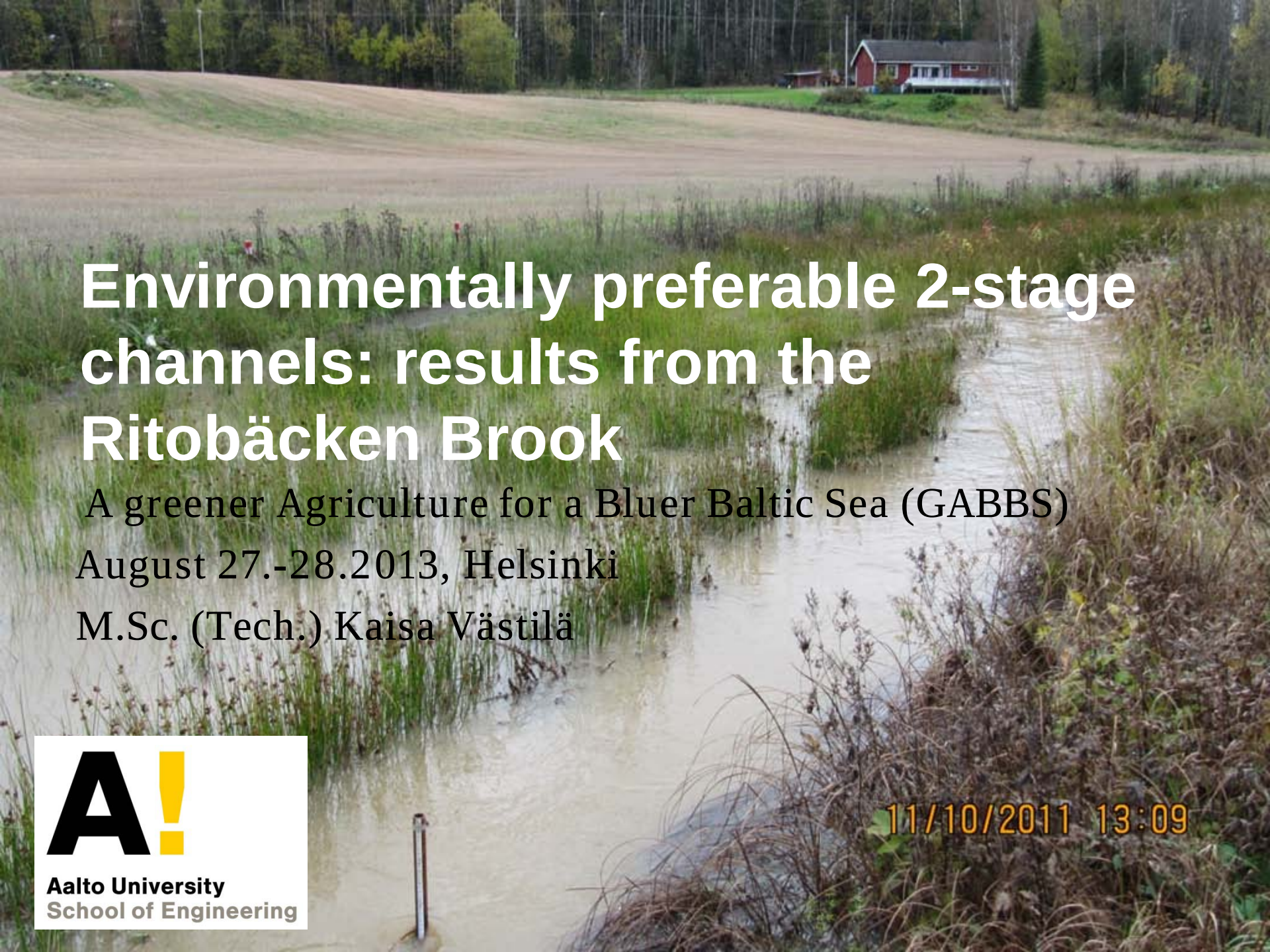

Environmentally preferable 2-stage channels: results from the Ritobäcken Brook

A greener Agriculture for a Bluer Baltic Sea (GABBS)

August 27.-28.2013, Helsinki

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Background

- Many brooks and catchments have been modified by humans for agricultural purposes

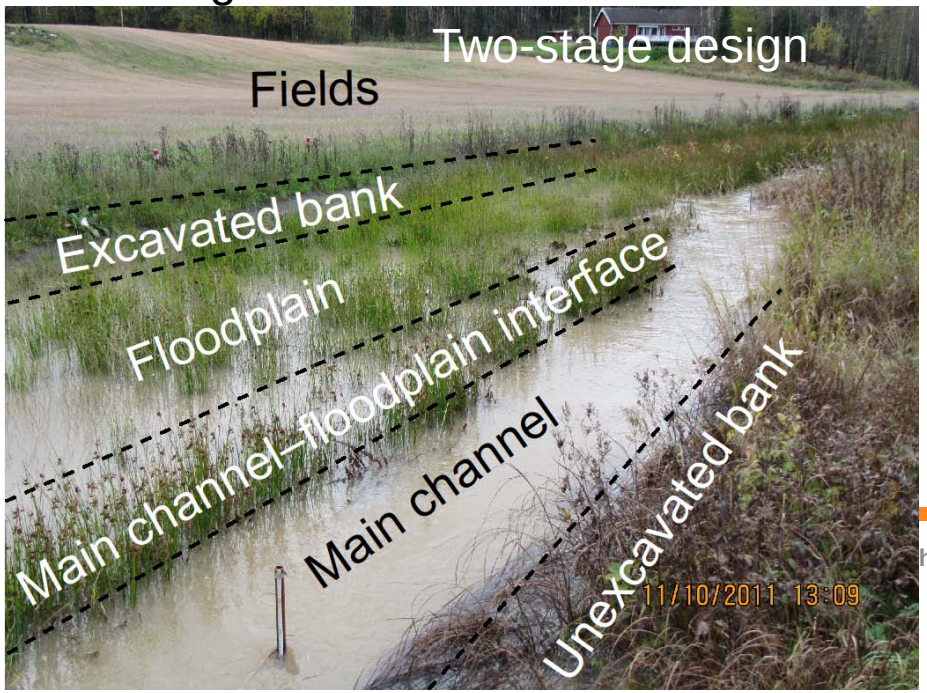
  -> increased sediment and nutrient input

  -> reduced flow and habitat variability in the channels

  -> problems with channel aggradation/degradation
- Need for environmentally preferable, self-sustaining drainage channels
- Drainage depth and conveyance need to be high enough -> full restoration not possible

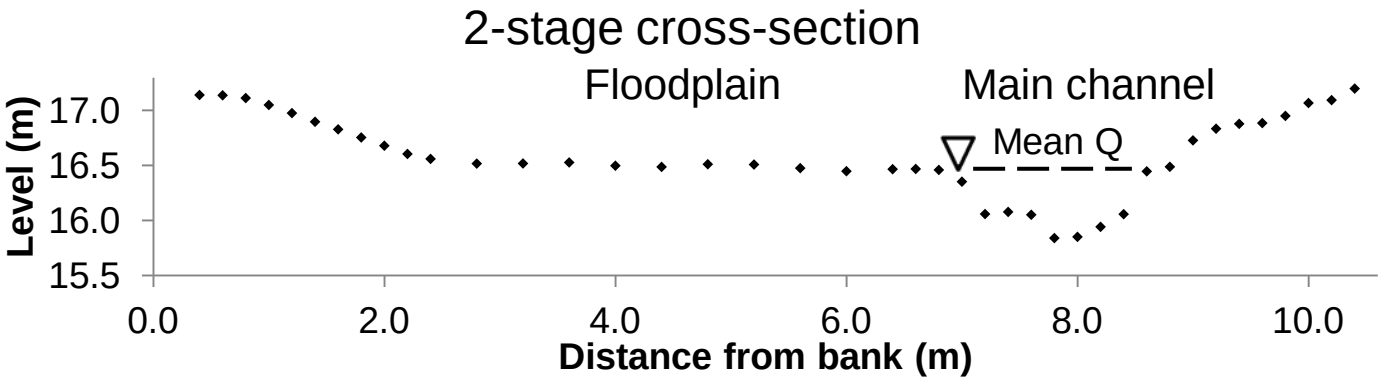
Environmentally preferable 2-stage channels: benefits expected by environmental authorities

- Alternative to conventional dredging
- Functions at low and high flows
- More diverse habitats, better water quality, limited floodplain connectivity
- More self-sustaining
- Design challenges due to e.g. cohesive sediments and flow resistance of vegetation

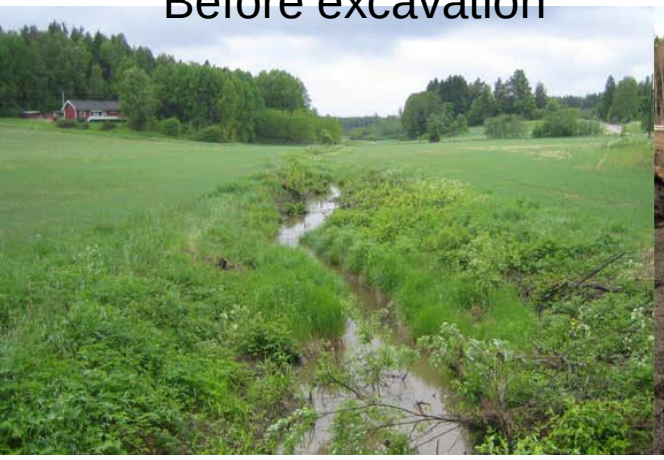


Ritobäcken Brook: a two-stage agricultural channel

- Floodplain was excavated at the level of mean discharge in February 2010 (by Uusimaa Centre for Economic Development, Transport and the Environment)
- Soil: silty clay loam; 13% of the catchment are fields, remainder mainly forests and mires
- Mean discharge: 115 l/s; floodplain inundated 1-4 months/year



Before excavation



After excavation

Excavation of the floodplain in Feb 2010

A short film on the two-stage channel (in Finnish) by Uusimaa Centre for Economic Development, Transport and the Environment: http://www.ymparisto.fi/default.asp?node=27009&lan=fi

The suspended sediment load during the excavation was approximately 2% of the total annual load. During the first spring's snowmelt, erosion on the unvegetated floodplain was approximately 6 mm.

Objectives of the 3-year field study

- Identify the catchment-scale sediment sources and processes of the two-stage agricultural channel
- Determine how the flow resistance and mean velocity depend on vegetation properties
- Understand the effect of different floodplain vegetation on sediment deposition and erosion

-> Our research is intended to aid in designing and managing environmental channels

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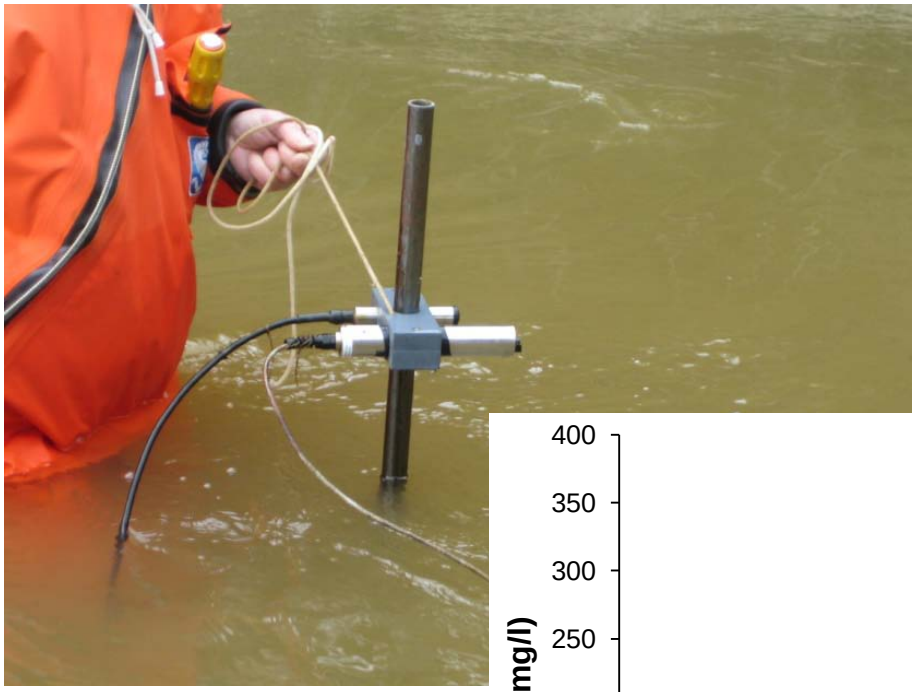
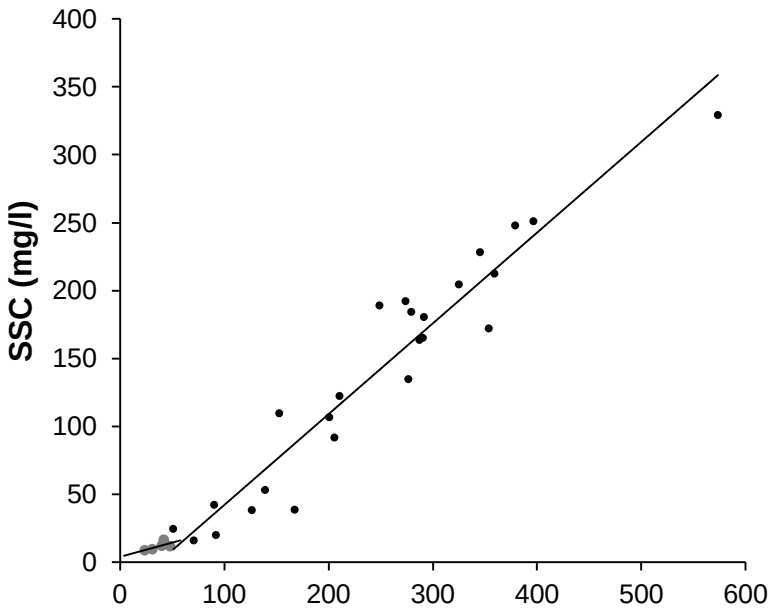
Monitoring of turbidity and water level at 5-min intervals in a 200 m long reach for determining net deposition and flow resistance



SSC=suspended sediment concentration



(Västilä & Järvelä 2011a)

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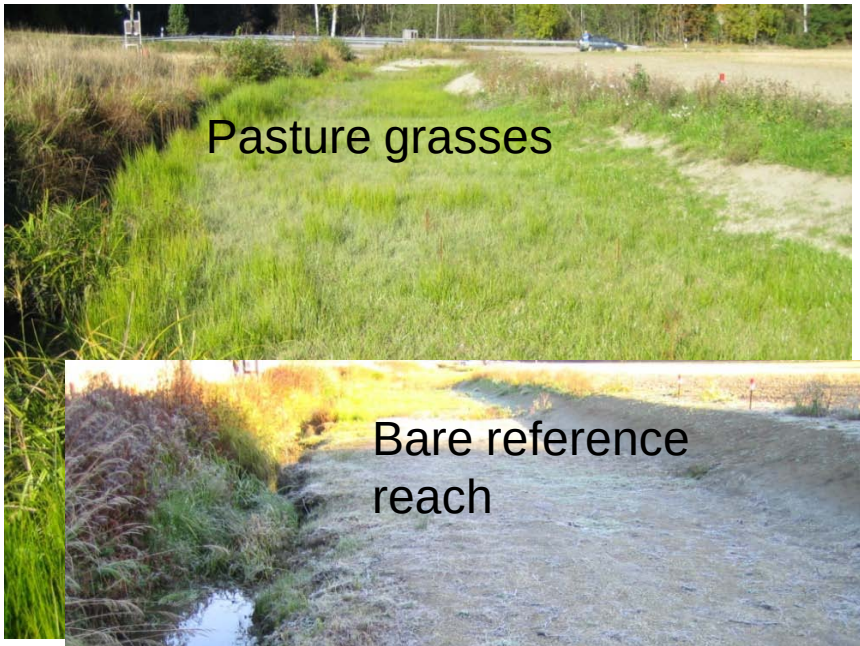
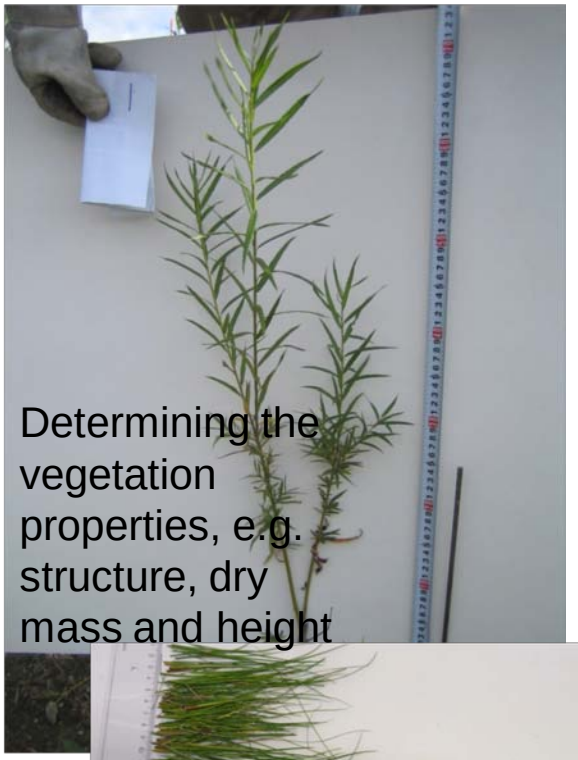
5 differently vegetated study reaches were established to examine how the flow resistance and erosion/deposition are related to measurable vegetation properties



3-year monitoring of the channel geometry, water levels and vegetation properties in the vegetated study reaches



Vegetation properties in autumn 2010

Table 1 Parameters of floodplain vegetation on the test reaches in the late summer.

Reach vegetation	Areal dry biomass (g/m^2)	Average height (cm)	Bulk density (g/m^3)	Leaf area index, LAI (m^2/m^2)
Grasses (mainly *Lolium perenne*)	140	8	1771	
Willows (*Salix viminalis*)	280	54	523	0.13
Naturally developing	345	33	1055	
Unvegetated	0	0	0	
Reach average	297	30	996	

stilä

(Västilä & Järvelä 2011b)

Planted, sown and naturally developing vegetation was established in the first summer on the floodplain, but parts of the excavated bank remained bare for 3 summers

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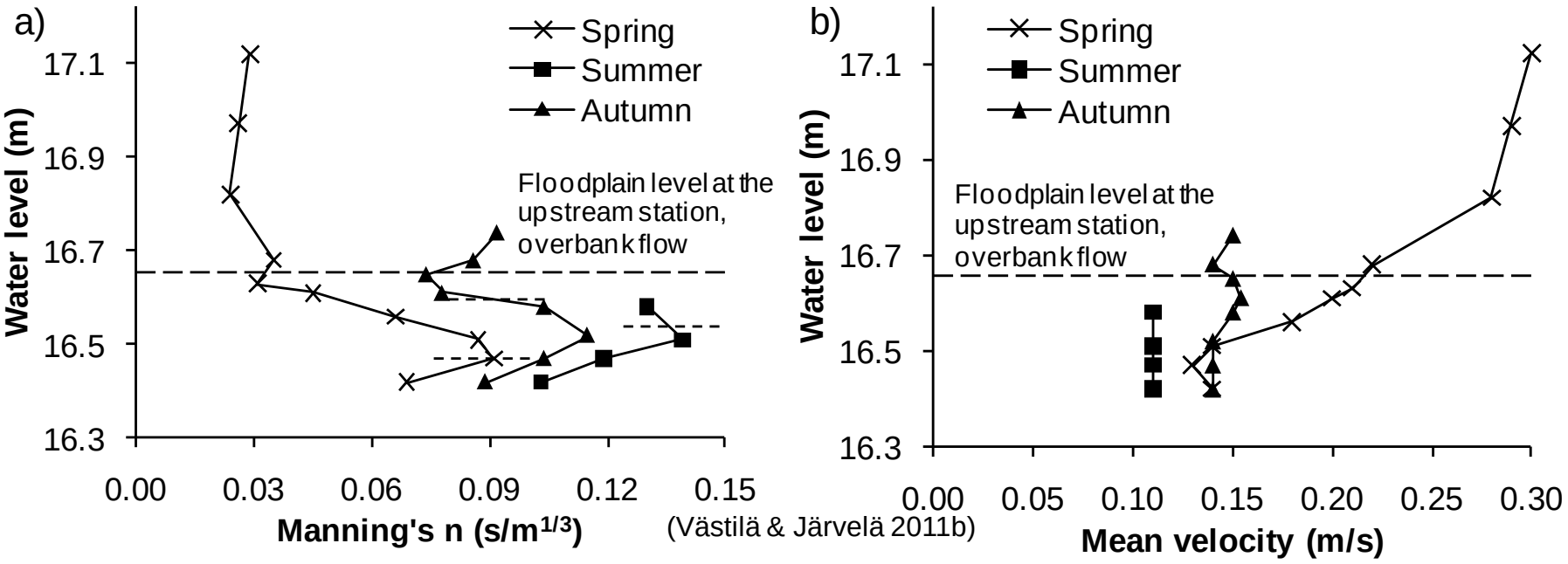
Effect of vegetation on flow resistance (Manning's n) and mean velocity



(Västilä & Järvelä 2011b)

Manning's n and mean velocity varied both according to vegetation properties and water level. The flow resistance could be estimated with simple vegetation properties (to be published).

$$n = \frac{1}{u} R^{2/3} S^{1/2}$$

where u=mean velocity,
R=hydraulic radius and
S=energy slope

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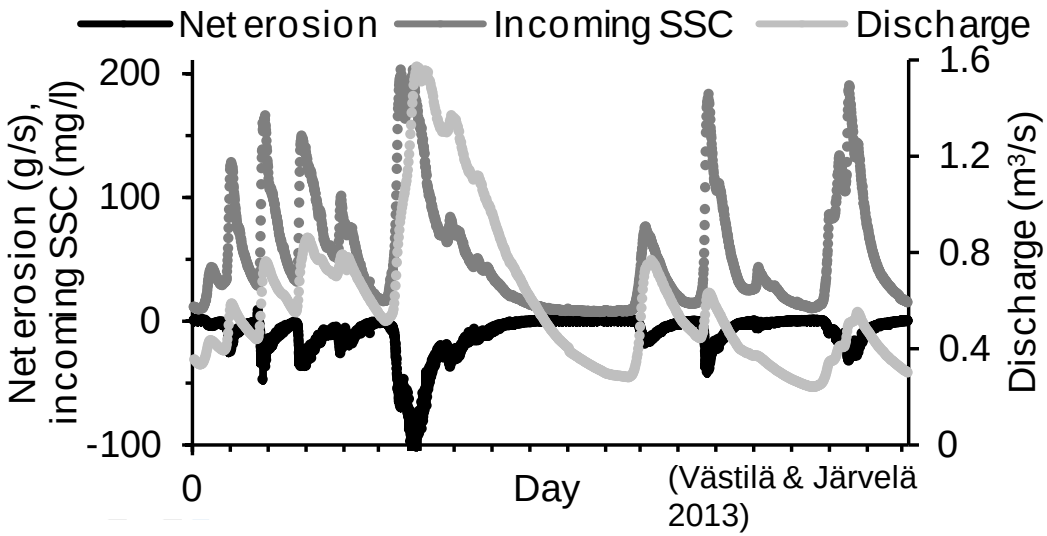
Sediment sources and processes at the cathment scale

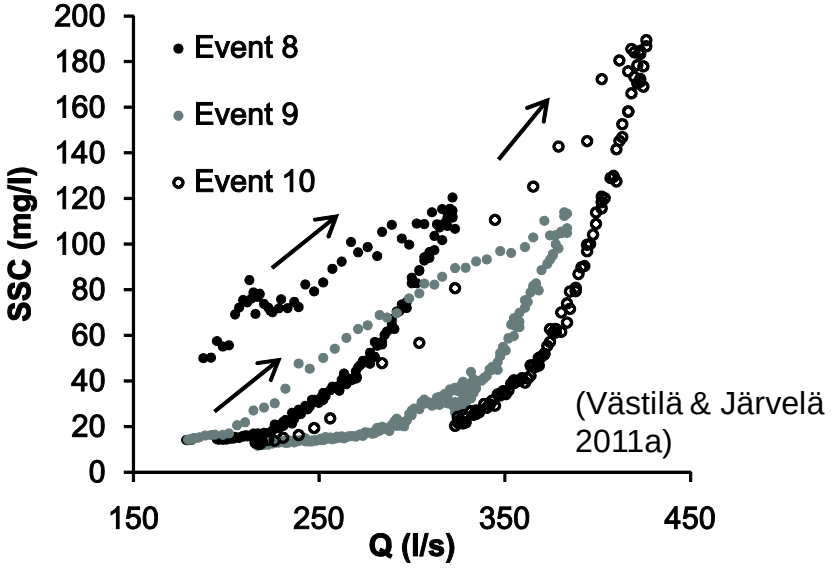
- After the vegetation had developed, no major channel erosion has been observed

  - the transported suspended sediment originates from the catchment areas
- Annual suspended sediment load: 10-20 t/km^2/a (Västilä & Järvelä, 2011a)
- Discharge-SSC correlations revealed that the catchment's two distinct land uses (agriculture and forests) differed in the timing of runoff generation and sediment input (Västilä & Järvelä, 2011a)

  - the large concentrations during the rising stage originated primarily from the agricultural areas
- Sediment deposition occurred in the channel when the incoming SSC was high -> reduction in SSC and turbidity
- SSC was significantly correlated with the total phosphorus (Janne Jurmu's candidate thesis, 2013)



(Västilä & Järvelä 2013)



(Västilä & Järvelä 2011a)

Sediment deposition and erosion on the floodplain: effect of vegetation properties (to be published)

- 2-year deposition in the differently vegetated study reaches was positively correlated with the areal inundated dry vegetation mass
- Erosion was observed when the vegetation mass was low
- The deposition on the 200 m long floodplain corresponded to approximately 4% of the incoming sediment load -> a higher share was likely deposited on the entire 850 m long floodplain
- Deposited sediment was primarily flocculated silt and clay (Niina Siitonen's master's thesis, 2013) -> some particle-bound phosphorus was also potentially deposited

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The landowner's thoughts on the two-stage channel

- So far the two-stage channel has served its purpose, i.e. significantly improved the drainage of the fields
- The fields have been inundated only occasionally e.g. during the snowmelt
- What kind of channel maintenance is required and how to achieve that?

  - e.g. regular mowing of the floodplain and bank vegetation to prevent the floodplain from becoming clogged with vegetation, potentially with similar equipment as used for mowing road slopes

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Some further remarks

- ? The effects of the two-stage channel on soluble nutrients

  - decreased flooding of the fields

  - the phosphorus content of the floodplain vegetation in the 200 m long reach is approximately 1% of the annually transported total P load (Janne Jurmu's candidate thesis, 2013)

  - floodplain vegetation should be mowed regularly to prevent nutrient leaching from decaying vegetation
- The processes of fine cohesive sediment are not well understood -> however, these processes are the key for understanding the fate of e.g. particle-bound phosphorus
- ? The effect of floodplain vegetation on the main channel erosion/deposition

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Conclusions

- The two-stage channel improved the drainage of the fields
- Develoment of floodplain vegetation increased the flow resistance and decreased the mean velocity
- The flow resistance could be estimated with simple vegetation properties, allowing the effect of vegetation to be taken into account in the design and management of environmental channels
- Sediment deposition and erosion could be related to simple vegetation properties
- Longer floodplains can trap a significant amount of the incoming sediment
- Channel vegetation may be potentially managed according to different objectives, such as controlling the flow velocity, preventing erosion, or enhancing the trapping of sediment and phosphorus

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Recommendations for the farmers to improve the knowledge base of 2-stage channels

- Consider the possibility of using the two-stage design as a solution instead of traditional dredging, because this would enable constructing more two-stage channels on real sites of different topography and soil
- If a two-stage channel is constructed on your fields, consider volunteering to help in simple and quick monitoring activities to provide knowledge of the functioning of the channel
- If a two-stage channel is constructed on your fields, consider allowing researchers to conduct detailed, multi-year studies at the site

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Recommendations for the decision makers

- Consider tying part of the funding for a two-stage channel construction project to monitoring activities to allow learning from both successes and failures
- Support both basic and applied research related to the two-stage concept (need for improved understanding on e.g. the in-channel nutrient processes and the comparison of the two-stage concept to other solutions, such as conventional channel with buffer strips)
- Foster holistic thinking about the agricultural water bodies (ecosystem services, biodiversity, water quality, habitat diversity, landscape aspects...)

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References

- Jurmu, J. 2013 Luonnonmukaisen uoman sisäisten prosessien vaikutus fosforin kulkeutumiseen. Candidate thesis at Aalto University.
- Siitonen, N. 2013 Cohesive sediment properties in an agricultural two-stage channel. Master's thesis at Aalto University.
- Särkelä, A., Aulaskari, H. & Västilä, K. 2011 Luonnonmukaisen kuivatushankkeen vesistövaikutukset ja uomassa tapahtuvat muutokset [in Finnish]. Loppuraportti. http://www.ymparisto.fi/download.asp?contentid=127683&lan=fi
- Västilä, K., Jalonen, J. & Järvelä, J. 2011 Sedimenttiprosessien vaikutukset luonnonmukaisten uomien suunnitteluun [in Finnish]. Vesitalous 2011(4): 28-31 .
- Västilä, K. & Järvelä, J. 2011a Environmentally preferable two-stage drainage channels: considerations for cohesive sediments and conveyance. Intl. J. River Basin Management. DOI: 10.1080/15715124.2011.572888.
- Västilä, K. & Järvelä, J. 2011b Cohesive sediment dynamics in a vegetated two-stage drainage channel: the first year after floodplain excavation. Proceedings of River, Coastal and Estuarine Morphodynamics 2011 conference, 6-9 Sep 2011,Beijing.
- Västilä, K. & Järvelä, J. 2013 Suspended sediment transport in a vegetated agricultural channel. Proceedings, 8th Symposium on River, Coastal and Estuarine Morphodynamics RCEM, 9-13 June 2013, Santander, Spain.

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Acknowledgements:
Juha Järvelä, instructor for my PhD
Landowners at Ritobäcken
Laboratory personnel at the Aalto Water Engineering
Thanks to Uusimaa Centre for Economic Development, Transport and the Environment, and Water Protection Association of the River Vantaanjoki and Helsinki Region for cooperation.

The research has been funded by the Academy of Finland, Maa- ja vesitekniikan tuki ry, Ministry for Agriculture and Forestry, Oskar Öflund Foundation, Emil Aaltonen Foundation and VALUE doctoral school

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