Maps of shallow geothermal potential

Project TransGeoTherm & other examples

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www.pgi.gov.pl

COST – GABI workshop, Lisbon
10.12.2015

Why we need maps of shallow geothermal potential ?

- The aim of producing geothermal maps is to provide cartographic image for a certain area, showing thermal properties of bedrocks
- Geothermal maps are used for evaluation of location suitability: opportunities as well as barriers and restrictions in developing shallow geothermal energy systems, especially <u>ground source heat pumps (GSHP)</u>
- Geothermal maps may serve as a decision making or auditing tool, which allow proper assessment of renewable energy sources at local and regional scale
- Geothermal maps can be used by local authorities, planners as well as business sector (producers and installers of GSHP) and individual investors

Basic types of shallow geothermal potential maps

TYPE 1

- general maps based on reprocessed geological and hydrogeological data indicating qualitative / descriptive categorizing of subsurface rocks

- Type 1 qualitative maps may present:

    - terrain with perfect / good / poor or bad rock properties and showing places with existing restrictions or exclusions considering use of GSHP,

    - terrains suitable for installation of different type of GSHP, eg. for „open" (water/water) systems, and „closed" systems (glycol/water) with differentiation into „horizontal collectors" and „vertical probes / heat exchangers"

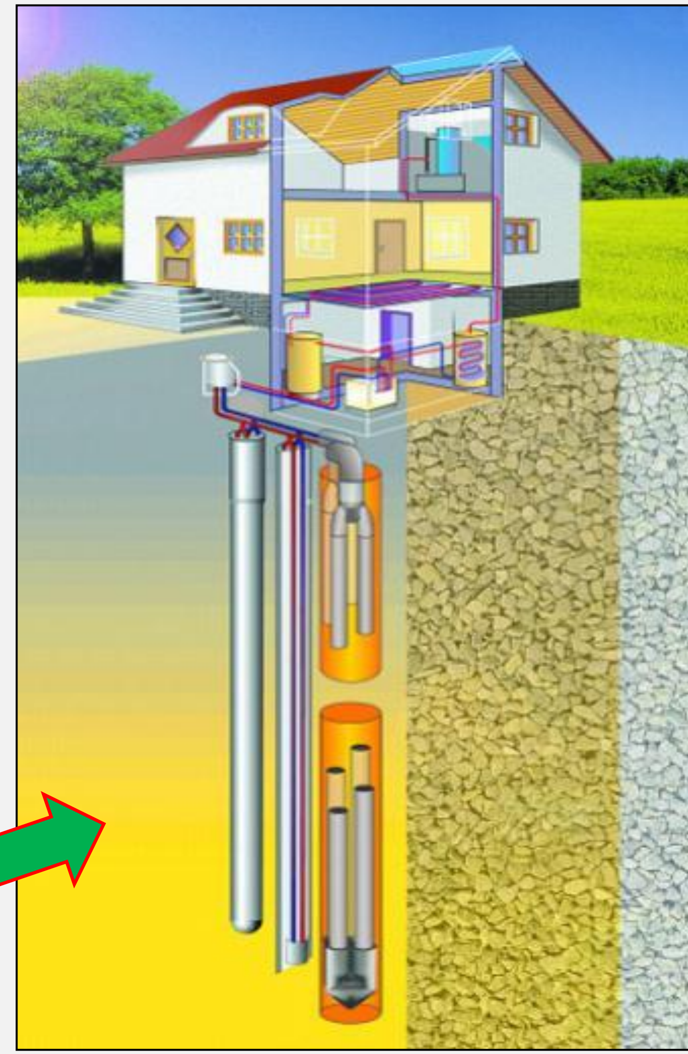
Basic types of shallow geothermal potential maps

TYPE 2

- detailed maps of geothermal potential, presenting quantitative estimation of the thermal parameters of rocks, usually to a max. depth of c. 130 m
- the maps allow planning the amount of power and technical requirements of the GSHP, especially for the pumps with vertical heat exchanger
- TYPE 2 quantitative maps can be divided into:
  - **maps based on the value of thermal conductivity of rocks expressed in W / m*K**
  - **maps based on the value of heat extraction rate expressed in W / m**
  - **maps based on the value of thermal power expressed in kWh / m**

Why we need shallow geothermal energy:

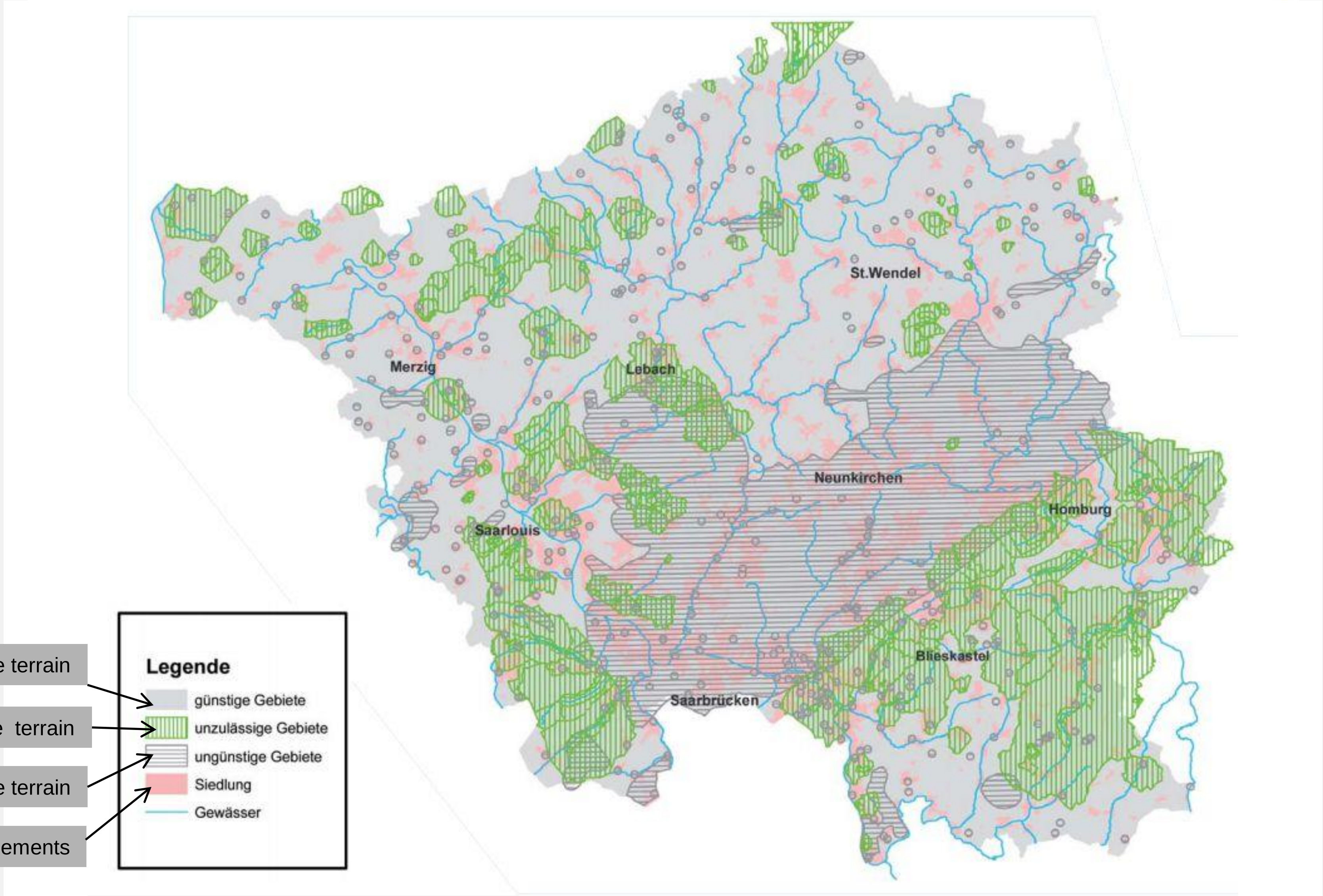
because in numerous part of Europe the air is very polluted by smog emitted from individual heating installations using coal !!!



We can clean the air
when old heating systems
are replaced by renewable energy sources like
GROUND SOURCE HEAT PUMPS

Examples of TYPE 1 qualitative geothermal maps

Land Saar: simplified map showing site assessment for installation of GSHP without specified conditions of classification



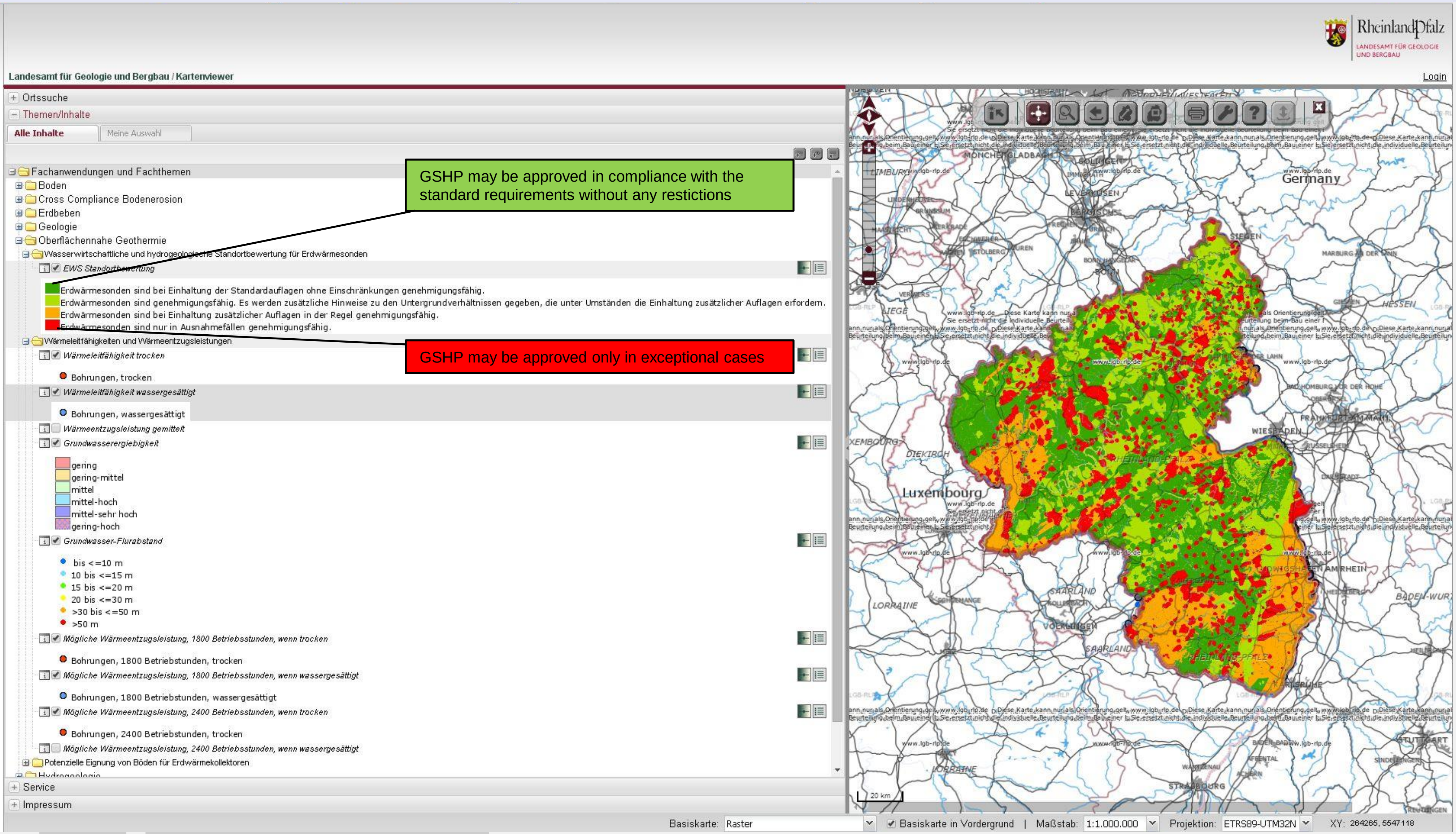
favorable terrain

inadmissible terrain

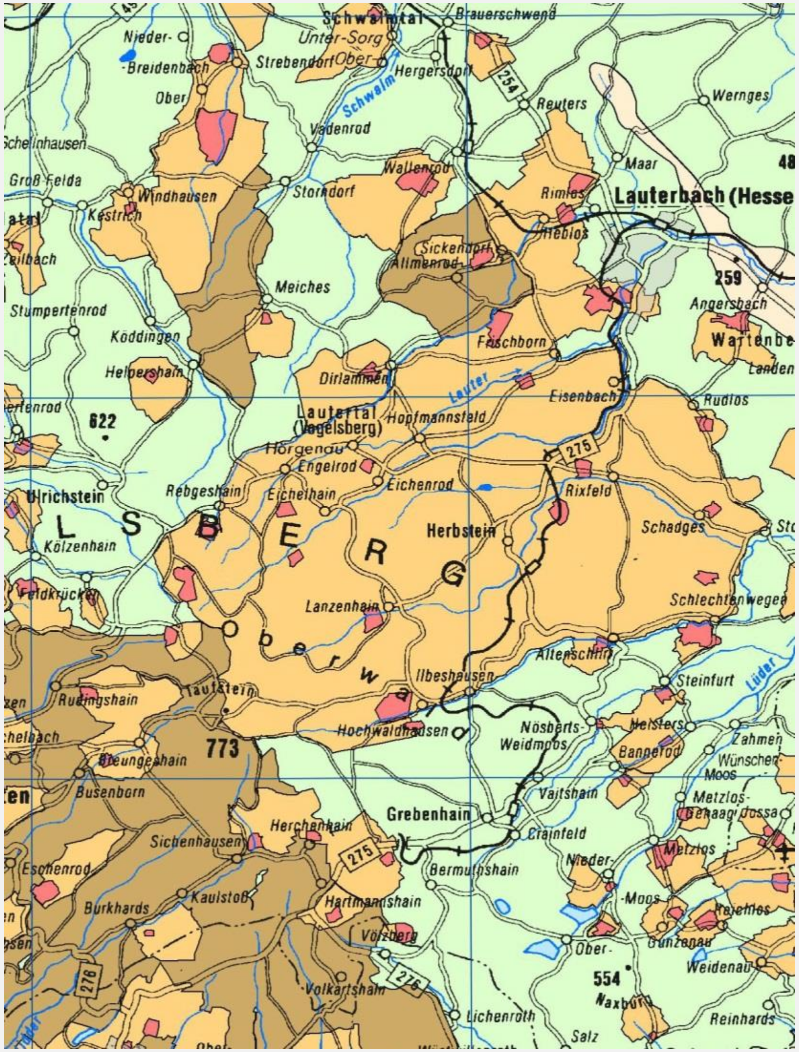
adverse terrain

settlements

Land RheinePfalz: map of site assessment for installation of GSHP with specified legal requirements and hydrogeological conditions



Land Hessen: Map of site assessment for installation of GSHP based on hydrogeology and water management conditions



Hessisches Landesamt für Umwelt und Geologie

HESSEN

Hydrogeologische und wasserwirtschaftliche Standortbeurteilung für die Errichtung von Erdwärmesonden in Hessen

1 : 200 000

Standortbeurteilung für die Errichtung von Erdwärmesonden in Hessen

(Bearbeitungsstand: 08. März 2012)

Bearbeitung: Dezernat W4 - Hydrogeologie, Grundwasser
Ansprechpartner: Dr. Sven Rumohr

favorable

Hydrogeologisch und wasserwirtschaftlich günstig
Gebiete mit mittlerer bis geringer Wasserdurchlässigkeit, ohne eine wesentliche Stockwerkstrennung und ohne Vorkommen von höher mineralisierten Grundwässern bzw. CO_2-Aufstiegszonen bei gleichzeitiger Lage außerhalb von Wasser- und Heilquellenschutzgebieten.

Hydrogeologisch ungünstig
Gebiete mit nennenswerten Grundwasser-, Mineralwasser- oder Heilwasservorkommen, die durch eine Grundwasserüberdeckung geschützt werden. Ungünstig sind auch Gebiete mit hoher Wasserdurchlässigkeit der Gesteine, einer wesentlichen, d.h. weiträumigen Stockwerkstrennung, mit Aufstiegszonen von CO_2 oder hoch mineralisierten Wässer oder mit artesisch gespannten Grundwasservorkommen sowie Tiefengrundwasserleiter (insbesondere im Festgestein), die nicht angefahren oder durchteuft werden sollten. Ungünstig sind zudem Gebiete mit quellfähigen Gesteinen, wie Anhydrit und bestimmten Tonen.

relevant

Wasserwirtschaftlich relevant (siehe Wichtiger Hinweis)
Gebiete in den Zonen WSG IIIB und HQSG III/2.

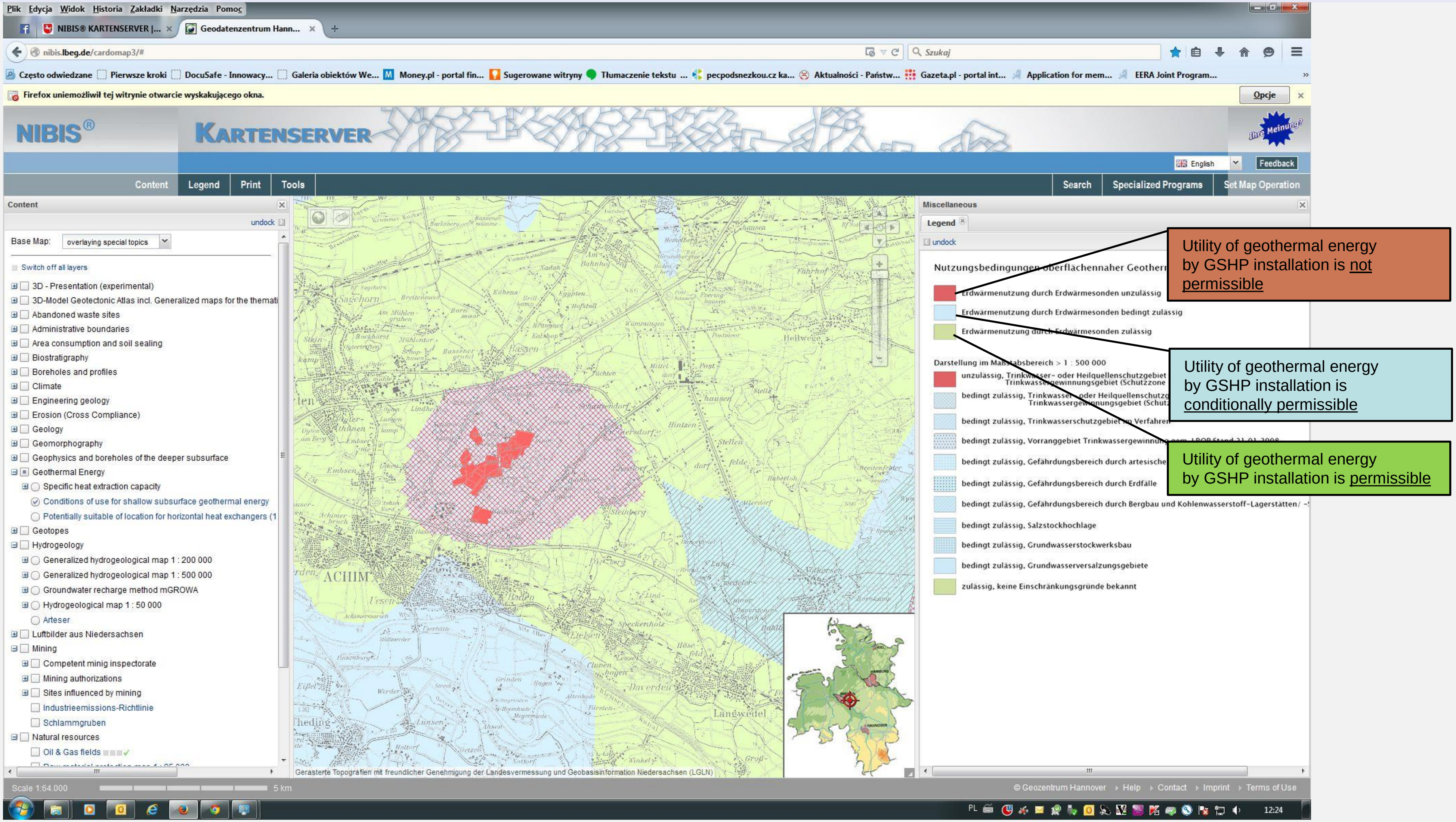
Wasserwirtschaftlich ungünstig (siehe Wichtiger Hinweis)
Gebiete in den Zonen WSG III und IIIA sowie HQSG III, III/1 und B.

Hydrogeologisch unzulässig
Gebiete, in denen aufgrund ungünstiger hydrogeologischer Gegebenheiten (s. o.) und nach bereits erfolgten Einzelfallprüfungen davon ausgegangen wird, dass die Errichtung von Erdwärmesonden in jedem Fall zu einer schädlichen Beeinflussung des Grundwassers führt.

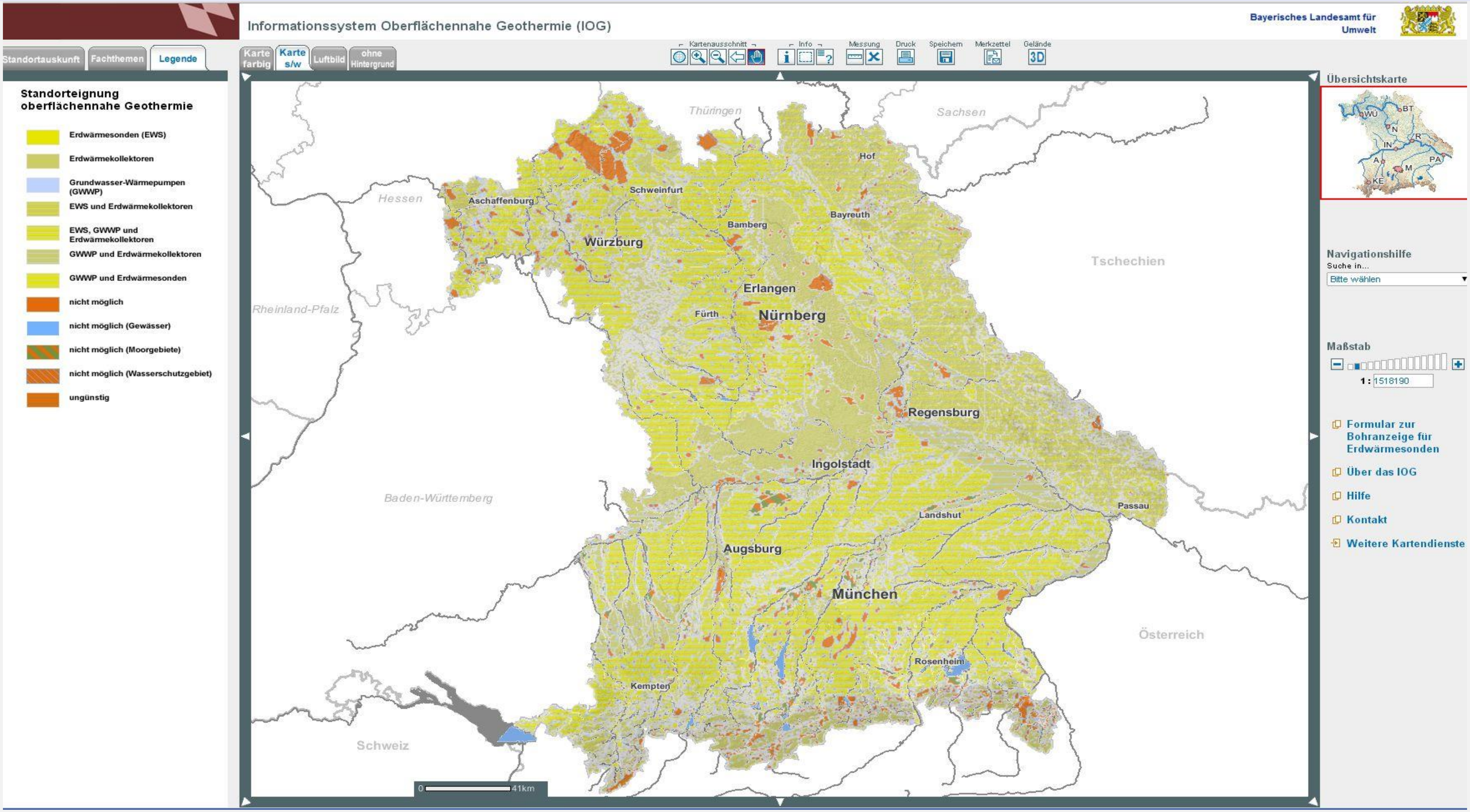
Wasserwirtschaftlich unzulässig
Gebiete in den Zonen WSG I, II und vereinzelt IIIA sowie HQSG I, II und A.

inadmissible

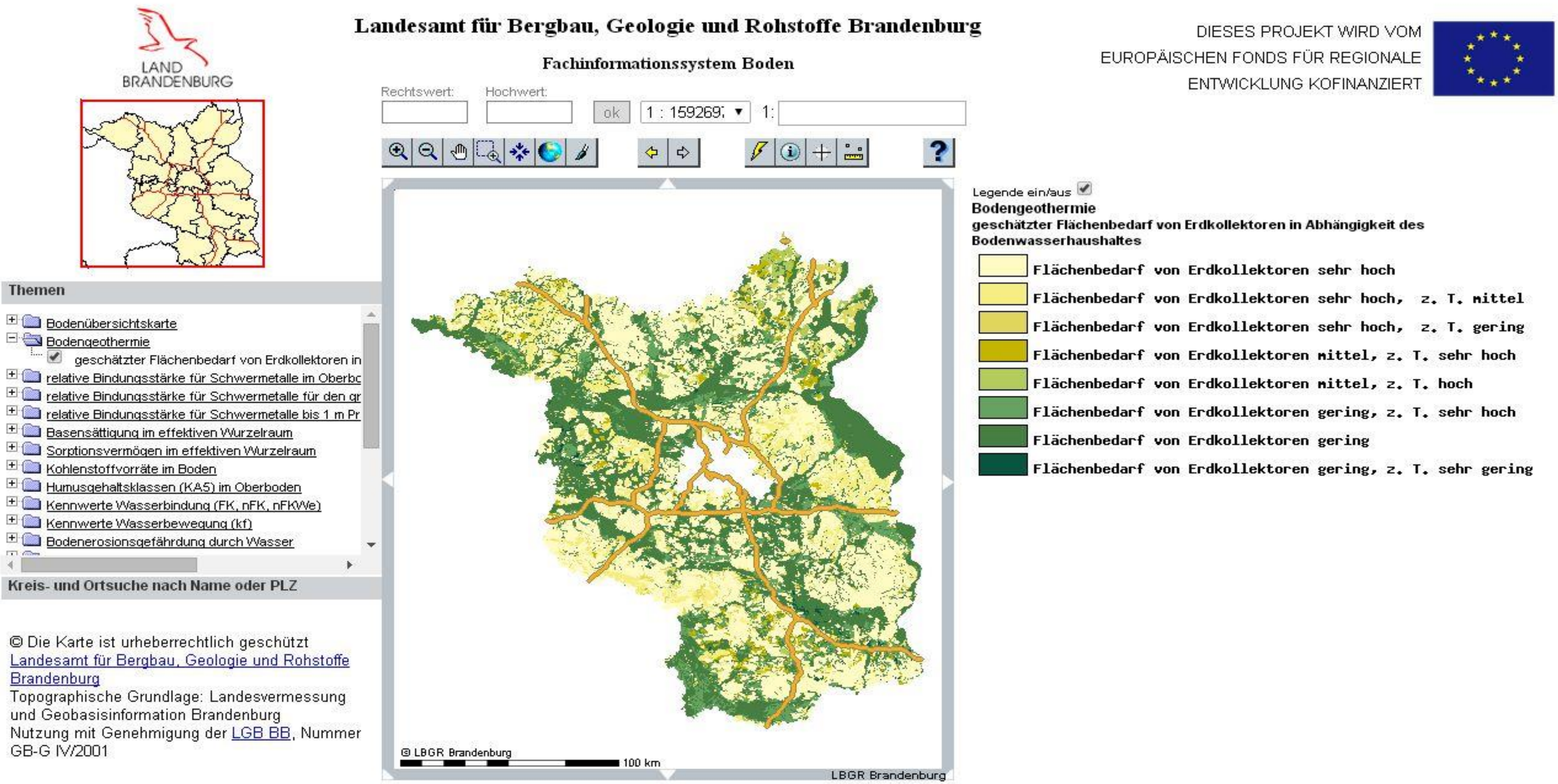
Land Lower Saxony: map of site assessment for installation of GSHP based on hydrogeology and water management conditions



Land Bavaria: Map of location suitability for installation of different systems of GSHP based on geology, hydrogeology and water management conditions

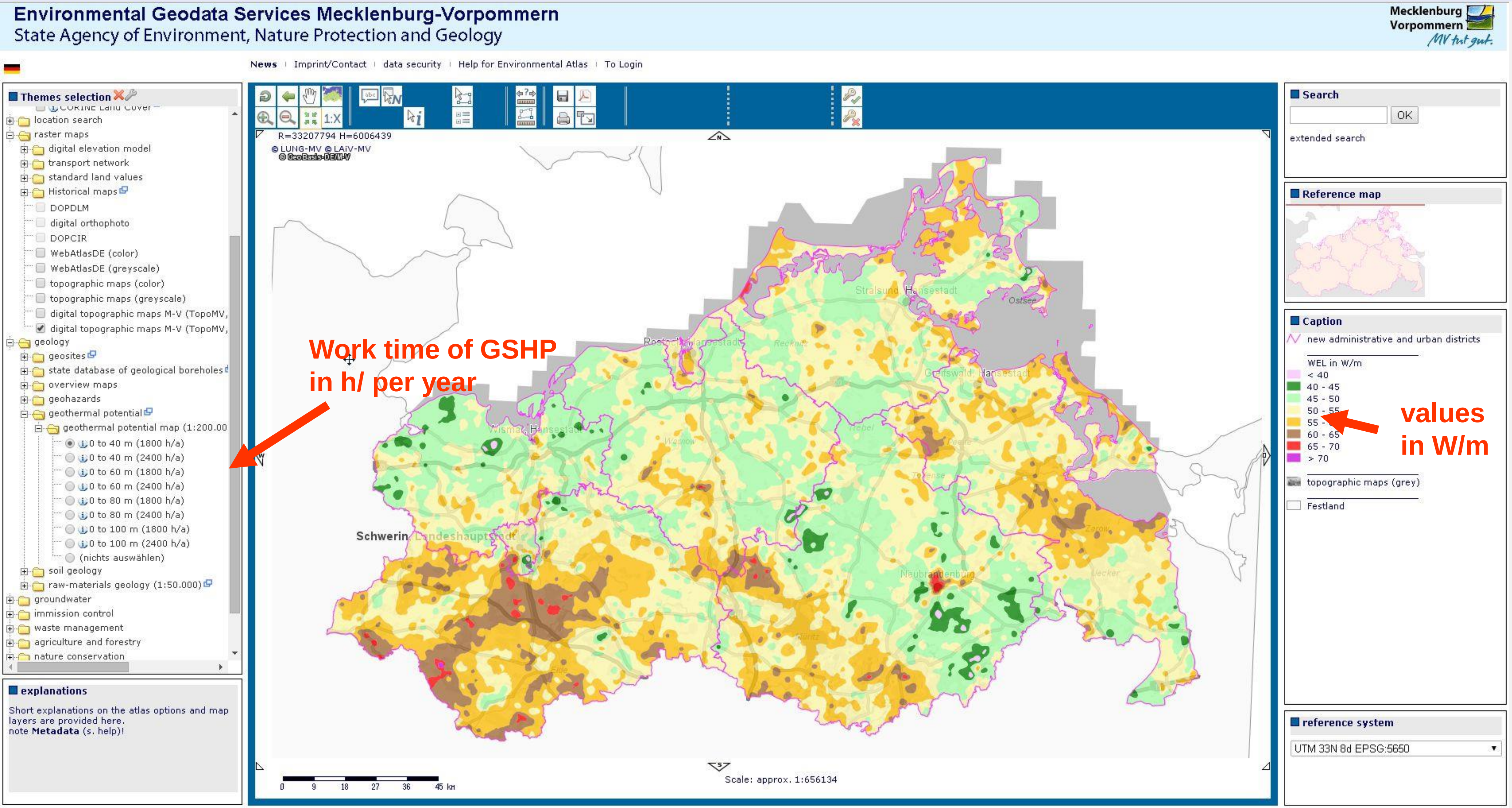


Land Brandenburg: map of site assessment for installation of GSHP with horizontal collectors based on hydrogeology and geothermal conditions of soil



Examples of TYPE 2 quantitative geothermal maps

Land Mecklenburg-Vorpommern: map of geothermal potential based on geological 3D model and calculated values of heat extraction rate [W/m], for depths of 40, 60, 80 and 100m; for 1800 and 2400 h per year of GSHP work time

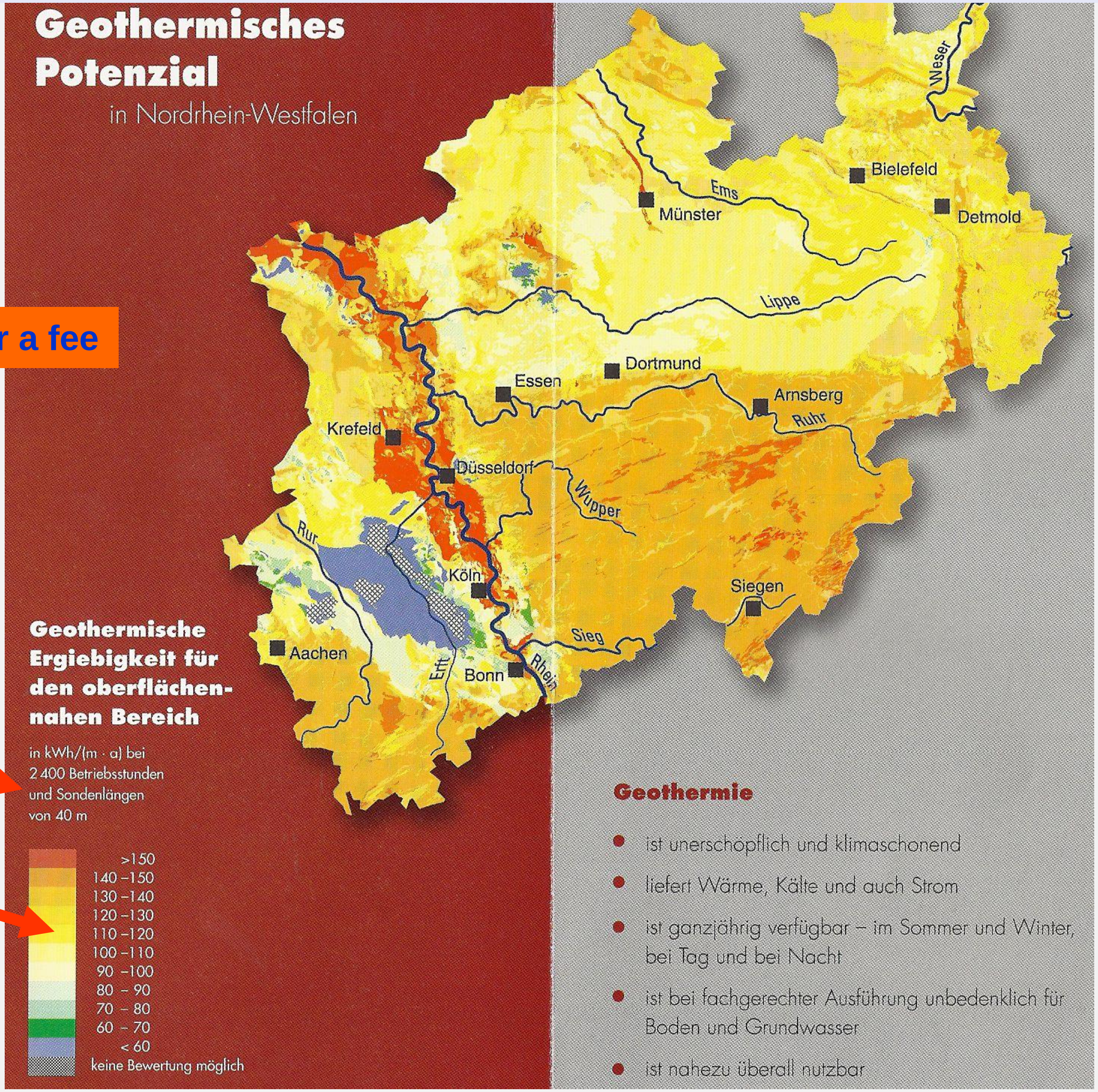


Land Rhine - North Westfalia: map of geothermal potential based on geological 3D model and calculated values of power extraction rate [kWh/m], for depths of 40, 60, 80 and 100m; for 1800 or 2400 h per year of GSHP work time

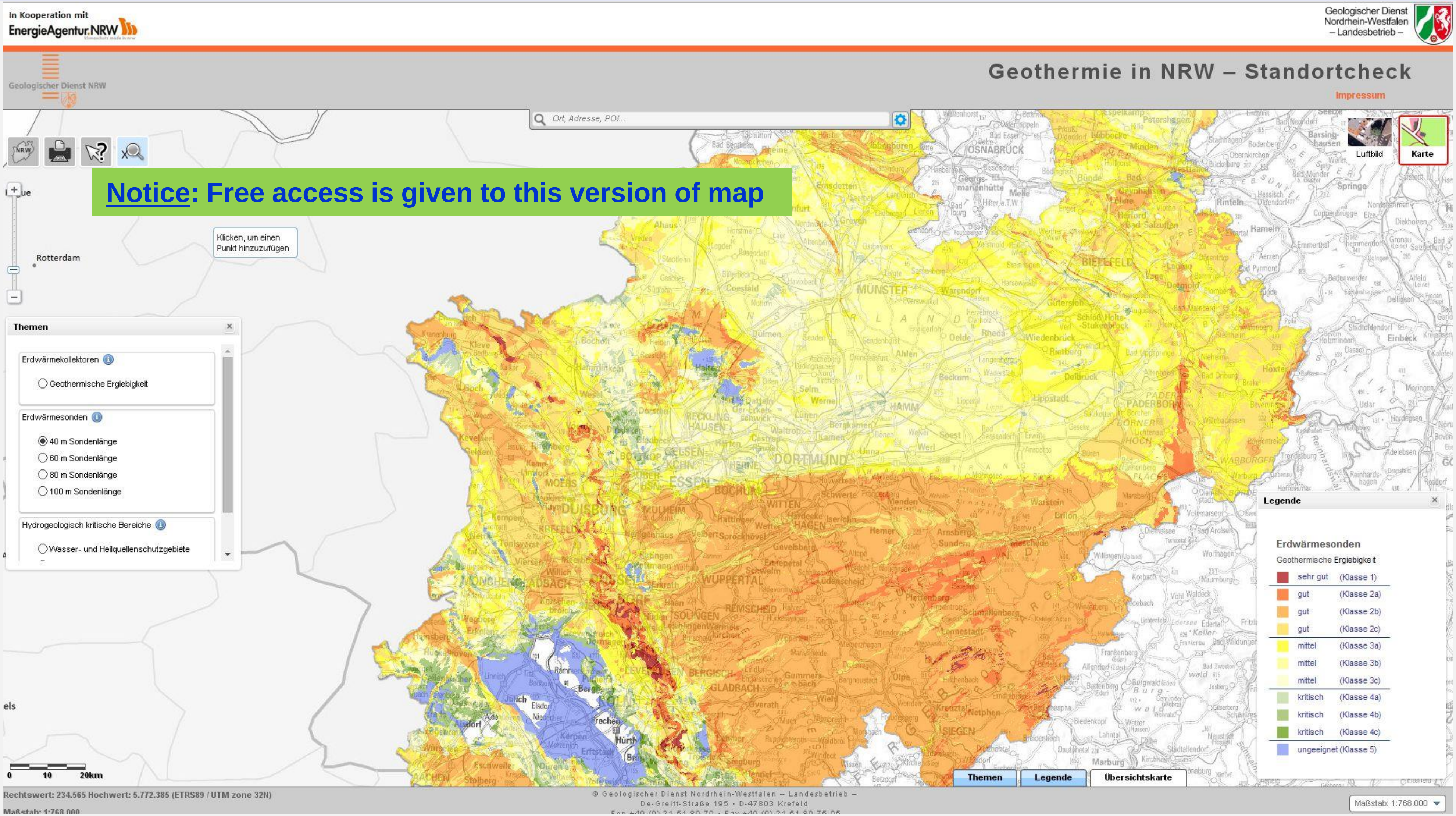
Notice: This version of map is available for a fee

Depth: 0-40 m
Work time of GSHP: 2400 h/a

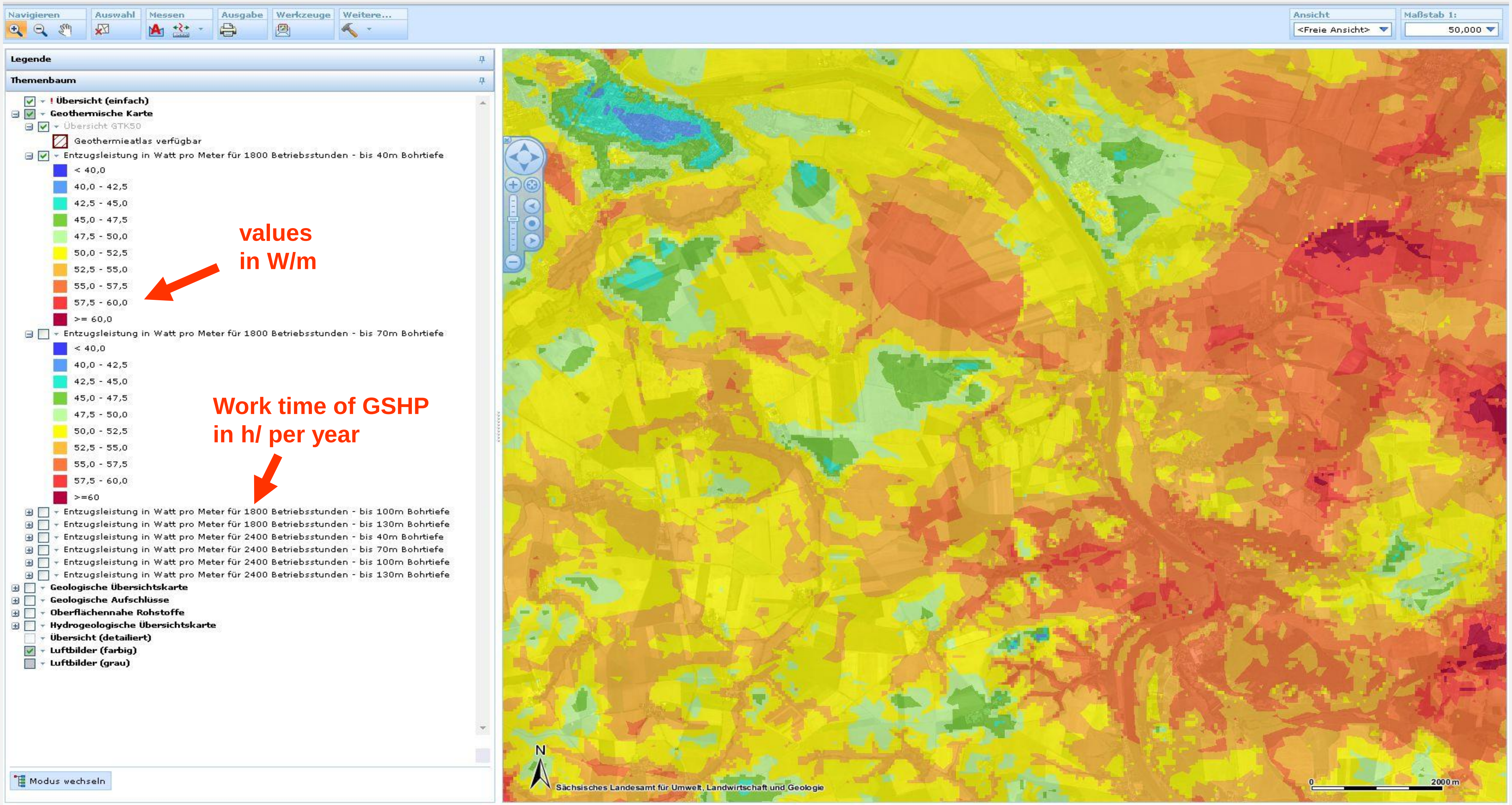
Values in kilowatt-hour kW/m



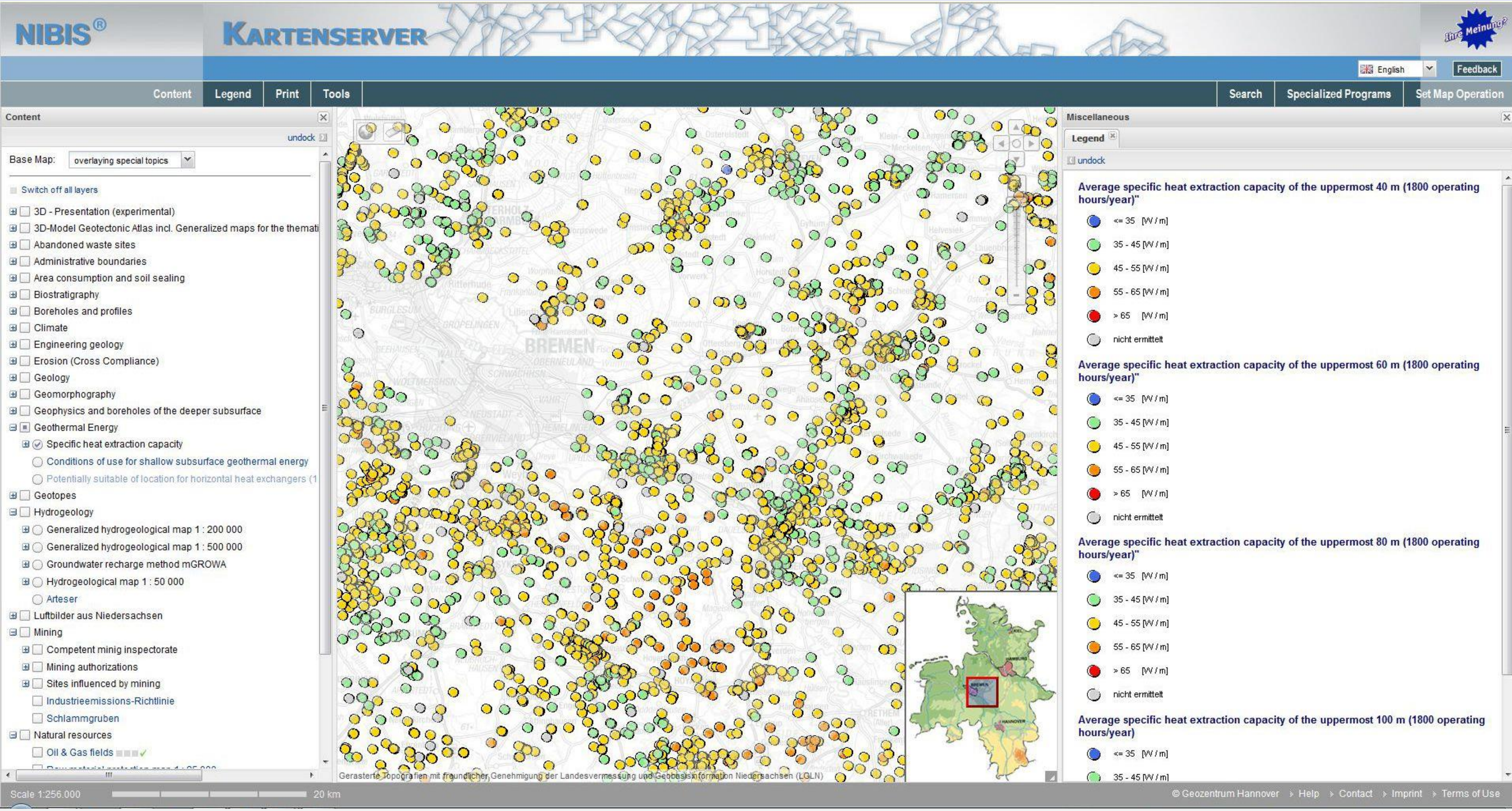
Land Rhine-North Westfalia: Map of site assessment for installation of GSHP based on thermal properties of rocks shown as classes (not real values)



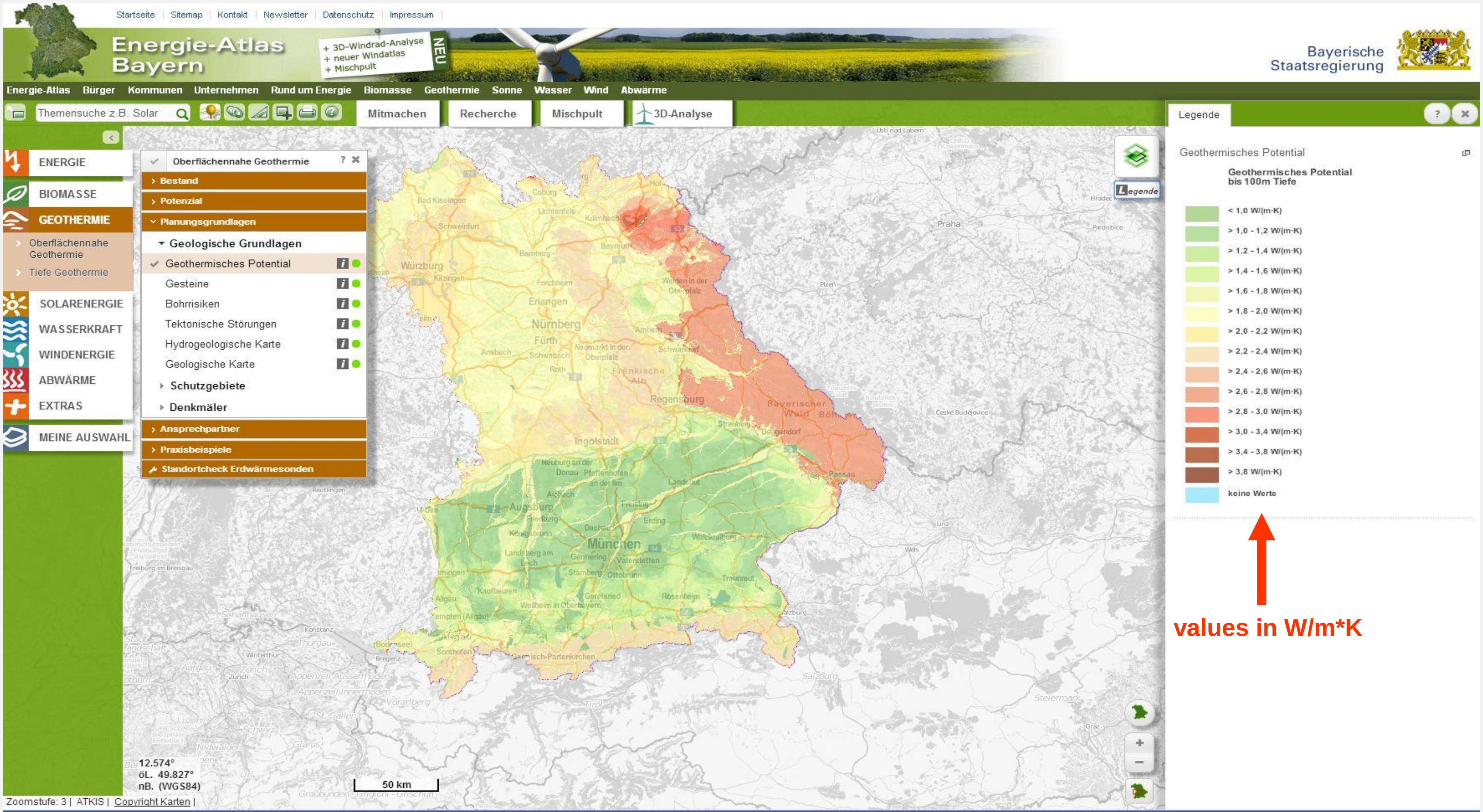
Land Saxony: map of geothermal potential based on geological 3D model and calculated values on heat extraction rate [W/m], for depths of 40, 70, 100 and 130m; 1800 and 2400 h per year of GSHP work time



Land Lower Saxony: map of geothermal potential based on geological data from boreholes and calculated values on heat extraction rate [W/m], for depths of 40, 60, 80 and 100m; 1800 h per year of GSHP work time



Land Bawaria: map of geothermal potential based on geological 3D model and calculated values of thermal conductivity of rocks [W/m*K], for depth of 100m



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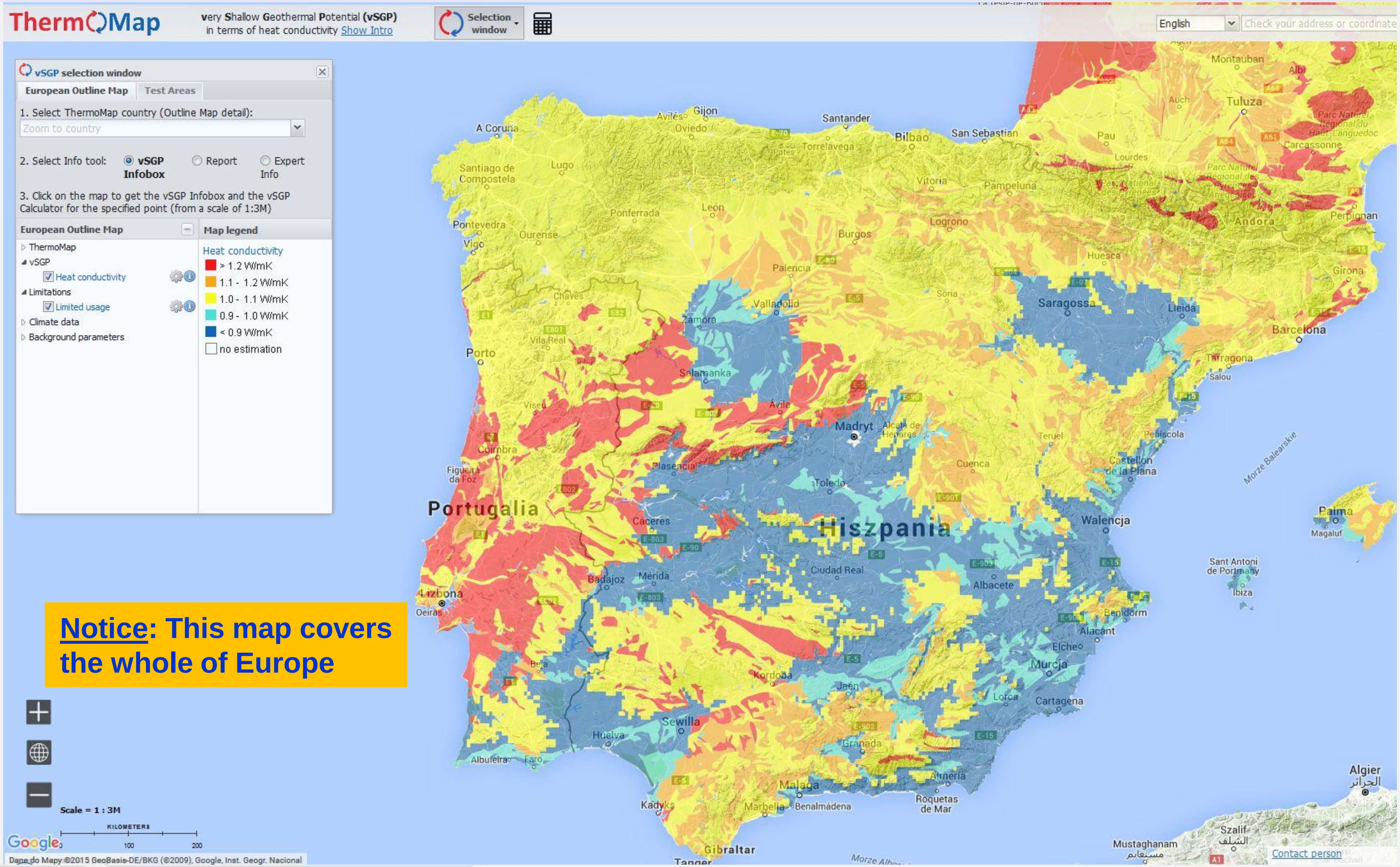
ThermoMap project: map for estimation of the very Shallow Geothermal Potential (vSGP) in terms of heat conductivity [W/m*K], of unconsolidated underground up to 10m



<u>Notice</u>: This map covers the whole of Europe

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Qualitative geothermal maps – Project Transgeotherm

Unia Europejska. Europejski Fundusz Rozwoju Regionalnego: Inwestujemy w waszą przyszłość/ Europäische Union. Europäischer Fonds für regionale Entwicklung: Investition in Ihre Zukunft

Title: TransGeoTherm – Geothermal energy for transboundary development of the Neisse region. Pilot project

Co-operation of two partners:

Lead partner: Polish Geological Institute – National Research Institute, Lower Silesian Branch:

Wiesław Kozdrój, Maciej Kłonowski, Adam Mydłowski, Urszula Domańska, Małgorzata Ziółkowska-Kozdrój, Janusz Badura, Bogusław Przybylski, Dorota Russ, Karol Zawistowski, Paweł Karamański, Dariusz Czerski

Project partner: Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie, Abteilung Geologie:

LANDESAMT FÜR UMWELT, LANDWIRTSCHAFT UND GEOLOGIE | Freistaat SACHSEN

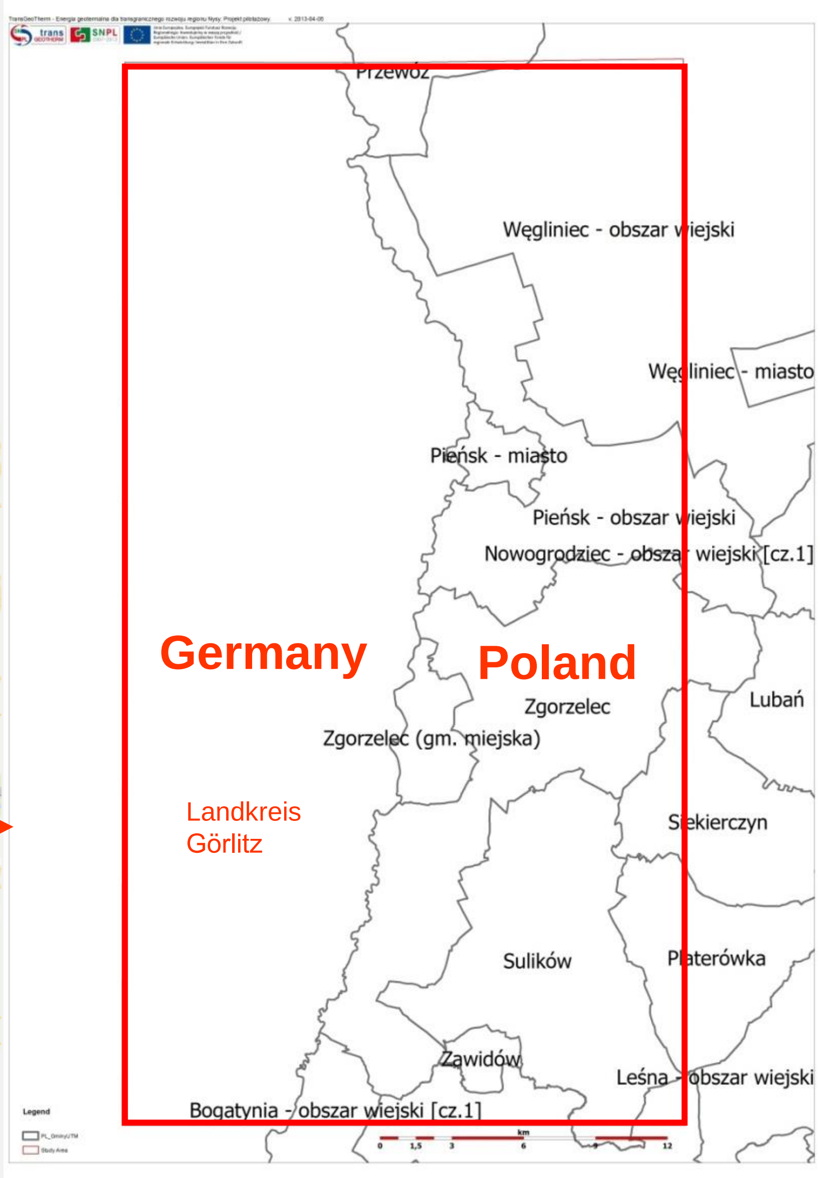
Ottomar Krentz, Karina Hofmann, Peter Riedel, Silke Reinhardt, Mario Breitschneider

Project is co-financed from the EU financial sources within the framework of the Operational Programme for Transboundary Co-operation Poland-Saxony 2007-2013

• project life time: **01.10.2012 – 31.12.2014**

Contact: transgeotherm@pgi.gov.pl www.transgeotherm.eu

Project TransGeoTherm covers area of ca 1 000 km^2



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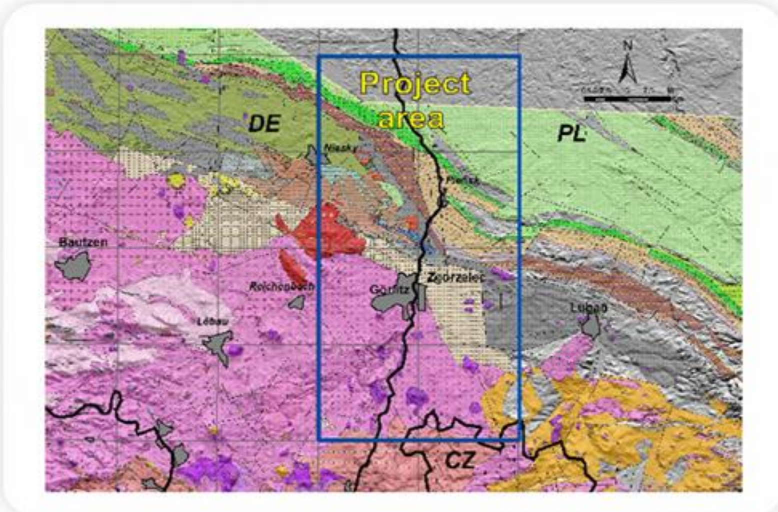
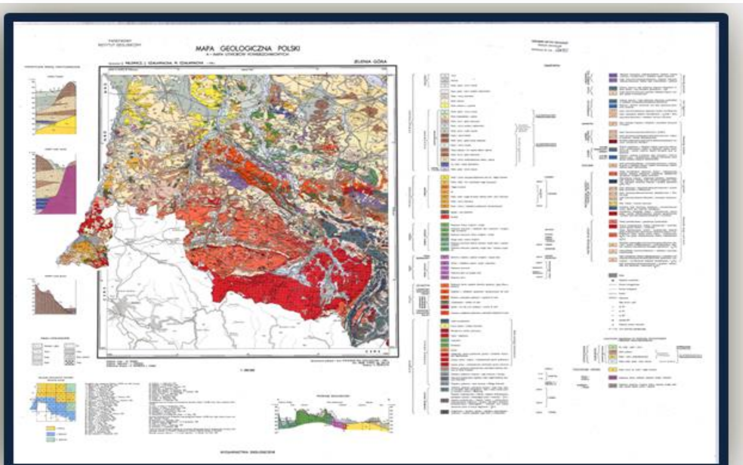
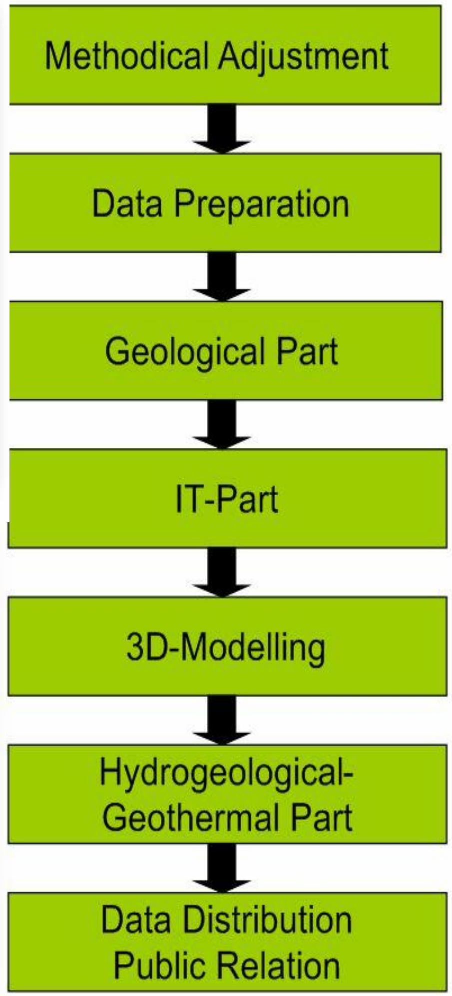
How the geothermal maps are produced?

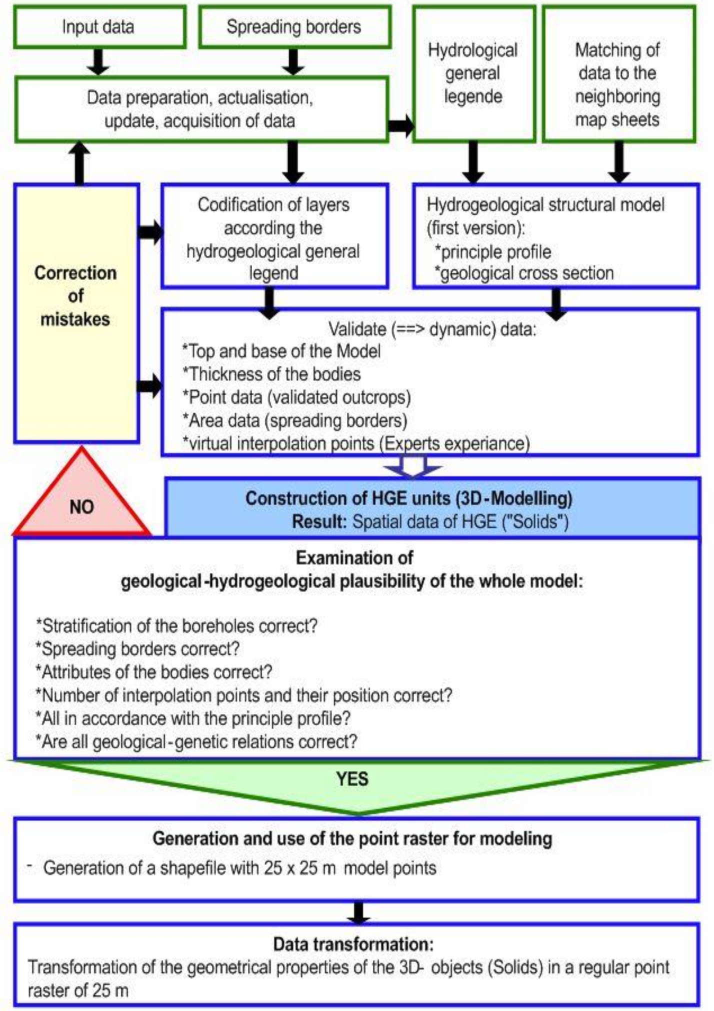
Geothermal maps of the project TransGeoTherm are based on innovative and advanced technology of analysis and interpretation of geological and hydrogeological data, thermal properties of rocks and preparation of a 3D numerical model.

All data are analysed, combined and interpreted following specifically established methodology









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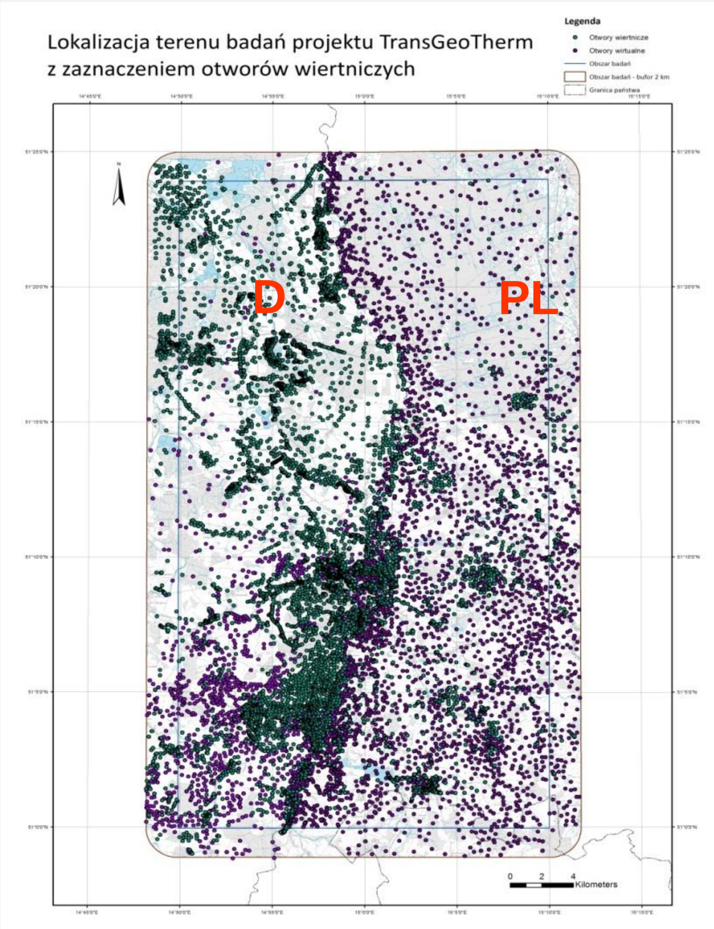
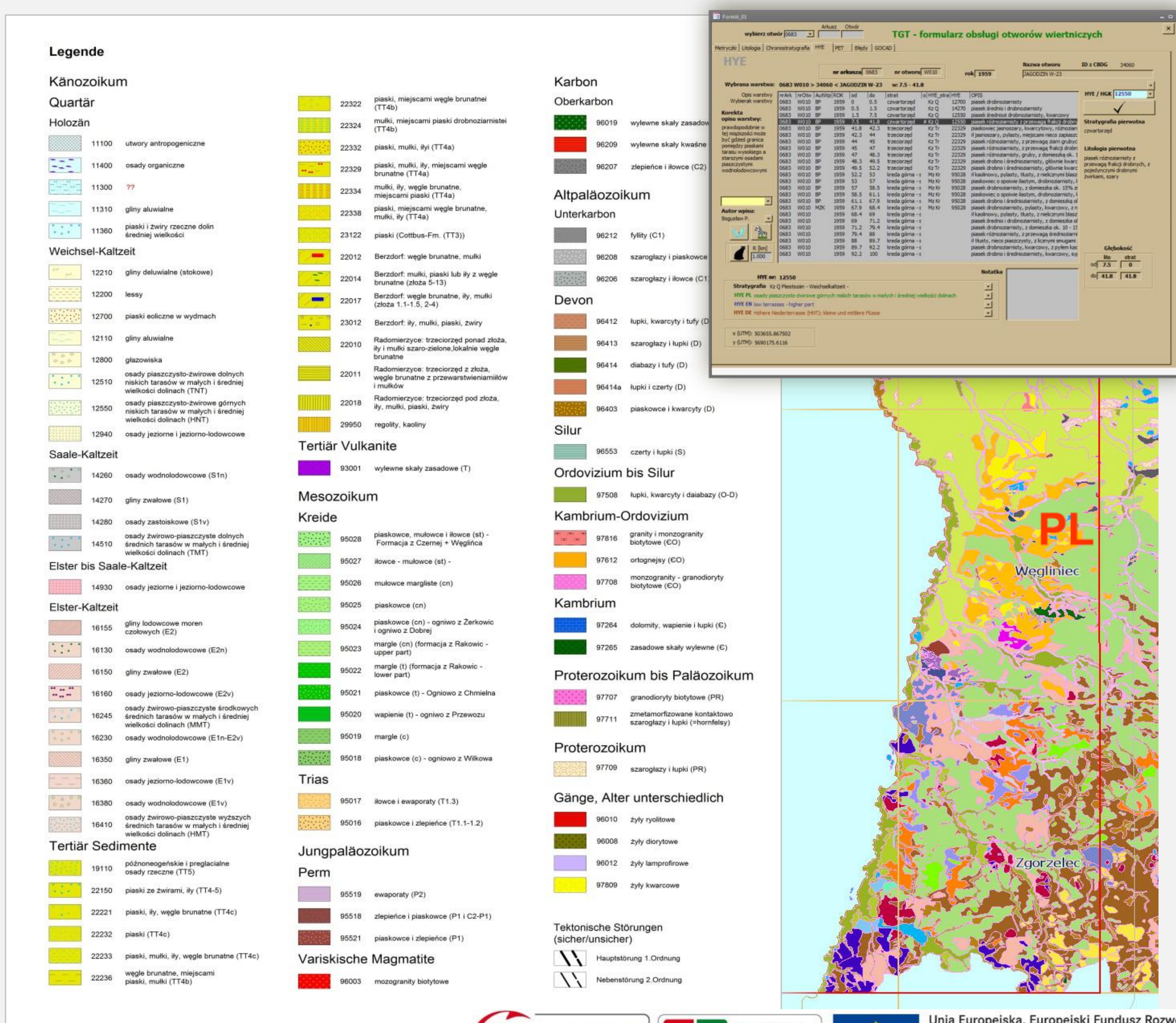
The core of the data base consists of : selected **5146** borehole logs + **5168** virtual boreholes, with lithological profiles grouped into 75 hydrogeological – geothermal (HGE) units





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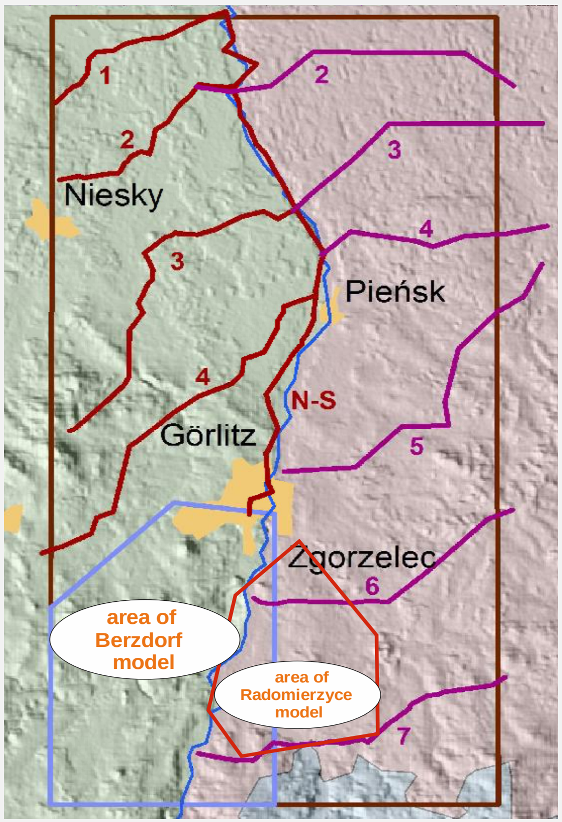
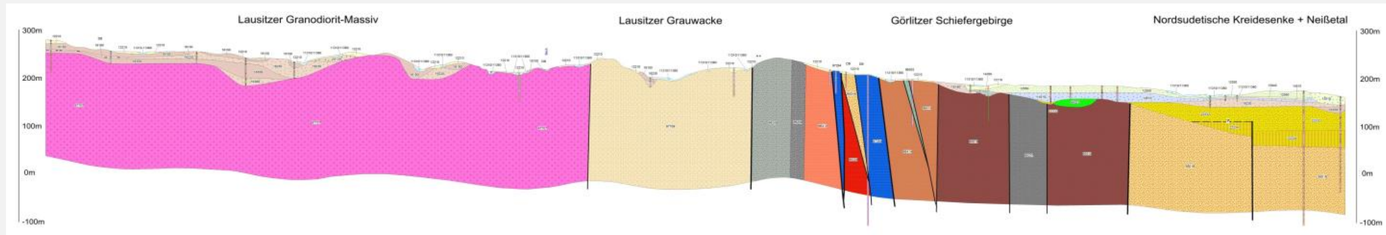
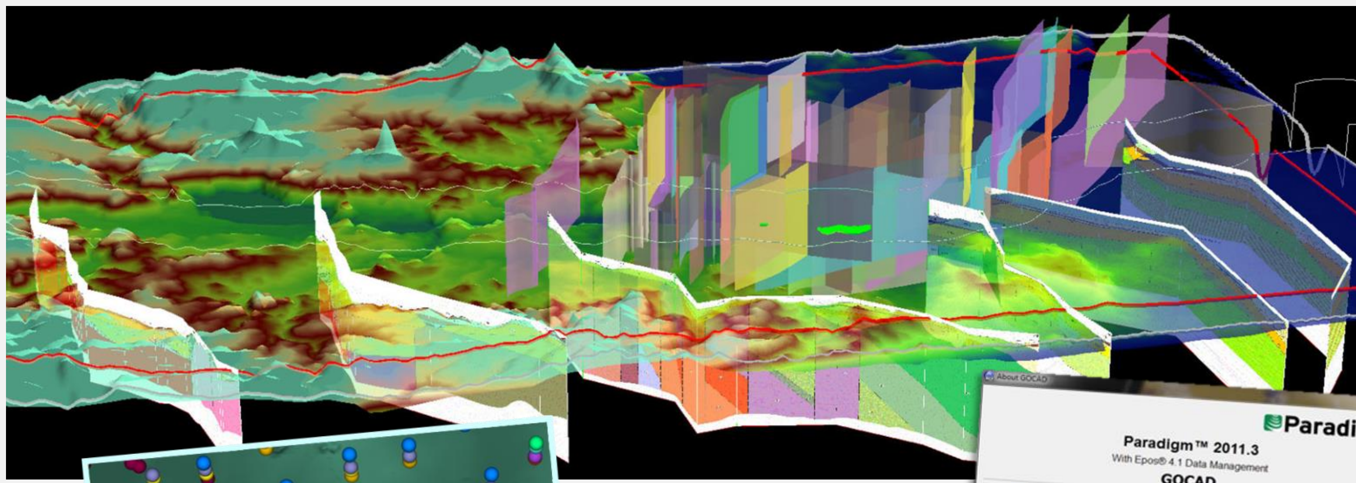
trans GEOTHERM
SNPL 2007–2013

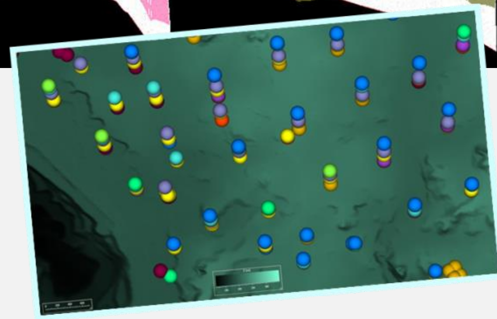
Unia Europejska. Europejski Fundusz Rozwoju Regionalnego: Inwestujemy w waszą przyszłość/
Europäische Union. Europäischer Fonds für regionale Entwicklung: Investition in Ihre Zukunft

Boreholes with codified lithologies (in accordance with HGE list) and several geological cross-sections are used as a leading reference to construct a 3D numerical model processed by the GOCAD software, down to 200 meters depth (locally down to 340 m)









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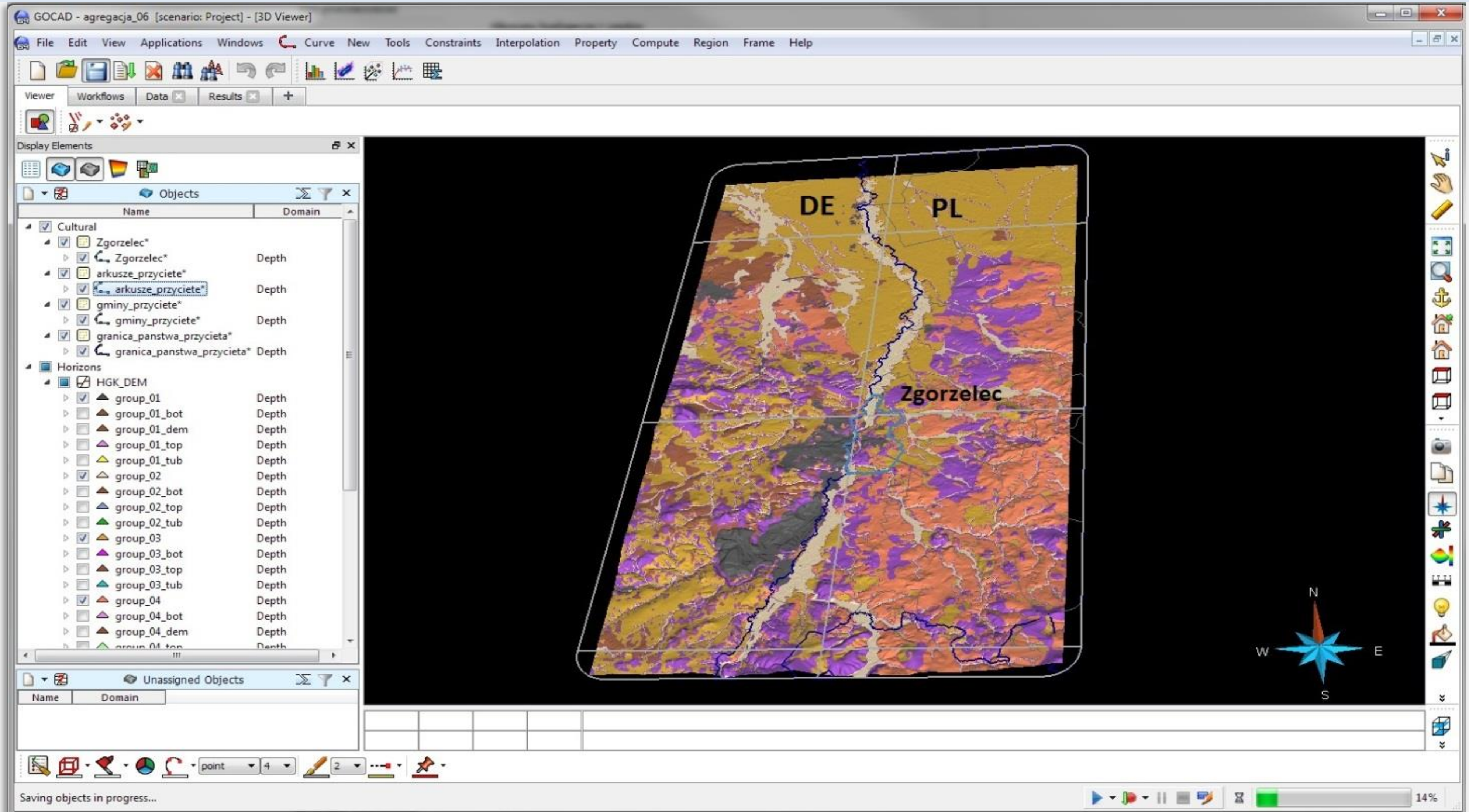
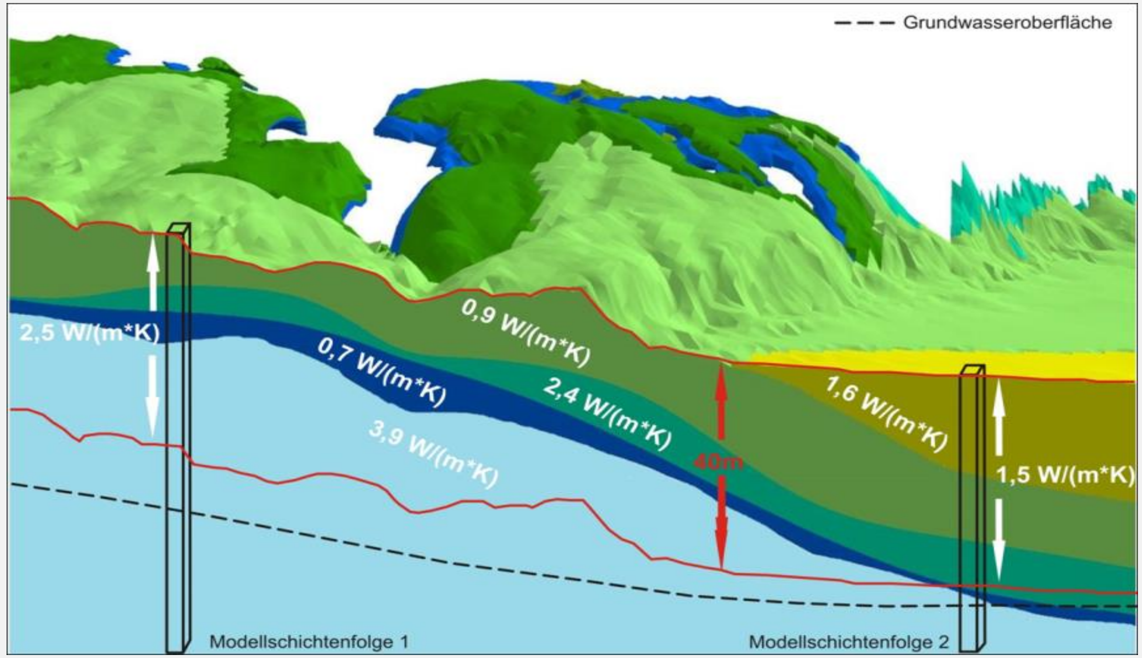
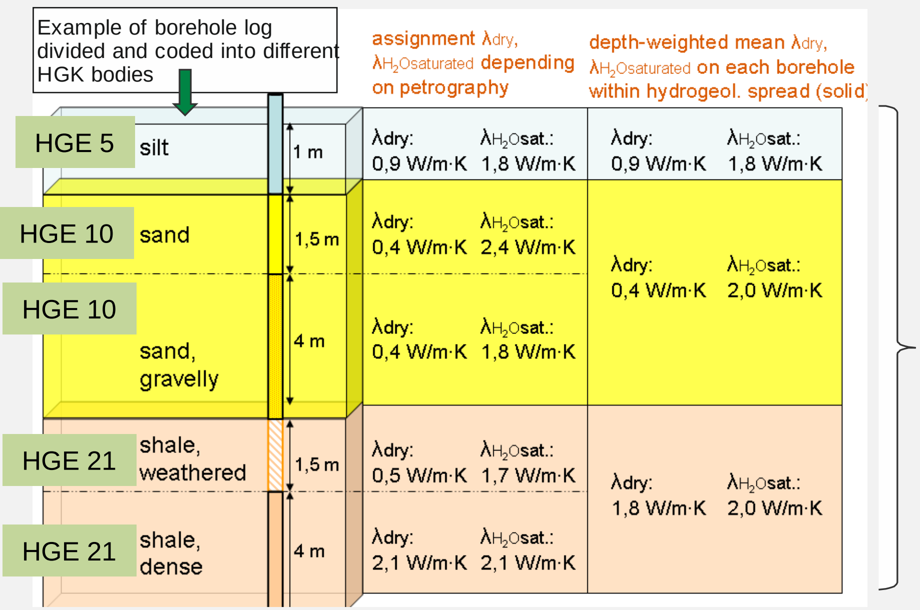
At the end of the Gocad modelling procedure the raster data sets of the top, bottom and thickness of every HGE unit is calculated from the 3D geological model with a grid-size of 25 by 25 metres.



Based on the geothermal properties of the rocks and their groundwater content a specific value of geothermal conductivity (λ) is allocated to each lithological layer (=petrographic rock type) at every borehole

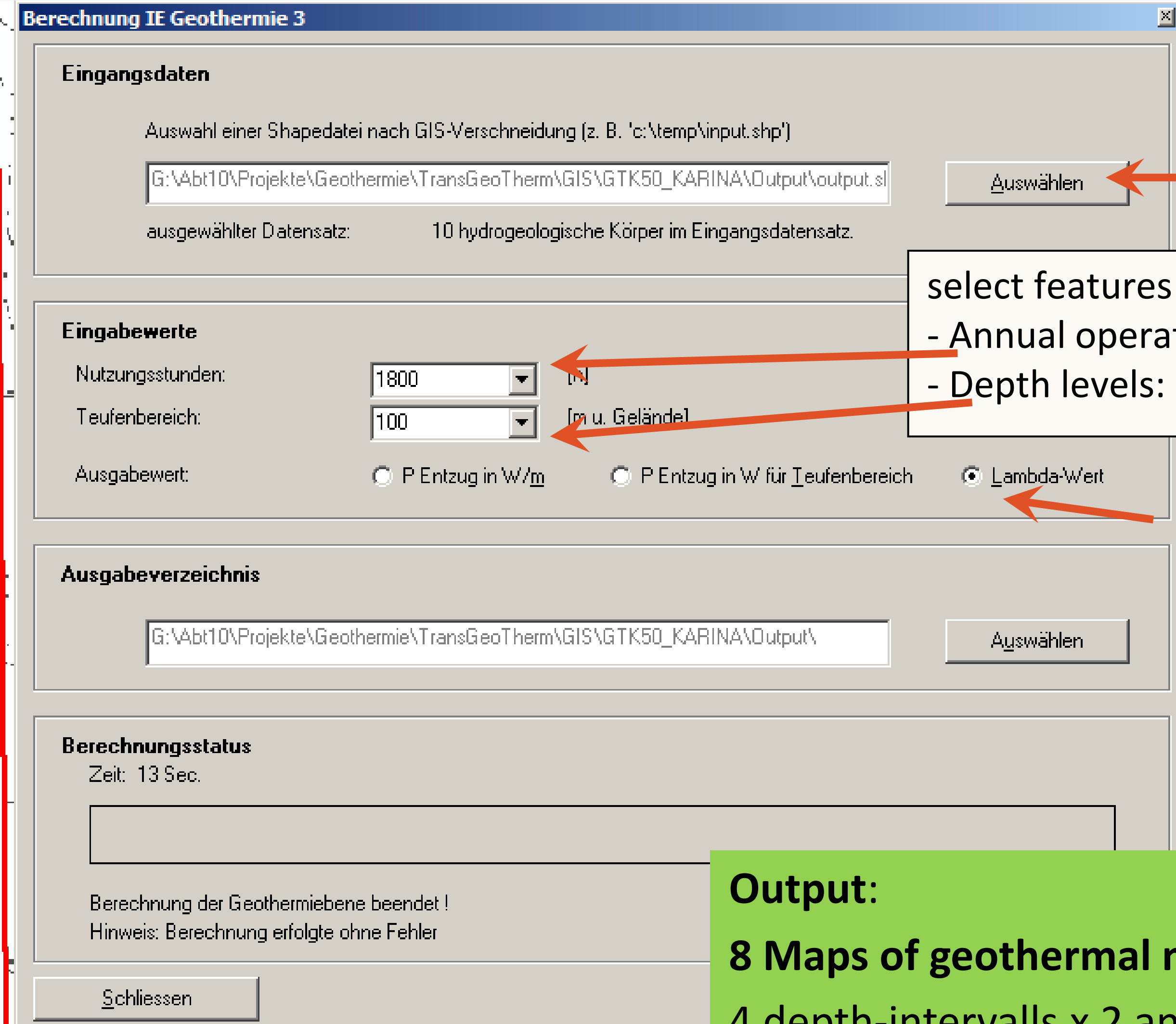




Result: for every section of a borehole, belonging to a certain HGE unit of the 3D geological model, a depth-weighted mean λ value is calculated.

Output: two-grid datasets of thermal conductivity (for dry and H_2O saturated rocks) for every HGE unit

Calculation of geothermal grids using specially designed GIS-Extension



select generated output_shape

select features:
- Annual operation hours of heat pump: 1800 h or 2400 h
- Depth levels: 40 m, 70 m, 100 m, 130 m

select output option

Output:

8 Maps of geothermal mean heat extraction rate [W/m] →

4 depth-intervalls x 2 annual operation hours (1800 and 2400)

4 Map of mean thermal conductivity [W/m·K] →

Lambda-distribution for 4 depth-intervalls

Results : 12 geothermal maps, including:

8 Maps of mean heat extraction rate in W/m
„public version“

for 1800 annual operation hours of heat pump (only for heating)

- 0 - 40 m
- 0 - 70 m
- 0 - 100 m
- 0 - 130 m

for 2400 annual operation hours of heat pump (heating + hot water)

- 0 - 40 m
- 0 - 70 m
- 0 - 100 m
- 0 - 130 m

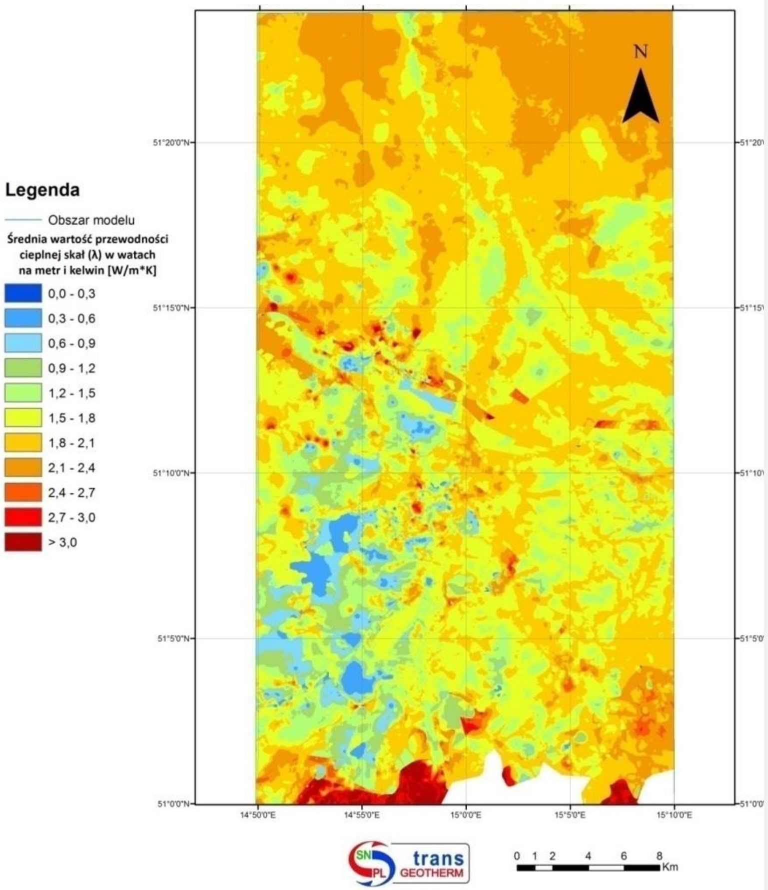
4 Map of mean thermal conductivity in W/m·K
“professional version”

- 0 - 40 m
- 0 - 70 m
- 0 - 100 m
- 0 - 130 m

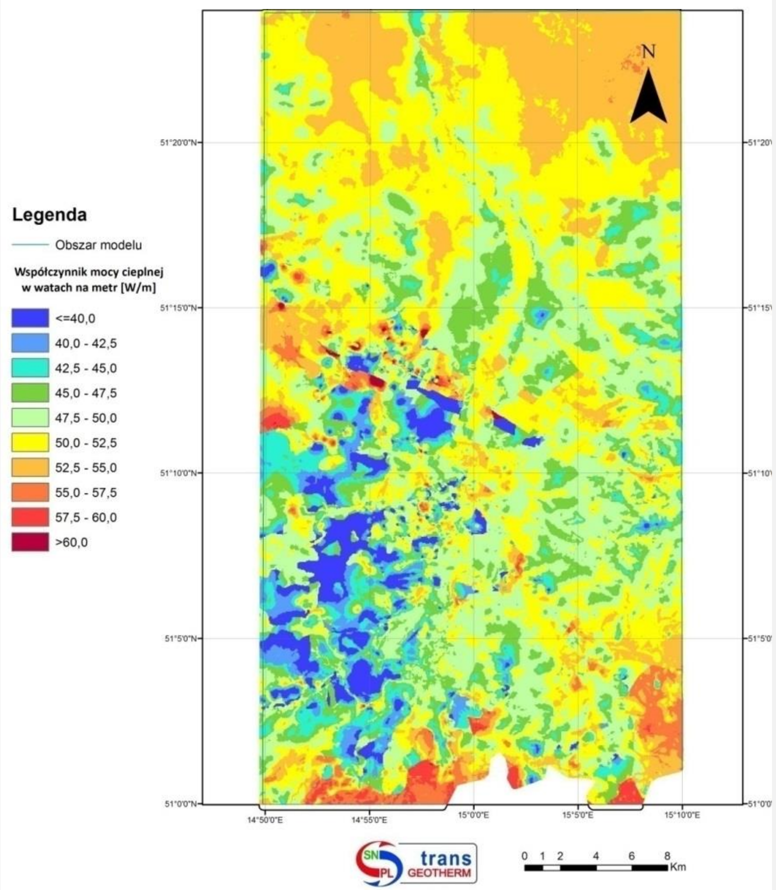
Example of geothermal maps available to download as .pdf files from project website

www.transgeotherm.eu

W/m*K , 0-40 m

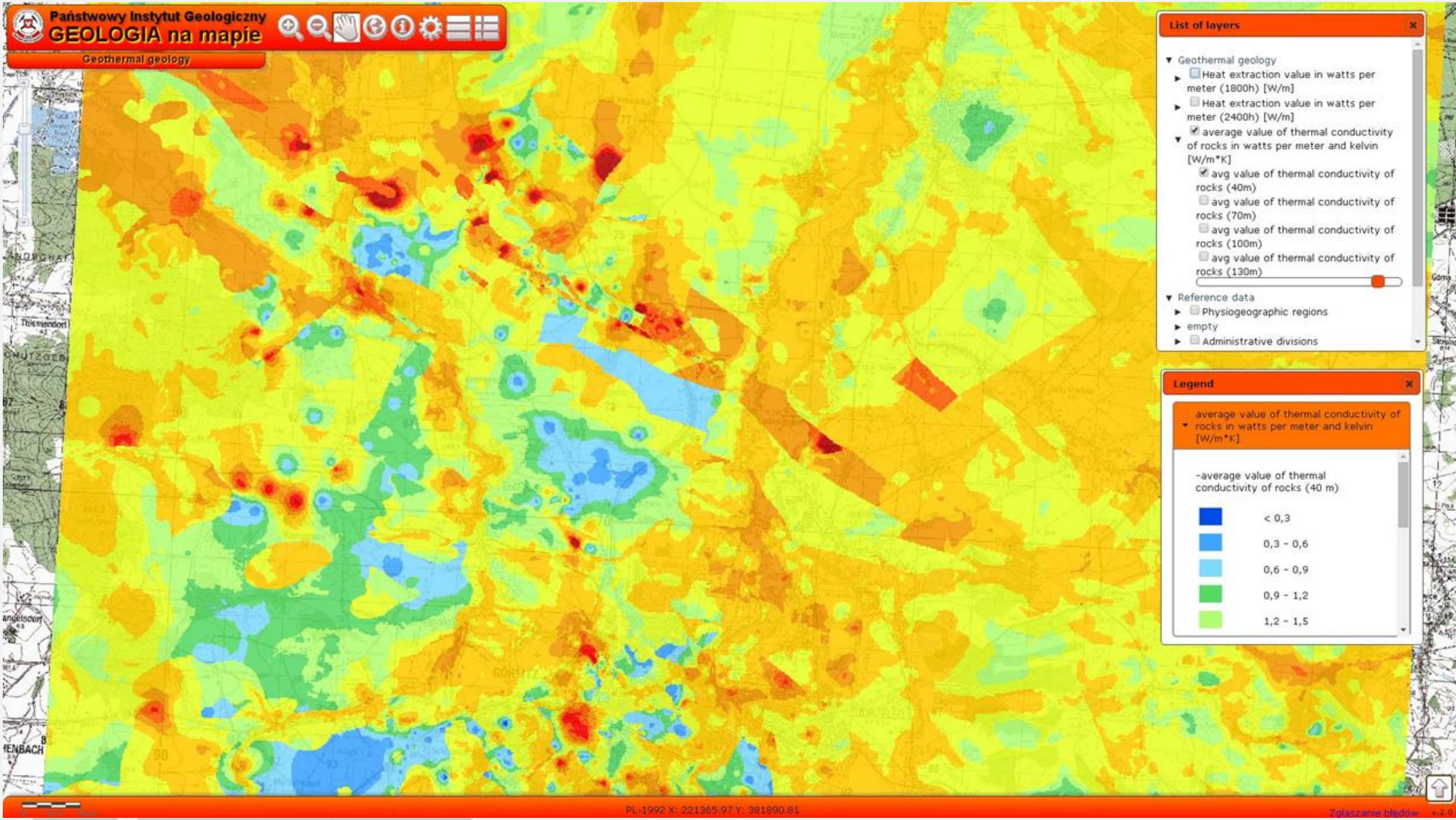


W/m , 0-40 m, 1800 h



Geothermal maps are also available on-line via internet application of PGI-NRI

www.transgeotherm.eu



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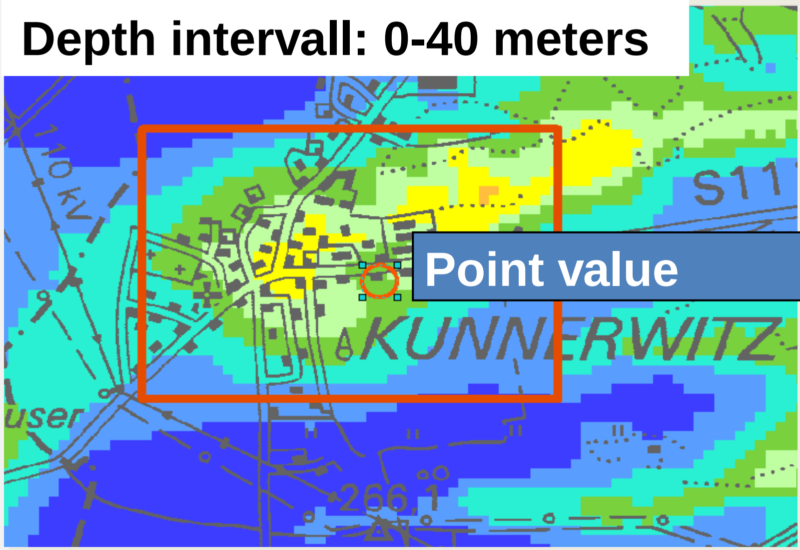
How to use geothermal maps?

How to use geothermal maps of the "public version"

Calculation of borehole number & depths for heat pump installation

Example: one family house,
12 kW power demand,
only for heating

Depth intervall: 0-40 meters



Point value

Legend:
heat extraction in watts per meter [W/m] at a depth of **0-40 meters** and **1800 annual operation hours** of a geothermal heat pump

- < 40
- 40,0 - 42,5
- 42,5 - 45,0
- 45,0 - 47,5
- 47,5 - 50,0
- 50,0 - 52,5
- 52,5 - 55,0
- 55,0 - 57,5
- 57,5 - 60,0
- >60,0

45,0 - 47,5 X 40 m = 1800 …1900 W

=

1,8 ... 1,9 kW

12 kW÷1,8 kW **= 6,6**

Result:
7 boreholes of 40 m deep

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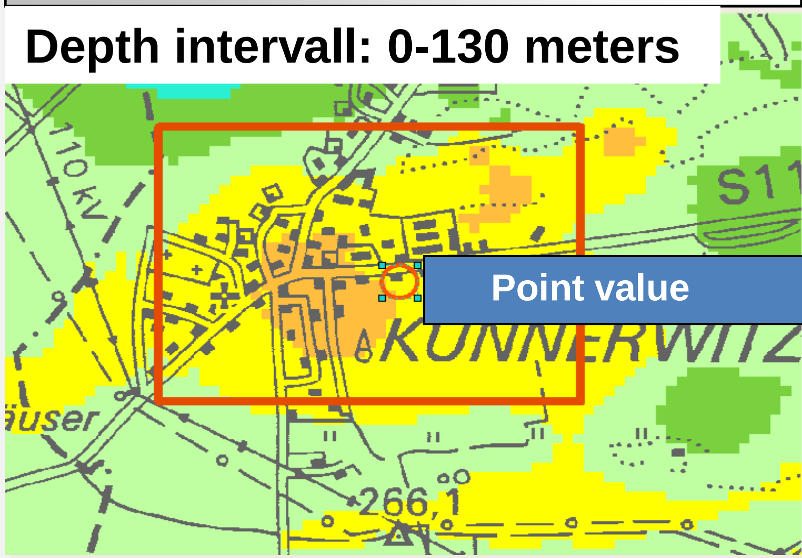
Source: Karina Hofmann (LfULG)

How to use geothermal maps of the “public version”

Calculation of borehole number & depths for heat pump installation

**Example: one family house,
12 kW power demand,
only for heating**

Depth intervall: 0-130 meters



Legend:
heat extraction in watts per meter [W/m] at a depth of **0-40 meters** and **1800 annual operation hours** of a geothermal heat pump

- < 40
- 40,0 - 42,5
- 42,5 - 45,0
- 45,0 - 47,5
- 47,5 - 50,0
- 50,0 - 52,5
- 52,5 - 55,0
- 55,0 - 57,5
- 57,5 - 60,0
- >60,0

50,0 - 52,5 X 130 m = 6500 ... 6825 W

= 6,5 ... 6,8 kW

12 kW÷6,5 kW **= 1,8**

**Result:
2 boreholes of 130 m deep**

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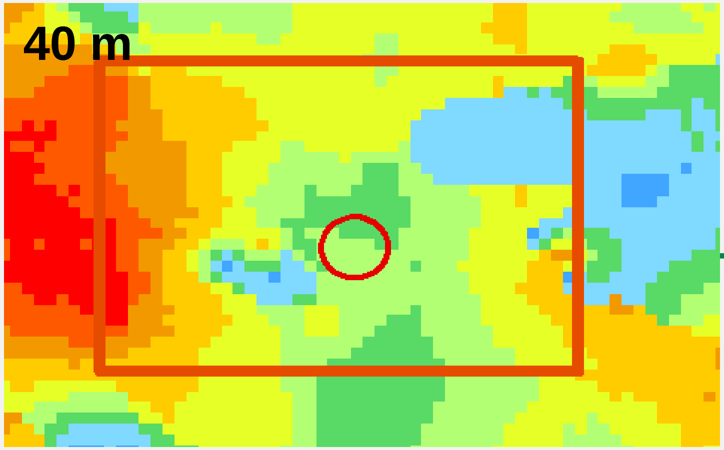
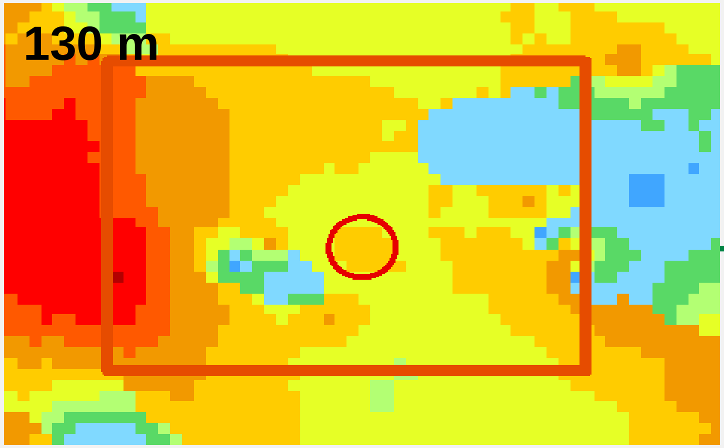
Source: Karina Hofmann (LfULG)

How to use geothermal maps of the “professional version”



Legend:
mean thermal conductivity
in W/m·K
for depth intervall **0-40 m**



Legend:
mean thermal conductivity
in W/m·K
for depth intervall **0-130 m**

Source: Karina Hofmann (LfULG)

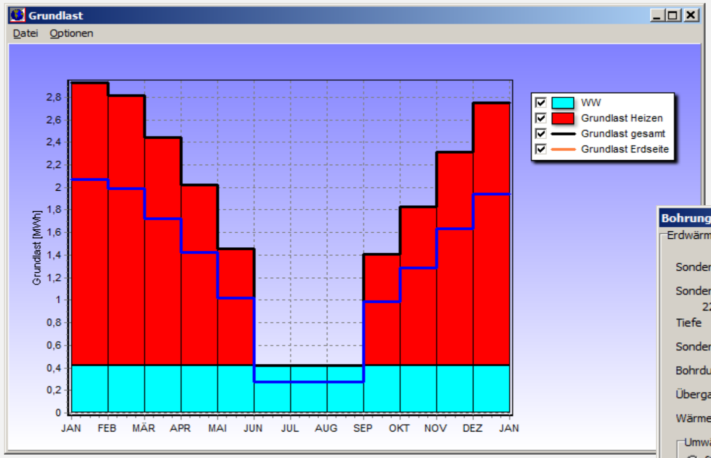
How to use geothermal maps of the “professional version”

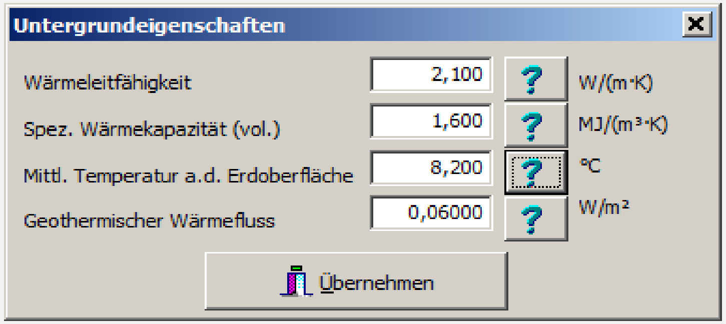
Variant: planned borehole of 130 m depth→ with mean value of λ = 2,1 W/m·K

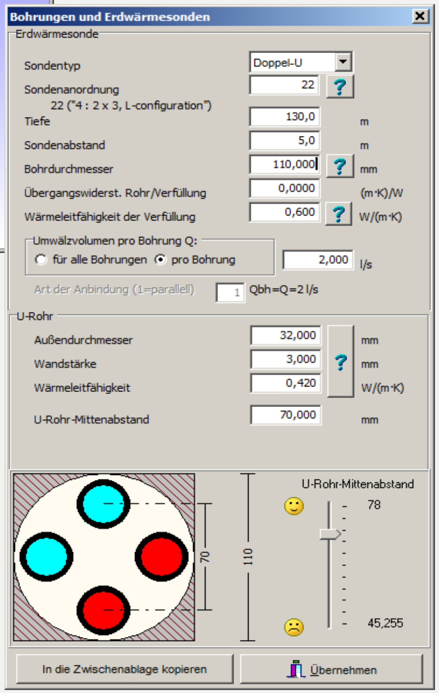
Correct valuation of ground heat pump installation for 25 years of exploatation using Earth Energy Designer EED sofware

<u>Other data are necessary !!! :</u>

- Technical specification of the heat pump
- Monthly energy power demand
- Technical parameters of heat pump exchanger and plumbing materials of borehole
- Location data:
  - Mean annual temperature
  - Thermal capacity of rocks
  - **Thermal conductivity λ of basement rocks**







Source: Karina Hofmann (LfULG)

Thank you very much for your attention