Hydrodynamic and hydrochemical evolution of the Bajo Guadalhorce Valley alluvial aquifer (Málaga, S Spain) in the last 40 years

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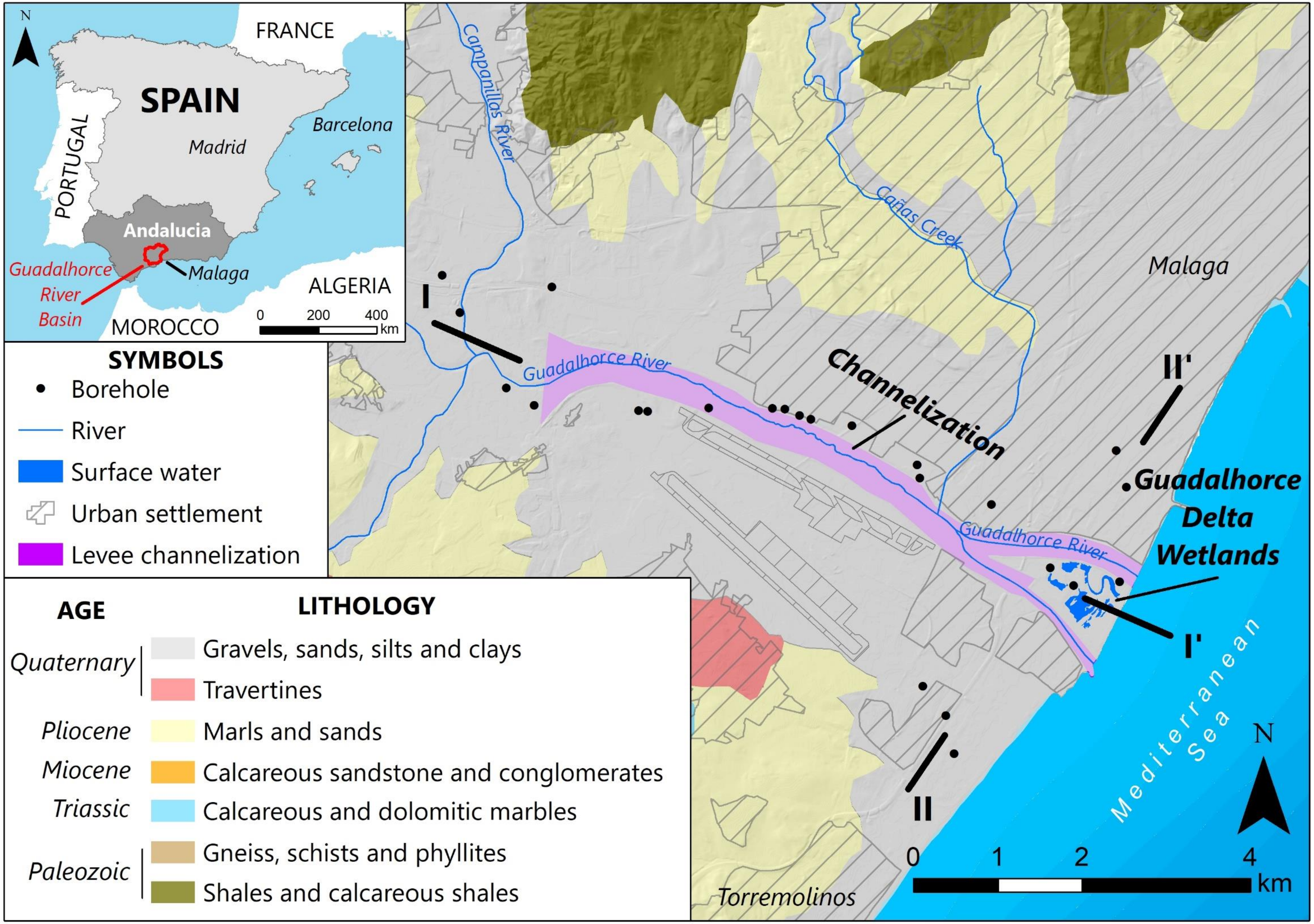
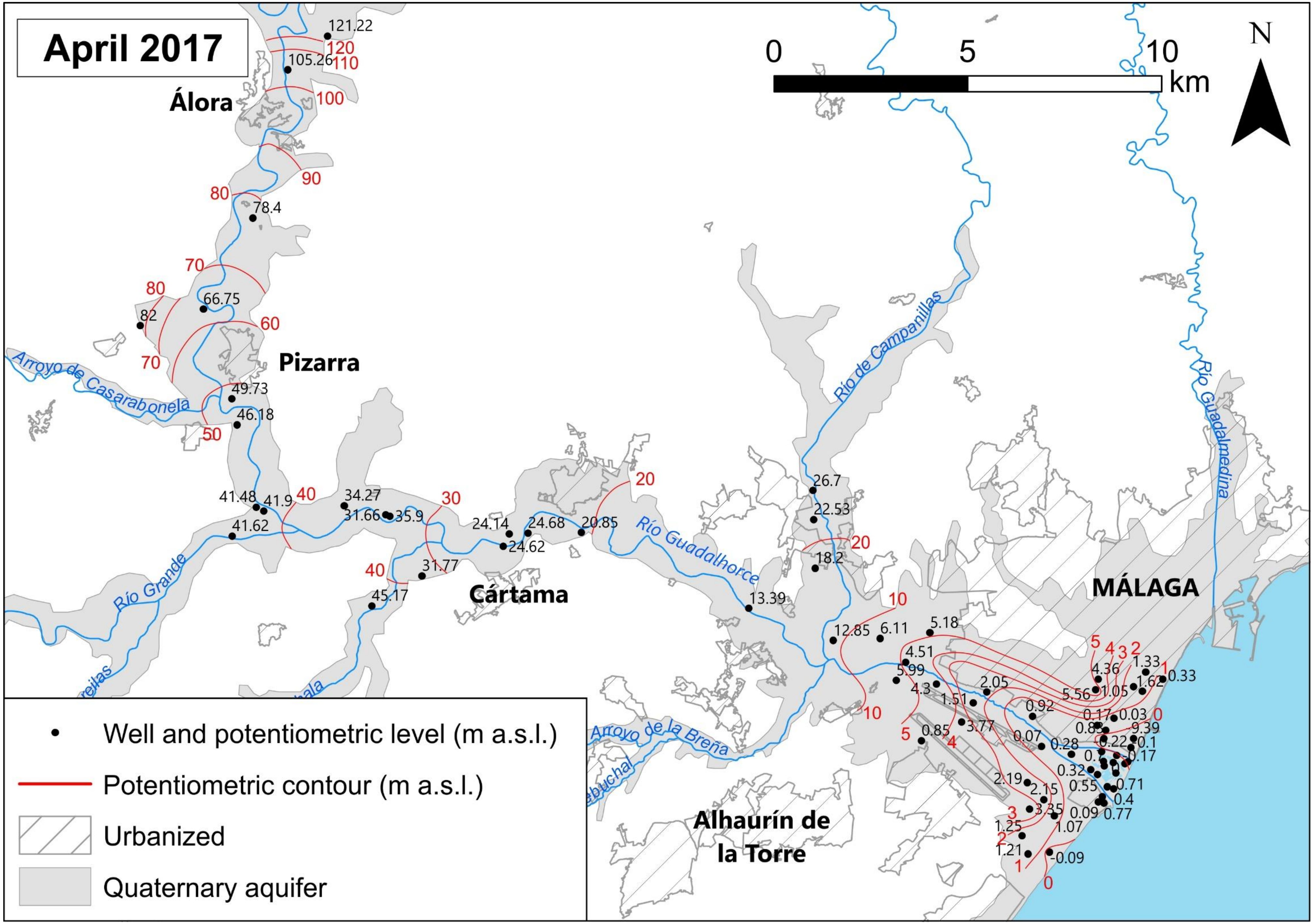
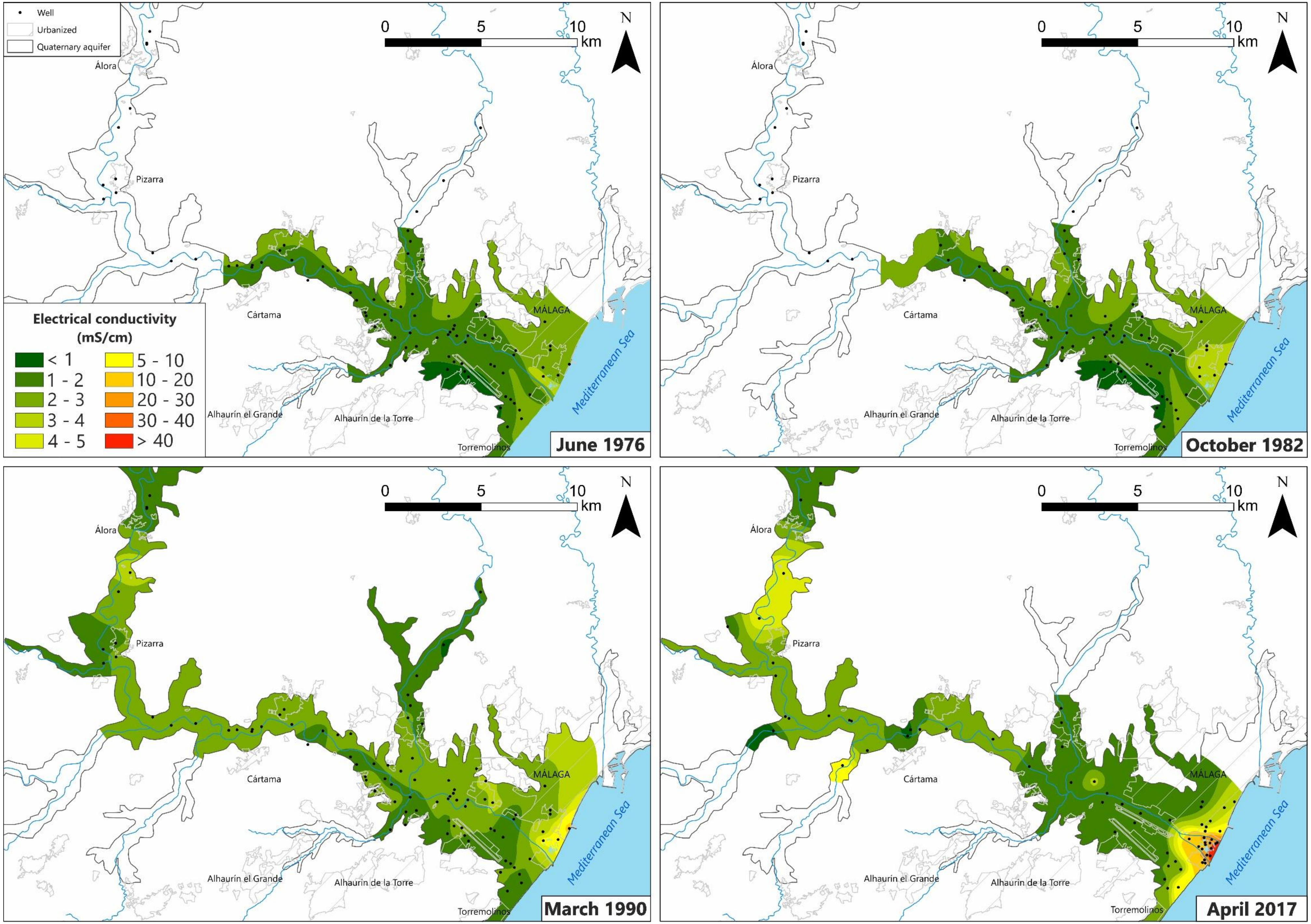

N
FRANCE
SPAIN
PORTUGAL
Madrid
Barcelona
Andalucia
Guadalhorce River Basin
Malaga
ALGERIA
MOROCCO
0 200 400 km
SYMBOLS
Borehole
River
Surface water
Urban settlement
Levee channelization
AGE
LITHOLOGY
Quaternary
Gravels, sands, silts and clays
Travertines
Pliocene
Marls and sands
Miocene
Calcareous sandstone and conglomerates
Triassic
Calcareous and dolomitic marbles
Paleozoic
Gneiss, schists and phyllites
Shales and calcareous shales
Campanillas River
Cañas Creek
Malaga
I
I'
II
II'
Guadalhorce River
Channelization
Guadalhorce Delta Wetlands
Mediterranean Sea
Torremolinos
0 1 2 4 km
N

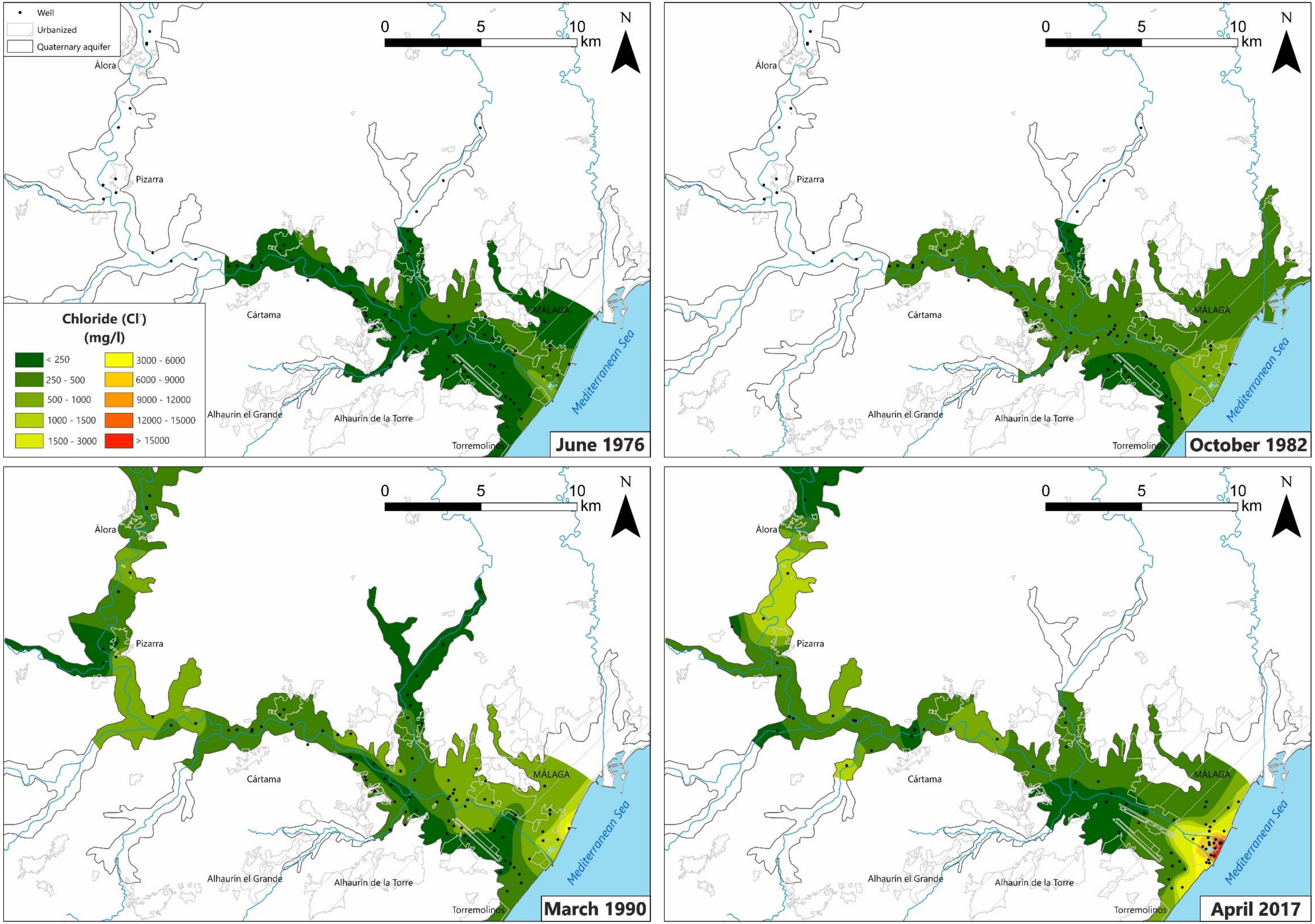
Results show that groundwater generally flows towards the Guadalhorce River, where gaining relationship remains more patent in its lower river stretch, and the Mediterranean Sea. Some negative groundwater elevations close to the coastal fringe are observed in several piezometers because of pumping during the study period.

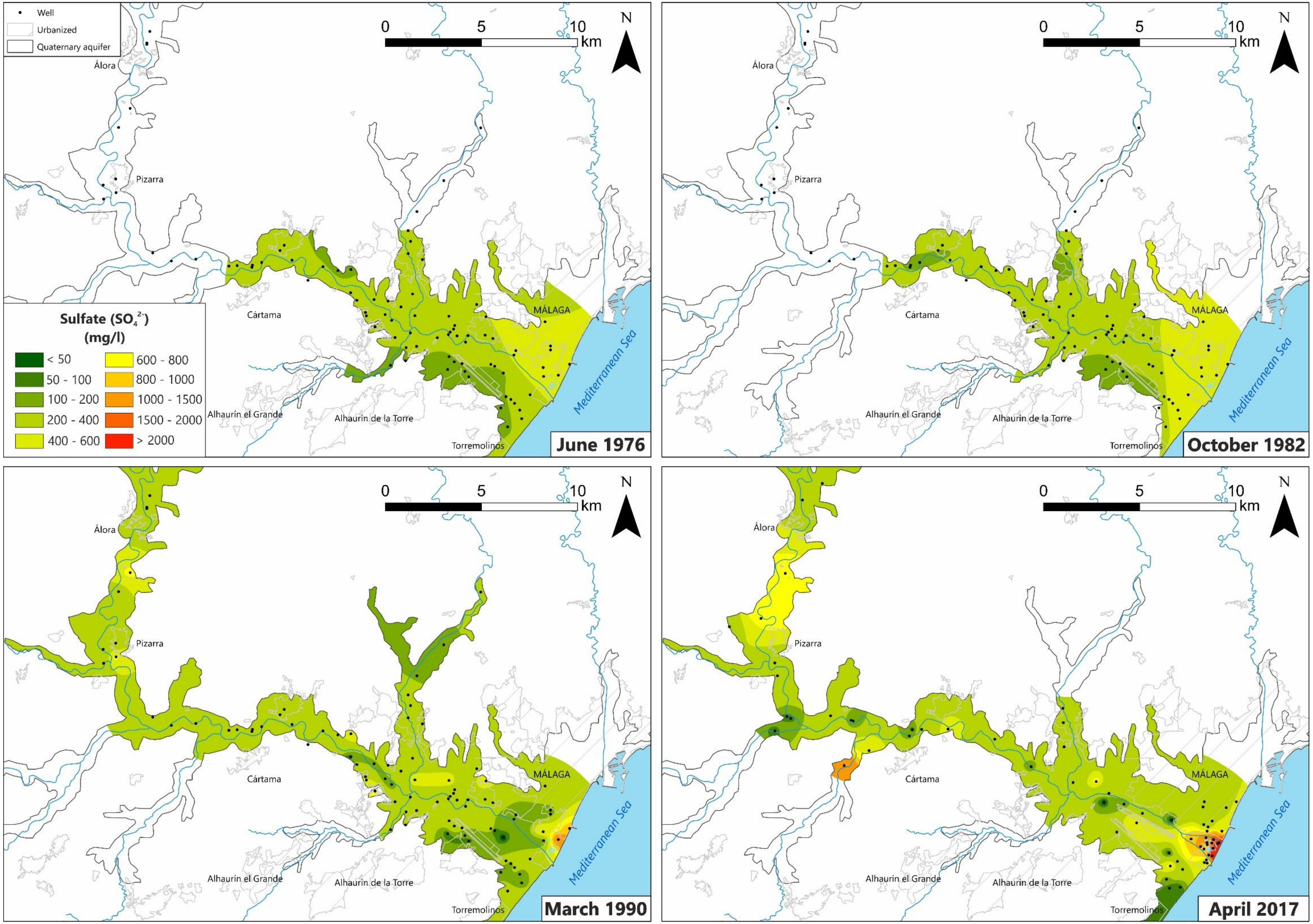


Electrical conductivity values were, generally, lower than 4 mS/cm in all samples and the major changes in groundwater mineralization were determined in the Guadalhorce River Mouth.



In the Guadalhorce River Mouth, substantial increases in groundwater mineralization were identified, up to 50% in some observation points. Cl^- and SO_4^{2-} concentrations in groundwater (the more concentrated solutes of all) evolve similarly in time to that of electrical conductivity, with maximum recorded values up to 10000 mg/l and 2000 mg/l, respectively, the coastal area in 2017.




Well
Urbanized
Quaternary aquifer
Sulfate (SO_4^{2-}) (mg/l)
< 50
50 - 100
100 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1500
1500 - 2000
> 2000
0
5
10
km
N
Álora
Pizarra
Cártama
MÁLAGA
Alhaurín el Grande
Alhaurín de la Torre
Torremolinos
Mediterranean Sea
June 1976
October 1982
March 1990
April 2017

Changes in EC and Cl^- and SO_4^{2-} concentrations in the river mouth area **could be related to the land use changes** that took place here between 1997 and 2003, where **channelization** works resulted in the splitting of the river in two branches. This could have affected to the aquifer hydrodynamics, due to the **reduced groundwater discharge** to the river mouth area between both branches. This could have favored the mixing among surface water, sea water and groundwater. Also, **the urbanized area has increased** over the years, reducing the recharge area of this part of the aquifer, but also flowing groundwater has increased because of pumping reduction (up to 7 hm^3/year). The presence of Cl^- in the aquifer, as well as SO_4^{2-}, is due to evaporite dissolution and the interaction with the Mediterranean Sea in the coastal area. An extra input of SO_4^{2-} comes from of the fertilizers used in agriculture.

The availability of long-term hydrogeological data in a coastal aquifer (1976-2017) has allowed to check a **remarkable salinization in the coastal area**, caused by land use modifications. So, the **monitoring** of hydrogeological data is a **very important tool** to be used by **land managers** in coastal aquifers, where groundwater can be seriously endangered by human activities.