



LESSONS LEARNED OVER 20 YEARS OF THE DANISH SGMA

DATA ACQUISITION AND DATA MANAGEMENT

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HYDRO-GEOPHYSICIST

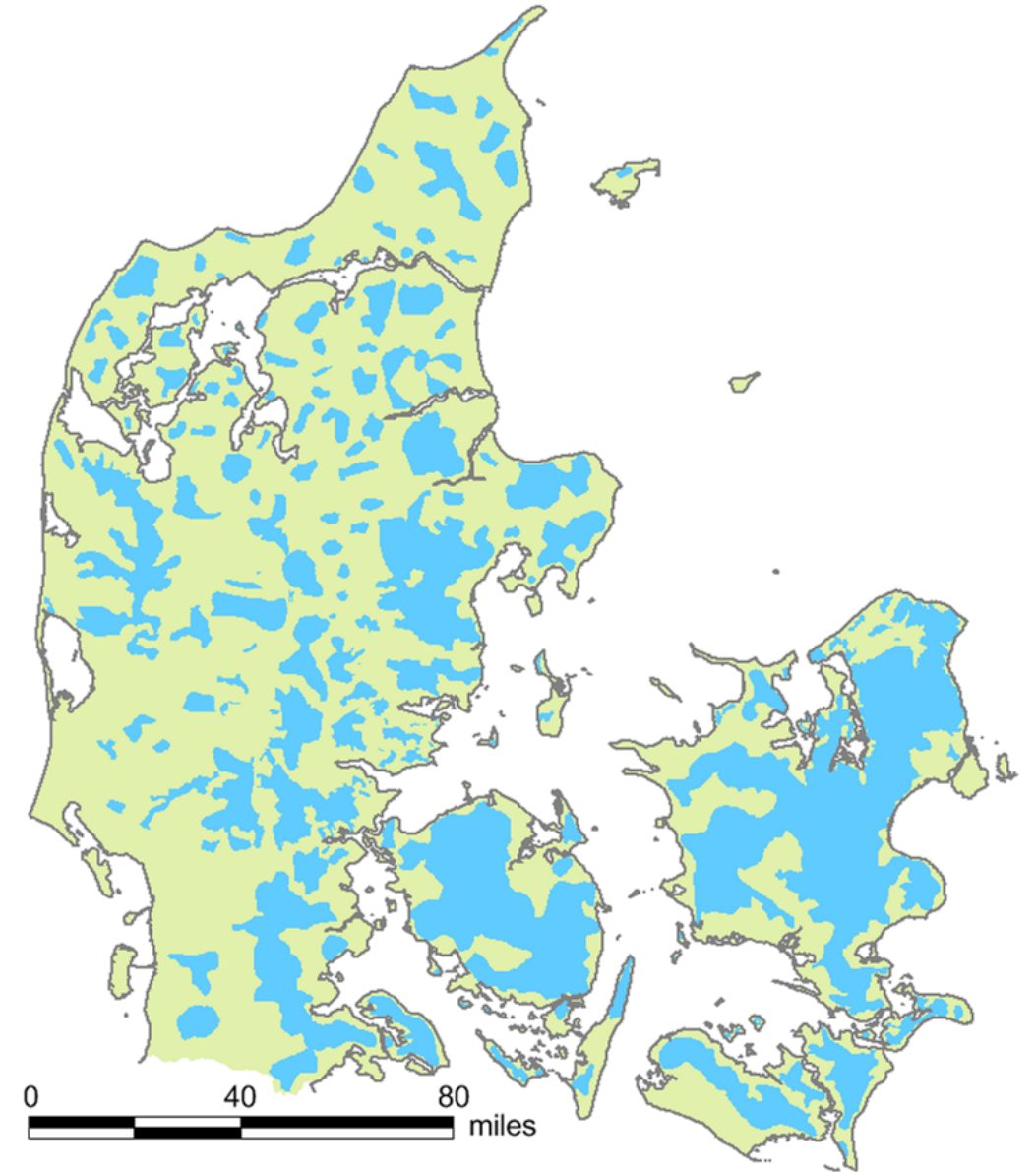
DENMARK 20-30 YEARS AGO



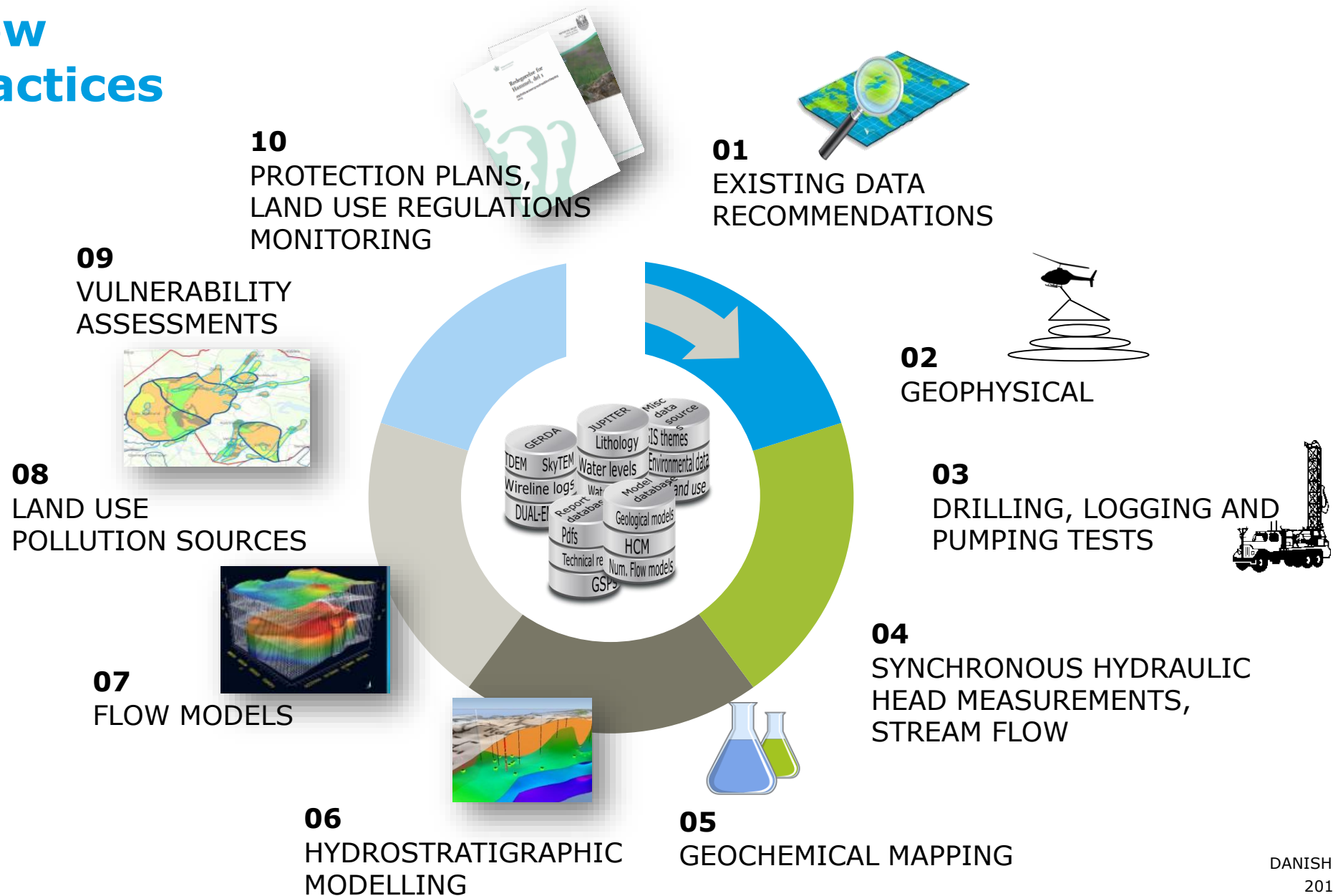
- Decreasing water tables
- Saline intrusion
- Lack of flows in streams in the summer time
- Water quality problems due to farming (P, NO₃, and pesticides) and point sources

THE DANISH GROUNDWATER MAPPING PROGRAM

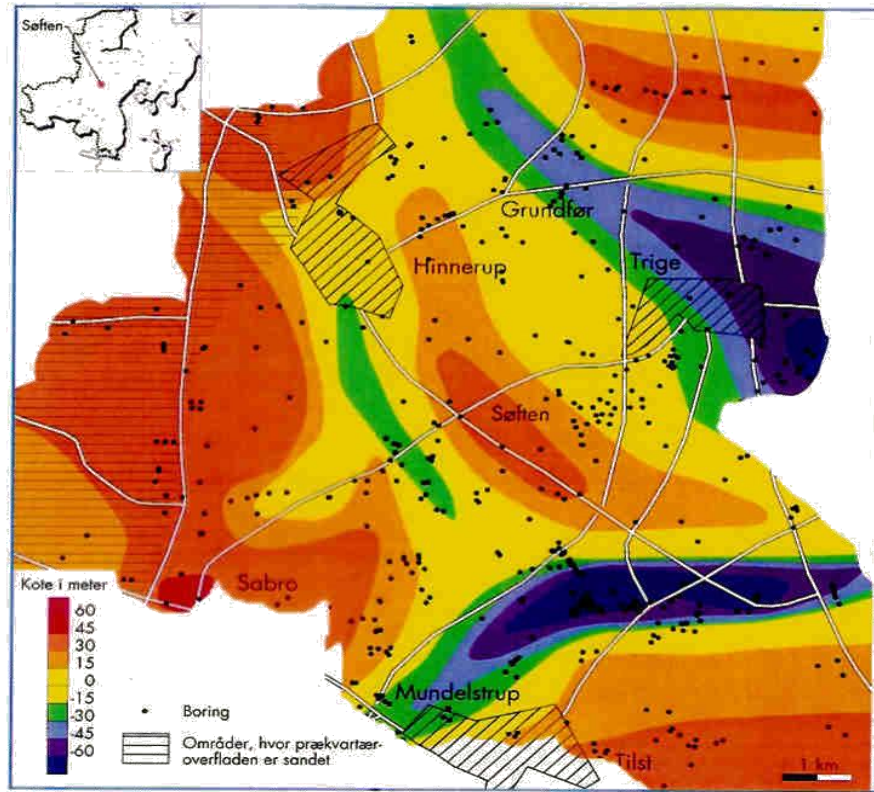
- National groundwater mapping 1999 – 2015
 - Driven by legislation & regulation
 - Delineation of aquifers
 - Vulnerability assessment
 - SGM
-
- Financed by water consumers 8,2 cents/AF
 - Cost: 400-500M USD
 - Result: Action plans (GSPs)



Workflow Best Practices



WE NEEDED MORE DATA TO REDUCE UNCERTAINTIES AND TO MANAGE OUR AQUIFERS

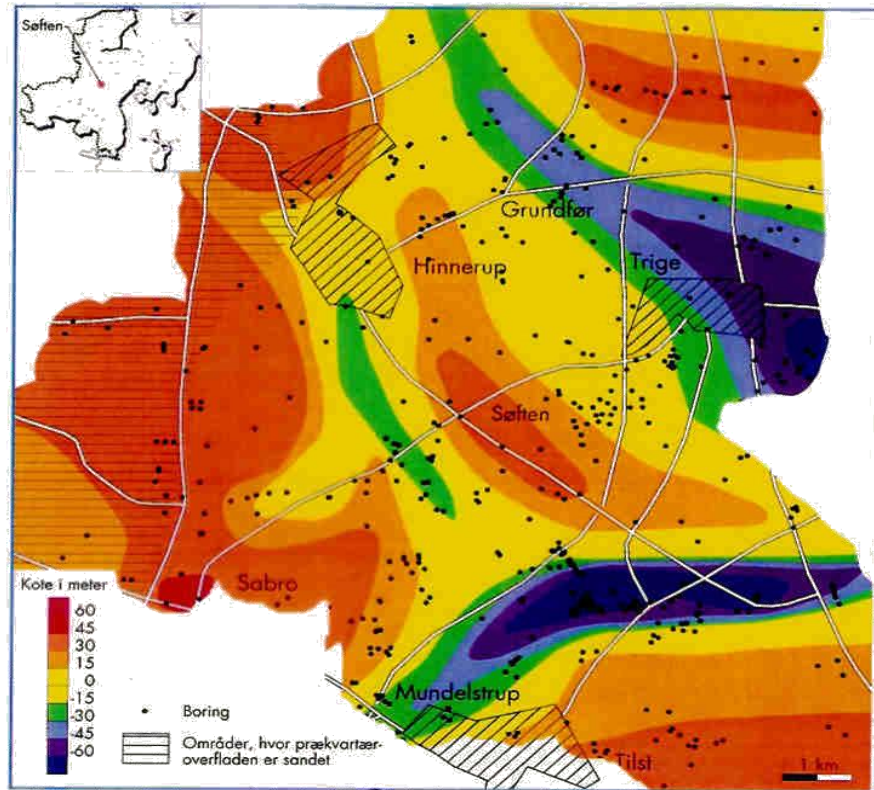


Thomsen et al. 2004

Data

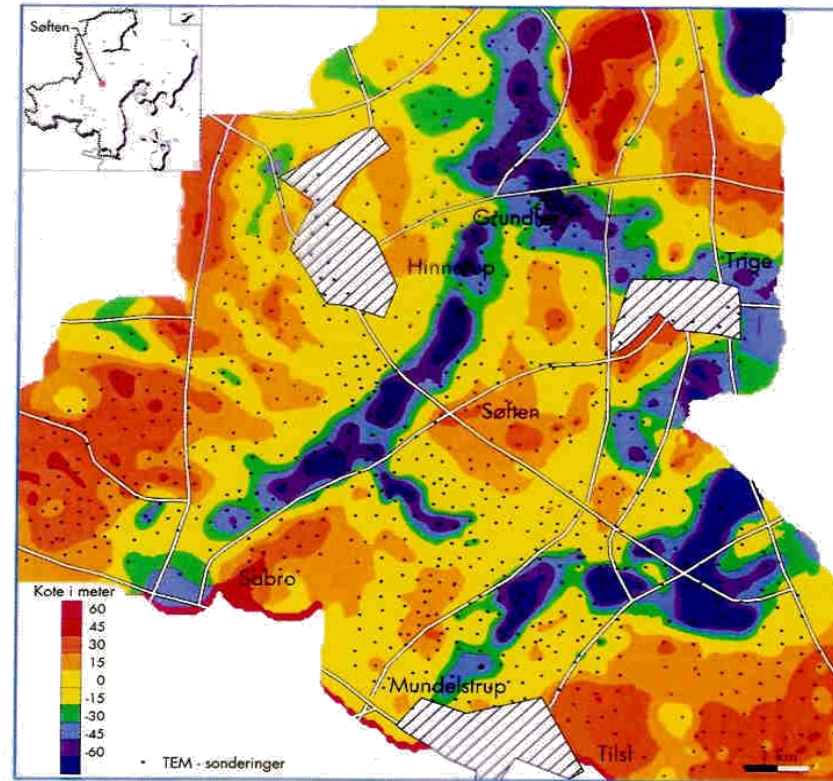
- Information from 518 wells

WE NEEDED MORE DATA TO REDUCE UNCERTAINTIES AND TO MANAGE OUR AQUIFERS



Data

- Information from 518 wells



Data

- Information from 518 wells
- And 1400 TDEM soundings

Thomsen et al. 2004

TAILORED GEOPHYSICAL "TOOLBOX"

PACES



Electric resistivity 0– 90 feet

NMR



Water Content, Permeability 0–360 feet

VARIOUS SEISMIC



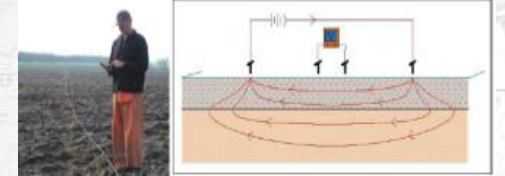
Acoustic velocity 30-3000 feet

DUALEM (GCM)



Electric conductivity 0–30 feet

ERT



Electric resistivity 0–360 ft

TEM



SkyTEM



Electric conductivity 15-1500 feet

WIRE LINE LOGGING



Various tools

AIRBORNE GEOPHYSICAL MAPPING

- Developed specifically for groundwater
- High production rate
- Cost efficient
- High vertical and lateral resolution
- No need to access the ground
- Strong correlation - resistivity to hydrogeology

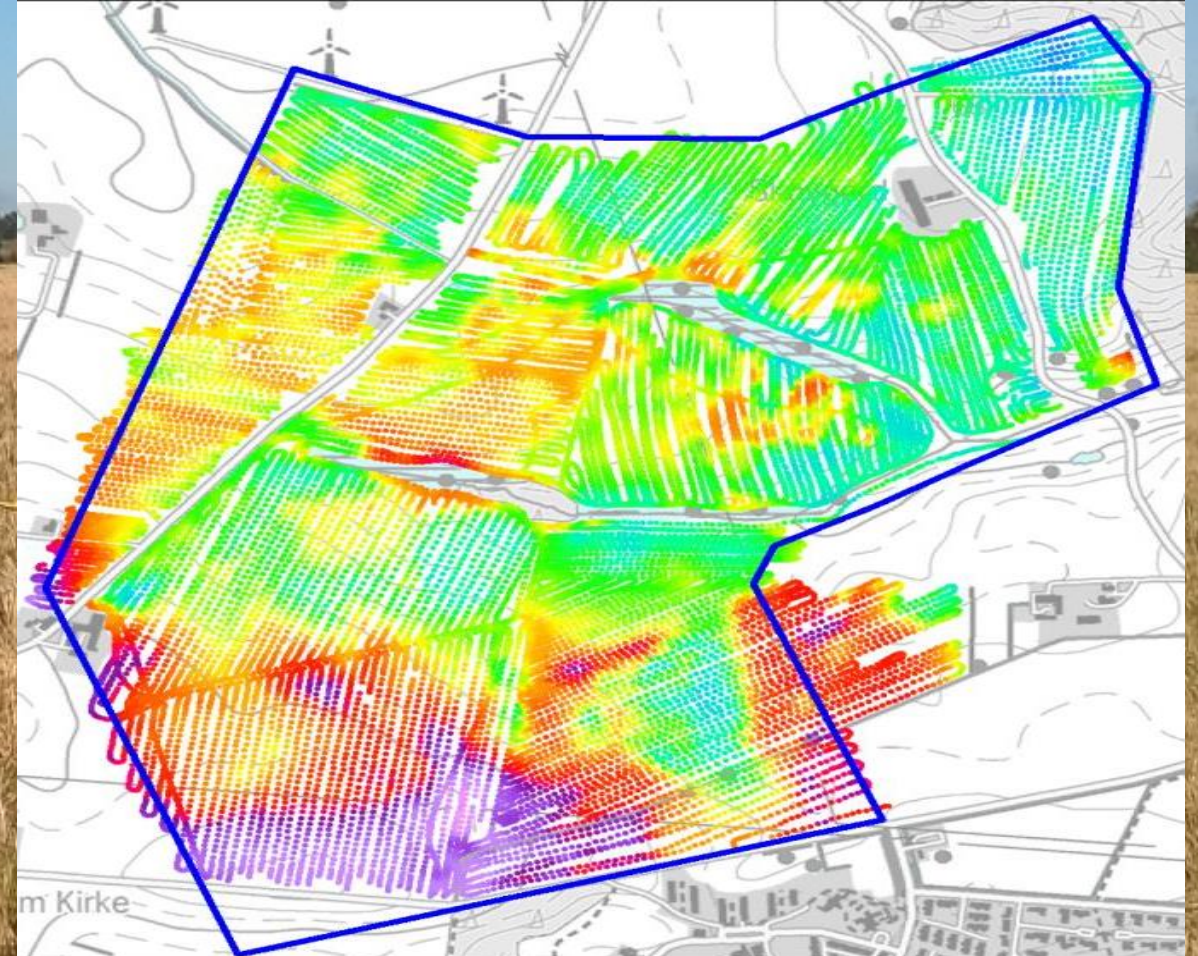


DUALEM WHERE TO INFILTRATE



DUALEM WHERE TO INFILTRATE

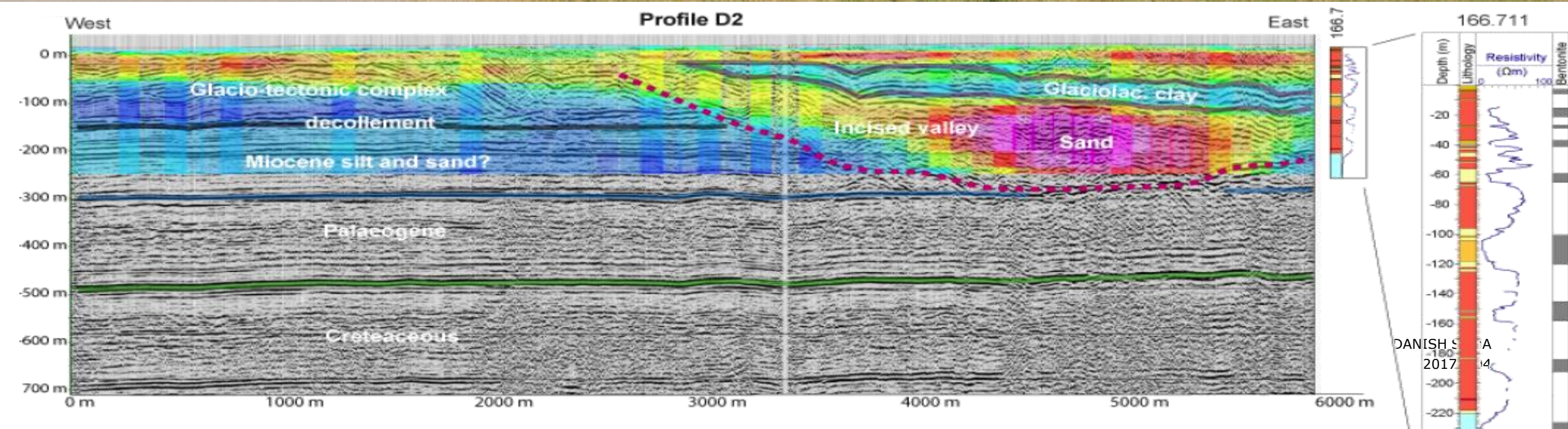
- Ground conductivity meter
- 50mi /day
- Mapping until 30ft



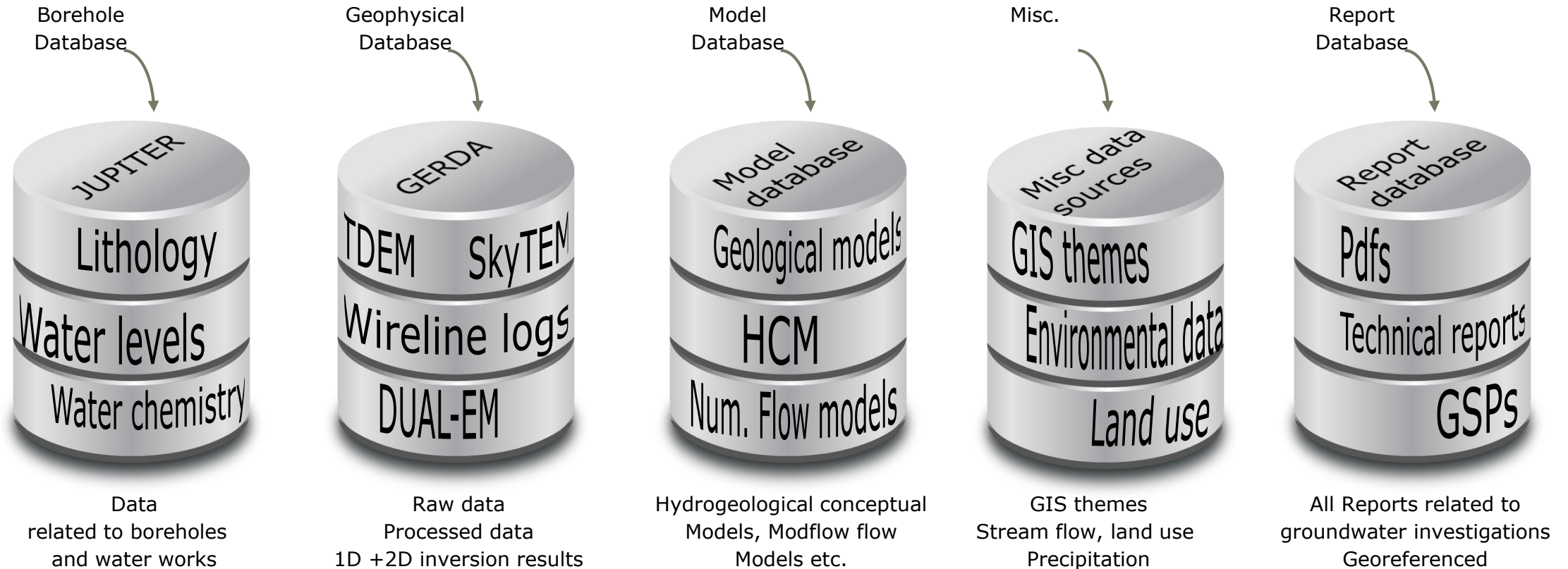
Reflection Seismic – Land streamer vibrosis



- 100-3000ft of depth
- 2mi /day

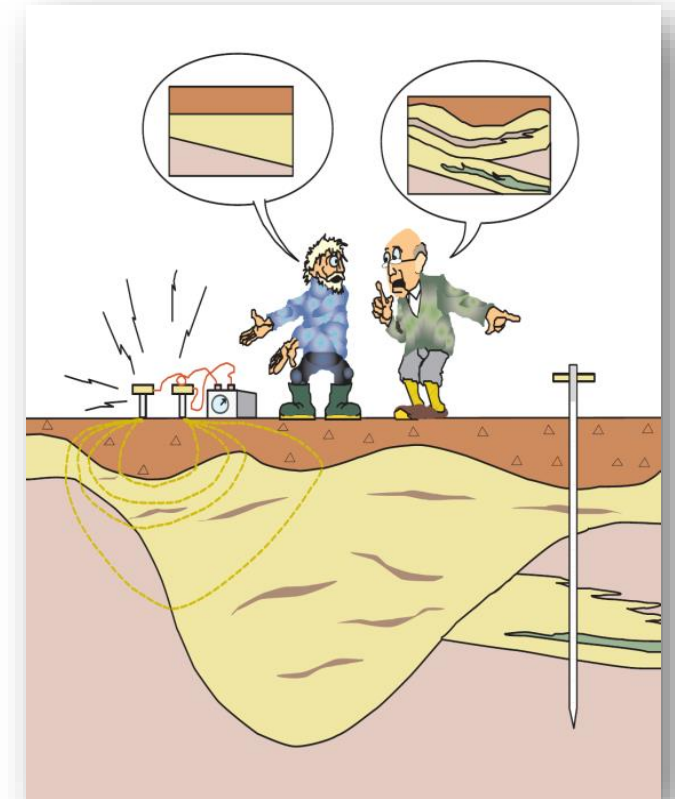
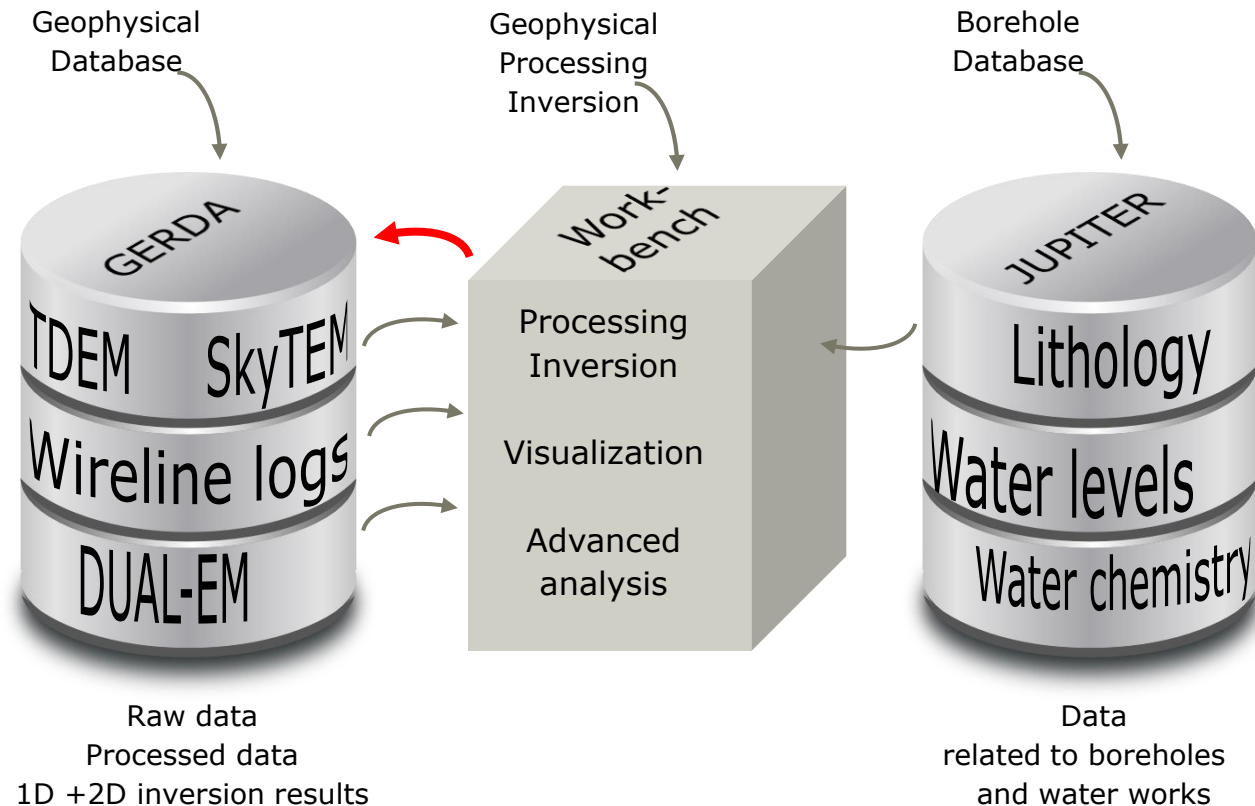


NATIONAL DATABASES

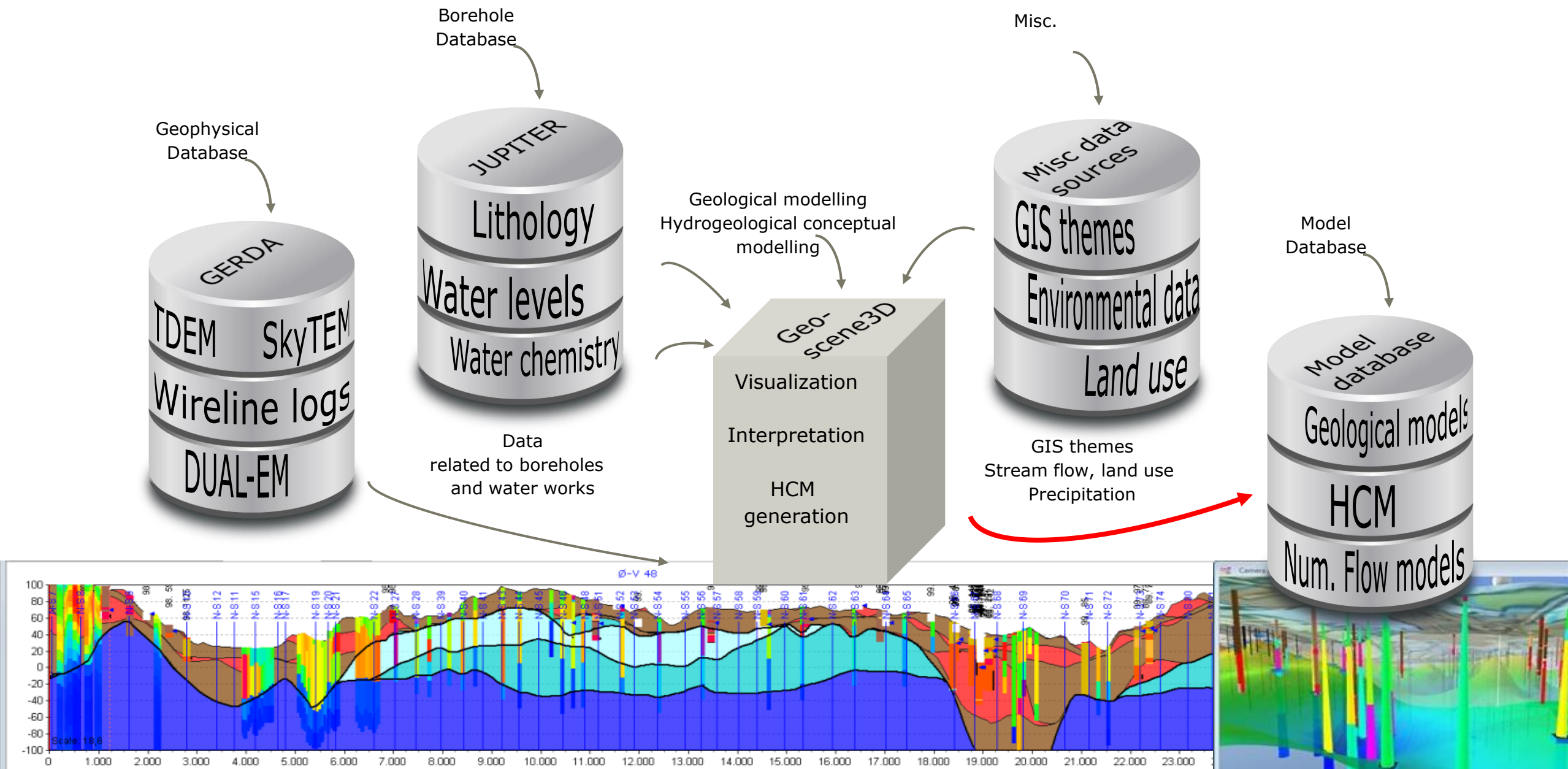


SOFTWARE - WORKBENCH

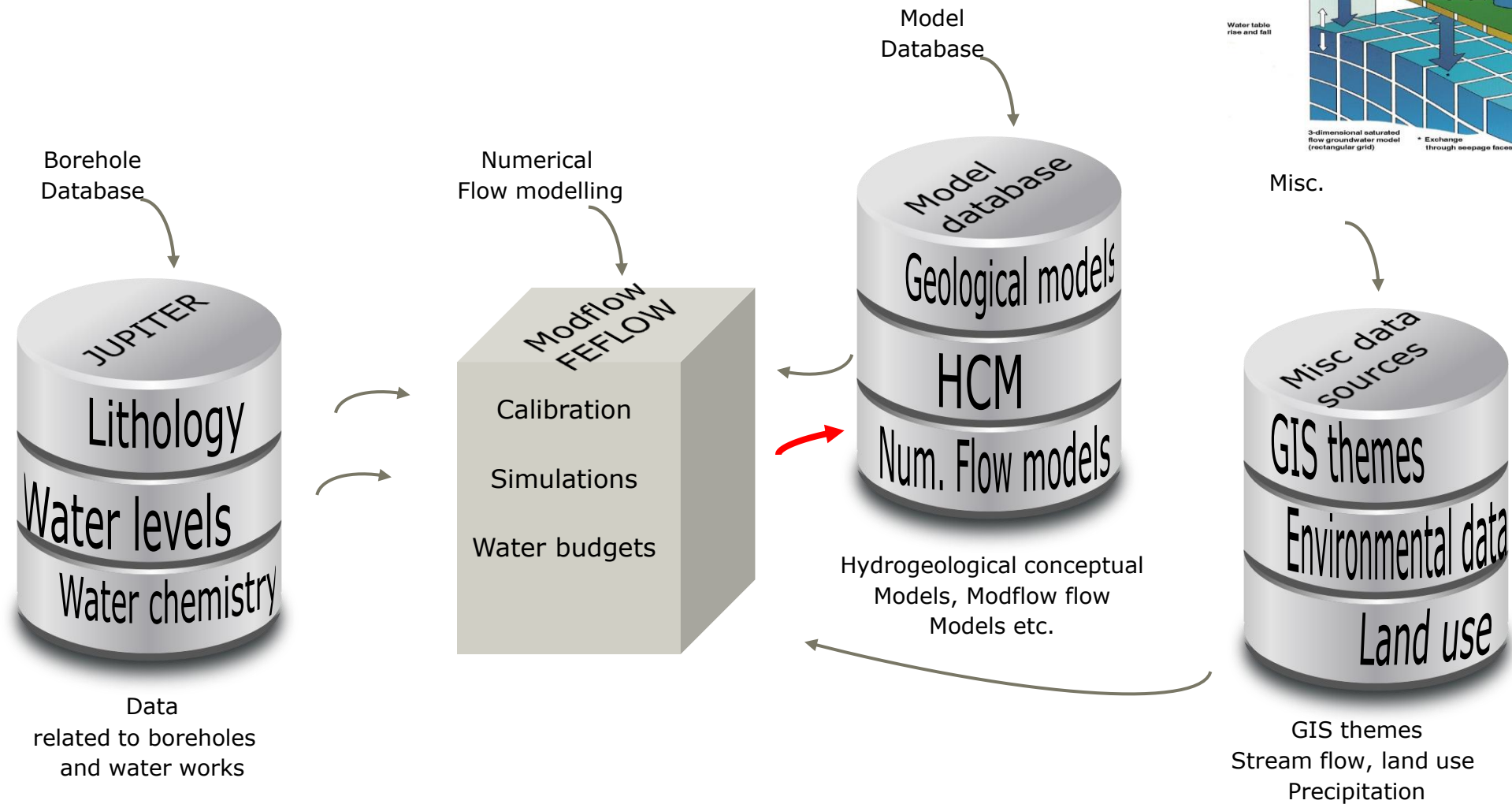
FROM SILO THINKING TO INTEGRATED INTERPRETATION



SOFTWARE - GEOSCENE3D

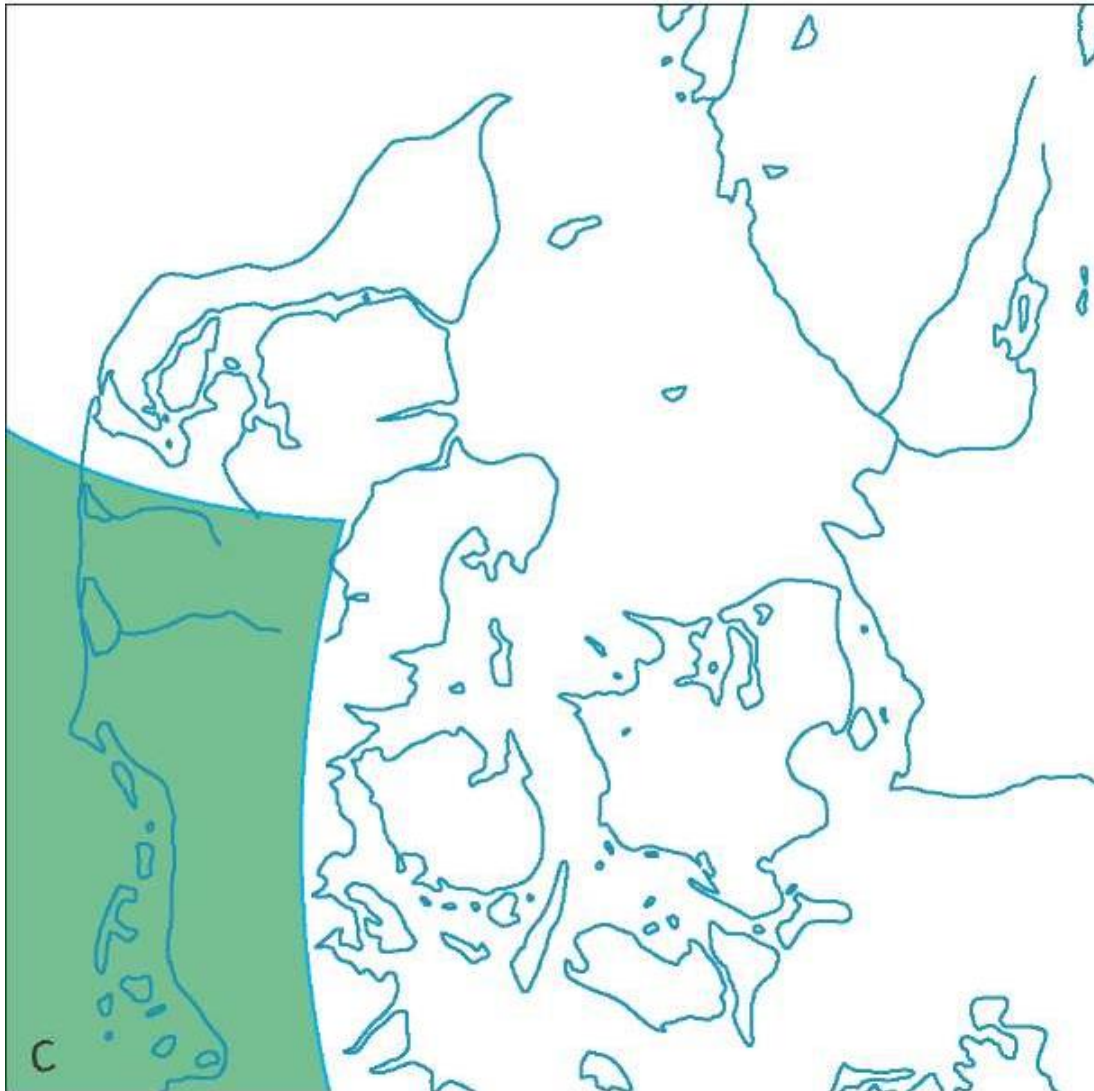


SOFTWARE - NUMERICAL FLOW MODELS



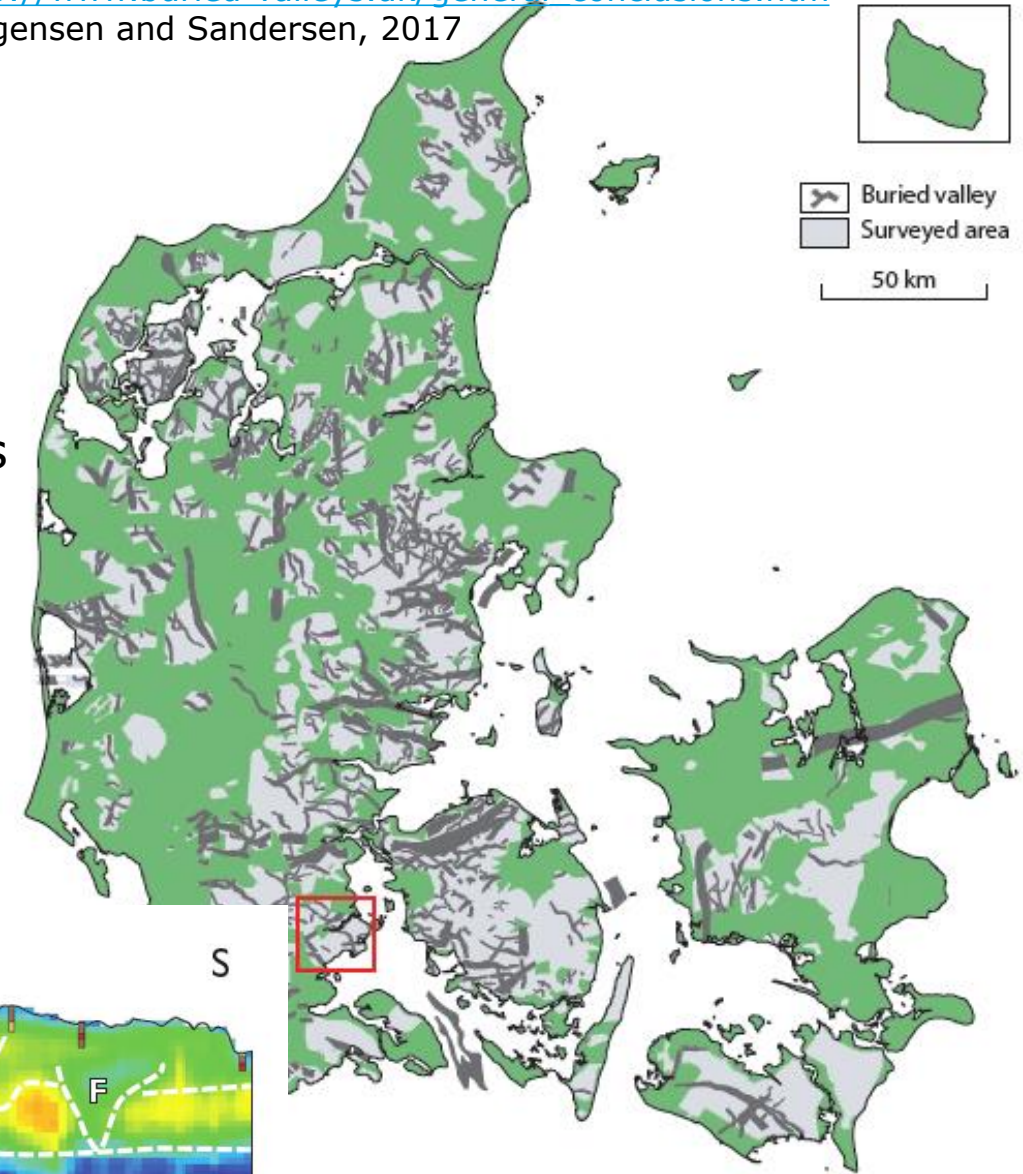
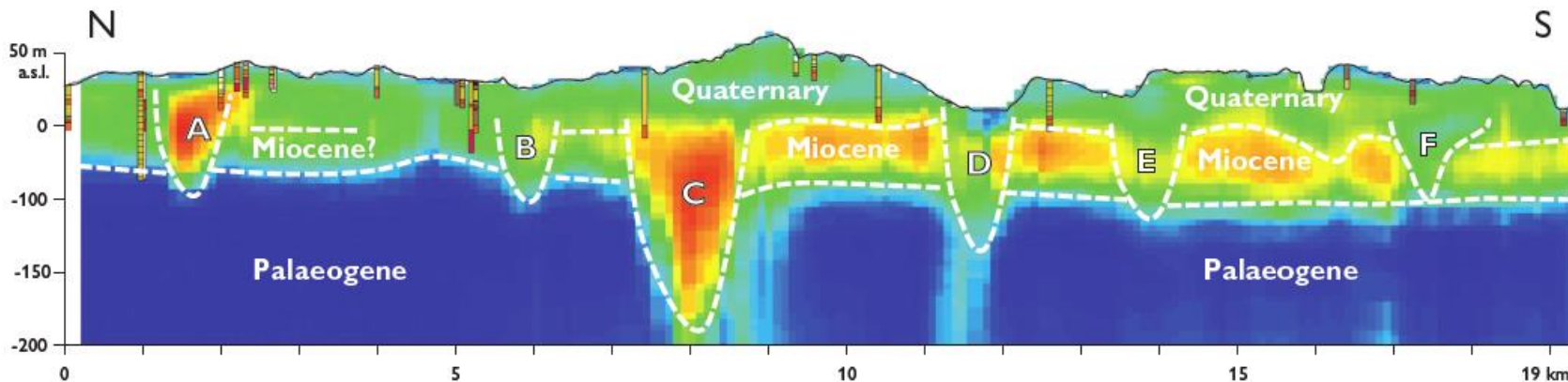
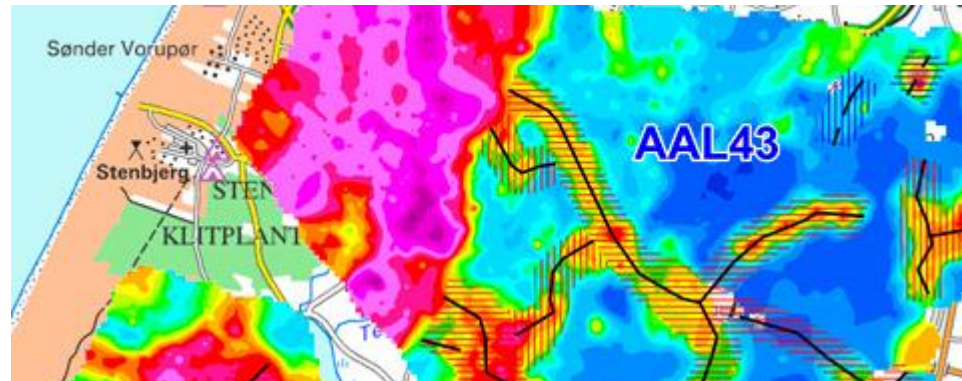
THE LAST ICE AGE IN DENMARK – GEOLOGICAL SETTINGS

Graham Fogg, UC Water, Plenary session



BURIED VALLEYS

- Total length 3,500 mi
- Typically between 75ft and 1200ft deep
- Between 0,3 og 2,2 mi wide
- Infill Quaternary sediments = high yielding aquifers



We need more data to reduce Uncertainties

Best Management Practices to secure the Quality and Seamless maps

Benefits from a national database system

Open formats and free of charge as basis for entrepreneurship (hw and sw)

Save time and money on well organized data

Geophysics is worth the investment

Good geophysical cases can convince most people

Max Halkjaer

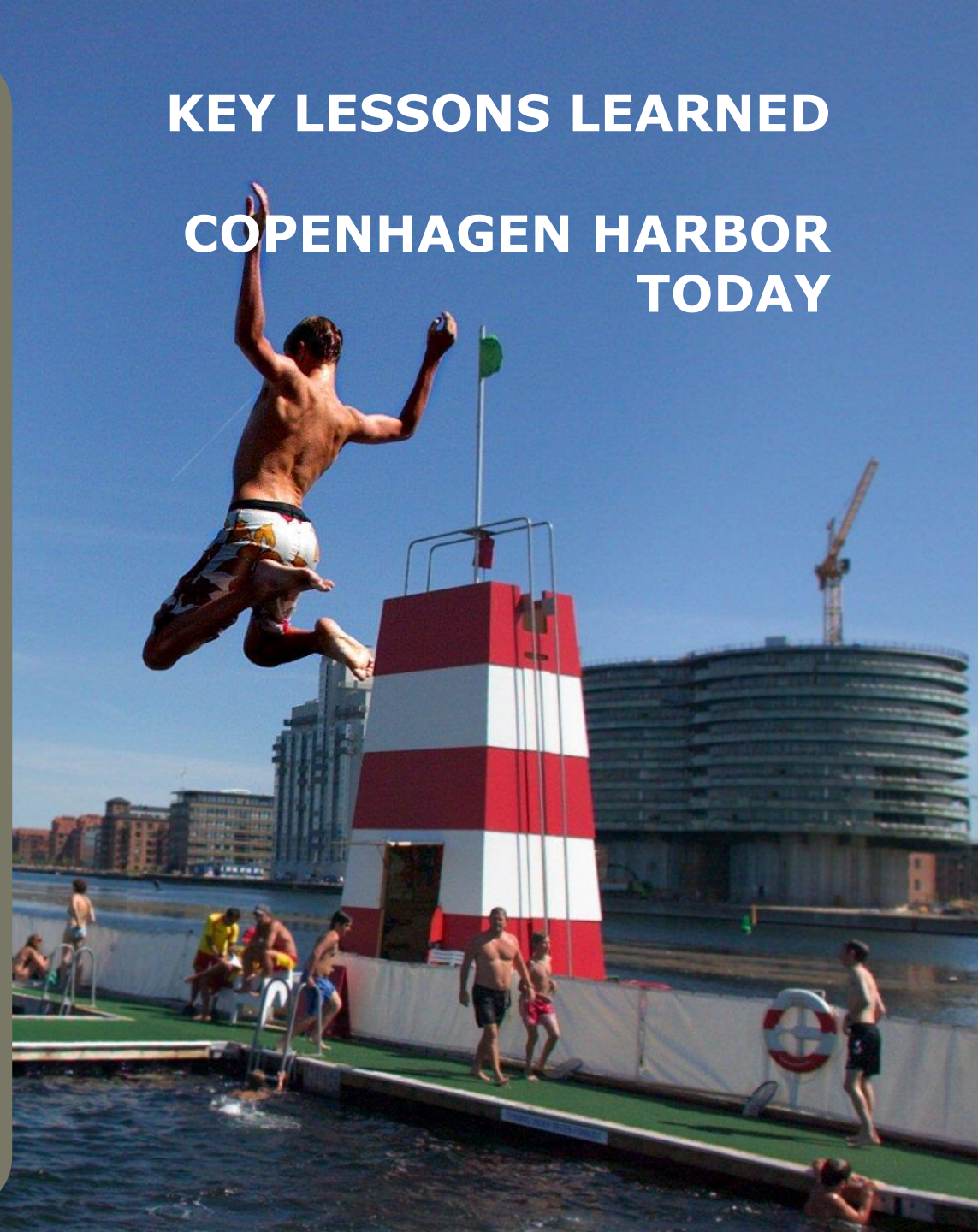
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KEY LESSONS LEARNED

**COPENHAGEN HARBOR
TODAY**



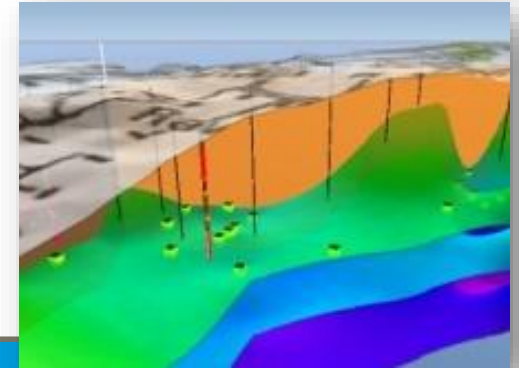
COLLABORATION



Danish EPA
• **Management**
• **Funding**

Municipalities
• **Action plans**
• **Implementation**

Consultants
• **Data**
• **Modelling**
• **GSPs**



Universities
• **Research**
• **Standards**
• **Candidates**

GEUS - Geological survey
• **Standards**
• **Databases**

