QGISRed v. 0.12

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 0.12

QGis versions: 3.2-3.99

What's new:

- Editor of the roughness-material table for the estimation of roughness according to material and age
- New option to import and export patterns/curves in CSV format
- New tool to import base demands at junctions (single or multiple) and its Id patterns from CSV file
- Added import of service connections from SHP
- New tool to obtain the minimum spanning tree of the network
- Updated the Epanet library to version 2.2
- Improved the interface for converting roughness coefficients
- Fixed error when displaying quality results
- Refresh of current units and headloss formula in the status bar when loading a QGis project
- Projects imported from INP are now also displayed in the list of projects
- Fixed error when nodes have no coordinates
- Negative lengths are now avoided when inserting valves or pumps
- Fixed error to access Patterns when TimeStep Pattern is 0:00
- Service connections are now read correctly

DETAILS OF PREVIOUS VERSIONS

Version 0.11

QGis versions: 3.2-3.99

Features:

- Created a Json file to define the different projections (.prj file content) in case the Internet is not available
- Implemented the reading of the PUMPS section formats inherited from Epanet version 1.1
- New single installer for both architectures (x86 and x64)
- The units and headloss formula are displayed in the status bar.

- The estimation of roughness coefficients as a function of age and material support different headloss formulas and unit systems
- Conversion of roughness coefficients between different headloss formulas and unit systems
- Tool to create a project backup (manual restoration)
- Fixed error when loading the plugin in QGIS version 3.14.15
- Fixed error for not allowing to express the hours in a format other than AM/PM in the Controls section
- Fixed error when not being able to take the user information from Windows in some computers
- New blue color labels in results for line elements
- Fixed error when cloning the project and losing the metadata
- Fixed error when saving a result scenario and freezing the map
- New alphabetical order in the link and node lists in the Simple Controls

Version 0.10

QGis versions: 3.0-3.14.1

Features:

- Fixed not correct behaviour in create/import tools when other layers are open.
- Headers of the INP sections written in English.
- Validation in element properties to prevent same final node in lines.
- Fixed error when importing tanks.
- Improved simplification of vertices to eliminate repetitions at the starting point.
- Fixed error writing the Times of Options.
- Metadata restructuring, now unified in the *_Metadata.txt file.
- Fixed error joining pipes with the same characteristics when they start and end in the same node.
- Check for new versions and notify the user.
- Fixed icons display in the legend for QGis version 3.12
- Fixed bug that prevented saving result styles.
- Fixed error in decimal symbol reading when the user uses the English format and changes the decimal symbol by comma.
- EditProject switches to LayerManagement to control visibility of layers and their creation.
- Now the projection is correctly saved in the PRJ file.
- New window with project options.
- Separation between Import (without project - INP or SHPs) and Add data (with project - only SHPs).
- Spatial tolerance when importing/adding data from SHPs.
- Manual includes ascii file format for elevation interpolation and classification of the 4 types of hydraulic sectors.
- Simplified 4 layers of meters in only 1.
- Fixed error when writing SHPs of issues in valves and pumps.
- Methods to assign roughness, check overlapping elements, aligned vertices, lengths, material, diameter or installation date now also for selected elements.
- Fixed error in very specific case when creating individual T-connections.
- New dependency management to avoid errors if they are in use.

- Some improvements on the features already offered in previous versions

Version 0.9

QGis versions: 3.0-3.99

Features:

- A new logo for the QGISRed plugin
- Easy creation of pipes, reservoirs and tanks, with snapping tool
- Tool to create (add as you click), move or delete (right click) vertices of links
- Fixed valve/pump orientation when inserted into pipes
- Tool to reverse links (pipes, valves and pumps)
- Tool to split and join pipes
- Tool to join / separate nodes
- Tool to create / undo T connections
- Tool to create / undo pipe crossings
- Tool to move valves and pumps
- Multiple selection of elements from different layers in one step (Ctrl adds, and Shift removes)
- Deletion of all selected elements within a polygonal region
- Removed most of double buttons and replaced by a new option in the dialog window
- New button to access the latest results without running the model again
- Results menu can be expanded and compressed to allow coupling other QGIS windows
- Fixed error when working with long paths
- Some improvements on the features already offered in previous versions

Version 0.8

QGis versions: 3.0-3.99

Features:

- Editing properties of the main elements through a dialog window, being able to navigate from it through the different elements contained in the model.
- Insertion/Elimination of valves and pumps in pipes. In the first case, by clicking on a point in the pipe, the pipe will be split or shortened (whichever the case may be) to introduce the new element. In the second case, by clicking on the valve or pump element, it will be eliminated by joining the adjacent pipes if possible.
- Editing the network layout, being able to move nodes of the model so that the rest of the connected elements also move accordingly.
- Rearrangement of all the buttons of the plugin in 5 categories to facilitate the handling of the different options.
- Correction of some bugs as control rules are read.
- Dialogs for editing analysis options and default values.
- Verification of repeated Ids during their generation.
- Hiding of legend data tables (Patterns, Curves, Controls, Rules, Options and Default Values).
- Changes in the results selection menu to show a single variable per node or per line. Reduction of refresh time.
- Option to visualize the value of the chosen parameter for each element by using static labels.

- Elimination of administrator permissions to install the necessary dependencies.
- Some improvements on the features already offered in previous versions.

Version 0.7

QGis versions: 3.0-3.99

Features:

- Abstract report with the number of elements of each type, as well as the flow units, the pressure loss formula and if any quality parameter is modeled.
- Modulation Curves Manager: Allows you to edit, create, delete, clone, export and import new patterns. Adds the option to define the pattern type. It also indicates which elements are associated with that pattern. Finally, it includes the functionality of working with real values (depending on the base value associated with the pattern) or with a multiplier or factor (traditional form).
- Curves Manager: Allows you to edit, create, delete, clone, export and import new curves. For curves associated with pumps, in the case of 1 or 3 points, the equation of the approximate curve is specified. The elements associated with these curves are also specified.
- Simple Controls Manager: Allows editing, adding, deleting, cloning and ordering Simple control laws. It includes the option of being able to disable a control law.
- Rules Manager: Allows editing, adding, deleting, cloning and ordering Rules. It includes the option of being able to disable a Rule. You can combine different conditions through the OR and AND operators, as well as select the appropriate combined condition to apply to the Rule.
- In both Controls managers its definition is done interactively and not by typing text (traditional way).

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).

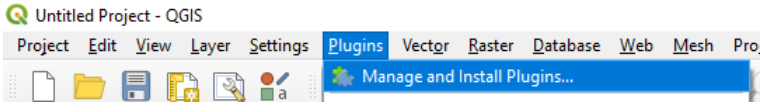
INSTALLATION

The QGISRed plugin requires the installation of dependencies (as detailed below). The QGISRed dependencies work under Windows operating system and require the installation of version 4.5 of the Windows .Net Framework component. Therefore, the QGISRed plugin will only work under these conditions.

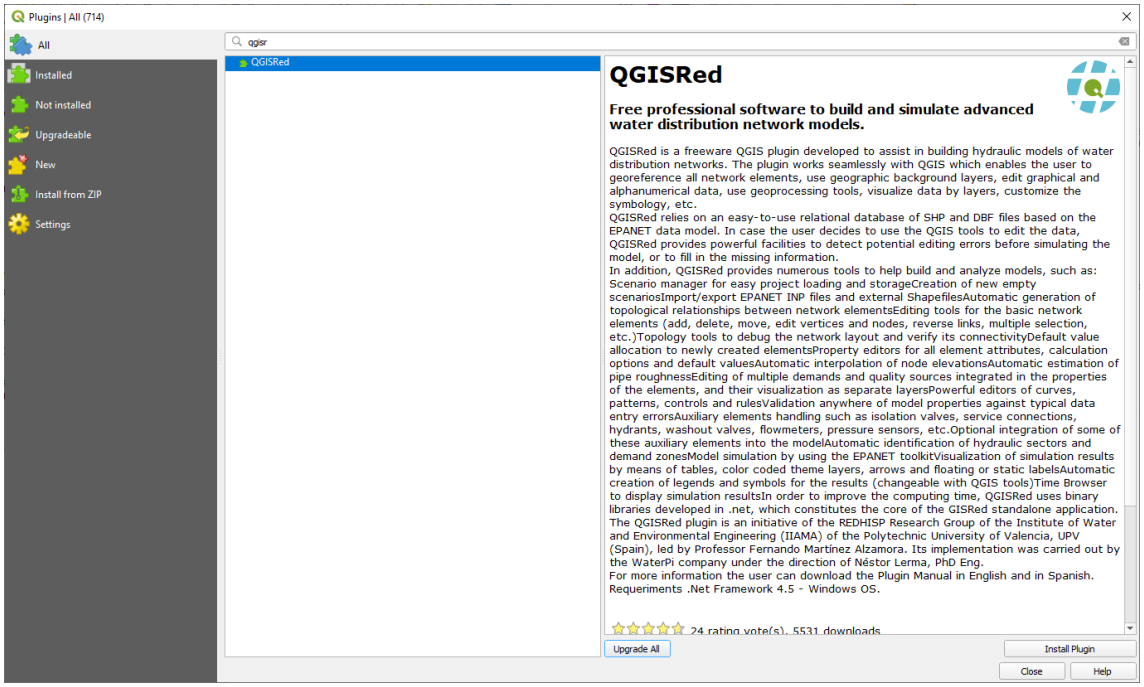
Repository

To install the plugin or an update from the official QGis repository, follow these steps:

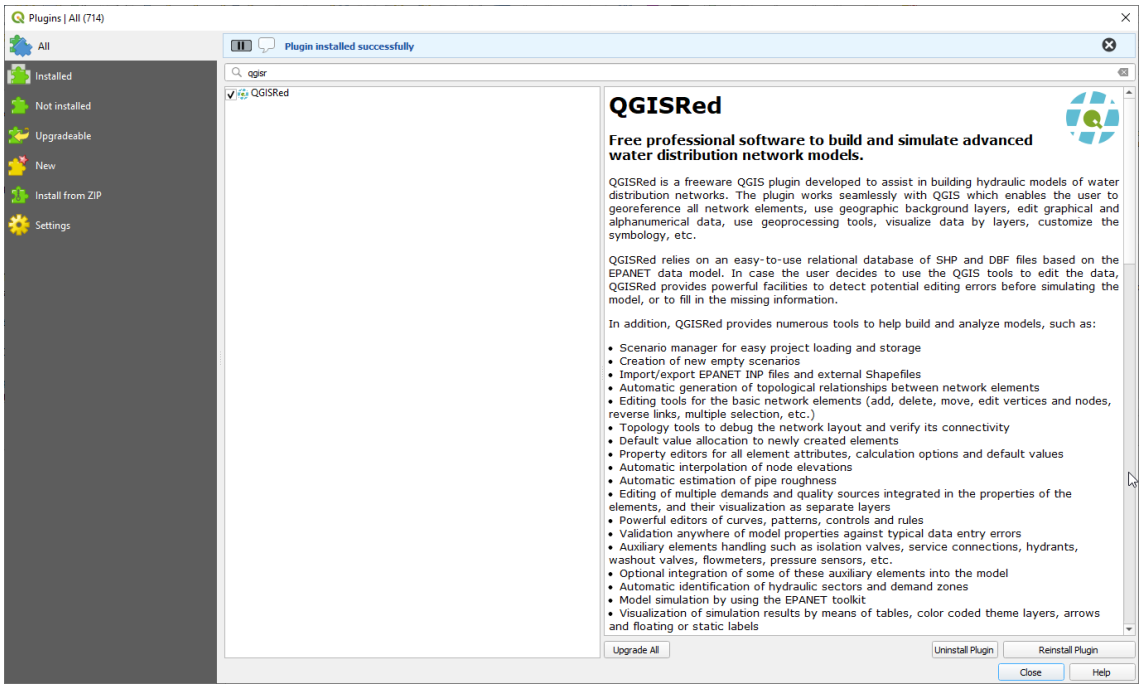
1. Start QGis v3.x
2. Go to Plugins menu→Manage and Install Plugins…



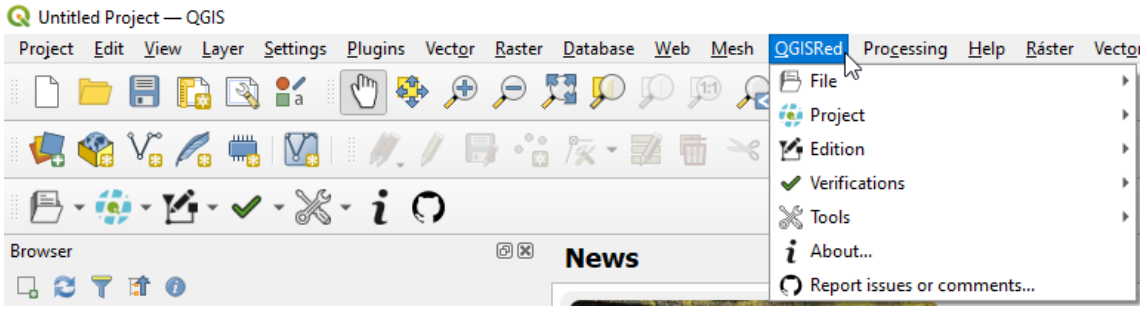
3. Select the "All" tab, in the top bar type QGISRed. Then select the only item that appears and finally press the button to install it in the lower right corner ("Install Plugin").



4. Once installed, a message will appear indicating that the plugin has been installed.



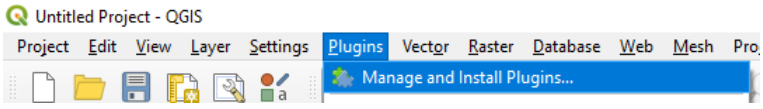
5. Close the window at the end of the process.
6. A new button bar and a new item should appear in the top menu.



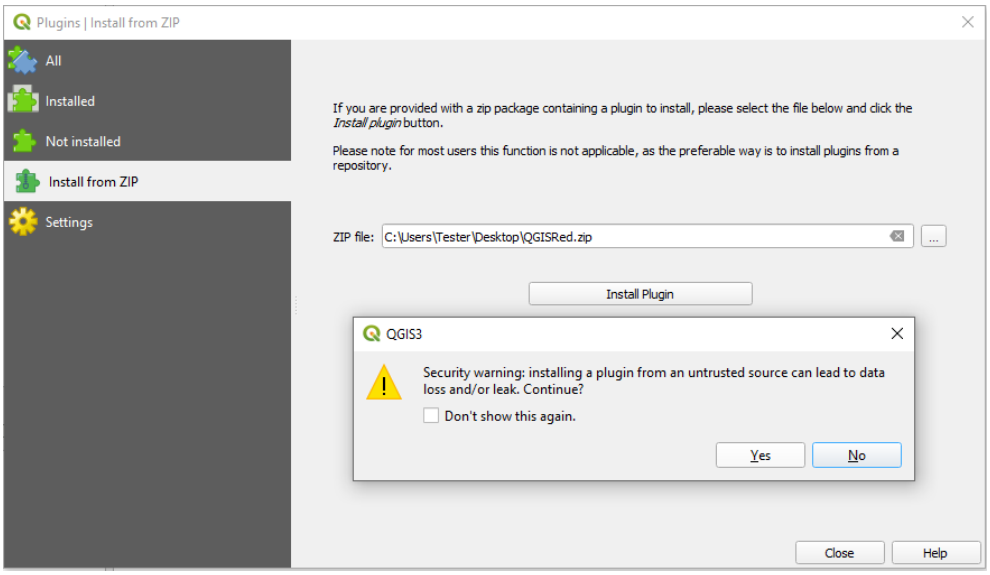
Local

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.

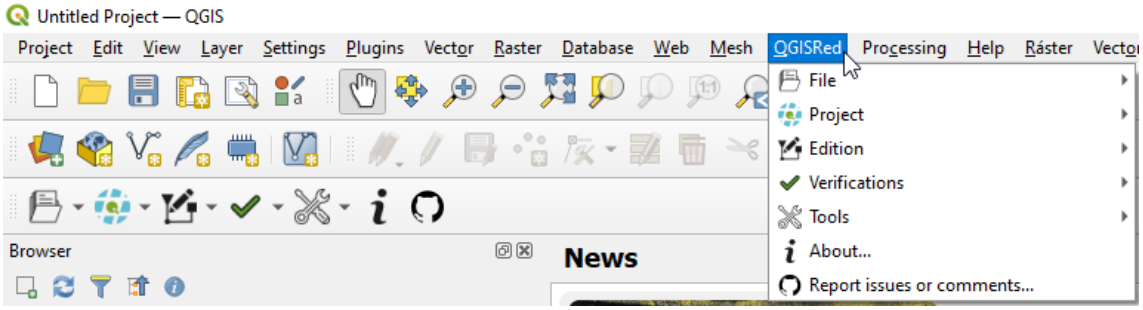
1. Start QGis v3.x
2. Go to Plugins menu→Manage and Install Plugins…



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".

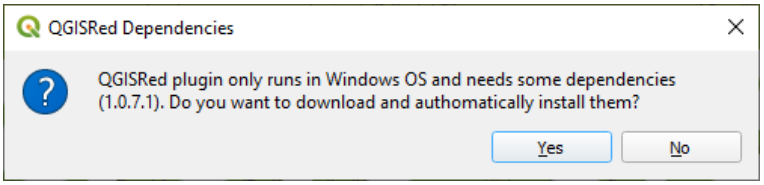


4. Close the window at the end of the process.
5. A new toolbar and a new item should appear in the top menu.



Dependencies

1. Once installed, when the user wants to use some plugin tool, a message will appear indicating the need to install the QGISRed dependencies mentioned above.



2. Clicking on the "Yes" button will download and install the necessary dependencies for the operation of the plugin (does not require administrator permissions).
3. In the case of pressing the "No" button, when the user tries again to use any tool of the plugin will indicate the need to install the plugin dependencies.

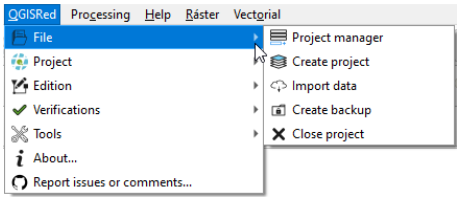
GETTING STARTED

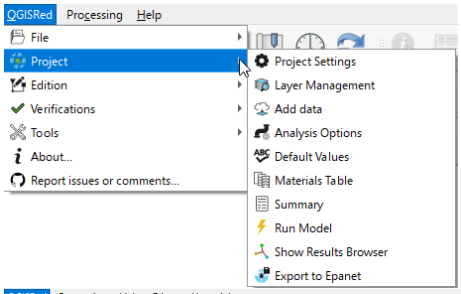
This section briefly introduces each tool available in the plugin. In the following sections more details will be presented.

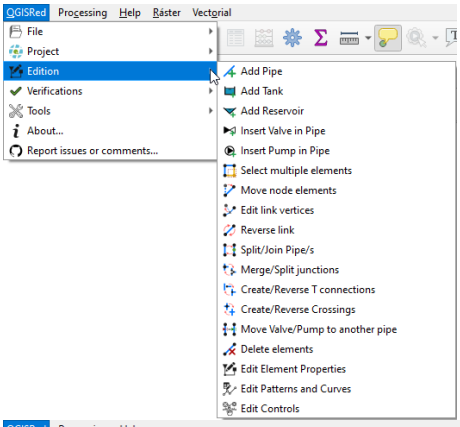
The plugin is mainly divided into five categories, each with a set of tools shown below.

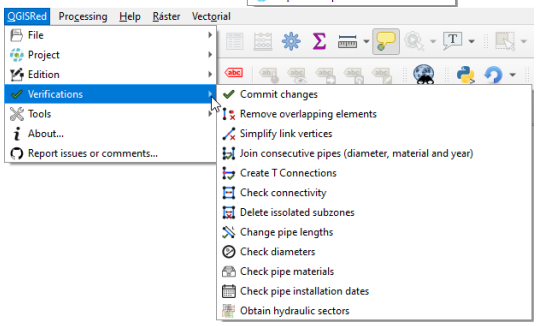
Categories:

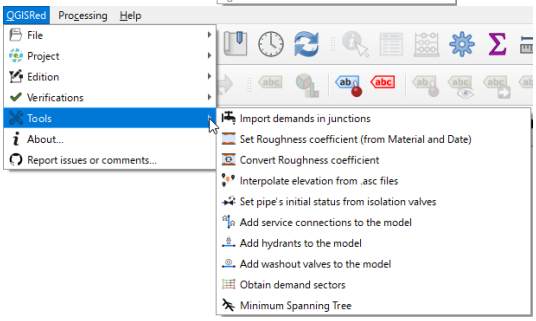
- File
- Project
- Edition
- Verifications
- Tools







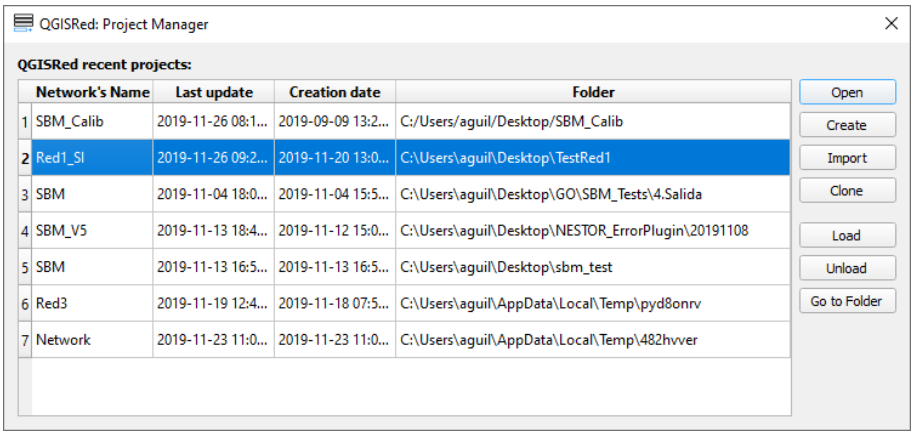




File

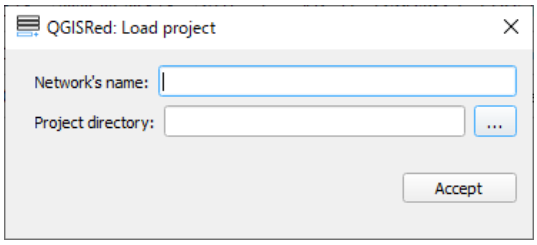
This category contains the tools related to the management of a project, that is, the basic utilities to open, create, import and close.

Project Manager



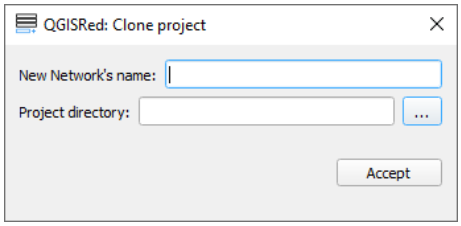
This window allows the user to manage recently opened QGISRed projects, but also to load projects that do not appear in the list, to unload those that the user do not want to appear, to make a copy of one, to create a new project, import data or to access to the project directory.

Load



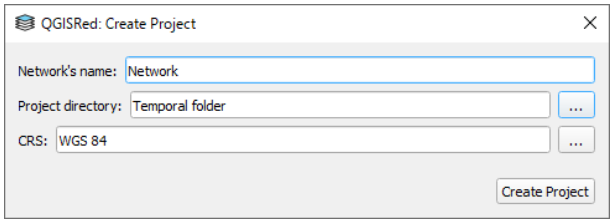
For importing a project it is necessary to specify the name of the network and the directory where the SHPs are stored.

Clone



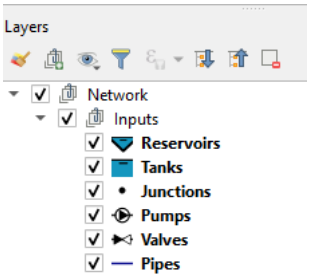
To clone a project, the user must specify the new name of the network and the directory where he wants to copy it. If the network name is different from the original, the directory can be the same. In other words, there can be several QGISRed projects in the same directory.

Create 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.

The required data to create a project is the name of the network and the directory where the information will be stored. It is possible to specify the Coordinate Reference System (CRS) too. 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.

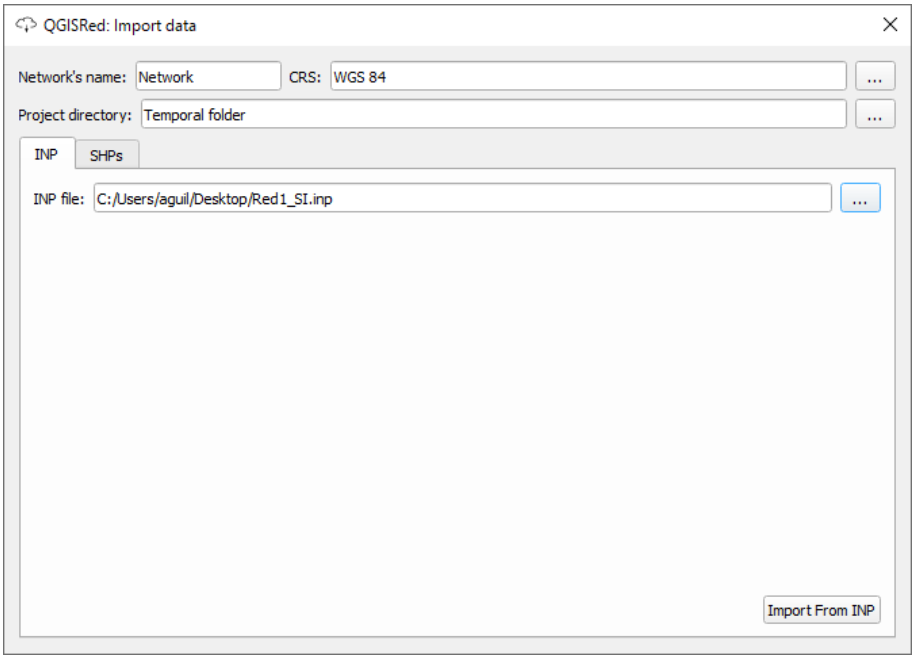


Once created, the following content will appear in the legend: A group with the name of the network which, in turn, will include another group titled "Inputs", thus indicating that this information is input data to build the model. Within the group, at least 6 SHPs are included, one for each type of EPANET base element.

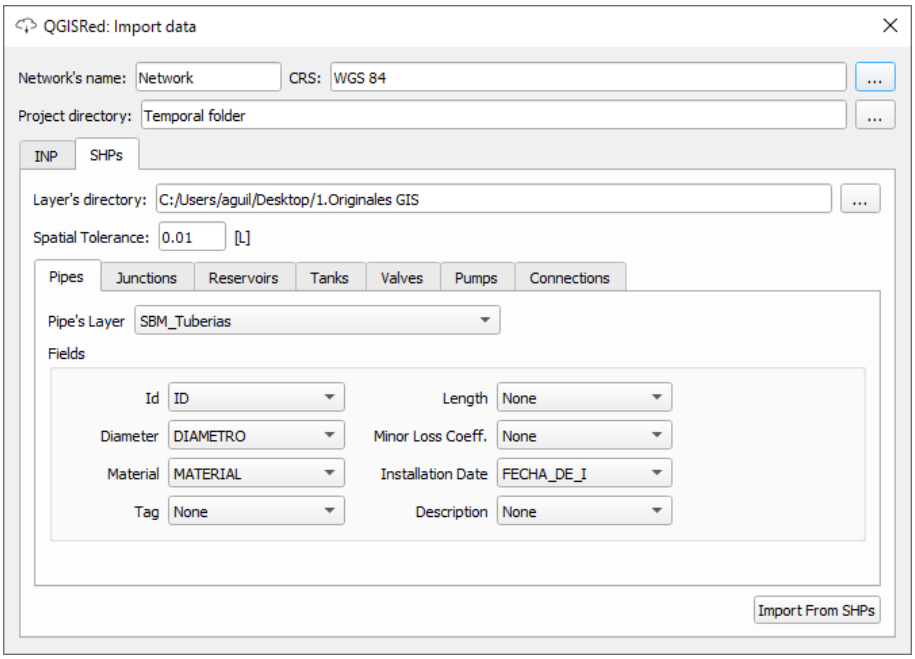
Import data

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. In this second case, a specific value for the spatial tolerance it is possible to stablish.

- From INP:



- From SHPs:



Create project backup

This tool allows you to create a backup of all the project files in a compressed file (ZIP).

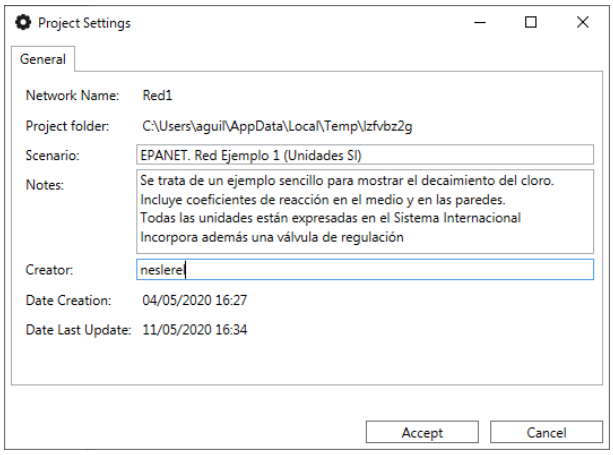
To restore it you would have to do it manually by unzipping the content in the project folder.

Project

This category allows you to edit the project, see a summary of what it contains, export it to another format and simulate the hydraulic and quality model.

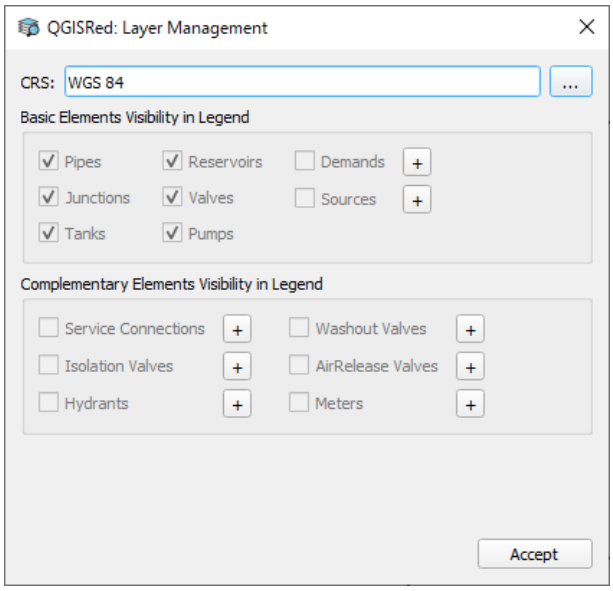
Project Settings

This window also allows you to specify a scenario name, write down a series of notes related to the scenario and edit the creator's name.



Layer management

This tool allows you to control which layers to see in the legend or, if they do not exist, to create the layer associated with an element. In addition, you can specify in which projection the information is (this tool does not reproject).

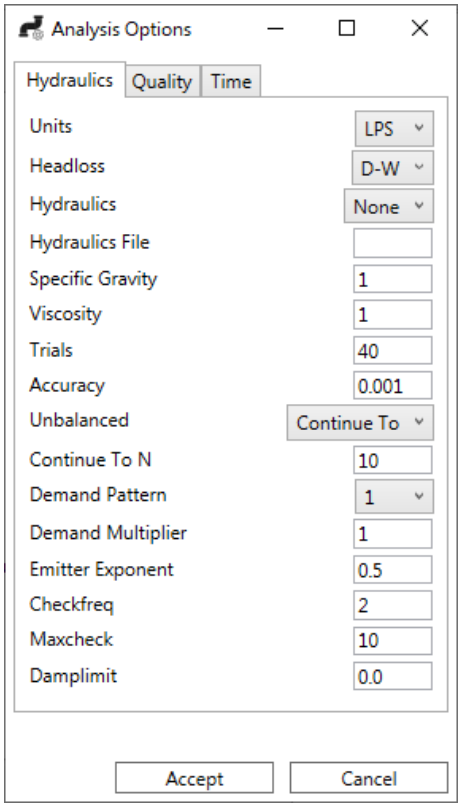


Add data

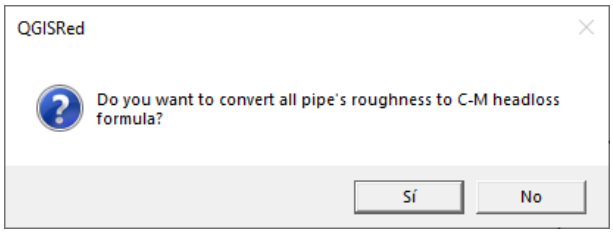
This tool is the same as Import data, but in this case, it does not allow you to add information from an INP to your current project.

Hydraulic Options

It is possible to edit the properties associated with the calculation of the hydraulic and quality model.

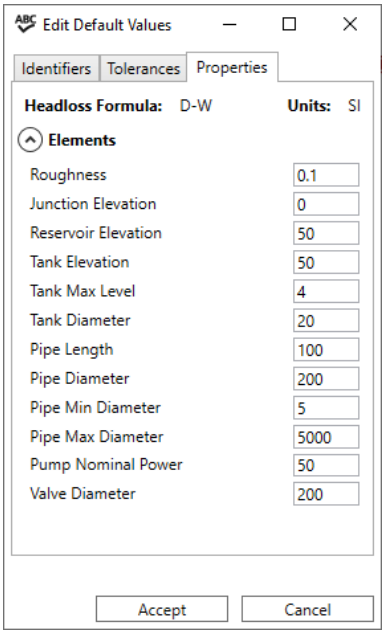


In the case of the headloss formula, when changing the value, you will be asked if you want to convert the roughness taking into account the new formula chosen.



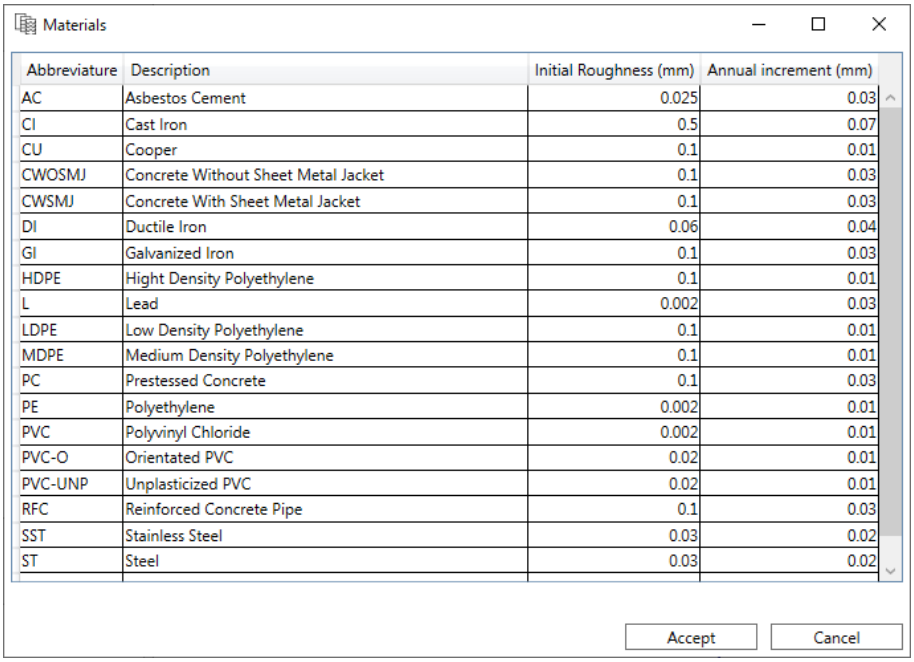
Default Values

Also, it is possible to edit the default values used in the creation of the different supported elements.



Materials table

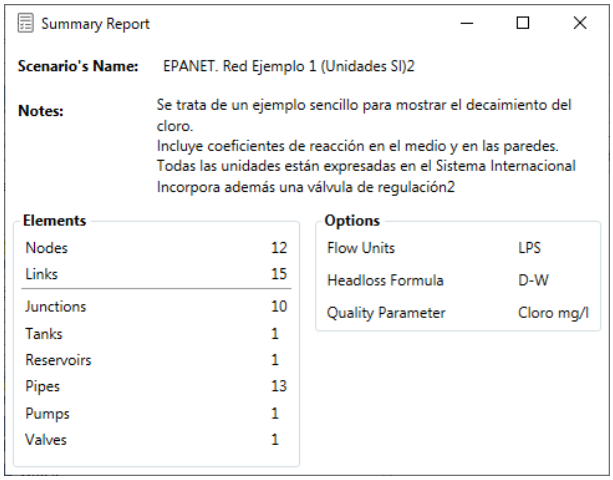
Allows the definition of the material together with the initial roughness and the annual increase. These data are used for estimating roughness as a function of the material and age of the pipes.



Abbreviature	Description	Initial Roughness (mm)	Annual increment (mm)
AC	Asbestos Cement	0.025	0.03
CI	Cast Iron	0.5	0.07
CU	Cooper	0.1	0.01
CWOSMJ	Concrete Without Sheet Metal Jacket	0.1	0.03
CWSMJ	Concrete With Sheet Metal Jacket	0.1	0.03
DI	Ductile Iron	0.06	0.04
GI	Galvanized Iron	0.1	0.03
HDPE	Hight Density Polyethylene	0.1	0.01
L	Lead	0.002	0.03
LDPE	Low Density Polyethylene	0.1	0.01
MDPE	Medium Density Polyethylene	0.1	0.01
PC	Prestessed Concrete	0.1	0.03
PE	Polyethylene	0.002	0.01
PVC	Polyvinyl Chloride	0.002	0.01
PVC-O	Orientated PVC	0.02	0.01
PVC-UNP	Unplasticized PVC	0.02	0.01
RFC	Reinforced Concrete Pipe	0.1	0.03
SST	Stainless Steel	0.03	0.02
ST	Steel	0.03	0.02

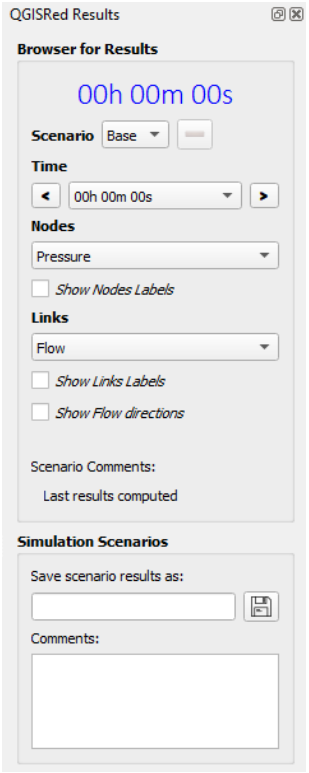
Summary

Allows access to a window where the elements contained in the template are summarized, as well as some units and formulas of interest.

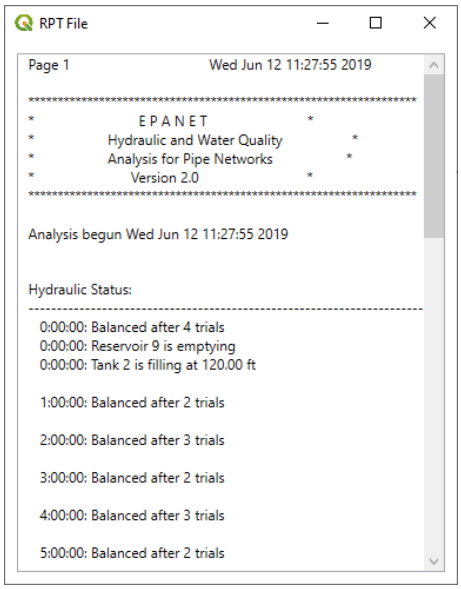


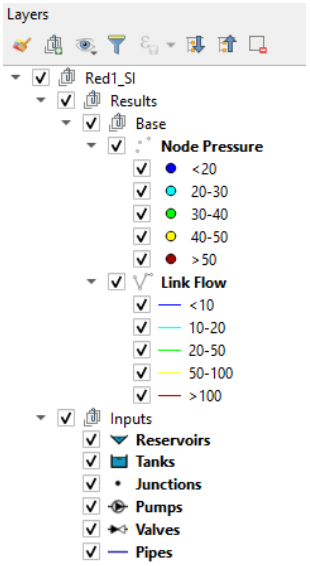
Run Model and Show Results

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 selected 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.

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.

Edition

This section allows you to edit the layout, element properties and other components such as curves and controls.

Creation of basic elements

With these buttons it is possible to create the basic elements that Epanet handles for a hydraulic network. The first, apart from creating a pipe and assigning its default properties, also generates the two extreme nodes (Junctions type).

The next two buttons allow you to create reservoirs and reservoirs. In this case, it is necessary to click on an existing node (it is not possible to create an isolated node).

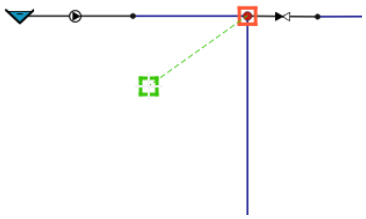
The last two buttons allow you to insert valves and pumps into existing pipes. Therefore, it is necessary to select a point of a pipe.

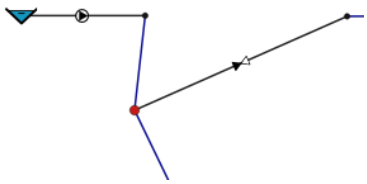
Multiple selection

With the button ( ) it is possible to select with a rectangle (by clicking and dragging) or with a polygon (by clicking on each of the points - without dragging) all the elements that are within the selected region. This allows, for example, to massively delete items. In next versions it will allow to apply certain tools on the selected elements.

Move nodes

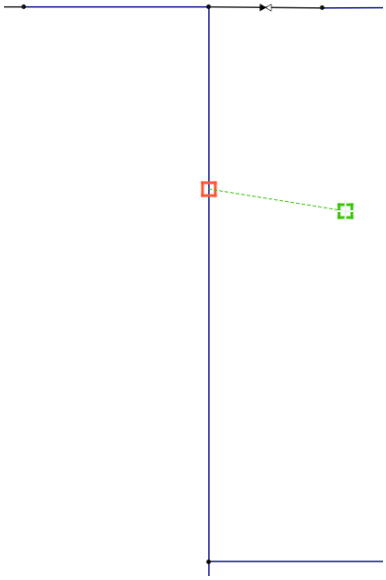
The button ( ) allows to move the nodes of our network (Junctions, Tanks, Reservoirs) and to move the rest of the elements that coincide spatially with this (other nodes, pipes, valves or pumps).

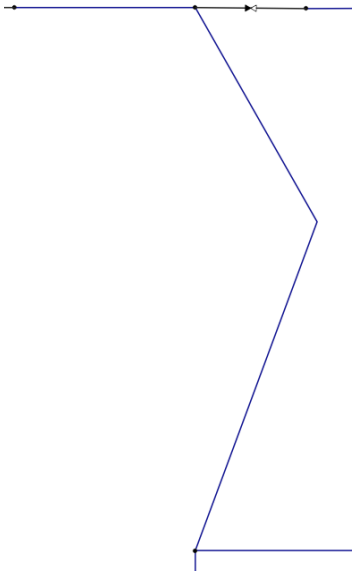




Vertex Editing

With this tool ( ) it is possible to move the intermediate vertices of the linear elements (pipes, valves and pumps), as well as create new vertices (by clicking where you want to add) or delete them (right click on the vertex).





Tools on network elements

With these tools it is possible:

- Reverse the orientation of a line (pipe, valve or pump)
- Split a pipe or join two pipes with the same properties (diameter, age and material)

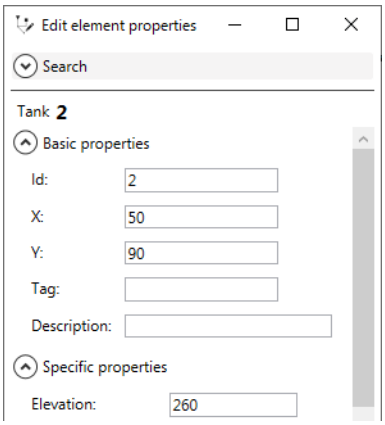
- Divide a node into several, one according to the number of lines you connect. Reverse process of joining nodes. The nodes must be of the Junction type. To divide, right click on the node. To join, it must be two by two. First select the origin node and then the destination node (left button).
- Create or reverse connections in T. It works similarly to the previous tool.
- Create or reverse pipe crossings. You must click with the left button on the junction node to merge or on the crossing point of two pipes.
- Move valves or pumps from one pipe to another (or in the same pipe, but in another position).

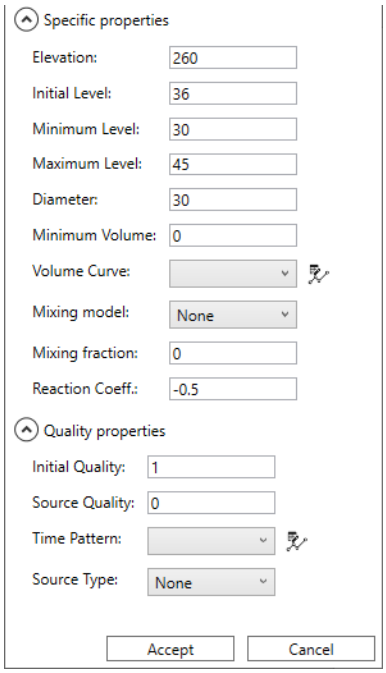
Remove elements

This tool ( ) allows you to delete elements. You can previously select those that you want to delete or, otherwise, select the element to be deleted by clicking on it.

Properties

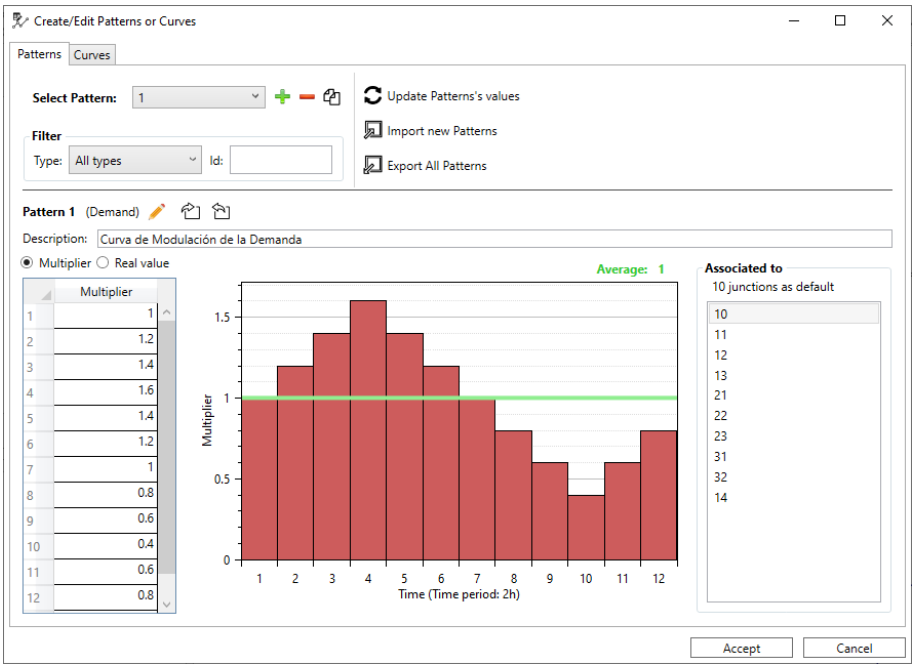
This button ( ) allows you to select any element of our model and access its properties (through a dialog window) and modify them in a simple and intuitive way.





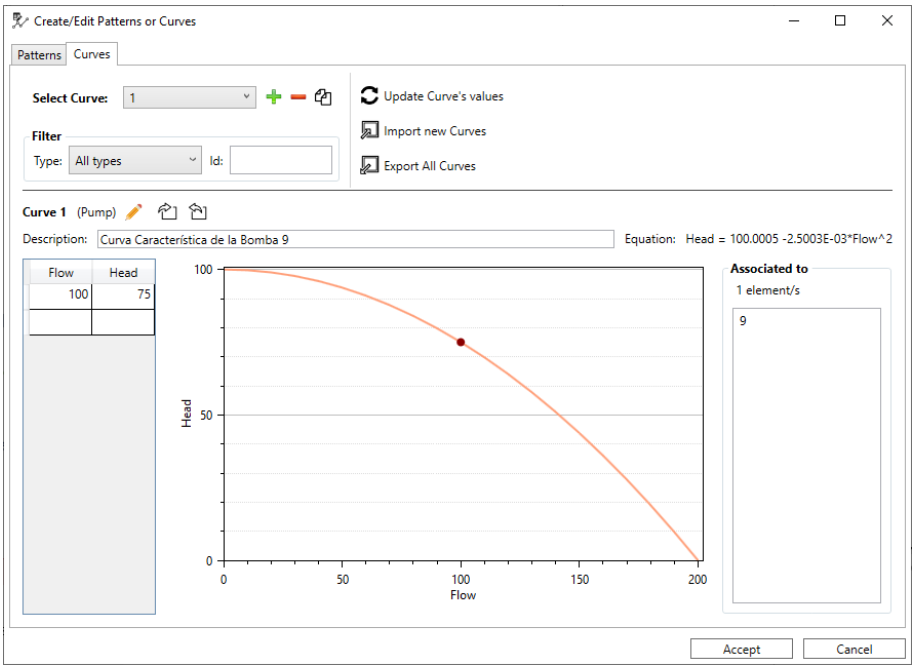
Patterns

The button gives access to edit Patterns and Curves. In the first tab of the window it is possible to manage the Patterns.



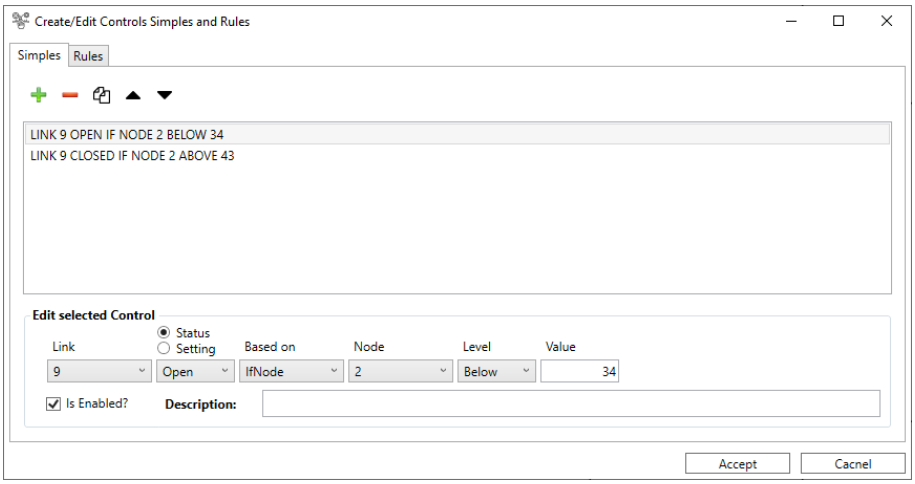
Curves

From the same button, but in the second tab, you can manage the Curves.



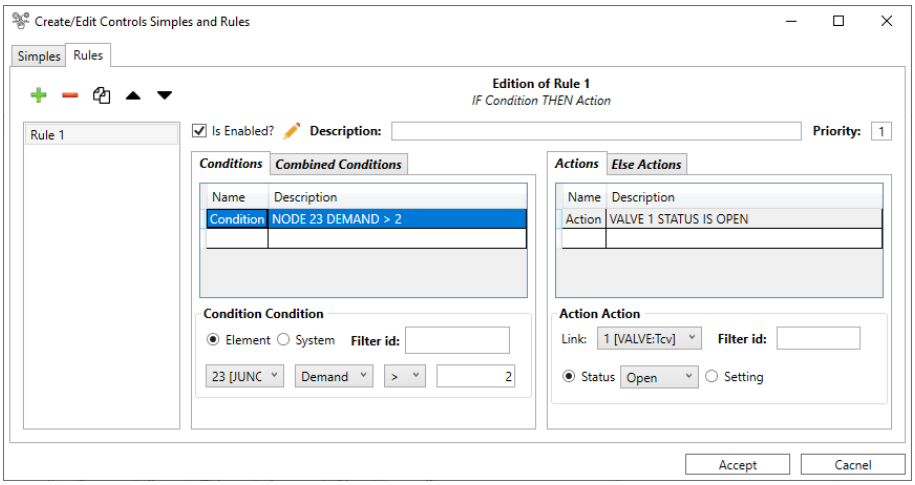
Simple Controls

The button  gives access to the editing of the different types of controls (Simple or Rules). In the first tab of the window you can manage the Simple controls.



Rules

From the same button, but in the second tab, you can manage Rules.



Verifications

This category contains a set of tools for verifying the topology and data introduced. The tools are applied massively to the entire network.

The current utilities allow:

- Consolidate the data introduced.
- Search for overlapping elements and delete them.
- Simplify aligned vertices in linear elements.
- Simplification or union of pipes with the same diameter, material and year of installation.
- 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.
- 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.
- 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.
- Hydraulic sectors: the tool tries to identify whether all demands can be supplied from available sources, tanks and reservoirs.
    - For each sector, depending on the existence or not of demands and tanks, it is classified into 4 types:
        - TYPE A: Sub-network in which there is at least one source of supply, i.e. a tank, a reservoir or an injection point, and in addition at least one of its nodes is a flow node and therefore with an assigned base demand. This sub-network would really be a hydraulically compatible sub-system, in which all its nodes could be supplied with guarantees.
        - TYPE B: Sub-network in which there is at least one source of supply, i.e., a reservoir, a reservoir or an injection point, but in which none of its flow nodes has an assigned base demand. This sub-network would be a hydraulically compatible sub-system, in which there would be no flow rate because there are no demand points.
        - TYPE C: Sub-network in which there are no sources of supply, but nevertheless its flow nodes have a base demand assigned. This sub-network would form an isolated, hydraulically incompatible sub-system, in which its nodes could not be supplied as there is no source of supply.
        - TYPE D: Sub-network in which there are no sources of supply, and in addition none of the flow nodes have a base demand assigned. This sub-network would be an isolated sub-system, but hydraulically compatible, since its nodes do not need to be supplied, and therefore no sources of supply are required.

Tools

In this category you have a set of utilities to apply properties or insert elements massively.

Current utilities allow:

- Import the base demand and the id of the pattern for the junctions
    - File format: IdJunction; Base Demand; IdPattern (split by ; or ,)
- Assignment of the roughness coefficient according to the material and the year of installation according to the headloss formula defined in the project.
- Conversion of the roughness between some headloss formulas and others:

  Darcy-Weisbach (D-W); Hazen-Williams (H-W); Chezy-Manning (C-M)

    - From D-W to H-W:

$$C_{HW} = A + B(log_{10}\varepsilon + 3)^C \quad , \quad \varepsilon \ in \ mm$$

$$If \ \varepsilon < 0.001 \ \rightarrow \ \varepsilon = 0.001 \ mm$$

    - From H-W to D-W

$$\varepsilon = 10^{\left[\left(\frac{C_{HW}-A}{B}\right)^{1/C}-3\right]}, \quad \varepsilon \ in\ mm$$

$$If\ C_{HW} > A \ \rightarrow \ C_{HW} = A$$

with:

$$A = 157 - 12(e^{-5D}) \qquad ; e\ (2.718281828)$$
$$B = -4.89 - 1.15(log_{10}D) \qquad ; D\ (m)$$
$$C = 1.97 - 0.263(log_{10}D)$$

- From D-W to C-M:

$$n = A + B(log_{10}\varepsilon + 3)^C, \varepsilon \ in\ mm$$

$$If\ \varepsilon < 0.001 \ \rightarrow \ \varepsilon = 0.001$$

- From C-M to D-W:

$$\varepsilon = 10^{\left[\left(\frac{n-A}{B}\right)^{1/C}-3\right]}, \qquad \varepsilon \ in\ mm$$

$$If\ n < A \ \rightarrow \ n = A$$

with:

$$A = 0.0101 + 0.00115(\log_{10}D), \qquad ; D\ (m)$$
$$B = 7.77 * 10^{-6} + 1.02 * 10^{-5} * e^{-5D} \qquad ; e\ (2.718281828)$$
$$C = 4.84$$

- From H-W to C-M:
  Converting from H-W to D-W and from D-W to C-M
- From C-M to H-W:
  Converting from C-M to D-W and from D-W to H-W

For more information go to this research.

- Massive interpolation of the elevations of node elements (junctions, tanks and reservoirs) from ASCII files.
  - The file format should be as follows:

```
NCOLS 5843
NROWS 3869
XLLCENTER 684010
YLLCENTER 4374410
CELLSIZE 5
NODATA_VALUE -999
377.278 377.468 377.551 377.641 377.756 377.955 378.114 378.25 378.253 378.275 378.
377.376 377.428 377.659 377.754 378.021 378.126 378.395 378.476 378.227 378.337 378
377.637 377.559 377.68 377.992 378.138 378.352 378.473 378.44 378.413 378.376 378.4
377.341 377.594 377.864 378.076 378.236 378.285 378.408 378.55 378.636 378.589 378.
377.391 377.717 377.946 377.961 378.097 378.237 378.253 378.304 378.348 378.446 378
377.618 377.942 378.03 377.992 378.129 378.379 378.304 378.225 378.318 378.642 378.
377.703 377.773 377.927 378.103 378.286 378.367 378.225 378.407 378.564 378.73 378.
```

    Where NCOLS is the number of columns, NROWS is the number of rows, XLLCENTER is the X coordinate of the center of the cell in the lower left corner of the grid, YLLCENTER is the Y coordinate of the center of the cell in the lower

left corner of the grid, CELLSIZE is the cell size and NODATA_VALUE is the default value of the cell when no data is available.

    - The interpolation is made only for the nodes whose elevation is equal to the default value (different according to the type of element: Junction, Reservoir or Tank). If the user has previously modified or imported that elevation, it is not interpolated.

- Assignment of the initial state of a pipe according to the state of the isolated (or cut) valves.
- Insert connections, both as a punctual node or as a link (pipe)
- Insert 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.
- Insert 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.
- 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.
- Minimum Spanning Tree.

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

From version 0.8 this data can be introduced from the properties window and does not need to know the available options. However, if you want to edit some data manually from the attribute table:

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 in versions before 0.12, 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*

From version 0.12, the value of *Material* field corresponds with the acronym of Material table.

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

From version 0.7 onwards, new tools are available for entering this information (see the corresponding section). This data is stored in data tables (DBF) that can be edited from QGis. To

modify this type of information directly from the tables, it is 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 three new fields (*RuleOrder, LineOrder y Name*). 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).

	RuleOrder	LineOrder	Clause	Object	IdObj	Attribute	Operator	Value	Name
1	1	6	AND	PIPE	2	STATUS	IS	OPEN	a2
2	1	5	THEN	PIPE	1	STATUS	IS	CLOSED	a1
3	2	1	RULE		2				
4	1	7	ELSE	PIPE	3	STATUS	IS	OPEN	ea1
5	2	3	THEN	PIPE	2	STATUS	IS	OPEN	Action
6	2	2	IF	NODE	2	PRESSURE	>	20	Condition
7	1	2	IF	NODE	1	PRESSURE	>	20	c1
8	1	1	RULE		1				
9	1	4	OR	NODE	2	PRESSURE	>	15	c3
10	1	3	AND	NODE	1	DEMAND	>	1	c2

In this case, it is necessary to sort by the *LineOrder* column and then by *RuleOrder*. 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 *RuleOrder* for all the rows that correspond to the same Rule and then specify the appropriate order for each row in the *LineOrder* field.

	RuleOrder ▲	LineOrder	Clause	Object	IdObj	Attribute	Operator	Value	Name
1	1	1	RULE		1				
2	1	2	IF	NODE	1	PRESSURE	>	20	c1
3	1	3	AND	NODE	1	DEMAND	>	1	c2
4	1	4	OR	NODE	2	PRESSURE	>	15	c3
5	1	5	THEN	PIPE	1	STATUS	IS	CLOSED	a1
6	1	6	AND	PIPE	2	STATUS	IS	OPEN	a2
7	1	7	ELSE	PIPE	3	STATUS	IS	OPEN	ea1
8	2	1	RULE		2				
9	2	2	IF	NODE	2	PRESSURE	>	20	Condition
10	2	3	THEN	PIPE	2	STATUS	IS	OPEN	Action

The last column "Name" allows you to name each of the conditions or actions defined, so that through the interface they can be easily recognized.

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:

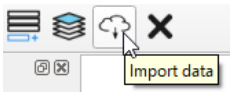
- In the Project Manager, to open a recent project it is enough to double-click on it.
- Importing a model from INP file replaces any previous information. However, the import of SHPs is incremental, i.e. you can import one layer and then another, obtaining at the end a combination of both.
- Any tool 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.

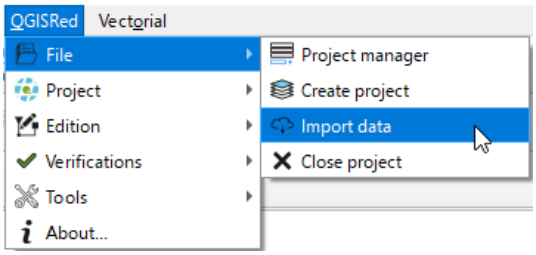
EXAMPLES

Example 1

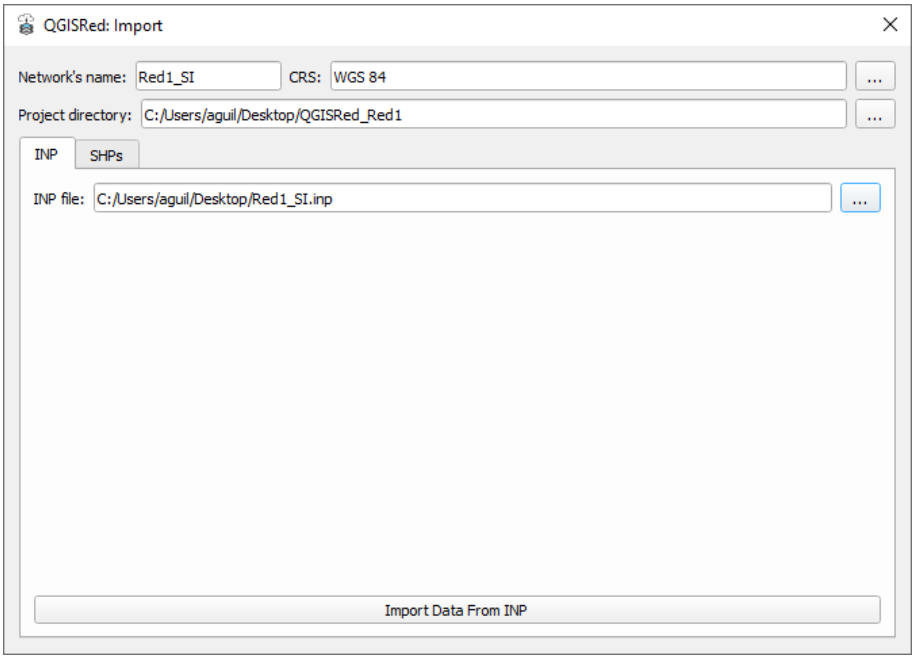
The first example illustrates the ease of importing a previous model available in an EPANET INP file and perform a hydraulic and quality simulation.

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

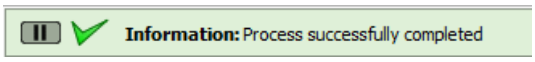




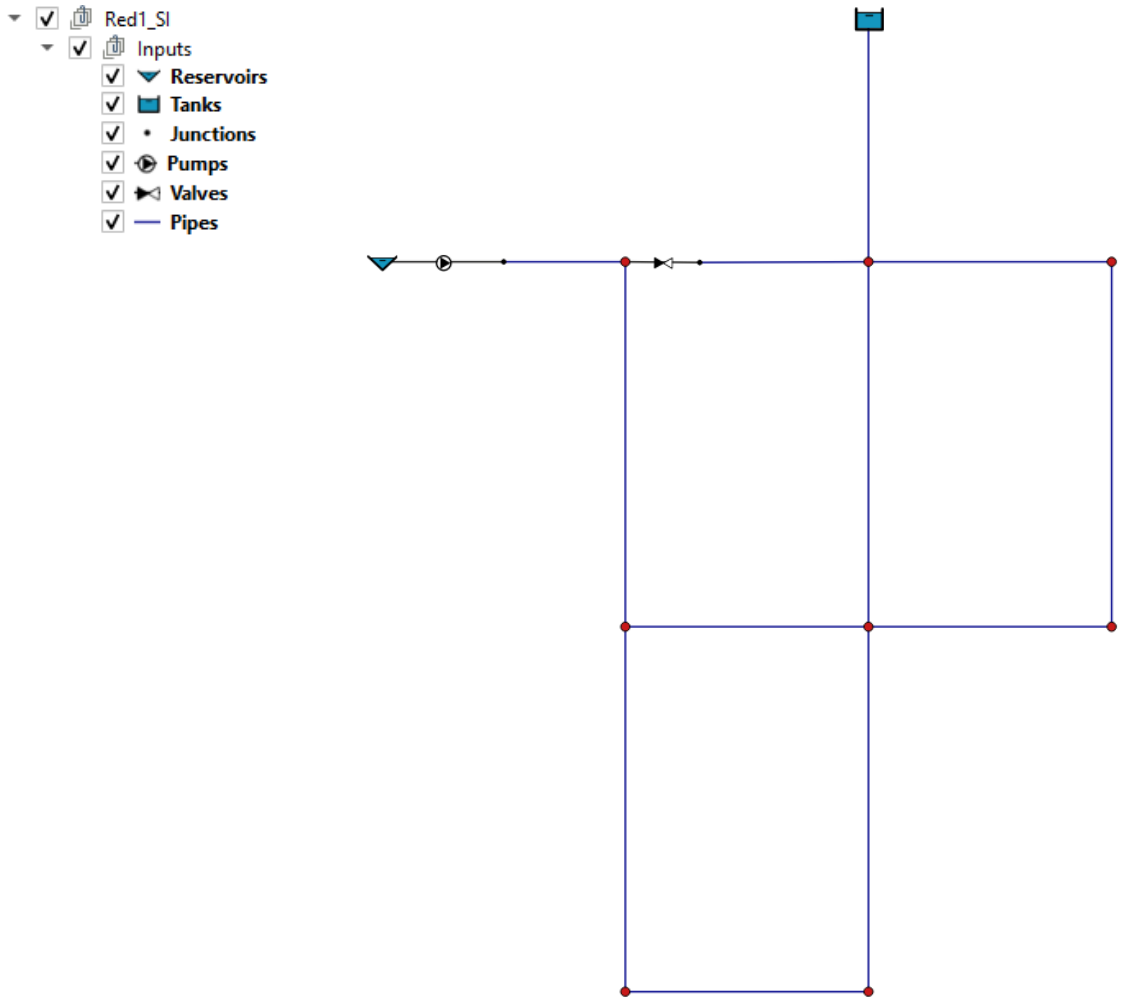
The following window will be opened, in which the user must define the name of the network, the directory where the SHPs will be stored, as well as the reference system (CRS) and the INP file. Once this information is indicated, press the "Import Data From INP" button.



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

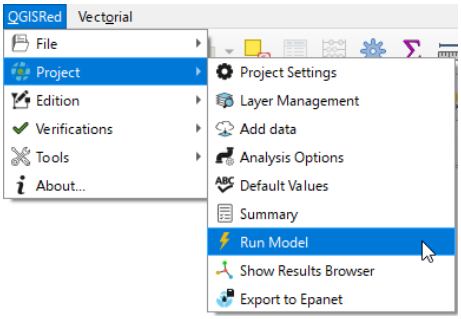


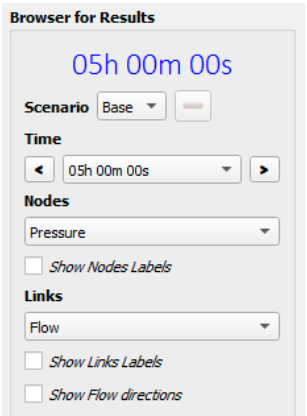
In the main QGis window the model layers and tables with non-spatial information will appear:



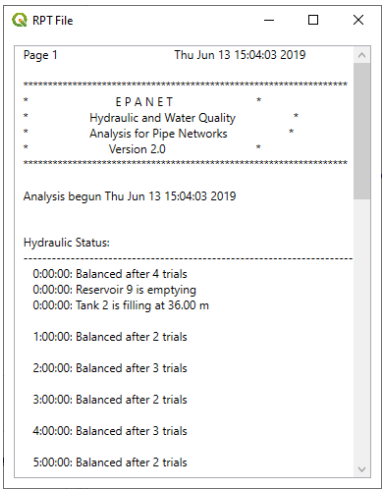
From version 0.7 onwards, data relating to curves (modeling and behavior) can be edited using the corresponding buttons. From version 0.8, the properties of each element can also be edited using the tool that allows access to the data through a dialog window. However, it is also possible to consult the data contained in each of the items that appear in the legend 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.

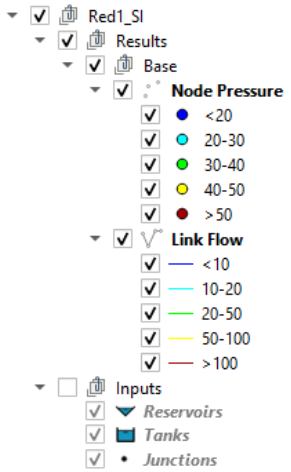
Assuming in this example that the model is completely defined, the hydraulic and quality simulation could be run. To do so, click on the "Run model" button and a right menu will appear.





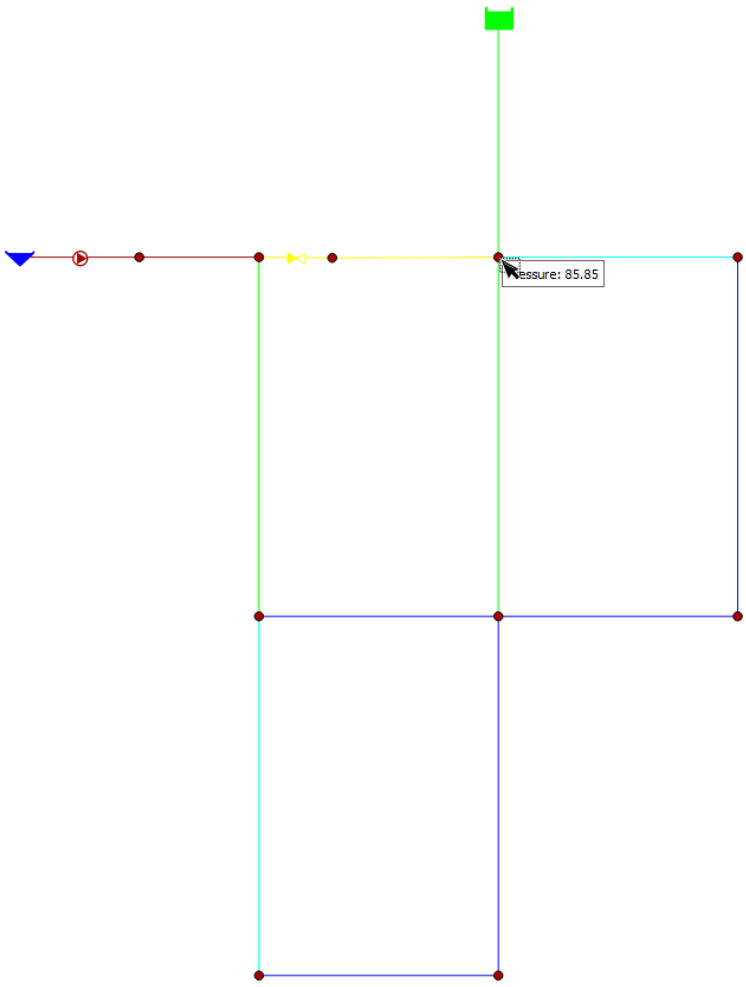
After performing the simulation, instantaneously for this example, a pop-up window appears with the report generated by the EPANET ToolKit, at the same time that the selected results are loaded (Flow and Pressure) in QGis legend.





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.

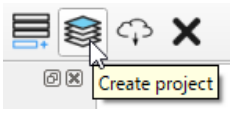


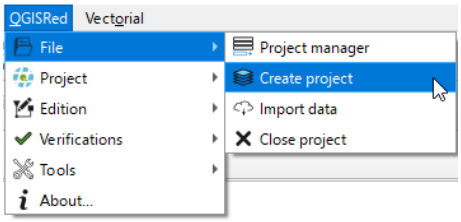
If the "Show Map Tips" option  is activated (if not), selecting a layer of results and holding the cursor over an element displays the value associated with that variable for the selected time.

Example 2

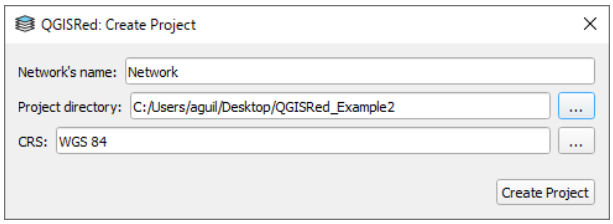
This example shows how to build the model of the previous example (*Red1_SI*) from the beginning, without importing, that is, creating the different elements in QGis.

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

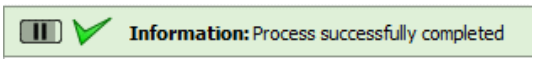


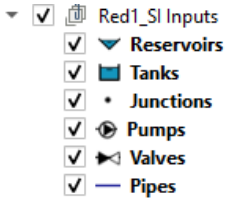


A window will be opened where the user must fill in the network name, the working directory and the reference system (CRS). For this example, that does not have a specific spatial location we can select the WGS 84. Then click on the "Create Project" button.



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).

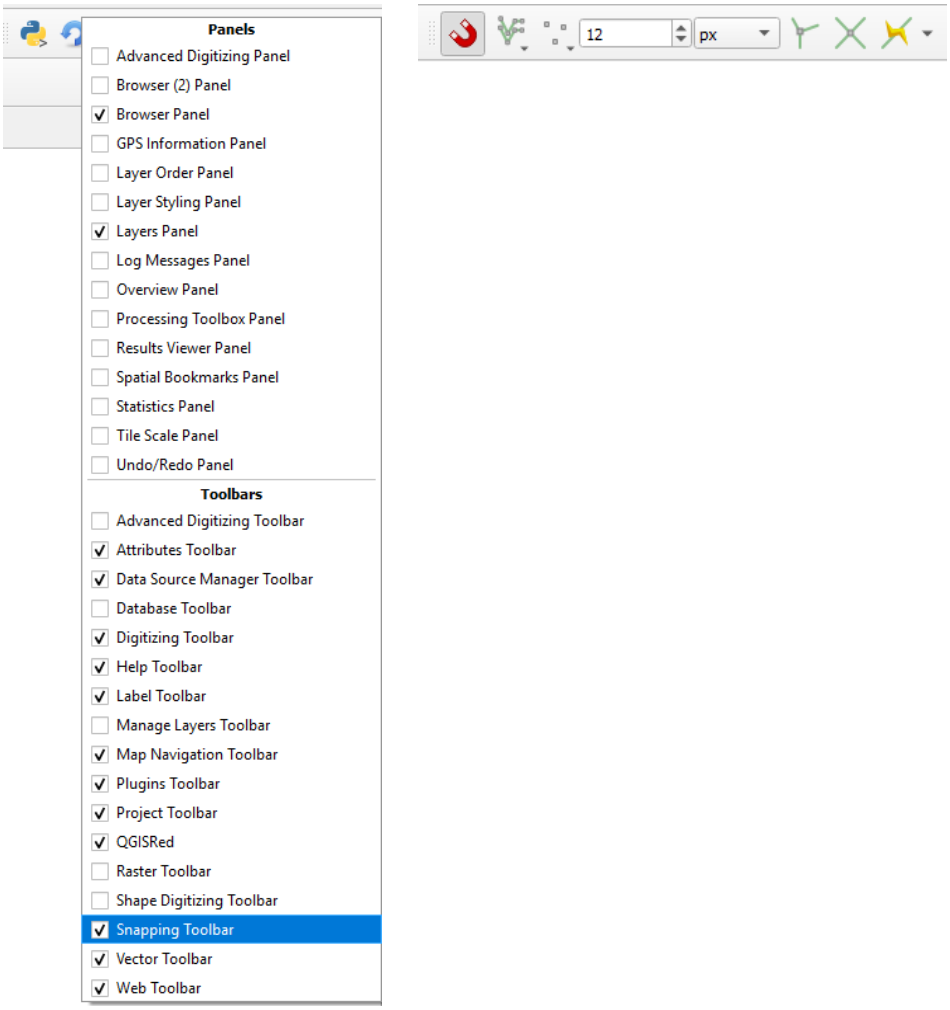




Before continuing and, as the process of create the network can take time, it is advisable to save the project with QGis. Thus, the next time we want to continue, whether we open the QGis project or the QGISRed project, everything will be the same as we left it the last time we saved it.

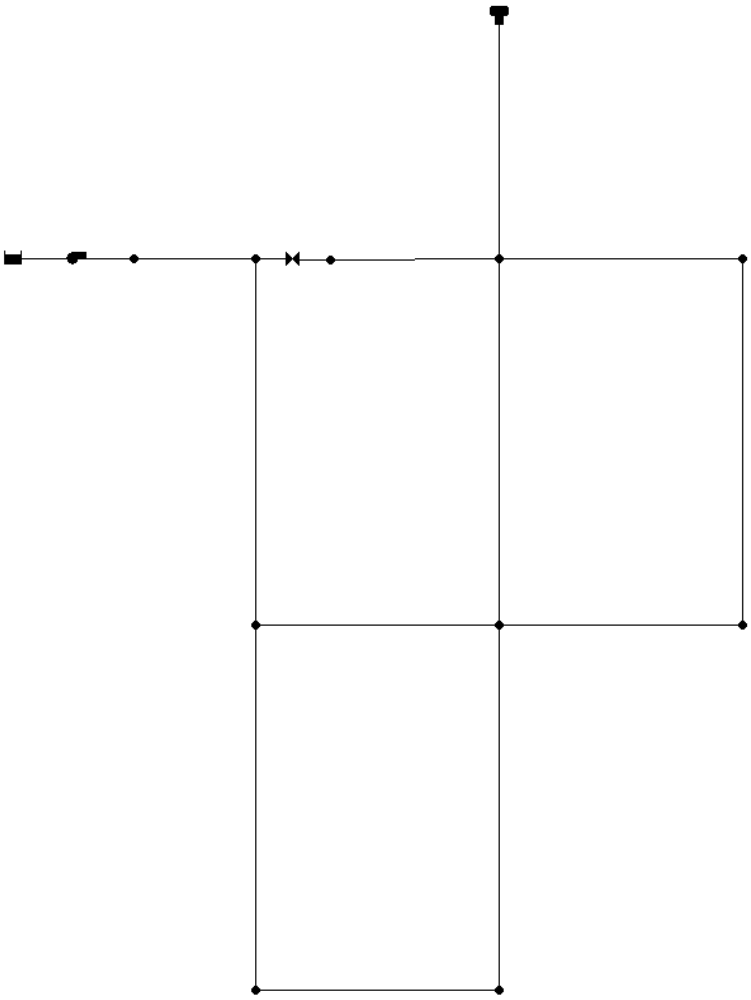
From version 0.9, the following operations can be performed using the tools of the QGISRed plugin.

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.

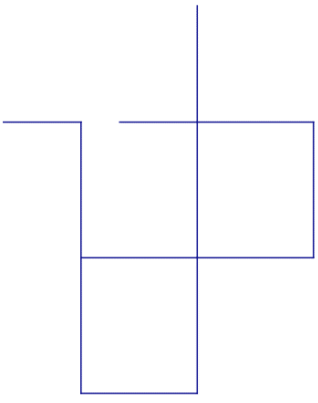
The model we must build is the following. As a starting point we can choose the pipe that starts from the upper tank.



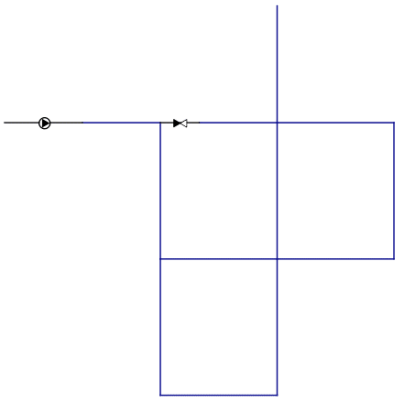
First steps:

1)

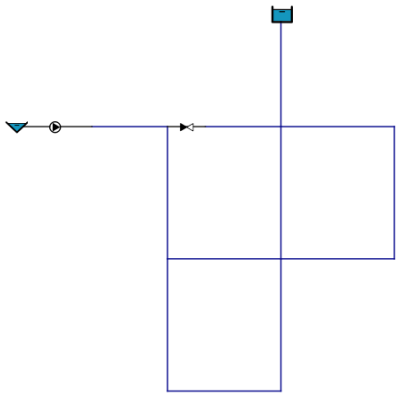
2)



3)

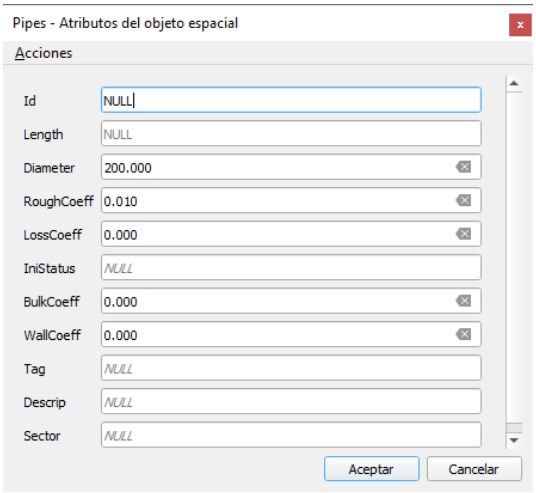


4)



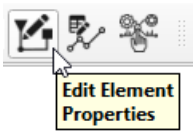
5)

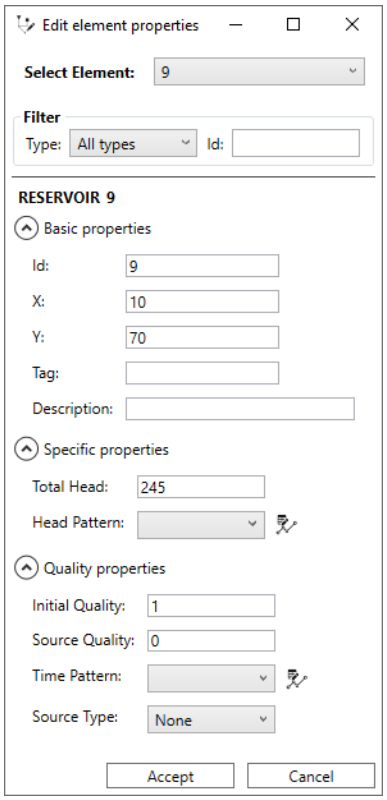
1) After selecting the second point of our pipe, we press right button to accept that link. At that moment a window appears to introduce the data associated to the model and that are contained in the table of attributes. In any case, when we generate or consolidate the model, the necessary empty data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



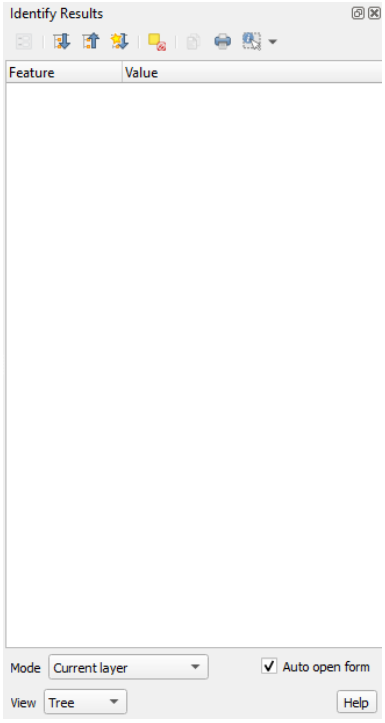
2) The fuchsia square facilitates the selection of the end of the previous pipe.
3) We finish drawing the rest of the pipes.
4) Draw the pump (activate layer edition) and the valve (activate layer edition).
5) Draw the tank (activate layer edition) and the reservoir (activate layer edition).

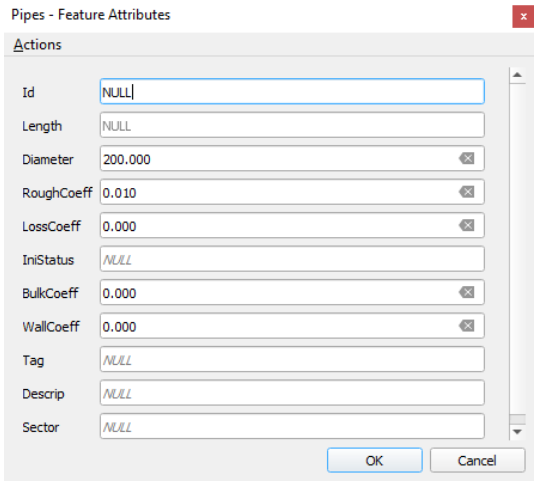
Once the topology has been built, the data for each element must be filled. To do this, we must save all the changes in the different edited layers. Once done, selecting the properties editing tool we can click on each element and modify its data.



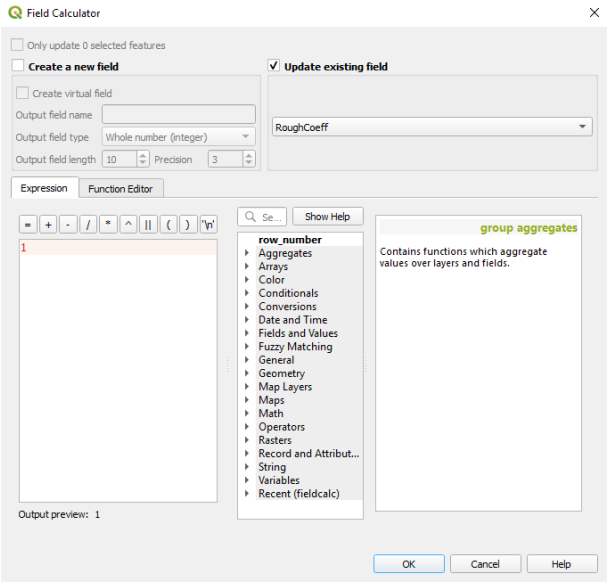


It is also possible to modify the data, maintaining the editing mode, opening the attribute table of a type of element, in which all the elements created for that type appear and complete the information. Another option is to use the object identifier  by selecting the "Auto open form" option from the right menu. This allows clicking on an element to open a pop-up window to enter data for that element only.

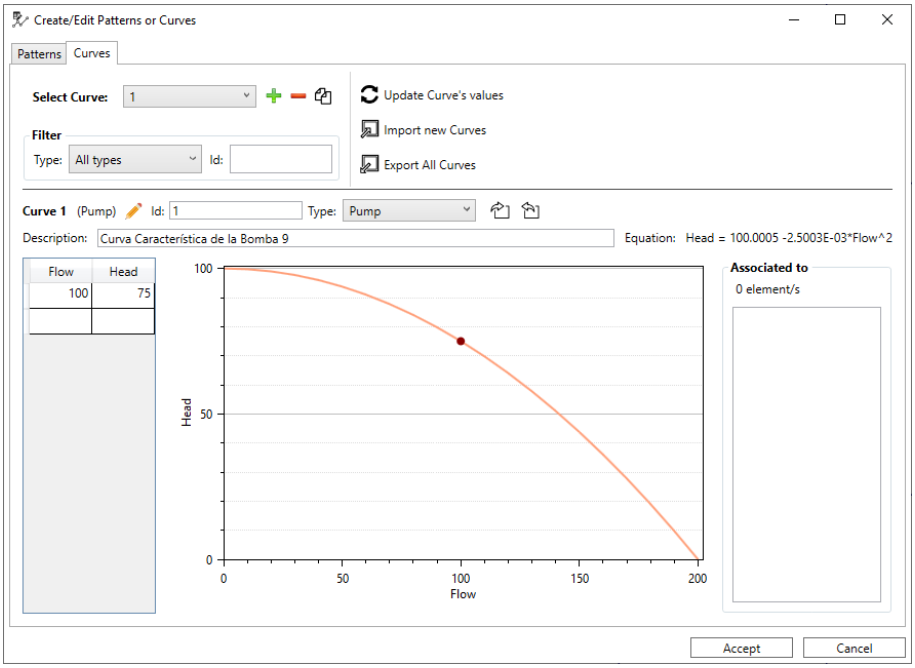




An additional option when the value of a field is repeated in all or almost all elements (e.g. the roughness coefficient of the pipes in the example), it is possible to use the field calculator . Select the option to update existing field, select the field and complete the desired value.

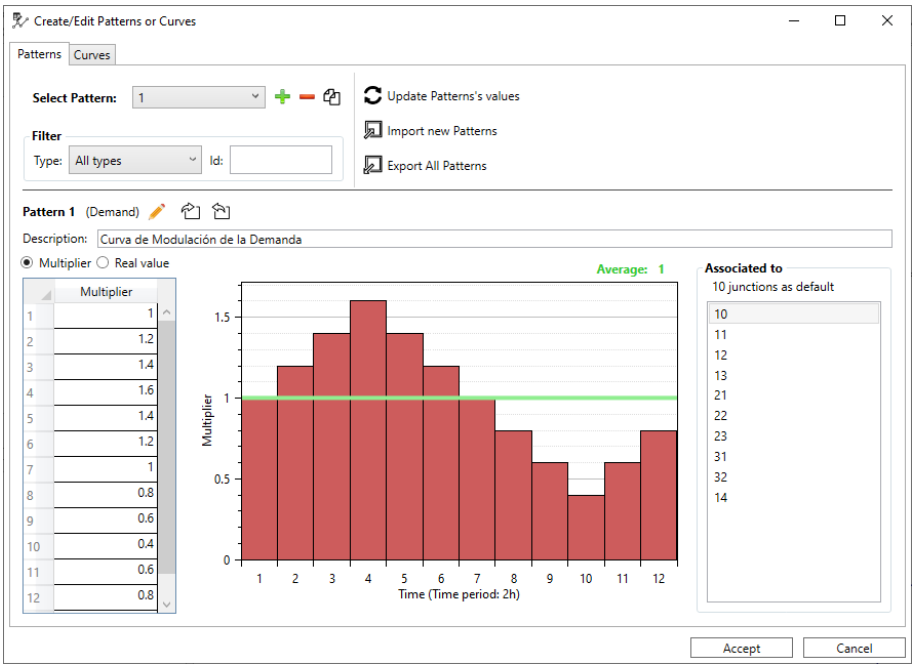


Once all the element data has been entered, the pump characteristic curve data must be completed. To do this, press the button and we access the edition of curves. In this example it is only necessary to enter a point of the curve and specify the type of curve.



The procedure is: add a new curve, edit the curve type with the icon , select the PUMP option and then add the corresponding pair of Flow-Head values.

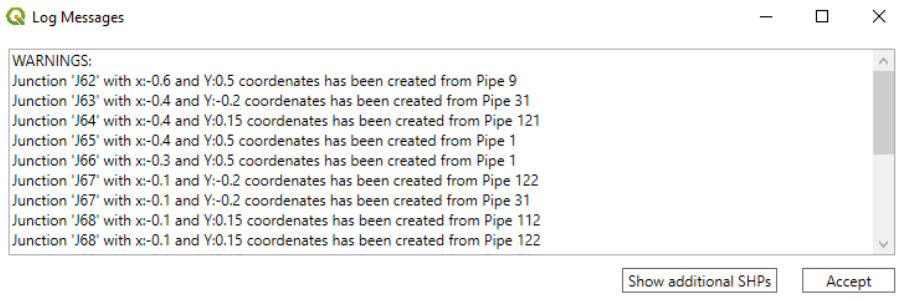
It is also necessary to enter the modulation curve data. From the same window, but in the corresponding tab, enter the values of the example.



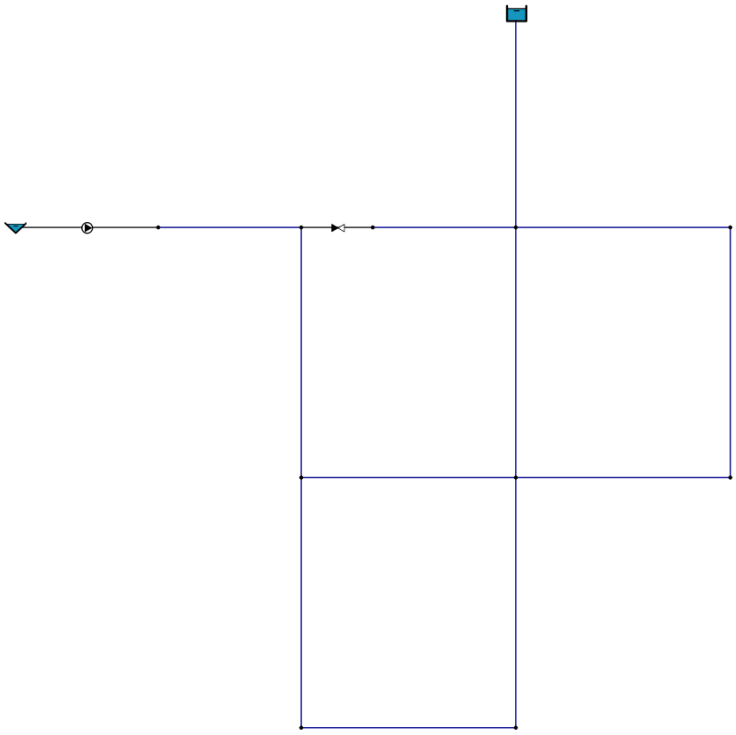
Once you have finished entering these data, click on the "Accept" button to save these changes. Then, it will be necessary in the pump to specify the Id of the curve in the *IdHFCurve* field.

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.

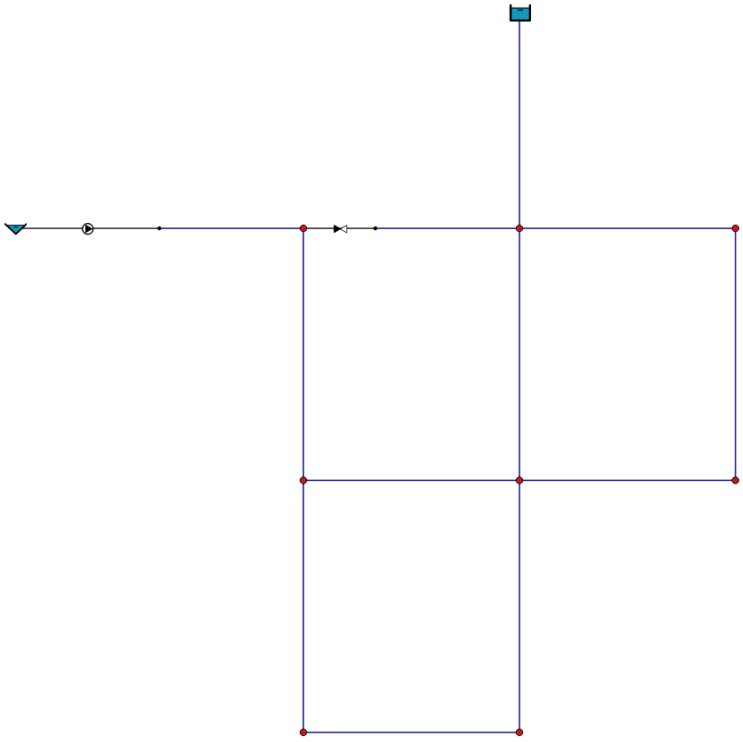
At this point, we can validate the topology and data entered. Pressing the button ✔ will show a list of messages, corresponding only to the creation of nodes (*junctions*) from pipes. Image may differ from version 0.9.



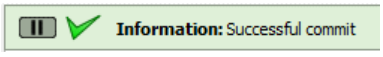
If we consider it correct, when clicking on the Accept button (pop-up window), we will see how the missing nodes have been created in the layout.



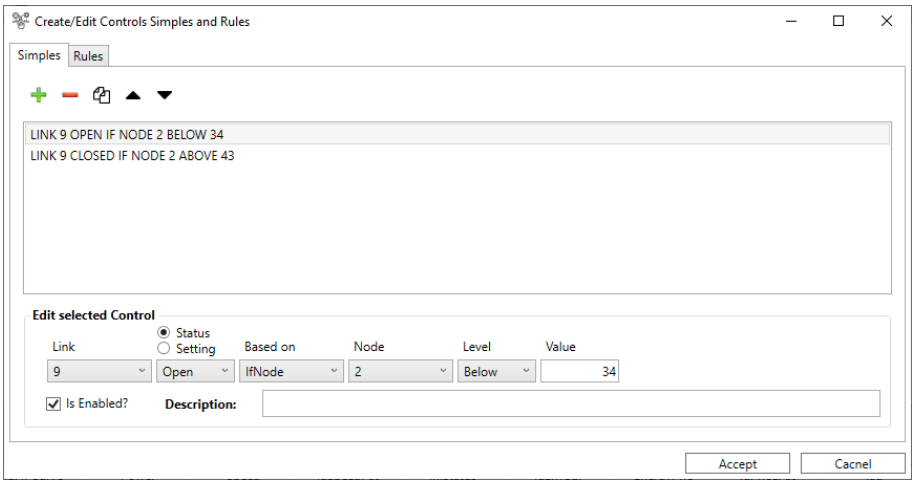
Once we have the nodes, we can complete their data, as has been done with the rest of the elements. Now we must visualize our scheme with the following figure.



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. It is accessed with the button  and, in the first tab, we create the two simple controls.



To finish, before proceeding with the simulation, it is necessary to modify the relevant options, to do so we press the button and modify the following.

HEADLOSS	D-W
UNBALANCED	CONTINUETO
CONTINUETO	10
QUALITY TYPE	CHEMICAL
CHEMICAL LABEL	Cloro
CONCENTRATION UNITS	mg/l
DURATION	24:00 (1.00:00:00)
QUALITY TIMESTEP	00:05
STATUS	YES
SUMMARY	NO

It should be mentioned that, the PATTERN by default that appears in the options is the Id 1. In this example corresponds to the Id of the pattern that has been created. Otherwise, it would be necessary to change it if we want to assign to all the junctions that curve or, to specify the corresponding Id in each node.

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