FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

European Commission

ict4water.eu

# CASE STUDY: Velké Žernoseky the H2020 FREEWAT platform

## FREEWAT
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VODNÍ ZDROJE
AKCIOVÁ SPOLEČNOST

# CASE STUDY: Velké Žernoseky / Píšťany

3x3km area of complex water use:

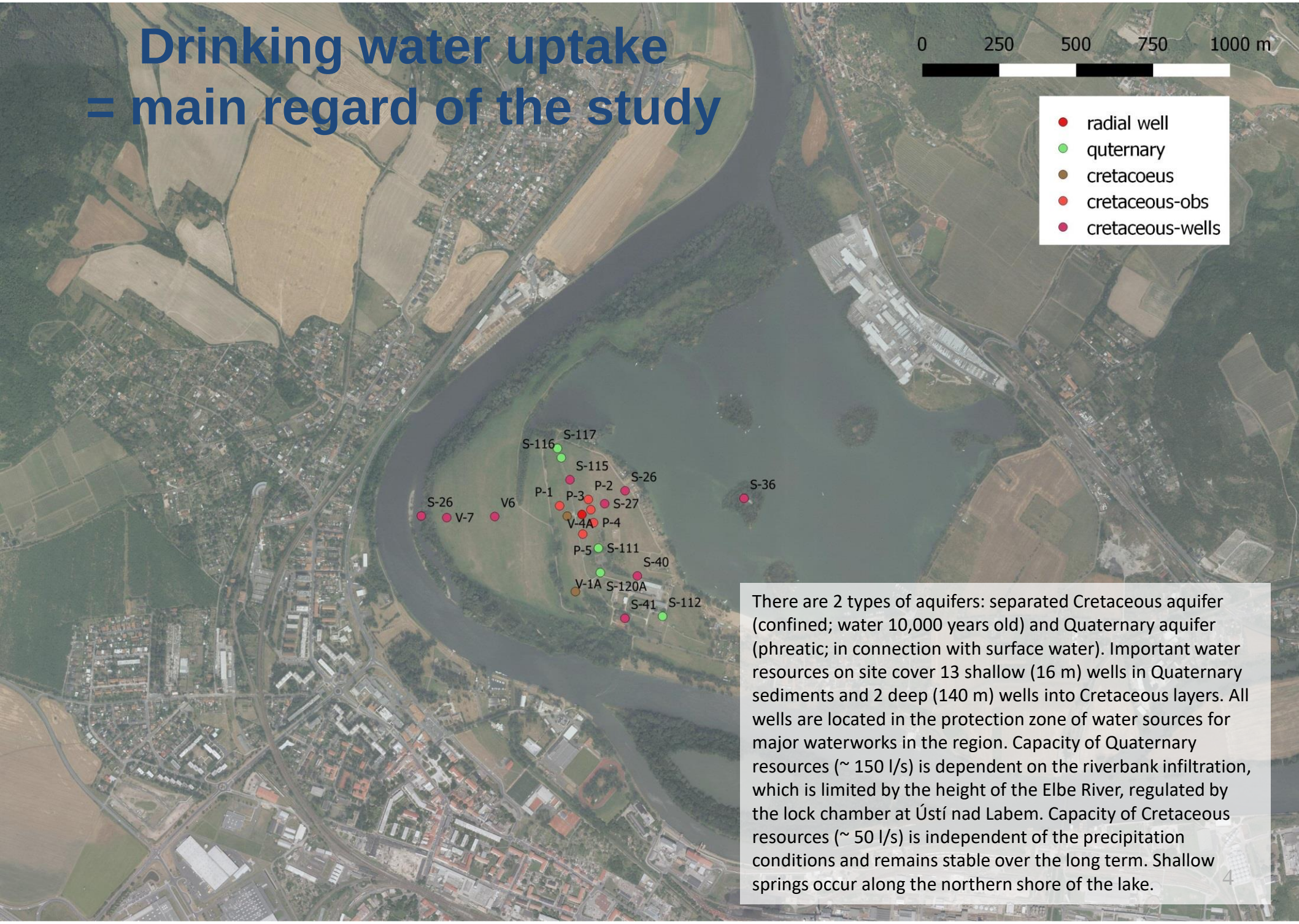
- Drinking water supply
- Elbe river navigability / hydropower generation
- Natural protected area
- Agricultural irrigation
- Chemical industry
- Recreation area

# partners involved / CS targets

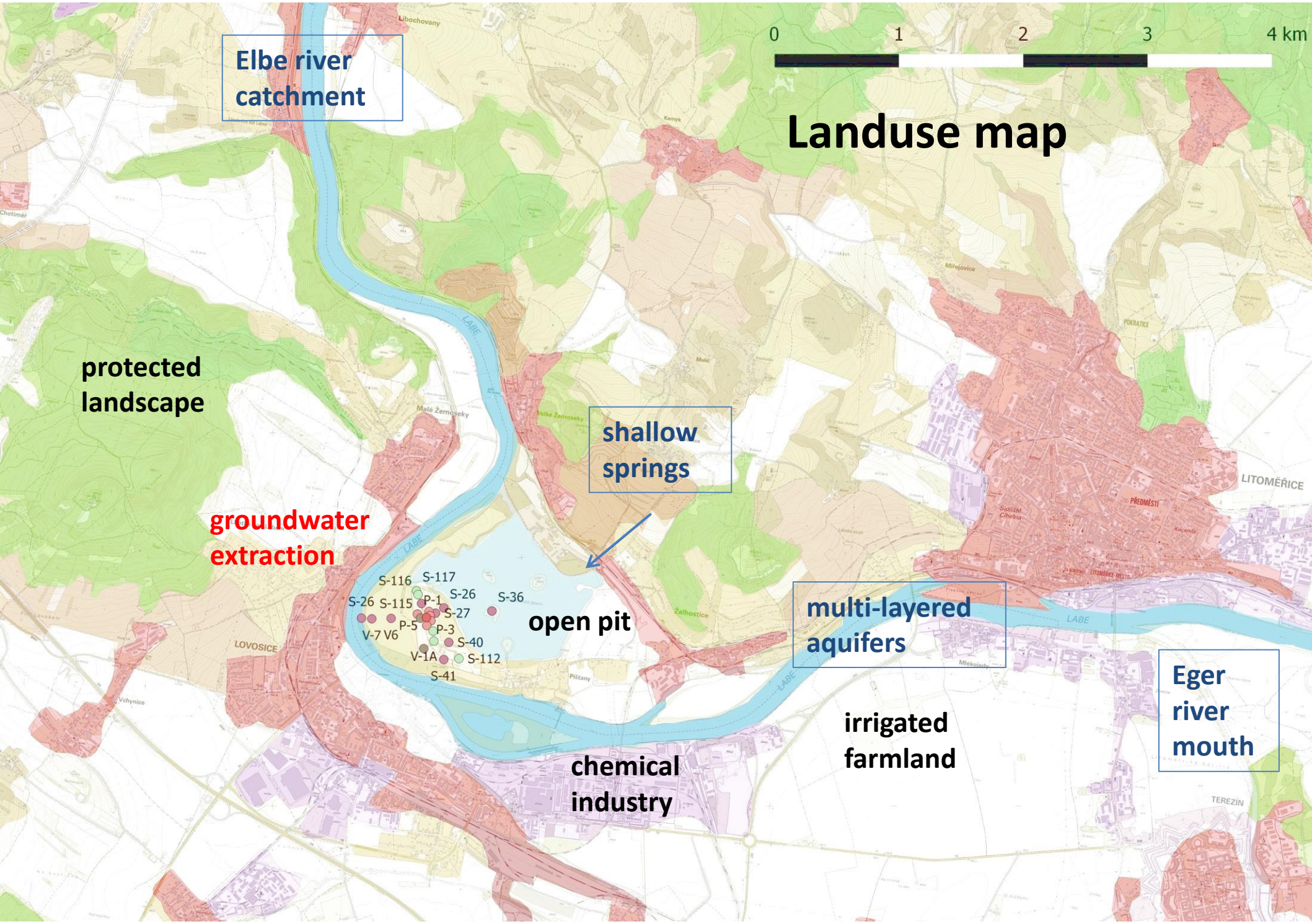
**Main beneficiary:** regional waterworks operator
**consultants**: Nature Conservation Agency of the Czech Republic , Elbe catchment authority, Eger river catchment authority
**Other partners:** Czech fishing Union, Ústecký region, Czech Hydrometeorological Institute
**5 municipalities**: Lovosice, Velké Žernoseky, Malé Žernoseky, Píšťany, Žalhostice
**water uptake for industry**: Lovosice
**irrigation**: Association of Private Farming of the Czech Republic

**MODFLOW model – ground water flow**
**BASIC TARGETS - variants:**
**ZERO – model calibration with no water pumping**
**AVR – average surface water heads and average pumping**
**finished**
**MIN – hydrologic balance for minimal water heads / droughts**
**MAX – hydrologic balance for maximal water heads**
not finished
**IRG** – further irrigation scenarios

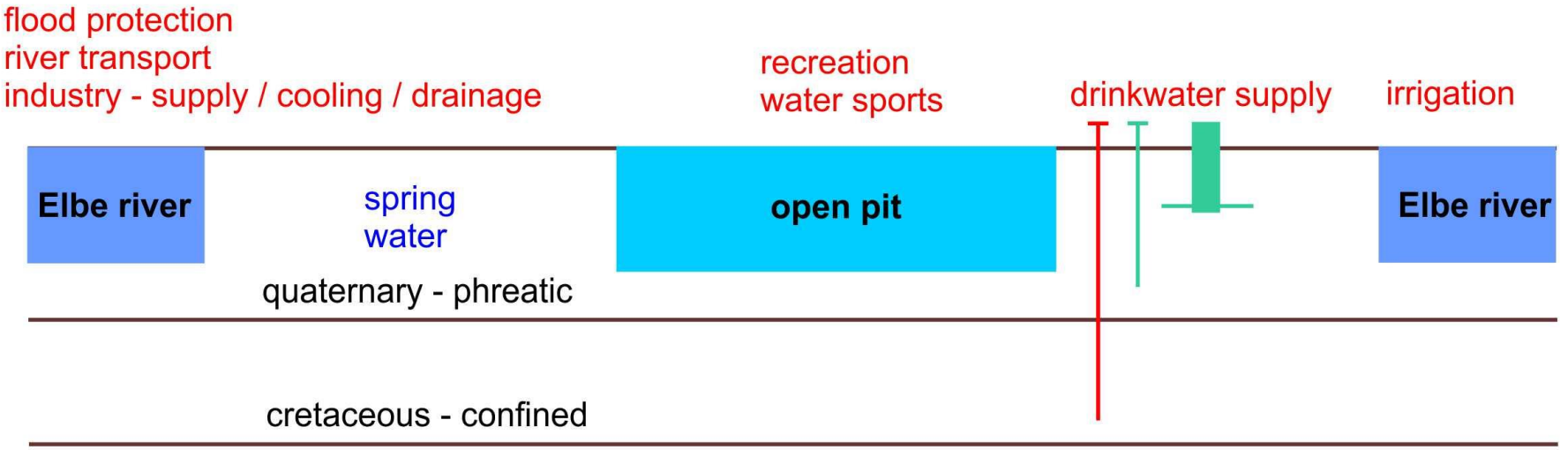
# Drinking water uptake = main regard of the study




There are 2 types of aquifers: separated Cretaceous aquifer (confined; water 10,000 years old) and Quaternary aquifer (phreatic; in connection with surface water). Important water resources on site cover 13 shallow (16 m) wells in Quaternary sediments and 2 deep (140 m) wells into Cretaceous layers. All wells are located in the protection zone of water sources for major waterworks in the region. Capacity of Quaternary resources (~ 150 l/s) is dependent on the riverbank infiltration, which is limited by the height of the Elbe River, regulated by the lock chamber at Ústí nad Labem. Capacity of Cretaceous resources (~ 50 l/s) is independent of the precipitation conditions and remains stable over the long term. Shallow springs occur along the northern shore of the lake.


Elbe river catchment
Landuse map
0
1
2
3
4 km
protected landscape
shallow springs
groundwater extraction
open pit
multi-layered aquifers
Eger river mouth
irrigated farmland
chemical industry
S-116
S-117
S-26
S-36
S-26
S-115
P-1
S-27
P-5
P-3
V-7
V6
S-40
V-1A
S-112
S-41
LABE
LOVOSICE
LITOMĚŘICE
TEREZIN

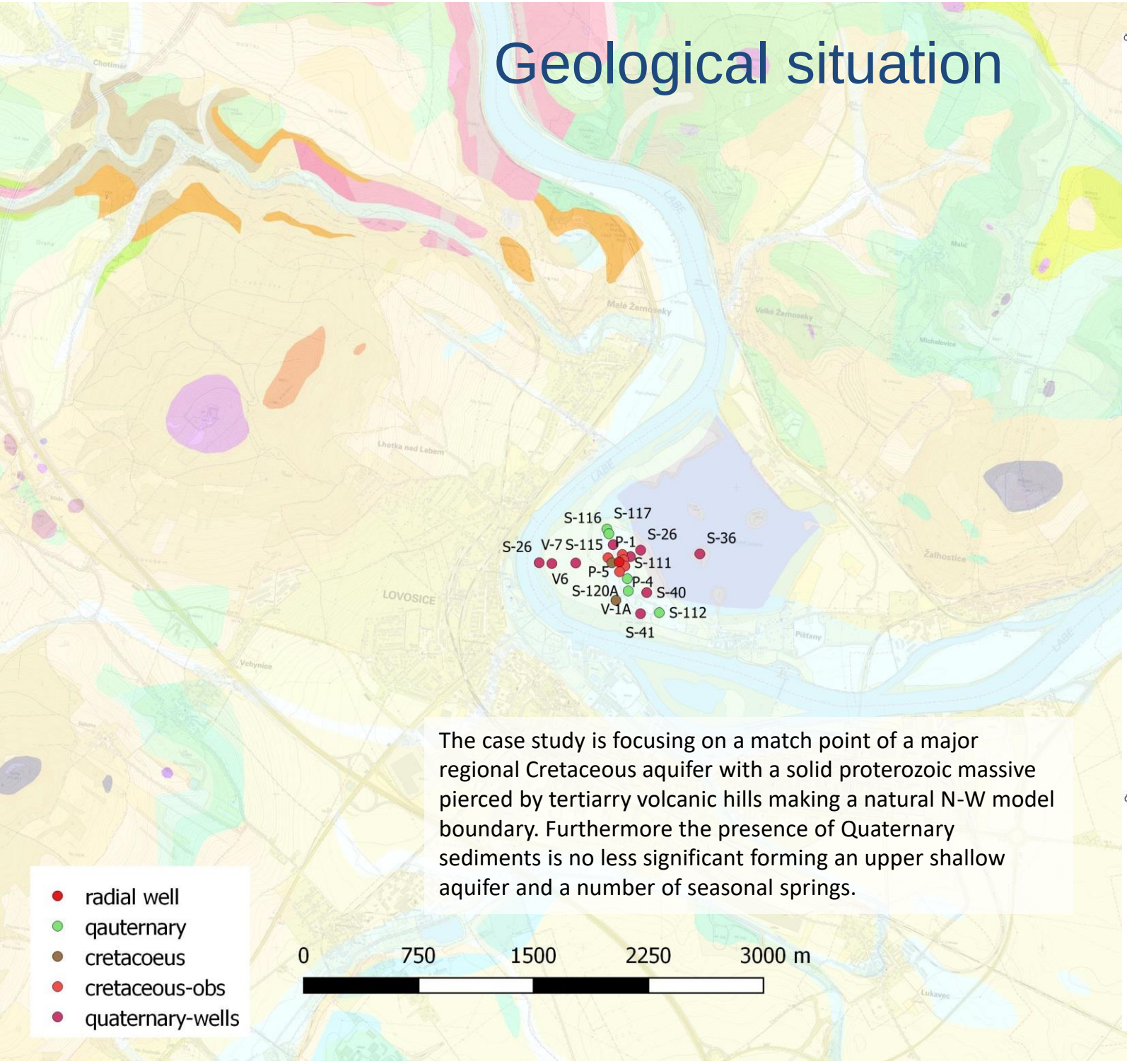
# conceptual model - PM




| aquifer | aquitard | stratigraphy | symbol | age | model layer |
|---|---|---|---|---|---|
| Q | | | | Quaternary | 1 |
| | | | | | |
| D | | merbolticke | Km | coniak / santon | není |
| | | brezenske | Kbr | | |
| | | rohatecke | Kr | | |
| | C/D | teplicke | Kt | Upper Turonian | |
| C | | jizerske | Kj | Cretaceous | 2 |
| | C/D | | | Middle Turonian | |
| B | | belohorske | Kb | Cretaceous | 3 |
| | | | | Lower Turonian | |
| A | | korycanske | KK | Cretaceous | 4 |
| | | perucke | Kp | Cenomanian | |

The main issue to be faced is optimization of groundwater sources management focusing on drinking water for major waterworks company in the region. The pumping wells cover 2 separated aquifers with direct influence of surface water management (transport, irrigation, industry, recreation, agriculture) and quality (surface water and groundwater relation)

# Geological situation



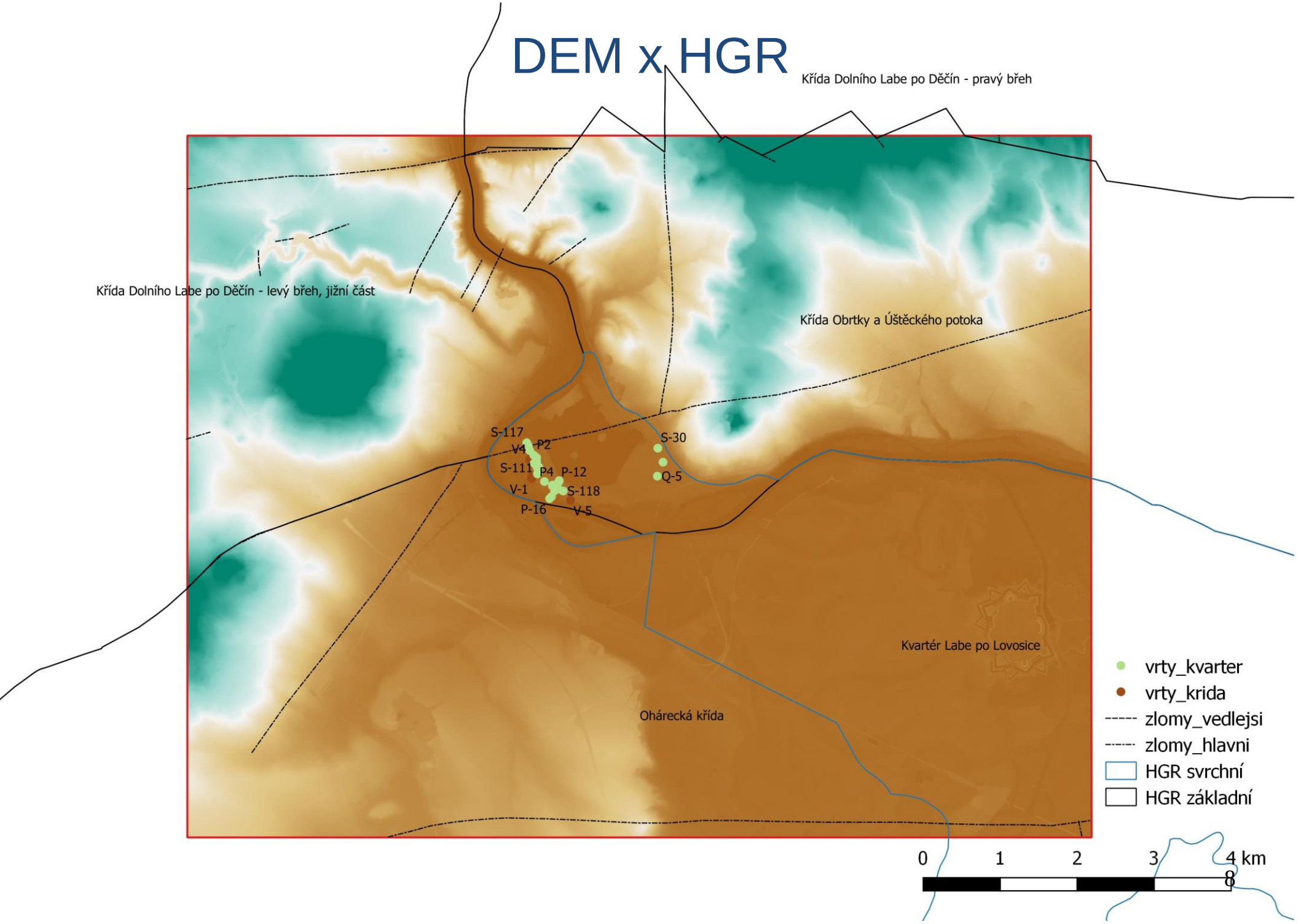

The case study is focusing on a match point of a major regional Cretaceous aquifer with a solid proterozoic massive pierced by tertiarry volcanic hills making a natural N-W model boundary. Furthermore the presence of Quaternary sediments is no less significant forming an upper shallow aquifer and a number of seasonal springs.

- radial well
- qauternary
- cretacoeus
- cretaceous-obs
- quaternary-wells

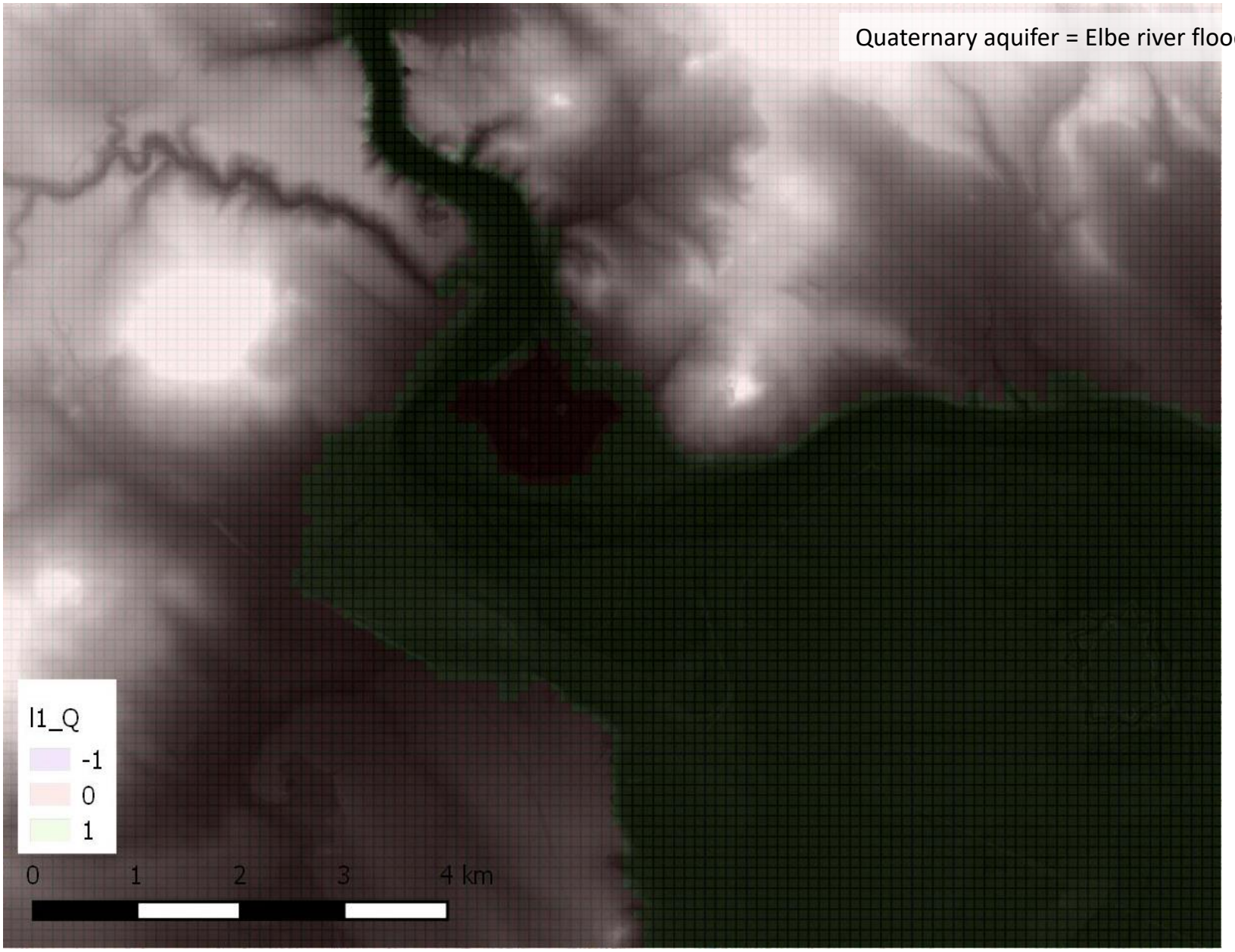
0 750 1500 2250 3000 m

Český masiv - pokryvné útvary a postvariské magmatity
- vulkanity permokarbonu
  - svrchní karbon a perm
    - Jednotka nerozlišena
      - 2049 ryolit
- česká křídová pánev
  - křída
    - labský vývoj, oharecký vývoj, orlicko-žďárský vývoj, lužický vývoj
      - 297 slínovce s polohami či konkrecemi vápenců, rytmy či cykly slínovec - vápenec (jílovito vápnité prachovce -lužický vývoj))
    - oharecký vývoj
      - 291 vápence jílovité a slínovce (střídání)
    - vltavo-berounský vývoj, orlicko-žďárský vývoj
      - 307 písčité slínovce až jílovce spongilitické, místy silicifikované (opuky)
    - oharecký vývoj, jizerský vývoj
      - 287 silicifikované jílovité vápence a slínovce
    - oharecký vývoj, lužický vývoj, labský vývoj
      - 281 vápnité jílovce, slínovce, vápnité prachovce
- rozptýlené alkalické vulkanity
  - terciér
    - výskyty v Krušných horách
      - 163 sodalitický trachyt
- podkrušnohorské pánve a přilehlé vulkanické hornatiny, rozptýlené alkalické vulkanity
  - terciér
    - České středohoří, území české křídové tabule
      - 193 olivinický nefelinit, analcimit a 'leucitit'
    - České středohoří, území české křídové tabule, západosudetská (lužická) oblast
      - 183 alk. ol. bazalt - bazanit - limburgit
- relikty sladkovodního terciéru
  - terciér
    - Jednotka nerozlišena
      - 130 štěrky, písčité štěrky, písky s vložkami jílů
- Region nerozlišen
  - kvartér
    - Jednotka nerozlišena
      - 13 kamenitý až hlinito-kamenitý sediment
      - 7 smíšený sediment
      - 17 spraš a sprašová hlína
      - 28 písek, štěrk
      - 1 navážka, halda, výsypka, odval
      - 48 karbonát sladkovodní (vápenec, travertin, pramenit, pěnovec)
      - 6 nivní sediment
      - 20 sediment deluvioeolický
      - 12 písčito-hlinitý až hlinito-písčitý sediment
      - 15 navátý písek
- Český masiv - krystalinikum a prevariské paleozoikum
  - krušnohorsko-smrčinské krystalinikum
    - sasko-durynská oblast (saxothuringikum)
      - Jednotka nerozlišena
        - 1485 ortorula
  - slavkovské krystalinikum
    - sasko-durynská oblast (saxothuringikum)
      - Jednotka nerozlišena
        - 1469 migmatit s prevahou ortosložky až hybridní granit
  - Barrandien
    - středočeská oblast (bohemikum)
      - proterozoikum Barrandienu
        - 767 chlorit-sericitický fylit
        - 772 zelená břidlice

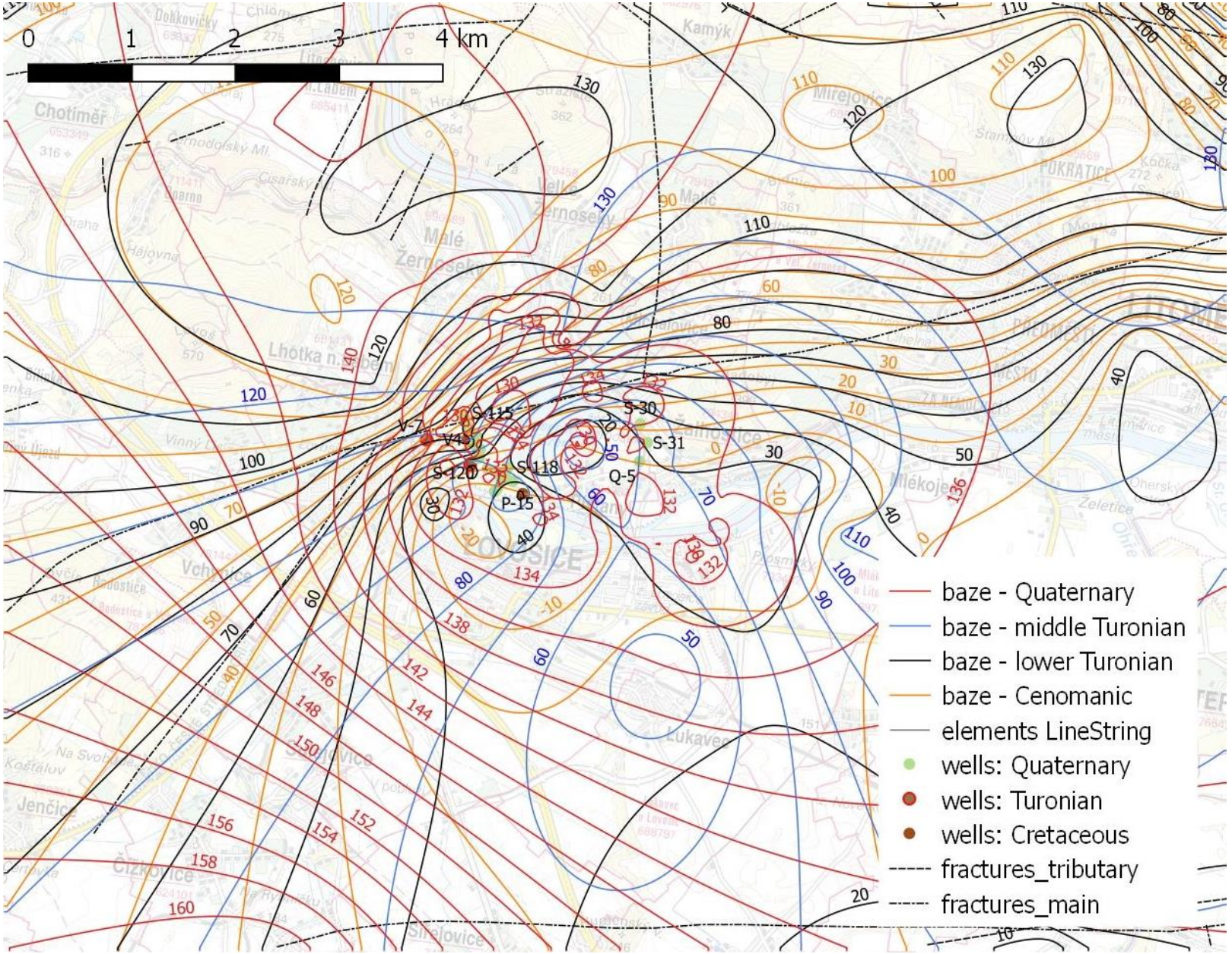
# DEM x HGR


Křída Dolního Labe po Děčín - pravý břeh
Křída Dolního Labe po Děčín - levý břeh, jižní část
Křída Obrtky a Úštěckého potoka
S-117
V4
P2
S-111
P4
P-12
V-1
S-118
P-16
V-5
S-30
Q-5
Kvartér Labe po Lovosice
Ohárecká křída
vrty_kvarter
vrty_krida
zlomy_vedlejsi
zlomy_hlavni
HGR svrchní
HGR základní
0
1
2
3
4 km

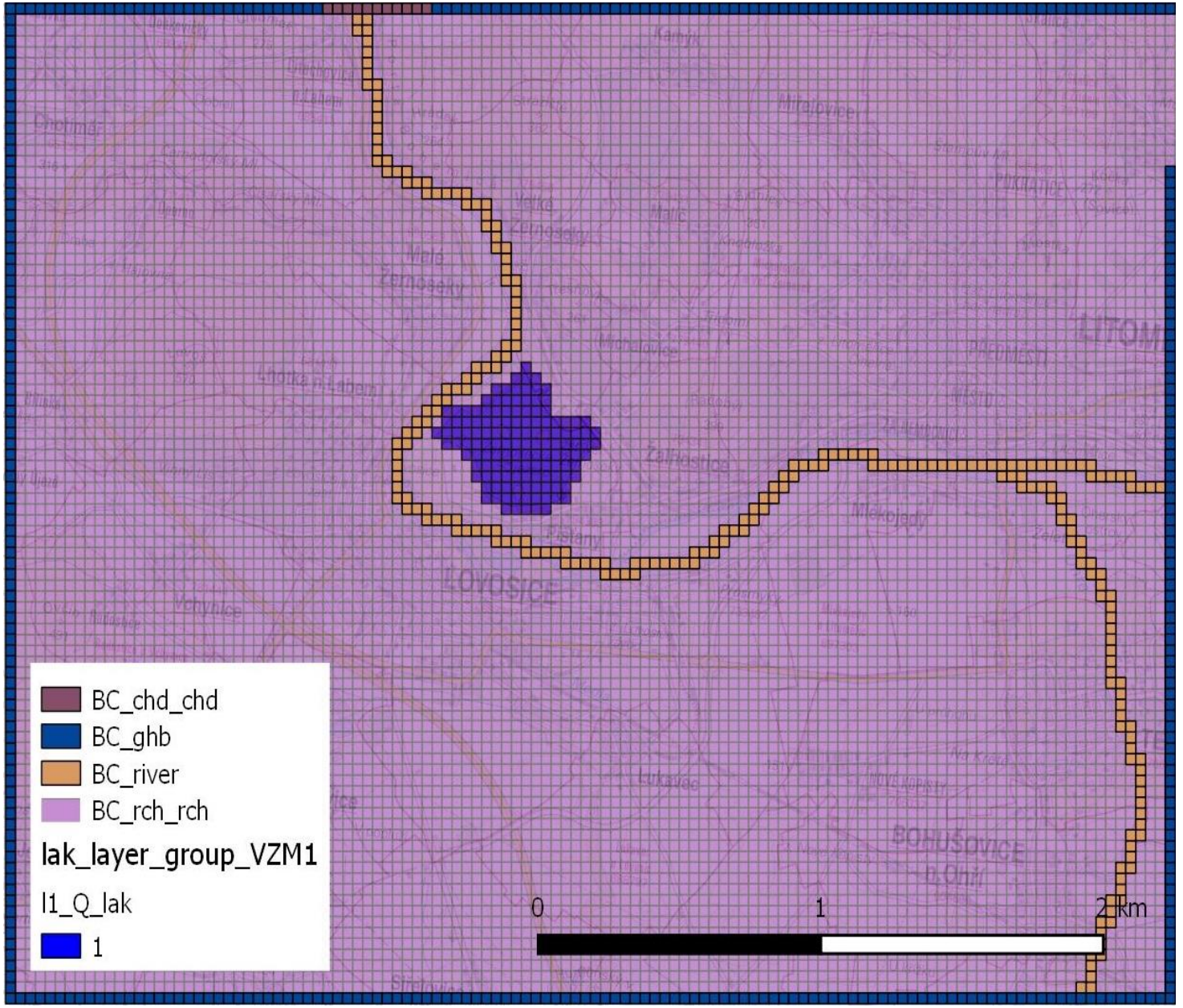
# model layer 1 – DEM based



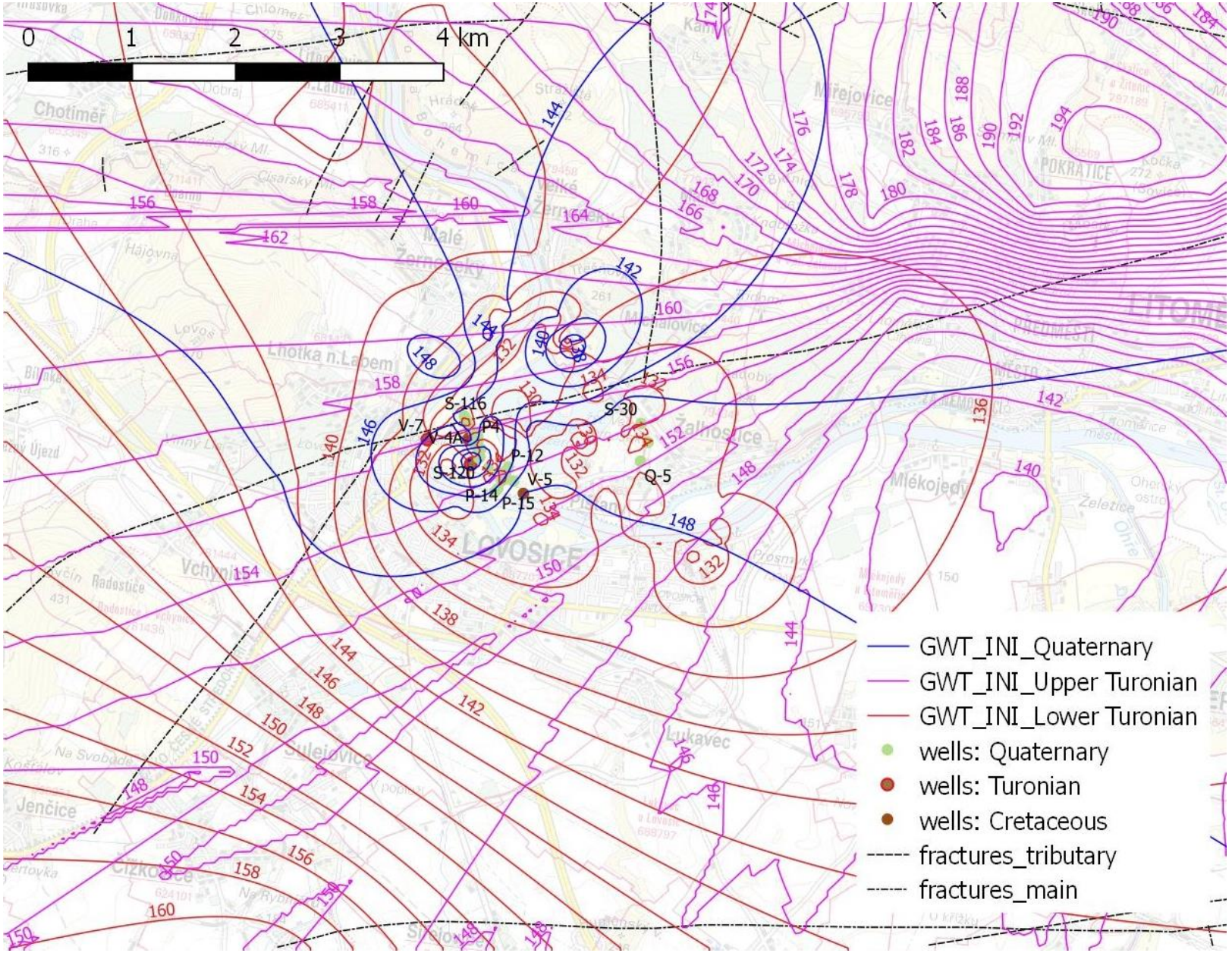
# GW aquifer bases



# GW – boundary conditions



# GW INITIAL heads



# MODFLOW – balance results
# ZERO/AVR

CUMULATIVE VOLUMES L**3 RATES FOR THIS TIME STEP L**3/T

IN:
---
STORAGE = 0.0000
CONSTANT HEAD = 12.8850
RIVER LEAKAGE = 8.3637
HEAD DEP BOUNDS = 3304.7778
RECHARGE = 1187.5275
LAKE SEEPAGE = 0.0000
TOTAL IN = 4513.5542

OUT:
---
STORAGE = 0.0000
CONSTANT HEAD = 34.3536
RIVER LEAKAGE = 1504.1893
HEAD DEP BOUNDS = 2967.4702
RECHARGE = 0.0000
LAKE SEEPAGE = 0.3879
TOTAL OUT = 4506.4009
IN - OUT = 7.1533
PERCENT DISCREPANCY = 0.16

IN:
---
STORAGE = 0.0000
CONSTANT HEAD = 3.5301E-02
RIVER LEAKAGE = 2.2914E-02
HEAD DEP BOUNDS = 9.0542
RECHARGE = 3.2535
LAKE SEEPAGE = 0.0000
TOTAL IN = 12.3659

OUT:
---
STORAGE = 0.0000
CONSTANT HEAD = 9.4119E-02
RIVER LEAKAGE = 4.1211
HEAD DEP BOUNDS = 8.1301
RECHARGE = 0.0000
LAKE SEEPAGE = 1.0627E-03
TOTAL OUT = 12.3463
IN - OUT = 1.9598E-02
PERCENT DISCREPANCY = 0.16

CUMULATIVE VOLUMES L**3 RATES FOR THIS TIME STEP L**3/T

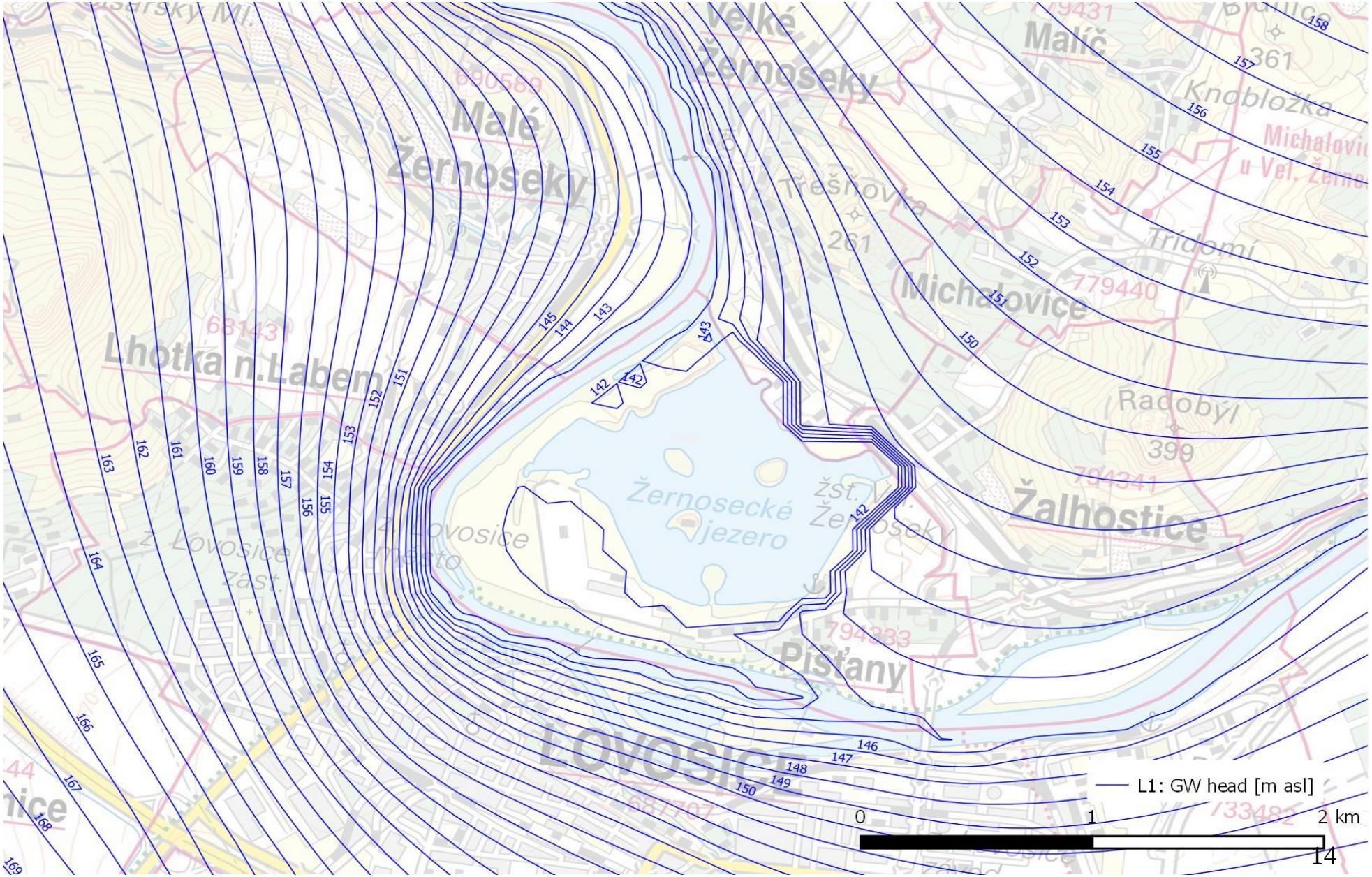
IN:
---
STORAGE = 0.0000
CONSTANT HEAD = 12.8906
WELLS = 0.0000
RIVER LEAKAGE = 8.2681
HEAD DEP BOUNDS = 9727.1982
RECHARGE = 1174.4969
LAKE SEEPAGE = 3.2884E-03
TOTAL IN = 10922.8564

OUT:
---
STORAGE = 0.0000
CONSTANT HEAD = 33.9201
WELLS = 55.3340
RIVER LEAKAGE = 1516.5037
HEAD DEP BOUNDS = 5189.5337
RECHARGE = 0.0000
LAKE SEEPAGE = 0.3669
TOTAL OUT = 6795.6582
IN - OUT = 4127.1982
PERCENT DISCREPANCY = 46.59

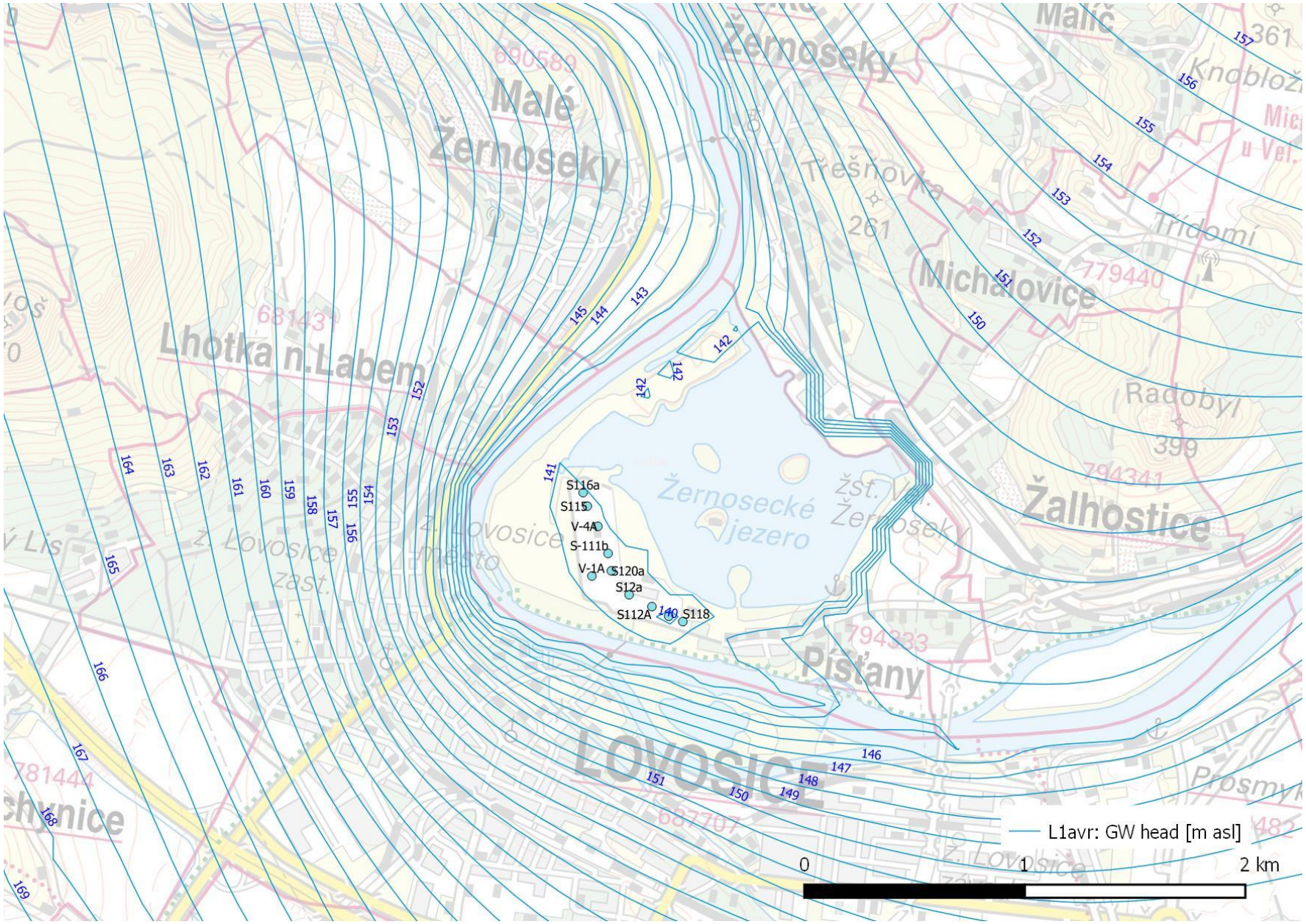
IN:
---
STORAGE = 0.0000
CONSTANT HEAD = 3.5317E-02
WELLS = 0.0000
RIVER LEAKAGE = 2.2652E-02
HEAD DEP BOUNDS = 26.6499
RECHARGE = 3.2178
LAKE SEEPAGE = 9.0092E-06
TOTAL IN = 29.9256

OUT:
---
STORAGE = 0.0000
CONSTANT HEAD = 9.2932E-02
WELLS = 0.1516
RIVER LEAKAGE = 4.1548
HEAD DEP BOUNDS = 14.2179
RECHARGE = 0.0000
LAKE SEEPAGE = 1.0052E-03
TOTAL OUT = 18.6182
IN - OUT = 11.3074
PERCENT DISCREPANCY = 46.59

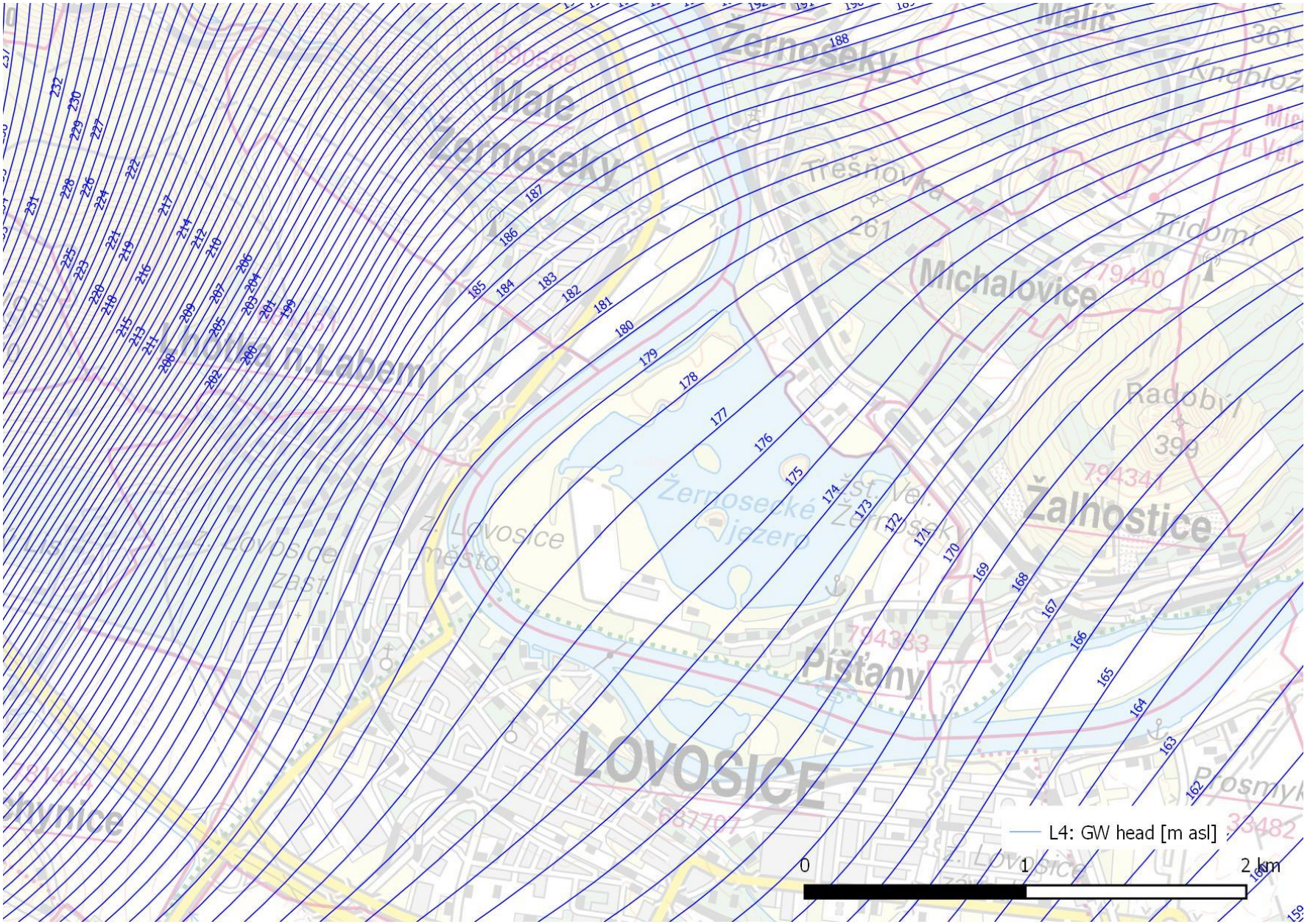
# WMS ZERO – L1 (Quaternary)



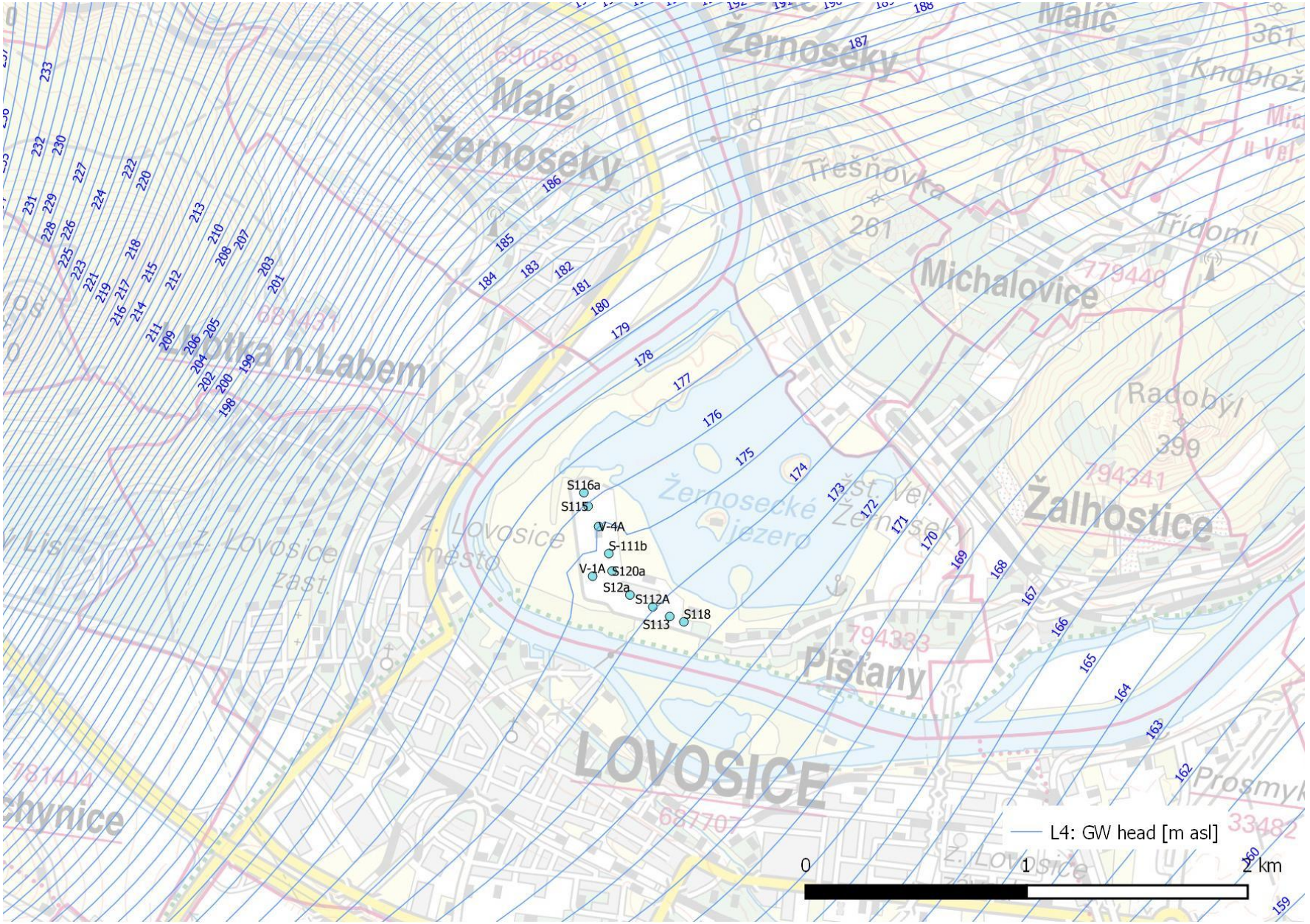
# WMS AVR – L1 (Quaternary)



# WMS ZERO – L4 (Cretaceous)



# WMS AVR – L4 (Cretaceous)

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