QGISRed v. 0.6

QGIS PLUGIN FOR THE CREATION OF REALISTIC MODELS OF WATER DISTRIBUTION NETWORKS

USER'S MANUAL

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INTRODUCTION

QGISRed is a tool to help the hydraulic engineer in the task of modelling a water distribution network and in the decision-making process, within the environment of a Geographic Information System (GIS). This tool is designed as a plugin to the free software QGis. However, QGISRed uses the source code of the GISRed software, an application designed as a desktop tool for the Windows operating system.

The QGISRed plugin is developed with the objective of being able to take advantage of all the tools that a GIS environment can provide in a native way. For example, geo-processing tools, use of satellite images, style management, etc. On the contrary, this plugin will have some limitations against the potential that may include the GISRed tool.

DETAILS OF CURRENT VERSION

Version: 0.6

QGis versions: 2.0-3.99

Features:

- Manage QGISRed projects. It is possible to open, create, import, clone or delete projects.
- Create or edit a QGISRed project. It allows to create vector layers (SHPs) of the basic elements that the EPANET software works with. If the user removes any of these SHPs, it is possible to recreate them.
- Data import from INP (EPANET) or SHPs files. In the first format you can import complete models developed with the popular EPANET software. Using SHPs, you can create or complete a model specifying for each type of element, the SHP from which you want to import information and which fields contain certain information needed for the model.
- Validation of the model, informing if there has been any error or warning when processing the information contained in the SHPs.
- Export to EPANET INP file, with the option to open this software once the file is generated.
- Simulation with the EPANET Toolkit to show the hydraulic and quality results.
- Plugin includes a set of tools associated with the layout (elimination of overlapped elements, simplification of aligned vertices, creation of T-type connections, pipe union with the same characteristics or analysis of network connectivity), with the properties of the elements (analysis of lengths, diameters, materials, installation dates, change of state of pipes or elevation interpolation), to add components (connections, hydrants, drains) or to sectorize (hydraulic sectors and demand sectors).

INSTALLATION

Local

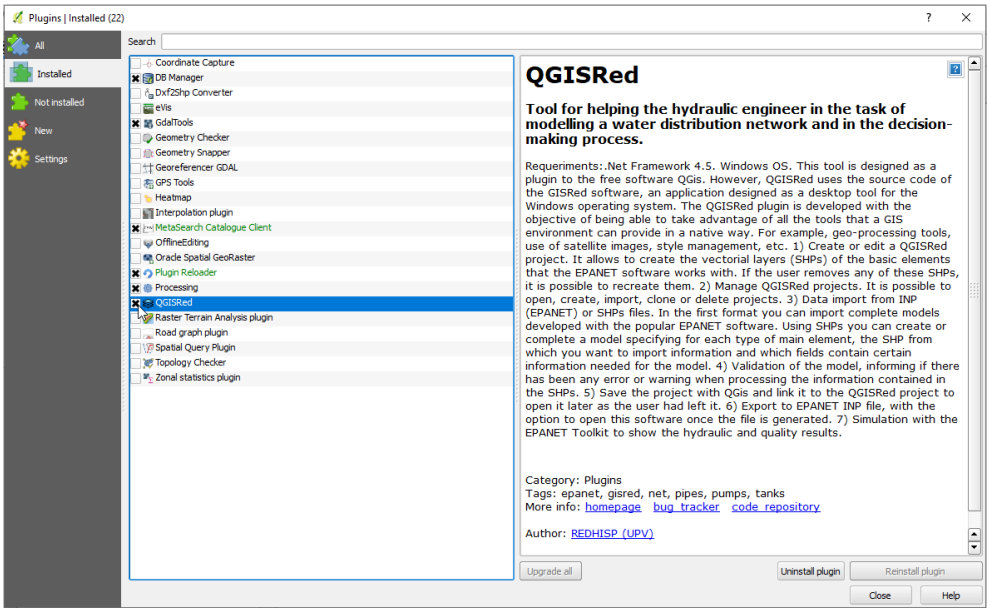
To install an update of the plugin locally, prior to the steps discussed below, it is necessary to uninstall it. To do this, you can uninstall it from the QGis plugin manager, or manually deleting the corresponding directory.

QGis v2.x

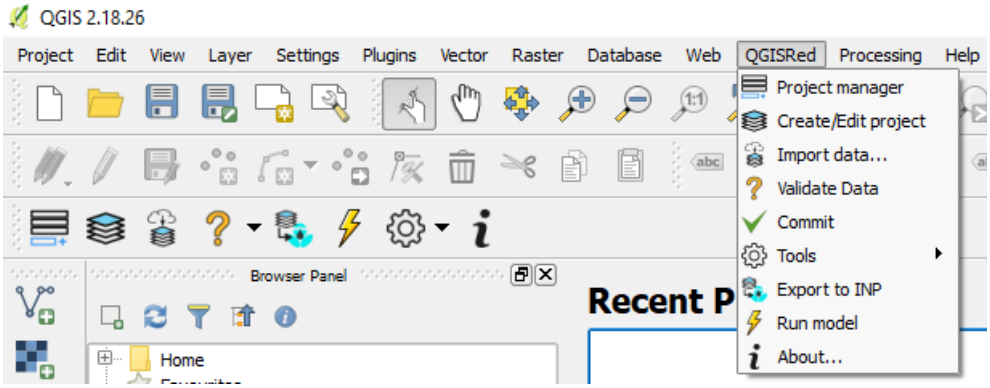
1. Go to the following path: "C:\Users***username***\.qgis2\python\plugins", where ***username*** is the Windows username you are logged on. If the *plugins* folder does not exist, create it manually.
2. Unzip the ***QGISRed.zip*** file in the previous directory (*plugins*). The final structure must be:

    plugins\
        QGISRed\
            dlls\
            images\
            layerStyles\
            ui\
            …
3. Start QGis v2.x
4. Go to Plugins menu→Manage and Install Plugins…

5. Select the "Installed" tab and mark the QGISRed plugin to enable it.

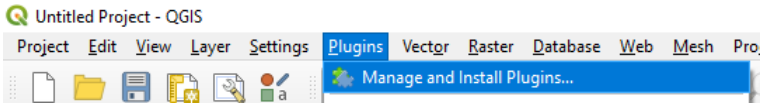


6. Close the window.
7. A new toolbar and a new item should appear in the top menu.

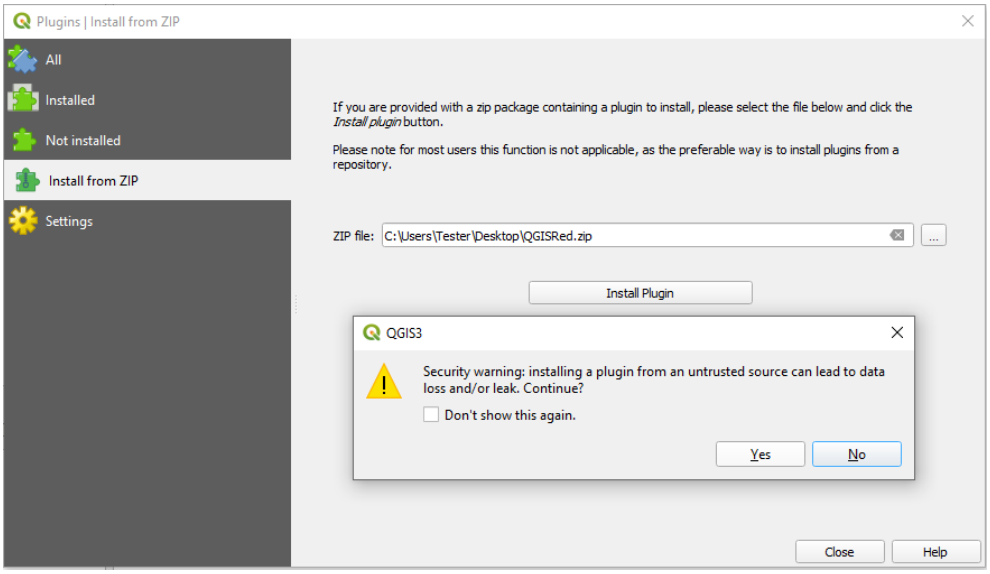


QGis v3.x

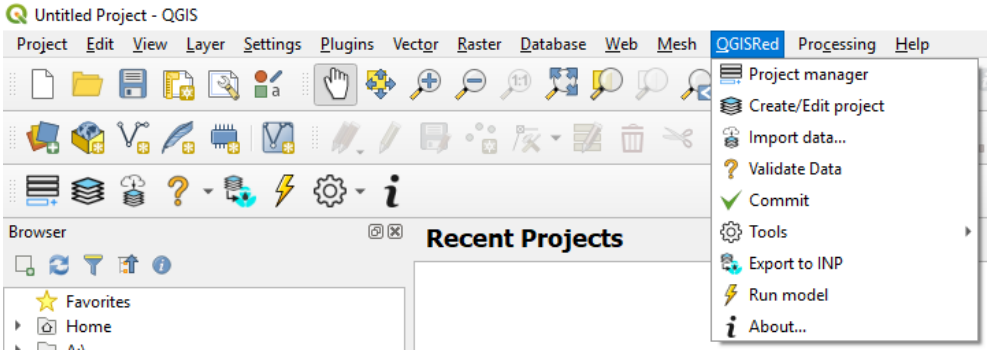
1. Start QGis v3.x
2. Go to Plugins menu→Manage and Install Plugins…



3. Select "Install from ZIP" tab, select the ***QGISRed.zip*** file. Then click on "Install Plugin" and if the warning message appears, click on "Yes".



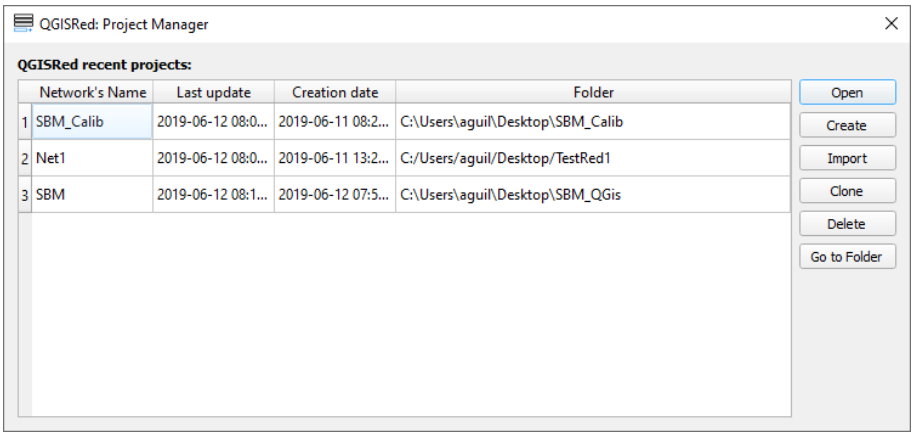
4. Close the window at the end of the process.
5. A new toolbar and a new item should appear in the top menu.



GETTING STARTED

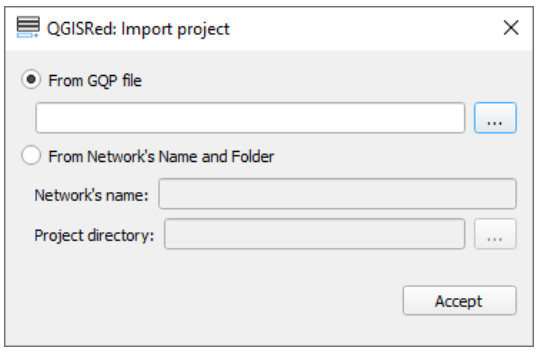
This section briefly introduces each tool available in the plugin. In the following sections more details will be presented.

Project Manager



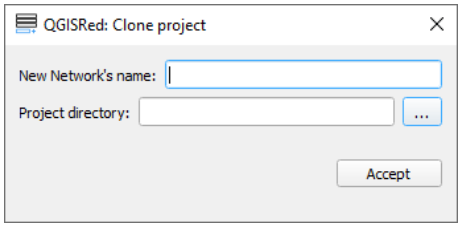
This window allows the user to manage recently opened QGISRed projects, but also to import projects that do not appear in the list, to delete those that the user do not want to appear, to make a copy of one, to create a new project or to access to the project directory.

Import



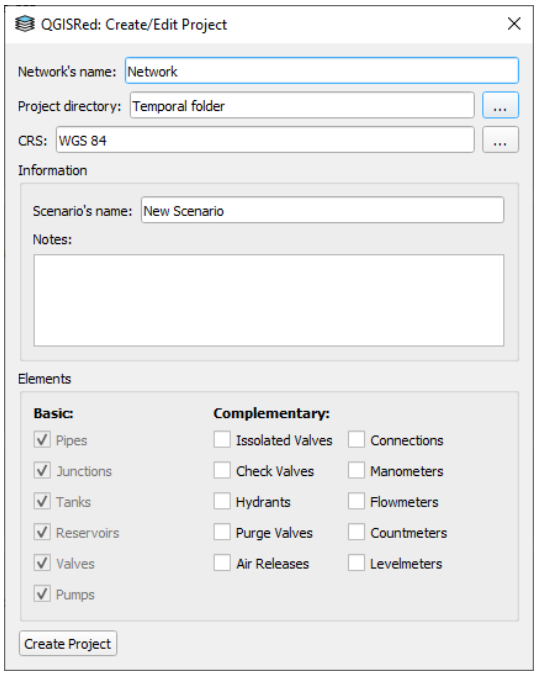
Two methods are available for importing a project. The first method is to select a file (extension ".gqp") that is generated when QGISRed project is created. The second method, specifying the name of the network and the directory where the SHPs are stored.

Clone



To clone a project, the user must specify the new name of the network and the directory where he wants to copy it. If the network name is different from the original, the directory can be the same. In other words, there can be several QGISRed projects in the same directory.

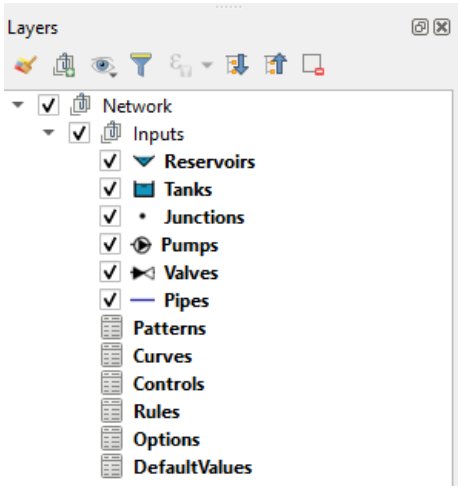
Create/Edit Project



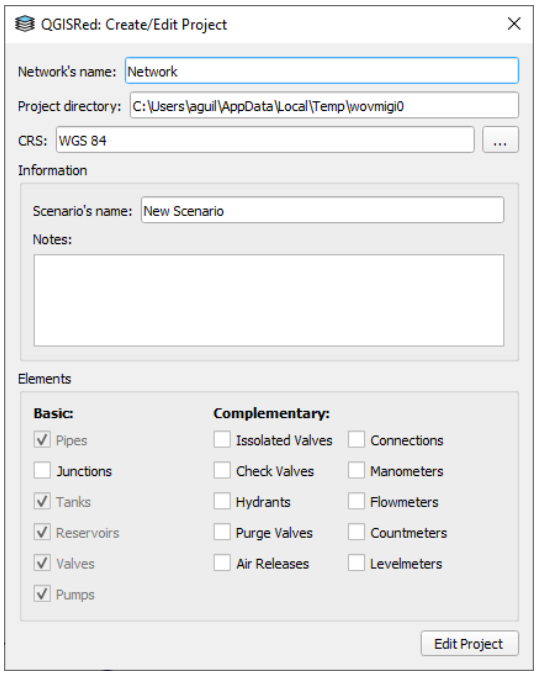
From this window it is possible to create a QGISRed project, i.e. the SHPs needed to build a model of a hydraulic network. It can also be edited, completing in case of missing layers, establishing the reference system (CRS) or providing information of the scenario (name and notes).

The required data to create a project is the name of the network and the directory where the information will be stored. If the default value "Temporary folder" is maintained in the directory field, the program will create a temporary directory that can be consulted in the Project Manager.

Once created, the following content will appear in the legend: A group with the name of the network which, in turn, will include another group titled "Inputs", thus indicating that this information is input data to build the model. Within the group, at least 6 SHPs are included, one for each type of EPANET base element and several tables to complete information such as patterns, curves, control and simulation options. In addition, other elements may appear if some of the complementary elements is marked.



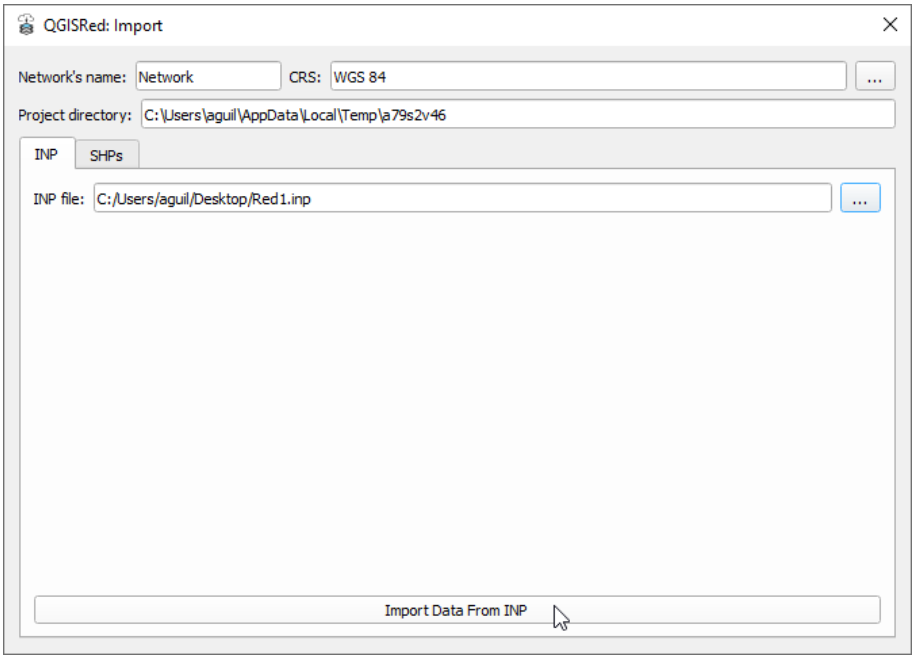
If any of the SHPs (base elements) is removed, when accessing the previous window, you will be able to mark this layer to create it again.



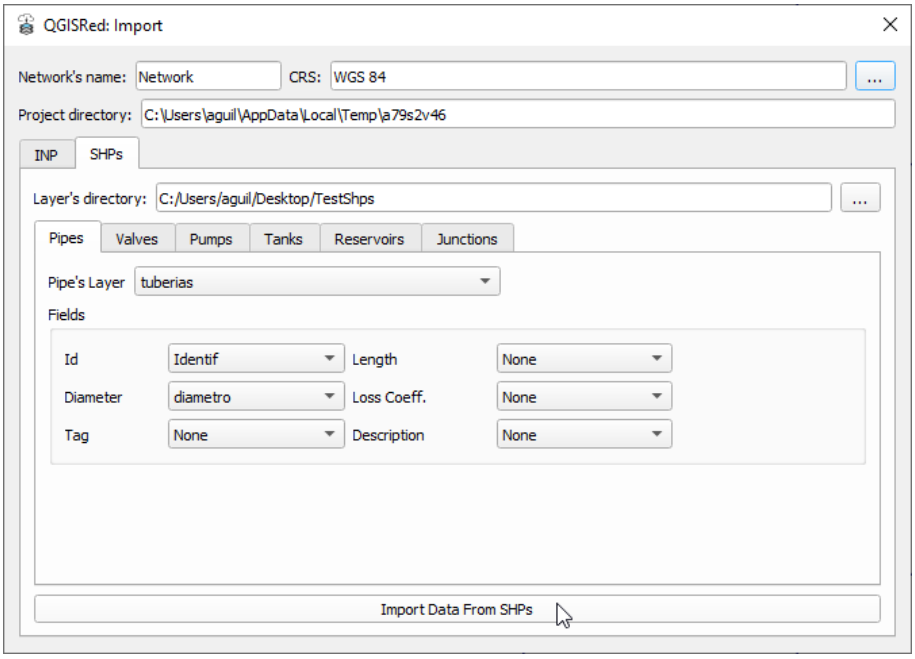
Import data

QGISRed allows to import a complete model from an EPANET INP file or import data from SHPs files. In the first case, you only need to select the INP file. In the second case, it is necessary to select the directory where the layers are stored, and then, for each type of element, select the corresponding layer and the fields to be imported.

- From INP:

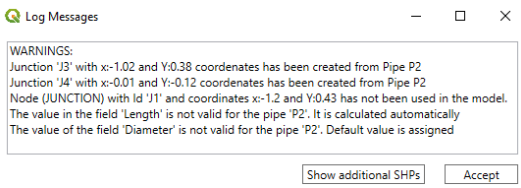


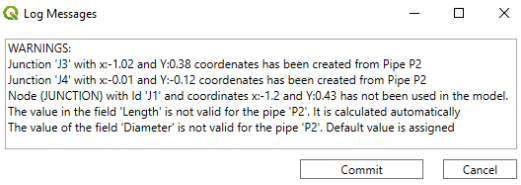
- From SHPs:



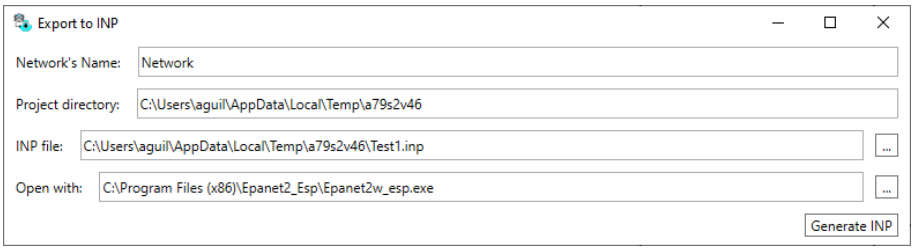
Validate/Commit data

Validation and Commit are two similar tools. Both validate that the data entered in the layers and in the auxiliary tables (Options, Rules, etc.) are correct, showing a report with all the incidents that have occurred in the process of building the model with this information. The difference between the two options is that the first only shows the list of issues and allows to load them in SPHs, while the second also rewrites the files with the necessary changes (adding or deleting of elements, changing values of the attributes, etc.).





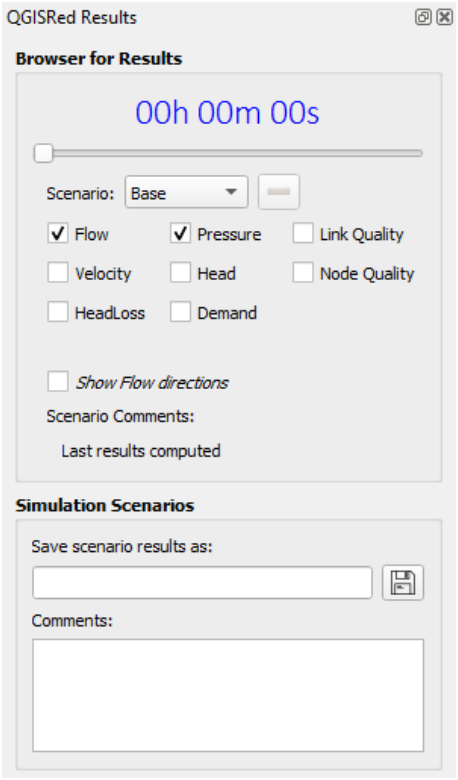
Export model to INP



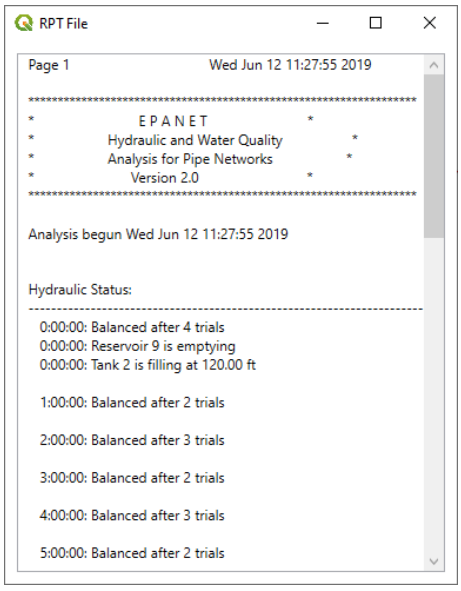
This window allows to export to an INP file the model generated from the information contained in the QGISRed project. It also has the option of specifying with which program to open the generated file.

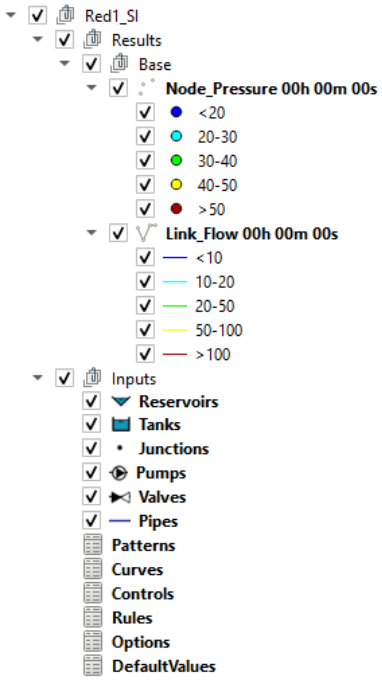
Run Model and Show Results

Clicking on the button simulates the network and a Result dock (like the following image) is opened. In this dock which results and which time interval to show can be selected.

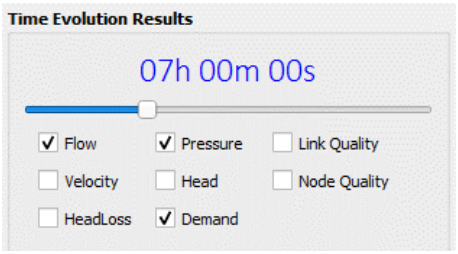


Once simulated, a window appears containing the simulation report generated by the EPANET Toolkit and the result marked in the "Browser for Results" group are opened as layers.





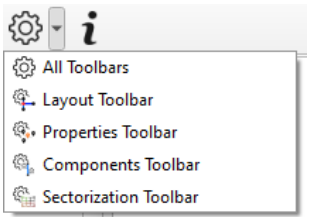
From the Result dock it is possible to open or close the different types of results, as well as change the instant of time to be displayed.



In addition, it is possible to save the simulation results by specifying a scenario name (corresponding only to the results and not to the data) and comments to indicate, for example, what characteristics that scenario has or what data has been changed.

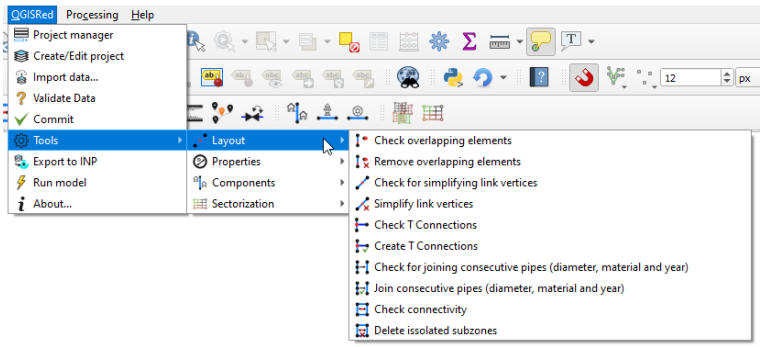
Tools

From the button or from the plugin menu you can access a series of tools, which will increase as new versions of the plugin are published.



Layout

This section contains tools associated with the layout of the network being designed. Normally, each tool has two options: analysis to see a report or SHPs of warnings or application of the requested changes, in an analogous way to the validation or commitment of data explained before. The tools are present both in the button panel and in the plugin menu.

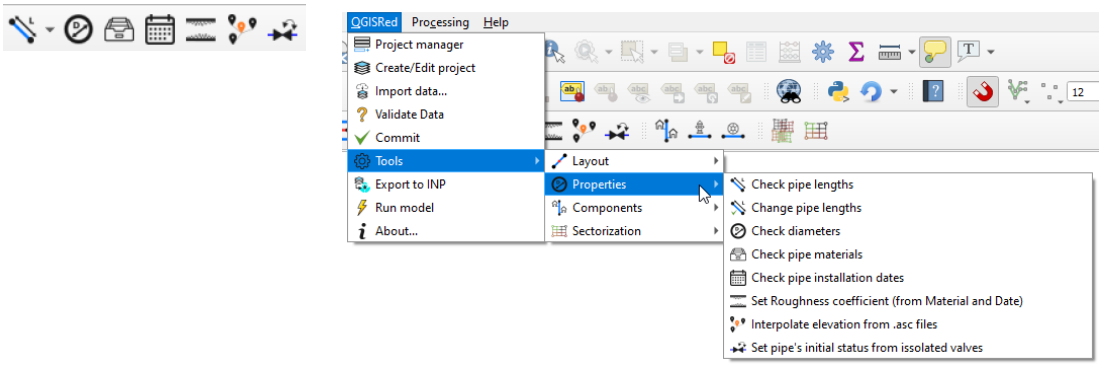


The current features allow:

- Search for overlapping elements (and delete them).
- Simplify aligned vertices in linear elements.
- Create T-type connections, that is, if a node with connectivity one coincides on a pipe, the last one is divided into two new pipes and connected all together.
- Simplification or union of pipes with the same diameter, material and year of installation.
- Analysis of network connectivity, showing isolated areas. This tool allows to eliminate subzones with less than a specific value of pipes indicated by the user.

Properties

This set of tools is associated with some of the properties of network elements. In this case, only some tools have the analysis/commitment option commented previously.

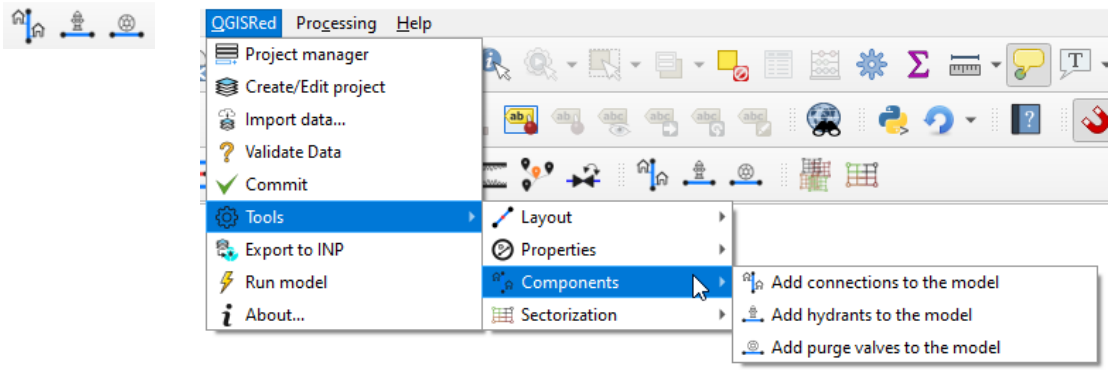


The current features allow:

- Analysis of pipe lengths. Compare the length assigned as an attribute with the Euclidean length. Displays a message if the difference is greater than a percentage specified by the user. There is the option of automatically modifying the length value with the Euclidean value if the user so indicates.
- Diameter analysis, indicating those higher or lower than pre-established thresholds.
- Analysis of materials, indicating those not recognized or unknown.
- Analysis of pipe installation dates, indicating incorrect or future dates.
- Assignment of the roughness coefficient according to the material and the year of installation.
- Massive interpolation of the elevations of node elements (junctions, tanks and reservoirs) from ASCII files.
- Assignment of the initial state of a pipe according to the state of the isolated (or cut) valves.

Components

These tools allow you to add complementary elements to the final model of the network such as pipes or nodes.

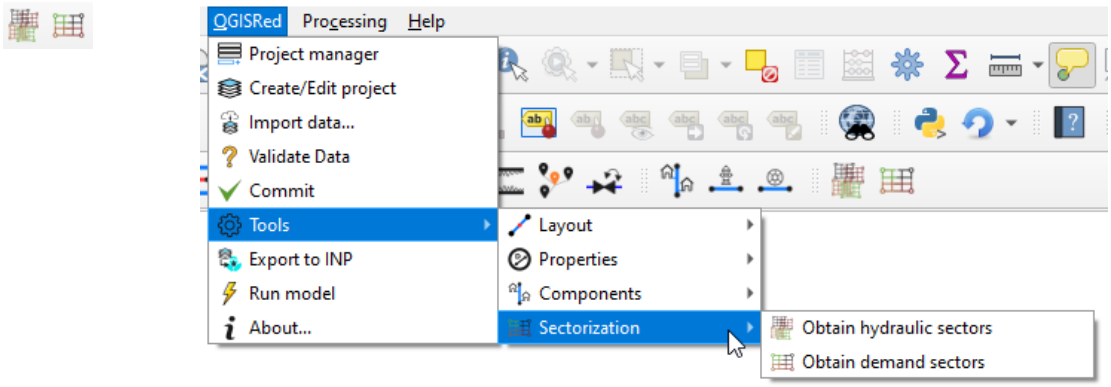


It is currently allowed to add:

- Connections, both as a punctual node or as a link (pipe)
- Hydrants, assigning the name of this one to the nearest node or in its defect creating one on the pipe in which spatially it is located.
- Drainage, assigning the name of this one to the nearest node or in its defect creating one on the pipe in which spatially it is located.

Sectorization

This block contains tools associated with the sectorization of the network.



It is currently possible to create:

- Hydraulic sectors: the tool tries to identify whether all demands can be supplied from available sources, tanks and reservoirs.
- Demand sectors: it allows the identification of areas of the network delimited by flowmeters and regulating elements that allow a pipe to be opened or closed.

INPUT DATA

This section details which values must be entered in the different fields that exist in the attribute tables of the elements that appear in the QGis legend and that are part of the QGISRed project. All data that must be entered with the same values as in EPANET will not be commented (check the EPANET manual).

Pipes

In the table of attributes of this type of element two additional fields appear with respect to those of EPANET, in this case, the field *Material* and *InstalDate*. The first corresponds to the material of the pipe and the values that can be defined are:

- GREY CAST IRON
- DUCTILE CAST IRON
- STEEL
- FIBER CEMENT
- GALVANIZEDIRON
- CONCRETE WITH SHEET METAL JACKET
- CONCRETE WITHOUT SHEET METAL JACKET
- PRESTESSED CONCRETE
- LEAD
- POLYETHYLENE
- ORIENTATED PVC
- UNPLASTICIZED PVC
- COPPER
- HIGHT DENSITY POLYETHYLENE
- LOW DENSITY POLYETHYLENE
- MEDIUM DENSITY POLYETHYLENE
- UNDETERMINED
- UNKNOWN

In the case of the *InstalDate* field, this corresponds to the date of installation of the pipe. The input format is *yyyyMMdd*, where *yyyy* corresponds to the four digits of the year, *MM* is the month number with two digits (adding a 0 before if necessary) and *dd* is the day (20190715, for July 15, 2019). With these two fields it is possible to estimate the roughness of the pipe.

Links

Unlike EPANET or other tools, GISRed and, therefore, QGISRed does not require the definition of the topology, that is, for each line it is not necessary to define the Id of the initial and final node. This process is done automatically by spatial analysis.

Patterns, Curves, Controls, Rules

The data associated with this type of information are entered very similarly to the EPANET INP file, but rather than separated by spaces, it is separated into different columns.

In the case of Patterns, an additional field is added indicating the order of the factors within the same modulation pattern or curve.

For the Rules, there are two new fields (*RuleId* and *Order*). If we import from an INP file that contains Rules, the first time we open the attribute table it will be unordered (depending on the QGis version).

	RuleId	Order	Clause	Object	IdObj	Attribute	Operator	Value
1	1	3	AND	NODE	1	DEMAND	>	1
2	1	4	OR	NODE	2	PRESSURE	>	15
3	1	1	RULE		1			
4	1	2	IF	NODE	1	PRESSURE	>	20
5	1	7	ELSE	PIPE	3	STATUS	IS	OPEN
6	2	1	RULE		2			
7	1	5	THEN	PIPE	1	STATUS	IS	CLOSED
8	1	6	AND	PIPE	2	STATUS	IS	OPEN
9	2	2	IF	NODE	2	PRESSURE	>	20
10	2	3	THEN	PIPE	2	STATUS	IS	OPEN

In this case, it is necessary to sort by the *Order* column and then by *RuleId*. In this way, we will see an aspect very similar to how Rules are written in EPANET, but as two additional columns at the beginning. These columns will allow us to add or modify components of a specific Rule. We will have to assign the same *RuleId* for all the rows that correspond to the same Rule and then specify the appropriate order for each row in the *Order* field.

	RuleId ▲	Order	Clause	Object	IdObj	Attribute	Operator	Value
1	1	1	RULE		1			
2	1	2	IF	NODE	1	PRESSURE	>	20
3	1	3	AND	NODE	1	DEMAND	>	1
4	1	4	OR	NODE	2	PRESSURE	>	15
5	1	5	THEN	PIPE	1	STATUS	IS	CLOSED
6	1	6	AND	PIPE	2	STATUS	IS	OPEN
7	1	7	ELSE	PIPE	3	STATUS	IS	OPEN
8	2	1	RULE		2			
9	2	2	IF	NODE	2	PRESSURE	>	20
10	2	3	THEN	PIPE	2	STATUS	IS	OPEN

Default Values

DefaultValues are a set of attributes that are used in the process of reading, building, or validating the model to correct or complete information. For example, the prefixes of new elements that are created, the minimum or maximum separation at the time of introducing an element on a pipe or the default values of some of the attributes of each element. The user can modify these data making a coherent use of them.

TIPS

This section discusses some interesting points to the QGISRed user:

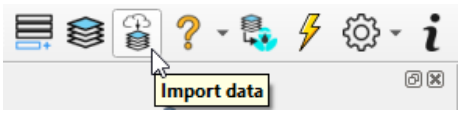
- In the Project Manager, to open a recent project it is enough to double-click on it.
- Any tool of the plugin that is used will take the information contained in the project directory, not only the open layers in QGis.
- When exporting the model to INP, if the user does not want to open the generated file, it is possible to right-click on the program path, leaving it blank.
- Saving the QGis project allows that when reopening the QGISRed project or directly the QGis project, everything appears as the user left it when saving.
- When “Show Map Tips” option is active, it requires selecting a specific layer for the labels appear.
- Importing a model from INP file replaces any previous information. However, the import of SHPs is incremental, i.e. you can import one layer and then another, obtaining at the end a combination of both.

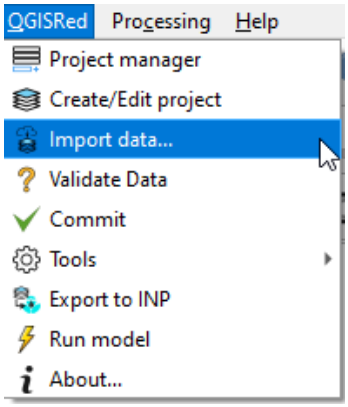
EXAMPLES

Example 1

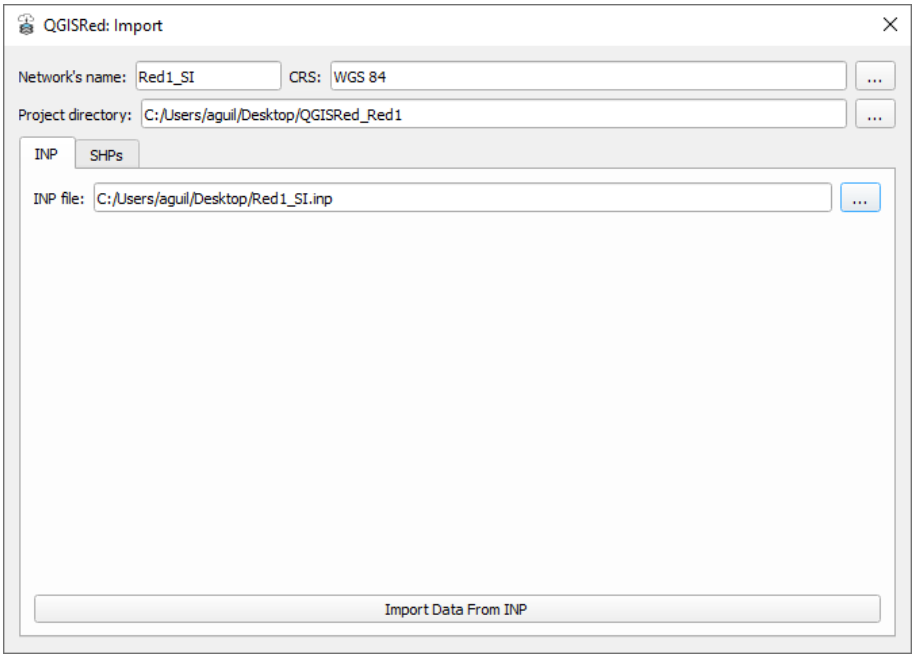
The first example illustrates the ease of importing a previous model available in an EPANET INP file and perform a hydraulic and quality simulation.

With the INP file ("Red1_SI.inp") and QGis opened, click on the import button (in the toolbar or in the upper menu):

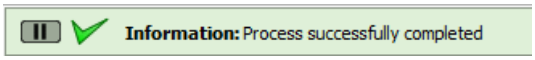




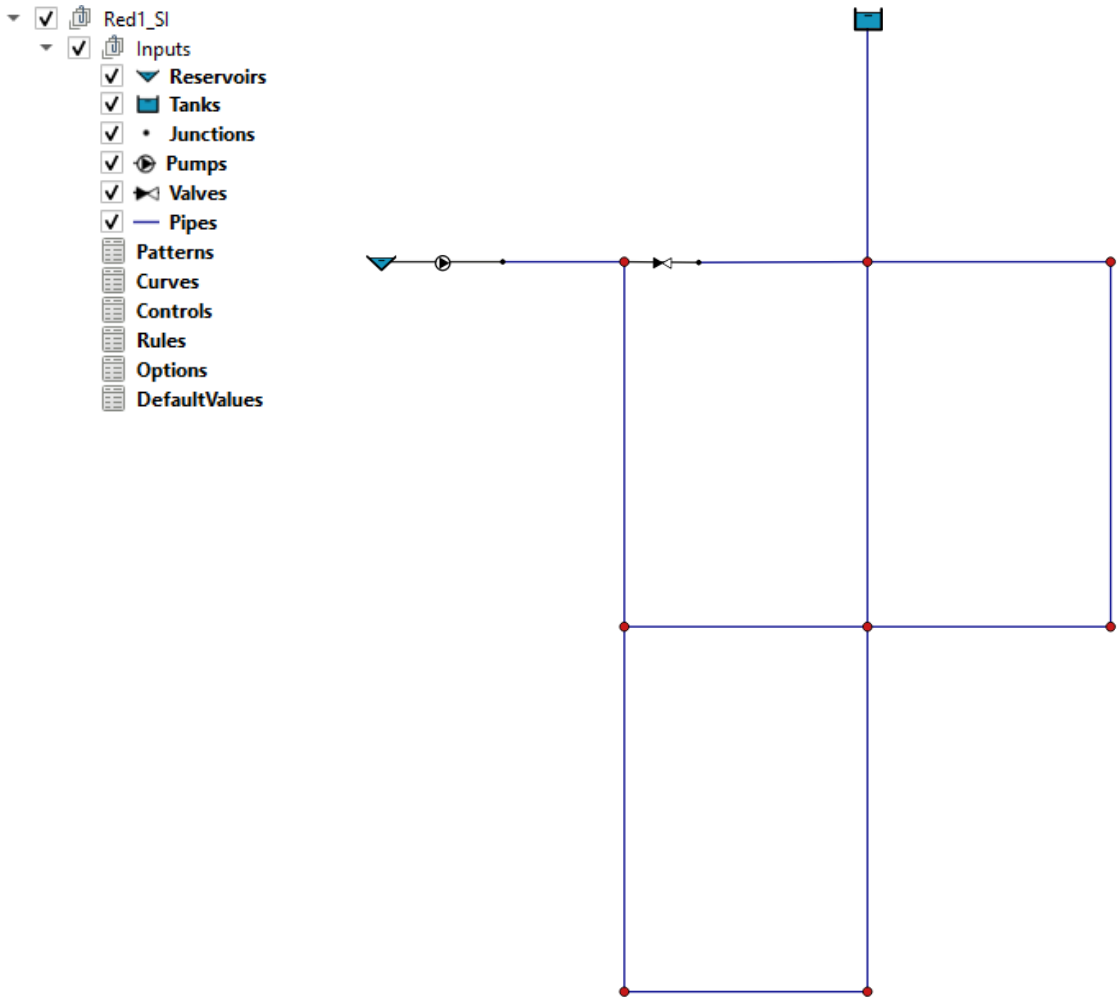
The following window will be opened, in which the user must define the name of the network, the directory where the SHPs will be stored, as well as the reference system (CRS) and the INP file. Once this information is indicated, press the "Import Data From INP" button.



In this example there is no warning in the import process, but if there were, a pop-up window would appear with the log.

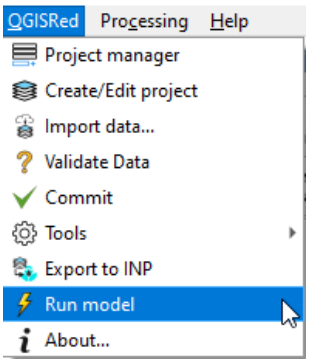


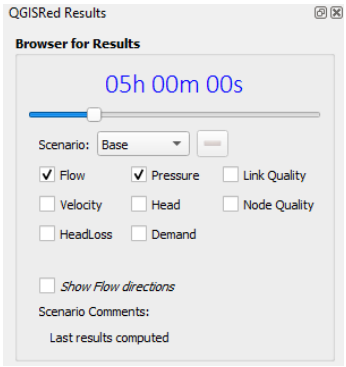
In the main QGis window the model layers and tables with non-spatial information will appear:



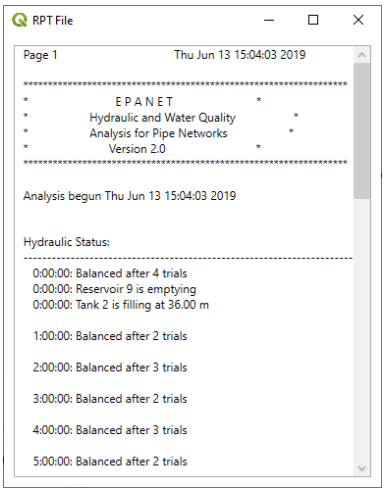
The data contained in each of the items that appear in the legend can be consulted by accessing its attribute table (secondary button on each layer or with the button available on the top toolbar). If you want to modify any value, you must enable the editing mode for the selected layer or table, change or even add some element and finally save the changes.

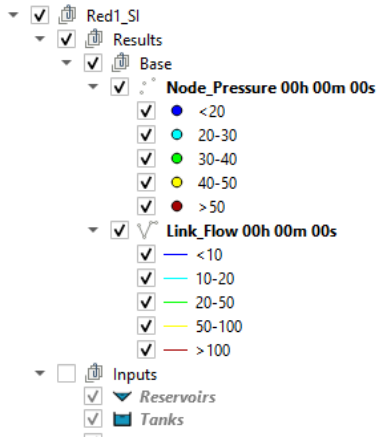
Assuming in this example that the model is completely defined, the hydraulic and quality simulation could be run. To do so, click on the "Run model" button and a right menu will appear.





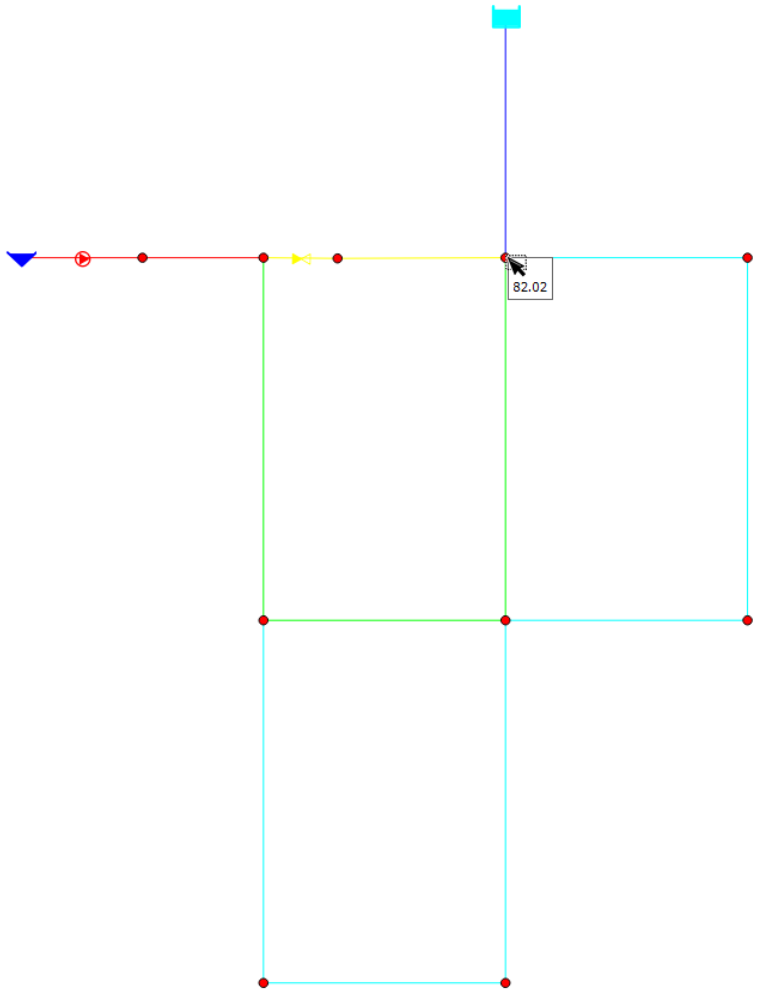
After performing the simulation, instantaneously for this example, a pop-up window appears with the report generated by the EPANET ToolKit, at the same time that the selected results are loaded (Flow and Pressure) in QGis legend.





From the right menu that appears when clicking on the simulate button, it is possible to show the different results, as well as change the instant of time to represent.

It is recommended to deactivate the Inputs group visualization, so that the representative colors of the results are better appreciated.

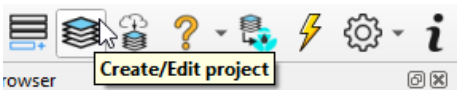


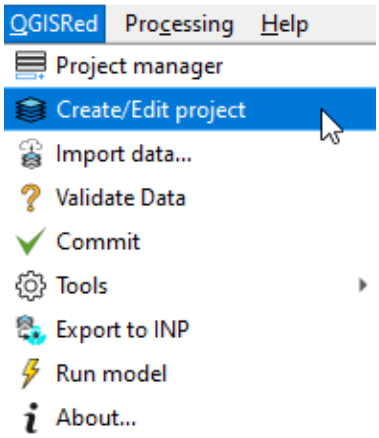
If the "Show Map Tips" option is activated, selecting a layer of results and holding the cursor over an element displays the value associated with that variable for the selected time.

Example 2

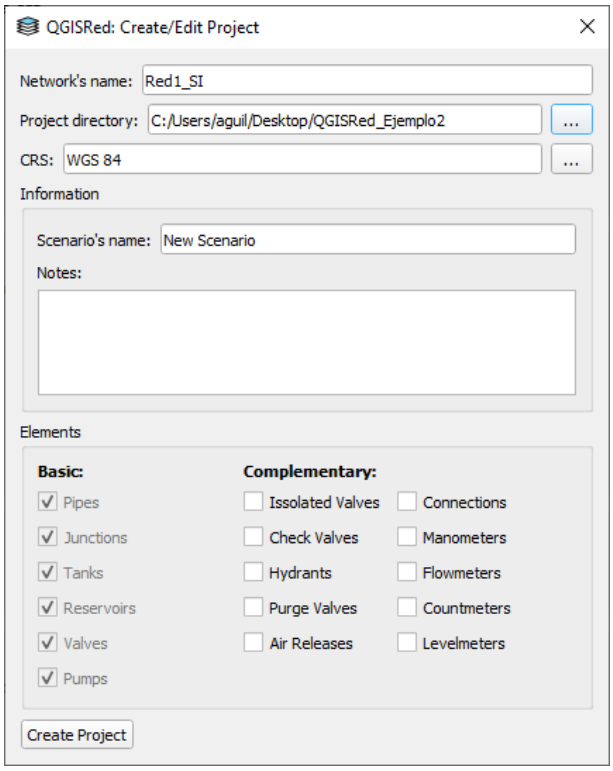
This example shows how to build the model of the previous example (*Red1_SI*) from the beginning, without importing, that is, creating the different elements in QGis.

The first thing to do, once QGis is opened, is to click on "Create/Edit Project". This can be done from the top menu or from the QGISRed plugin's own toolbar.

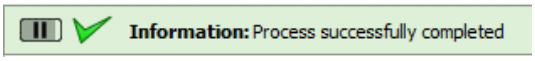


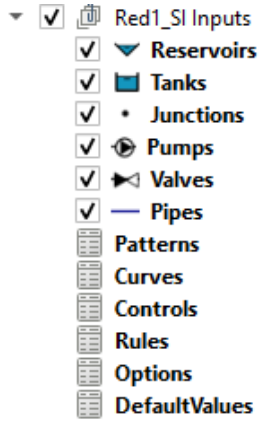


A window will be opened where the user must fill in the network name, the working directory and the reference system (CRS). For this example, that does not have a specific spatial location we can select the WGS 84. Then click on the "Create Project" button.



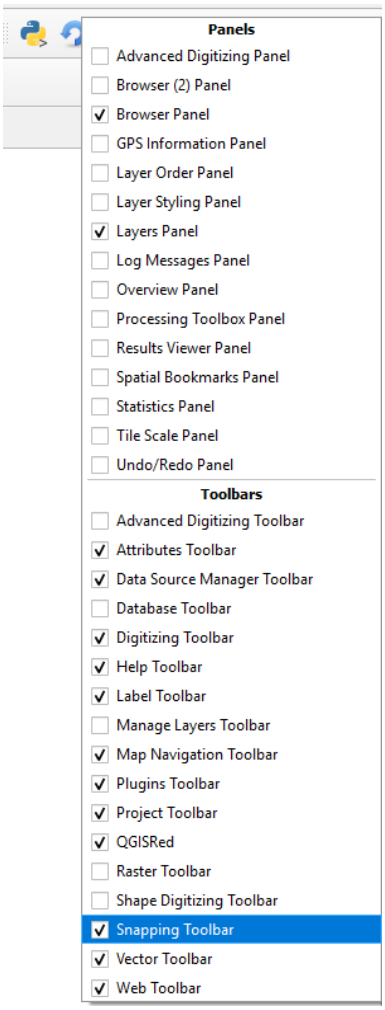
A message will appear showing that the process has been successfully completed and the legend will include the layers and tables (empty or with default values).

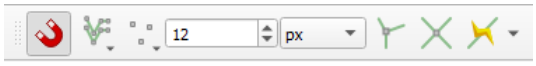




Before continuing and, as the process of create the network can take time, it is advisable to save the project with QGis. Thus, the next time we want to continue, whether we open the QGis project or the QGISRed project, everything will be the same as we left it the last time we saved it.

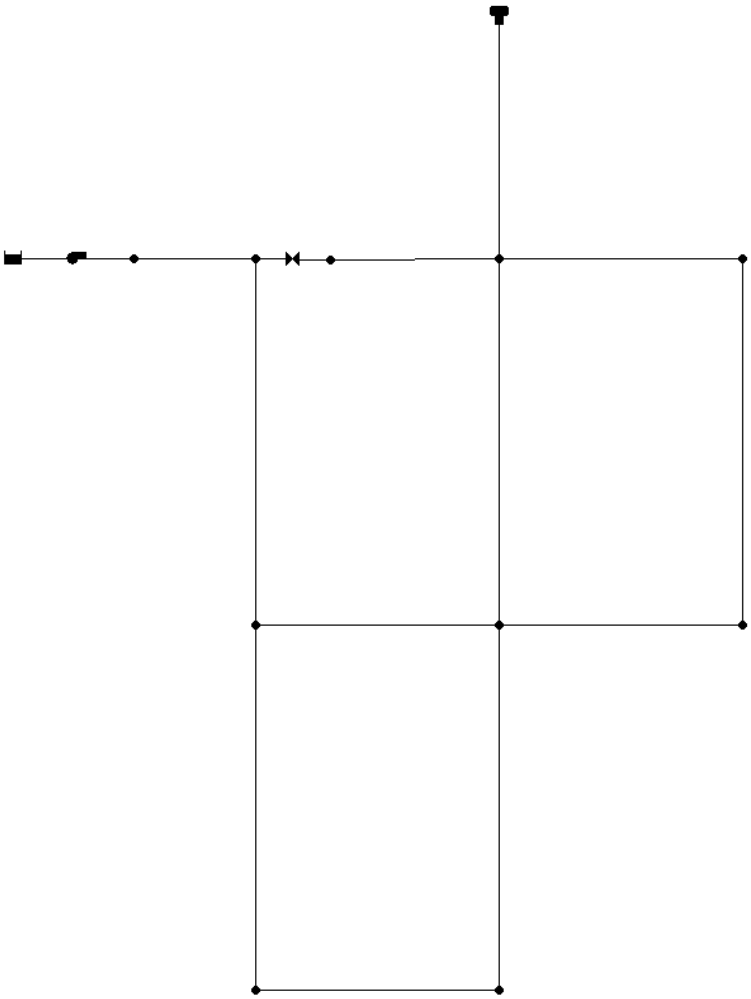
Before starting to draw the layout of our model it is convenient to activate the option of "Snapping" of QGis. This option will facilitate the creation of an element from a previous point of our model. To do this, show the "Snapping Toolbar" and activate the first button.



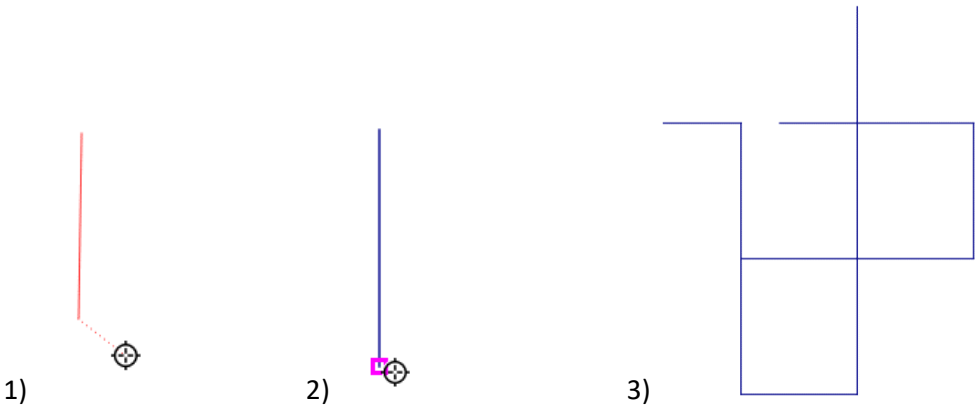


At this point we can begin to draw the layout. Possibly the most convenient thing is to begin with the pipes, then valves and pumps and, finally, tanks and reservoirs. Therefore, we should activate the Pipes layer in edit mode , select the button to create a new line.

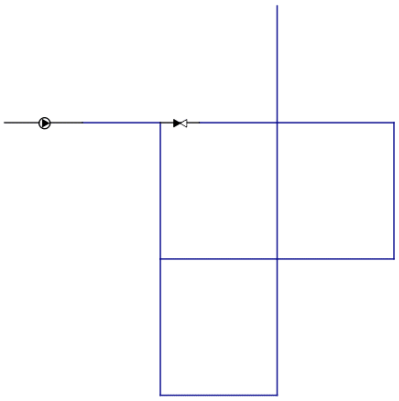
The model we must build is the following. As a starting point we can choose the pipe that starts from the upper tank.



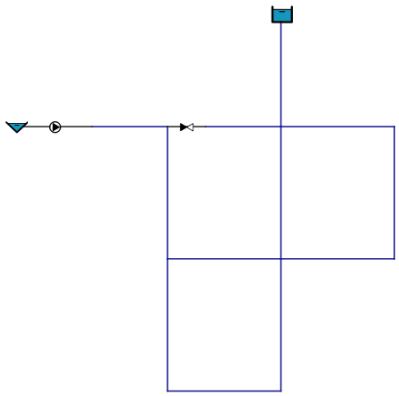
First steps:



1) 2) 3)

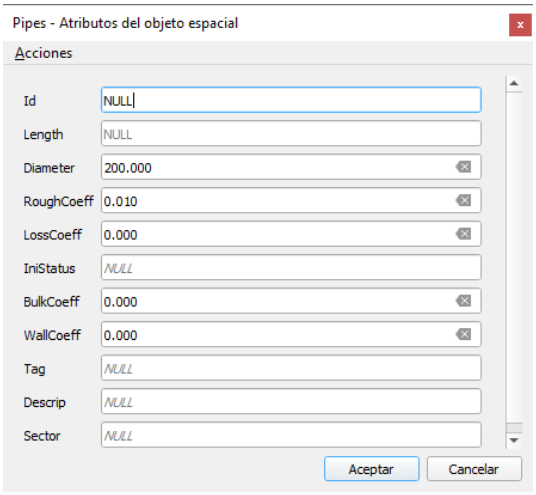


4)



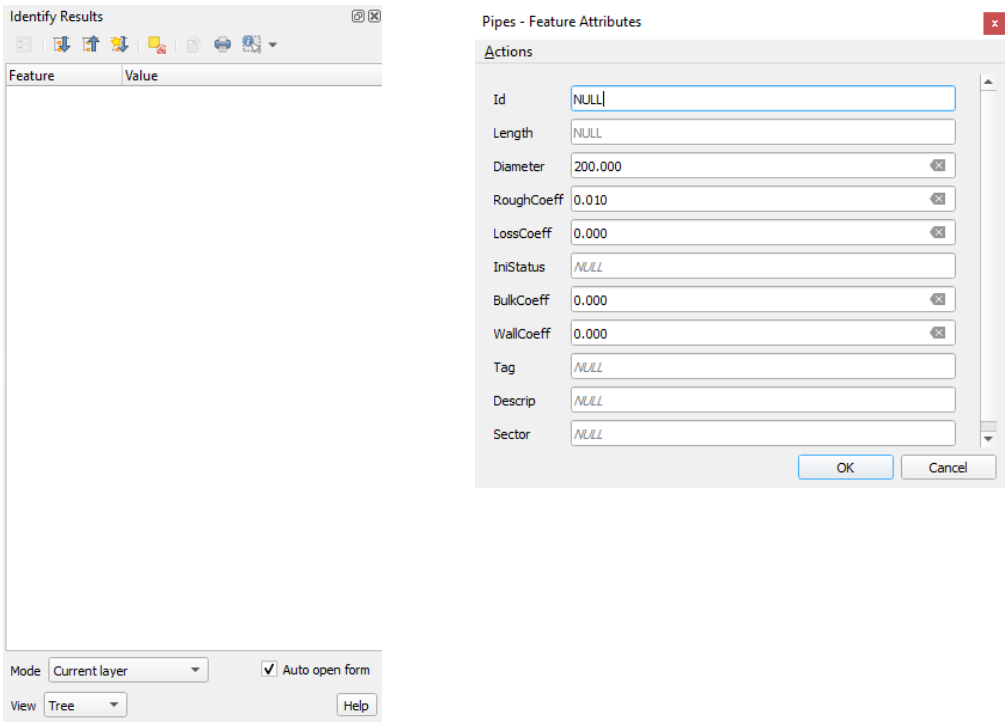
5)

1) After selecting the second point of our pipe, we press right button to accept that link. At that moment a window appears to introduce the data associated to the model and that are contained in the table of attributes. In any case, when we generate or consolidate the model, the necessary empty data will be filled in.

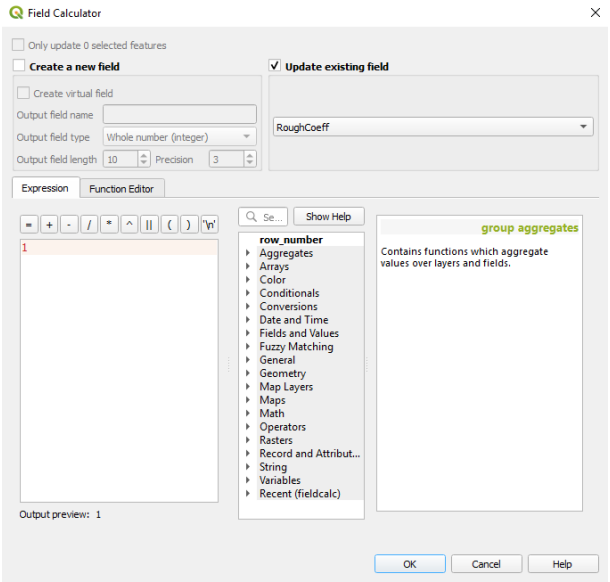


2) The fuchsia square facilitates the selection of the end of the previous pipe.
3) We finish drawing the rest of the pipes.
4) Draw the pump (activate layer edition) and the valve (activate layer edition).
5) Draw the tank (activate layer edition) and the reservoir (activate layer edition).

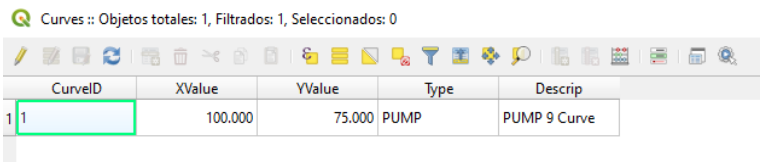
Once the topology has been built, the data for each element must be filled. To do this, maintaining the editing mode we can open the table of attributes of a type of element, in which all the elements created for that type appear and complete the information. Another option is to use the object identifier by selecting the "Auto open form" option from the right menu. This allows clicking on an element to open a pop-up window to enter data for that element only.



An additional option when the value of a field is repeated in all or almost all elements (e.g. the roughness coefficient of the pipes in the example), it is possible to use the field calculator . Select the option to update existing field, select the field and complete the desired value.

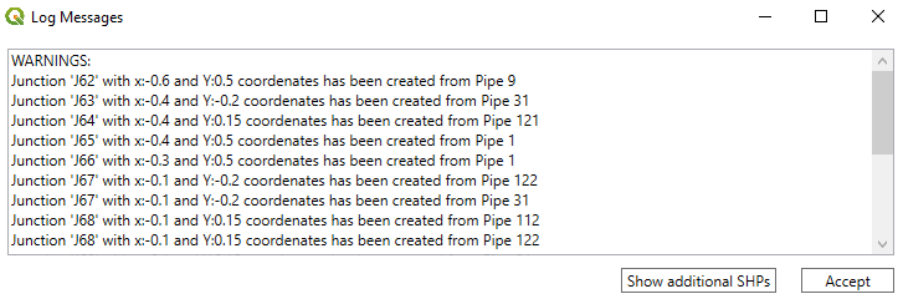


Once all the element data has been entered, the pump characteristic curve data must be completed. To do this, we open the table of attributes of the element of the legend entitled Curves, enable the editing mode, add a new record and complete the necessary information.

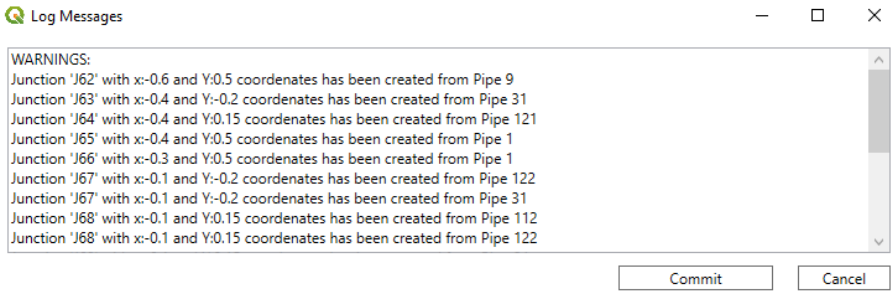


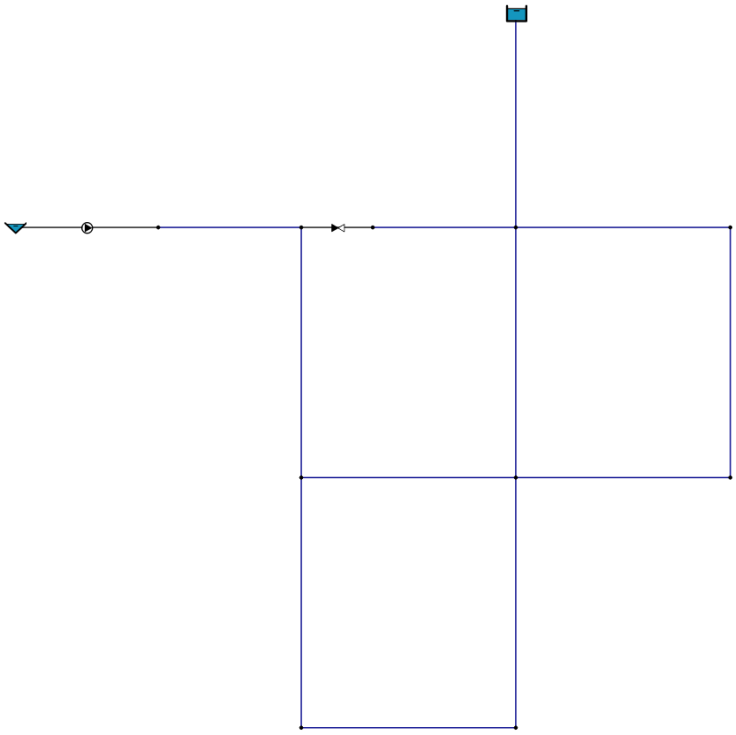
As the reader will have observed, no junctions have been introduced at this time. They could be added manually one by one and complete their information or, once we validate and commit the model, these elements will be created and it will be enough to complete the data such as, for example, those related to the base demand.

At this point, we can validate the topology and data entered. Pressing the button ? will show a list of messages, corresponding only to the creation of nodes (*junctions*) from pipes. However, we can see in QGis how these elements have not been created. This is the difference with the Commit button ✓, which, apart from showing the corresponding warnings, applies the changes to our SHPs files.

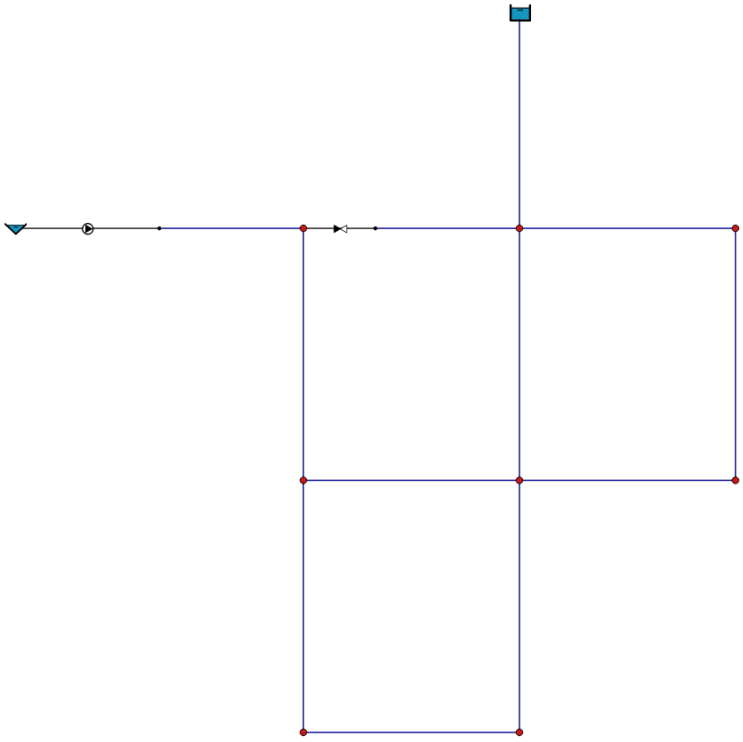


If we therefore proceed to commit ✓, the same list of messages will appear. If we consider it correct, when clicking on the Commit button (pop-up window), we will see how the missing nodes have been created in the layout.

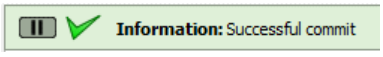




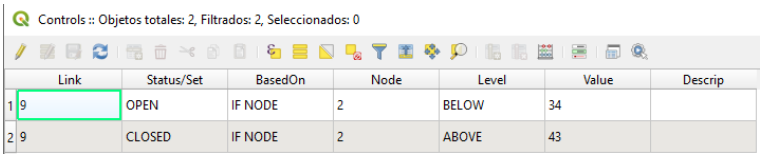
Once we have the nodes, we can complete their data, as has been done with the rest of the elements. Now we must visualize our scheme with the following figure.



If we validate again, we'll see how no messages appear in the log pop-up window.



Another aspect to complete are the simple controls that are defined for this example. In the attribute table of the Controls element of the legend two records must be added.



To finish, before proceeding with the simulation, it is necessary to modify the relevant options, to do so we access the attribute table of the Options element of the legend.

HEADLOSS	D-W
UNBALANCED	CONTINUETO
CONTINUETO	10
QUALITY TYPE	CHEMICAL
CHEMICAL LABEL	Cloro
CONCENTRATION UNITS	mg/l
DURATION	24:00
QUALITY TIMESTEP	00:05
STATUS	YES
SUMMARY	NO

If we simulate in the same way as in the Example 1, we will see that the same results are obtained.