Wir machen Schifffahrt möglich.

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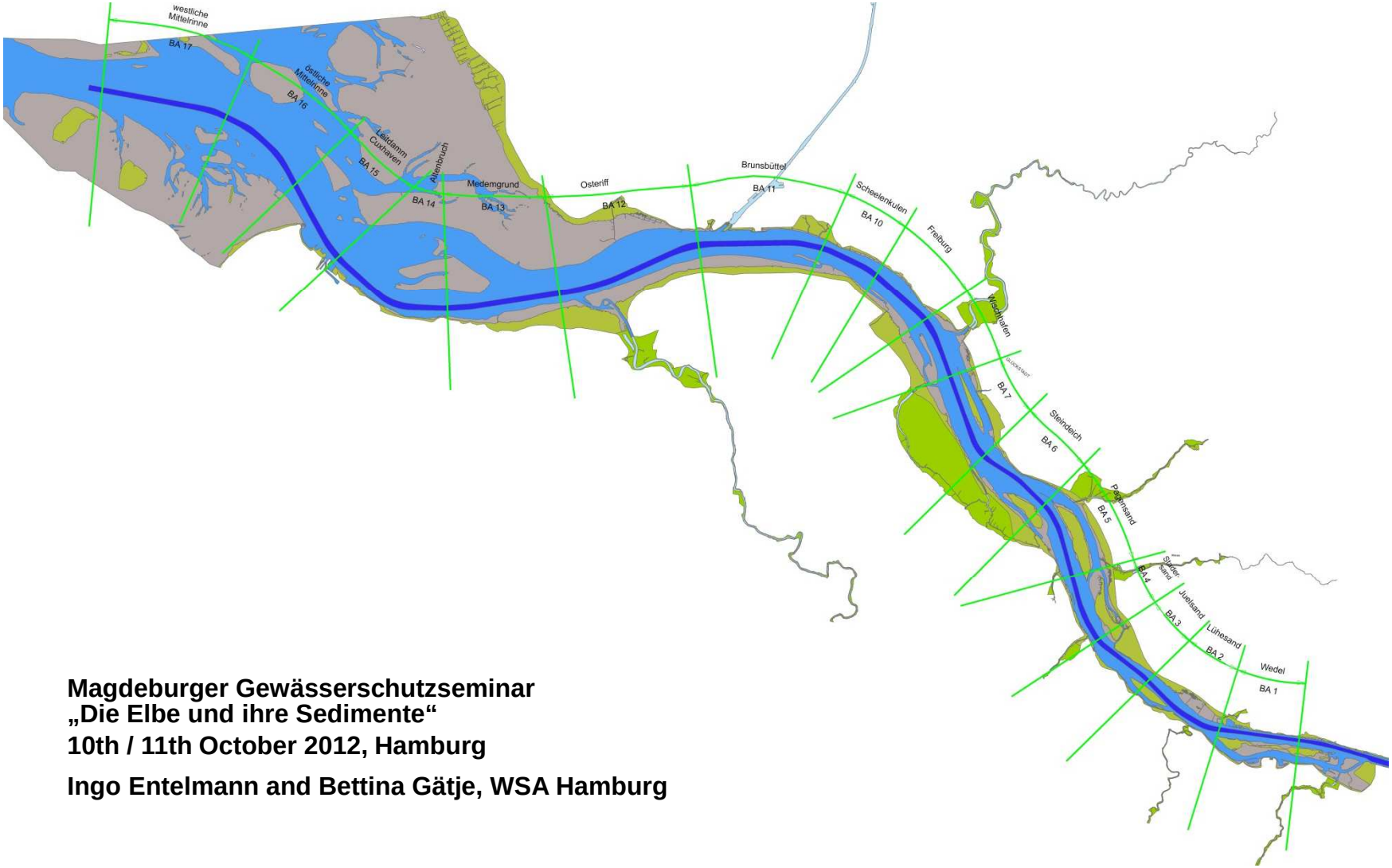
Wasser- und Schifffahrtsverwaltung des Bundes

Sediment management in the Tidal Elbe
Optimization of relocation strategies



Magdeburger Gewässerschutzseminar
„Die Elbe und ihre Sedimente“
10th / 11th October 2012, Hamburg

Ingo Entelmann and Bettina Gätje, WSA Hamburg

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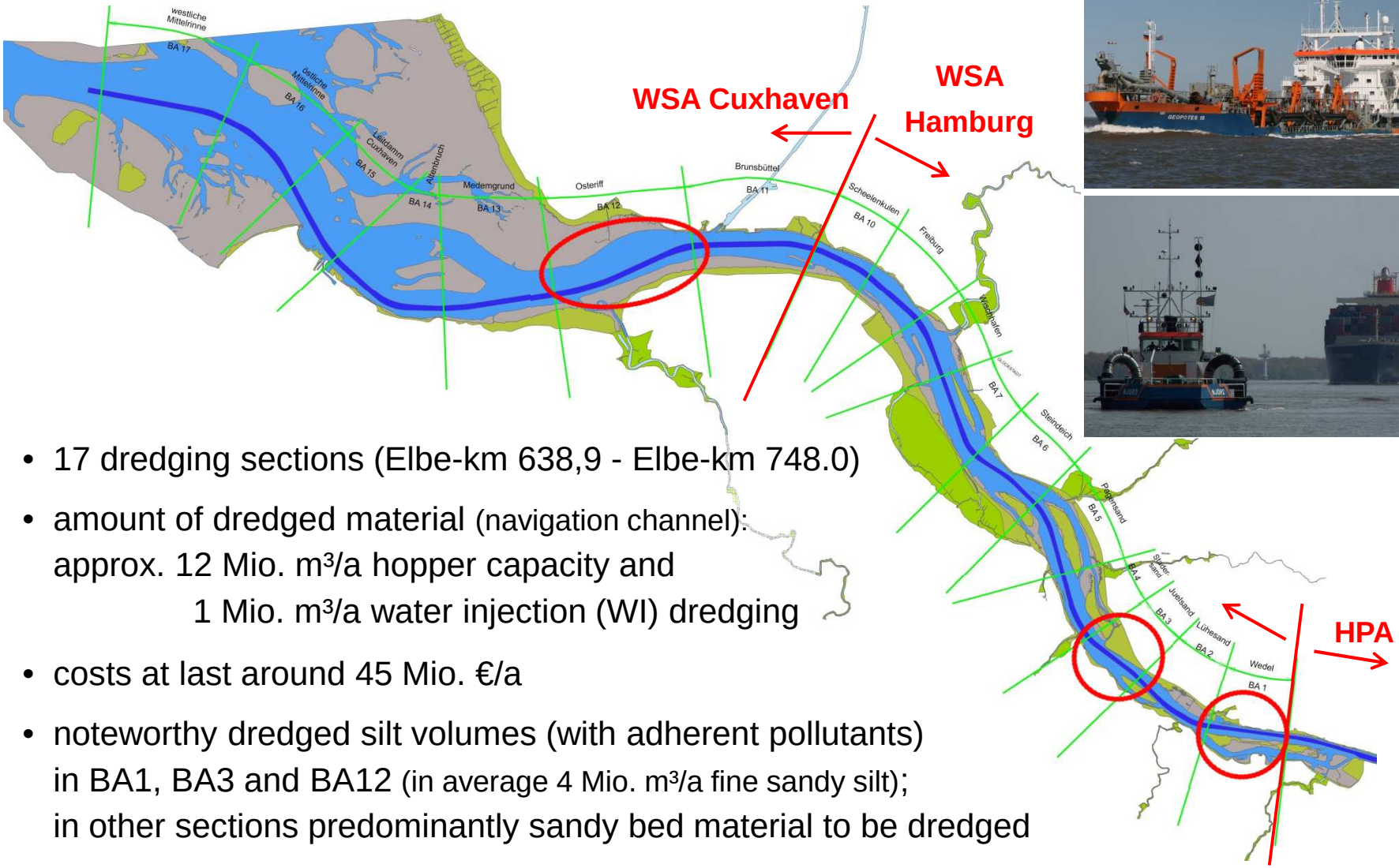
Dredging sections in charge of the the Waterways and Shipping Offices Hamburg und Cuxhaven



- 17 dredging sections (Elbe-km 638,9 - Elbe-km 748.0)
- amount of dredged material (navigation channel):
  approx. 12 Mio. m³/a hopper capacity and
  1 Mio. m³/a water injection (WI) dredging
- costs at last around 45 Mio. €/a
- noteworthy dredged silt volumes (with adherent pollutants)
  in BA1, BA3 and BA12 (in average 4 Mio. m³/a fine sandy silt);
  in other sections predominantly sandy bed material to be dredged

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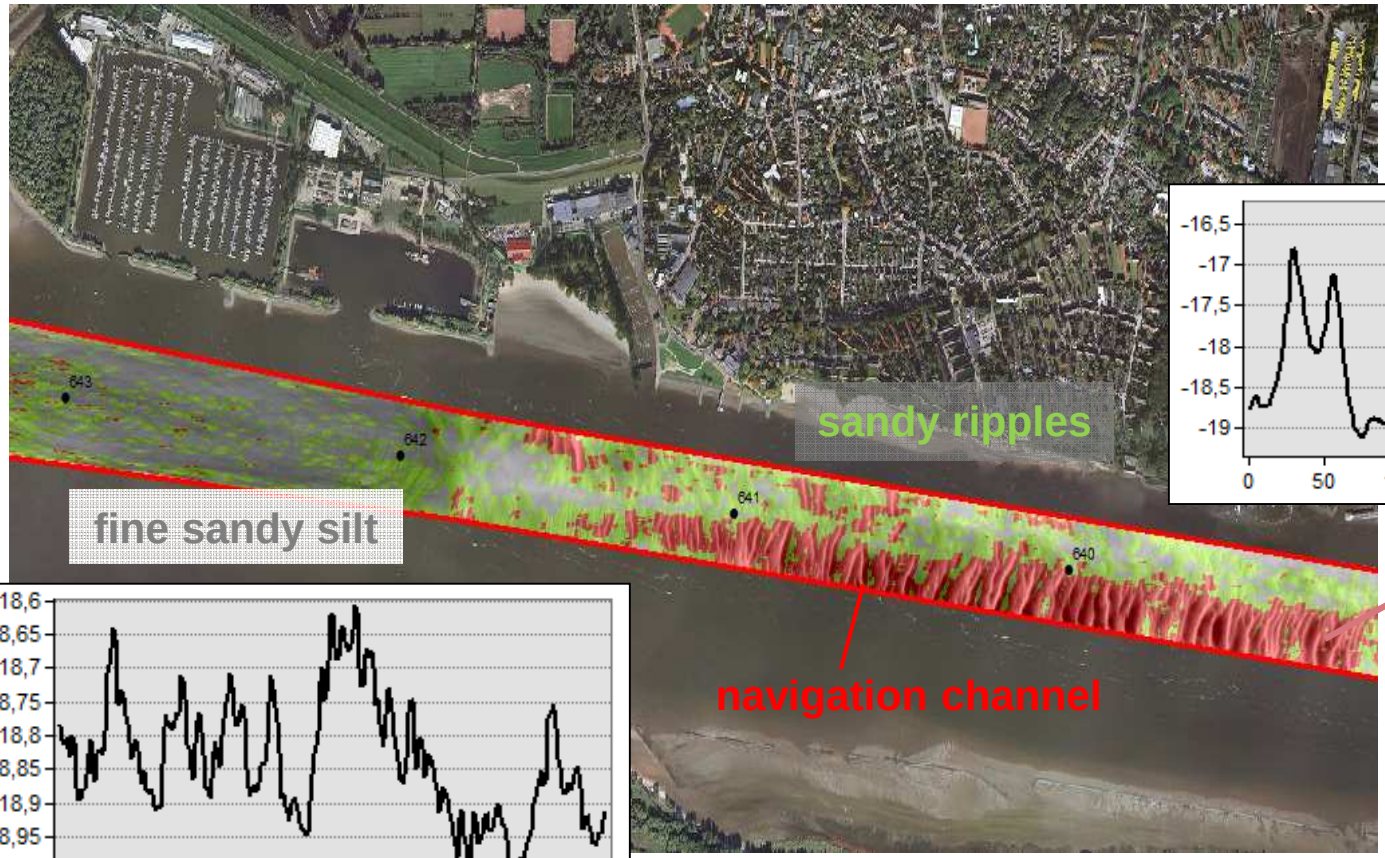
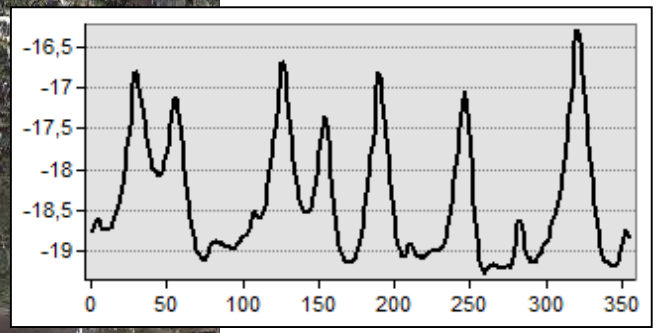
Morphological structures in the navigation channel

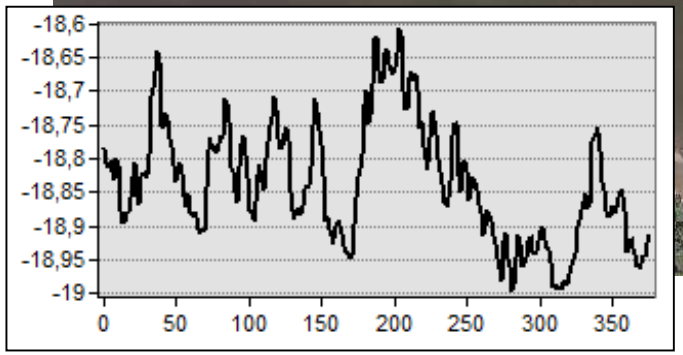


(dune height: 2 to 3 meters)



medium sandy dunes

(isolated shallows, preferred charge of WI-dredgers)



Elbe-km 639 to 643

(plane sedimenation / large-area shallows, in general charge of hopper dredgers)

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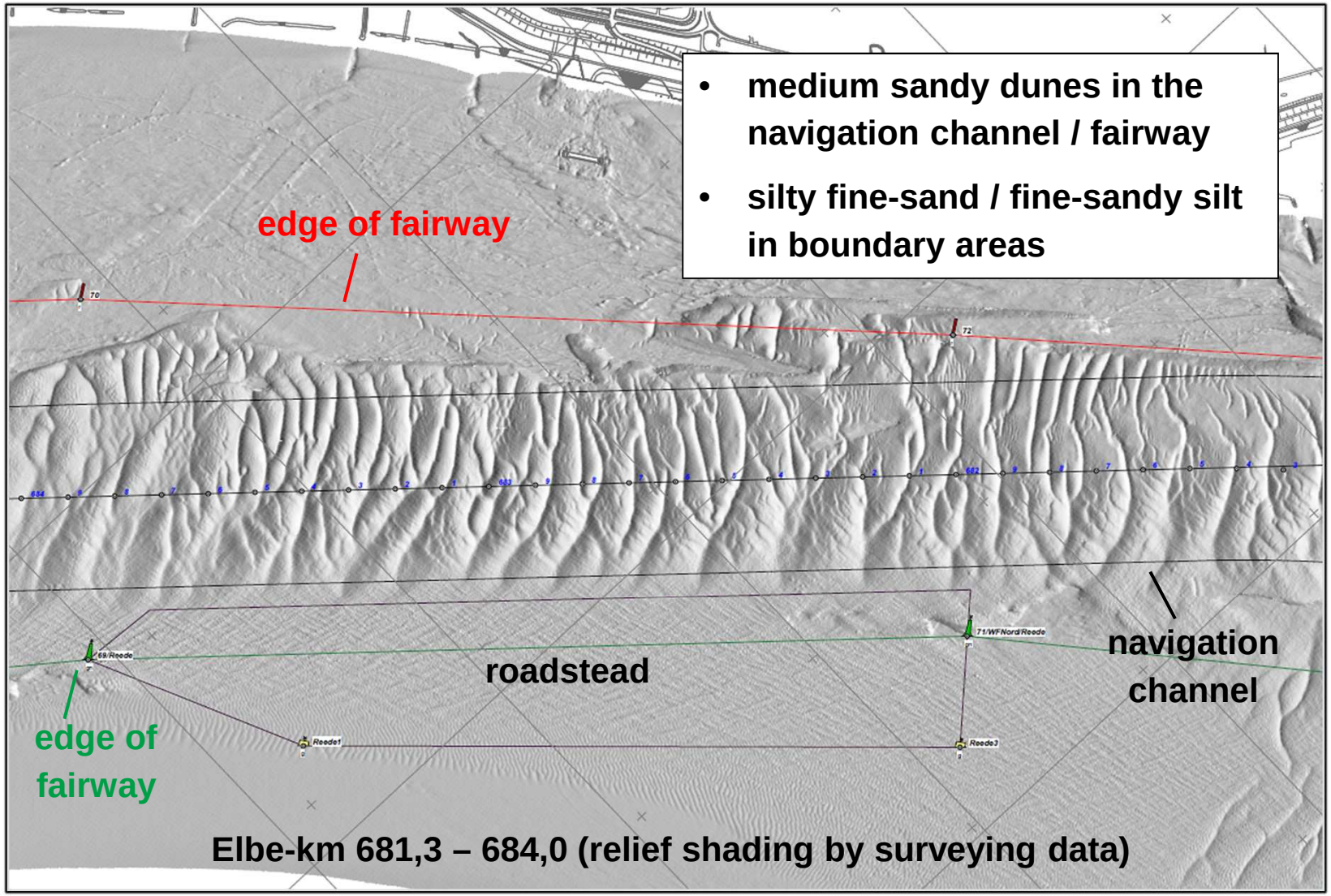
Morphological structures in the river channel



- medium sandy dunes in the navigation channel / fairway
- silty fine-sand / fine-sandy silt in boundary areas

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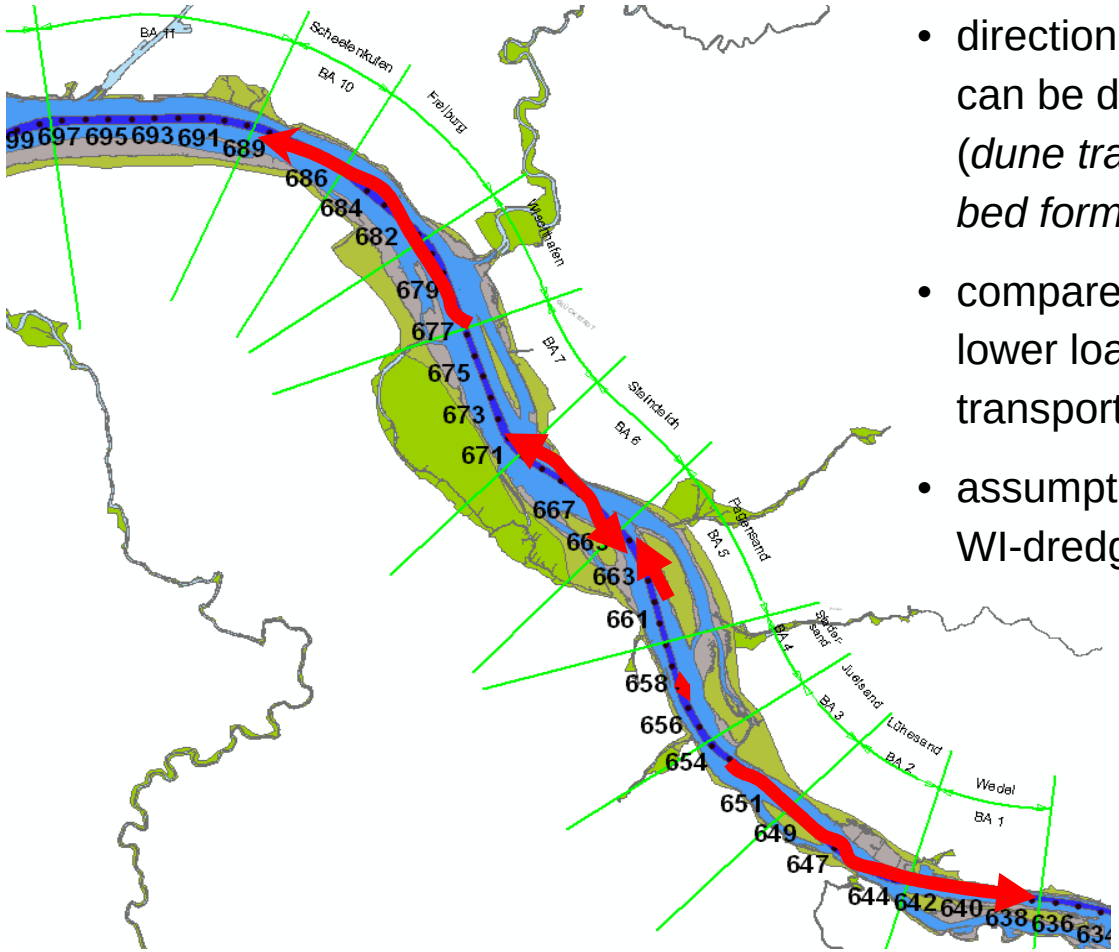
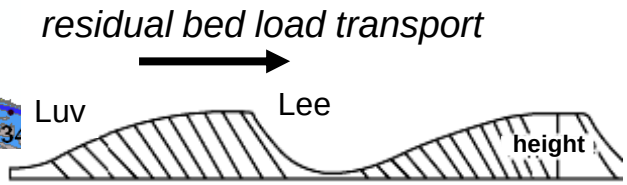
Dredging and relocation strategies - medium-sandy sections of the navigation channel



- direction of residual bed load transport can be determined by surveying data (*dune tracking* resp. *bed form tracking*)
- compared to suspended load transport lower loads and very much lower residual transport rates
- assumption for „inner estuary“: charge of WI-dredgers senseful, alternativ charge of hopper dredgers and - as far as possible - near-by relocation



residual transport of bed load, Elbe-km 638 - 689

(*Qrefa-Sander, WSA Hamburg 2011*)

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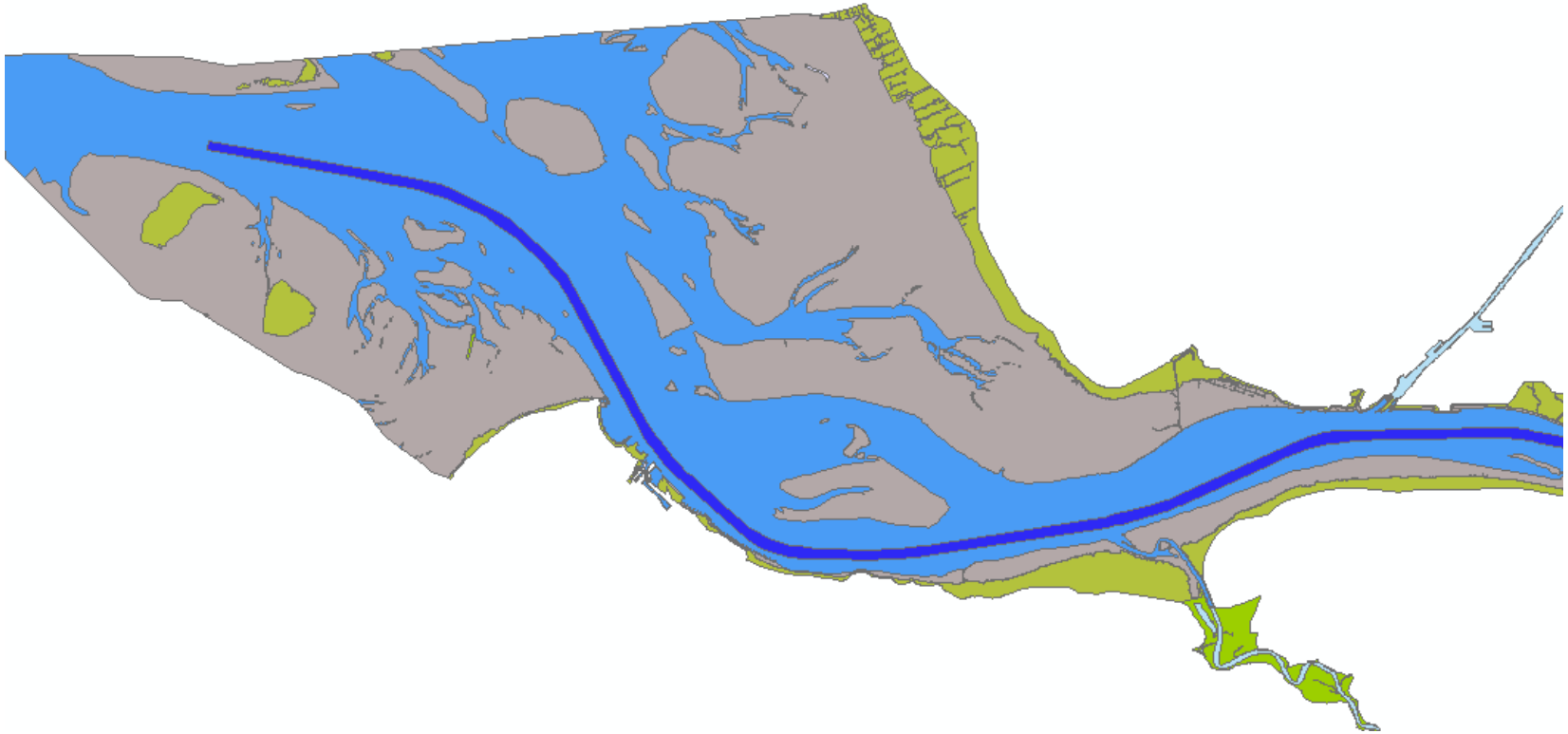
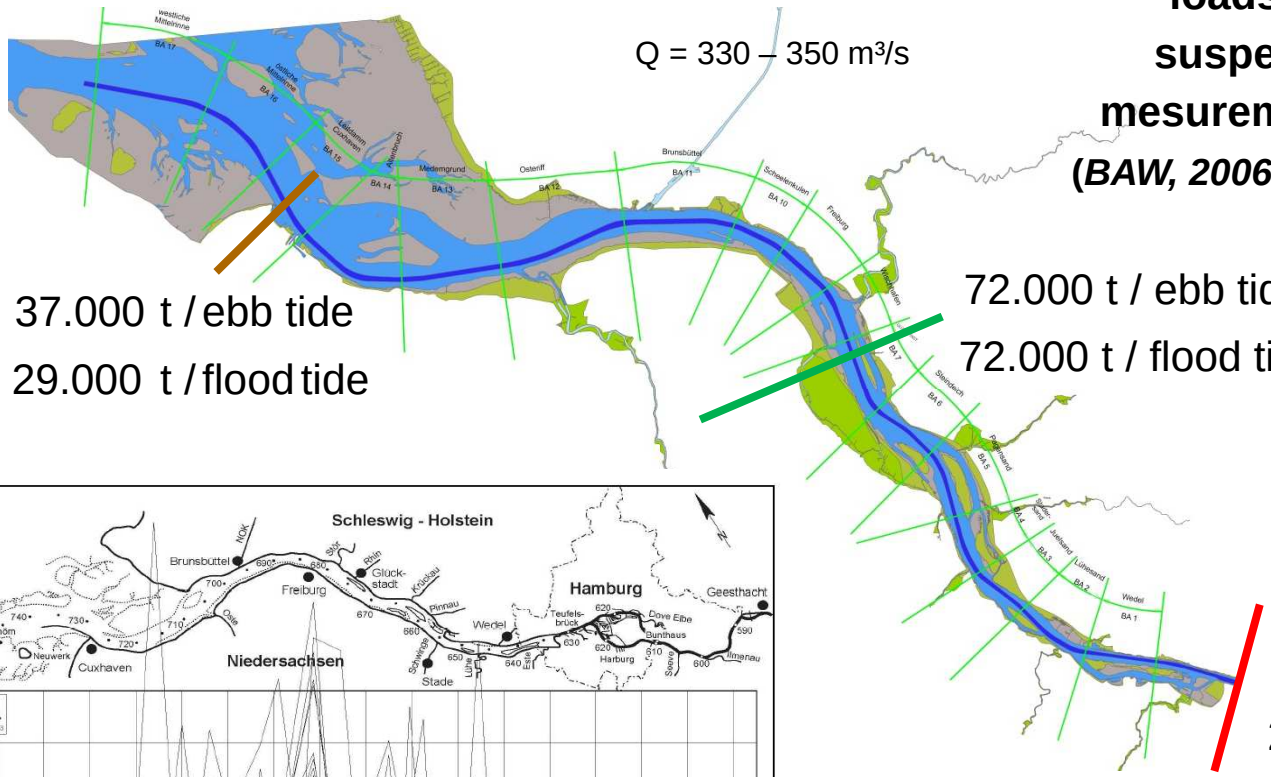
Dredging and relocation strategies - (medium-)sandy sections of the navigation channel

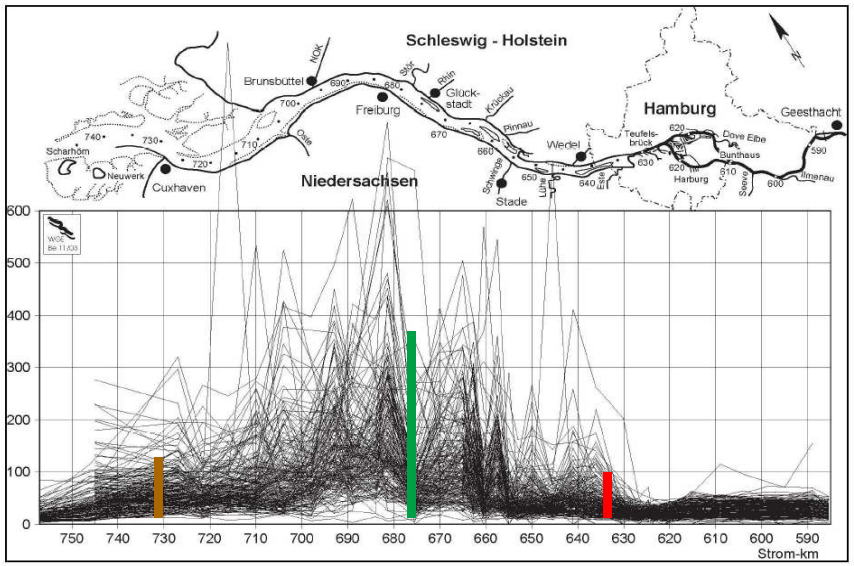


no topic in this presentation: morphodynamics in the mouth of the Elbe estuary (dynamic transport processes not comparable with processes in the „inner estuary“, shifting of banks and branches can lead to unexpected rise in dredging amount, predication of morphological chances is a complex task)

Suspended load transport in the Tidal Elbe, turbidity zone of the Tidal Elbe

loads calculated by suspended sediment mesurements using ADCP
(*BAW, 2006; Weilbeer et al., 2012*)

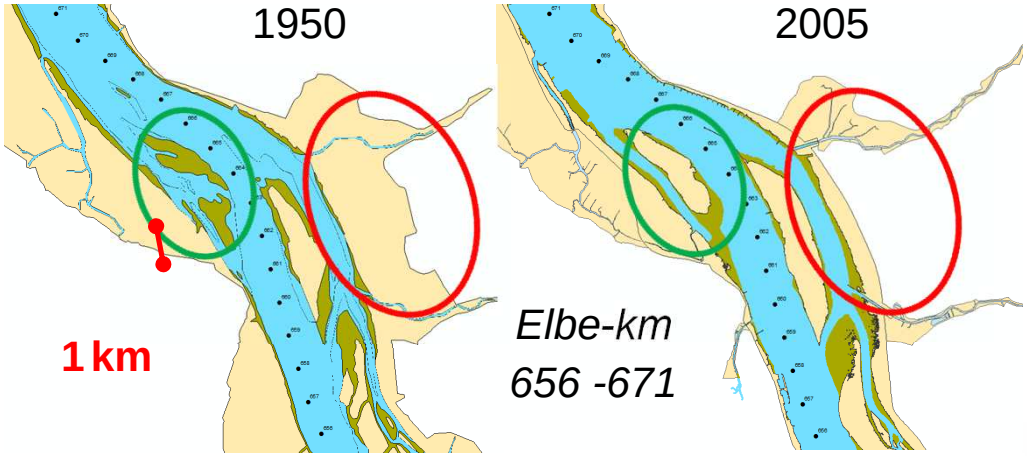




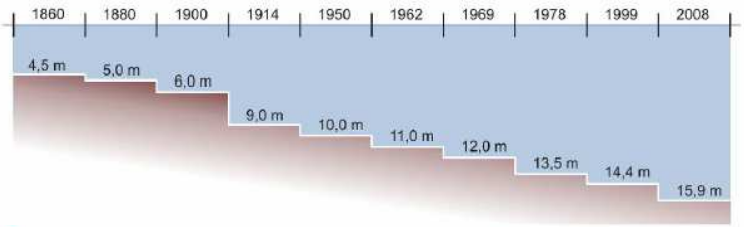
turbidity zone of the Tidal Elbe, pictured by surface-near suspended matter concentrations

(Source: ARGE Elbe)

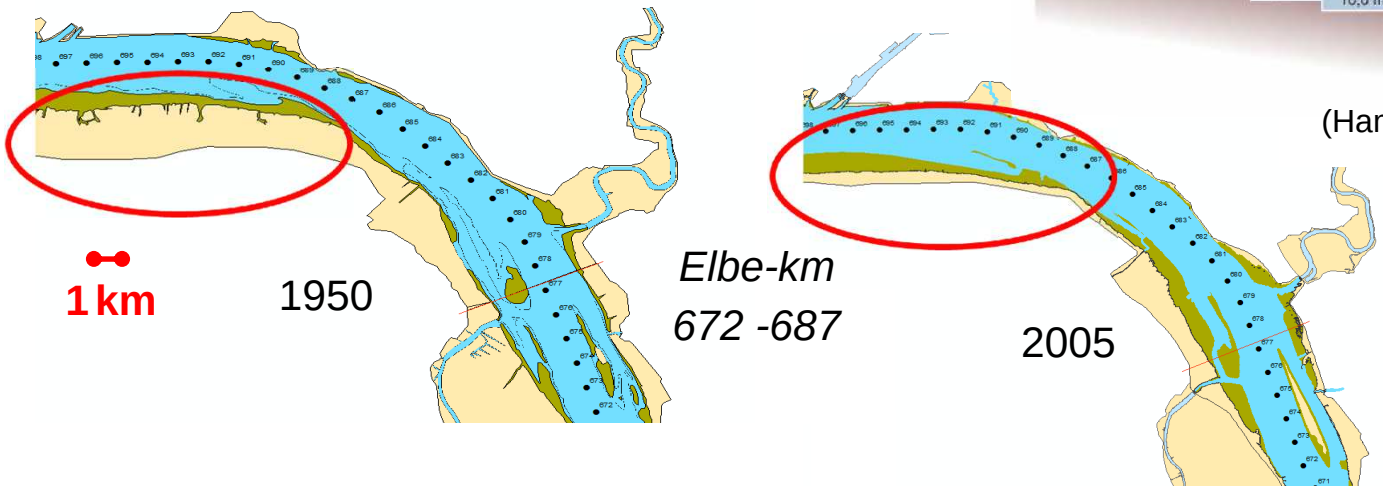
Morphological evolution of the Tidal Elbe and resulting effects on the turbidity zone



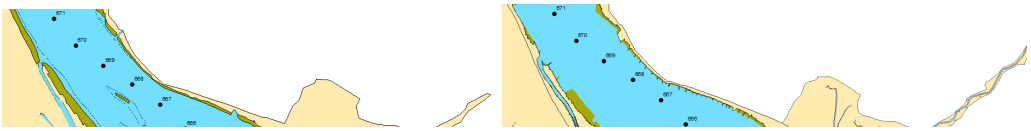
- silting up of tidal floodings, isolation of sediment spaces (e.g. by lost of floodings due to flood dyking), repeated upgrading of the navigation channel etc. have reinforced the tendency to siliting up in the upper reaches of the Tidal Elbe

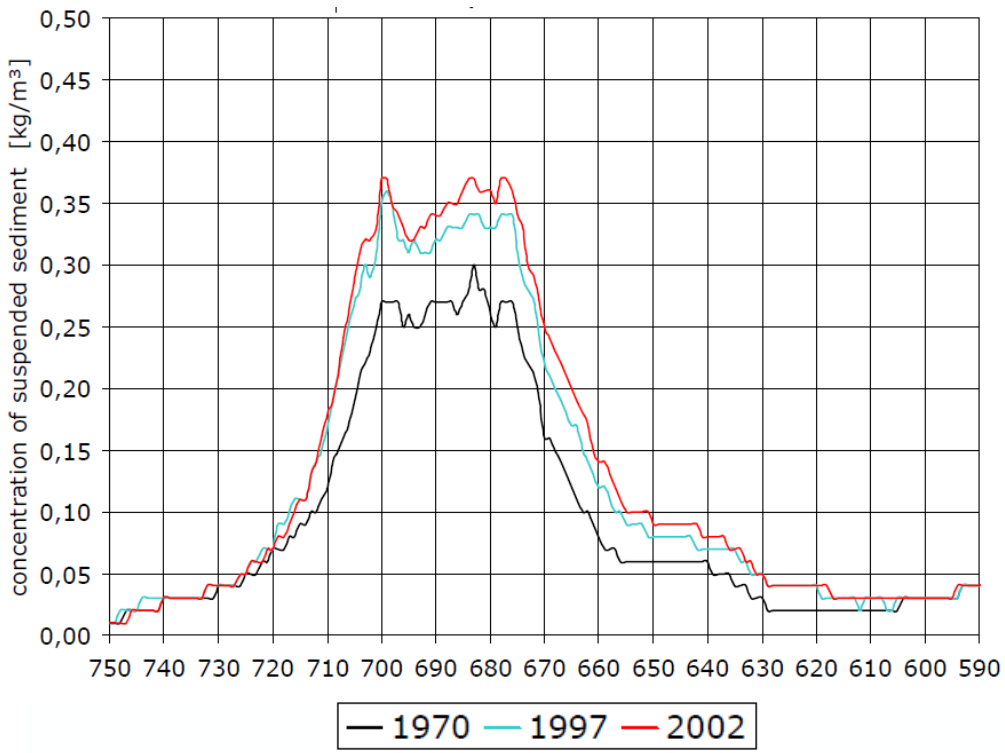


(Hamburger Abendblatt, 2006)



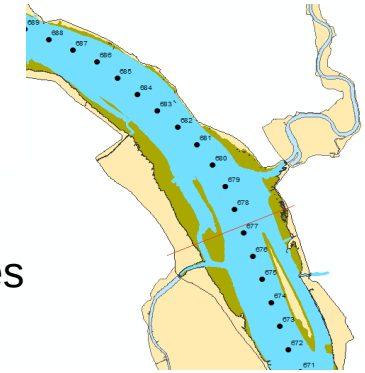
Morphological evolution of the Tidal Elbe and resulting effects on the turbidity zone





Source: Hindcast studies on different historical states with a 3-d hydro-morphodynamical model (*Weilbeer and Paesler, 2008*)

- silting up of tidal floodings, isolation of sediment spaces (e.g. by lost of floodings due to flood dyking), repeated upgrading of the navigation channel etc. have reinforced the tendency to siliting up in the upper reaches of the Tidal Elbe
- effects on the turbiditiy zone can only be estimated by model simulation (no resp. only unsatisfying nature measurements before 2006)



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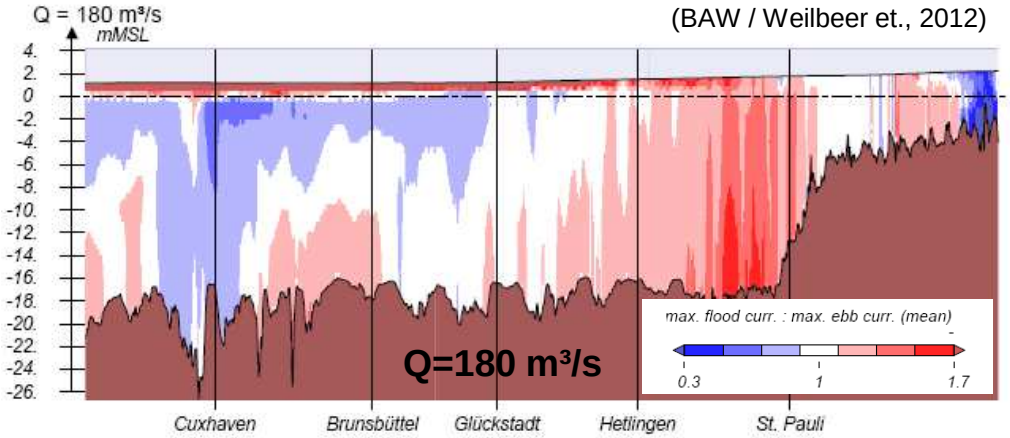
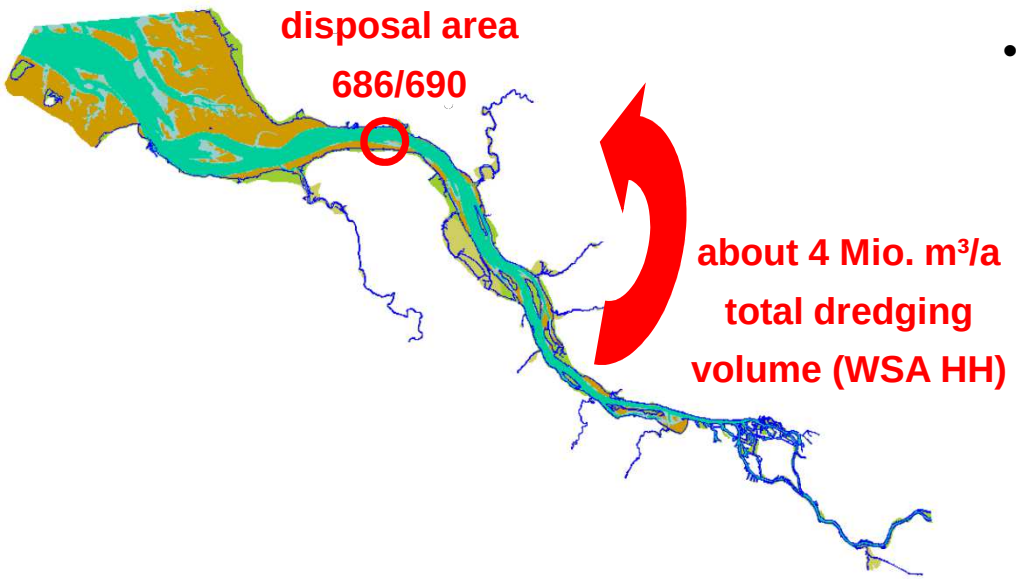
Dredging and relocation strategies - fine-sandy silty sections of the navigation channel (I)



(BAW / Weilbeer et., 2012)

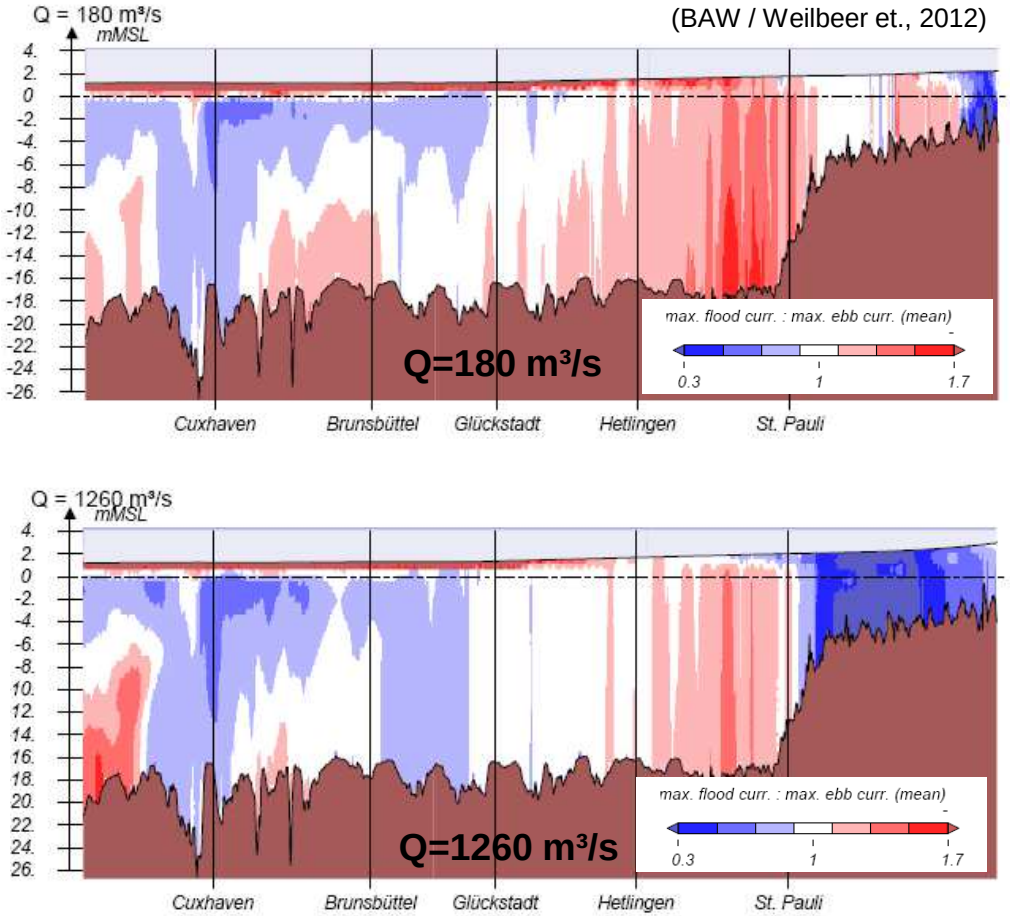


- direction of residual suspended load transport can only be determined by nature measurements **<u>and</u>** simulation (hydro- and morphodynamic models)
- herefrom it is known, that upstream Elbe-km 677 high residual transport rates towards Hamburg are common („tidal pumping“)
- answer for „inner estuary“: basically relocation downstream, only charge of hopper dredgers + longer transport distances senseful (no near-by relocation)

transport distances by <u>changed relocation strategy</u> of WSV up to 47 km

Dredging and relocation strategies - fine-sandy silty sections of the navigation channel (II)

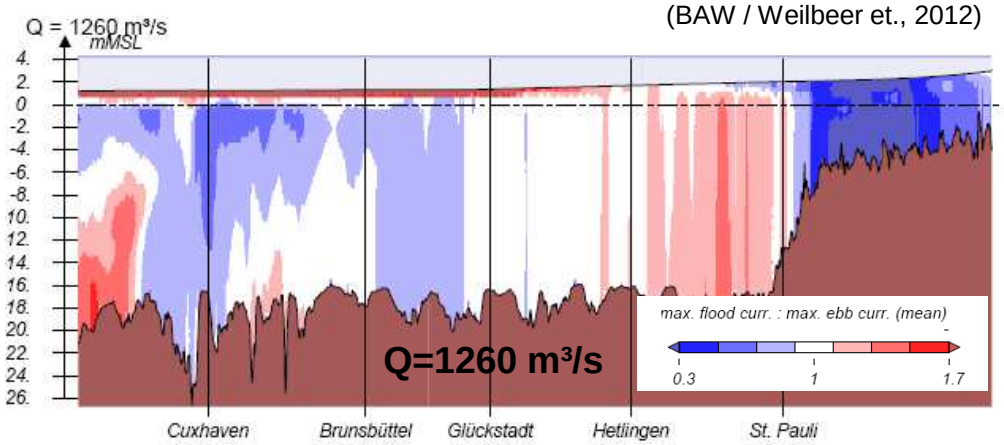
(BAW / Weilbeer et., 2012)

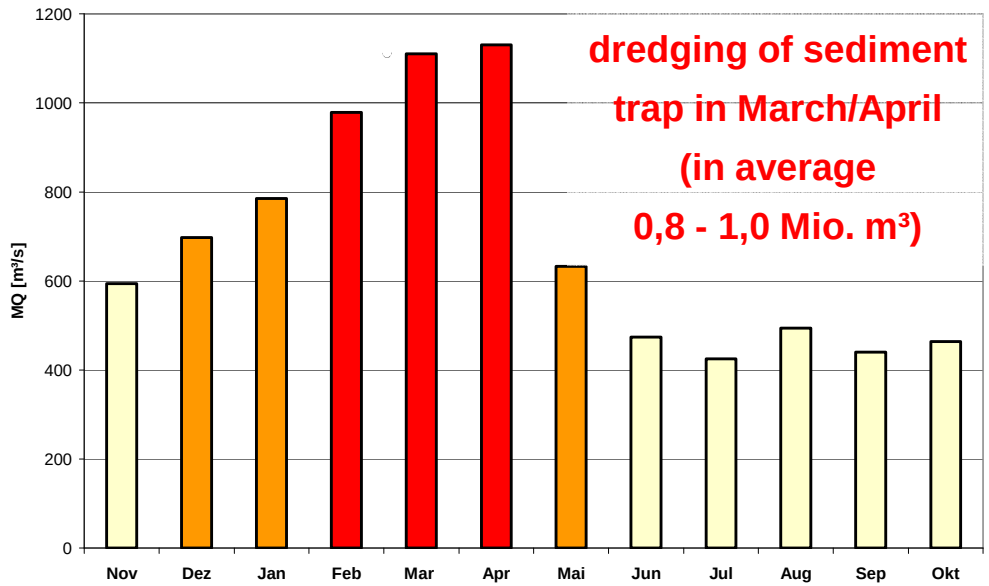


- furthermore it is known, that residual transport upstream is lower at high headwater discharge (less „tidal pumping“)
- accordant effects could also be shown for the disposal area 686/690 (simulation of erosion and drifting of fine sediments; *BAW / Weilbeer et al. 2012*)

Dredging and relocation strategies - fine-sandy silty sections of the navigation channel (II)

(BAW / Weilbeer et., 2012)





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- accordant effects could also be shown for the disposal area 686/690 (simulation of erosion and drifting of fine sediments; *BAW / Weilbeer et al. 2012*)
- this knowledge is used in dredging of an in 2008 build „sediment trap“ at Elbe-km 641,8 – 643,8 (dredging in months with normally high headwater discharge)

10-years series (2001/2010) of mean monthly discharge Neu Darchau (Elbe km 536.4)

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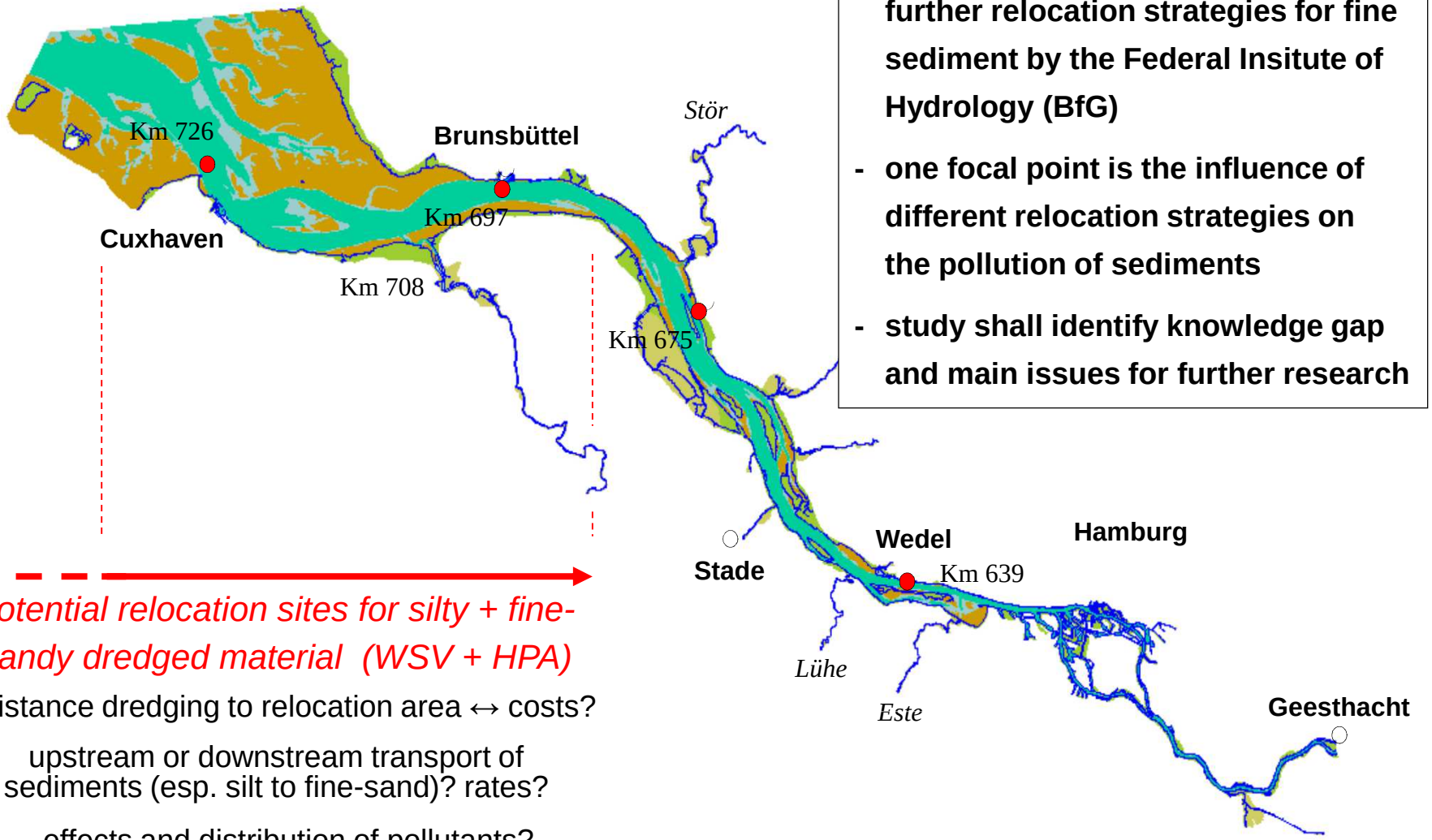
Outlook: Further optimisation of the changed relocation strategy (fine material)

- currently ecological evaluation of further relocation strategies for fine sediment by the Federal Insitute of Hydrology (BfG)
- one focal point is the influence of different relocation strategies on the pollution of sediments
- study shall identify knowledge gap and main issues for further research



potential relocation sites for silty + fine-sandy dredged material (WSV + HPA)

distance dredging to relocation area ↔ costs?

upstream or downstream transport of sediments (esp. silt to fine-sand)? rates?

effects and distribution of pollutants?

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More information …

- optimisation of relocation strategies is only one topic in the River Engineering and Sediment Management Concept (RESMC) of HPA and WSV for the Tidal Elbe
- presentation could can only give some flashlights on topics / acitivities regarding relocation strategies
- some more information on RESMC with a focus on contamination of Tidal Elbe sediments will be given by Axel Netzband („Sediment Management for the Port of Hamburg“)
- serveral aspects of monitoring programs / long-term measurements will be discussed on field trip „measuring station Seemannshöft“

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→ Projekte

→ Strombau- und Sediment-management Tideelbe

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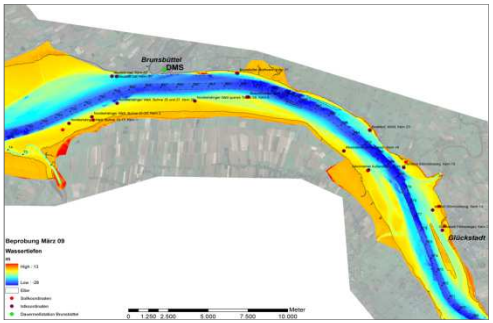
→ dynamisch




Thank you for paying attention!