



University of Split
Faculty of Civil Engineering, Architecture and Geodesy

Modelling seawater intrusion in Neretva coastal aquifer system - climate change and mitigation measures

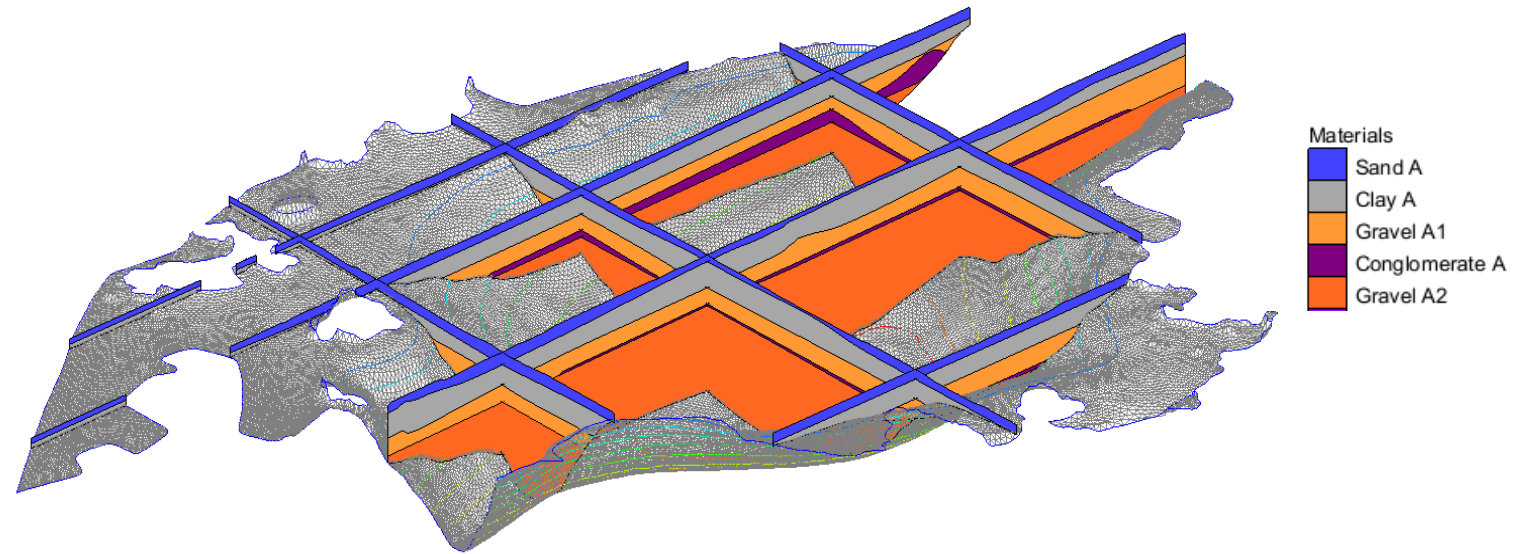
Iva Matic
Chioggia, October 11, 2021

Content

- Model display
- Flow and transport boundary conditions
- Spatial-temporal analysis of salinity fields
- Steady state models
 - Winter period
 - Summer period
 - Summer period with barrier
- Calibration and verification
- Climate changes
- Mitigation measures

Model display

- Opuzen-Adriatic sea-River Neretva
- Horizontal discretization -50x50m
- Vertical discretization – 11 layers
- Bedrock determination
- Determination of geological layers



Geological layer	Max depth (m)	Min depth (m)	Kh (m/s)	Specific storage	Specific yield	Porosity
Sand	10.0	-10.0	1e-4	0.00004	0.25	0.3
Clay	-10.0	-30.0	1e-8	0.0055	0.02	0.45
Gravel	-30.0	-45.0	1e-3	3e-6	0.25	0.3
Conglomerate	-45.0	-48.0	1e-15	1e-15	1e-15	0
Gravel	-48.0	-150.0	1e-3	3e-6	0.025	0.3

Flow boundary conditions

- Bedrock – dynamic boundary condition $\frac{dh}{dz} = 0$
- Sea boundary condition
 - Tide gauge readings
- Opuzen boundary condition
 - Specified flow
- River Neretva
 - Tide gauge and limnigraph readings
- Mala Neretva and channels – RIV Package
 - CS Prag-Vidrice and CS Modrič
 - Field measurements

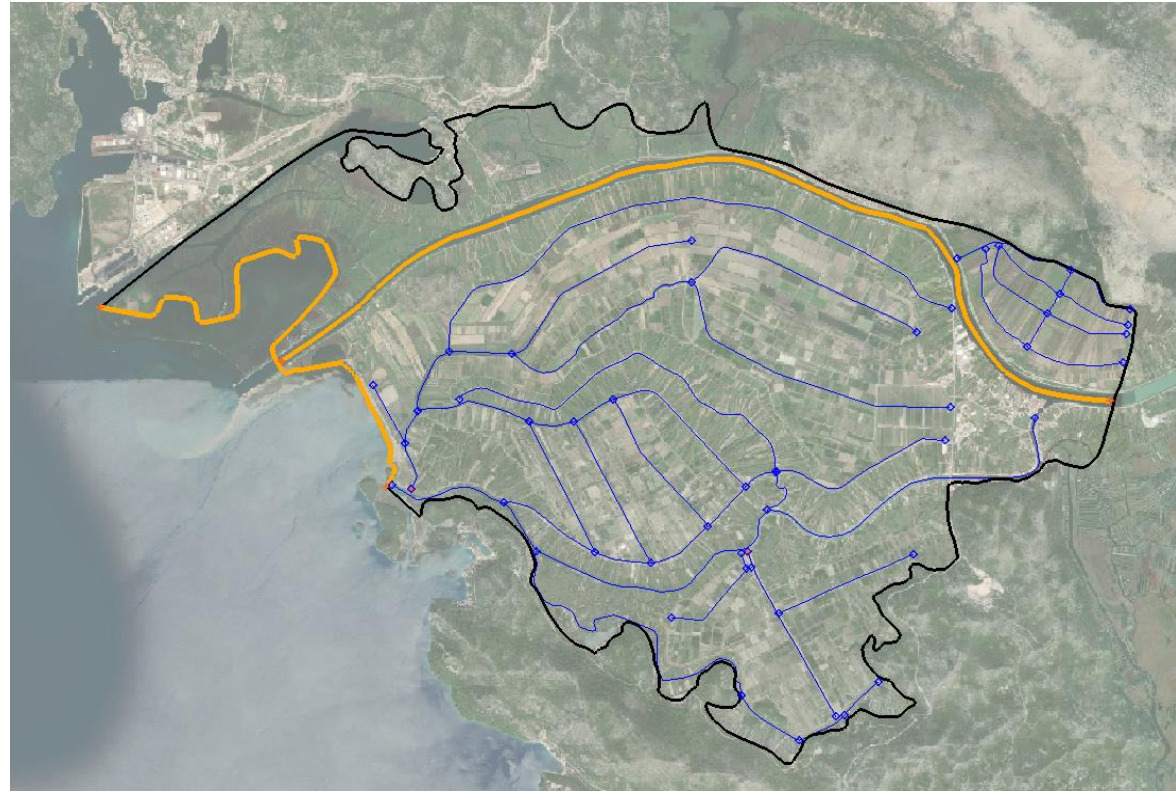


Transport boundary conditions

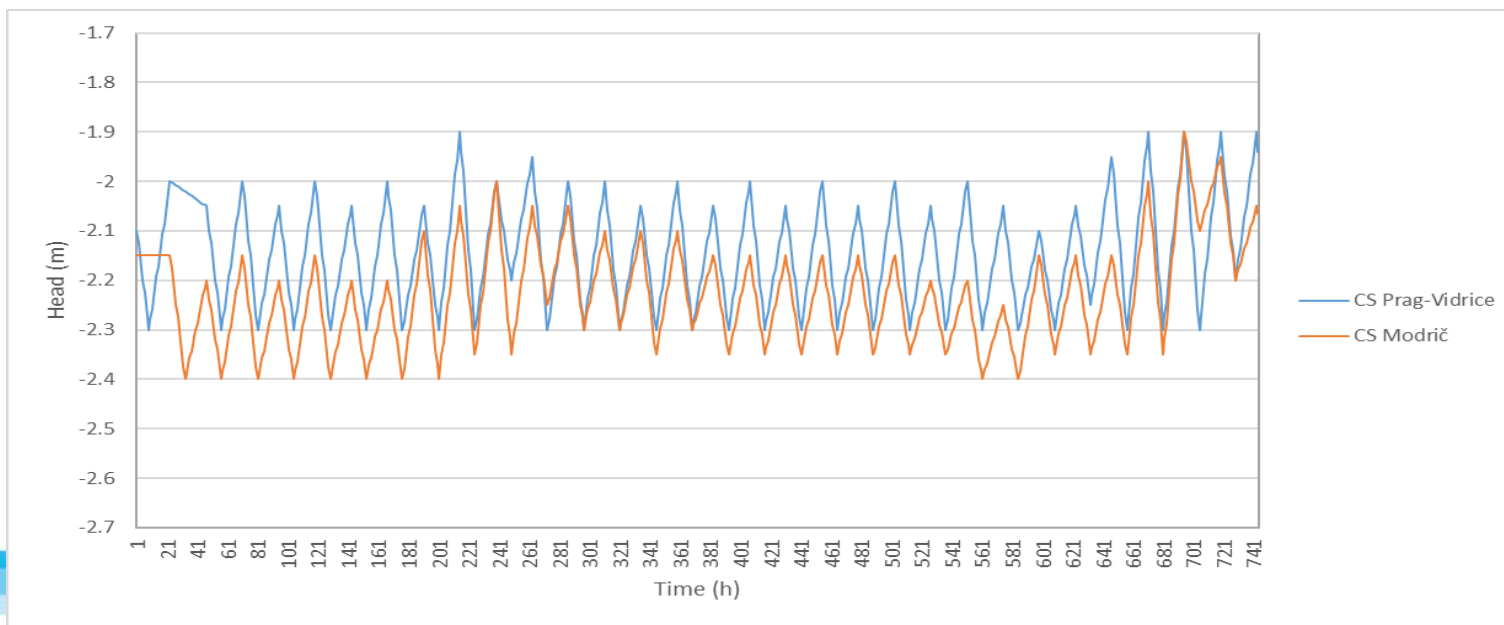
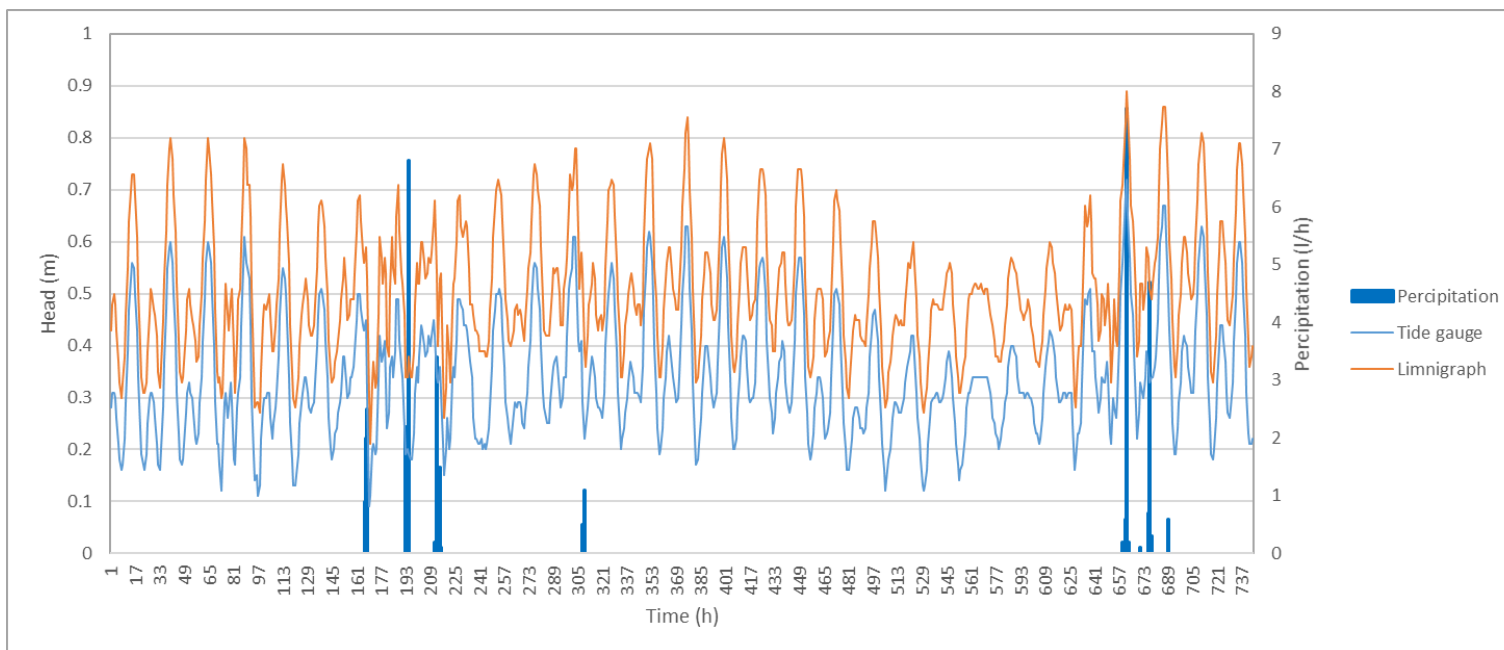
- Sea boundary condition
 - Concentration 36 g/l
- Opuzen boundary condition
 - $\frac{dC}{cX} \neq 0$
- River Neretva
 - Winter period – 0 g/l
 - Summer period – 36 g/l
- Mala Neretva and channels
 - $\frac{dC}{dX} \neq 0$; $\frac{dC}{dZ} \neq 0$

Initial conditions

- $C(x, y, z, 0) = 0 \text{ g/l}$



- Levels obtained on the tide gauge and limnigraph are used as a boundary condition for the sea and the river Neretva in the model
- Levels from CS Prag-Vidrice and CS Modrič are used as levels in the canals
- Precipitation is used for transient model simulations



Spatial-temporal analysis of salinity fields

- Scenarios

- Winter period – Sea concentration 36 g/l
- Summer period – Sea and river Neretva concentration 36 g/l
- Summer period with barrier – Sea concentration 36 g/l
– River Neretva concentration to the barrier 36 g/l

Boundary conditions for initial state

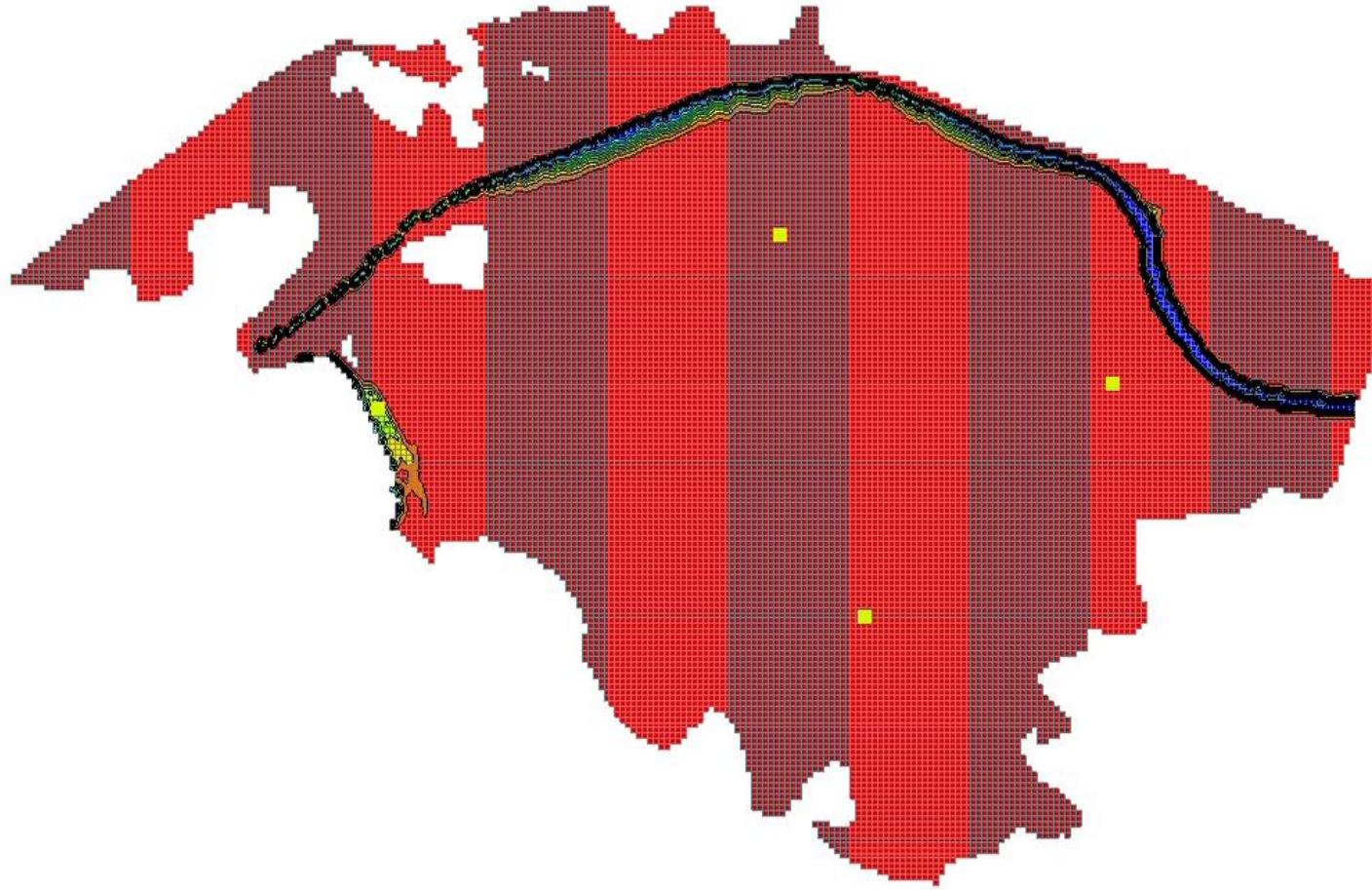
Steady state (200-500 years)

Initial conditions for flow and transport

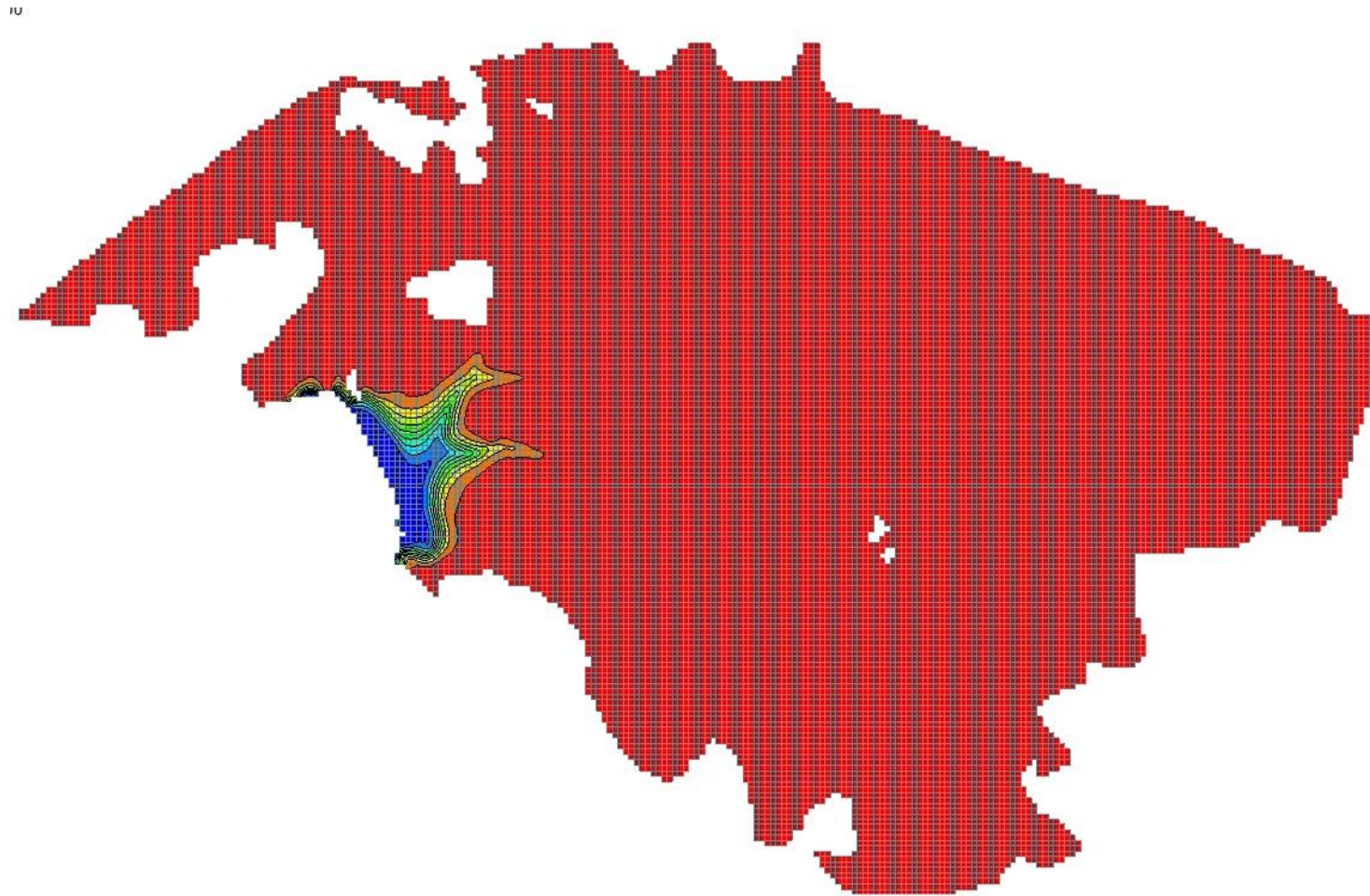
Boundary conditions for transient model

Model establishment

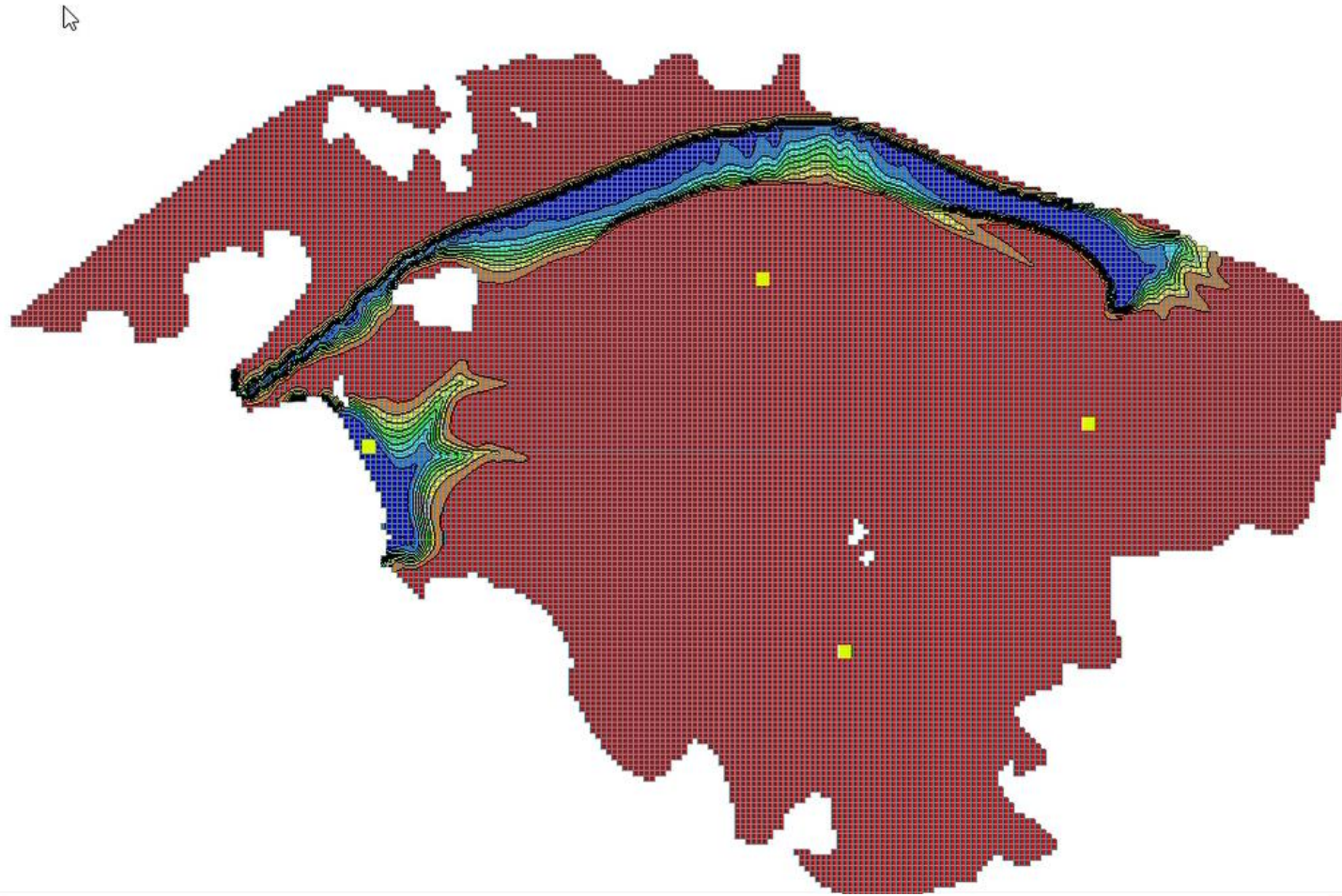
Steady state model – winter period



Steady state model – summer period

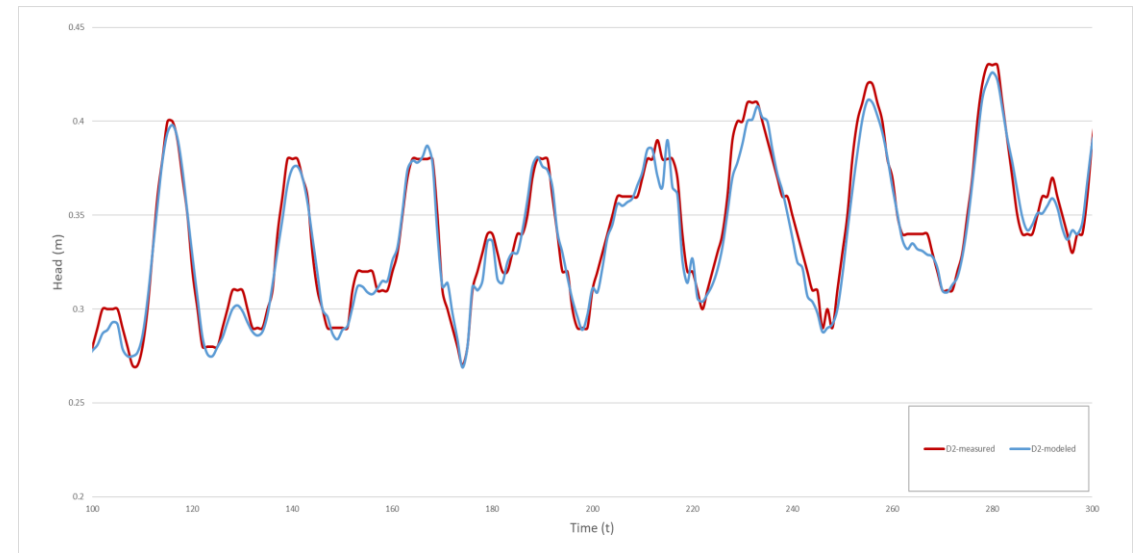
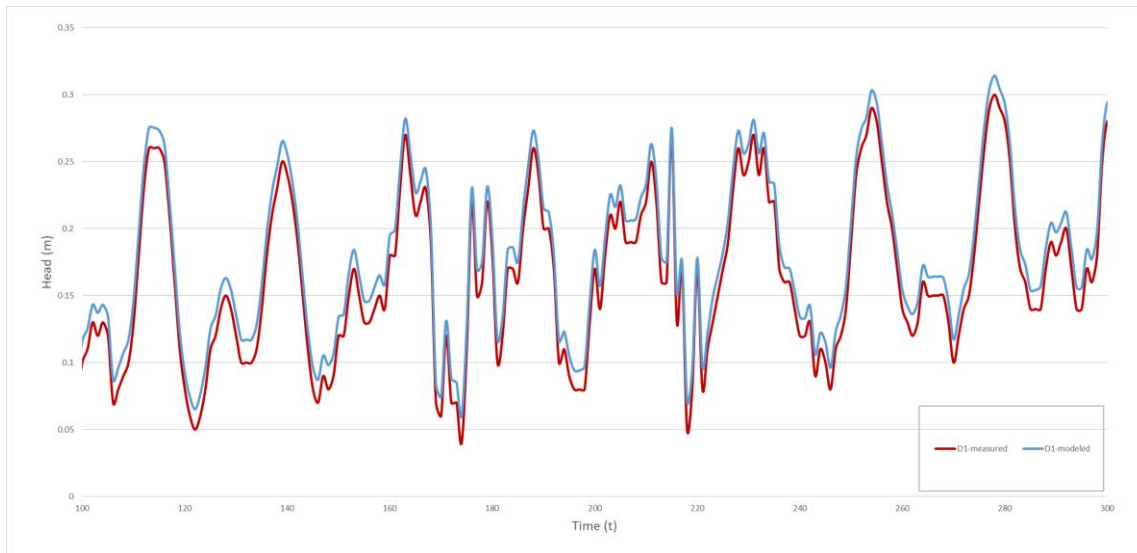


Steady state model – summer period with barrier



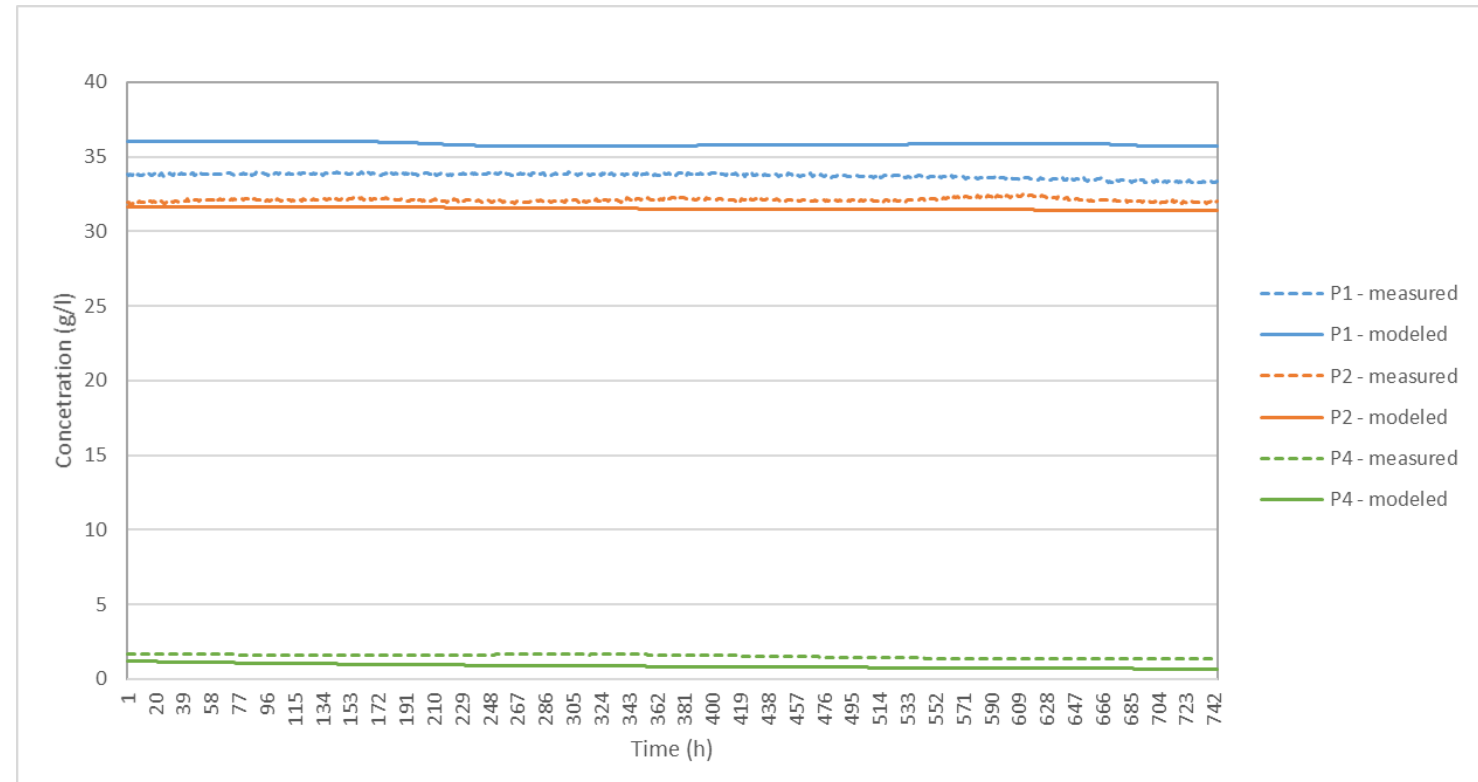
Calibration and verification of results

- Values measured on piezometers (P1-D4) compared with values obtained in the model
- Calibration of geological layer characteristics and boundary conditions
- Zoning of the layers in the model
- Calibration of channel conductance
- Verification on piezometer values in another time period



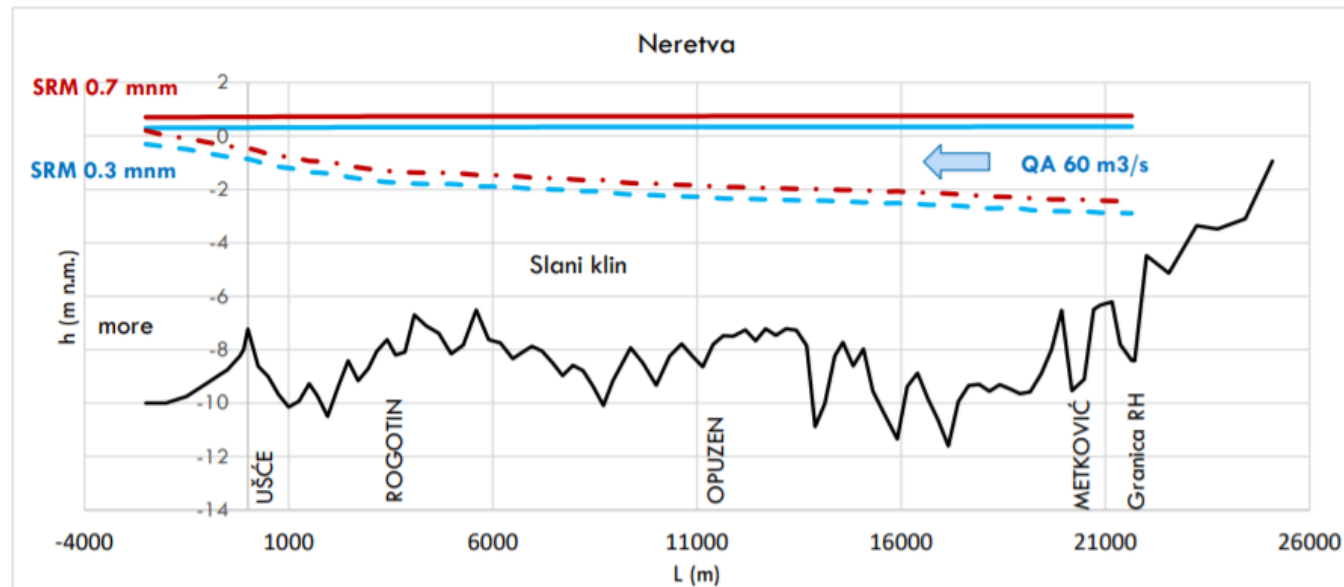
Salinity results calibration

- Transient simulation for July 2019
- Initial conditions from summer steady state results
- P1 – mean measured value 33.72 g/l
- P1 – mean modeled value 35.8 g/l
- P2 – mean measured value 32.1 g/l
- P2 – mean modeled value 31.5 g/l
- P4 – mean measured value 1.5 g/l
- P4 – mean modeled value 1.2 g/l

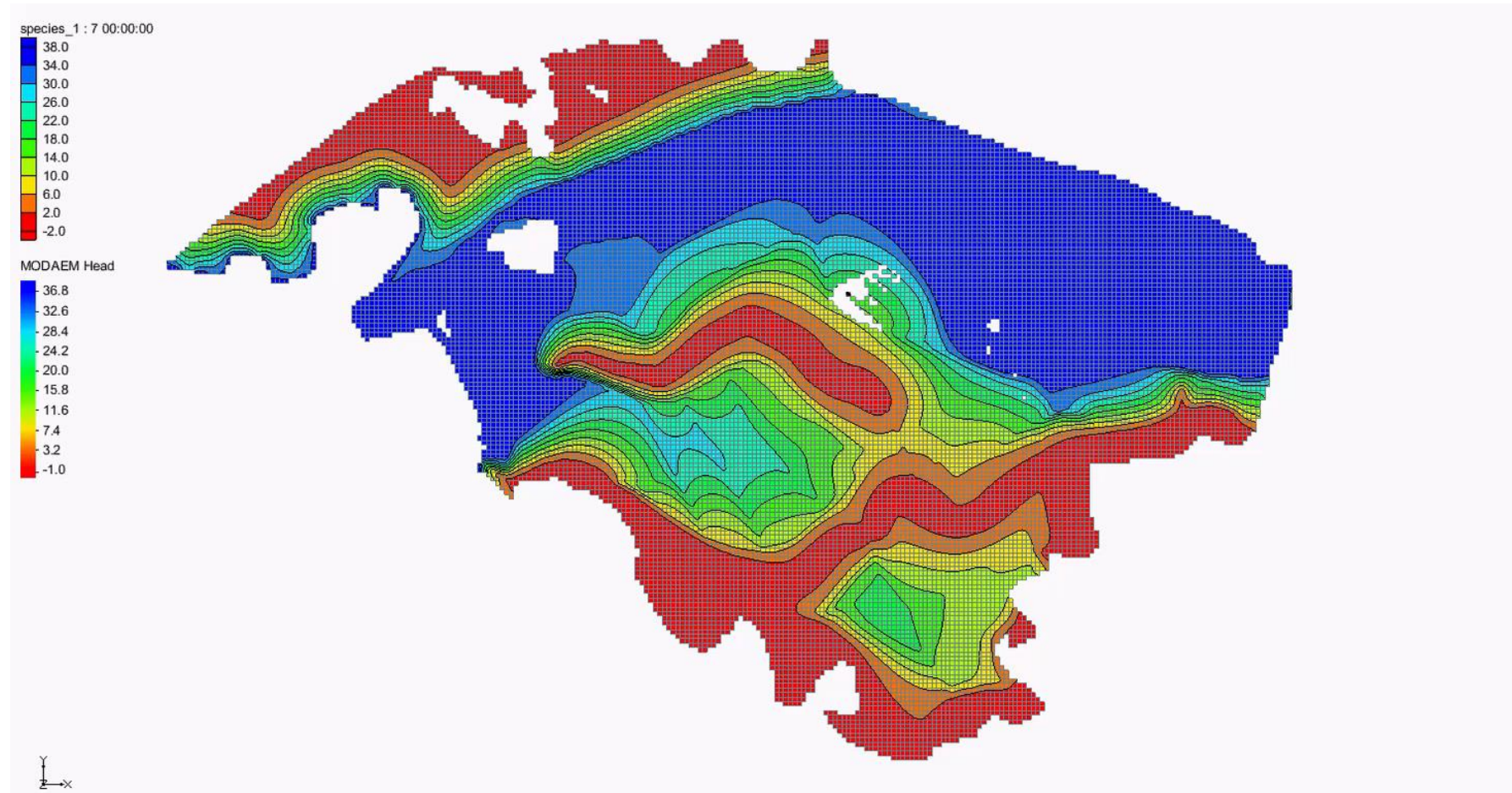


Climate changes

- For the coastal area, the most important elements of climate change are: sea level rise, changes in the precipitation regime, increase in air temperature, sea surface temperature rise, increase in sea salinity and changes in wind regime.
- Sea level rise - assumed future level +0.7 m

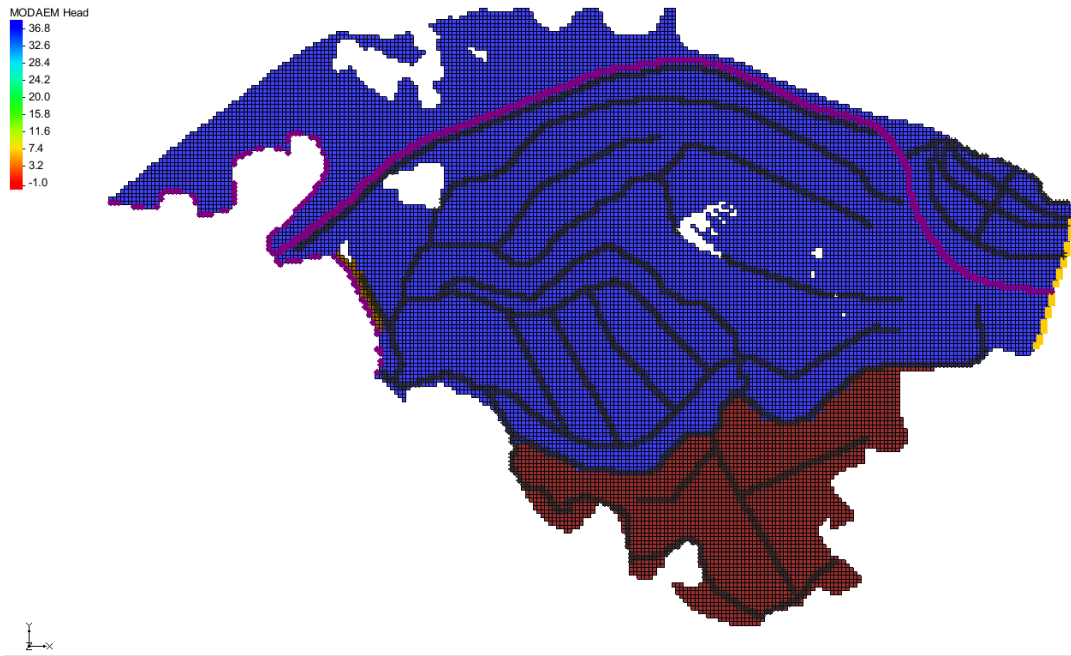


Climate changes – sea level rise

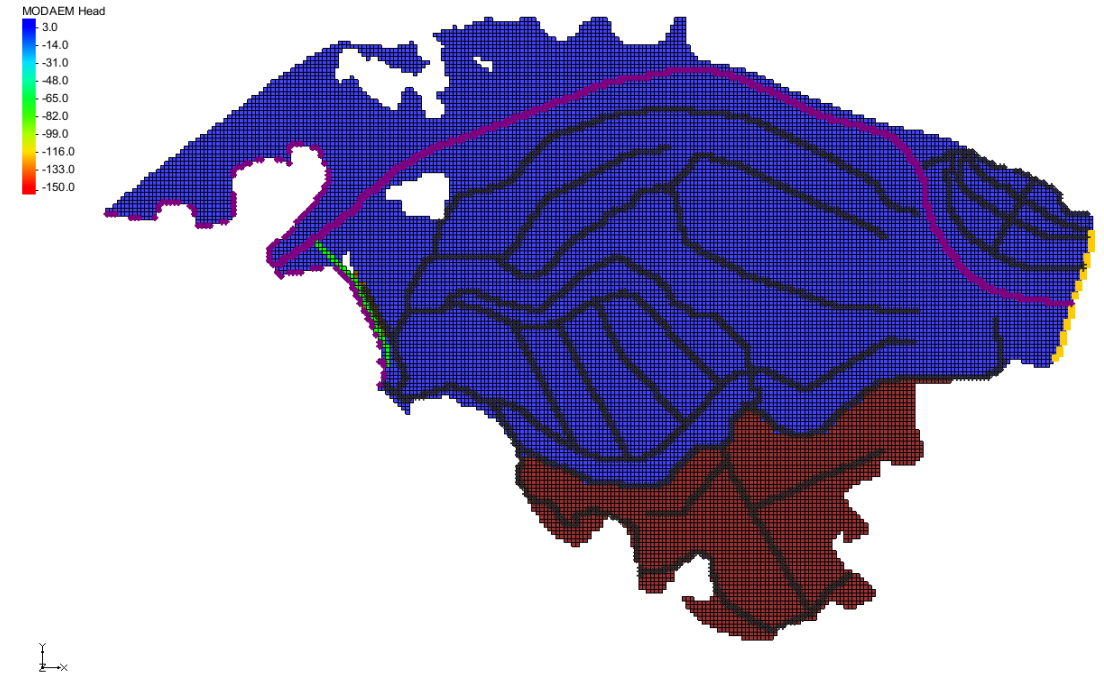


Mitigation measures

Channel parallel with River Neretva



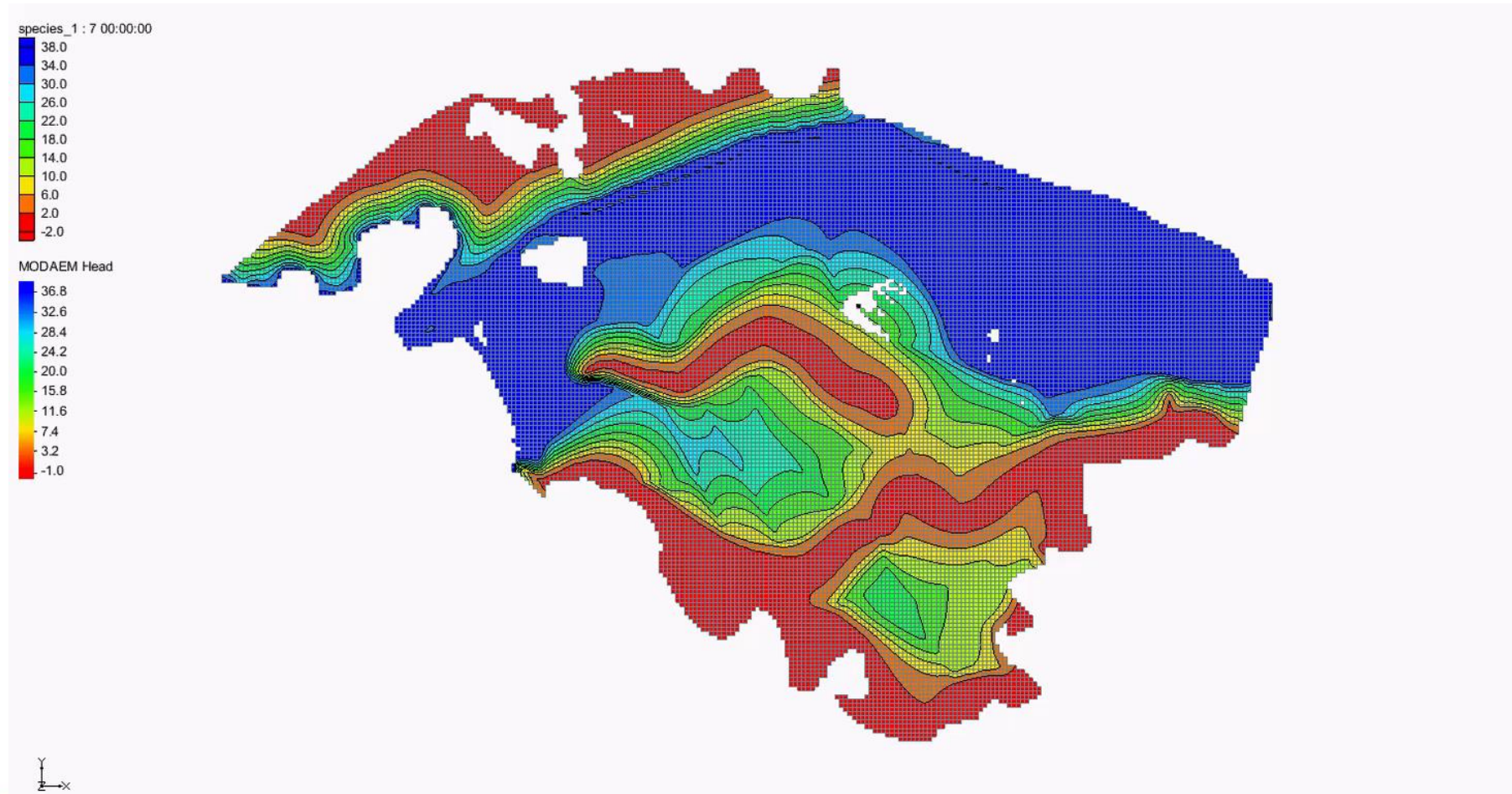
Underground barrier on Diga



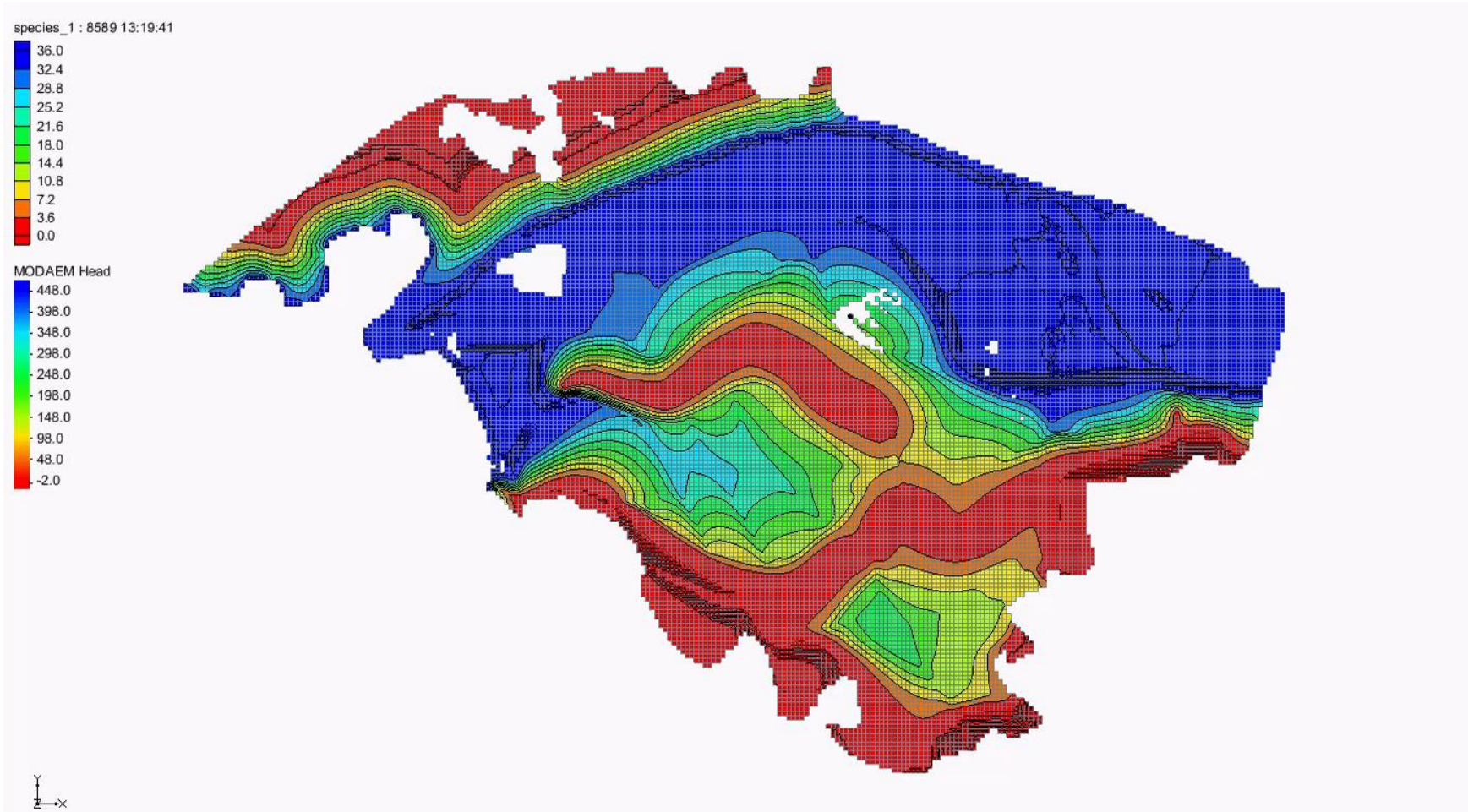
- Channel parallel with River Neretva
- From barrier till mouth
- Upstream head 0.3 m higher from Neretva

- Underground barrier below Diga embankment
- From Neretva till Mala Neretva
- In sand layer – up to clay
- $K_h=10-12$ m/s

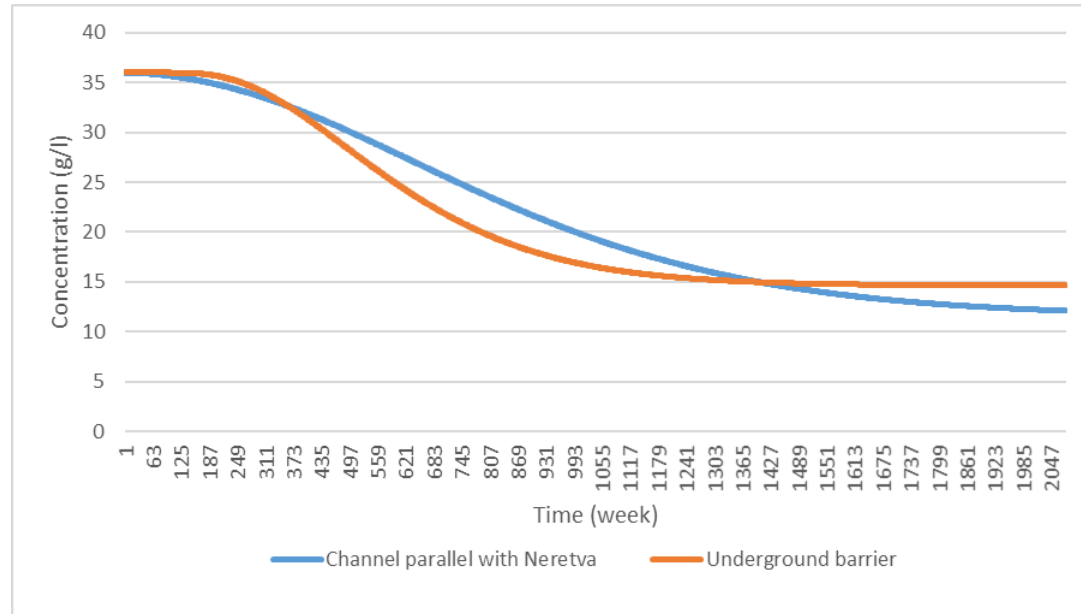
Mitigation measures –channel parallel with River Neretva



Mitigation measures – Underground barrier below Diga



Area near Diga embankment



2 km south from Opuzen

