FREEWAT

Free and Open Source Software Tools for Water Resource Management

EU HORIZON 2020 Project

FREE and Open Source Software Tools for WATer Resource Management

FREEWAT User Manual - Volume 4

AkvaGIS (Hydrochemical Analysis Tools and Hydrogeological Analysis Tools)

Version 1.0
September 30th, 2017

This page has been intentionally left blank

FREEWAT User Manual - Volume 4

AkvaGIS (Hydrochemical Analysis Tools and Hydrogeological Analysis Tools)

Version 1.0

September 30th, 2017

By A. Serrano[(1)], R. Criollo[(1)], V. Velasco[(1)], C. Riera[(1)], and E. Vázquez-Suñé [(1)]

(1) Institute of Environmental Assessment and Water Research (IDÆA), Barcelona (ES)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642224

This project document reflects only the authors' views and the European Union is not

Liable for any use that may be made of the information contained therein.

FREEWAT Development has received funding from the following projects:

1. Hydrological part has been developed starting from a former project, named SID&GRID, funded by Regione Toscana through EU POR-FSE 2007-2013 (sidgrid.isti.cnr.it)

2. Porting of SID&GRID under QGis has been performed through funds provided by Regione Toscana to Scuola Superiore S.Anna - Project Evoluzione del sistema open source SID&GRID di elaborazione dei dati geografici vettoriali e raster per il porting negli ambienti QGis e Spatialite in uso presso la Regione Toscana (CIG: ZA50E4058A)

3. Saturated zone solute transport simulation capability has been developed within the EU FP7-ENV-2013-WATER-INNO-DEMO MARSOL. MARSOL project receives funding from the European Union's Seventh Framework Programme for Research, Technological Development and Demonstration under grant agreement n. 619120 (www.marsol.eu)

4. Latest Version of FREEWAT is under development within EU H2020 project FREEWAT - Free and Open Source Software Tools for Water Resource Management. FREEWAT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n. 642224 (www.freewat.eu)

Suggested citation:

Serrano, A., Criollo, R., Velasco, V., Riera, C., and Vázquez-Suñé, E. FREEWAT User Manual, Volume 4 - AkvaGIS (Hydrochemical Analysis Tools and Hydrogeological Analysis Tools), version 1.0, September 30th, 2017.

FOREWORD

FREEWAT is a HORIZON 2020 project financed by the EU Commission under the call WATER INNOVATION: BOOSTING ITS VALUE FOR EUROPE. FREEWAT main result is an open source and public domain GIS-integrated modeling environment for the simulation of water quantity and quality in surface water and groundwater with an integrated water management and planning module. Specific objectives of the FREEWAT project are: to coordinate previous EU and national funded research to integrate existing software modules for water management in a single environment into the GIS-based FREEWAT platform and to support the FREEWAT application in an innovative participatory approach, gathering technical staff and relevant stakeholders in designing scenarios for the proper application of water policies.

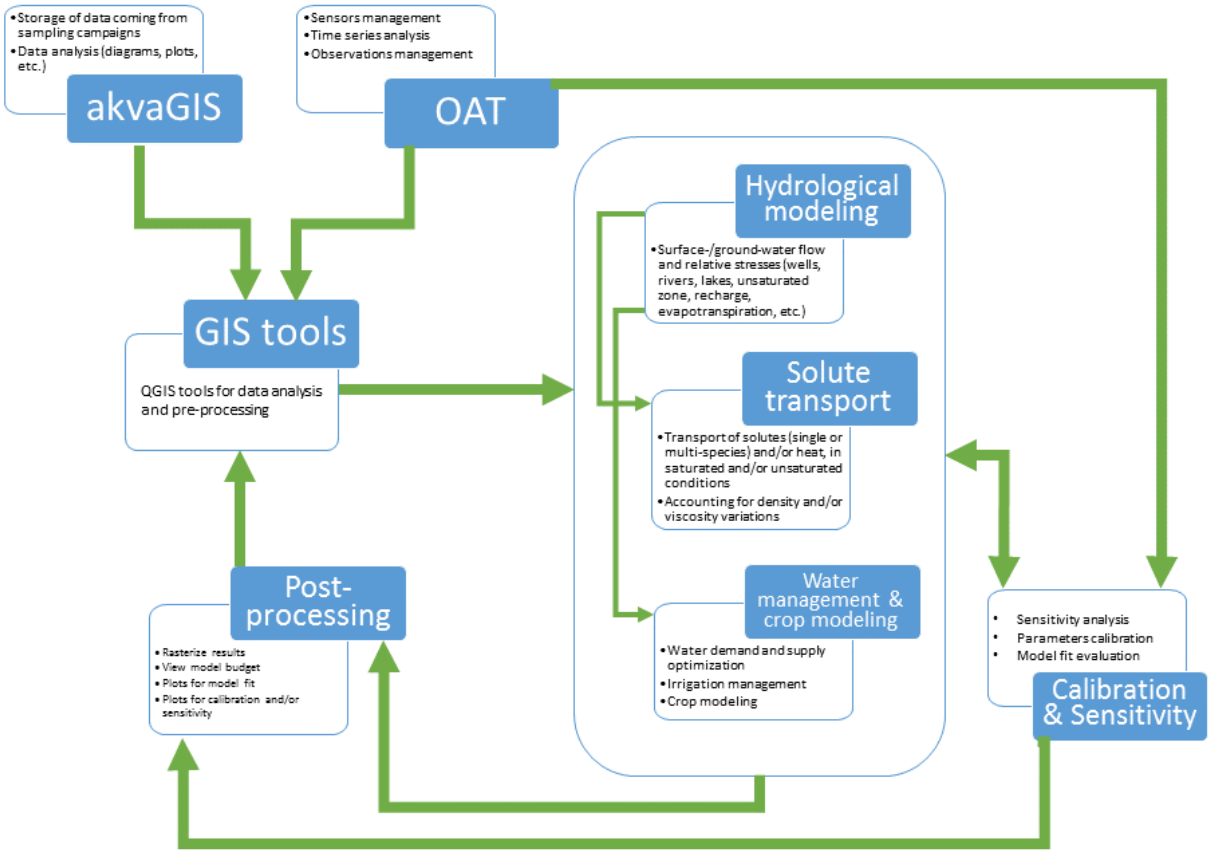
The open source characteristics of the platform allow considering this an initiative "ad includendum", as further research institutions, private developers etc. may contribute to the platform development.

FREEWAT is conceived as a composite plugin for the well-known GIS open source desktop software QGIS (http://qgis.org). The selected reference version of QGIS is the latest LTR (Long Term Release), namely QGIS 2.14: even if this release will be maintained as the reference one, it is worth mentioning that any test performed so far with subsequent versions (e.g. 2.16 and 2.18) worked without experiencing any problem.

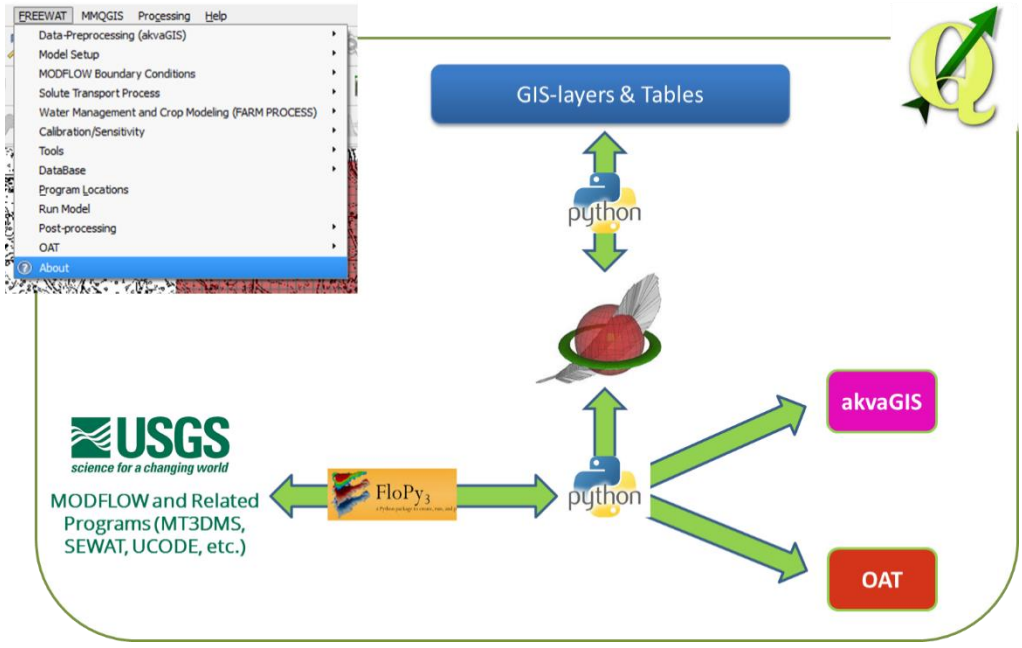
As composite plugin, FREEWAT is designed as a modular ensemble of different tools: some of them can be used independently, while some modules require the preliminary execution of other tools. Capabilities integrated in FREEWAT are:

- Simulation of models related to the hydrological cycle (Volume 1)
- A module for simulating solute transport in the unsaturated/saturated zone, including density and viscosity dependent flow (Volume 2)
- A module for water resource management and optimization of conjunctive use, including issues related to irrigation management in rural environment (Volume 3)
- Tools for the analysis, interpretation and visualization of hydrogeological and hydrochemical data and quality issues (Volume 4)
- A module for time-series processing to support input data processing and advanced model calibration (Volume 5)
- A module for calibration, uncertainty and sensitivity analysis (Volume 6)

The following diagram shows how these different modules are interconnected, taking as reference a standard modeling procedure.



FREEWAT architecture is based on the integration of different software tools (the so called FREEWAT pillars): SQLITE relational database manager, external (free and open source) codes like MODFLOW and MODFLOW-related programs as well as codes specifically developed for the FREEWAT. The way of interconnecting such tools is done via Python programming language, with extensive use of the Python library FloPy. A schematic representation of FREEWAT pillars and their interconnection is showed in the following figure.



Contents

Abstract

The main goal of this set of tools is to provide FREEWAT platform with different instruments to analyze and interpret the hydrochemical and other hydrogeological data. This set of tools (**AkvaGIS**) perfectly integrated in the platform FREEWAT can be divided into two modules:

1. Tools for the hydrochemical analysis and interpretation.
2. Hydrogeological analysis and interpretation tools.

The first module, the **Hydrochemical Analysis Tools**, is composed by a geospatial database implemented in Spatialite and a set of tools for improving the harmonization, integration, standardization, visualization and interpretation of hydrochemical data. These tools include different instruments that cover a wide range of methodologies for querying, interpreting, and comparing groundwater quality data and facilitates the pre-processing analysis for being used in the realization of groundwater modelling and other water assessments like river/lake contamination remediation or irrigation water quality evaluation, among others. Some of the tools developed are: ionic balance calculations, chemical time-series analysis, correlation of chemical parameters, regulatory parameters analysis tool, calculation of various common hydrochemical diagrams (Salinity, Schöeller-Berkaloff, Piper, and Stiff), and the link to the free codes EASYQUIM, MIX, and Statistical Analysis, among others. Furthermore, the sub-module allows the generation of maps of the spatial distributions of parameters, diagrams and thematic maps for the parameters measured in the queried area and classified according to the threshold approach established by a given guideline, e.g. WFD.

The second module, the **Hydrogeological Analysis Tools**, is devoted to a better interpretation of the groundwater units, which in turn is crucial in modelling activities to define the conceptual model. The set of tools was developed for improving the management, visualization and interpretation of the hydrogeological data and allow us: (1) to manage and query the hydrogeological measurements (e.g. head, wells abstractions, etc.) performed in wells, piezometers, springs, etc. stored in the database; (2) to apply one or several query criteria (e.g. time interval, groundwater measurement) and to combine them for advanced spatio-temporal queries on the hydrogeological data stored in the database; (3) to create thematic maps (e.g. piezometric maps) of the selected points, time interval and parameters; (4) to calculate some general statistics such as the minimum, maximum or average for each selected hydrogeological parameter, such as head level, depth to the water or pumping rates; (5) to query the depth or the thickness of the defined hydrogeological units and to represent these values in a map as point features, with the possibility to interpolate results.

CHAPTER 1

Users Manual AkvaGIS

AkvaGIS include different instruments to fulfil the aforementioned requirements in an Open source GIS platform: (i) to manipulate large data sets collected for different period of time; (ii) to integrate data from diverse sources that are gathered by different data access techniques and formats; (iii) to manage data with different temporal and spatial scales; and (v) to integrate groundwater information with other relevant data (e.g. water quality) and its pre-processing analysis, particularly to use it as a previous step to outline the numerical groundwater model.

Software Design and Structure

AkvaGIS is built in QGIS (http://www.qgis.osgeo.org), an Open Source GIS User interface supported in the main IOS (Linux, Mac OSX, Windows and Android) and is a widely used GIS open source platform with a large community of developers (Development Team, 2009).

AkvaGIS has been designed as an Object Oriented code and avoiding code repetition in order to reduce errors and improve the maintainability. The code (current version 1.0) is developed in Python and it is freely available in the FREEWAT project repository under the GNU Lesser General Public License v3.0 (GPL-3.0). The code uses different third party libraries (with GPL and MIT/BSD license types). Some of them are distributed with the plugin and others should already be installed in the Python distribution for a correct behavior of the tool (dependencies).

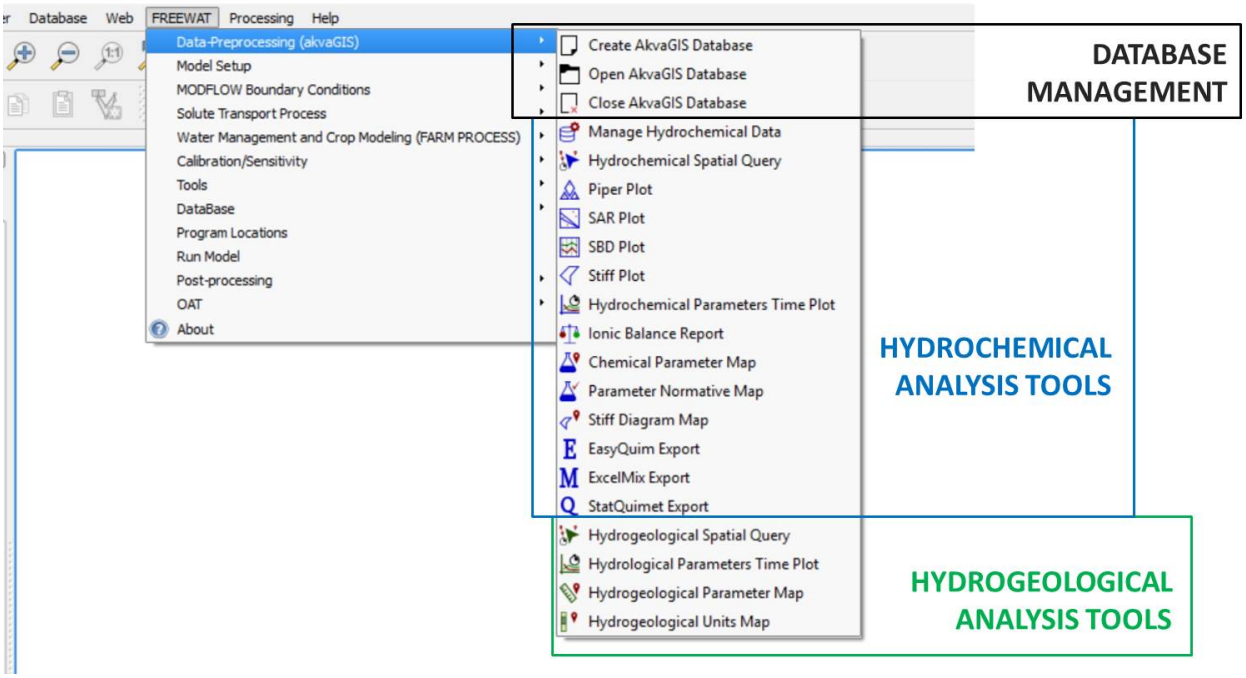
The third party libraries are provided with the plugin distribution: (i) *ChemPlotLib 1.0*: A GPL licensed library that draws the chemical plots provided in the plugin: Stiff diagram, Piper diagrams and SAR plots but also standard plots as 1D line plots. This library offers extensive customization of plots, title labels, axis, edges sizes and colours can be chosen by users and it relies on *Matplotlib 1.5*; (ii) *Openpyxl2.3* (https://openpyxl.readthedocs.io): A MIT licensed library for reading and writing Excel 2010 files. AkvaGIS uses it to export data to Open Office spreadsheets format but the User can save it within the MSExcel formats (xlsx/xlsm/xltx/xltm files); (iii) *Odfpy 1.3* (https://pypi.python.org/pypi/odfpy): A library to read and write OpenDocument v.1.2 files. AkvaGIS uses it to export data to ODF spreadsheets format; (iv) *Pyexcel 0.2* (https://pyexcel.readthedocs.io): A BSD licensed Python Wrapper that provides one API for reading, manipulating and writing data in csv, ods, xls, xlsx and xlsm files. AkvaGIS uses it to export data to different spreadsheets formats.

The dependencies that AkvaGIS apply are: (i) *PyQt4*: The Qt version 4 Python wrapper; (ii) *Matplotlib 1.5* (http://matplotlib.org/): A Python 2D plotting library which produces publication quality figures in a variety of hard copy formats and interactive environments across platforms. For a more detailed information about the code, please see *Database Documentation Section*.

The AkvaGIS plugin enhances QGIS with hydrochemical and hydrogeological data processing and analysis. All reference and measurement data is stored in a SQLite database (called AkvaGIS database).

The QGIS project (.qgis file) manages the AkvaGIS database (.sqlite file) and additional files that are showed in the canvas or layer panel. The Database Management tools allow users to create, open and close the AkvaGIS database in which the hydrochemical and the hydrogeological spatio-temporal data are stored previous to their representation or analysis.

1.1 AkvaGIS main menu



1.2 Database tools

The **AkvaGIS database** is the core of AkvaGIS Tools and it was implemented in RDBMS Spatialite. Its structure facilitates: 1) the data standardization and harmonization, 2) the storage and management of large amount of spatial features and time-dependent data and 3) the creation and the execution of queries. This database has been designed to include a wide range of information related to hydrochemistry and hydrogeology. The user is able to store all data related to the study zone and to gradually incorporate new data. The information can be easily shared with other users without losing information.

SpatiaLite is an SQLite Database engine with spatial functions added. SQLite is a Database Management System (DBMS) which is simple, robust, easy to use and very lightweight. Each SQLite database is simply a file. You can freely copy it, compress it, and port it between Windows, Linux, MacOs etc.

For more information about SpatiaLite database you can see: http://www.gaia-gis.it/gaia-sins/spatialite-cookbook/index.html#family There many free open source browsers to manage and visualize data stored in a database (e.g. Spatialite-gui or DB Browser for SQLite). For instance, these browsers aid the users to upload large datasets at the same time.

The spatial points containing location of collected samples and measurements are the basic information to start using the AkvaGIS tools. These Points can be piezometers, wells, springs, swallow holes, seeps, vanishing points or any other water bodies (i.e. river, lake, sea).

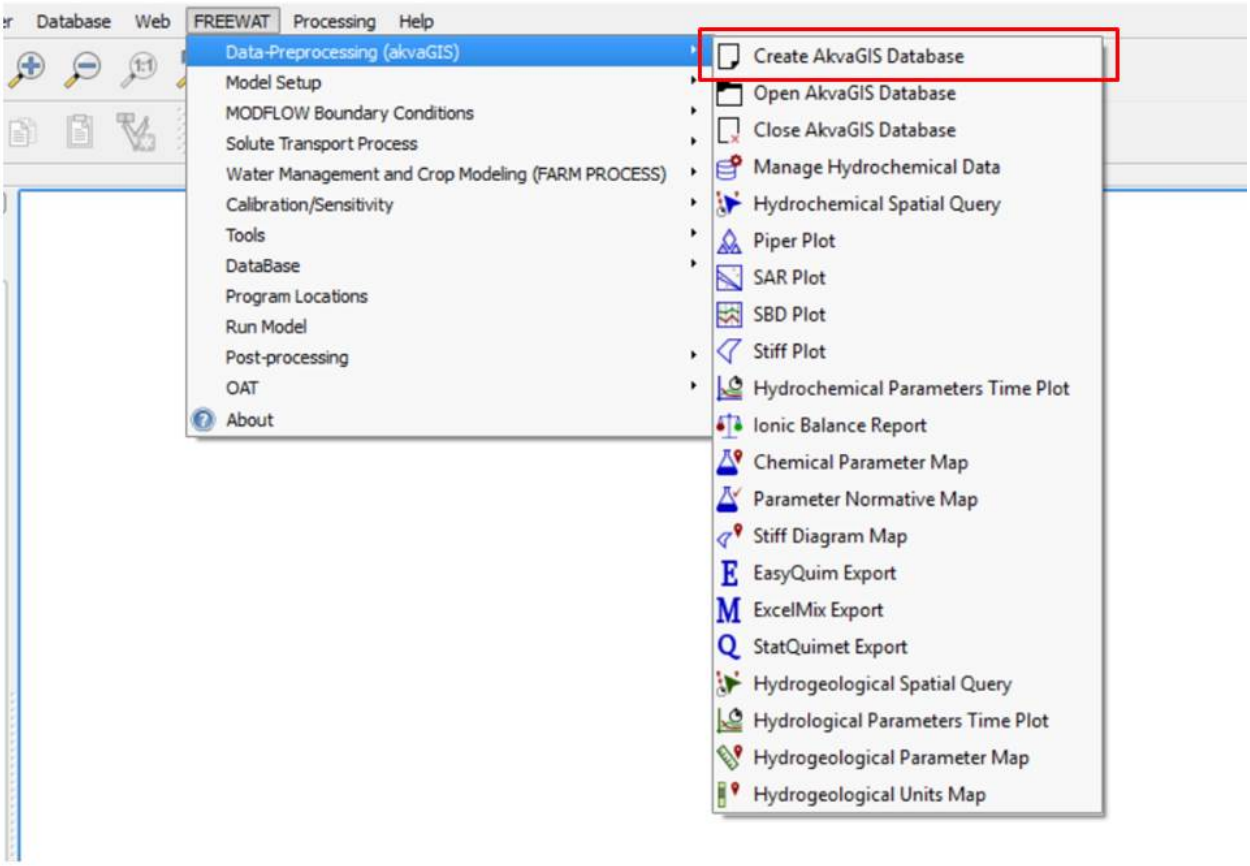
The Basic hydrochemical information related to each spatial point, i.e. *HydrochemicalSamples* and *HydrochemicalMeasurements* tables, contains the dates of when each named sample was taken, the dates of the physical and chemical parameters analysis, as well as their corresponding values and units. The list of analysed parameters is stored in a library/catalogue (*ListHydrochemicalParametersCode*) that can be updated by the user.

Similarly, the basic hydrogeological information is related to the corresponding spatial point where the hydrogeological measures were observed. The measurements date, the measured parameters and the corresponding values and units

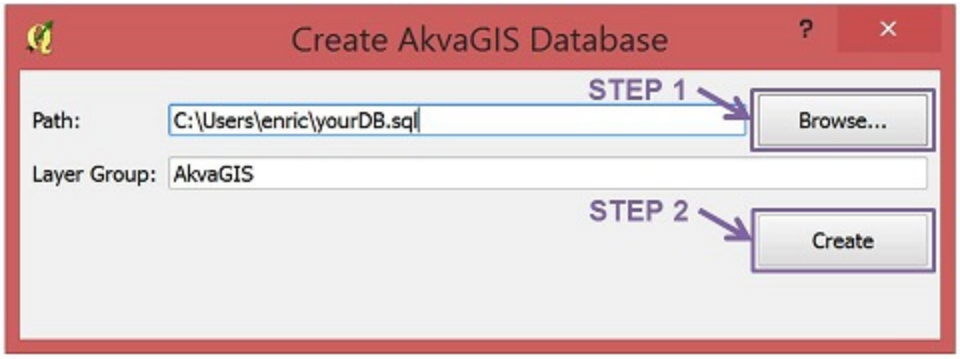
are stored in the tables *HydrogeologicalPointsObservations* and *HydrogeologicalPointsMeasurements*. The default hydrogeological parameters available in the library/catalogue *ListHydrogeologicalParametersCode* are: flow rate, depth to water, pressure and head stored. This list of parameters can be customized by the user. To create hydrogeological surfaces units, to be used in a numerical model, the hydrogeological unit observed at each point can be defined and stored in the tables *HydrogeologicalUnits* and *WellsHydrogeologicalUnit*.

Additional information, such as field campaigns, entities in charge of measurements or responsible parties, among others, can also be stored. This information is not essential for using AkvaGIS tools but it is useful to manage the hydrogeological and hydrochemical data. Detailed information of each table are described in section **Database documentation**.

1.2.1 Create AkvaGIS database

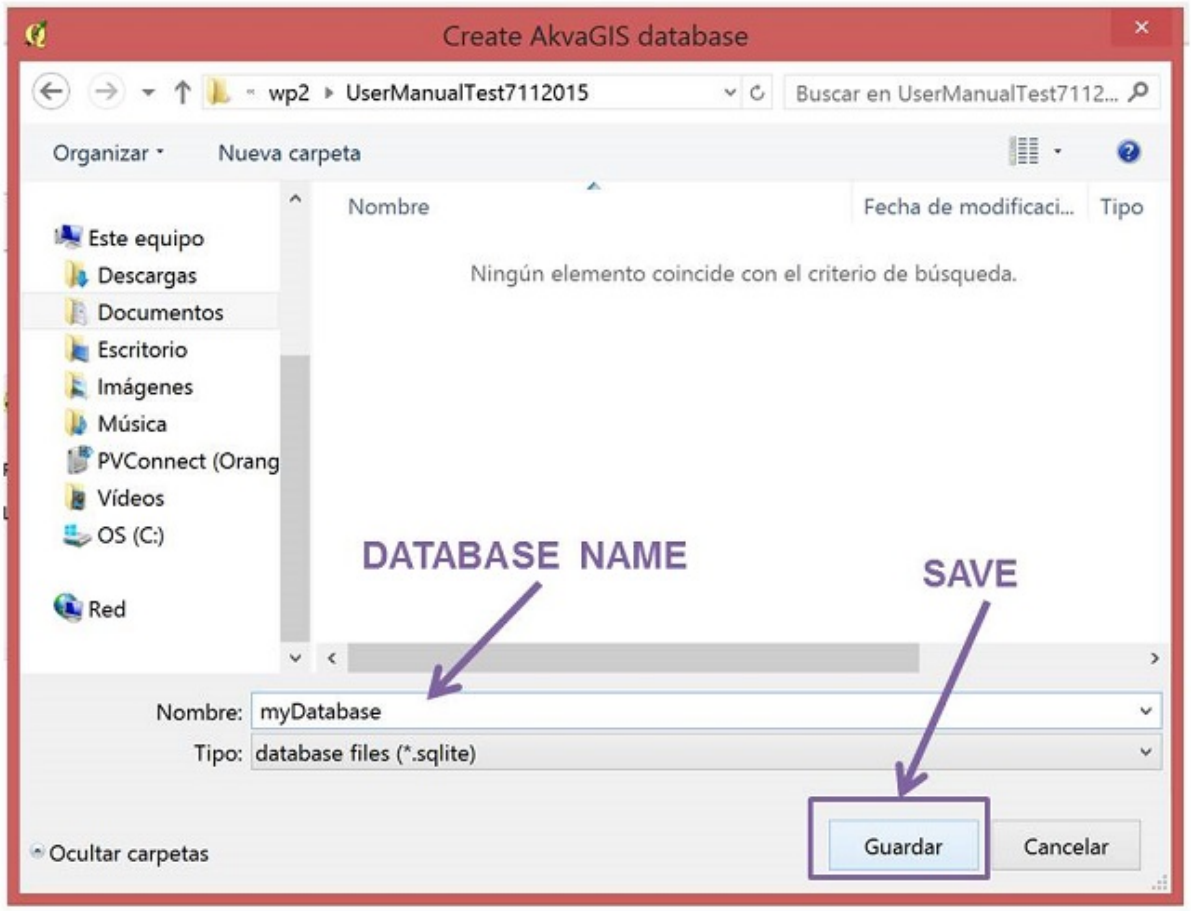


This command enable us to create a new AkvaGIS SpatiaLite database where the hydrochemical and the hydrogeological data will be introduced to be queried by AkvaGIS Analysis Tools.

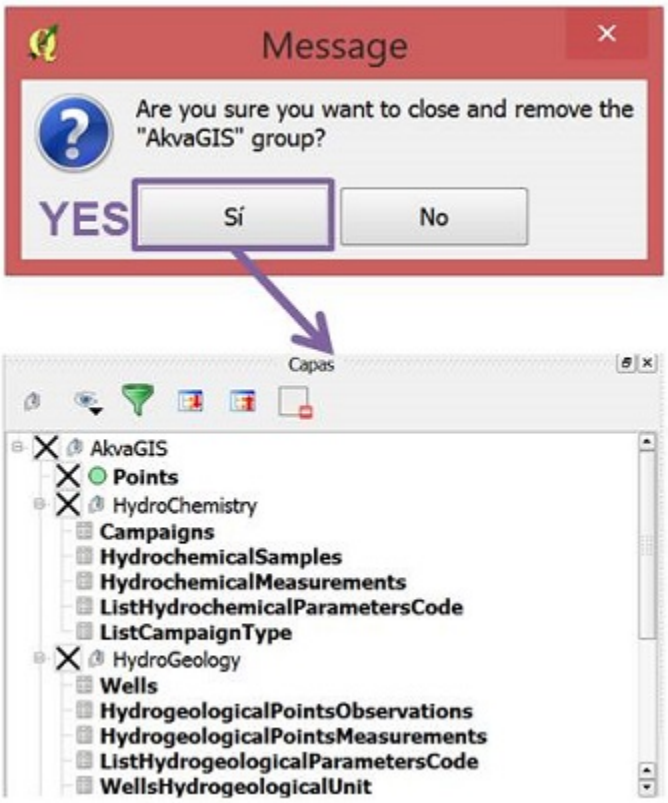


For further information about the AkvaGIS database, please read *Database Documentation Section*.

- *Step 1*: Select path in your computer where the database will be created.



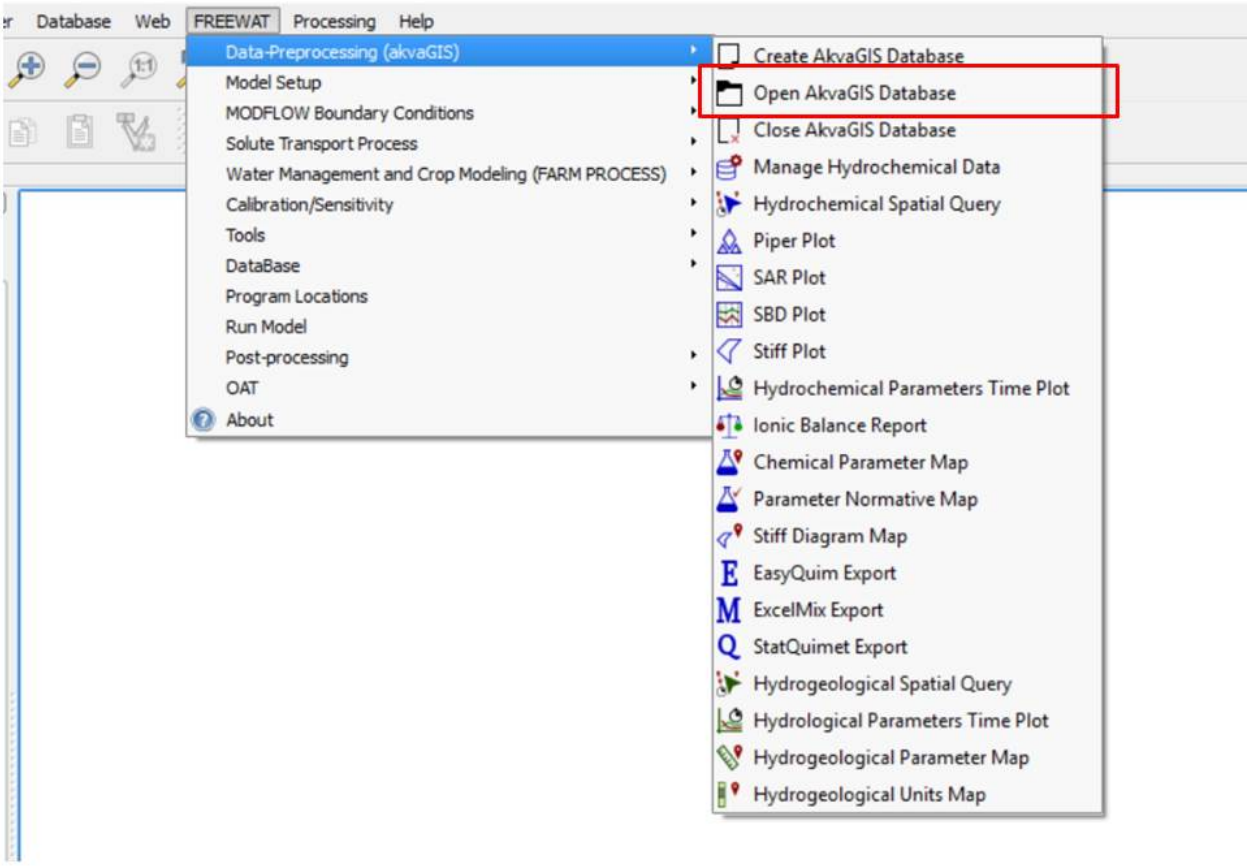
- *Step 2*: Create new Database (empty) and it automatically will be loaded in QGIS.



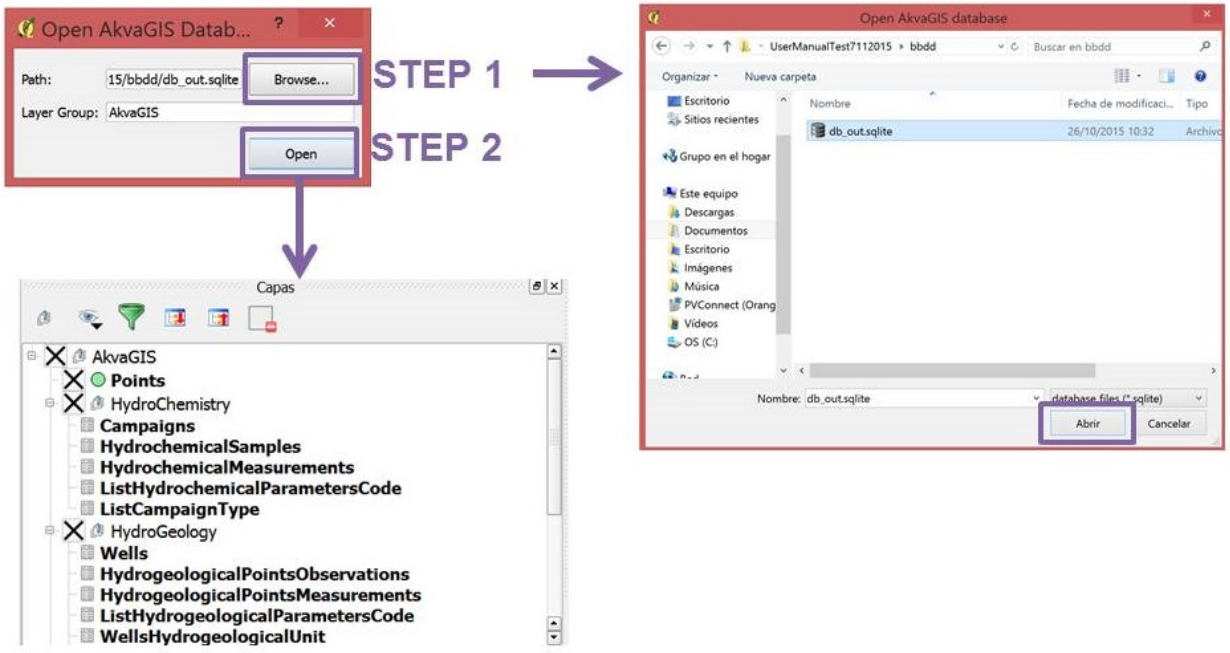
To create new geometric entities (e.g. Points) and entering data in the attribute tables, the user can use the in-built utilities of QGIS (or SpatiaLite utilities).

The **AkvaGIS database** contains the required tables, geospatial entities as well as code lists to enable the user starting a new project from the scratch. Notice that the AkvaGIS tools include also a command composed by a GUI that facilitate the incorporation of hydrochemical data into the database (see section 2.1 *Manage Hydrochemical Data*).

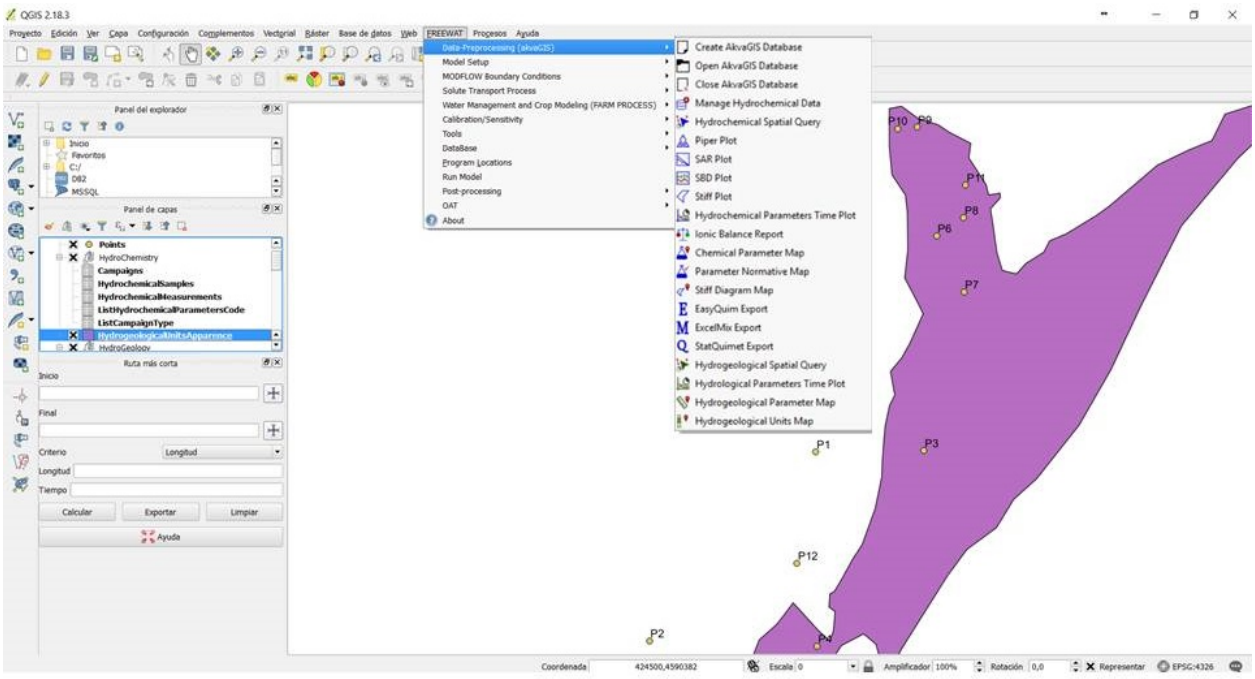
1.2.2 Open AkvaGIS database



This command open an existing AkvaGIS database stored in your computer.

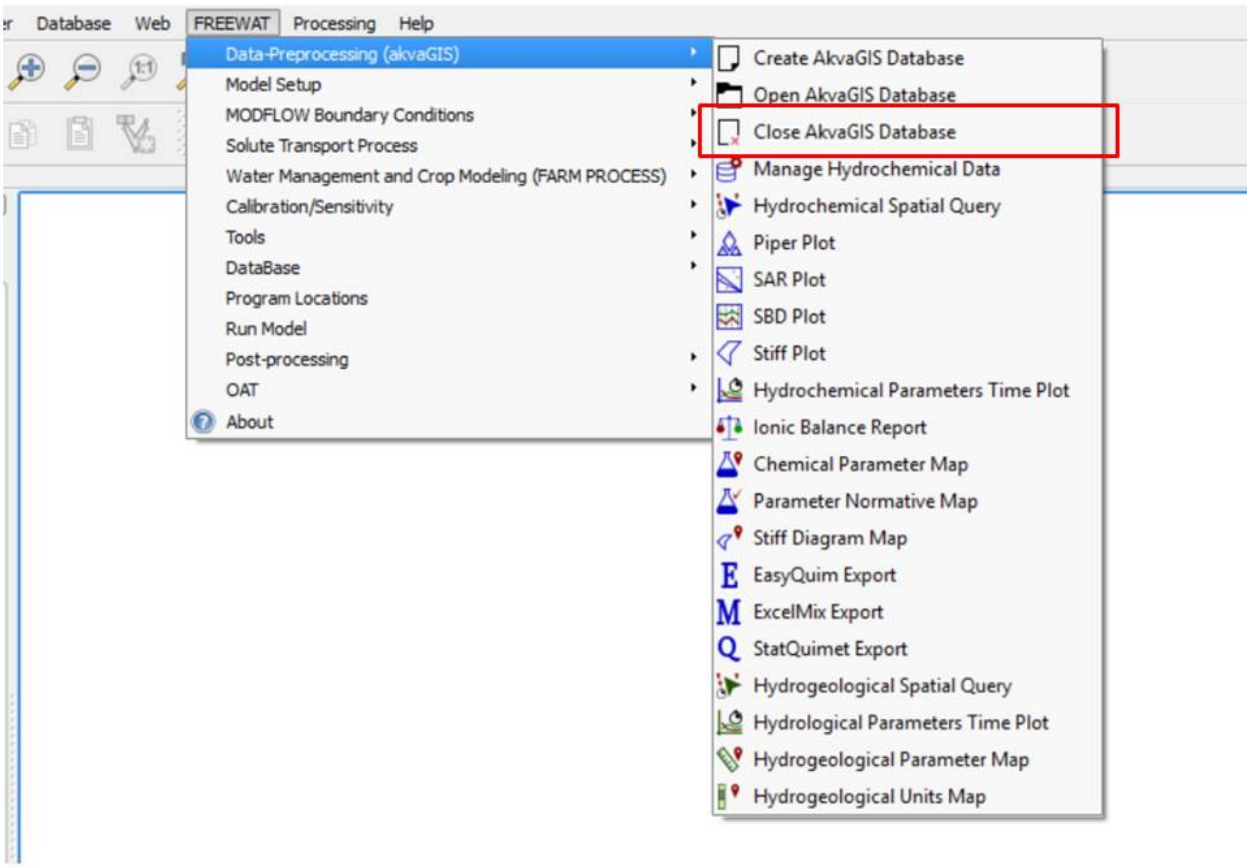


- *Step 1*: Select path in your computer where the database is stored.
- *Step 2*: Automatically the main geometrical entities (Points and HydrogeologicalUnits) and the main attributes table will be shown in the Layers Panel.



The Points entities shown in the figure represent points where samples have been taken to be analysed or points where hydrogeological observations and measurements have been performed (for further information of the database, please see *Database Documentation Section*).

1.2.3 Close AkvaGIS database



Use this command to close and remove the opened database.

Note: This is an important command if you want to open another AkvaGIS Database (avoiding to close the QGIS session).

CHAPTER 2

Hydrochemical analysis tools

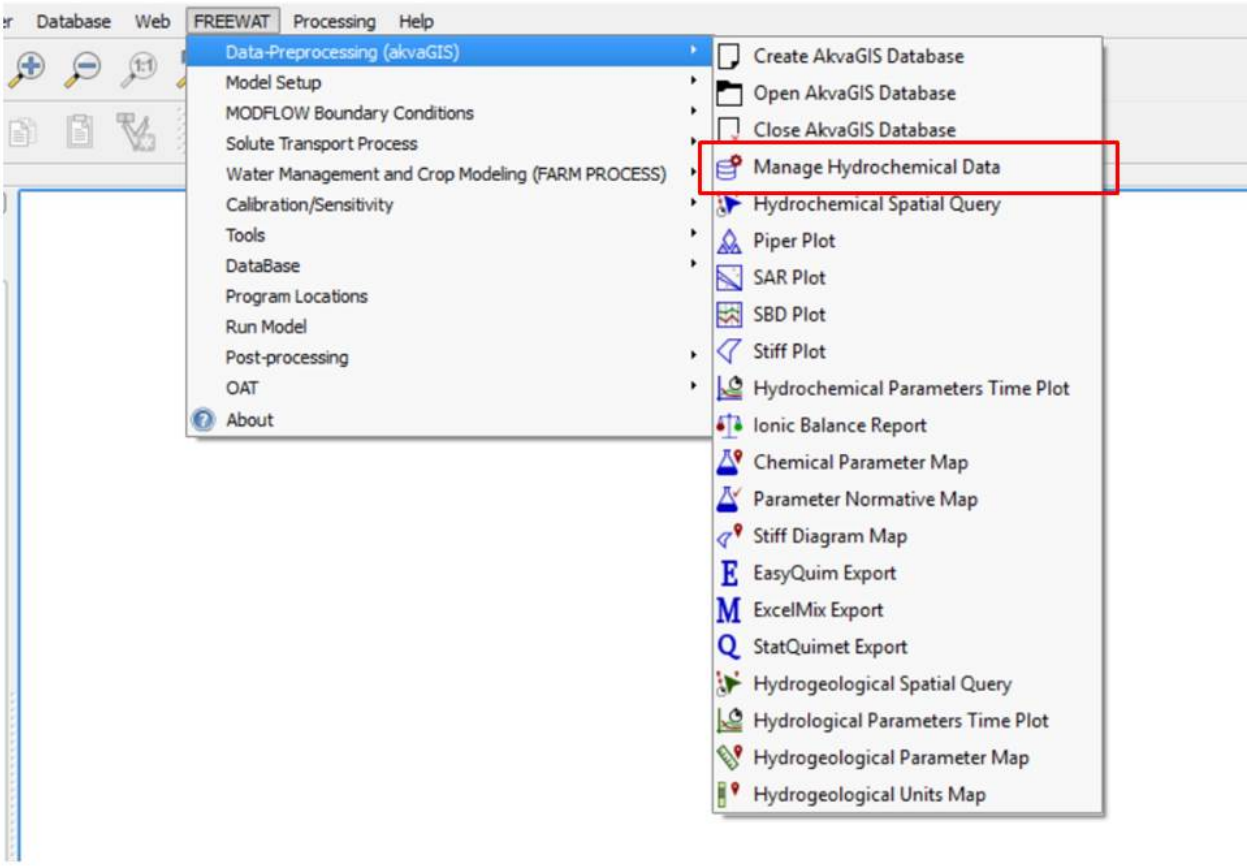
The **Hydrochemical Analysis Tools** sub-module of AkvaGIS was created to complement the functionalities of the FREEWAT platform.

These tools facilitate the management of different hydrochemical data with a wide range of methodologies for querying, interpreting, and comparing groundwater quality data and facilitates the pre-processing analysis for being used in the realization of water assessments like river/lake contamination remediation or irrigation water quality evaluation, among others.

The core of these tools is a geospatial database implemented in Spatialite which contains the hydrochemical spatio-temporal information, ready to be represented or analyzed.

The hydrochemical tools was developed for improving the harmonization, integration, standardization, visualization and interpretation of hydrochemical data measured in rivers, lakes, springs, wells, etc. Some of the tools developed are: ionic balance calculations, chemical time-series analysis, correlation of chemical parameters, regulatory parameters analysis tool, calculation of various common hydrochemical diagrams (Salinity, Schöeller-Berkaloff, Piper, and Stiff), and the link to the free codes EASYQUIM, MIX, and Statistical Analysis, among others. Furthermore, the sub-module allows the generation of maps of the spatial distributions of parameters and thematic maps for the parameters measured in the queried area and classified according to the threshold approach established by a given guideline, e.g. WFD.

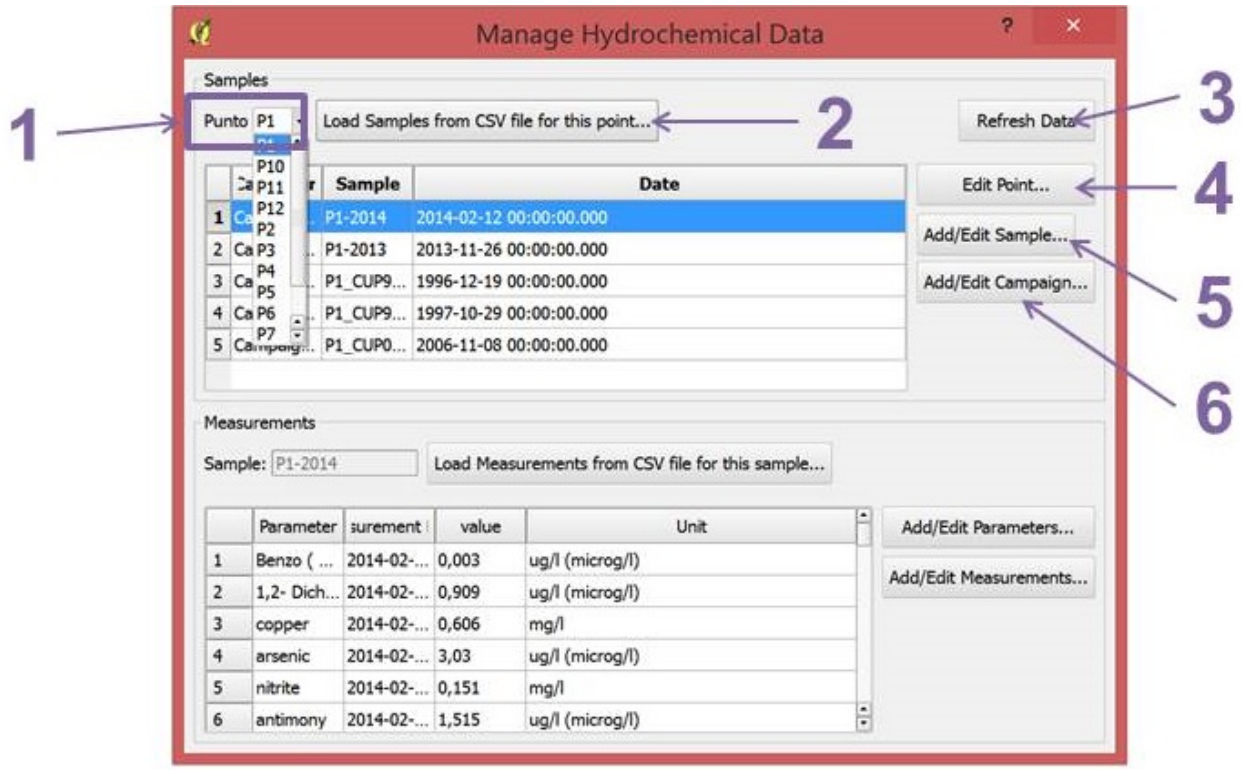
2.1 Manage Hydrochemical Data



This utility enables the user to modify, insert and visualize hydrochemical data from existing points stored in the database.

Click on Manage Hydrochemical Data command and it opens automatically the management window GUI.

With this GUI, the user can: 1) edit the information of the sampling Points, 2) Add/edit Samples (one by one or massively using .csv files, 3) add/edit campaign, 4) add/edit Hydrochemical Measurements (one by one or massively for each selected sample using .cvs files). In the following paragraphs each of this utilities will be explained:

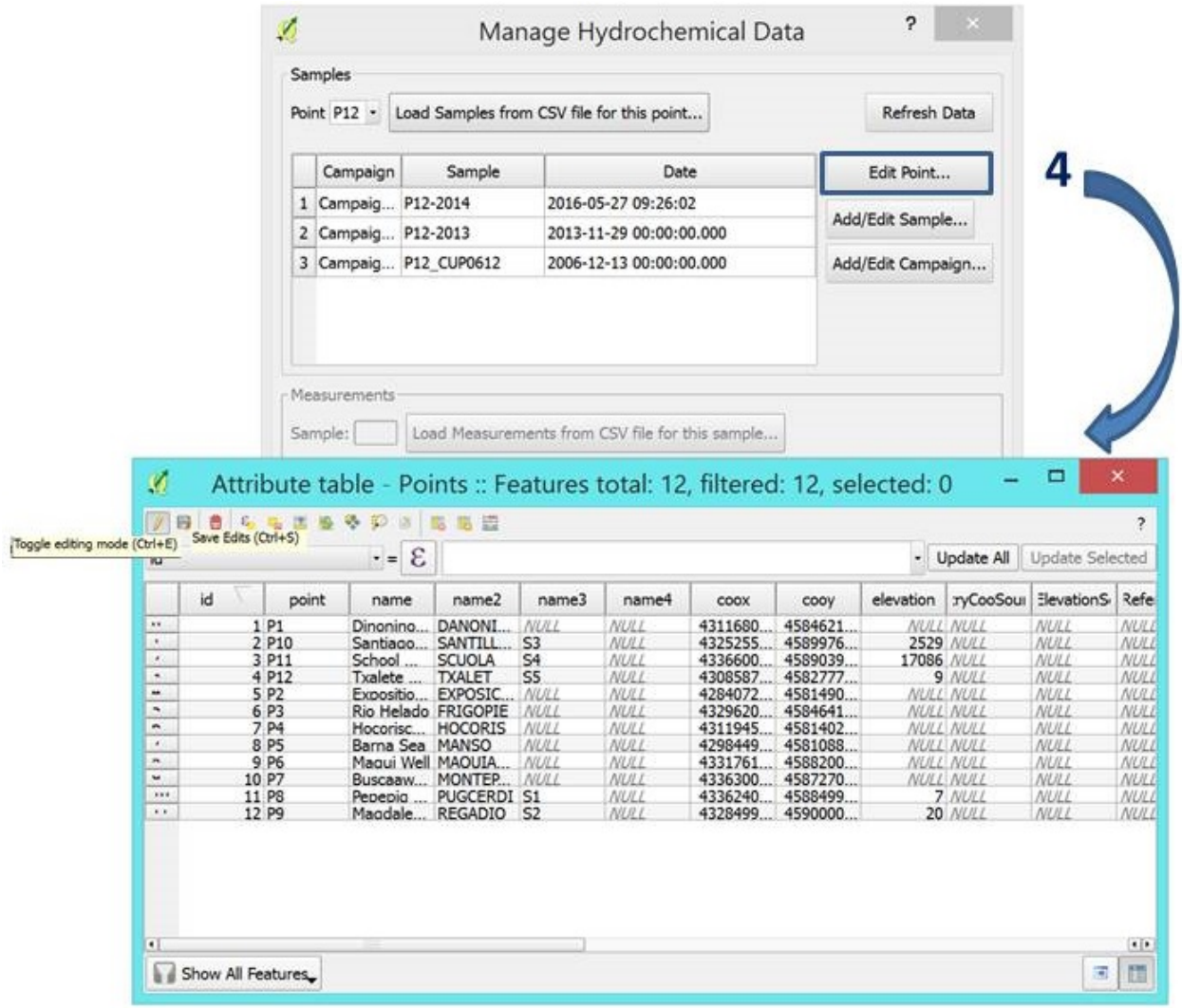


- *1. Point*: Click here to select the point that you want to modify/add a newsample/campaign/hydrochemical measurement.
- *2. Load Samples from csv file*: Click here to add samples to the selected point from CSV file. The csv file format has to be like akvaGIS tables.

  CVS File format: sample; samplingTime; campaignId; fieldname; currentLocation; sampleSize; sampleSizeUom; samleLenght; samplingMethodId; responsiblePartyId; otherChemSamplesDetails; observations. For further information about the contents of this table, please see Database Documentation section.

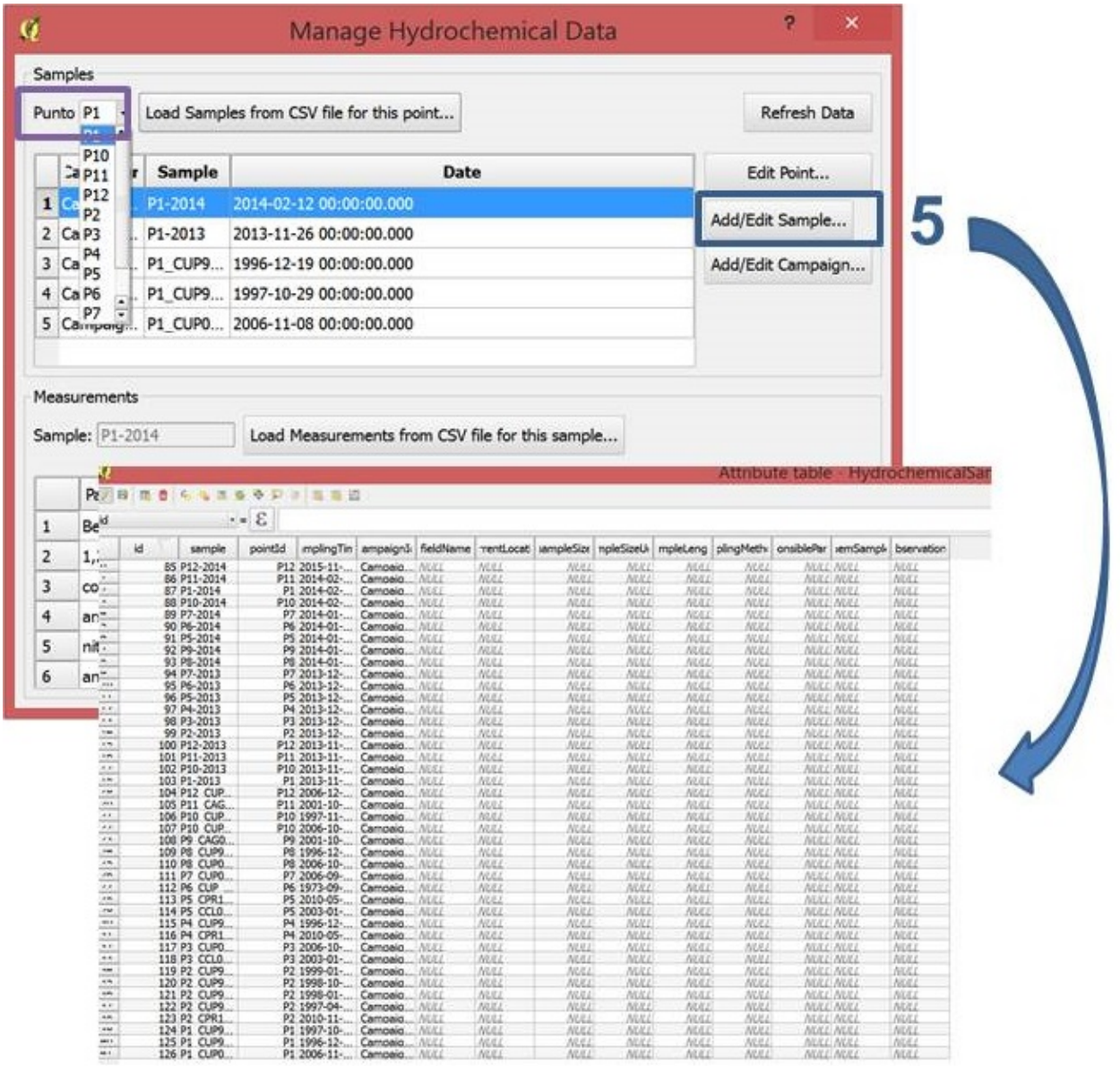
- *3 Refresh Data button*: This command enables us to visualize and update the editing or the new data included in the database.

Note: This command has to be used after every change in the database applied using this GUI.

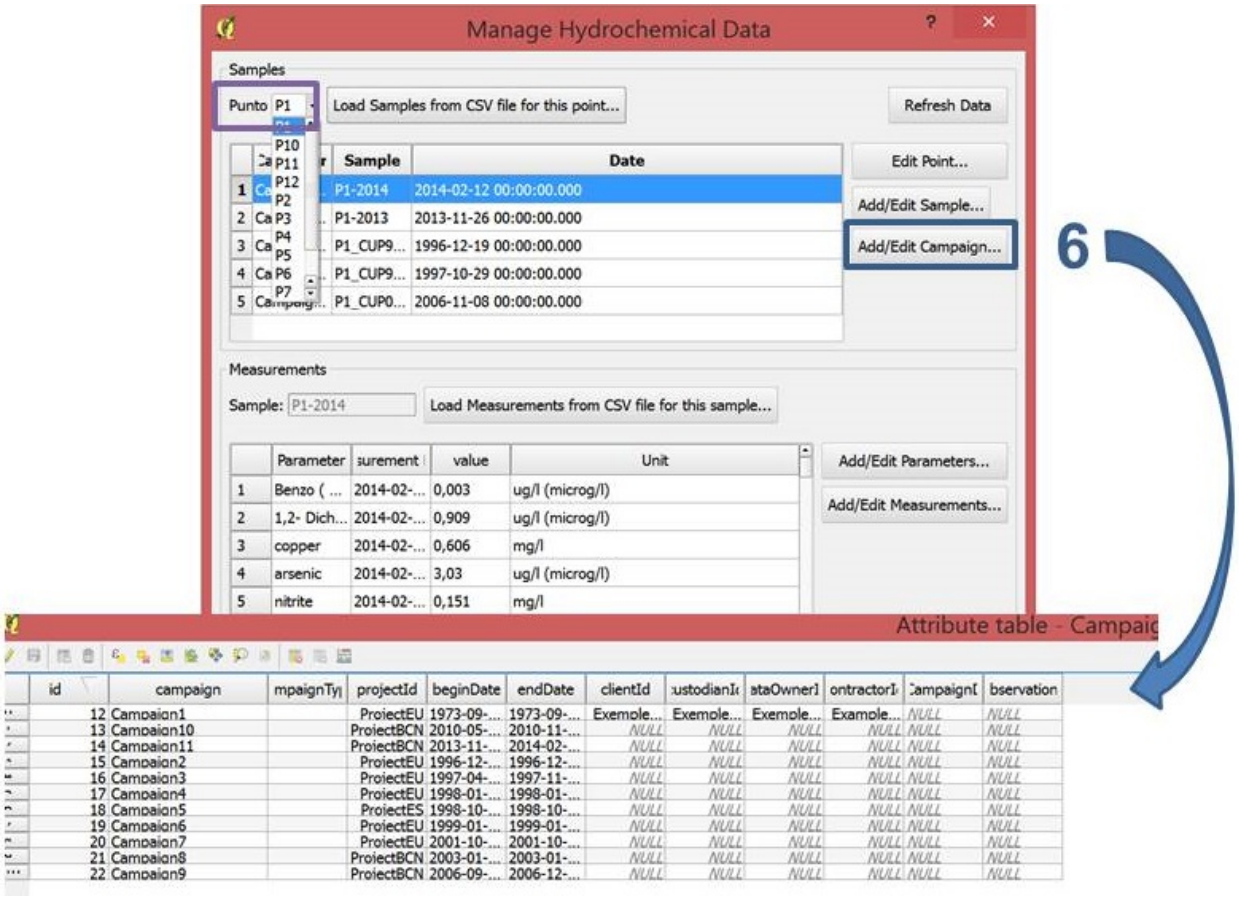


- *4. Edit Point*: Click here to edit the information related to the Points of sampling. Please, notice that using this function the editing mode of QGIS will be automatically activated.

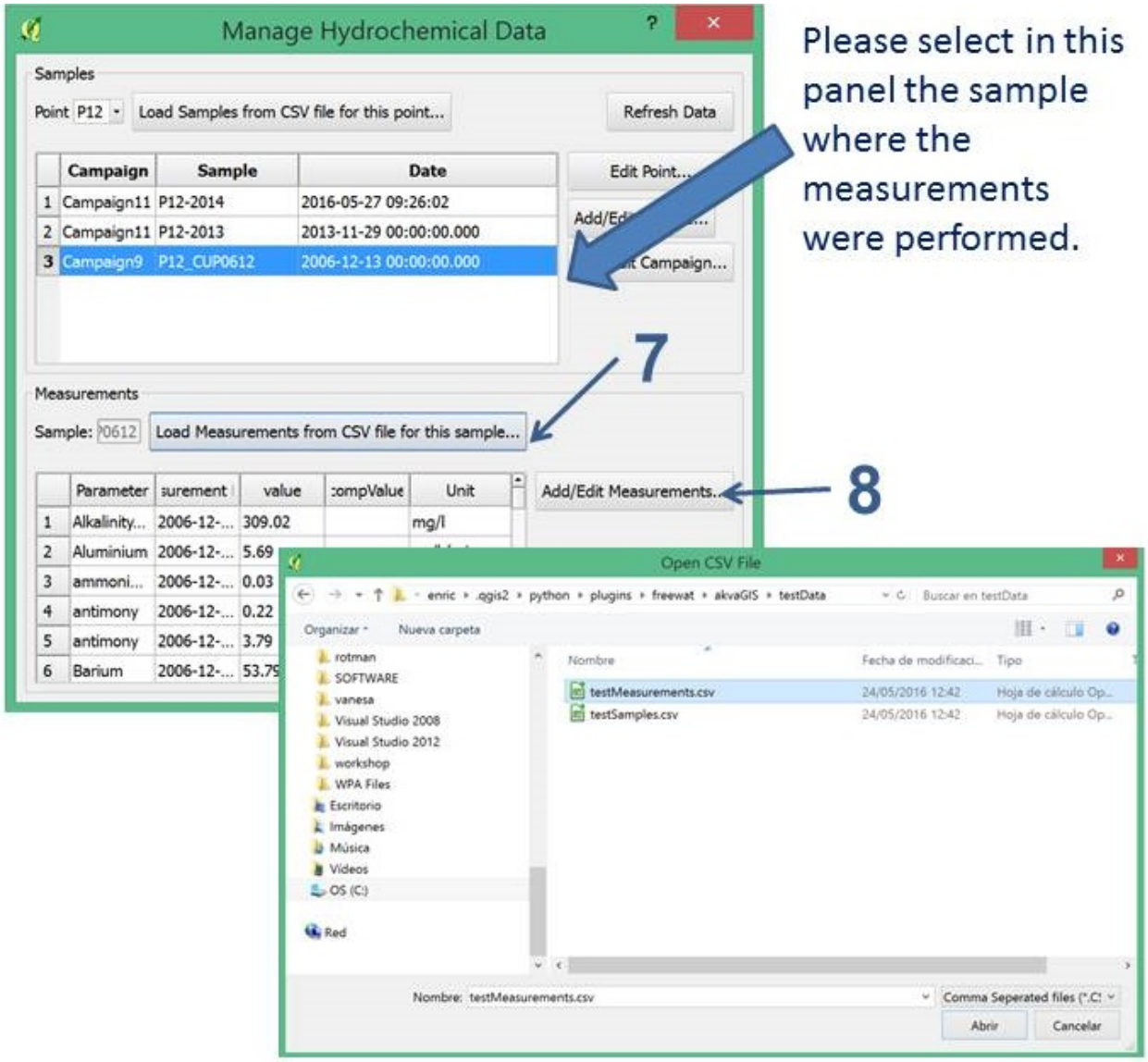
Note: After the required editions in the table, please use the command of save edits of QGIS.



- *5. Add/edit sample*: Click here for adding/editing samples taken from the selected Points. Please, notice that using this function the editing mode of QGIS will be automatically activated. **After the required editions in the table, please use the command of save edits of QGIS**.



- *6. Add/edit campaign*: Click here for adding/ editing campaign information from the selected Points.

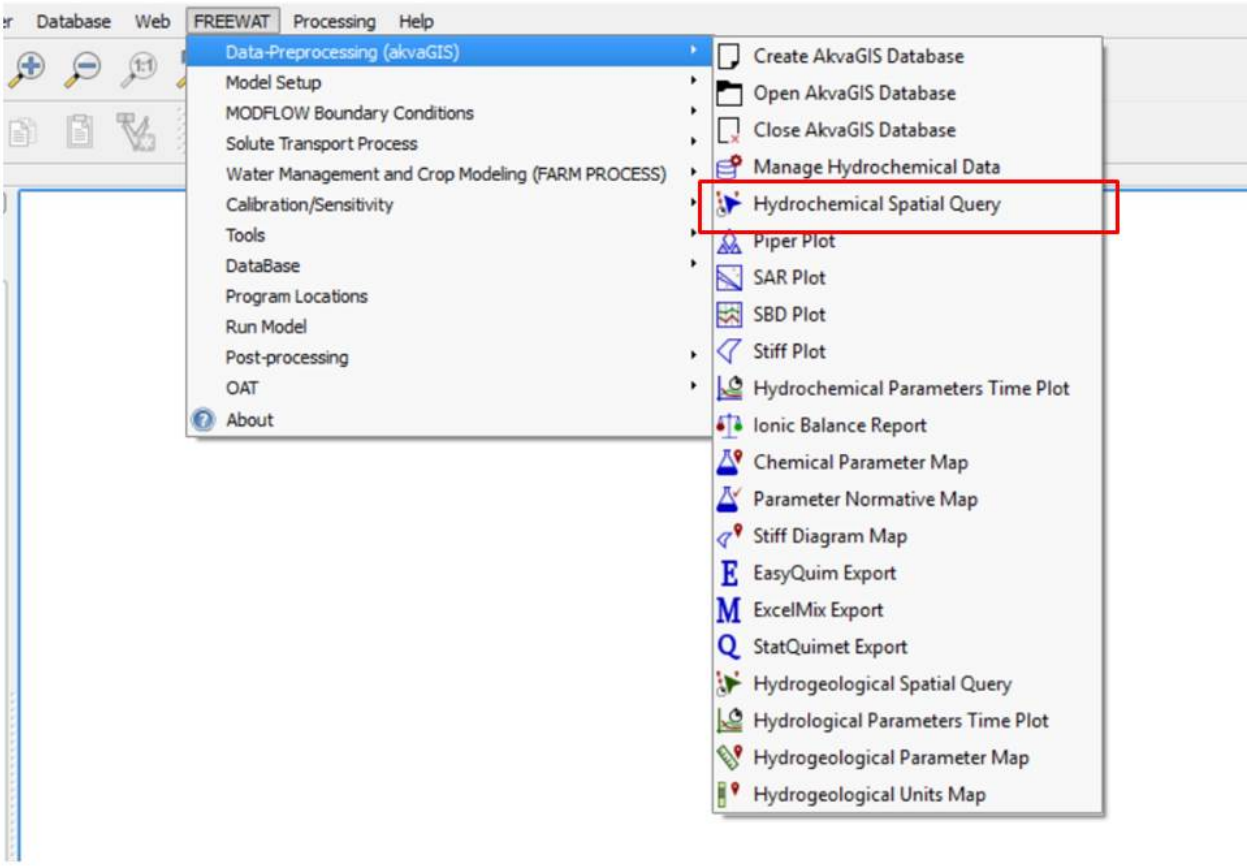


- *7. Load Measurements from csv file*: This command allows us to include into the database massively the different hydrochemical measurements performed for the selected sample for the selected point using a CVS file. The csv file format has to be like akvaGIS table.

  CVS File format: hydrochemicalParameterCode; resultTime; value; compValue; responsiblePartyId; processId; citationId; otherChemMeasurementsDetails; observations. For further information about the contents of this table, please see *Database Documentation Section*.

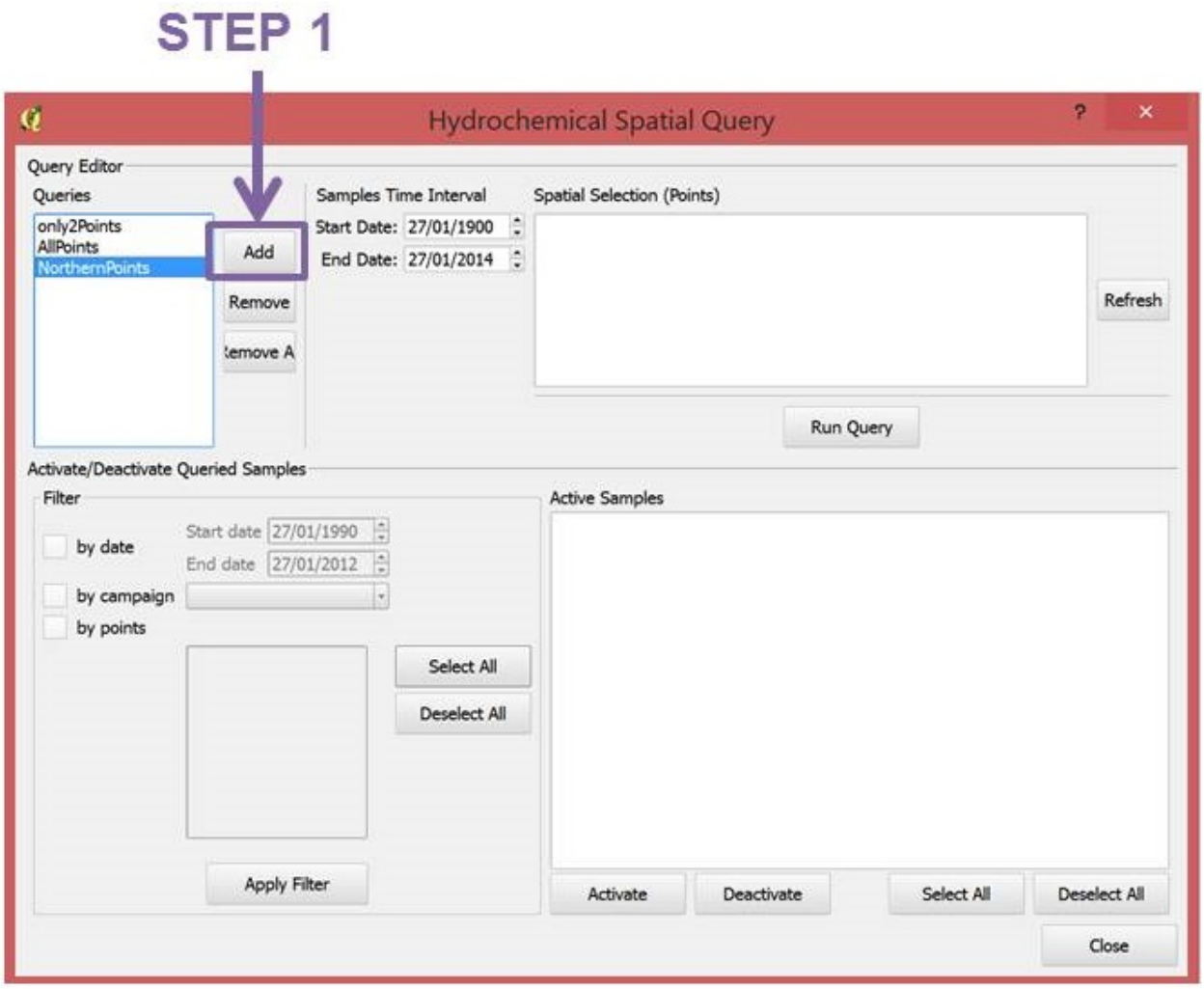
- *8. Add/edit Measurements*: Click here for adding/ editing measurements.

2.2 Hydrochemical Spatial Query

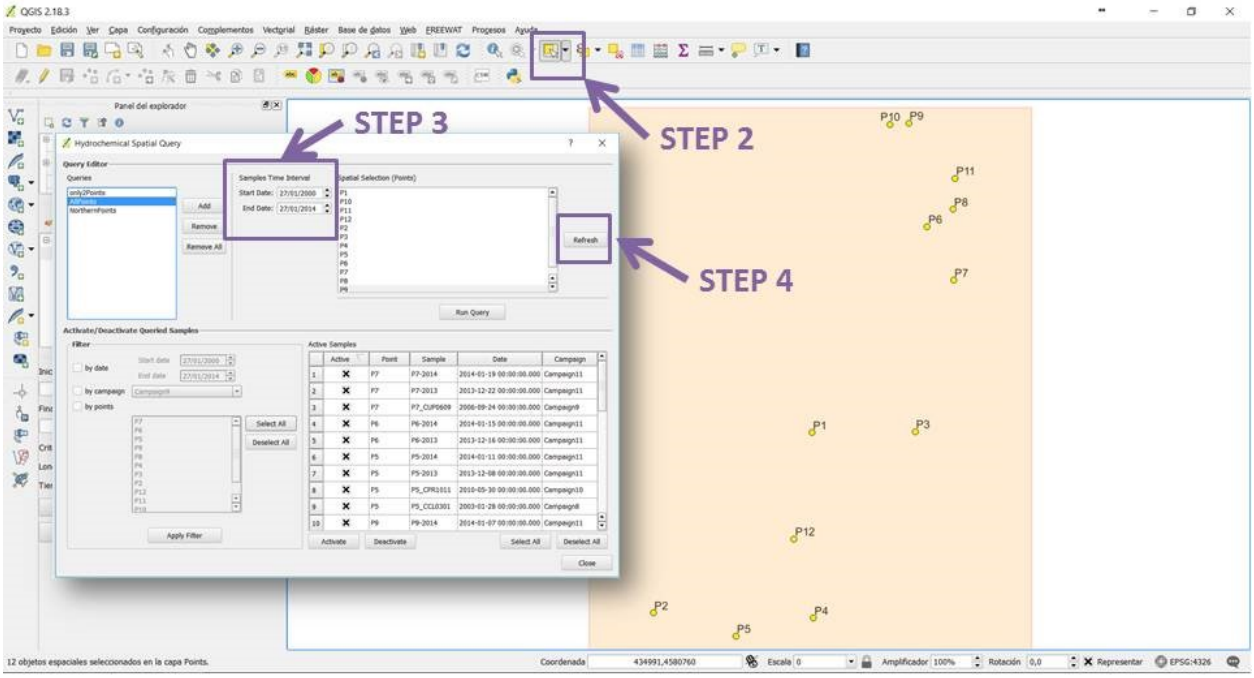


This command enable us to create a query for the selected point or set of points on the screen that represents sampling sites (Points). Thereafter, the user select other query criteria such us period of time of sampling or campaigns.

The Hydrochemical Spatial Query created by the user can be stored in the database to the other hydrochemical tools (e.g. piper, stiff, ionic mass balance, etc.) included in akvaGIS toolbar.

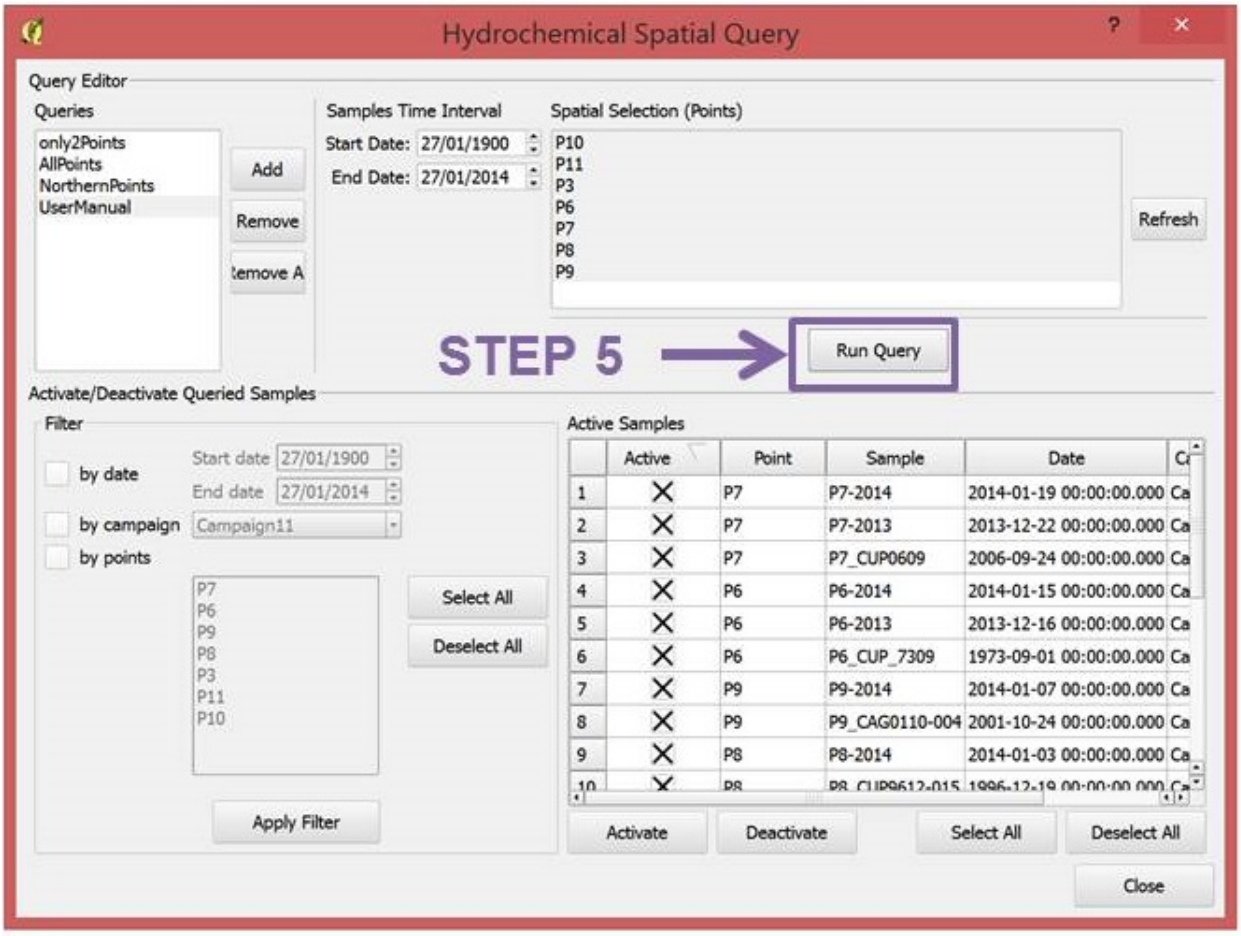


- *Step 1*: This command to create and add to the database a new query of the selected sampling points (spatial selection) for the desired time interval. Also campaign can be used as a query criteria. Thus, hydrochemical tools can be applied to the queries stored in the database or it can be used in future analysis. Using the command Remove, the selected Query can be deleted from the database and using Remove All, all the queries stored in the database will be deleted.

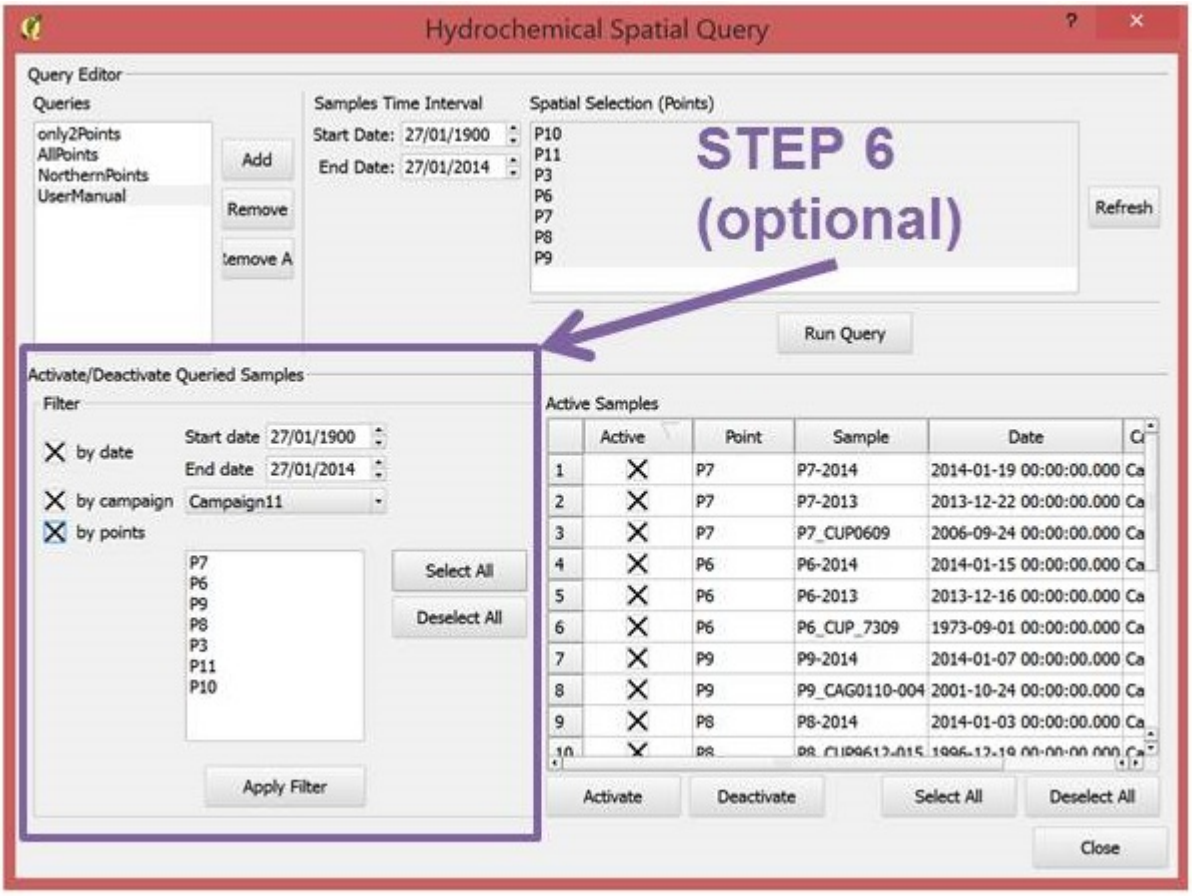


- *Step 2*: Select (using inbuilt tools of QGIS) the points to be included in the query on the screen.
- *Step 3*: Select the desired time interval to be queried.
- *Step 4*: Refresh for visualize the new query.

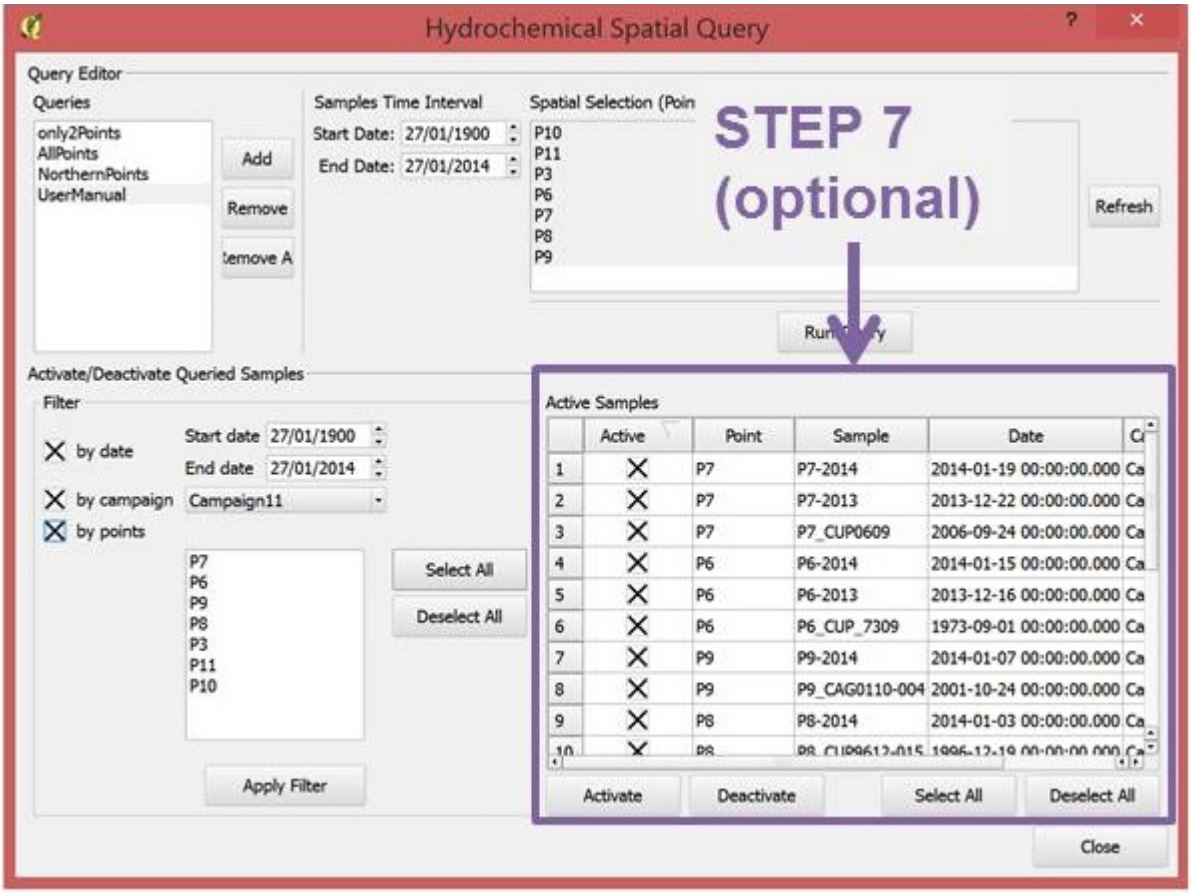
> **Note:** This command has to be used after every change in the query applied using this GUI.



- *Step 5*: Run Query.



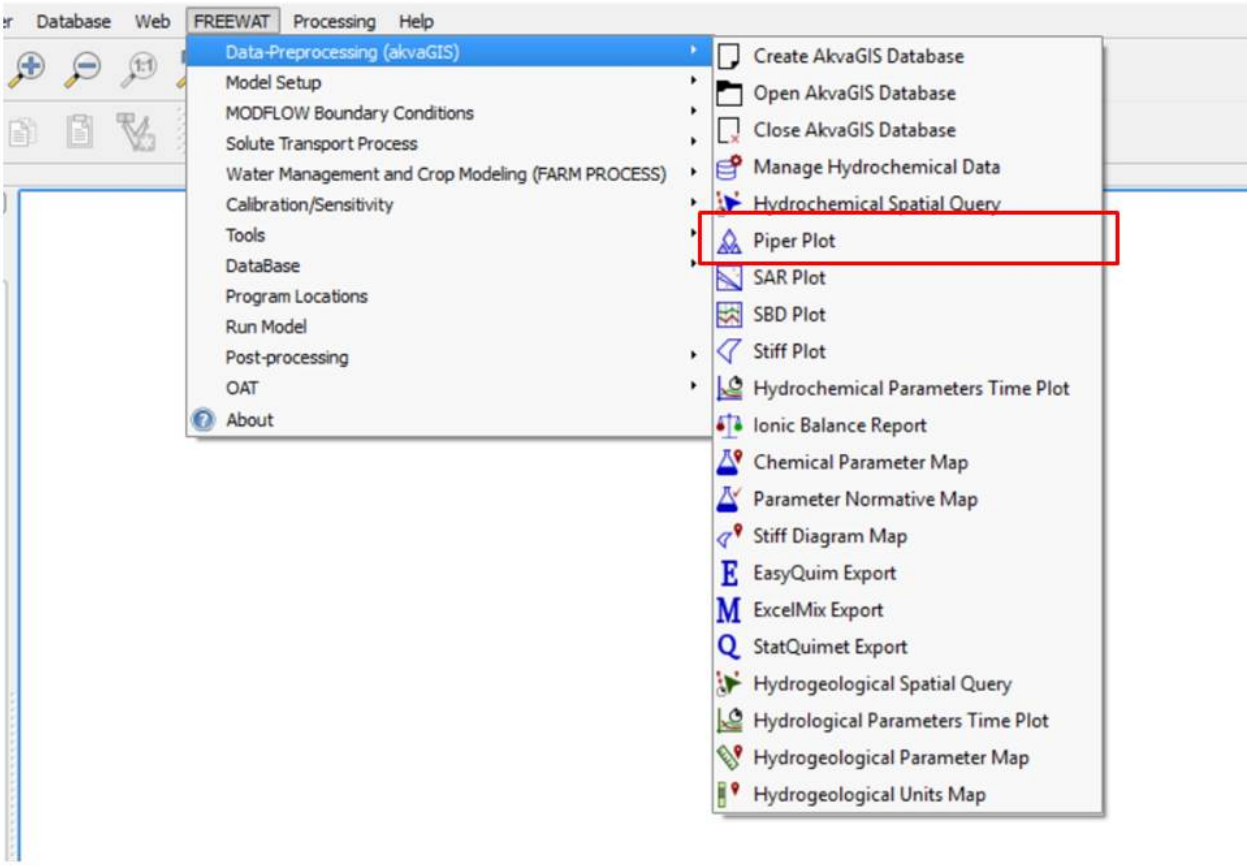
- *Step 6*: Filter chosen any available query criteria by date, by campaign or by points (optional) .



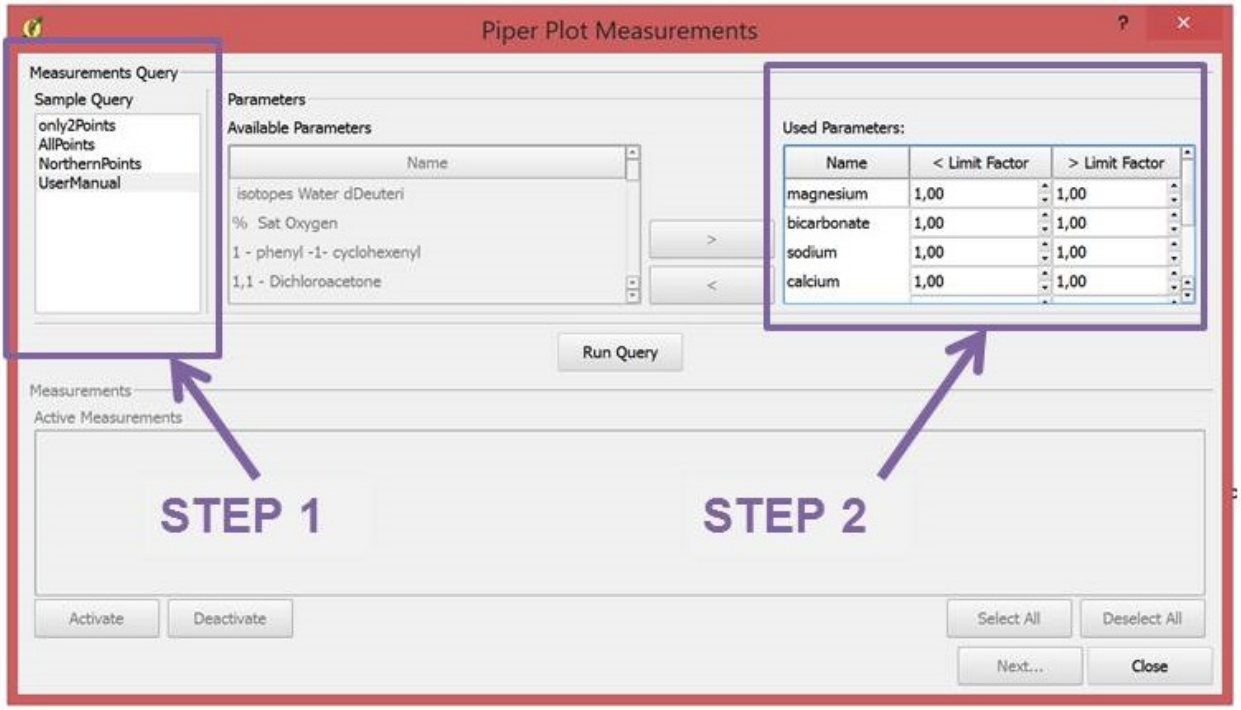
- *Step 7*: Activate/Deactivate the desired samples to be included in the query. For activate/deactivate please, select the row (also select all/deselect all) (optional).

Finally, click in close button to close the query form.

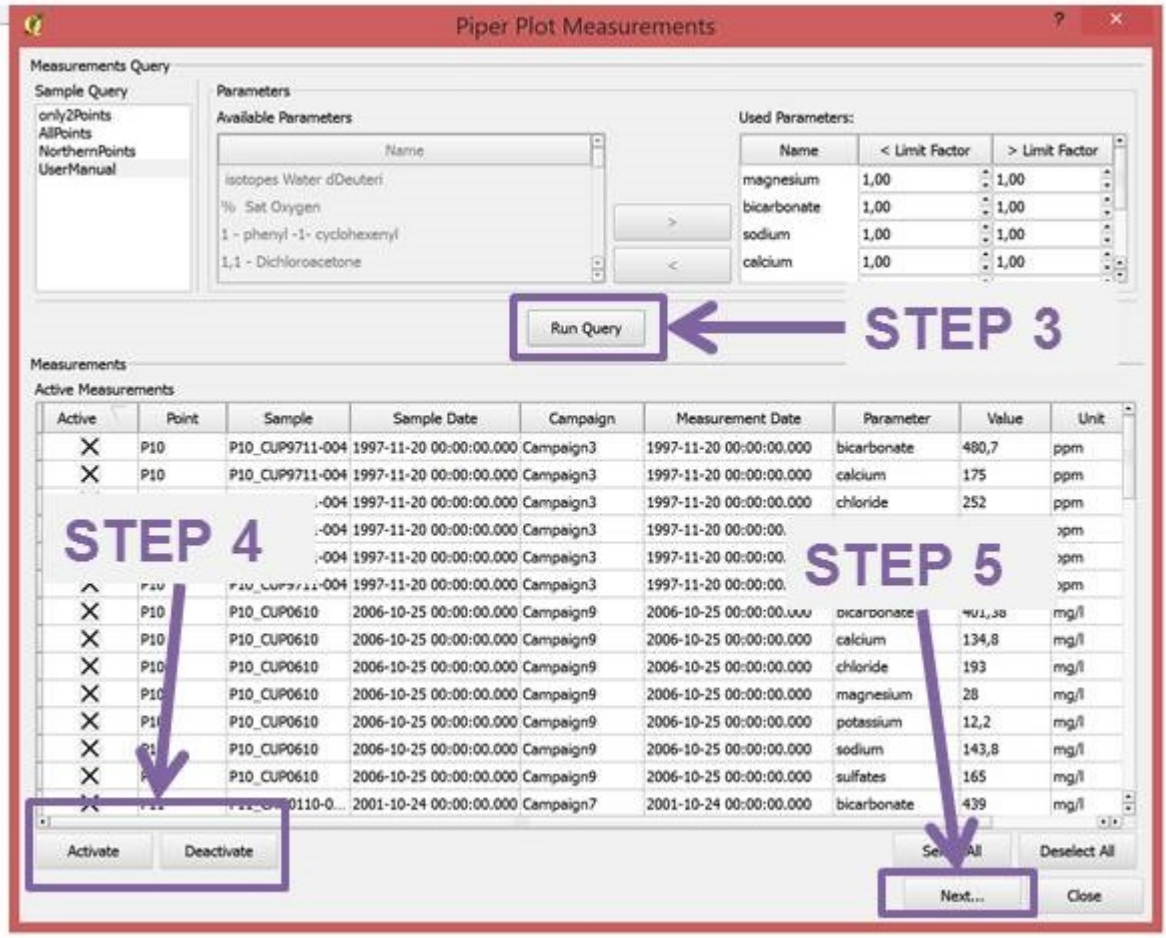
2.3 Piper Plot



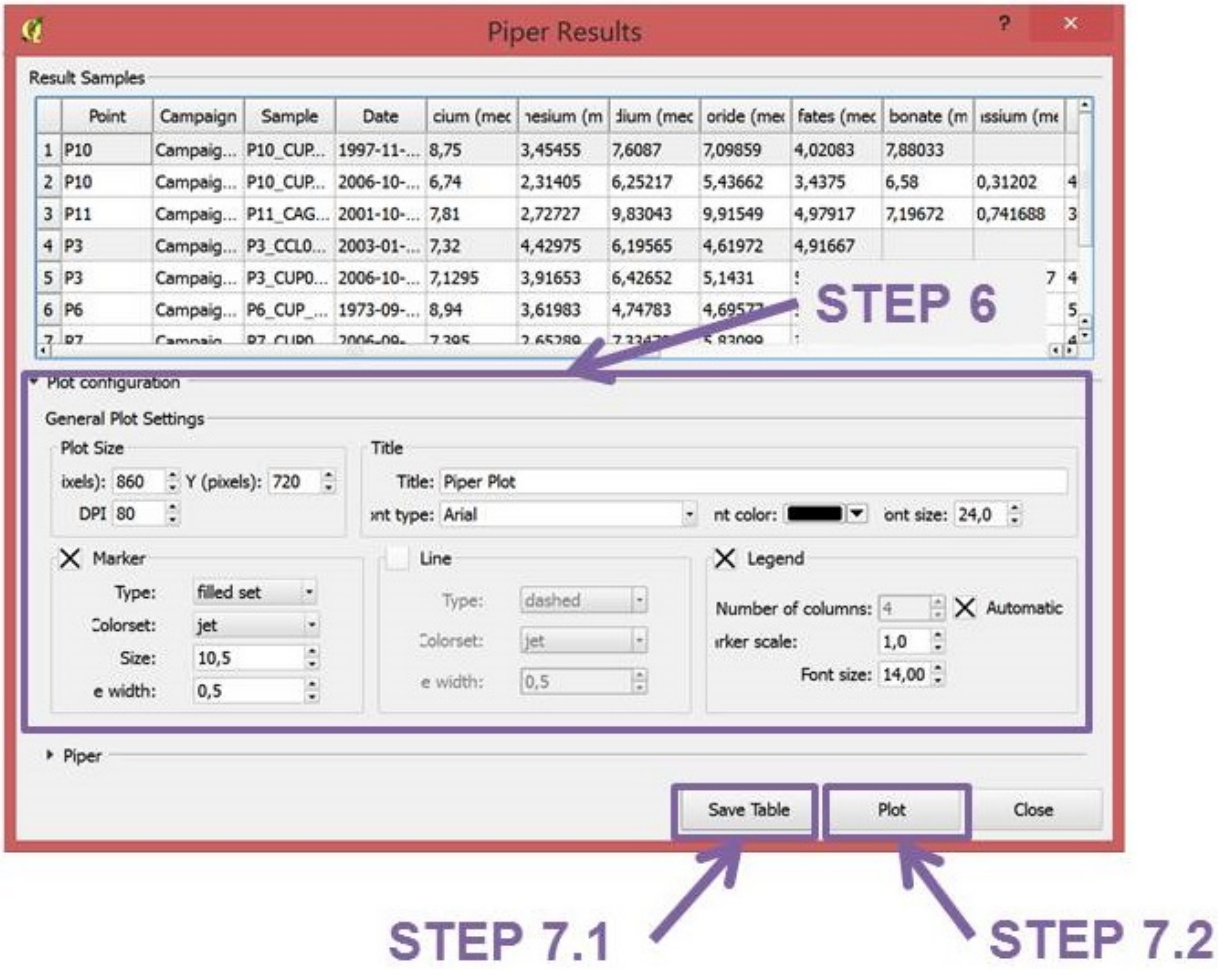
Use this command to create automatically Piper Plots for the selected query created previously with the Hydrochemical Spatial Query tool (section 2.2 *Hydrochemical Spatial Query*). This diagram will be created only if the measurements required for the creation of this diagram are available.



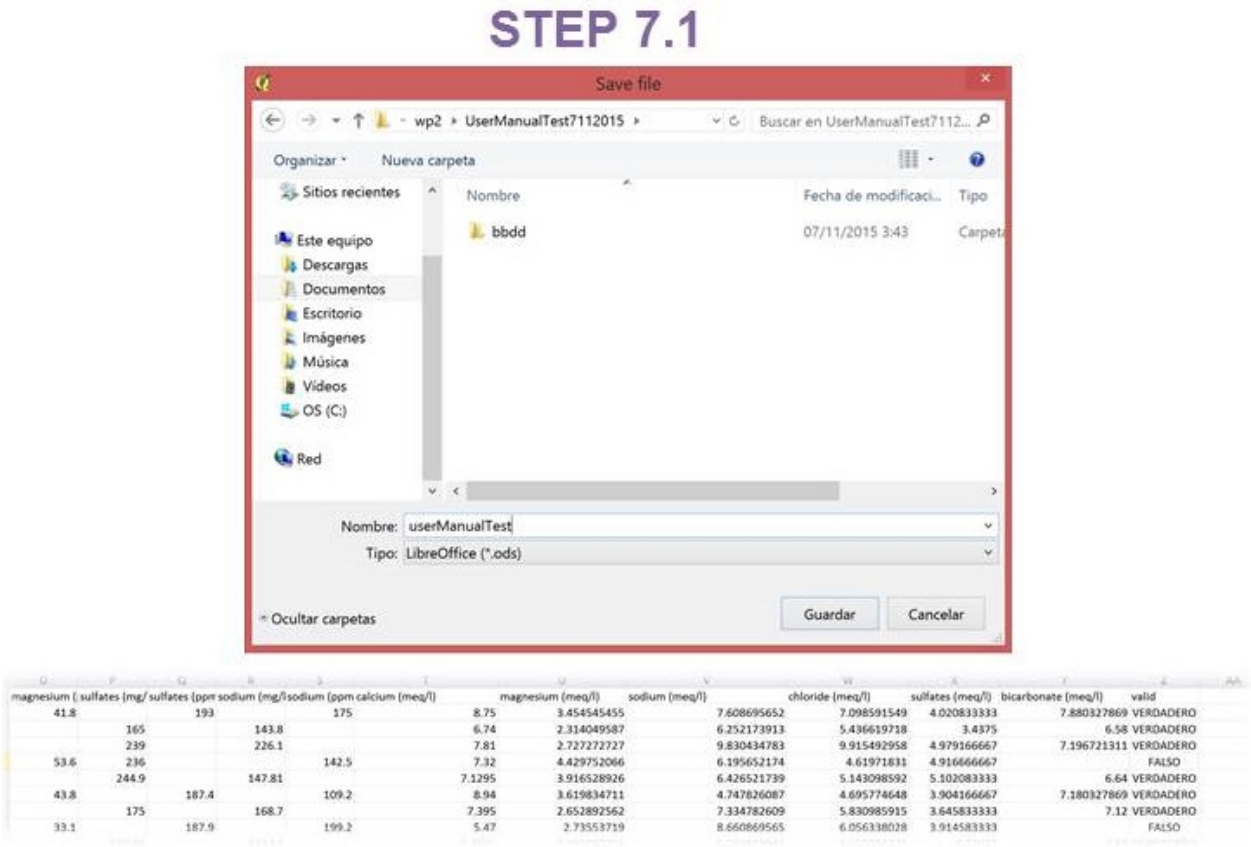
- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the selected measurements.
- *Step 5*: Click Next.

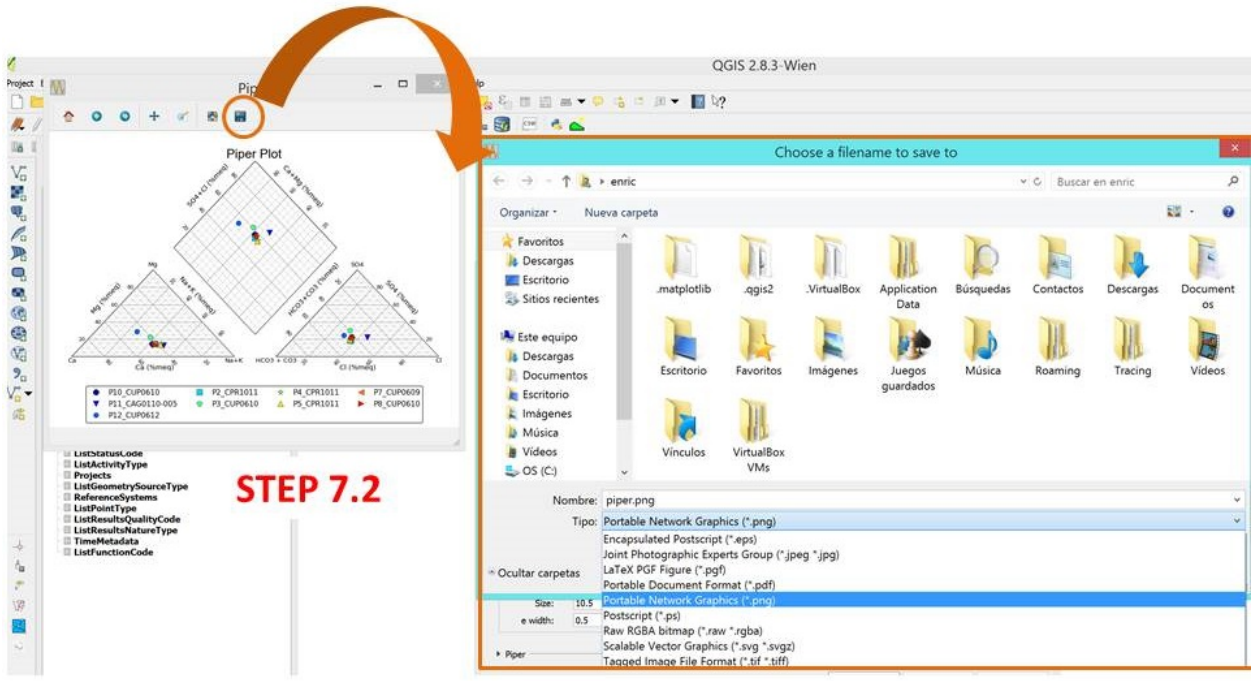


- *Step 6*: Plot configuration. Choose the plot size, title, markerstyle, legend, etc. (optional).



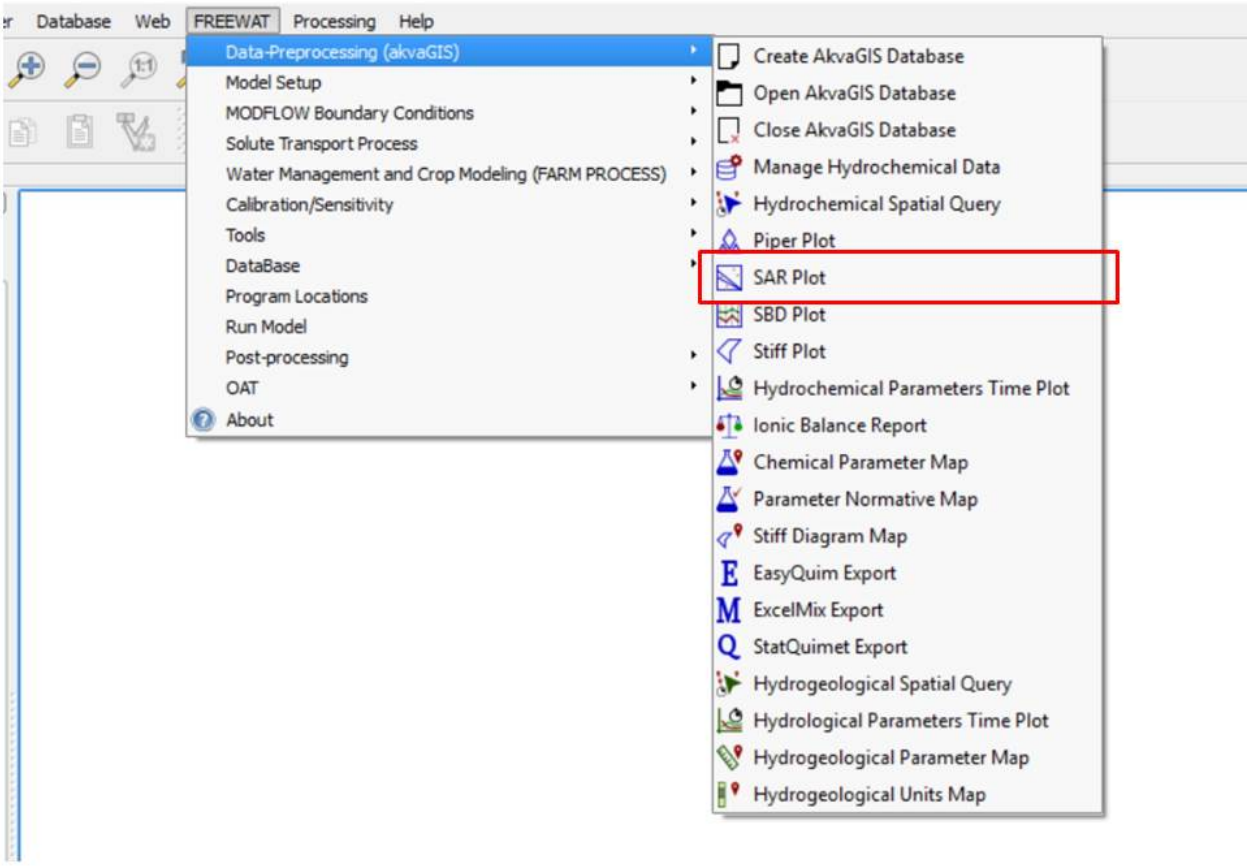
magnesium (	sulfates (mg/	sulfates (ppm	sodium (mg/l	sodium (ppm	calcium (meq/l)	magnesium (meq/l)	sodium (meq/l)	chloride (meq/l)	sulfates (meq/l)	bicarbonate (meq/l)	valid
41.8		193		175	8.75	3.454545455		7.608695652	7.098591549	4.020833333	7.880327869 VERDADERO
	165		143.8		6.74	2.314049587		6.252173913	5.436619718	3.4375	6.58 VERDADERO
	239		226.1		7.81	2.727272727		9.830434783	9.915492958	4.979166667	7.196721311 VERDADERO
53.6	236			142.5	7.32	4.429752066		6.195652174	4.61971831	4.916666667	FALSO
	244.9		147.81		7.1295	3.916528926		6.426521739	5.143098592	5.102083333	6.64 VERDADERO
43.8		187.4		109.2	8.94	3.619834711		4.747826087	4.695774648	3.904166667	7.180327869 VERDADERO
	175		168.7		7.395	2.652892562		7.334782609	5.830985915	3.645833333	7.12 VERDADERO
33.1		187.9		199.2	5.47	2.735537190		8.660869565	6.056338028	3.914583333	FALSO

- *Step 7.1*: Save Piper query results in different formats (e.g. csv, ods, etc.).

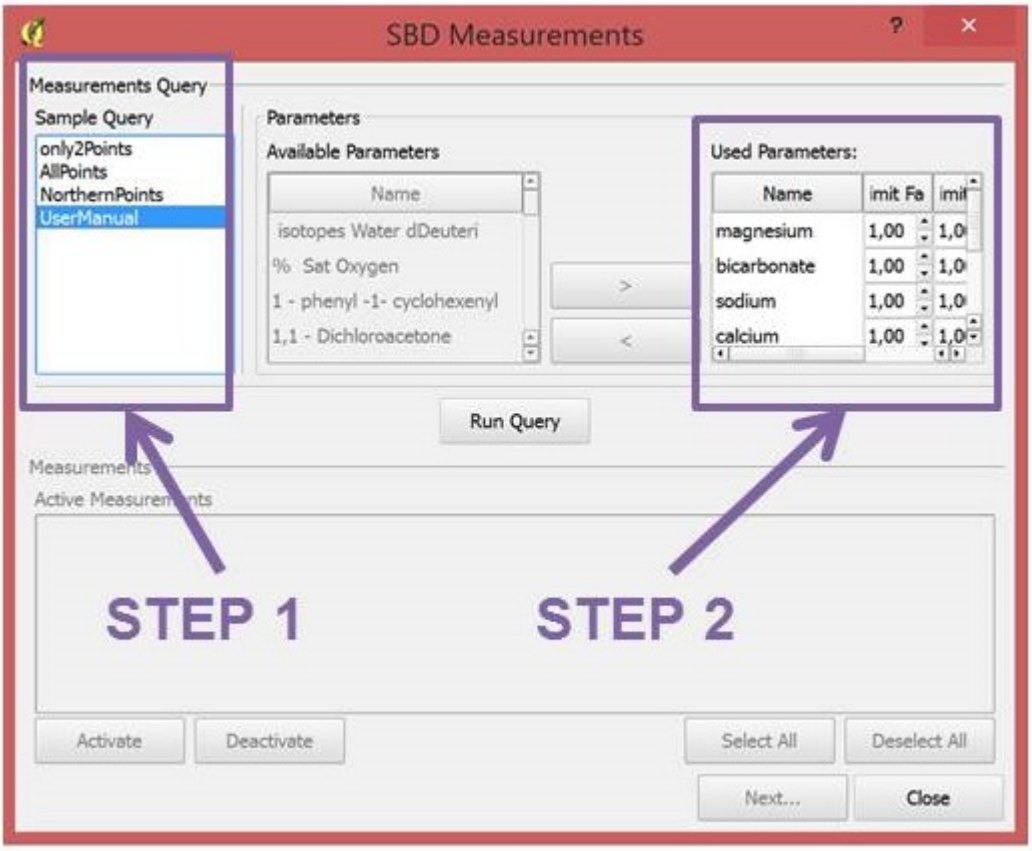


- *Step 7.2*: Plot Piper diagram automatically. The plot GUI, enable the user to save the plot in different formats, to pan axes, to zoom, to configure subplots and to save the plot in dfferent formats such as .pdf, .png, .tiff, .svg, etc.

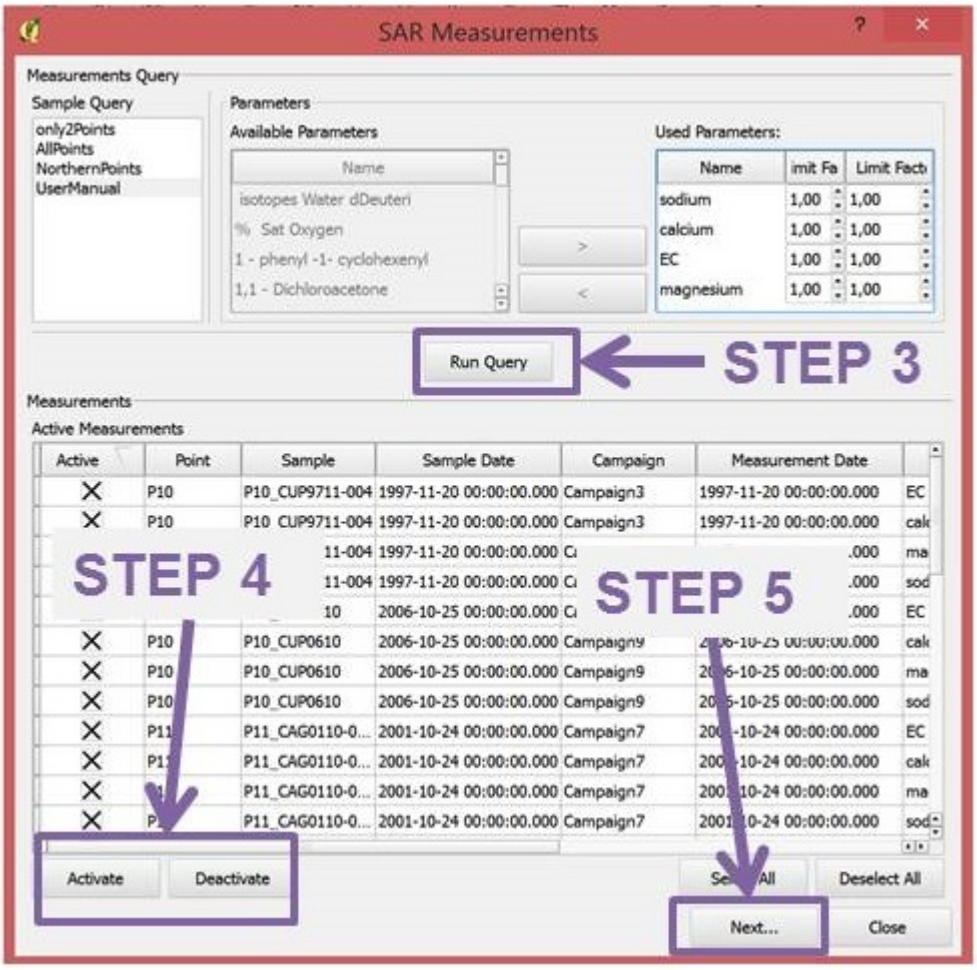
2.4 SAR plot



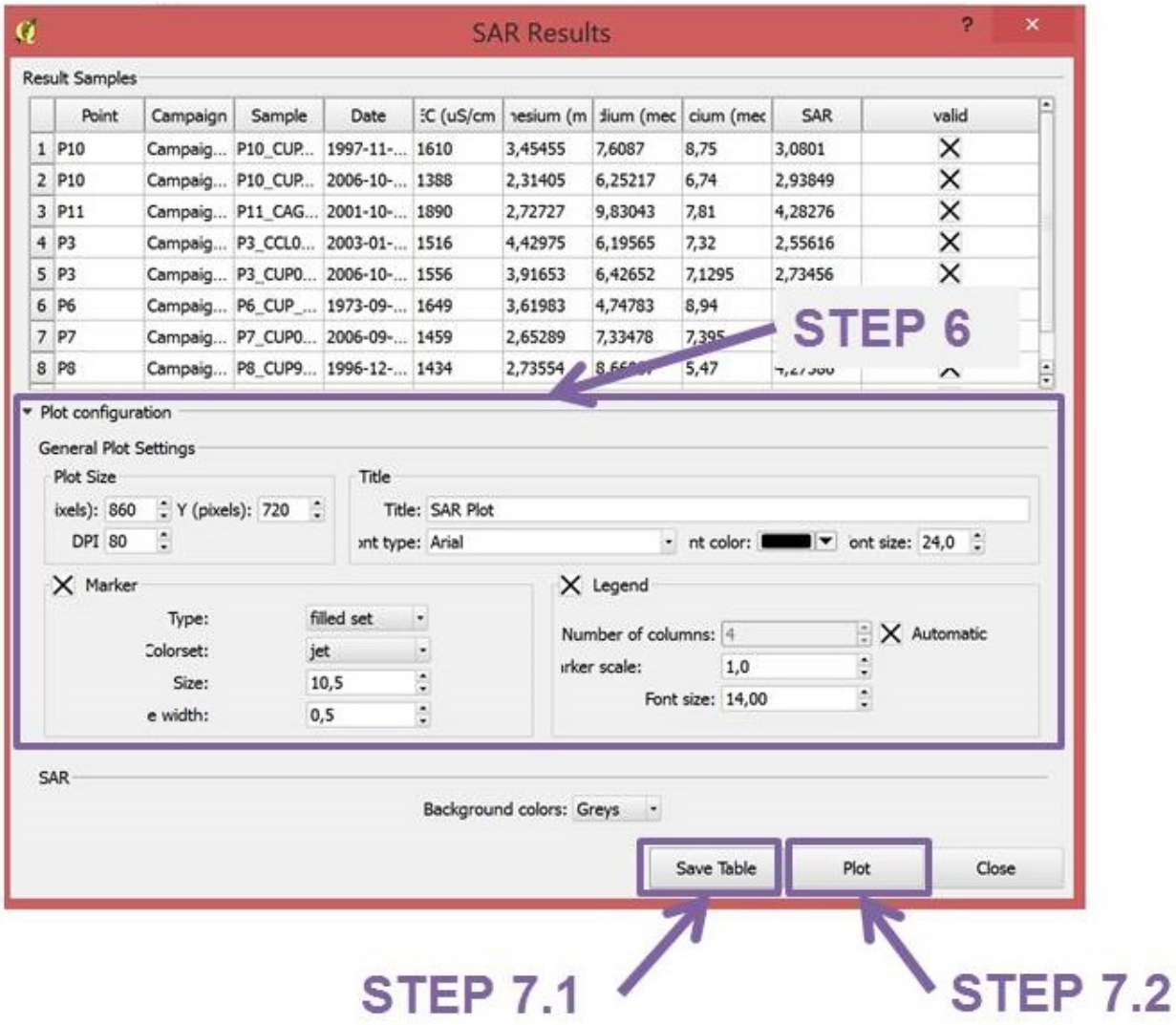
Use this command to create automatically Salinity Diagrams of the selected query created previously with the Hydrochemical Spatial Query tool (section 2.2 *Hydrochemical Spatial Query*). This diagram will be created only if the measurements required for the creation of this diagram are available.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.

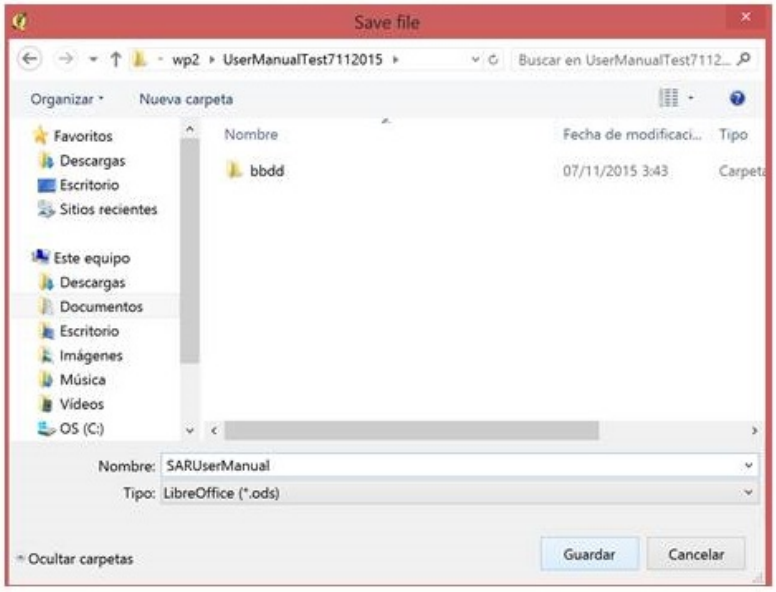


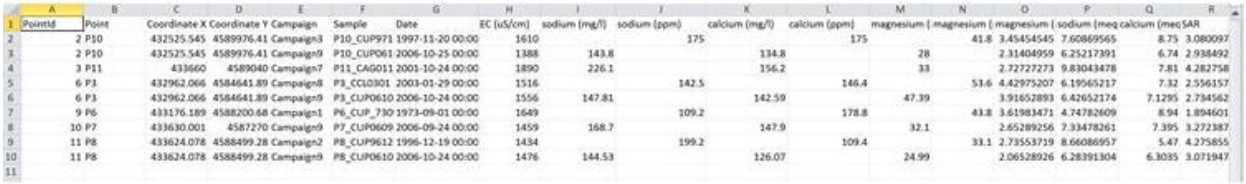
- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.



- *Step 6*: Plot configuration. Choose the plot size, title, markerstyle, legend, background colours, etc.

STEP 7.1

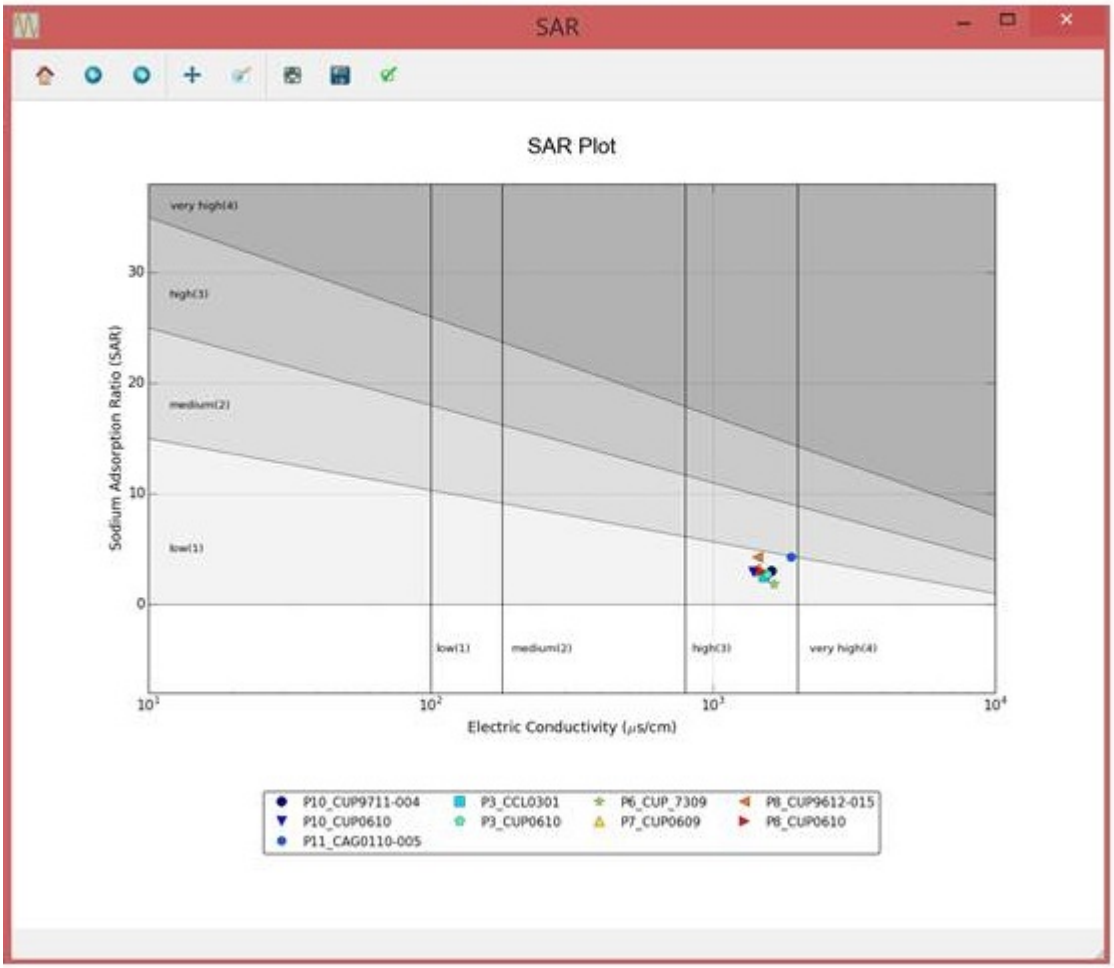




	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	PointId	Point	Coordinate X	Coordinate Y	Campaign	Sample	Date	EC (uS/cm)	sodium (mg/l)	sodium (ppm)	calcium (mg/l)	calcium (ppm)	magnesium (	magnesium (	magnesium (	sodium (meq	calcium (meq	SAR
2	2	P10	432525.545	4589976.41	Campaign3	P10_CUP971	1997-11-20 00:00	1610		175		175		41.8	3.45454545	7.60869565	8.75	3.080097
3	2	P10	432525.545	4589976.41	Campaign9	P10_CUP061	2006-10-25 00:00	1388	143.8		134.8		28		2.31404959	6.25217391	6.74	2.938492
4	3	P11	433660	4589040	Campaign7	P11_CAG011	2001-10-24 00:00	1890	226.1		156.2		33		2.72727273	9.83043478	7.81	4.282758
5	6	P3	432962.066	4584641.89	Campaign8	P3_CCL0301	2003-01-29 00:00	1516		142.5		146.4		53.6	4.42975207	6.19565217	7.32	2.556157
6	6	P3	432962.066	4584641.89	Campaign9	P3_CUP0610	2006-10-24 00:00	1556	147.81		142.59		47.39		3.91652893	6.42652174	7.1295	2.734562
7	9	P6	433176.189	4588200.68	Campaign1	P6_CUP_730	1973-09-01 00:00	1649		109.2		178.8		43.8	3.61983471	4.74782609	8.94	1.894601
8	10	P7	433630.001	4587270	Campaign9	P7_CUP0609	2006-09-24 00:00	1459	168.7		147.9		32.1		2.65289256	7.33478261	7.395	3.272387
9	11	P8	433624.078	4588499.28	Campaign2	P8_CUP9612	1996-12-19 00:00	1434		199.2		109.4		33.1	2.73553719	8.66086957	5.47	4.275855
10	11	P8	433624.078	4588499.28	Campaign9	P8_CUP0610	2006-10-24 00:00	1476	144.53		126.07		24.99		2.06528926	6.28391304	6.3035	3.071947
11																		

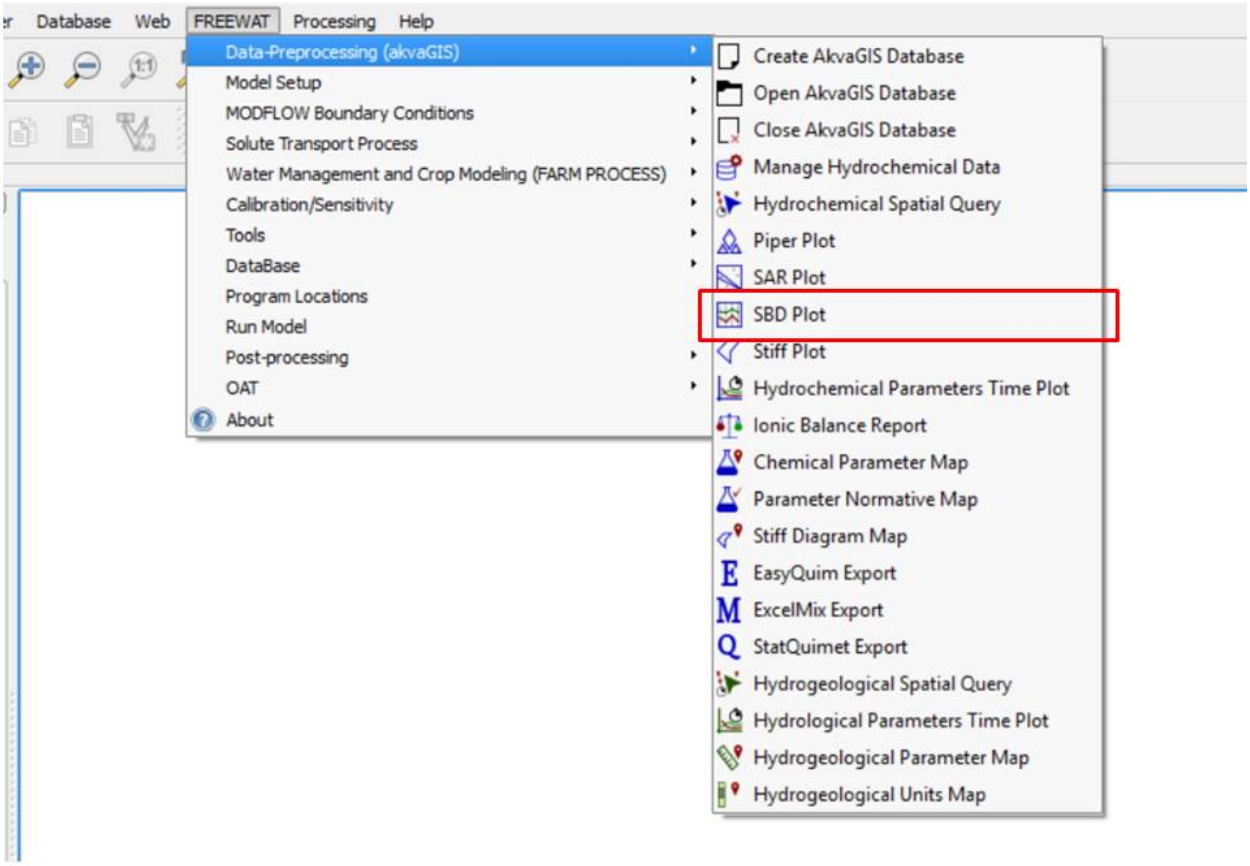
- *Step 7.1*: Save SAR query results in different formats.

STEP 7.2

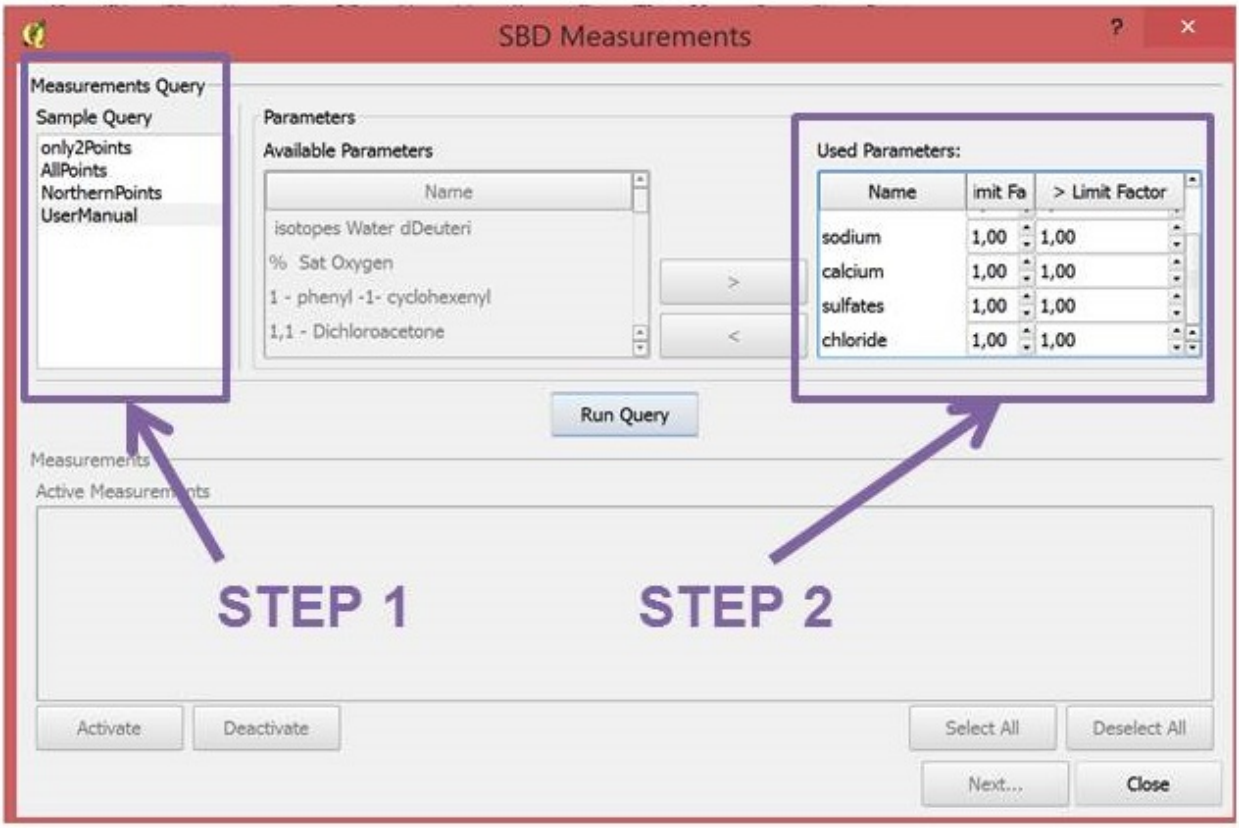


- *Step 7.2*: Plot SAR diagram automatically. The plot GUI, enable the user to save the plot in different formats, to pan axes, to zoom, to configure subplots and to save the plot in dfferent formats such as .pdf, .png, .tiff, .svg, etc.

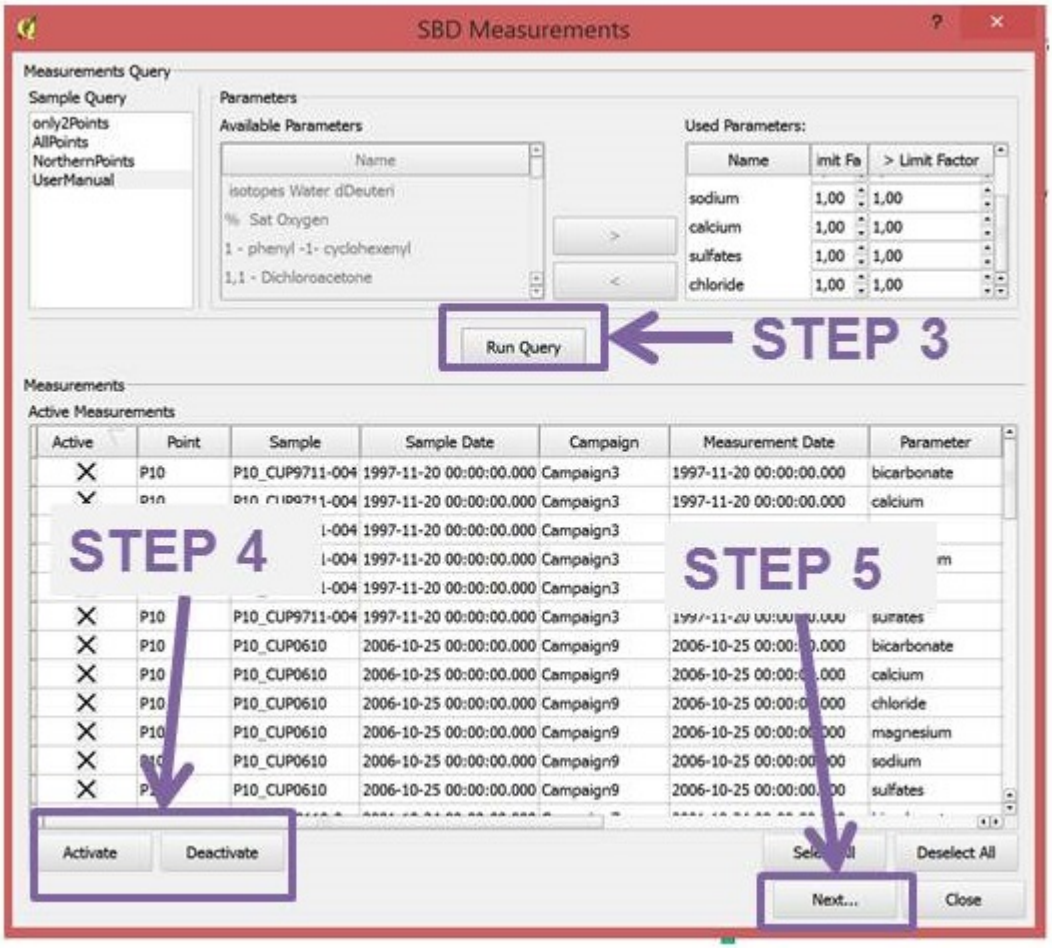
2.5 SBD Plot



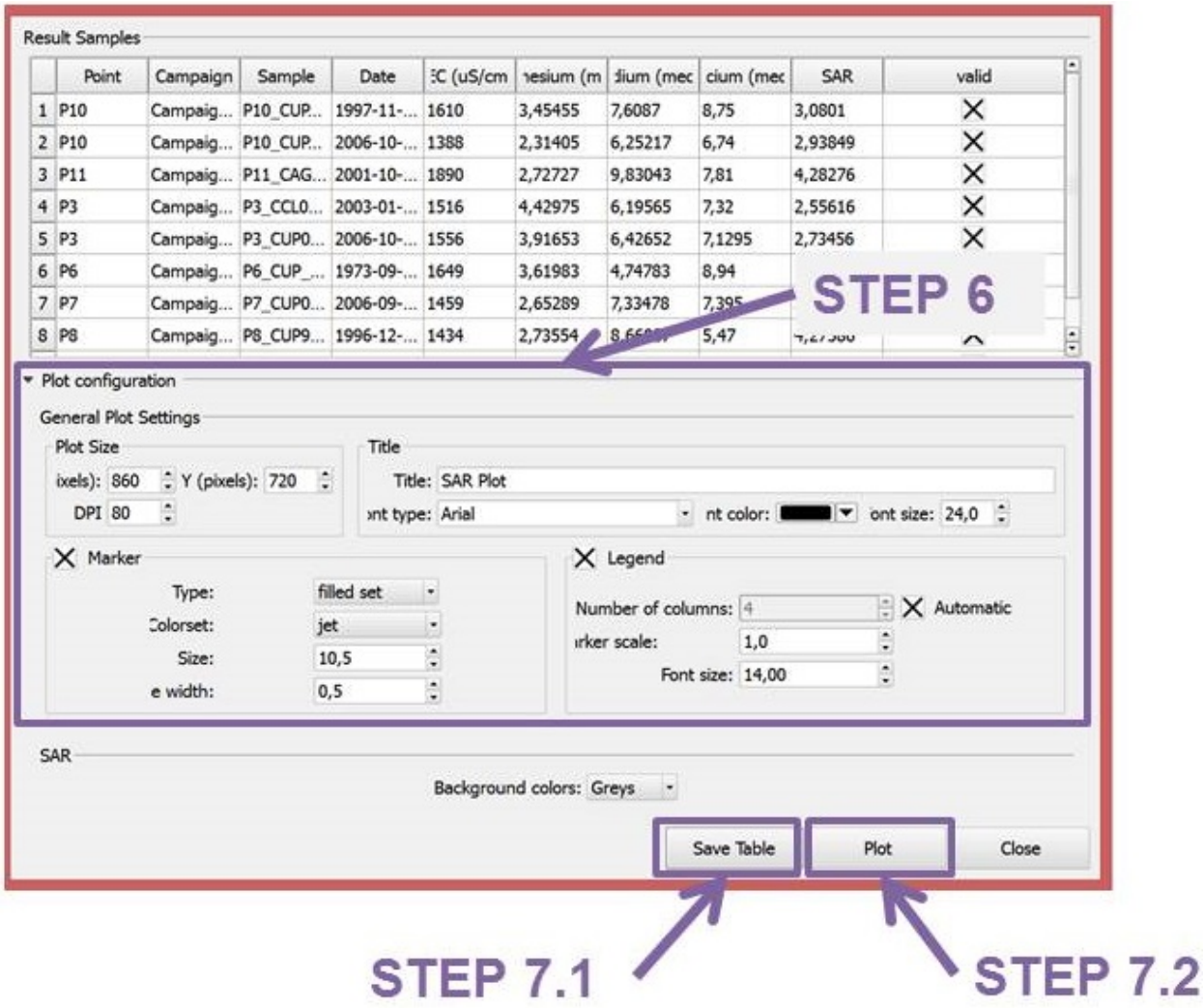
Use this command to create automatically Shöeller-Berkaloff diagrams of the selected query created previously with the Hydrochemical Spatial Query tool (section 2.2 *Hydrochemical Spatial Query*). This diagram will be created only if the measurements required for the creation of this diagram are available in the akvaGIS Database.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.

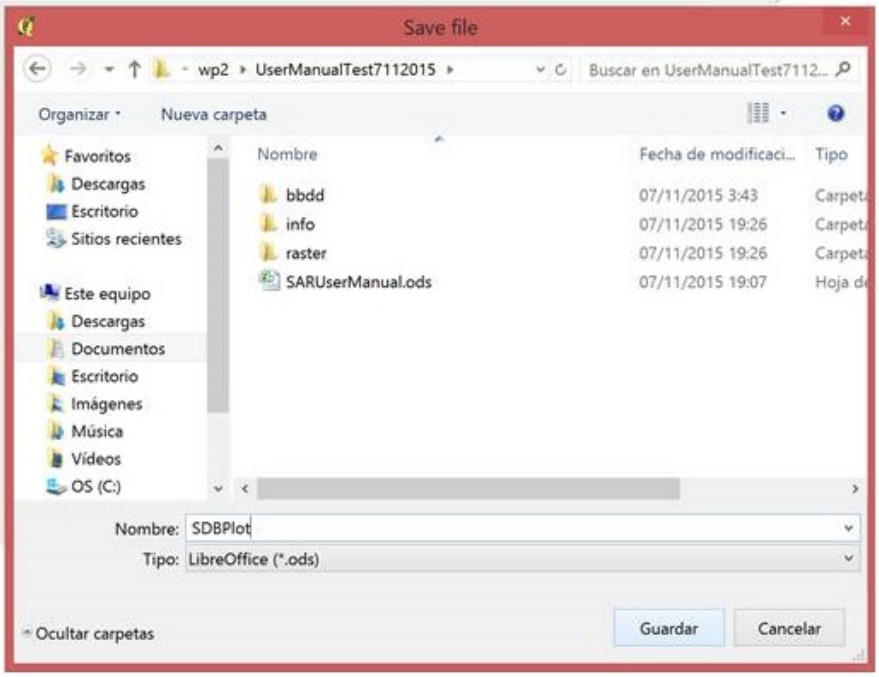


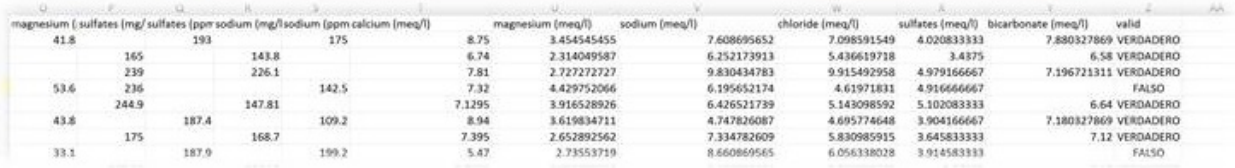
- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.



- *Step 6*: Plot configuration.Choose the plot size, title, marker style, legend, background colours, etc.

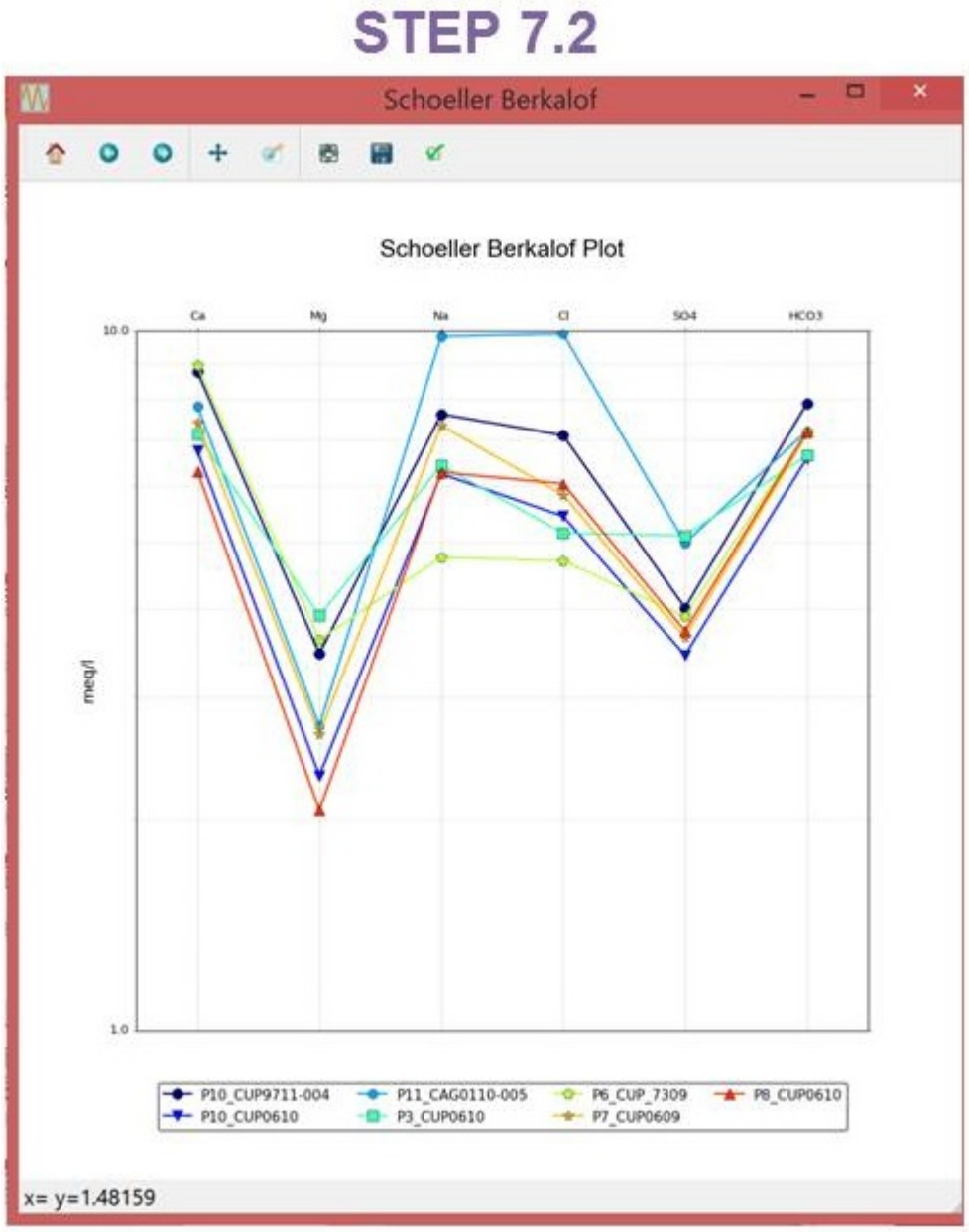
STEP 7.1





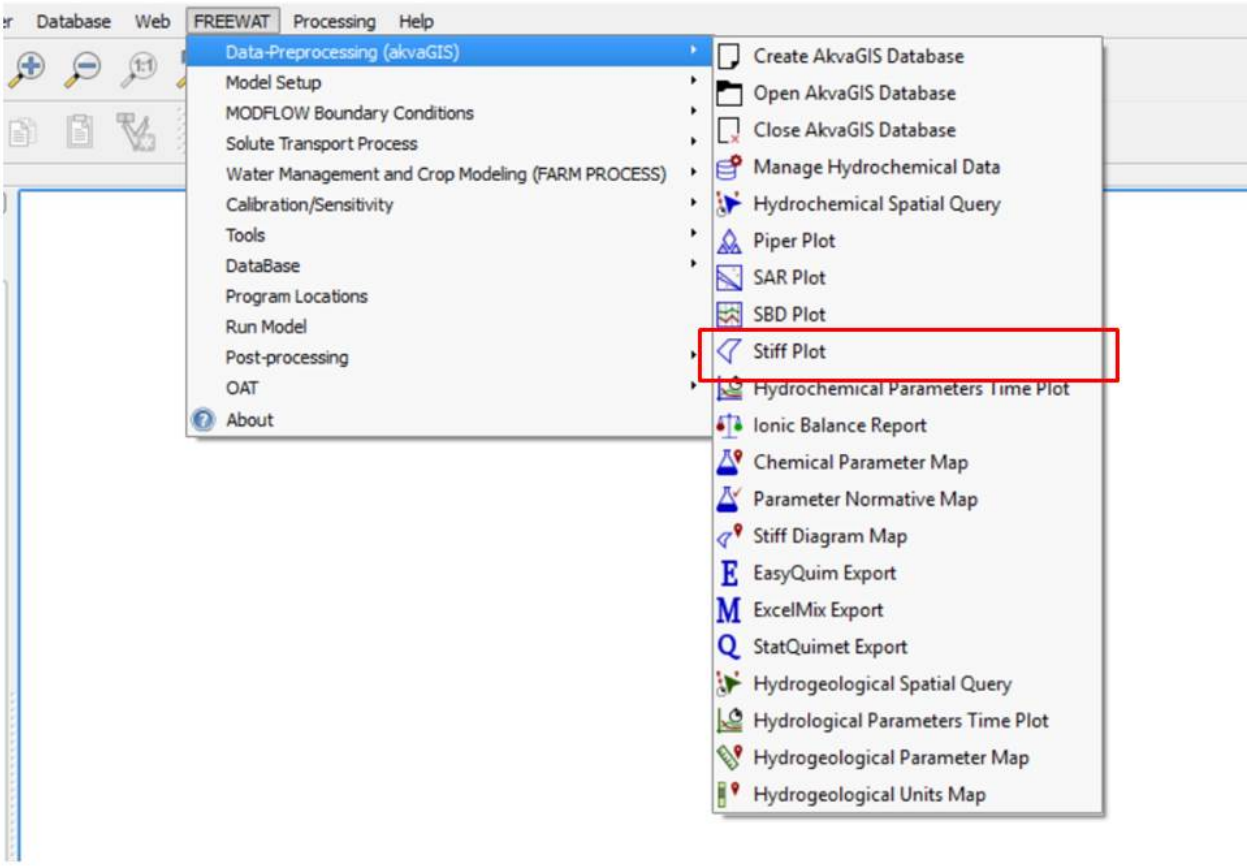
magnesium (.	sulfates (mg/	sulfates (ppm	sodium (mg/l	sodium (ppm	calcium (meq/l)	magnesium (meq/l)	sodium (meq/l)	chloride (meq/l)	sulfates (meq/l)	bicarbonate (meq/l)	valid
41.8		193		175	8.75	3.454545455		7.608695652	7.098591549	4.020833333	7.880327869 VERDADERO
	165		143.8		6.74	2.314049587		6.252173913	5.436619718	3.4375	6.58 VERDADERO
	239		226.1		7.81	2.727272727		9.830434783	9.915492958	4.979166667	7.196721311 VERDADERO
53.6	236			142.5	7.32	4.429752066		6.195652174	4.61971831	4.916666667	FALSO
	244.9		147.81		7.1295	3.916528926		6.426521739	5.143098592	5.102083333	6.64 VERDADERO
43.8		187.4		109.2	8.94	3.619834711		4.747826087	4.695774648	3.904166667	7.180327869 VERDADERO
	175		168.7		7.395	2.652892562		7.334782609	5.830985915	3.645833333	7.12 VERDADERO
33.1		187.9		199.2	5.47	2.73553719		8.660869565	6.056338028	3.914583333	FALSO

- *Step 7.1*: Save Shöeller-Berkaloff query results in different formats.



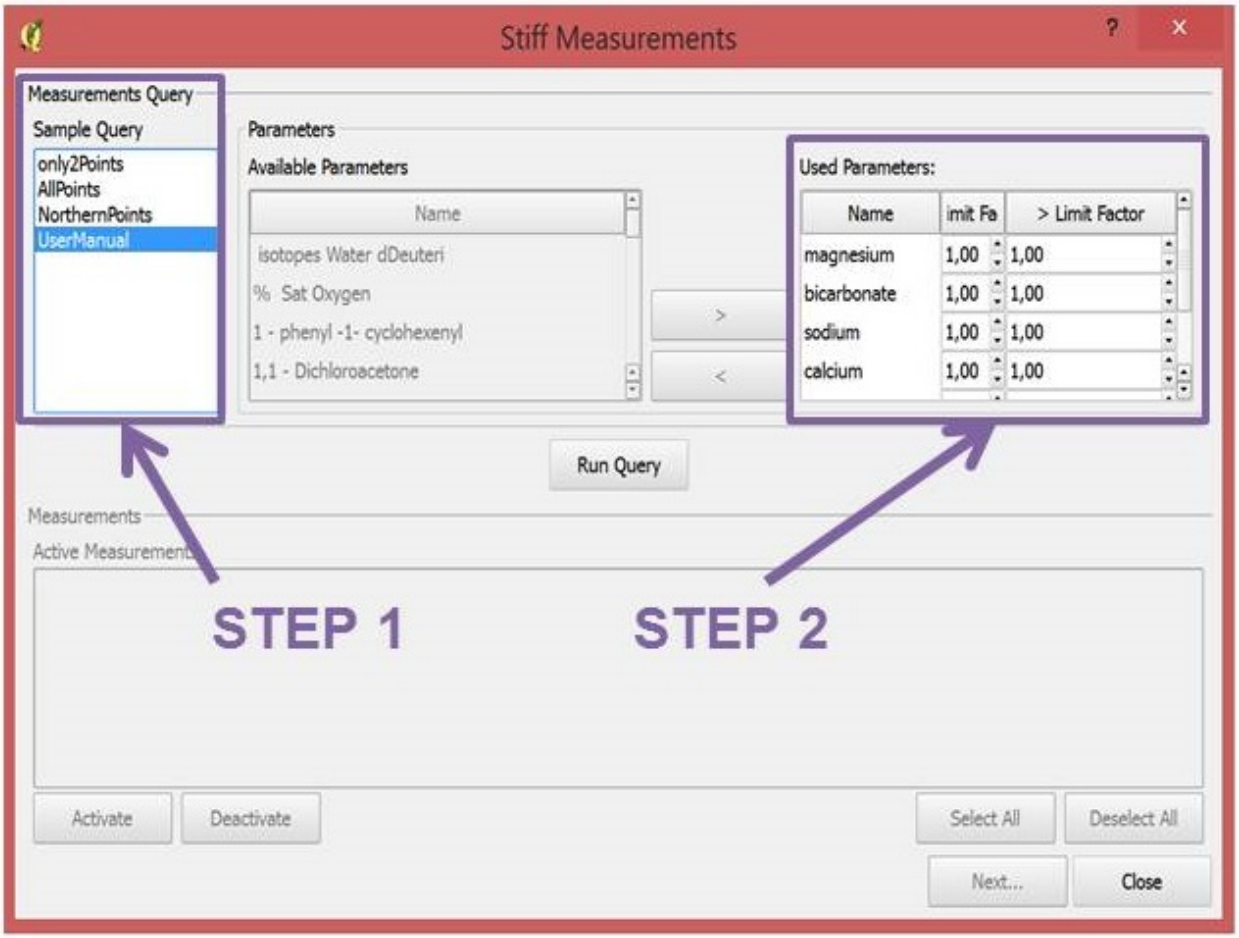
- *Step 7.2*: Plot Shoeller-Berkaloff diagrams automatically. The plot GUI, enable the user to save the plot in different formats, to pan axes, to zoom, to configure subplots and to save the plot in different formats such as .pdf, .png, .tiff, .svg, etc.

2.6 Stiff Plot

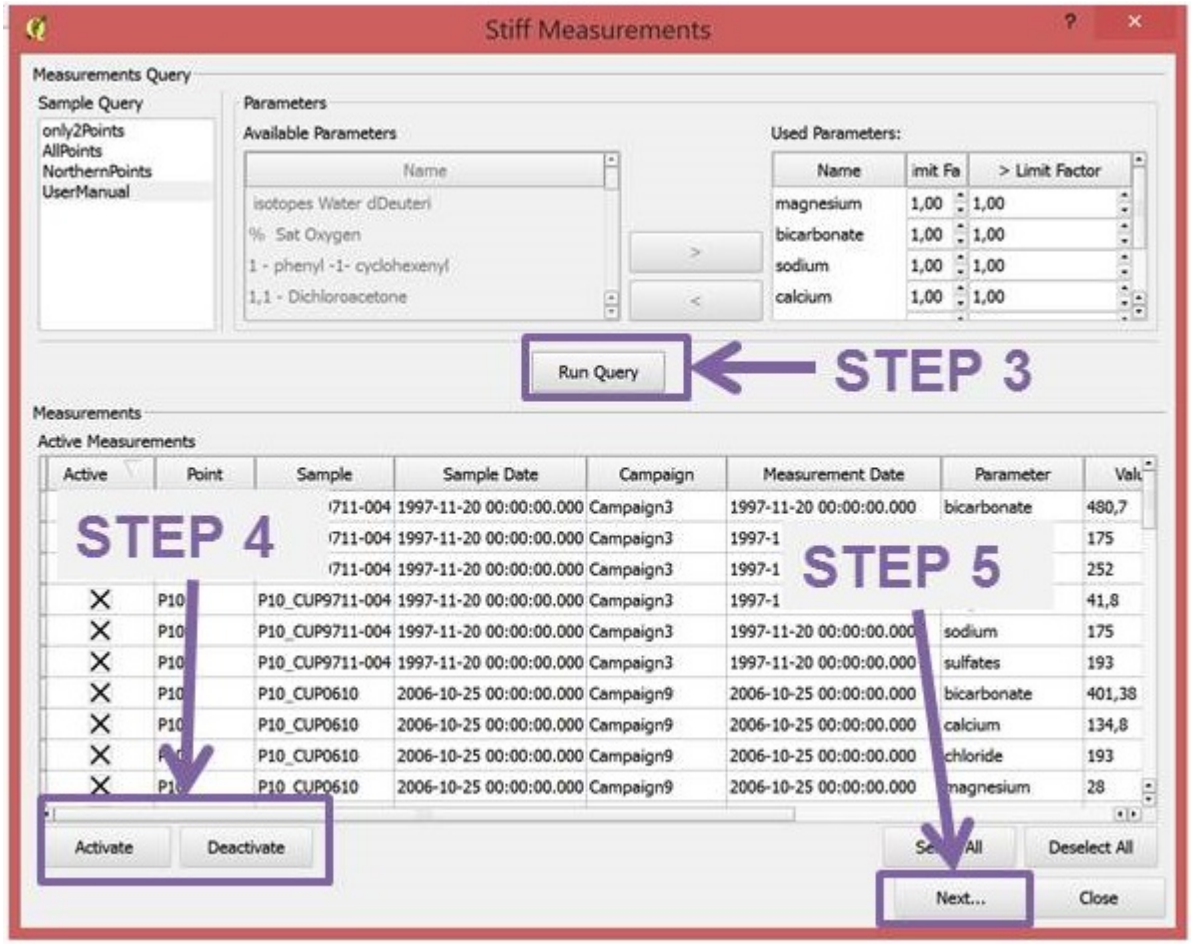


Use this command to create automatically Stiff plots of the selected query created previously with the Hydrochemical Spatial Query tool (section 2.2 *Hydrochemical Spatial Query*). This diagram will be created only if the measurements required for the creation of this diagram are available.

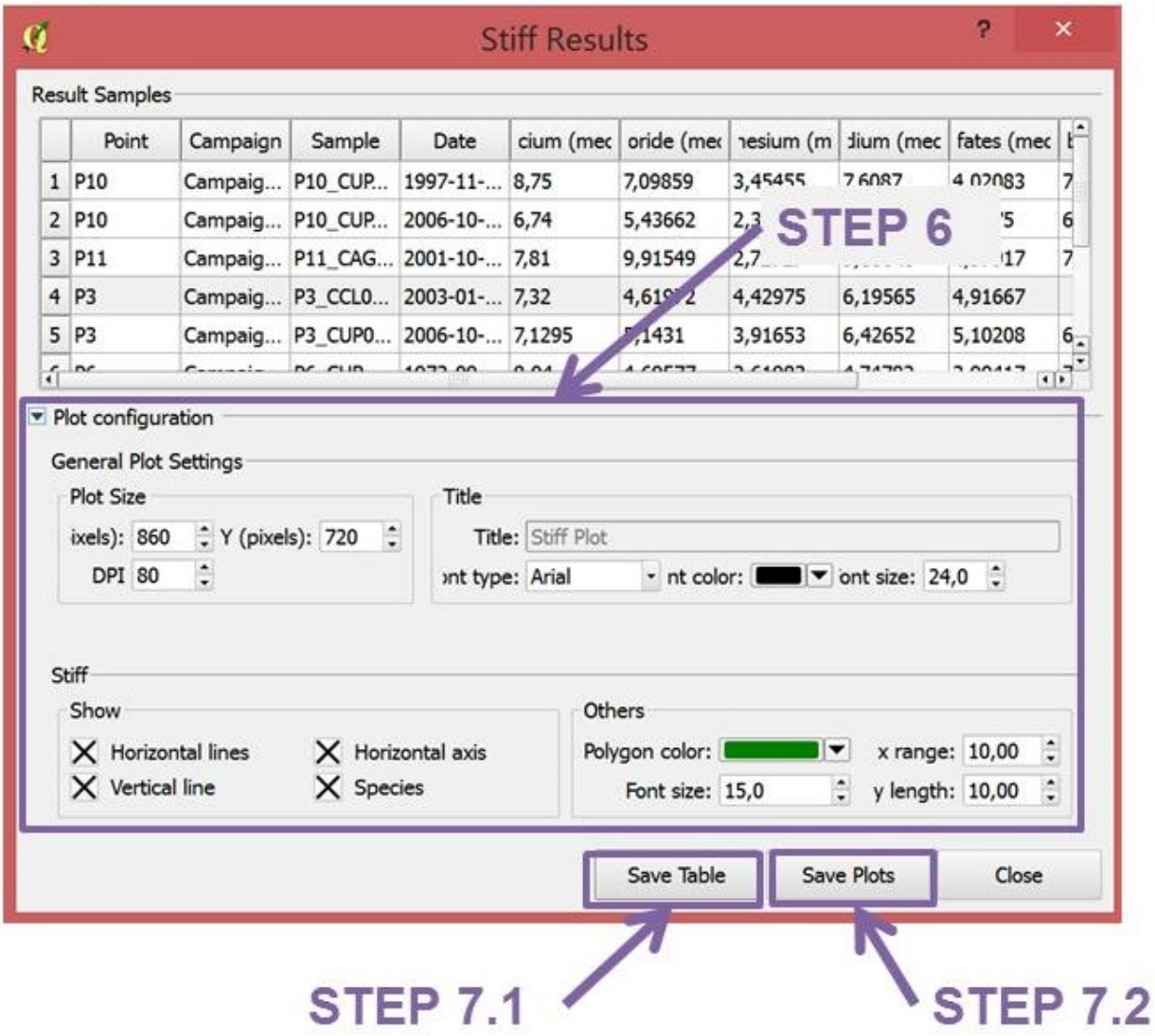
For obtaining stiff maps, use command Stiff Diagram Map in section 2.11 *Stiff Diagram Map*.



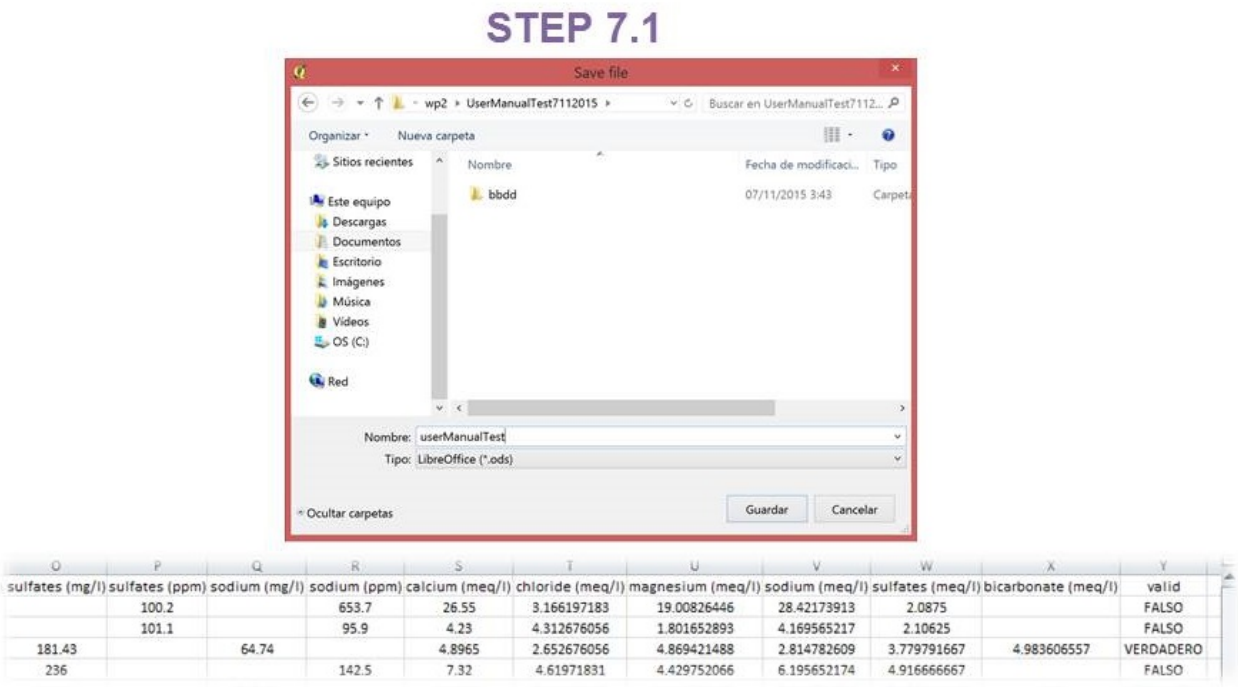
- *Step 1*: Choose the Query created previously with the tool shown in section 2.1 *Manage Hydrochemical Data*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.

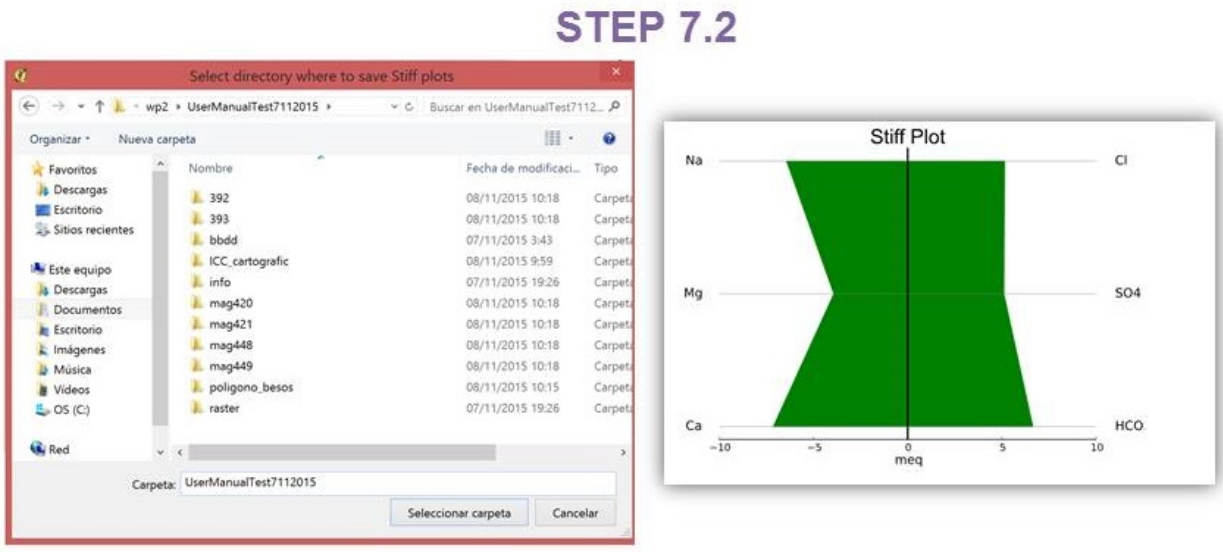


- *Step 6*: Plot configuration. Choose the plot size, title, Polygon colour, etc. (optional).



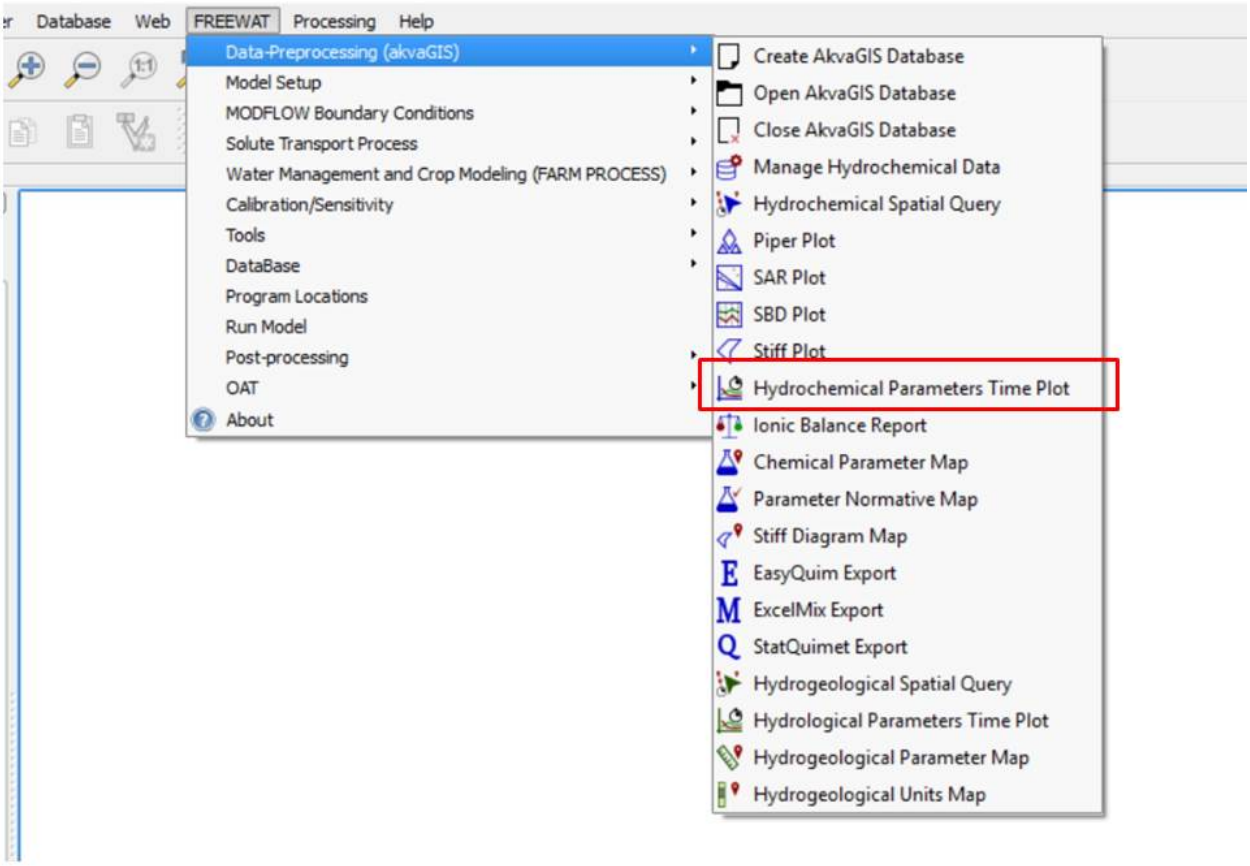
O	P	Q	R	S	T	U	V	W	X	Y
sulfates (mg/l)	sulfates (ppm)	sodium (mg/l)	sodium (ppm)	calcium (meq/l)	chloride (meq/l)	magnesium (meq/l)	sodium (meq/l)	sulfates (meq/l)	bicarbonate (meq/l)	valid
	100.2		653.7	26.55	3.166197183	19.00826446	28.42173913	2.0875		FALSO
	101.1		95.9	4.23	4.312676056	1.801652893	4.169565217	2.10625		FALSO
181.43		64.74		4.8965	2.652676056	4.869421488	2.814782609	3.779791667	4.983606557	VERDADERO
236			142.5	7.32	4.61971831	4.429752066	6.195652174	4.916666667		FALSO

- *Step 7.1*: Save Stiff query results in different formats.

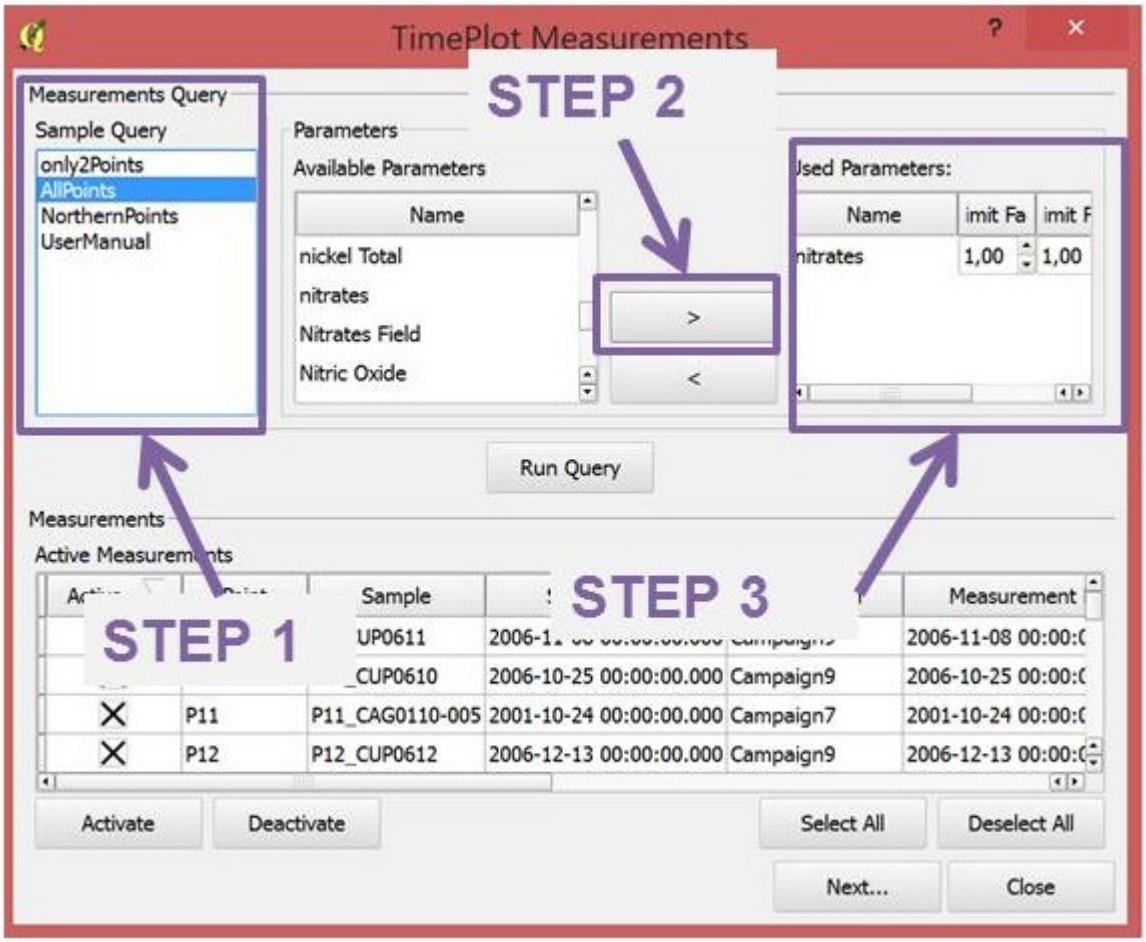


- *Step 7.2*: Save Plots. This button creates *svg* files with the stiff diagram for each point selected during the query.

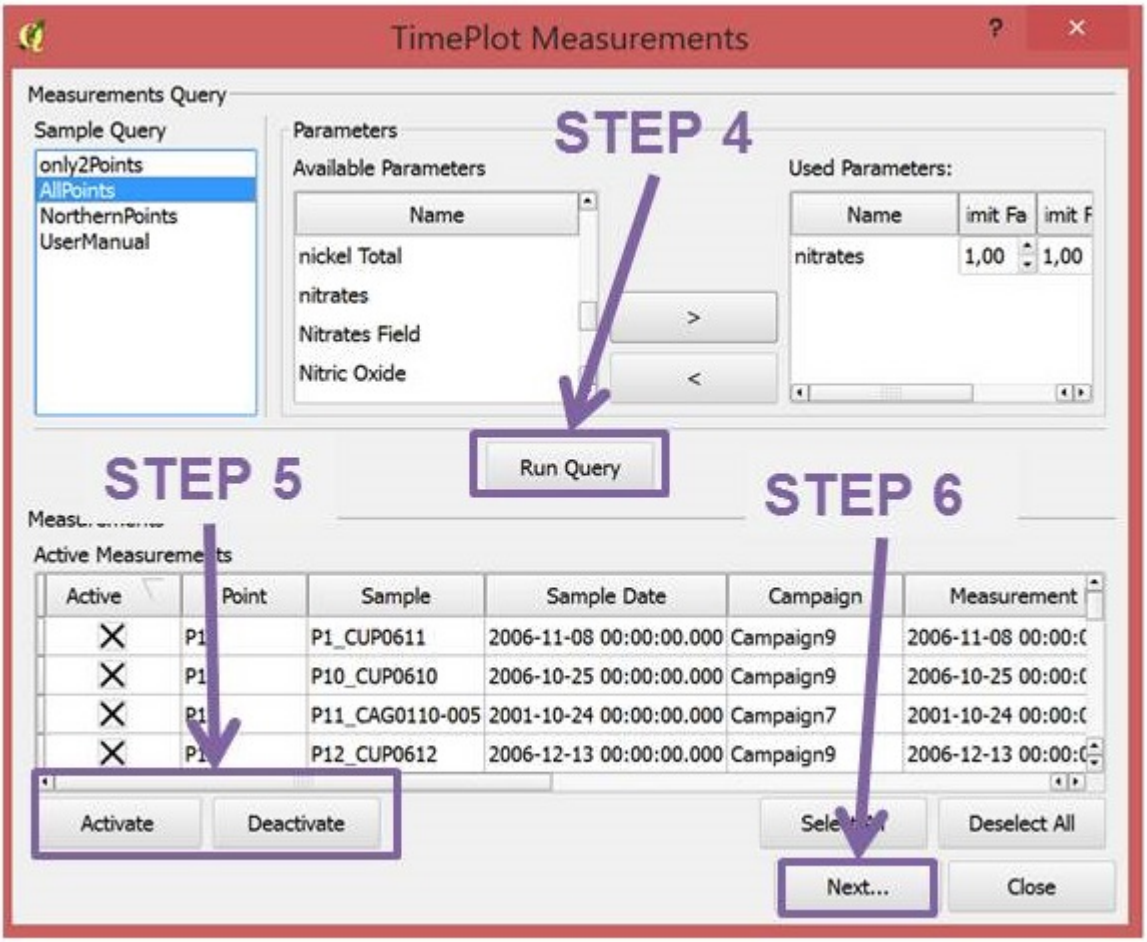
2.7 Time Plot. Hydrochemical Parameters



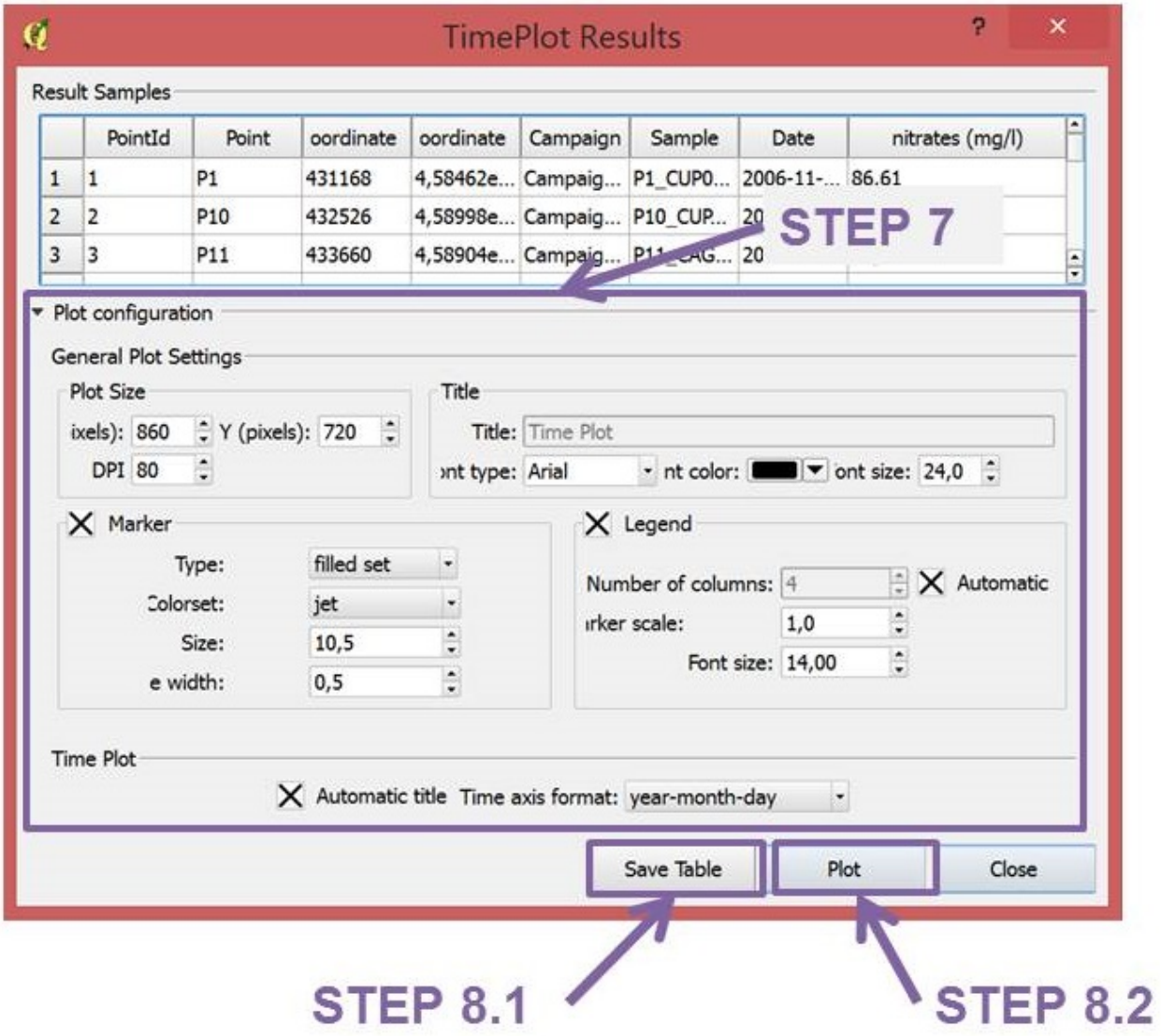
Use this command to create time plots of the selected query (created previously with the *Hydrochemical Spatial Query tool*, section 2.2) for the selected parameters.



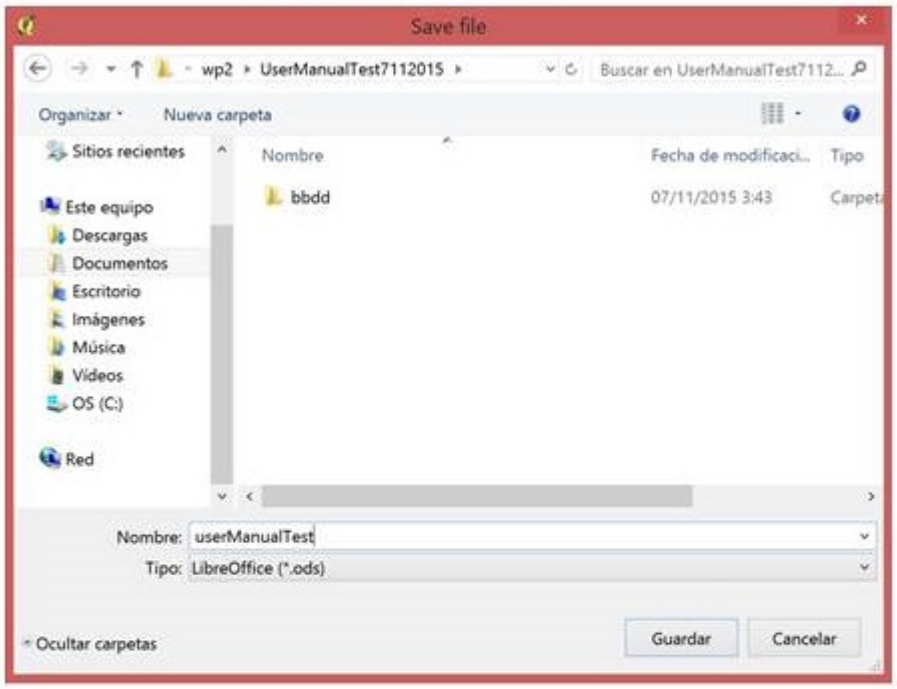
- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the parameter to be queried for the analysis.
- *Step 3*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 4*: Run Query.
- *Step 5*: Use this commands to activate or deactivated the desired measurements.
- *Step 6*: Click Next.

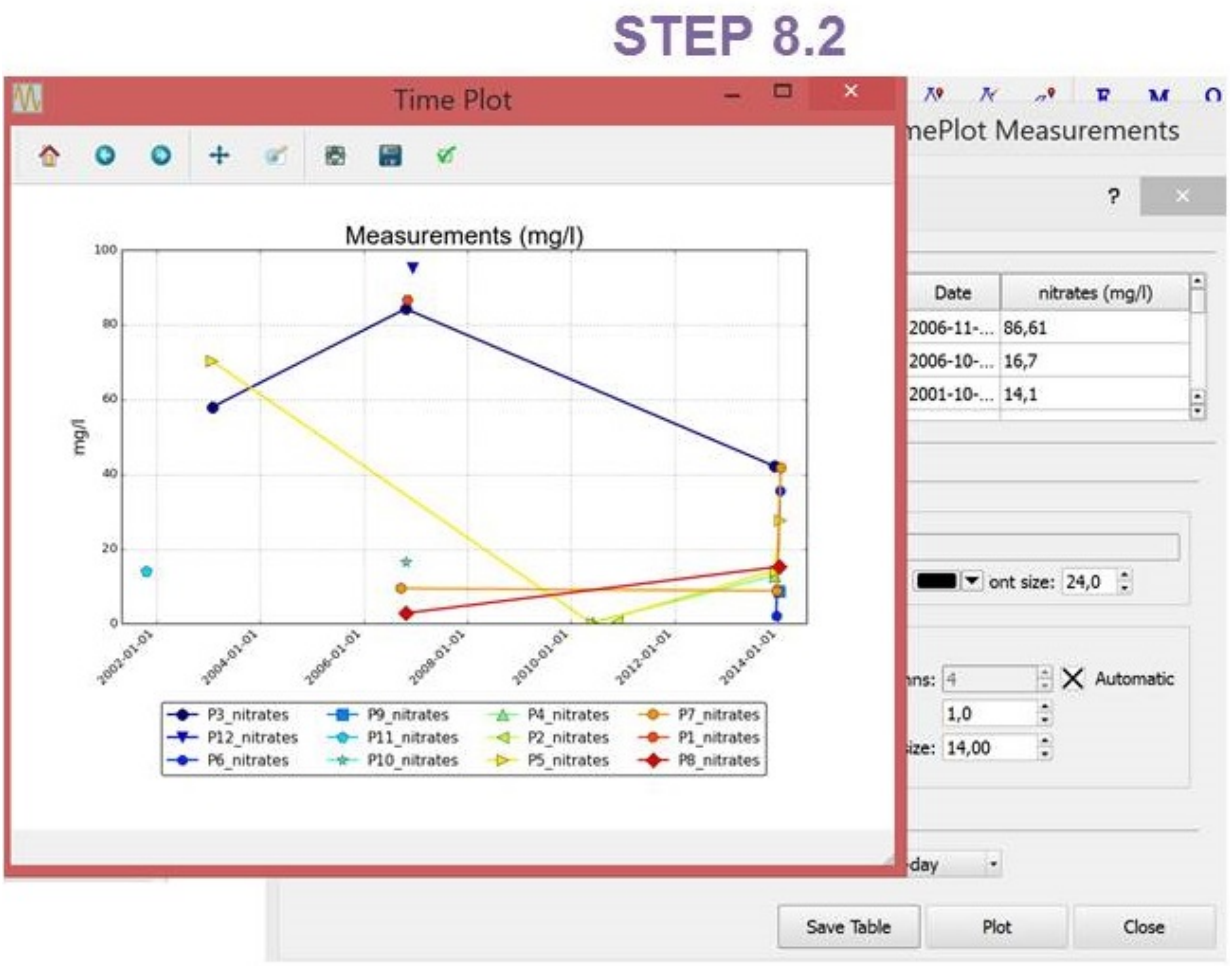


- *Step 7*: Plot configuration. Choose the plot size, title, markers, time axis format, etc.



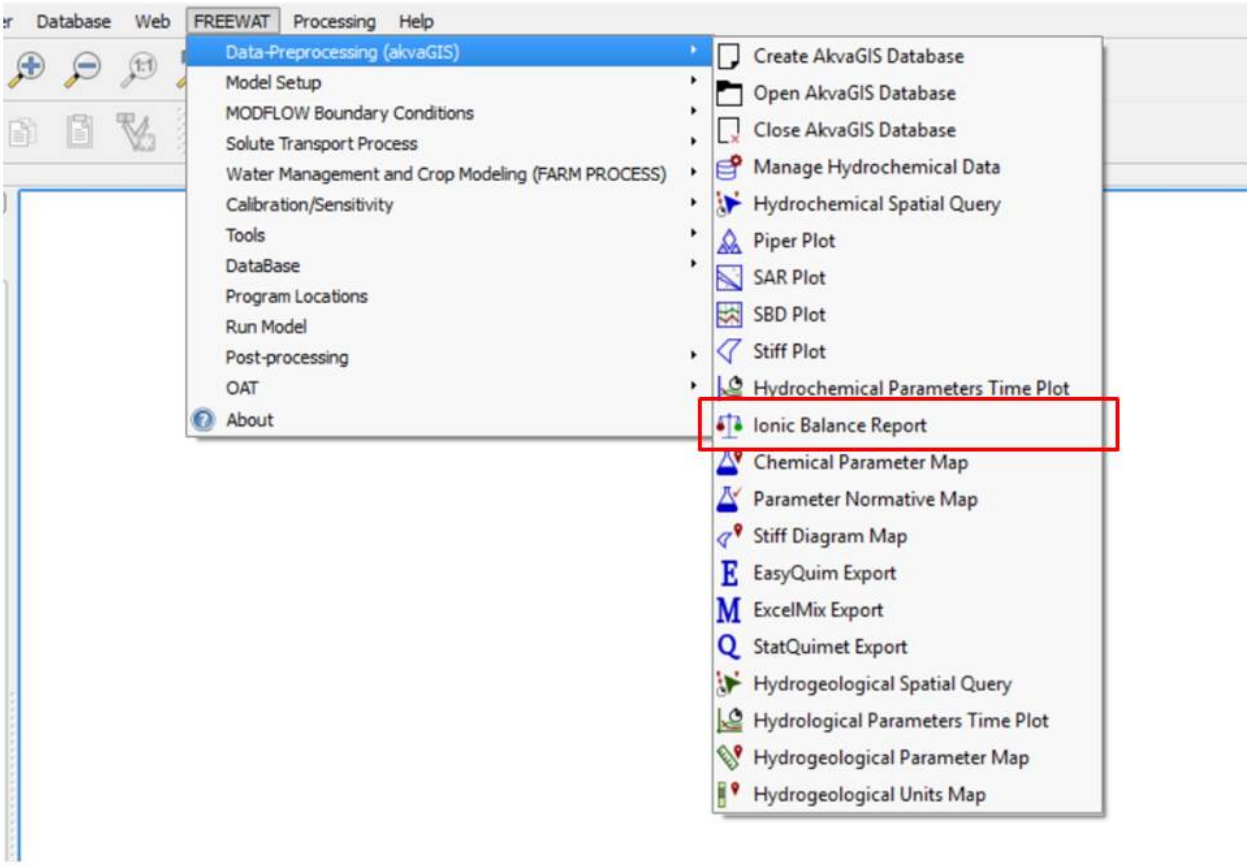
E	F	G	H	I	J
Campaign	Sample	Date	silicates (mg/l)	sulfates (mg/l)	nitrates (mg/l)
Campaign9	P1_CUP0611	2006-11-08 00:00:00.000	10.43	181.43	86.61
Campaign9	P10_CUP0610	2006-10-25 00:00:00.000	9.28	165	16.7
Campaign7	P11_CAG0110-005	2001-10-24 00:00:00.000		239	14.1
Campaign9	P12_CUP0612	2006-12-13 00:00:00.000	8.96	158.22	95.08
Campaign10	P2_CPR1011	2010-11-24 00:00:00.000		142.45	0.6
Campaign8	P3_CCL0301	2003-01-29 00:00:00.000		236	57.9
Campaign9	P3_CUP0610	2006-10-24 00:00:00.000	8.69	244.9	84.22

- *Step 8.1*: Save query results in different formats.

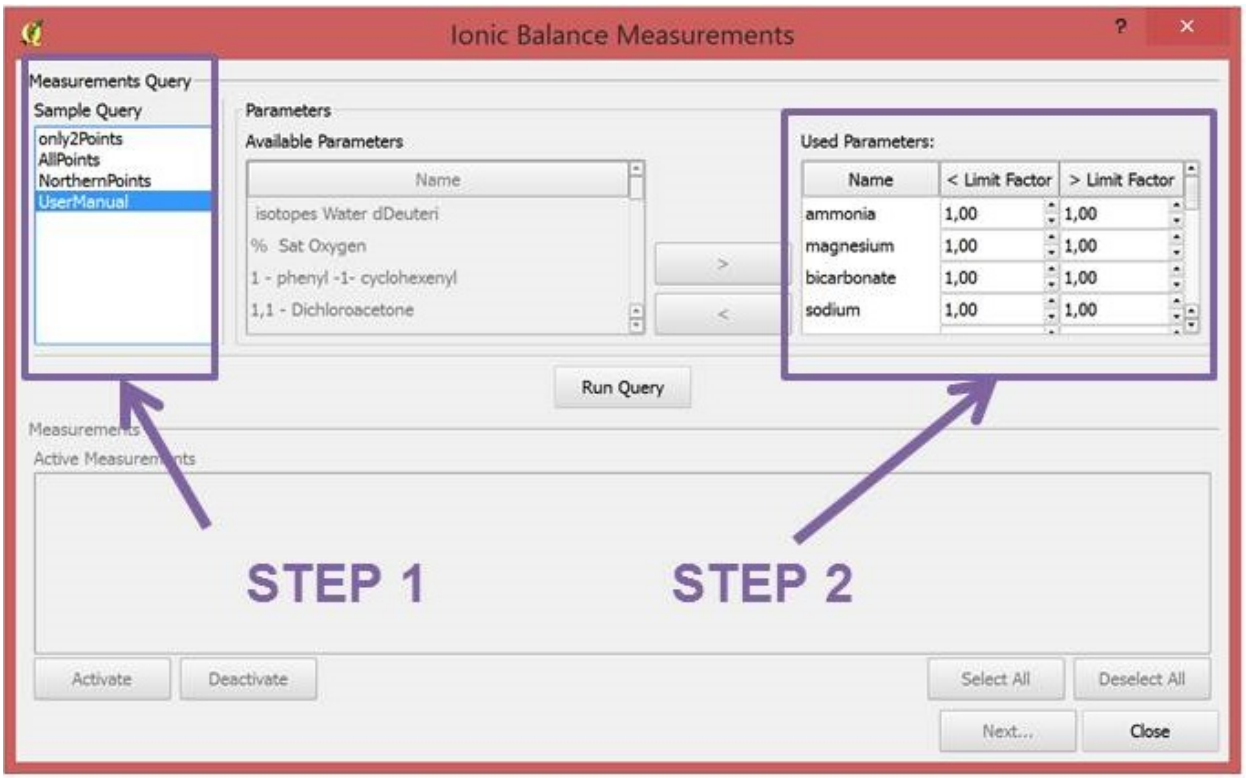


- *Step 8.2*: This button creates automatically time plots. Here, the user can edit the plot and save it. The plot GUI, enable the user to save the plot in different formats, to pan axes, to zoom, to configure subplots and to save the plot in dfferent formats such as .pdf, .png, .tiff, .svg, etc.

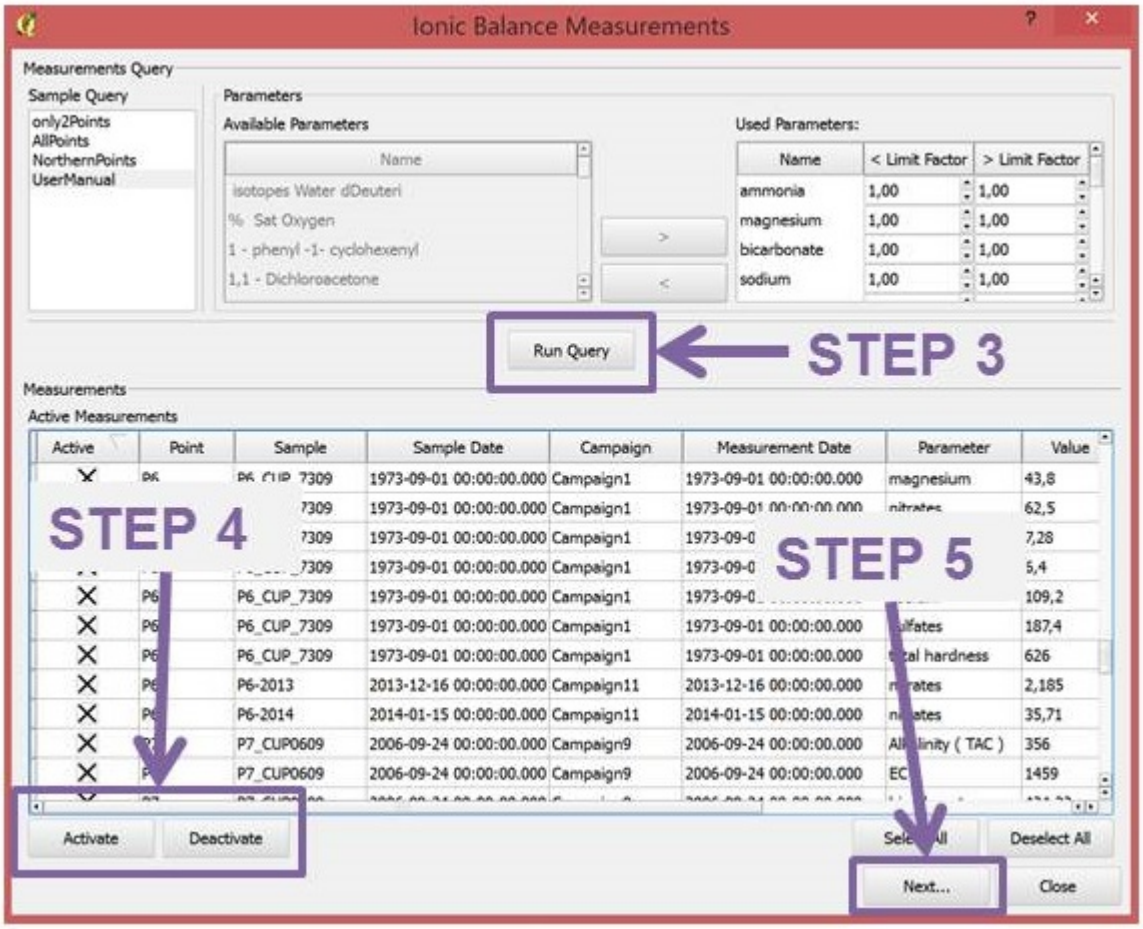
2.8 Ionic Balance Report



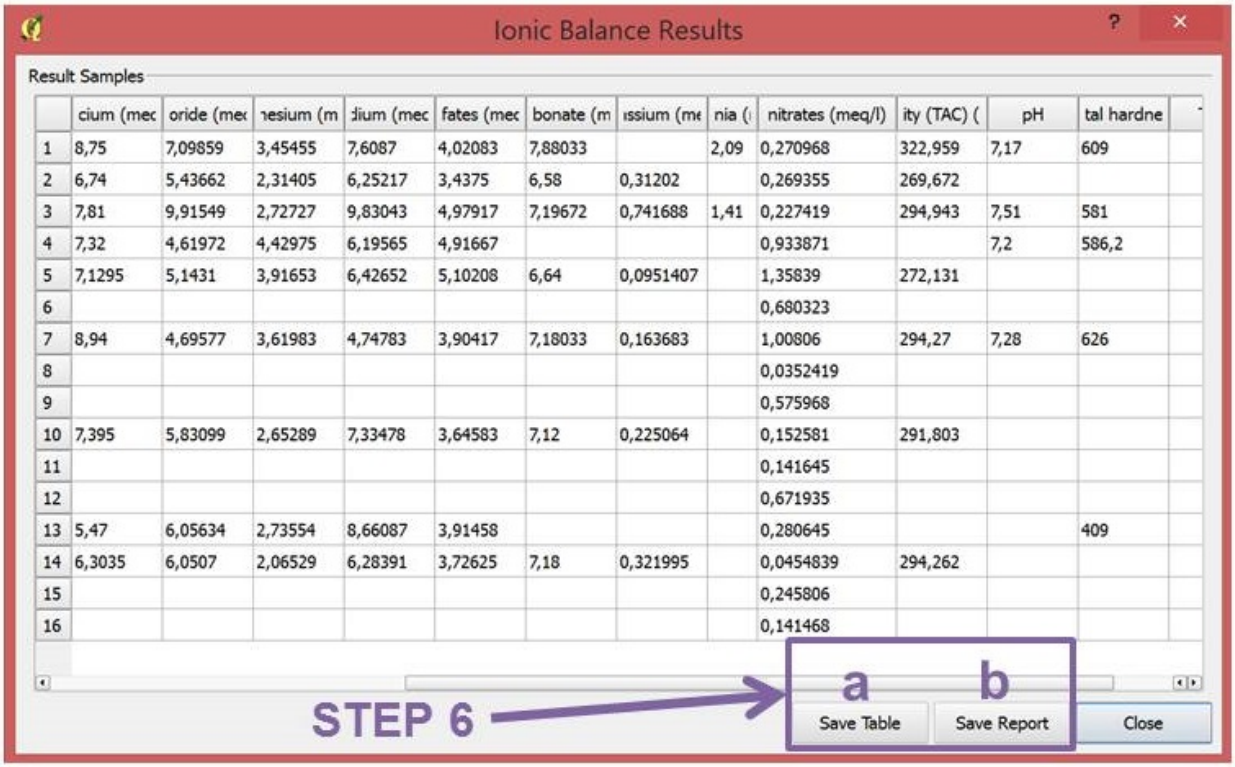
This command was created to calculate ionic balance Report. To date automatically converts all units to meq/l and automatically select the majors ions of the selected sample.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.



	cium (mec	oride (mec	ɔesium (m	dium (mec	fates (mec	bonate (m	ıssium (me	nia (i	nitrates (meq/l)	ity (TAC) (	pH	tal hardne
1	8,75	7,09859	3,45455	7,6087	4,02083	7,88033		2,09	0,270968	322,959	7,17	609
2	6,74	5,43662	2,31405	6,25217	3,4375	6,58	0,31202		0,269355	269,672		
3	7,81	9,91549	2,72727	9,83043	4,97917	7,19672	0,741688	1,41	0,227419	294,943	7,51	581
4	7,32	4,61972	4,42975	6,19565	4,91667				0,933871		7,2	586,2
5	7,1295	5,1431	3,91653	6,42652	5,10208	6,64	0,0951407		1,35839	272,131		
6									0,680323			
7	8,94	4,69577	3,61983	4,74783	3,90417	7,18033	0,163683		1,00806	294,27	7,28	626
8									0,0352419			
9									0,575968			
10	7,395	5,83099	2,65289	7,33478	3,64583	7,12	0,225064		0,152581	291,803		
11									0,141645			
12									0,671935			
13	5,47	6,05634	2,73554	8,66087	3,91458				0,280645			409
14	6,3035	6,0507	2,06529	6,28391	3,72625	7,18	0,321995		0,0454839	294,262		
15									0,245806			
16									0,141468			

- *Step 6*: Save query results in different formats with all information related (a) or ionic balance report in ods format (b). It is useful to analyze in detail data stored in the user database necessary to ionic balance calculations and its results.

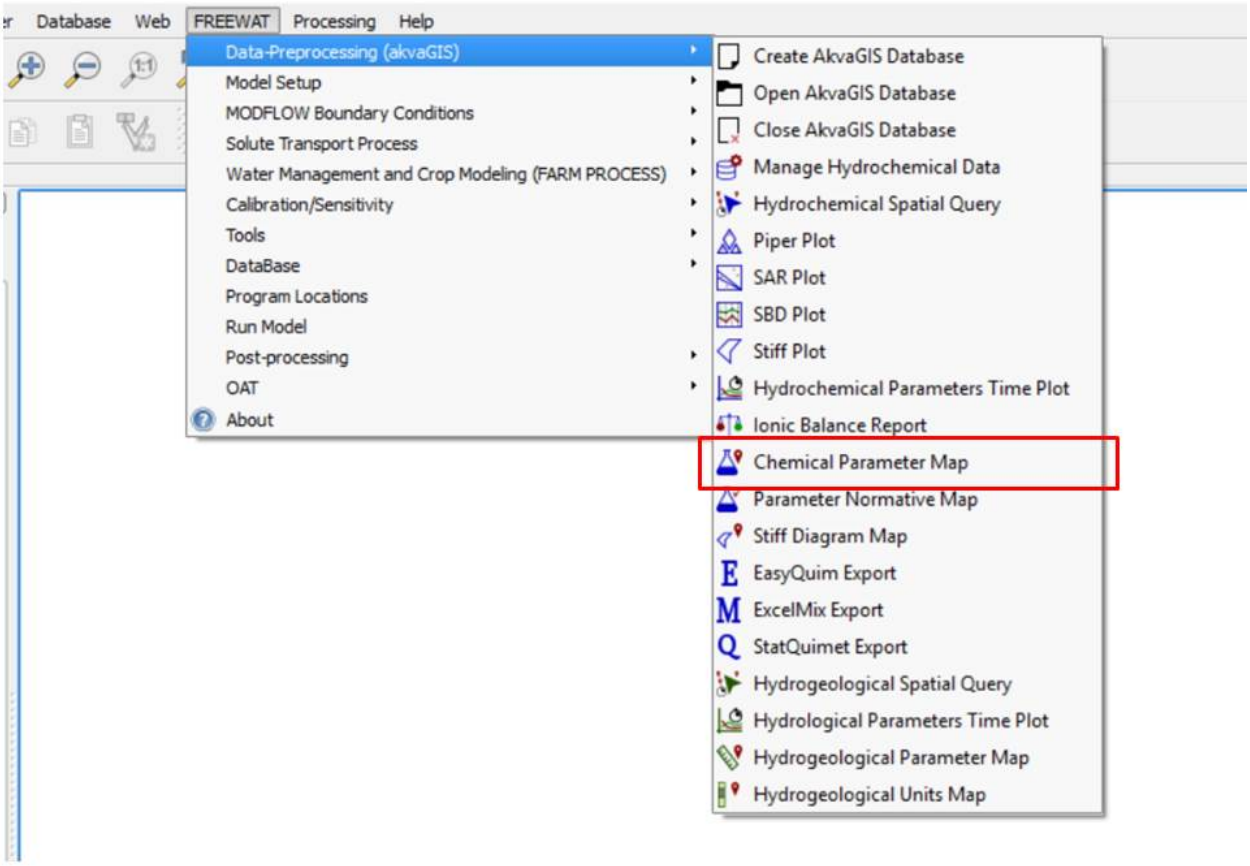
a

Point	Coordinate X	Coordinate Y	Campaign	Sample	Date	sodium (mg/l)	sodium (ppm)	chloride (mg/l)	magnesium (r	magnesium (r	sulfates (mg/l)	ammonia (mg	pH (u. ph)	pH (°C)	total hardnes	total hardnes	nitrates (mg/l)	calcium (m
P10	432525,5449	4589976,413	Campaign9	P10_CUP06	2006-10-25	143,8		193	28		165			7,21			16,7	13
P11	433660,0001	4589040	Campaign7	P11_CAG01	2001-10-24	226,1		352	33		239	1,41	7,51		581		14,1	15
P12	430858,7211	4582777,016	Campaign9	P12_CUP06	2006-12-13	82,96		139,89	49,72		158,22			7,49			95,08	129
P2	428407,2487	4581490,897	Campaign10	P2_CPR101	2010-11-24	146,33		206,41	28,01		142,45		7,59				0,6	130
P3	432962,0663	4584641,892	Campaign8	P3_CCL0301	2003-01-29		142,5	164		53,6	236		7,2			586,2	57,9	
P3	432962,0663	4584641,892	Campaign9	P3_CUP061	2006-10-24	147,81		182,58	47,39		244,9			7,47			84,22	142
P3	432962,0663	4584641,892	Campaign11	P3-2013	2013-12-03												42,18	
P4	431194,5767	4581402,259	Campaign10	P4_CPR101	2010-05-30	165		201,22	28,48		145,55		7,69				0,36	122
P4	431194,5767	4581402,259	Campaign11	P4-2013	2013-12-04												12,86	
P5	429844,9611	4581088,809	Campaign8	P5_CCL0301	2003-01-28		152,1	305		68,6	438,8		7,2			800,7	70,3	
P5	429844,9611	4581088,809	Campaign10	P5_CPR101	2010-05-30	156,07		183,01	26,18		139,14		7,42				0,0001	117
P5	429844,9611	4581088,809	Campaign11	P5-2013	2013-12-08												14,15	
P5	429844,9611	4581088,809	Campaign11	P5-2014	2014-01-11												27,77	
P6	433176,1889	4588200,677	Campaign11	P6-2013	2013-12-16												2,185	
P6	433176,1889	4588200,677	Campaign11	P6-2014	2014-01-15												35,71	
P7	433630,0011	4587270	Campaign9	P7_CUP060	2006-09-24	168,7		207	32,1		175			7,34			9,46	14
P7	433630,0011	4587270	Campaign11	P7-2013	2013-12-22												8,782	
P7	433630,0011	4587270	Campaign11	P7-2014	2014-01-19												41,66	
P8	433624,0783	4588499,284	Campaign9	P8_CUP061	2006-10-24	144,53		214,8	24,99		178,86			7,64			2,82	126
P8	433624,0783	4588499,284	Campaign11	P8-2014	2014-01-03												15,24	
P9	430949,9997	4590000	Campaign11	P9-2014	2014-01-07												8,771	

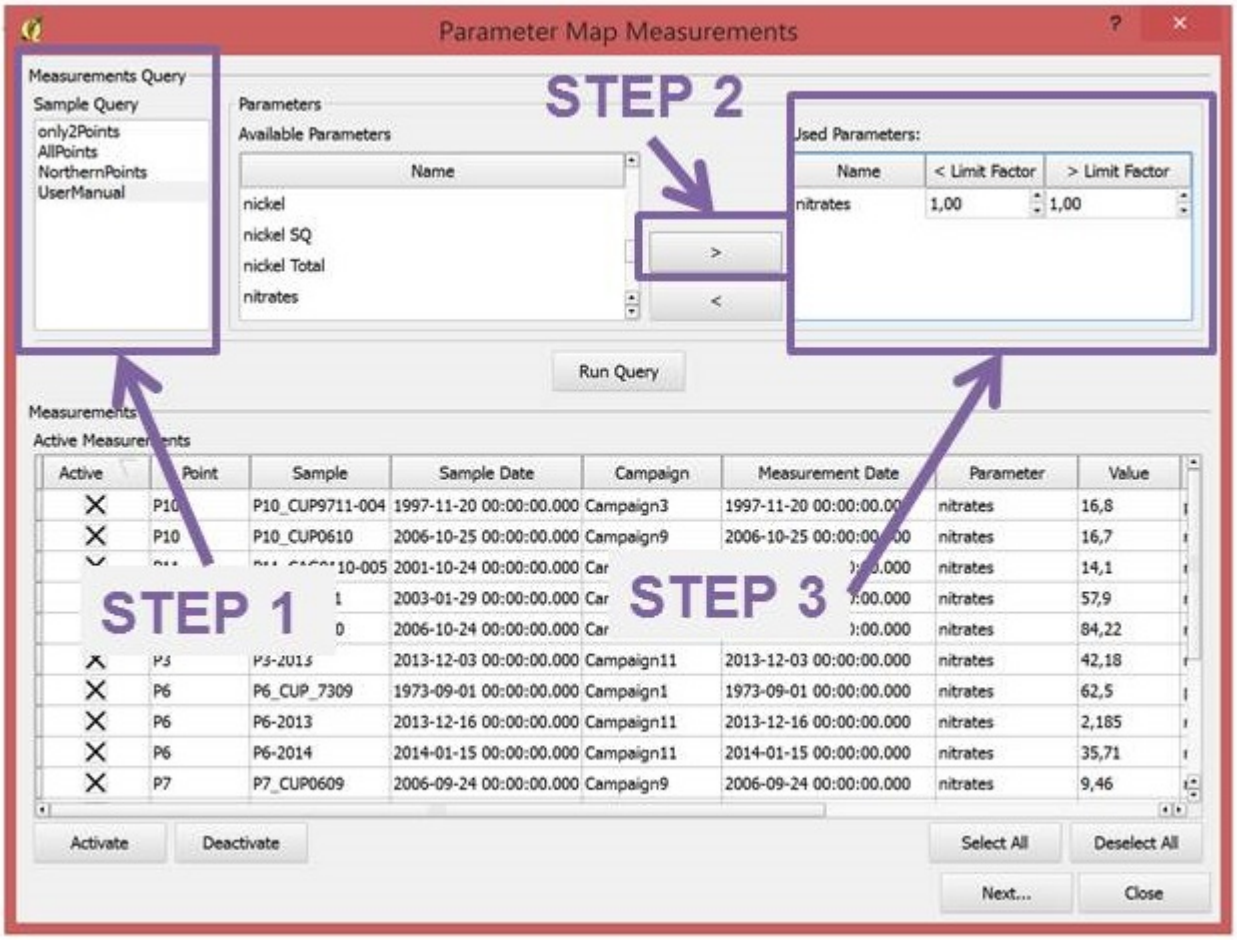
b

	Cations Weight Percentage				Anions Weight Percentage				Cations meq Percentage				Anions meq Percentage				Ionic Balance
Total(meq)	Ca(mg/l %)	Mg(mg/l %)	Na(mg/l %)	K(mg/l %)	Cl(mg/l %)	SO4(mg/l %)	HCO3(mg/l %)	NO3(mg/l %)	Ca(meq/l %)	Mg(meq/l %)	Na(meq/l %)	K(meq/l %)	Cl(meq/l %)	SO4(meq/l %)	HCO3(meq/l %)	NO3(meq/l %)	Error(%)
15,72347456	0,422835634	0,08782936	0,451066499	0,038268507	0,248685703	0,212606948	0,51718895	0,0215184	0,431546595	0,148163237	0,40031222	0,019977948	0,345764525	0,218622162	0,418482567	0,017130745	-0,67150496
22,31880029	0,351564258	0,074274139	0,508890389	0,065271213	0,337132459	0,228905277	0,420457811	0,013504454	0,369977435	0,129197102	0,465690019	0,035135444	0,444266396	0,223092935	0,322451082	0,010189587	-5,56967555
14,95068964	0,491149104	0,188062637	0,313790756	0,006997504	0,181630507	0,205429829	0,489489606	0,123450058	0,455426687	0,288238684	0,253015673	0,003318956	0,263570676	0,220474779	0,413380788	0,102573756	-4,75802577
15,90535851	0,400453529	0,085833359	0,448411118	0,065301995	0,263483067	0,18183791	0,553913121	0,000765902	0,414697511	0,146919701	0,403792116	0,034590671	0,36556021	0,186585441	0,447245911	0,000608438	-0,94307685
18,24356902	0,417528037	0,138766068	0,432813095	0,0108928	0,199162249	0,267142265	0,441826472	0,091869014	0,405832218	0,222939307	0,365814814	0,005415661	0,281912963	0,279664759	0,363963871	0,074458408	-3,77465576
15,54020156	0,368184695	0,085837427	0,497302511	0,048675367	0,263376963	0,190510471	0,545641361	0,000471204	0,380592155	0,146661262	0,447009663	0,02573692	0,36474231	0,195125633	0,439758416	0,000373641	3,219322865
14,64806124	0,369269521	0,08243073	0,491404282	0,056895466	0,252640118	0,192078826	0,555280918	0,000000138	0,383884274	0,141641537	0,444219843	0,030254345	0,351938129	0,197893083	0,450168678	1,1011E-07	4,193197142
16,74939989	0,413706294	0,08979021	0,471888112	0,024615385	0,250672092	0,211920851	0,525951222	0,011455836	0,419985778	0,150666281	0,416565839	0,012782103	0,348131035	0,21766949	0,425089857	0,009109619	4,996569797
17,0024381	0,40907911	0,081088974	0,468979168	0,040852748	0,257411979	0,214342209	0,524866381	0,003379431	0,420943404	0,137918599	0,4196354	0,021502597	0,35587274	0,219159745	0,422292377	0,002675138	-12,6824426

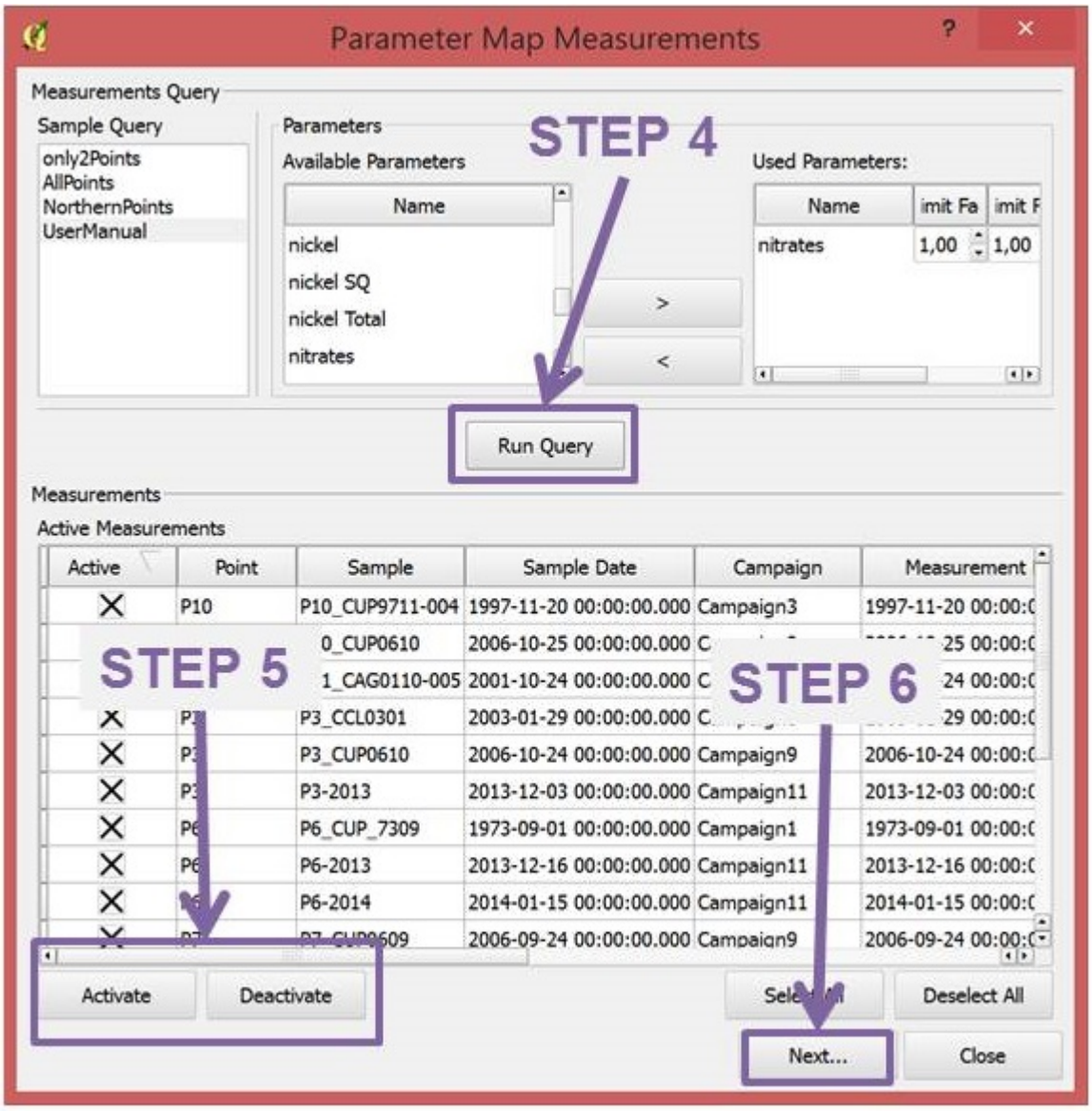
2.9 Chemical Parameter Map



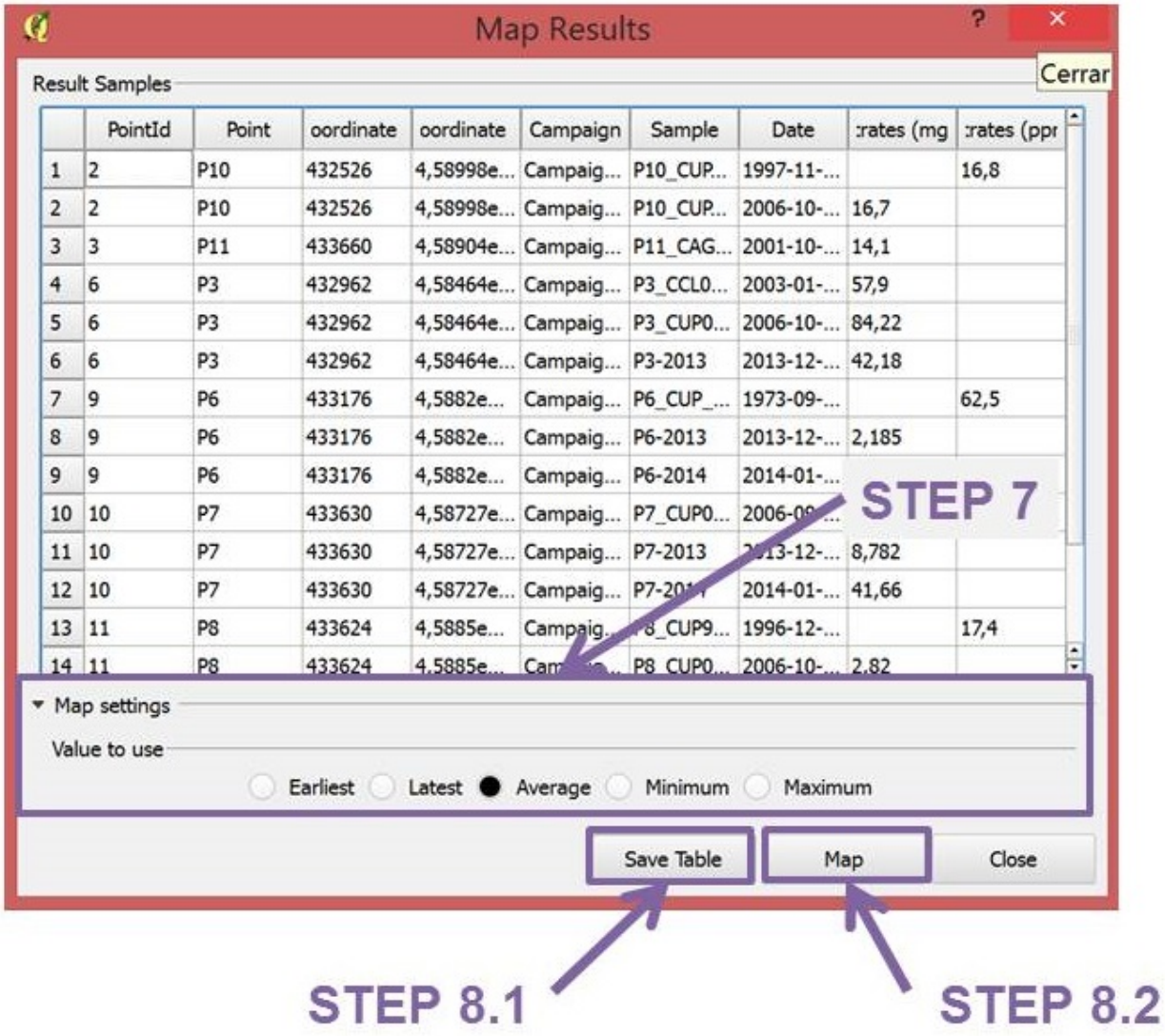
Use this command to obtain the minimum, maximum and average for each selected parameter, for the selected query and to represent these values in a map.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the parameter to be queried for the analysis.
- *Step 3*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.

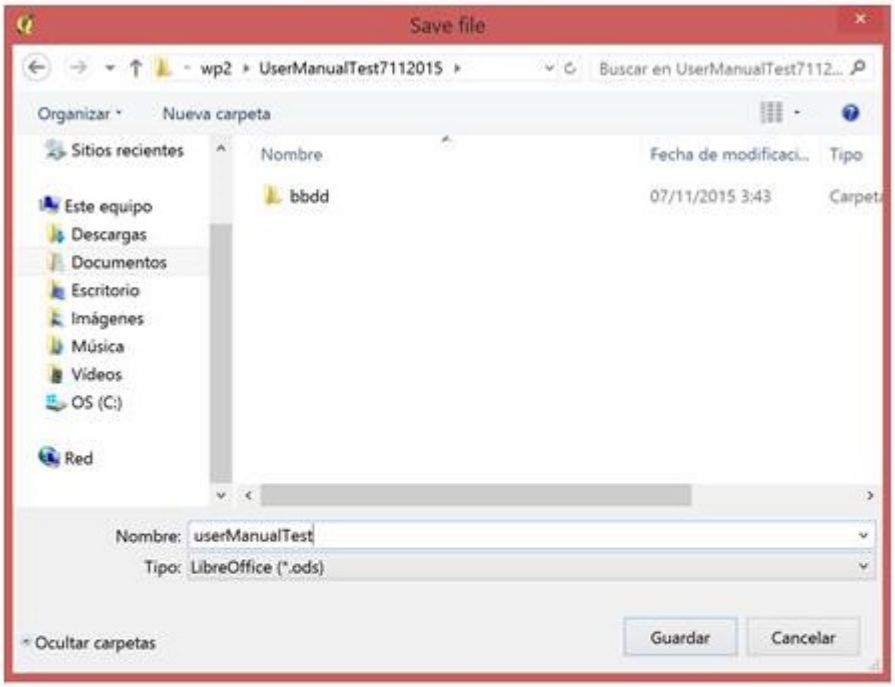


- *Step 4*: Run Query.
- *Step 5*: Use this commands to activate or deactivated the desired measurements.
- *Step 6*: Click Next.



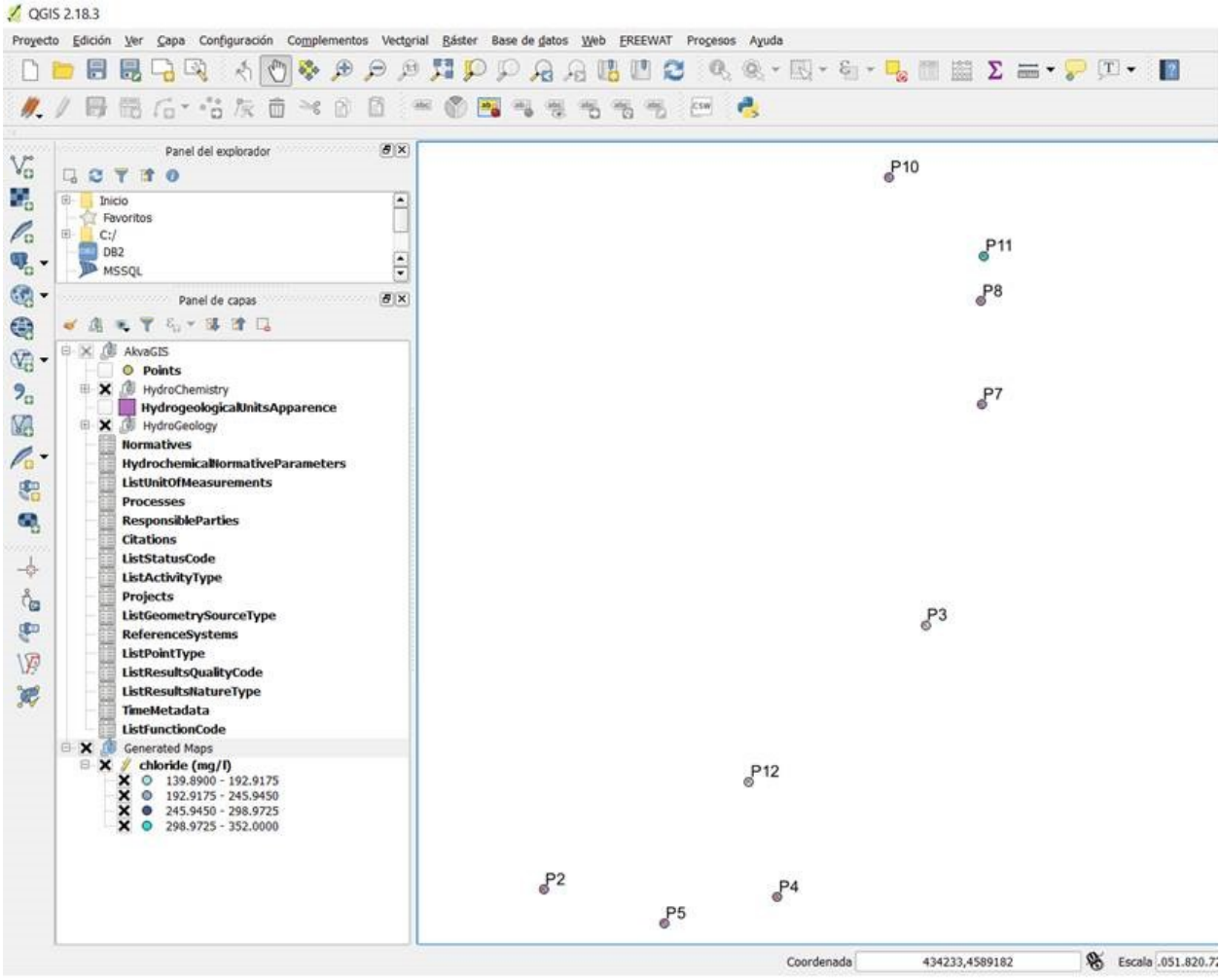
- *Step 7*: Map settings. Select the value to use in the map. Statistical calculations can be used to be represented in the maps such as average value, mean, minimum, etc.

STEP 8.1



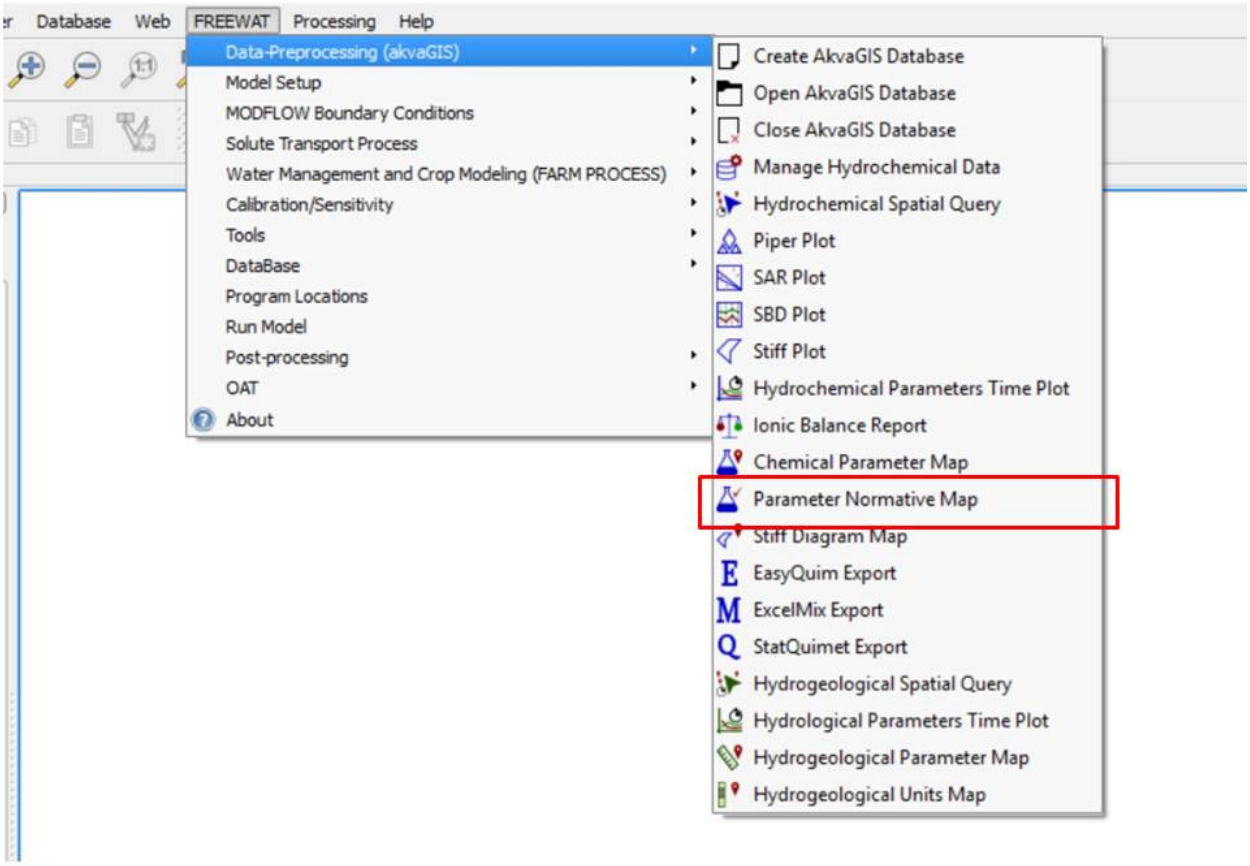
Campaign	Sample	Date	silicates (mg/l)	sulfates (mg/l)	nitrates (mg/l)
Campaign9	P1_CUP0611	2006-11-08 00:00:00.000	10.43	181.43	86.61
Campaign9	P10_CUP0610	2006-10-25 00:00:00.000	9.28	165	16.7
Campaign7	P11_CAG0110-005	2001-10-24 00:00:00.000		239	14.1
Campaign9	P12_CUP0612	2006-12-13 00:00:00.000	8.96	158.22	95.08
Campaign10	P2_CPR1011	2010-11-24 00:00:00.000		142.45	0.6
Campaign8	P3_CCL0301	2003-01-29 00:00:00.000		236	57.9
Campaign9	P3_CUP0610	2006-10-24 00:00:00.000	8.69	244.9	84.22

- *Step 8.1*: Save query results in different formats.

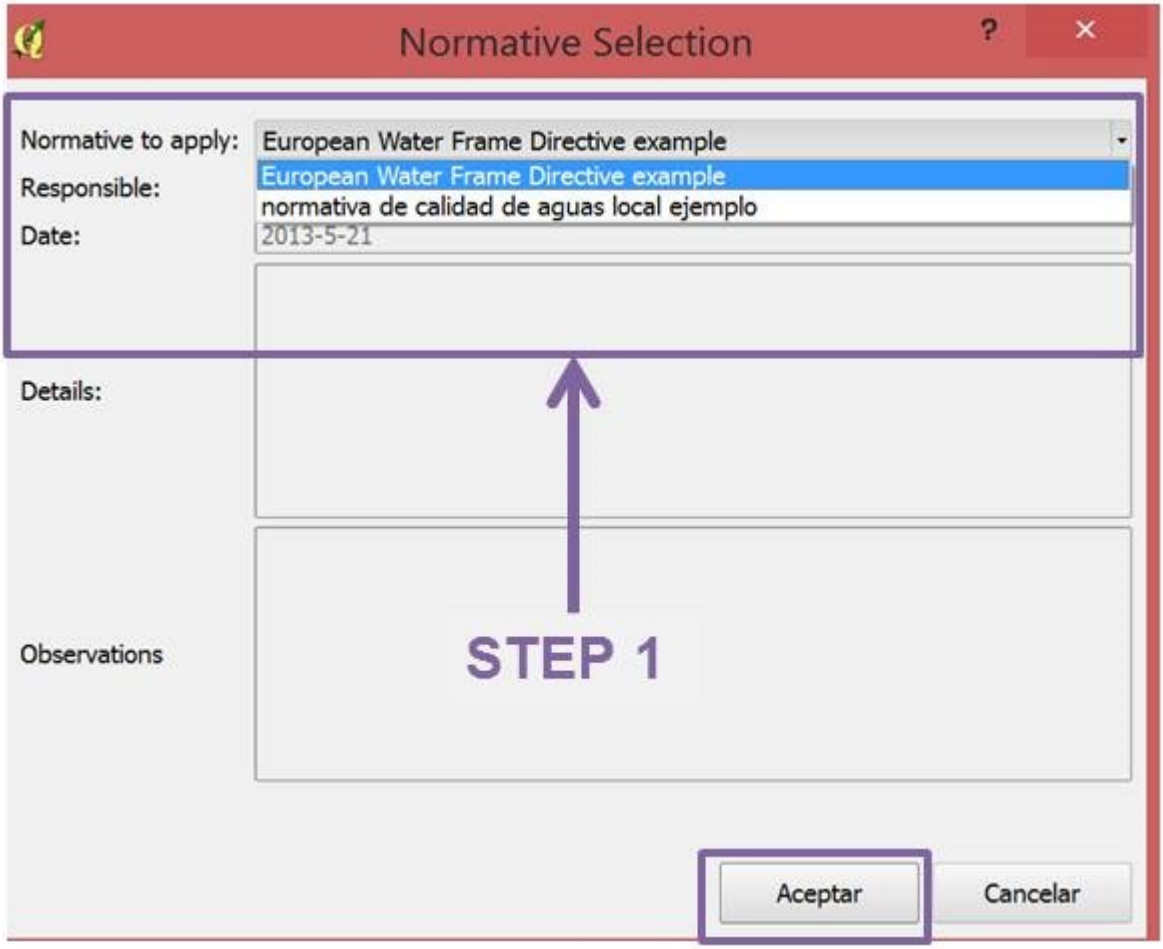


- *Step 8.2*: This button creates automatically the map with the selected values.

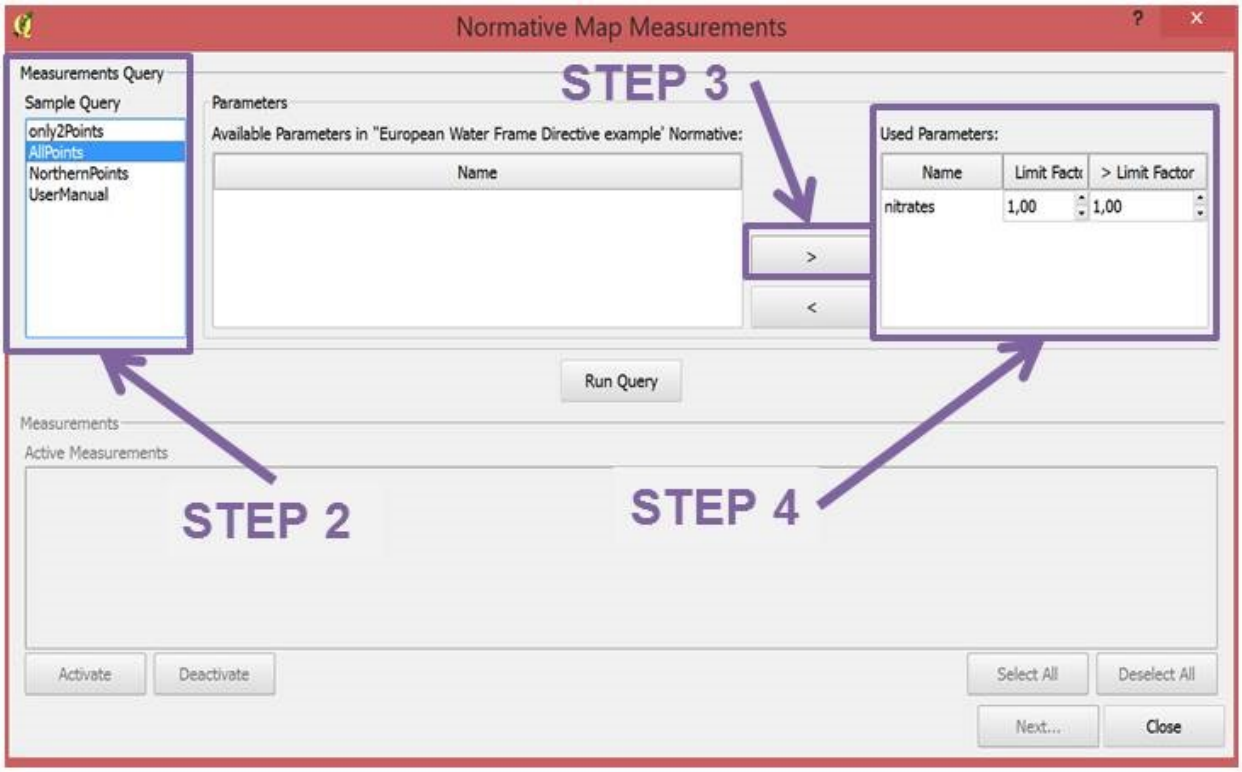
2.10 Parameter Normative Map



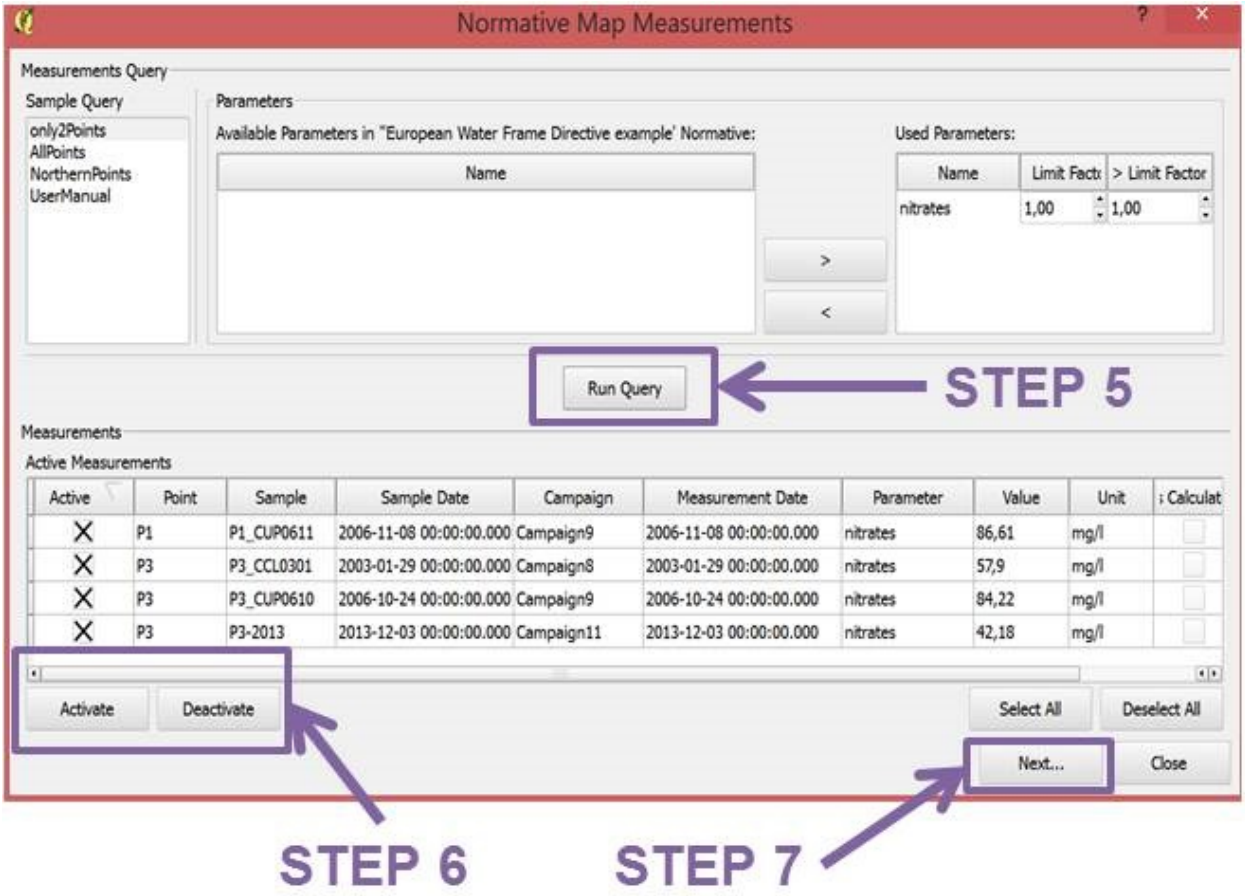
This command enables the user to obtain thematic maps for the queried parameters, classified according to the threshold approach established by a given guideline (e.g. Water Framework Directive).



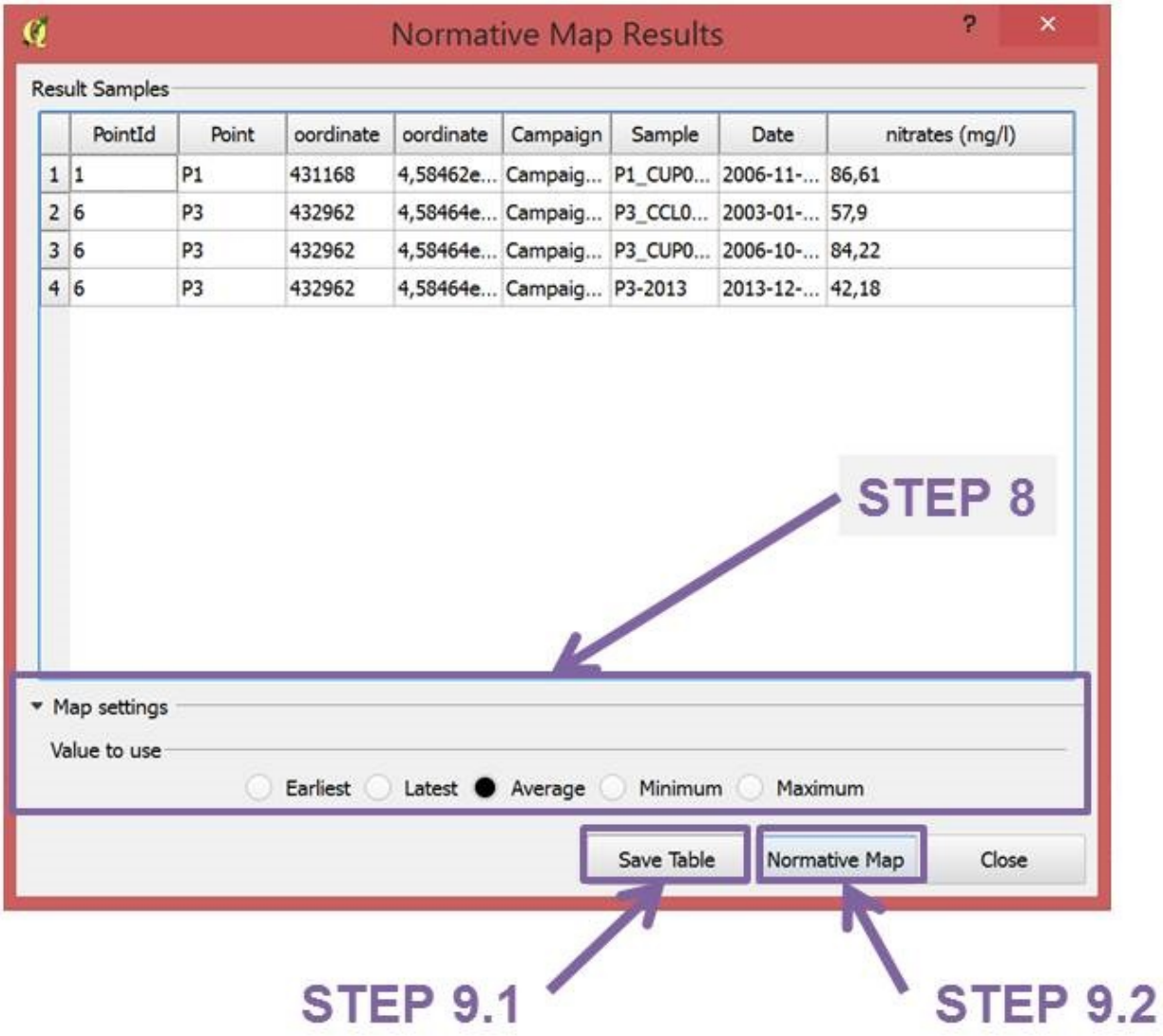
- *Step 1*: Choose the Normative to be applied (The different normatives and the threshold values must to be entered in the database, in the tables *Normatives* and *Normatives Parameters*) and click accept. For further information about the contents of this table, please see the *Database Documentation Section*.



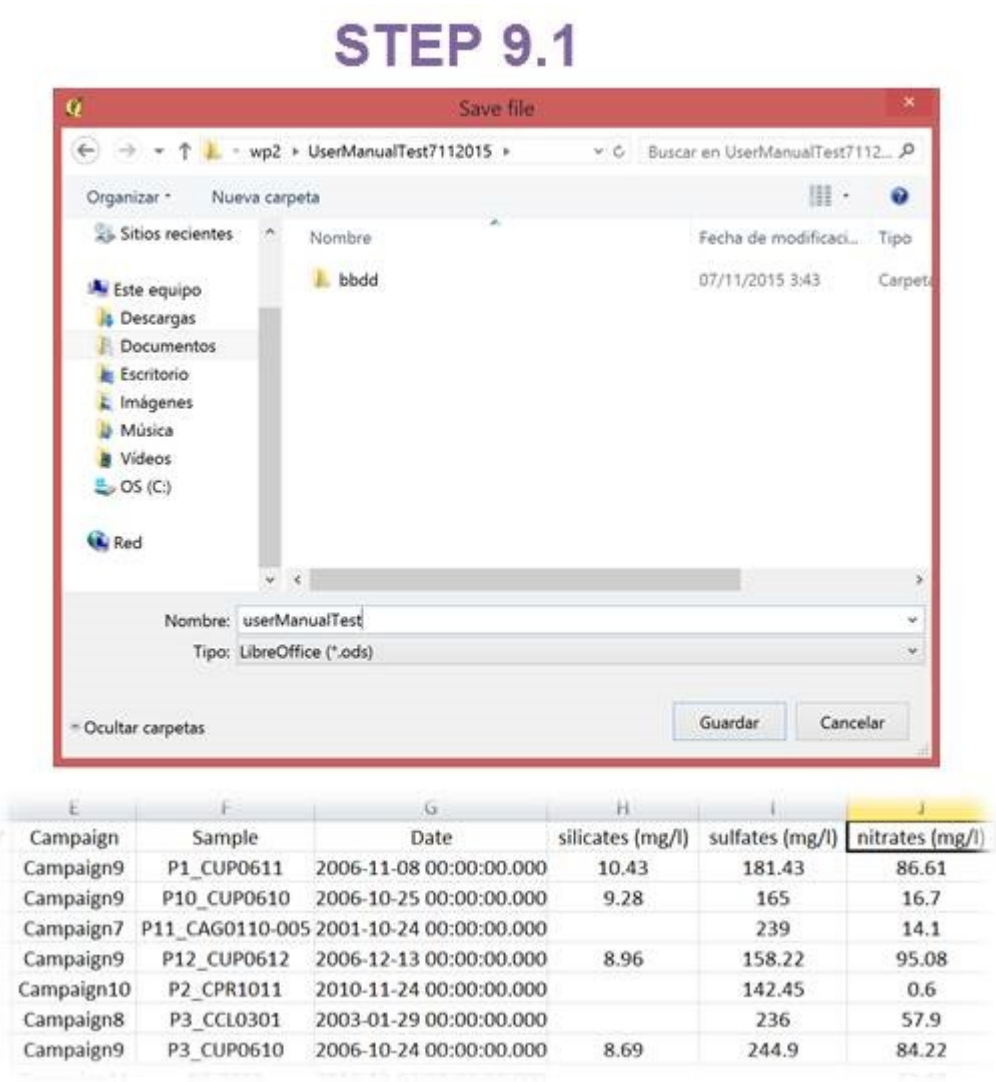
- *Step 2*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 3*: Choose the parameter to be queried for the analysis.
- *Step 4*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 5*: Run Query.
- *Step 6*: Use this commands to activate or deactivated the desired measurements.
- *Step 7*: Click Next.

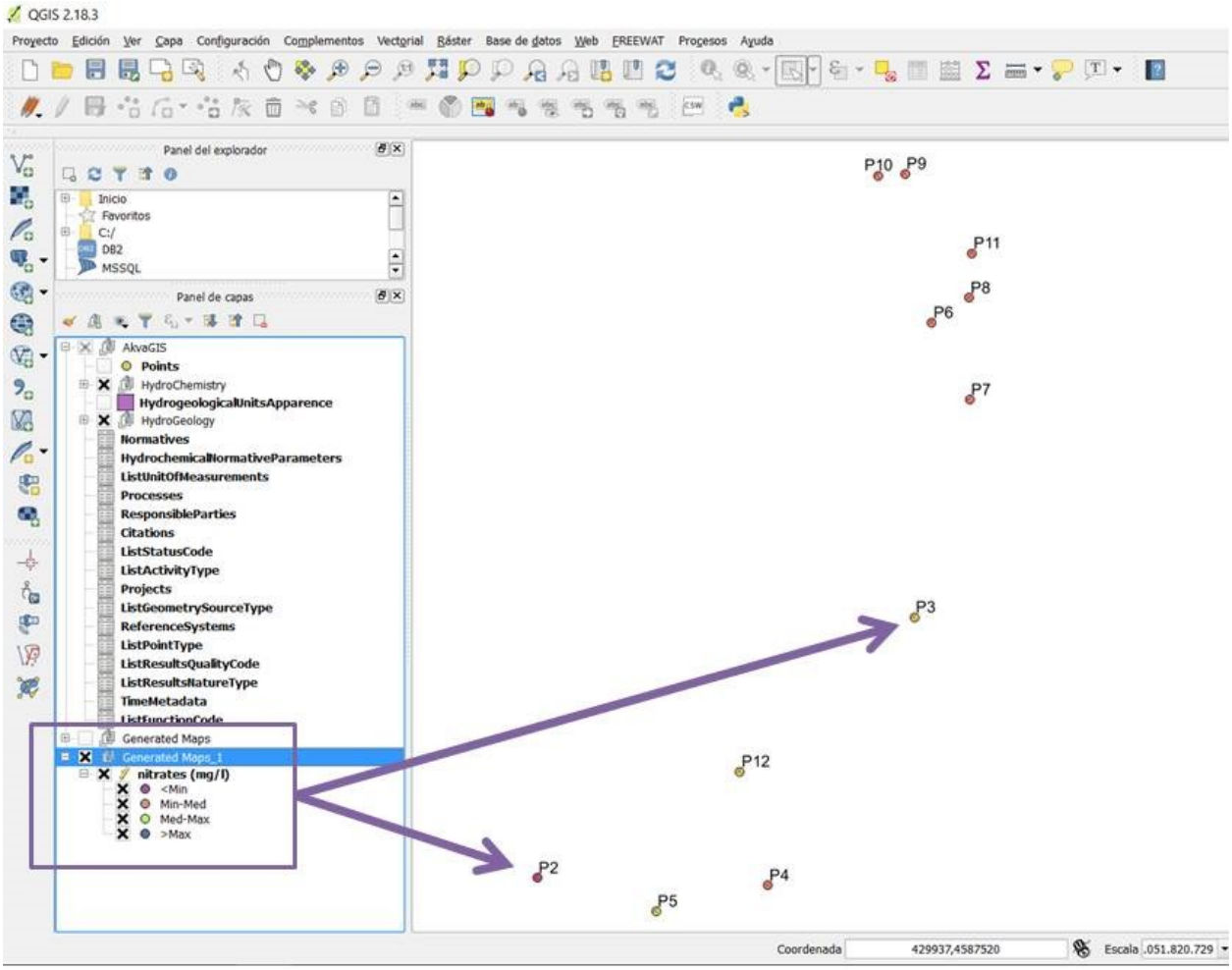


- *Step 8*: Map settings. Select the value to use in the map. Statistical calculations can be used to be represented in the maps such as average value, mean, minimum, etc.



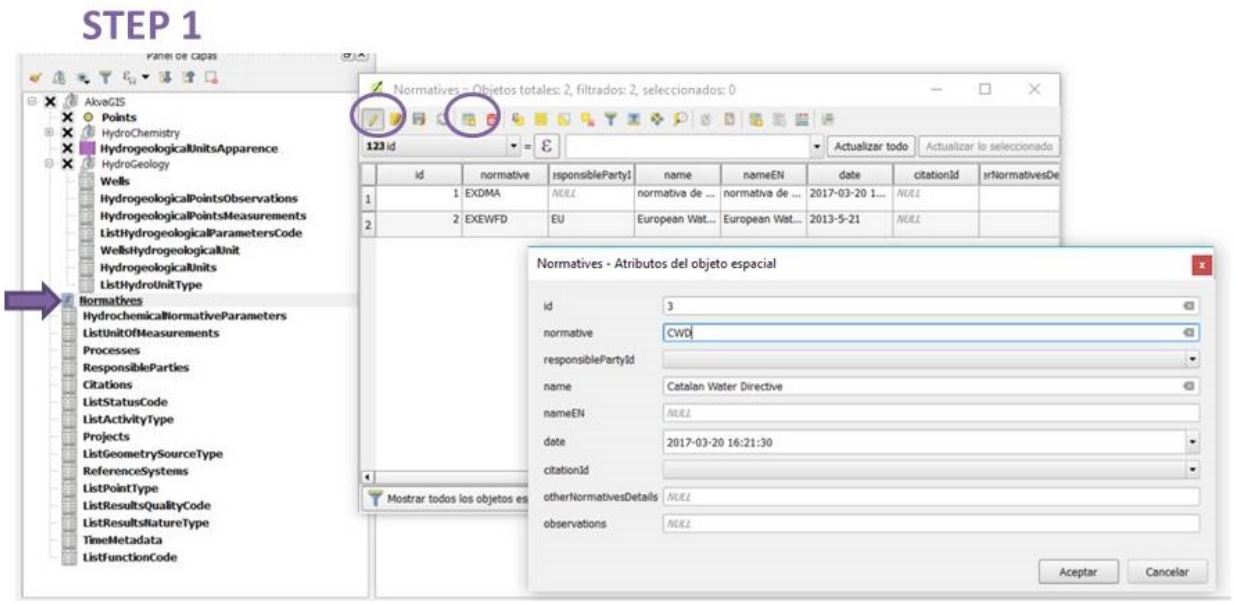
E	F	G	H	I	J
Campaign	Sample	Date	silicates (mg/l)	sulfates (mg/l)	nitrates (mg/l)
Campaign9	P1_CUP0611	2006-11-08 00:00:00.000	10.43	181.43	86.61
Campaign9	P10_CUP0610	2006-10-25 00:00:00.000	9.28	165	16.7
Campaign7	P11_CAG0110-005	2001-10-24 00:00:00.000		239	14.1
Campaign9	P12_CUP0612	2006-12-13 00:00:00.000	8.96	158.22	95.08
Campaign10	P2_CPR1011	2010-11-24 00:00:00.000		142.45	0.6
Campaign8	P3_CCL0301	2003-01-29 00:00:00.000		236	57.9
Campaign9	P3_CUP0610	2006-10-24 00:00:00.000	8.69	244.9	84.22

- *Step 9.1*: Save query results in different formats.



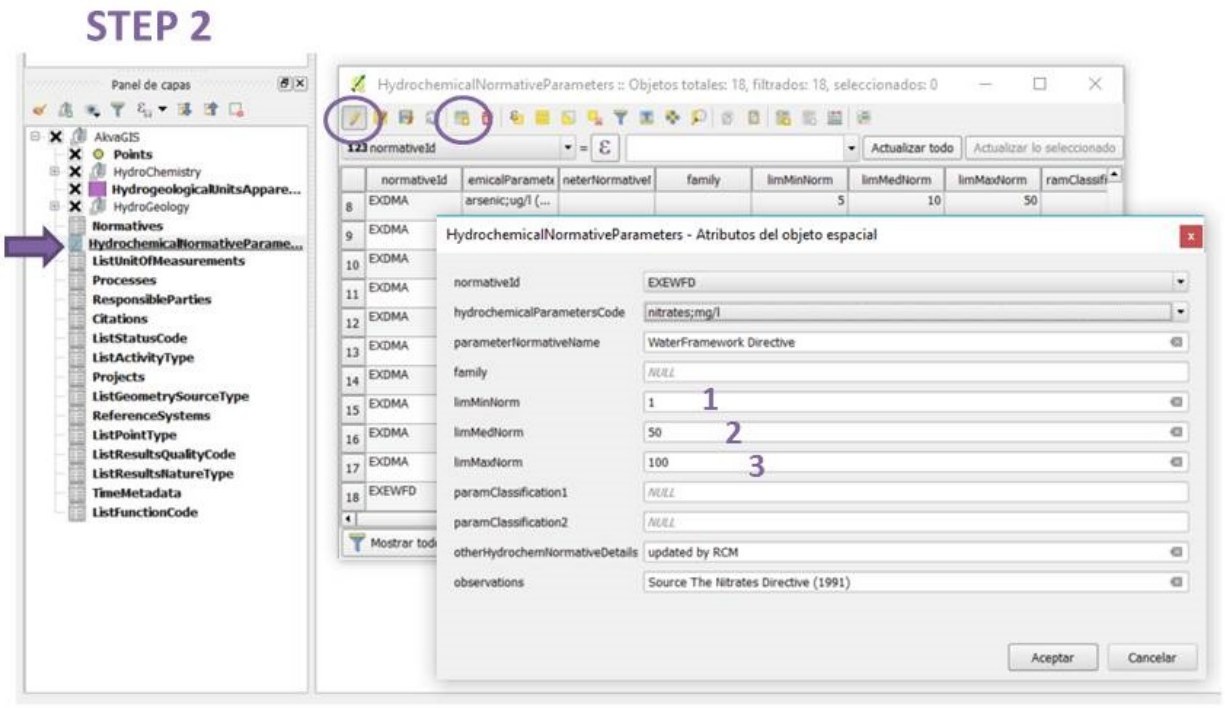
- *Step 9.2*: This button creates automatically the map with the selected parameter.

2.10.1 How to edit / add new normatives and its limit values?



- *Step 1*: Edit or add a new normative if is not included in the table *Normatives*. Select *Normative* table and open its attribute table. The following data has to be added:
  - *Id*: Unique identifier number.
  - *Normative*: Short name of the normative.
  - *ResponsiblePartyId*: Responsible entity of this normative. In case this entity is not in the list, add a new entity in the *Responsible Party Table*.
  - *Name*: Long name of the normative in native language (recommended).
  - *NameEN*: Long name of the normative in English (recommended).
  - *Date*: Date of the normative (recommended).
  - *CitationId*: Unique identifier number of each citation of the document where the normative is described. In case the citation is not in the list, add a new citation in the table *Citation* (from the TOC) (recommended).
  - *otherNormativeDetails*: Additional data (recommended).
  - *observations*: Observations of the person that introduce the data into the database (recommended).

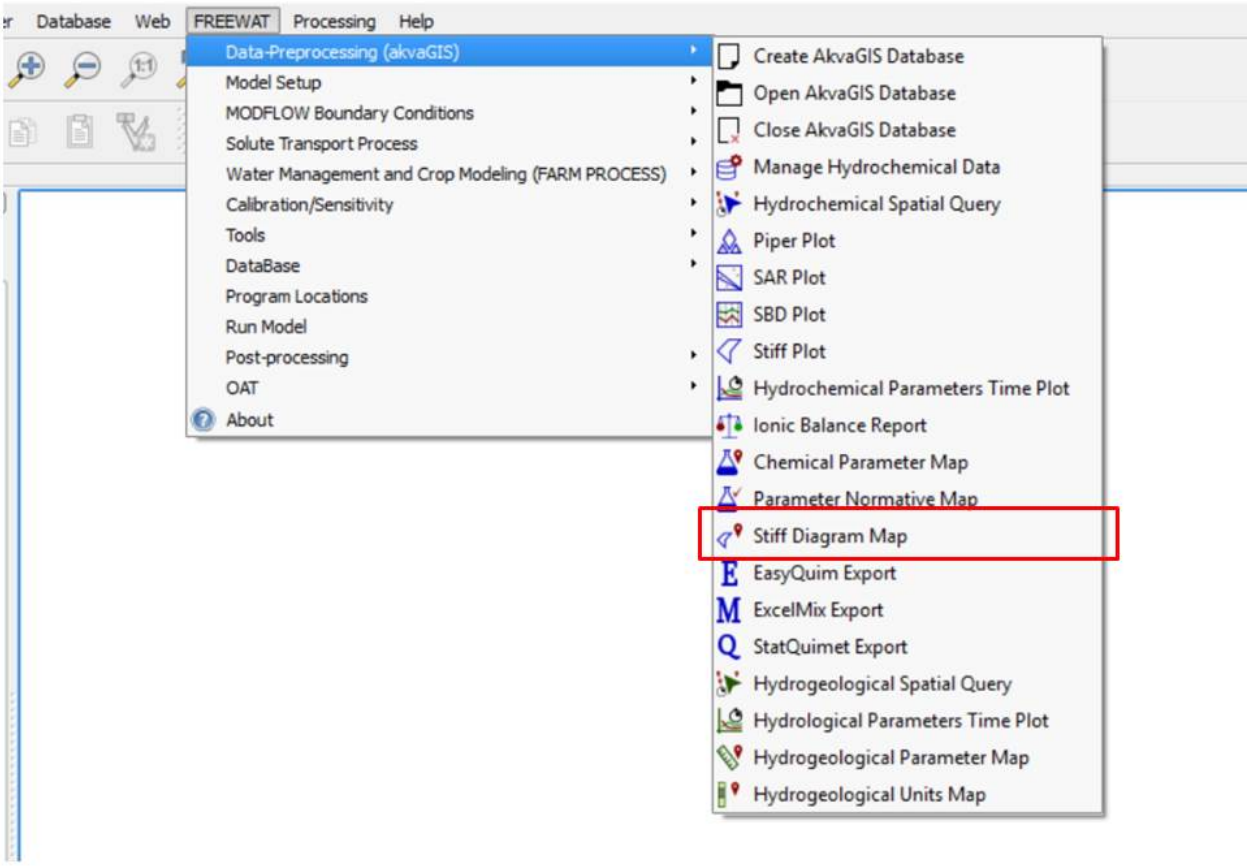
Note: After update normative information, do not forget to save the edition session.



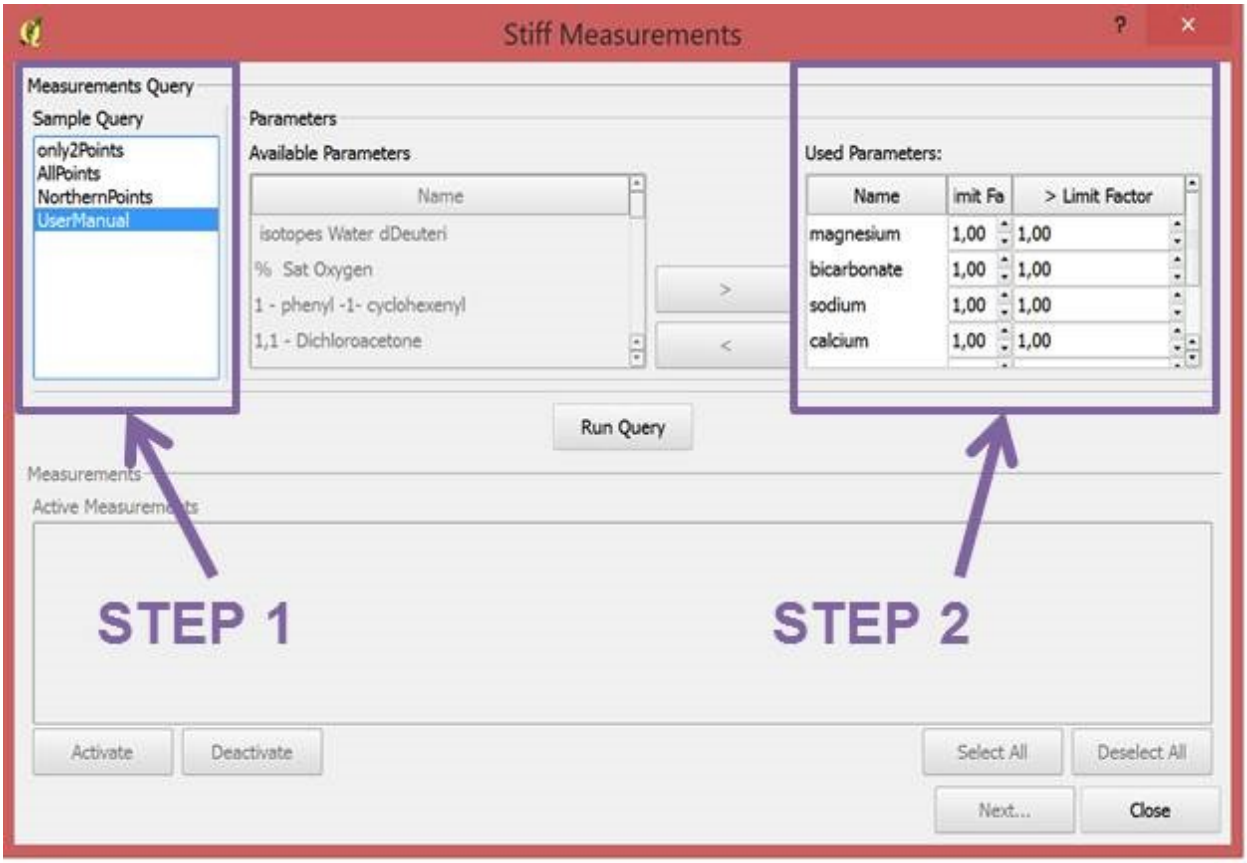
- *Step 2*: Add/editing threshold values for each parameter for each normative. The user can introduce 3 limits: Minimum (1), Medium (2) and Maximum (3) in *Hydrochemical Normative Parameter* table. These limit values will be used to create automatic maps with different colors for each limit value (e.g. red for higher values than the maximum acepted by the normative, blue for lower values than the minimum acepted by the normative).
  - *NormativeId*: Unique identifier number of each normative stored in akvaGIS database.
  - *HydrochemicalParametersCode*: Chemical Parameter to update in the table. All this chemical parameters are stored in *ListHydrogeologicalParametersCode* table.
  - *ParameterNormativeNale*: Name of the Normative.
  - *family*: Classification of the different parameters following users defined normative/criteria for its subsequent classification according to the threshold approach established by a given guideline/normative.
  - *limMinNorm*: Threshold value 1 for a given paramater for a given normative.
  - *limMedNorm*: Threshold value2 (> than limMinNorm) for a given paramater for a given normative.
  - *limMaxNorm*: Threshold value 3 (> que LimMedNorm) for a given paramater for a given normative.
  - *paramClassification*: Classification parameter1-2 by the normative.
  - *otherhydrocheNormativeDetails*: Additional data (recommended).
  - *observations*: Observations of the person that introduce the data into the database (recommended)

Note: After update normative parameters information, do not forget to save the edition session.

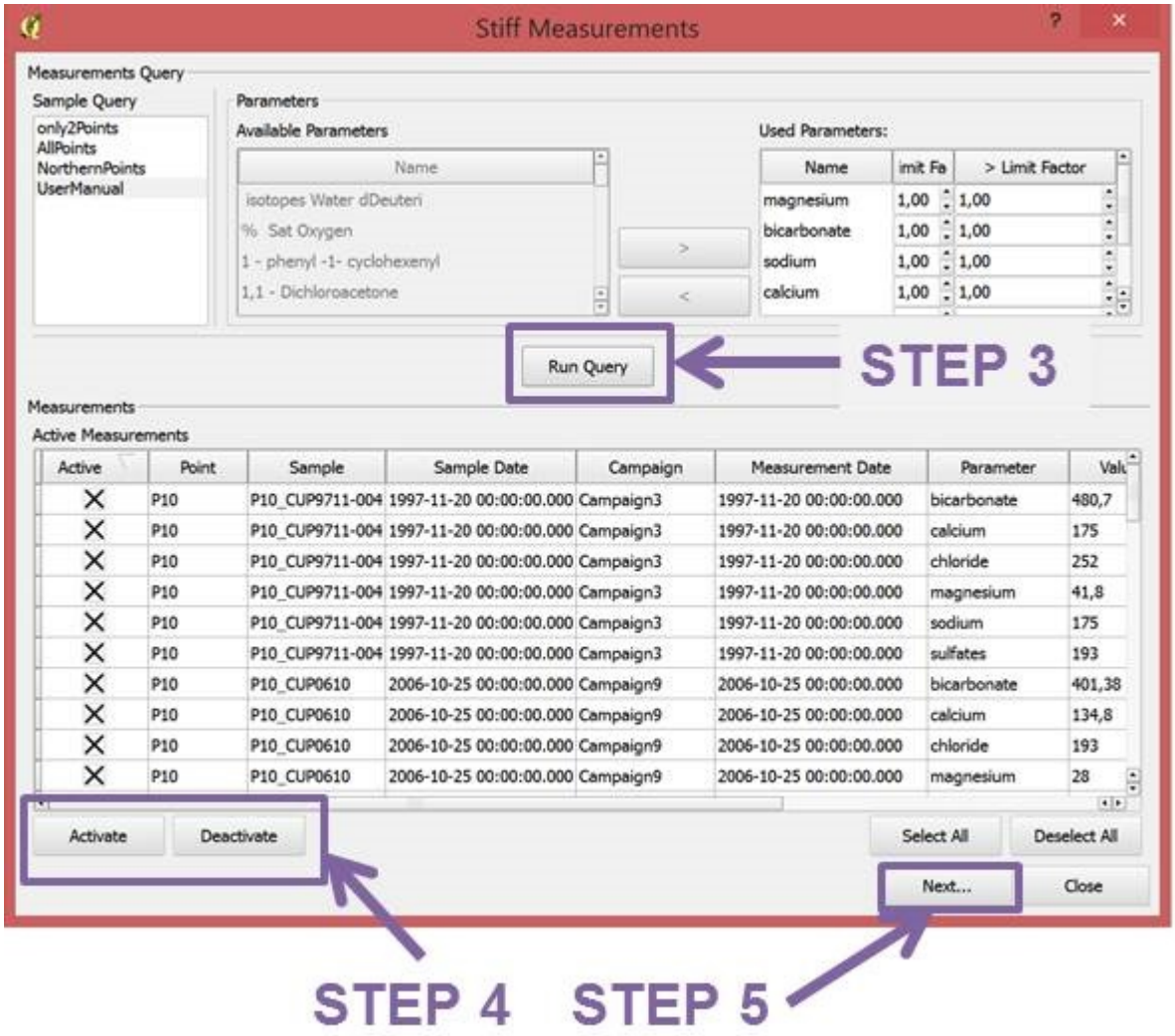
2.11 Stiff Diagram Map



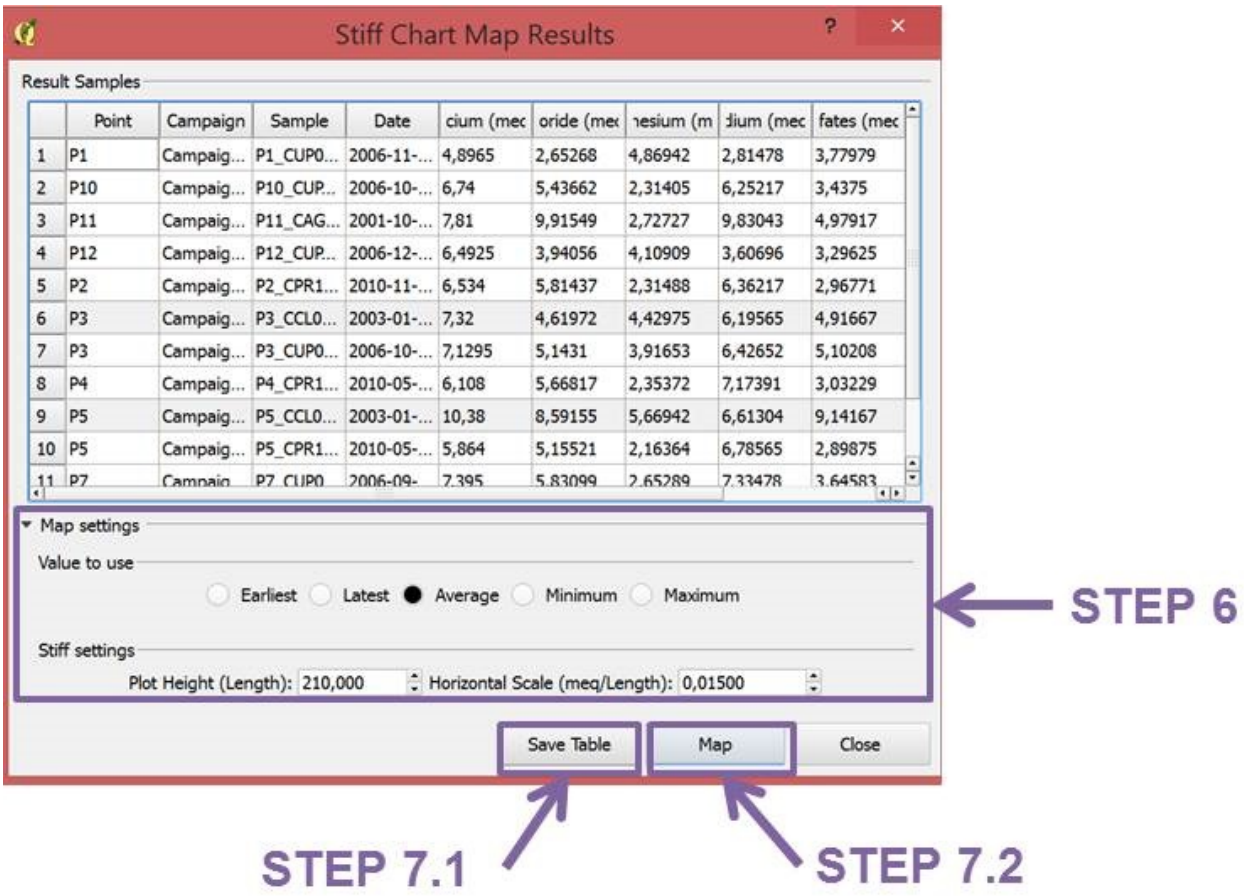
Use this command to create the Stiff diagram map for the selected query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*. For obtaining single stiff diagrams, use command Stiff Plot Tool in section 2.6 *Stiff Plot*. This diagram will be created only if the measurements required for the creation of this diagram are avalaible in the akvaGIS Database.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



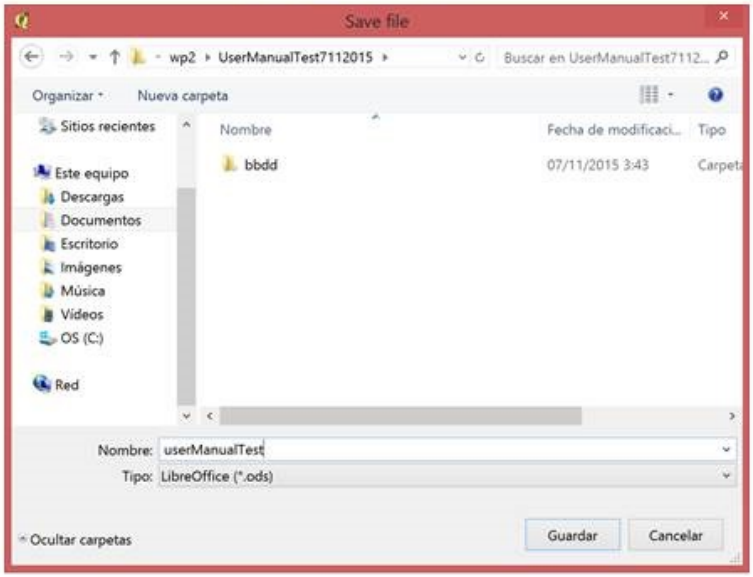
- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.



- *Step 6*: Map settings (optional). Select the value to use in the map. Statistical calculations can be used to be represented in the maps such as average value, mean, minimum, etc.

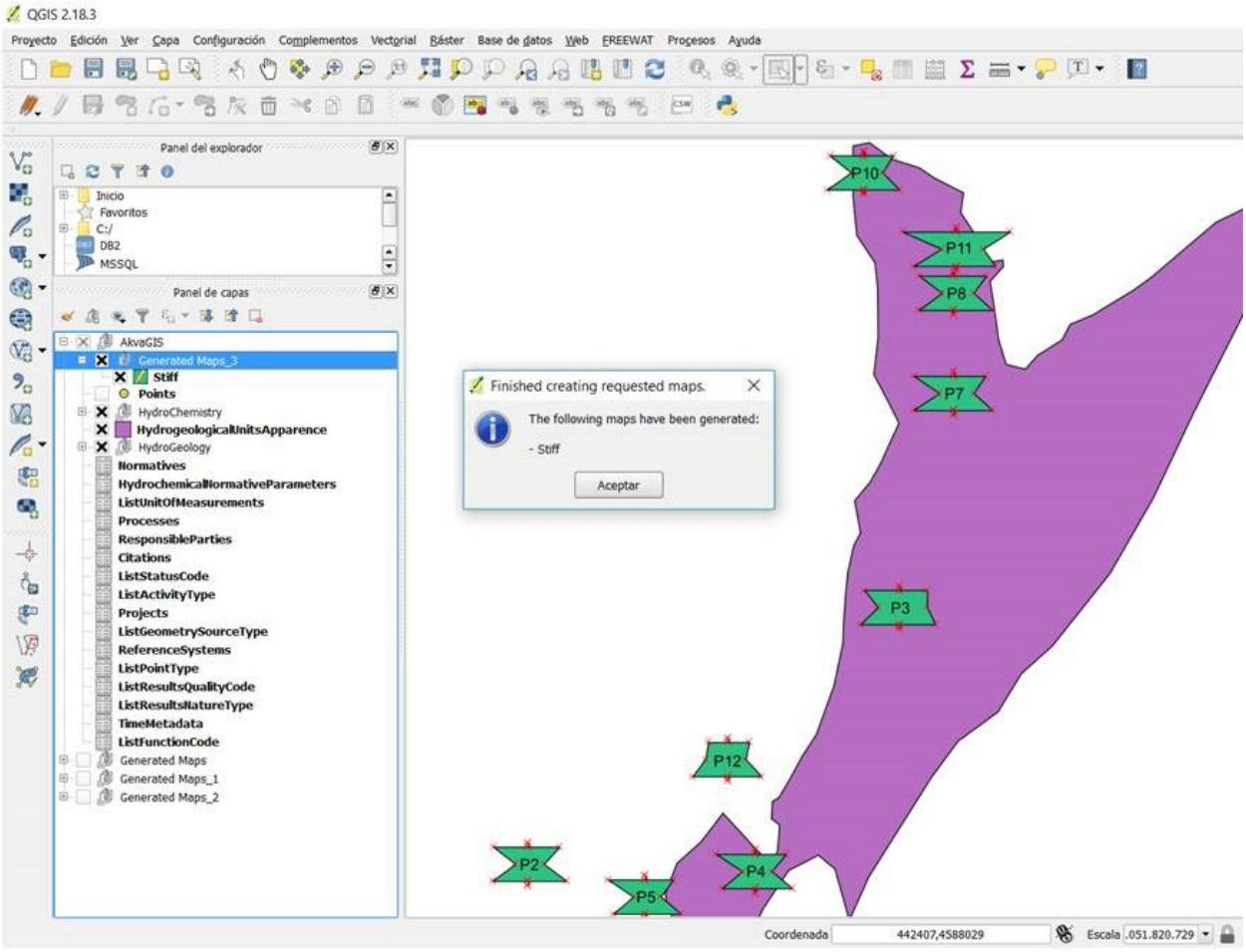
  Using the Stiff settings it is possible to choose the plot height and the horizontal scale. To plot settings such as stiff colour see layer properties.

STEP 7.1



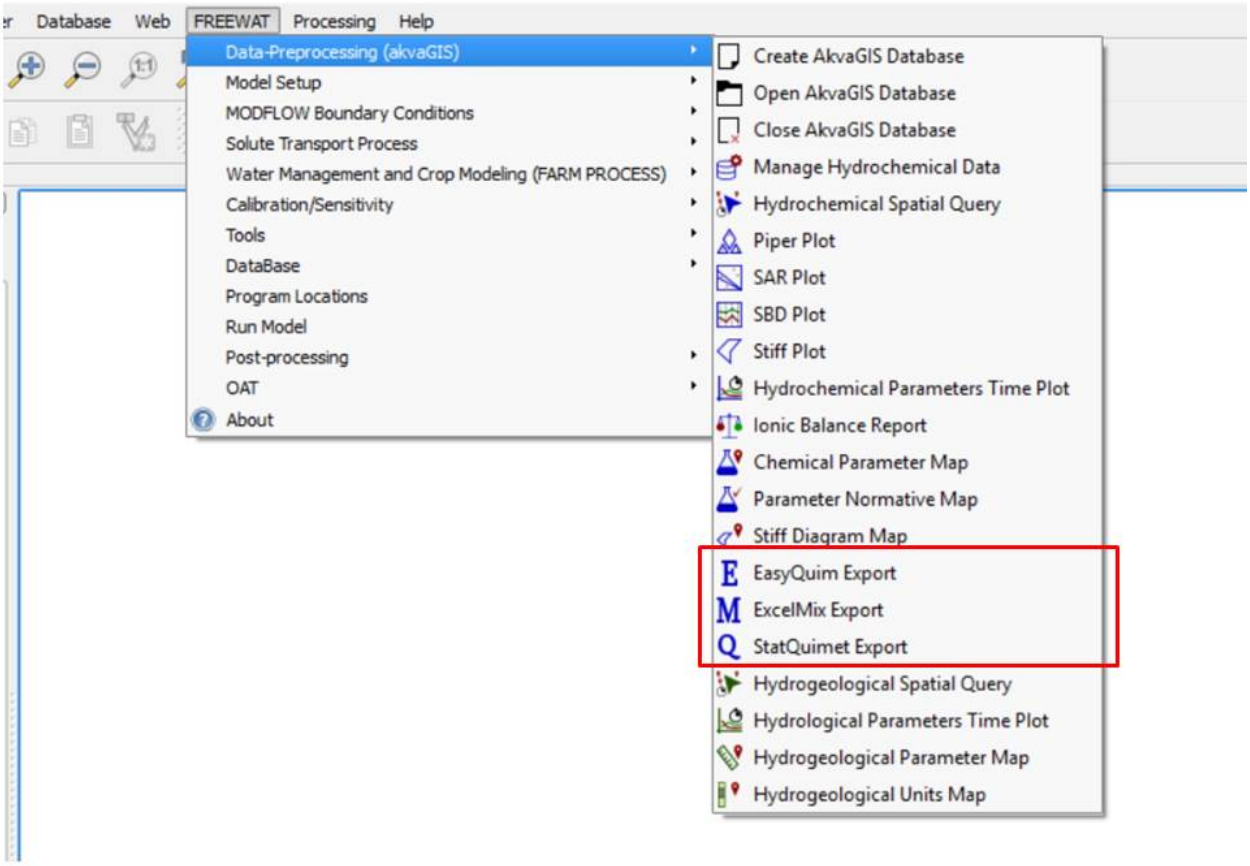
sulfates (mg/l)	sodium (mg/l)	sodium (ppm)	calcium (meq/l)	chloride (meq/l)	magnesium (meq/l)	sodium (meq/l)	sulfates (meq/l)	bicarbonate (meq/l)	valid
181.43	64.74		4.8965	2.652676056	4.869421488	2.814782609	3.779791667	4.983606557	VERDADERO
165	143.8		6.74	5.436619718	2.314049587	6.252173913	3.4375	6.58	VERDADERO
239	226.1		7.81	9.915492958	2.727272727	9.830434783	4.979166667	7.196721311	VERDADERO
158.22	82.96		6.4925	3.94056338	4.109090909	3.606956522	3.29625	6.180327869	VERDADERO
142.45	146.33		6.534	5.814366197	2.314876033	6.362173913	2.967708333	7.113606557	VERDADERO
236		142.5	7.32	4.61971831	4.429752066	6.195652174	4.916666667		FALSO
244.9	147.81		7.1295	5.143098592	3.916528926	6.426521739	5.102083333	6.64	VERDADERO
145.55	165		6.108	5.668169014	2.353719008	7.173913043	3.032291667	6.833934426	VERDADERO

- *Step 7.1*: Save Stiff query results in different formats such as .ods.



- *Step 7.2*: Plot Stiff diagram automatically. The resulting layer will be automatically loaded into the bottom of the Layer Panel.

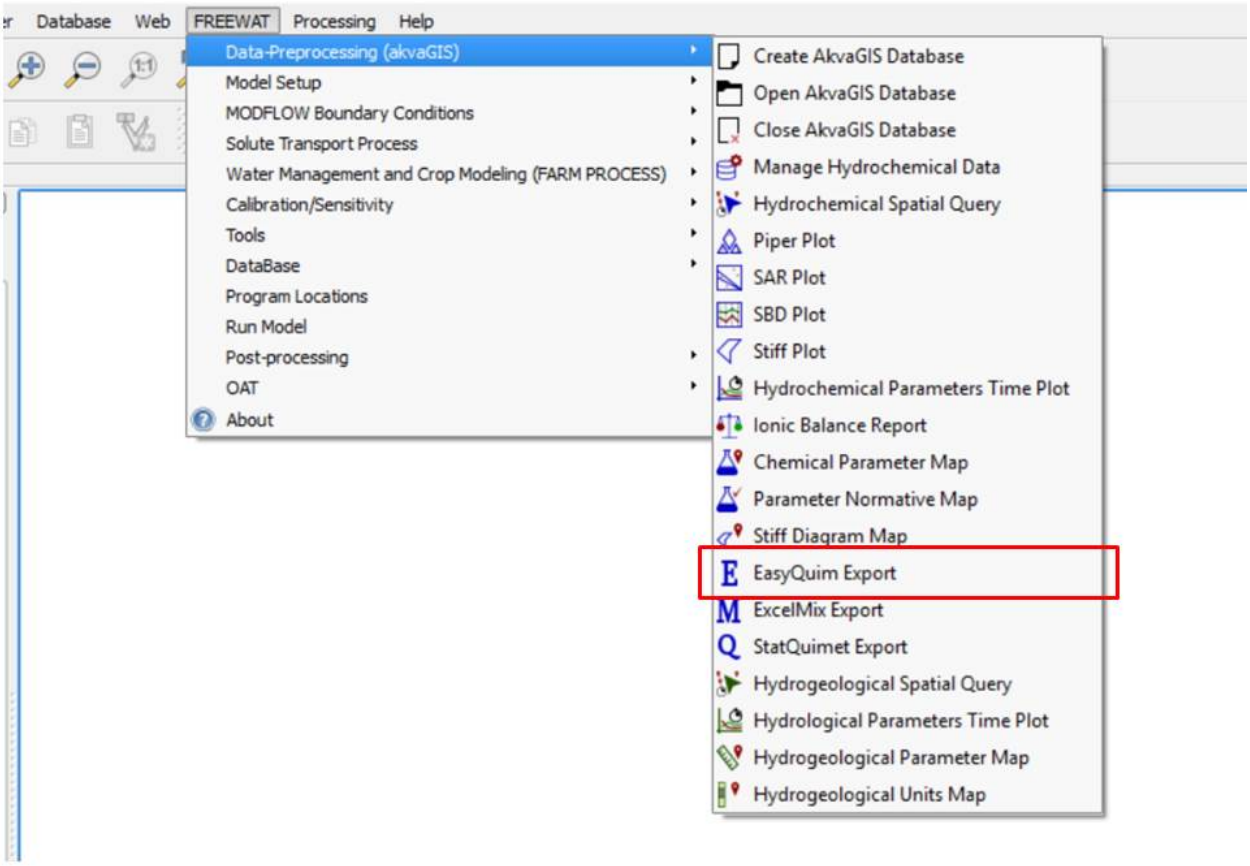
2.12 Export Tools



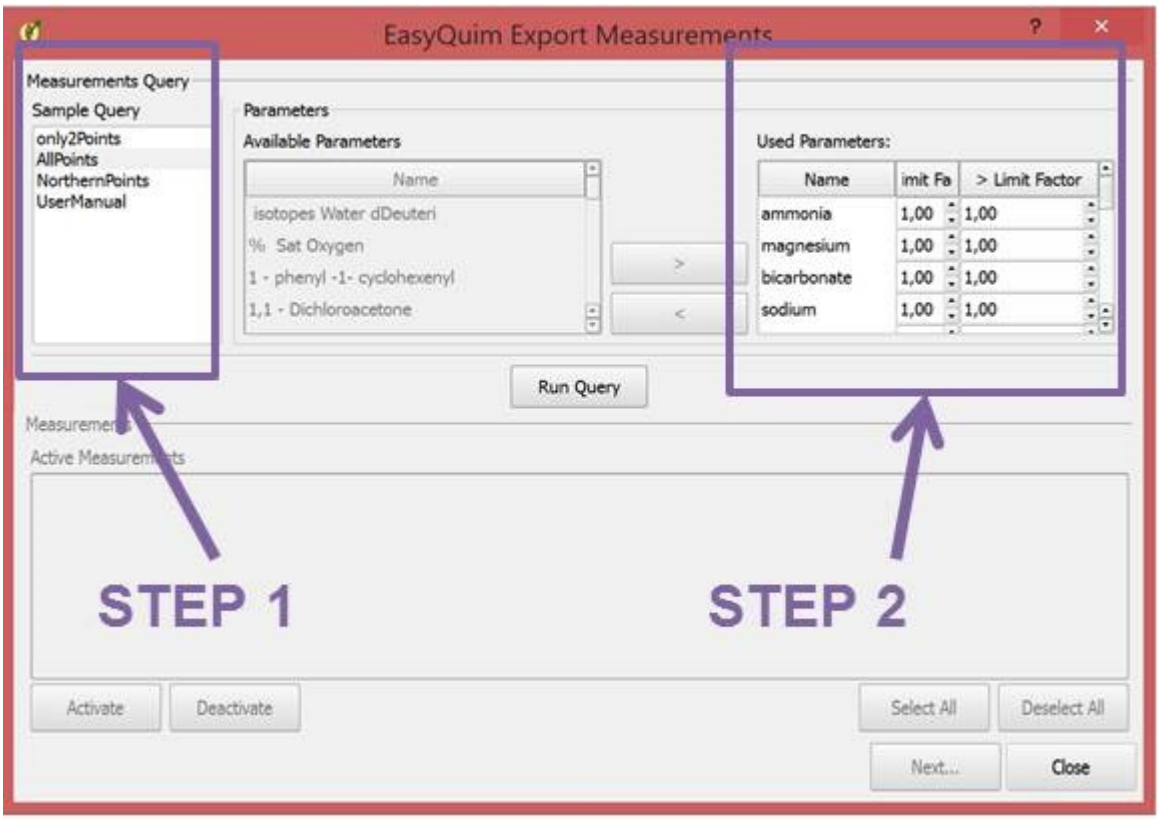
This set of tools enables us to use different query criteria to be exported to external formats (e.g. ods, xls or csz files). In addition allow us to export the query data to further external platforms (e.g. Easy_Quim, MIX or Statistical Tools).

For more information see: http://h2ogeo.upc.edu/en/investigation-hydrogeology/software

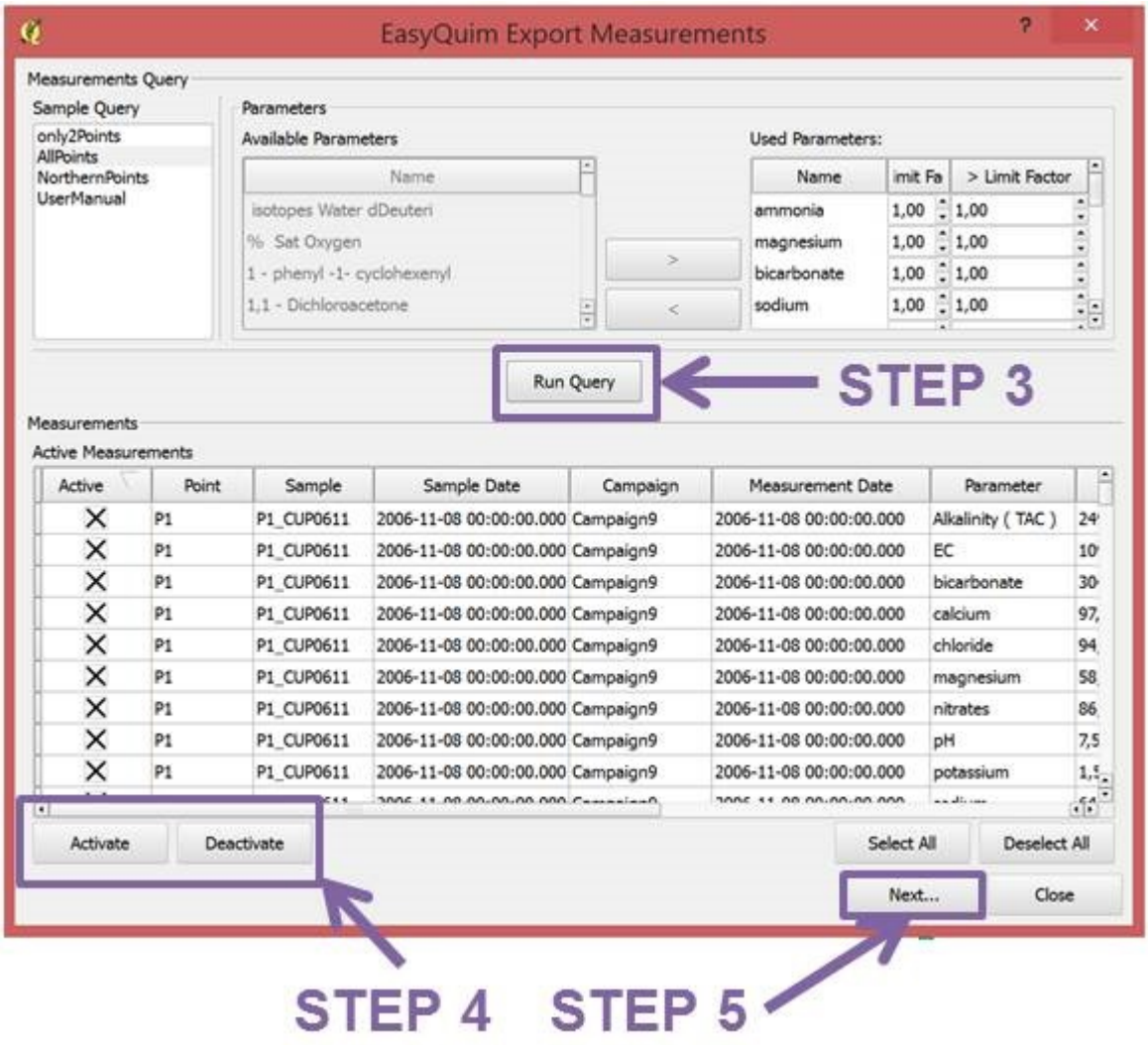
2.13 Export Major Ions



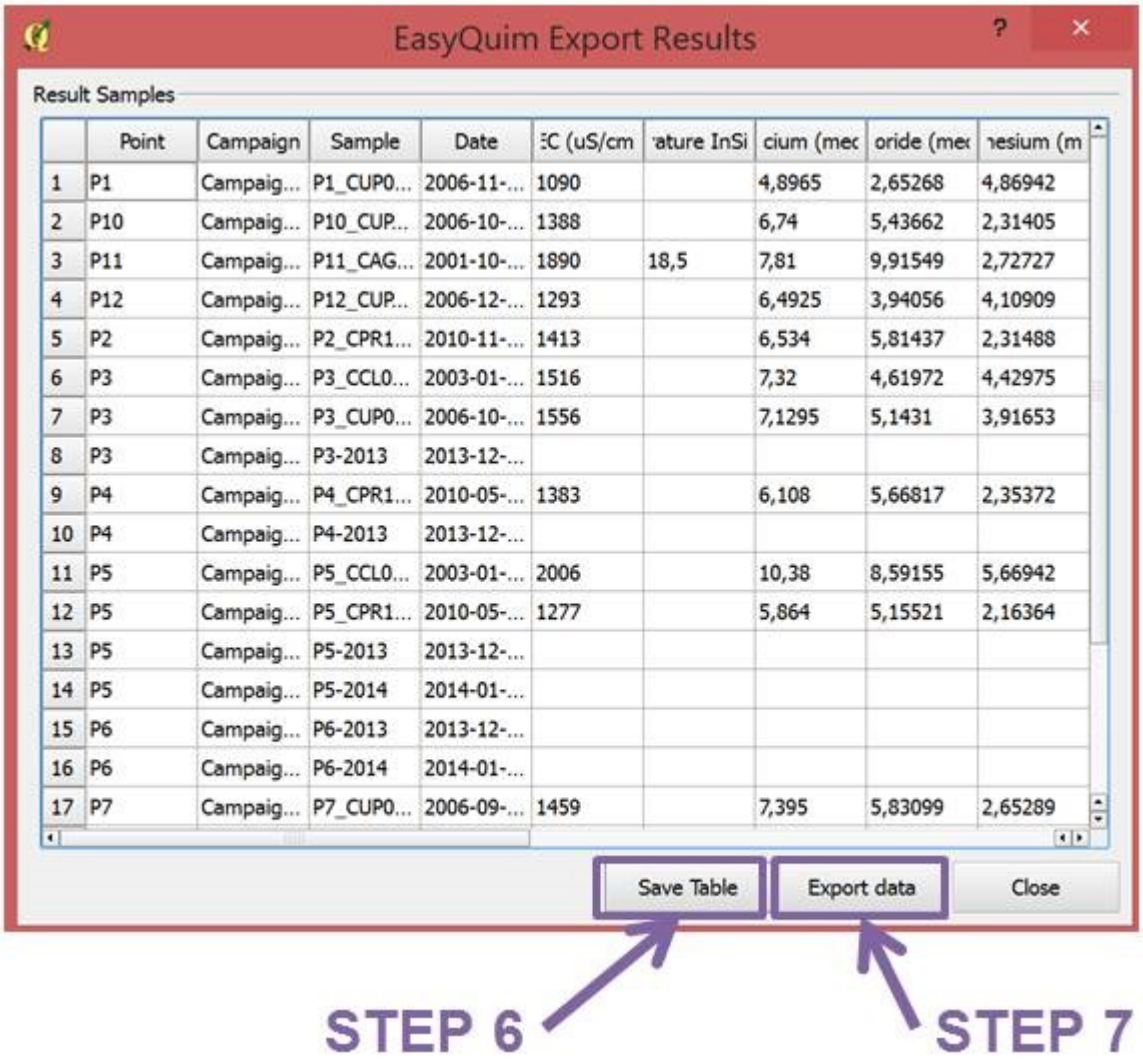
This tool provides a query form that enables the user to automatically query the common major ions of the selected sample query.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.

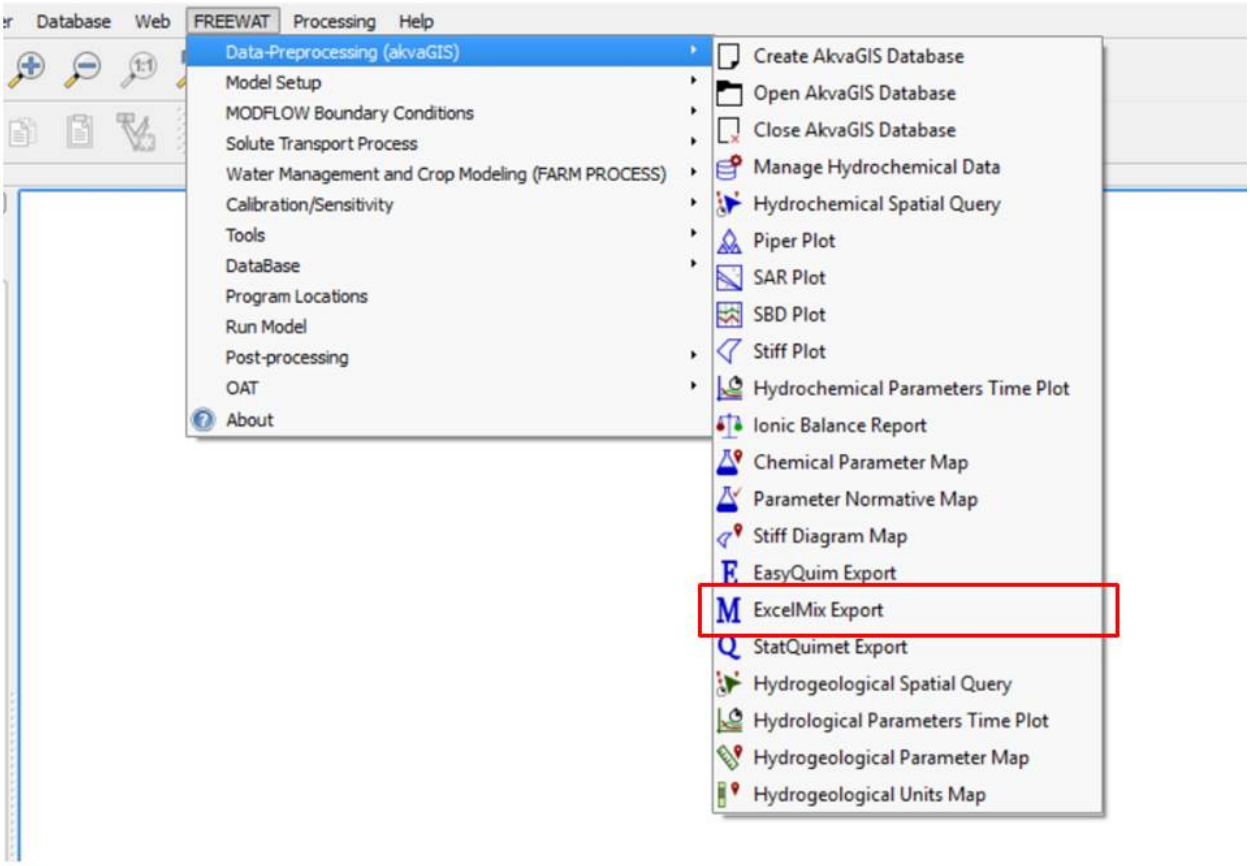


- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.



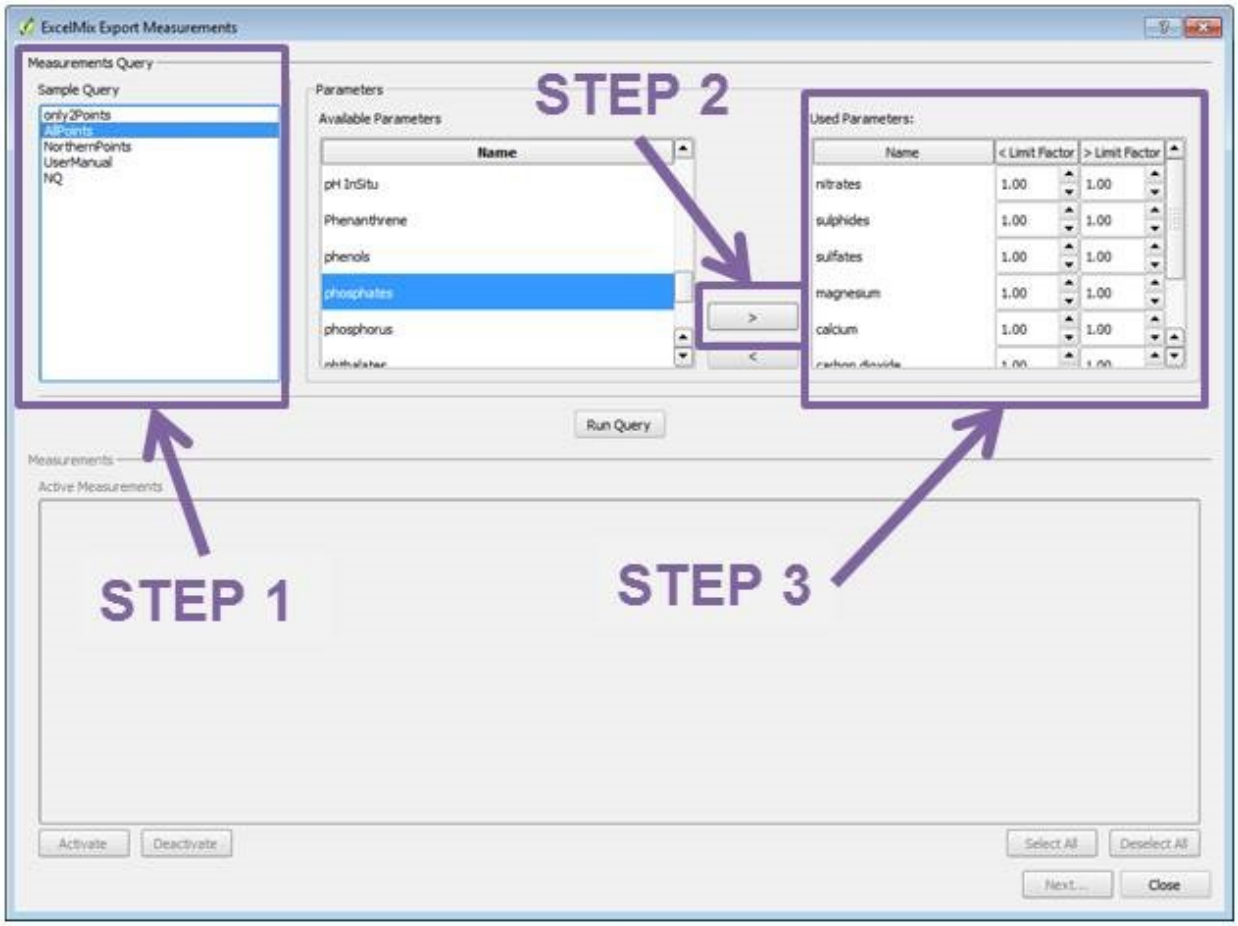
- *Step 6*: Save table where the selected parameters for the selected points are shown.
- *Step 7*: Export query results to different formats (.xls, .csv, .ods) including the query of the major ions for the selected Query (i.e. for the selected points in the desired intervals). The resulting spreadsheet follows the required format of EasyQuim.

2.14 Export to Mixing

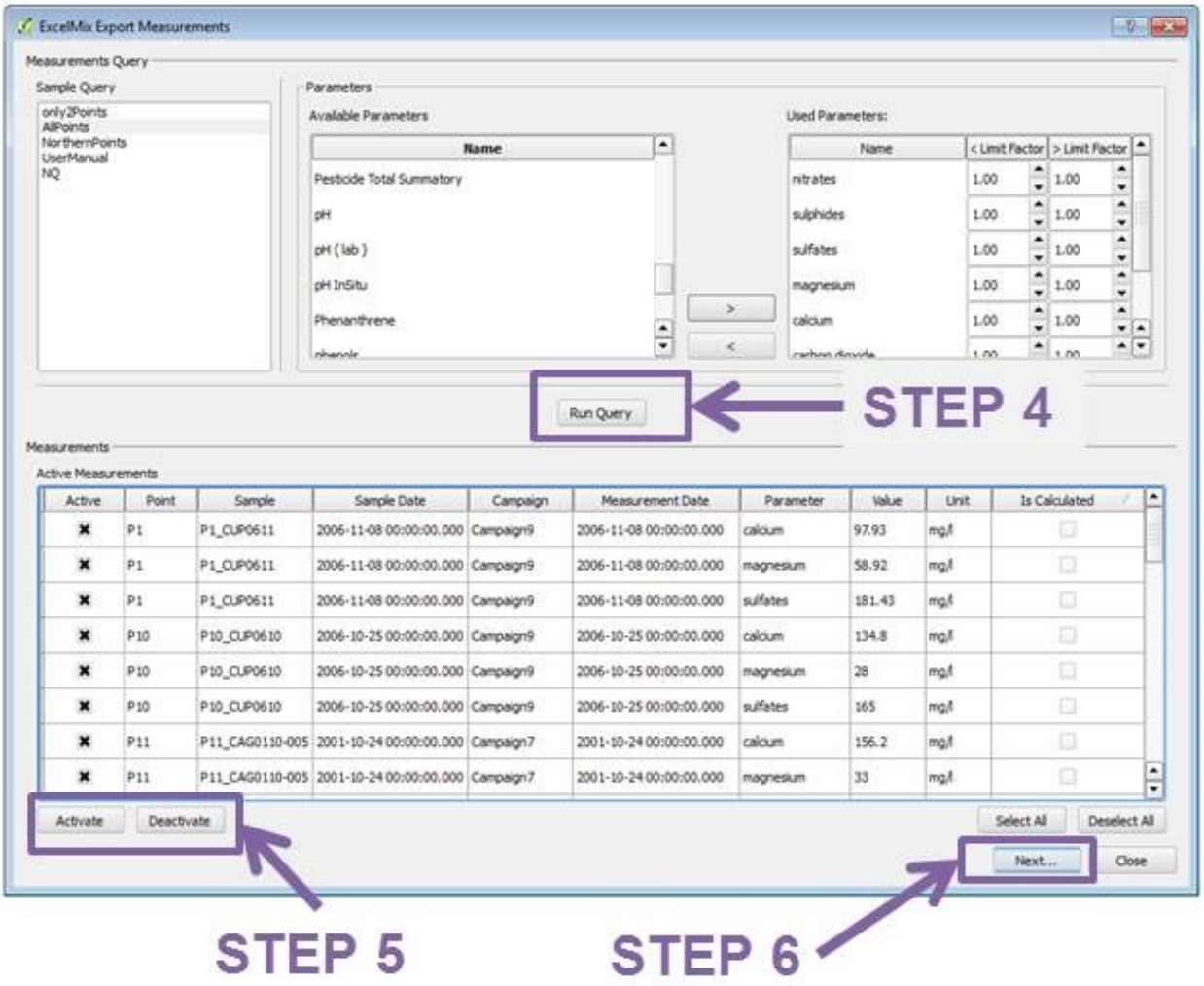


Mixing calculations involve computing the ratios in which two or more end-members are mixed in a sample. Mixing calculations are useful for a number of tasks in hydrology, such as hydrograph separation, water or solute mass balances, and identification of groundwater recharge sources. Most methods available for computing mixing ratios are based on assuming that end-member concentrations are perfectly known, which is rarely the case. Often end-members cannot be sampled and their concentrations vary in time and space. Still, much information about them is contained in the mixtures. To take advantage of this information, a maximum likelihood method to estimate mixing ratios, while acknowledging uncertainty in end-member concentrations can be exported to used it in an external free software. Maximizing the likelihood of concentration measurements with respect to both mixing ratios and end-member concentrations leads to a general constrained optimization problem. Results allow us to conclude that the method outperforms traditional approaches, such as least squares or linear mixing, in the computation of mixing ratios.

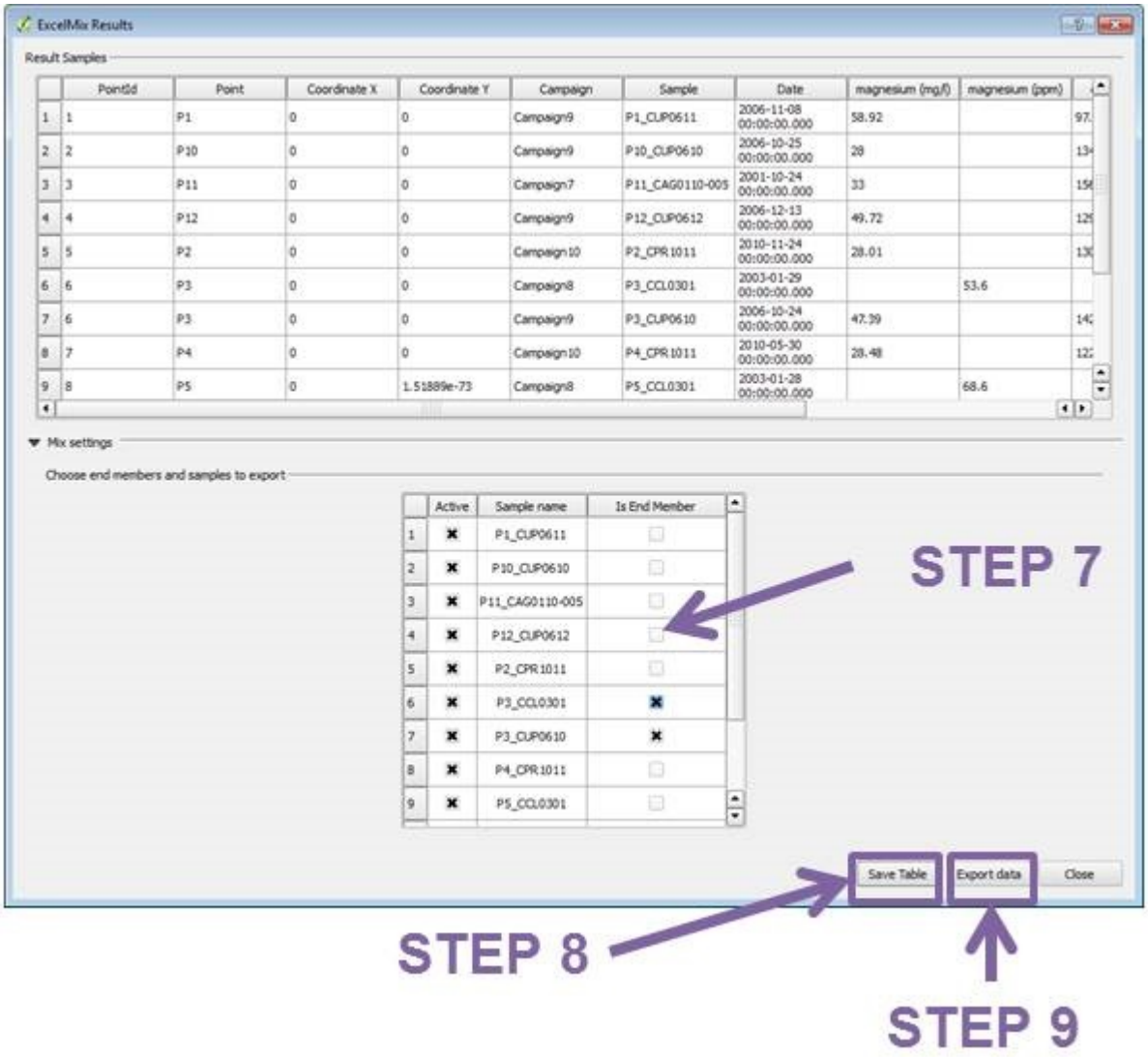
This tool provides a query form that enables the user to apply different query criteria oriented to evaluate the mixing ratios of the samples. As result, a classification of the samples in end members(that is, samples that represents the extreme composition of a mixing) or in samples members can be obtained for the selected parameters.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the parameter to be queried for the analysis.
- *Step 3*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.

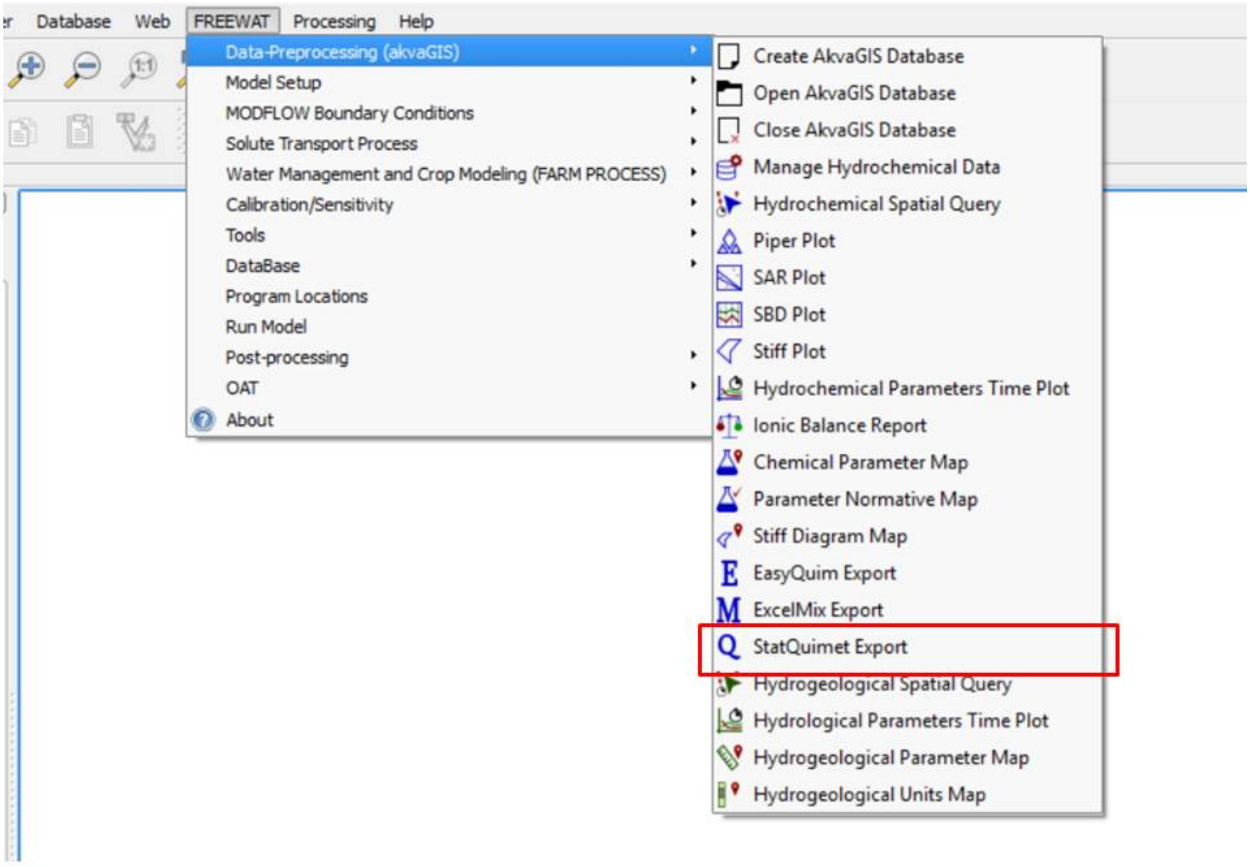


- *Step 4*: Run Query.
- *Step 5*: Use this commands to activate or deactivated the desired measurements.
- *Step 6*: Click Next.

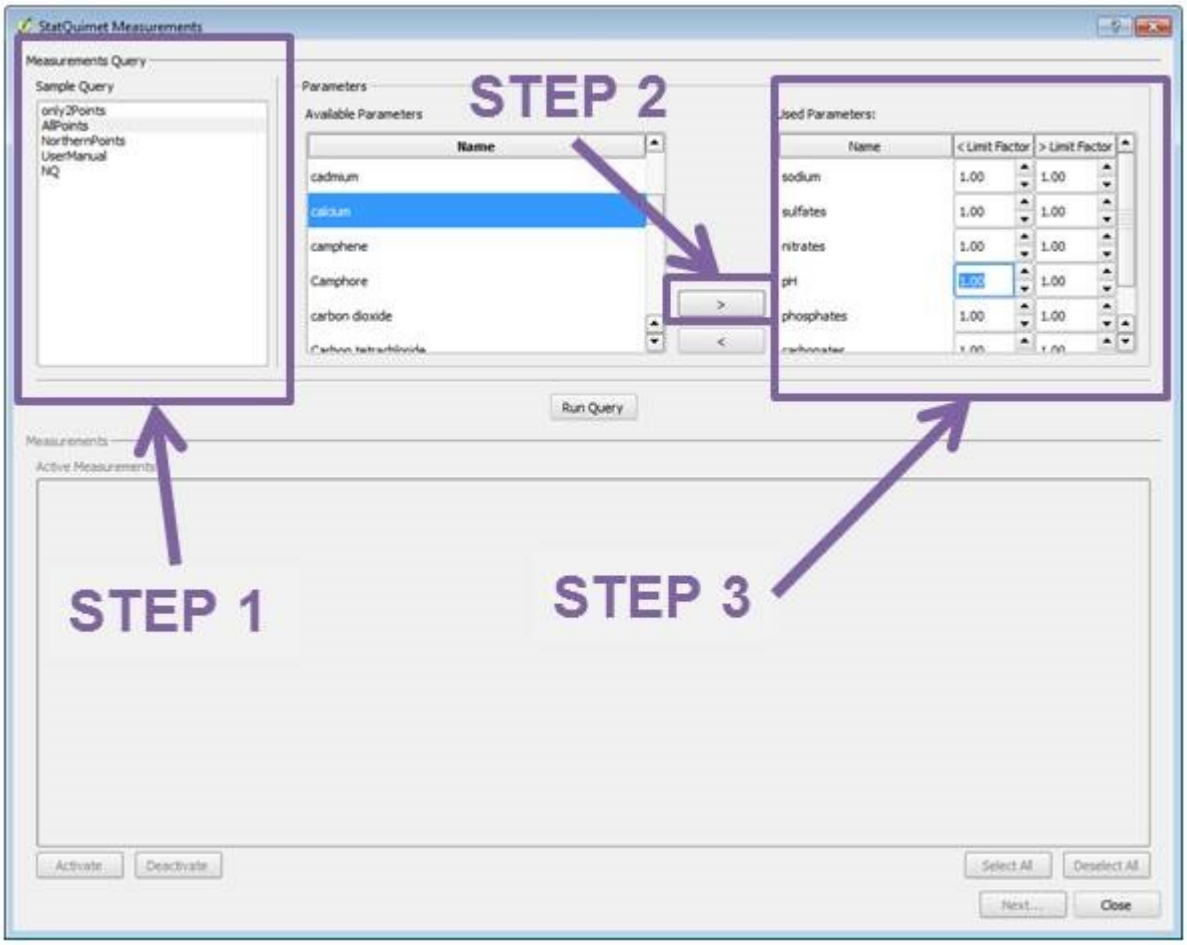


- *Step 7*: Select the end member. If the sample is not selected, it is considered as sample. Here the user select if the sample is a mixing of the recharge sources or an end member (unique recharge source sample).
- *Step 8*: Save table where the selected parameters for the selected points are shown.
- *Step 9*: Export query results to different portable format (e.g. .xls, .csv,.ods) including the query of end members and sample members. The resulting spreadsheet follows the required format of Mix.

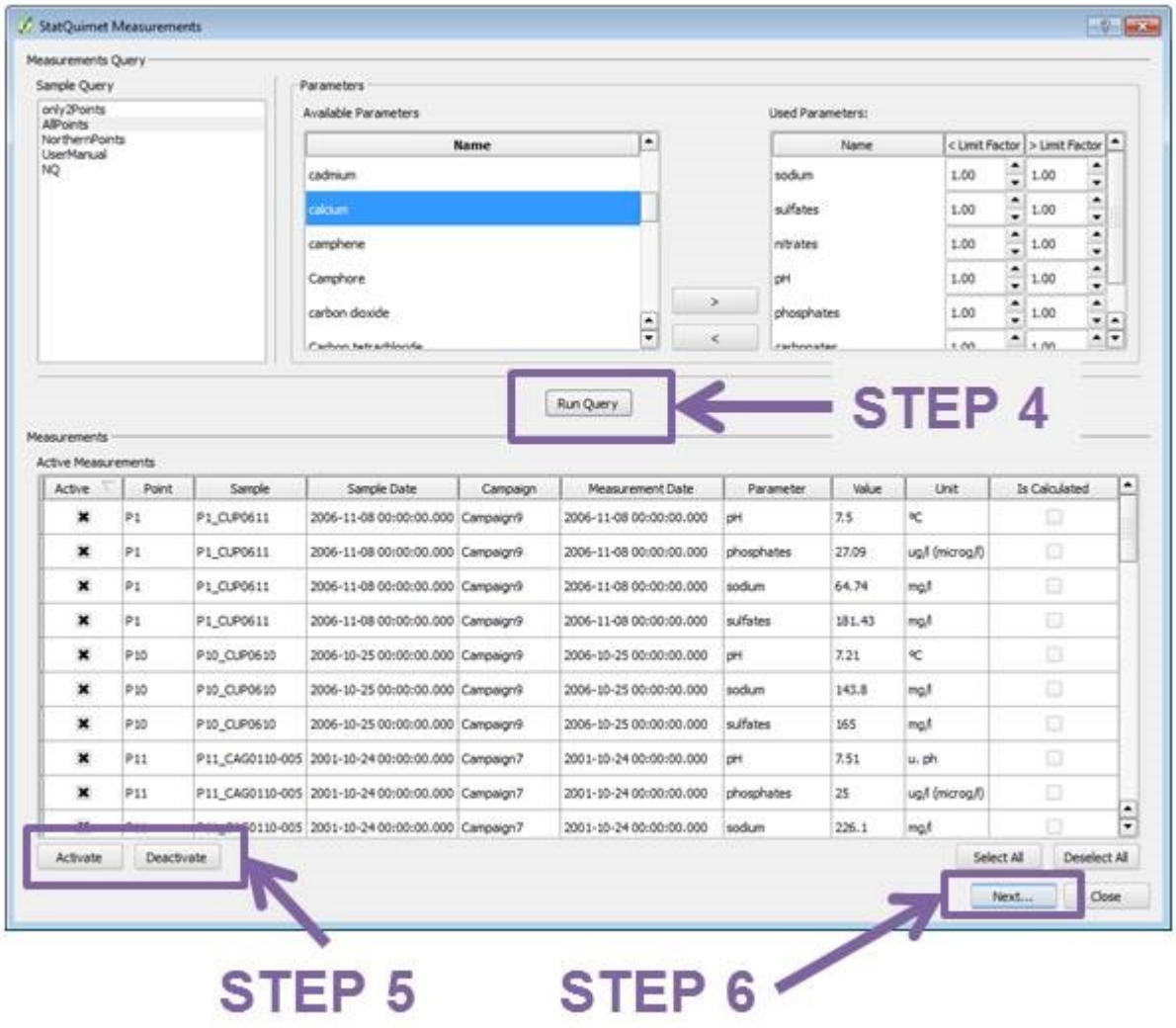
2.15 Export to Statistical Analysis



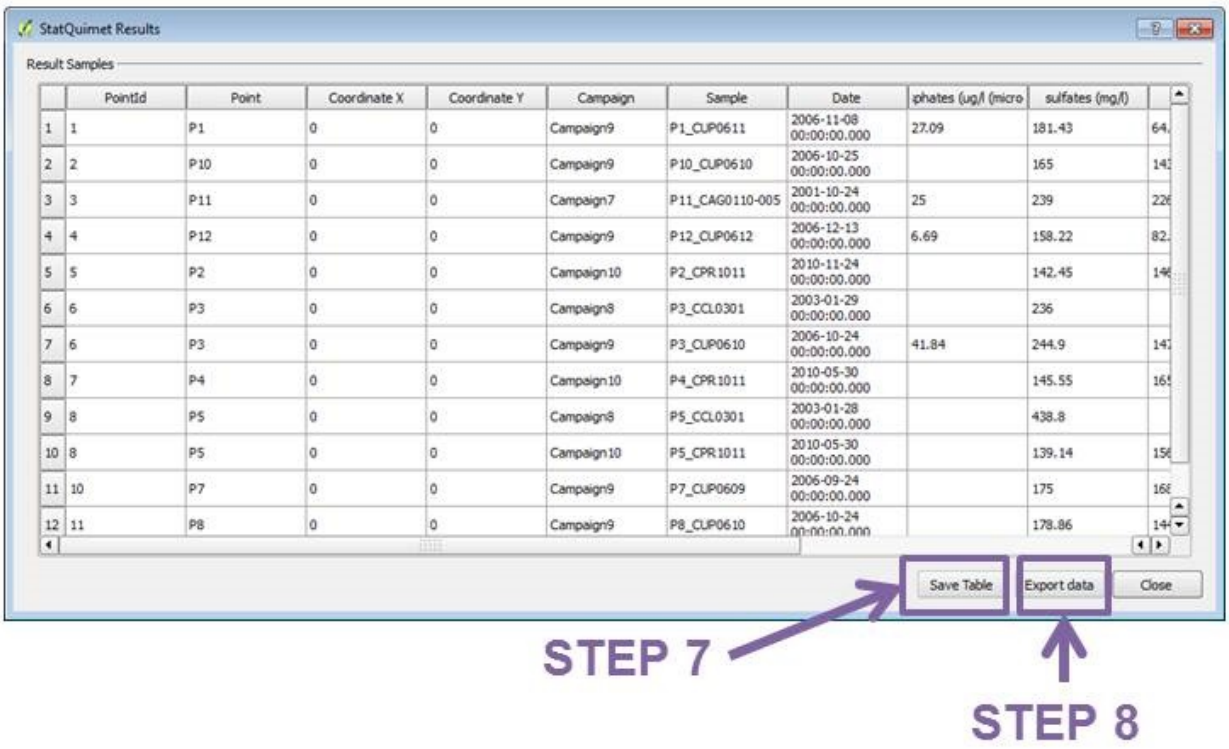
This tool enables us to obtain for the selected query sample and for the selected parameters different portable reports for further analysis (e.g. further statistical analysis). The statistical analysis performed with the related external platform could provide additional statistical anlysis to the statistical analysis already provided with the different instruments included in AkvaGIS.



- *Step 1*: Choose the Query created previously with the tool shown in section 2.2 *Hydrochemical Spatial Query*.
- *Step 2*: Choose the parameter to be queried for the analysis.
- *Step 3*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the concentration of some elements reported as less than, < limit factor, or greater than, > limit factor.



- *Step 4*: Run Query.
- *Step 5*: Use this commands to activate or deactivated the desired measurements.
- *Step 6*: Click Next.



- *Step 7*: Save table where the selected parameters for the selected points are shown.
- *Step 8*: Two tables will be exported:

  DATA_W file with all samples measurements including incompleted samples (samples without measurements for each of the selected parameters).

  DATA file which store only samples with measurements for each of the selected parameter. This query can be used for the further statistical analysis using external platforms as Statistical Tools.

CHAPTER 3

Hydrogeological analysis tools

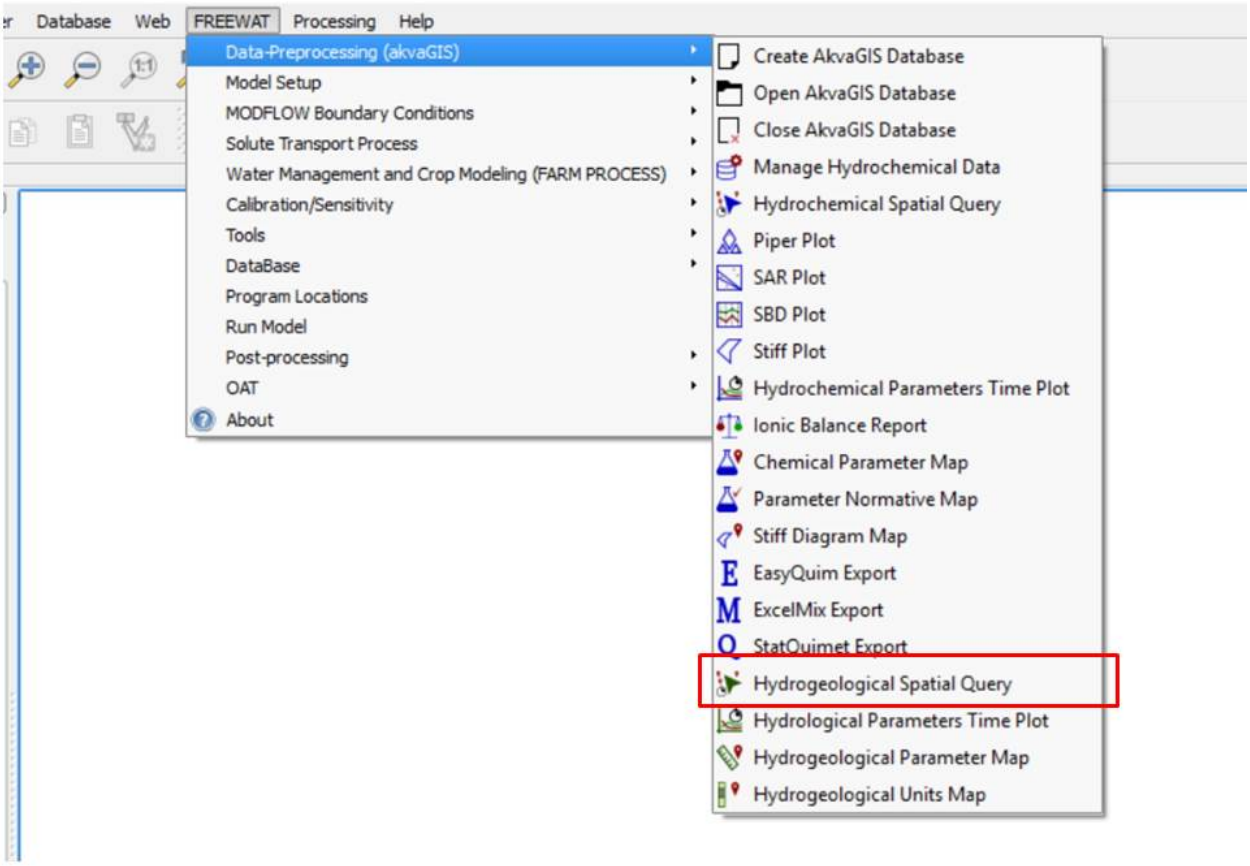
The **Hydrogeological Analysis Tools** sub-module of AkvaGIS form part of a wider framework developed into FREE-WAT platform.

These tools facilitate the management of different hydrogeological data with a wide range of methodologies for querying, interpreting, and comparing groundwater quantity data and facilitates the pre-processing analysis for being used in the realization of groundwater modelling.

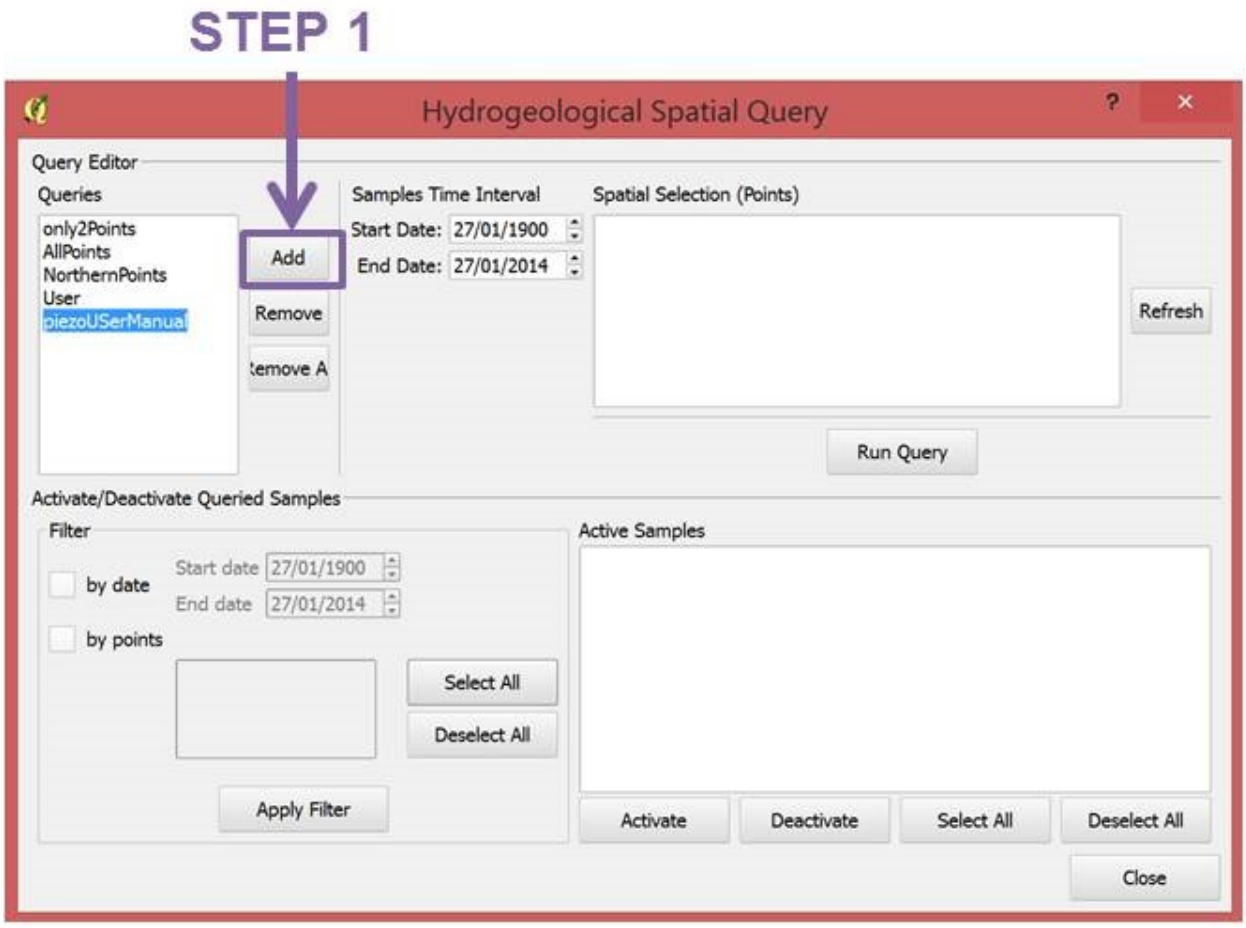
The core of these tools is a geospatial database implemented in Spatialite which contains the hydrogeological spatio-temporal information, ready to be represented or analyzed.

More in detail, the hydrogeological set of tools improve the harmonization, integration, standardization, visualization and interpretation of hydrogeological data and allow us: (1) to manage and query the hydrogeological measurements (e.g. head, wells abstractions, etc.) performed in wells, piezometers, springs, etc. stored in the database; (2) to apply one or several query criteria (e.g. time interval, groundwater measurement) and to combine them for advanced spatio-temporal queries on the hydrogeological data stored in the database; (3) to create thematic maps (e.g. piezometric maps) of the selected points, time interval and parameters; (4) to calculate some general statistics such as the minimum, maximum or average for each selected hydrogeological parameter, such as head level, depth to the water or pumping rates; (5) to query the depth or the thickness of the defined hydrogeological units and to represent these values in a map as point features, with the possibility to interpolate results.

3.1 Hydrogeological Spatial Query

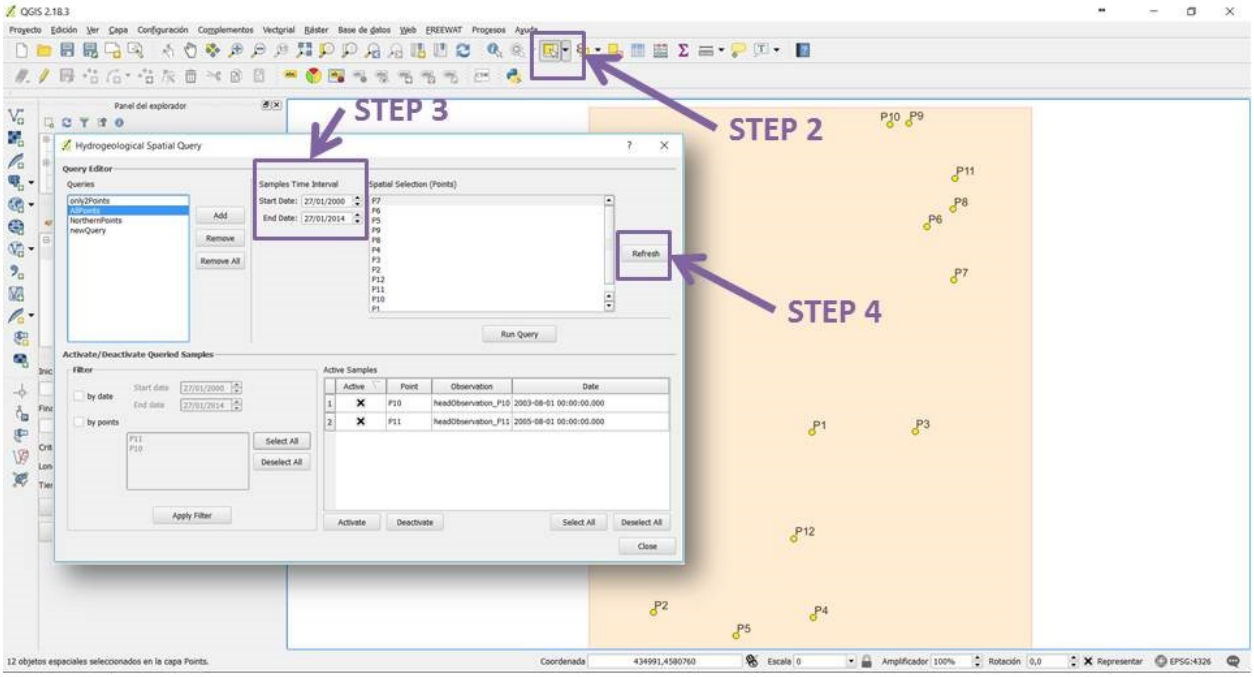


This tool enable us to query the hydrogeological measurements (e.g. head, wells abstractions, etc.) performed in wells, piezometers, springs, etc. This query only acts for those points where hydrogeological observations and measurements have been done. Please, see AckvaGIS database report.

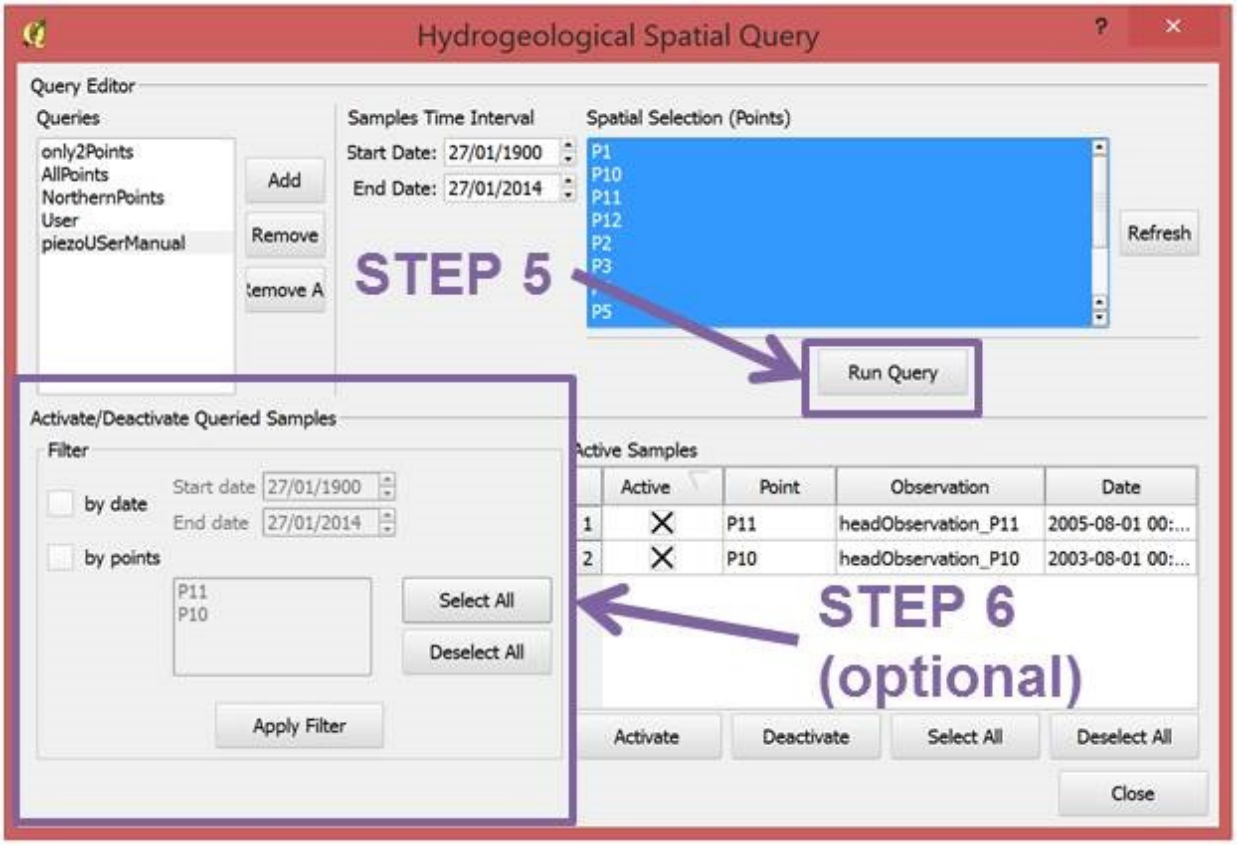


- *Step 1*: Use this command to create and add to the database queries of the selected points (spatial selection) for the desired time interval. Also campaign can be used as a query criteria. Thus, hydrogeological tools can be applied to the queries stored in the database or it can be used in future analysis.

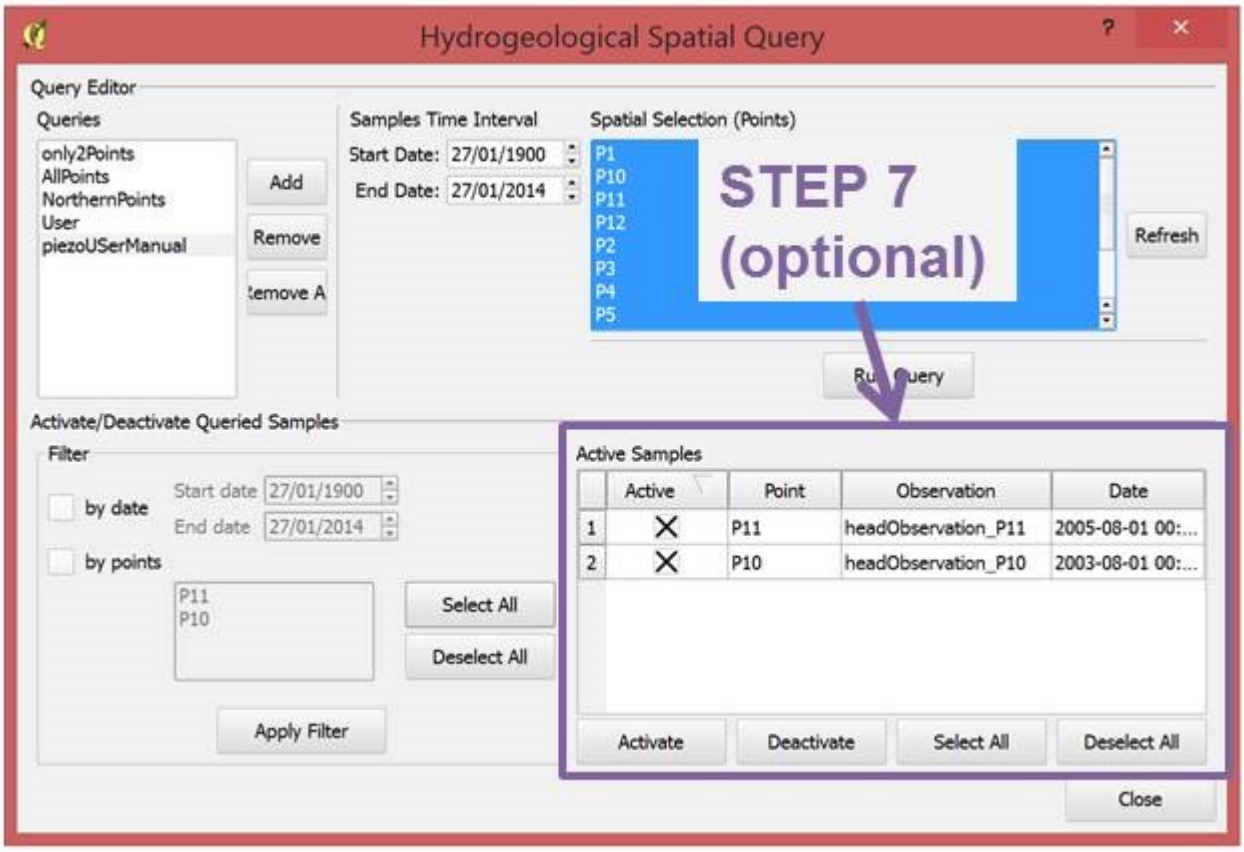
Note: Use the command *Remove* for deleting the selected query from the database or use the command remove all for removing all the queries from the database.



- *Step 2*: Select (using inbuilt tools of QGIS) the points to be included in the query.
- *Step 3*: Select the desired time interval to be queried.
- *Step 4*: Refresh for visualize the new query.



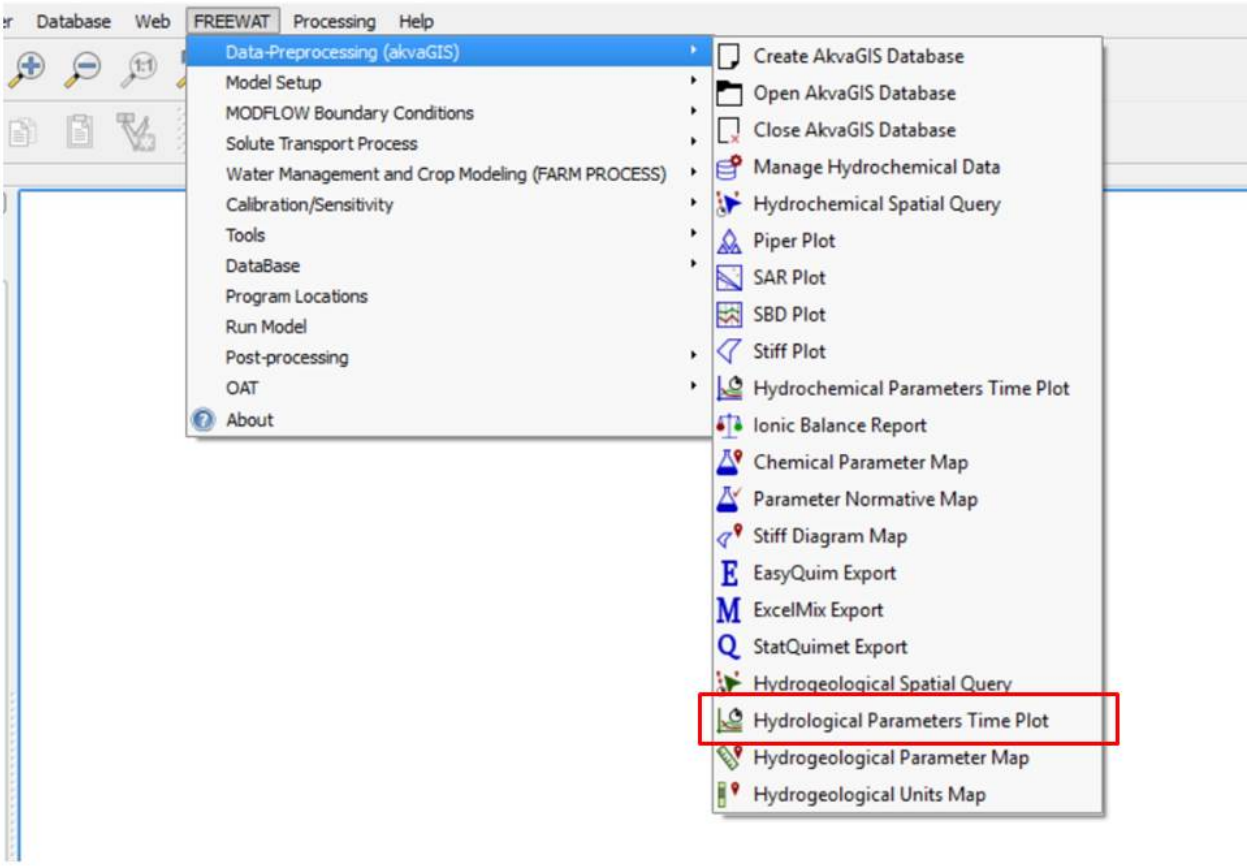
- *Step 5*: Run Query.
- *Step 6*: (Optional) Filter chosen any available query criteria (by date or by points).



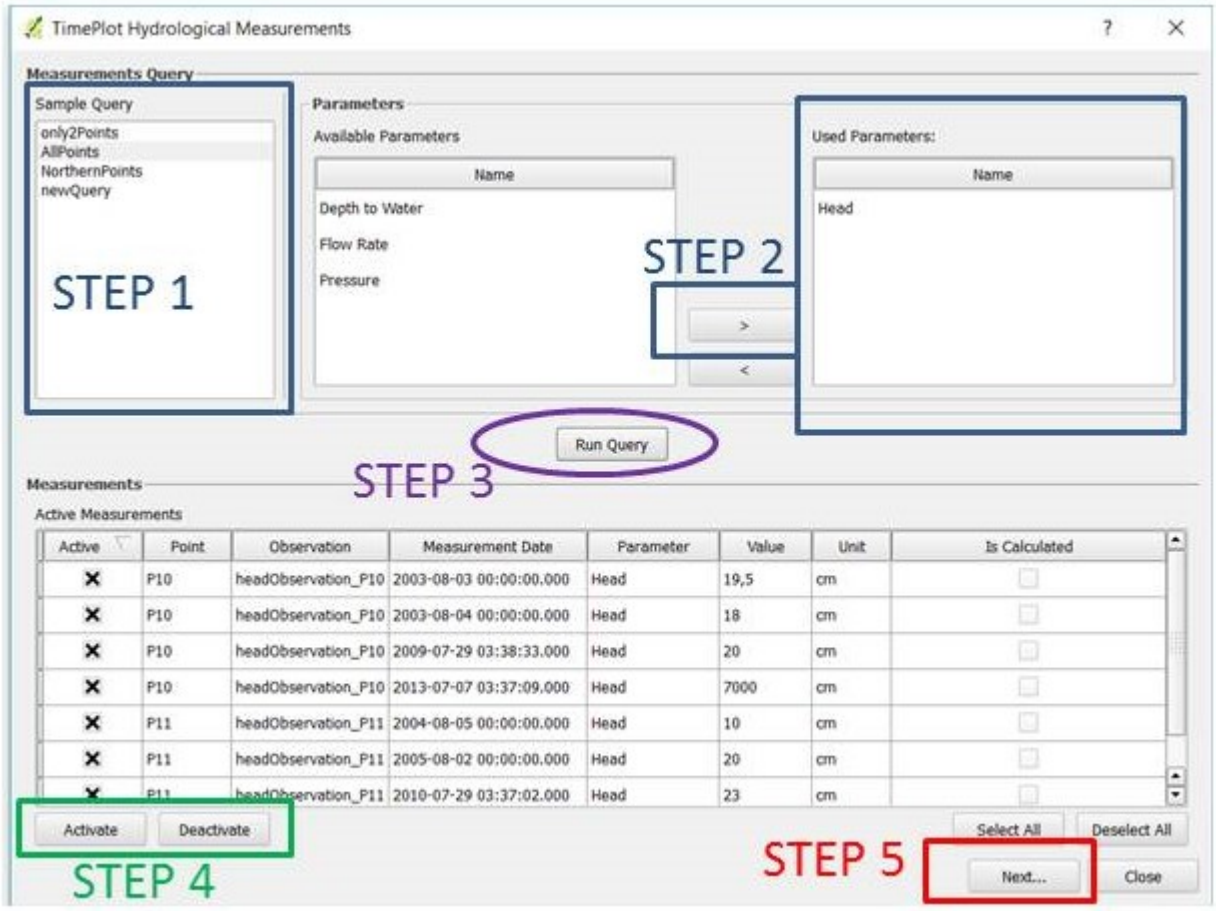
- *Step 7*: (Optional) Activate/Deactivate the desired samples to be included in the query. For activate/deactivate please, select the row (also select all/deselect all).

Finally, click in close button to close the query form.

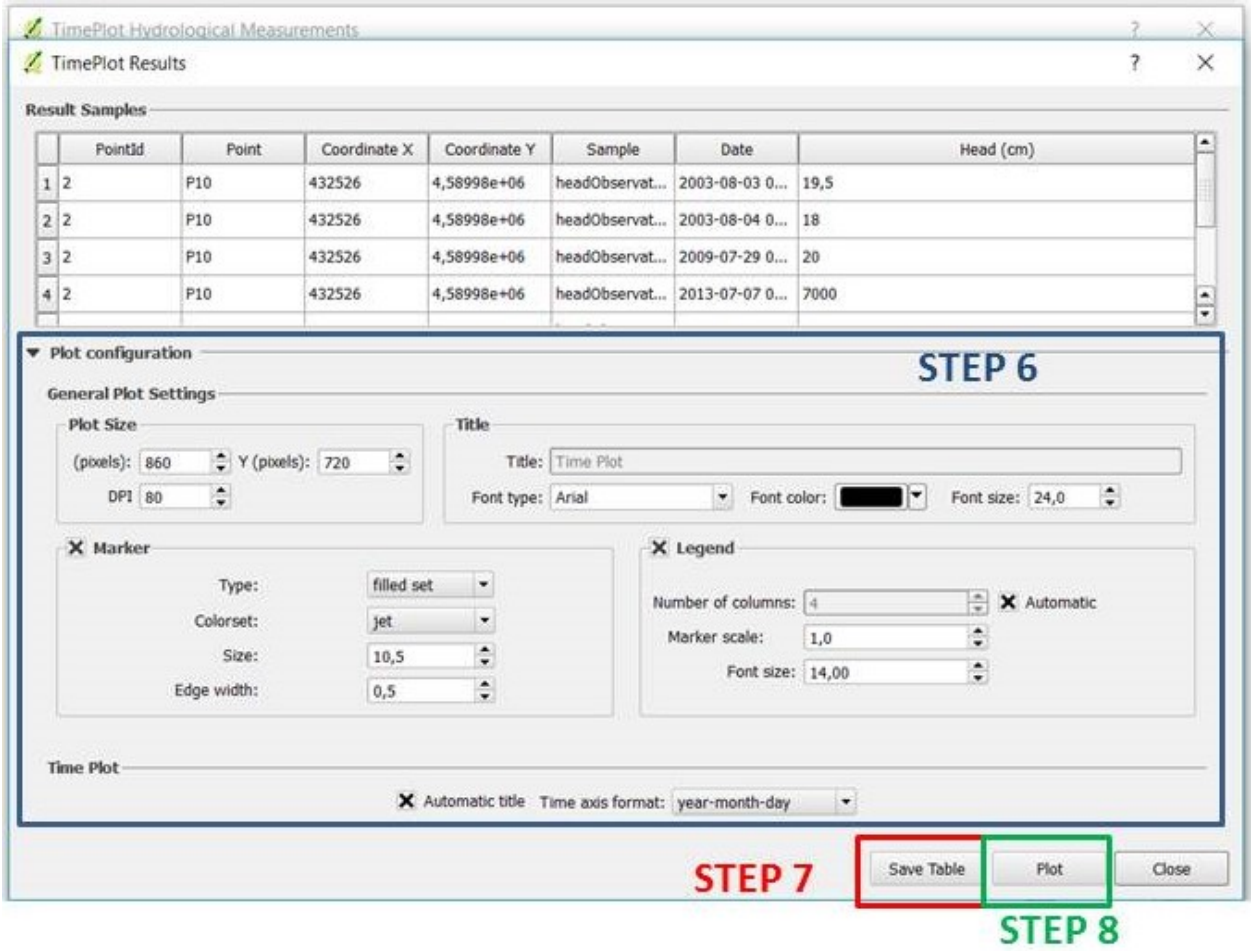
3.2 Time Plot. Hydrogeological Parameters



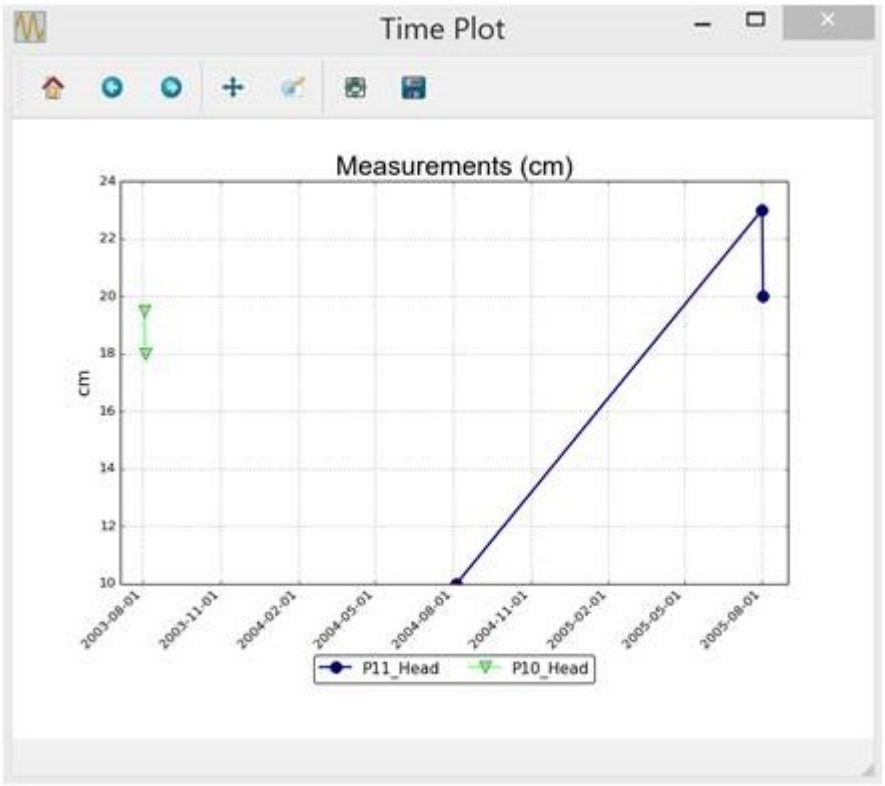
Use this command to create time plots of the selected query (created previously with the *Hydrogeological Spatial Query tool*, section 3.1) for the selected parameters.



- *Step 1*: Choose the Query created previously with the *Hydrogeological Spatial Query tool*, section 3.1.
- *Step 2*: Choose the parameter to be queried for the analysis (e.g. head).
- *Step 3*: Run Query.
- *Step 4*: Use this commands to activate or deactivated the desired measurements.
- *Step 5*: Click Next.

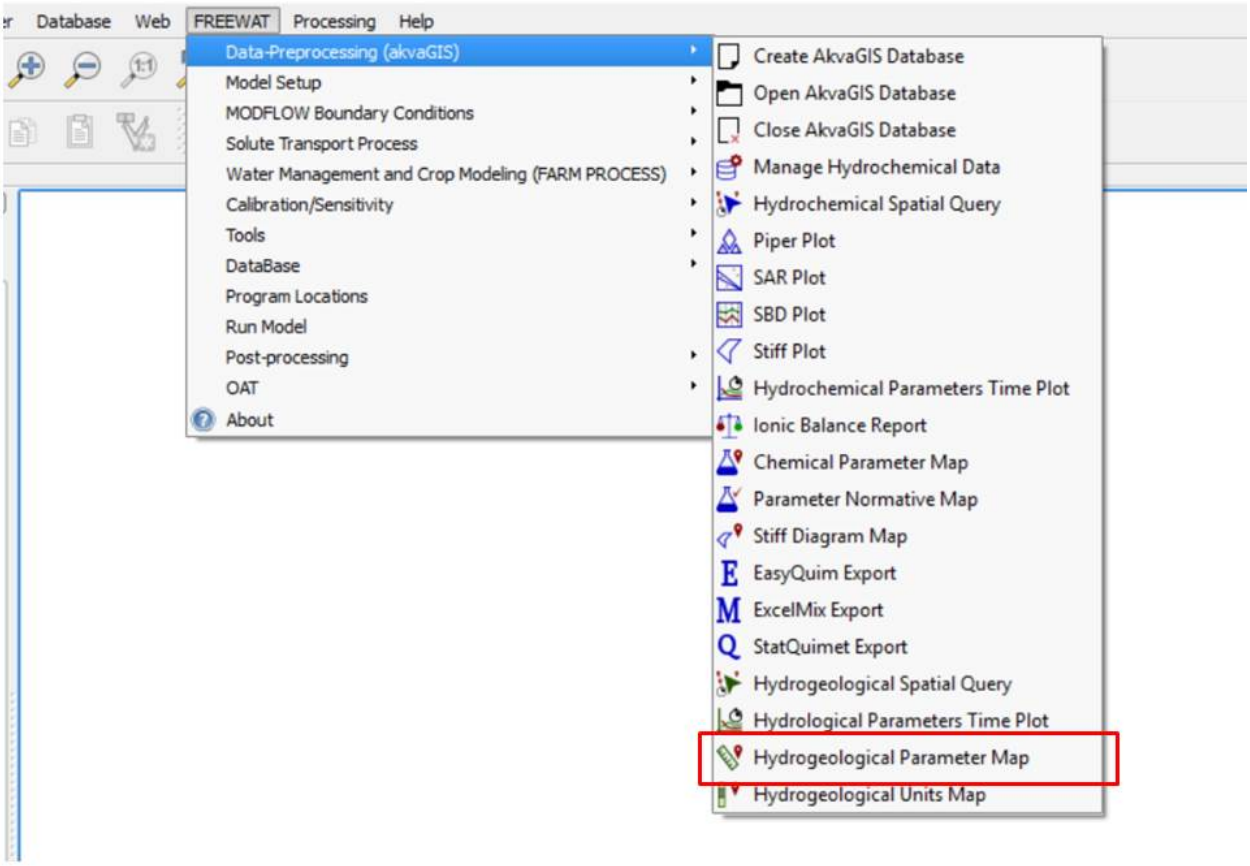


- *Step 6*: Plot configuration. Choose the plot size, title, markers, time axis format, etc.
- *Step 7*: Save query results in different formats (.ods, .csv..).

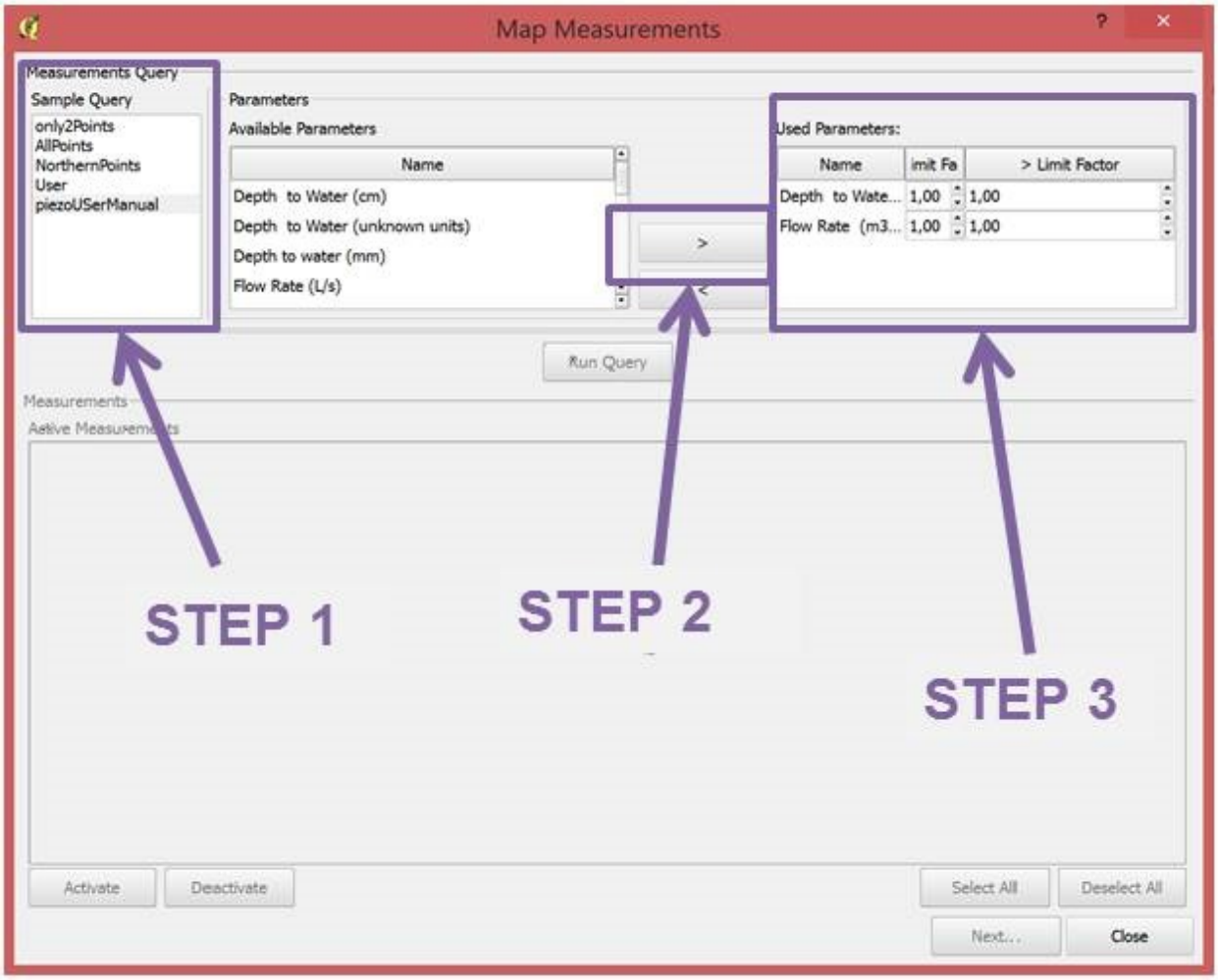


- *Step 8*: This button creates automatically time plots. The plot GUI, enable the user to save the plot in different formats, to pan axes, to zoom, to configure subplots and to save the plot in different formats such as .pdf, .png, .tiff, .svg, etc.

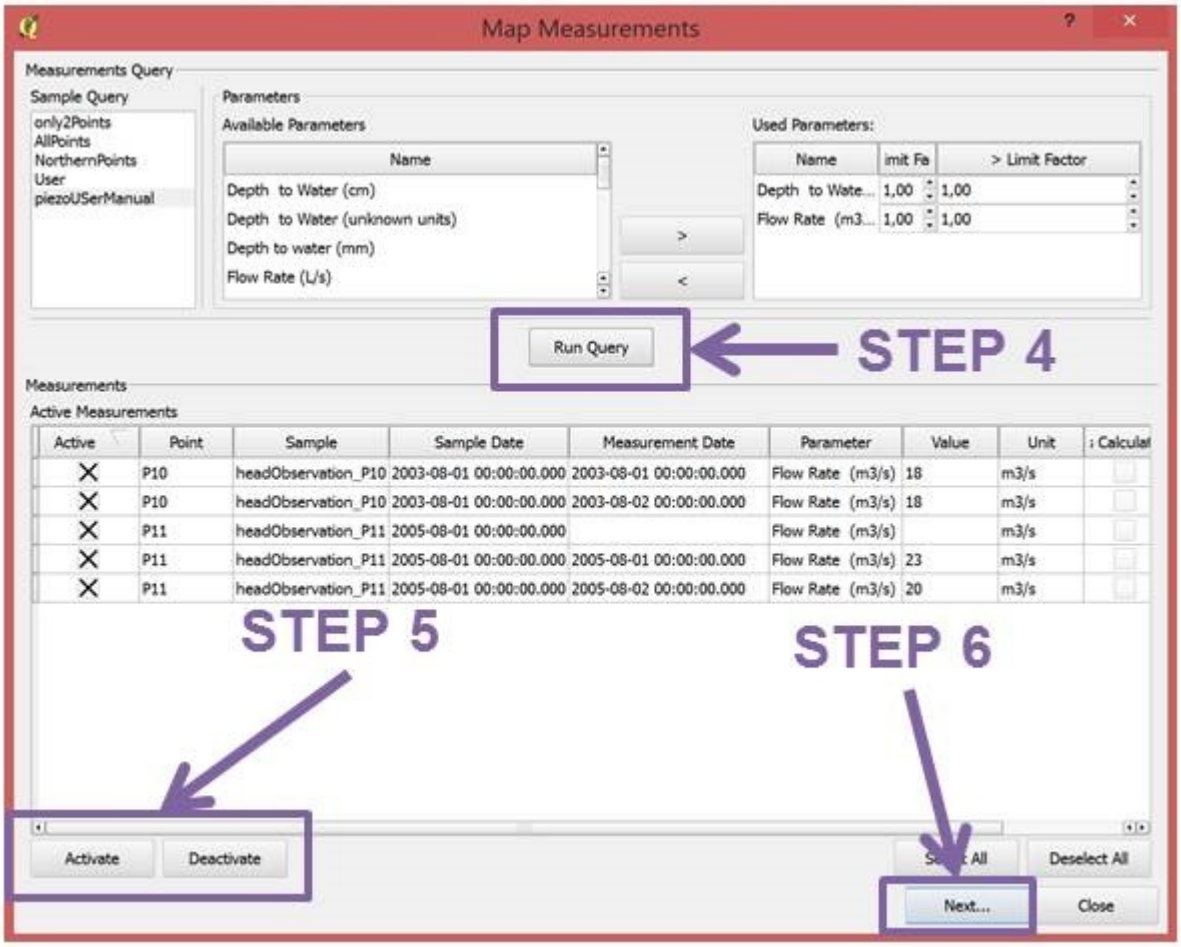
3.3 Hydrogeological Parameter Map



Use this command to create parameter plots of the selected query (created previously with the *Hydrogeological Spatial Query tool*, section 3.1) for the selected parameters.

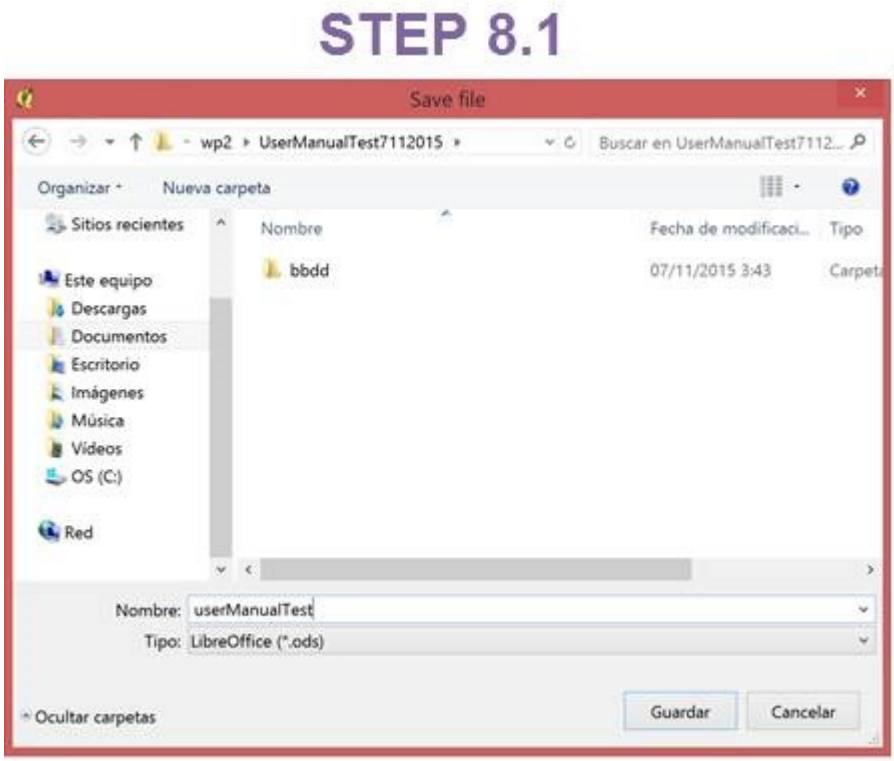


- *Step 1*: Choose the Query created previously with the tool shown in section 3.1 (*Hydrogeological Spatial Query tool*).
- *Step 2*: Choose the parameter to be queried for the analysis.
- *Step 3*: Choose the limit factor to be applied to the censored values. With this tool the user has the option to substitute the censored values by this factor times the detection limits. The censored values are the parameter value reported as less than, < limit factor, or greater than, > limit factor.

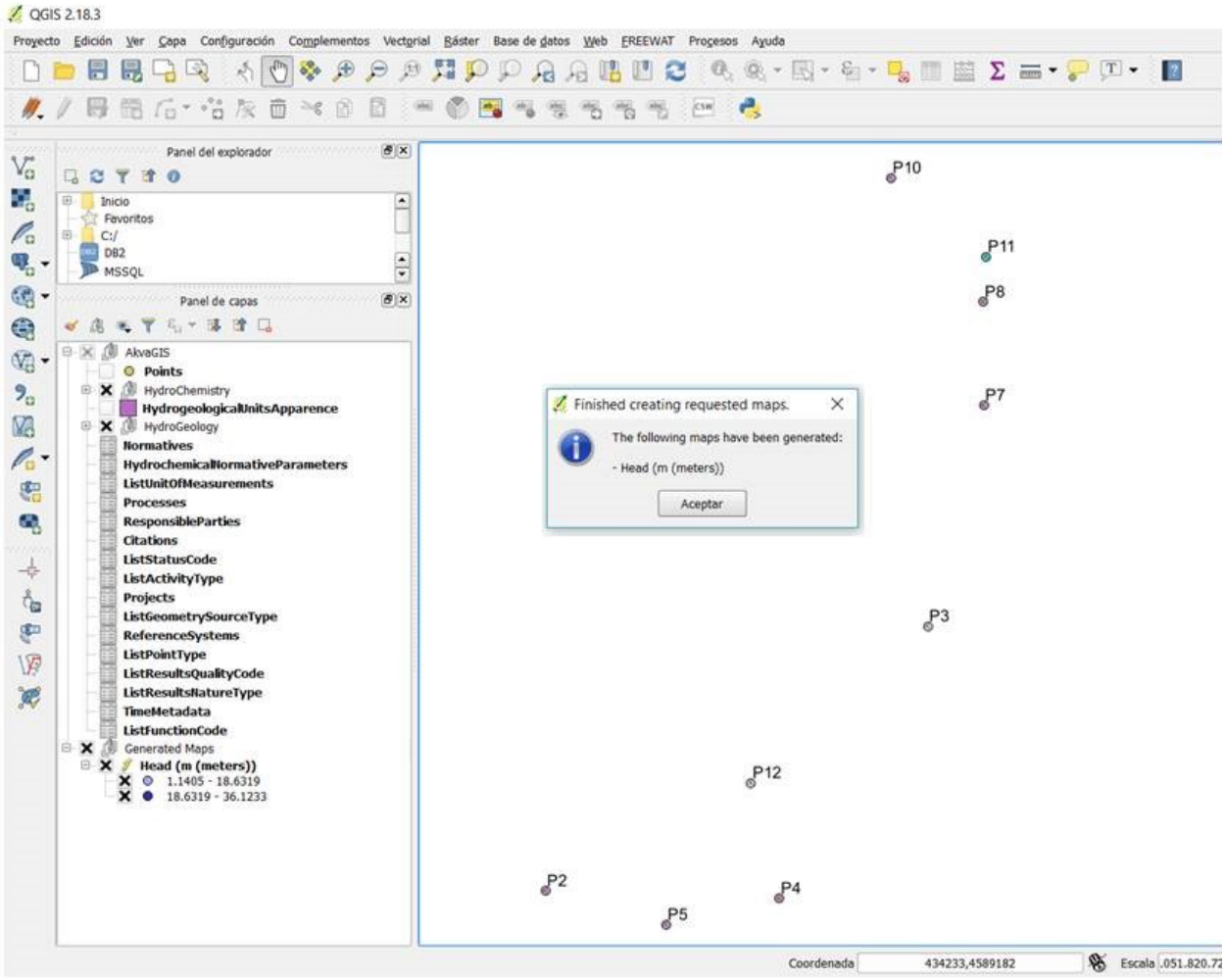


- *Step 4*: Run Query.
- *Step 5*: Use this commands to activate or deactivated the desired measurements.
- *Step 6*: Click Next.

- *Step 7*: Map settings. Select the value to use in the map (earliest, latest, average, etc.)

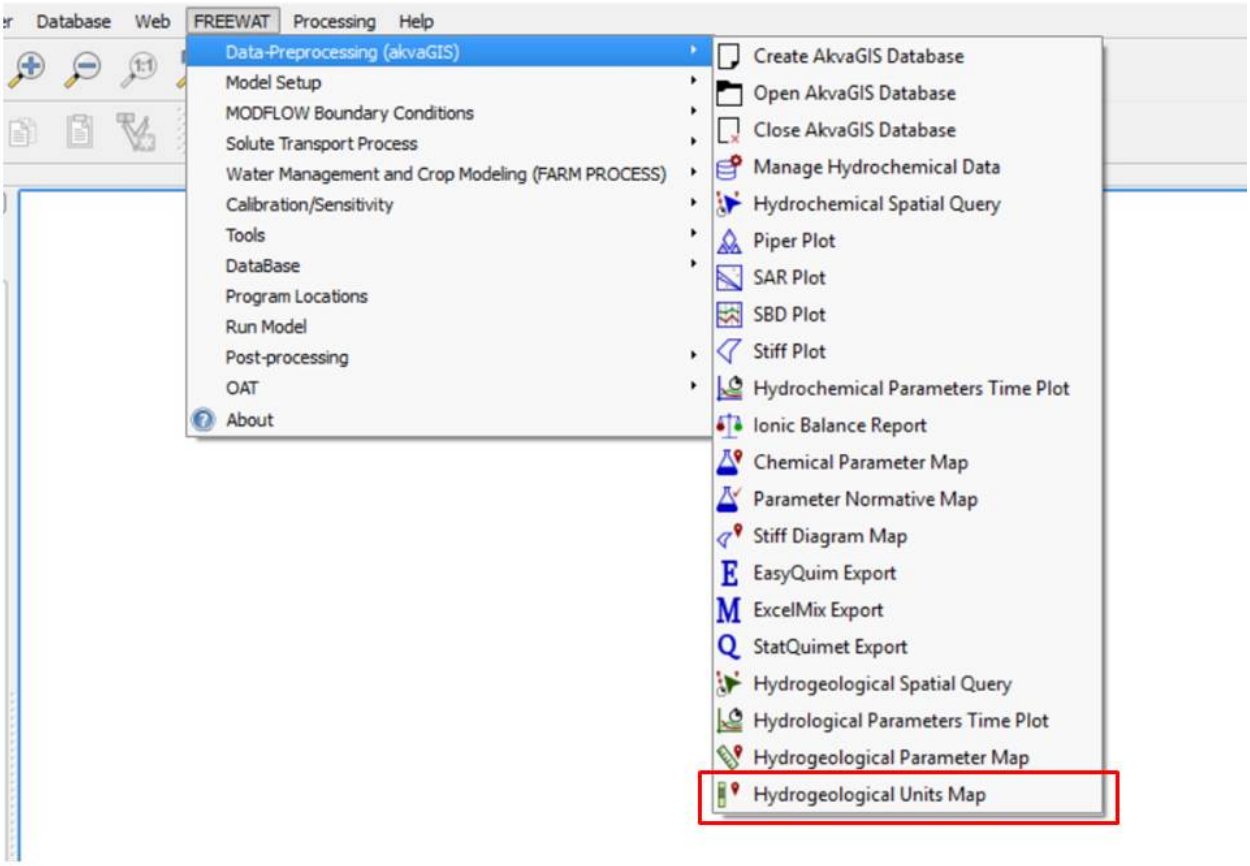


- *Step 8.1*: Save query results in different formats.

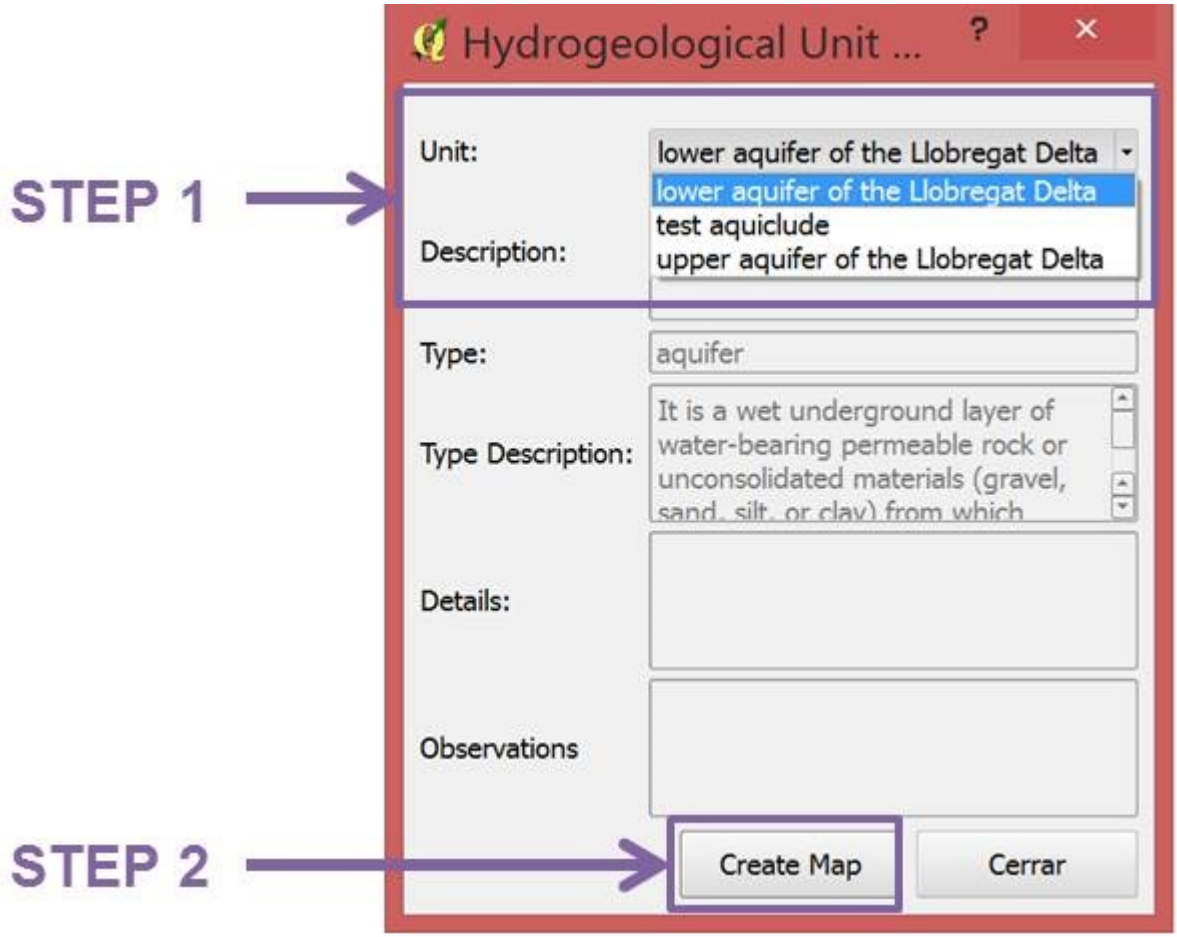


- *Step 8.2*: This button creates automatically parameter map.

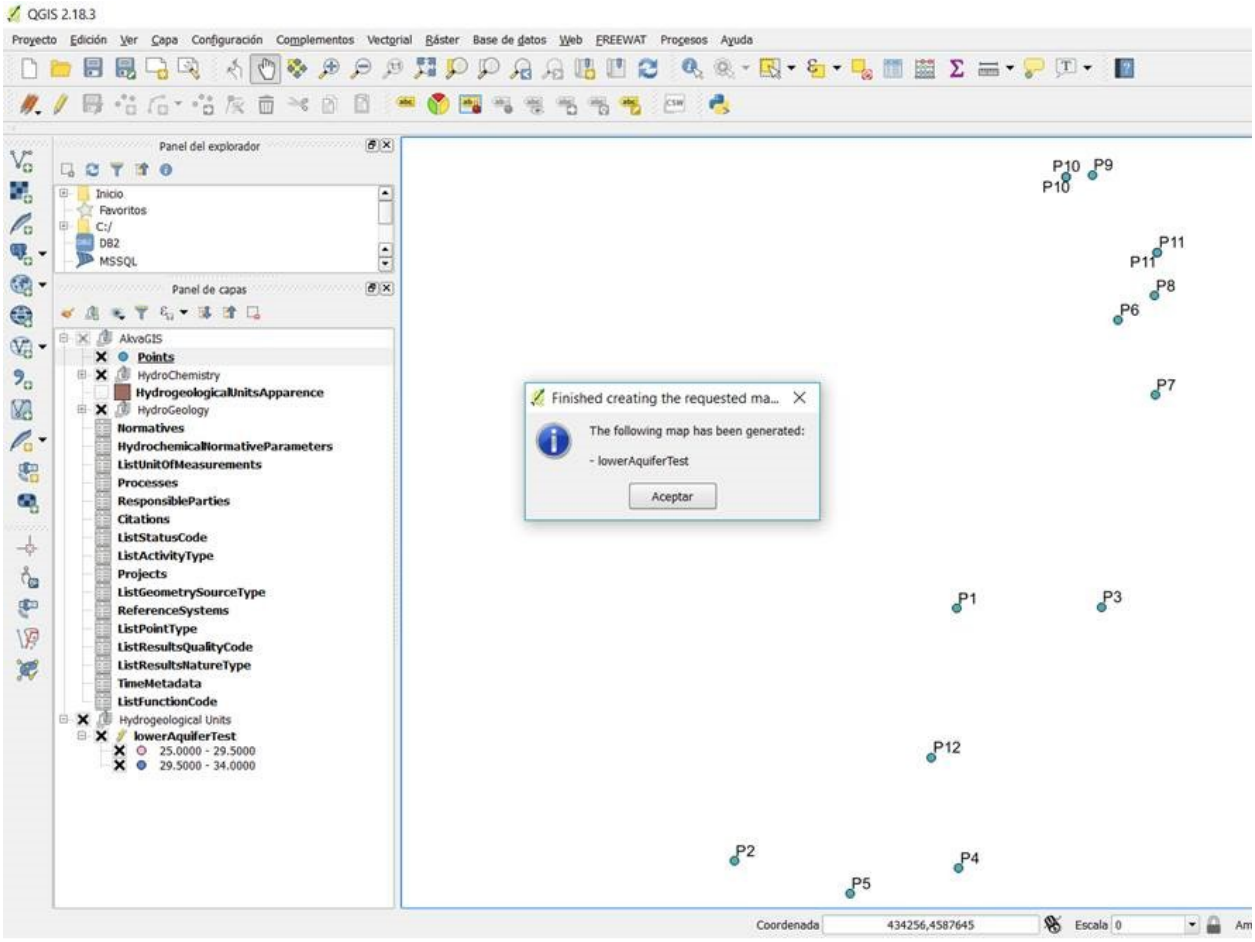
3.4 Hydrogeological Units Maps



This command enables the user to create maps of top/bottom hydrogeological units defined in the wells.



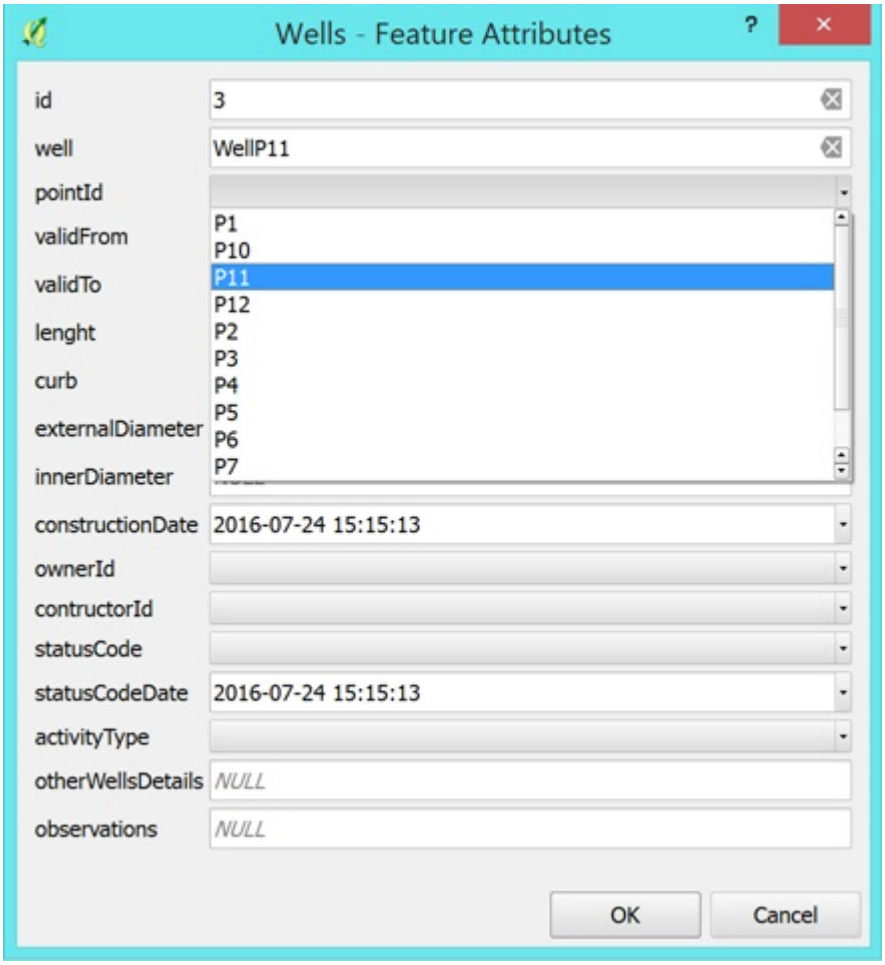
- *Step 1*: Choose the hydrogeological unit that you want to query.
- *Step 2*: Create map for selected hydrogeological unit.



3.4.1 How to edit/add the top/bottom of a hydrogeological units?

To introduce a hydrogeological unit, *Wells*, *HydrogeologicalUnits* and *WellsHydrogeologicalUnits* tables are involved. To ensure a proper updated, the next workflow has to be done.

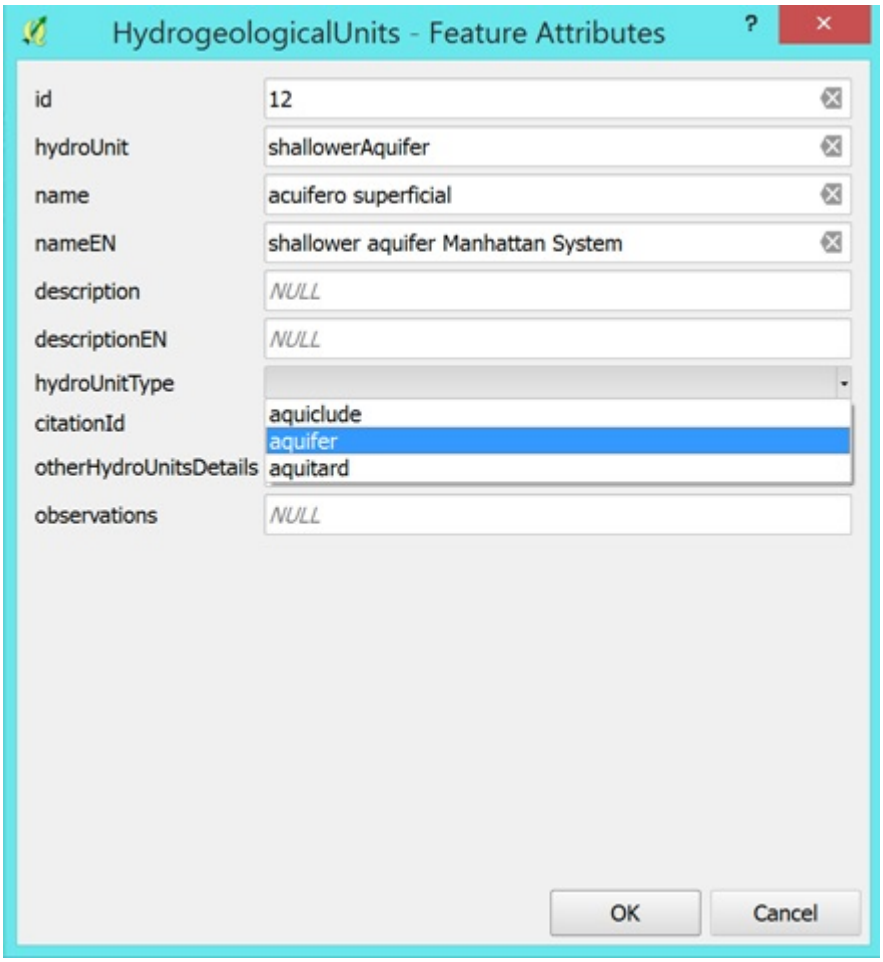
Select and open *Well* attribute table.



- *Step 1*: Introduce the general characteristic of the well that provide the information of the limits of the hydrogeological Unit (i.e. Top/bottom length of the Hydrogeological Unit). For further information about the database, please see AckvaGIS database documenttation section. In the *Wells* table, the following data are required:
  - *Id Number*: Unique identifier number.
  - *Name well*: Name of the well where hydrogeological unit is described.
  - *idPoint*: Unique identifier point name defined before in the *Points* table.
  - *valid From*: Start date when the well started to being used.
  - *valid To*: End date when the well ceased to being used. If this field is not fullfiled means that the well is still active.
  - *Length*: The distance along the well. This will be determined by the data provider (i.e., *length* can have different sources like drillers measurement loggers measurement survey).
  - *curb*: Distance from land to well curb (meters).
  - *externalDiameter*: Approximate Externe diameter (in mm).
  - *innerDiameter*: Approximate Interne diameter (in mm).
  - *constructionDate*: Date of Construction.
  - *ownerId*: Responsible party that owns the well.
  - *contructorId*: Party that carries out the development of the Well.

- *statusCode*: Values which describes the status of man-made hydrogeological objects.
- *statusCodeDate*: When was the last observation of the WellStatus.
- *activityType*: Type of activity carried out by the well.

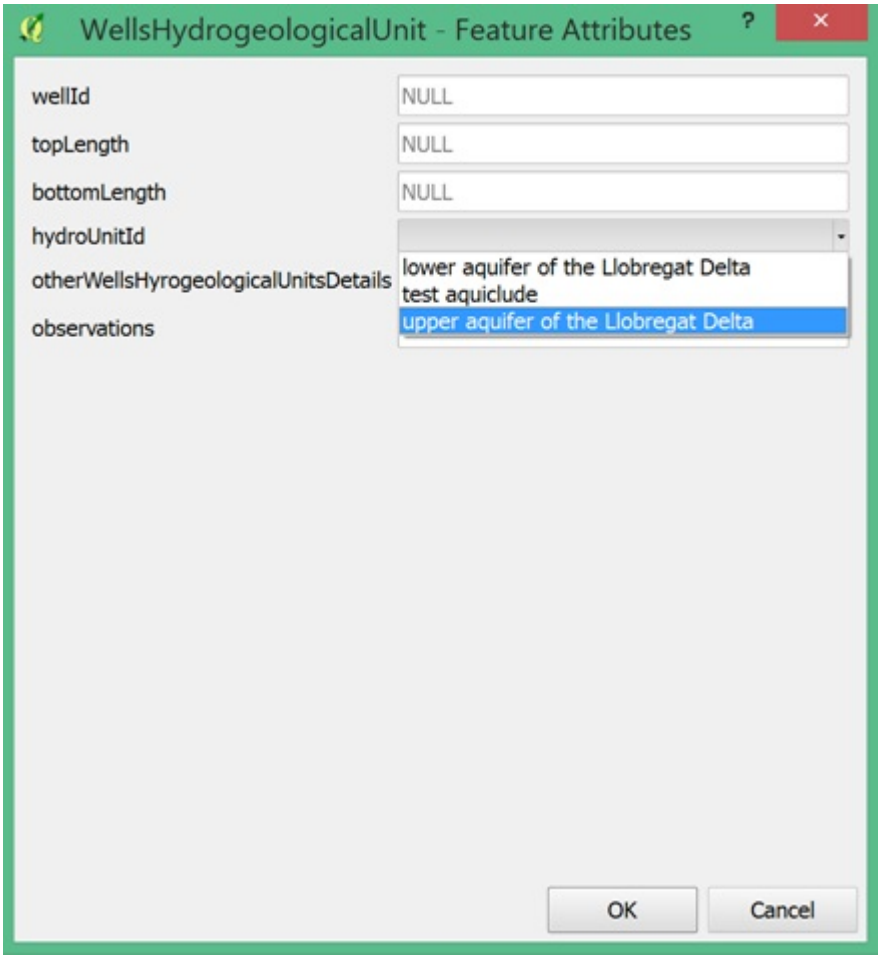
Note: After update hydrogeological information, do not forget to save the edition session.



- *Step 2*: Edit or add a new hydrogeological Unit if is not included in the table *HydrogeologicalUnits*. Select and open the attribute table. Here, some information has to be added:
  - *Id Number*: Unique identifier number.
  - *HydroUnit*: Short name of the Hydrogeological Unit (unique).
  - *Name*: Full name of the aquifer in local language and *NameEN* field store the aquifer name in English (recommended).
  - *Description*: Description of the hydrogeological Unit in native language and *DescriptionEN* field store this information in English (recommended).
  - *hydroUnitType*: Type of hydrogeological Unit (Aquifer, Acuiclude, Aquitard). Further information about the hydrogeological units according to their classification in aquifers, aquicludes and aquitards will be introduced in further attributes tables (See chapter 4; Tables *Aquifers*, *Aquitards*, *Aquiclude* and *Aquifer System*). It is recommended to complete these tables as much as possible, even when they are not required for the use of the presented instruments.

- *CitationId*: Citation of the document where the normative is described. In case the citation is not in the list, add a new citation in the table *Citation* (from the TOC) (recommended).
- *OtherHydroUnitDetails*: Additional data (recommended).
- *observations*: Observations of the person that introduce the data into the database.(recommended)

Note: After update hydrogeological unit information, do not forget to save the edition session.



- *Step 3*: Complete the required fields of the table *WellsHydrogeologicalUnits*. Select and open the attribute table. Here, some information has to be added:
  - *WellId*: Unique identifier of wells where the hydrogeological Units were observed.
  - *TopLenght*: Top of the depth described (in meters).
  - *BottomLenght*: Bottom of the depth described (in meters).
  - *HydrogeologicalUnitId*: Hydrogeological Unit defined along the well.
  - *otherHydrogeologicalUnitsDetails*: Additional data (recommended).
  - *observations*: Observations of the person that introduce the data into the database (recommended).

Note: After update wells hydrogeological units information, do not forget to save the edition session.

CHAPTER 4

Database documentation

- "*" Primary Key
- "**" Foreign Key
- Tables used in the Pre-processing tools (IDAEA - CSIC)

4.1 Documentation of the project

The first step in the introduction of the data into AkvaDatabase is to describe the different documents, projects, campaigns or entities that provide the information. For entering the data in the AkvaDatabase, the user can use the utilities of Spatialite database or the utilities of QGIS.

4.1.1 Citations

In this table we introduce the information about the source of data. The source of data can be technical report, scientific papers, files, other databases, etc. This table acts as a library of terms, if the reference of the source of information (document, paper, etc.) that have been already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each citation	Integer; YES
citation	Citation is a human readable title and the publication date. e.g. Velasco2015Also citationId for technical reports, names of databases, etc. E.g. GA2378297459EU	Text; 50; NO
title	Title of the report/paper/database etc	Text; 255; NO
alternateTitle	Short name or other language name by which the cited information is known. Example: "DCW" as an alternative title for "Digital Chart of the World"	Text; 50; NO
description	Short description of the source of data in local language	Text; 255; NO
descriptionEN	Short description of the source of data in English	Text; 255; NO
presentationFormCode**	mode in which the resource is represented	Integer; YES
citedResponsiblePartyId**	name and position information for an individual or organization that is responsible for the resource	Integer; YES
citationSearch	Document's location where it can be available and/or who can facilitate it). E.g. file path in your computer	Text; 255; NO
citationDate	Date of edition/publication/revision of the document source of the data, date of the last change of the database, date of the technical report	Date
otherCitationDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database.	Text; 255; NO

4.1.2 ResponsibleParties

This is the description of the organisation responsible for the establishment, management, maintenance and distribution of the resource. This description shall include the name of the organisation and a contact e-mail address. This table acts as a library, if the entity is already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each responsable party	INTEGER; YES
responsibleParty	Unique name for each entity (laboratory, company, employees, etc.). E.g. For Technical University of Catalonia, ResponsiblePartyId can be UPC	Text; 50; YES
individualName	name of the responsible personsurname, given name, title separated by a delimiter	Text; 255; NO
organisationName	name of the responsible organization	Text; 255; NO
positionName	role or position of the responsible person	Text; 255; NO
deliveryPoint	address line for the location (as described in ISO 11180, Annex A)	Text; 255; NO
city	city of the location	Text; 255; NO
administrativeArea	state, province of the location	Text; 255; NO
postalCode	ZIP or other postal code	Text; 255; NO
Country	country	Text; 255; NO
electronicMailAddress	address of the electronic mailbox of the responsible organization or individual	Text; 255; NO
Phone	telephone numbers at which the organization or individual may be contacted	Text; 255; NO
onlineResource	on-line information that can be used to contact the individual or organization	Text; 255; NO
Linkage	location (address) for on-line access using a Uniform Resource Locator address or similar addressing scheme such as http://www.statkart.no/isotc211URL (IETF RFC1738 IETF RFC 2056)	Text; 255; NO
Protocol	connection protocol to be used	Text; 255; NO
applicationProfile	name of an application profile that can be used with the online resource	Text; 255; NO
onlineResourceName	name of the online resource	Text; 255; NO
Description	detailed text description of what the online resource is/does	Text; 255; NO
functionCode**	Code for function performed by the online resource. From the table ListFunction-Codes	INTEGER; NO
hoursOfService	time period (including time zone) when individuals can contact the organization or individua	Text; 255; NO
contactInstructions	supplemental instructions on how or when to contact the individual or organization	Text; 255; NO
otherResponsiblePartyDetails	Additional data	Text; 255; NO
Observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.1.3 Projects

This table allows the user to introduce information about the project that provides the information. This table acts as a library, if the project is already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Project's Unique identifier	INTEGER; YES
project	Project's Unique identifier name. E.g. PANACEA	Text; 50; NO
name	Project's full Name	Text; 200; NO
description	Short description of the project in local language	Text; 255; NO
descriptionEN	Short description of the project in English	Text; 255; NO
citationId**	Reference of the document that contains the agreement, proposal, etc.	INTEGER; NO
principalInvestigatorId**	Key party responsible for gathering information and conducting research of this project.	INTEGER; NO
parentProject	The parent Project. A large investigation project may have several sub projects.	Text; 255; NO
otherProjectDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.1.4 Campaigns

This table contains details about the campaign (e.g. hydrochemical campaign) performed to obtain the data. This table acts as a library, if the campaign is already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each field campaign	INTEGER; YES
campaign	Name of the Unique identifier for each field campaign. E.g.Campaign01	Text; 50; NO
campaignType**	Type of a campaign must be one of the item listed in ListCampaignType	INTEGER; NO
projectId**	Unique identifier for each project related with the field campaign	INTEGER; NO
beginDate/endDate	Start/End date of the campaign	Date; NO
clientId**	Party to which investigation is carried out	INTEGER; NO
custodianId**	Party responsible to maintain data related to the campaign	INTEGER; NO
dataOwnerId**	Responsible party that owns the data related to the campaign.	INTEGER; NO
contractorId**	Party that carries out the survey	INTEGER; NO
otherCampaignDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.2 Geography/general data

These tables contain information about the location of the points of interest (i.e. of the observed feature such as wells, springs, sea...)

4.2.1 Points

This is a geometric feature (point) that represents points where hydrogeological observations have been done.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	unique identifier for each point with information	INTEGER; YES
point	Name of the unique identifier for each point with information	Text; 50; YES
beginLifespanVersion	Specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set (INSPIRE)	Date
endLifespanVersion	Specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set. If the endLifespanVersion is null, this indicates that the object is the current representation of the feature(INSPIRE)	Date
name	Place name of the point (popular name of the point, e.g. Well of the Major, Spring of the butterflies?)	Text; 100; NO
name2/name3/name4	Point's name in different databases or references. Note that the same point can provide different information of different nature and origin and can be termed with different names in different reports	Text; 100; NO
description	Text providing description of object	Text; 255; NO
cooX	Coordinate X	Double; YES
cooY	Coordinate Y	Double; YES
elevation	Elevation (Z) in meters	Double; NO
geometryCooSourceType**	Type of CooX, CooY (e.g. BoreholeO&M, cartographicalO&M) ListGeometrySourceType	INTEGER; NO
geometryElevationSourceType**	Type of source of the geometry of Elevation (e.g. BoreholeO&M, CartographicalO&M) ListGeometrySourceType	INTEGER; NO
elevationReferenceSystemId**	reference System of the Elevation	INTEGER; NO
cooReferenceSystemId**	reference System of the coordinators X, Y	INTEGER; NO
sourceReferenceSystemId**	spatial reference system used by the source data	INTEGER; NO
nameCitation/name2Citation/name3Citation/name4Citation**	Reference of the name indicated in Nam1-4Point. Here introduce the reference of the report/database were the information point were obtained	INTEGER; NO
adressPoint	Adress of the point of interest (e.g. Palm Beach, 92, Cuenca)	Text; 255; NO
accessPoint	Description of the access to the point (e.g. easy access, it is in the middle of the street, talk to the owner, its unknown) . In any case the information has to be accompanied with the date	Text; 255; NO
pointType**	Type of point (spring, seep, swallowHole, well, seepoint, lakepoint)	INTEGER; NO
otherPointDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.2.2 ReferenceSystems

This package contains the identification of the spatial and temporal reference system(s) used in a dataset.This table act as a library, if the reference system code already exist in this you do not need to fill this table.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each reference system	INTEGER; YES
referenceSystem	Refer to ISO 19111 when coordinate system is not given through reference system identifier	Text; 255; YES
name	name of the reference system used in the local language	Text; 255; NO
nameEN	name of the reference system used in English	Text; 255; NO
domainOfValidity	range which is valid for the reference system	Text; 255; NO
OtherReferenceSystemDetails	additional details	Text; 255; NO
observation	Observations of the person that introduce the data into the database	Text; 255; NO

4.3 Hydrogeological objects

4.3.1 HydrogeologicalUnits

The INSPIRE hydrogeological data model considers 3 areas: Hydrogeological Units (e.g. Aquifers, Aquitards and aquiclude). Hydrogeological Systems and man-made and natural objects wich interact with those systems. The HydrogeologicalUnits stores the conceptual description and attributes of the hydrogeological units identified. A hydrogeological unit is a part of the terrain with distinct parameters for water storage and conduction. There are 3 main subclasses of hydrogeological units: Aquifer, Aquitard and Aquiclude. This table act as a library, if the Hydrogeological Unit has been already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each hydrogeological unit	INTEGER; YES
hydrogeologicalUnit	Name of the Unique identifier for each hydrogeological unit (e.g.UpperAquiferLlobregat)	Text, 50; NO
name	Name of the hydrogeological Unit in the local language	Text; 255; NO
nameEN	Name of the hydrogeological Unit in English.	Text; 255; NO
description	Short description of the hydrogeological Unit in local language	Text; 255; NO
descriptionEN	Short description of the hydrogeological Unit in English	Text; 255; NO
hydroUnitType**	Type of hydrogeological unit (aquifer, aquitar or aquiclude)	INTEGER; NO
citationId**	Document containing information about this Hydrogeological Units	INTEGER; NO
otherHydroUnitsDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.2 HydrogeologicalUnitsApparence

The hydrogeological units have different spatial representations in 2D.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each hydrogeological unit apparence	INTEGER; YES
hydrogeologicalUnitId**	Unique identifier for each hydrogeological unit	INTEGER; YES
approximateDepth	Approximate depth (mean value) of the hydrogeological unit	Double
approximateThickness	Approximate thickness (mean value) of the hydrogeological unit	Double
beginLifespanVersion	Stores the date that the new object was created	Date; NO
endLifespanVersion	The date that the next version of the object was created. If the endLifespanVersion is null, this indicates that the object is the current representation of the feature	Date; NO
sourceReferenceSystemId**	spatial reference system used by the source data	INTEGER; NO
referenceSystemId**	reference System of the Aquifer	INTEGER; NO
geometrySourceType**	The type of source for the geometry of a hydrogeological feature.	INTEGER; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.3 Aquifers

This table store the properties of the Hydrogeological Units defined as Aquifers. An Aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted by a groundwater well. (INSPIRE).

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique Identifier for each aquifer	INTEGER; YES
aquifer	name for each Unique Identifier ofeach aquifer	Text; 50: NO
hydrogeologicalUnitId**	name of Unique Identifier for each aquifer defined in the table HydrogeologicalUnit E.g. e.g. UpperAquiferLlobregat	INTEGER; YES
name	Aquifer's name in the local language	Text; 255; NO
nameEN	Aquifer's name in English	Text; 255; NO
aquiferType**	Water in an Aquifer is, or is not, under pressure. Based on those unconfined, confined, artesian, or subartesian types are distinguished. Further information in INSPIRE data specifications	INTEGER; NO
mediaType**	The classification of the medium in which the groundwater flow occurs	INTEGER; NO
isExploited	Indicates if groundwater from aquifer is exploited by wells or intakes	boolean
isMainInSystem	Indicates if aquifer is the main useful aquifer in the aquifer system	boolean
permeabilityCoefficient	The volume of an incompressible fluid that will flow in unit time through a unit cube of a porous substance across which a unit pressure difference is maintained. The parameter represents the hydraulic conductivity of a rock container. Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. NOTE: Because of their high porosity and permeability, sand and gravel have higher hydraulic conductivity than clay or unfractured granite aquifers.NOTE OF THE AUTHORS: This should be a mean value. The aquifers media is heterogeneous	Double; NO
permeabilityCoefficientUomCode**	Unit of measurement of permeability coefficient	INTEGER; NO
storativityCoefficient	The ability of an aquifer to store water. NOTE OF THE AUTHORS: This should be a mean value. The aquifers media is heterogeneous	Double;NO
vulnerabilityPollution	An index value or interval of values determining the potential degree of aquifer risk arising from the geological structure, hydrogeological conditions and the existence of real or potential source of contamination. A single value should be used if it is determined directly from the DRASTIC method. If attribute data comes from another data source which is expressed by categorized items, for example: low, moderate or high, interval should be used expressed by lowest and highest value of category. EXAMPLE: Moderate means interval from 101 to 140.(INSPIRE)	Text; 255; NO
hydroGeochRockType**	The rock type with respect to the soluble rock components and their hydrogeochemical influence of groundwater. Defines the prevailing geochemical character of natural groundwater within the Aquifer. Further information in http://inspire.ec.europa.eu/codeList/HydroGeochemicalRockType	INTEGER; NO
aquiferSystemId**	The AquiferSystem of which the Aquifer is a part	INTEGER; NO
otherAquiferDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.4 Aquitards

This table store the properties of the Hydrogeological Units defined as Aquitards. It does not yield water freely to wells, but may transmit appreciable water to or from adjacent aquifers and, where sufficiently thick, may constitute an important ground-water storage unit. Aquitards are characterized by values of leakance that may range from relatively low to relatively high. A really extensive aquitard of relatively low leakance may function regionally as boundaries of aquifer flow systems (INSPIRE).

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique Identifier for each aquitard	INTEGER; YES
aquitard	name of the unique identifier for each aquitard	Text; 50: NO
hydrogeologicalUnitId**	Unique Identifier for each aquitard defined in HydrogeologicalUnits	INTEGER; YES
name	Aquitard's name in the local language	Text; 255; NO
nameEN	Aquitard's name in English	Text; 255; NO
IdHydroGeochRockType**	The rock type with respect to the soluble rock components and their hydrogeochemical influence of groundwater. Defines the prevailing geochemical character of natural groundwater within the Aquifer. NOTE OF THE AUTHORS: This should be a mean value. The aquifers media is heterogeneous	INTEGER; NO
approximatepermeabilityCoefficient	The volume of an incompressible fluid that will flow in unit time through a unit cube of a porous substance across which a unit pressure difference is maintained. The parameter represents the hydraulic conductivity of a rock container. Describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation. NOTE: Because of their high porosity and permeability, sand and gravel have higher hydraulic conductivity than clay or unfractured granite aquifers	Double; NO
permeabilityCoefficientUomCode**	Unit of measurement of permeability coefficient	INTEGER; NO
approximatestorativityCoefficient	The ability of an aquifer to store water. NOTE OF THE AUTHORS: This should be a mean value. The aquifers media is heterogeneous	Double; NO
aquiferSystemId**	The AquiferSystem of which the Aquitard is a part	INTEGER; NO
Observations	Additional data	Text; 255 ;NO
ObsInput	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.5 Aquicludes

This table store the properties of the Hydrogeological Units defined as Aquiclude. It is a formation which, although porous and capable of absorbing water slowly, will not transmit water fast enough to furnish an appreciable supply for a well or spring. Aquicludes are characterized by very low values of "leakage" (the ratio of vertical Hydraulic Conductivity to thickness), so that they transmit only minor inter-aquifer flow and also have very low rates of yield from compressible storage. Therefore, they constitute boundaries of aquifer flow systems (INSPIRE).

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique Identifier for each aquiclude	INTEGER; YES
hydrogeologicalUnitId**	Unique Identifier for each aquiclude defined in the table defined in HydrogeologicalUnits	INTEGER; YES
name	Aquiclude's name in the local language	Text; 255; NO
nameEN	Aquiclude's name in English	Text; 255; NO
hydroGeochRockType**	The rock type with respect to the soluble rock components and their hydrogeochemical influence of groundwater. Defines the prevailing geochemical character of natural groundwater within the Aquifer	INTEGER; NO
aquiferSystemId**	The AquiferSystem of which the Aquitard is a part	INTEGER; NO
otherAquicludeDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.6 AquiferSystems

A collection of aquifers and aquitards, which together constitute the environment of groundwater - "communicating vessels", that are filled or can be filled with water. Attributes of Aquifer System and its components determine the feasibility of water collection, its movement, as well as the impact on its chemical state. NOTE: The Aquifer System components and their attributes (including geometry) are relatively stable over time except in special cases.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique Identifier for each aquifer system	INTEGER; YES
aquiferSystem	name of Unique Identifier for each aquifer system	Text; 50: NO
name	AqufferSystem's name in the local language	Text; 255; NO
nameEN	AquiferSystem's name in English	Text; 255; NO
isLayered	Indicates if the AquiferSystem consists of more than one layer.	boolean
otherAquiferSystemDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255 ;NO

4.3.7 Wells

This table store the main attributes of the wells.

NAME OF THE FIELD	DESCRIPTION	FORMAT
id*	Unique identifier for each well	INTEGER; YES
pointId**	Unique identifier for each point with information.	INTEGER; YES
well	name of the Unique identifier for each well	Text; 50: YES
validFrom	The date the well started being used	Date
validTo	The date the well ceased being used. If this field is not fullfiled means that the well it is still active	Date
lenght	The distance along the well. This will be determined by the data provider (ie, "length"" can have different sources like drillers measurement loggers measurement survey)"	Double; NO
curb	Distance from land to well curb (meters)	Double; NO
externalDiameter	Approximate Externe diameter (in mm)	Double; NO
innerDiameter	Approximate Interne diameter (in mm)	Double; NO
constructionDate	Date of Construction	Date; NO
ownerId**	Responsible party that owns the well	INTEGER; NO
contructorId**	Party that carries out the development of the Well	INTEGER; NO
statusCode**	Values describing the status of man-made hydrogeological objects	INTEGER; NO
statusCodeDate	When was the last observation of the WellStatus	Data; NO
activityType**	The type of activity carried out by the well.	INTEGER; NO
otherWellsDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.8 WellsHydrogeologicalUnit

This table store the definition of the boundaries of the different hydrogeological units identified for each well.

NAME OF THE FIELD	DESCRIPTION	FORMAT
wellId**	Unique identifier of wells where the hydrogeological units were observed	INTEGER; YES
top/bottomLength	Top and the bottom of the depth described (in meters)	Double; YES
hydrogeologicalUnitId**	HydroUnits defined/identified along the well (defined in the table HydrogeologicalUnits)	INTEGER; YES
otherWellsHyrogeologicalUnitsDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.9 Screens

In this table the main characteristics of the screens of the wells can be introduced. This table acts as a library, if the screen is already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique identifier for the screen installed in the wells/piezometers	INTEGER; YES
screen	name of the unique identifier for the screen installed in the wells/piezometers	Text; 50; NO
responsiblePartyId**	Model Entity	INTEGER; NO
screenType**	ScreenType from the ListScreenType(e.g. Slotted Plastic Pipe, continuous-slot screen)	INTEGER; NO
description	Short description in the local language of the screen	Text; 255; NO
descriptionEN	Short description of the screen in English	Text; 255; NO
OtherScreenDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.10 WellScreens

This table has been designed to contain the screen type and the intervals screened. It also establishes (for each screened interval) the link of the well to the hydrogeological unit that is screened. Thus, a well can be screened in diverse hydrogeological units whereas a hydrogeological unit can be screened by different wells.

NAME OF THE FIELD	DESCRIPTION	FORMAT
wellId**	Unique identifier for each well	INTEGER; YES
screenId**	Unique identifier for the screen installed in the wells	INTEGER; YES
topLenght	Length of the top of the Screen (in meters)	Double; NO
bottomLenght	Length of the bottom of the Screen (in meters).	Double; NO
screenExtentCode**	Extent of the screen in the hydrogeological unit (partial, entire, etc.)	INTEGER; YES
instalationDate	Date of installation	Date;NO
hydrogeologicalUnitsId**	Hydrogeological unit that is screened	INTEGER; YES
otherWellScreensDetails	Additional data	Text; 255; NO
Observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.3.11 Springs

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique identifier for spring	INTEGER; YES
pointId**	Unique identifier for each point	INTEGER; YES
springType**	SpringType	Text; 50; NO
persistenceCode	The degree of persistence of water flow.E.g . Intermittent, seasonal, perennial, notSpecified ephemeral, ... http://inspire.ec.europa.eu/codeList/WaterPersistenceValue	INTEGER; NO
approximateQuantityOfFlow	An approximate value defining the water yield in a natural hydrogeological object	Double; NO
approximateQuantityOfFlowUom-Code	Units of measurements of the quantity of flow	INTEGER; NO
description	Short description in the local language of the spring	Text; 255; NO
waterPersistenceCode descriptionEN	Short description of the spring in English	Text; 255; NO
OtherSpringDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.4 Hydrogeological observations and measurements

The HydrogeologicalPointsObservations and HydrogeologicalPointsMeasurements tables were designed to manage hydrogeological data observed at a given groundwater point such as time series of head measurements, or rate and volume of abstraction or recharge .The aforementioned tables related to the temporal measurements (TimeMetadata) and to the process used to carry out the observation (Processes) are linked to these tables. A code list of hydrogeological measurements with its corresponding units (ListHydrogeologicalParametersCode) was also developed.

4.4.1 HydrogeologicalPointsObservations

This table store information of the hydrogeological data observed at a given groundwater point (e.g. well abstraction, water level, etc.).

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique identifier for each observations/measurements performed for each groundwater point defined	INTEGER; YES
pointId**	Unique identifier for each point with groundwater information (based on O&M:FeatureOfInterest)	INTEGER; YES
hydrogeologicalParametersCode**	This property is used to describe the phenomenon that is being observed (including the uom) (based on O&M: observed property)	INTEGER; YES
qualifier	Define potentially influential conditions occurring whilst the measurement was taking place (after WTDF). E.g. pumping ocurring	Text; 50; NO
processId**	Unique identifier for each process used to carry out the observation (based on O&M:Procedure)	INTEGER; NO
phenomenomTime	This may be the time when the observation procedure was performed on a real-world feature (based on O&M:phenomenomTime)	Data
timeMetadataId**	Unique identifier for each characteristic time-series	INTEGER; NO
beginDate	Start time period, defining the start and end times of the time series (after WaterML 2.0)	Date/Hour
endDate	End time period, defining the start and end times of the time series (after WaterML 2.0)	Date/Hour
citationId**	Reference of the source of information	INTEGER; NO
responsiblePartyId**	Unique identifier for the person/entity in charge of the measurement	INTEGER; NO
resultsQualityCode**	This is used to describe the overall quality of a time series. Time series often require per point quality information, which is provided by the specific time-series types that are used	INTEGER; NO
resultsNatureType**	Nature of the results (e.g. simulated)	INTEGER; NO
otherObservationsDetails	Additional data	Text; 255; NO
Observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.4.2 HydrogeologicalPointsMeasurements

This table store the information related to the hydrogeological data observed at a given groundwater point such as time series of head measurements, or rate and volume of abstraction or recharge.

NAME OF THE FIELD	DESCRIPTION	FORMAT
hydroPointObsId**	Unique identifier for each observations/measurements performed for each groundwater point defined	INTEGER; YES
resultTime	The attribute resultTime describes the time when the result became available, typically when the procedure associated with the observation was completed For some observations this is identical to the phenomenonTime (based on O&M:resultTime)	Date/hour; YES
value	The value is a Record that indicates the value of the property of interest for the observation. (based on O&M:values)	Double; YES
qualifier	Property of the value. E.g. > , <?	Text; 10; NO
otherHydroMeasurementsDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.4.3 TimeMetadata

This table contains details of the time series obtained in the observation point.

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique identifier for each characteristic time-series. Describe the time-serie	INTEGER; YES
accuracy	This property allows for a quantitative assertion of the estimated accuracy of the measurement value (e.g. Standard Deviation)	Double; NO
spacing	The spacing property of the time series is used to specify the time between points	Double; NO
interpolationType**	One of the core characteristics of measurement time series is the nature of the relationship between the time instant and the recorded value. This relationship is determined by the procedure that was used in making the estimate that the value represents. WaterML2.0 defines a number of types of time series. (e.g. Continuous, Average in preceding interval, ...)	INTEGER; NO
nilReasonCode**	This property describes the reason that a point has been identified as null. This provides context for interpreting null points (e.g. missing, withheld etc.). Further information in WML2.0.	INTEGER; NO
otherTimeMetadataDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.4.4 Processes

It has the role of describing generic procedures that are common in practice and can be referenced from many observations that were made in the same or similar way. It has name, unique identifier, documentation, responsibleParty to inform the user about the nature of the procedure and the authority that maintains the record.

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique Identifier for each type of process used	INTEGER; YES
name	Name of the process used for performing the measurement, the sampling, etc. in the local language	Text; 50; NO
nameEN	Name of the process used for performing the measurement in English	Text; 50; NO
description	Short description of the process in the local language	Text; 255; NO
descriptionEN	Short description of the process in English	Text; 255; NO
responsiblePartyId**	Responsible party to the user about the nature of the procedure and the authority that maintains the record	INTEGER; NO
processParameterCode**	Generic process parameter	INTEGER; NO
processType**	Process Used type	INTEGER; NO
citationId**	Documentation of the process used	INTEGER; NO
otherProcessDetails	Additional data	Text; 255; NO
oservations	Observations of the person that introduce the data into the database	Text; 255; NO

4.5 Hydrochemical observations and measurements

The hydrogeochemical data from each sampling point are stratified within the database in accordance with the sampling point, campaign, sampling date, name and lenght (in HydrochemicalSamples). Thereafter, each sample is stratified in accordance with sampling data analysis, parameter, value and measurement units (in HydrochemicalMeasurement). The different observed properties (physico-chemical parameters) are included in a codelist termed ListHydroChemical-Parameters.

4.5.1 HydrochemicalSamples

This table store the main properties of the samples to be analysed.

NAME OF THE FIELD	DESCRIPTION	FORMAT
pointId**	Unique identifier for each point where the sample has been taken (pointId from Points). In the O&M:The sampledFeature is the feature the SamplingFeature was sampled from, providing the ultimate context for the observation. An example of sampledFeature would be the river segment a specimen was taken from.In the O&M schema also the FoI is modelled as a SF_Specimen; the location pertaining to the measurement is provided by the attribute samplingLocation	INTEGER; NO
samplingTime	Date of sample collection	Date; YES
Id	Unique identifier for each sample. In the O&M standard it is correspond with Specimen. A specimen is a feature sampled from a feature of interest to enable ex-situ observation, such as in a laboratory	INTEGER; YES
sample	Unique name/identifier for each sample	Text; 50; YES
campaignId**	Unique identifier for the campaign in which the sample was taken. CampaignId from campaigns; campaignId	TINTEGER; NO
fieldName	Name of the sample in the field before to send to the lab	Text; 30; NO
currentLocation	If present, the attribute currentLocation: Location shall describe the location of a physical specimen. This may be a storage location, such as a shelf in a warehouse or in a laboratory	Text; 50; NO
sampleSize	Size of the sample. Measure shall describe a physical extent of the specimen. This may be volume	Double; NO
sampleSizeUom	Unit of measurement (vol) of the sample Size	Text; 50; NO
sampleLenght	Lenght/Depth where sample was obtained (m)	Double; NO
samplingMethodId	The attribute samplingMethodId shall describe the method used to obtain the specimen	INTEGER; NO
samplingTime	The time the sample was taken. (based on O&M scheme)	Data
responsablePartyId**	Person /entity responsible of the sample collection	TINTEGER; NO
otherChemSampleDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.5.2 HydrochemicalMeasurements

This table store the measurement of the aforementioned samples.

NAME OF THE FIELD	DESCRIPTION	FORMAT
sampleId**	Unique identifier for each sample defined in HydrochemicalSamples	TINTEGER; YES
hydrochemicalParametersCode **	Unique Identify for each parameter from ListHydroChemicalParameters; field:parameterId	TINTEGER; NO
resultTime	Provides the time the results of the laboratory analysis were made available. If the measurement was done in situ, resultTime is equal to samplingTime (table HydrochemicalSamples)	Date; NO
value	Result, numeric value	Doble; NO
compValue	censored values (which are the concentrations of some elements reported as non-detected?, or as less-than? or greater-than?)	Text; 50; NO
responsablePartyId**	Laboratory from ResponsibleParties where the sample was analyzed. If the measurement was done in situ, here the author of such measurement	INTEGER; NO
processId**	Procedure of the analysis	INTEGER; NO
citationId**	Citation to the laboratory report. From the table Citations	TINTEGER; NO
otherChemMeasurementDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.5.3 Normatives

This table store information of the different regulatory guideline. This table acts as a library, if the normative/guideline details are already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
Id*	Unique identifier for each normative, directive, etc.	INTEGER; YES
responsiblePartyId**	Entity/Agency/ organism that has developed (or applied) the normative	INTEGER; NO
name	Name of regulations, guidelines, etc. in the local language	Text; 50; NO
nameEN	Name of regulations, guidelines, etc. in English	Text; 50; YES
date	Date of regulations, guidelines, etc.	Date; NO
citationId	Documentation of the normative	INTEGER; NO
otherNormativeDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.5.4 HydrochemicalNormativeParameters

This table acts as a library, if the normative/guideline details for a given parameter are already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
normativeId**	Unique identifier for each normative, directive, etc.	INTEGER; YES
hydrochemicalParametersCode **	Unique Identify for each parameter from ListHydroChemicalParameters; field:parameterId (the uom is included into the code)	INTEGER; YES
parameterNormativeName	Unique Identifier/name for each parameter defined by the normative/guideline (e.g. Nitrate)	Text; 50; NO
family	Classification of the different parameters following users defined normative/criteria for its subsequent classification according to the threshold approach established by a given guideline/normative	Text; 255; NO
limMinNorm	Threshold value 1 for a given paramater for a given normative	Double; YES
limMedNorm	Threshold value2 (> than limMinNorm) for a given paramater for a given normative	Double; YES
limMaxNorm	Threshold value 3 (> que LimMedNorm) for a given paramater for a given normative	Double; NO
paramClassification1/ paramClassification2	Classification parameter1-2 by the normative	Text; 50; NO
otherhydrocheNormativeDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

4.5.5 HydrochemicalLaboratoryParameters

This table acts as a library, if the parameters nomenclature and its properties for a given laboratory/entity is already included, you do not need to add a new term.

NAME OF THE FIELD	DESCRIPTION	FORMAT
hydrochemicalParametersCode **	Unique Identify for each parameter from ListHydroChemicalParameters; field:parameterId	INTEGER; YES
laboratoryId**	Laboratory entity in charge of collecting data in lab or the entity that provide the information	INTEGER; YES
laboratoryParameter	Parameter used by the entity in charge of providing/analysing hydrochemical data	Text; 30; NO
uomCode	Units of measurements of the laboratoryParameter	INTEGER; YES
detectionLimit	Parameter detection limit	Double; NO
processId**	Procedure of the analysis	INTEGER; YES
paramClassification1/ paramClassification2	Classification parameter1-2 by the entity	Text; 50; NO
citationId**	Citation of the document that contain the details of the analysis methodology, nomenclature, etc of the parameter (e.g. protocol established by the laboratory). *Dropdown* list from DB_References	INTEGER; YES
otherHydrochemicalLaboratoryDetails	Additional data	Text; 255; NO
observations	Observations of the person that introduce the data into the database	Text; 255; NO

References

This data model was generated taken into account different International Standards and on-going projects. These include data specification of the following:

- Criollo, R., Velasco, V., Vàzquez-Suñé, E., Serrano-Juan, A., Alcaraz, M., García-Gil, A., 2015. An integrated GIS-based tool for Aquifer Test Analysis. Environmental Earth Sciences. DOI: 10.1007/s12665-016-5292-3
- ESRI, 2012. ArcGIS 10. Environmental Systems Research Institute, Redlands, United States of America. Available at http://www.esri.com/software/arcgis/arcgis-for-desktop.
- INSPIRE, 2013. Infrastructure for Spatial Information in Europe. D.2.8.11.4. Data specification on Geology-Draft Technical Guidelines.
- INSPIRE, 2011. Infrastructure for Spatial Information in Europe. D2.9_V1.0. Guidelines for the use of Observations&Measurements and Sensor Web Enablements-related standards in INSPIRE AnnexII and III data specification development.
- OGC, 2003. Observations and Measurements, 03-022r3,. http://portal.opengeospatial.org
- OGC, 2006. Observations and Measurements, 05-087r4,. http://portal.opengeospatial.org
- OGC, 2007. Observations and Measurements, Part 1, Observation schema, 07-022r1. http://www.opengeospatial.org/standards/om
- OGC, 2012. OGC Water ML 2.0:Part 1-Timeseries.10-126r3.
- ONEGeology, 2013. ONEGeology Project. Available at: http://www.onegeology.org. Accessed 11/10/2013.
- Sen, M., Duffy, T., 2005. GeoSciML: Development of a generic GeoScience Markup Language, Computers & Geosciences. DOI: 10.1016/j.cageo.2004.12.003
- Velasco, V., Gogu, R., Vázquez-Suñé, E., Garriga, A., Ramos, E., Riera, J., Alcaraz, M., 2012. The use of GIS-based 3D geological tools to improve hydrogeological models of sedimentary media in an urban environment. Environmental Earth Sciences. DOI:10.1007/s12665-012-1898-2
- Velasco, V, 2013. GIS-based hydrogeological platform for sedimentary media. PhD Thesis. Technical University of Barcelona (Spain).
- Velasco, V., Tubau, I., Vázquez-Suñé, E., Gogu, R., Gaitanaru, D., Alcaraz, M., Serrano-Juan, A., Fernández-Garcia, D., Garrido, T., Fraile, J., Sanchez-Vila, X, 2014.GIS-based hydrogeochemical analysis tools (QUIMET)2014. Computers & Geosciences. DOI: 10.1016/j.cageo.2014.04.013

Release history

31/07/2016 release of vesion 0.1

23/02/2017 release of version 0.2

(new abstract inserted; minor changes in the text and figures)

31/01/2017 release of version 0.3.1

(new abstract inserted; minor changes in the text and figures)

20/03/2017 release of version 0.4

(minor changes in the text)

30/09/2017 release of version 0.4.1

(minor changes in the text)