



<i>Time</i>	<i>Topic</i>	<i>Responsible</i>
09:00 – 09:30	<i>Registration / Coffee</i>	<i>All</i>
<b>WORKSHOP ON «Options Appraisal / Selection for FAST DANUBE project»</b>		
09.30 – 9:45	<b>Introduction:</b> <ul style="list-style-type: none"> <li>– Welcome</li> <li>– H&amp;S moment</li> <li>– Project status</li> </ul>	<b>Mr. Dan TARARA</b> <b>Mr. Romeo SOARE</b>
09.45 – 11.00	<b>Session 1:</b> <ul style="list-style-type: none"> <li>– Initial option preferences, morphological (Prof Colin Thorne via skype)</li> <li>– Revised options, modelling / engineering / CBA</li> <li>– Environmental studies</li> <li>– Q&amp;A</li> </ul>	<b>Mr. Paul RAYNER</b> <b>Mr. Damian DEBSKI</b> <b>Ms. Roxana DORNEANU</b> <b>Ms. Charlotte HANDY</b>
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11.30 – 13.00	<b>Session 2:</b> <ul style="list-style-type: none"> <li>– Multi-criteria analysis: introductory session</li> </ul>	<b>Mr. Dan TARARA</b> <b>Mr. Paul RAYNER</b> <b>Ms. Roxana DORNEANU</b> <b>Ms. Charlotte HANDY</b>
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15.30 – 16.00	<b>Session 4:</b> <ul style="list-style-type: none"> <li>– Consensus view on long term sustainable options</li> </ul>	<b>Ms. Roxana DORNEANU</b> <b>Ms. Charlotte HANDY</b>
16.00	<b>Closing statement</b>	<b>Mr. Romeo SOARE</b>



## DESIGN APPROACH / PRINCIPLES USED TO DEVELOP OPTIONS

- Sinuous channels: morphological basis for developing options
- Planning and design principles underlying options
- Next steps




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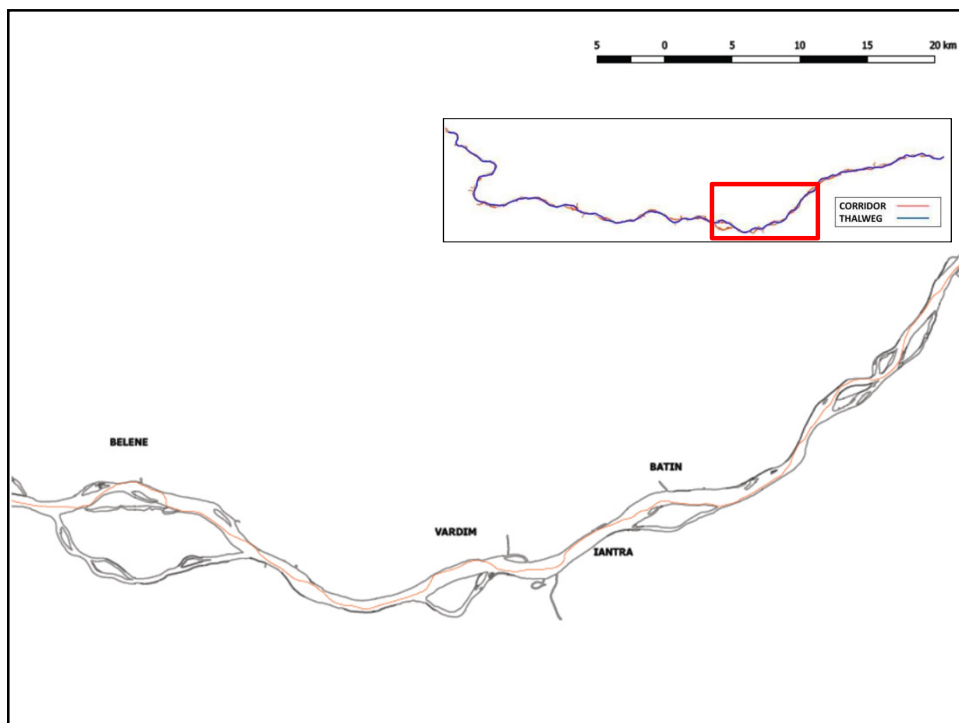
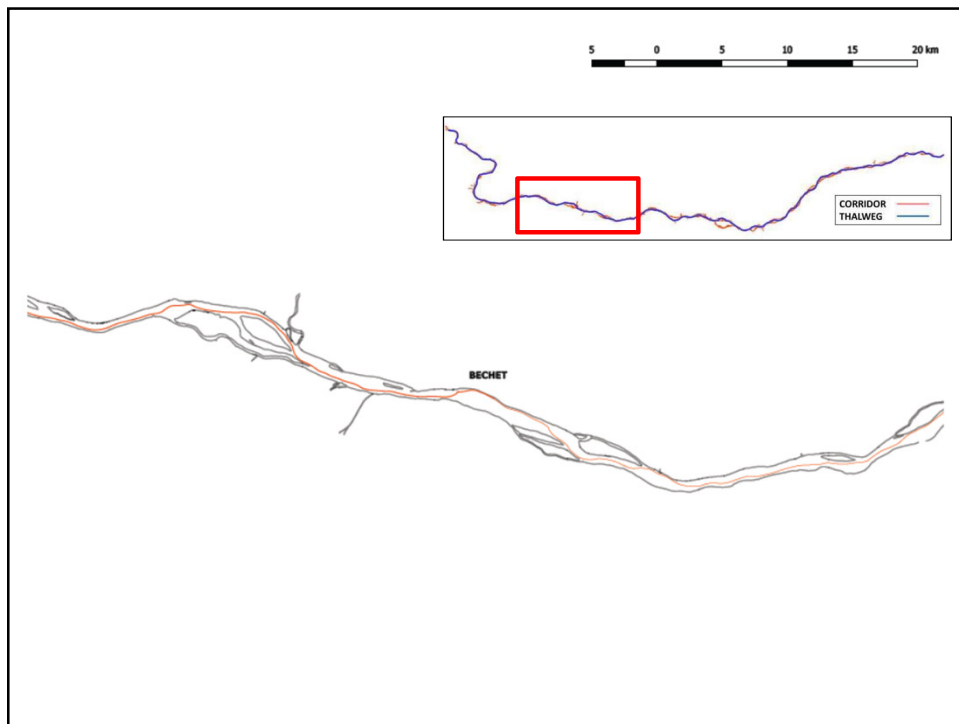
## DESIGN APPROACH / PRINCIPLES USED TO DEVELOP OPTIONS


### Morphological features used as basis to develop options

- Lower Danube displays planform elements that are straight, meandering, braided and anastomosed patterns.
- Navigation problems are to be expected in straight reaches due to lack of the large-scale, coherent, secondary flows necessary to scour and maintain a clear thalweg
- Re-align straight reaches of the navigation fairway and/or install hydraulic structures that 'work with natural processes' to generate flow and create thalweg curvature
- All frictional fluid tends to follow a sinuous path. Crossings between consecutive curves are spaced at intervals of 6 and 7 times river width. Flows in the lower Danube are no exception and any plans to train the river should recognise this.
- Most of the critical sites are characterised by sub-reaches with flows that divide around medial bars or islands ie anastomosed planforms with sinuous anabranches




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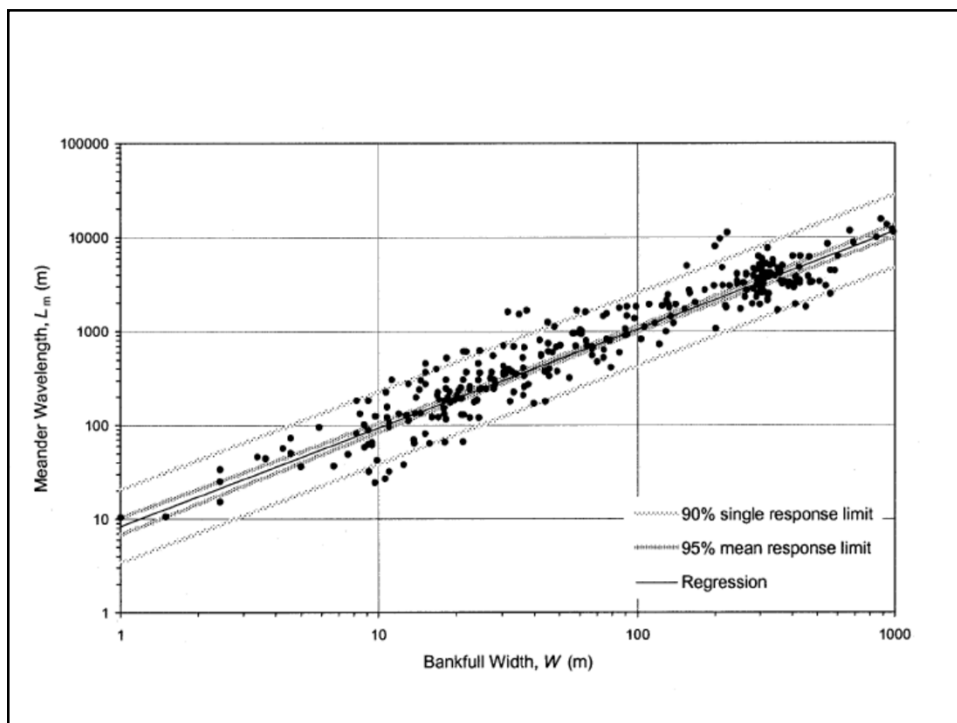
## DESIGN APPROACH / PRINCIPLES USED TO DEVELOP OPTIONS

**Generalised characteristics of Lower Danube**

- Danube can be as narrow as 750m but 'normal' width 900-1000m
- At its broadest usually coincides with double re-entrant banks, e.g. Bechet, can be as broad as 1350m (and ~1800m with island(s))
- 'Normal' bank width ~1000m
- Garla Mare to Dobrina: amplitude say 4-5km, frequency say ~15km
- Dobrina to Batin: amplitude say 3-4km, frequency say ~15km
- Batin to Popina: amplitude say 1-2km; frequency say ~10-12km.



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**Winkley: Training the Lower Mississippi: studies and analysed four reaches in detail over decades (1930's to late 1970's) – actual hands-on lessons of sinuous versus straight channels for a very large sand river**

**Ozark-Eutaw Reach (24km)**: naturally very sinuous: cut-off and revetted into permanent sinuous alignment but less sinuous than natural: has had little or no navigation and maintenance problems

**Greenville reach (28km)**: naturally very sinuous : cut-off and straightened: locked into semi-straight channel: has had long history of navigation and maintenance problems

**Kentucky Bend-Mayersville reach (42km)**: naturally very sinuous: straightened with cut-offs: perpetually troublesome: realigned to sinuous path; now trouble free

**Baleshed-Ben Lomond reach (24km)**: historically straight: always troublesome: locked in to a straight reach: continues to be troublesome for navigation and maintenance

**Investment in heavy engineering (groynes) and maintenance dredging dredging commitment: Mississippi: 1930s to late 1970s**

- **Ozark-Eutaw: sinuous channel:**  
very few groynes (~3km): little or no dredging
- **Greenville: semi-straight:** 20km groynes:  
high dredge commitment (60,000cum/km)
- **Kentucky-Mayersfield: straight:** 10km groynes:  
high dredge commitment (60,000cum/km): then put into sinuous alignment: dredge commitment eliminated
- **Baleshed – Loch Lomond: straight:** 18km groynes:  
very high dredge (90,000cum/km)



### Summary: advantageous reasons to form a sinuous navigation channel

- It generates strong secondary currents that help maintain a deep thalweg and hence sufficient navigation depths in the curved reaches of the primary channel between crossings
- It harmonises with the natural tendency of the thalweg to cross from one side of the river at intervals of about 6 or 7 channel widths
- It enhances sediment transport continuity at a wide range of discharges, including flood flows and so limits (not eliminates) maintenance dredging needed to reduce bed elevations at crossings.



### Planning / design principles (1) for navigation channels

#### Deciding on planform and its alignment: based on morphological considerations

- Identify alternative anabranch sinuous channel alignments
- Match frequency and amplitude of channels to reach based parameters
- Match entry and exit of sinuous channel to upstream and downstream channel
- Identify alternative sinuous channel alignments with regard to bank planform
- Identify alternative sinuous channel alignments with regard to historic alignments
- Select alignment/anabranch which is less likely to braid: reasonable stream power
- Allow straights but avoid unduly long straight sections of channel



## Planning / design principles (2) for navigation channels

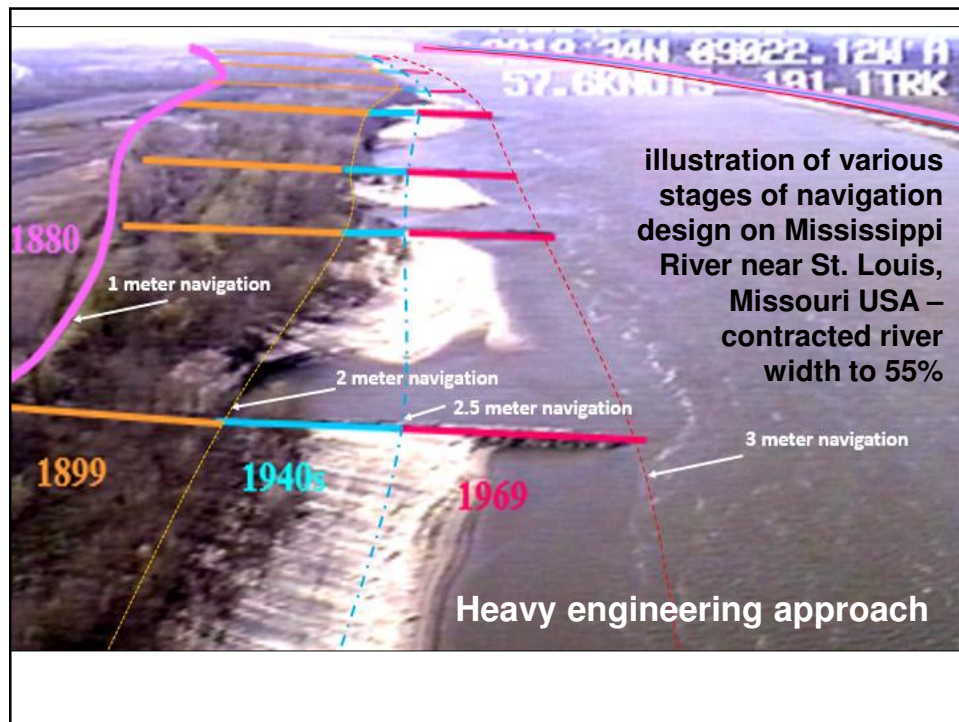
### **Deciding on the planform and its alignment: planning considerations**

1. Ensure planform consistent with navigation channel geometry requirements: in terms of width and minimum radius or curvature at bends
2. Avoid impacts or imposing constraints upon existing infrastructure such as docks, harbours, ferry crossings, agricultural and power station abstraction and intakes
3. Avoid the location of important environmental assets where these have been identified

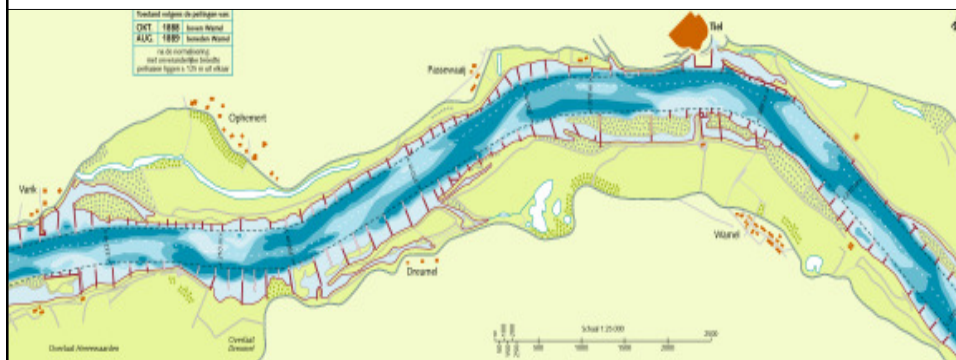


### **Identifying optional works to create/promote the required planform : principally groynes, chevrons, islands and bank stabilisation measures**


1. Seek to avoid extensive heavy engineering: identify potentially effective “minimum intervention” first stage works
2. Plan for the need for further second (and subsequent) stage adaptive works viz in terms of financial, institutional and resource requirements



**Heavy engineering: Waal River Netherlands: mid- to late 1800s:**  
**contraction of planform of river down to 50-60% of width**







**Planning and design principles for navigation channels**

**Deciding on the planform and its alignment: morphological considerations**

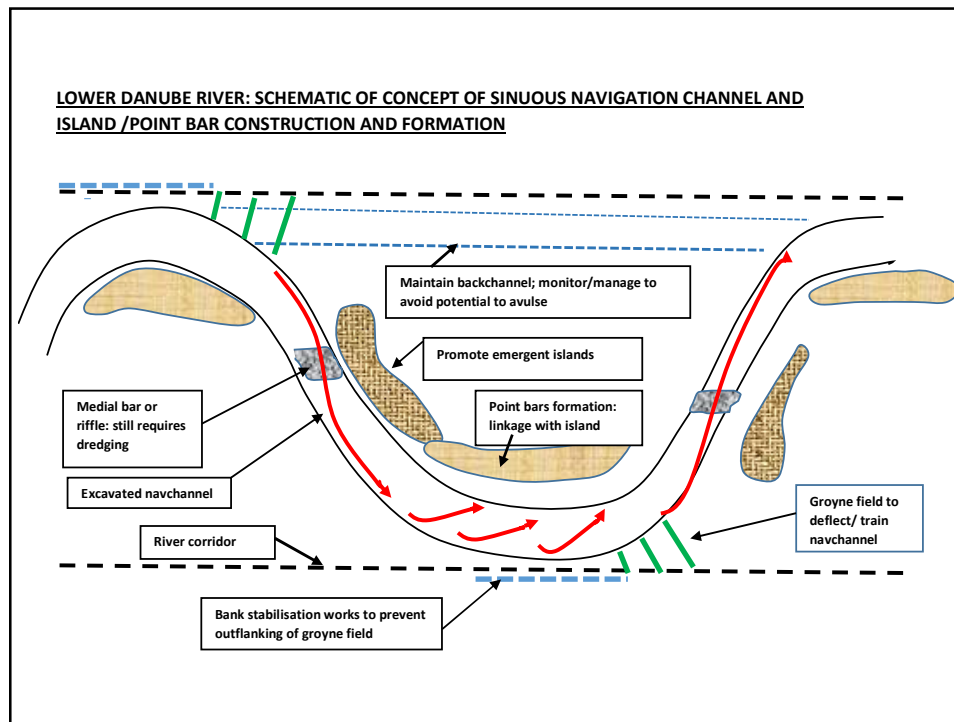
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- Select alignment/anabranch so less likely to braid: reasonable stream power
- Allow straights but avoid unduly long straight sections of channel

**Deciding on the planform and its alignment: planning considerations**

- Ensure planform consistent with navigation channel geometry requirements
- Avoid impacts or constraints upon existing infrastructure
- Avoid the locations of important environmental assets

**Identifying optional works to create/promote the required planform :  
principally groynes, chevrons, islands and bank stabilisation measures**

1. Seek to avoid extensive heavy engineering: identify “minimum intervention” first stage works; plan for the need for further second (and subsequent) stage adaptive works
2. Allow back channels/minor anabranches to continue to function as fully as possible ie maintain or promote anastomosed planform
3. Consider constructing and promoting the growth of islands to influence and train the river planform; locate on inside of navchannel bends; islands are part of natural river processes
4. Consider constructing chevrons to influence and train the river planform; similar location to islands but principal function is to narrow river and concentrate flows in navchannel
5. Consider groynes to divert/deflect river flows into sinuous alignment: typically located on outside of navchannel bend; bank location/connected
6. Consider river bank stabilisation with range of green and grey types of measures: to reduce risks of river widening with potential braiding and subsequent loss of sinuosity
7. Identify measures which might provide mitigation for environmental impacts, or even betterment eg ladder of pools for sturgeon in minor anabranches/back channels



### Other general principles for design and hence appraisal of options

#### Curved and straight navigation channels

- River engineering is very different from road engineering: roads stay where you put them, rivers are unpredictable and move and change constantly
- River engineering therefore has to be based on two principles (a) prepare designs which have the best possibility of sustainability i.e. reflect natural processes (b) plan to be able to respond to change i.e. adaptive management
- This conflicts with navigators who prefer straight channels; so, in principle some straight sections have been incorporated where stable for (some) time; may be due to constant dredging effect of propellers during low flow conditions: but expect significant change and need for adaptive management

#### River bank stabilisation

- Many different treatments ranging from green (purely vegetative) to grey (stone pitching/rip-rap): selected depending upon (a) impacts on velocities due to new works (b) exposure/offshore conditions (c) bank orientation (d) insitu material (rock, soil) (e) existing vegetation etc etc
- Principles are (a) maximise green measures but ensure stability (b) identify high priority banks (shoreline, island) (c) classify others as precautionary - monitored for adaptive management viz avoid over-engineering banks which would reduce sediment source/load with further impacts on morphology and delta

#### Island building

- Islands have been built before – but not in this setting or to this scale
- Cannot be “built” in short term: have to be initiated (first stage construction) and then promoted (intelligent dredge disposal; will take seasons/years to form)
- Innovative: but if achievable will be morphologically based solution
- Key issues are (i) ensure island in morphologically optimum location (further 3D/physical modelling) (ii) maintaining stability of disposed material (use of geotubes)



## Next steps in terms of option development

- Comparative performance of options evaluated at this stage using 2D modelling to test/prove their potential feasibility; and to assess environmental impacts and economic implications and allow MCA appraisal
- Once preferred option selected, detailed designs will need to be developed from these design concepts: must be based on 3D/physical modelling: potentially the latter used to calibrate the former: to refine and optimise location, line and level of works
- Only then can procurement contracts for implementation be considered

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