Deltares
Enabling Delta Life

Horizontal directional drilling

Pipeline installation by pulling or pushing

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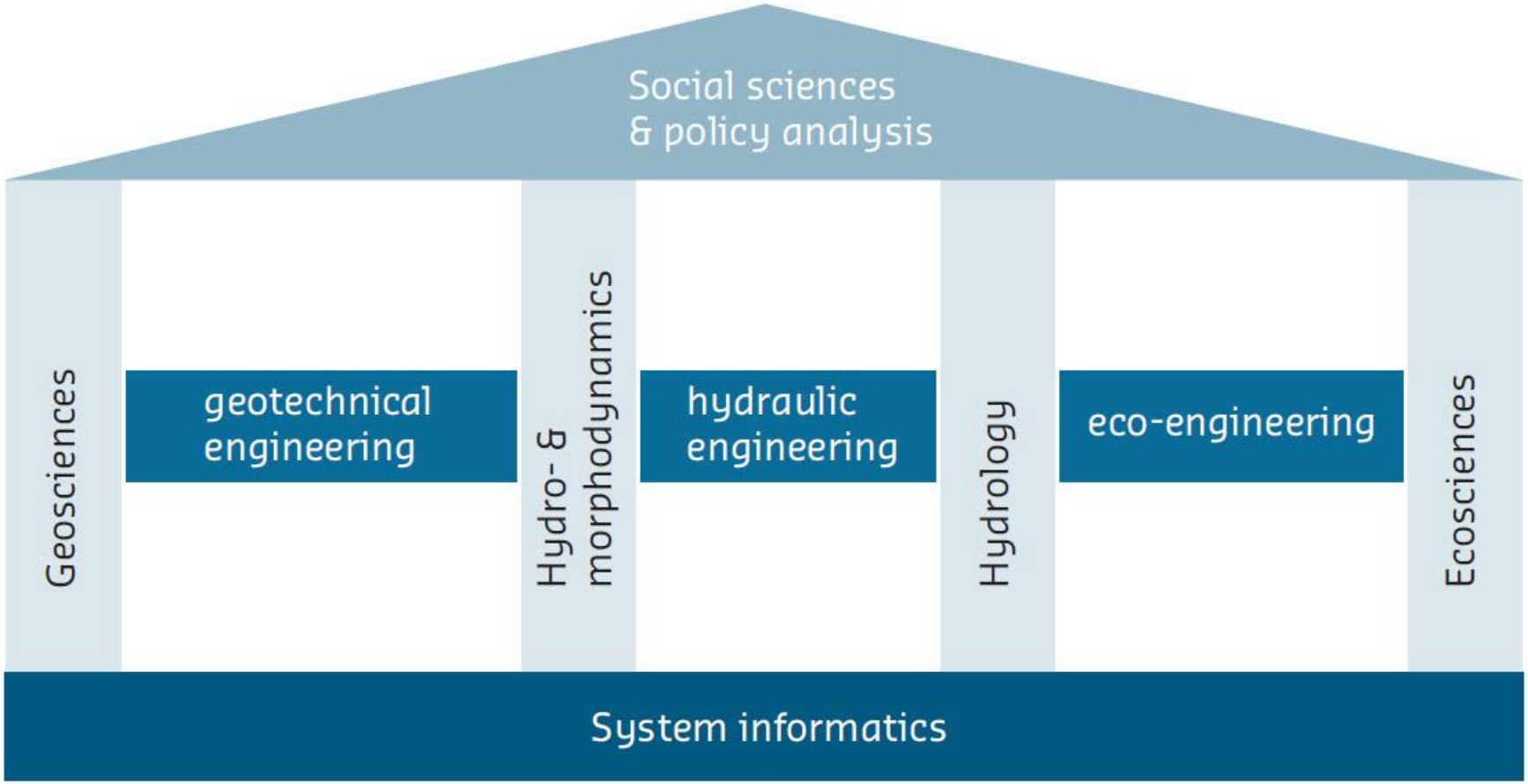
LMR DRILLING
Ein Unternehmen der Ludwig Freytag Gruppe

Deltares is a Dutch National Institute



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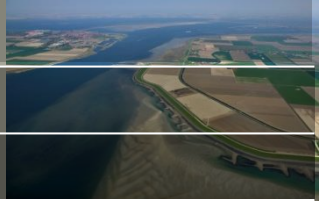
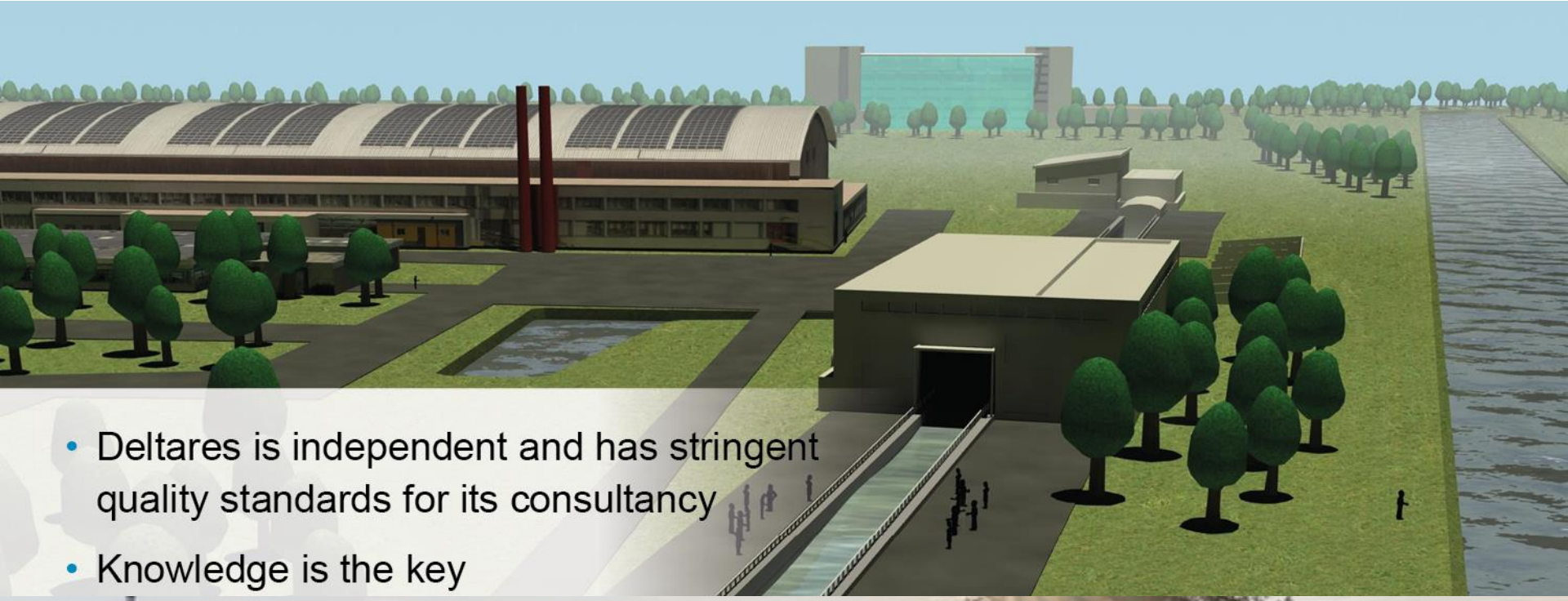
Research and consultancy





- Deltares is independent and has stringent quality standards for its consultancy
- Knowledge is the key

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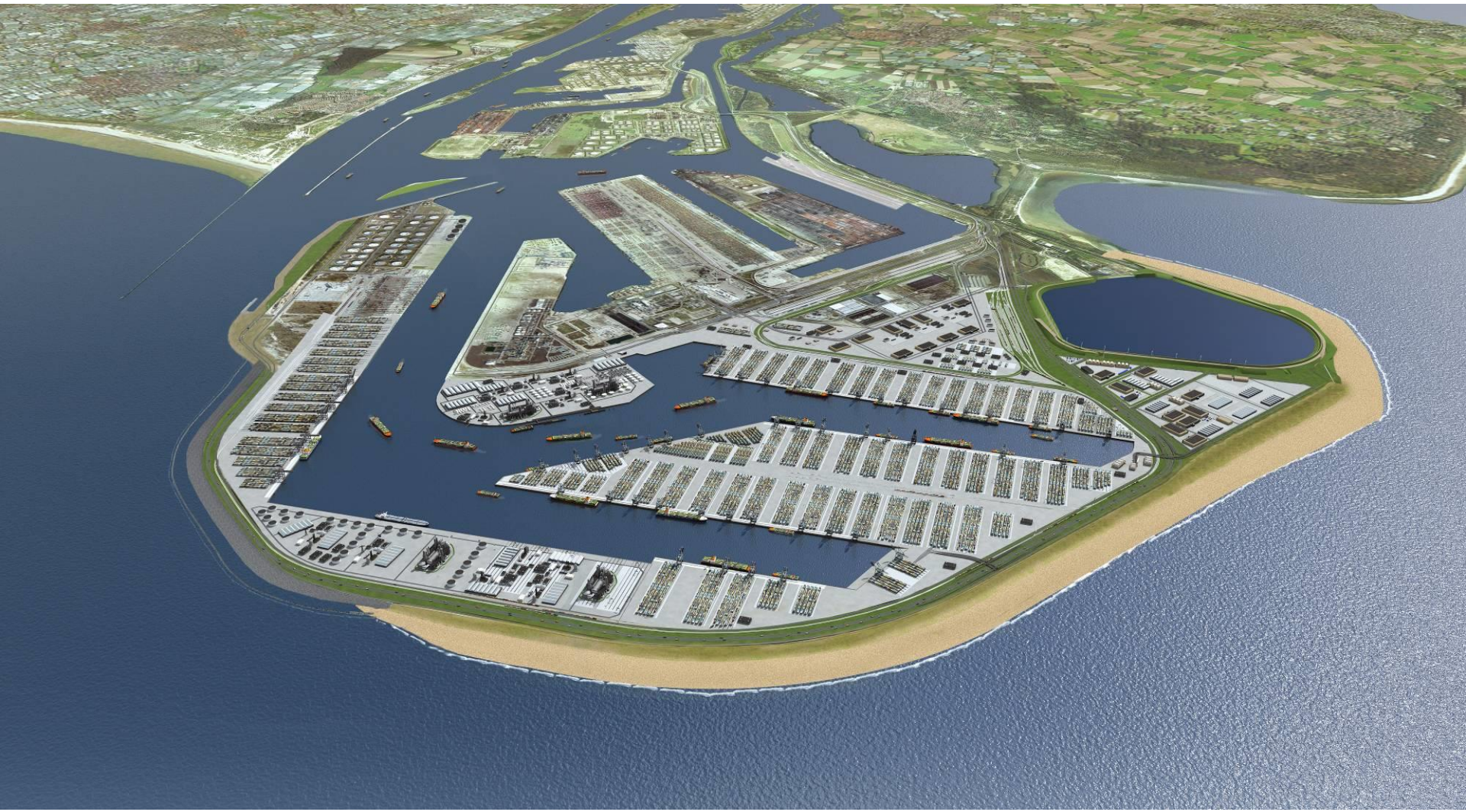
Design of the extension of the harbour in Rotterdam



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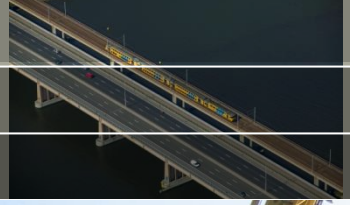
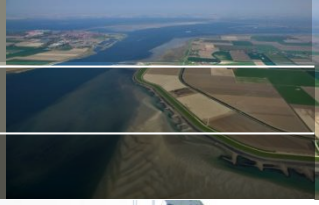
Horizontal directional drilling





Horizontal directional drilling is the most used trenchless method for pipeline installation.

- **In the Past, pipelines were installed by pull back**
- **In the Future forward pipeline installation will be carried out more often**

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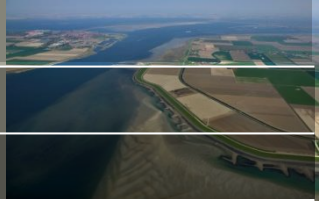
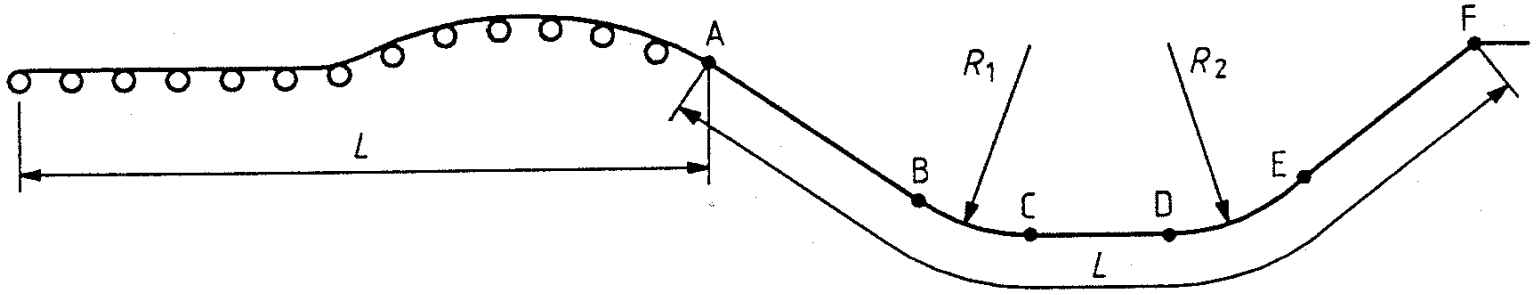
Pull back operation



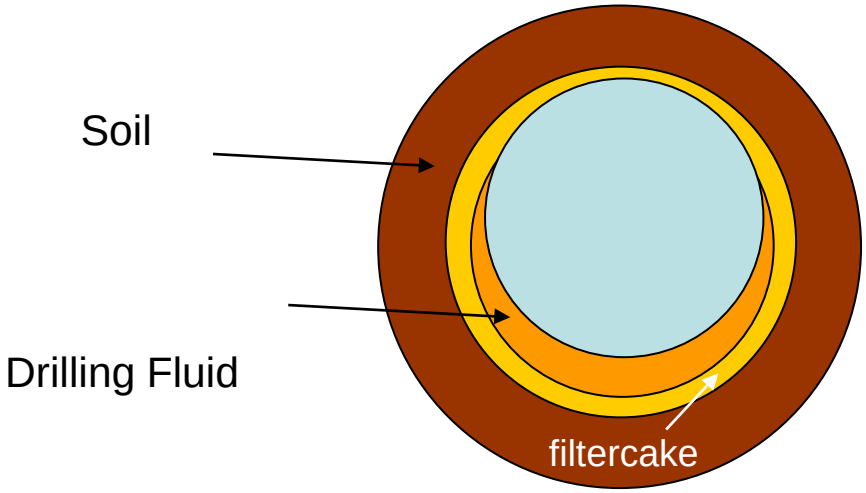
- Standard prediction model to calculate the pulling force is available
- The model ‘works well’ but has several shortcomings
  - Independent soil type
  - No influence of the shape of the borehole
  - Application of overall safety factor
- Ballasting of the pipeline is important

Pulling force calculation

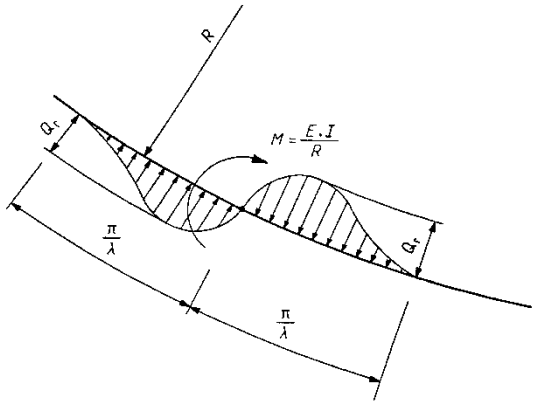
Simple prediction model based on downhole mechanisms



Buoyant weight



Soil reaction in the curves



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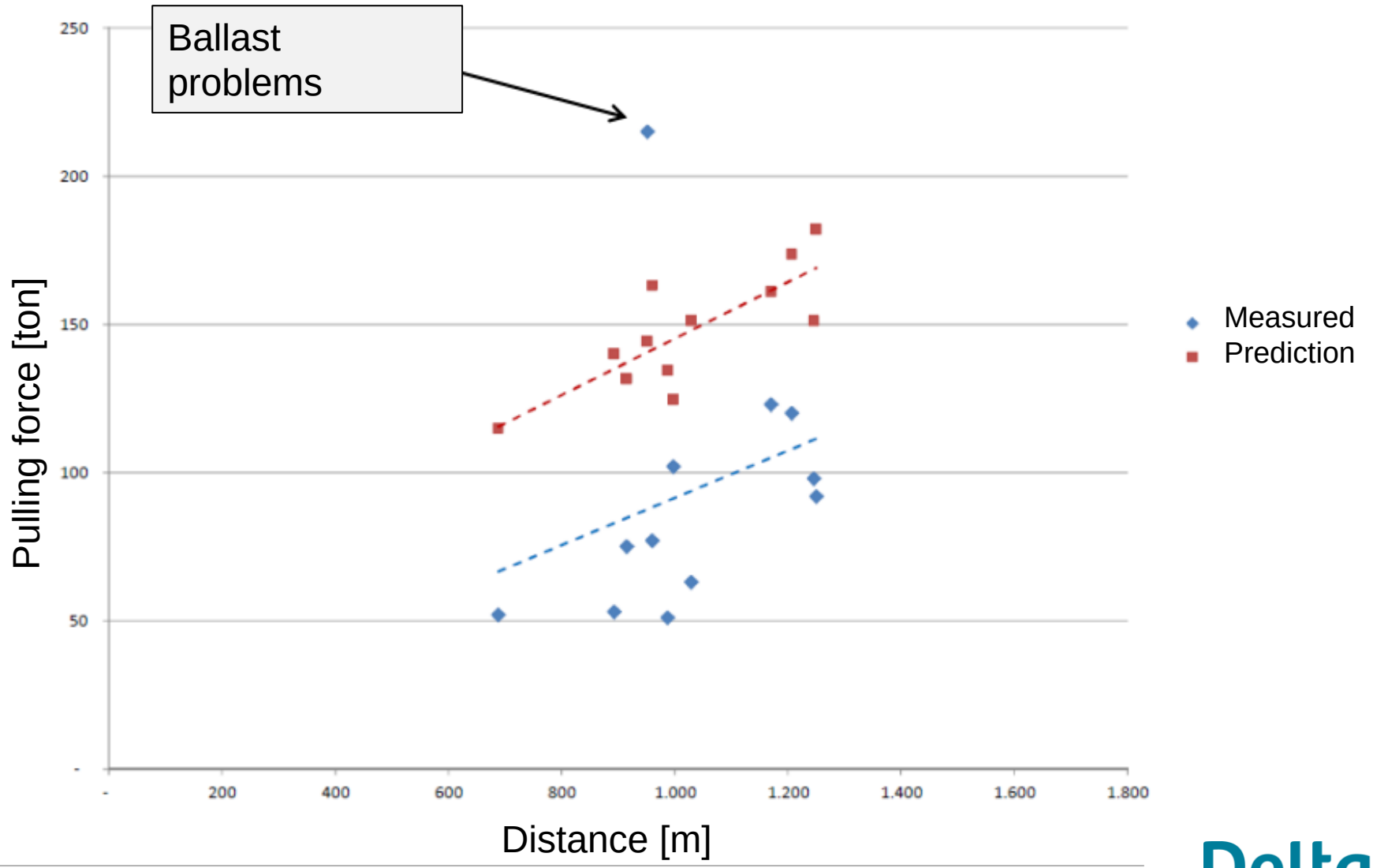
Buoyant weight

Ballasting techniques have been improved

Pulling forces lower than predictions



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Shape of the Borehole important for pull back

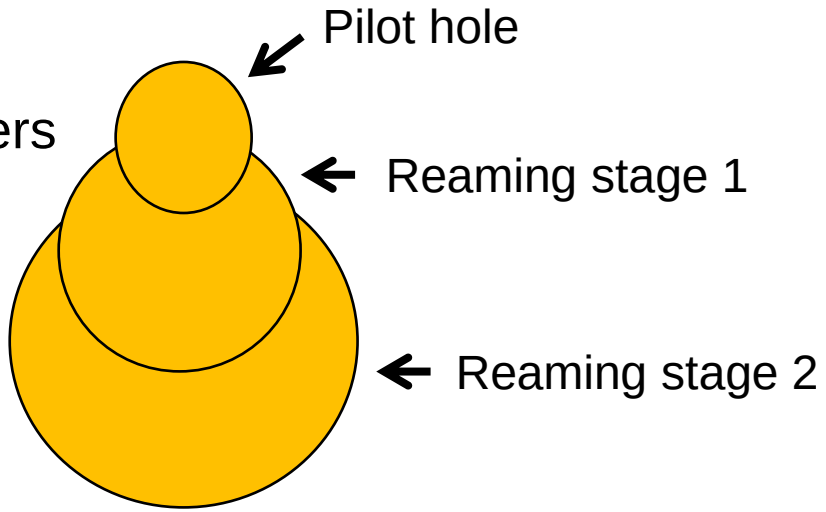
- Axial shape of the borehole.

  Quality of the drilling line depends on steering of the drilling head

- Tangential shape of the borehole

  Determined by the interaction of the downhole drilling tools and the soil.

  Often loose soils and heavy reamers are a Risk factor for the creation of irregular boreholes



Drilling line : Steering using the Gyroscope

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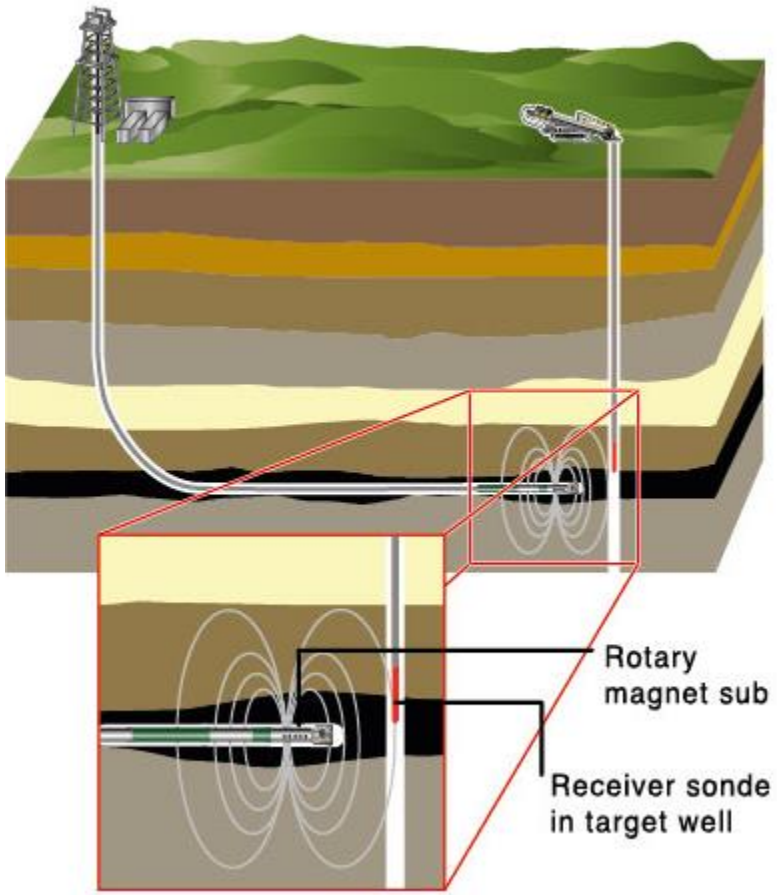
Drilling line Steering Magnetic system



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The drilling line control

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The drilling line at the exit point

Exit point

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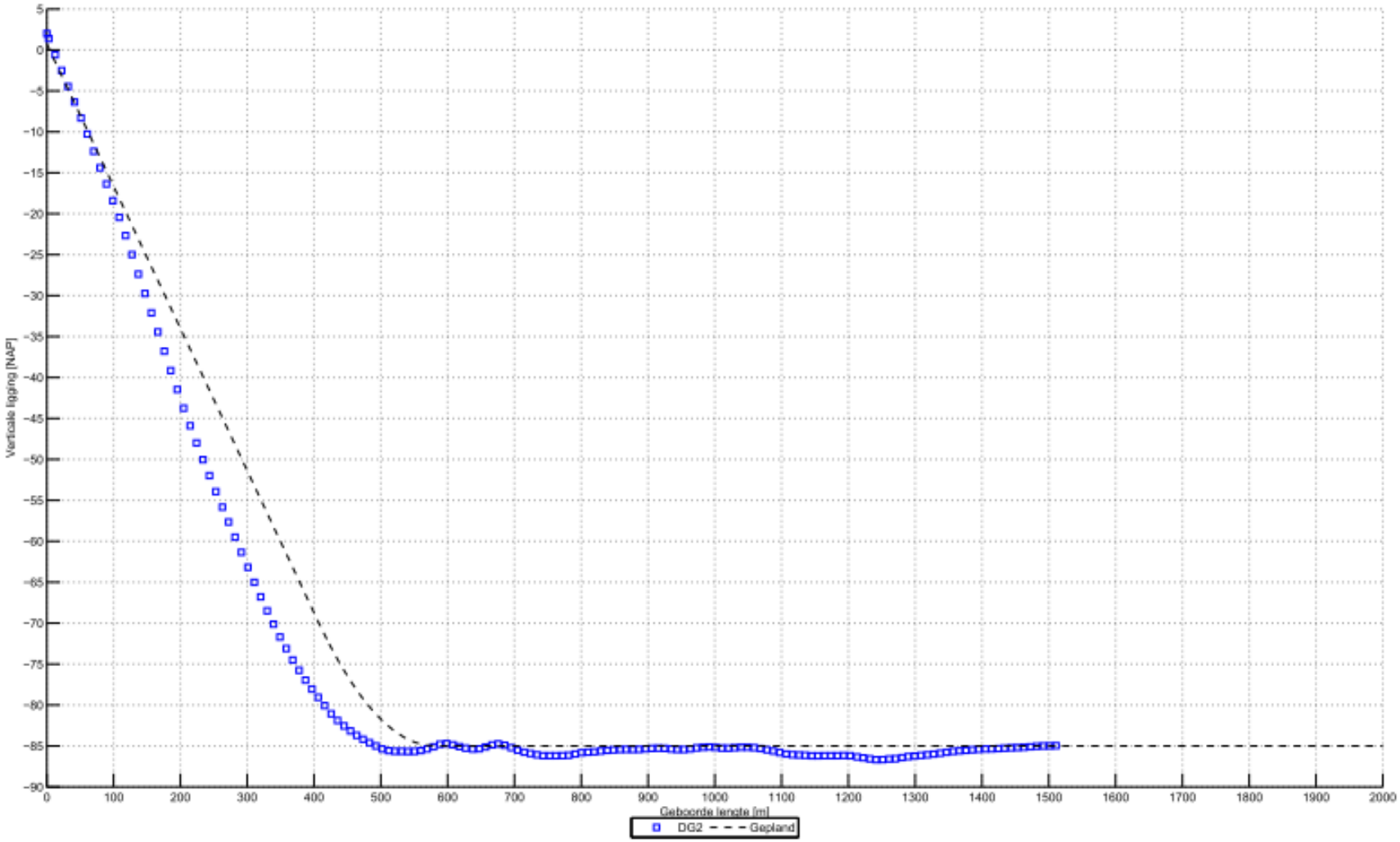
Drilling line in between entry and exit point



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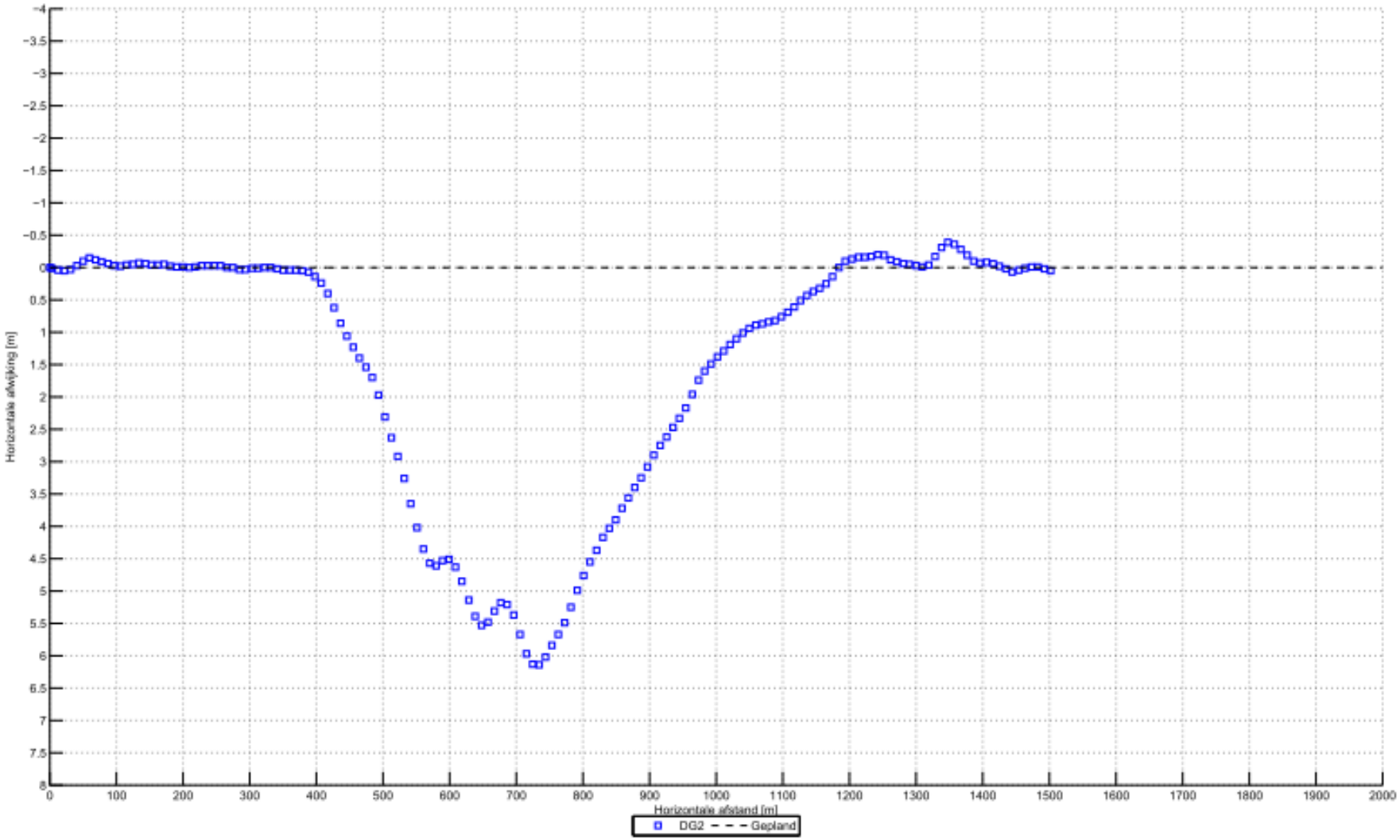
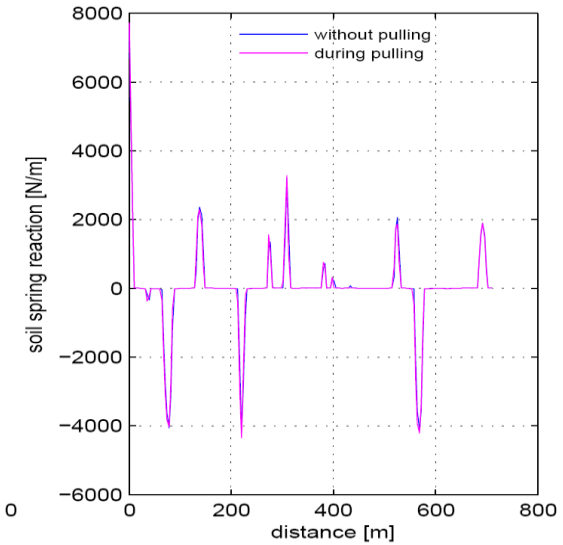
Drilling line in between entry and exit point



Monitoring of drilling line required

- Friction increases considerably
  in irregular shaped boreholes



- *Avoiding so called dog legs by experienced drillers and sufficient soil investigation*
- *Avoiding a small bending radius by analyzing the measurement data from the pilot stage*
- *Continuation of the monitoring during reaming and or wiper trip*

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Forward pipeline installation

- Landfall of offshore electricity cables
- Installation of 4 * 800 mm PE pipes for the cables
- Drillings carried out by LMR GmbH

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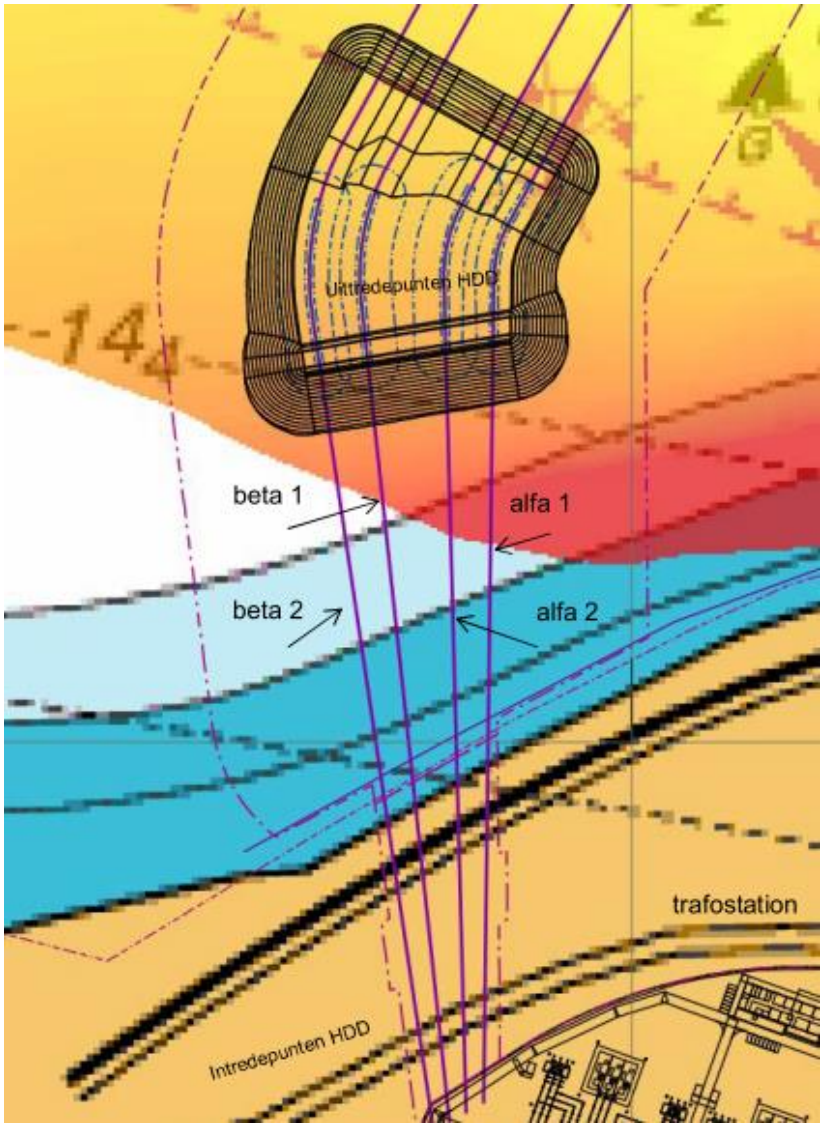
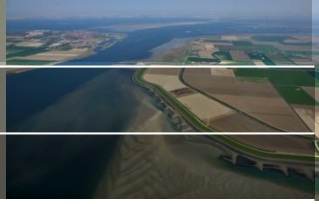
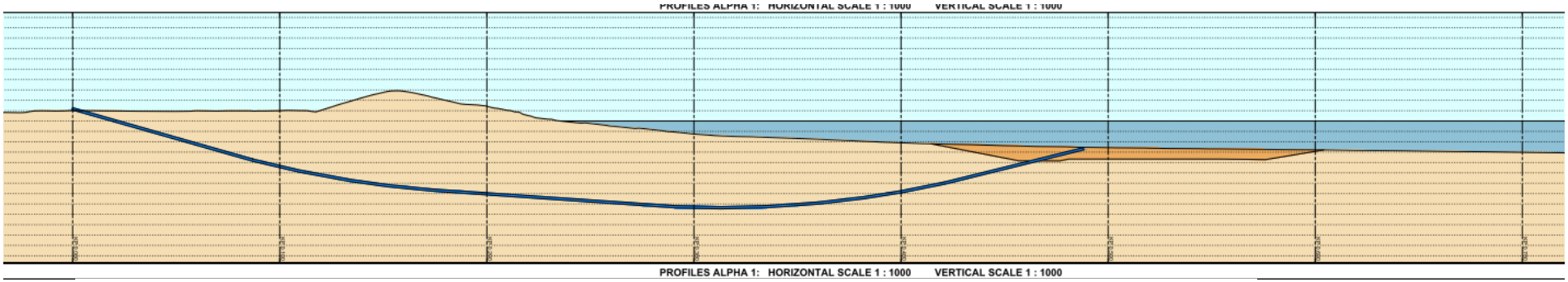
4 HDD's with exit points in a dredged pit

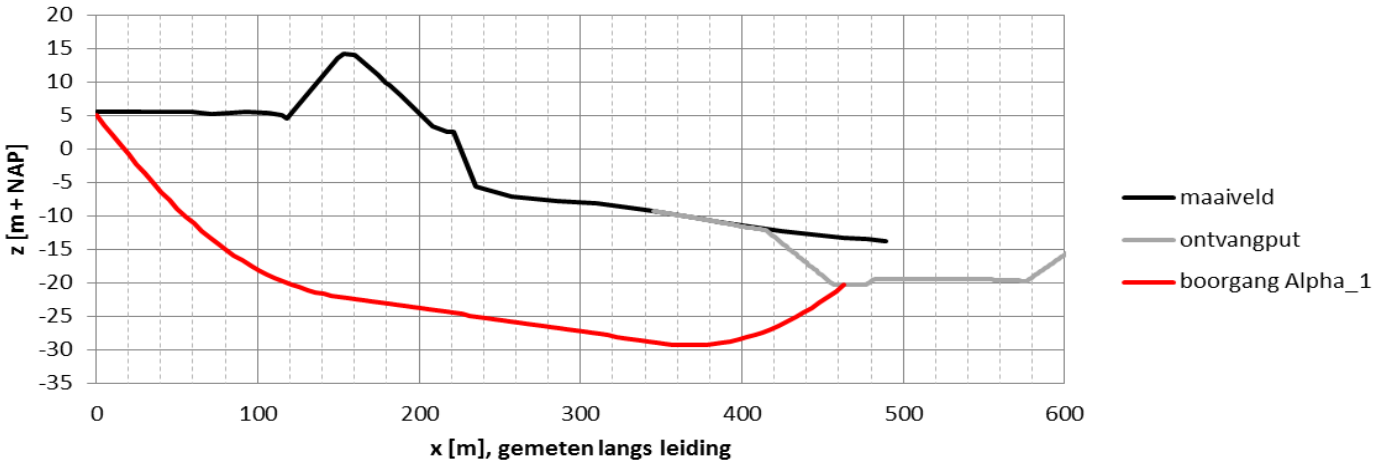


Drilling with forward reaming



- Exit point at a distance of 160 m from the sea dike
- Exit point in dredged pit with a slope angle of 1:5





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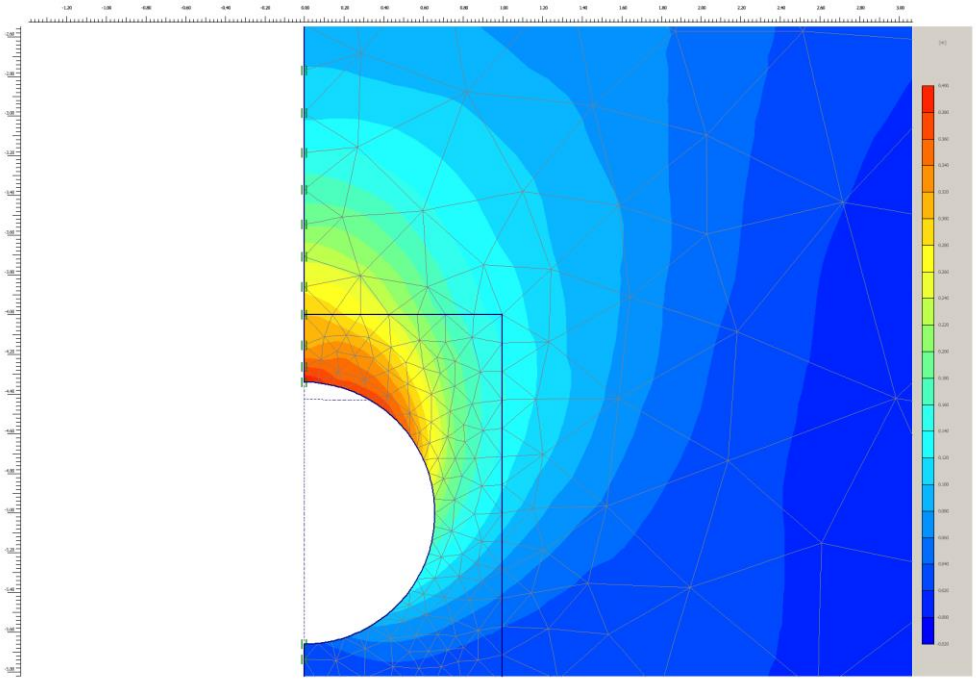
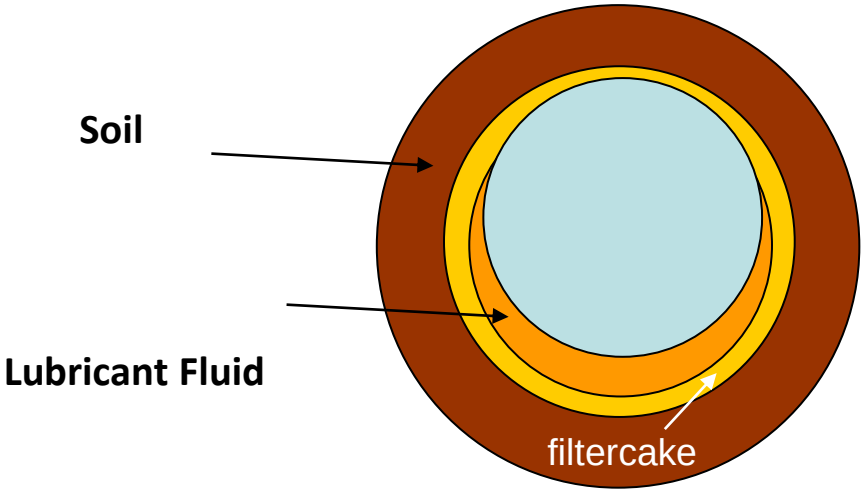
Calculation of required thrust force.





- **Behavior in the bends is different from pulling**
- **Buckling may play a role**

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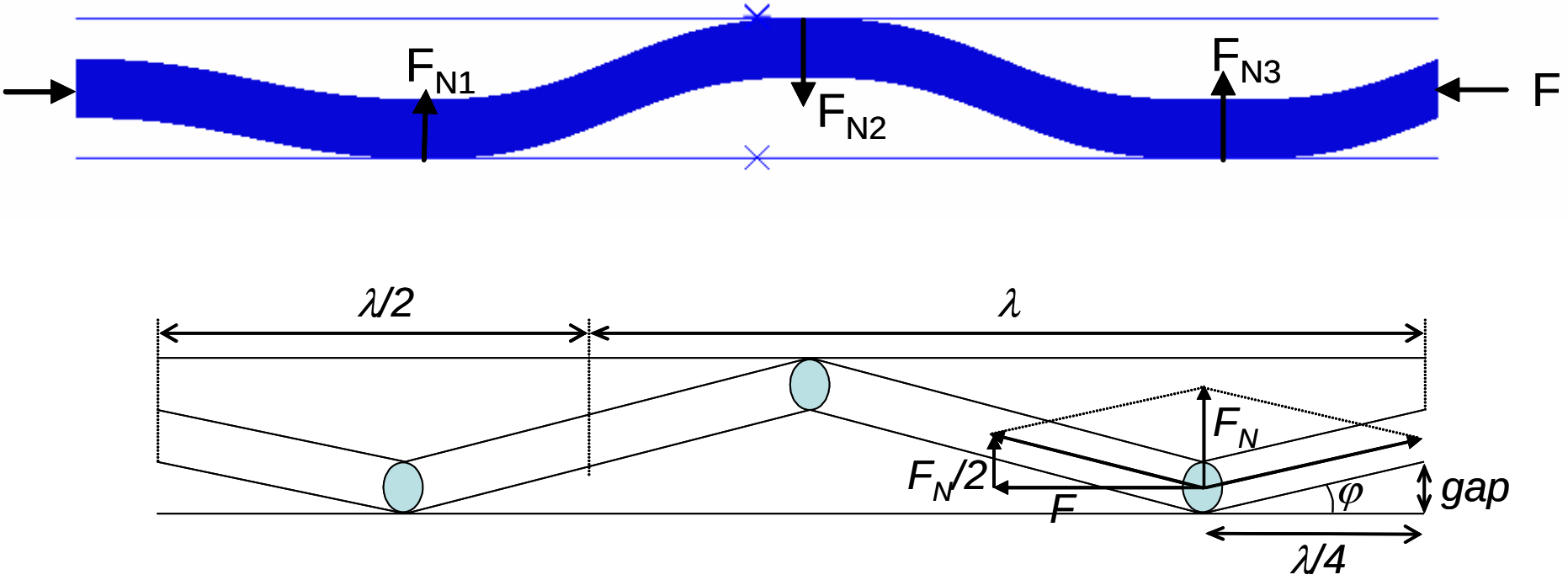
Calculation formula’s for the thrust force

- Normal firction determined by the buoyant weight of the pipe
- Interaction bewteen the buoyant weight and the thrust force
- Effect of the thrust force partly determined by additional friction in the bend’s.
- Buckling of the pipe is considered in a conservative way
- Assumptions for the safety factor

Friction due to buckling of the pipe



Stiffness of the pipe and gap size/ overcut of the borehole play an important role

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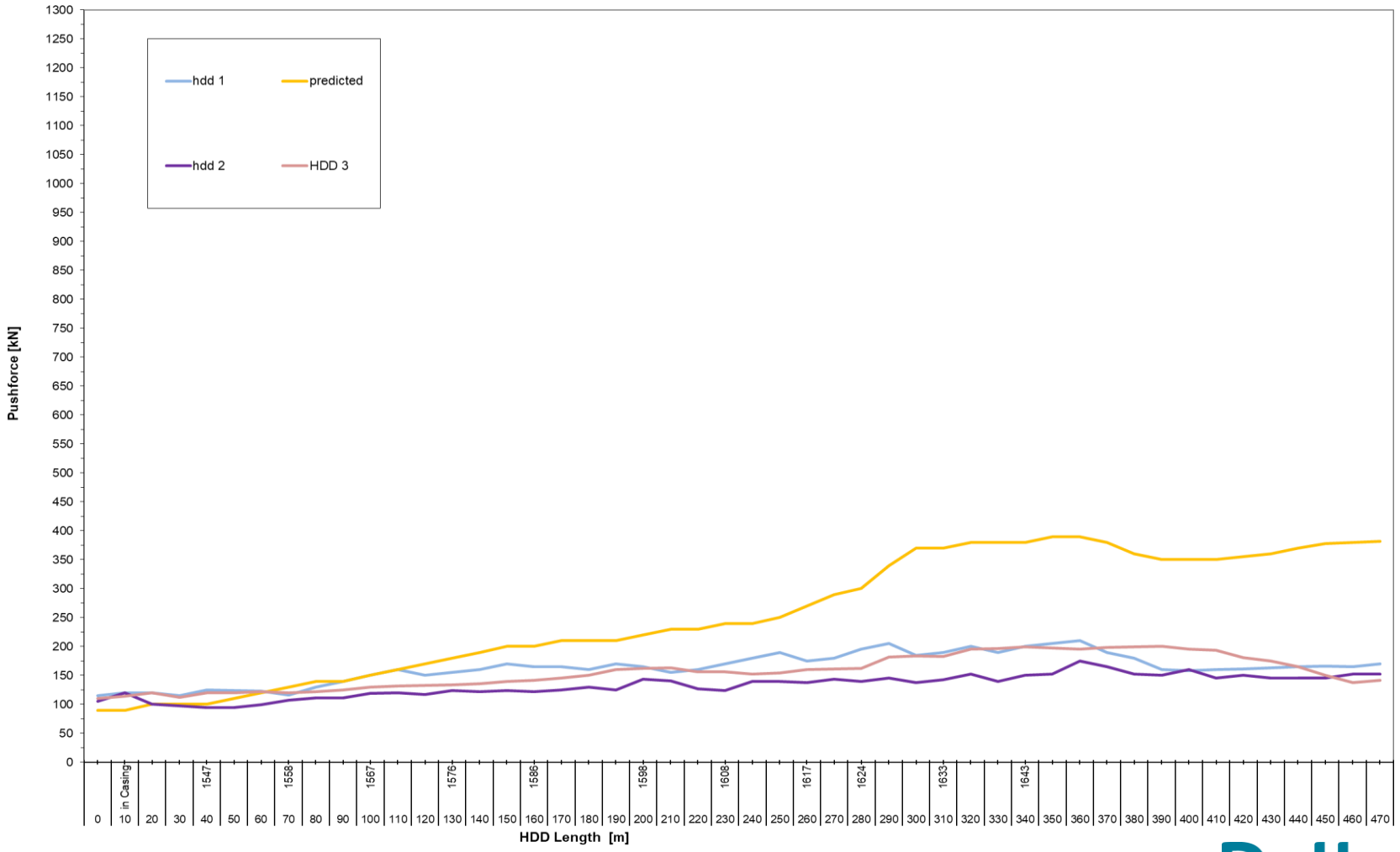
Results of Thrust forces for three HDD's



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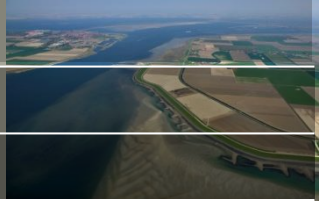
Conclusions



1) The prediction of the pulling force can and should be improved

2) Shape of the borehole is important for pipeline installation

3) Calculation formulas for forward pipe installation are available

4) Predicted Thrust forces for forward installation are higher than measured

5) Forward pipe installation is carried out more often nowadays
   and in the future

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End