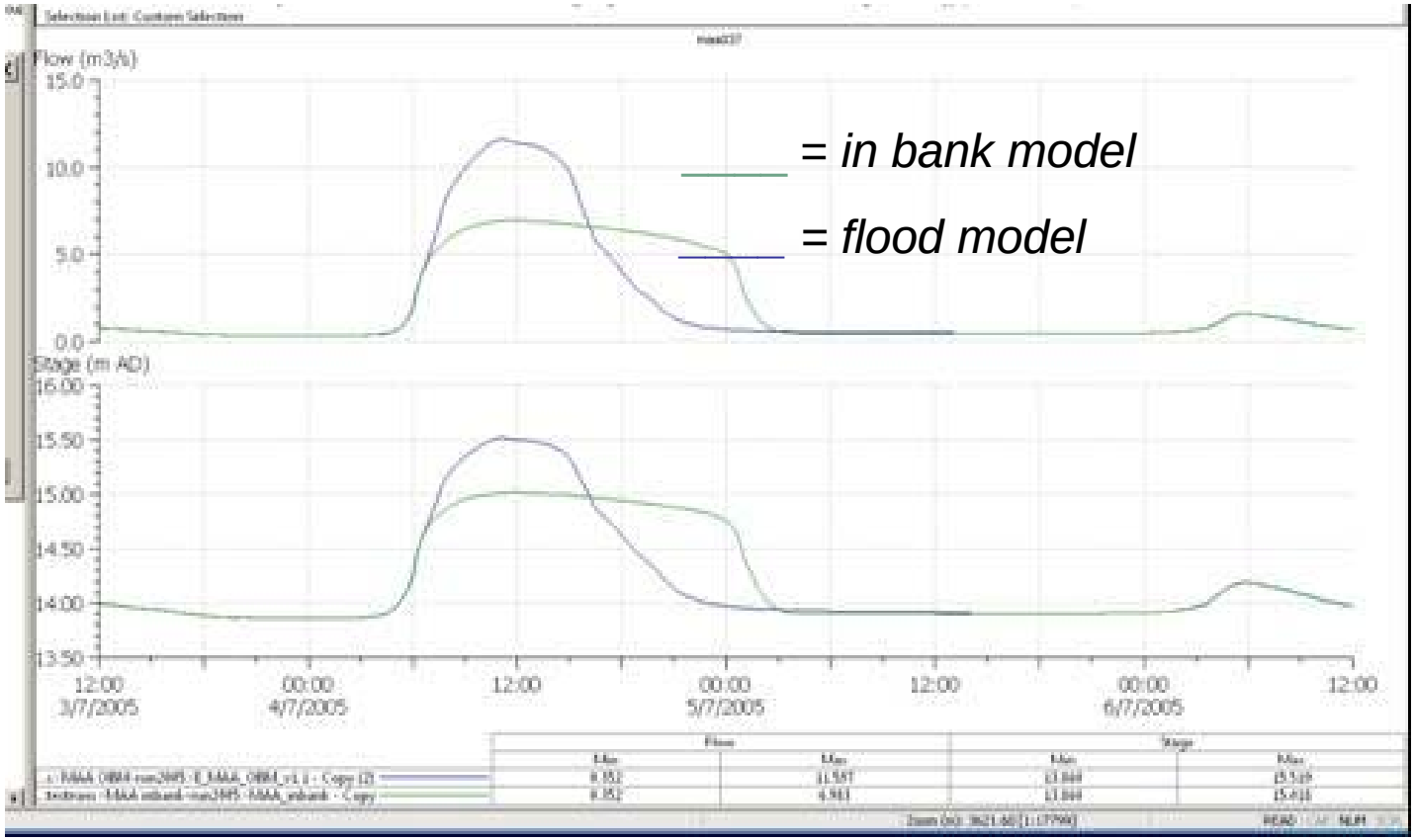
III Challenges tackeled so far - River

In bank model vs model including flood areas

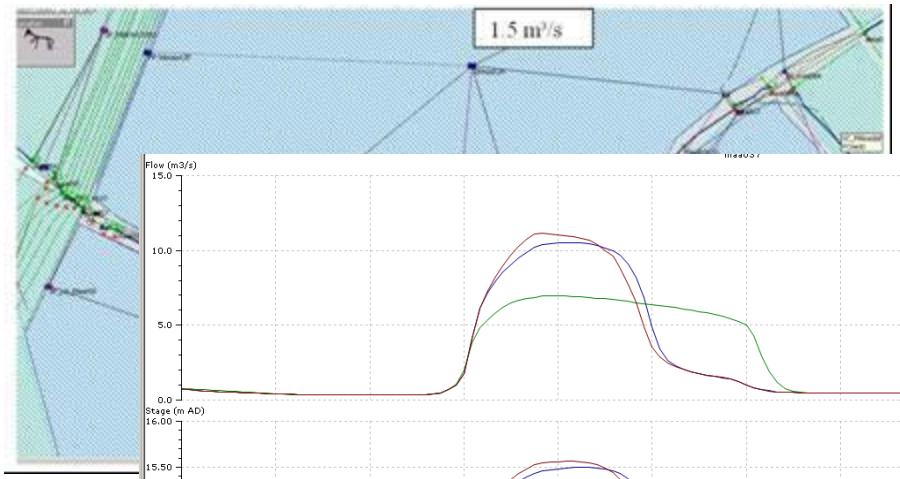


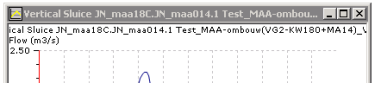
III Challenges tackeled so far - River

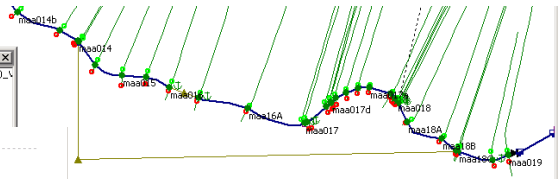
In bank model vs model including flood areas

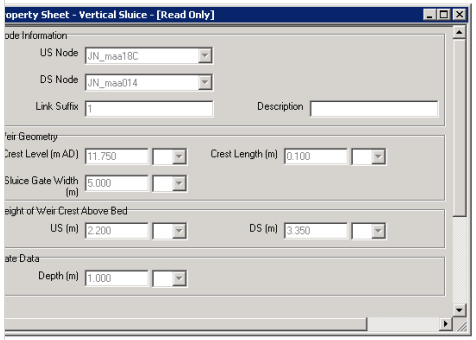
- Flooded structures: adding flooding volumes by vertical sluices
- Flooded river banks:

  → example confluence Nederaalbeek - Molenbeek (KW180)









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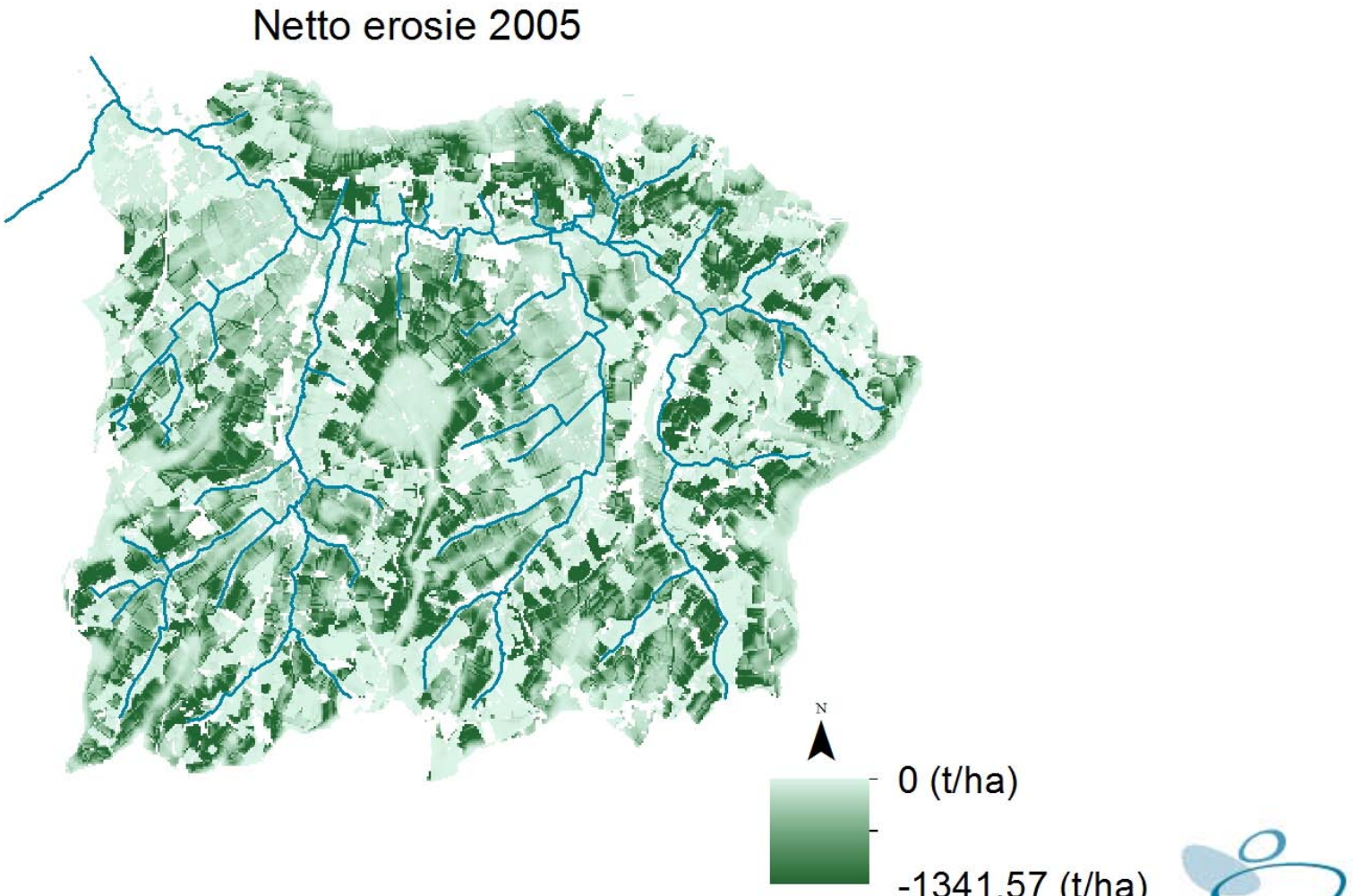
IV Results - soil

WaTEM/ SEDEM



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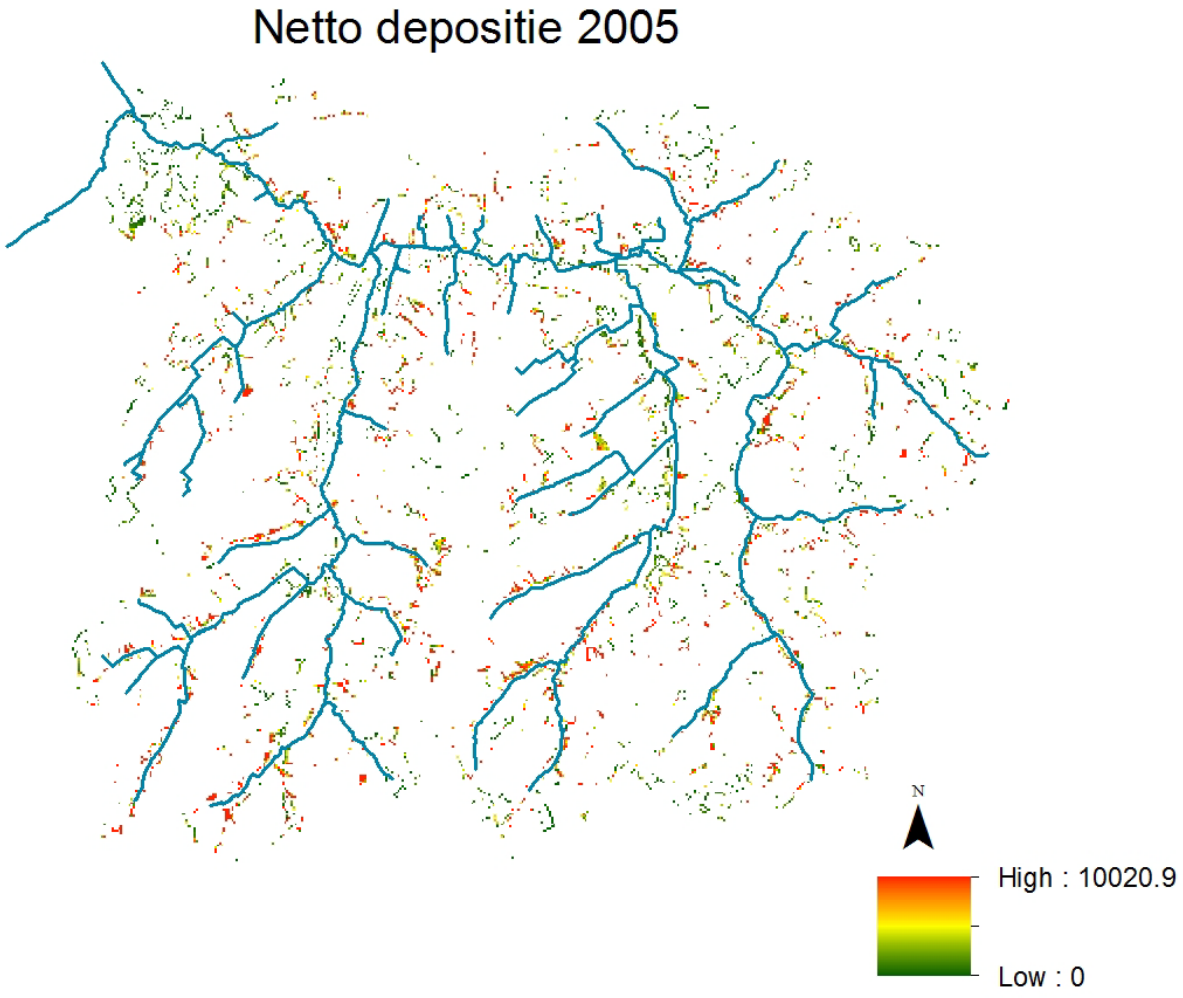
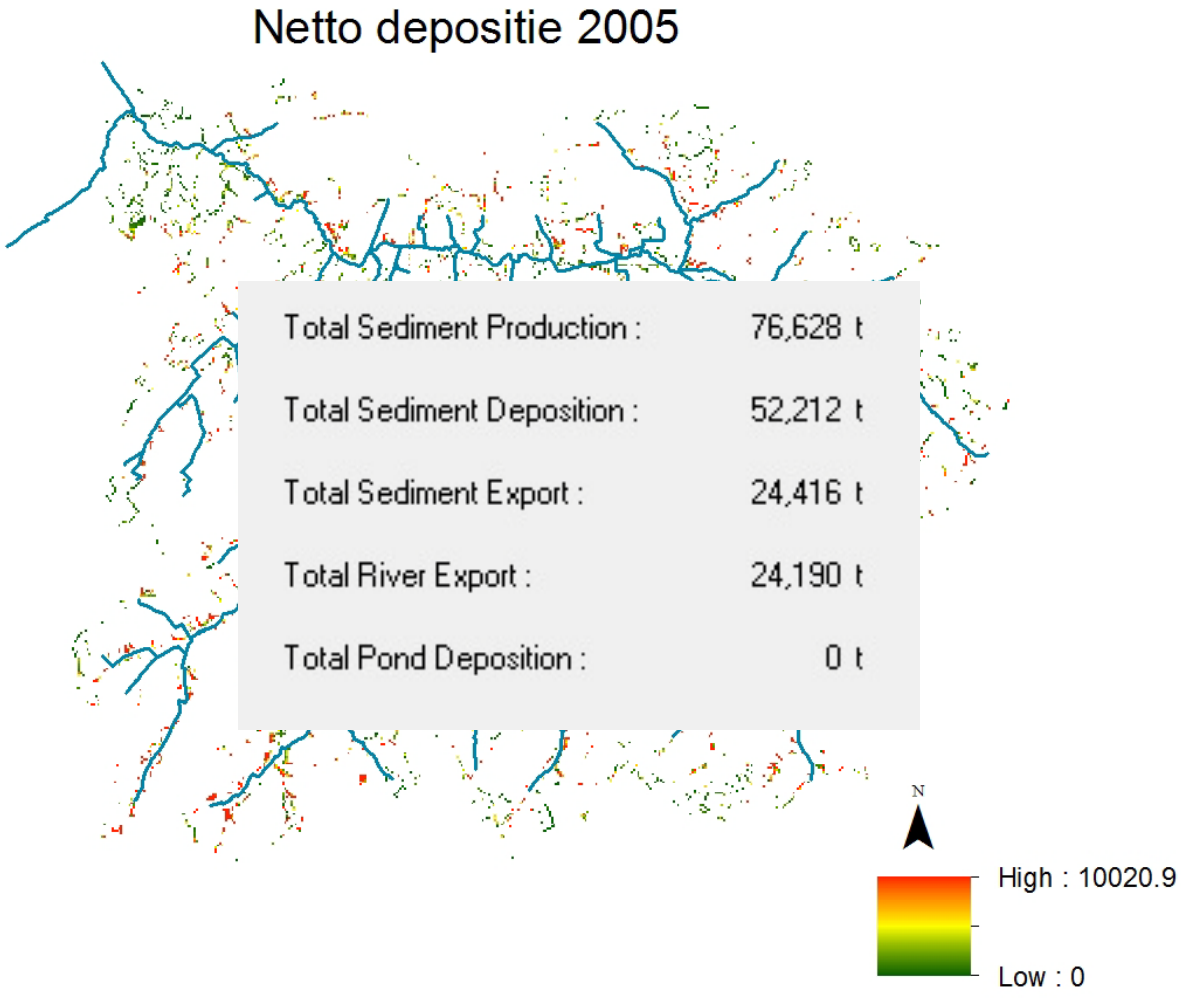
IV Results - soil

WaTEM/ SEDEM



IV Results - soil

WaTEM/ SEDEM



IV Results - soil

WaTEM/SEDEM: output for each VHA segment

	A	B	C	D
1	River_id	Hillslope sediment input	Sediment input upstream river	Sediment output river
2	1	395	0	395
3	2	210	0	210
4	3	356	0	356
5	4	204	395	598
6	5	219	356	575
7	6	253	0	253
8	7	13	0	13
9	8	219	0	219
10	9	313	210	524
11	10	165	219	384
12	11	0	384	384
13	12	81	13	94
14	13	922	0	922
15	14	615	0	615
16	15	85	709	793
17	16	245	1174	1419

IV Results - River

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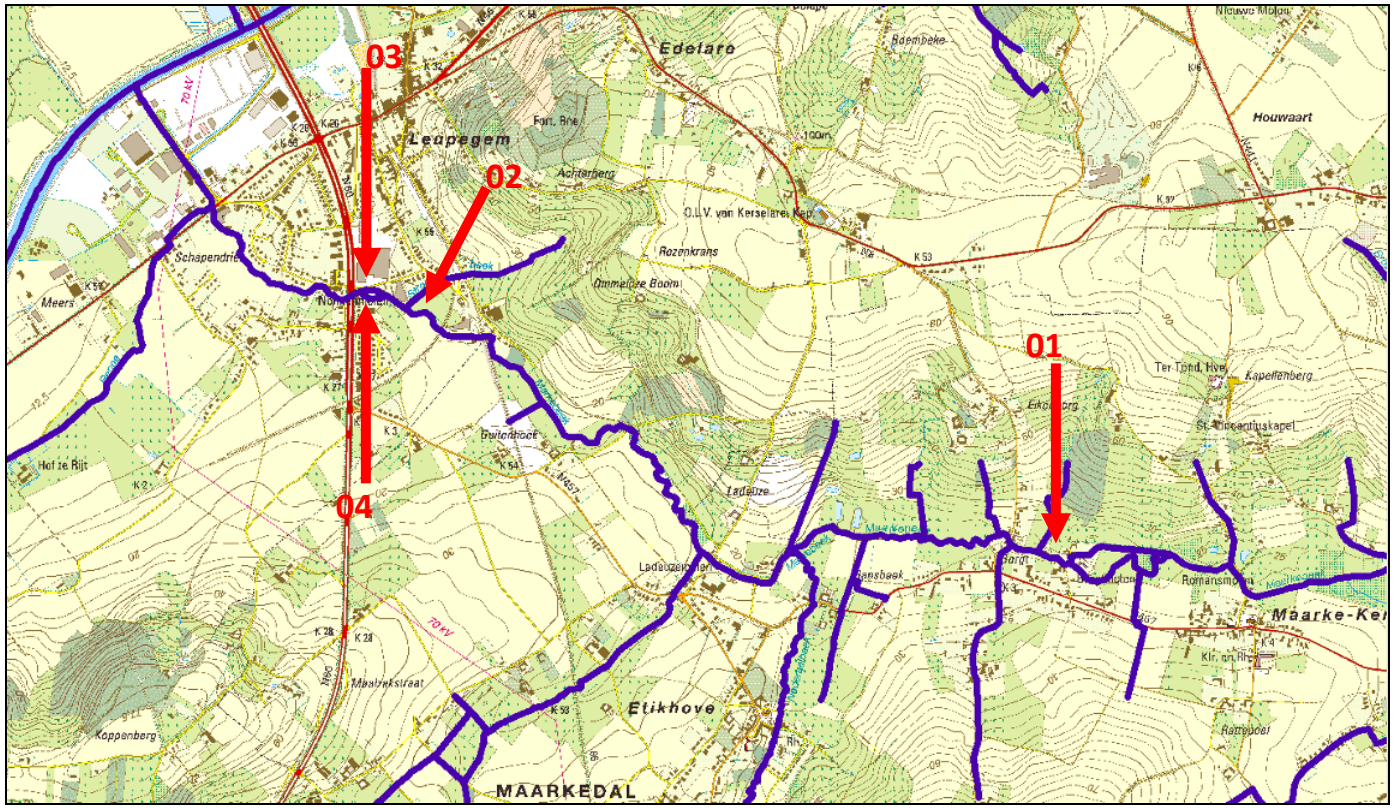
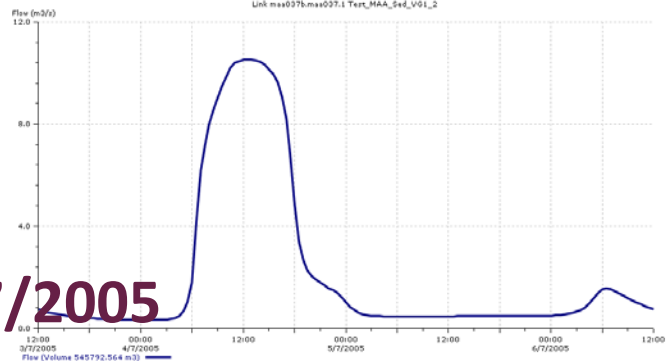
IV Results - River

Watershed Maarkebeek: Selected sedimentation zones



IV Results - River



Watershed Maarkebeek: tests on event 4/7/2005

–> scenario 1

Start Date-Time	01 januari 2000 00:00:00
Sediment Transport Eqn. Coeff.	1.000
Depth Change Criteria (m)	0.010
Bed Elevation Distribution	1.000
Active Layer Thickness Factor	2.000
Bed Porosity	0.500
Channel Geometry Update	None
Transport Calculation Method	Composite
Grading	☑
D0 and D100	☐
Sediment Size D0 (mm)	0.010
Sediment Size D100 (mm)	0.250
Hard Bed	☐
Dredging	☐
Dredging Type	Constant Level
Dredging Time Unit	Seconds

	Diameter (mm)	rho (kg/m3)	Transport equation	Proportion	Cohesive	Cohesive threshold (N/m2)	Cohesive \/s (mm/s)
▶	0.050	2650.0	Westrich & Jurashek	0.900	☒	0.100	1.960
2	0.200	2650.0	Engelund & Hansen	0.100	☐		
✳					☐		

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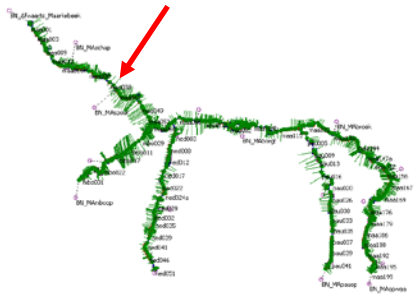
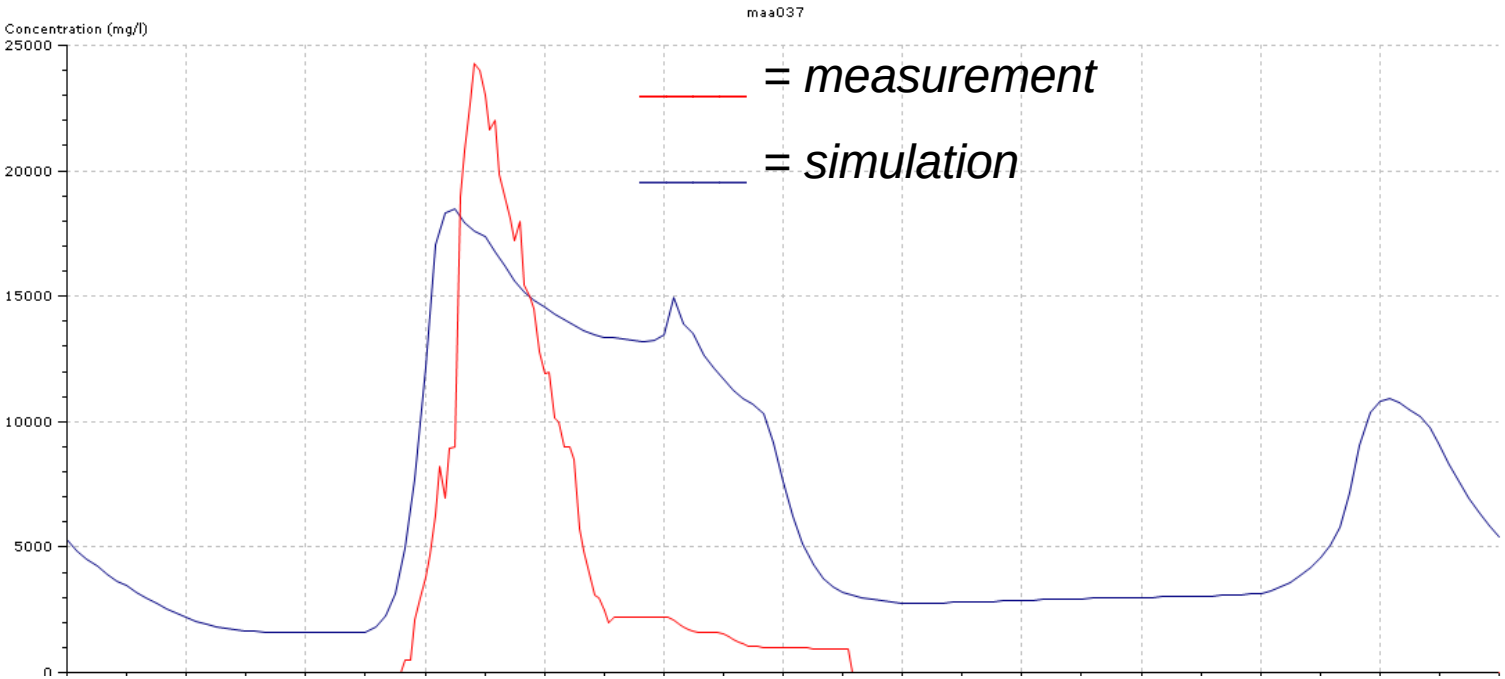
IV Results - River



Scenario 1, measuring location 347 at Leupegem

Simulation Plot Produced by d12235 (26/09/2013 12:10:39) Page 1 of 2
Sim: >Maarkebeek>Run Group>Test_MAA_Sed_VG1_2>EV_MAA_Sed_VG1_2 (20/09/2013 15:02:58)
Selection List: Custom Selection



	Min	Max
>Maarkebeek>Run Group>Test_MAA_Sed_VG1_2>EV_MAA_Sed_VG1_2	1607.743	18488.621

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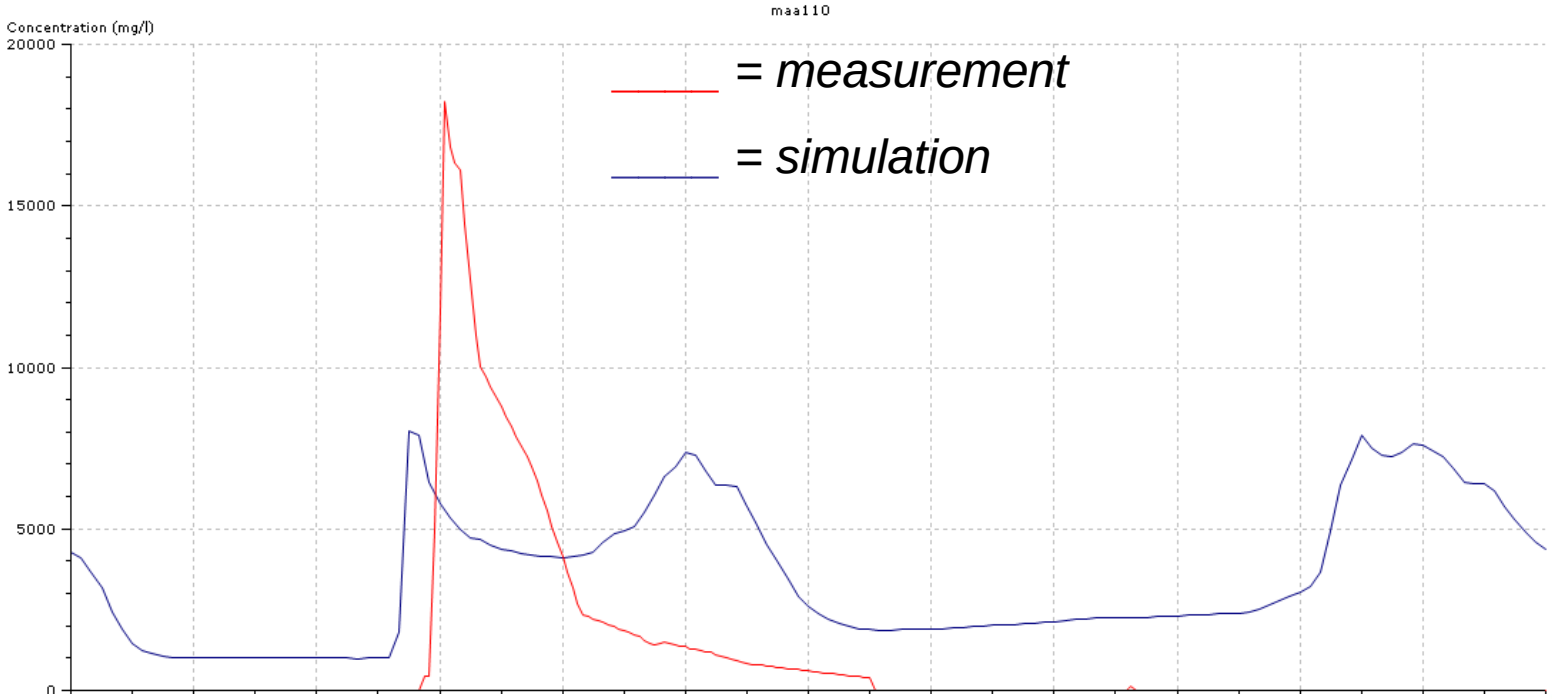
IV Results - River

Scenario 1, measuring location at Maarke-Kerkem

Simulation Plot Produced by d12235 (26/09/2013 12:10:39) Page 2 of 2
Sim: >Maarkebeek>Run Group>Test_MAA_Sed_VG1_2>EV_MAA_Sed_VG1_2 (20/09/2013 15:02:58)
Selection List: Custom Selection



	Min	Max
>Maarkebeek>Run Group>Test_MAA_Sed_VG1_2>EV_MAA_Sed_VG1_2	993.376	8038.858

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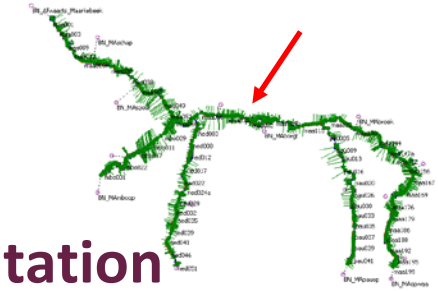
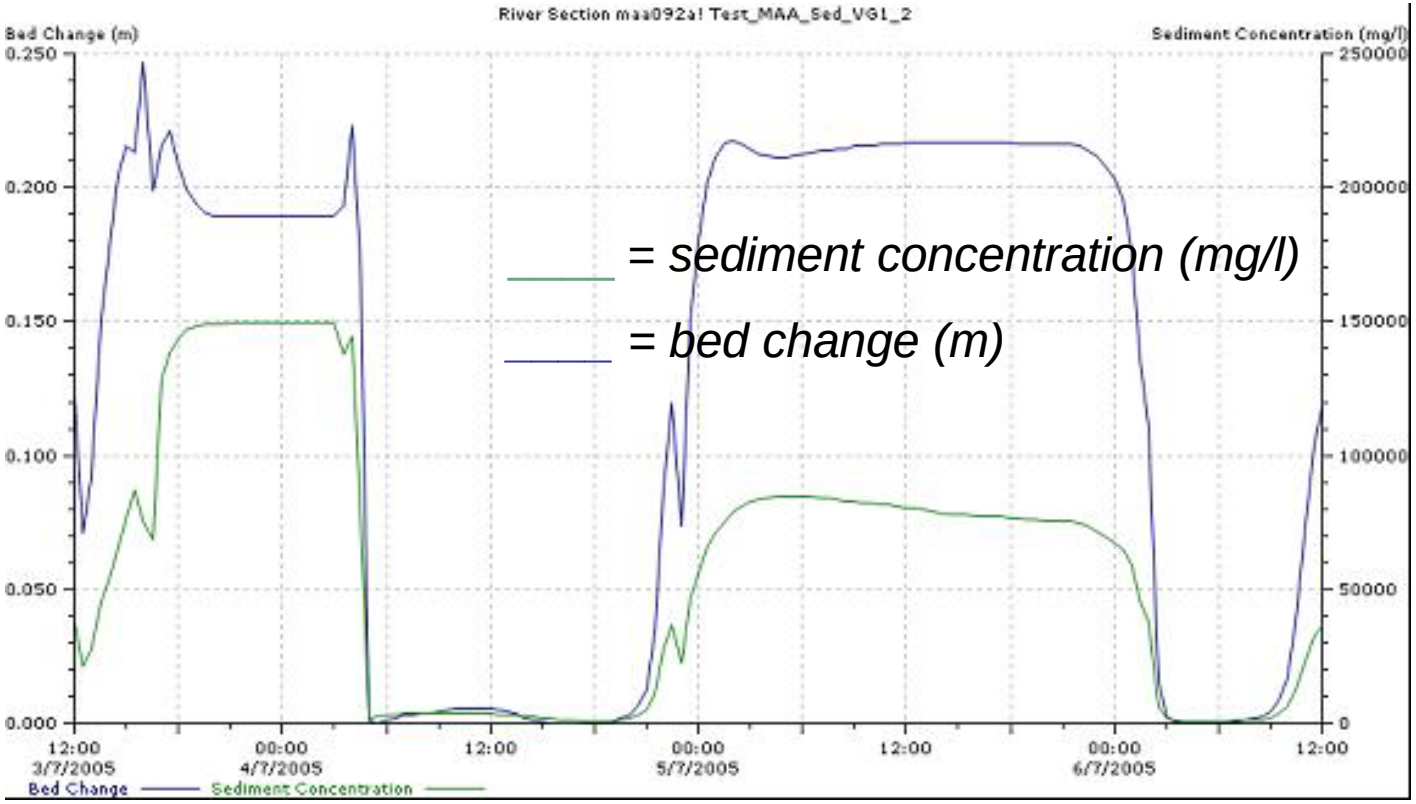
IV Results - River



Scenario 1, downstream ter Borgtmolen (sedimentation location)



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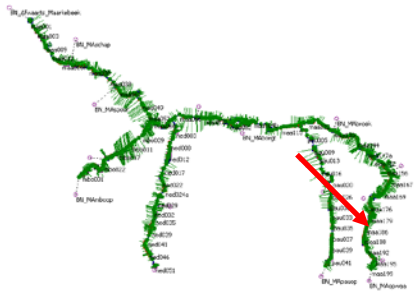
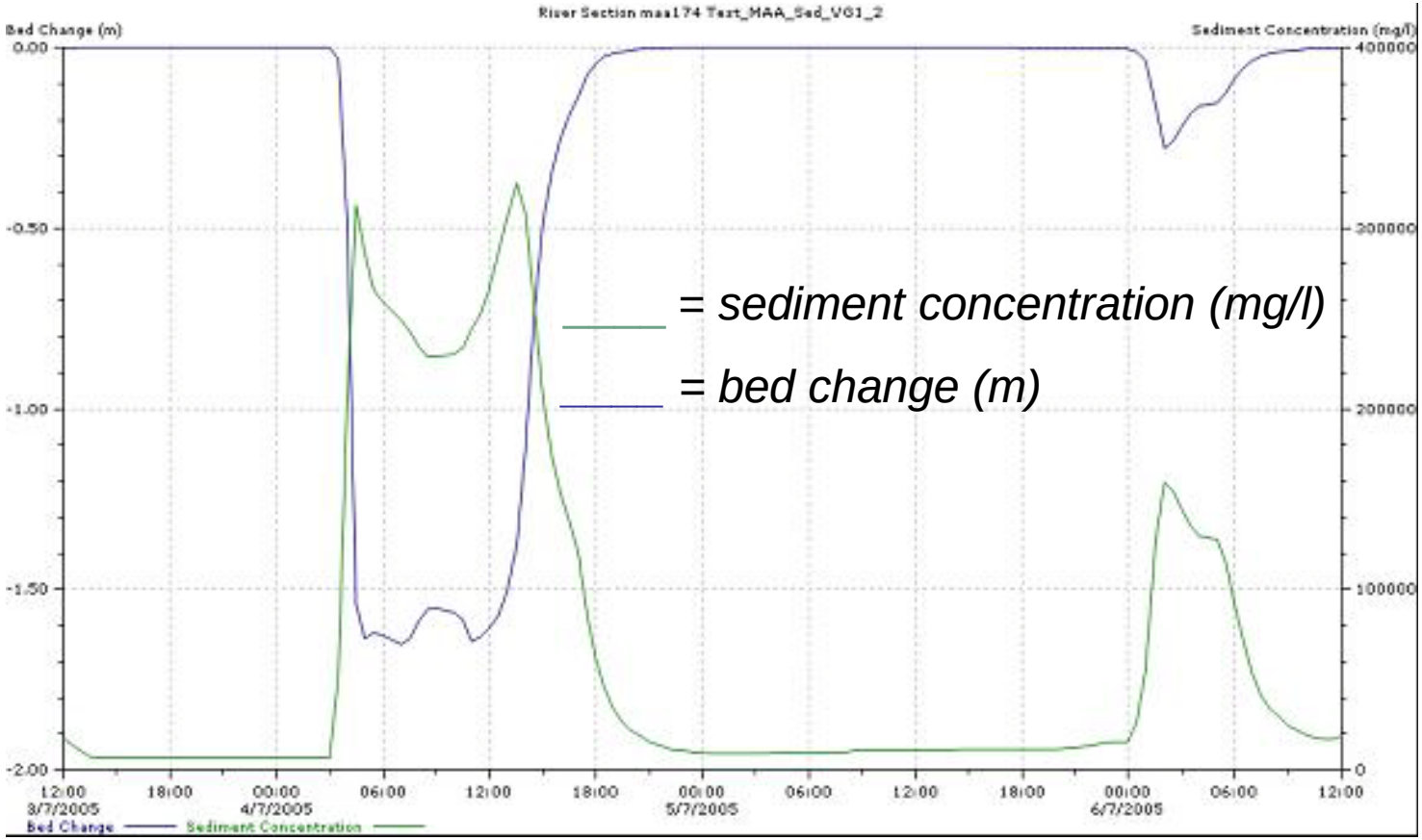
IV Results - River



Scenario 1, upstream Maarkebeek (erosion)



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IV Results - River

Scenario 1, sediment balance

Cumulative sediment mass balance (tonnes)

influx = 4948.6

outflux = 4104.5

net deposition (tonnes) = 738.7

net deposition (m^3) = 557.5

→ Good results sediment balance, but unrealistic high fluxes and sedimentation volumes

IV Results - River

Watershed Maarkebeek: tests on event 4/7/2005

–> # scenario's, parameters: composite, armouring, Active layer thickness, settling velocity, hard bed, porosity

–> scenario 217: . Model without grading, increased cohesive treshold and lowered settling velocity

	Diameter (mm)	rho (kg/m3)	Transport equation	Proportion	Cohesive	Cohesive threshold (N/m2)	Cohesive Vs (mm/s)
1	0.050	2650.0	Westrich & Jurashek	0.900	☒	50.000	0.100
▶	0.200	2650.0	Engelund & Hansen	0.100	☐		
*					☐		

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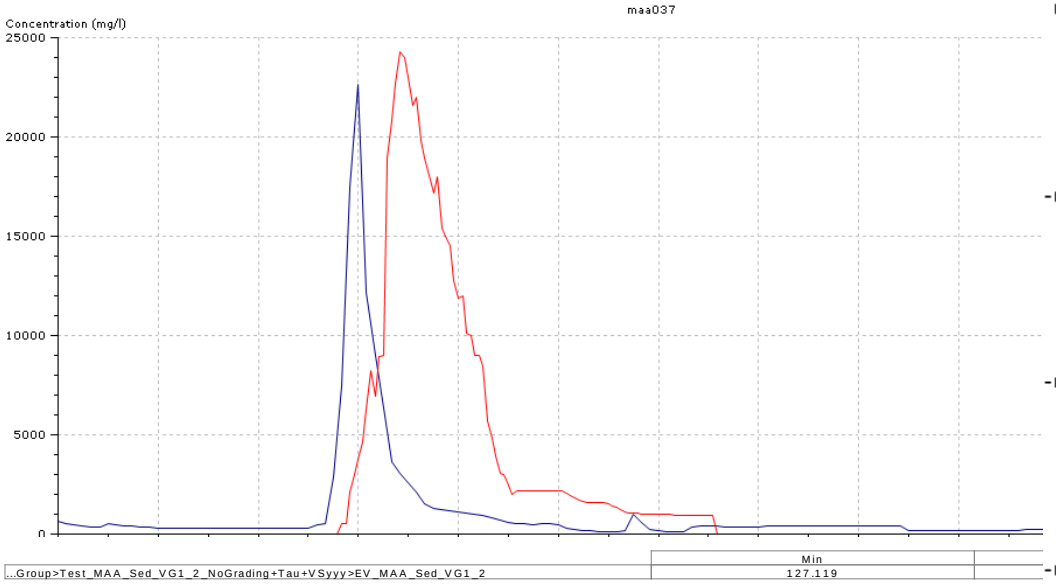
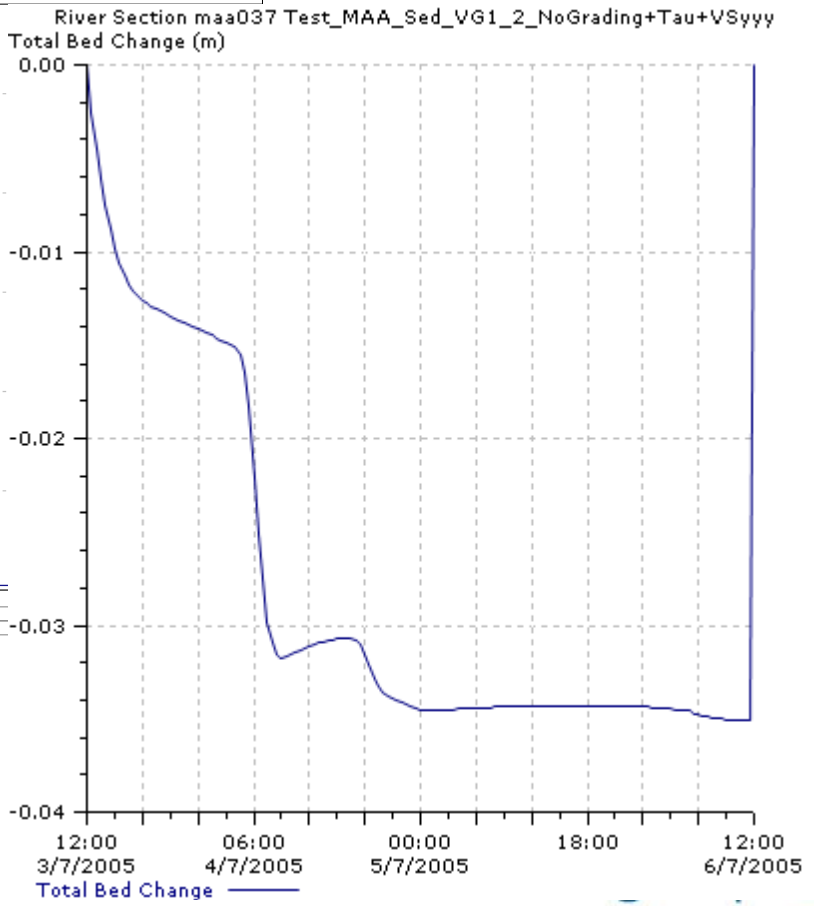
IV Results - River

Scenario 217, measuring location 347 at Leupegem

Simulation Plot Produced by d12235 (26/09/2013 13:49:34) Page 1 of 2
Sim: >Maarkebeek>Run Group>Test_MAA_Sed_VG1_2_NoGrading+Tau+VSyyy>EV_MAA_Sed_VG1_2 (26/09/2013 13:38:41)
Selection List: Custom Selection



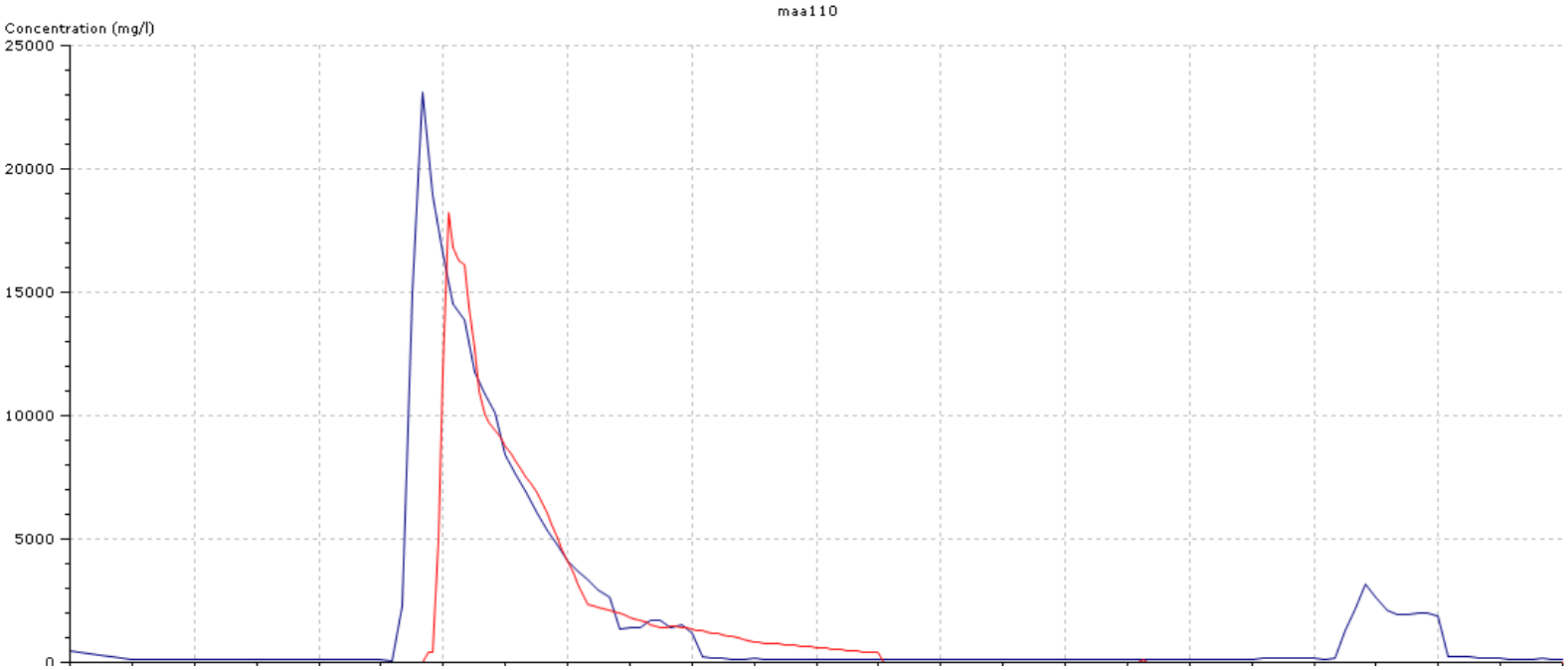
	Min
...Group>Test_MAA_Sed_VG1_2_NoGrading+Tau+VSyyy>EV_MAA_Sed_VG1_2	127.119



IV Results - River

Scenario 217, measuring location at Maarke-Kerkem

Simulation Plot Produced by d12235 (26/09/2013 13:49:34) Page 2 of 2
Sim: >Maarkebeek>Run Group>Test_MAA_Sed_VG1_2_NoGrading+Tau+VSyyy>EV_MAA_Sed_VG1_2 (26/09/2013 13:38:41)
Selection List: Custom Selection



	Min	Max
...Group>Test_MAA_Sed_VG1_2_NoGrading+Tau+VSyyy>EV_MAA_Sed_VG1_2	54.121	23144.049

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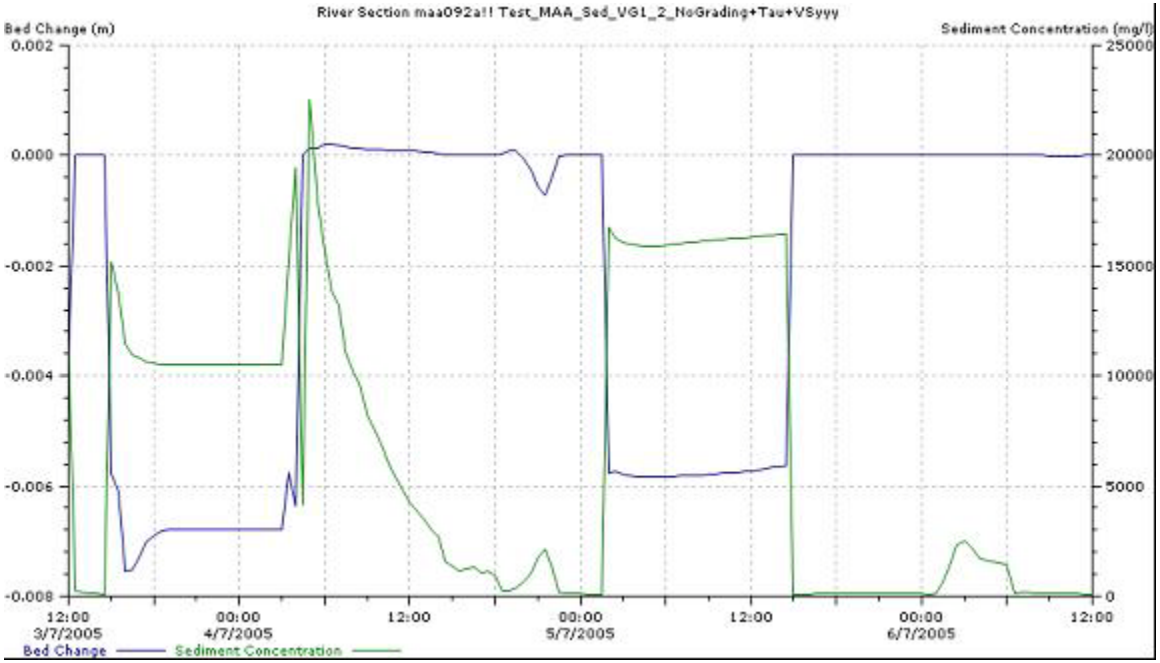
IV Results - River

Scenario 217, downstream ter Borgtmolen (sedimentation location, but erosion)



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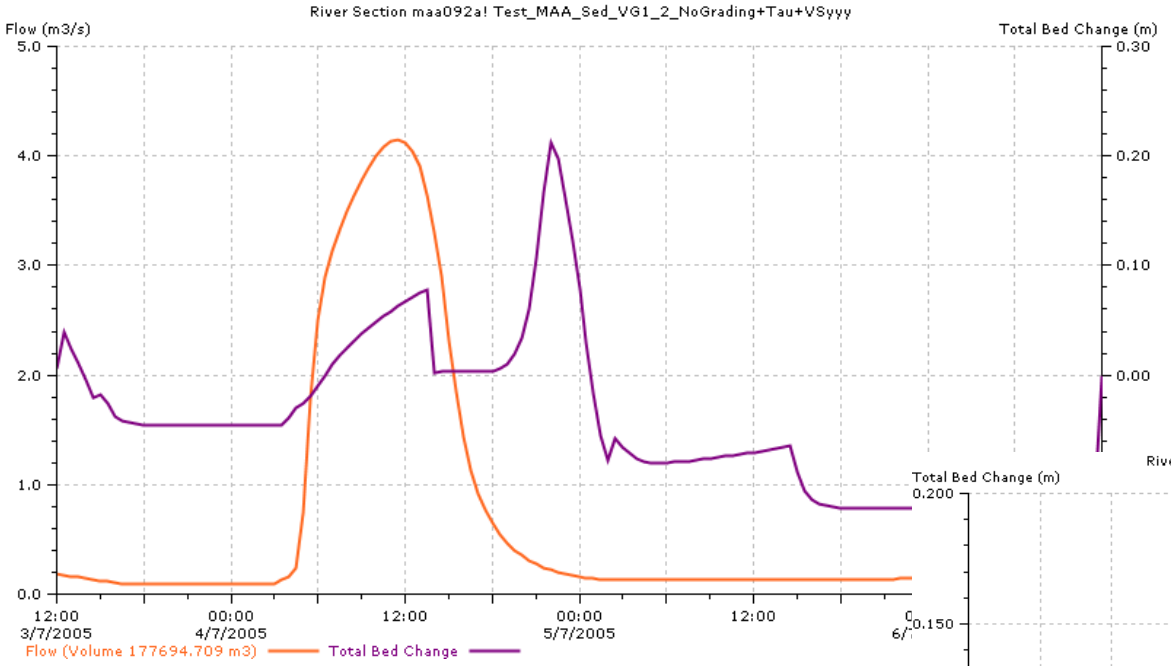
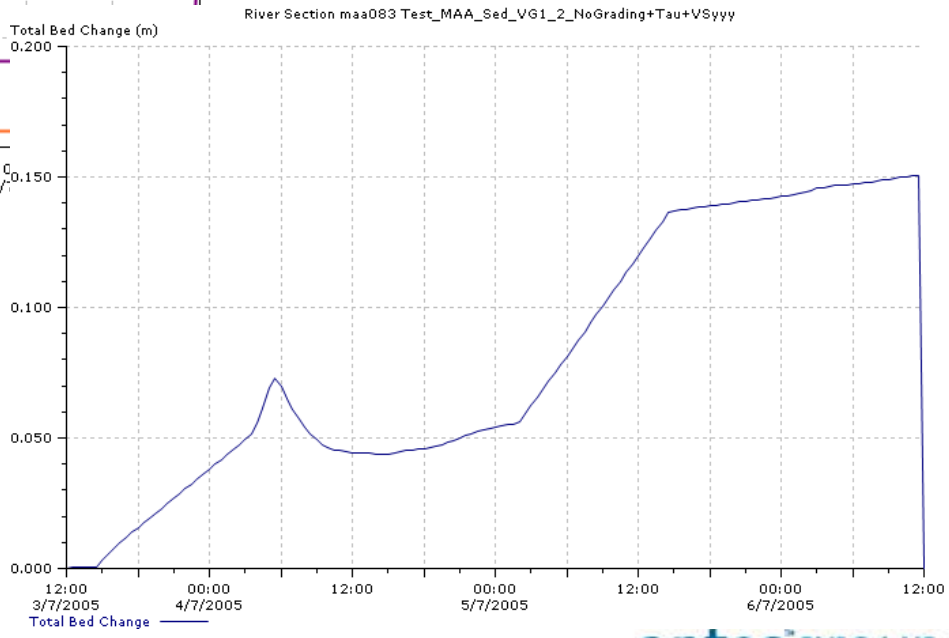
IV Results - River



→ net erosion

But downstream node:



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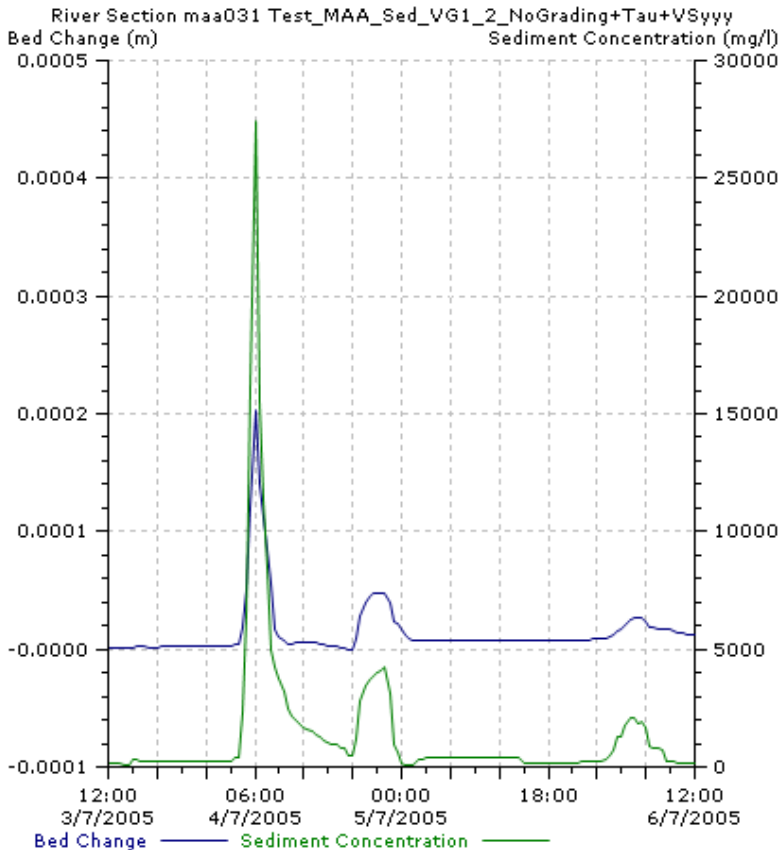
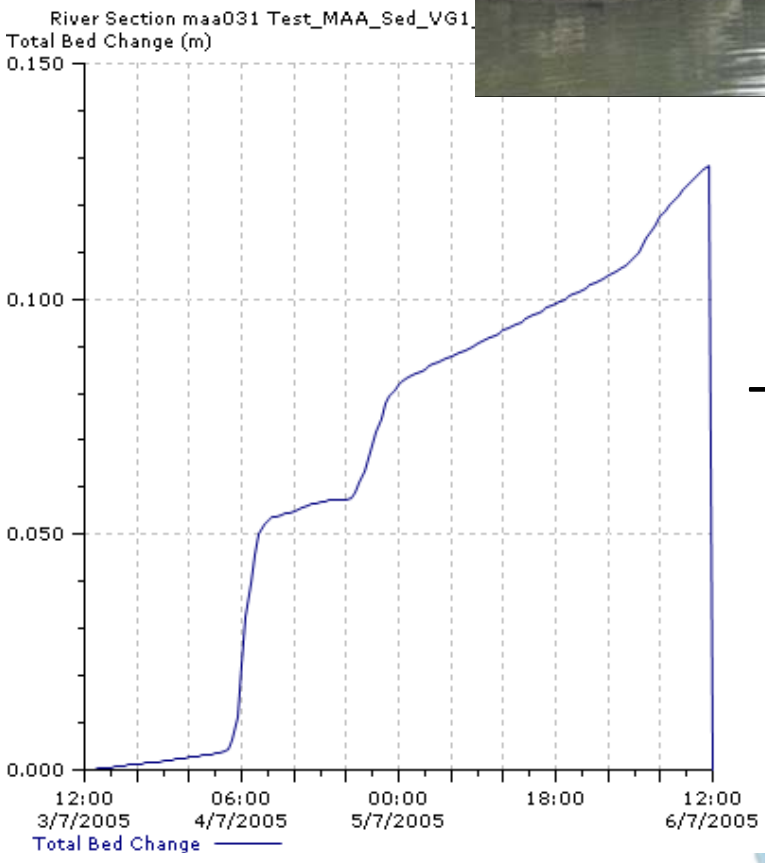
IV Results - River

Scenario 217, bend upstream Nonnemolen





→ Dep.

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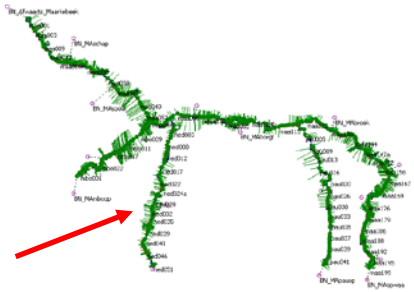
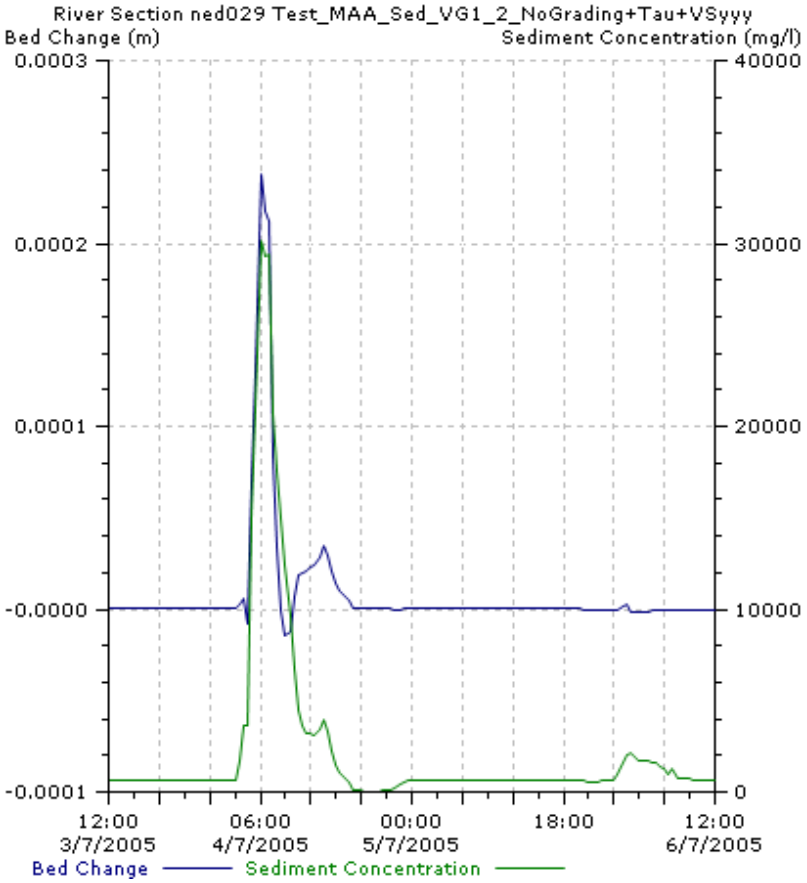
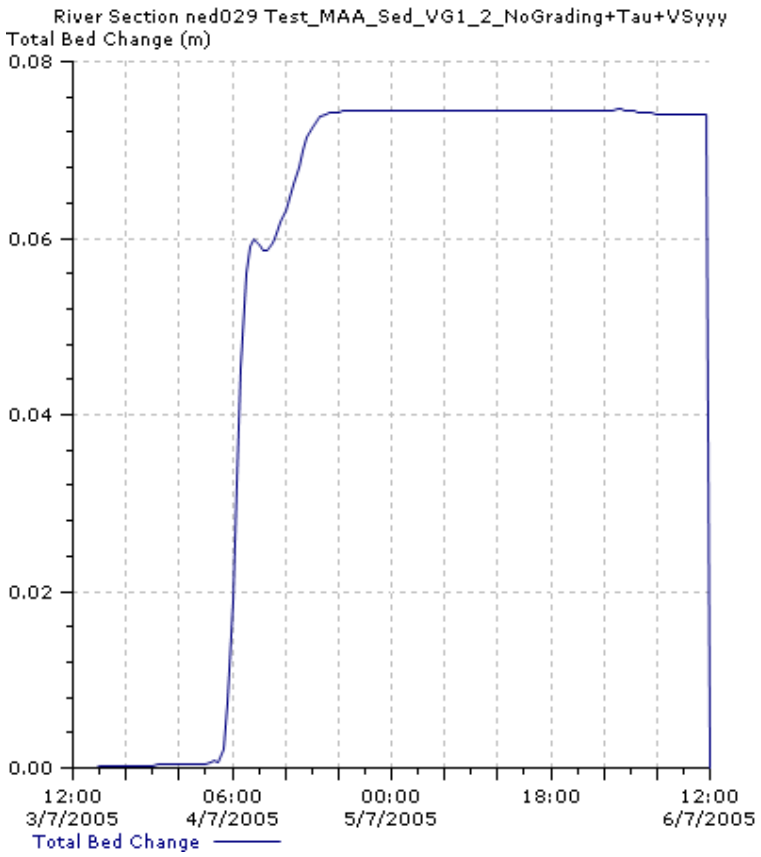
IV Results - River



Scenario 217, GOG Etikhove





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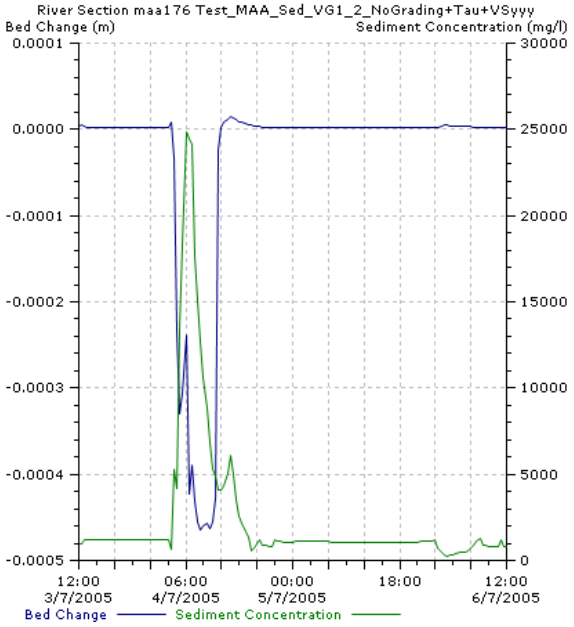
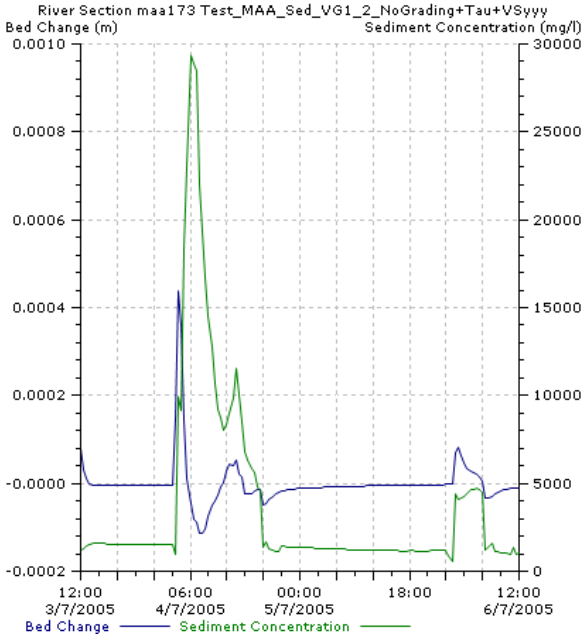
IV Results - River

Scenario 217, typical erosion/sedimentation profiles (upstream)





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IV Results - River

Scenario 217, sediment balance

Cumulative sediment mass balance (tonnes)

influx = 4948.8

outflux = 1207.6

net deposition = 3730.2

net deposition (m^3) = 2815.3

→ Realistic fluxes, but unrealistic sedimentation volumes

V Challenges to come - soil

- WaTEM/SEDEM
  - Erosion part - Sedimentation part
  - Calibration for a higher resolution (5 x 5m)

- LISEM
  - Evaluation based on available datasets
  - If necessary: adaptations to LISEM

- Resolution ↑: optimal model results ↓

- Runoff model: Feasibility of the CN method

- Grain size distribution

- Implementation connectivity hillslope – river

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V Challenges to come - River

- Further calibration & validation of sediment modules
- Comparison between flood compatible and inbank IWRS model
- (Hydrodynamic) stabilization of IWRS (and ICM) model
- Simulate geometry update
- Comparison IWRS and ICM in terms of performance and calculation time
- Upstream extension of model (cfr. VHA)


Thank you for your attention