WFD compliant planning tool

WFD-Explorer

Deltares

Enabling Delta Life

User Manual

WFD-EXPLORER

WFD compliant planning tool

User Manual

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WFD-EXPLORER, User Manual

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1 WFD-Explorer

1.1 Introduction

The EU Water Framework Directive obliges water managers to improve the chemical and ecological status of many water bodies. The chemical and ecological status of a water body is defined by so-called EQRs: ecological quality ratios. The EQR includes metrics on concentrations of total nitrogen, phosphorus, chlorophyll-a and on species composition and/or abundance of phytoplankton, macro fauna, macrophytes and fish.

To improve the chemical and ecological status of water bodies, water managers define sets of measures. However, it is often not clear to what extend the defined measures improve the EQR of a water body. Since measures are expensive, insight into the effectiveness and cost efficiency of possible measures is helpful. The WFD-Explorer has been developed to assist water managers in making decisions on the implementation of appropriate measures to improve the chemical and ecological functioning of a water body. Moreover, the WFD Explorer is a useful communication tool and fuels the discussion on measures.

1.2 Version overview

KRW-Verkenner 2.0 (2013) First release using the Deltashell framework.

KRW-Verkenner 2.1 (2015) Upgraded version regarding performance, saving and ecological knowledge rules.

KRW-Verkenner 2.3 (2017) Scripting functionalities are added as well as georefferenced webservices like Openstreetmaps. Ecological knowledge rules are upgraded with the latest insights

KRW-Verkenner 2.4 (2021) Aditional upgrade of the ecological knowlegde rules.

1.3 Conceptual framework

The WFD Explorer consists of a water balance, a substance balance, an ecological module and a cost module. Additionally, measures can be inserted into the WFD Explorer on substance and ecological level. The WFD Explorer generates output as tables and maps (1.1). These outputs contain information on substance concentrations and chemical and ecological EQRs.

In short, the WFD Explorer works as follows: the water balance constructs a water flow through a network of water bodies, such as ditches, streams and lakes. The water balance is used as input for the substance balance: it transports the substances through the network. Next, information on nutrient concentrations together with characteristics of the water body (e.g., sheet piling, weirs) is used in the ecological module.

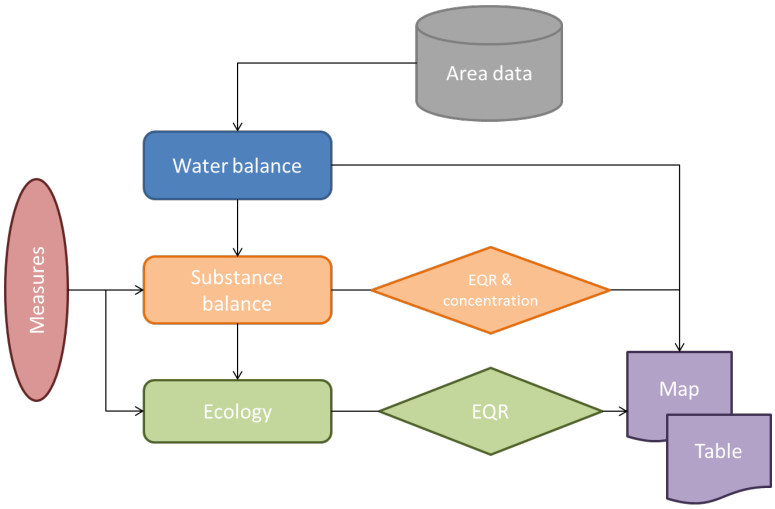


Figure 1.1: *Flow chart of the WFD Explorer*

1.3.1 Water balance

The water balance is semi static because it constructs the water flow on a quarterly basis. The calculation core of the water balance is the Wabacore software. Wabacore is a steady state water balance model which is used as a pre-processor for the substance balance in the WFD Explorer. Wabacore needs the following information from the user interface:

- ◇ All segments (basins and SWUs[1]) within the network,
- ◇ The relations between the segments (i.e., links), and
- ◇ All water discharges and retrievals in the network.

All water discharges and retrievals in the network.

The WFD Explorer can import data from external databases, such as the 1-D hydrological model SOBEK. The data can also be user defined.

Water sources can discharge either into a basin or an SWU. Eventually, basins discharge their water surplus into one or more SWUs. When several SWUs receive water from one basin, a user predefined ratio is needed for the water distribution. The routing of the water flow is automatically defined when the order of the SWUs discharges is specified. Additionally, a fixed discharge route can be applied to model for instance water inlet that is opposed to the main water flow.

Note: that the water balance always sums to zero, because one degree of freedom is added to every calculation unit (basins and SWUs) when the WFD Explorer is running a case. This implies that during water shortage, the WFD Explorer adds water to system. This is “clean water”: water without any substances. When this happens, substance concentrations are diluted.

[1] Basins are confined discharge areas and SWUs are the surface water units for which the WFD Explorer calculates the chemical and ecological status

1.3.2 Substance balance

DWaq is the calculation core of the substance balance. DWaq is used within and outside Deltares to simulate complex water quality models (Deltares (2020a), Deltares (2020b)). The WFD Explorer uses the steady state solvers that are available within DWaq. This results in a quick and efficient calculation method.

All inflowing substance flows must be defined before running the WFD Explorer. The necessary data can be obtained from different data sources, such as:

- ◇ Measurement data;
- ◇ National data bases, and
- ◇ Model studies.

Unfortunately, there are uncertainties in these data sources. Therefore, a thorough analysis of the available data sets is recommended before filling out the WFD Explorer.

All substances can be simulated by the WFD Explorer. Please note that, there are five predefined substances, viz. total nitrogen and phosphorus, ammonium (NH_4), chloride and the biological oxygen demand (BOD). These four substances are predefined because they have a link to the ecological module of the WFD Explorer (see paragraph 1.3.3).

The substance concentrations are calculated by:

$$\frac{dM}{dt} = \sum Q_{in} \times C_{in} - \sum Q_{out} \times C - k \times C \times V = 0 \tag{1.1}$$

Where:

M	Mass (g)
Q_{in}	Infow (m^3/s)
Q_{uit}	Outflow (m^3/s)
C_{in}	Substance concentration of the upstream segment (g/m^3)
C_{in}	Substance concentration in the actual segment (g/m^3)
V	Volume of the segment (m^3)
k	Decay rate ($1/d$)

The decay rate constant can be defined for each substance individually. Additionally, the decay rate constant can be made temperature dependent, according to:

$$k = k_{20} \times \theta^{T-20} \tag{1.2}$$

Where:

k	Decay rate $(1/d)$
k_{20}	Decay rate at 20 ℃ Celsius $(1/d)$
θ	Temperature coefficient, default is 1.047 (-)
T	Water temperature (℃ Celsius)

1.3.3 Ecology

The WFD Explorer has three calculation methods for the ecological module. All methods are based on the linkage between steering factors and chemical and ecological quality. The relation between steering factors (see Table 1.1 , Table 1.2 and Table 1.3) and chemical and ecological quality is based on a Dutch dataset which includes, among others, information on nutrient concentrations, landscape design, management and ecological quality of different types of water bodies (e.g., fast and slow flowing streams, deep and shallow lakes, canals, ditches and brackish to saline waters). The dataset was used to train and validate the three different models:

- ◇ Random Forest (Neural network) (default);
- ◇ PUNN (Neural Network); and
- ◇ Regression Trees.

All three methods are available in the WFD-Eplorer.

Table 1.1: *Chemical steering factors and water body types*

Watertype cluster	**BZV**	**Chloride**	**NH4**	**Tot-N**	**Tot-P**	**msPAF**
Slow flowing streams	X		X	X	X	
Fast flowing streams			X	X	X	
Riverine marshes	X		X		X	
Marshy streams	X		X	X	X	
Ditches			X	X	X	X
Canals			X	X	X	X
Shallow lakes			X	X	X	
Deep lakes			X	X	X	
Lightly brackish waters		X	X	X	X	X
Brackish to saline waters		X	X	X	X	X

Table 1.2: *Other steering factors and water body types*

Watertype cluster	**Connectivity**	**Maintenance**	**Shipping**	**Meandering**	**Shadow**	**Impoundment**	**Bank design**	**Water level dynamics**	**Secchi Depth**
Slow flowing streams				X	X	X			
Fast flowing streams				X	X	X			
Riverine marshes				X					
Marshy streams					X	X			
Ditchers		X					X		
Canals		X	X				X	X	X
Shallow lakes							X	X	X
Deep lakes							X		X
Lightly brackish waters	X	X				X	X		X
Brackish to saline waters	X	X				X	X		X

Table 1.3: *Classes or units, values and descriptions of the steering factors*

Steering factor	Classes or unit	Values and description
Bank design	1 - 3	1 = sheet piled or steep and bare; 2 = helophytes; 3 = natural
Water level dynamics	1 - 3	1 = unnatural; 2 = stable; 3 = natural
Maintenance	1 - 2	1 = intensive; 2 = extensive
Connectivity	1 - 3	1 = isolated; 2 = periodically isolated; 3 = open connection
Meandering	1 - 5	1 = straight and regulated profile; 2 = straight and natural profile; 3 = slightly meandering; 4 = meandering; 5 = meandering freely
Shading	1 - 3	1 = not shaded or without rough growth on the banks; 2 = partly shaded or rough growth on the banks; 3 = largely or totally shaded
Scheepvaart	1 - 2	1 = intensief bevaren, 2 = niet of nauwelijks bevaren
Impoundment	1 - 3	1 = impoundments without fish ladder; 2 = impoundments with fish ladder; 3 = no impoundments
Secchi Depth	0.03 - 12 m	Summer average (April to September) Secchi Depth
Chloride (Cl)	85 - 17883 mg Cl/l	Summer average (April to September)
Total P	0.01 - 10 mg P/l	Summer average (April to September)
Total N	0.1 - 38.4 mg N/l	Summer average (April to September)
Toxicity (msPAF)	0 - 1 (-)	ms PAF value
Ammonium (NH_4)	0 - 75 mg NH_4/l	Maximum concentration
BOD	0.001 - 32.8 mg O_2/l	Summer average (April to September)

1.4 Measures

Measures can be defined both related to point sources such as sewage treatment plants and diffuse sources such as agriculture and traffic. Measures can also be defined for water body design, such as meandering and impoundment. This makes it possible to calculate the effectiveness of for instance restoration measures such as stream re-meandering or the construction of near-natural riparian zones.

2 Installation manual

2.1 System requirements

WFD-Explorer 2.4.1 requires Microsoft Windows (7 or 10) as operating system.

Component	Minimaal	Geadviseerd
Processor	2 GHz	3 GHz
RAM	2 GB	4 GB
Hard disk space	2 GB	10 GB

2.2 Installation

The setup of the latest version can be downloaded at the WFD-Explorer website: www.krw-verkenner.nl. Start the program setup (named WFD Explorer (2.4.1.#).msi[1]). The following screen pops up:

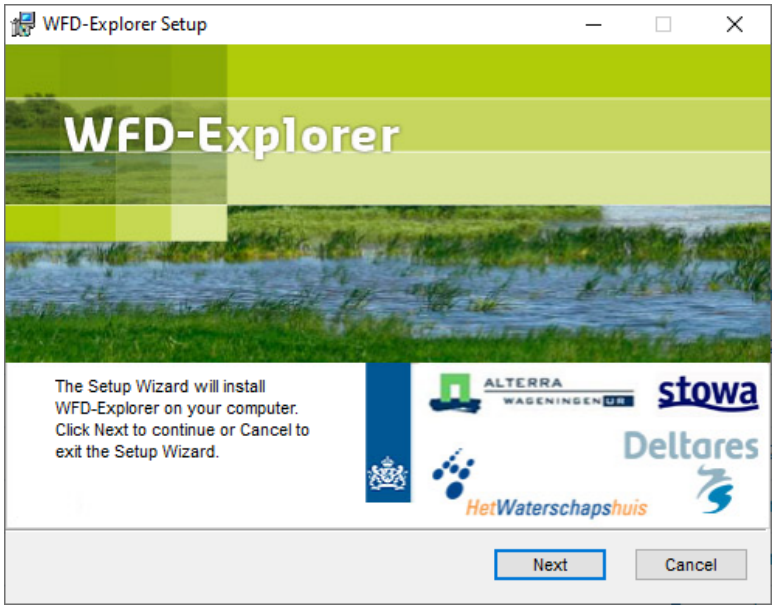


Figure 2.1: *Start installation of the WFD-Explorer*

Click *<next>* to continue. Next screen shows the software license agreement, which the user should accept (figure 2.2). The WFD-explorer software is free to use.

[1] # represents the build number, a unique identifier.

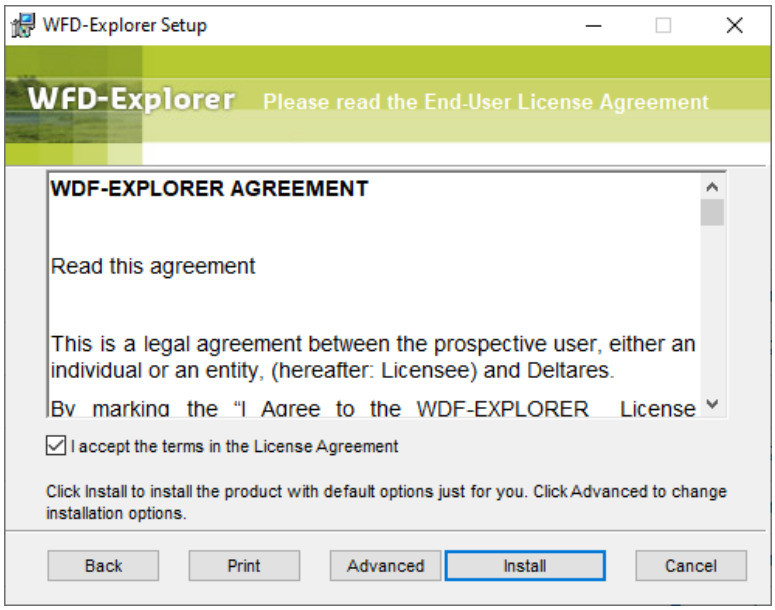


Figure 2.2: *Accept the license agreements*

The button <advanced> makes it possible to:

- ◇ Install WFD Explorer for all users (default) of only the current user (see figure 2.3); and
- ◇ Set the installation path (see figure 2.4)

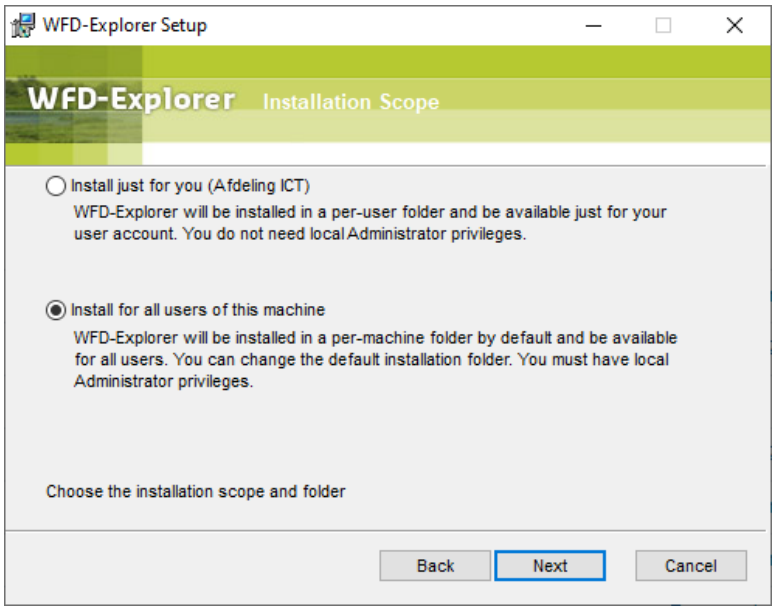


Figure 2.3: *Advanced installation options (1/2)*

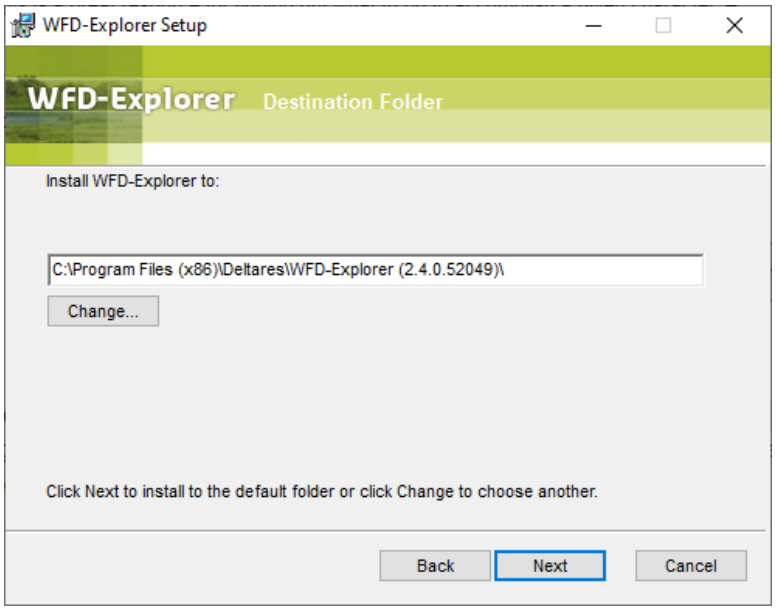


Figure 2.4: *Advanced installation options (2/2)*

The default path for the WFD-Explorer is:

c:\Program Files (x86)\Deltares \WFD-Explorer (2.4.1.#)

During the installation, a shortcut for the WFD-Explorer will be placed in the start Menu under the folder *"Deltares"* together with an shortcut on the desktop.

Click on the icon WFD-Explorer 2.4.1 to start the WFD-Explorer software:

2.3 Uninstall the WFD-Explorer

The WFD-Explorer software can be removed by running the un-installer from the Start menu: Click <Start>, programs - Delares - Uninstall WFD-Explorer.

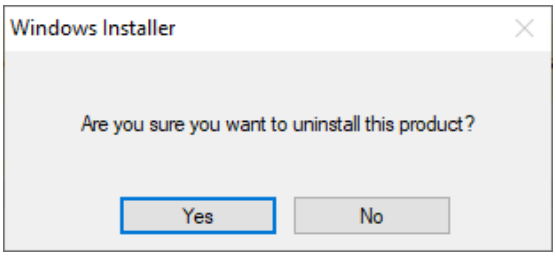


Figure 2.5: *Uninstall WFD-Explorer*

2.4 WFD-Explorer support

Support regarding using the software or advice regarding applications can be found on either the website www.krw-verkenner.nl (Dutch only) or by sending an email to: krw-verkenner@deltares.nl.

3 Hands on

3.1 Setup a WFD model

Open the WFD Explorer by double clicking on the WFD-Explorer 2.4.1 icon on the Desktop:

After the WFD-Explorer is started, add a new WFD-project:

- ◇ right click on "project1";
- ◇ click <add>;
- ◇ click <new item>;
- ◇ Choose <WFD-project>.

3.1.1 Add Background map

Fold out the WFD project in the Project Explorer. Double click on Default map, listed in the folder “General”. An empty screen with tab name “Default map” opens in the Project Viewer and in the Map Contents window a text block “Default map” appears (see Figure 3.1). - Right click on this text block - Choose “Add Layer” - Browse to tutorial folder - Add Basins.shp and Waterbodies.shp (one at a time)

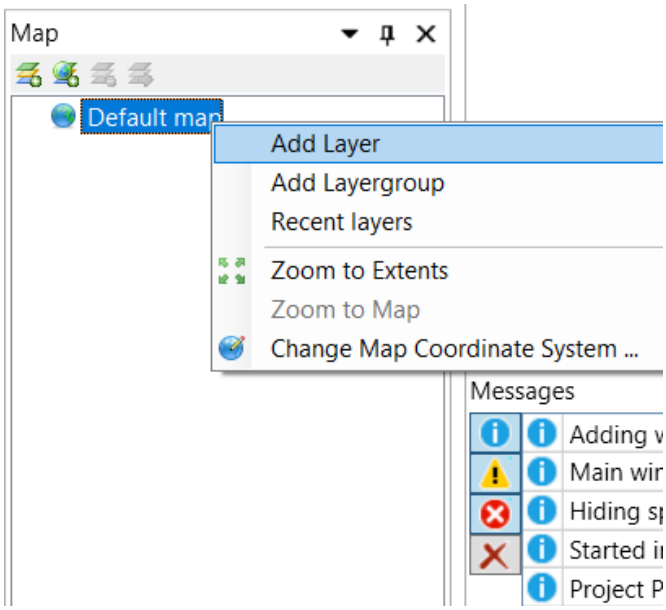


Figure 3.1: *Map contents window*

You can configure your map to look the same as figure 3.2:

- ◇ Right click on “Basins” and choose properties

- ◇ Left click on the colour box next to Fill colour to activate the colour scheme
- ◇ Choose a colour of your liking
- ◇ Press “OK”
- ◇ Do the same for “Waterbodies”

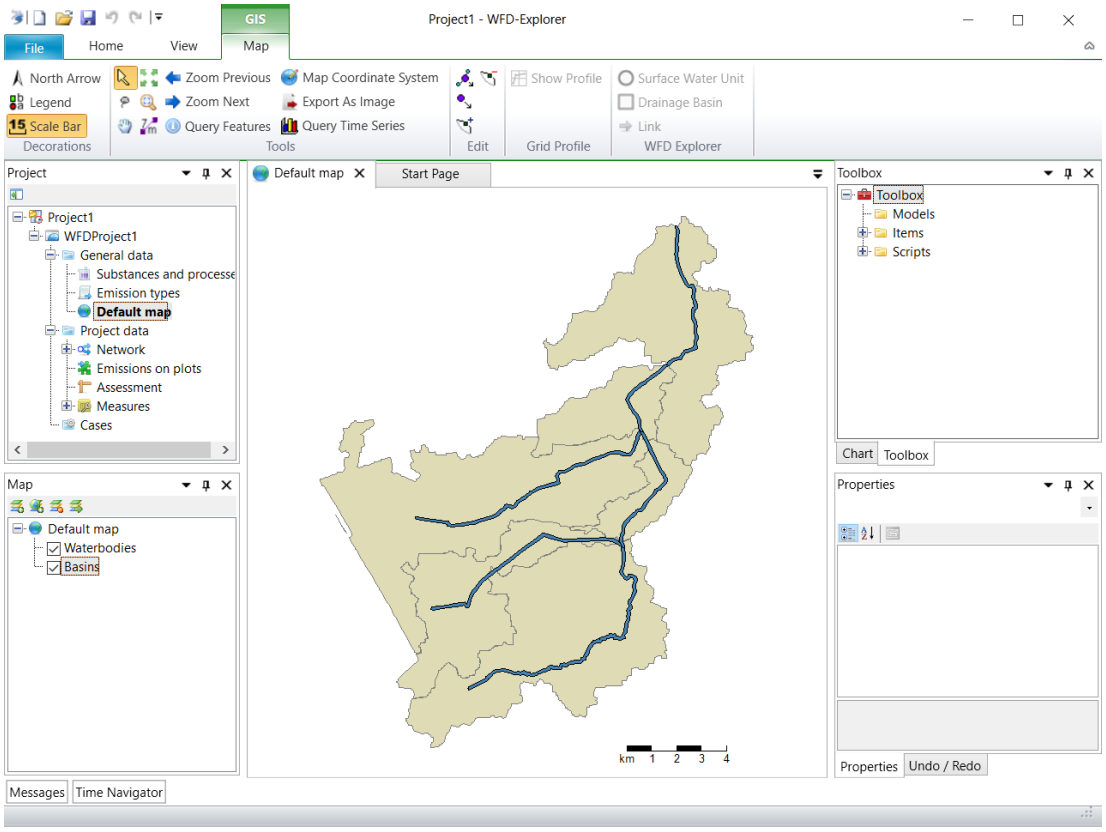


Figure 3.2: *Background map*

3.1.2 Generate nodes

The background maps can serve as input for generating computational elements (nodes). Double click on the “Network” in Project Data. A window opens that includes the background map.Then:

- ◇ Right click on any location in the Network map (see fig X)
- ◇ Choose “Generate Surface Water Unit Nodes”

A window pops up with the names of the background layer maps.

- ◇ Select “Waterbodies”
- ◇ Do the same for the basins

Data is derived from the GIS attributes for each generated node such as ID, Name, Volume and WFD type. Data is derived from the GIS attributes.

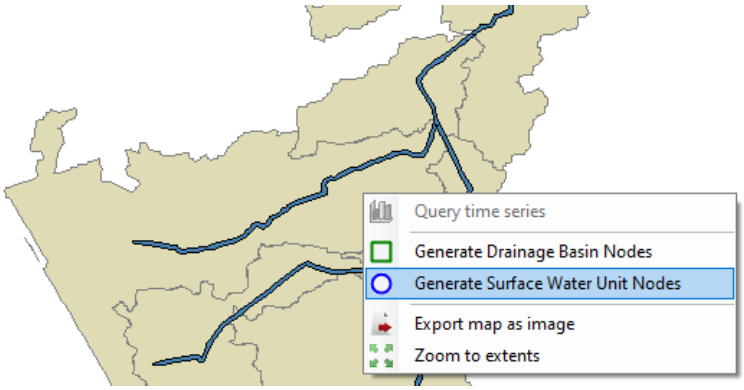


Figure 3.3: *Generate nodes*

After this step, your network should look like figure 3.4.

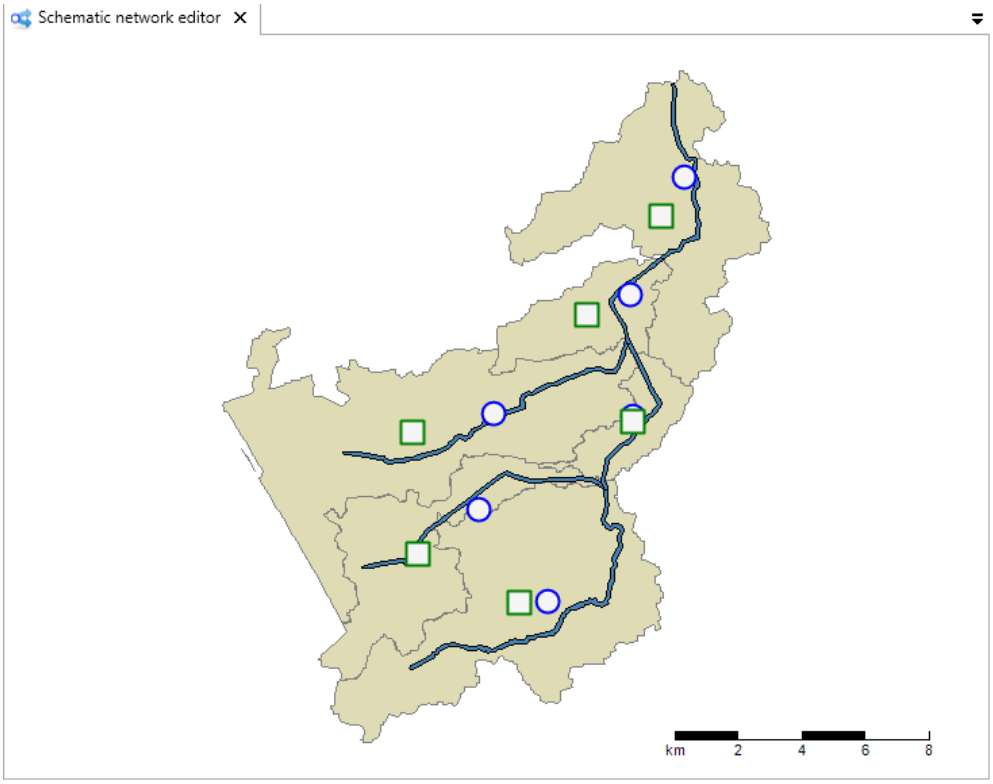


Figure 3.4: *Result after generating nodes*

3.1.3 Connecting nodes

The generated nodes need to be connected by links to define the water flow between the nodes: the flow routing. The flow routing can be created in two ways:

1 By hand:

(a) Define links between the nodes (LinkID, Tag, From, To), by using the symbol in the tool bar. Drag the line from one node to the next (use escape to stop drawing links)

(b) Define “Internal_Flows” (LinkID, Absolute/Fraction, Year, Period) by double clicking on the link (you may need to refresh your window)

2 Import prepared data.

In this tutorial, we use prepared data:

◇ Right click on <Network> under Project Data

◇ Choose “Import” (see figure 3.5)

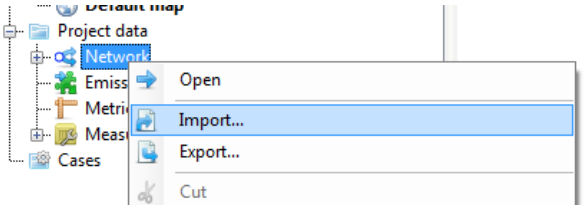


Figure 3.5: *Import data for the network*

Next, a dialog window pops up (see Figure 2.6).

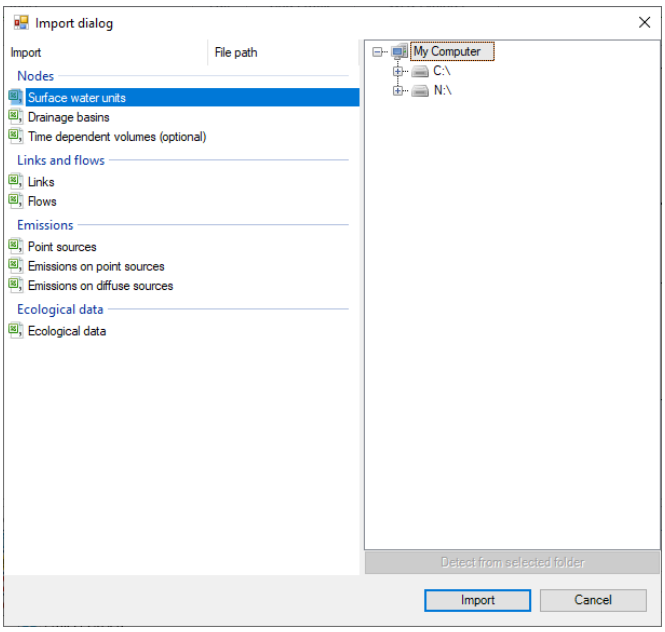


Figure 3.6: *Import window for file selection*

◇ Browse in the right panel to “d:\Tutorial folder”;

◇ Highlight “Links” in the left panel by left clicking and then click on Links.csv in the right panel. You can do the same for Flows (in left panel) and Links_flows.csv. An alternative is to right click on Links_flows.csv and select “Links file” from the drop down menu (see figure 3.7); and

◇ Click <Import>.

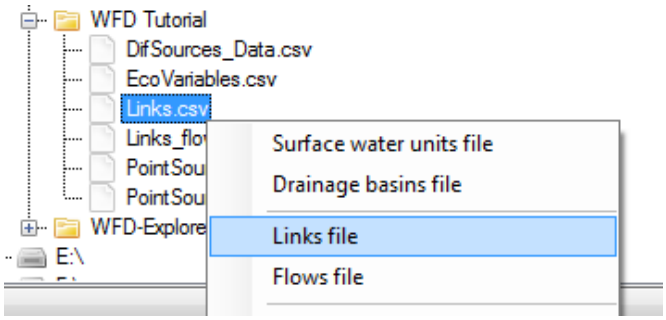


Figure 3.7: *Select a file*

Reopen the WFD network. It should look like figure 3.8.

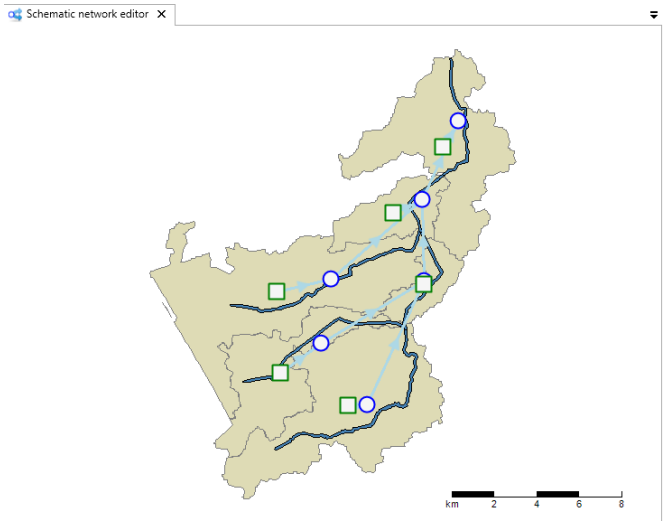


Figure 3.8: *Result after link imports*

3.1.4 Emissions and ecological variables

Data on emissions from point and diffuse sources and ecological variables can also be imported from CSV files.

◇ Import the following files:

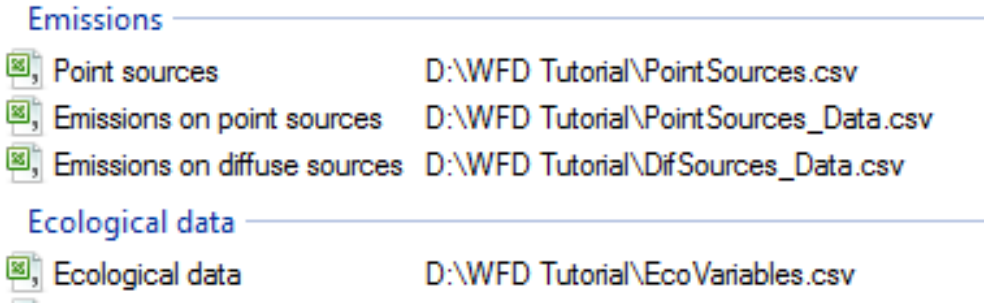


Figure 3.9: *Files for importing*

3.2 Create a case

Now, the basic model is ready. To run a specific year, in this case 2010, the user must add a case. A case must contain at least the following information:

- ◇ Year of simulation
- ◇ Type: Full computation (flow, water quality, ecology), only substances (flow and water quality) or only ecology
- ◇ Selection of substances used in the computation
- ◇ Period: Specific quarter, summer period (Q2 and Q3) or full year.

Add a case by right clicking on <Cases> in the Project explorer and choose “Add case”:

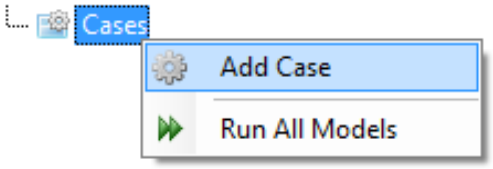


Figure 3.10: *Add case*

Consequently, the Case Wizard pops up which will guide you through the creation of a case:

- ◇ Add a case to your project (see figure 3.11)
- ◇ Finish the Case Wizard by clicking “Next” and “Finish”.
- ◇ Run the model by right click on the newly created case and choose :Run Model”

Please note that it is also possible to run the separate modules.

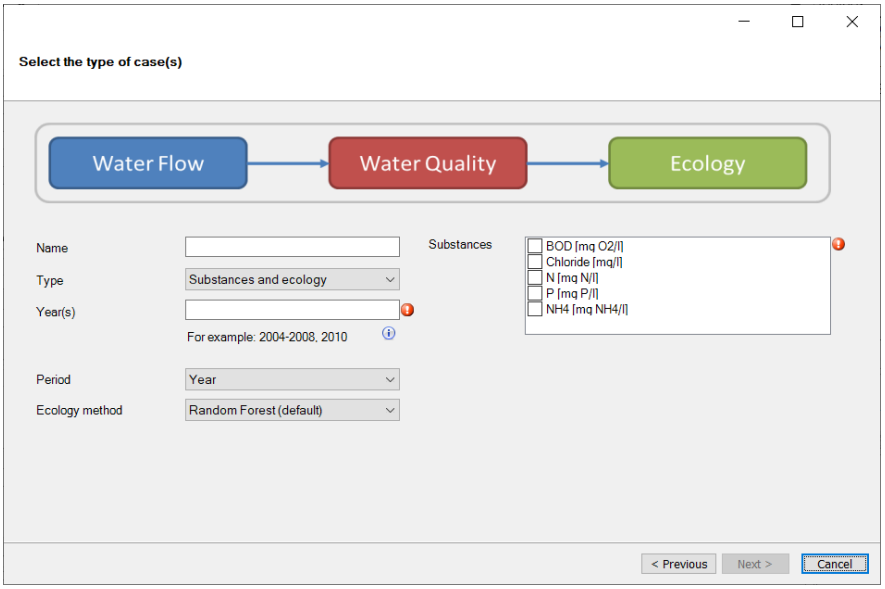


Figure 3.11: *Case wizard*

The Case wizard will generate a computational structure. This structure comprises all sub models and the linkages between those sub models. For instance, the output of the flow model “water flows” is used as input for the water quality model.

3.3 Results

After a successful run, the results of the WFD Explorer can be inspected. Each module has its own characteristic outputs:

- ◇ Flow model: Results of water flows on links
- ◇ Water quality: Results of concentrations on nodes
- ◇ Ecology model: EQR scores for nodes.

You can have a look at the results by double clicking on the output files. Double clicking forces a window to pop up where you can choose to see you results in table or map form.

When you use the map format, you can inspect the differences in results for the four quarters that were calculated by the WFD-Explorer: use the Time Series Navigator (see figure 3.12). When you choose the table format, the *Time Series Navigator* shows a static view over the four quarters for each node or water body.

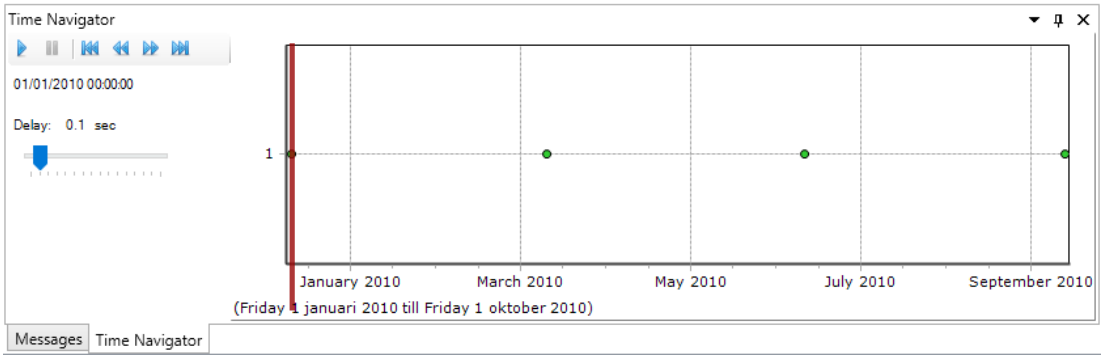


Figure 3.12: *Time series navigator*

Exercise: Explore the results of the different modules and try to get an idea of the most important causes of the poor ecological status in the different water bodies.

3.4 Add a measure

A measure is added in the WFD Explorer according to the following three steps (figure 3.13):

1. Add a specific measure such as a (point) source reduction or an ecological measure.
2. Add details of the measure such as the source type for an emission reduction (i.e., WWTP, Industries) or the reintroduction of meandering.
3. Select the nodes that are involved. You can do that by using a table or a map.

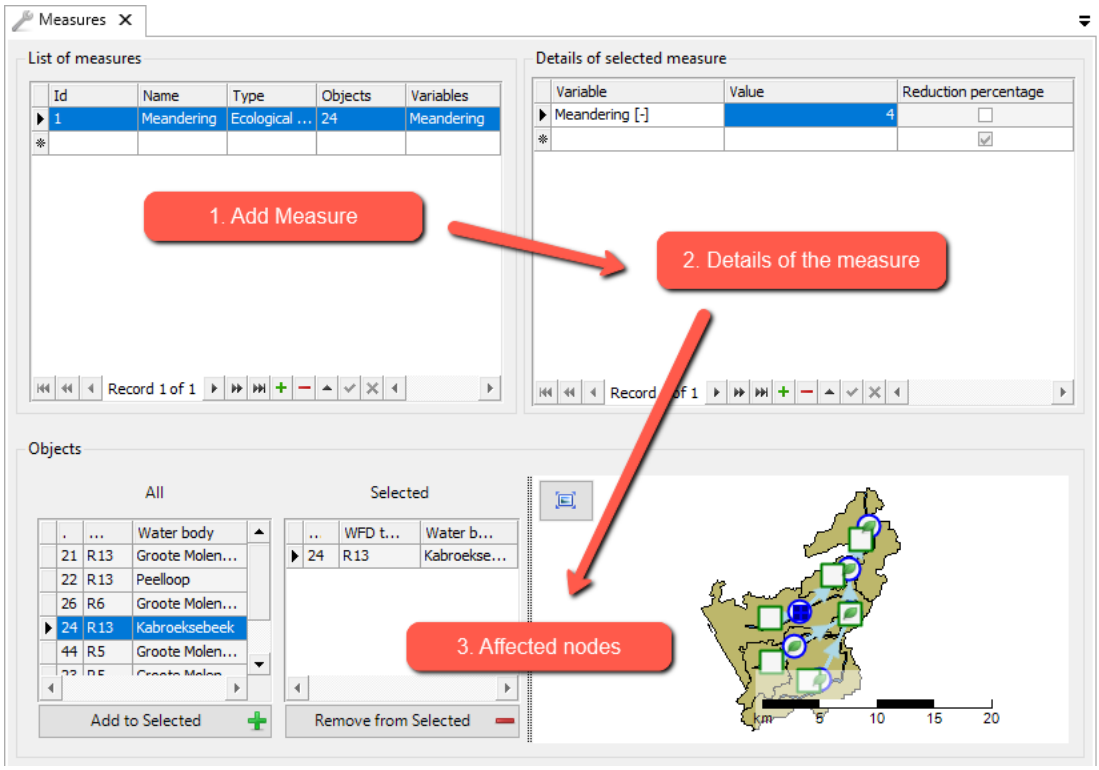


Figure 3.13: *Measure input screen*

The ecological status in the "Kabroekse beek" is poor. The main problems turn out the be high nutrient loadings due to discharges of a WWTP and a bad structure of the river (straight, weirs etc). As a first exploration, we want you to investigate what the effects are of N and P emission reduction of the WWTP:

- ◇ Fold out the Measures box under Project data in the Project Explorer
- ◇ Double click on Measures in the folded out menu
- ◇ Fill out the window according to figure 3.14

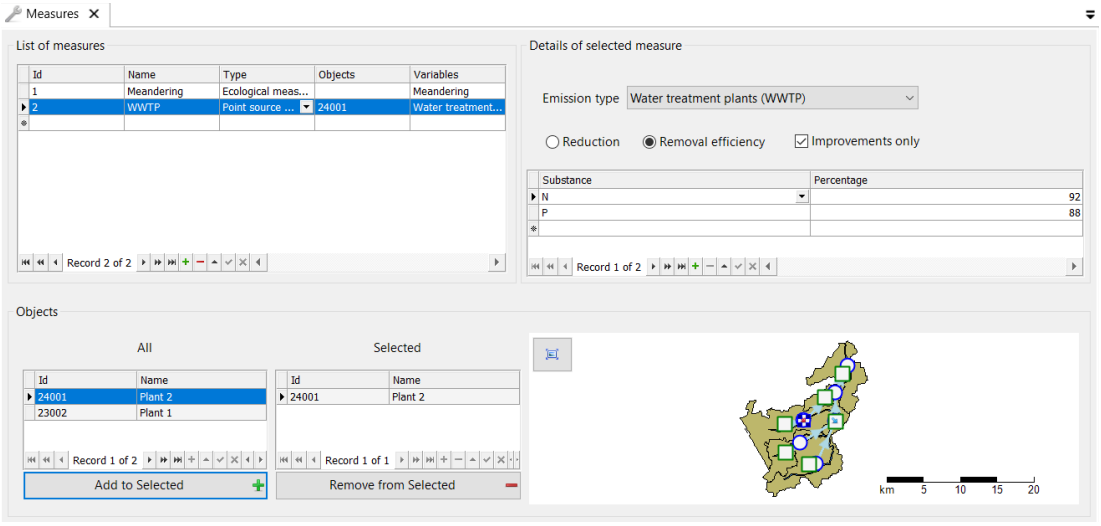


Figure 3.14: *Reduction values for WWTP*

Because the WFD Explorer cannot run with only one measure, the user must specify a measure collection. This collection can contain one or several measures. In this case, only this point source reduction measure will be taken into account.

- ◇ Double click on Measure collection
- ◇ Add a new collection
- ◇ Add the point source measure to the list of selected measures

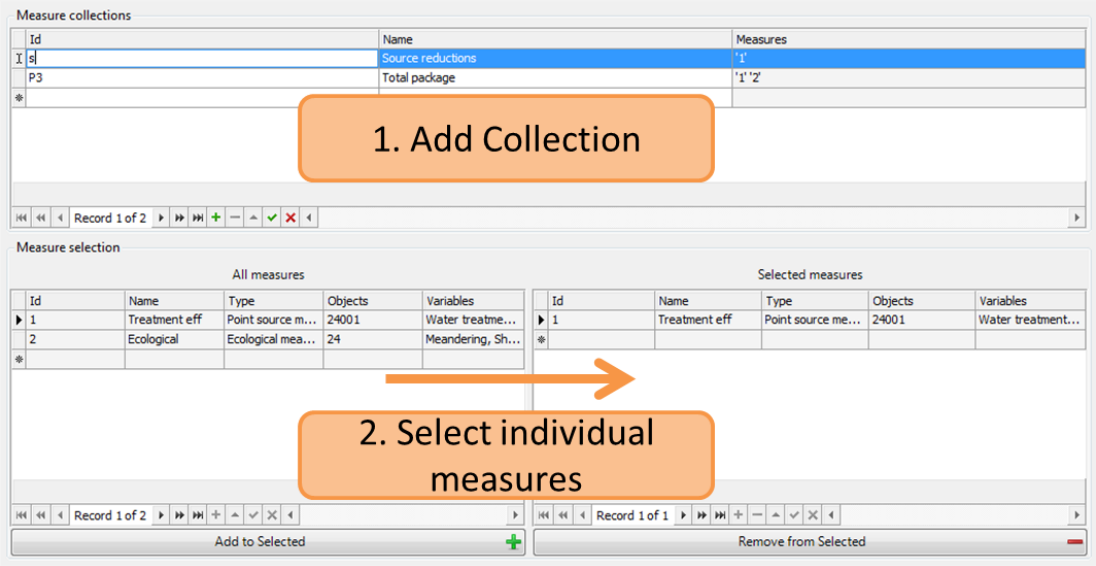


Figure 3.15: *Measure collection window*

Lastly, add the measure collection to a case:

- ◇ Add a new case
- ◇ Add the following characteristics:
  - Name: Measure
  - Year: 2010
  - Type Substances and ecology
  - Period: Year
  - Substances: N and P
- ◇ Click next
- ◇ Check the point source measure
- ◇ Run the Measure case

Has the reduction of nutrients improved the ecological quality? Why? You can add another measure to improve the ecological quality, for instance by adding some ecological measures (use again the measure and measure collection windows for this). Suggestions of ecological measures are given in Figure 2.16.

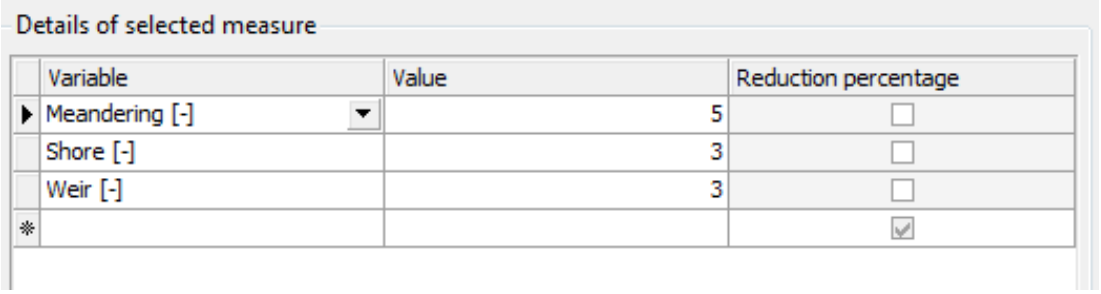


Figure 3.16: *Ecological measures*

4 User interface

The WFD Explorer's start window is depicted in figure 4.1. From this window, all functions required for building a WFD Explorer project, performing calculations and presenting the results are available. This start window can be divided in three, viz. the Project Explorer, the Map Contents and the Project Viewer. Additionally, there are four sub windows that can be pinned to the basic window if desired. These sub windows are important while working with a WFD Explorer project. The four sub windows are: messages, time series navigator and properties.

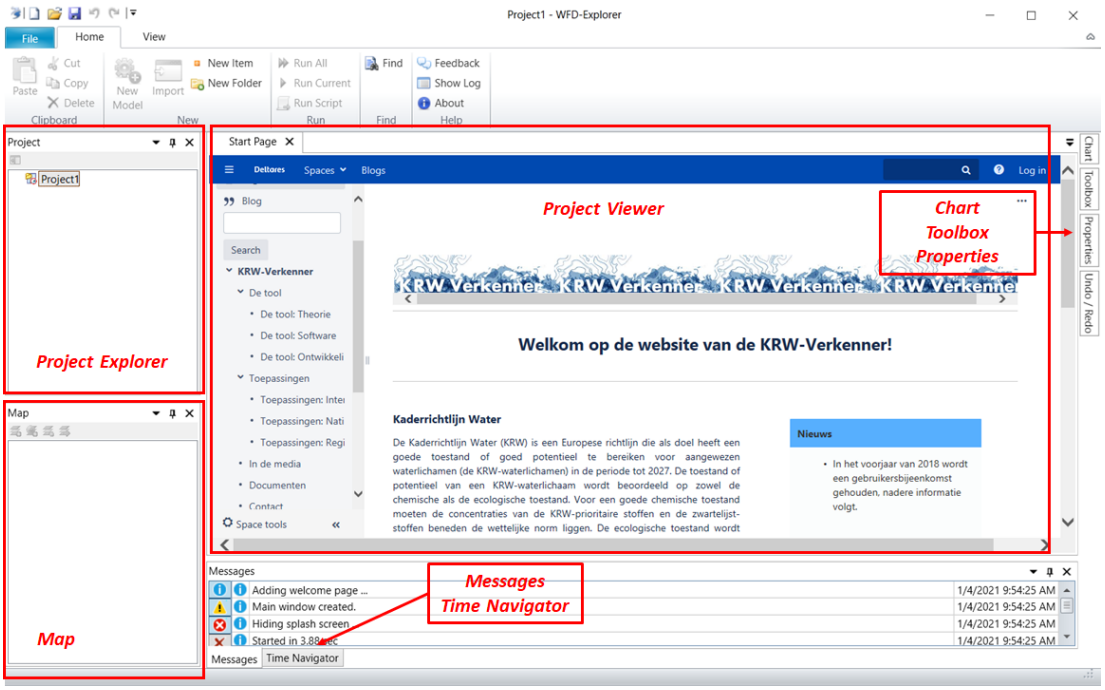


Figure 4.1: *Start window of the WFD Explorer*

The toolbar is located above the Project Viewer and is divided in several tabs (like MS Word) and respond with the actual view. On the ***File*** tab the following commands are available:

- ◇ Start new WFD Explorer project;
- ◇ Open WFD Explorer project;
- ◇ Save project;

On the ***Home*** tab the following commands are available:

- ◇ New item - Add a new WFD project or other item ()script, map, web link, etc) to the project explorer;
- ◇ New folder - add a new folder in the project explorer;
- ◇ Find - search any object (Ctrl-F);
- ◇ Show log - open the log file in notepad; and
- ◇ About - information about sorftware version.

When a map or WFD Network are opened in the main window, the ***Map*** toolbar is available (figure 4.2). Buttons in this toolbar are related to maps and the network. The buttons represent from left to right the following actions:

Table 4.1: *Map functions*

Button	Action
North Arrow	Toggle visibility of the north arrow
Legend	Toggle visibility of the legend
Scale Bar	Toggle visibility of the scale bar
	Select a single object.
	Select multiple objects by lasso.
	Pan the map.
	Zoom to full map extends
	Zoom by dragging a box
	Measuring distance between two locations
Zoom Previous	Go to previous zoom extend
Zoom Next	Go to previous zoom extend
Query Features	Additional information: when this button is activated, specific information of a location on the map can be inquired by clicking it
Map Coordinate System	Choose the coordinate system of the map
Export As Image	Export current view to an image file
Query Time Series	Get time serie of an object
	Move point
	Move point keeping current connections
	Add geometry point
	Remove geometry point
Surface Water Unit	Insert SWU node
Drainage Basin	Insert Basin node
Link	Insert link

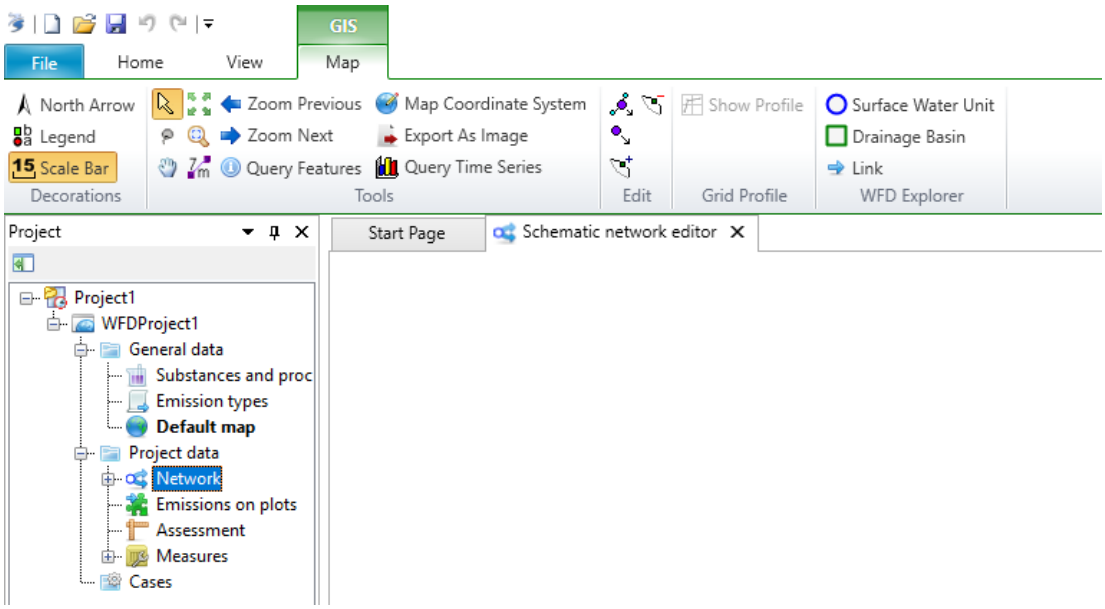


Figure 4.2: *Map toolbar*

All the information of a WFD Explorer project is stored in the Project Explorer. The information is clustered by means of categories and is comparable with the Windows Explore structure (see figure 4.3). Categories are:

- ◇ General information
- ◇ Information on the schematisation
- ◇ Cases and their results

In the next paragraph, each part of the Project Explorer is explained.

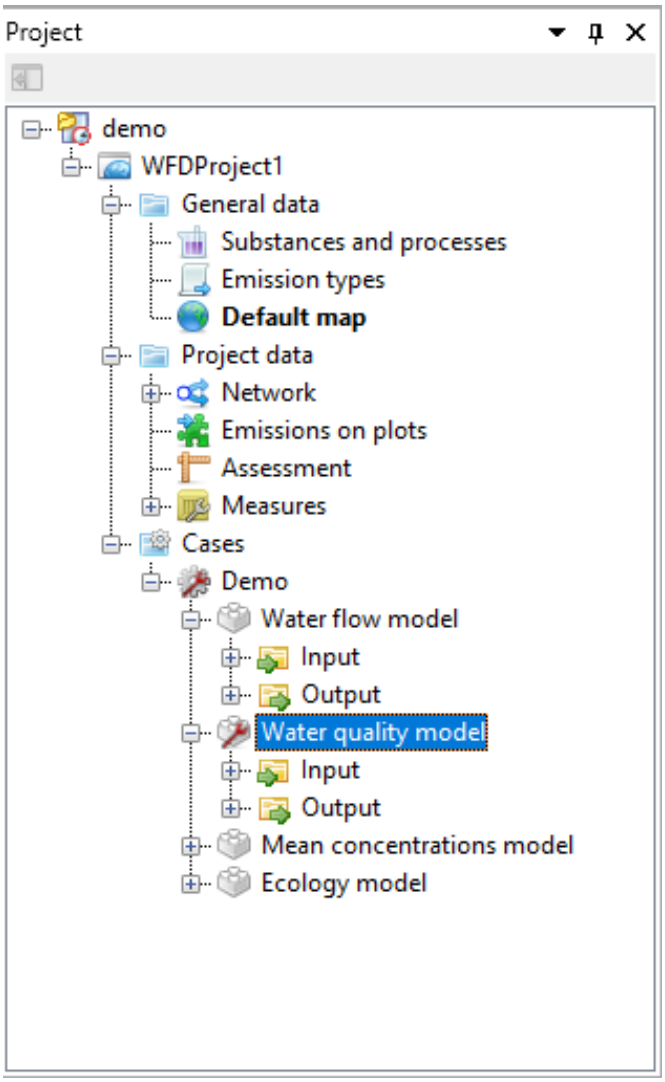


Figure 4.3: *Project Explorer*

4.1 General data

4.1.1 Substances and processes

In this window, the settings of substances and processes can be adjusted, like the decay rate constant of substances and the temperature dependency of this decay rate constant. The decay rate is the representation of all water quality processes, such as the sedimentation of substances in the sediment or internal eutrophication. Additional substances can also be added here (see figure 4.4).

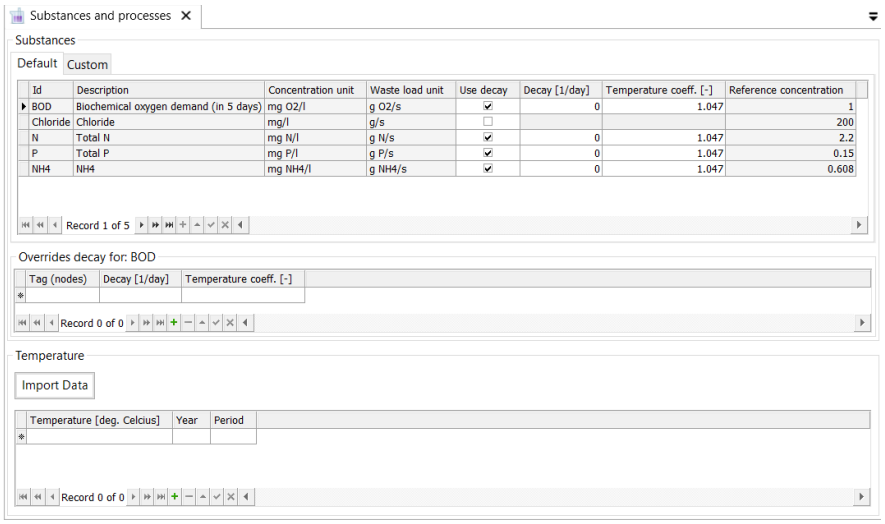


Figure 4.4: *The Substance and Processes window*

Adding substances and processes

There are two worksheets available in the Substances and Processes window. The first worksheet shows the predefined substances in the WFD Explorer. In the second worksheet (Custom), the user can define his/her own substances. Like for the predefined substances, the user can set decay rates and temperature dependencies of the decay rates for each of his/her added substances.

When the user adds any substances, these substances should at least be discharged in one node of the WFD Explorer schematisation. When additional substances are defined in the emission file (see later) and are not added to any discharge unit in the WFD user interface, the added substances will discharge anyway and have default setting (i.e., no decay rate).

Local overrides

Tags can be used to group model parts in a traceable way. Additionally, specific decay rates can be assigned to these tags, thereby giving the possibility to distinguish between the impacts of water quality processes on substance concentrations between water bodies. Note that the overrides window switches according to the row that is selected in the substance window.

Temperature settings

Next to the decay factor, temperature influence on water quality processes can be taken into account. Measured temperature data can be imported in the WFD Explorer per quarter of a year. When no temperature is defined, the WFD Explorer uses the default temperature of 20℃.

4.1.2 Emission types

There is an overview of the most common emission types for water quality simulations in the Emission types window (See figure 4.55). The user can change and add the names and description of emission types. When during the import of the emission files emission types are missing, the WFD Explorer automatically adds these missing emission types to this window.

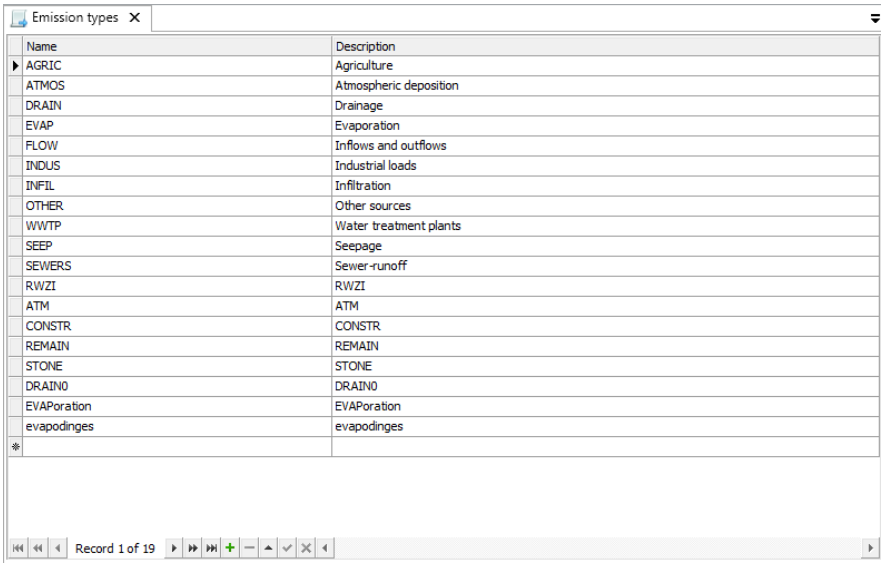


Figure 4.5: *Emission types window*

4.1.3 Background maps

To support modelling and get an impression of the research area, the WFD Explorer has the option to use background maps. Background maps can be imported via Default map (see figure 4.6). Maps that are added as background maps are visible in all map format views of the WFD Explorer. Because the option Default map is GIS related, the maps should be geo referenced. Some GIS options, such as adapting map colours and changing legends, are available via Map Contents. When the background maps comprise the right information, model schematisations can be built from these background maps.

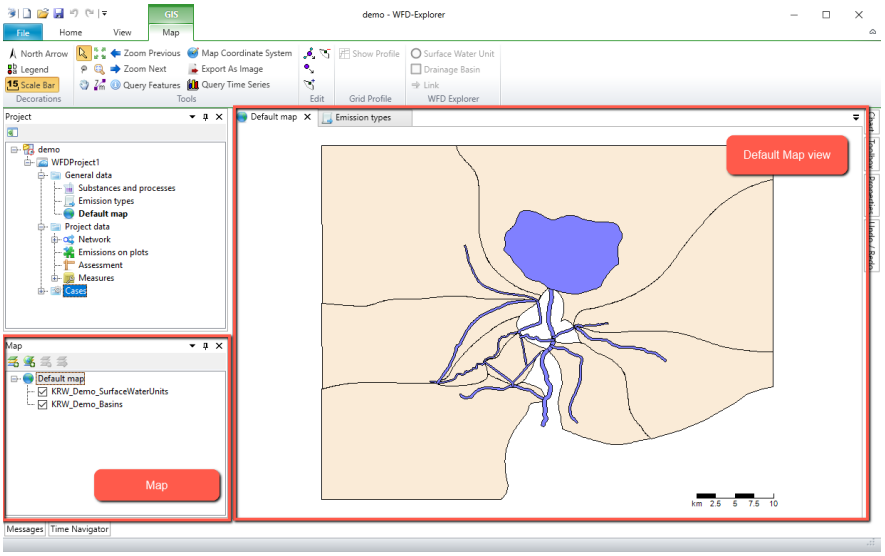


Figure 4.6: *Background map*

4.2 Project data

4.2.1 Network

Doubling clicking on Network opens the model schematisation in the Project Viewer. Here the schematisation can be viewed and changed. A WFD Explorer model consists of Basin and SWU nodes that are joined via links. Basin nodes contain information on smaller water bodies in a confined area that discharges into SWU nodes. SWU nodes are the water bodies that are actually modelled. Both types of nodes hold data on the dimensions (length, area and volume) of the node together with information on the name, ID, WFD-type and emission sources. The links contain data on the flow direction and distribution of the water.

4.2.1.1 Generate a network

A network can be generated in two ways:

- ◇ Building a network by hand: use the basin, SWU and link button in the tool bar and add all information by hand.
- ◇ Use the background maps and import CSV files: background maps can be used to add basin and SWU nodes by right clicking on the schematisation in the Project Viewer and choose Generate Drainage Basin Nodes and Generate Surface Water Unit nodes. In principle this can also be done via CSV import. Information on links, flows, point and diffuse sources, ecology and more can be added via the Network importer (see figure 4.7): right click on Network in the Project Explorer and choose import: the window depicted in figure X pops up. Here you can navigate to the location of the import files and assign them to specific parts of the WFD Explorer. Note: if the user uses straightforward names for his / her files, the Importer selects the right files.

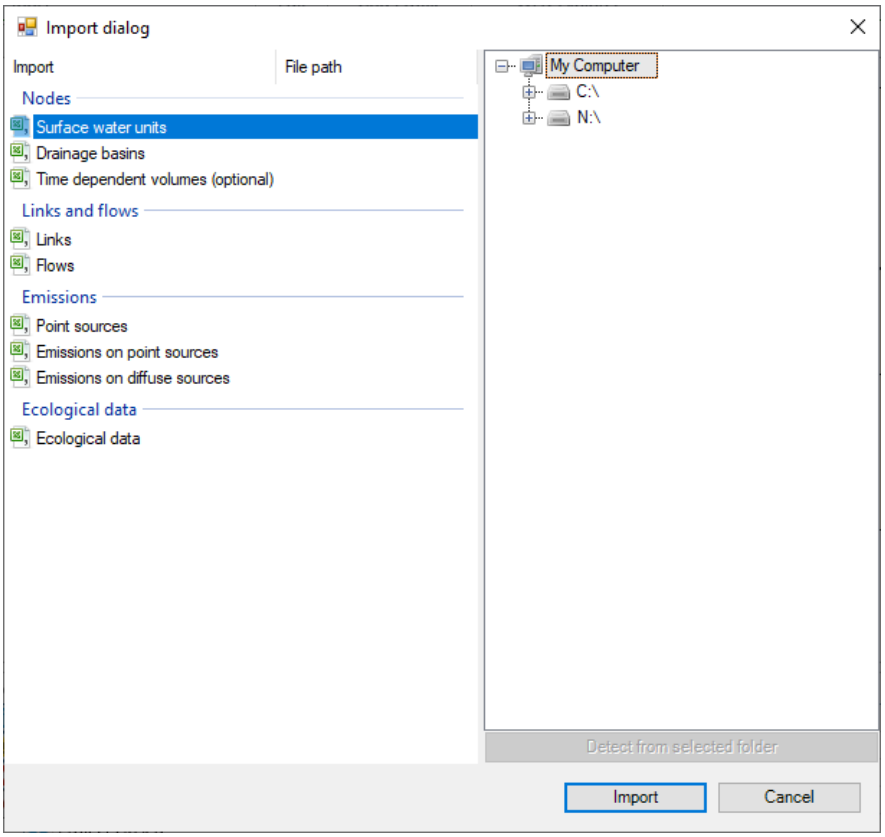


Figure 4.7: *Network importer*

After generating the network, the Network window is closed because of efficiency reasons. When the Network is reopened, the actual model is visible. The Basin nodes are green bordered squares and the SWU nodes are blue bordered circles. They are connected via light blue links. Information per node or link becomes available by double clicking the specific node or link. An overview of basic information of the nodes and links can be viewed via the properties window (see paragraph **??**).

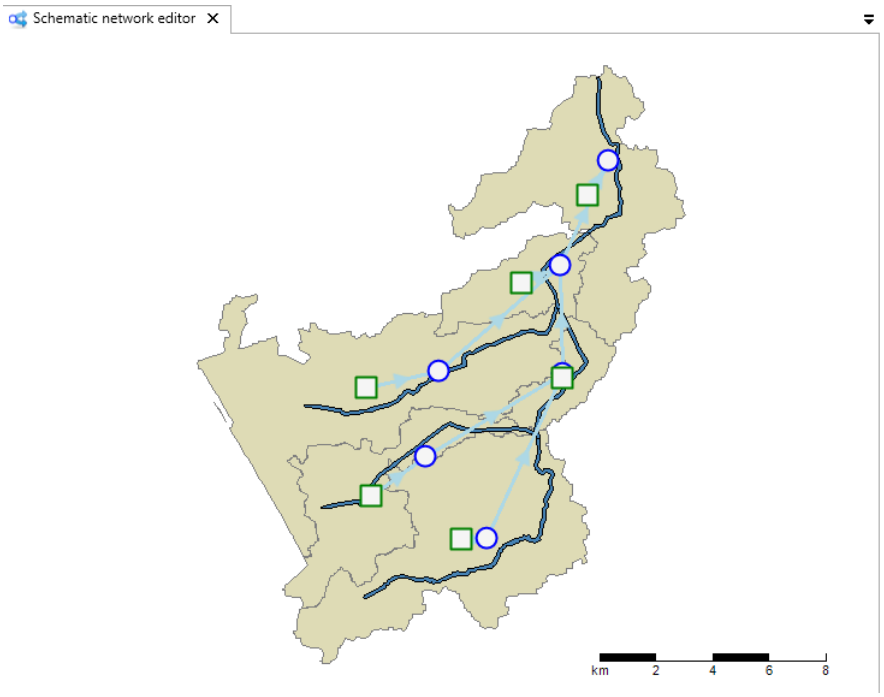


Figure 4.8: *Example of a WFD network after making a model*

4.2.1.2 Nodes

The Nodes window contains the following data on all the nodes in the schematisation (see 4.9):

- ID, which is unique for every node;
- Name, which is useful for identification;
- Type, Basin or SWU;
- Tag, label for specific settings like decay and presentation;
- WaterbodyID, the water body ID in which a SWU lies. Only applicable for SWU nodes. (please note that a WaterBodyID can contain multiple SWU nodes);
- WFDtype; the WFD class of the water body in which the SWU lies;
- X en Y coordinates;
- Volume and Horizontal Surface Horizontal area; geometry aspects of the node.

Nodes

Id	Name	Type	Tag	Water body	WFD type	X coordinate	Y coordinate	Volume data type	Year	Period	Volume	Horizontal surface
A6	Afwateringsgebied Jonge Vliet	Drainage basin	Basin (def)			1.0952E+05	5.1852E+05	Constant			4.004E+07	6.8124E+07
A2	Afwateringsgebied Stadsbeek	Drainage basin	Basin (def)			1.3147E+05	5.239E+05	Constant			1.3485E+07	1.4237E+07
A7	Afwateringsgebied Weteringen	Drainage basin	Basin (def)			1.2136E+05	5.284E+05	Constant			5.2533E+06	9.7965E+06
A3	Afwateringsgebied Schoone Beek	Drainage basin	Basin (def)			1.4219E+05	5.2649E+05	Constant			8.4659E+06	4.7705E+07
A5	Afwateringsgebied Oude Vliet	Drainage basin	Basin (def)			1.1721E+05	5.2903E+05	Constant			1.3248E+07	2.4614E+07
A9	Afwateringsgebied Ringvaart	Drainage basin	Basin (def)			1.0786E+05	5.3132E+05	Constant			4.1507E+06	8.0377E+06
A4	Afwateringsgebied Sprengbeek	Drainage basin	Basin (def)			1.5E+05	5.31E+05	Constant			9.4248E+06	3.3264E+07
A8	Afwateringsgebied Noorderloop	Drainage basin	Basin (def)			1.0742E+05	5.4514E+05	Constant			1.0001E+07	3.1908E+07
A10	Afwateringsgebied Noordermeer	Drainage basin	Basin (def)			1.3228E+05	5.4707E+05	Constant			1.5094E+06	2.7346E+06
10	Noordermeer	Surface water unit	SWU (def)	Nmeer	M14	1.2761E+05	5.4218E+05	Time dependent	2010	1	1000	600
10	Noordermeer	Surface water unit	SWU (def)	Nmeer	M14	1.2761E+05	5.4218E+05	Time dependent	2010	2	1050	610
10	Noordermeer	Surface water unit	SWU (def)	Nmeer	M14	1.2761E+05	5.4218E+05	Time dependent	2010	3	1035	605
10	Noordermeer	Surface water unit	SWU (def)	Nmeer	M14	1.2761E+05	5.4218E+05	Time dependent	2010	4	1010	600
4	Sprengbeek	Surface water unit	SWU (def)	Sprengb	R5	1.3101E+05	5.3287E+05	Constant			42149	28099
8	Noorderloop	Surface water unit	SWU (def)	Nloop	M10	1.1876E+05	5.3833E+05	Constant			1.5885E+05	79425
3	Schoone beek	Surface water unit	SWU (def)	SchBeek	R13	1.3466E+05	5.3041E+05	Constant			1.6246E+05	96270
11	Benedenloop Schoone beek	Surface water unit	SWU (def)	SchBeek	R13	1.2763E+05	5.3198E+05	Constant			18050	24067
13	Oude Vliet Oost	Surface water unit	SWU (def)	OVliet	R6	1.242E+05	5.3117E+05	Constant			97043	48521
2	Stadsbeek	Surface water unit	SWU (def)	StadsB	R6	1.2875E+05	5.2621E+05	Constant			1.8314E+05	12209
14	Ringvaart Oost	Surface water unit	SWU (def)	Ringv	M3	1.2386E+05	5.3359E+05	Constant			89782	44891
9	Ringvaart	Surface water unit	SWU (def)	Ringv	M3	1.1699E+05	5.3219E+05	Constant			2.5E+05	1.5712E+05
7	Weteringen	Surface water unit	SWU (def)	Wet	M6a	1.2163E+05	5.2803E+05	Constant			1.7083E+05	85417
6	Jonge Vliet	Surface water unit	SWU (def)	JVliet	M10	1.199E+05	5.2454E+05	Constant			2.2808E+05	1.1404E+05
1	Rivier de Afwentel	Surface water unit	SWU (def)	RivAfw	R6	1.2532E+05	5.2505E+05	Constant			1.8527E+06	4.6318E+05
5	Oude Vliet	Surface water unit	SWU (def)	OVliet	R6	1.1678E+05	5.2833E+05	Constant			2.2643E+05	1.1322E+05
12	Rivier de Afwentel Noord	Surface water unit	SWU (def)	RivAfw	R6	1.2596E+05	5.3368E+05	Constant			1.8527E+06	4.6318E+05

Figure 4.9: *<Nodes> overview window*

Time dependant or constant volumes?

The user might apply the volume of a node as constant or as timeseries, depending on the local characteristics. Please note that:

- ◇ Volume is only affecting the hydraulic residence time and therefore the decay processes. When using a conservative approach of the WQ computation, no effects of volume are visible.
- ◇ Each node however requires a volume. The use can decide for each node if a time dependant volume is necessary or not.

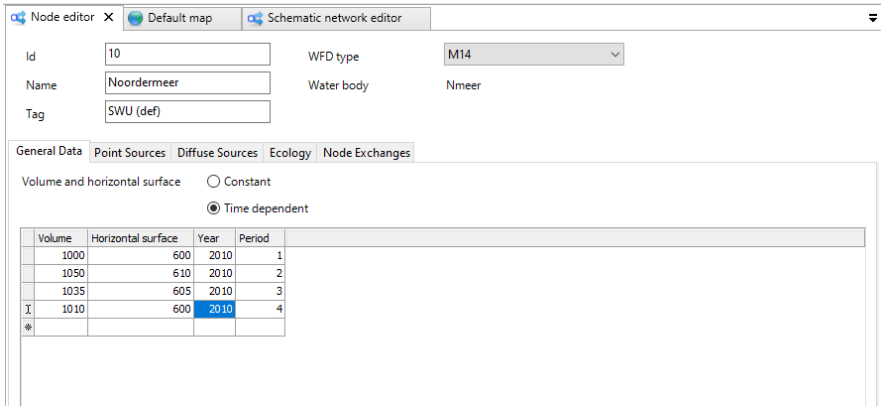


Figure 4.10: *Node editor, showing time dependent volumes*

4.2.1.3 Links and flows

The Links and Flows window (see 4.11) contains the following data on all the links in the schematisation:

- ◇ ID, which is unique for every link;
- ◇ Tag, a label for inditifying, filtering and/or visibly settings in the UI;
- ◇ From, the start of the link (flow direction);

- ◇ To, the end of the link (flow direction);
- ◇ Flow, dthe discharge over the link. Discharge can be defined in absolute (m^3/s) or relative (% from the total outflow) values;
- ◇ Percentage, if checked, the flow is in percentage;
- ◇ Flow year, the year of the flow;
- ◇ Flow period, the period of the flow (1st, 2nd, 3rd or 4th quarter or 0 a whole year)

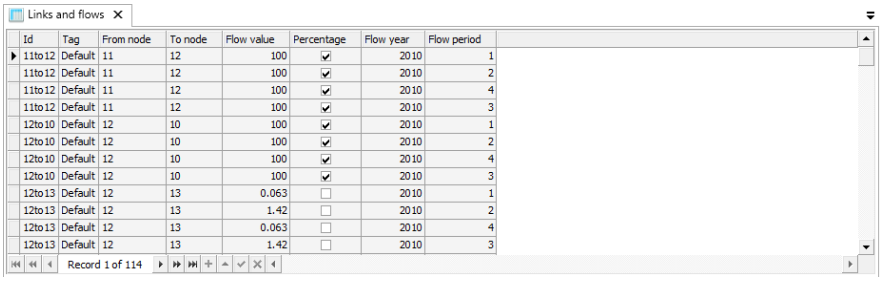


Figure 4.11: *<Links and Flows> overview*

4.2.1.4 Point source emissions

The Point source emissions window contains the following data on all point sources in the schematisation:

- ◇ Sourcename, the name of the source;
- ◇ SourceID, the unique ID of the source;
- ◇ NodeID, the node where the emission takes place;
- ◇ Nodetype, type of node where the emission takes place (SWU or Basin);
- ◇ Source emission type: the type of emission (see paragraph 4.1.2);
- ◇ EmissionValue, the amount of the emission (absolute value in g/s for substances or m^3/s for dicharges of water);
- ◇ RemovalEfficiency, the removal of the emission before it enters the water system (%);
- ◇ EmissionSubstance, the emitted substance;
- ◇ EmissionPeriod, the quarter of the year for which the emission value is valid (1st, 2nd, 3rd or 4th quarter or 0 a whole year);
- ◇ EmissionYear, the year of the emission.

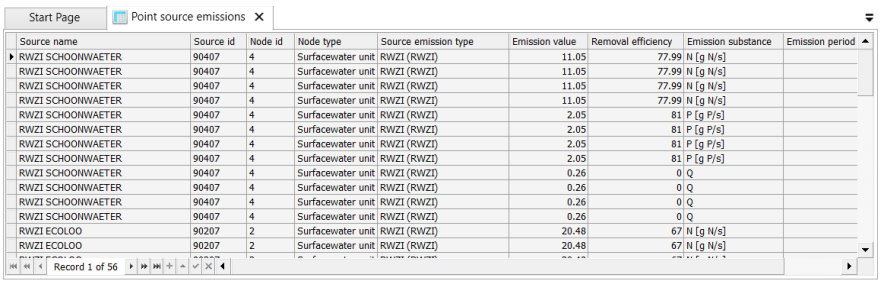
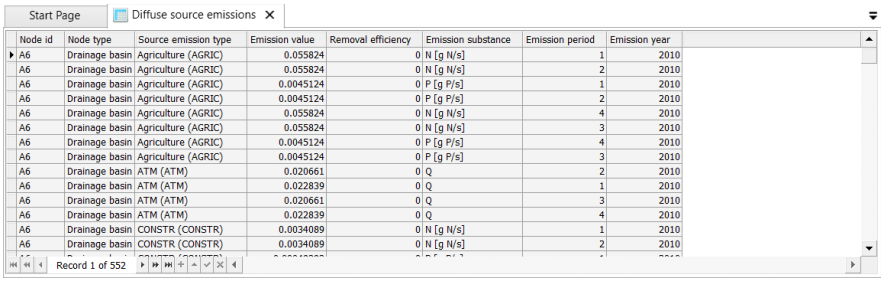


Figure 4.12: *<Point source emissions> overview*

4.2.1.5 Diffuse source emissions

The Diffuse source emissions window contains the following data on all diffuse sources in the schematisation (4.13):

- ◇ NodeID, the node where the emission takes place;
- ◇ Nodetype, type of node where the emission takes place (SWU or Basin);
- ◇ Source emission type: the type of emission (see paragraph 4.1.2);
- ◇ Emission Value, the amount of the emission (absolute value in g/s for substances or m^3/s for dicharges of water);
- ◇ Removal Efficiency, the removal of the emission before it enters the water system (%);
- ◇ Emission Substance, the emitted substance;
- ◇ Emission Period, the quarter of the year for which the emission value is valid (1st, 2nd, 3rd or 4th quarter or 0 a whole year);
- ◇ Emission Year, the year of the emission.



Node id	Node type	Source emission type	Emission value	Removal efficiency	Emission substance	Emission period	Emission year
A6	Drainage basin	Agriculture (AGRIC)	0.055824	0	N [g N/s]	1	2010
A6	Drainage basin	Agriculture (AGRIC)	0.055824	0	N [g N/s]	2	2010
A6	Drainage basin	Agriculture (AGRIC)	0.0045124	0	P [g P/s]	1	2010
A6	Drainage basin	Agriculture (AGRIC)	0.0045124	0	P [g P/s]	2	2010
A6	Drainage basin	Agriculture (AGRIC)	0.055824	0	N [g N/s]	4	2010
A6	Drainage basin	Agriculture (AGRIC)	0.055824	0	N [g N/s]	3	2010
A6	Drainage basin	Agriculture (AGRIC)	0.0045124	0	P [g P/s]	4	2010
A6	Drainage basin	Agriculture (AGRIC)	0.0045124	0	P [g P/s]	3	2010
A6	Drainage basin	ATM (ATM)	0.020661	0	Q	2	2010
A6	Drainage basin	ATM (ATM)	0.022839	0	Q	1	2010
A6	Drainage basin	ATM (ATM)	0.020661	0	Q	3	2010
A6	Drainage basin	ATM (ATM)	0.022839	0	Q	4	2010
A6	Drainage basin	CONSTR (CONSTR)	0.0034089	0	N [g N/s]	1	2010
A6	Drainage basin	CONSTR (CONSTR)	0.0034089	0	N [g N/s]	2	2010

Figure 4.13: *<Diffuse source emissions> overview*

4.2.1.6 Ecological variables

The Ecological variables window contains the following data on the nodes (see figure 4.14).

- ◇ ID, unique ID of the node;
- ◇ Name, name of the node;
- ◇ WaterType, KWFD classification for the node;
- ◇ Year, the year of the data;
- ◇ BOD (mg O2/l), the summer averaged (April-September) O2 concentration on the node;
- ◇ Chloride (mg Cl/l), the summer averaged (April-September) Cl concentration on the node;
- ◇ Connectivity:
  - 1 = isolated;
  - 2 = isolated periodically;
  - 3 = open connection;

◇ Maintenance:

1 = intensive;
2 = extensive;

• Meandering:

1 = straight with regulated profile;
2 = straight with natural profile;
3 = slightly meandering;
4 = meandering;
5 = freely meandering;

◇ N (mg N/l), the summer averaged (April-September) N concentration on the node;

◇ P (mg P/l), the summer averaged (April-September) P concentration on the node;

◇ Shadow:

1 = not shaded or without rough growth on the banks;
2 = partly shaded or rough growth on the banks;
3 = largely or totally shaded;

◇ Shipping:

1 = intensive shipping;
2 = no shipping;

◇ Shore / Bank design:

1 = sheet piled or steep and bare;
2 = helophytes;
3 = natural;

◇ Water level dynamics:

1 = unnatural;
2 = fixed;
3 = natural;

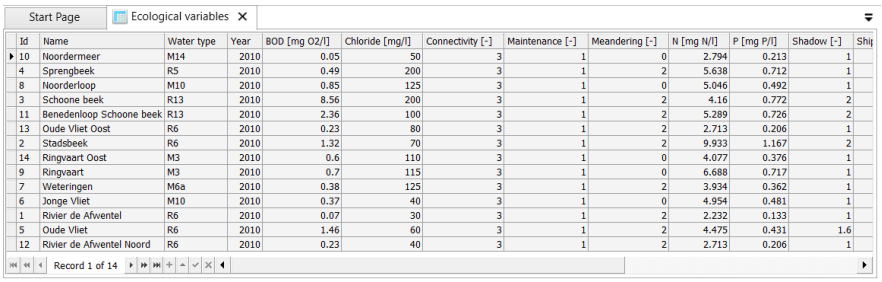
◇ Weir / - Impoundment:

1 = impoundments without fish passage;
2 = impoundments with fish passage;
3 = no impoundments.

◇ msPaf, value for Toxicity (0-1).

◇ NH4 (mg N/l), the summer maximum (April-September) NH4 concentration on the node;

◇ SecchiDepth (m).



Id	Name	Water type	Year	BOD [mg O2/l]	Chloride [mg/l]	Connectivity [-]	Maintenance [-]	Meandering [-]	N [mg N/l]	P [mg P/l]	Shadow [-]	Shi
10	Noordermeer	M14	2010	0.05	50	3	1	0	2.794	0.213	1	
4	Sprengbeek	R5	2010	0.49	200	3	1	2	5.638	0.712	1	
8	Noorderloop	M10	2010	0.85	125	3	1	0	5.046	0.492	1	
3	Schoone beek	R13	2010	8.56	200	3	1	2	4.16	0.772	2	
11	Benedenloop Schoone beek	R13	2010	2.36	100	3	1	2	5.289	0.726	2	
13	Oude Vliet Oost	R6	2010	0.23	80	3	1	2	2.713	0.206	1	
2	Stadsbeek	R6	2010	1.32	70	3	1	2	9.933	1.167	2	
14	Ringvaart Oost	M3	2010	0.6	110	3	1	0	4.077	0.376	1	
9	Ringvaart	M3	2010	0.7	115	3	1	0	6.688	0.717	1	
7	Weteringen	M6a	2010	0.38	125	3	1	2	3.934	0.362	1	
6	Jonge Vliet	M10	2010	0.37	40	3	1	0	4.954	0.481	1	
1	Rivier de Afwentel	R6	2010	0.07	30	3	1	2	2.232	0.133	1	
5	Oude Vliet	R6	2010	1.46	60	3	1	2	4.475	0.431	1.6	
12	Rivier de Afwentel Noord	R6	2010	0.23	40	3	1	2	2.713	0.206	1	

Record 1 of 14

Figure 4.14: *<Ecological Variables> overview*

4.2.1.7 Exporting network

Information of the network or parts of it can be exported by right clicking on the network or its sub parts in the Project Explorer and choose export. The data is exported in CSV format and can be saved to a user defined location. These files can be edited behind the scenes and, if wanted, imported again.

4.2.2 Emissions on plots

Emissions in the WFD-Explorer are mostly directly applied to nodes (SWU, Basins). Sometimes, emission data comes from other models, using their own spatial reference. Therefore, the WFD-Explorer has the opportunity to import emission data on "plots". Applying this emission data on plots is slightly more difficult and takes two steps:

1 Applying an "Area Division". The user defines one or more different plots.

2 For each "Area Divions"the following data is needed:

2.1 Sub Area – node relation. This is a table containing the relation between an AreaId and the relative contribution to the a NodeID.Figure 4.15 shows that the emission of Sub area 1192 is placed for 50% to node 3 for 50% to node 4.

2.2 The actual emission per sub-area.

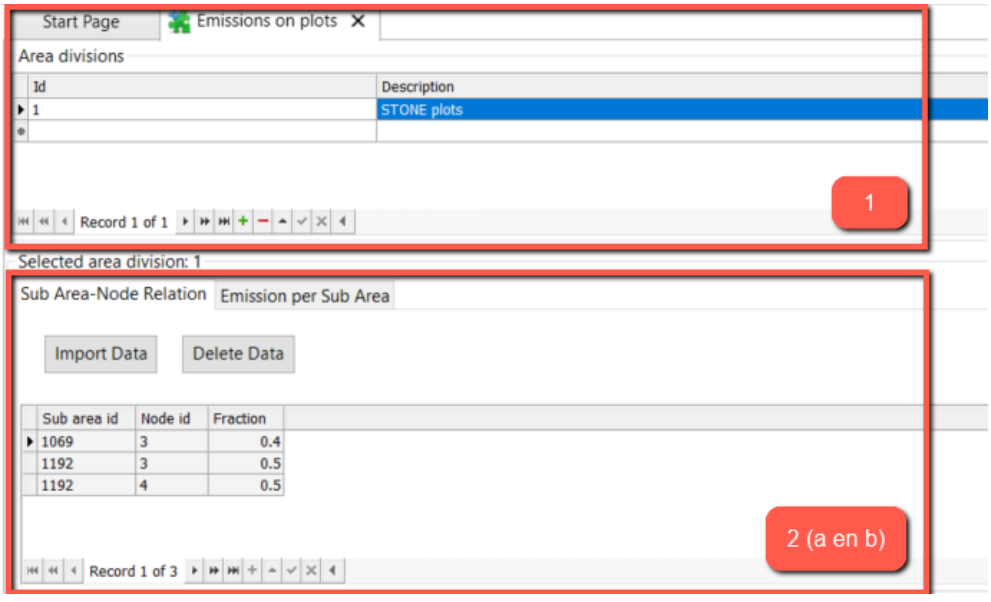


Figure 4.15: *<Emissions on plots> window*

The data for emissions on plots can only be imported by csv files.

’9

4.2.3 Assessment

Model results are tested against WFD metrics. The result of this testing is depicted in tables and maps according to the metrics classification shown in table 4.2. Additionally, the user is allowed to define his/her own metrics instead of using the predefined WFD metrics.

Table 4.2: *WFD classes, their colouring and their chemical and ecological assessment*

Class number	**Class**	**Colour**	**Assessment water quality**	**Assessment EQR**
1	High	Blue	< 0.5* MTD	0.8 - 1,0
2	Good	Green	0.5 - 1 * MTD	0.6 - 0.8
3	Moderate	Yellow	1 - 2 * MTD	0.4 - 0.6
4	Poor	Orange	2 - 5 * MTD	0.2 - 0.4
5	Bad	Red	> 5 * MTD	0 - 0.2

4.2.4 Define measures

4.2.4.1 Measures

To implement measures in the WFD Explorer, those measures should first be defined. There are two buttons available to define measures: Measures and Measure collections. Measures are defined separately, but can be grouped together.

The Measures window is divided in four (see Figure 3.9). The general characteristics of a measure are depicted top left:

- ◇ ID (user defined)
- ◇ Recognizable name (user defined)
- ◇ Type: point source, diffuse source of ecological measure
- ◇ Objects
- ◇ Variables

The latter two are automatically updated when the other parts of the window are adjusted.

The top right part of the Measures window contains detailed information on the measure. When the measure is aimed at a point or diffuse source, the option emission type becomes visible. Here, the type of emission source can be chosen (e.g. agriculture, WWTPs). Next, the substance that is affected by the measure can be defined. This can be done by absolute or relative values. When the measure is an ecological improvement, the values of the steering factors (see section 4.2.4.2) need to be adjusted.

In the lower half of the Measures window, measures can be assigned to specific nodes. This can be done by using the table (left) or the map (right).

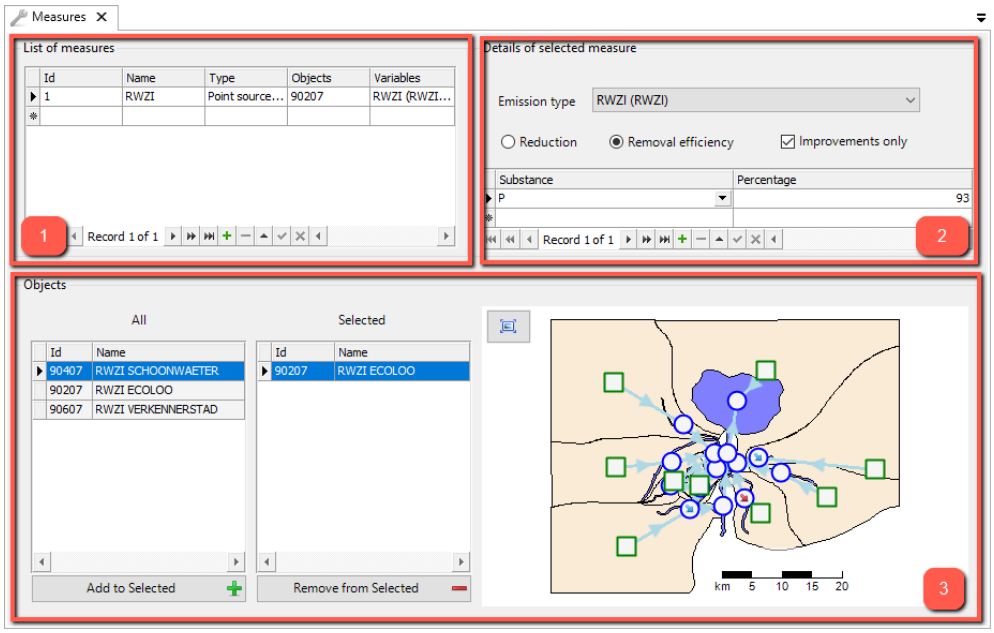


Figure 4.16: *Example of the Measure window*

4.2.4.2 Measure collections

The WFD Explorer works with a collection of measures only. Therefore, one or more measures should be combined in a measure collection. In the upper half of the Measure collection window (see Figure 3.10), the measure collection is given a user defined ID and name. In the third column, the WFD Explorer gives the measure collection an ID which is used in the lower half of the Measure collection window. In this lower half, measure collections can be selected and deselected.

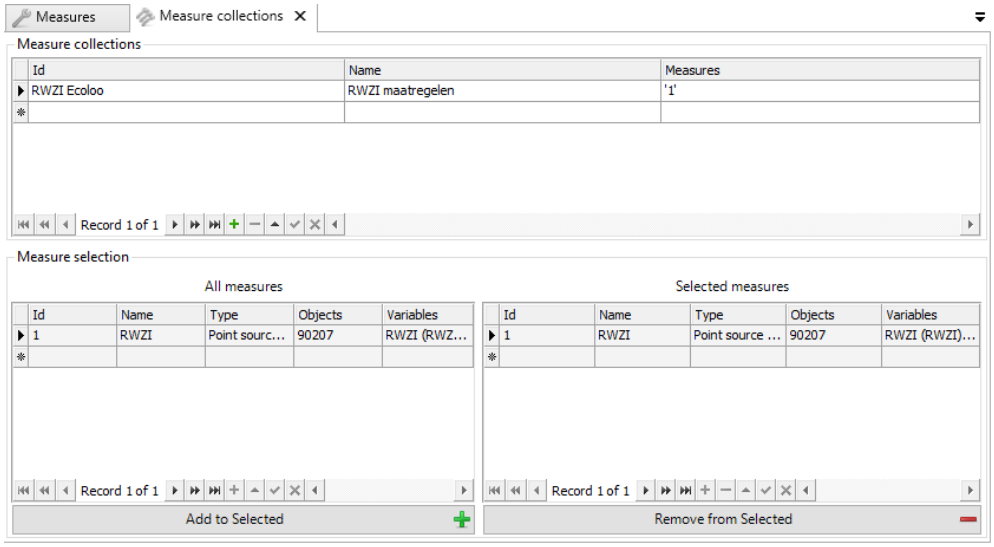


Figure 4.17: *The Measure Collection window*

4.2.5 Costs

The cost module can only be used after the creation of at least one measure collection. The Cost module window consists of 3 parts (see figure 4.18):

- ◇ General;
- ◇ Summary of costs; and
- ◇ Costs per measure and measure collections.

In the General part (upper left) the user can choose for a cost accounting per measure or per measure collection. No mixing between cost accounting per measure and measure collection is allowed. The interest rate can be changed, but is used for all measures or measure collections. The summary of costs part (upper right) is automatically updated when changes are made in the lower half of the Cost module window. The costs are presented in 1000*unit money.

In the lower half of the Cost module window, the measures or measure collections are visible. The user can insert several aspects that determine the total costs of the measure or measure collection. The aspects are: Investment: costs for financing the measure or measure collection Depreciation period: this is the life span over which the value of the measure or measure collection is reduced to 0 and should be equal to the time period needed to pay back the investment. Maintenance: costs to maintain the measure or measure collection. The assumption is made that maintenance is perpetual. Land costs: for some measures or measure collections acquisition of land is necessary. Depreciation period of land: normally these costs are very low, but it is included for the sake of transparency. The yearly costs are the sum of the discounted investment and the yearly maintenance costs. The discounted investment (C) is calculated as follows:

$$C = \frac{PV}{\left(\frac{1-(1+i)^{-n}}{i}\right)} \tag{4.1}$$

With PV the investment costs, i the interest rate and n the depreciation period.

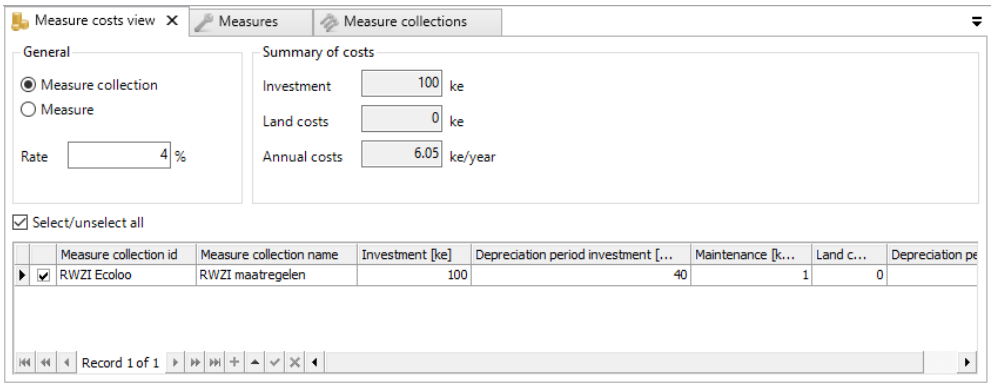


Figure 4.18: *The Costs window*

4.3 Cases

The user can add a case to the WFD Explorer project by right clicking on Cases and then choose add case. Consequently, the case wizard is started to guide the user through the process of adding a case. The case wizard has two windows: one for defining a case without measures and one for a case with measures.

4.3.1 Case wizard without measures

In this window of the case wizard (figure 4.19), the characteristics of the case are determined. The window allows the user to fill out the following characteristics:

- ◇ Name: the name of the case
- ◇ Type: this gives the user the choice to calculate:
  - □ both substances and ecology
  - □ only substances
  - □ only ecology
- ◇ Year: the year that is to be calculated. An error message appears when there is no data of that year in the model
- ◇ Period: which period should be calculated: trimesters or the whole year
- ◇ Substances: the user can choose which substances should be taken into account for this case.

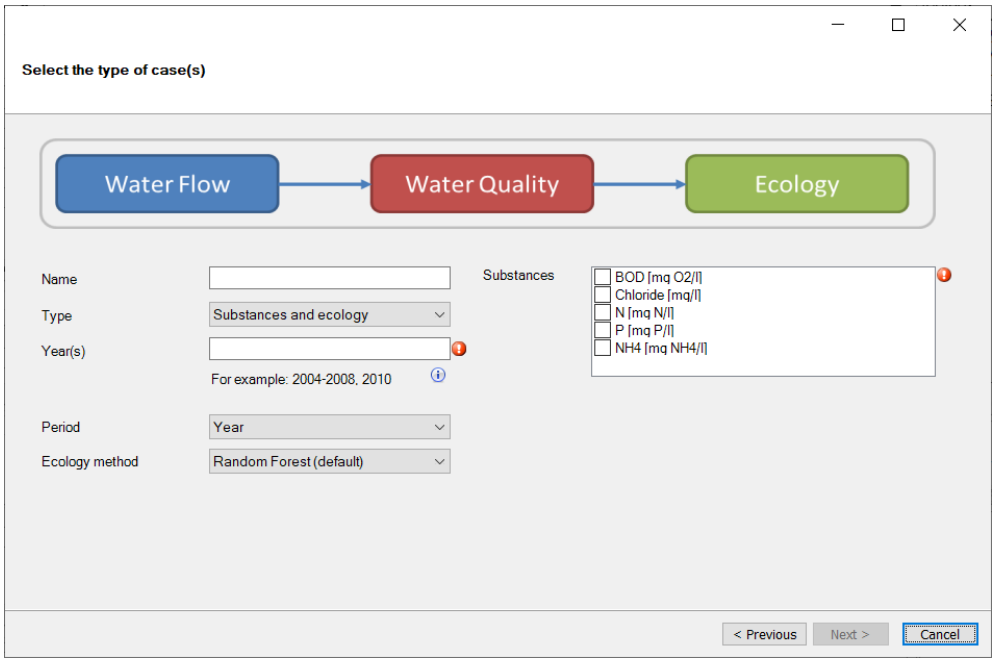


Figure 4.19: *Input window of the Case Wizard*

When everything is filled out correctly, the next button is activated which allows the user to finish the case.

4.3.2 Case wizard with measures

When measure collections are defined, the window depicted in figure 4.20 appears after the window in figure 4.19. In this window, the user has to choose his/her measure collections for that case. The measure collection or collections that are applied on a case become visible in tree diagram of Cases.

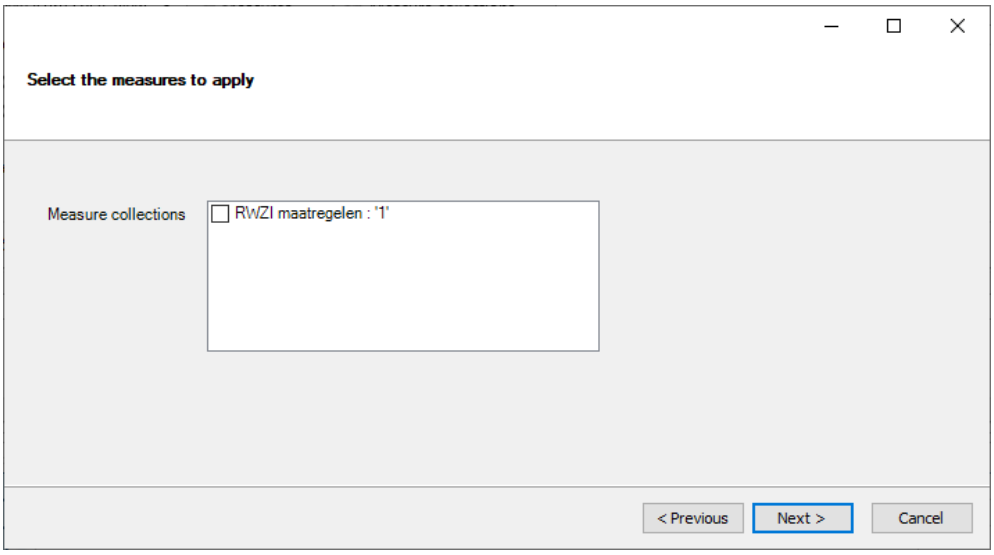


Figure 4.20: *Choice-of-measures window in the Case Wizard*

4.3.3 When the Case wizard is finished...

After a case is added, the case is depicted as a tree diagram. This tree diagram (see figure 4.3) contains:

- ◇ Case name
- ◇ Water flow model
- ◇ Water quality model
- ◇ Mean concentration model
- ◇ Ecology model.

4.4 Sub windows

When using the WFD Explorer for the first time, the sub windows remain hidden. However, the user can pin these windows to the main User Interface, making them a fixed part of the main window.

4.4.1 Messages

This window can give important information. In this Message window, messages are posted that have a relation to the user's or the WFD Explorer's actions. There are three types of messages:

Table 4.3: *Message window*

Icon	Message
	Informative messages: the WFD Explorer performs basis actions (e.g., opening or closing a window).
	there is an error, but the WFD Explorer can cope with it (but may be not in the way the user wants it).
	Error messages: there is an error and the WFD Explorer skips an action or halts.
	The clear message button removes all messages from the Message window.

4.4.2 Time Series Navigator

The Time Series Navigator window can be used when viewing the results. This navigator allows the user to "walk through" the results per time period. There are points on the navigator that shows where a result is available.

4.4.3 Properties

The Properties window gives background information of the schematisation visible in the Project Viewer window. When clicking on a point, location, node or link, the Properties window gives information that is available in files related to this point, location, node or link.

References

Deltares, 2020a. *D-Water Quality, Description of Input files*. Rev 68417.

Deltares, 2020b. *D-Water Quality Processes Library Description*. Rev 68417.

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