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Sand island reshaping in response to selected discharges: the Vistula River returning its natural state

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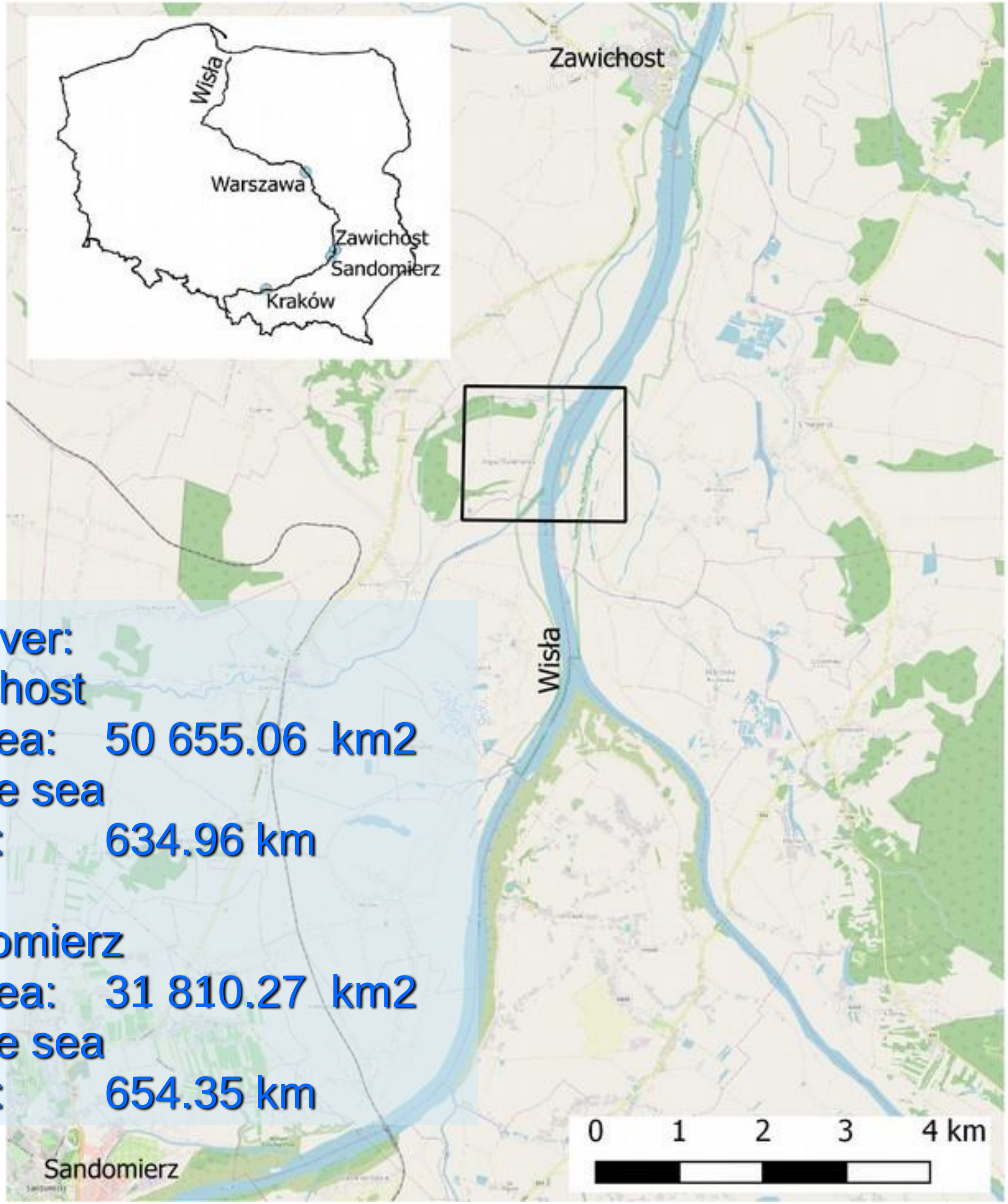
Presentation schedule

1. Object description
2. The goal of the study
3. Methodology
4. Results
5. Conclusions



Wisła River:
in Zawichost
basin area: 50 655.06 km2
km to the sea
(MPHP): 634.96 km

in Sandomierz
basin area: 31 810.27 km2
km to the sea
(MPHP): 654.35 km

investigated reach

channel width: 400m
width of alluvial terrace: about 1000 m

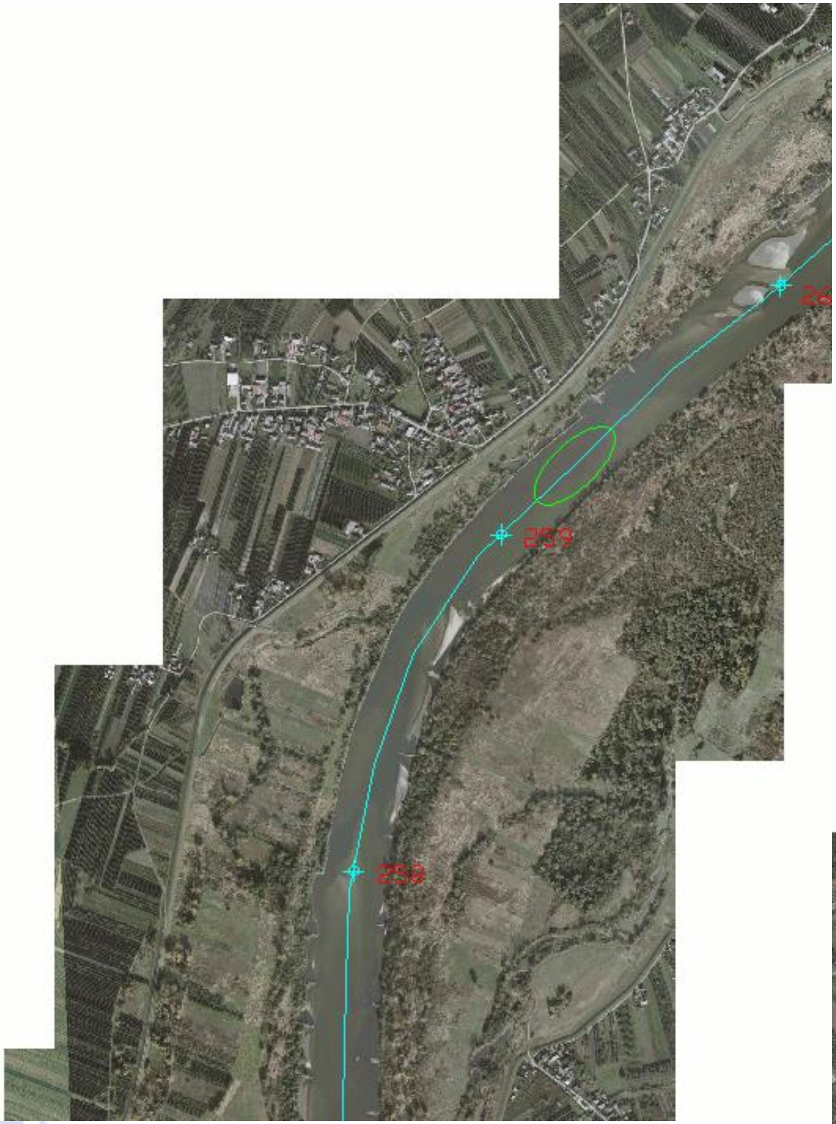
reach length: 1900 m
river slope: 0.00025 to 0.00329 [-]

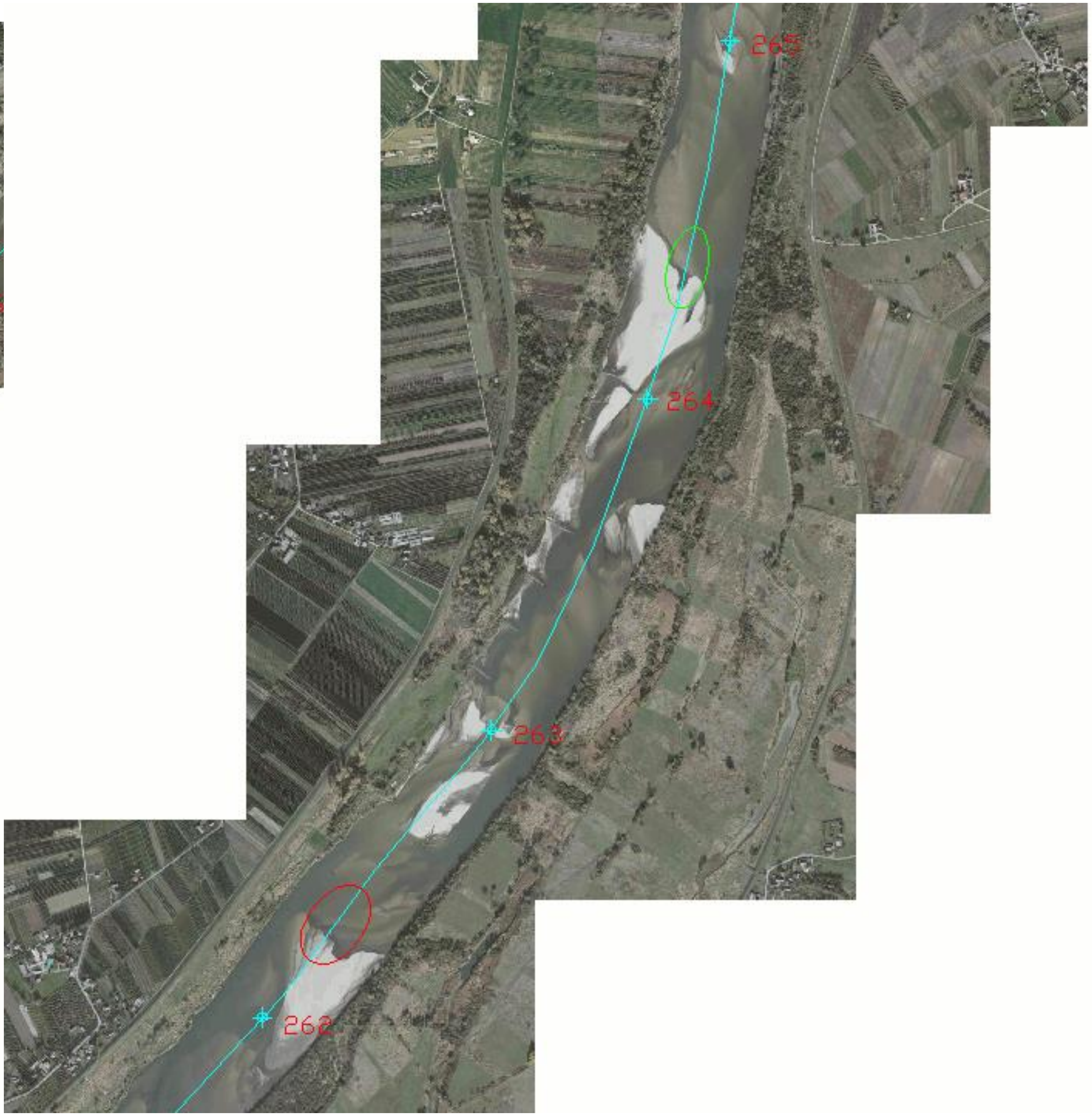
the island (Q = 300 m3/s):
length: 700 m
width: 136 m

Sternula albifrons

21-27 cm, 45-60 g,
wingspan 45-55 cm

http://www.avibirds.com/euhtml/Little_Tern.html


259
258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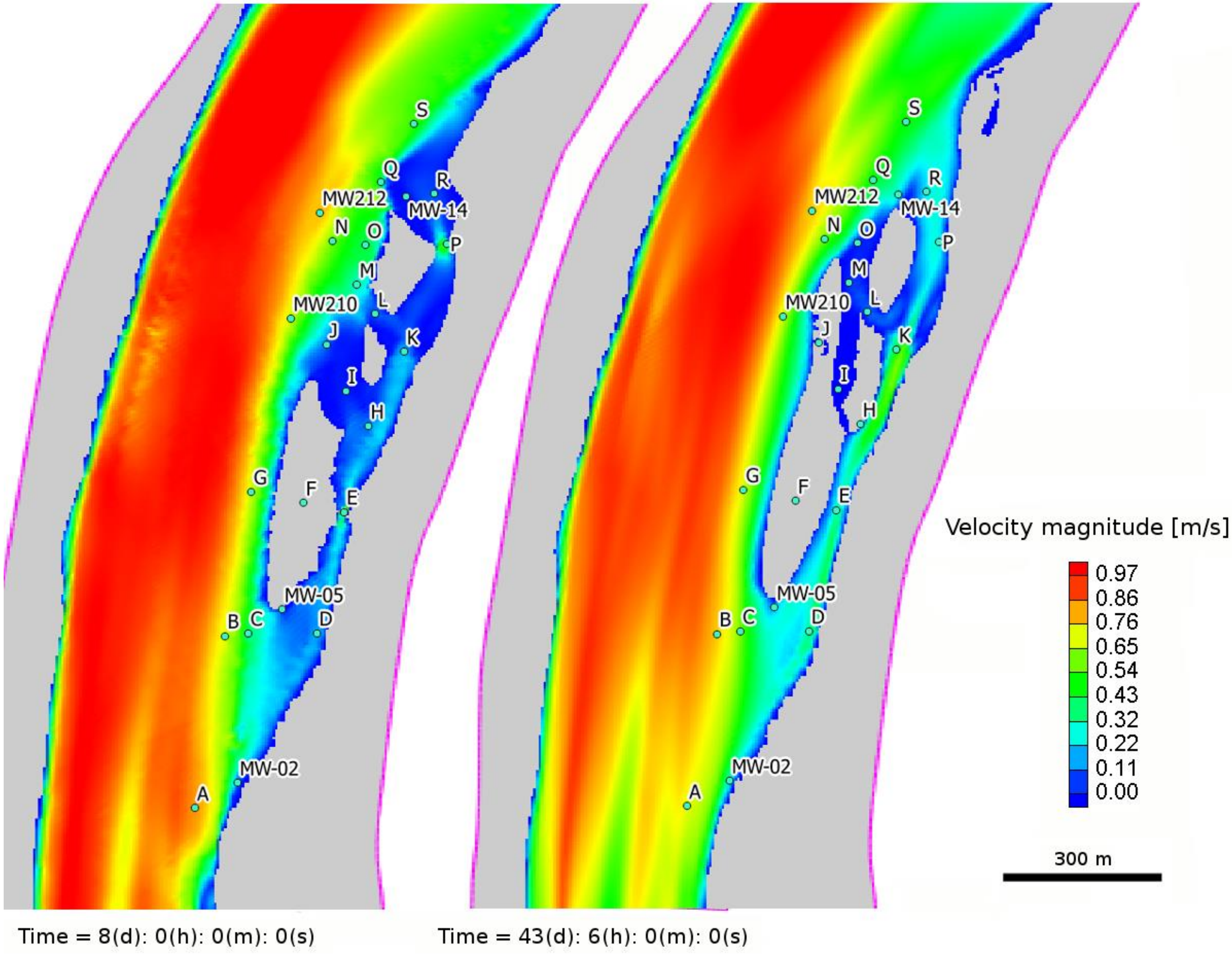
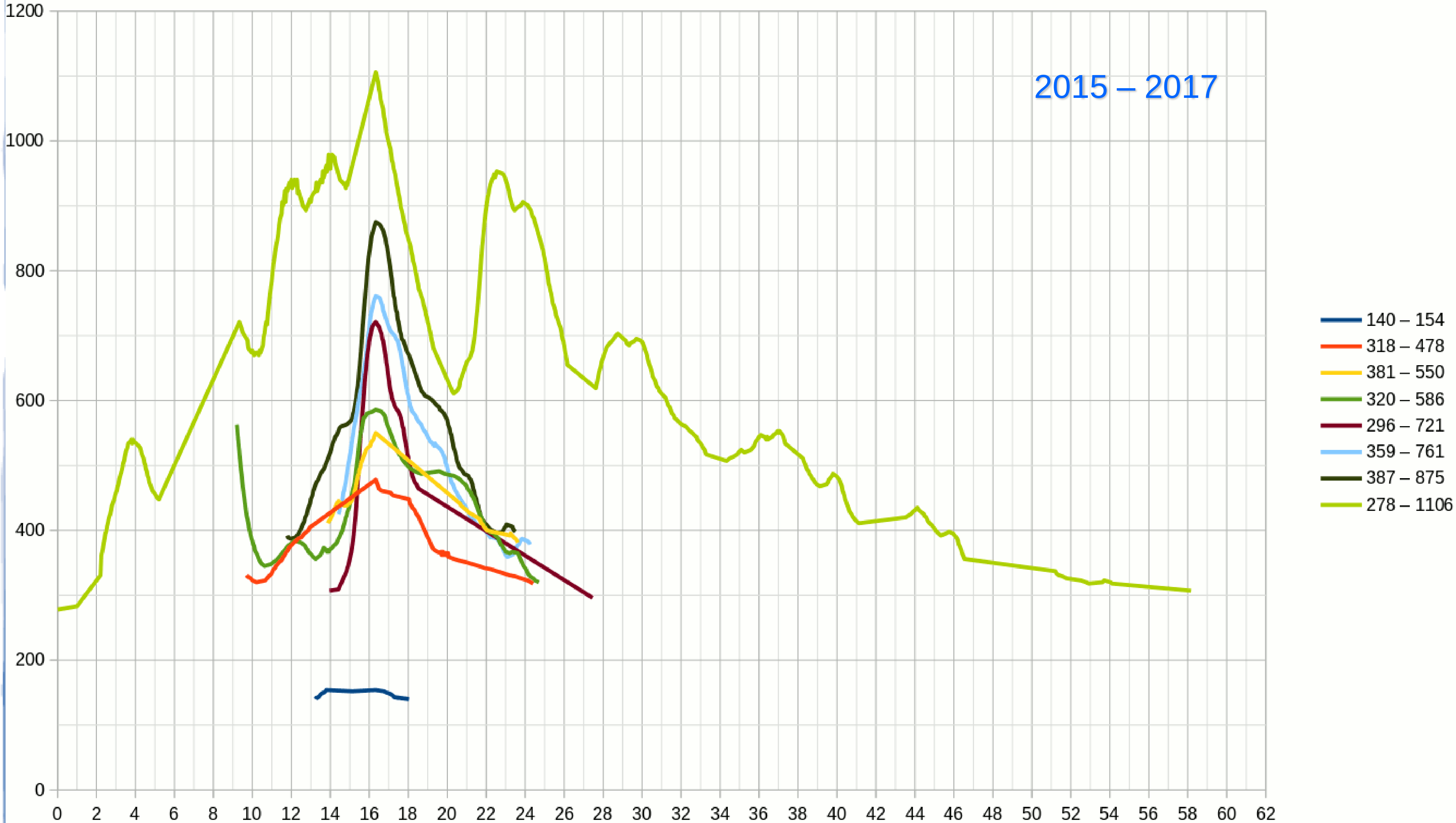
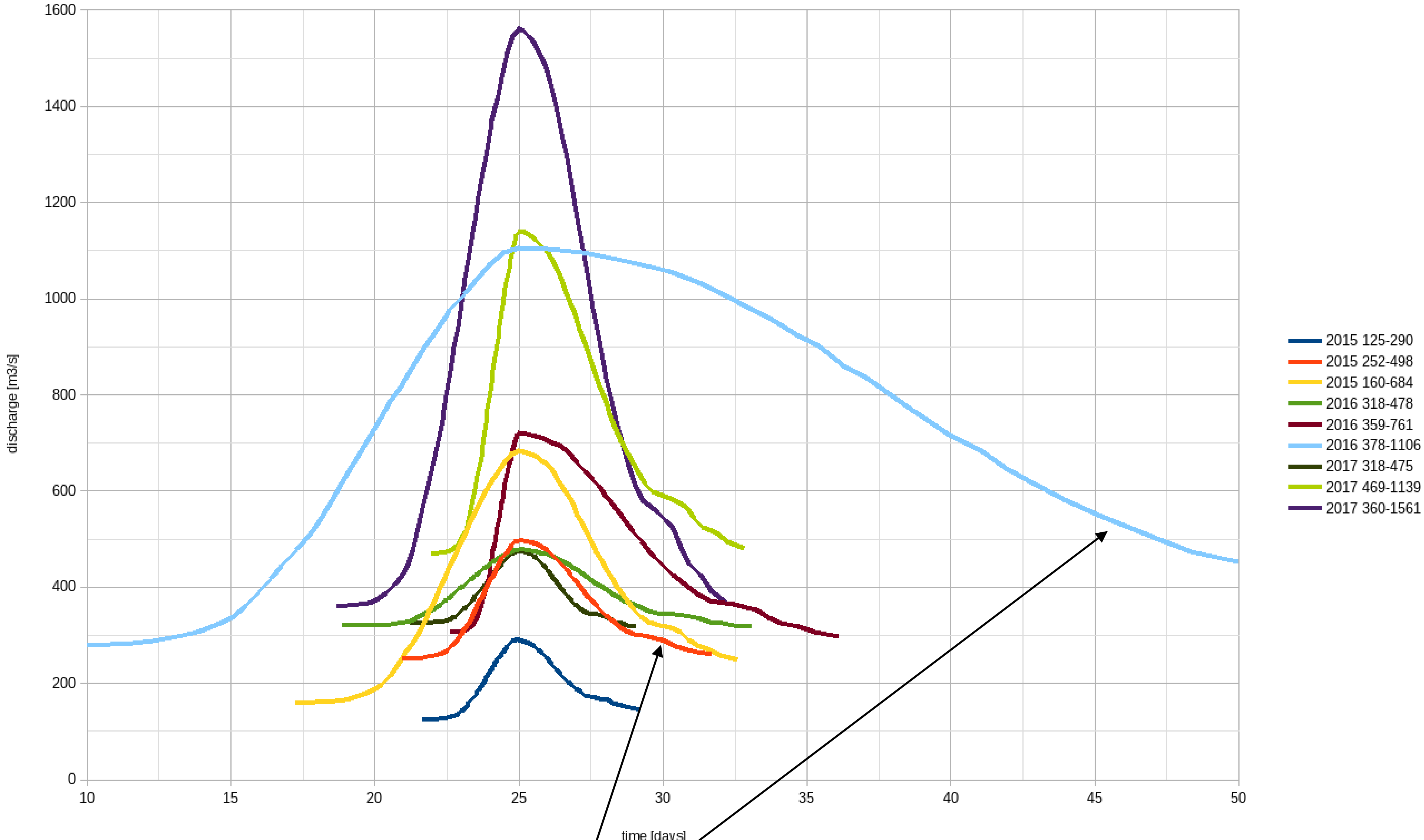


The purpose of this paper is to identify the conditions for the formation and disappearance of sand islands within the limited discharge (well below bankfull).

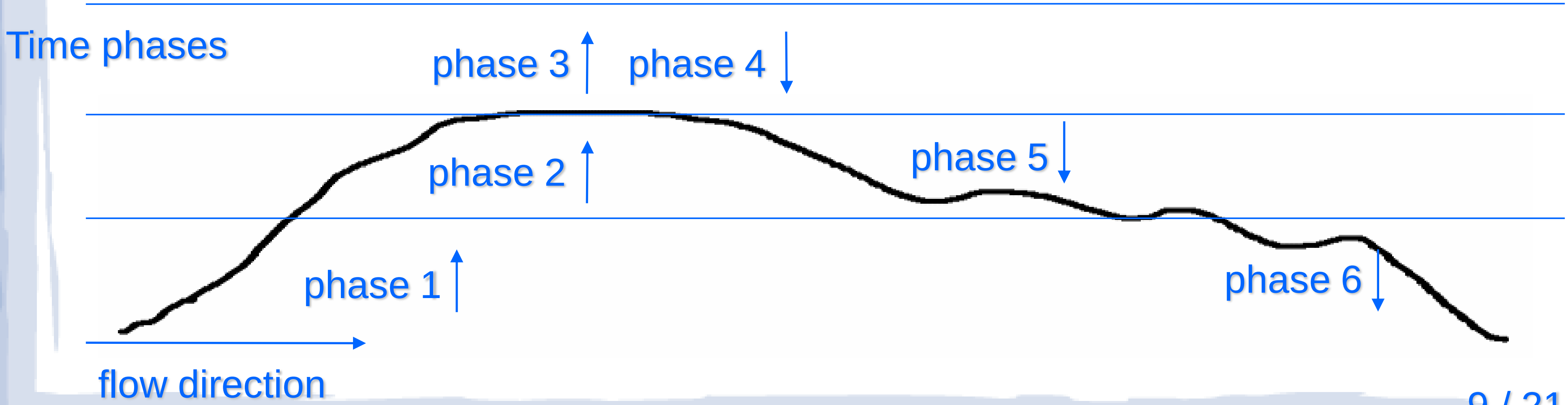


Mean Annual Flow 416.47 m^3s^{-1},
Mean Low Flow 139.7 m^3s^{-1},
Low Low Flow 104 m^3s^{-1},
guaranteed flow at 90% 158 m^3s^{-1}



Wave_1 – 498 [m3/s], 10.75 [day]
Wave_2 – 1106 [m3/s], 58.17 [day]

TI		Description	Time [days] Discharge [m^3s^{-1}] Wave_1	Time [days] Discharge [m^3s^{-1}] Wave_2
0-1	-	Initial parameters	0 / 252	0 / 278
	I	Gradual flooding of the island, causing activation of 3 streams acting on it	3.5 485	8 444
	II	Increasing flow in 3 streams (arms) leading to the total submerging of the island (nesting unsuccessful)	-[1]	5 900
	III	Flow from the total covering of the island to reaching the maximum discharge Q_{max}	1 498	3.3 1106
1-2	IV	Flow from the maximum discharge Q_{max} to the resurfacing of the island	-[1]	12.5 790
	V	Flow from the resurfacing of the island's top to the re-emergence of 3 streams (phase I)	1.75 397	14 439
	VI	The end of the simulation	3.75 / 259	14 / 307



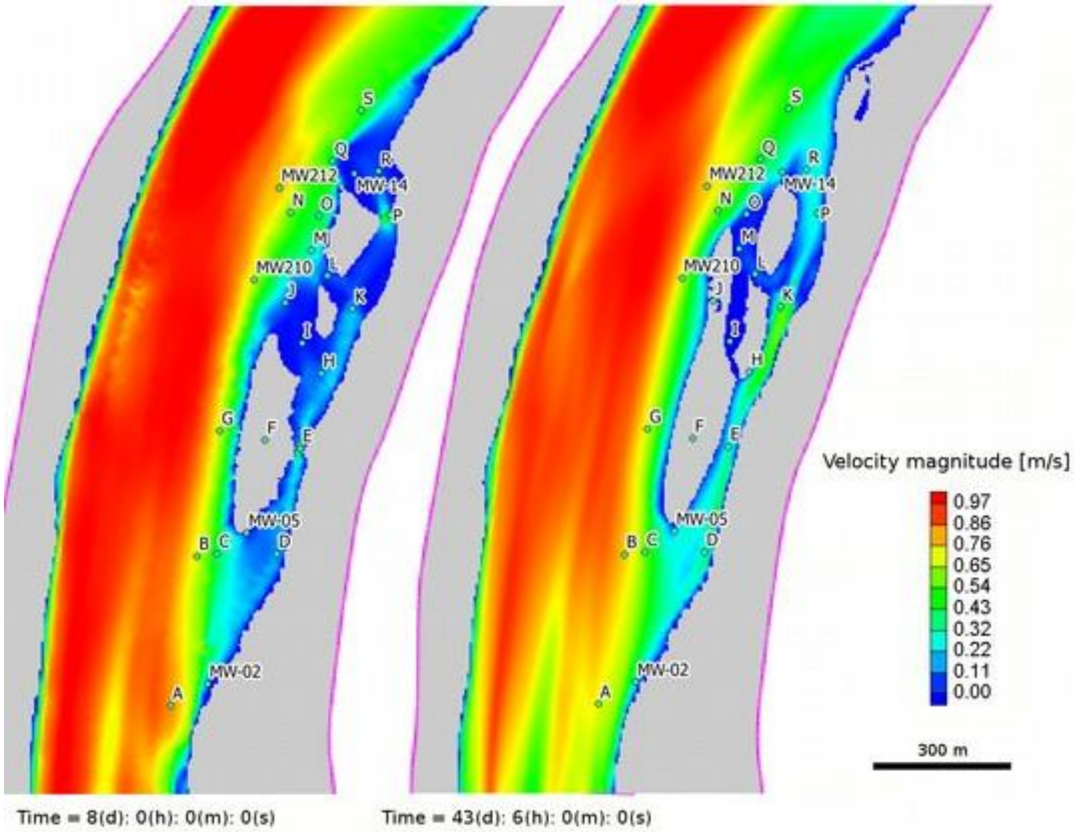
CCHE2D model with sediment transport

Wu et al. equation

modeled reach
length – 1900 m
width – 540m

average cell dimensions – 5x5 m

time step – 5 sec



Analysed modelling results

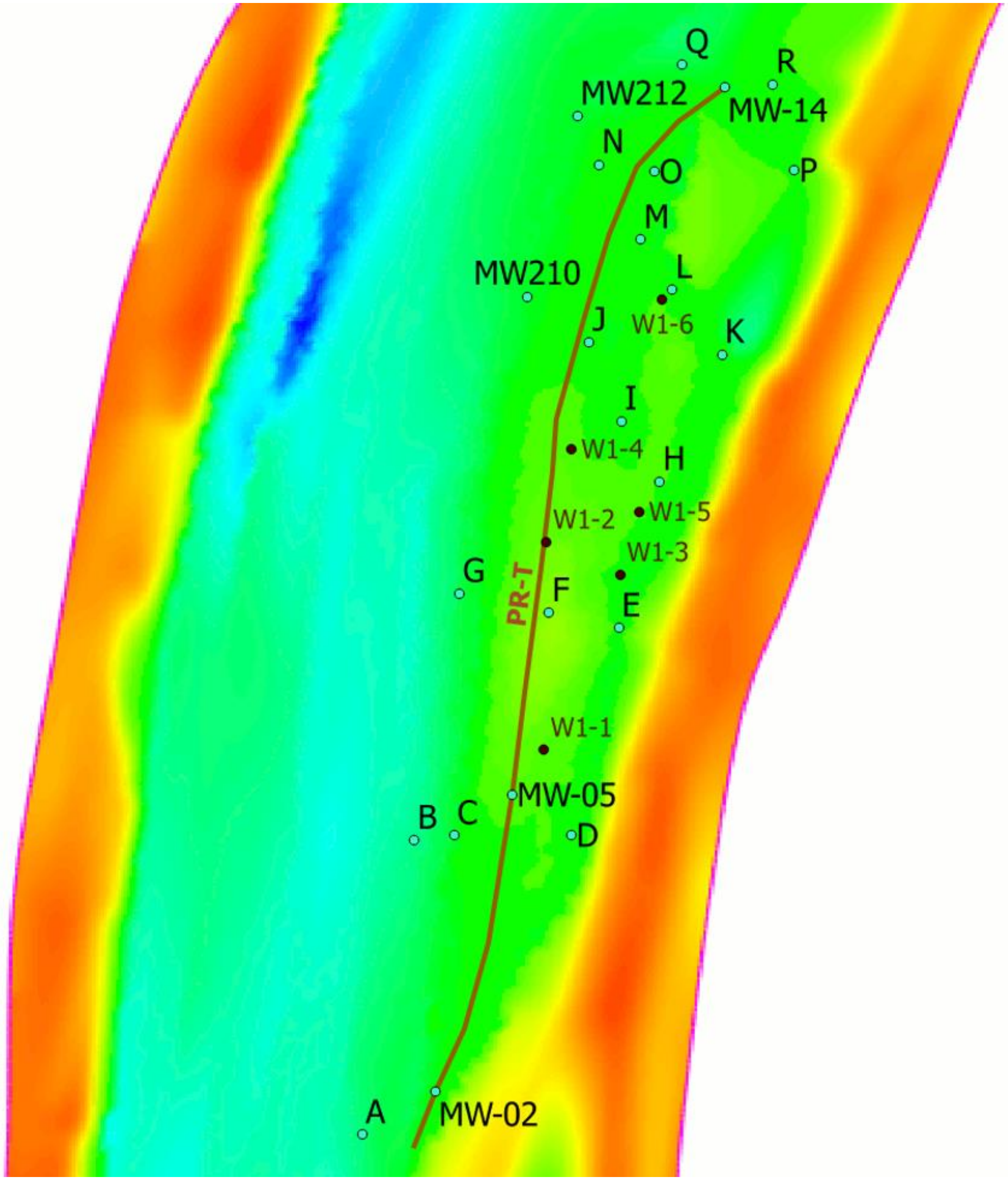
- longitudinal profile

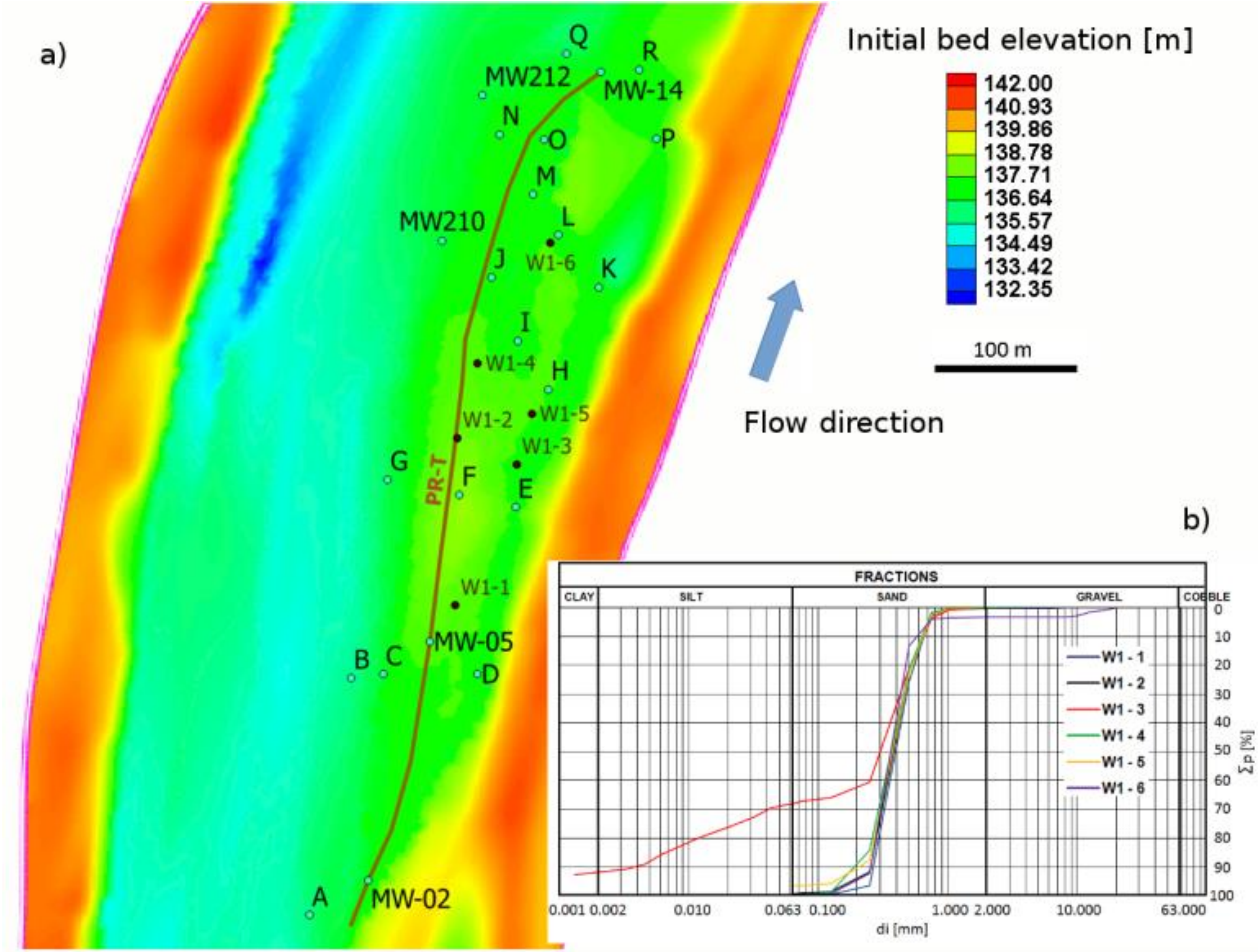
- 22 monitor points

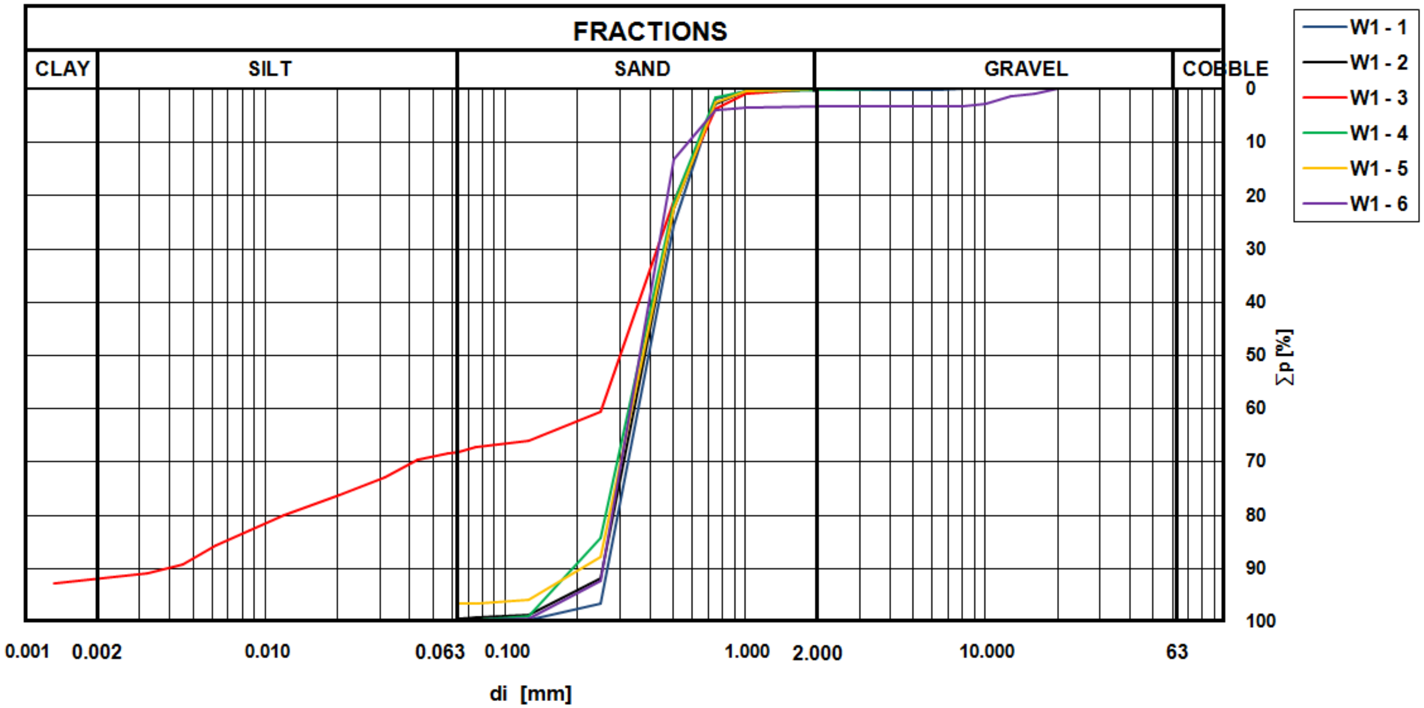
Bed material characteristics

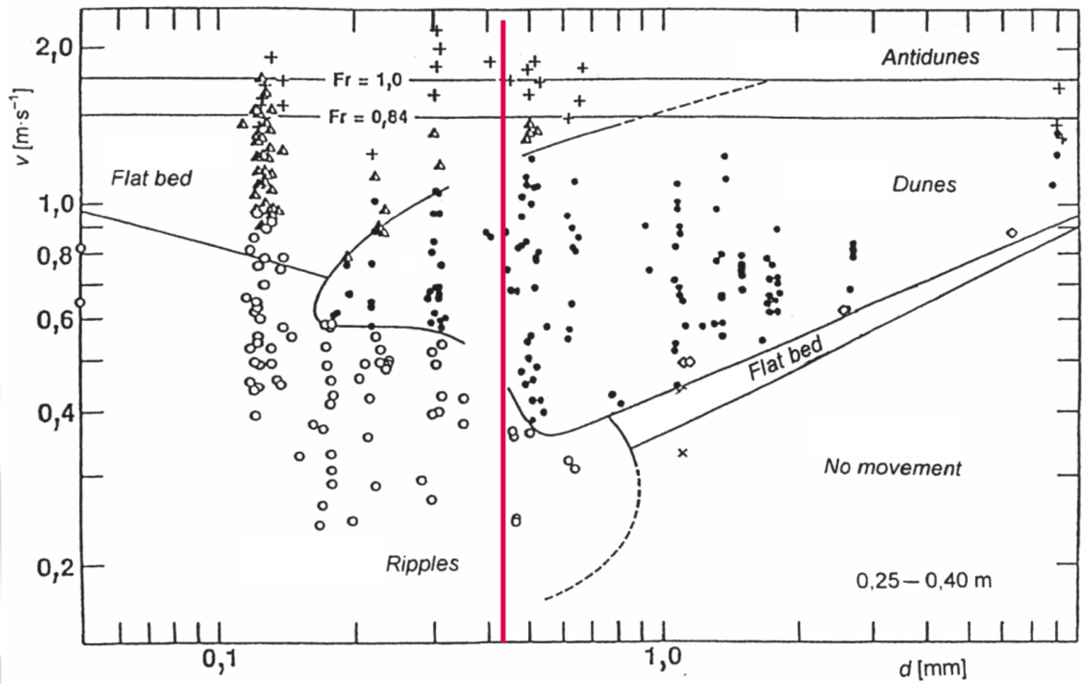
- 6 probes from the island

- measurements in the river




a)
Q
R
MW212
MW-14
N
O
P
M
MW210
L
J
W1-6
K
I
W1-4
H
W1-2
W1-5
W1-3
G
PR-T
F
E
W1-1
MW-05
B
C
D
A
MW-02
Initial bed elevation [m]
142.00
140.93
139.86
138.78
137.71
136.64
135.57
134.49
133.42
132.35
100 m
Flow direction
b)
FRACTIONS
CLAY
SILT
SAND
GRAVEL
COBBLE
W1 - 1
W1 - 2
W1 - 3
W1 - 4
W1 - 5
W1 - 6
Σp [%]
0
10
20
30
40
50
60
70
80
90
100
0.001
0.002
0.010
0.063
0.100
1.000
2.000
10.000
63.000
di [mm]





d_{50} = 0.42 mm

bedform creation in rivers
Southard and Boguchwal

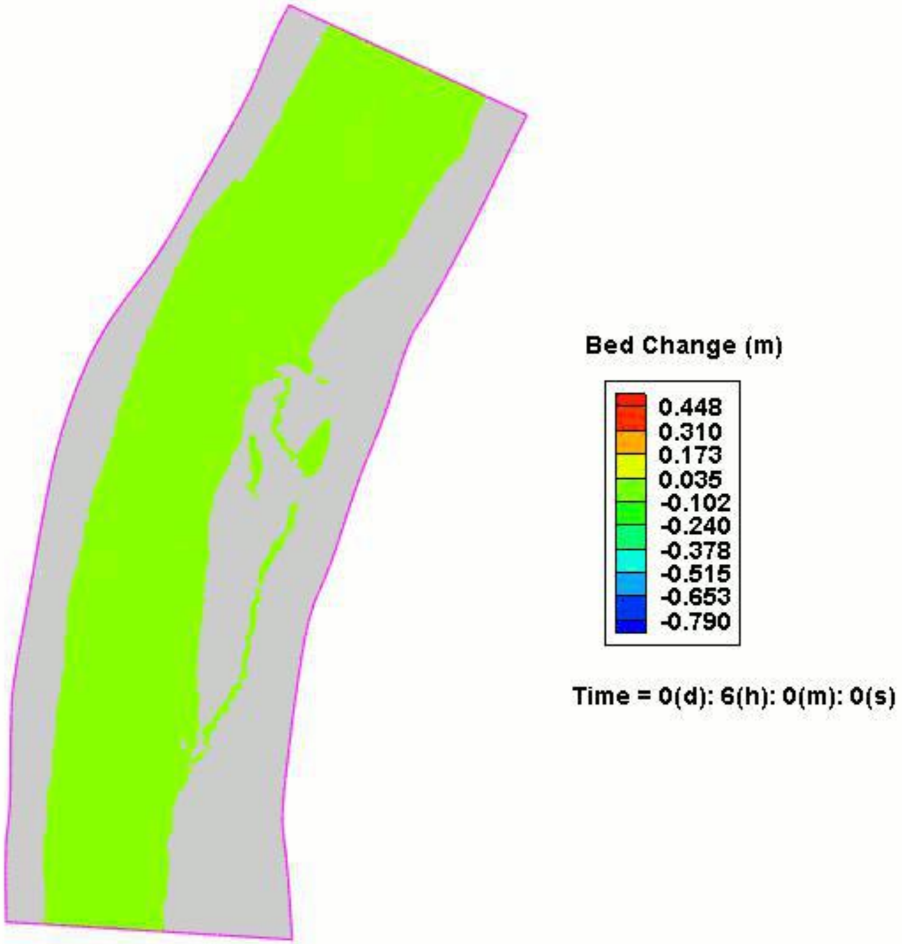
All analysed data

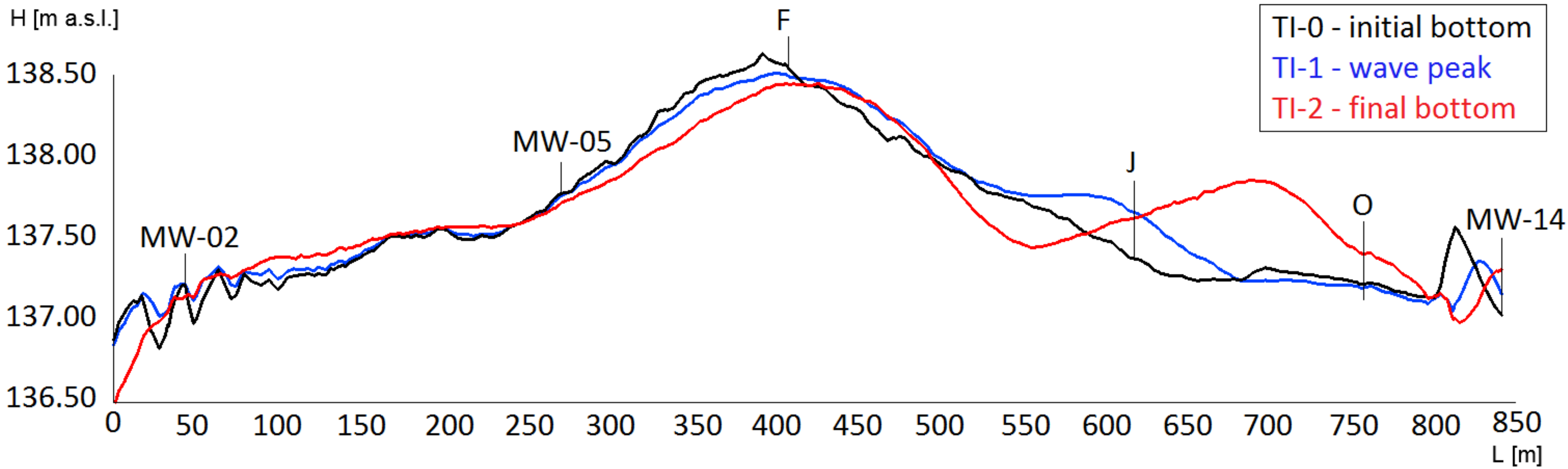
water flow
- velocity
- shear stresses

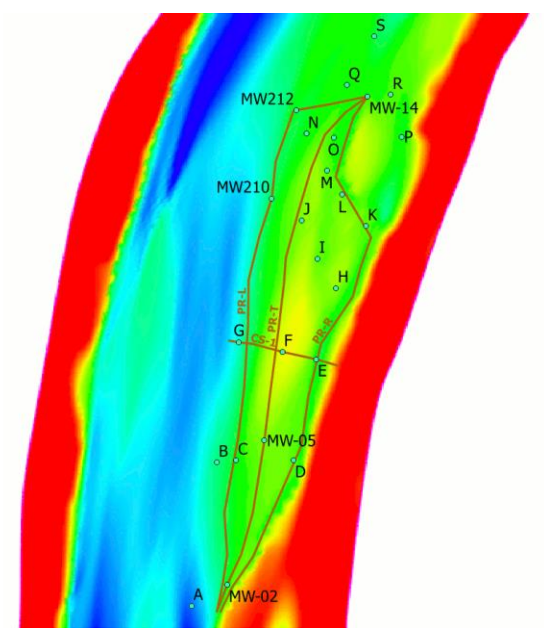
island bottom
- elevation change
- bedforms
- critical stresses

With division on flow phases
in rising ans recession limb

Wave_1







Wave_2

Profile PR-T

Wave_1

Bed change

total shear stress

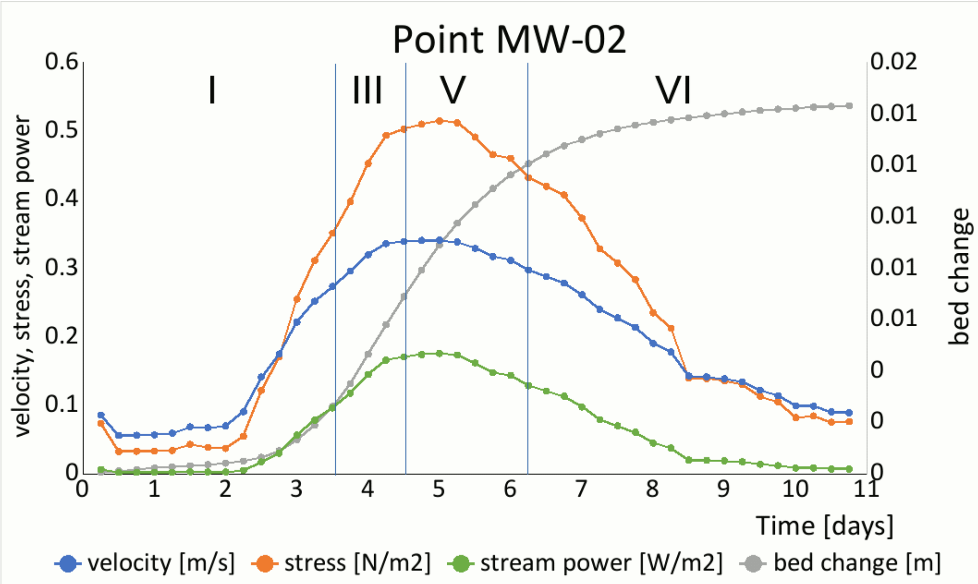
velocity

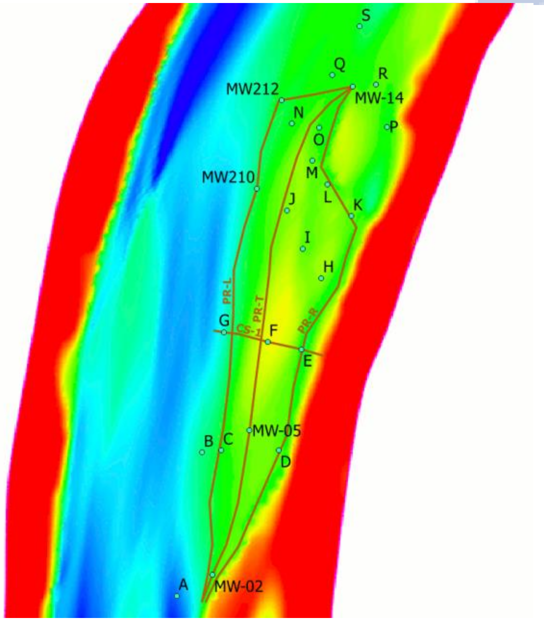
Wave_2

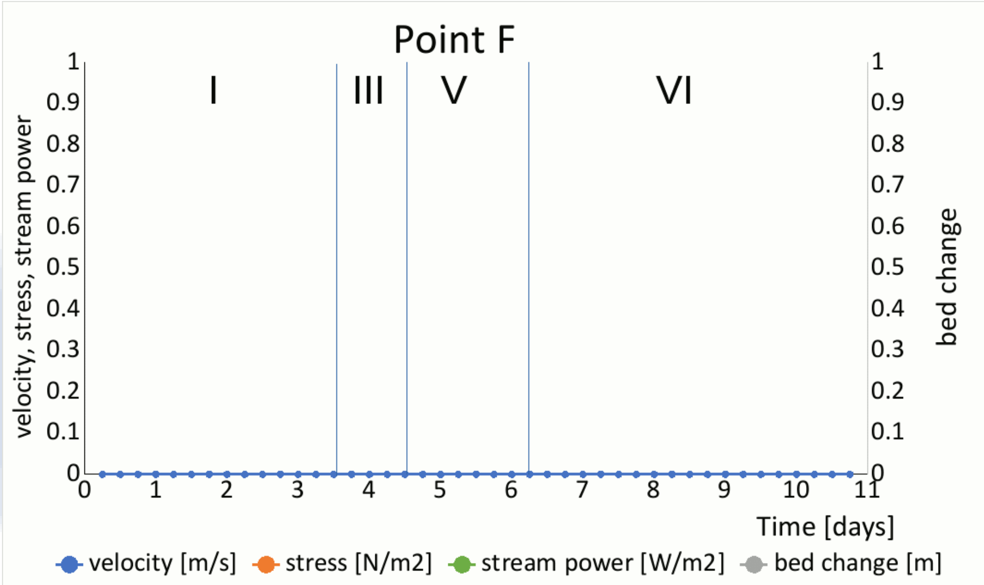
Bed change

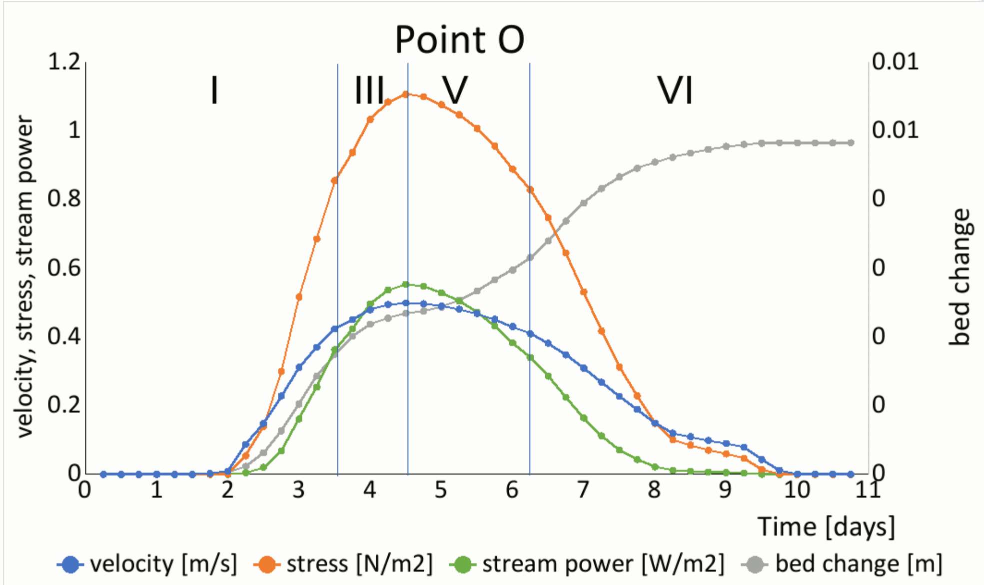
total shear stress

velocity

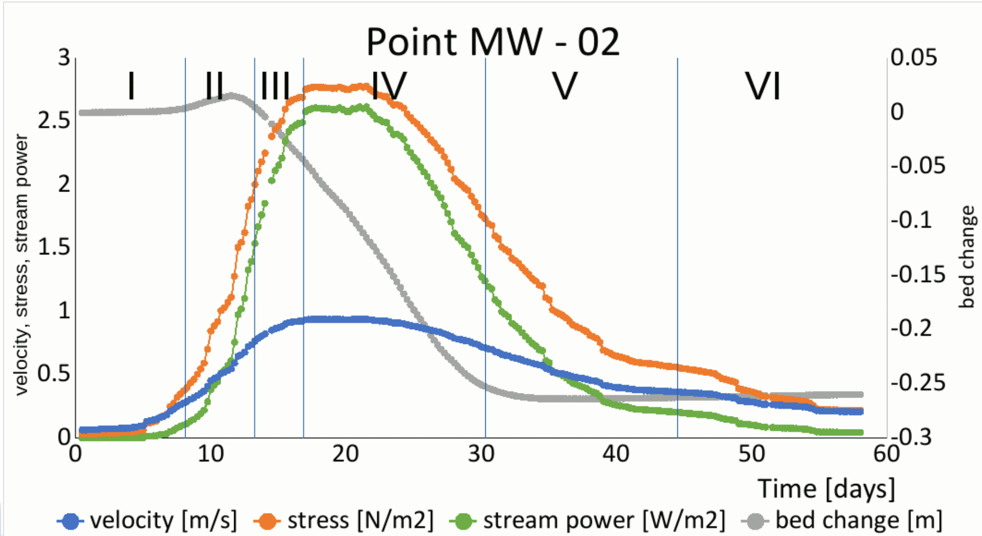


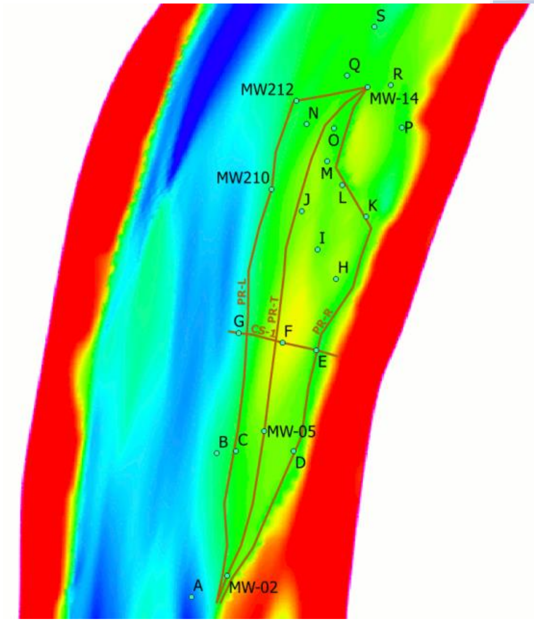


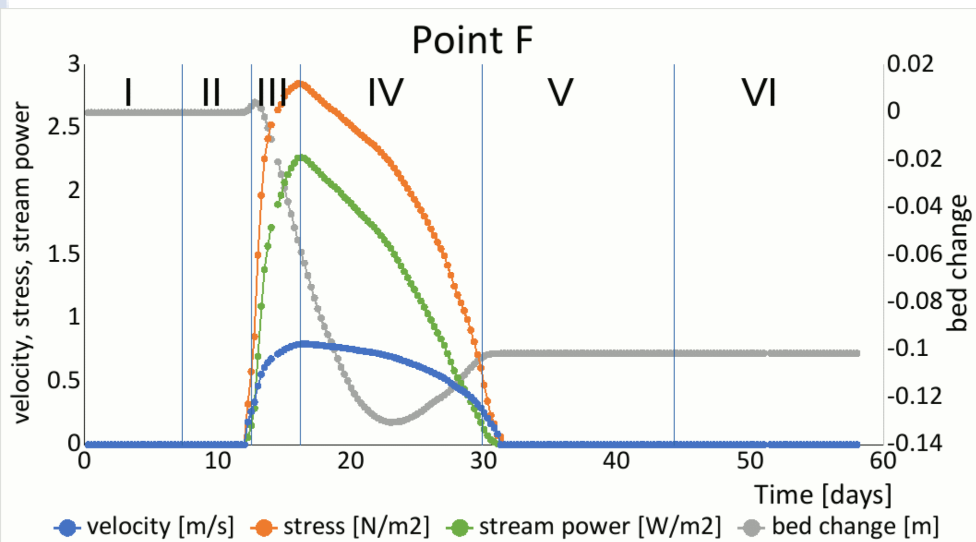


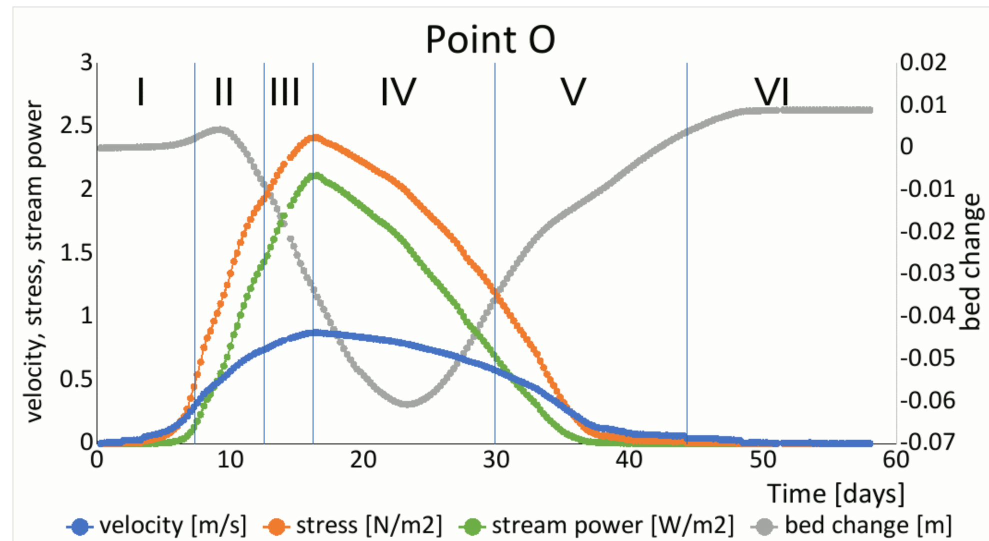


Data gathered in monitor points - Wave_1









Data gathered in monitor points - Wave_2

Wave_1

Flow phase	Point					
	MW-02	MW-05	F	J	O	MW-14
I	acc. +0.003[1] 0.07 – **0.35**[2] nm / rp[3] 0.12 / 0.27[4]	acc. +0.021 **0.33 – 0.96** rp /dn 0.32 / 0.51	–	no. +0.000 0.00 – 0.10 nm 0.03 / 0.13	acc. +0.000 0.00 – **0.86** nm / rp 0.11 / 0.42	no. +0.000 0.00 – 0.00 nm 0.01 / 0.04
III	acc. +0.007 **0.40 – 0.50** rp 0.32 / 0.34	acc/er +0.022 **1.12 – 1.42** dn 0.60 / 0.63	–	acc +0.001 0.12 – 0.17 nm / rp 0.17 / 0.18	acc. +0.002 **0.94 – 1.11** rp /dn 0.48 / 0.50	no +0.000 0.00 – 0.00 nm 0.02 / 0.03
V	acc. +0.012 **0.51 – 0.43** rp 0.33 / 0.34	er/acc +0.023 **1.41 – 0.95** dn 0.57 / 0.63	–	acc. +0.001 0.17 – 0.07 rp / nm 0.15 – 0.18	acc. +0.003 **1.10 – 0.83** dn / rp 0.46 / 0.50	no +0.000 0.00 – 0.00 nm 0.02 / 0.03
VI	acc. +0.014 **0.42** – 0.08 rp / nm 0.17 / 0.29	acc. +0.032 **0.92 – 0.33** rp 0.36 / 0.49	–	acc. +0.001 0.08 – 0.00 rp / nm 0.02 / 0.11	acc. +0.005 **0.75** – 0.00 rp / nm 0.14 / 0.38	no +0.000 0.00 – 0.00 nm 0.01 / 0.03

[1] bed process: no – no change, acc – accumulation, er – erosion; altitude change [m]
[2] shear stresses [Nm^{-2}], bold means incipient motion exceedance
[3] bed form description: nm – no movement, rp – ripples, dn – dunes
[4] velocity average / maximal [ms^{-1}]

Wave_2

<table>
<tr><th rowspan="2">FP</th><th colspan="6">Point</th></tr>
<tr><th>MW-02</th><th>MW-05</th><th>F</th><th>J</th><th>O</th><th>MW-14</th></tr>
<tr><td>I</td><td>acc +0.004
0.03 – 0.38
nm / rp
0.12 / 0.28</td><td>no 0.000
0.00 – 0.00
nm
0.00 / 0.00</td><td>no 0.000
0.00 – 0.00
nm
0.00 / 0.00</td><td>no 0.000
0.00 – 0.09
nm
0.01 / 0.11</td><td>acc +0.003
0.00 – 0.55
nm / rp
0.09 / 0.32</td><td>no 0.000
0.00 – 0.01
nm
0.02 / 0.05</td></tr>
<tr><td>II</td><td>acc/er +0.008
0.40 – 1.89
rp / dn
0.50 / 0.74</td><td>acc/er -0.007
0.00 – 1.45
rp / dn
0.36 / 0.60</td><td>acc/err +0.004
0.00 – 1.50
nm / rp
0.06 / 0.47</td><td>acc +0.066
0.09 – 1.59
nm / rp / dn
0.35 / 0.65</td><td>acc / er -0.011
0.64 – 2.02
rp / dn
0.59 / 0.77</td><td>no/acc +0.031
0.01 – 0.69
nm / rp
0.17 / 0.45</td></tr>
<tr><td>III</td><td>er -0.036
2.01 – 2.68
dn
0.86 / 0.92</td><td>er -0.027
1.52 – 2.07
dn
0.71 / 0.77</td><td>er -0.059
1.97 – 2.85
dn
0.72 / 0.80</td><td>acc +0.226
1.69 – 2.65
dn
0.79 / 0.87</td><td>er -0.034
2.07 – 2.42
dn
0.84 / 0.88</td><td>acc +0.104
0.74 – 1.49
rp / dn
0.59 / 0.69</td></tr>
<tr><td>IV</td><td>er -0.250
2.69 – 1.83
dn
0.89 / 0.94</td><td>er -0.083
2.09 – 1.65
dn
0.74 / 0.78</td><td>er / acc -0.104
2.84 – 0.61
dn / rp
0.64 / 0.80</td><td>acc/er +0.336
2.70 – 2.37
dn
0.86 / 0.91</td><td>er / acc -0.036
2.42 – 1.21
dn
0.77 / 0.88</td><td>acc +0.313
1.53 – 1.21
dn
0.68 / 0.72</td></tr>
<tr><td>V</td><td>er/acc -0.263
1.76 – 0.57
dn / rp
0.51 / 0.72</td><td>er/acc -0.078
1.62 – 0.19
dn / rp
0.38 / 0.63</td><td>acc / no -0.101
0.47 – 0.00
rp / nm
0.02 / 0.25</td><td>er +0.257
2.33 – 0.00
dn / rp / nm
0.36 / 0.73</td><td>acc +0.003
1.17 – 0.02
dn / rp / nm
0.24 / 0.57</td><td>acc/er +0.316
1.19 – 0.38
dn / rp
0.35 / 0.56</td></tr>
<tr><td>VI</td><td>acc -0.260
0.57 – 0.22
rp / nm
0.28 / 0.37</td><td>acc -0.077
0.19 – 0.00
nm
0.02 / 0.15</td><td>no -0.101
0.00 – 0.00
nm
0.00 / 0.00</td><td>no +0.257
0.00 – 0.00
nm
0.00 / 0.00</td><td>acc/ no +0.009
0.02 – 0.00
nm
0.01 / 0.06</td><td>er / no +0.315
0.39 – 0.00
rp / nm
0.19 / 0.28</td></tr>
</table>

[1] bed process: no – no change, acc – accumulation, er – erosion; altitude change [m],
[2] shear stresses [Nm^{-2}], bold means incipient motion exceedance,
[3] bed form description: nm – no movement, rp – ripples, dn – dunes,
[4] velocity average / maximal [ms^{-1}].

Wave_1 caused only processes which smoothed the lower parts of the island and did not break the nesting. When flows similar to Wave_1 pass and do not cover the top of the island (point F), this may lead to gradual expansion on areas downstream of its top.
Wave_2 produced a strong effect of depositing and shifting the island, although it seems that a wave that fits in the channel may cause its shape to change to more elongated and narrow (fusiform), and to relocate the island downstream. Additionally, this wave turned the breeding unsuccessful in the nesting colony.

Phases I and II, which cover a part of the island, seem not to be essential to the course of the island's formation process, although it is during phase II (i.e., from the moment water starts flowing over a significant area of the island to the moment when it is completely flooded), that fluvial processes gain in strength and become the reason for relatively large changes to the shape of the island.
The passage of the wave culmination does not change the trends of processes occurring.
The clearest change in the trend of fluvial processes occurs in phases IV and V, when the local water layer covering the island disappears. Cross-flows having the nature of a sheet flow then occur in dips within the main body of the island, and these have significant erosion capability.

The 2D modelling carried out provided data supporting the thesis that exceeding the conditions of bed material movement does not always lead to activation of the erosion processes.
With the right load of material transported in the river bed, the transport capacity of the stream may be exhausted and, as a result, the bottom will not be eroded.
For this reason, the next step in the analyses will be to establish the transport balance along different cross-sections of this island.

Thank you for your attention