



# **FREEWAT**

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



 **ict4water.eu**

# Open Workshop 1st FREEWAT User and Developers International Workshop

September 21<sup>st</sup> 2017

IDAEA. CID - CSIC

16 Jordi Girona. 08034 Barcelona

## FREEWAT architecture in details and potential new development.

**EIP Water** Online Market Place  
Matchmaking for water Innovation

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

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**idæa<sup>a</sup>**



**CID** CELEBRAR  
INNOVAR  
DEBATRE  
CSIC CENTRE D'INVESTIGACIÓ I DESENVOLUPAMENT 1967-2017

Taken from: <http://travessa-pirineus.blogspot.com.es/2014/08/dia-15-de-lospitalet-al-refugi-de-juclar.html>

# Outlook

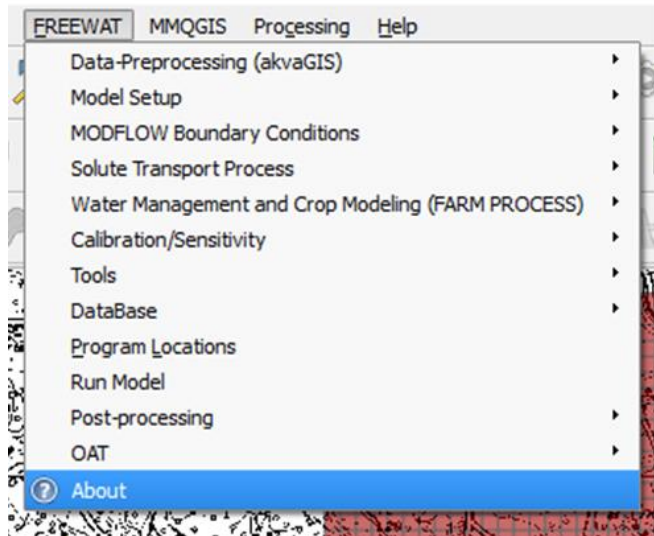
- ❑ FREEWAT architecture
- ❑ Capabilities: a summary
- ❑ FREEWAT Community: a first attempt
- ❑ Looking to the future ...



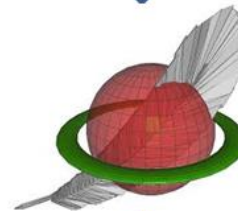
# FREEWAT Pillars and Conceptualization

FREEWAT is a composite plugin of QGIS, conceived as a canvas, where several simulation codes might be integrated in a unique GIS desktop.

Coupling the power of GIS geo- and post-processing tools to simulation software capabilities



GIS-layers & Tables



akvaGIS

OAT



MODFLOW and Related Programs (MT3DMS, SEWAT, UCODE, etc.)





# QGIS: FREEWAT's framework

## QGIS

### A Free and Open Source Geographic Information System

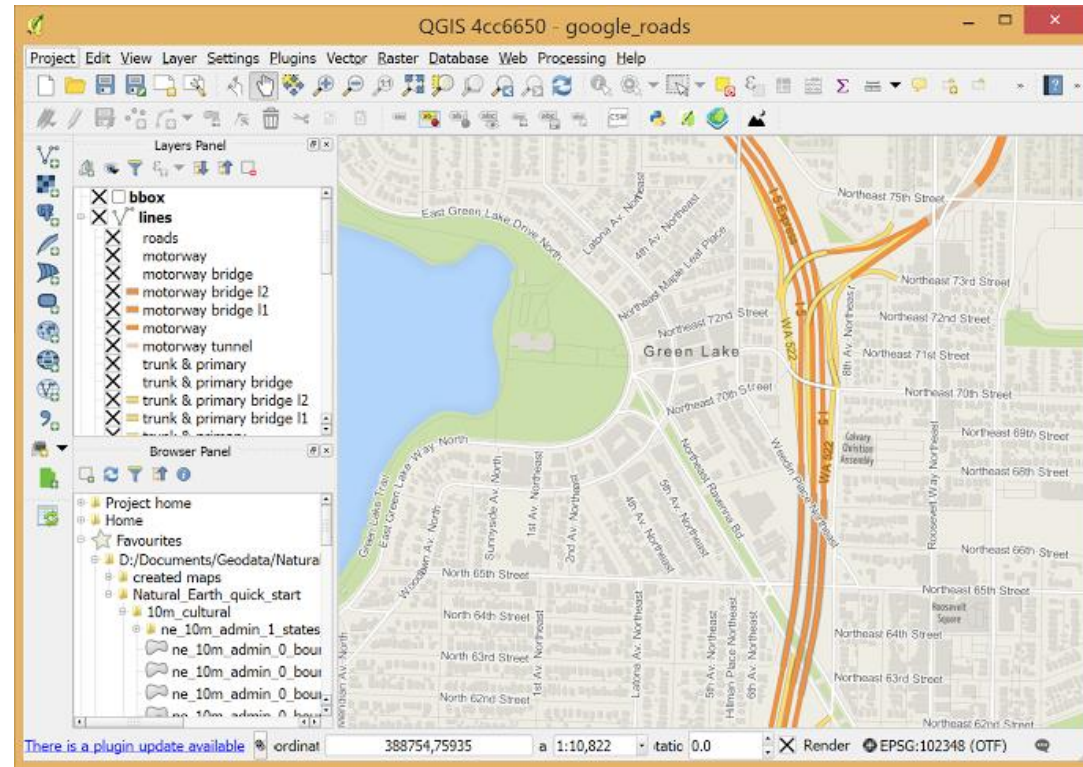
QGIS → cross-platform, user friendly, free and open-source GIS application that provides data viewing, editing, and analysis.

It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

**QGIS is the leading Open Source Desktop GIS**



- A huge and worldwide community
- Several plugins available



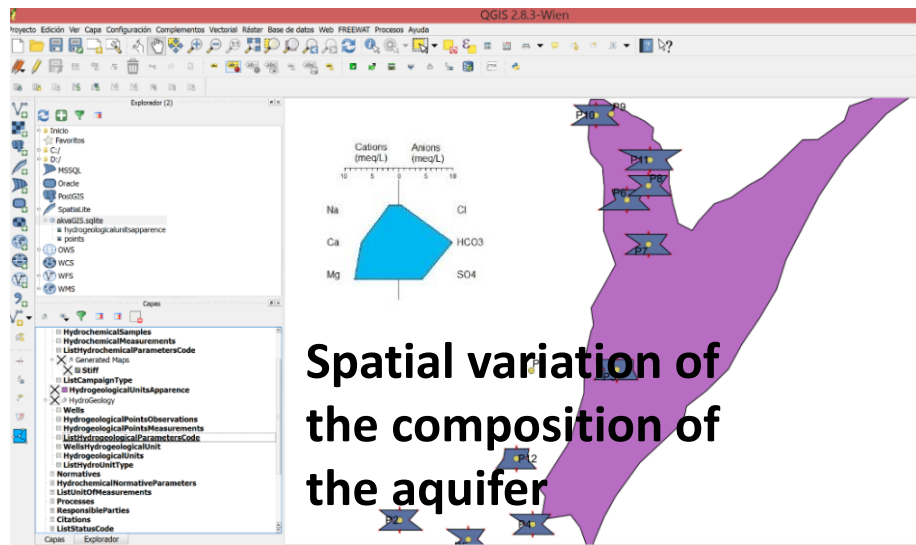
[www.qgis.org](http://www.qgis.org)

# FREEWAT Capabilities:

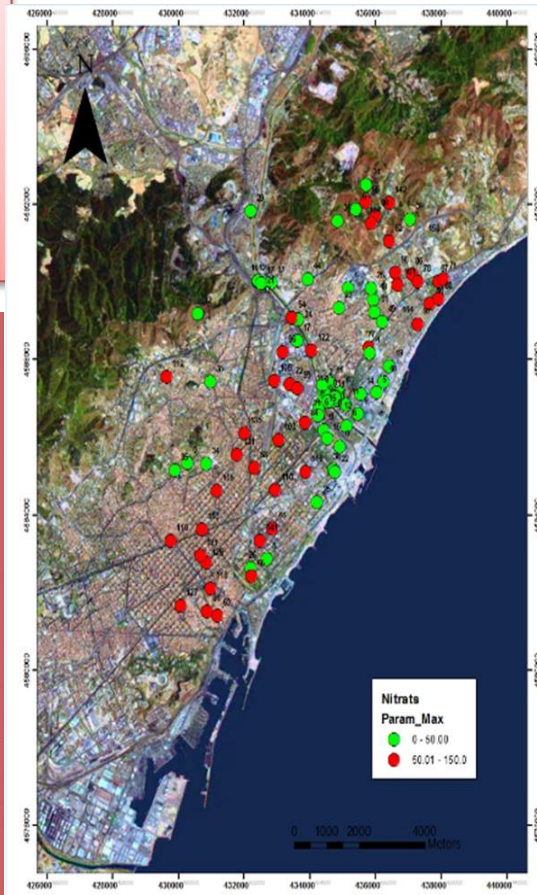
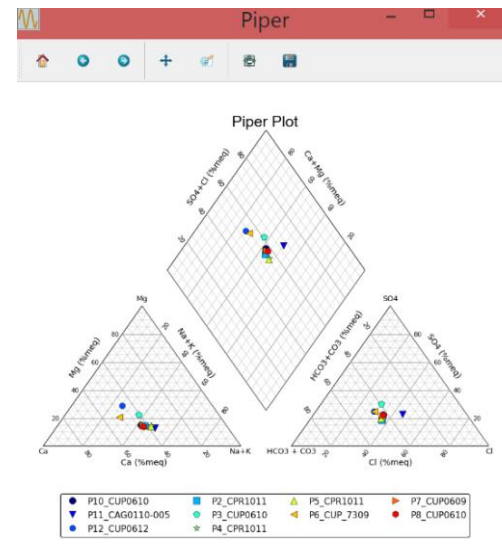
## Data pre-processing (akvaGIS)

- ✓ **Hydrogeological models** require the use of a **wide variety of information** (hydrogeological, geological, hydrochemical, etc.)
- Necessity of integrating data from **different sources** gathered with different data access techniques (boreholes, pumping tests, etc.) and **different formats**

A specific tool in FREEWAT that brings together a **spatial database** and a set of **tools** that allow us to:  
**Harmonize, collect, store, manage, analyze, interpret and pre-process the hydrogeological data in a GIS.**



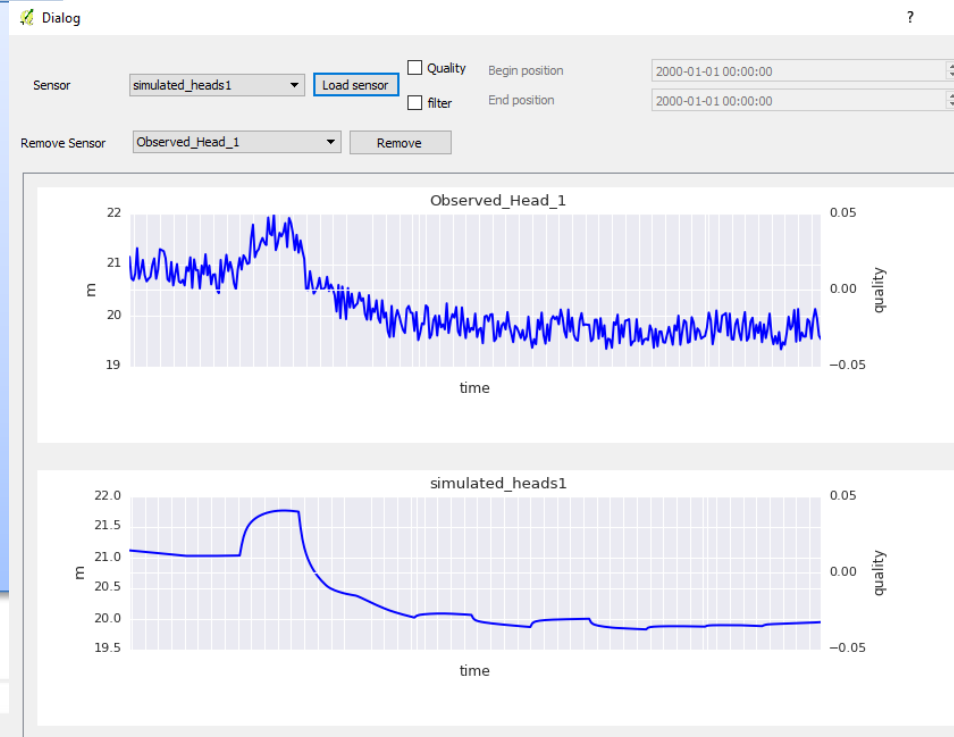
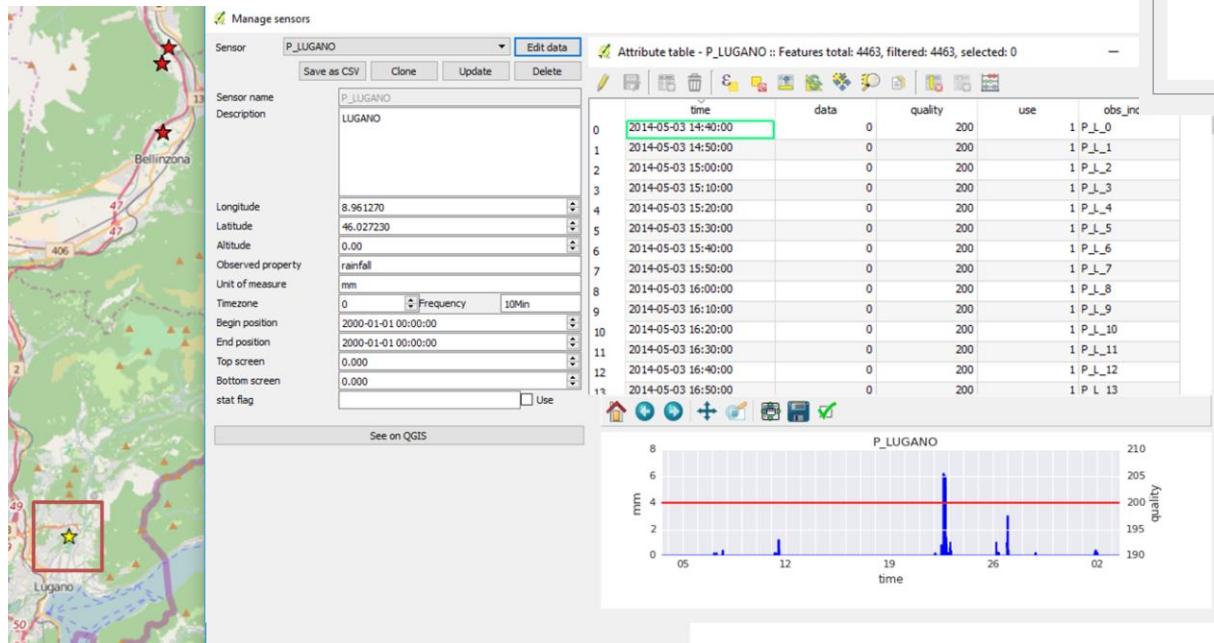
**Spatial variation of the composition of the aquifer**



# FREEWAT Capabilities: Observations Analysis Tool (OAT)

## OAT - Observations Analysis Tools

- ✓ Import sensor data
  - From Servers
  - From local files
- ✓ Manage and edit sensor data and metadata
- ✓ Perform various operations with data
- ✓ Display and compare sensor data

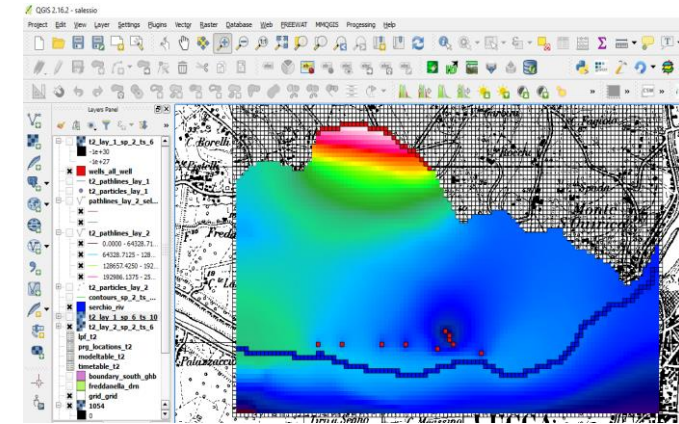




# FREEWAT Capabilities:

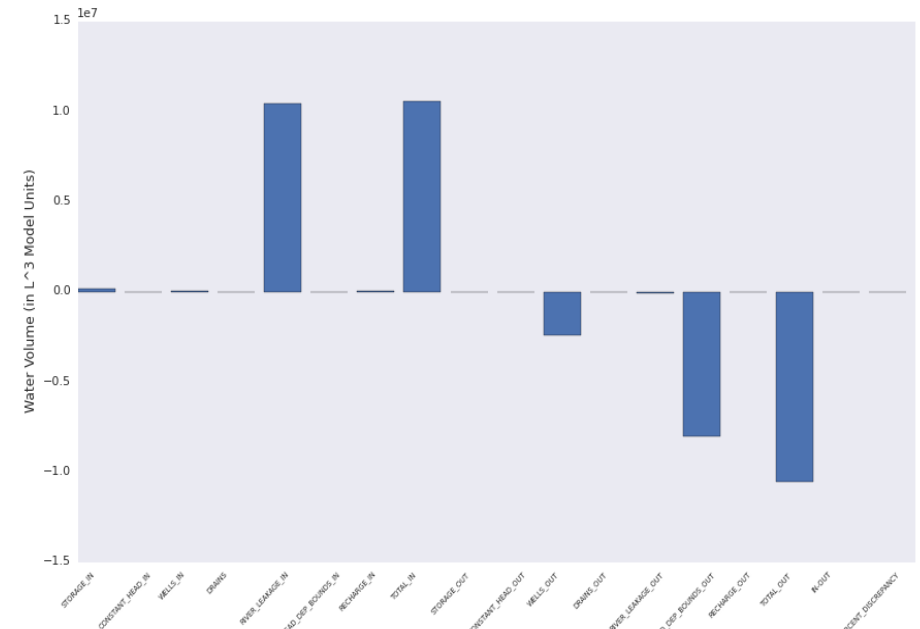
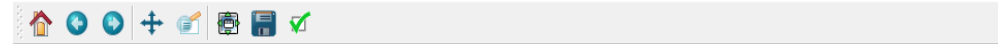
## Surface/ground-water Flow Modeling

Solving coupled surface/ground-water flow  
Considering different water stresses in the  
model domain: wells, rivers and canals,  
evapo-transpiration, aquifer recharge,  
lakes, unsaturated zone



### Getting the water budget

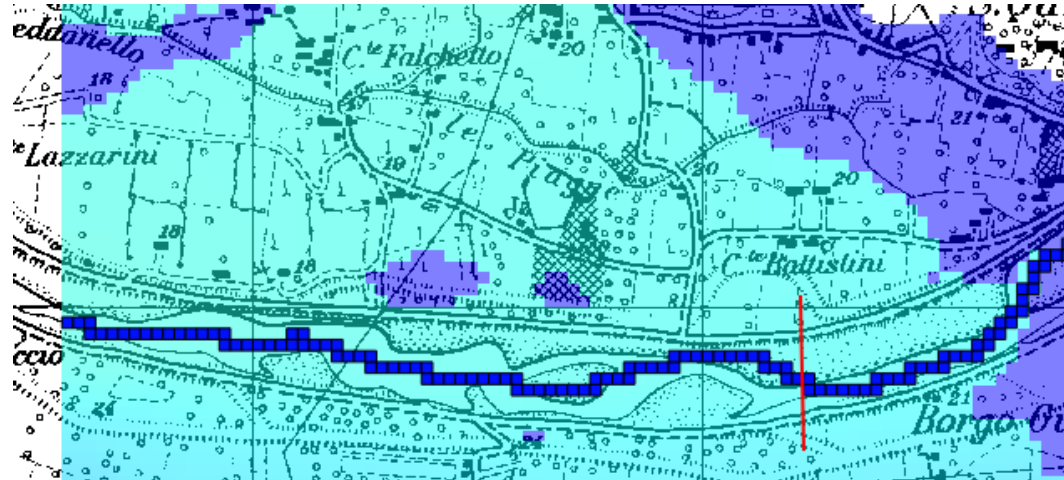
Figure 1



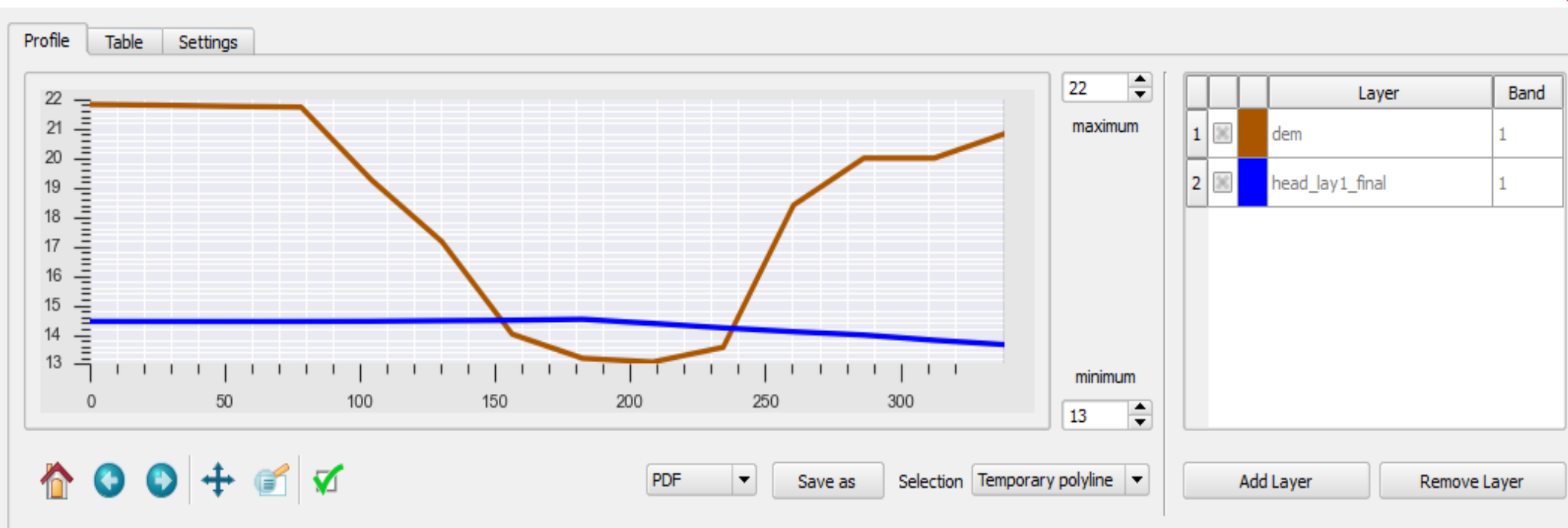
VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 10, STRESS PERIOD 6

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:			
STORAGE =	201311.3594	STORAGE =	12.1037
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	71220.0000	WELLS =	240.0000
DRAINS =	0.0000	DRAINS =	0.0000
RIVER LEAKAGE =	30683864.0000	RIVER LEAKAGE =	119135.0156
HEAD DEP BOUNDS =	0.0000	HEAD DEP BOUNDS =	0.0000
RECHARGE =	45662.5000	RECHARGE =	0.0000
TOTAL IN =	31002058.0000	TOTAL IN =	119387.1172
OUT:			
STORAGE =	79236.8594	STORAGE =	0.6955
CONSTANT HEAD =	0.0000	CONSTANT HEAD =	0.0000
WELLS =	3330000.0000	WELLS =	0.0000
DRAINS =	67558.8047	DRAINS =	195.3501
RIVER LEAKAGE =	280639.6250	RIVER LEAKAGE =	1137.2496
HEAD DEP BOUNDS =	27243630.0000	HEAD DEP BOUNDS =	118034.1328
RECHARGE =	0.0000	RECHARGE =	0.0000
TOTAL OUT =	31001064.0000	TOTAL OUT =	119367.4297
IN - OUT =	994.0000	IN - OUT =	19.6875
PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.02

# Plot cross sections using *ProfileTool* (*water table* vs *terrain elevation*)



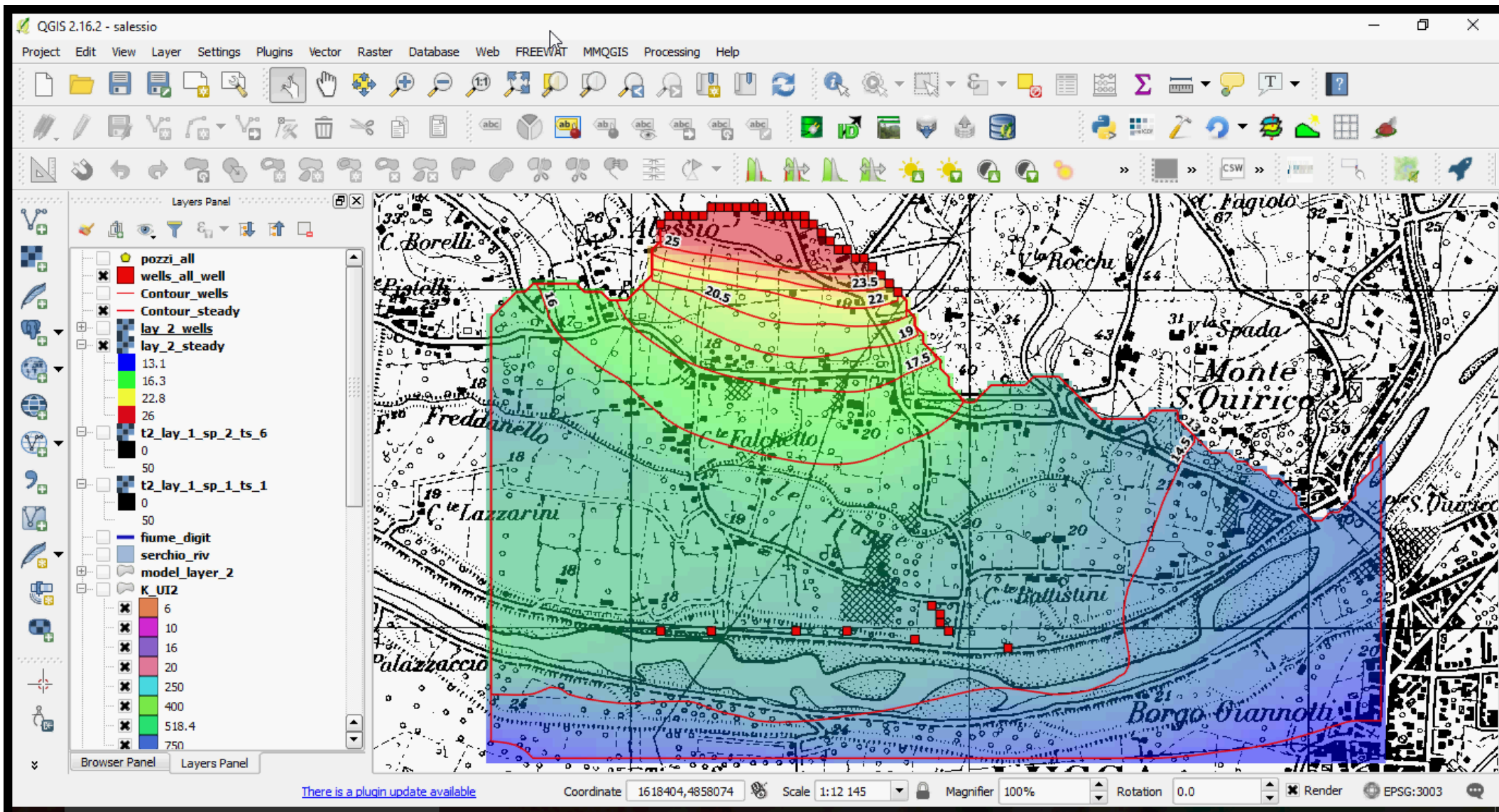
Profile Tool





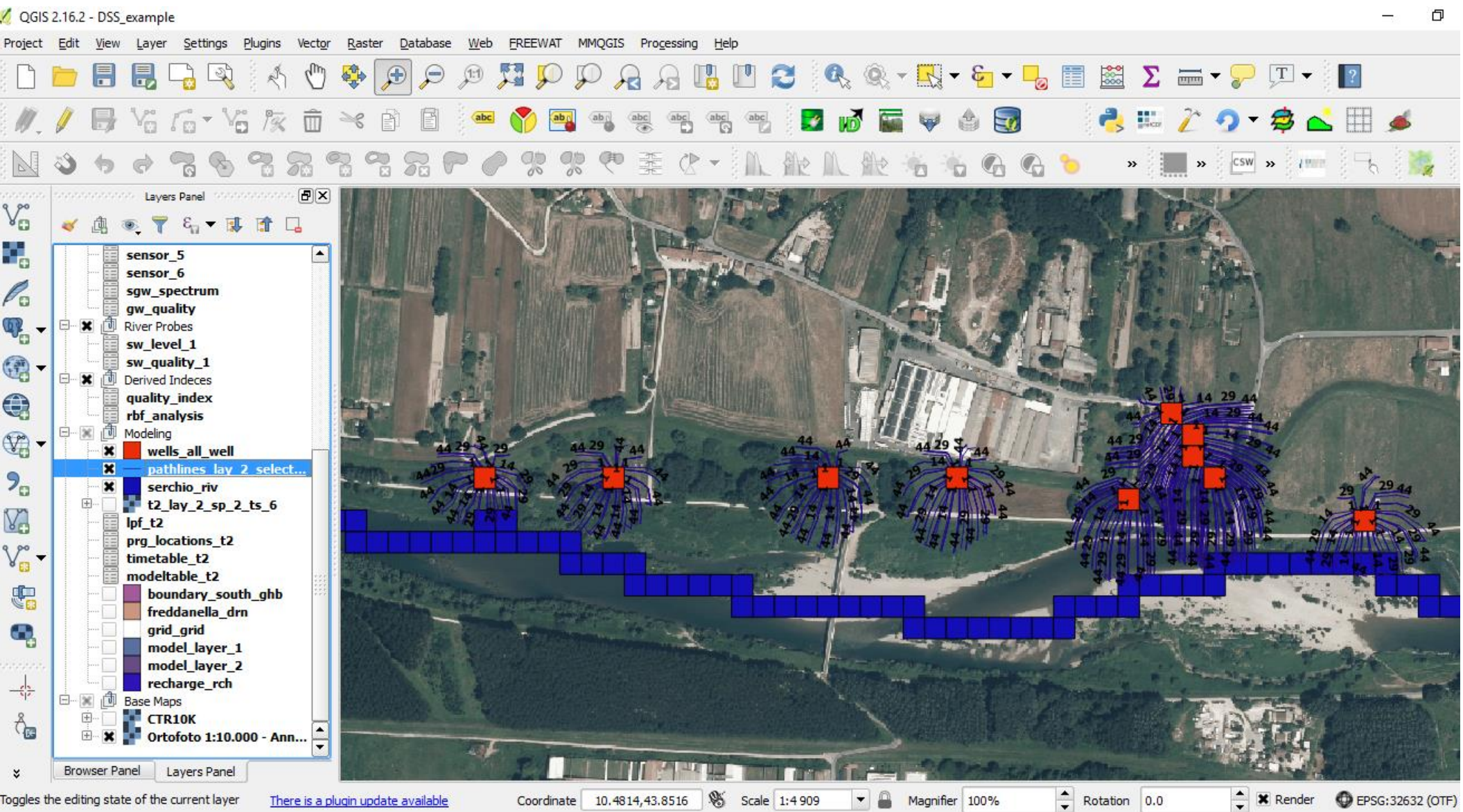
# Rasterize the model outputs

(estimate the effect of pumping on the water table)





# Creating well capture zones



# FREEWAT Capabilities: Solute Transport

With FREEWAT the User can solve problems of groundwater contamination, to evaluate several scenarios, such as:

- ✓ Landfills/waste disposal
- ✓ Remediation of contaminated sites
- ✓ Salinization of coastal aquifers



# FREEWAT Capabilities: Solute Transport



## Solute Transport in Unsaturated Zone

### ❑ USB (Unsaturated Solute Balance)

- ✓ Computes concentration reaching the water table
- ✓ Possibility to use this result as input for MT3DMS (saturated zone)

### ❑ UZT (Uns. Zone Transport) Package of the new MT3D-USGS

### MT3DMS (saturated zone)

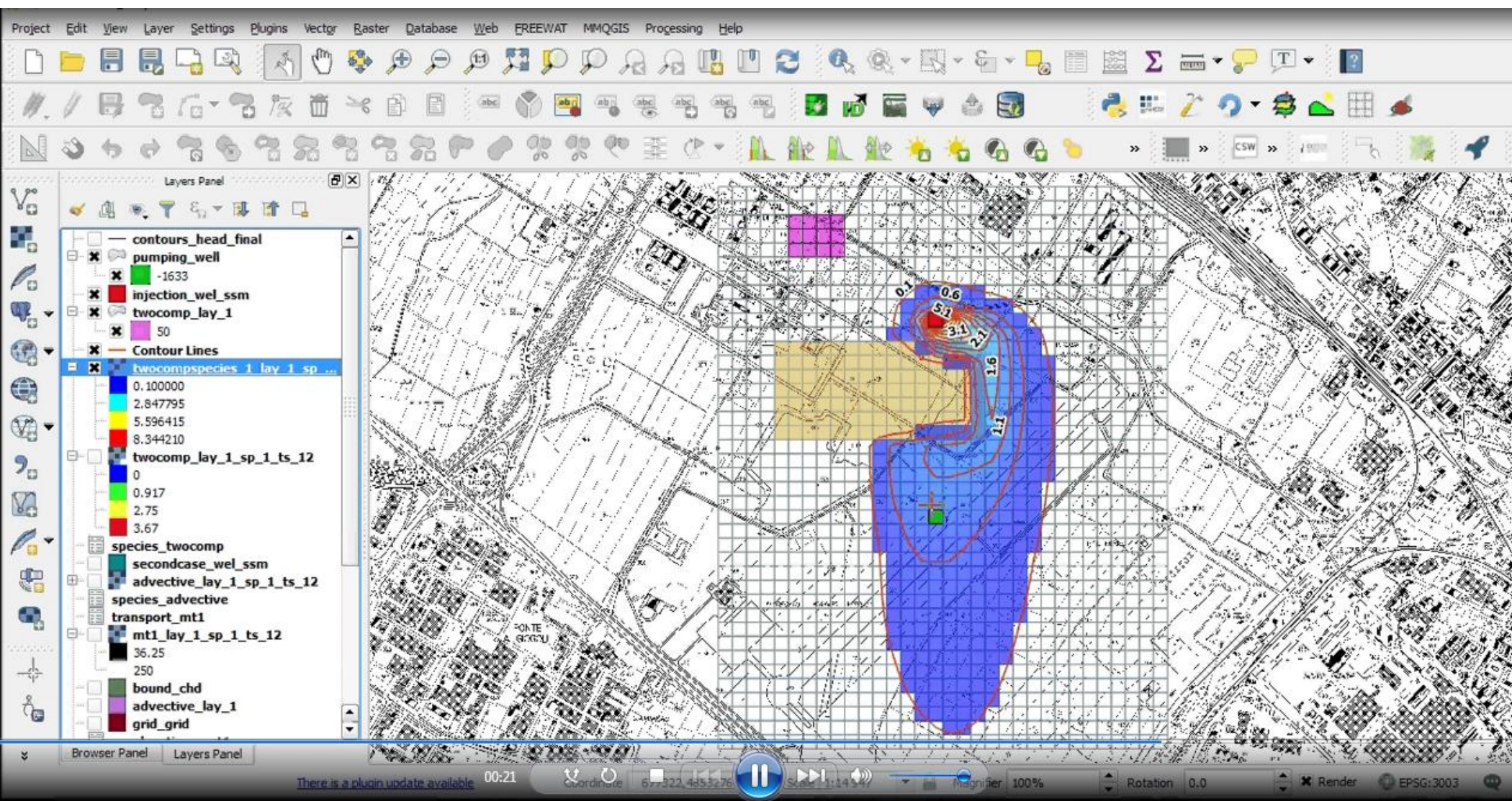
- ✓ ADV - Advection
- ✓ DSP - Dispersion
- ✓ SSM - Source & Sink terms
- ✓ RCT - Reaction

### SEAWAT (saturated zone)

- ✓ Density-dependent flow (VDF)
- ✓ Viscosity-dependent flow (VCF)



# Visualize contamination maps

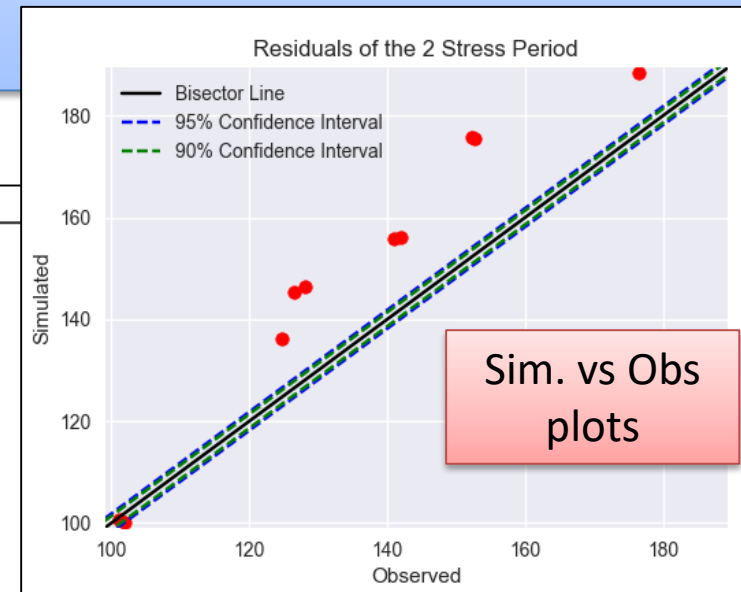
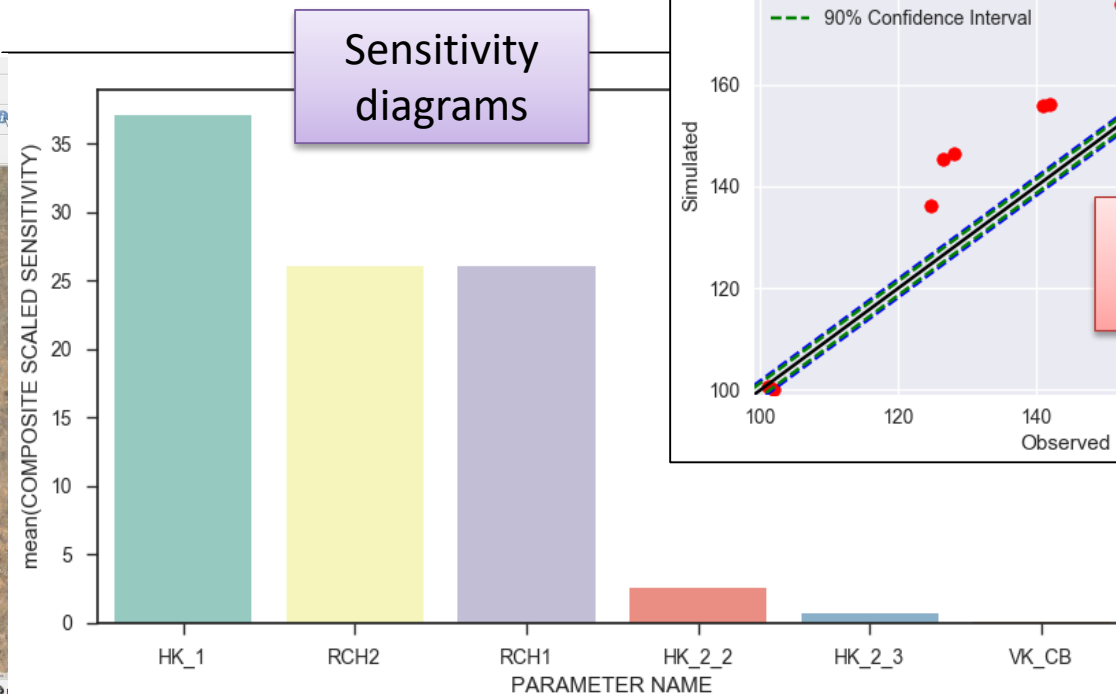
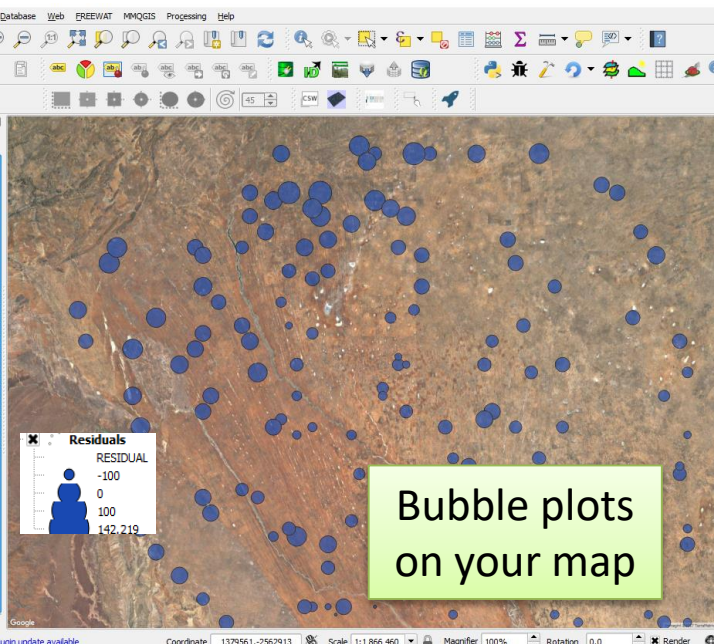




# FREEWAT Capabilities:

## Calibration, Sensitivity analysis & Parameter estimation

- ✓ Comparing simulated vs observed data
- ✓ Evaluating the effect on the model of selected parameters (*sensitivity analysis*)
- ✓ Estimating the best value of selected parameters (*parameter estimation*)





# FREEWAT Capabilities:

## Water Supply Management

(conjunctive use of surface/ground-water urban & rural water units)

### Upscaling the model grid

- ✓ Define **Water Demand Units** : any "entity" consuming water
- ✓ Define in your domain the distribution of **Soils and Crops**

### Compute the Water Demand (for each Water Unit)

- ✓ Agricultural (crops + soils)
- ✓ External (e.g. urban/domestic)

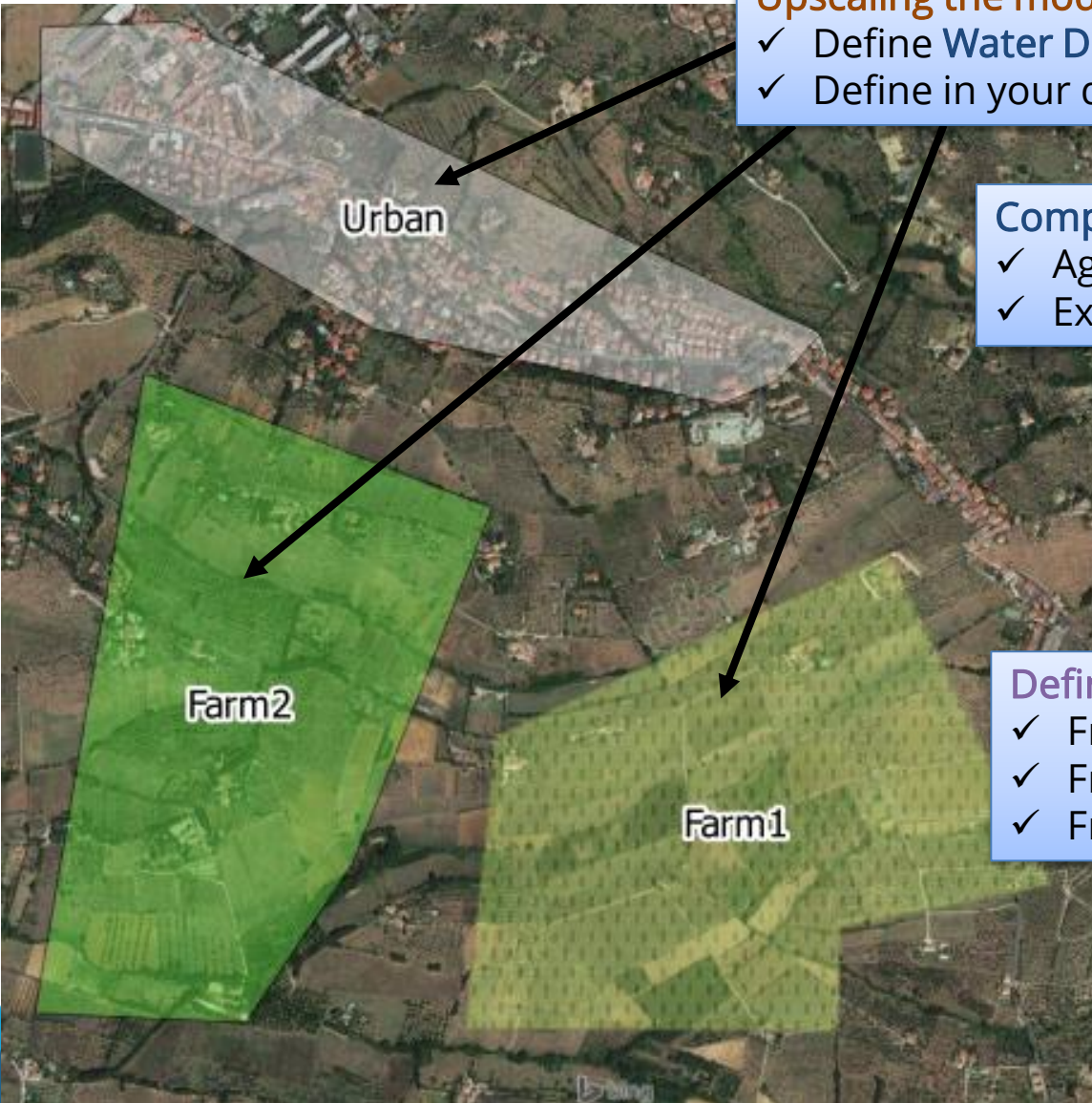
### Define (potential) supply constraints: Water Rights

- ✓ Limits on Surface Water diversion
- ✓ Limits on Pumping Rate

### Define the available source for Water Supply



- ✓ From **external deliveries** (also time-dependent)
- ✓ From **streams/canals**
- ✓ From **groundwater** (Pumping Wells)

### Compute the Water Supply Optimization



# Conjunctive use of surface/ground-water (urban & rural water units)



-  Surface water canal
-  Irrigation canal

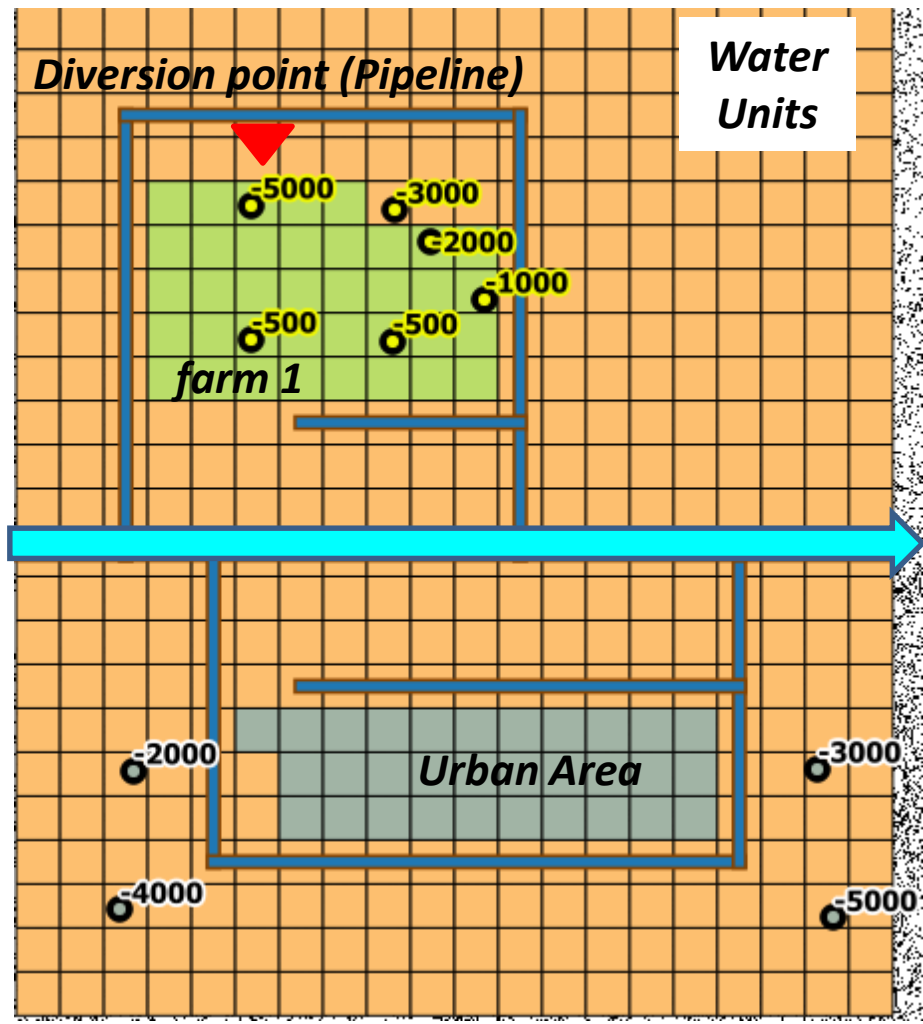
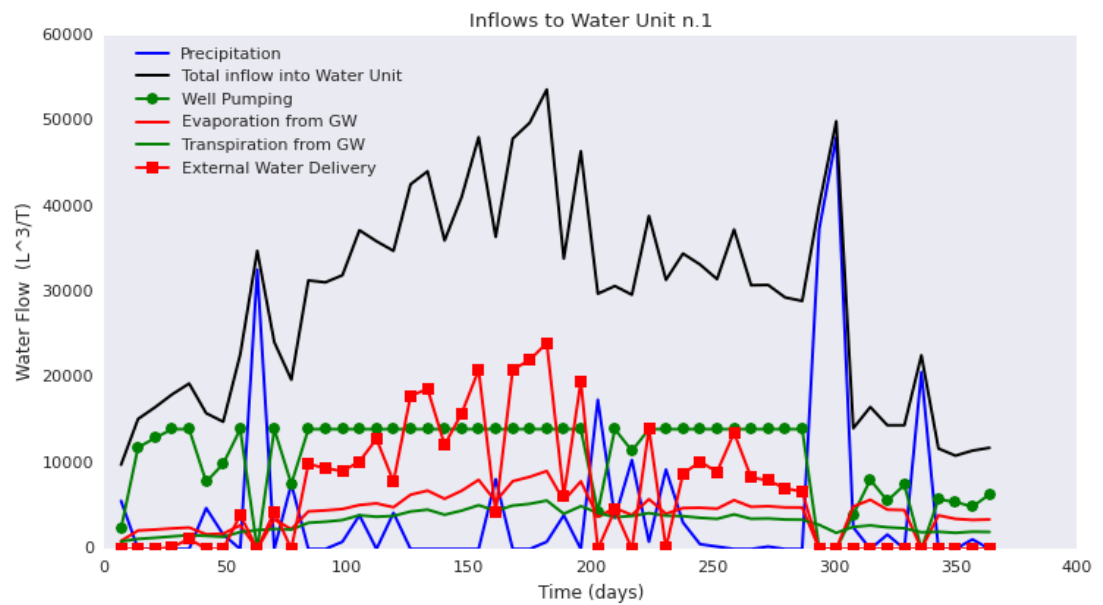


Figure 1



Figure 1



# How to get FREEWAT

Starting from April 1<sup>st</sup>, 2017, you can free download  
FREEWAT:

<http://www.freewat.eu/download-information>

Once you have filled out the registration form (only for statistical purposes!), you get:

- *freewat* QGIS-plugin
- User's Manuals (6 Volumes)
- Several tutorials (including slides and data to run the exercise)

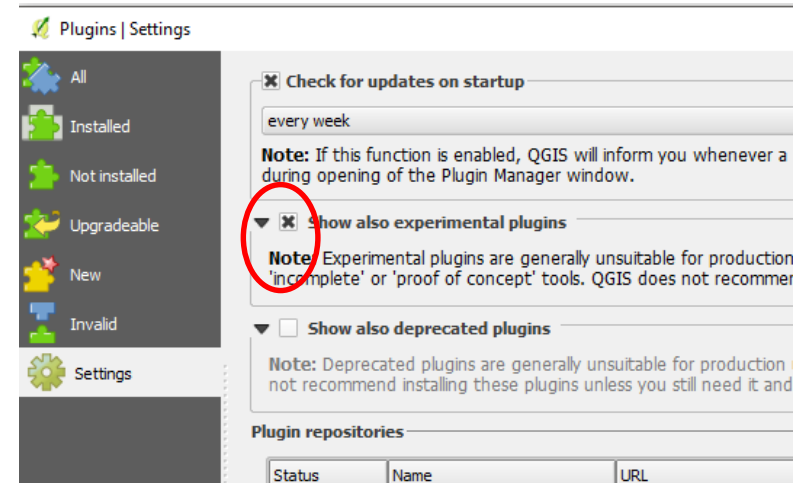
Registration includes you in the FREEWAT mailing list, useful to receive updates on new release, bug fixing, new tutorials, etc.





# FREEWAT is now an Official QGIS Plugin

- You can get FREEWAT (and its update version in the future) directly from Plugin Manager
- It is still tagged as *Experimental*: So to find FREEWAT you have to activate “*Show also experimental plugins*”, under *Plugin Manager > Settings*



Download latest

## FREEWAT



★★★★★ (1) votes

207 downloads  
in 6 days !!!!

simulation environment to run hydrological/hydrogeological and water management models.

About Details Versions

Version	Experimental	Minimum QGIS version	Downloads	Uploaded by	Date
1.0.0	yes	2.14.0	119	laborsi	Sept. 14, 2017, 9:41 a.m.
1.0	yes	2.14.0	88	laborsi	Sept. 13, 2017, 4:14 a.m.

# FREEWAT Community: Repository

We are using  GitLab as free repository  
Repo is now *public* (since last week – Sept. 12, 2017)

<https://gitlab.com/iaborsi/freewat/>

- ✓ For code development and sharing
- ✓ To browse and report bugs (tracker, using *issues*)
- ✓ We have set up **Governance** and **Release Policy** documents (they are saved within the plugin folder) to manage code (new) developments and improvements

# FREEWAT: get involved !

## Being part of the Users' Community

To support FREEWAT application and usage, we set up a Users Google Group, to manage a shared system of Q&A

<https://groups.google.com/forum/#!forum/freewat-users-group>

Join the Group!!



# FREEWAT: get involved !

Keep working on development once the project ends

To support FREEWAT development, we set up a Developers Community

Any one interested to suggest (and develop!) enhancements and/or new capabilities is welcome!!!

If you want to join us, subscribe to the Developers Group:

**Join the Group!!**

<https://groups.google.com/forum/#!forum/freewat-developers-group>

and you'll get involved in FREEWAT future dev.

# FREEWAT: some ideas on future enhancements

Thanks to project partners, we have a long list.... Let's itemize the most popular requests

## ☐ Improvements of what exists already:

- Possibility to set-up rivers starting from polygon shape files
- Visualize only selected layers as Rasterized solution
- Save the model setting input in Run Model ui
- ...

# FREEWAT: some ideas on future enhancements

- ❑ Including additional options on what already exists:
  - Grid refinement
  - New architecture for managing time-dependent data, to cope with long-term models (=several Stress Periods)
  - Additional packages of MT3D-USGS (Stream-flow transport, transport in lakes, for instance)
  - Including more options for Farm Process (e.g. Time-variant Farms and Crops): be aware that MODFLOW-OWHM 2.0 is coming soon!



# FREEWAT: some ideas on future enhancements

- ❑ Including other processes to be coupled (or not) to what exists:
  - Specific tools to compute Nitrates (or other contaminant) source at the top surface.
  - Coupling with Surface Water Modeling: HEC-RAS? Hydro-BID? ... ?
  - Multi-phase flow simulator: useful for addressing contamination events including hydrocarbons, surfactant, or for geothermal simulations (medium-high enthalpy ranges): FEHM ? OpenGeoSys ?

# FREEWAT: some ideas on future enhancements

□ Let's start discussing ....