Belgium geothermal potential

Where are the most interesting areas ?

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Shallow Geothermal Energy
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Parameters
what are we looking at ?

- shallow geothermal potential = < 100m
- open system = water-water
  - we make use of the temperaure of the water
- closed system = ground-water
  - we make use of the temperauure of the ground

Open system

what makes a good potential open system ?

- temperature : as high as possible
  - approx. the same all over Belgium : 9-10°C
- yield : there should be enough water
  - we need 0.3 to 0.35 m^3/Hr per kW
  - normal housing system : 12kW = 3 to 4m^3/Hr
- quality : most limiting factor.
  - should be able to infiltrate into the same aquifer

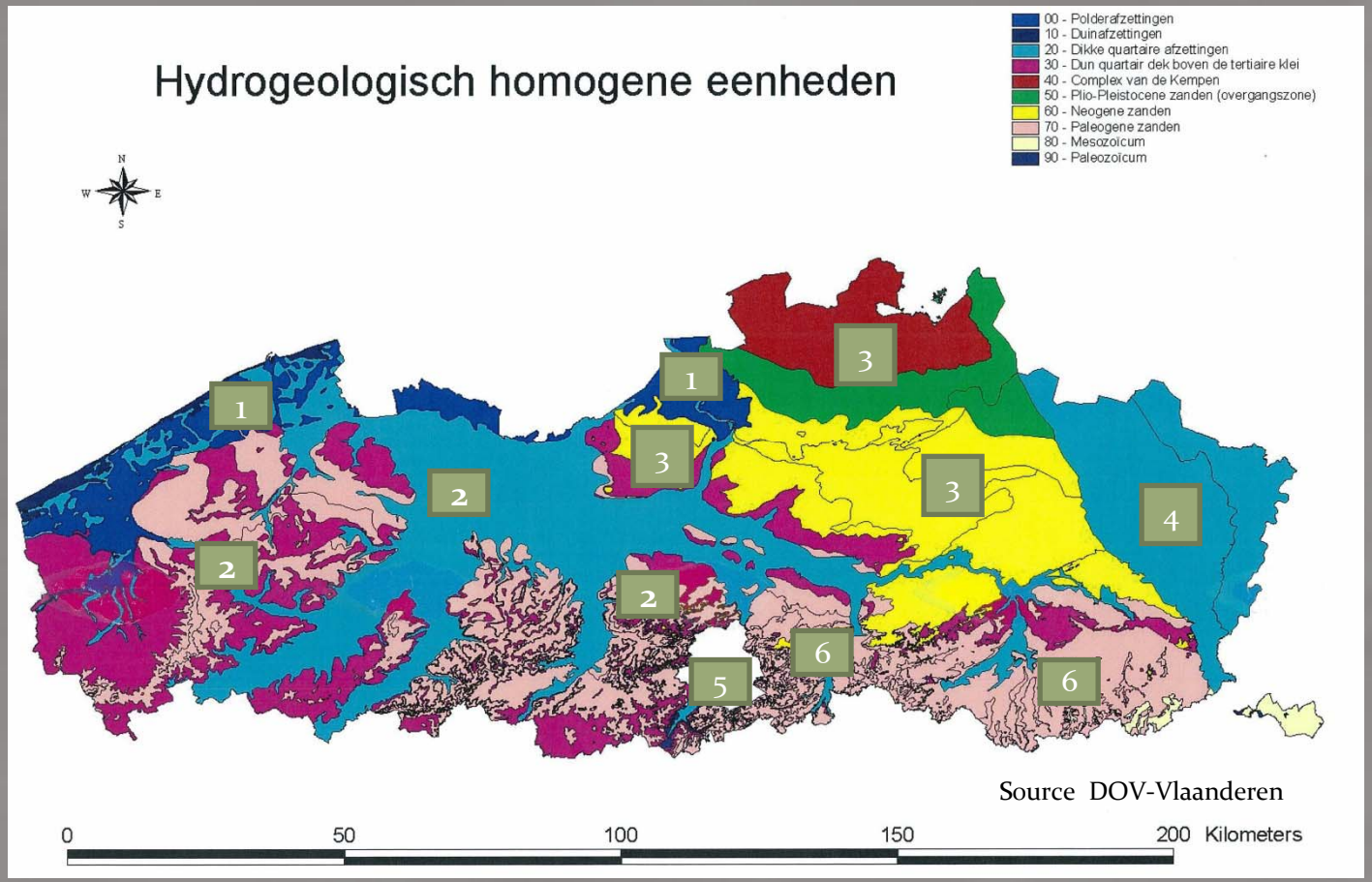
Quality demands for water-water system

- Electrical conductivity : < 500-600 µS/cm
- pH : 6-9
- Chlorides : < 300 mg/l, Sulfates : < 300mg/l
- CO_2 free: < 20 mg/l, O_2 : < 8mg/l, H_2S : < 0.05 mg/l
- Fe : < 0,2 mg/l, Mn : < 0.1 mg/l
- NH_3 : < 20mg/l, NO_3 : < 100mg/l
- SO_3 : < 5mg/l, Cl_2 : < 5mg/l
- HCO_3^- : < 300 mg/l, HCO_3^-/SO_4^{2-} < 1

Different aquifersystems in northern part of Belgium

- 1. Coast- and poldersystem
- 2. Central Flemish system
- 3. Central Campine system
- 4. Maas system
- 5. Bedrock "Sokkel"-system
- 6. Bruland Chalk system

Different aquifersystems in northern part of Belgium



1. Coast- and polder system

- quaternary and tertiairy sand deposits
- yield : 20-30m/day in quaternary sands, Yield in tertiairy sands is small : 0.5-1.5m/day
- mostly brakish water : to high chlorides content
- only small area with fresh water along coast area
- areas with fresh water often protected

2. Central Flemish system

- alternation of sands and clays
- quality of quaternary sand deposits in “Flemish valley” is very variable, high Fe-content possible. Yield is also very variable 10-60m/day
- tertiairy sands of Formation of Brussels and Lede have high HCO3- content. Yield is between 5-15m/day.
- mostly clay deposits. Sands in Formation of Kortrijk have low yield (1-3m/day) and high iron content

3. Central Campine system

- mostly sand deposits. Northern part clay deposits
- main aquifer is Formation of Diest. Yield 10-20m/day.
- tertiairy sands of Formation of Diest have high Fe- content.
- mostly clay deposits. Sands in Formation of Kortrijk have low yield (1-3m/day) and high iron content

4. Maas system

- mostly sand and gravel deposits.
- high yields in gravel deposits 100-1000m/day. Sands are coarse sand and often gravel bearing.
- locally very good quality
- important aquifer with a lot of protection areas

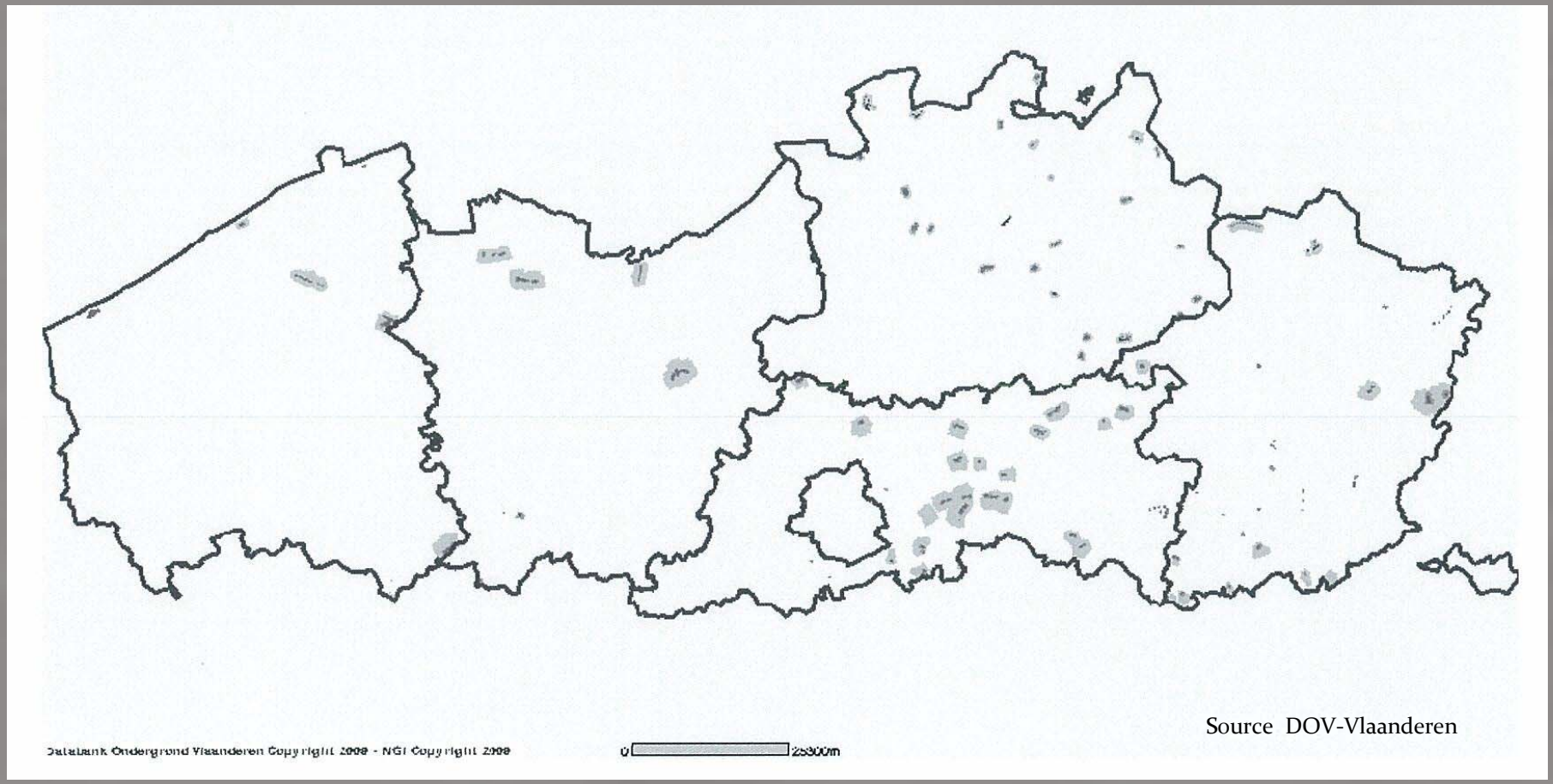
5. Bedrock “Sokkel” system

- water is present according to secondary porosity. Yield is very variable . 2-4m/day and gradually increases to 100m/day in south
- water present in marl, chalk , shale and sandstone deposits .
- in marl and chalk deposits high content of HCO_3^-
- in shale and sandstone deposits often high Fe-content

6. Bruland Chalk system

- sand , chalk and marl deposits. In sand deposits primary porosity with yields up to 20m/day. In marl and chalk deposits yield increases from east to west and from north to south from 2m/day to 100m/day
- generally in sand, marl and chalk deposits high content of HCO_3^-
- important aquifer with a lot of prtotection areas.

Protection areas around captations

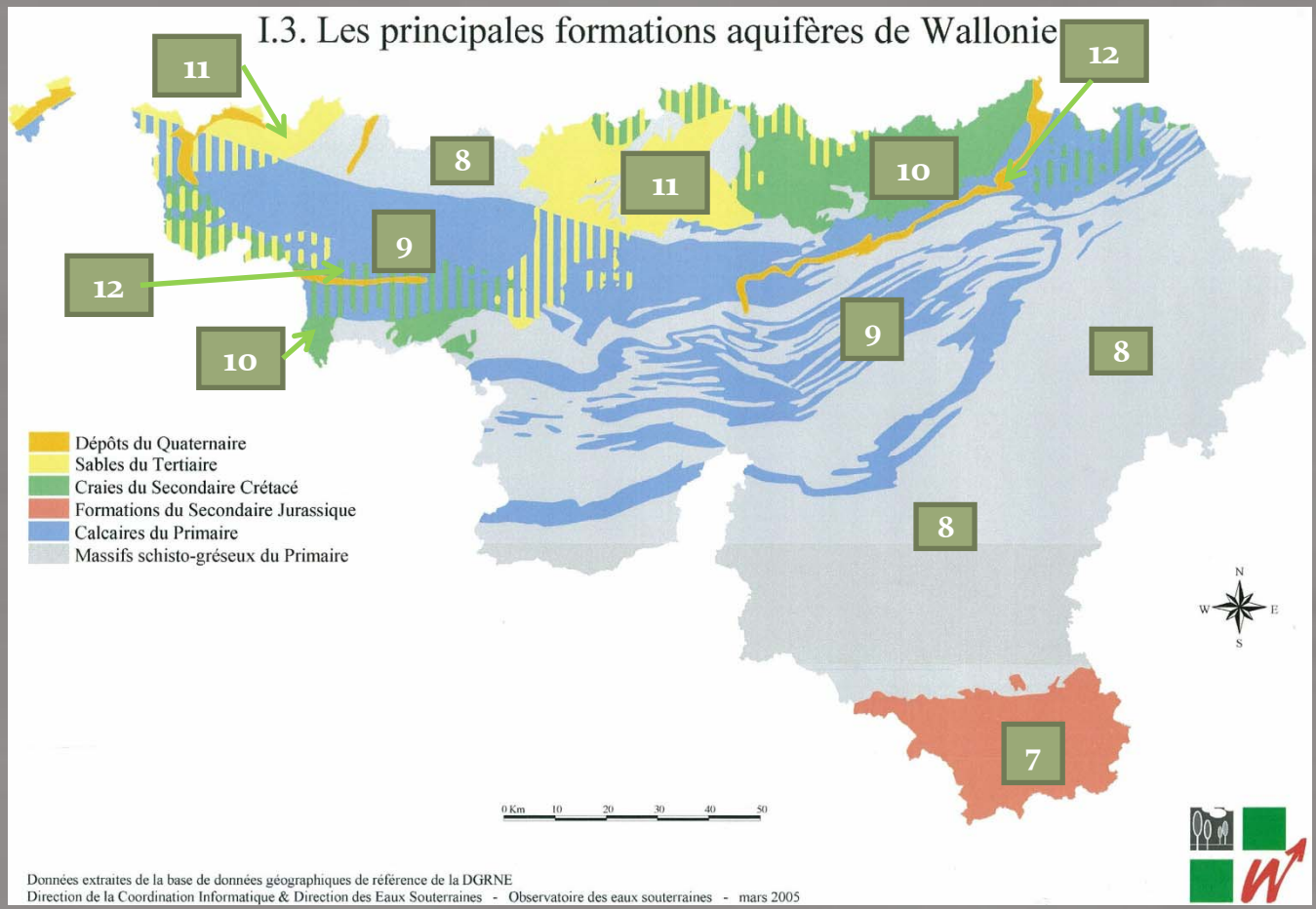


Source DOV-Vlaanderen

Different aquifersystems in southern part of Belgium

- 7. Jurassic system
- 8. Shale and sandstone system
- 9. Limestone system
- 10. Chalk system
- 11. Tertairy sand system
- 12. Quaternary gravel system

Different aquifersystems in southern part of Belgium



7. Jurassic system

- chalk and marl deposits with secundary porosity.
- yield is very variable
- high HCO_3--content
- low Fe- and Mn-content. increases to the south

8. Shale and sandstone system

- mostly devonian shale and sandstone deposits.
- yield is quite low
- relative acid water. pH decreases to the NE
- locally very high Fe- and Mn-content. increases to the NE

9. Limestone system

- mostly middle and late devonian limestone deposits.
- yield is very variable . Generally 10 to 30m/day
- relative acid water. pH decreases to the NE
- very high HCO3-content. Low Fe- and Mn-content.
- important aquifer with several protection areas. mostly important in the western part.

10. Chalk system

- Chalk deposits with variable but quite high yield up to 50-100m/day
- relative acid water. pH decreases to the NE
- very high HCO3-content. Low Fe- and Mn-content.
- important aquifer with several protection areas. mostly important in the eastern part.

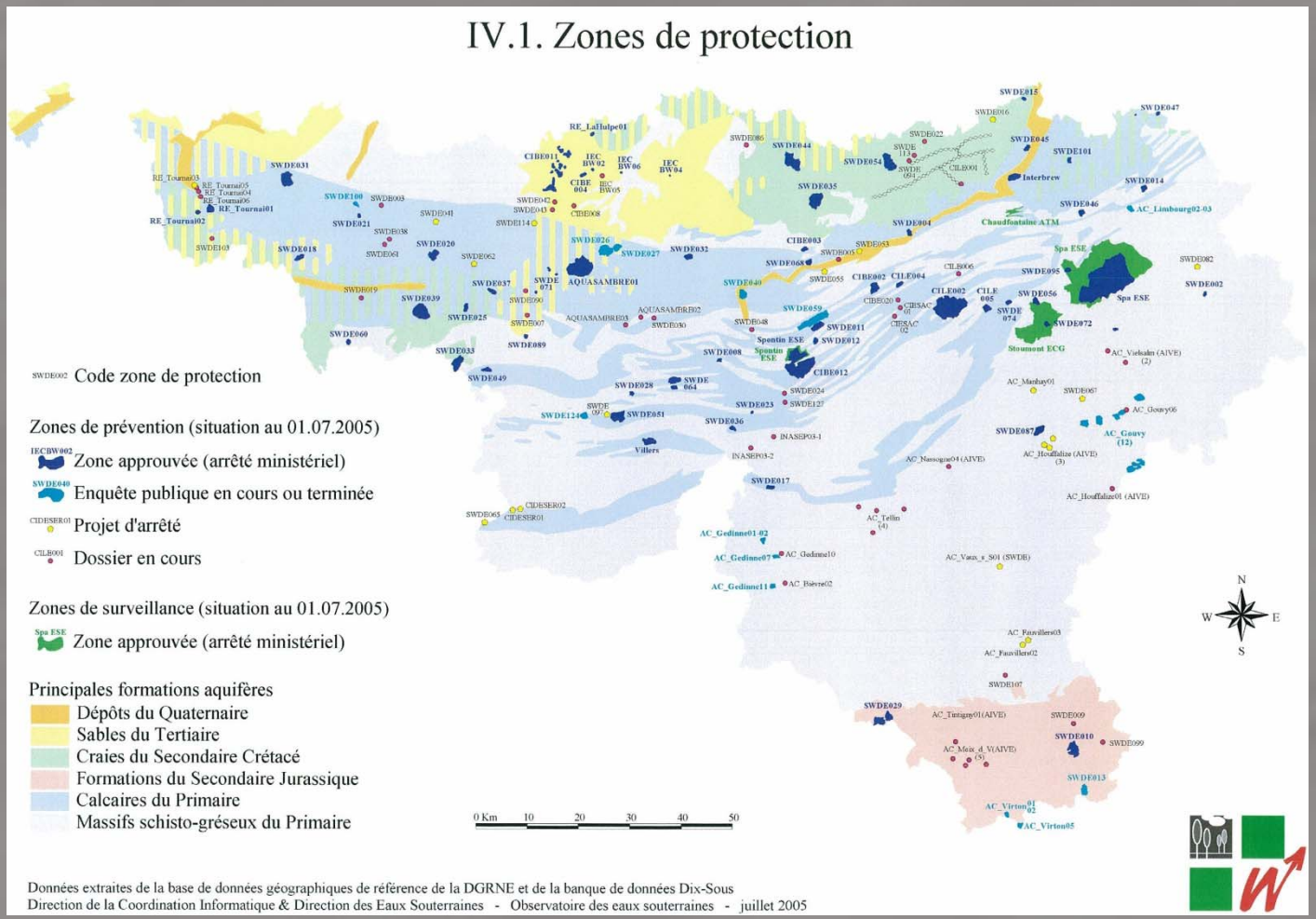
11. Tertiairy sand system

- mainly sand deposits of the Formation of Brussel. Yield 15-25m/day
- very high HCO3-content. Relatively high Fe- and Mn-content.
- present in the central area around Brussel

12. Quaternary gravel system

- alluvial gravel deposits of the river Meuse in the valley of the Meuse. Yield up to 1000m/day
- Relativelly high Fe- and Mn-content in the area of Liège.

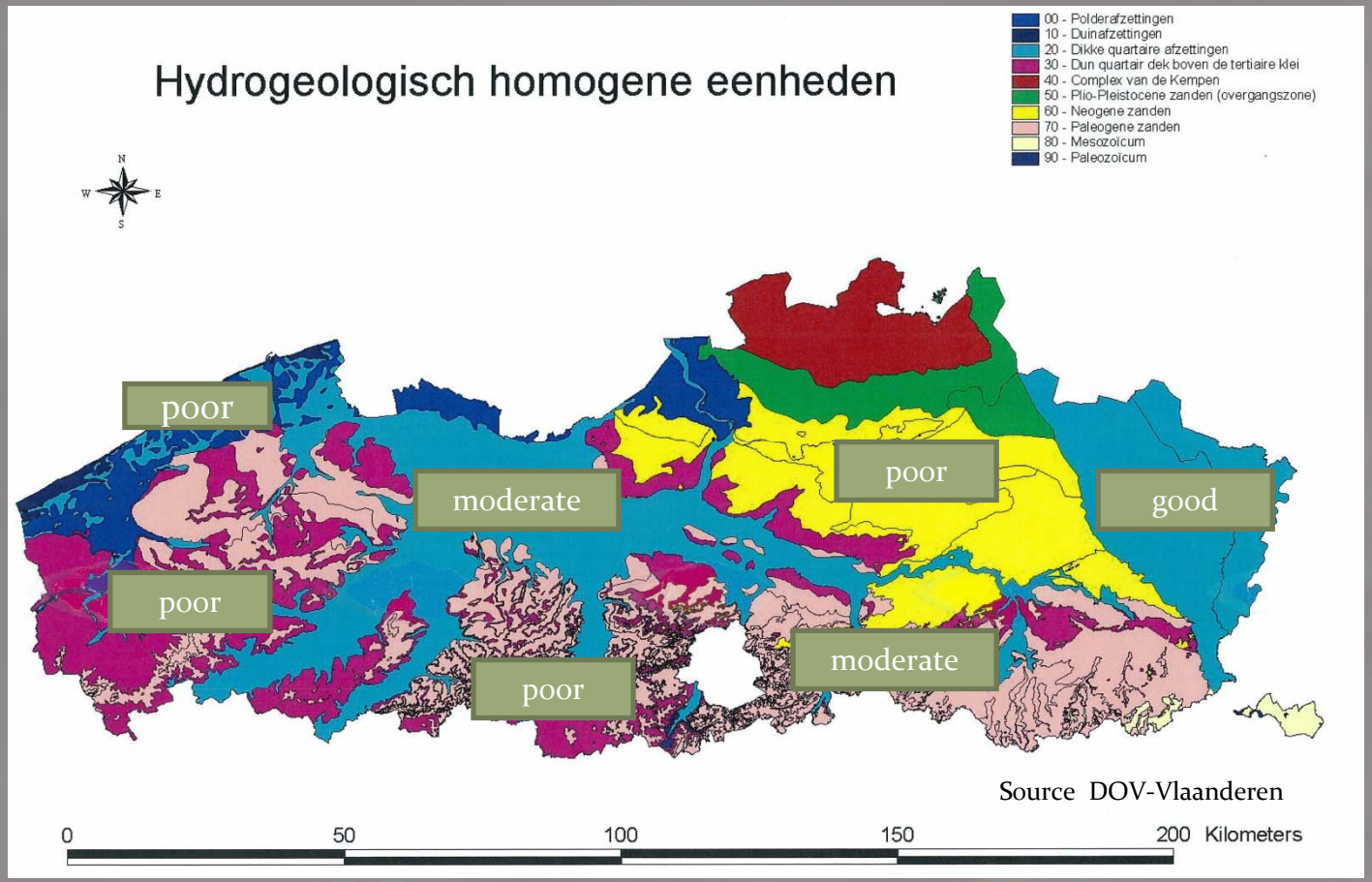
Protection areas around captations



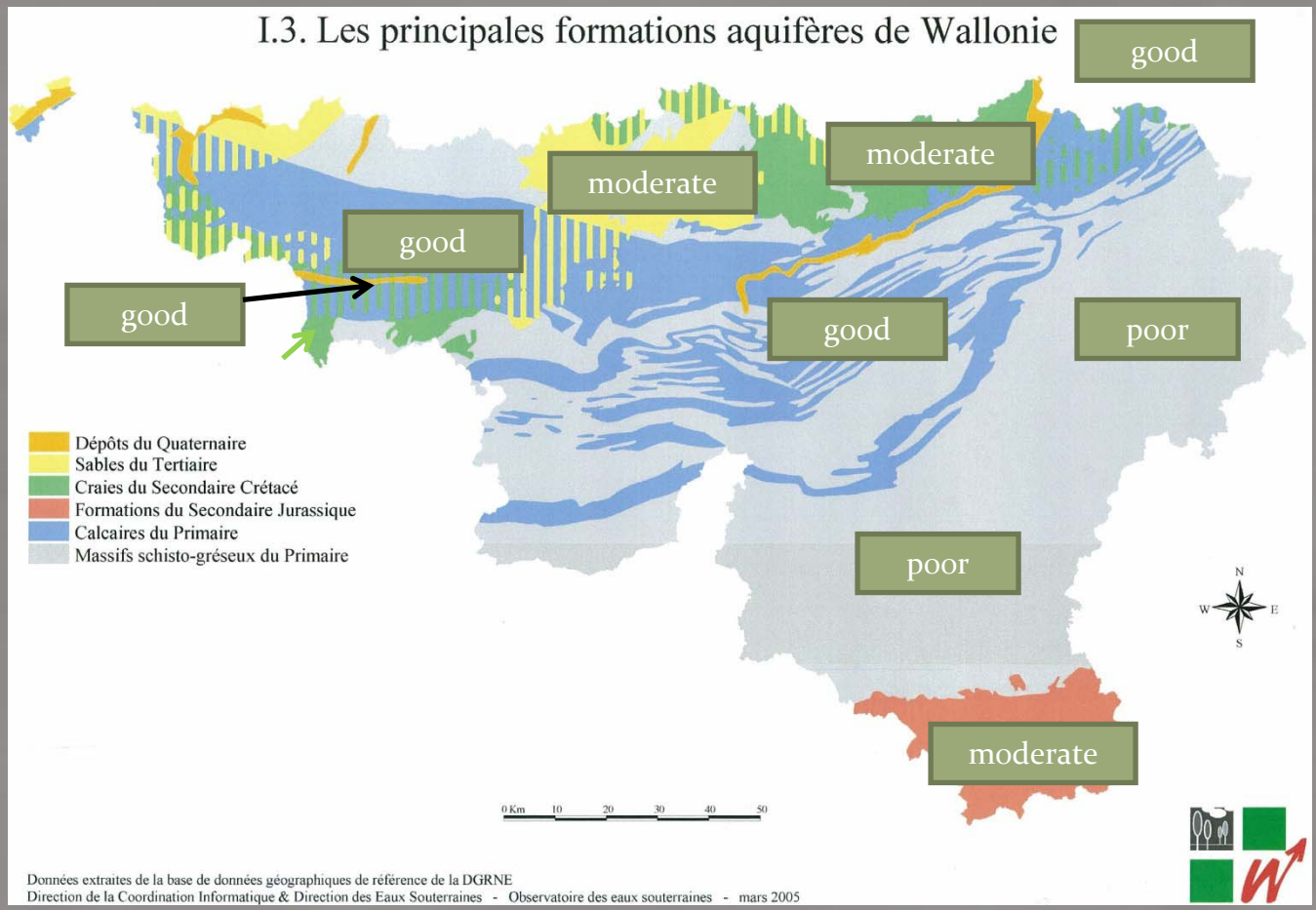
Conclusions Open System

- in most cases enough water is present to use open system. Most suitable systems are the Maas system in the northern part and quaternary gravel system in southern part mainly situated along the valley of the river Maas/Meuse.
- often quality of the water can cause problems with the re-infiltration of the cooled water. More specific high HCO_3-content of the aquifers of the Forlation of Brussel, Lede, Chalk/Marl and Limestone Formations. Also the high Fe-content in the neogene Formations of Diest and Kasterlee.

Good open systems in northern part of Belgium



Good open systems in southern part of Belgium



Closed system

what makes a good potential closed system ?

- thermal conductivity
- thermal diffusivity
- groundwater velocity, especially in unconsolidated formations , is probably most important driving force

Thermal conductivity

- quantity of heat transmitted per unit area per temperature gradient in unit time
- main mechanisme of transfer of heat from interior of earth to surface
- influenced by porosity, composition of the bedrock and nature of saturating fluids
- increasing porosity will decrease thermal conductivity but effect is reduced when saturated with water
- Shale, sandstone, limestone : 2.2 – 2.6 W/m K
- 5 % to 30 % porosity sandstone : 6.5 to 2.5 W/m K

Thermal diffusivity

- amount of energy(heat) required to change unit mass of the material by unit temperature or amount of energy(heat) absorbed before its temperature changes
- rock density will decrease thermal diffusivity
  - basalt 0.06m²/day, , gneiss : 0.11m²/day, quartzite : 0.26m²/day, clay 0.08m².day,
- water will increase thermal diffusivity

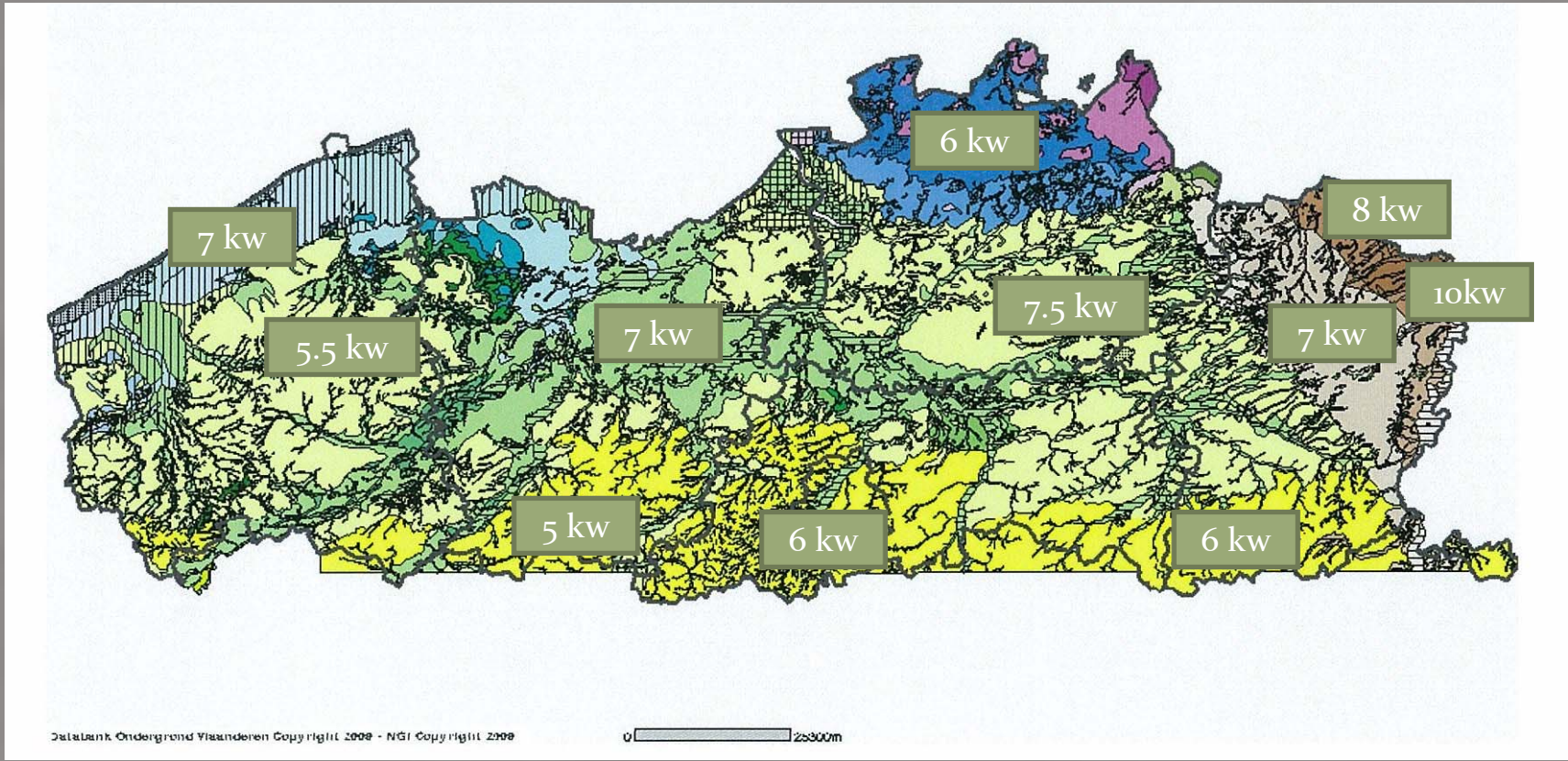
Groundwater velocity

- yield
  - Chalk formation : 2-75m/day
  - Paleocene Marl formation : 2-10m/day
  - Clay Formations of Boom/Kortrijk : 0.00001/0.0001m/day
  - Eocene sand Formation of Maldegem/Lede/Brussel : 0.55-5-15m/day
  - Oligocene and Eocene sand Formation of Bilzen/Diest : 3-5-15m/day
  - Pliocene sand Formation of Mol : 10-20m/day
  - Quaternary sand and gravel deposits : 50-500m/day
- hydraulic gradiënt

Ground extraction rate and amount of drilling meters /kW

	Ground extraction rate	Amount of drilling meters pro kW
Gravel dry wet	<20W/m 65 – 80 W/m	35-45 m 7- 9 m
Sand dry fine wet medium wet coarse wet	20 – 25 W/m 35 –40 W/m 45 - 50 W/m 55 – 60 W/m	25-30 m 14-18m 12-16m 10-14 m
Loam dry wet	25 – 30 W/m 35 – 45 W/m	25-30 m 16-20m
Clay dry wet	20-30 W/m 30-40 W/m	30-35 m 14-18 m
Chalk	35-45 W/m	15 -20m

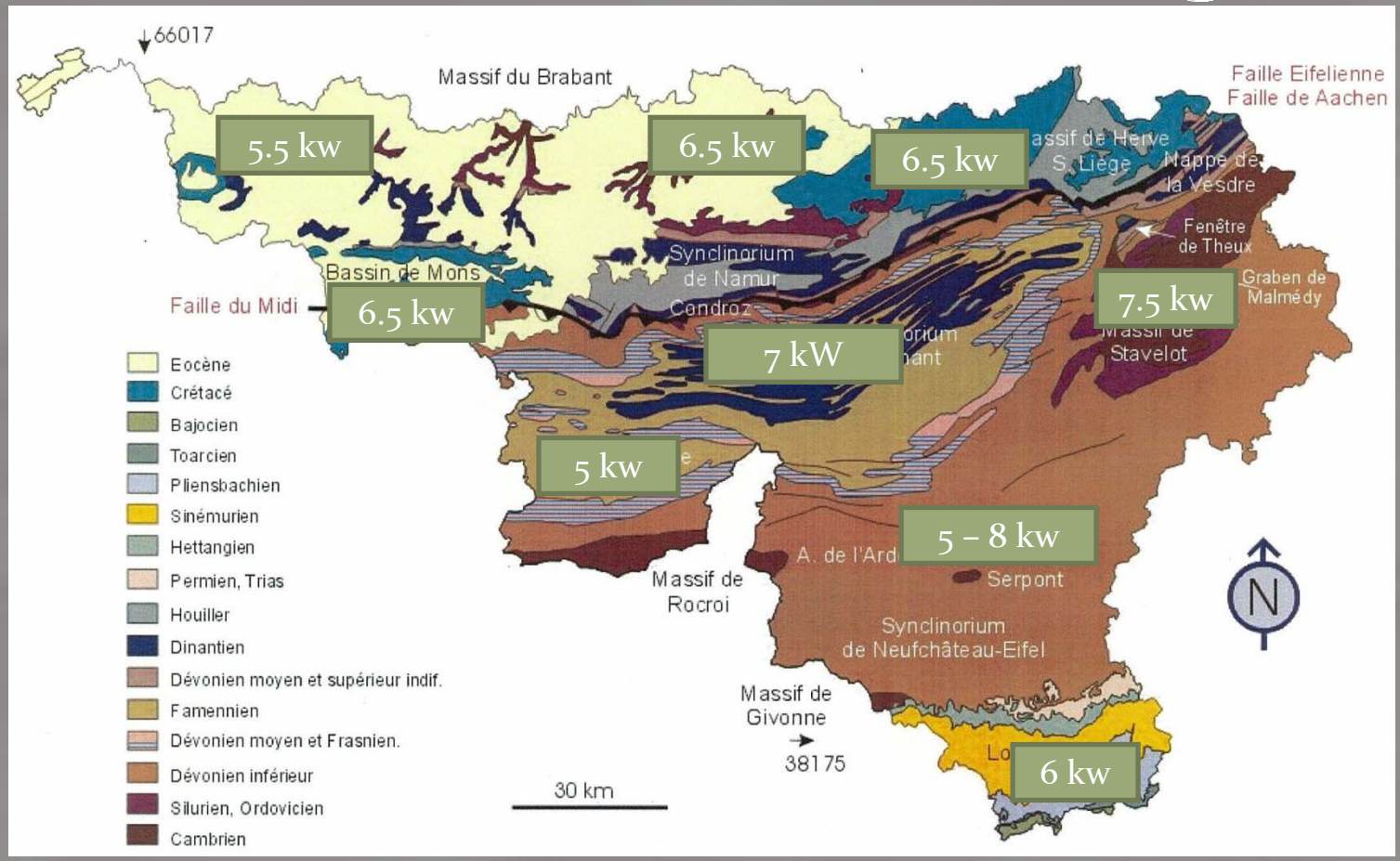
Amount of kW per 100m of drilling in northern part of Belgium



Ground extraction rate and amount of drilling meters /kW

Baslat	Ground extraction rate	Amount of drilling meters pro kW
Chalk	40 – 50 W/m	12 – 15 m
Shale	35 – 40 W/m	15 – 20 m
Sandstone	55 – 65 W/m	10 – 12 m
Quartzite	60 – 70 W/m	8 – 10 m
Limestone	45 – 60 W/m	11 – 15 m
Granite	55 – 65 W/m	9 – 12 m
Basalt	35 – 55 W/m	12 – 19 m

Amount of kW per 100m of drilling in southern part of Belgium



Influence of grouting on thermal capacity

- traditional grouts : 0.75/0.80 W/m.K to 0.80/0.87 W/m.K
- thermal enhanced grouts : 1.6/2.1 W/m.K

(air =0.03 W/m.K, water = 0.6 W/m.K

dry sand : 0.4 W/m.K, wet sand : 1.8/2.4 W/m.K

dry silt/clay : 1.4 w/m.K wet silt/clay : 1.7 W/m.K

sandstone : 2.3 W/m.K, limestone : 2.8 W/m.K

basalt : 1.7 W/m.K, granite : 3.4 W/m.K

Conclusions Closed Systems

- in the northern part of Belgium wet gravel deposits will be the most interesting system for closed sytem. On the contrary dry gravel deposits have the worst performance . There is a direct relationship between the groundwater velocity and length of borehole heat exchanger needed. Most suitable sand formations are the Formations of Brussel, Diest and Mol.
- in the southern part of Belgium best conditions will be found in the sandstone and quartzite formations of the Devonian. In case of water bearing limestone the presence of water will improve the themal capacity highly.
- grouting will have only a small effect on thermal capacity in unconsolidated formation but will influence the performance in consolidated formations.