





FREEWAT

(FREE and open source software tools for WATer resource management)

Final Meeting September 20th – 22th 2017

IDAEA, CSIC Barcelona

Case study Vrbanski plato Slovenia

Irena Kopač (IEI), Matevž Vremec (IEI-UM)



MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

Objectives

Testing the flow model

- Diverse hydrological features
 - *dammed river, drainage, artificial recharge wih river bank filtrate, river island*
- Monitoring data
- Testing the transport model
 - Real life scenario -> oil spillage
 - IEI contracted for complete remediation measures
 - comparison with on-site data











Geographical setting













Major pumping stations for the water supply system



Maribor water supply is the largest in Slovenia (1300 km pipelines, 37 wells, 73 water storages, 79 pumping stations)







EIP Water Online Market Place Matchmaking for water Innovation MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AGI28)



Regulation of the water protection zone



Regulation of the water protection zone of a body of water aquifers Rus Vrbanski plateau Limbuška dobrave and Drava fields (Official Gazette of RS, Nos. $\frac{24/07}{32/11}$, $\frac{22/13}{32/11}$ and $\frac{79/15}{32/15}$)







Atchmaking for water Innovation MRR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)



Hydrodynamic conditions



Conceptual model









MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)



Recharge with river bank filtrate

THE SCHEME OF BANK FILTRATION AS PRE-TREATMENT FOR ARTIFICIAL RECHARGE AND "ACTIVE" DRINKING GROUNDWATER PROTECTION ON THE WATERWORKS OF THE CITY OF MARIBOR









EIP Water Online Market Place Matchmaking for water Innovation MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)



Existing wells



Existing wells











Existing observing wells



Observing wells











Planned second step of IRBF system



Wells in planned second step of groundwater recharge











Steps and methods

- 1. Establishment and calibration of a 50 x 50 m steady-state model
- 2. Establishment and calibration of a 5 x 5 m steady-state model
 - *I.* Location of the groundwater divide during different scenarios of pumping/recharging
- 3. Upgrade into a transient 5 x 5 m model
 - *I.* Location of the groundwater divide after the counstruction of the remediation wells
 - II. Particle tracking (MODPATH)
- 4. Upgrade into a transport model
 - I. Contamination area
 - II. Efficiency of the remediation wells











Geometry of the domain

Horizontal discretization

The investigated domain is 2250 m large and 6400 m long. The domain is divided in 5 m x 5 m cells. The horizontal grid consists of 450 rows and 1280 columns.













Geometry of the domain

Vertical discretization

The sandy aquifer is represented by one model layer, whose thickness ranges from 0.2 m to 44 m.











Solutions - Managed Aquifer harge Strategies and Actions (AG128)



Geometry of the domain



aquifer bottom

terrain











Summary of Model Setting

The groundwater flow model has the following features: -Model layer is unconfined, ranging in thicknes from 0.2 m to 44 m -Horizontal hydraulic conductivity (K_x and K_y) are in the range 6 - 300 m/day -Vertical hydraulic conductivity: $K_z = K_x/10$ m/day.







ict4water.eu





Boundary conditions

The groundwater model has the following boundary conditions:

- Inactive cells located in the northern part of the domain
- Assigned head on northern south-east boundary: package CHD
- River infiltration and drainage with package RIV
- Drainage on the south-west boundary by package DRN.













RIVER package

The geometry of the river bottom was determined on the basis of measurements of the cross sections of the reservoir from the HEPP Maribors island to Melje dam











Sink and source terms

The next hydrological sink and source terms were taken into account:

• WEL package simulating pumping and recharge wells in the area of the pumping station Vrbanski plato and two remediation wells constructed in the area of the fuel oil spillage,

• RCH package simulating the rainfall infiltration.



WELL package

- 15 extraction wells in the area of the pumping station Vrbanski plato
- 3 extraction wells in the area of Maribor island
- 2 recharge wells and 2 remediation wells



Model calibration



Model validation





Scenarios of the 50 x 50 m and 5 x 5 m steady-state model













Results of the 50 x 50 m and 5 x 5 m steadystate model













Location of the oil spillage













Oil spillage – location of remediation wells













Remedial measures













Time course









MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG120)



Time discretization

SP number	From	То	Length (days)	State	Description
1	01.07.2014	01.03.2016	609	Transient	Model simulation
2	01.03.2016	10.03.2016	9	Transient	Oil spill + flow through the unsaturated zone
3	10.03.2016	12.04.2016	33	Transient	Flow through the unsaturated zone
4	12.04.2016	16.10.2016	187	Transient	Pumping of piezometers
Construction of the remediation wells					Pumping values [m³/dan]*
5	16.10.2016	25.10.2016	9	Transient	492,5
6	25.10.2016	31.10.2016	6	Transient	0
7	31.10.2016	08.11.2016	8	Transient	60,5
8	08.11.2016	15.11.2016	7	Transient	1036,8
9	15.11.2016	28.11.2016	13	Transient	712,8
10	28.11.2016	27.12.2016	29	Transient	864
11	27.12.2016	09.01.2017	13	Transient	604,8
12	09.01.2017	30.06.2017	127	Transient	604,8











Results of the 5 x 5 m transient model













Particle tracking using MODPATH













Particle tracking using MODPATH











MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)



Eveluating the efficiency of the remediation wells







ict4water.eu

P Water Online Market Place atchmaking for water Innovation MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG120)



Results of the 5 x 5 m transport model





FREEWAT







550300

Results of the 5 x 5 m transport model





550200

FREEWAT









FREEWAT in the future

University of Maribor

- Part of a regular curriculum
- 2 master thesis and planned new ones (University of Ljubljana)

Vrbanski plato

- Inter-municipalities agency for environmental protection
- Maribor Water Supply company

Collaboration with Slovenian Environmental Agency, Environmental Protection College Velenje, Faculty of Natural sciences and Engineering Ljubljana, Department of Geology

Combining water resources modeling and management with hydraulic management QGIS/ FREEWAT + EPANET











Thank you for your attention!

<u>irena.kopac@iei.si</u> <u>matevz.vremec@gmail.com</u>











