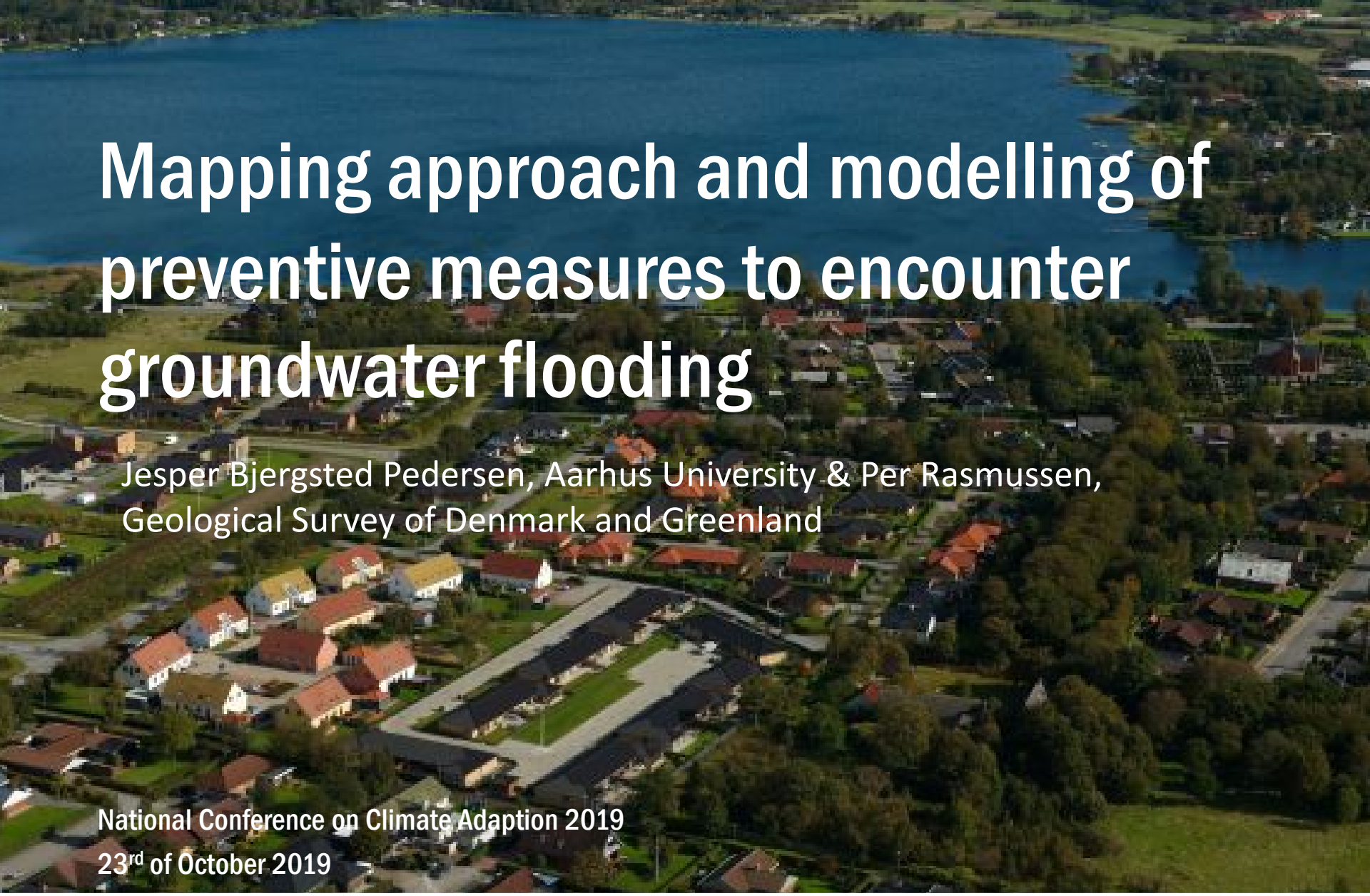
Mapping approach and modelling of preventive measures to encounter groundwater flooding

Jesper Bjergsted Pedersen, Aarhus University & Per Rasmussen, Geological Survey of Denmark and Greenland



National Conference on Climate Adaption 2019

23rd of October 2019

AARHUS UNIVERSITY

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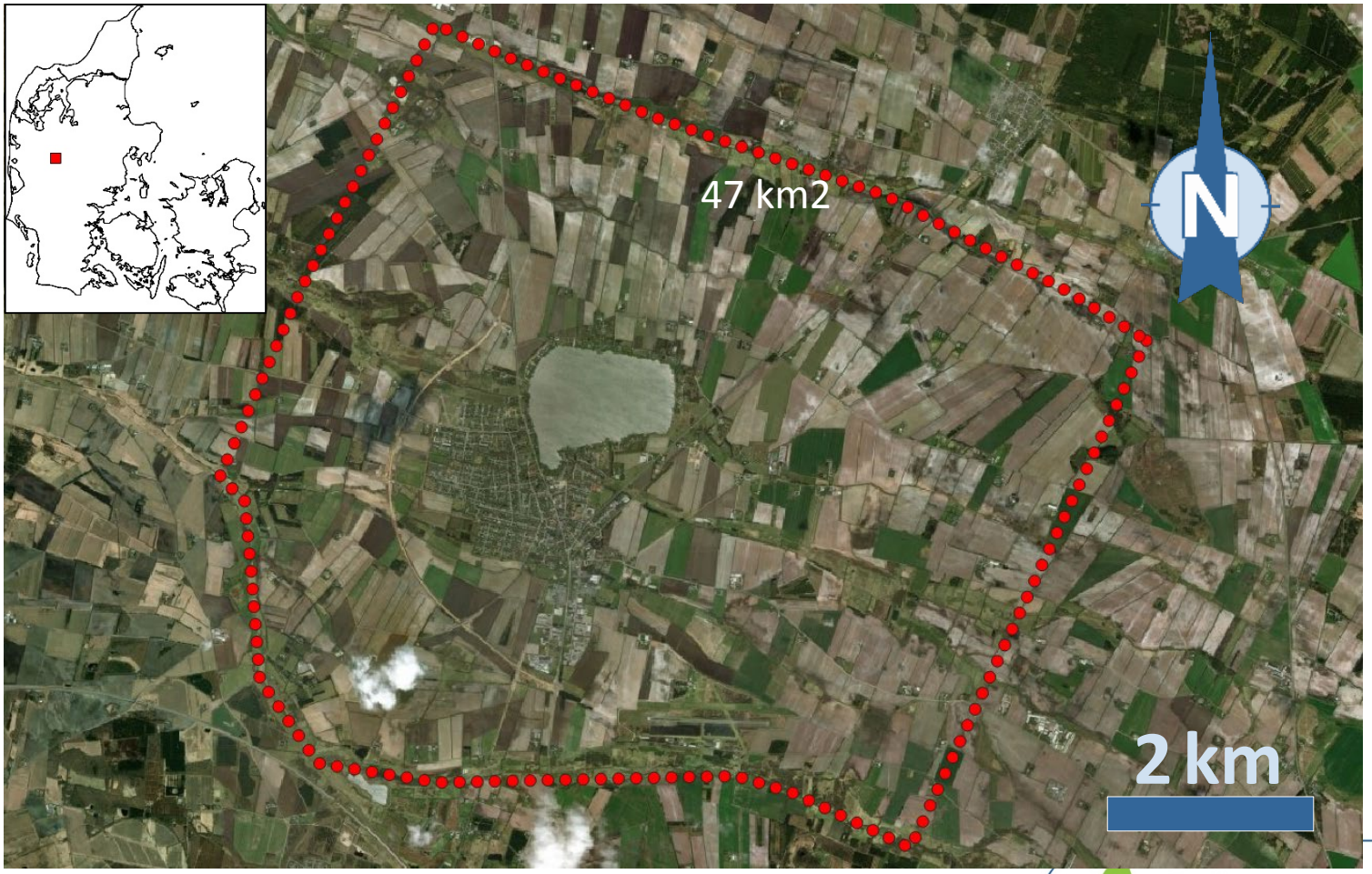
City of Sunds, Denmark



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What is the challenge in Sunds?

- Rising groundwater level resulting in flooding of basements/agricultural areas/green areas

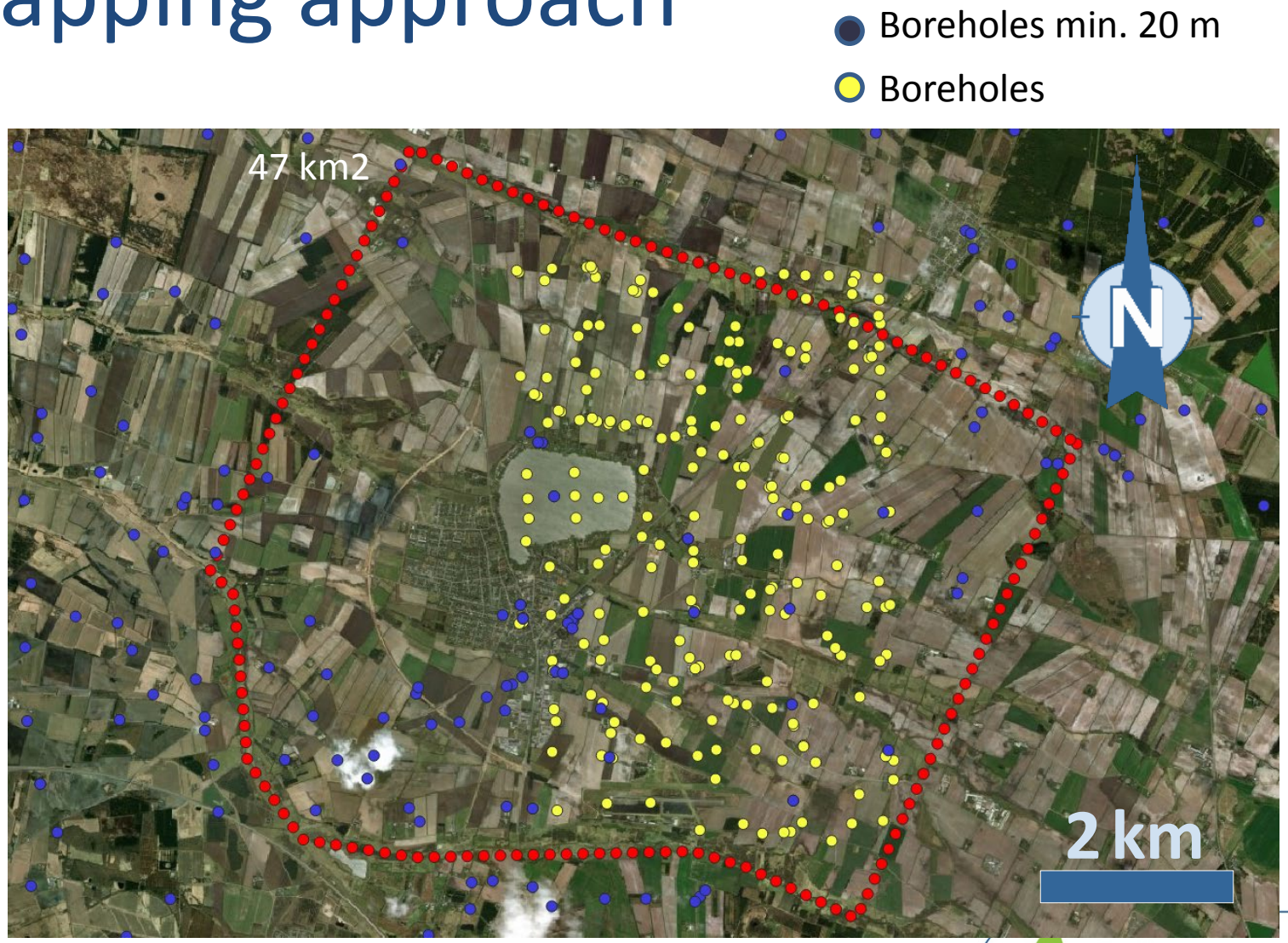
What is the challenge in Sunds?

- Flooding is most likely due to change in climate (increased precipitation) and human behavior (renewal of sewage systems, abstraction etc.)

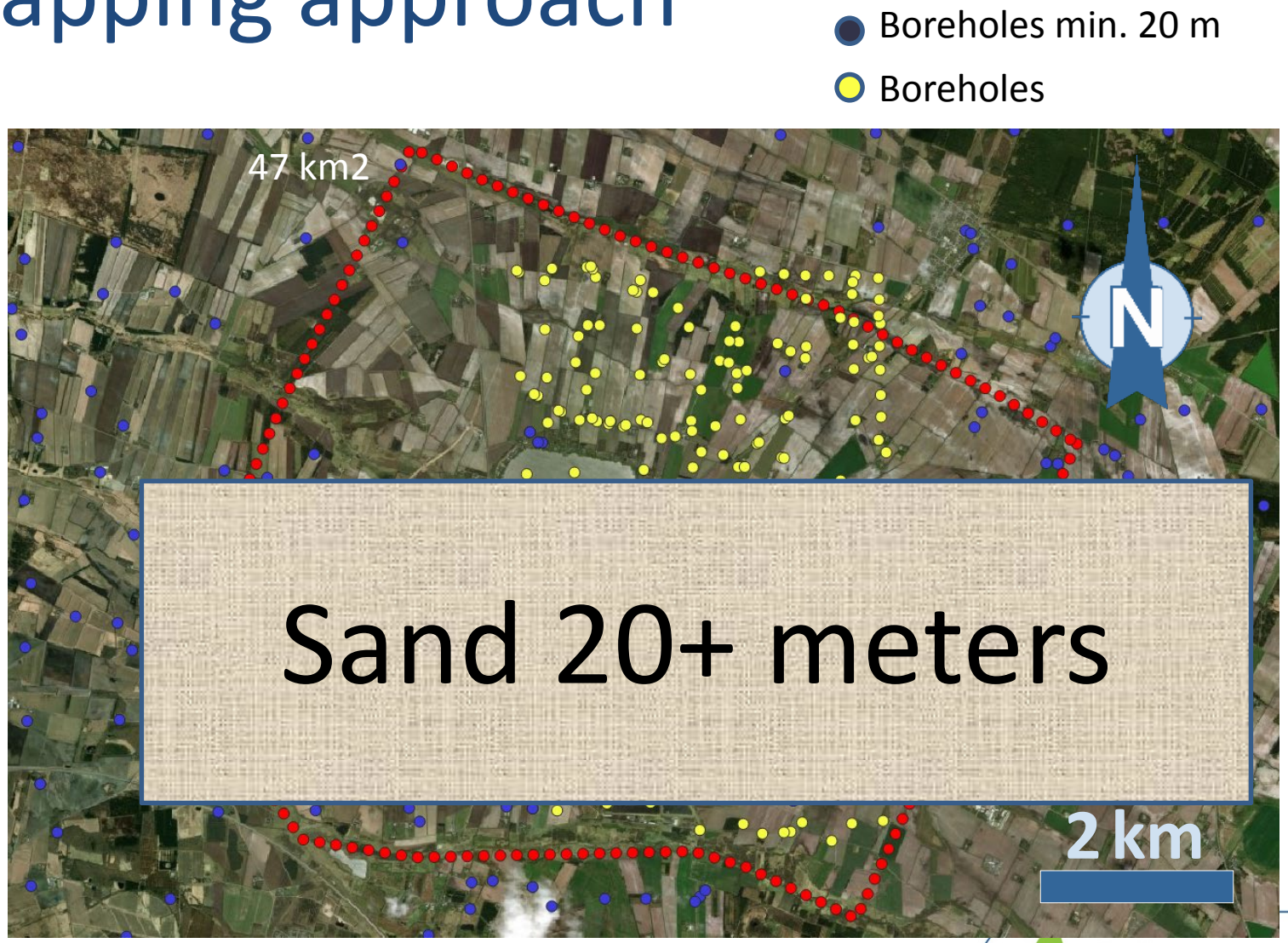
Mapping approach

- Need for detailed information on hydrological framework at/around the city to make preventative measures -> **DATA!**

Mapping approach

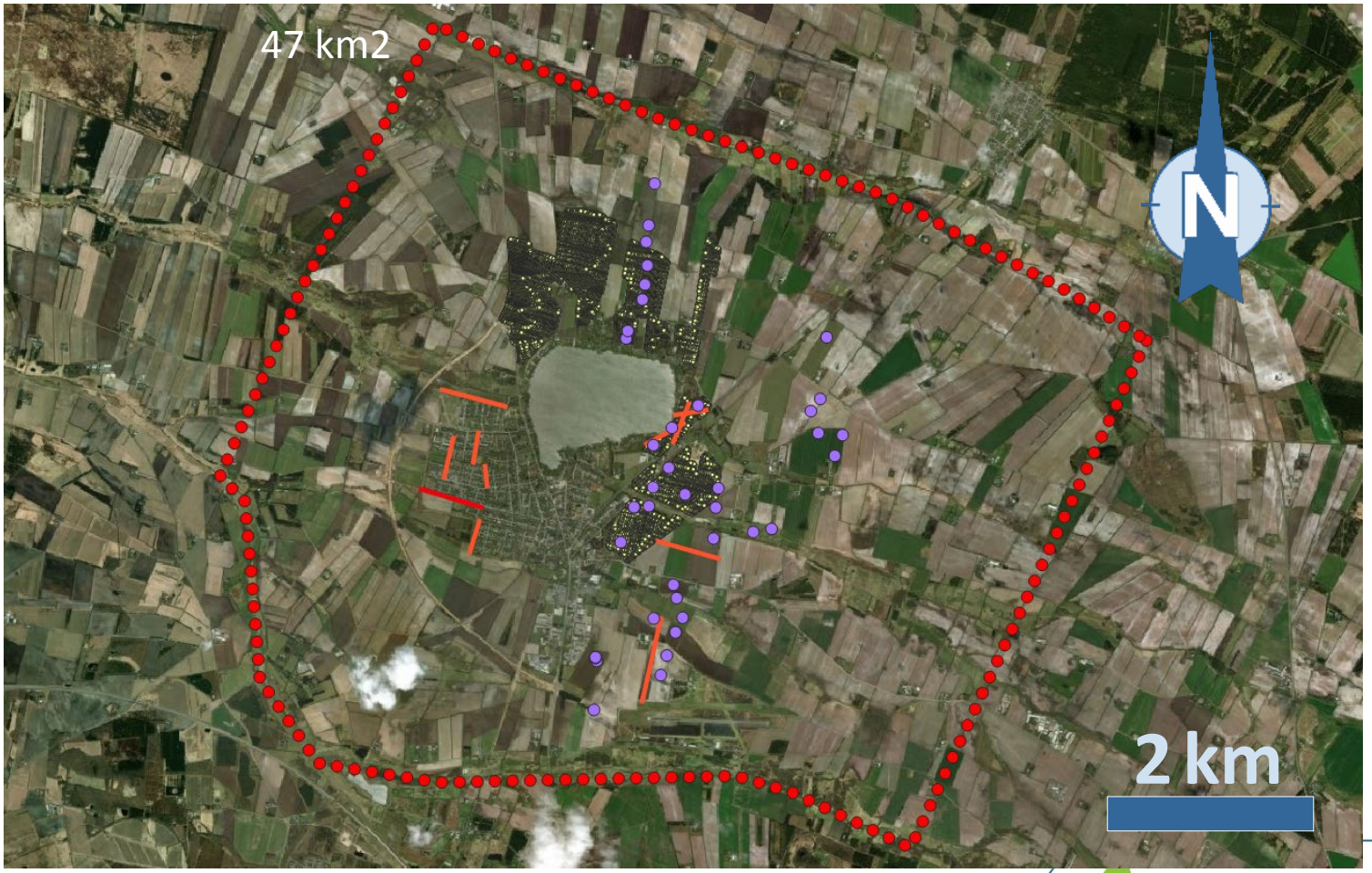


Mapping approach



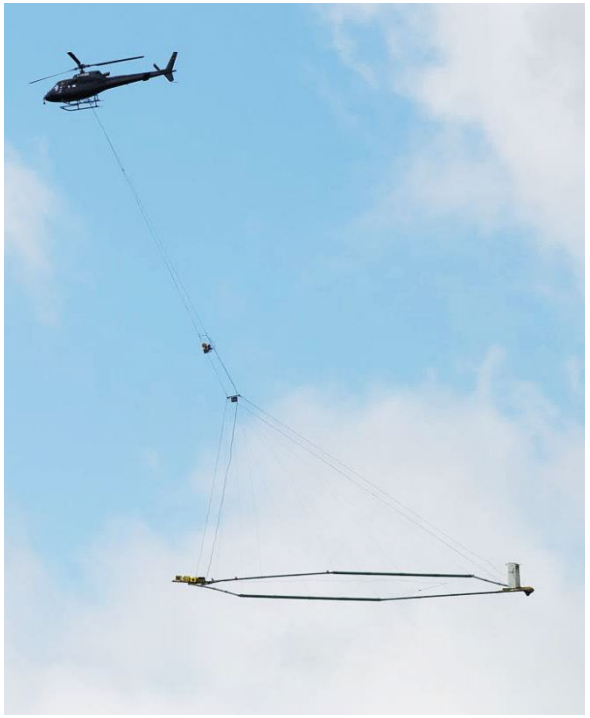
Mapping approach

- WalkTEM (38 Measurements)
- GCM (84252 Measurements)
- ERT (11 profiles)



Mapping approach

- SkyTEM / WalkTEM
  - \+ Fast, effective, deep investigation (several hundred m)
  - ÷ Large *footprint*, coarse resolution



Mapping approach

- SkyTEM / WalkTEM
  - + Fast, effective, deep investigation (several hundred m)
  - ÷ Large *footprint*, coarse resolution
- ERT
  - + High resolution, verified
  - ÷ Ineffective

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Mapping approach

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  - + Fast, effective, deep investigation (several hundred m)
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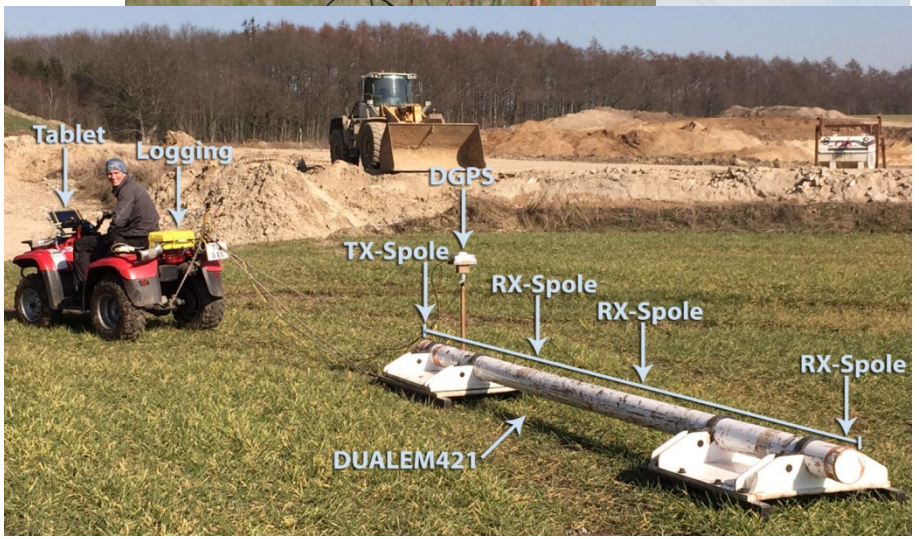
  - + High resolution, verified
  - ÷ Ineffective
- GCM
  - + Effective, high resolution
  - ÷ Shallow exploration (5-8 m)



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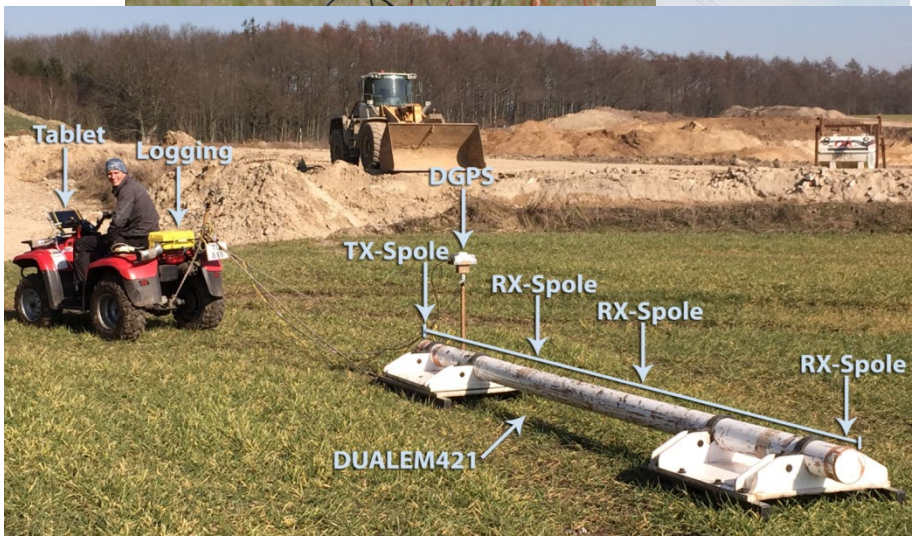
Mapping approach

- SkyTEM / WalkTEM
  - + Fast, effective, deep investigation (several hundred m)
  - ÷ Large *footprint*, coarse resolution
- ERT
  - + High resolution, verified
  - ÷ Ineffective
- GCM
  - + Effective, high resolution
  - ÷ Shallow exploration (5-8 m)
- tTEM
  - + Effective, high resolution
  - + Shallow and intermediate exploration (upper 30 m of the soil as a minimum)



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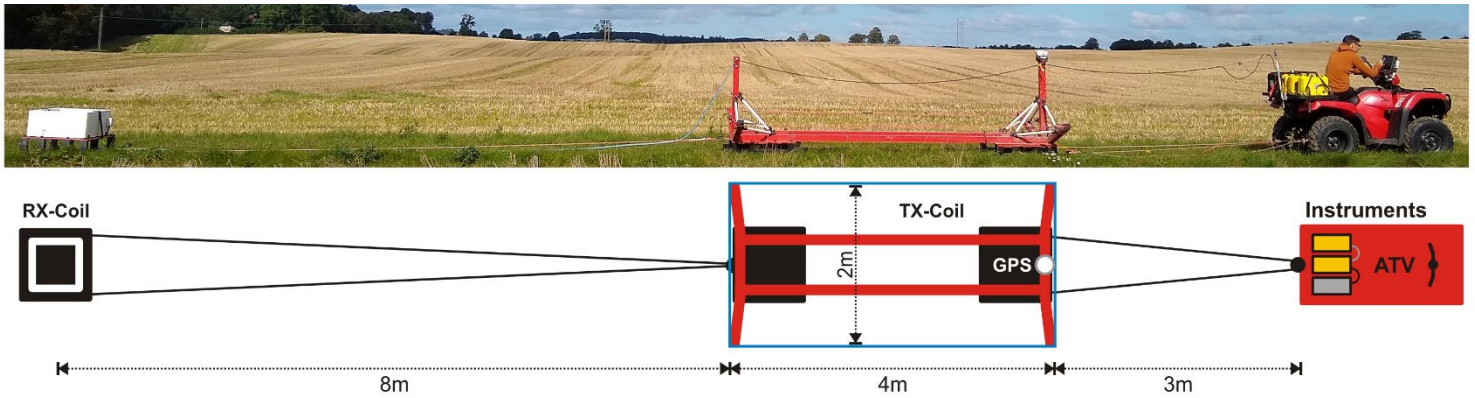
Mapping approach



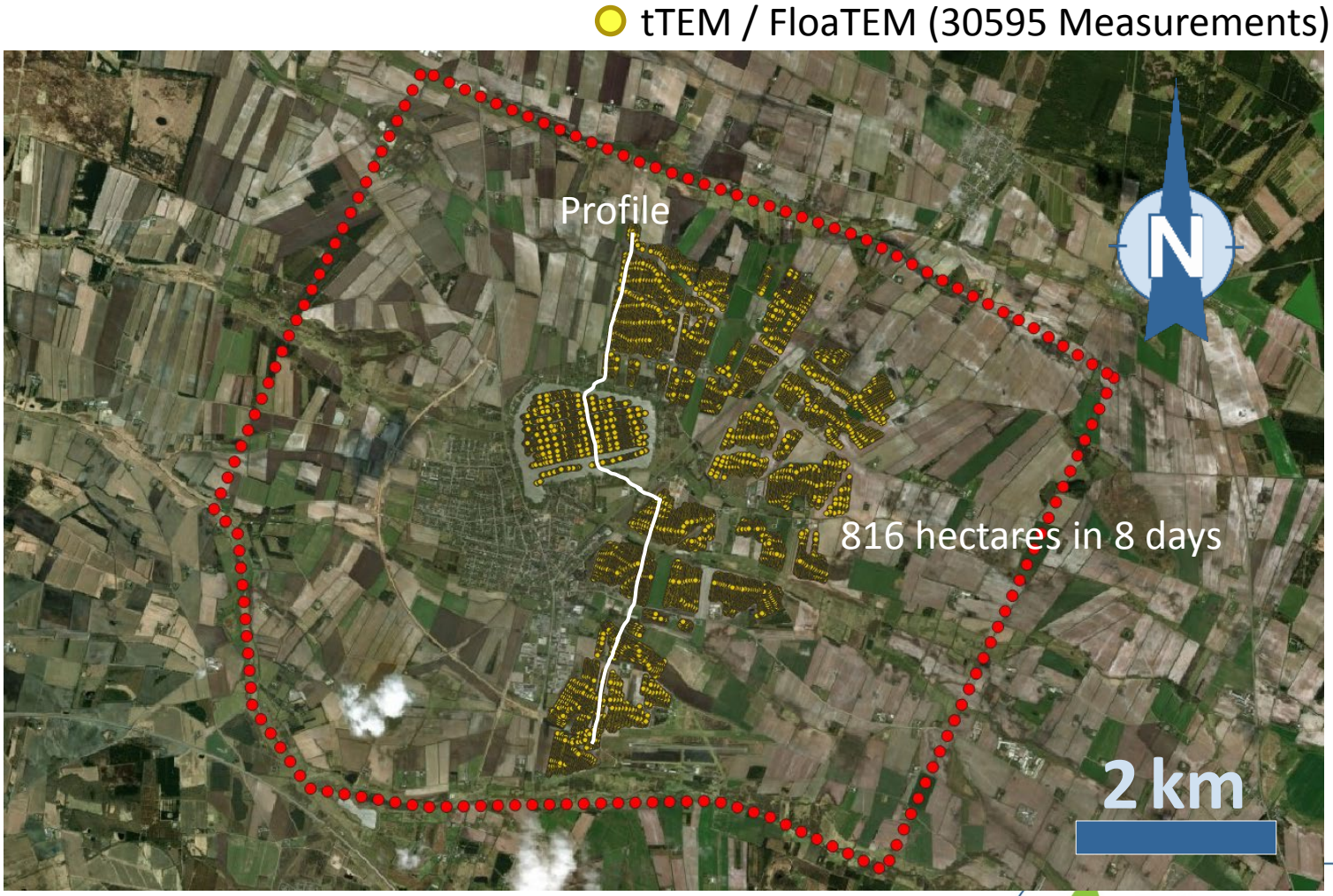
Technical details

- Measurement takes a few milliseconds resulting in 3-10 meters lateral resolution
- Depth of investigation 0-100 meters

Mapping details

- 10-20 km/hour ~ 3-5 m/s
- Line distance is typically 10-20 meters (spraying tracks distance)
- Coverage is 100-200 hectares per day

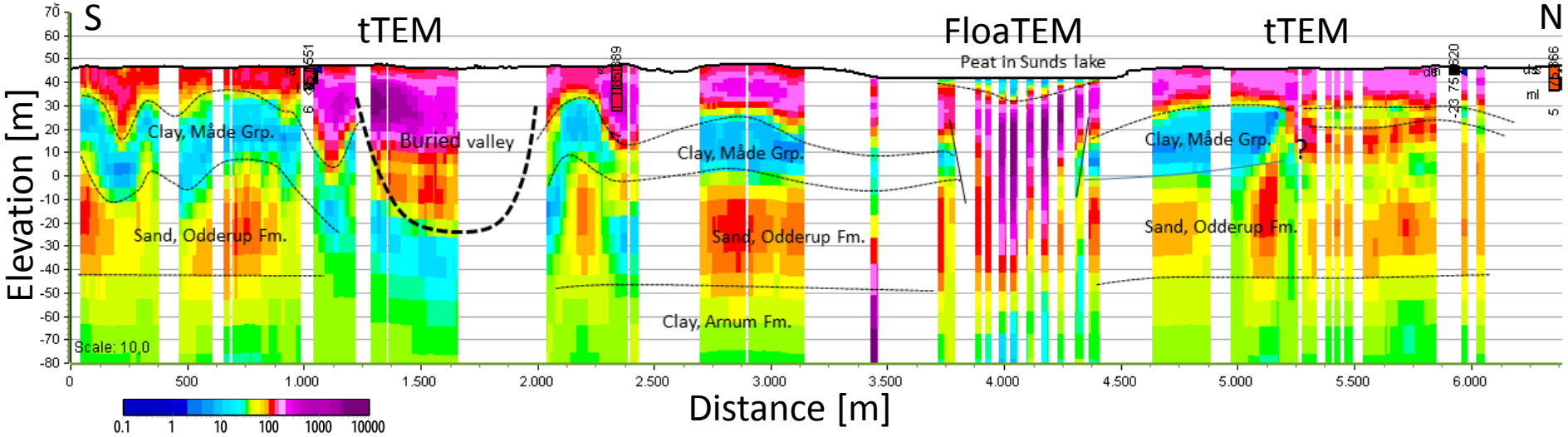
Mapping approach



Mapping approach

tTEM / FloaTEM (30595 Measurements)

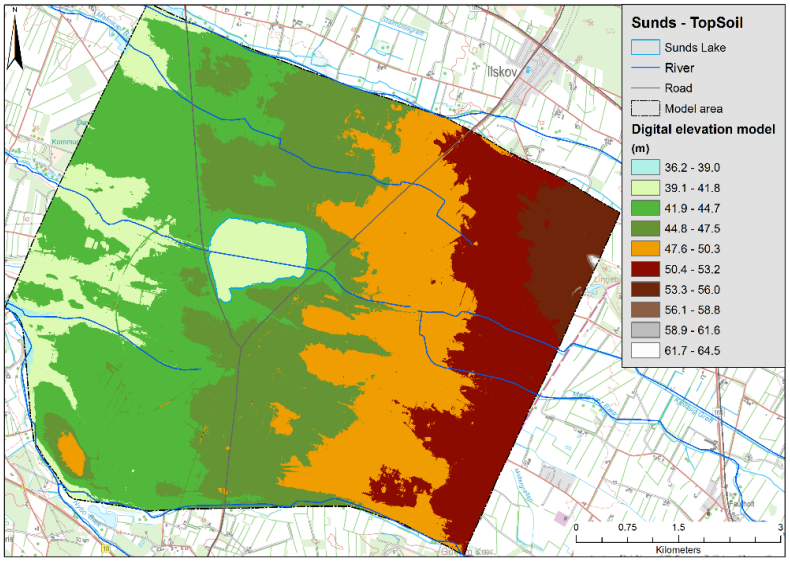
Resistivity profile

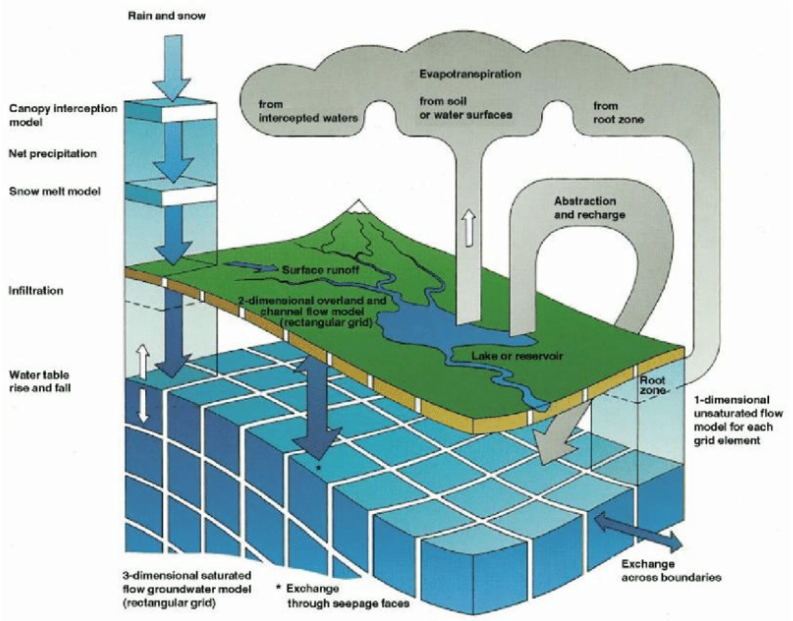


Modelling of preventive measures to encounter groundwater flooding

- Hydrological model

- Detailed description of surface water system

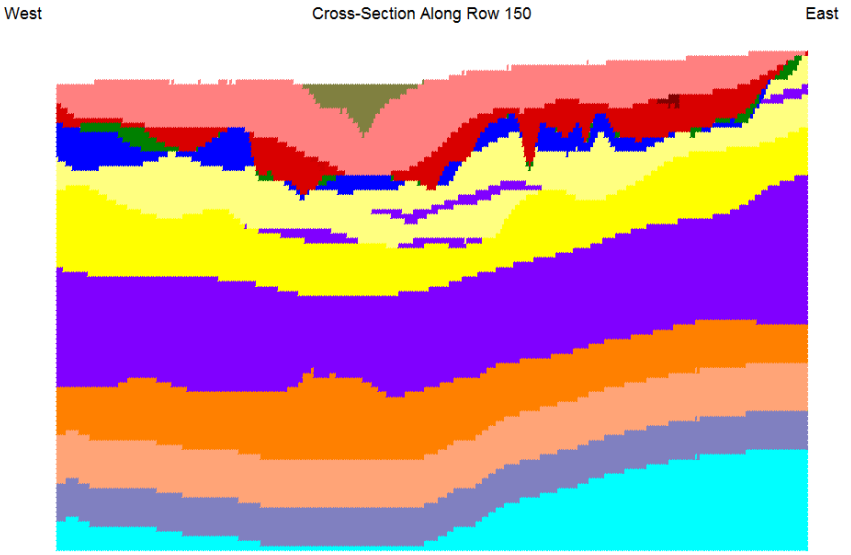




From geological to hydrological model

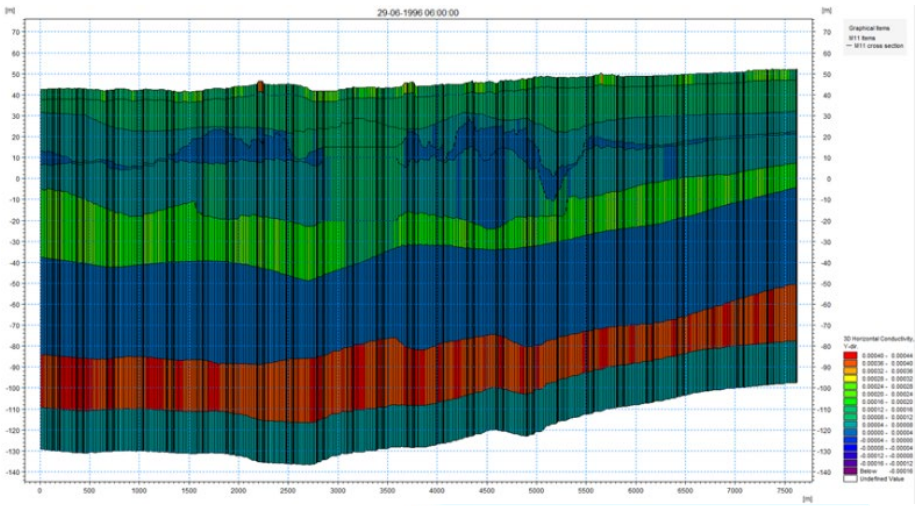
Detailed geological model

- 103 geological layers
- > 7 mio voxels
- Each voxel: 25 x 25 x 2 m



Hydrological model

- 9 calculation layers

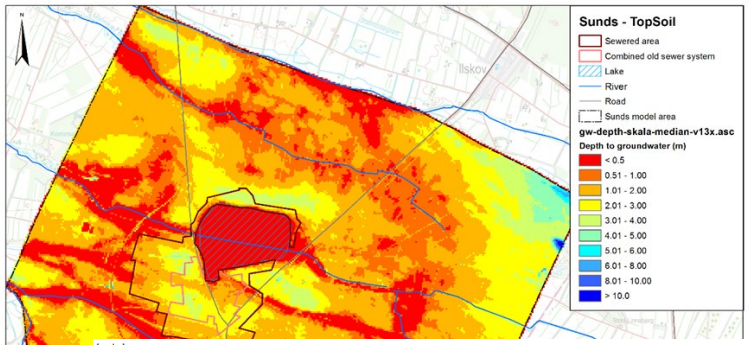


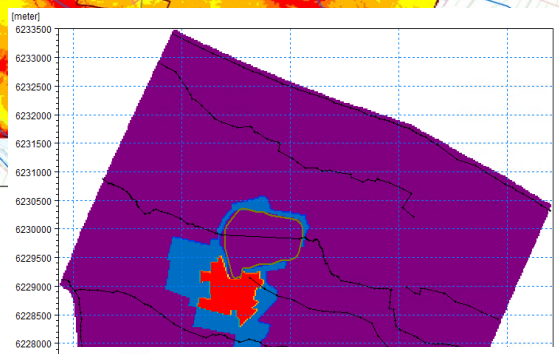
The challenge: Flooding

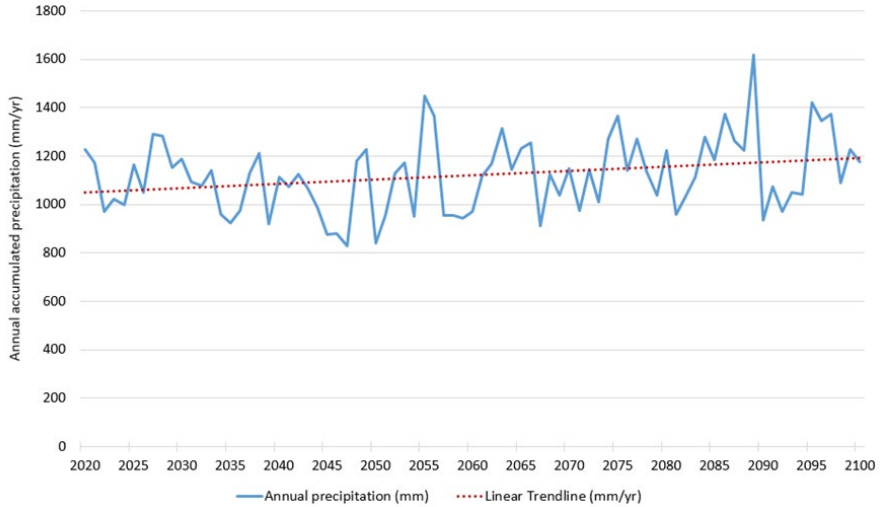
Three causes:

- Existing high groundwater level
- Renovation of leaking sewer pipes
- Predicted wet future climate

Source: AquaClew http://aquaclew.eu)

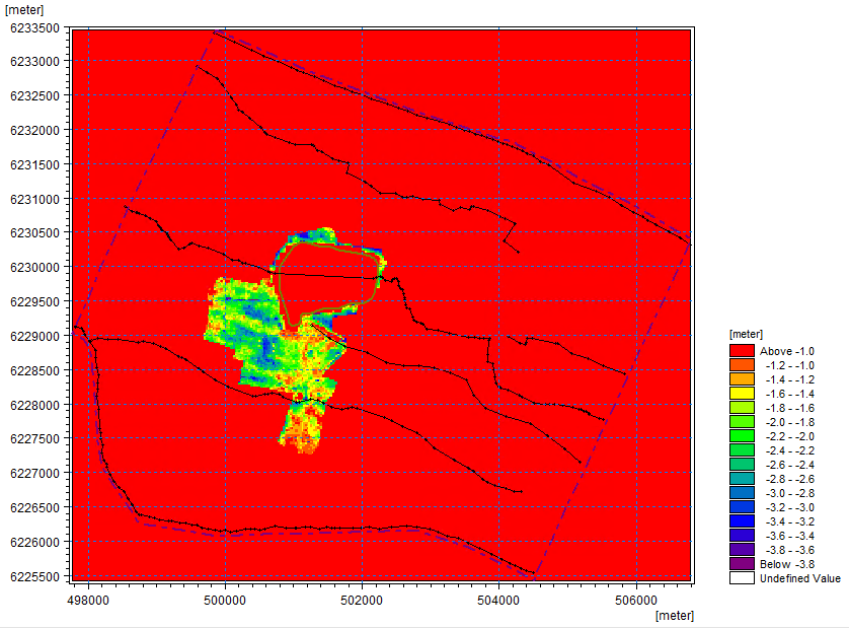




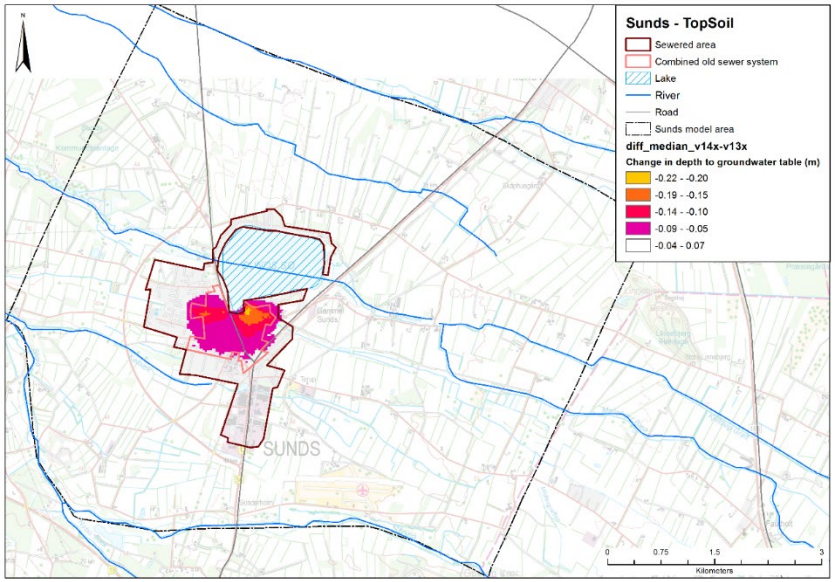


Renovation of sewer pipes

Depth of drainage system (m b.g.s.)



Change in depth to groundwater table (m)



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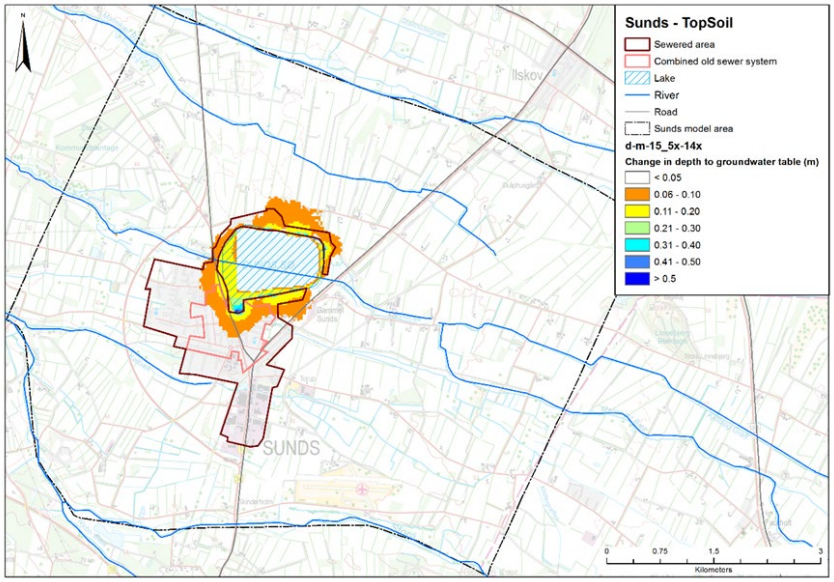
Preventive measures to encounter groundwater flooding

1. Fixed water level in Sunds Lake
2. Plantation of coniferous forest
3. Drain pipes in town – The 3rd pipe
4. Combined effect of measures

- Effect of wet climate prediction

Fixed water level in Sunds Lake

- Lowering the water table in Sunds Lake to “the summer level”

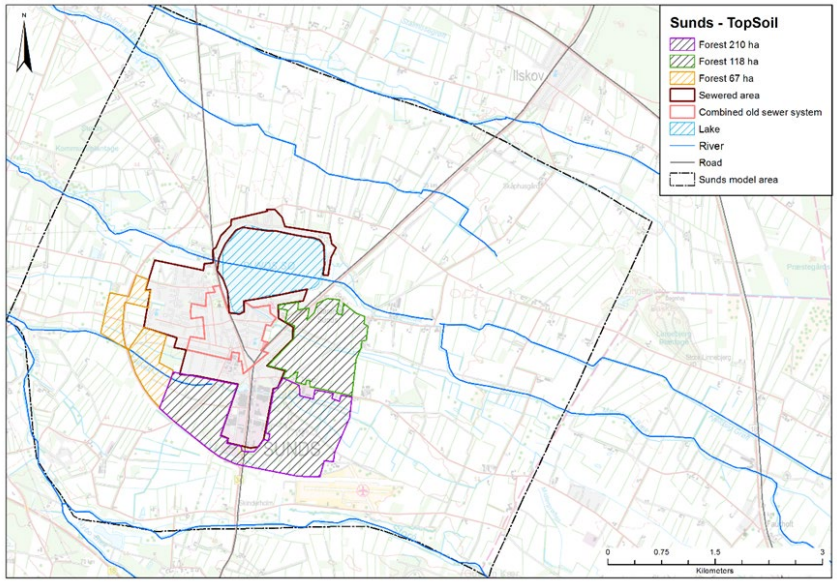


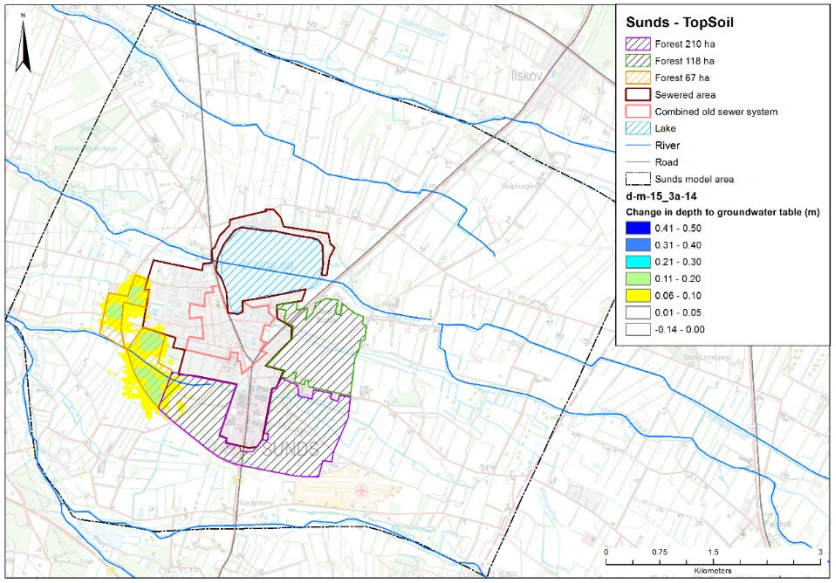
Change in depth to median groundwater level (m)

Plantation of coniferous forest - effect on groundwater table

Test of forest plantation in 3 areas around the town

67 ha

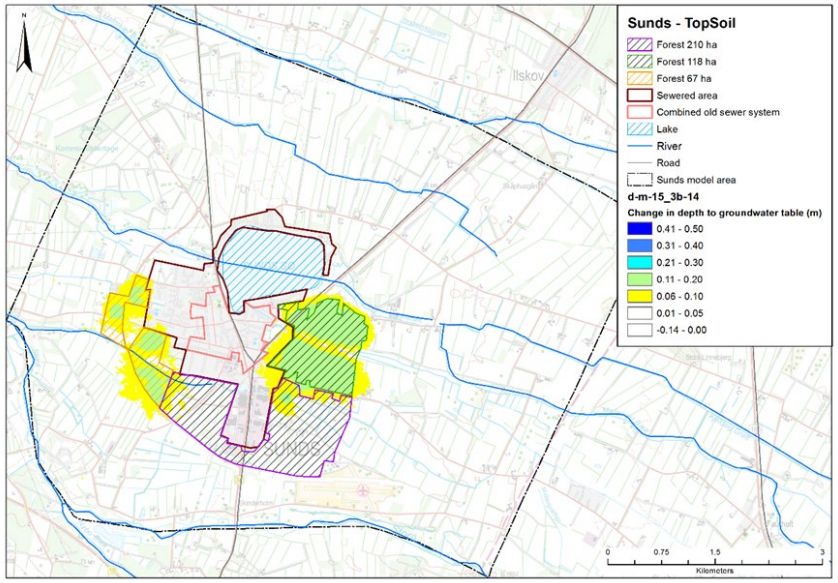




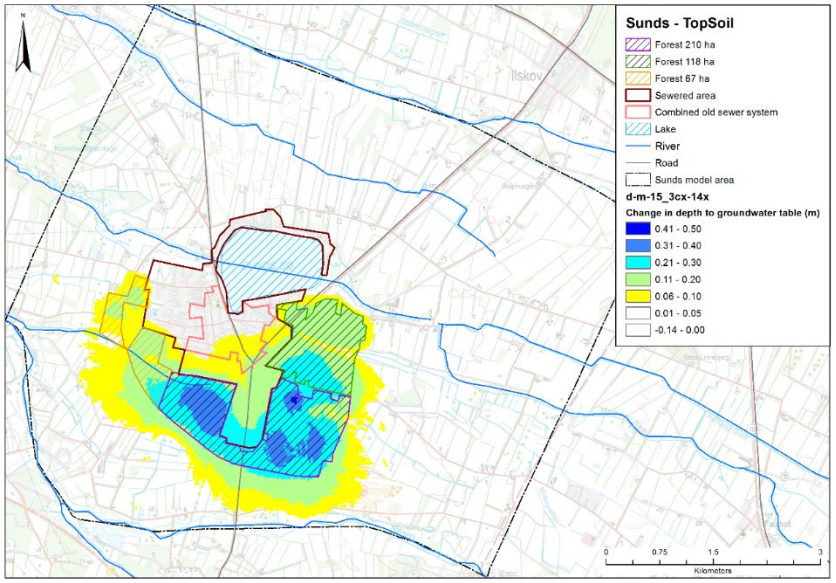
Change in depth to median groundwater level (m)

Plantation of coniferous forest - effect on groundwater table

185 ha



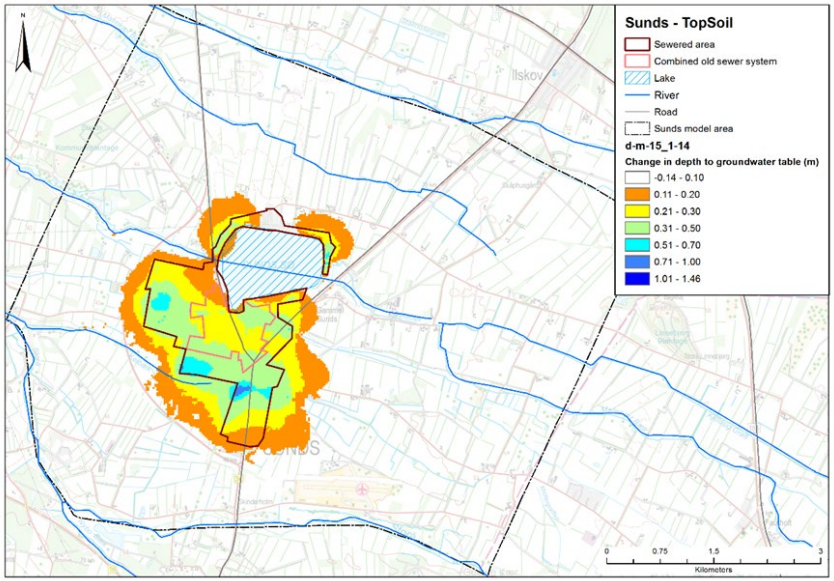
395 ha



Change in depth to median groundwater level (m)

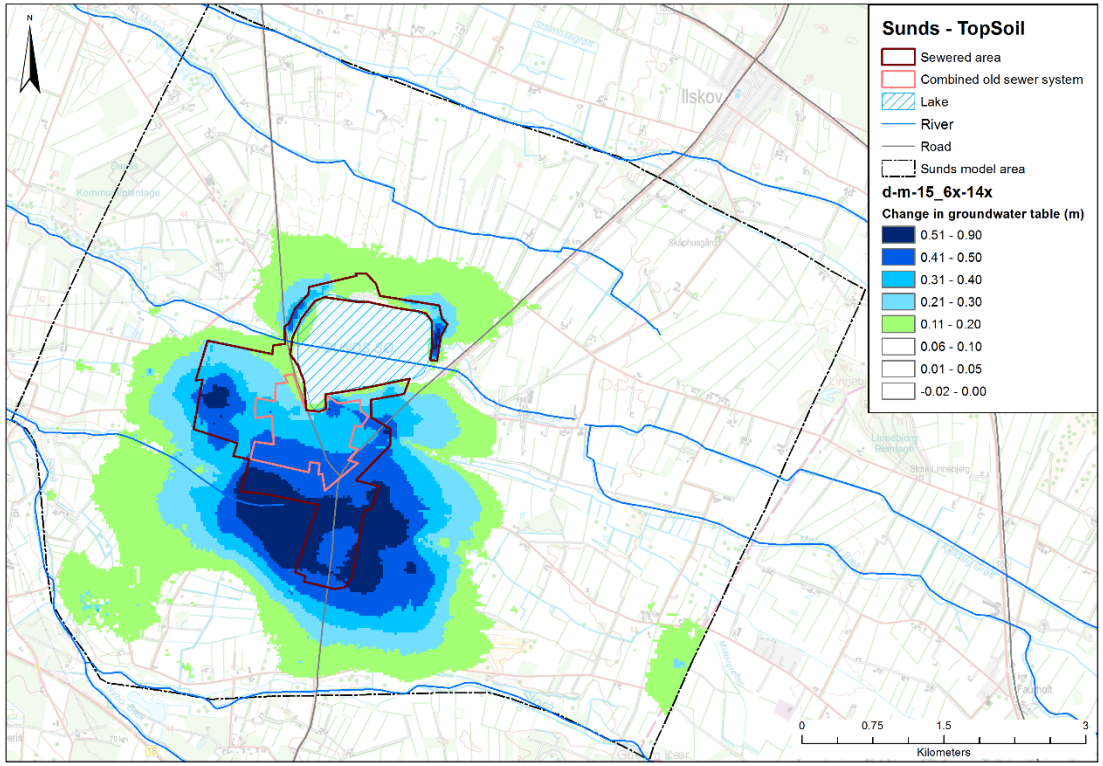
Drain pipes in town – The 3rd pipe

- Drains established drains whole urban area
- Same depth as existing sewer pipes



Change in depth to median groundwater level (m)

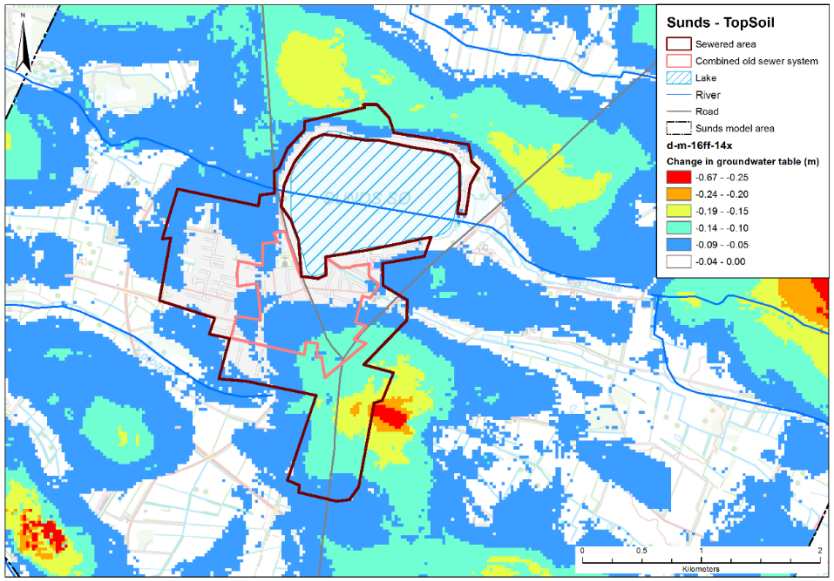
The combined effect measures



Change in depth to median groundwater level (m)

Effect of wet climate prediction

- A medium wet climate scenario in far future (2081-2100)
- Compared to the situation today (1996-2016



Change in depth to median groundwater level (m)

To conclude …

- Installing drainage systems in the city
- Make the city more green?
- Combination of measures