Ministry of Environment of Denmark
Environmental Protection Agency

Pingtan Island – Strategic Sector Cooperation – a case site presentation

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World Water Day
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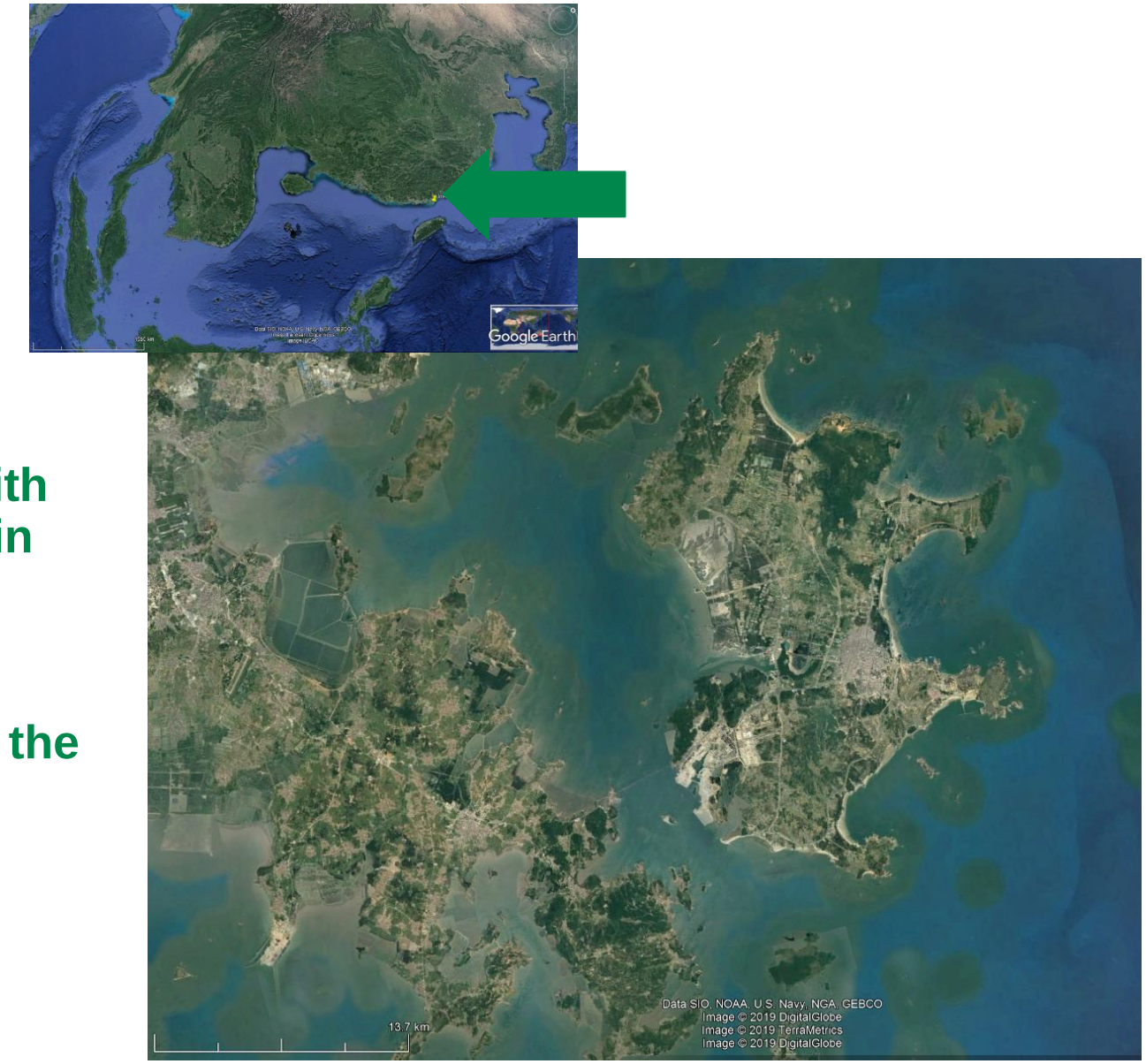
Pingtan Island

- Located in The South China Sea
- Area 263 km^2
- Population 400.000
- Development of the infrastructure with new urban areas and high-speed train
- Increase in population
- Expected water shortage problem in the future



Challenge

400.000 people would require app. 16 million m^3 water per year (110 litre/day)

Water supply from surface water

- **Surface water is vulnerable with respect to pollution and dry periods.**

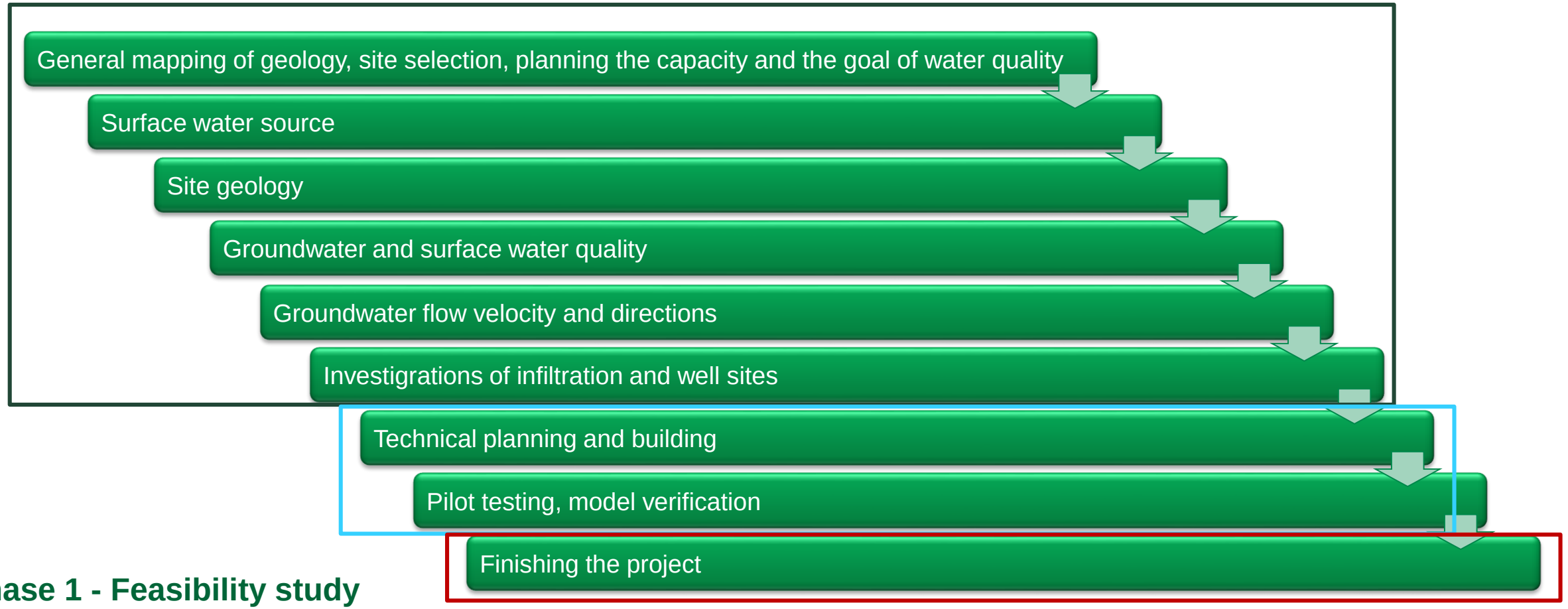
Benefits from using groundwater instead of surface water

- **In general - better water quality**
- **Less vulnerable with respect to dry periods and climatic changes**
- **Storage of surface water for use in dry periods**

How much groundwater can be abstracted in a sustainable way on Pingtan Island with use of Mannaged Aquifer Recharge?

- **Groundwater abstraction may not exceed groundwater recharge**
- **Prevent intrusion of saltwater**

MAR investigation and planning

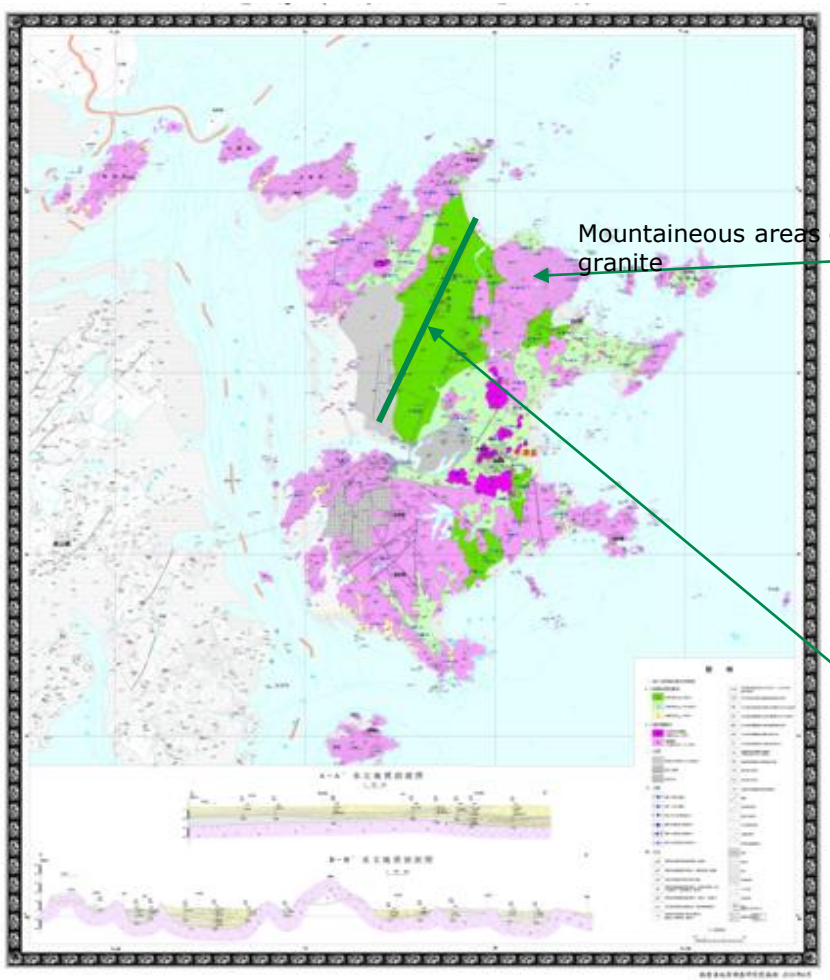


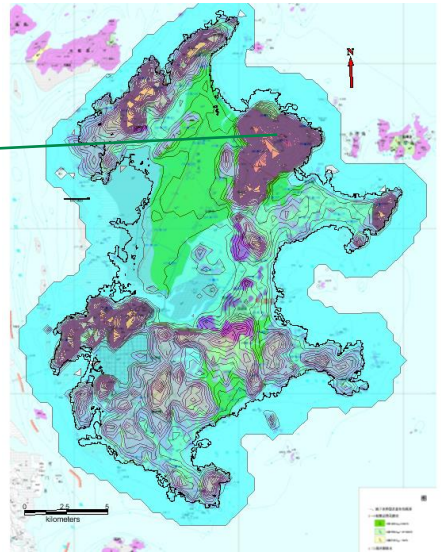
Phase 1 - Feasibility study

Phase 2 – Pilot testing

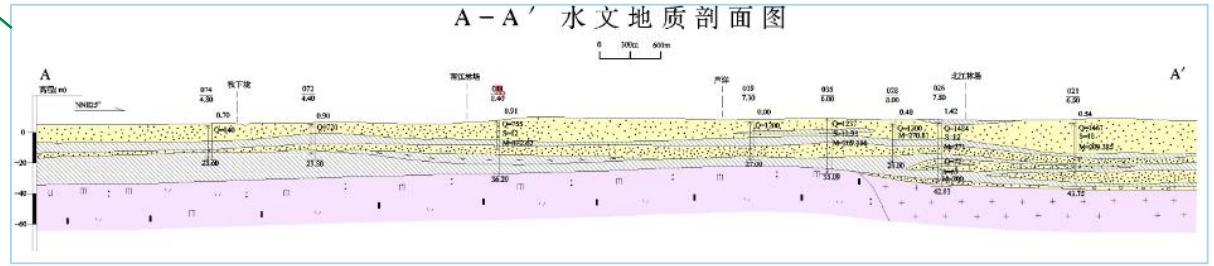
Phase 3 – Full scale implementation

Setting





- **Mountainous areas (purple areas) with elevations up to nearly 400 m**
- **Lowland dominated by marine deposits down to 20-30 m below ground level**
- **Basement rock - granite**

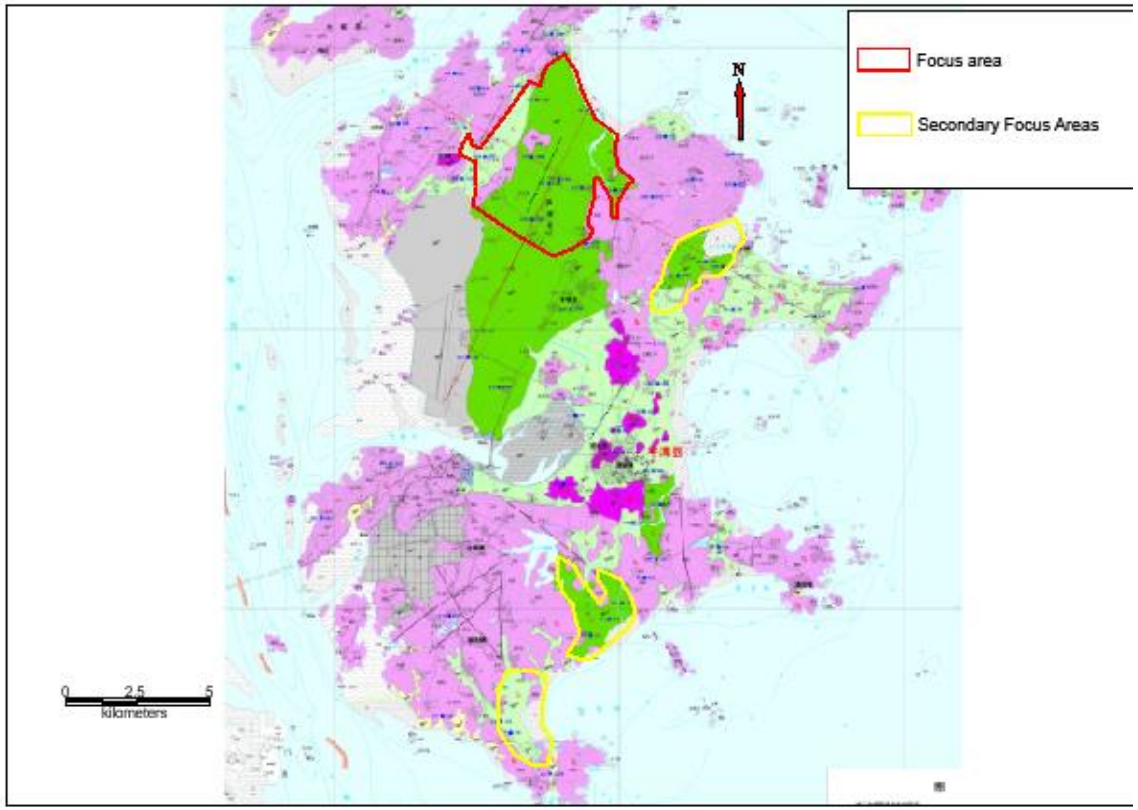


Focus areas

- Geology – aquifers with potential high yield
- Surface water availability
- Local plans for development and infrastructure

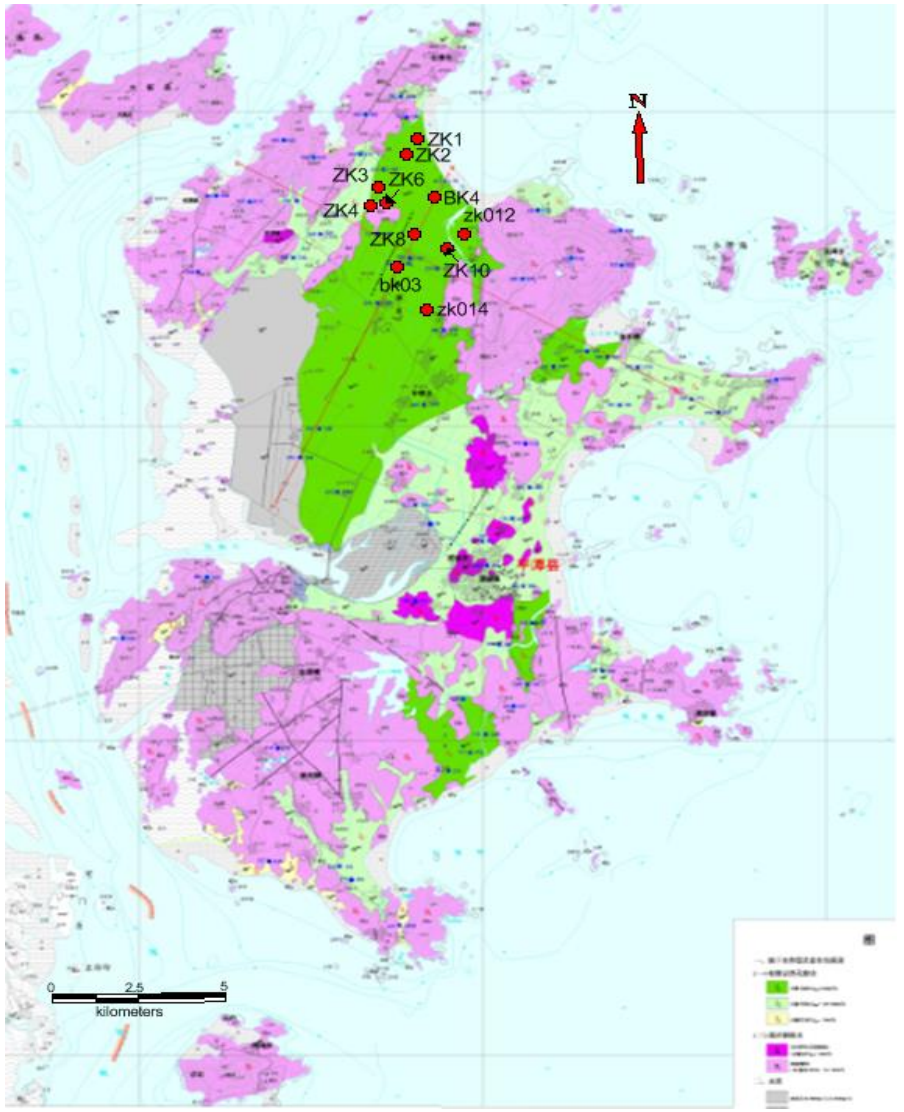
Challenges in the focus area with regard to groundwater abstraction and MAR

- Shallow water table
- Threat from salt water intrusion

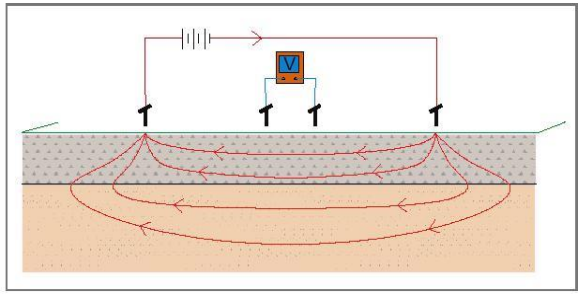


Collection of existing data

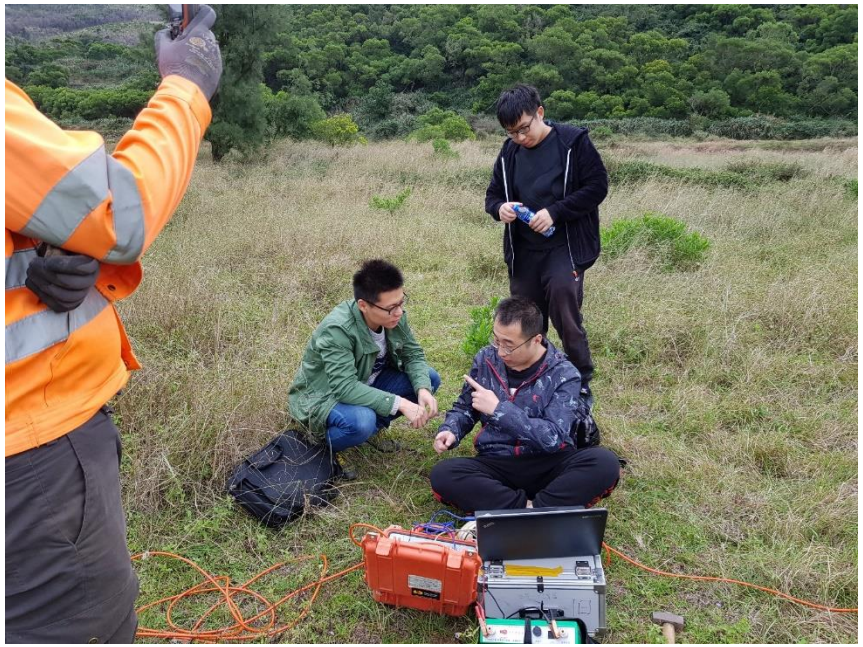
- Geological data from 10 boreholes located at the Lyungphu aquifer
- Measurements of groundwater levels in the period 2015-2018
- Elevation model for the island in a resolution of 30x30 meters
- CAD layers showing planned locations of larger infrastructures as large roads



Field investigations

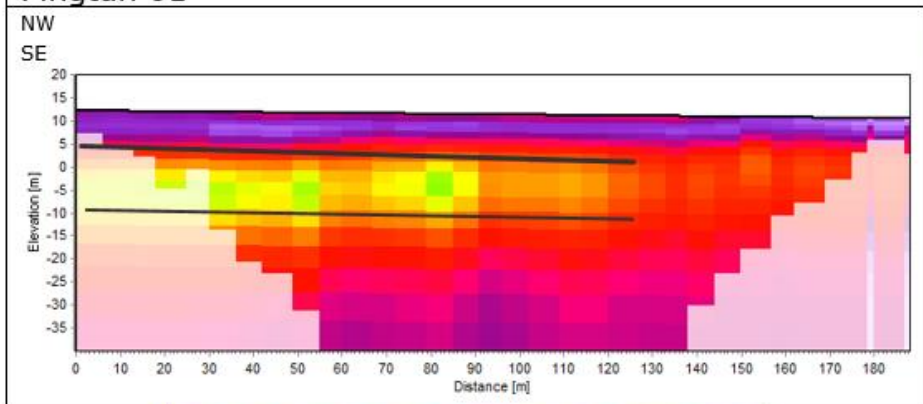


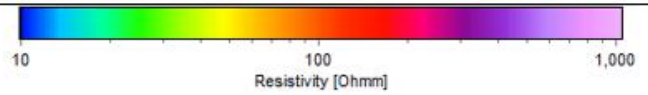
- Electrical Resistivity Tomography (ERT)
- Infiltration tests
- Borehole registration and measurements of groundwater heads
- Water sampling



Electrical Resistivity Tomography (ERT)

Pingtan 01



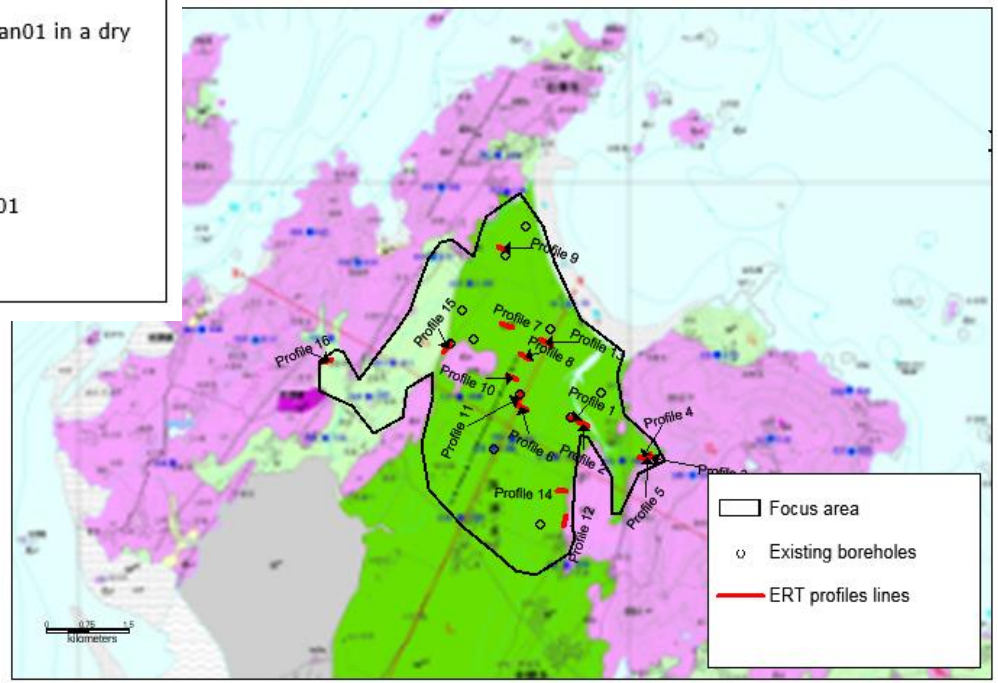


Existing well: Borehole no zk10 located 11m north of Pingtan01. Sand from elevation 7.21 m to -25.69 m. Mucky soil from -25.69 m to -33 m and below that bedrock

Infiltration test (surface): 17m west of Pingtan01 in a dry river.
K-value: 5.5E-4 m/s.
Depth to GWT: 0.3m.
Elevation of GWT: 3.8m

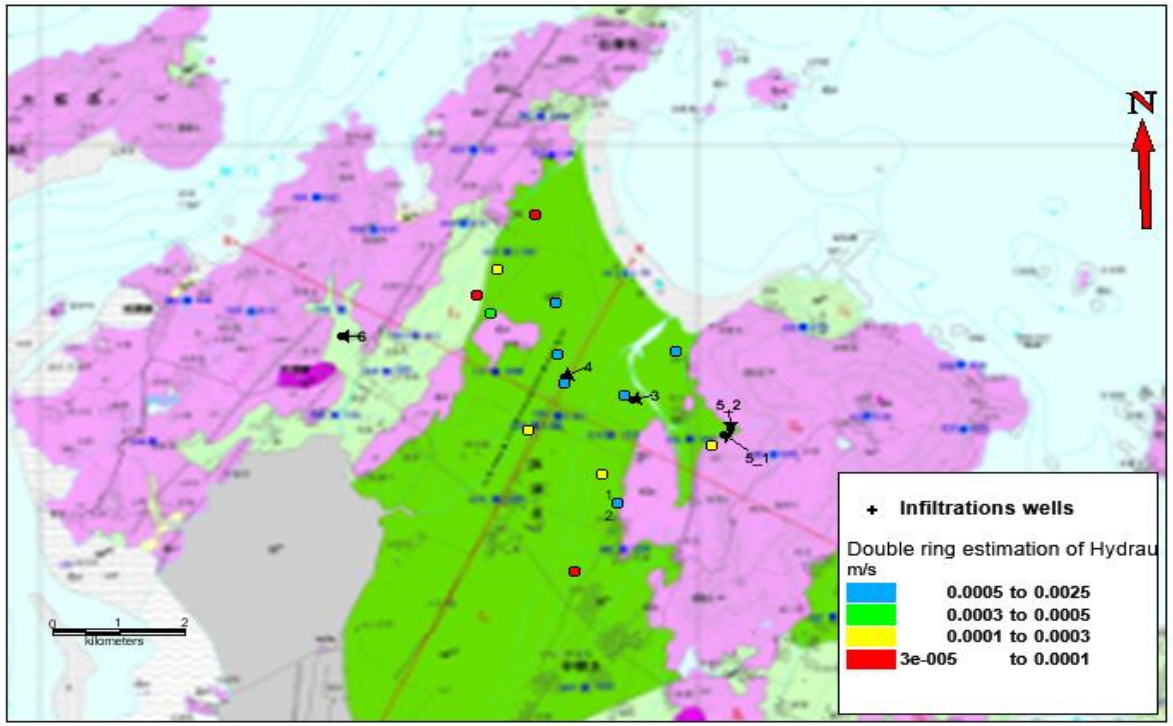
Infiltration test (well): 14m south of Pingtan01
30-60cm: 1.9E-4 m/s
185-215cm: 2.0E-4 m/s
285-315cm: 3.1E-4 m/s

- **16 profiles of 180 meters**
- **Covering focus area**
- **Modifying the conceptual geological model**



Infiltration tests

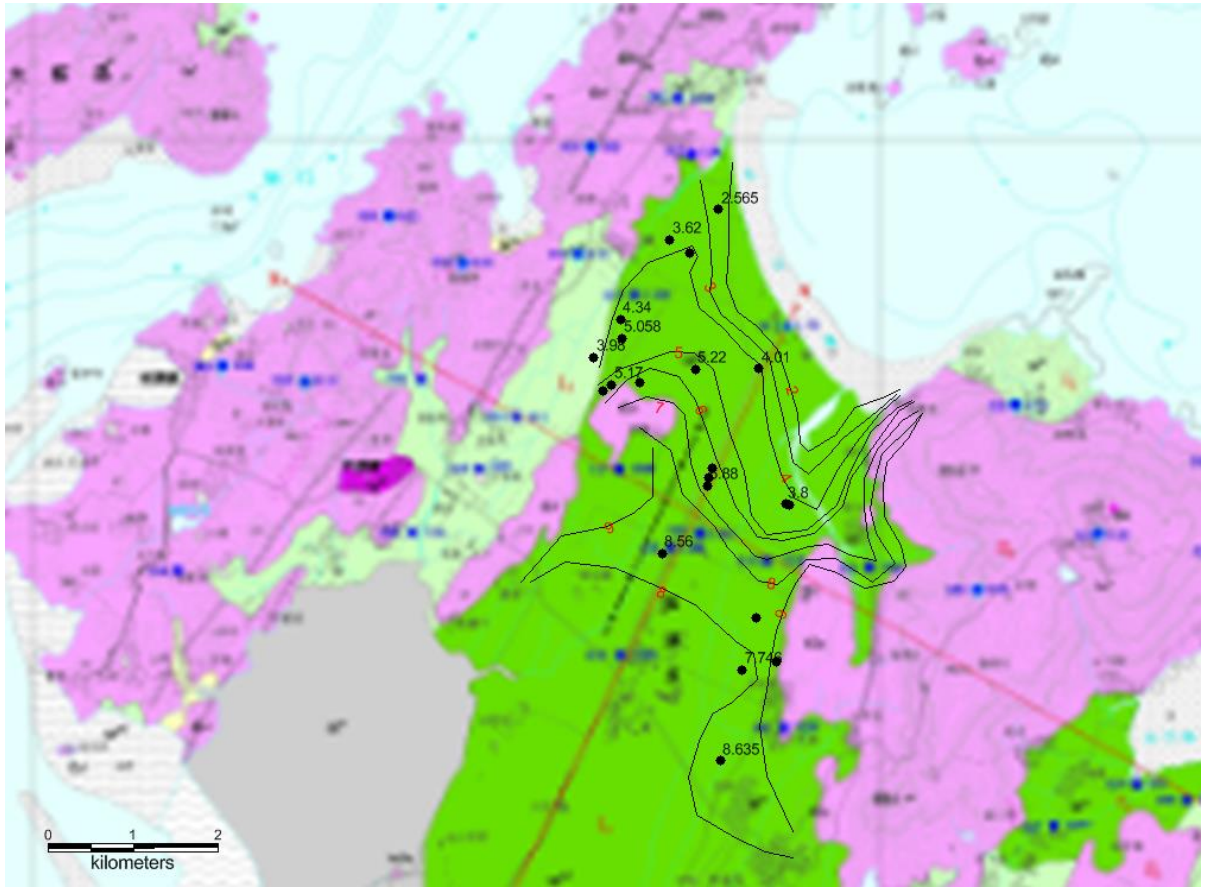
- Double ring estimation in shallow holes
- Permeameter test in handmade boreholes
- Parameters incorporated in hydrological model

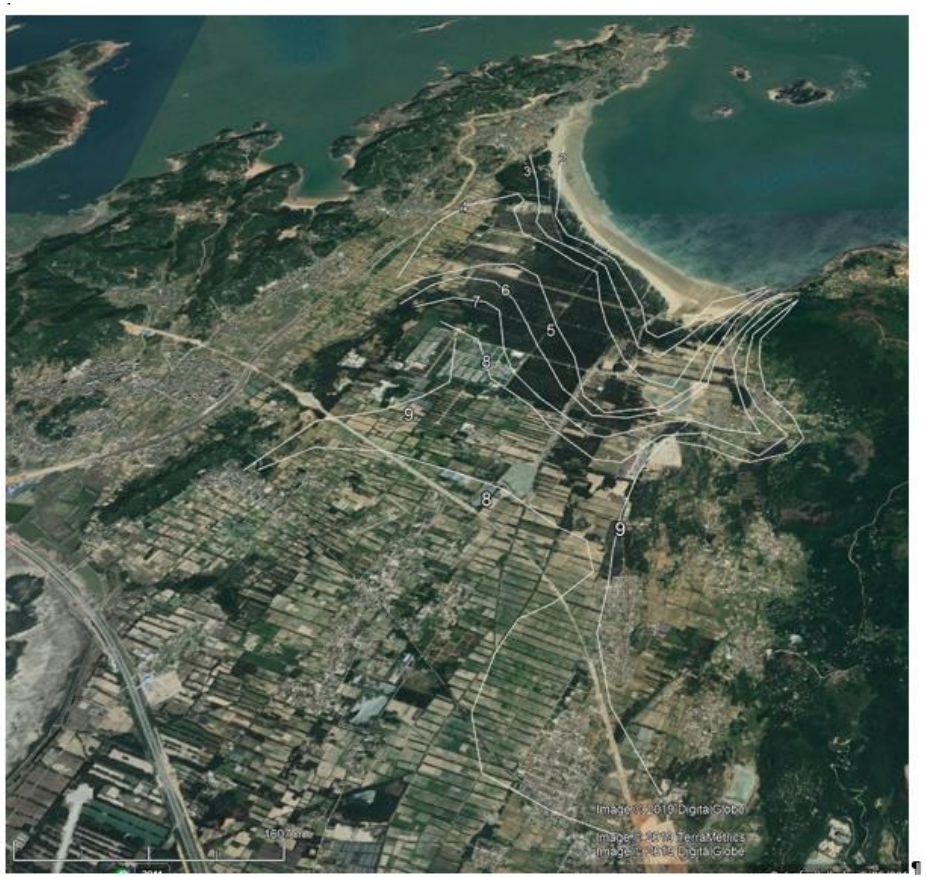


K determined by permeameter test

Borehole	Date	Depth cm	K cm/day	K m/s
Borehole 1	27-11-2018	85-115	625.7	7.20E-05
Borehole 1	27-11-2018	185-215	217.8	2.50E-05
Borehole 1	27-11-2018	285-315	63.3	7.30E-06
Borehole 2	27-11-2018	35-65	182.3	2.10E-05
Borehole 3	28-11-2018	30-60	1641.6	1.90E-04
Borehole 3	28-11-2018	185-215	1728	2.00E-04
Borehole 3	28-11-2018	285-315	2678.4	3.10E-04
Borehole 4	29-11-2018	70-100	303.9	3.50E-05
Borehole 4	30-11-2018	110-140	297.9	3.40E-05
Borehole 5_1	29-11-2018	35-65	2073.6	2.40E-04
Borehole 5_1	29-11-2018	35-65	918	1.10E-04
Borehole 5_2	29-11-2018	35-65	1555	1.80E-04
Borehole 5_2	29-11-2018	70-100	225.1	2.60E-05
Borehole 6	30-11-2018	100-130	31.3	3.60E-06

Groundwater flow

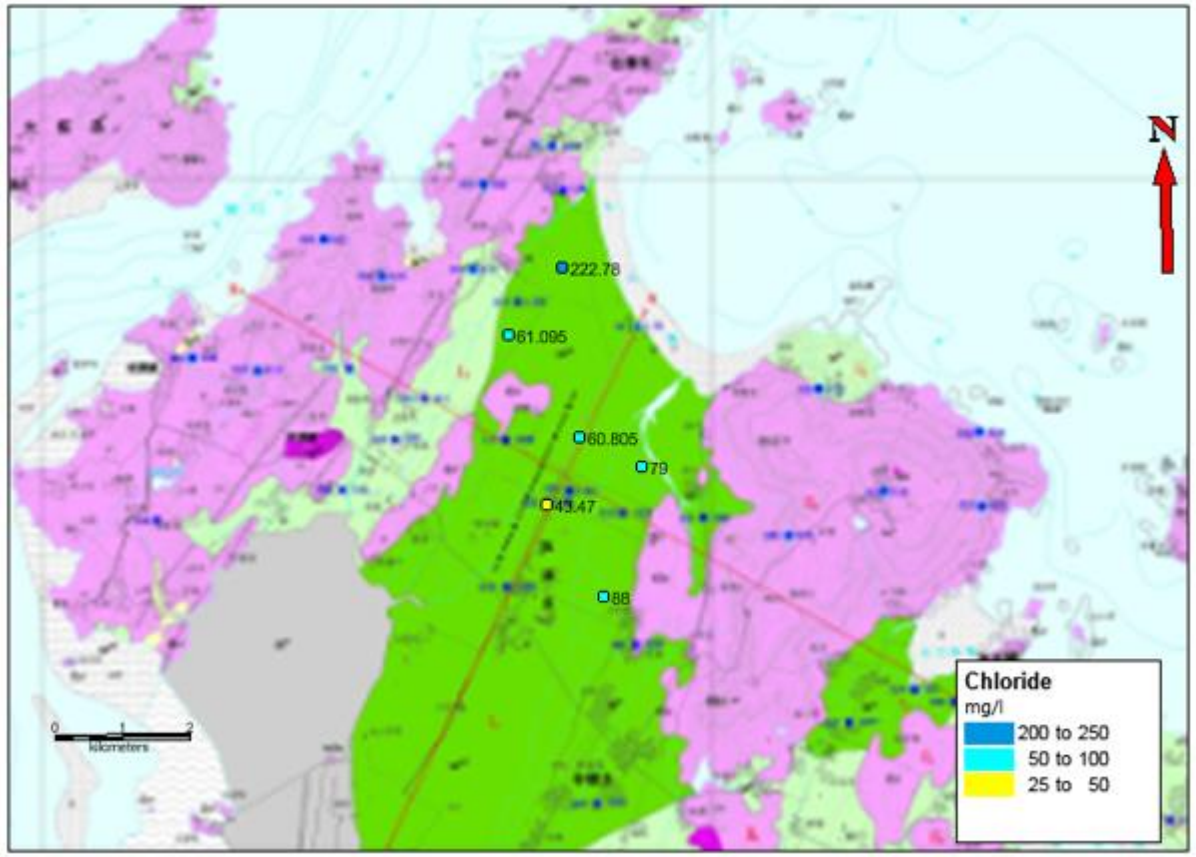




In general the water table is shallow (1-3 meters below the surface) at the coastal plain with increasing depth at the border of the mountains

Groundwater and surface water chemistry

Nitrate concentrations (mg/l) and delineation of agricultural areas within focus area

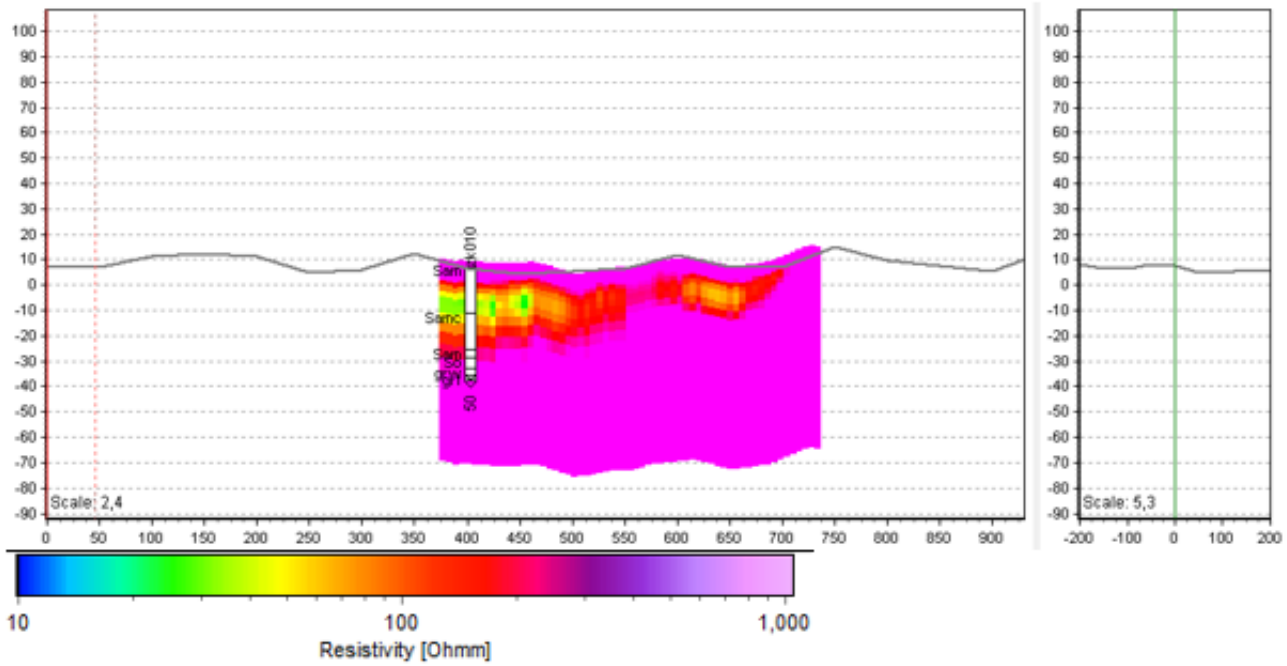


The Lyungphu aquifer can be characterized as an oxidized vulnerable groundwater with high concentrations of sulfate and low concentrations of iron.

Surface water sample had good water quality low in iron.

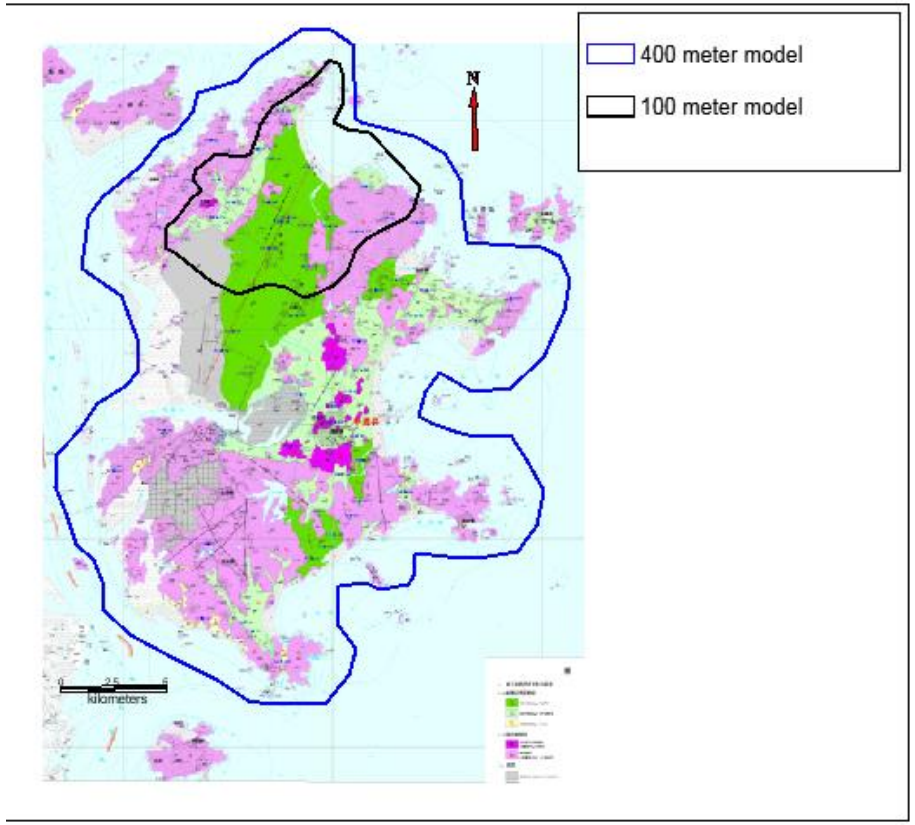
Geological model

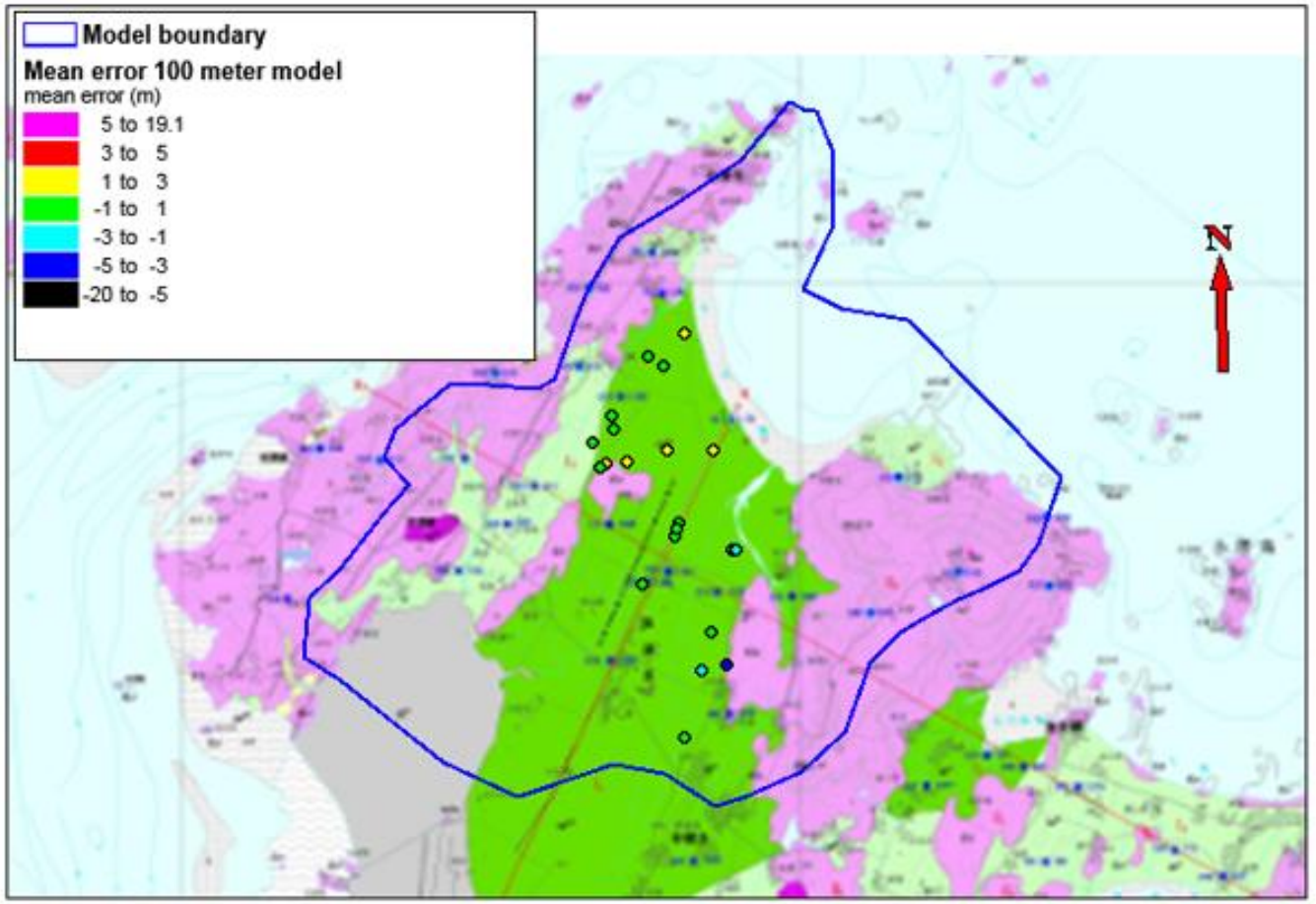
Id geological layer	Deposit type	Hydrostratigraphally model
1	Silty fine sand	1
2	Silt	
3	Medium Coarse sand	2
4	Medium Sand	
5	Medium Coarse sand	
6	Clay	3
7	Medium Sand	4
8	Mucky soil	5
9	Sand	6
10	Weathered granite	
11	Fractured granite	
12	Unfractured granite	7



Zones with lower resistivity is implemented as lenses with lower permeability in the groundwater model

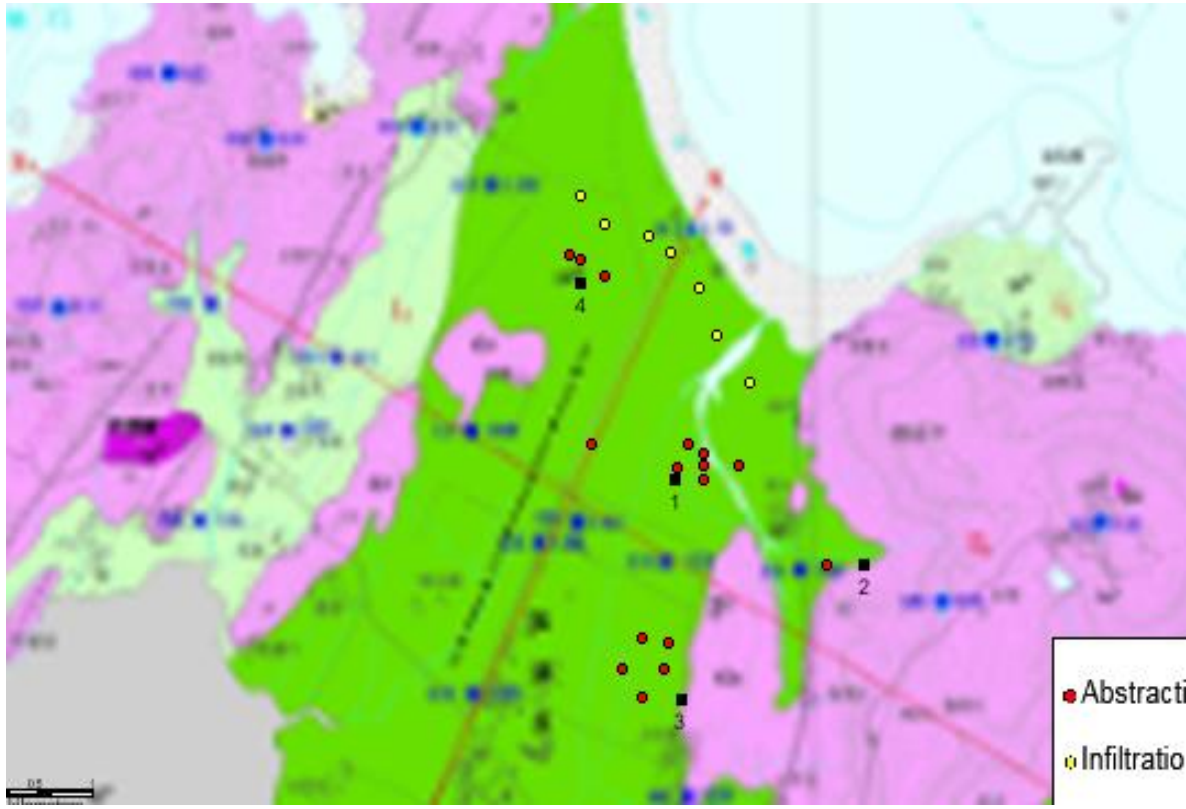
Hydrological model – Mike She





MAR solutions

- Preliminary estimations has shown a potential for abstracting 2.3-3 million m^3 without MAR.
- Our final scenario: Possible to abstract 10 million m^3 per year with infiltration of 3.9 million m^3 distributed on 4 basin sites – rapid infiltration. Combined with injection wells at the coast line to form a hydraulic barrier to prevent salt water intrusion.
- The surface water come from water running down from the mountains.
- The groundwater table in general is shallow => focus has been along the borders of the mountains where the depth to the groundwater table is biggest and where rain/surface water is naturally running down and/or the measured infiltration capacity and the aquifer potential is very high.



Conclusion

The model simulations show that

- **a combination of rapid infiltration basins with infiltration wells or lateral recharge shafts at the coastline with MAR may avoid salt water intrusion**
- **since the infiltration is rapid, rates can be very high and evaporation minimized**
- **the MAR solution is effective despite the shallow groundwater table and shallow unconfined high yielding aquifers when the groundwater abstraction increase**
- **the groundwater abstraction can be increased 2-3 times (from app. 3 to 10 million m^3 per year) at Pingtan Island with infiltration of rain and surface water from the mountains**

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